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FOREWORD

The effort required to develop the Global Reference Atmospheric Model was sponsored by the Atmospheric Sciences Division, Space Sciences Laboratory, NASA Marshall Space Flight Center. This report represents the latest developmental work on the model and was accomplished under the technical monitorship of Mr. Orvel E. Smith, the NASA Contracting Officer's Representative. Qualified requestors may obtain copies of the computer program for this NASA/MSFC Global Reference Atmospheric Model upon request to the Chief, Atmospheric Sciences Division, Space Sciences Laboratory, NASA, Marshall Space Flight Center, Alabama 35812.

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1. INTRODUCTION

In response to needs for empirical model atmospheres of wider scope and application, Georgia Tech developed, under NASA sponsorship, a Global Reference Atmosphere Model (GRAM) with latitude, longitude, and monthly variations over a height range from 0 to 700 km (Justus, et al., 1974 a, b, 1975, 1976). This report describes additions to this model whereby winds can be computed from a spherical harmonic model, based on observed wind data, rather than using the geostrophic relations originally employed. This section describes the basic GRAM model and Section 3 provides a more detailed description of the GRAM program. Section 3 presents some sample results with the new spherical harmonic wind model. Section 4 and 5 are user's manual and programmer's manual section for the GRAM program.

1.1 Description of the Basic Model

The Georgia Tech Global Reference Atmospheric Model (GRAM), is an amalgamation of two previously existing empirical atmospheric models for the low (<25 km) and high (>90 km) atmosphere, with an empirical latitude-longitude dependent model for the middle atmosphere. The high atmospheric region above 115 km is simulated entirely by the Jacchia (1970) model. The Jacchia program sections are in separate subroutines so that later Jacchia models (Jacchia, 1971) or other thermospheric-exospheric models could easily be adapted and substituted into the program if required for special applications. The atmospheric region between 25 km and 115 km is simulated by a latitude-longitude dependent empirical model, which is a modification of the latitude dependent empirical model developed by Groves (1971), described more fully in this report. Between 90 km and 115 km, a smooth transition between the modified Groves values and the Jacchia values is accomplished by a fairing technique. Below 25 km the atmospheric parameters are computed by a 4-D world-wide atmospheric model developed for NASA by Allied Research Associates (Spiegler and Fowler, 1972). Between 25 and 30 km an interpolation scheme is used between the 4-D results and the modified Groves values. Figure 1.1 presents a schematic summary of the Global Reference Atmospheric Model program atmospheric regions and how they are modeled.

The modifications to Groves model to produce longitude as well as latitude variations in the monthly mean were accomplished in two steps. For the original version, upper air summary map data for monthly means at the 10 mb level for 1966 and 1967 (NOAA, 1969b) and the 2 and 0.4 mb levels for 1966, 1967, and 1968 (NOAA, 1969a, 1970, 1971) were read and converted to values for the 30, 40, and 52 km levels. These upper air map values at the 2 and 0.4 mb levels were extended around the entire northern hemisphere by subjective extrapolation. For the earlier Mod 2 version of GRAM, additional 10 mb data for 1964 and 1965 (NOAA, 1967a) and 2 and 0.4 mb data for 1964 and 1965 (NOAA, 1967 b, c) and 1972 (NOAA, 1975) were also read and added to the earlier data. The 1972 2 and 0.4 mb data extended into the eastern hemisphere, so no extrapolation of it was necessary. Next the 30, 40, and 52 km latitude-longitude dependent values were extrapolated to 90 km by an extrapolation scheme developed by Graves, (1973). All of the map-generated and extrapolated data were converted to percent deviation from the longitudinal mean and these are applied as deviations (called stationary perturbations) to the Groves model values, which are taken as the latitude dependent longitudinal means.

The seasonal variations in the middle atmosphere (25-115 km) are assumed to be the same in northern and southern hemispheres with a six months' phase

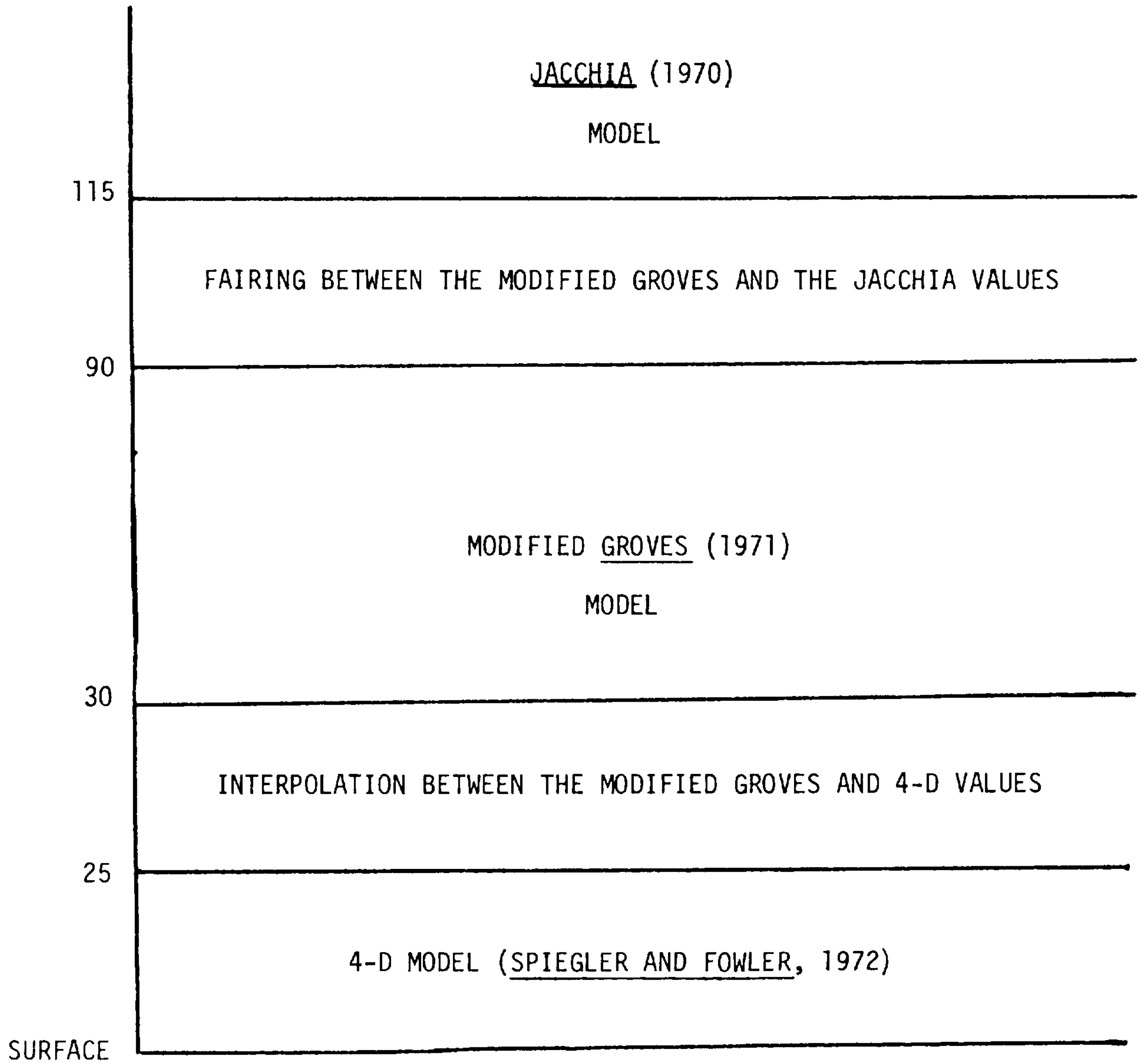


Figure 1.1 Schematic summary of the atmospheric regions in the Global Reference Atmospheric Model (GRAM) program and the simulation methods used for mean monthly values in each region

lag. That is, the southern hemisphere July is the same as the northern hemisphere January. In the 4-D region ($\leq$25 km) separate global coverage data values are available for each of the twelve months. A set of annual reference period data are also available for the 4-D and modified Groves regions. If the annual reference period is selected, the Jacchia section sets the exospheric temperature to 1000°K to represent annual mean conditions.

Below 25 km and above 90 km, the monthly mean geostrophic winds are computed from horizontal pressure gradients, estimated by finite differences. Near the equator, a newly devised interpolation scheme is used instead of the geostrophic relation (which approaches infinite values as the latitude approaches zero). In the height range 25 to 90 km, the newly developed spherical harmonic wind model is used, at all latitudes. Mean vertical winds, of the order of 1 cm/sec, are evaluated from the slopes of isentropic surfaces and the horizontal advective winds. Wind shear in the monthly mean horizontal wind is estimated from horizontal temperature gradients in the regions below 25 km and above 90 km. In the 25-90 km height range, mean wind shear is computed from finite differences of the spherical harmonic winds at adjacent height levels.

In addition to the monthly mean values of pressure, density and temperature, two types of perturbations are evaluated: quasi-biennial (QBO) and random. The QBO oscillations in pressure, density, temperature, and winds, empirically determined to be represented by an 870 day period sinusoidal variation, have amplitudes and phases which vary with height and latitude. The QBO amplitudes are primarily significant at low altitudes ($\gtrsim$ 20 - 40 km) at equatorial latitudes and at higher altitudes (50 - 60 km) at higher latitudes. For the earlier Mod 2 version, the QBO amplitudes and phases were newly evaluated from a larger data set, which included MRN data through 1972.

For realistic simulation of actual atmospheric parameter values as they would likely be at any given time, random perturbations are also computed and applied as perturbations to the monthly mean values. The random perturbations are evaluated by a simulation technique which uses empirical values of variation magnitudes and scales to generate random perturbations which have realistic space and time correlations.

Originally the perturbation model was characterized by a single vertical scale and horizontal scale, and no attempt was made to insure compliance with constraints on the perturbation magnitudes, required by the perfect gas law (Buell, 1970) and hydrostatic equation (Buell, 1972). In an earlier report (Justus and Woodrum, 1975), the revisions were described which improved the data base of the perturbation magnitudes, and adjusted the magnitude profiles to insure compliance with the Buell constraints. For the earlier Mod 2 version reported here, the use of a two scale perturbation model was implemented. This model simulates separately the perturbations of small scale (e.g., turbulence and gravity waves) and large scale (e.g., tides and planetary waves) effects. These perturbations are treated stochastically, however--no deterministic model of these physical processes is used.

The following sections give a technical description of the Global Reference Atmospheric Model - Mod 3 with emphasis on the new additions, and new users manual descriptions of the program aspects of the revised model.

2. TECHNICAL DESCRIPTION OF THE MODEL

2.1 The Jacchia Section

The Jacchia (1970) model for the thermosphere and exosphere was originally implemented to compute atmospheric density at satellite altitudes. The Jacchia model accounts for temperature and density variations due to solar and geomagnetic activity, diurnal and semi-annual variations, and seasonal and latitudinal variations. The Jacchia model assumes a uniformly mixed composition from sea level to 105 km, with diffusive equilibrium among the constituents (nitrogen, oxygen, argon, helium, and hydrogen) above 105 km. Fixed boundary values for temperature and density are assumed at 90 km. Alterations, described in Justus et al (1974 a), were made to allow atmospheric pressure to be computed from the density and temperature. Geostrophic winds are evaluated in the Jacchia section by computing horizontal pressure gradients with successive evaluations of the Jacchia model at different latitudes and longitudes.

2.2 The 4-D Section (below 25 km)

The 4-D atmospheric model, developed by Allied Research Associates (Spiegler and Fowler, 1972) was designed to extract from data tapes and interpolate on latitude and longitude, mean monthly and daily variance profiles of pressure, density, temperature, at 1 km intervals from the surface to a height of 25 km for any location on the globe. The data tapes contain empirically determined atmospheric parameter profiles at a large array of locations. The northern hemisphere grid array is equivalent to the NMC grid network. Grids spaced at 5 degree intervals of latitude and longitude are used in the equatorial and southern hemisphere regions.

Technical changes made in the 4-D program were: a modified latitude-longitude interpolation method, previously described in Justus et al. (1974 a), an adjustment routine to modify the variance to comply with the Buell constraints, and a check routine to determine vertical and horizontal consistency of the 4-D data.

The method of application of the 4-D model in the GRAM program is as follows: at the first time that atmospheric parameters at a location below 30 km are required, a set of atmospheric profiles of monthly mean and daily variances of pressure, density, and temperature are generated at a 16 point grid of locations spaced at 5 degree latitude and longitude intervals (a slightly different grid is used near the poles). This grid of profiles, covering 15° x 15° of latitude-longitude is then stored in the computer and all further atmospheric parameter values in the 0-25 km range are found by interpolation between locations within this grid. If the trajectory goes outside this grid while the height remains below 25 km, the program attempts an estimate of the atmospheric parameters by an additional call on the routine which sets up the 4-D data grid.

The location of the grid points to be evaluated is determined dynamically based on the position and direction of travel along the trajectory when the 4-D grid is first required by a procedure described in Justus et al (1974 a). The 4-D data tapes normally contain data for the surface to 25 km in 1 km steps. At locations where the surface is at more than 1 km above sea level the surface value will be followed by one or more zero records, and the first non-zero record above the surface value will be at the lowest integer km higher than the surface. For example, if the surface is at 700 m then there will be data at surface, 1 km, 2 km, etc., but if the surface is at 1.3 km the data will contain the surface, one zero record, 2 km, 3 km, etc. In the Mod-3 version an interpolation routine (based on the hydrostatic relation and constant lapse rate altitude segments) is used to fill in data between sea level and the first non-zero data above the surface. Interpolation is also used to fill in any missing data immediately below the 25 km height. The basic interpolation equations were described in Justus et al (1974 a).

2.3 The Modified Groves Section (25 - 90 km)

The starting point for the middle atmosphere (25 - 110 km) is the latitude dependent model of Groves (1971). This empirical model combines many observations from a wide range of longitudes. Observational results over approximately six years were used to compute longitudinal averages, which are presented versus latitude and month. Latitude coverage of the Groves model is from the equator to 70° or in some cases 80°. Southern hemisphere data were utilized in developing the Groves model as northern hemisphere data with a 6-month change of date. Tabulations of the Groves model are at intervals of 5 km in height, 10° in latitude (northern hemisphere), and one month in time (southern hemisphere displaced six months). If the Groves values of an atmospheric parameter y were known up to 80° latitude, then the 90° latitude Groves value was computed from

$$y_{90} = (4y_{80} - y_{70})/3 \tag{2.1}$$

If Groves values of the atmospheric parameter y were known only up to 70° latitude, then the 80° and 90° latitude Groves values was computed from

$$y_{90} = (9y_{70} - 4y_{60})/5 \tag{2.2}$$

$$y_{80} = (8y_{70} - 3y_{60})/5 \tag{2.3}$$

The Groves model data has only height and latitude variation for each month. For longitude variation, the Groves model data is modified by longitude, latitude, and height dependent stationary perturbations. These stationary perturbations are derived, by methods described more fully in Justus et al (1974 a) from 10, 2, and 0.4 mb map data and extrapolation up to 90 km. The stationary perturbations were evaluated at longitudes 10°, 40°, 70°, ... 340° for latitudes 10°, 30°, 50°, 70°, and 90°.

Originally, only the 1966 and 1967 10 mb monthly mean values (NOAA, 1969 b) were read and averaged. The 2 mb and 0.4 mb weekly mean maps for 1966, 1967, and 1968 (NOAA, 1969 a), 1970, 1971) were read for the first week of each month, and averaged over the three years. For the earlier Mod 2 version, additional 10 mb data for 1964 and 1964 (NOAA, 1967 a) and 2 and 0.4 mb data for 1964 and 1965 (NOAA, 1967 b, c) and 1972 (NOAA, 1975) were also read and added to the earlier data.

After the upper air chart data were averaged, the next step was to convert the readings to constant heights of 30, 40, and 52 km. This was done by assuming that the temperature followed a constant lapse rate between each chart level and the nearest interpolation altitude with lapse rates based on the Groves model.

In order to introduce longitude variability at heights above 52 km, the extrapolation technique of Graves et al. (1973) was used to project the 52 km interpolated chart data up to 90 km. The 5 extrapolation height levels are 60, 68, 76, 84, and 90 km.

After the chart data were interpolated to 30, 40, and 52 km and extrapolated to 60, 68, 76, 84, and 90 km, the stationary perturbations (relative deviations to be added to the Groves values) were calculated. At each altitude and latitude the stationary perturbation s_y for a parameter y (which can represent pressure, density, or temperature) was computed by the relation

$$s_y = (y - \langle y \rangle)/\langle y \rangle \tag{2.4}$$

where $\langle y \rangle$ represents the longitude averaged value of y (i.e. averaged around a circle of fixed latitude). Note that the definition of s_y makes it be identically zero at the pole. The stationary perturbation s_y for parameter y is added to the Groves value G_y to produce the longitude variable modified Groves value G'_y, according to the relation

$$G'_y = G_y(1 + s_y) \tag{2.5}$$

The modified Groves values, determined by relation (2.5) are used as the monthly mean values for the altitude range 30 to 90 km.

2.4 Interpolation and Fairing

The 4-D data are available on the data tapes at one km height intervals and at 5° x 5° latitude-longitude grids in the southern and equatorial areas and at the NMC grid locations in the northern hemisphere. NMC grid profiles are always converted (by interpolation) to 5° x 5° grids before interpolation to the trajectory locations. The general interpolation requirements for the 4-D section are height interpolation over 1 km and latitude-longitude interpolation over a 5° x 5° square grid.

The Groves data are tabulated at 5 km height intervals and 10° latitude intervals. Interpolation is required between these tabulated locations. The stationary perturbations are evaluated at 20° latitude and 30° longitude intervals and at 30, 40, 52, 60, 68, 76, 84, and 90 km altitudes. Interpolation between these tabulated locations is also required. For values between 25 km and 30 km interpolation between the 4-D data and Groves-plus-stationary-perturbation data are required. The interpolations are always carried out in the program by doing the latitude (Groves) or latitude-longitude (4-D) interpolation first, and then doing the height interpolation.

The Jacchia model can be evaluated at any height above 90 km and at any latitude and longitude, so no interpolation is required. However, between 90 and 115 km there is overlap between the Groves data and the Jacchia model, so a fairing procedure is used to effect a smooth transition between the Groves data at 90 km and the Jacchia values at 115 km.

The method used to interpolate pressure, density, and temperature over a height interval between heights z_1 and z_2 is to assume linear variation of the temperature and of the logarithm of the density. The latitude interpolation for the Groves data is done by assuming linear variation between the latitudes ϕ_1 and ϕ_2 (which are at $\Delta\phi = 10°$ apart). Two dimensional latitude-longitude interpolation between a square or rectangular array of positions at latitudes ϕ_1 and ϕ_2 and west longitudes λ_1 and λ_2, is done by the relation

$$F(\phi , \lambda) = F_0 + (F_1 - F_0)\delta\phi + (F_2 - F_0)\delta\phi + (F_3 - F_1 - F_2 + F_0)\delta\phi \; \delta\lambda$$

where $\delta\phi$ is $(\phi - \phi_1)/(\phi_2 - \phi_1)$ and $\delta\lambda$ is $(\lambda - \lambda_1)/(\lambda_2 - \lambda_1)$.

To accomplish smooth transition between the Groves values at 90 km and the Jacchia values at 115 km a fairing technique is used. This fairing technique was described in Justus et al (1974 a). The fairing is done only at the altitudes 95, 100, 105, 110, i.e. heights for which there are Groves values. Linear interpolation is then used to fill in the remaining heights, as discussed in the height interpolation section above.

Interpolation of the random perturbation magnitudes is done linearly on the variance (σ^2) rather than linearly on the magnitude (σ). This is because the Buell adjustment equations (see later sections) are nearly linear in the variances. Thus, once variances have been Buell adjusted, their adjustment would tend to be preserved by linear interpolation on variances, not magnitudes.

2.5 Geostrophic Winds

The eastward (i.e., blowing toward the east) wind component u and northward component v can be evaluated from the geostrophic wind equations

$$u = -(1/\rho f)\ \partial p/\partial y \qquad (2.6)$$

$$v = (1/\rho f)\ \partial p/\partial x \qquad (2.7)$$

where ρ is the density, f is the Coriolis parameter ($2\ \Omega \sin \phi$) and $\partial p/\partial x$ and $\partial p/\partial y$ are the eastward and northward components of the horizontal pressure gradient. For evaluation in the model, the pressure gradient terms must be approximated by finite differences.

Geostrophic wind values are computed in the 4-D height range, by finite differencing of the 4-D pressure data, and in the Jacchia height range by evaluating the Jacchia model at 5 degree increments of latitude and longtitude and taking finite differences of the resulting pressure. In a recent comparison between the GRAM-computed winds and observed winds at Eglin AFB, Florida, the mean deviation was 1 m/s EW and -16 m/s NS, with an rms deviation of 60 m/s between model and observed. Thus, the mean winds are modeled with fair accuracy, and the rms deviation is about the same as the wind perturbation magnitude expected on the basis of the GRAM perturbation model.

2.6 Thermal Wind Shear

The wind shear components $\partial u/\partial z$ and $\partial v/\partial z$ in the 0-25 km and above 90 km height ranges are evaluated by the thermal wind equations

$$\partial u/\partial z = -(g/fT)\ \partial T/\partial y \qquad (2.8)$$

$$\partial v/\partial z = (g/fT)\ \partial T/\partial x \qquad (2.9)$$

which is the usual form, leaving off a correction term in $\partial T/\partial z$, which is normally small. The horizontal temperature gradient terms are estimated by finite differences in a similar manner to the pressure gradient components in equations (2.6) and (2.7).

Thermal wind shears are also computed in the Jacchia height range in a manner similar to that described for the wind calculations. Again, however, for the reasons already discussed, these values should not be taken as precise.

Since the ordinary geostrophic winds are inversely proportional to the coriolis parameter f (which goes to zero at the equator), these relations give unrealistically large winds at low latitudes. To overcome this problem interpolation between about +15° and -15° latitude is used in the MOD-3 version of GRAM. This interpolation limit, being on the "minimum geostrophic latitude," is specified in the program input.

2.7 The Spherical Harmonic Wind Model

The spherical harmonic equation, including terms through second order in co-latitude (ϕ) and longitude (θ), are:

$$\begin{aligned} u(m, z, \theta, \phi) = {} & a_1 P_0(\mu) + a_2 P_1(\mu) \\ & + [a_3 \cos\theta + a_4 \sin\theta] P_{11}(\mu) + a_5 P_2(\mu) \\ & + [a_6 \cos\theta + a_7 \sin\theta] P_{21}(\mu) \\ & + [a_8 \cos 2\theta + a_8 \sin 2\theta] P_{22}(\mu) \end{aligned} \tag{2.10}$$

where $\mu = \cos\phi$, m is month, z is height, u is either the wind component being modeled, and the a coefficients all depend on both m and z. The $P_{ij}(\mu)$ are Legendre functions given by

$$
\begin{aligned}
P_0(\mu) &= 1 \\
P_1(\mu) &= \mu \\
P_2(\mu) &= (3\mu^2-1)/2 \\
P_{11}(\mu) &= (1 - \mu^2)^{1/2} \\
P_{21}(\mu) &= 3\mu(1 - \mu^2)^{1/2} \\
P_{22}(\mu) &= 3(1 - \mu^2)
\end{aligned}
\tag{2.11}
$$

With the substitution of (2.11) into (2.10), the spherical harmonic model representation for a wind component becomes

$$
\begin{aligned}
u(m, z, \theta, \phi) = a_1 &+ a_2 \cos\phi + a_3 \cos\theta \sin\phi \\
&+ a_4 \sin\theta \sin\phi + a_5(3 \cos^2\phi - 1)/2 \\
&+ a_6 \cos\theta \, (3 \sin\phi \cos\phi) + a_3 \sin\theta \, (3 \sin\phi \cos\phi) \\
&+ a_8 \, (2 \cos^2\theta - 1) \, (3 \sin^2 \phi) + a_9 \, (2 \sin\theta \cos\theta) \, (3 \sin^2\phi)
\end{aligned}
\tag{2.12}
$$

If (2.12) is the representation of the eastward wind component, then a completely analogous equation, with different coefficient values., is used to represent the northward wind component. Appendix A describes the data and processes used to evaluate the spherical harmonic coefficients which are used in the GRAM MOD-3. Values of the spherical harmonic coefficients used in the program are given in the "SCIDAT" data tape listing, in Appendix B.

Spherical harmonic winds are computed at all latitudes, within the height range 25-90 km. Geostrophic winds are used at latitudes above a selected "minimum geostrophic latitude," over the height ranges 0-20 and above 90. Smooth fairing between spherical harmonic winds and geostrophic winds is carried out between 20 and 25 km and between 90 and 95 km.

2.8 Mean Vertical Winds

GRAM also evaluates mean vertical winds from the slope of isentropic surfaces. On such surfaces, the entropy function ψ is constant, where ψ is

$$\psi = C_pT + gz + (u^2 + v^2)/2 = \text{const.} \tag{2.13}$$

Therefore, on isentropic surfaces

$$\partial\psi/\partial t + u\partial\psi/\partial x + v\partial\psi/\partial y + w\partial\psi/\partial z = 0 \tag{2.14}$$

and, if $\partial\psi/\partial t$ is assumed zero, the vertical wind w can be solved for as

$$w = -[u\partial\psi/\partial x + v\partial\psi/\partial y]/(\partial\psi/\partial z) \tag{2.15}$$

By differentiation of (2.13), with the assumption that u and v are the geostrophic winds u_g and v_g, and that $\partial u/\partial z$ and $\partial v/\partial z$ are given by the thermal wind relations, (2.15) becomes

$$w = -C_p\,[u_g(\partial T/\partial x) + v_g(\partial T/\partial y)]/ \{g + C_p(\partial T/\partial z) + (g/fT)[v_g(\partial T/\partial x) - u_g(\partial T/\partial y)]\} \tag{2.16}$$

Mean vertical winds evaluated by (2.16) are generally less than a cm/sec, and hence are realistic values for the large scale mean vertical winds affecting mean meridional circulation.

2.9 The Quasi-Biennial Perturbations

In the Mod-0 Global Reference Atmospheric Model, MRN data from 1964-1969 were used to evaluate quasi-biennial amplitudes and phases in the height range 25-65 km. The quasi-biennial period which produce minimum variance, when simultaneously evaluating the annual, semi-annual, and quasi-biennial variation, was found to be 870 days. For the Mod 2 version, the harmonic analysis was done the same way with MRN data for 1970-1972 added to the original data base. Again, the 870 day period was found to produce minimum variance for the QBO winds, while a 900 day period did slightly better for the thermodynamic variables. In order to retain a single period, the original 870 day period was chosen as still the preferable value overall. The revised quasi-biennial magnitudes and phases are listed in the "SCIDAT" data tape listing at the end of this report (Appendix B).

2.10 The Two-Scale Random Perturbation Model

The original single scale perturbation model in the Global Reference Atmosphere Model (Justus et al., 1974 a) was evaluated by the following method: first the density perturbation ρ_2' at the new location was computed from ρ_1' the density perturbation at the previous location by the relation

$$(\rho_2'/\bar{\rho}_2) = A(\rho_1'/\bar{\rho}_1) + Br_1 \tag{2.17}$$

where $\bar{\rho}_1$ and $\bar{\rho}_2$ are the known mean densities at the previous and new positions, A and B are determined from the required conditions, and r_1 is a random number selected from a Gaussian distribution with mean zero and unit standard deviation. The required conditions to be used in determining A and B are

$$\langle \rho_2' \rho_1' \rangle = R\,\sigma_{\rho 1}\,\sigma_{\rho 2} \tag{2.18}$$

$$\langle \rho_2'^2 \rangle = \sigma_{\rho_2}^2 \tag{2.19}$$

where $\sigma_{\rho 1}$ and $\sigma_{\rho 2}$ are the known standard deviations in density at the previous and new location, and R is the known autocorrelation in density perturbations between the previous and new locations. Next (with analogous notation as in (2.17) through (2.19), the new temperature perturbation was computed by

$$(T_2'/\bar{T}_2) = C(T_1'/\bar{T}_1) + D(\rho_2'/\bar{\rho}_2) + Er_2 \tag{2.20}$$

In addition to the autocorrelation R (assumed the same for T' and ρ' in the original one-scale model) the cross correlation $(R_{\rho T})_2$ was also maintained (through the coefficient D in equation (2.20)). The correlation $(R_{\rho T})_2$ was determined from the known standard deviations and means by the <u>Buell</u> (1970) relation

$$(R_{\rho T})_2 = \frac{[(\sigma_p)_2/\bar{p}_2]^2 - [(\sigma_\rho)_2/\bar{\rho}_2]^2 - [(\sigma_T)_2/\bar{T}_2]^2}{2[(\sigma_\rho)_2/\bar{\rho}_2]\,[(\sigma_T)_2/\bar{T}_2]} \qquad (2.21)$$

Once the density and temperature perturbations were evaluated, the pressure perturbation was determined via

$$(p_2'/p_2) = (\rho_2'/\bar{\rho}_2) + (T_2'/\bar{T}_2) \qquad (2.22)$$

which is a first order perturbation equation from the perfect gas law. In the original single scale perturbation model, wind perturbation components u' v' were assumed to be uncorrelated with each other and with the thermodynamic variables, and hence were computed by relations analagous to equation (2.17).

In the original one-scale model, only the total perturbations are considered (e.g. $\rho = \bar{\rho} + \rho'$) while in the new two scale model the perturbations are assumed to be made up of a large scale and small scale component (e.g. $\rho = \bar{\rho} + \rho_L + \rho_S$). To first order in the perturbations the state of the mean atmosphere is described by

$$\bar{p} = \bar{\rho}\, R\, \bar{T} \qquad (2.23)$$

and the mean plus large scale perturbations by

$$(\bar{p} + p_L) = (\bar{\rho} + \rho_L)\, R(\bar{T} + T_L) \qquad (2.24)$$

and the actual atmospheric parameters p, ρ, and T by

$$p = \rho\, R\, T \qquad (2.25)$$

Division of equations (2.24) and (2.25) by $\bar{p}$ on the left and by $\bar{\rho}\, R\, \bar{T}$ on the right yields, to first order in the perturbations

$$p_L/\bar{p} = (\rho_L/\bar{\rho}) + (T_L/\bar{T}) \tag{2.26}$$

$$p_s/\bar{p} = (\rho_s/\bar{\rho}) + (T_s/\bar{T}) \tag{2.27}$$

These results mean that the small scale and large scale perturbations each separately must obey the Buell triangle relationships for their magnitudes. Thus, analogous to equation (2.21), the correlations $R_{\rho_L T_L}$ for large scale perturbations and $R_{\rho_s T_s}$ for small scale perturbations are given in terms of their respective magnitudes by

$$R_{\rho_L T_L} = \frac{(\sigma_{p_L}/\bar{p})^2 - (\sigma_{\rho_L}/\bar{\rho})^2 - (\sigma_{T_L}/\bar{T})^2}{2(\sigma_{\rho_L}/\bar{\rho})(\sigma_{T_L}/\bar{T})} \tag{2.28}$$

$$R_{\rho_s T_s} = \frac{(\sigma_{p_s}/\bar{p})^2 - (\sigma_{\rho_s}/\bar{\rho})^2 - (\sigma_{T_s}/\bar{T})^2}{2(\sigma_{\rho_s}/\bar{\rho})(\sigma_{T_s}/\bar{T})} \tag{2.29}$$

The large and small scale components are assumed to be independent so correlations such as $R_{\rho_s T_L}$, $R_{\rho_L T_s}$ etc. are taken to be zero.

The density perturbations ρ_{L_2} and ρ_{s_2} at the new position are thus computed from the known perturbations ρ_{L_1} and ρ_{s_1} at the previous position by relations analogous to equation (2.17)

$$(\rho_{L_2}/\bar{\rho}) = A_L(\rho_{L_1}/\bar{\rho}_1) + B_L r_{L_1} \tag{2.30}$$

$$(\rho_{s_2}/\bar{\rho}) = A_s(\rho_{s_1}/\bar{\rho}_1) + B_s r_{s_1} \tag{2.31}$$

where A_L, B_L, A_s and B_s can each be determined (as before) from the conditions

$$\langle \rho_{L_2} \rho_{L_1} \rangle = R_L(\rho)\, \sigma_{\rho L_2}\, \sigma_{\rho L_1} \tag{2.32}$$

$$\langle \rho_{L_2}^2 \rangle = \sigma_{\rho L_2}^2 \tag{2.33}$$

$$\langle \rho_{s_2} \rho_{s_1} \rangle = R_s(\rho)\, \sigma_{\rho s_2}\, \sigma_{\rho s_1} \tag{2.34}$$

$$\langle \rho_{s_2}^2 \rangle = \sigma_{\rho s_2}^2 \tag{2.35}$$

where the density autocorrelations $R_L(\rho)$ and $R_s(\rho)$ are determined from the known horizontal and vertical scale of the large scale and small scale perturbations (see the following section on scales). Similarly, the temperature perturbations are computed (analogous to equation (2.20) by

$$(T_{L_2}/\bar{T}_2) = C_L(T_{L_1}/\bar{T}_1) + D_L(\rho_{L_2}/\bar{\rho}_2) + E_L r_{L_2} \tag{2.36}$$

$$(T_{s_2}/\bar{T}_2) = C_s(T_{s_1}/\bar{T}_1) + D_s(\rho_{s_2}/\bar{\rho}_2) + E_s r_{s_2} \tag{2.37}$$

where again D_L and D_s are determined by the required cross correlations $R_{\rho_s T_s}$ and $R_{\rho_L T_L}$ at the new position, as computed from equations (2.28) and (2.29). Once the density and temperature perturbations are computed, the pressure perturbations are evaluated from equations (2.26) and (2.27).

A further addition to the new model has been brought about by empirically evaluated correlations $R_{u_L v_L}$, $R_{u_s v_s}$, $R_{u_L \rho_L}$, and $R_{u_s \rho_s}$. The new method of evaluating the velocity perturbation components is somewhat analogous to that employed for the temperature component. The equations used are

$$u_{L_2} = F_L u_{L_1} + G_L \rho_{L_2} + H_L r_{u_L} \tag{2.38}$$

$$u_{s_2} = F_s u_{s_1} + G_s \rho_{s_2} + H_s r_{u_s} \tag{2.39}$$

and

$$v_{L_2} = I_L v_{L_1} + J_L u_{L_2} + K_L r_{v_L} \tag{2.40}$$

$$v_{s_2} = I_s v_{s_1} + J_s u_{s_2} + K_s r_{v_s} \tag{2.41}$$

where the coefficients G_L and G_s are determined from the newly evaluated correlations $R_{u_L \rho_L}$ and $R_{u_s \rho_s}$, and the coefficients J_L and J_s are evaluated from the correlations $R_{u_L v_L}$ and $R_{u_s v_s}$.

For evaluation of the coefficients C, D, and E in (2.36) and (2.37), and the coefficients F through K in (2.38) through (2.41), these equations are successively multiplied through by the perturbation quantities on the right-hand side (see Appendix B in Justus et al, (1974 a)). The relations thus established for the coefficients A through K (with analogous equations for both large scale A_L - K_L and small scale A_s - K_s) are

$$A = R(\rho)\ \sigma_{\rho_2}/\sigma_{\rho_1} \tag{2.42}$$

$$B = \sigma_{\rho_2}[1 - R^2(\rho)]^{1/2} \tag{2.43}$$

$$C = [R(T)\ \sigma_{T_2}/\sigma_{T_1}]\ \{[1 - R_{T_2\rho_2}\ R_{T_1\rho_1}]/ [1 - R^2(T)\ R^2_{T_1\rho_1}]\} \tag{2.44}$$

$$D = [R(T)\ \sigma_{T_2}\sigma_{T_1} - C\sigma^2_{T_1}]/(A\ R_{T_1\rho_1}\ \sigma_{T_1}) \tag{2.45}$$

$$E = [\sigma^2_{T_2} - C^2\ \sigma_{T_1}^2 - D^2\sigma_{\rho_2}^2 - 2\ C\ D\ R(T)\ R_{T_1\rho_1}\ \sigma_{T_1}\ \sigma_{\rho_2}]^{1/2} \tag{2.46}$$

$$F = (\sigma_{u_2}/\sigma_{u_1})\ \{[R(u) - R(\rho)\ R_{u_2\rho_2}\ R_{u_1\rho_1}]/ [1 - R^2(\rho)\ R^2_{u_1\rho_1}]\} \tag{2.47}$$

$$G = (R(u)\,\sigma_{u_2} - F\,\sigma_{u_1}]/[R(\rho)\,R_{u_1\rho_1}\,\sigma_{\rho_2}] \tag{2.48}$$

$$H = [\sigma_{u_2}^{\,2} - F^2\,\sigma_{u_1}^{\,2} - G^2\,\sigma_{\rho_2}^{\,2} -$$

$$2\,F\,G\,R\,(\rho)R_{u_1\rho_1}\,\sigma_{\rho_2}\,\sigma_{u_1}]^{1/2} \tag{2.49}$$

$$I = (\sigma_{v_2}/\sigma_{v_1})\,\{[R(v) - R(\rho)\,R^2_{v_2\rho_2}\,R_{v_1\rho_1}]/$$

$$[1 - R^2\,(\rho)\,R_{v_1\rho_1}]\} \tag{2.50}$$

$$J = [R(v)\,\sigma_{v_2} - I\,\sigma_{v_1}]/[R(\rho)\,R_{v_1\rho_1}\,\sigma_{\rho_2}] \tag{2.51}$$

$$K = [\sigma_{v_2}^{\,2} - I^2\,\sigma_{v_1}^{\,2} - J^2\,\sigma_{\rho_2}^{\,2} -$$

$$2\,I\,J\,R\,(\rho)\,R_{v_1\rho_1}\,s_{\rho_2}\,\sigma_{v_1}]^{1/2} \tag{2.52}$$

where the autocorrelations of density $R\,(\rho)$, temperature $R(T)$ and wind $R(u)$ ($R(u)$ and $R(v)$ are assumed equal), are determined from the horizontal and vertical scales L_{Z_ρ}, L_{H_ρ}, L_{Z_T}, L_{H_T}, L_{Z_u} and L_{H_u} by the relations

$$R(\rho) = \exp\{-[(\Delta x^2 + \Delta y^2)/L^2_{H_\rho} + \Delta z^2/L^2_{Z_\rho}]^{1/2}\} \tag{2.53}$$

$$R(T) - \exp\{-[(\Delta x^2 + \Delta y^2)/L^2_{H_T} + \Delta z^2/L^2_{Z_T}]^{1/2}\} \tag{2.54}$$

$$R(u) = \exp\{-[(\Delta x^2 + \Delta y^2)/L^2_{H_u} + \Delta z^2/L^2_{Z_u}]^{1/2}\} \tag{2.55}$$

3. SAMPLE RESULTS

The ability of the GRAM program to model pressure, density, and temperature fields has been well documented in earlier reports (Justus, et al., 1974 a, b, 1975, 1976). The results shown here are confined to the new spherical harmonic wind model simulations of wind components in the 25 to 90 km height range. Figures 3.1 through 3.12 show observed and spherical harmonic model winds at three low-latitude sites (Kwajalein, Ft. Sherman and Ascension) at mid-latitude and high-latitude northern hemisphere sites (Kennedy SFC, and Ft. Churchill, respectively) and at a southern hemisphere site (Woomena), for the months of June and December. In all cases, the spherical harmonic model winds are seen to reproduce fairly well the features at the observed winds.

Data sources and methods used to evaluate the spherical harmonics appear in Appendix A. The spherical harmonic coefficient values are given in the SCIDAT tape listing in Appendix B.

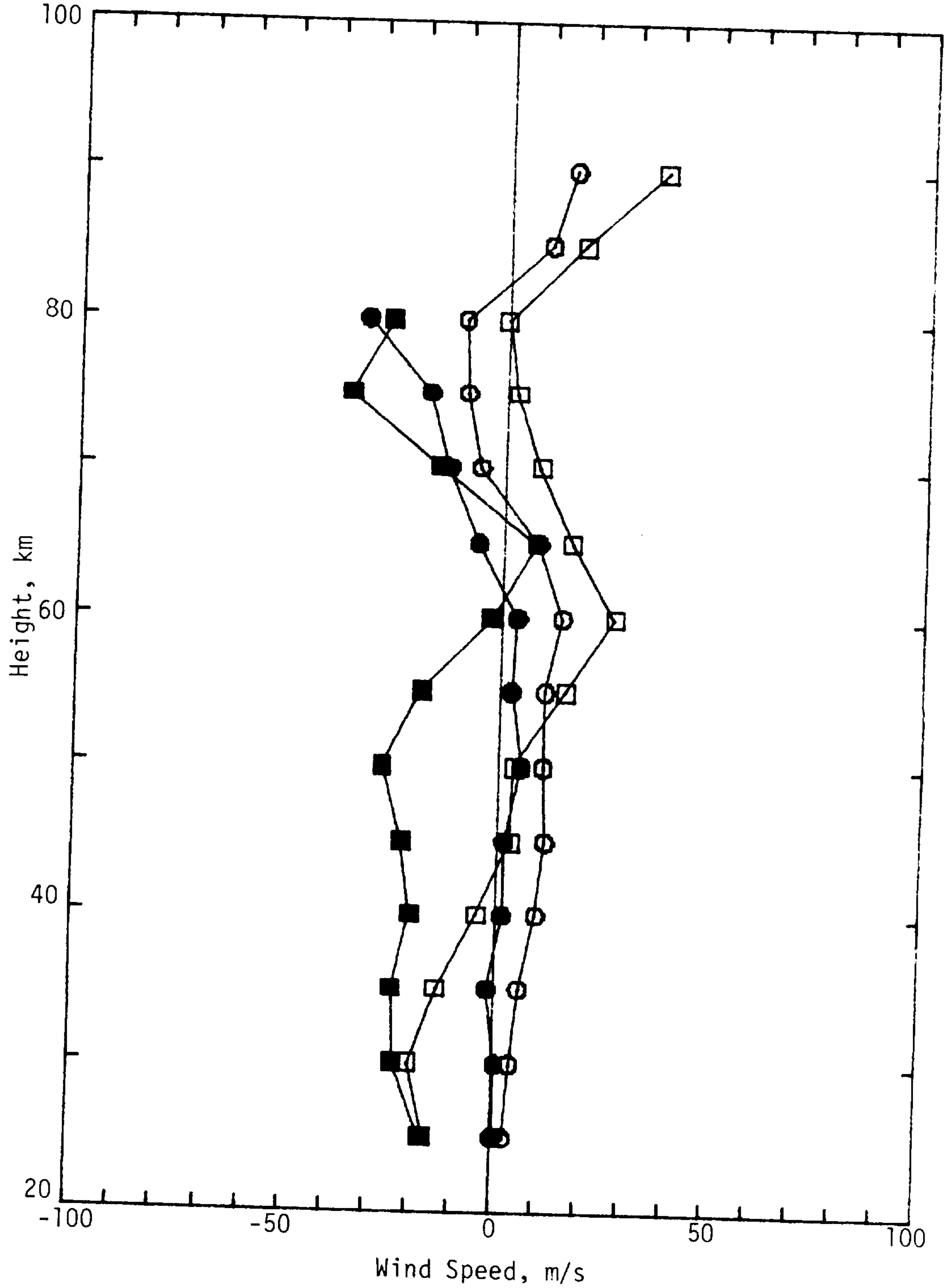


Figure 3.1. Observed (■ E-W, ● N-S) and Spherical Harmonic Model (□ E-W, ○ N-S) Winds for June at Kwajalein.

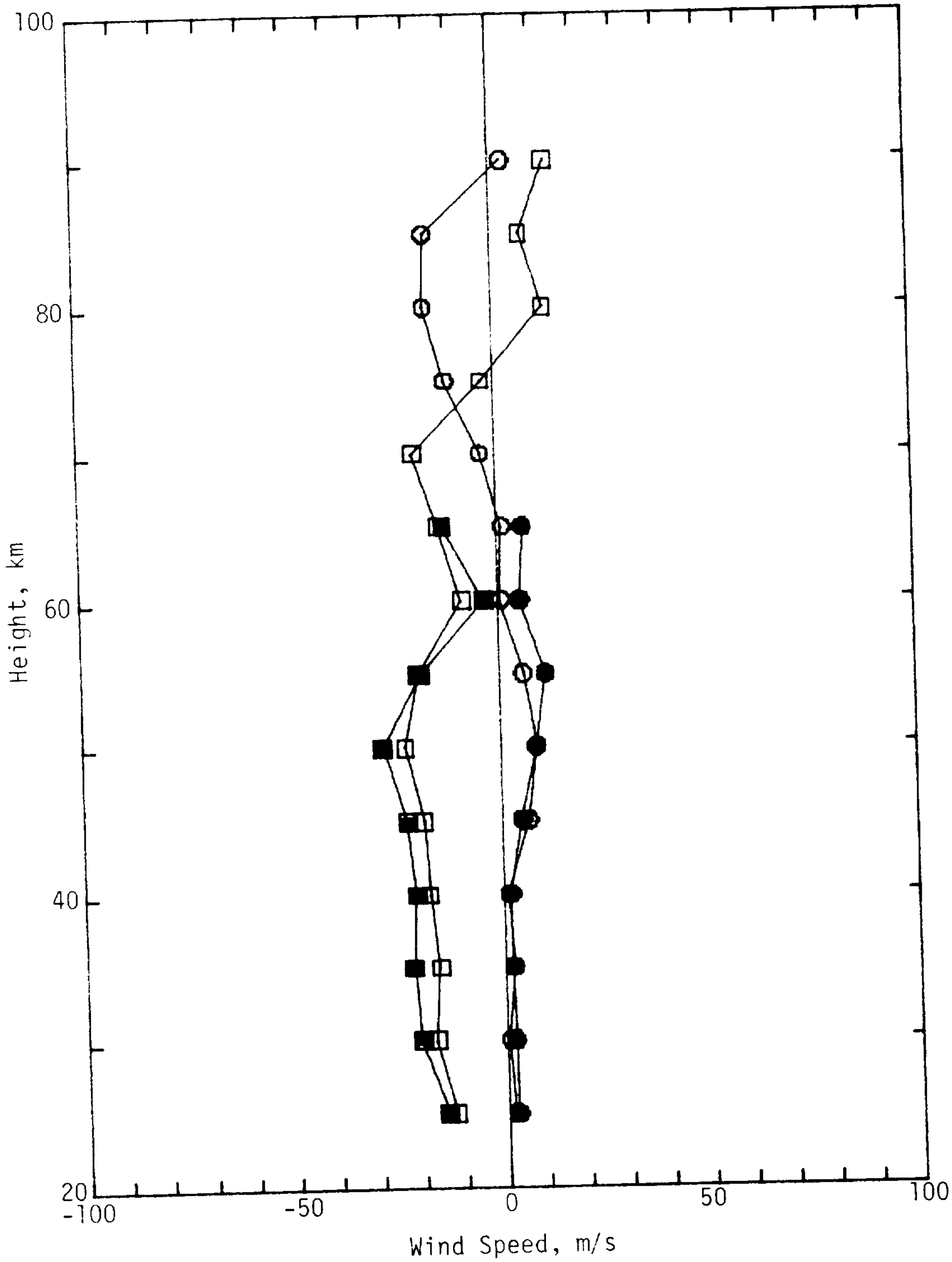


Figure 3.2. As in Figure 3.1 for Fort Sherman

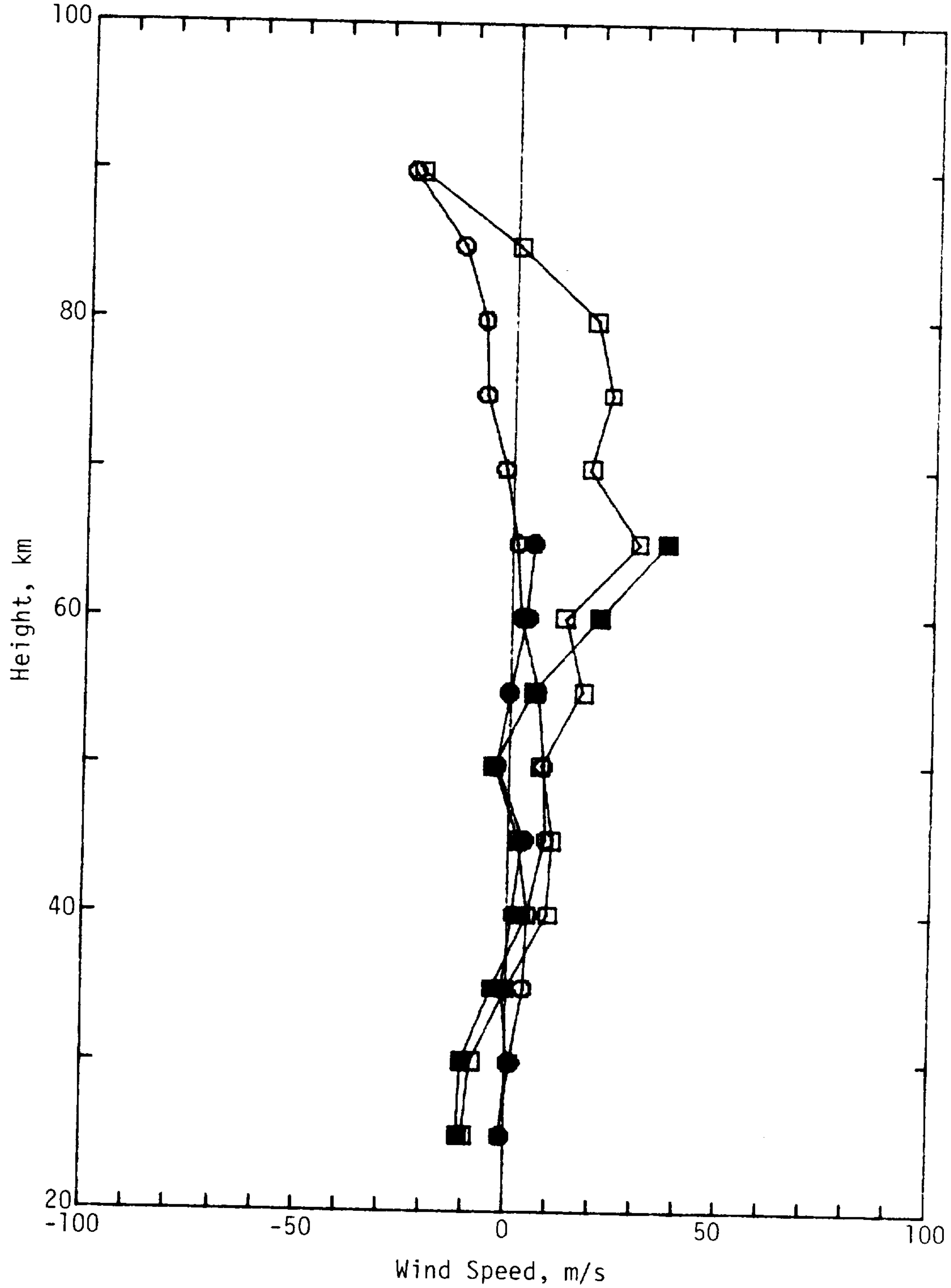


Figure 3.3. As in Figure 3.1 for Ascension.

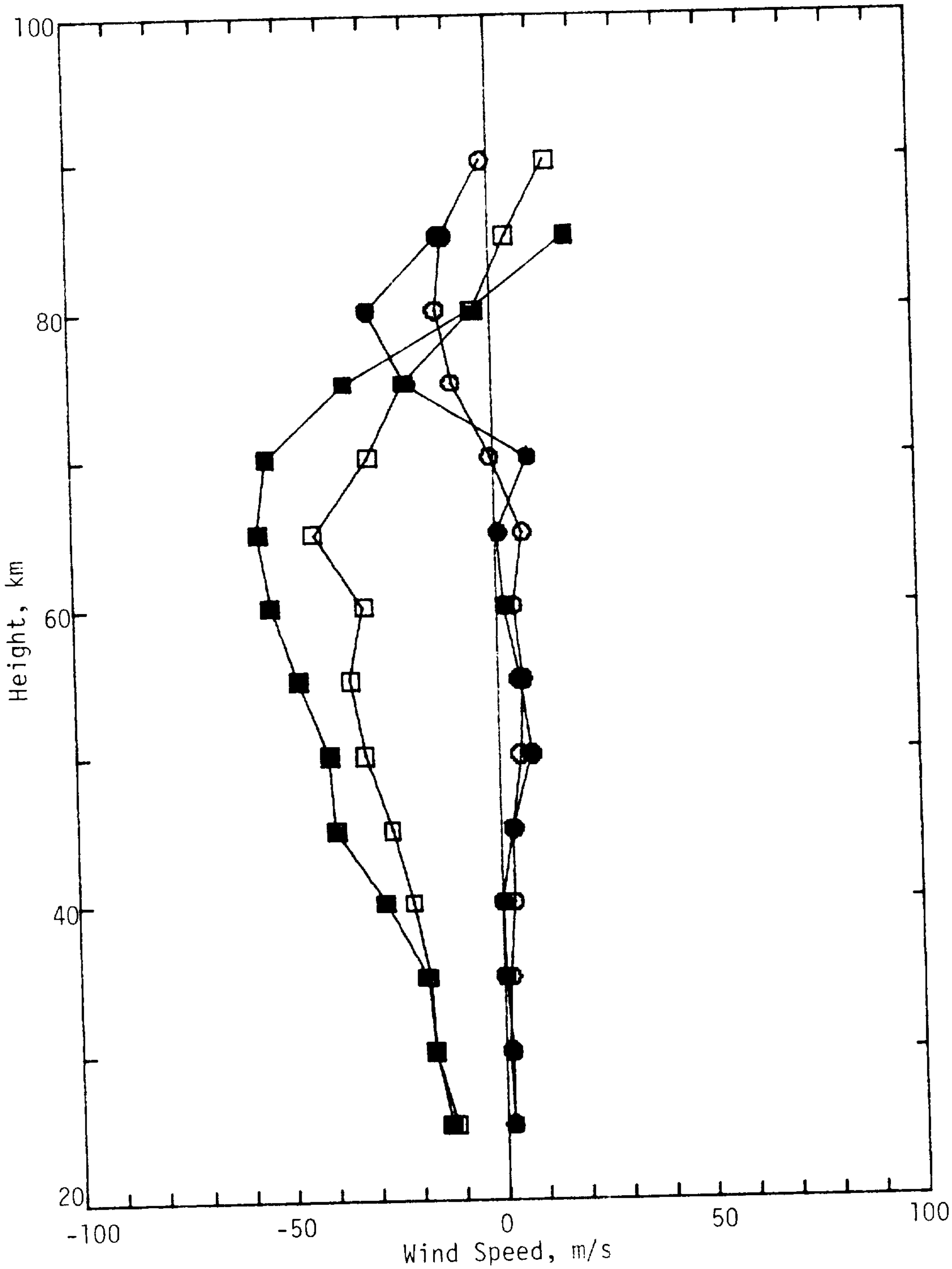


Figure 3.4. As in Figure 3.1 for Kennedy SFC.

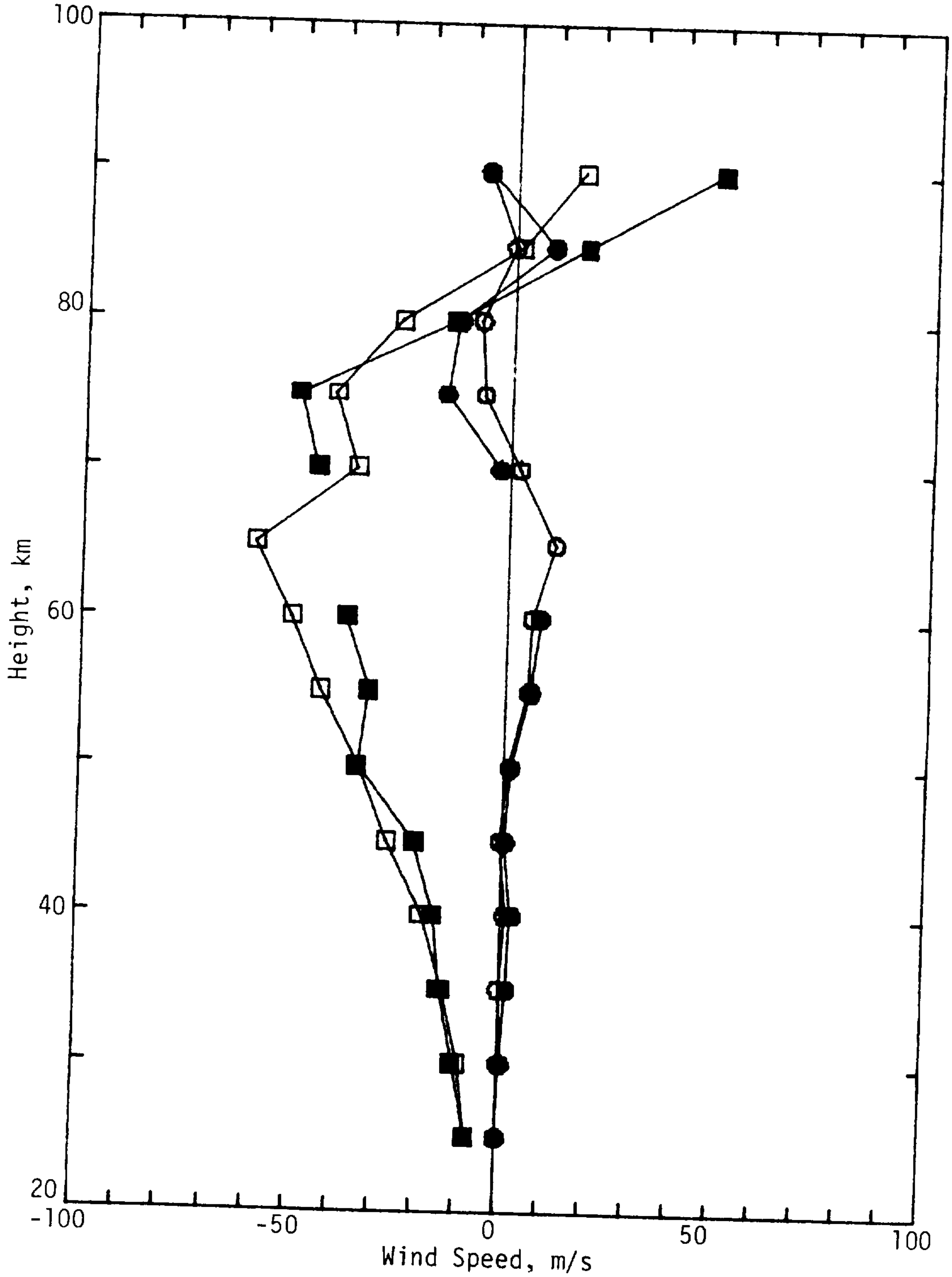


Figure 3.5. As in Figure 3.1 for Fort Churchill.

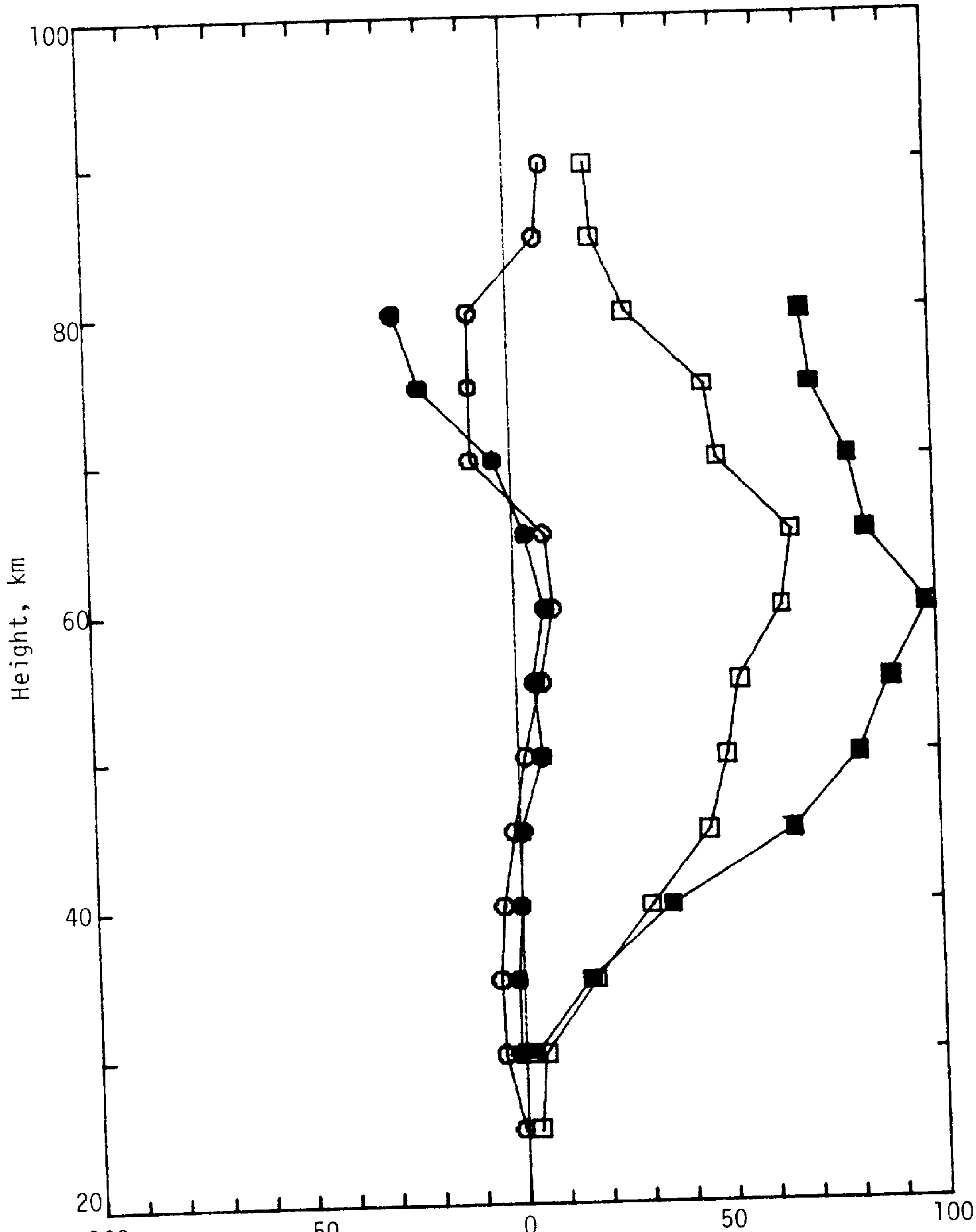


Figure 3.6. As in Figure 3.1 for Woomera.

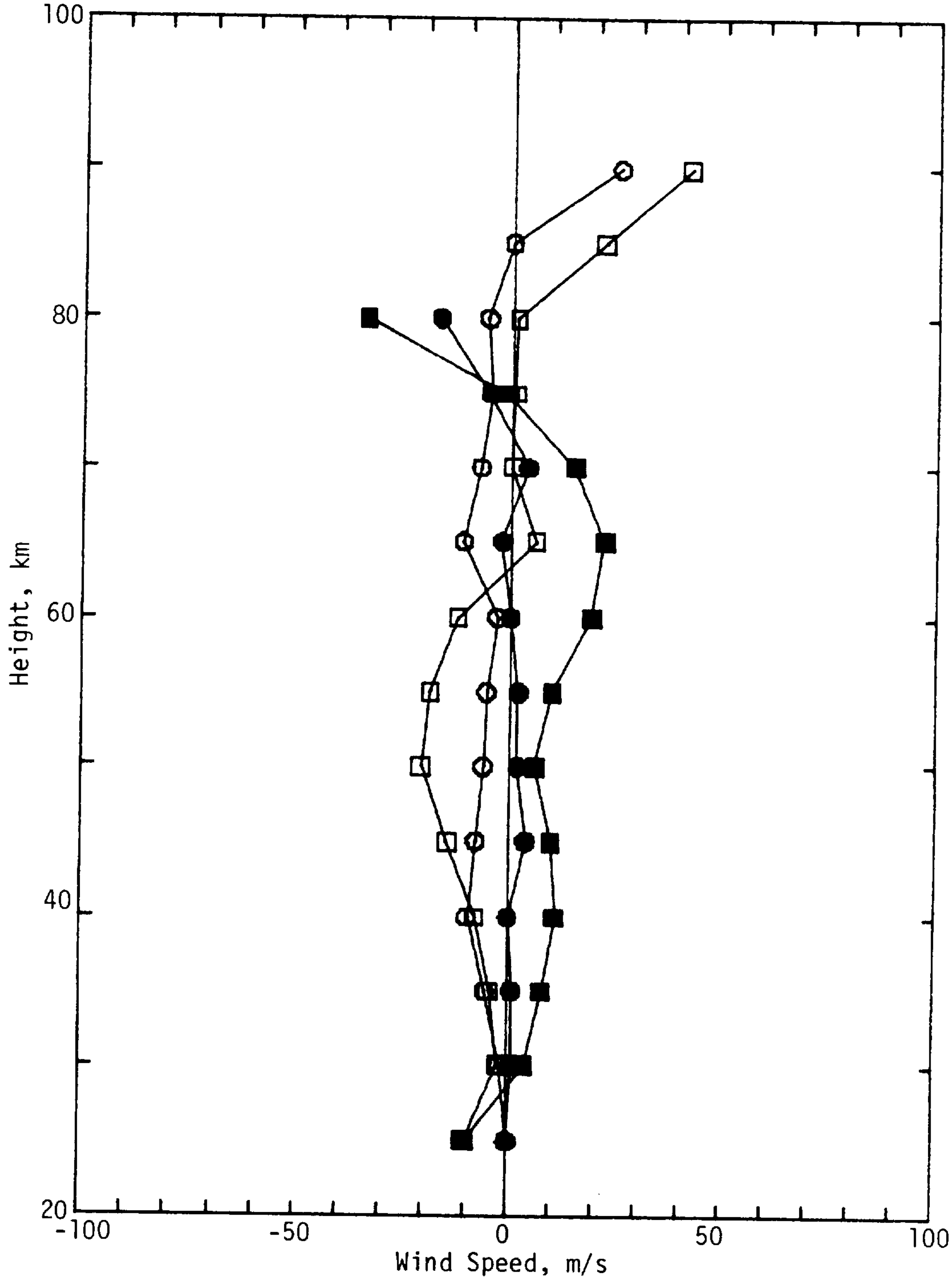


Figure 3.7. As in Figure 3.1 for December, Kwajalein.

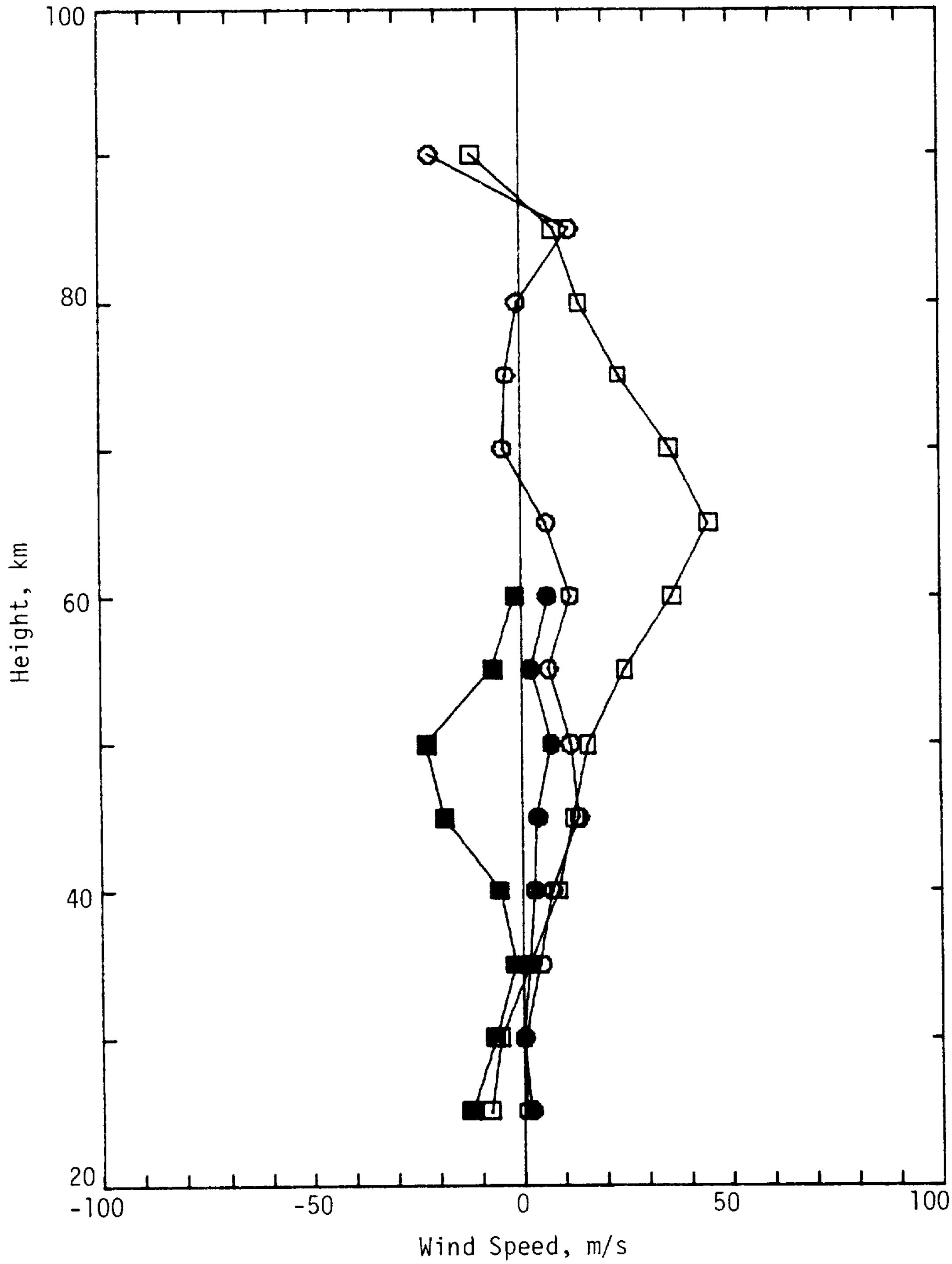


Figure 3.8. As in Figure 3.1 for December, Fort Sherman.

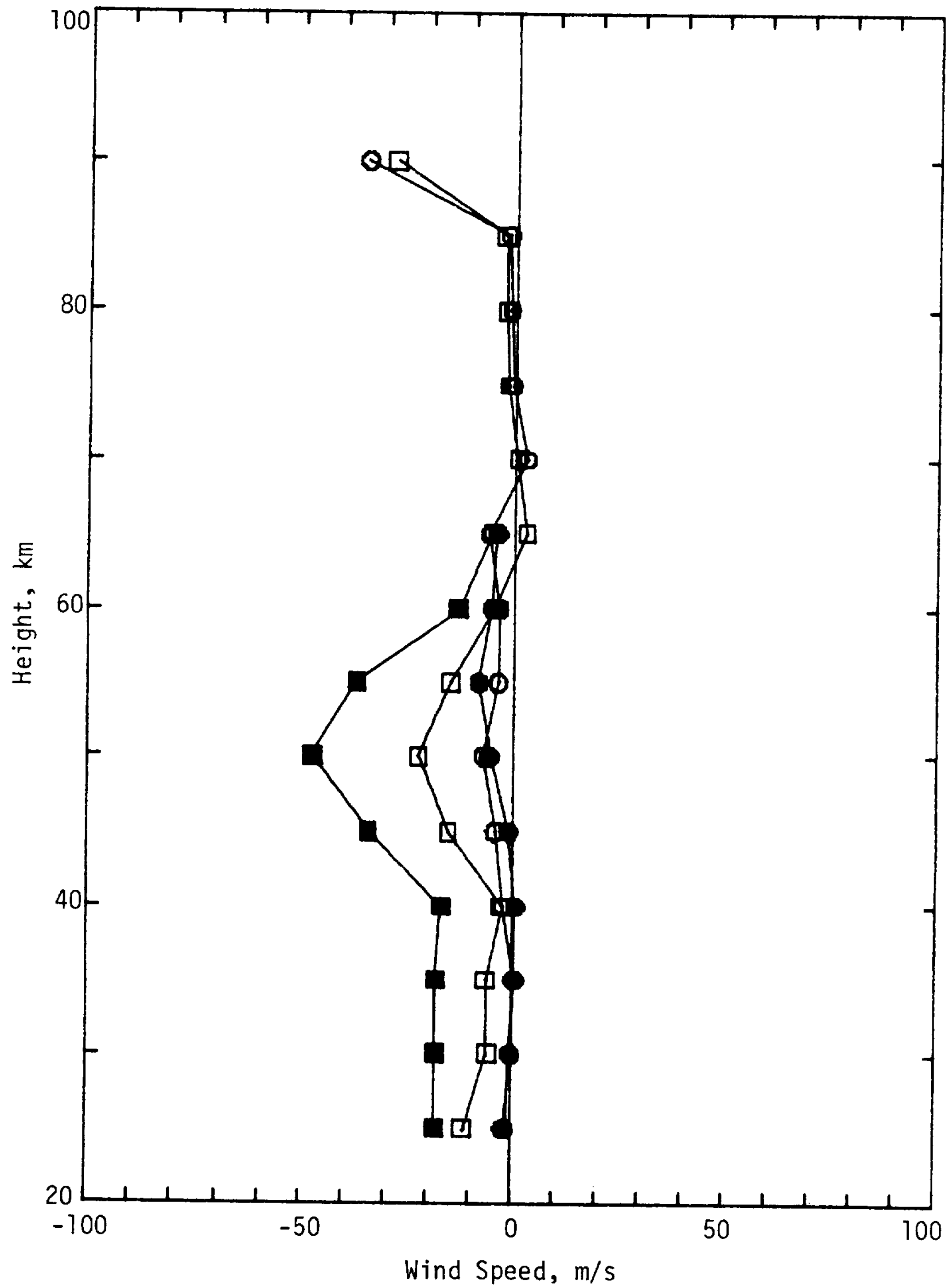


Figure 3.9. As in Figure 3.1 for December, Ascension.

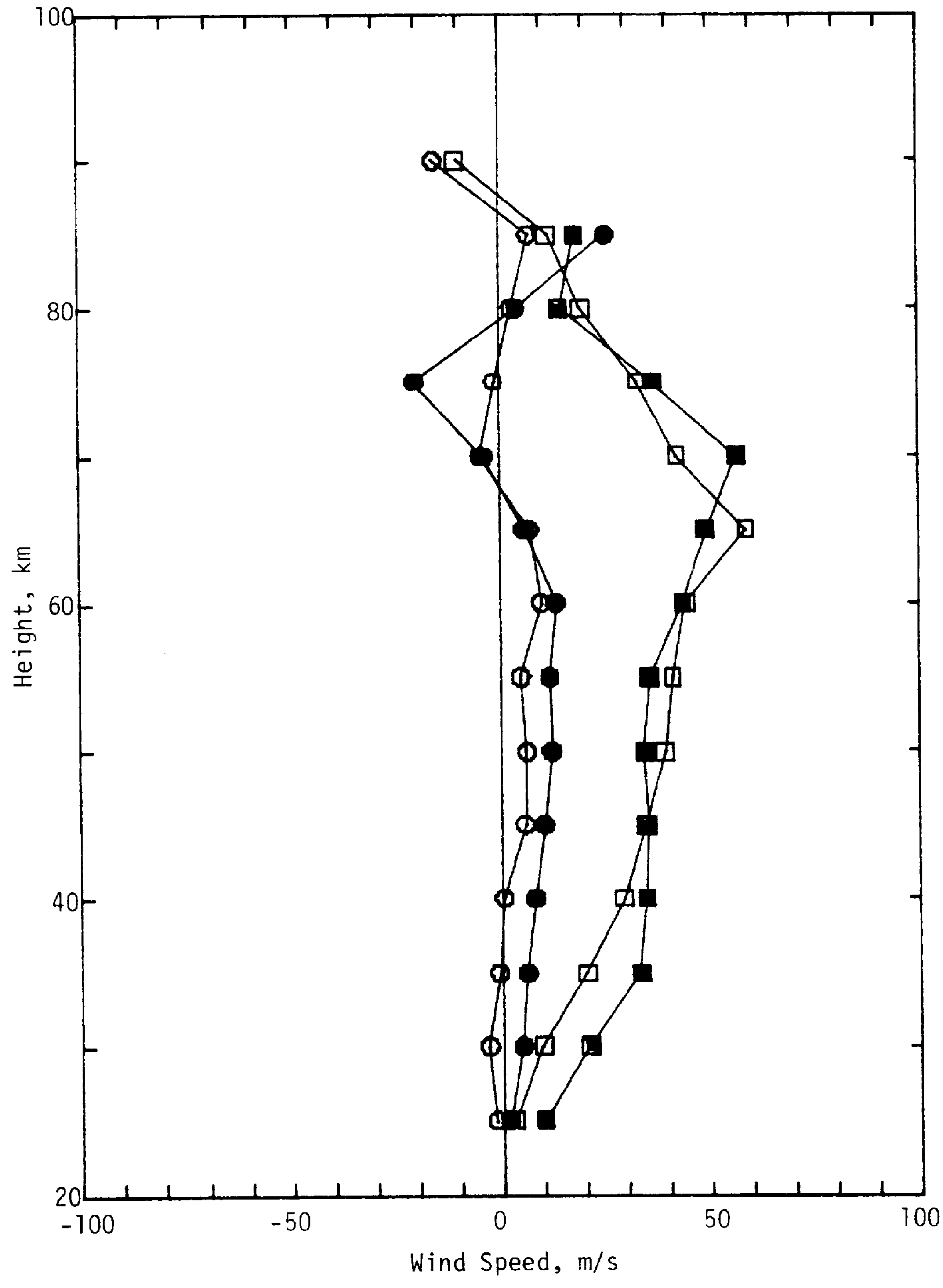


Figure 3.10. As in Figure 3.1 for December, Kennedy SFC.

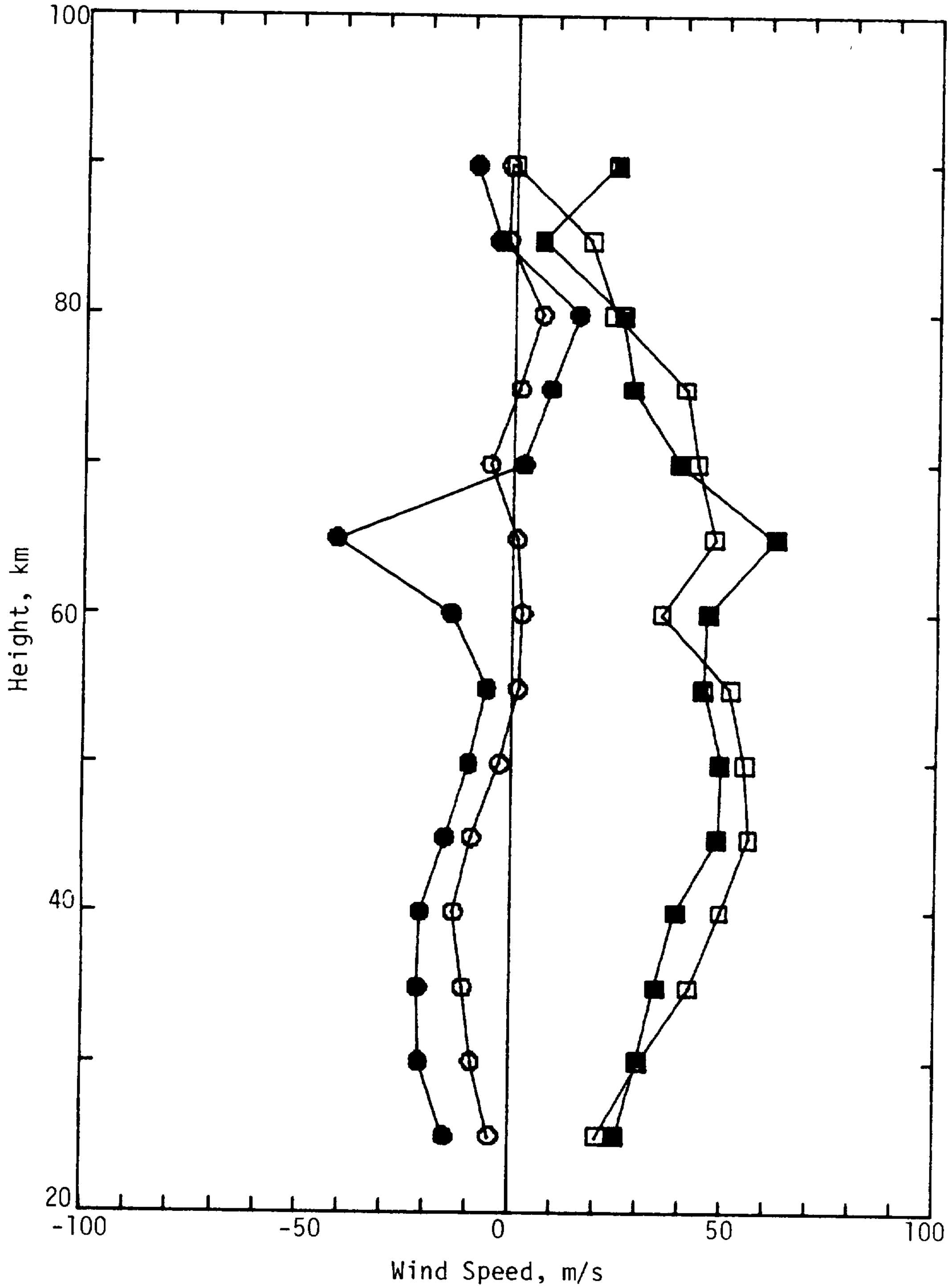


Figure 3.11. As in Figure 3.1 for December, Fort Churchill.

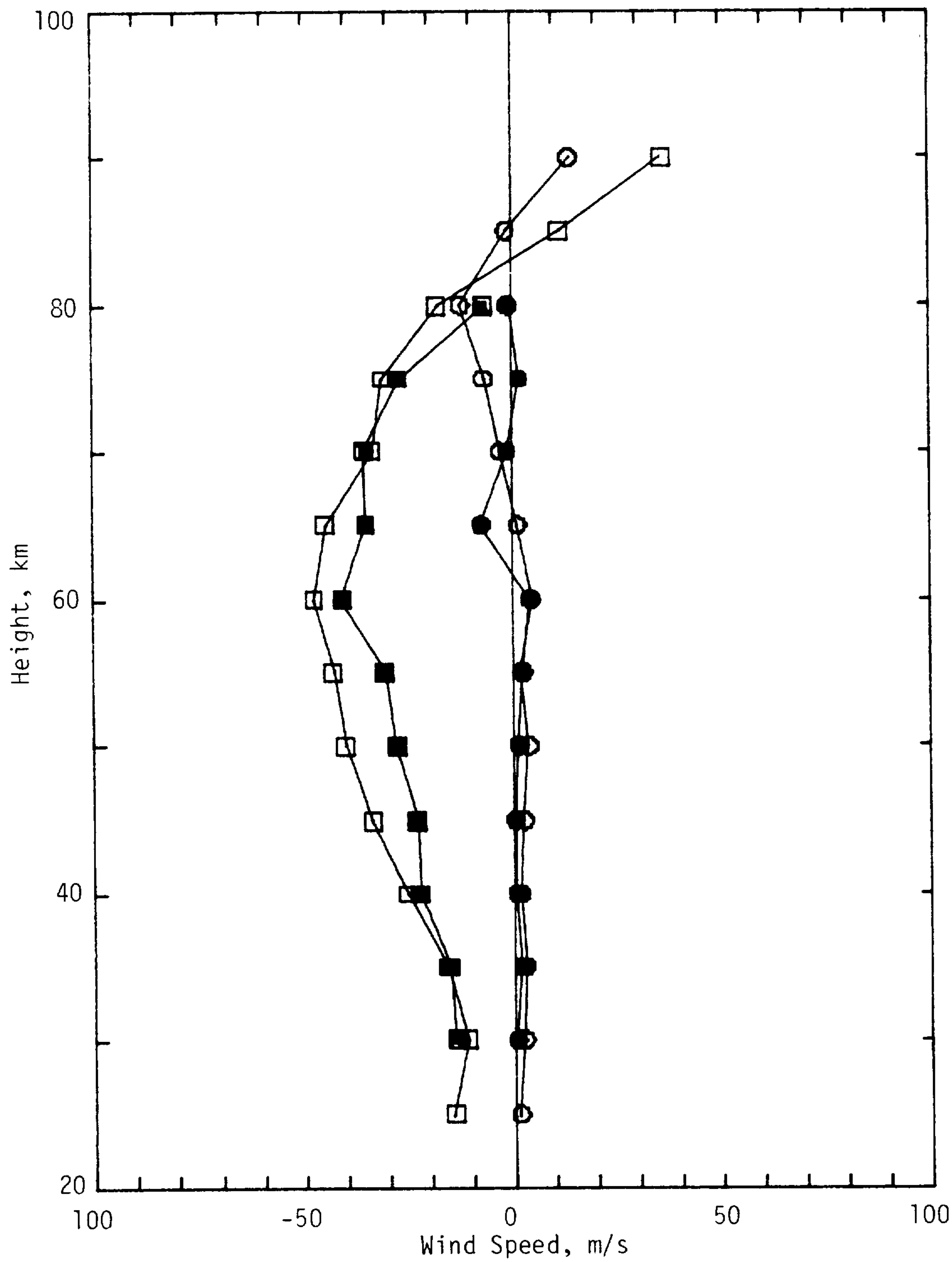


Figure 3.12. As in Figure 3.1 for December, Woomera.

4. USERS MANUAL

The Global Reference Atmospheric Model (GRAM) program is designed to produce atmospheric parameter values either along a linear path (to be called a profile) with automatically stepped constant height, latitude, and longitude increments, or along any set of connected positions (to be called a trajectory) which must be input individually into the program.

There are three general types of input to the GRAM program: (1) A set of three cards, called the initial data, which contain the values of the program options, the initial position, the profile increments, and other information required before the calculations are begun, (2) A data tape (SCIDAT) containing parameter values for the Groves (1971) model, the stationary perturbations (deviations from the Groves model, to produce longitude varying monthly means), and random and quasi-biennial perturbation parameter values, and (3) The data tapes with one data file for each month, containing profiles of monthly mean pressure, density, temperature, and their variances from the surface to 25 km, for the entire globe. If it is desired to compute atmospheric parameters along a trajectory instead of a linear profile, then a fourth type of data - the trajectory times and positions - must be input.

In terms of program function, the major elements of the GRAM program are the main segment (GRAM), the subroutine SCIMOD, which is a driver for all of the atmospheric evaluation subroutines, and SETUP, a subroutine used to read the SCIDAT data tape, and load the necessary starting conditions for execution. Figure 4.1 shows a simplified schematic of the main segment and illustrates the function of the SETUP and SCIMOD subroutines.

Output of the GRAM program consists of monthly mean pressure, density, temperature, wind and wind shear, total (mean plus perturbation) values of

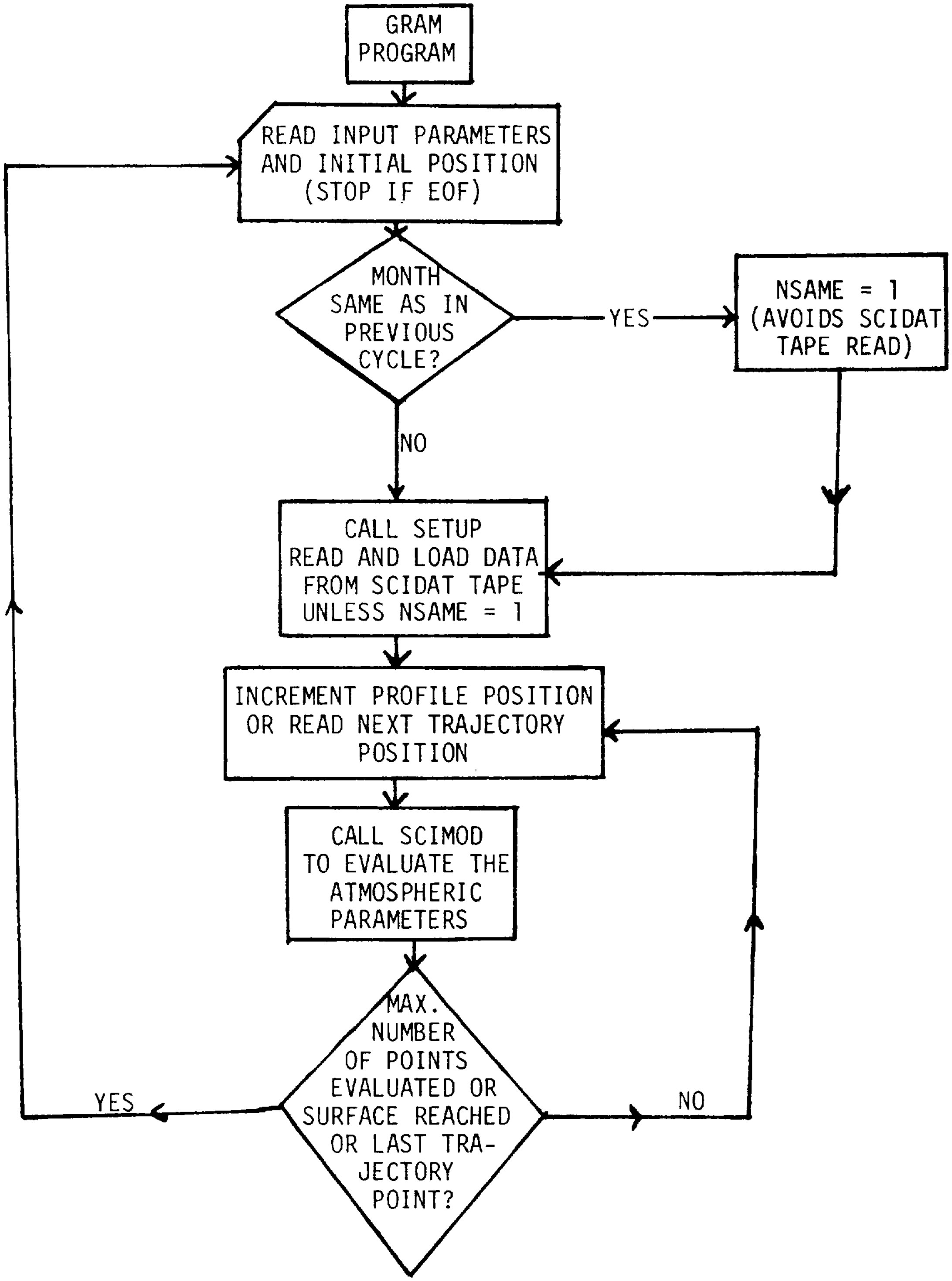


Figure 4.1: Simplified flow chart of the GRAM program.

pressure, density, temperature, winds, perturbation values, and magnitudes.

Complete discussion of the input, output, and program operation characteristics for the GRAM program are given in the following sections of the users manual.

4.1 The 4-D Data Tapes (0-25 km)

The description contained in this section was paraphrased from the 4-D program users manual (Fowler and Willard, 1972). For more information on the 4-D section of GRAM, consult that document and Spiegler and Fowler (1972).

The world-wide meteorological data set developed for the 4-D model by Allied Research Associates is stored on three 7-track, 800 bpi binary tapes labelled WW1A-WW3A. Each tape contains four files of data where one file represents one month; WW1A contains months 1-4, WW2A contains months 5-8, and WW3A contains months 9-12. A 13th month containing the annual reference period has been added as a fourth tape.

Within each file are 3490 records representing the values at individual grid points. These points are grouped into three grids: 288 points on the northern hemisphere equatorial (EQN) grid; 1977 points on the northern hemisphere (National Meteorological Center) grid; and 1225 points on the southern hemisphere (SH) grid. On the NMC grid, the data were computed at NMC points and stored in the order given by the NMC grid table shown in the SCIDAT data tape listing in Appendix B. On the other two grids, the data was given at 5^{o} latitude-longitude intersections westward from the Greenwich Meridian to 5^{o} east. The EQN grid covers the latitudes from 0^{o} to 15^{o} north with points occurring in the following order: 1-4 = Lon. 0, Lat. 0, 5, 10, 15; 5-8 = lon. 5W, Lat. 0, 5, 10, 15; ... 285-288 - Lon. 5^{o} E, Lat. 0, 5, 10, 15. The SH grid contains all data from 5^{o} south to the south pole as follows: 1 = South Pole, 2-18 = Lon. 0, Lat. -5 to -85; 19-35 = Lon. 5^o W, Lat. -5 to -85; ... 1209 - 1225 = Lon. 5^o E, Lat. -5 to -85. It should be noted that the south pole is given only once, as the first point of the SH data set.

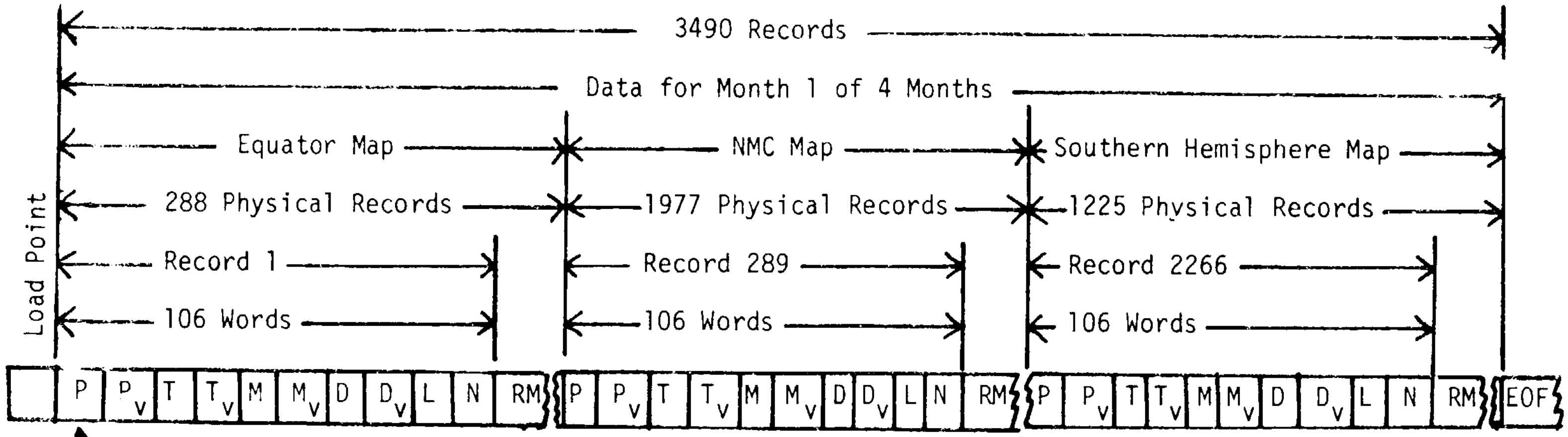
Each record consists of 106 36-bit words where the first 104 words contain the computed data for a point and the last two are identifiers. All data values are multiplied by 100 and converted to integer; they are then packed with two 18-bit values to a word. The data is arranged by level for each parameter; thus, the first 13 words contain the pressure means from the surface to 25 km and the next 13 words contain the pressure variances for the same levels. This pattern continues for the 26 levels of temperature means and variances, moisture means and variances, and density means and variances.

Word 105 contains the latitude and longitude of the point in question. There are integer values that have been multiplied by 10; each occupies 18 bits of the word. The latitude is always positive (since the southern hemisphere is identified by grid), and the longitude is always west.

The last word contains three 12 bit integer values. The left-most group of bits is the homogeneous moisture region in which the point lies, the center group is the point number, and the right-most group of bits is the month. It should be noted that the points are numbered within the grid that contains them, and not by their location on tape. Thus the point numbers run from 1-288, 1-1977, and 1-1225, not from 1-3490. Figure 4.2 shows the tape structure for one month.

4.2 The SCIDAT Data Tape

This section describes in detail the data contained on the SCIDAT data tape. A listing of this tape, and a synopsis of the data contained on



This box represents 26 integer values of pressure in millibars x 10^2. Each value is packed sequentially as an 18 bit byte, starting with the surface and ending with the 25 km value

Variances are the square of the standard deviations.

RM denotes end of record mark.

EOF Denotes end of file mark.

P	-	Pressure (mb x 10^2)
P_v	-	Pressure Variance (mb^2 x 10^2)
T	-	Temperature (^oK x 10^2)
T_v	-	Temperature Variance ($^oK^2$ x 10^2)
M	-	Moisture (g/m^3 x 10^2)
M_v	-	Moisture Variance (g^2/m^6 x 10^2)
D	-	Density (g/m^3 x 10^2)
D_v	-	Density Variance (g^2/m^6 x 10^2)
L	-	Word 105 Containing Latitude and Longitude
N	-	Word 106 Containing Homogeneous Region Number, MSF Point Number, and Month Number

Figure 4.2: Record Structure on the 4-D Data Tapes

it are given in Appendix B.

NMC Grid Data. This data set gives the 4-D northern hemisphere point number and the dual index for the corresponding NMC location. The NMC grid locations form an octagonal array, centered on the North Pole. The points are at square grid locations on the polar projection used for the NMC grid. A conversion between the latitude and longitude (treated as polar coordinates on the flat NMC grid plane) and the NMC grid indices (treated as Cartesian coordinates on the projection plane) is accomplished by a polar to Cartesian coordinate transformation, via equations programmed into the 4-D model. The NMC grid data on the SCIDAT tape merely establishes the equivalence between the sequential 4-D NMC point number and the two-dimensional x-y NMC grid point location. The NMC grid data constitute the first file on the SCIDAT tape. An end of file marker appears on the tape at the end of the NMC grid data. The NMC grid data file contains 396 FORTRAN readable records with code "N" and 15 integers (A2, 15I7 Format) in each record.

Groves Data. The Groves (1971) data for monthly mean pressure, density, and temperature are tabulated at 10 degree latitude intervals from 0 to 90^0 for each month. The yearly average Groves data is coded as month 13. The southern hemisphere data is the same as the northern hemisphere data displaced by 6 months. Annual mean (month 13) data is the same for both northern and southern hemispheres.

The format of the Groves data is the same as in Groves (1971) original report, except that a prefix code P, D, or T has been added at the front of each record. Each record contains the code, the month, the height in km and the 0, 10, 20, ..., 90^0 latitude values of the parameter expressed as a three digit integer, with an exponent common to all of the values in the field appearing at the end of the record. Thus a value of 276 with an exponent at the end of the record of -6, would be the same as $276 \times 10^{-6} = 2.76 \times 10^{-4}$. Pressure data are in units of N/m^2, density values are in kg/m^3, and temperatures are in °K. The Groves data set contains 702 FORTRAN readable records with 13 integer values (13I7) in each record (following the code word P, D, or T, in A2 format).

Stationary Perturbations. The stationary perturbations are latitude-longitude dependent relative perturbations to be applied to the Groves values, considered to be the longitudinal mean value. Data for each of 12 months and for the annual reference period (month 13) are given for the northern hemisphere latitudes. Southern hemisphere data are the same as the northern hemisphere values displaced by 6 months.

Each record contains the code S, the month, the height in km, the west longitude, in degrees, and then 15 values of stationary perturbations in per mill (%/10). The first five of the values are for pressure perturbations at latitudes 10, 30, 50, 70, and 90. The next five values are for density, and the last five values are for temperature. The monthly mean value y_m for parameter y at any latitude and longitude can be computed from the Groves value G_y at the latitude and the stationary perturbation s_y (in per mill) at the latitude and longitude by the relation

$$y_m = G_y (1 + s_y/1000) \tag{4.1}$$

Note that the stationary perturbation values at 90^o latitude are always zero. However, there is a place for 90^o values on the data tape, so that if a systematic departure from Groves values is desired at the poles, a set of stationary perturbation data reflecting this condition could be developed and put on the tape. The stationary perturbations listed on the Mod-3 SCIDAT tape have been revised, as described in Section 2, by the addition of data read from 1964, 1965, and 1972 upper air charts.

The Groves data and stationary perturbation data constitute the second file on the SCIDAT tape. An end of file marker appears at the end of the stationary perturbation data. The stationary perturbation code S data consists of 1248 FORTRAN readable records, with 18 integer values (18I7) (following the code word S A2 format).

The Random Perturbation Data. Random perturbation magnitudes (standard deviations) are latitude dependent only. Each code R record has the code, the month (1-13) and the height in km, followed by 15 values of random perturbation magnitude, five for pressure (in per mill, at latitudes 10, 30, 50, 70, and 90), five for density, and five for temperature. These data give the relative standard deviations σ_p/p, σ_ρ/ρ, and σ_T/T, for use in the random perturbation model.

The code RW data are similar, except that only ten wind values appear in each record (after the code, month, and height): five for eastward wind magnitude (in m/s at latitudes 10, 30, 50, 70, and 90) and five for northward wind magnitude.

The code R and RW total perturbation magnitudes have been revised by the incorporation of new data sources, as described in Justus and Woodrum, (1975). The code R data have also been subjected to Buell (1970, 1972) adjustment, also described in Justus and Woodrum (1975).

The code R and RW data constitute the third file on the SCIDAT tape. An end-of-file mark appears on the tape at the end of the code RW data. The code R data consist of 260 FORTRAN readable records with 17 integer values (17I7) in each record following the code word R (A2). For the code RW data, there are 325 records with the code word RW and 12 integers (A2, 12I7).

Large Scale Fraction Data. From daily difference analysis described in Section 2, the fraction of the total variance (σ^2 from code R and RW data) contained in the large scale perturbations has been determined as a fraction of height and latitude. Separate evaluations by month were also made, but were not found to be significantly different from the annual averages. Therefore the SCIDAT tape contains only the annual average fraction (expressed as per mill) of total variance contained in the large scale. Large scale and small scale magnitudes σ_L and σ_S are computed from the fractional data f_L in per mill (code P for pressure, density, and temperature or code PW for winds), by the relations

$$\sigma_L = \sqrt{f_L/1000}\ \sigma_T \tag{4.2}$$

$$\sigma_S = \sqrt{1 - f_L/1000}\ \sigma_T \tag{4.3}$$

where σ_T is the total perturbation magnitude (code R or code RW data). The code P and code PW data sets each contain 25 FORTRAN readable records, with code word P or PW, followed by 17 integer values (A2, 17I7) on each record.

Density-Velocity Correlations. Daily difference analysis described in Section 2 was also used to evaluate the cross correlations $R_{u\rho}$ and $R_{v\rho}$ for use in the velocity perturbation model (equations (2.38) - (2.41) and (2.44) - (2.50)). Both large scale and small scale values of the density-velocity correlations were evaluated, and are given on the SCIDAT data tape (codes CL and CS) in per mill (i.e. divide by 1000 to get correlations in the range -1 to +1).

The code P large scale fraction data and the code CS and CL density-velocity correlation data constitute the fourth file on the SCIDAT tape. An end-of-file mark appears on the tape at the end of the code CL data. The code CS and CL data consist of 50 FORTRAN readable records, with code word CS or CL, followed by 12 integer values (A2, 12I7) in each record.

The Quasi-Biennial Oscillation (QBO) Data. The QBO data consists of height and latitude dependent amplitudes and phases for quasi-biennial variations in pressure (QP), density (QD), temperature (QT), and eastward and northward wind components (QU and QV, respectively). The amplitude of the QBO thermodynamic parameters are in per mill (%/10). The amplitudes of the QBO wind components are in decimeters per second (0.1 m/s). The phases of all of the QBO parameters are measured in days after January 0, 1966 for the occurrence of the first maximum value. Since the period of the QBO variations is taken to be 870 days, the phases could vary from 0 to 870.

Each QBO data record contains the code, the height in km, the amplitude and phase for 10^{0} latitude, the amplitude and phase for 30^{0} latitude, etc. out to the amplitude and phase for 90° latitude. There are 80 FORTRAN readable records in the QBO data set. Each record contains 11 integer values followed by a code word (QP, QD, QT, QU, or QV).

An end of file mark appears at the end of the code QV data.

The Spherical Harmonic (SP) Data. The spherical harmonic coefficient data consists of values of the 9 spherical harmonic coefficients (equation 2.12) for both northward and eastward wind components. Each record consists of the code (SP), the height (km), the month, and 9 spherical harmonic coefficients (in cm/s). Eastward wind component coefficients are first, followed by northward wind component coefficients.

A final end-of-file mark appears at the end of the SP data. Appendix B gives a brief summary of the data on the SCIDAT tape and a listing of all the values appearing in the tape records.

4.3 The Initial Input Data

The initial input data consists of two free field (no set format with commas after each number) cards containing initial position data, program options, and other information required to begin computation, plus an optional third free field card to give initial random perturbation data if random perturbations are to be computed, plus an optional set of trajectory position data cards (followed by a backup card), if trajectory positions are to be read in rather than a linear profile generated automatically in the program. Appendix C gives a brief summary of the input characteristics, a summary of the data deck setup, and some sample input and output for the program. The following gives a more detailed description of each program input card.

Input Card Number 1. The first input card, read in by the main program segment PROFILE in free field format contains the following information. Designation R indicates real quantities, I denotes integer quantities.

1. Initial Height (R): The initial height in km for the beginning point of the profile or trajectory. This can be any non-negative real number. Atmospheric parameters are never evaluated at the first position, which is used only to establish the initial conditions.

2. Initial Latitude (R): The latitude of the initial position in degrees, with southern latitudes negative. If the initial latitude, or any subsequent latitude is greater than 90^o in absolute magnitude, then a transformation

$$\text{lat} = (180^\circ - |\text{lat}|)(\text{lat}/|\text{lat}|) \tag{4.4}$$

$$\text{lon} = \text{lon} + 180^o \tag{4.5}$$

is made.

3. Initial West Longitude (R): The west longitude of the initial

position in degrees. East longitude can be put in as negative or converted to 0 - 360° west longitude. If negative (east) longitudes are input they are converted to the 0 - 360° scale before being used by the program. At any time during the run if a longitude gets outside the 0 - 360° range it is put back into that range by adding or subtracting 360°, as necessary.

4. F10.7 (R): The solar 10.7 cm radio noise flux in units of 10^{-22} watts/m^2 (the normal units for this parameter) at the time for which the atmospheric values are to be computed. This factor is used only in the Jacchia section, so a value of zero can be used on input if the height never goes above 90 km. A value of 230 for both design steady state conditions and for maximum conditions may be used, or consult the Aerospace Environment Division (AED) of Marshall Space Flight Center (MSFC) for monthly predictions.

5. Mean F10.7 (R): The 81 day mean solar 10.7 cm radio flux. This parameter is used in the Jacchia section to compute the nighttime minimum global exospheric temperature (equation (14) in Jacchia, 1970). Use zero if the height does not go above 90 km. A value of 230 may be used for both design steady state or maximum conditions, or consult the AED or MSFC for monthly predictions.

6. AP (R): The geomagnetic index a_p, used to compute a geomagnetic correlation to the exospheric temperature, in equation (22) of Jacchia, (1970). Use zero if the height does not go above 90 km. A design steady state value of 20.3 and a maximum condition value of 400 may be used for a_p, or consult the AED at MSFC for monthly predictions.

7-9. Date (I): The date, for the starting time of the trajectory or profile evaluation in month/day/two digit year form, as three integer input values. The day of the month and the year have no direct effect on the program calculations, except in the case of the quasi-biennial oscillation terms. For the annual reference period, use month 13. The quasi-biennial terms are automatically set to zero if month 13 is used. The month is used to establish which Groves data, stationary perturbation data, and random data (including large scale fractions and velocity-density correlations) to load from the SCIDAT data tape into the working arrays. The program will work more efficiently if multiple trajectories or profiles are evaluated during one run operation and the months are the same. (This avoids repeated look-up of the Groves, stationary perturbation, and random data from the SCIDAT tape.)

10-12. Greenwich Time (I): The Greenwich mean time for the starting position in hours, minutes, and seconds as three integer values. Only the Jacchia section is directly affected by the time of day, so unless the height goes above 90 km, the starting time would serve merely as a reference parameter for the particular run being done. Greenwich time corresponding to a local time of 0900 hours should be used for design steady state Jacchia section conditions, and for maximum conditions the local time should be taken as 1400 hours.

13. Latitude Increment (R): If a linear profile is to be generated automatically this is the latitude increment (in degrees) between successive profile positions. The new latitude would be the old latitude plus the latitude increment. For a profile with decreasing latitude (going southward) the increment must be negative. Use zero if separate trajectory position input is to be read in. If a vertical profile (i.e. changing only height) is to be evaluated, then use zero latitude increment.

14. West Longitude Increment (R): If a linear profile is to be generated automatically this is the west longitude increment (in degrees) between successive profile positions. The new longitude will be the old longitude plus the longitude increment. For a profile progressing eastward use a negative increment. Use zero if separate trajectory position input is to be read in. If a vertical profile is to be evaluated, then use zero increment.

15. Height Increment (R): The height decrease in km between successive positions, for an automatically generated linear profile. The profiles normally are generated downward (descending height). (New height = old height minus the height increment). If an upward generated profile is desired the height increment should be negative. Downward generated profiles will be evaluated until the height is incremented to a negative value or until the maximum number of positions (item 16, 1st card) is exceeded.

16. Maximum Number of Positions (I): The maximum number of profile positions to be generated automatically. This does not include the initial position, for which no atmospheric parameters are evaluated. Use zero if trajectory positions are to be read in.

17. Time Increment (I): The time displacement (seconds) between successive automatically generated profile positions. This would normally be set to zero, but could be used as a counter to be printed out in the time position with the output. For trajectories the time for each position is read in with the position data (see trajectory input section below). The hours, minutes, and seconds parameters (read in as items 10-12, 1st card) are updated according to the new time generated by the time increment. However, only the elapsed time in seconds is printed out on the present output.

18. Trajectory Option (I): This option tells the program whether a trajectory or a linear profile is to be evaluated. A value of 0 means a linear profile is to be generated automatically from the parameters read on the first card. A value greater than zero means that trajectory position data must be read in to determine the positions at which atmospheric parameters are to be evaluated. The unit from which the trajectory data are to be read is specified by the (non-zero) trajectory option. Thus, if trajectory data are to be read in from cards, use a trajectory option of 5 (the card input unit).

19. Output Option (I): This option tells the program whether or not to produce non-print output of the atmospheric parameters (see the output description section). Non-print (i.e. disk or cards) output is convenient to use as input to plotter programs. A value of 0 means no non-print output. A value greater than 0 means to output the data on the unit number equal to the output option value.

20. Minimum Geostrophic Latitude (R): Below this latitude (in absolute magnitude) the second order geostrophic relations are used. Above this latitude, or above 90 km, only the usual geostrophic relations are used.

With normal numbers of decimal places and no unnecessary blank spaces, the above 20 items should fit onto one card. However, if they occupy more than the 80 columns allowed on one card, they may be spread out onto two cards if the following rules of free field input are observed on the first of the two cards: (1) Do not put a comma after the last number appearing on the first card. (2) If the last number on the first card is an integer, it should be right justified to column 80. For input on other computers, consult your operations manual for characteristics of free field input.

Input Card Number 2. The second input card is read in by the subroutine SETUP and contains various unit numbers to be used and options controlling the random and quasi-biennial calculations. The unit numbers are the parameters used in read statements in the FORTRAN program to control which file is being read from. The unit numbers are required in the input in order to give maximum flexibility in choice of I/O devices for the program. All input items on card number 2 are integers.

1. Groves Input Unit: This is the unit number of the SCIDAT tape file. If the SCIDAT tape has been assigned by the UNIVAC control statements -

```
@ ASG, T     SCIDAT,   T,   U1961 N
@ USE     3, SCIDAT
```

where U1961 is the reel number for tape SCIDAT, then the Groves input unit number should be 3 on this input card. The Groves and stationary perturbation data must be read from the SCIDAT tape. Later options on this card allow the NMC grid data, the random perturbation data, and the quasi-biennial data each to be read from other files.

2. Random Input Unit: This is the unit number for the random perturbation standard deviations (and the large scale fraction data and density-velocity correlations). If this unit number is the same as the Groves input unit number, then all of the random perturbation data are read from the SCIDAT data tape. Otherwise all of the random perturbation data are read from the file for whatever the unit number is set to. For card input, the unit number should be set to 5. The SCIDAT tape is read with NTRAN, but if alternate random data are read in from a different file, the file

must be FORTRAN readable with format

1X, A1, I2, I4, 3(1X, 5I4)

for the random pressure, density, and temperature data (see Appendix B and Section 4.3 for which values must go in each record). For the random wind data the FORTRAN readable format for the alternate data is

1X, A2, I2, I4, 2(1X, 5I4)

If the random data input unit is different from the Groves input unit, then the code P and PW large scale fraction data and code CS and CL density-velocity correlation data must follow (after an end-of-file) the code RW data on the random input unit. The FORTRAN readable format for the large scale fraction (code P) data is

1X, A1, I2, I4, 3(1X, 5I4)

The format for the code PW data is

1X, A2, I2, I4, 2(1X, 5I4)

The format for the CS and CL data is

1X, A2, I2, I4, 2(1X, 5I5)

See Appendix B and Section 4.3 for description of the values which must go in each of these records.

All of the random perturbation data, random pressure, density, and temperature data, random wind data, large scale fraction data, and density-velocity correlation data must be read in from the same file, either all from SCIDAT, or all from the alternate FORTRAN readable file.

3. QBO Input Unit: If the QBO data parameters are to be read in from the SCIDAT data tape, this unit number is set the same as the Groves input unit. If alternate QBO parameters are to be read in the QBO unit number can be any FORTRAN readable file. Use Unit 5 for card input. The

format for all of the alternate QBO input is

1X, A2, I3, 5(I4, I5)

(See Appendix B and Section 4.3 for which data values must go into each record). All of the QBO pressure, density, temperature, and wind data must be read from the same file, either all from SCIDAT or all from the alternate QBO input file.

4. <u>4-D Input Unit</u>: This is the unit number for the 4-D data tape. Any available unit number can be used. If the 4-D tape WW1A, containing the January data, has been assigned by the control statements

```
@ ASG,   T   WW1A,   T,  U 2400 N
@ USE    4,  WW1A
```

then the 4-D input unit number is 4.

5. <u>Random Option</u>: This option tells the program whether or not to compute random perturbations. If the value is 1 random perturbations are computed. If the value is 2 then random perturbations are not computed. If any values other than 1 or 2 are input the run is terminated with a message "ERRØR IN SETUP INPUT" and a dump of the parameters most recently read in.

6. <u>QBO Option:</u> This option tells the program whether or not to compute QBO perturbations. If the value is 1 QBO perturbations are computed. For 2 no QBO perturbations are computed, and for any other values the "ERRØR IN SETUP INPUT" and dump of most recent parameters read in is given.

7. <u>First Random Number</u>: This number is required as a starting parameter for the random number generating subroutine RAND. Any odd positive integer can be used. Use a value of 1 for a standard design appli-

cation run. Provided all other input is the same, a given value for the starting random number will always produce the same random perturbation output. Therefore, to get a set of different perturbations along a given single trajectory, a set of different starting random numbers should be used. Note, however, that if any other parameters are changed (different spacing along the trajectory, different starting position, etc.) then the same starting random number will produce a different set of random perturbations.

8. NMC Read Option: This option tells the program whether to read the NMC grid data from the SCIDAT data tape (value 0 for the option) or from an input card file (any non-zero value for the option).

9. 4-D Scratch Unit: In order to save array space the 4-D profiles required to interpolate to the 5° x 5° grid locations are read from the tapes to this scratch file rather than being put into arrays. The unit number for this scratch file can be any available unit. Normally the file is a temporary drum file, and, if so, does not (on the UNIVAC) have to be assigned (@ ASG) before execution of the program.

10. NMC Grid Point Scratch Unit: Also in order to save computer storage, the NMC grid point array read in from the SCIDAT tape (or from cards) is stored in a temporary scratch file (usually on drum). If the drum scratch file is used, it does not have to be assigned (on the UNIVAC) before execution of the program.

Input Card Number 3. This card is read by the SETUP subroutine and contains starting values for the random perturbation parameters at the initial position. If random perturbations are not to be computed (Random Option = 2), then this card should not be put in. All values of this free field format card are real. For a normal design application the values on this card should all be zero, unless the run is to be a continuation of a previously run trajectory or profile segment, in which case the output random parameters of the last output position are input, and the last output position becomes the initial position of the new run.

1-6. Initial PL, PS, DL, DS, TL, TS: These are initial values of random relative pressure ($p'/\bar{p}$), density ($\rho'/\bar{\rho}$), and temperature ($T'/\bar{T}$) in percent for the large scale (L) and small scale (S) components. These are starting values for the initial position. Use zero for standard design applications.

7-10. Initial UL, US, VL, VS: Initial values of the random eastward (U) and northward (V) random wind components in m/s for the large scale (L) and small scale (S) components. Use zeros for standard design applications.

Trajectory Input. The free field trajectory position input and backup record are put in only if a trajectory is to be evaluated, rather than a linear profile, generated automatically in the program from information on the first input card. There is no limit to the number of trajectory position records which can be put in. The program continues evaluating the atmospheric parameters and looping back to read a new trajectory position until a position below the surface is reached, or until the trajectory backup record is reached. Each free field trajectory record has the time (integer seconds), the height (kilometers), the latitude (degrees, southern latitude negative), and the west longitude (degrees, 0-360° or east longitudes negative). Any east longitudes read in as negative values are converted to the 0-360° system before being used by the program. The trajectory backup record has the same free field form as a regular trajectory record, except any negative value for height is used. The negative height terminates the loop which evaluates atmospheric parameters and reads a new trajectory record. If a trajectory height goes negative, then any remaining trajectory input cards are read and ignored. The trajectory input can either be input from cards (trajectory option = 5) or form any other unit (with trajectory option = unit number). The trajectory option is item 18 on card #1.

4.4 Output of the Program

The first few lines of print output are primarily a listing of the input parameters. Following a heading which describes each output value for the trajectory or profile evaluations, the position, time monthly mean and total pressure, density, temperature, and winds are listed for each position. The thermal wind shear for the monthly mean winds, the percent deviation from the standard atmosphere (p, ρ, and t), the mean vertical wind and the perturbation data are also given for each position. The perturbation data consist of the stationary perturbations, the quasi-biennial values at the position and time, the quasi-biennial magnitudes, the random perturbation values, and the random perturbation standard deviations. Optional non-print (e.g. disk or punch) output for values at each position is also available to be used for input to plotter programs, or for other purposes.

Heading Information. Primarily the heading information contains a listing of the input data values. However, there are some changes from the values input. If an east longitude is put in as a negative value, $-180° <$ lat $< 0°$, then it is converted to a west longitude in the 0-360 range before the heading is listed. The program evaluates the initial random pressure, density, temperature and wind standard deviations and the initial density velocity correlation from data on the SCIDAT data tape, and lists the computed values on the heading. The Julian date is computed by the program from the input date and is also listed with the heading information. The Julian date is required by the Jacchia and QBO sections of the program. If month 13 (annual reference period) is input, then the Julian date is set to zero. (The Jacchia section takes the exospheric temperature to be 1000° K and the QBO section is bypassed if month 13 is input).

Position and Time Output. Positions and times as generated by the automatic linear profile features or as input by the trajectory input cards are listed on the output. The time is given in seconds. Within the program, the input time in hours, minutes, and seconds are updated in that form also. However, only a continuously increasing time in seconds is printed out. If time in hours, minutes, and seconds were desired, these variables could easily be printed out by adding them to the output list. All output west longitudes are converted to the 0-360 range before being printed out. If a latitude greater than 90° in absolute magnitude is generated (or input) then a transformation

$$\text{lat} = (180° - |\text{lat}|)(\text{lat}/|\text{lat}|) \tag{4.6}$$

$$\text{lon} = \text{lon} + 180° \tag{4.7}$$

is made.

Monthly Mean Data. The monthly mean values of pressure, density, and temperatures, consist of either: (1) values from the 4-D data tapes if the height is below 25 km, (2) the sum of Groves plus stationary perturbation values if the height is between 30 and 90 km, (3) an interpolation between 4-D at 25 km and Groves plus stationary perturbations at 30 km if the height is between 25 and 30 km, (4) Jacchia model values if the height is above 115 km, or (5) faired values between Groves and Jacchia if the height is between 90 and 115 km.

The percent deviations from the U.S. 1962 Standard Atmosphere are evaluated by using standard atmosphere values computed by the subroutine STDATM. The percent deviations are evaluated by the relations $100(T - T_s)/T_s$, $100(\rho - \rho_s)/\rho_s$, and $100(p - p_s)/p_s$, where the subscript s refers to the standard atmosphere values. This subroutine accurately reproduces the tabulated U.S. Standard Atmosphere 1962 values to within an accuracy of better than 0.2% above 90 km. The STDATM values are based on a model of parabolic segments for the height variation of the molecular weight above 90 km. The subroutine reproduces the tabular values even more accurately in the height region below 90 km, where the molecular weight is constant. Since the U.S. 1962 Standard Atmosphere is not defined above 700 km, the percent deviations printed out for heights above 700 km are zero.

The thermal wind shear values are values of $\partial u/\partial z$ and $\partial v/\partial z$ for the monthly mean geostrophic wind (see Section 2). The wind values, computed from the usual geostrophic wind equation or the second order geostrophic relation if the latitude is less than the input value of minimum geostrophic latitude, are determined by horizontal gradients of the monthly mean pressure. The thermal wind shear components, computed by the thermal wind equations, are determined by the horizontal gradients of the monthly mean temperature. Thus, a comparison of numerically differentiated geostrophic mean winds and the thermal wind shear serve as a check of the mean pressure and temperature fields. The mean vertical wind is evaluated, as described in Section 2, by combinations of horizontal and vertical temperature gradients and the geostrophic winds.

The Total (Mean Plus Perturbation) Data. The parameter values listed under the heading of "Mean Plus Perturbations" are the monthly mean values, as defined above, plus the random perturbations, plus (if the height is between 10 and 90 km) the quasi-biennial perturbations. These mean-plus-perturbation values represent values which would be typical "instantaneous" values of the pressure, density, temperature or winds. The percent deviations from the U.S. Standard atmosphere are computed in the same way as for the percent deviations of the monthly mean values from the standard atmosphere.

Perturbation Values. The data under the "Perturbation Values" heading are the various perturbation values, magnitudes, and amplitudes. The stationary perturbations (denoted SP on the printout) are defined only if the height is between 30 and 90 km. The monthly mean y_m of parameter y should be the Groves value G_y, evaluated from the SCIDAT data tape, modified by the given stationary perturbation value s_y, in percent, by the relation

$$y_m = G_y (1 + s_y/100) \tag{4.8}$$

The data labeled "QBO" are the values of the QBO oscillation at the output time and position. The data labeled "MAG" gives the magnitude of the QBO oscillations at the output position and time. The QBO perturbation values should always be less than or equal to the magnitude values in absolute value. The data labeled "RANL", "RANS","RANT" are the large scale, small scale and total random perturbations evaluated at the output time and place. The data labeled "SIGL", "SIGS", and "SIGT" are the standard deviations of the large scale, small scale, and total random components at the output time and positions. According to the Gaussian distribution, on which the random perturbations are based, the perturbation values should be within the range

$\pm\ \sigma$ 68% of the time and outside the range $\pm\ \sigma$ 32% of the time. Similarly, the perturbation values should be within the range $\pm\ 2\sigma$ 95% of the time, and outside the range $\pm\ 2\sigma$ 5% of the time. The evaluation of the QBO and random perturbation output can be suppressed by the QBO and random options, if desired.

Non-Print Output. The non-print output is available as an option, controlled by the input value of the output option parameter. If non-print output is desired, it comes out in the form of records with format F5.1, F6.2, F7.2, 2F5.1, 3F5.0, 5F5.1, 2E10.3, I5, I3 containing the following information: (1) the height in km, (2) the latitude in degrees, (3) the west longitude in degrees 0-360, (4-5) the percentage deviation of the mean monthly values of pressure and density from the 1962 U.S. Standard Atmosphere, (6) the monthly mean temperature, (7-8) the eastward and northward components of the monthly mean (geostrophic) wind, (9-13) the magnitudes of the total random perturbations in pressure, density, temperature (per cent, and eastward and northward wind (m/s), (14-15) the monthly mean pressure (N/m^2) and density (kg/m^3), (16) the time, in seconds, and (17) the month (with 13 indicating annual mean).

4.5 Program Diagnostics. There are several possible reasons which can cause the printing of diagnostic messages and termination of the run during the SETUP phase. If, during the setup procedure, the NMC grid point number data table does not contain the required 1977 values, a message Diagnostic 1: "N RECØRDS WRITTEN BY SETNMC IN SCRATCH FILE M" is printed, and EXECUTION IS TERMINATED. This situation should only arise if the NMC grid point table is being read from cards, rather than the SCIDAT data tape. If during the reading of the SCIDAT data tape, any record is read which does not have the expected code character or characters (N, P, D, T, S, R, RW, P, PW, CS, CL, QP, QD, QT, QU, QV, or SP; see Appendix B), then the message results

Diagnostic 2: "ERROR IN SETUP INPUT" followed by a listing of the latest data values read in. This message is also produced if the random option and the quasi-biennial option do not have a value of either 1 or 2. Any condition which results in this error message terminates the execution.

There are also general conditions which could result in diagnostic messages in the 4-D section: If during the reading of the 4-D data tape on the first access of the region below 30 km, a parity error is encountered, a message

Diagnostic 3: "INPUT UNIT NØ. M IN ERRØR (-3) FØR RECØRD NØ N" is printed - execution continues. Such an error will only be of consequence if the particular record read is required for interpolation. If an end of file is read, a message is written

Diagnostic 4: "***** UNIT NØ. JT IN ERRØR IRC RECØRDS READ IREAD(IRN, 3) + XXXX MP = XX MØNTH = XX IP = XXXX IPT(I, J) = XXXX IRN = XX M STATUS L"

Where

JT = Unit on which 4-D data tape is mounted

IRC = Total number of records read thus far from 4-D tape

IREAD(IRN, 3) = Sequential point number selected by SELEC4

MP = Month word in last record read

MØNTH = Run month

IP = Point number word in last record read

IPT(I, J) = Point number required for profile J to be interpolated to Ith requested profile

IRN = Sequential point number required

M = Unit status (READ)

L = NTRAN status (-2 for end of file, -3 for parity, etc.)

and EXECUTION IS TERMINATED

If IRC > IREAD(IRN, 3), the diagnostic message 4 is written - L should be 106, and IRC and IREAD values should indicate this condition. EXECUTIØN IS TERMINATED.

If MP ≠ MØNTH, or IP ≠ IP(I, J) the diagnostic message 4 is printed, again with L = 106, and MP/MONTH or IP/IP(I, J) indicating error. EXECUTIØN IS TERMINATED.

The writing of scratch file SCRCH1 with data for subsequent unpacking and interpolation is also checked. If there is a write error, the diagnostic 4 is printed, with JT the scratch file unit number, M as WRITE and L as -3 or -4. EXECUTIØN IS TERMINATED.

These diagnostics can arise if a bad or wrong 4-D data tape is being accessed, or if there is a malfunction of the tape drive. In some cases a tape will, for example, indicate parity errors when being read from one tape drive, but not another.

If, during the course of evaluation of position in the 4-D height range, it is found that the position is outside the previously established 4-D grid, then a new grid is generated by calling GEN4D. If this occurs again, the message results

Diagnostic 5: "UNABLE TO GENERATE 4-D GRID" and EXECUTIØN IS TERMINATED.

The wind diagnostic symbol (asterisk), has also been added to the program. Presence of the asterisk between the E-W and N-S wind components on the print output indicates a diagnostic condition yielding questionnable wind values. The conditions which can produce this is a 4-D data consistency check violation (i.e., unrealistic scale heights or unrealistic horizontal pressure gradients) within the 4 x 4 grid of 4-D data profiles.

Diagnostic 6: "PREMATURE END-OF-FILE FOUND ON UNIT M"

"CALLED FROM SUBROUTINE XXXXXX"

And end-of-file mark was encountered before it was expected by one of the following subroutines while it was loading the associated data.

XXXXXX	DATA
GETNMC	NMC GRID DATA
RTRAN	STATIONARY OR RANDOM PERTURBATION DATA
RTRAN1	GROVES DATA
RTRAN2	QBO DATA

UNIT m refers to the input unit number. This error should never occur while using the SCIDAT data type as the data source.

5. PROGRAMMERS MANUAL

5.1: Description of Subroutines

The following is a brief description of each of the PROFILE program subroutines, in alphabetical order:

ADJUST: Adjusts the 4-D profiles of pressure, density, and temperature variance (read from the 4-D tapes) to satisfy the Buell constraints imposed by the perfect gas law and hydrostatic equation

CHECK: A consistency check routine for the 4-D 16 profile grid data produced by GEN4D. CHECK is called for each height to be evaluated, and tests for reasonable values of scale height immediately above and below that height. It also tests for reasonable horizontal pressure gradients. Failure of either test produces the diagnostic asterisk between the output values of wind components.

CORLAT: Evaluates the horizontal and vertical scales for large and small scale density, temperature, and wind components, computes the autocorrelations and cross correlations for the two scale perturbation model, and evaluates new perturbation values having appropriate correlations with the perturbations at the previous position.

DIAGEQ: A matrix diagonalizing procedure used by the ADJUST subroutine.

FAIR: Fairs between the Groves and Jacchia values in the 90 to 115 km height range.

GEN4D: Generates the polar ($|\text{latitude}| > 75°$) or non-polar (16 5° x 5° points) grid of pressure, density, temperature and variance profiles. See Figure 5.1 for a flow chart of this subroutine.

GETNMC: Reads the NMC grid point values from the SCIDAT data tape or from cards and loads them onto a scratch file. This subroutine is essentially unchanged from the subroutine of the same name in the original 4-D program.

GRAM: The main segment of the Global Reference Atmospheric Model program. The main segment serves as a driver for the SETUP and SCIMOD subroutines.

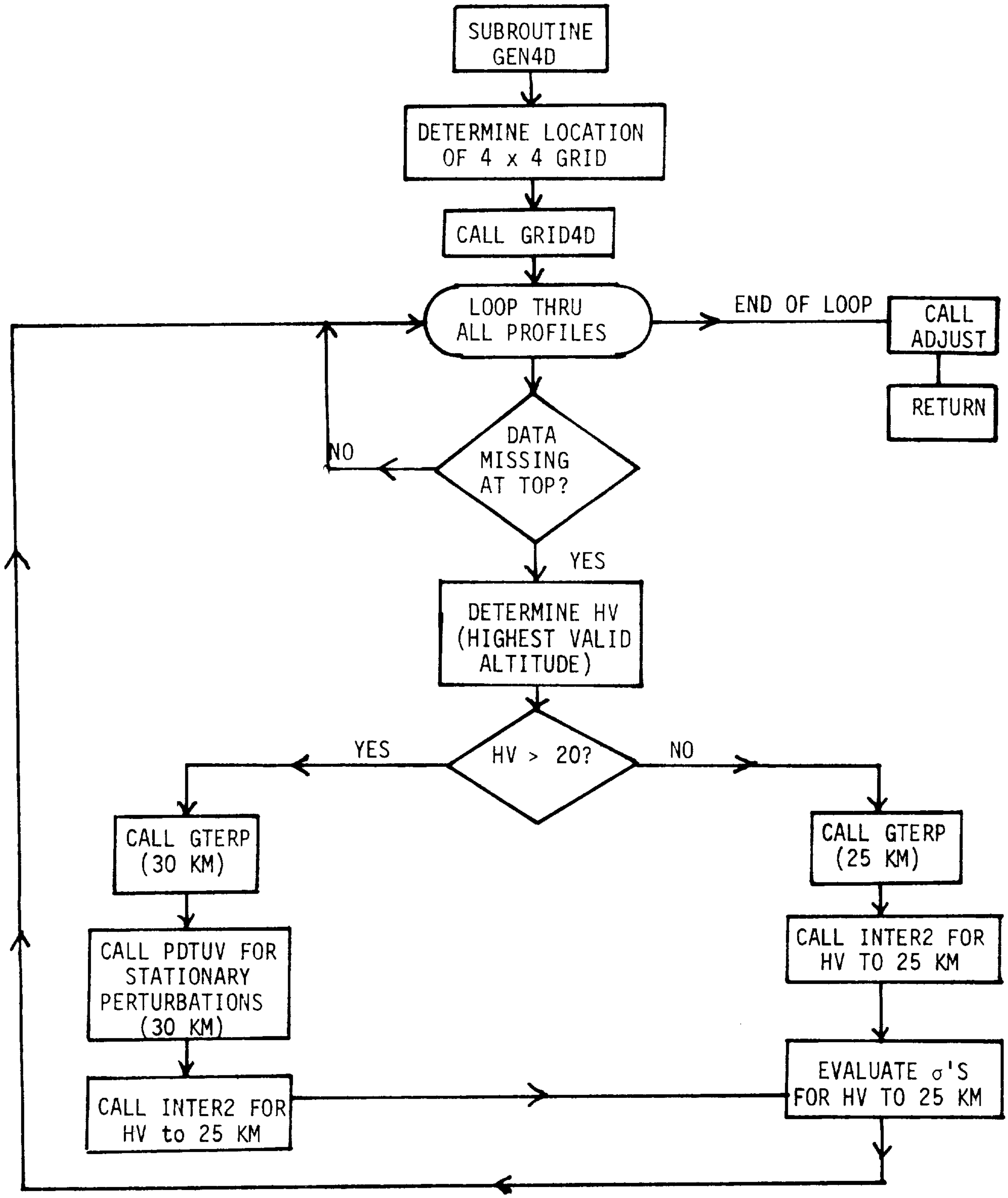


Figure 5.1: Simplified flow chart of the GEN4D subroutine.

GRID4D: After array of 4-D grid lat-lons has been evaluated, this subroutine looks up the data from the 4-D data tapes and interpolates to determine profiles of pressure density, temperature, and variance at the 4-D grid locations. Profiles to be interpolated to 4-D grid locations are loaded onto a scratch file from the tapes before the interpolation is done.

GRØUP A subroutine, called by CHECK, which groups the 16 4-D pressure data at the given height into one or more groups which have consistent and reasonable horizontal pressure gradients within each group. If the subsequent geostrophic wind calculations in WIND use horizontal pressure gradients evaluated from differences across inconsistent groups of 4-D data, the diagnostic asterisk is printed between the output values of wind components.

GTERP: Uses linear latitude interpolation and linear temperature and linear logarithm of density interpolation on height to evaluate Groves data to a given latitude and height. See Section 5 of Justus et al (1974a).

INTERW: Two variable linear interpolation between known value U1 and V1 at Z1 and U2 and V2 at Z2 to determine U and V at Z, where Z is between Z1 and Z2.

INTERZ: Three variable interpolation, linear on temperature, and gas constant ($R = p/\rho T$), and linear on the logarithm of pressure, with pressure computed from perfect gas law and interpolated temperature and density, and gas constant.

INTER2: Three variable interpolation, linear on all three variables.

INTER4: Interpolates between the pressure, density, and temperature profiles at the 4-D grid locations. This subroutine calls subroutine INTLL to do the latitude interpolation.

INTLL: One variable interpolation between values in an array of latitude and longitude locations by equation (5.6) of Justus et al (1974a).

INTRP4: The subroutine for the latitude-longitude interpolation of values from the 4-D data tapes into the 4-D grid array. This is a modification of the INTERP subroutine of the original 4-D program.

INTRUV: Evaluates the standard deviations of the random wind components at given height and latitude by calling INTERW subroutine.

JAC: Calculates the molecular weight, density, and temperature for the Jacchia model.

JACCH: Main subroutine of the Jacchia section, serves as a driver for JAC and other Jacchia section subroutines. JACCHIA also evaluates the seasonal and latitudinal variations in the lower thermosphere.

NORMAL: Computes two independent random numbers selected from a Gaussian distribution with mean zero and unit standard deviation.

PDTUV: Interpolates the stationary perturbations on latitude and longitude at a given height. This subroutine is similar to INTLL.

PERTRB: Evaluates the pressure, density, temperature and wind component random perturbations by the correlated random perturbation model discussed in Section 8 of the technical description section of the report.

PHASE: A linear height-latitude interpolation routine for the quasi-biennial phase. The interpolation properly accounts for the phase discontinuity between 0 and 870 days (the quasi-biennial period).

QBOGEN: Computes the QBO perturbation values and their amplitudes and phases. The amplitudes and phases of the QBO pressure, density, temperature, and wind perturbations are interpolated from the amplitude and phase data from the SCIDAT data tape, by calling the INTERZ and INTERW subroutines.

RAND: Produces a random number selected from a uniform distribution between 0 and 1. This is required as input to the subroutine NORMAL.

RIG: Computes the acceleration of gravity and the radius from the center of the Earth for a position at a given latitude and height.

RTERP: Computes the standard deviations of the random pressure, density, and temperature perturbations by calling subroutine INTERZ.

RTRAN: This subroutine contains several NTRAN read sections with multiple entry points coming from subroutine SETUP. The NTRAN read statements are for reading the SCIDAT data tape.

SCIMOD: The heart of the GRAM program. This subroutine branches on height to evaluate the atmospheric parameters by the Jacchia, the modified Groves, or the 4-D methods. The QBO and random perturbations are also evaluated and the output is printed (and optionally also punched) by the SCIMOD subroutine. See Figure 5.2 for a flow chart of the SCIMOD subroutine and Figure 4.1, for a flow chart showing how SCIMOD fits into the overall GRAM prog- gram.

SELEC4: Selects the 4-D data needed for interpolation. This subroutine is a modification of the INPUT subroutine of the original 4-D program.

SETUP: This subroutine reads in the NMC grid points with the GETNMC subroutine and reads and loads the data from the required month on the SCIDAT data tapes into arrays. See Figure 5.3 for a flow chart of the SETUP subroutine, and Figure 4.1 for a flow chart showing how SETUP fits into the overall GRAM program.

SORT4: Sorts the 4-D locations for sequential tape reading from the 4-D data tapes. This subroutine is a modification of the SORT subroutine from the original 4-D program.

SPHERE: Called by WIND, this subroutine evaluates the wind components by the spherical harmonic model.

STDATM: Evaluates the 1962 U.S. Standard Atmosphere values of pressure, density, and temperature, at any given height up to 700 km.

TINF: This subroutine computes the exospheric temperature for the Jacchia model.

TME: This subroutine calculates the variables necessary for input into the subroutine TINF in the Jacchia model.

WIND: This subroutine evaluates the geostrophic winds from input values of horizontal pressure gradient if the height is less than 25 km or more than 90 km. If the latitude is below the minimum geostrophic latitude, it evaluates geostrophic wind at minimum geostrophic north latitude and at minimum geostrophic south latitude and then interpolates in between. If the height is between 25 and 90 km, the spherical harmonic wind model is used. Between 20 and 25 km and between 90 and 95 km, a smooth fairing between geostrophic and spherical harmonic wind is used.

The UNIVAC tape reading library routine NTRAN is not available on all computers. However, a similar function (reading 36 bit binary integer arrays in tape records) can be performed easily by alternate program techniques. For example, on Georgia Tech's CDC Cyber 74 system, this function is done by BUFFER IN statements. These routines are used to read the SCIDAT and 4-D data tapes. Also the FLD function, a UNIVAC library routine used to divide the 36 bit 4-D tape words onto 2 18 bit integers, must also be programmed by alternate methods on non-UNIVAC machines. On Georgia Tech's CDC machine, this is done by specially written subroutines (WRDCHG, RFLD, and FLD) which utilize the SHIFT and MASK bit manipulating CDC library routines.

If the GRAM program is mapped without segmenting the program, it requires approximately 80 K decimal words core storage on Georgia Tech's CYBER. In order to take up less core storage (e.g., be accommodated into smaller core partitions), the program can be mapped in segmented form. An efficient segment of the program can be accomplished by subdividing the program into a primary segment, a setup segment, a Jacchia segment, and a 4-D segment. The primary segment should contain CORLAT, GRAM, GTERP, INTERW, INTERZ, INTER2, INTRUV, NORMAL, PDTUV, PERTRB, PHASE, QBOGEN, RAND, RIG, RTERP, SCIMOD, SPHERE, STDATM, and WIND. The setup segment should contain: GETNMC, RTRAN, and SETUP. The Jacchia segment should contain: FAIR, JAC, JACCH, TINF, and TME. The 4-D segment should contain: ADJUST, CHECK, DIAGEQ, GEN4D, GRID4D, GROUP, INTER4,

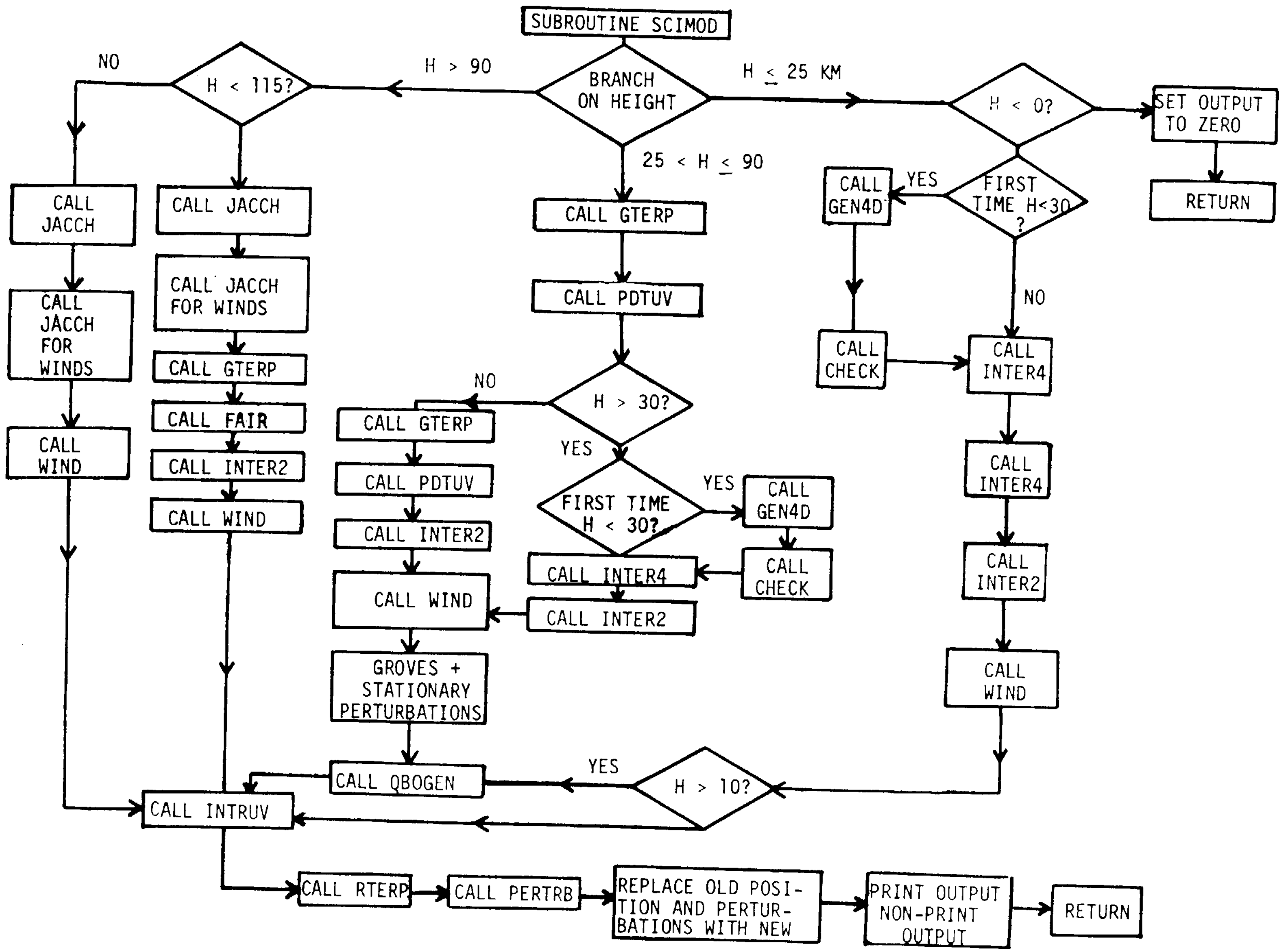


Figure 5.2: An abbreviated flow chart of the SCIMOD subroutine.

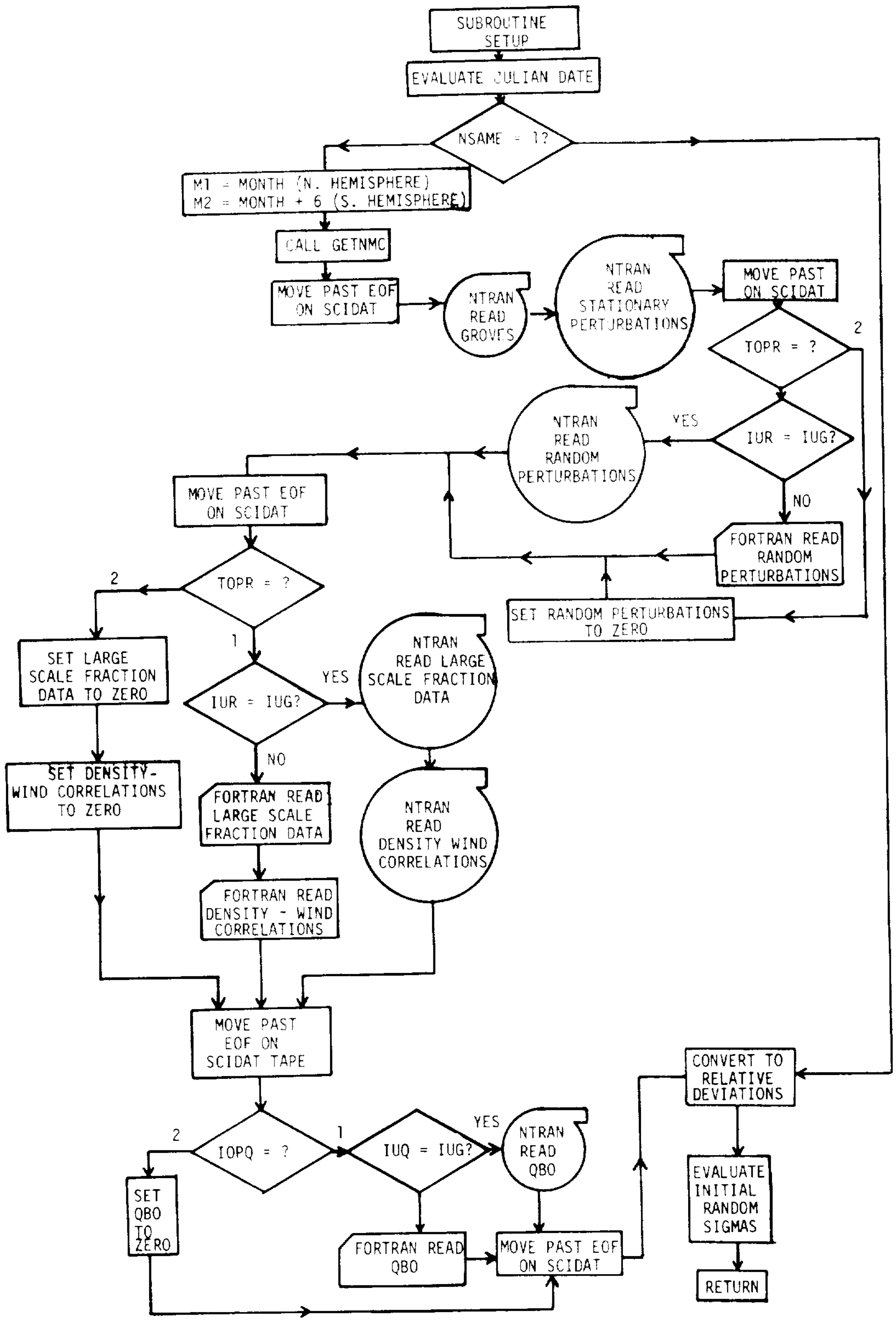


Figure 5.3: Abbreviated flow chart of the SETUP subroutine.

INTLL, INTRP4, SELEC4, and SORT4. The following MAP statement for file GRAM to create absolute element ABS will accomplish the mapping of the program with these segments setup as described:

```
@MAP, IS . GRAM. ABS
   IN GRAM. CORLAT,  . GRAM,  . GTERP,  . INTERW,  . INTERZ
   IN GRAM. INTER2,  . INTRUV,  . NORMAL,  . PDTUV,  . PERTRB,  . PHASE
   IN GRAM. QBOGEN,  . RAND,  . RIG,  . RTERP
   IN GRAM. SCIMOD,  . SPHERE,  . STDATM,  . WIND
   NOT TPF$
   SEG SETUP*
   IN GRAM.  GETNMC,  . RTRAN,  . SETUP
   NOT TPF$
   SEG JACCH*,  SETUP
   IN GRAM.  FAIR,  . JAC,  . JACCH,  . TINF,  . TME
   NOT TPF$
   SEG SEG4D*,  SETUP
   IN GRAM.  ADJUST,  . CHECK,  . DIAGEQ
   IN GRAM.  GEN4D,  . GRID4D,  . INTER4,  . INTLL,  . INTRP4
   IN GRAM.  SELEC4,  . SORT4,  . GROUP
   NOT TPF$
   END
```

This segmented map saves approximately 4 K (decimal) in core storage, but does not significantly affect run time, since the segments being overlayed (the setup, Jacchia, and 4-D segments) only have to be loaded in once during any given trajectory or profile evaluation. If further reduction in size is desired the 4-D segment can be subdivided into two parts, one containing only CHECK, GROUP, INTER4, and INTLL and another segment containing ADJUST, DIAGEQ, GEN4D, GRID4D, INTRP4, SELEC4 and SORT4. This saves another 1 K in storage, approximately.

Some characteristics of some of the subroutines in each of these segments are described more fully in the following sections.

5.2: The Primary Section

This section consists of the main program segment GRAM, the SCIMOD subroutine, the subroutines for evaluating Groves values, the stationary perturbations, the QBO and random perturbations, and general interpolation subroutines. With the exception of GRAM and SCIMOD the parts of this section were adequately described in the previous section.

Many of the subroutines transfer their input and output via COMMON statements. This procedure saves much in core storage space. The discussion in this and subsequent sections describes the input and output of some of the subroutines, both by argument lists and via COMMON statements.

Main Segment GRAM. This program serves as a driver for the SETUP and SCIMOD subroutines (see Figure 4.1). It reads one card, the first input card, in free field format. This card contains:

1.	The initial height	H1
2.	The initial latitude (degrees)	PHI1
3.	The initial west longitude (degrees)	THET1
4.	The F10.7 solar flux	F10
5.	The 81 day mean F10.7 solar flux	F10B
6.	The a_p geomagnetic index	AP
7-9.	The date month/date/2 digit year	MN/IDA/IYR
10-12.	The Greenwich time hours: minutes: seconds	IMRO; MINO; ISECO
13-15.	The latitude, longitude, and height increments	DPHI, DTHET, DH
16.	The maximum number of profile positions	NMAX
17.	The time increment between profile positions	INCT
18.	The trajectory option	IOPT
19	The output option	IOPP
20.	The minimum geostrophic latitude	GLAT

The trajectory input records (if used) are also read by GRAM, after control has returned from SETUP, which reads the second and third initial data input cards. See Section 4.4 and Appendix C for further description of the card input.

The COMMON "IOTEMP" transfers data from the card input in GRAM to the other subroutines called by GRAM (SETUP, SCIMOD, and RIG).

Subroutine SCIMOD. This program is the primary subroutine of the GRAM program. It serves as a driver for all of the various sections of the atmospheric evaluation. See Figure 5.2 for a flow chart of this subroutine.

The input to SCIMOD, transferred by COMMON statements IOTEMP and PDTCOM, is:

1.	Acceleration of gravity (m/sec^2)	G
2.	Earth radius to height H (km)	RI
3.	Height (km)	H
4.	Latitude (radians)	PHIR
5.	Longitude (radians)	THETR
6.	F10.7 solar flux	F10
7.	Mean F10.7 solar flux	F10B
8.	Geomagnetic index a_p	AP
9-11.	Date	MN/IDA/IYR
12-14.	Time	IHR: MIN: ISEC
15.	Previous height (km)	H1
16.	Previous latitude (radians)	PHI1R
17.	Previous longitude (radians)	THET1R
18-20.	Previous random pressure, density, and temperature perturbations (%), large scale (L) and small scale (S)	RP1L, RD1L, RT1L, RP1S, RD1S, RT1S
21-23.	Previous random pressure, density, and temperature standard deviations (5), large scale (L) and small scale (S)	SP1L, SD1L, ST1L, SP1S, SD1S, ST1S

24-25. Previous random winds (m/s), large scale (L) and small scale (S) — RU1L, RV1L, RU1S, RV1S

26-27. Previous standard deviation of random winds (m/s), large scale (L) and small scale (S) — SU1L, SV1L, SU1S, SV1S

The COMMON "PDTCOM" contains data transferred into SCIMOD from SETUP. The COMMON "IOTEMP" transfers data in from GRAM. The COMMON "C4" transfers data out to the 4-D section of the program. The COMMON "COMPER" transfers data out to the random perturbation subroutines.

The SCIMOD subroutine prints and (optionally) punches on a non-print output file, the output described in Section 4 and Appendix C. It also transfers output to other subroutines via the above-mentioned COMMON lists. The SCIMOD subroutine updates the profile or trajectory positions by setting the current position equal to the previous position before exit. The previous position information then stays in the COMMON list unit the next call to SCIMOD. The previous random perturbations are handled in similar fashion.

5.3 The Setup Section

The function of the setup section of the program is to load the initial data and the data from the SCIDAT tape. See Figure 4.1 for a flow chart illustrating how the SETUP subroutine fits into the overall program and Figure 5.2 for a flow chart of the SETUP subroutine.

The SETUP subroutine reads the second and third cards of input. The second cards contains:

1. Groves input unit	IUG
2. Random input unit	IUR
3. QBO input unit	IUQ
4. 4-D input unit	IU4
5. Random option	IOPR

6. QBO option IOPQ

7. First random number NR1

8. NMC read option NMCOP

9. 4-D scratch unit IOTEM1

10. NMC grid point scratch unit IOTEM2

The third card (optional, read only if IOPR = 1) contains:

1-6. Initial random perturbations in pressure, density, and temperature (%), large scale (L) and small scale (S) RP1L, RD1L, RT1L RP1S, RD1S, RT1S

7-10. Initial random wind perturbation (m/s), large scale (L) and small scale (S) RU1L, RV1L, RU1S, RV1S

The COMMON list "PDTCOM" transfers the arrays, loaded with the appropriate data from the SCIDAT data tape, to the other subroutines. This COMMON list contains the following arrays:

1-3. Groves pressure, density, and temperature PG, DG, TG

4-6. Stationary perturbations in pressure, density, and temperature PSP, DSP, TSP

7-11. Amplitudes of QBO pressure, density, and temperature, and winds PAQ, DAQ, TAQ, UAQ, VAQ

12-16. Phases of QBO pressure, density, and temperature, and winds PDQ, DDQ, TDQ, UDQ, VDQ

17-21. Standard deviations for the random pressure, density, temperature and winds PR, DR, TR, UR, VR

The COMMON list "COTRAN" is used to transfer data to setup from the NTRAN read subroutine RTRAN, which has multiple entry points for various different types of data from the SCIDAT data tape. The COMMON "CHIC" is used to transfer the spherical harmonics coefficients to the SPHERE subroutine.

5.4 The Jacchia Section

The subroutine JACCH calculates the pressure, density, and temperature at a point in space for heights above 90 km for a particular time.

1.	Height in km	H
2.	Latitude in radians	PHIR
3.	West longitude in degrees (0 to 360 degrees)	THET
4.	Solar radio noise flux F10.7 (10^{-22} watts/m^2)	F10
5.	81 - day average solar flux F10.7	F10B
6.	Geomagnetic index a_p	AP
7.	Month	MN
8.	Day of month	IDA
9.	Year	IYR
10.	Hour of day in universal time	IHR
11.	Minute of hour in universal time	MIN
12.	Mean Julian day	XMJD

The outputs are:

1.	Pressure in units of nt/m^2	PH
2.	Density in units of kg/m^3	DH
3.	Temperature in Kelvin degrees	TH

The theory and methods used in JACCH for calculating the pressure, density, and temperature are given in Jacchia, (1970). A brief explanation will be given below.

The subroutine JACCH consists of four sections: the main routine and three imbedded subroutines. All sections have numerous comments to explain each part of the program.

Main Routine (JACCH). The main routine acts as the calling routine, and also, calculates the seasonal - latitudinal variations in the lower thermosphere.

The seasonal - latitudinal density variations are given by equation

(2.1) of Justus et al (1974 a).

The equations for the molecular weight and the relative temperature were given as equations (2.2) and (2.3) of Justus et al (1974 a). After the density, temperature, and molecular weight are calculated, the pressure is calculated from the ideal gas law:

$$P = \frac{\rho RT}{M}$$

where ρ is the density, R is the universal gas constant, T is the temperature, and M is the molecular weight.

An option is included in the main routine whereby the yearly mean values of the density, pressure, and temperature may be calculated directly. If the value of the month input variable is thirteen, (MN = 13), the exosphere temperature is immediately set equal to 1000° K (which is the recommended design value for annual mean conditions) and the yearly mean density, pressure, and temperature values are calculated. Note that the 1962 U.S. Standard Atmosphere has an exospheric temperature of approximately 1500° K and is thus considerably different from the 1000° K results of the annual mean in the PROFILE program.

Subroutine TME. This subroutine calculates variables necessary for input into the subroutine TINF. The input variables are:

1.	month (month = 13 denotes annual mean and bypasses this subroutine)	MN
2.	day of month	IDA
3.	year	IYR
4.	hour of day in universal time	IHR
5.	minute of day in universal time	MIN
6.	mean Julian day	XMJD

7.	latitude in radians	XLAT
8.	longitude in degrees (input: 0 to 360 degrees turning westward; output: -180 to + 180 degrees)	XLONG

The output variables are:

1.	solar declination angle in radians	SDA
2.	solar hour angle in radians	SHA
3.	day number from January 1	DD
4.	day number divided by tropical year (365.2422 days)	DY

<u>Subroutine TINF</u>. This subroutine calculates the exospheric temperature. The input variables are:

1.	solar radio noise flux (10^{-22} watts/m^2)	F10
2.	81 - day average F10	F10B
3.	geomagnetic latitude in radians	XLAT
4.	solar declination angle	SDA
5.	solar hour angle	SHA
6.	day number divided by tropical year	DY
7.	diurnal factor equal to 0.31	R

The output is the exospheric temperature, TE. Factors included in the calculation of the exospheric temperature are solar activity variations, diurnal variations, variations with the geomagnetic activity, and semi-annual variations.

<u>Subroutine JAC</u>. This subroutine calculates the molecular weight, density, and temperature without the seasonal - latitudinal variations. The input variables are:

1.	height in km	Z
2.	exospheric temperature	T

The output variables are:

1. temperature — TZ
2. molecular weight — EM
3. density — DENS

5.5 The 4-D Section

GRID4D and subroutines SØRT4, INTRP4 and SELEC4 are basically the MAIN PRØGRAM, SØRT, INTERP and INPUT as documented in the 4-D users reference manual and subsequent updates.

Some changes have been made.

In GRID4D, NTRAN MØVE statements are used to select the appropriate file for a given month on the 4-D data tape mounted on UNIT IT in the UNIVAC version. In Georgia Tech's CDC version, and on other machines, separate reads for each record must be used until an end of file is reached, and reading continues until the proper file is found. If a parity error is encountered in reading IT, a message

"INPUT UNIT NO. IT IN ERRØR FØR RECØRD NØ IRC"

is printed - execution continues. Such an error will only be of consequence if the particular record read in error is required for interpolation.

Grid point profiles for subsequent interpolation are tagged and filed on a dynamically assigned scratch UNIT SCRCH1 (IØTEM1 in calling program), instead of occupying core as in the 4-D model.

Any error in the handling of the 4-D data tape or UNIT SCRCH(IØTEM1 in calling program) by TRID4D which results in a transfer to

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is fatal, and results in the printing of an error message and termination of execution (see Section 4.5).

Slight changes have been made to the logic of SØRT4 in the interests of efficiency.

SELEC4 is concerned only with the selection of the record numbers of the appropriate interpolation profiles.

GETNMC has been added to file the NMC grid point data, read either from cards of the SCIDAT data tape on UNIT IUG, on a dynamically assigned scratch file SCRCH2 (IOTEM2 in calling program), instead of occupying 1977 words of core as in the 4-D model. If other than 1977 records are filed, an error message

"N RECØRDS WRITTEN BY GETNMC ON SCRATCH FILE M"

is printed and execution terminated.

INTRP4 uses a modified latitude - longitude interpolation scheme in the mixed NMC - equatorial, equatorial and southern hemisphere regions.

The dimensions of some variables have been altered in keeping with the maximum number of profiles to be used in interpolation (16 instead of 25 as in the 4-D model), and to provide the index word for each record of SCRCH1 (IN (107) instead of (106)).

All references to, and subroutines associated with, the determination of the coefficients of the best fit polynomials to the selected profiles, as performed in the original 4-D model, have been deleted. All vertical interpolations required are performed by SCIMØD.

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APPENDIX A

THE SPHERICAL HARMONIC WIND MODEL

The spherical harmonic wind model is based on the second order spherical harmonic expansion relation (equation 2.12)

$$
\begin{aligned}
u(m, z, \theta, \phi) = {} & a_1 + a_2 \cos\phi + a_3 \cos\theta \sin\phi \\
& + a_4 \sin\theta \sin\phi + a_5 (3\cos^2\phi - 1)/2 \qquad \text{(A-1)} \\
& + a_6 \cos\theta(3 \sin\phi \cos\theta) + a_7 \sin\theta(3 \sin\phi \cos\phi) \\
& + a_8 (2 \cos^2\theta - 1)(3 \sin^2\phi) + a_9(2 \sin\theta \cos\theta)(3 \sin^2\phi)
\end{aligned}
$$

where u is the eastward wind component (or a similar equation for v, the northward component), m is the month, z is the height, θ is the longitude, and ϕ is the co-latitude. The coefficients (a's) must be estimated from observed data, as a function of month and height. Five kilometer height intervals were selected at which to evaluate the coefficients.

Estimation of the Model Coefficients

The spherical harmonic model may be expressed as a linear function by the transformation

$$
\begin{aligned}
x_1 &= 1 \\
x_2 &= \cos\phi \\
x_3 &= \cos\theta \sin\phi \\
x_4 &= \sin\theta \sin\phi \\
x_5 &= 3(\cos^2\phi - 1)/2
\end{aligned}
$$

$$
\begin{aligned}
x_6 &= \cos\theta \ (3 \sin\phi \cos\phi) \\
x_7 &= \sin\theta \ (3 \sin\phi \cos\phi) \\
x_8 &= (2 \cos^2\theta - 1) \ (3 \sin^2\phi) \\
x_9 &= (2 \sin\theta \cos\theta) \ (3 \sin^2\phi)
\end{aligned} \tag{A-2}
$$

Using this transformation, the model becomes

$$
u = \sum_{i=1}^{9} a_i x_i = \underline{A} \cdot \underline{X} \tag{A-3}
$$

where $\underline{A}$ and $\underline{X}$ are 9-component vectors with components a_i and x_i, respectively. If similar coefficient b_i are defined for v, the northward component, its representation becomes

$$
v = \underline{B} \cdot \underline{X}
$$

Since the wind components vary with month and height, the $\underline{A}$ and $\underline{B}$ vectors will depend on month and height. Over altitudes 25 to 65 km the all a component of the $\underline{A}$ and $\underline{B}$ coefficient vectors are evaluated every 5 km, for each month. Above 65 km, where fewer wind observations were available, a 5 km height increment was still used, but only the 1st-order coefficients (1-4) were evaluated; the 2nd-order coefficients (5-9) were set identially to zero (see the printout of the spherical harmonic in the SCIDAT tape listing of Appendix B).

The least-squared error approach (Draper and Smith, 1966) was used to estimate the coefficient vectors $\underline{A}$ and $\underline{B}$.

The Data

Four sources of wind data were available for this analysis. The most extensive source was the SUMS tape from the World Data Center (NOAA, 1976). This tape contained monthly wind data averaged over the period 1969 to 1976. Up to 20 stations around the world reported winds in the altitude range 25 to 90 km. These stations were located primarily in the Western hemisphere.

Data from three Eastern hemisphere stations--Thumba, India; Volograd, USSR; and Heiss Island--were available (NASA, 1978). This also was monthly averaged data ranging from 25 to 60 km.

The third source of data was grenade soundings from four locations: Point Barrow, Alaska; Wallops Island, Virginia; Fort Churchill, Canada; and Natal/Ascension Island (Theon, et al., 1972). The Natal/Ascension data were annual means; the other stations were averaged over three seasons; summer, winter, and Equinox. A sinusoidally weighted interpolation scheme was used to estimate monthly wind averages. In this scheme, the summer and winter observations were assumed to be the extremes, and the equinox was the nominal wind value.

The fourth data source was from Woomera, Australia (Pearson and Johnson, 1973). Monthly average wind components from 30 to 80 km were available from this source.

The four data sources were combined and used as input to a multiple regression program for estimating the spherical harmonics coefficients, as previously described. Monthly wind averages based on less than three observations were filtered from the data.

Very little southern hemisphere wind data were available, resulting in eratic wind prediction at southern latitudes. To alleviate this problem, data from the northern hemisphere was used as southern hemisphere data, displaced by 6 months, with both latitude and longitude reversed.

The number of stations which had enough wind data for meaningful averages varied considerably from one month to the next and from one altitude to the next. There was a maximum of 23 stations and a minimum of 5 stations at a given height. The geographic distribution of the stations was strongly biased towards the north-west quarter-sphere. These factors, along with the large variance in the wind data result in the spherical harmonics coefficients having large standard deviations. As a result of this, increased emphasis should be placed on perturbation analysis available in the GRAM program. As more and better wind data becomes available, the spherical harmonics model coefficients may be updated, and better results obtained.

The spherical harmonic model is used at all latitudes to calculate winds between the heights of 25 and 95 km. Between 20 and 25 km and between 90 and 95 km, a Fairing technique is used to smooth the winds between the spherical harmonic model values and the geostrophic winds. At low latitudes (below the "minimum geostrophic latitude" given in the input), the geostrophic relation is not used. Instead interpolation is done between plus and minus minimum geostrophic latitude (below 25 km and above 90 km only).

APPENDIX B

LISTING OF THE REVISED TAPE "SCIDAT-MOD-3" FOR THE GRAM PROGRAM

The tape contains the following data, identified by code characters at the beginning of each record. Month 13 refers to annual mean values. For code P, D, T, S, R and RW data, southern latitudes are given by northern hemisphere data displaced six months. Annual mean data and the QBO parameters are the same for both southern and northern hemispheres. For a more complete discussion of the input data, see Section 4.2.

Code	Data	Description
N	NMC Grid Data	Same as NMC Grid Required by NASA version 4-D program. Data consists of sequential point number followed by the two corresponding NMC grid indices. There are five points per record on the tape.
P	Groves Pressure (nt/m^2)	Month, height, values at latitudes 0, 10, 20, ... 90 exponent. Same format as in Groves report.
D	Groves Density (kg/m^3)	
T	Groves Temperature (°K)	
S	Stationary Perturbations in monthly means (per mill)	Month, height, longitude, Δp at north latitude, 10, 30, 50, 70, 90, Δp same, ΔT same.
R	Random pressure, density and temperature perturbation magnitudes (per mill)	Month, height, Δp at north latitude 10, 30, 50, 70, 90, $\Delta\rho$ same, ΔT same
RW	Random magnitudes wind perturbation (m/s)	Month, height, Δu at north latitude 10, 30, 50, 70, 90, Δv same
P	Fractional variance in large scale thermodynamic variables	13 (Annual), height, fractional variance in large scale per mill for pressure, density and temperature, each at latitude 10°, 30°, 50°, 70°, 90°
PW	Fractional variance in large scale winds	13 (Annual), height, fractional variance in u at 10°, 30°, 50°, 70°, 90° latitude, same for v

Code	Data	Description
CS	Small scale density-velocity correlations	13 (Annual), height, $\langle \rho u \rangle_S$ at 10°, 30°, 50°, 70°, 90° latitude, same for $\langle \rho v \rangle$
CL	Large scale density-velocity correlations	13 (Annual), height, $\langle \rho u \rangle_L$ at 10°, 30°, 50°, 70°, 90° latitude, same for $\langle \rho v \rangle_L$
QP	QBO pressure parameters-amplitude (per mill) and phase (days after Jan. 0, 1966 when 1st maximum occurs)	
QD	QBO density parameters (as in QP)	
QT	QBO temperature parameters	Height, amplitude and phase at 10° latitude, amplitude and phase at 30° ... , amplitude and phase at 90°
QU	QBO eastward wind parameters-amplitude (0.1 m/s) and phase (days after Jan. 0, 1966)	
QV	QBO northward wind parameters - (as in QU)	
SP	Spherical harmonic coefficient	Height, month, and coefficient values a_1-a_9, cm/s.

The tape consists of six FORTRAN readable files with an end of file marker after each file. The first file contains the NMC grid data, the second contains the Groves and Stationary perturbation data, the third contains the random perturbation data, the fourth contains the fractional large scale variances and the density-velocity correlations, and the fifth contains the QBO data. Each record of the NMC grid data file contains the code (N) and x-y coordinates for 5 points. The Format is (A2, 15I7). The total number of NMC grid points is 1977. The NMC grid data file contains a total of 396 records, with the last record containing points 1976 and 1977 and zeros for the remaining values. The format for the Groves data is (A2, 13I7), for the stationary perturbation it is (A2, 18I7), for the code-R data it is (A2, 17I7), for the code RW data it is (A2, 12I7), for the large scale fractional variances in thermodynamic variables it is (A2, 17I7), for the large scale fractional wind variances it is (A2, 12I7) for the density-velocity correlations (small scale and large scale) it is (A2, 12I7), and for the quasi-biennial data it is (A2, 11I7), and for the spherical harmonic it is (A2, 11I7). The Groves data contains 702 records, the stationary perturbation data contains 1248 records, the code R random data contains 260 records, the code RW random winds data contain 325 records, the code P large scale fractional variances contain 25 records, the code PW large scale fractional wind variances contain 25 records, and code CS and CL density-velocity correlation data contain 25 records each, the QBO data contain 80 records, and the spherical harmonics data contain 336 records.

Following is a listing of the data contained on the SCIDAT tape.

*** NMC GRID DATA***

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P	1	60	241	237	232	217	198	177	155	134	121	117	-1
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P	1	75	255	249	243	236	222	207	183	148	127	120	-2
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P	1	90	197	194	187	184	190	191	174	138	116	109	-3
P	1	95	803	791	767	778	833	873	813	646	546	512	-4
P	1	100	350	345	338	345	379	401	376	301	256	241	-4
P	1	105	168	164	160	163	177	190	181	145	123	116	-4
P	1	110	898	889	856	843	899	939	887	701	589	552	-5
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P	2	105	199	182	178	171	174	179	174	135	112	104	-4
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P	3	40	299	297	290	279	267	262	255	242	234	232	0
P	3	45	159	158	154	146	139	135	130	121	116	114	0
P	3	50	860	859	833	781	741	718	675	616	581	569	-1
P	3	55	465	461	446	416	392	380	354	319	298	291	-1
P	3	60	244	241	231	214	203	196	181	162	151	147	-1
P	3	65	121	117	113	106	101	98	90	79	72	70	-1
P	3	70	569	547	528	503	487	475	434	372	335	322	-2
P	3	75	255	240	237	231	225	223	205	171	151	144	-2
P	3	80	110	105	105	103	102	102	94	76	65	62	-2
P	3	85	476	444	450	446	438	444	420	339	290	274	-3
P	3	90	206	191	191	188	187	191	182	146	124	117	-3
P	3	95	903	811	802	789	785	804	783	645	562	535	-4
P	3	100	419	374	362	354	354	365	355	298	264	252	-4
P	3	105	213	183	175	169	167	174	177	153	139	134	-4
P	3	110	122	104	96	89	88	94	98	86	79	76	-4
P	4	25	251	250	246	244	241	241	240	239	238	238	1
P	4	30	119	119	117	116	114	114	113	111	110	109	1
P	4	35	590	588	583	570	554	553	545	522	508	504	0
P	4	40	305	306	300	291	282	282	273	254	243	239	0
P	4	45	163	162	159	153	148	149	142	130	123	120	0
P	4	50	886	883	861	825	801	804	761	686	641	626	-1
P	4	55	478	473	462	439	427	430	407	363	337	328	-1
P	4	60	250	247	240	229	223	225	210	188	175	170	-1
P	4	65	123	121	119	114	111	112	106	93	85	83	-1
P	4	70	575	568	565	551	539	546	511	448	410	398	-2
P	4	75	253	250	257	253	250	253	240	209	190	184	-2
P	4	80	110	109	113	114	112	114	108	93	84	81	-2
P	4	85	479	471	494	493	478	475	458	392	352	339	-3
P	4	90	212	206	213	212	198	192	184	158	142	137	-3
P	4	95	920	880	900	873	813	769	754	658	600	581	-4
P	4	100	416	386	386	380	359	348	341	305	283	276	-4
P	4	105	202	182	178	172	165	167	176	164	157	154	-4
P	4	110	112	98	93	89	86	92	102	99	97	97	-4
P	5	25	251	254	250	249	247	246	249	254	257	258	1
P	5	30	120	120	120	118	117	117	118	120	121	122	1
P	5	35	595	598	595	584	576	577	581	586	589	590	0
P	5	40	309	311	307	299	298	300	299	292	288	286	0
P	5	45	164	165	163	159	158	160	159	155	153	152	0
P	5	50	889	896	882	859	861	880	869	832	810	802	-1
P	5	55	480	481	475	463	464	474	470	456	448	445	-1
P	5	60	253	254	248	242	244	250	248	239	234	232	-1
P	5	65	126	127	125	122	122	126	125	123	122	121	-1
P	5	70	582	597	600	587	591	607	608	596	589	586	-2
P	5	75	254	263	271	268	267	276	280	283	285	285	-2
P	5	80	111	115	118	115	115	118	121	121	121	121	-2
P	5	85	489	496	505	485	464	459	472	477	480	481	-3

P	5	90	213	214	215	199	181	169	170	170	170	170	-3
P	5	95	887	899	901	819	700	619	622	649	665	671	-4
P	5	100	379	379	382	351	308	276	280	292	299	302	-4
P	5	105	172	172	175	163	145	135	145	162	172	176	-4
P	5	110	91	88	89	84	78	79	89	100	107	109	-4
P	6	25	251	253	253	253	256	258	260	265	268	269	1
P	6	30	119	120	121	121	122	123	125	128	130	130	1
P	6	35	592	597	597	599	602	611	627	642	651	654	0
P	6	40	306	308	306	308	311	318	326	330	332	333	0
P	6	45	161	163	162	163	166	171	176	178	179	180	0
P	6	50	869	881	878	886	905	935	965	974	979	981	-1
P	6	55	468	474	474	477	487	508	528	537	542	544	-1
P	6	60	248	251	249	251	258	271	282	288	292	293	-1
P	6	65	125	127	126	125	128	137	144	150	154	155	-1
P	6	70	585	599	592	593	607	652	695	731	753	760	-2
P	6	75	255	265	264	262	265	286	313	335	348	353	-2
P	6	80	112	114	114	111	110	117	128	136	141	142	-2
P	6	85	486	487	479	456	423	423	453	483	501	507	-3
P	6	90	208	206	201	183	156	141	145	152	156	158	-3
P	6	95	853	852	833	737	577	480	489	526	548	556	-4
P	6	100	360	362	361	327	260	214	216	230	238	241	-4
P	6	105	162	164	167	156	127	108	112	124	131	134	-4
P	6	110	840	837	867	836	719	640	689	771	820	937	-5
P	7	25	250	252	256	259	263	265	269	274	277	278	1
P	7	30	118	119	122	123	125	128	130	133	135	135	1
P	7	35	582	591	600	605	622	640	653	662	667	669	0
P	7	40	299	301	305	309	318	331	340	345	348	349	0
P	7	45	157	158	161	163	169	177	184	185	186	186	0
P	7	50	84	85	87	88	91	96	101	102	103	103	0
P	7	55	454	457	466	470	492	521	551	564	572	574	-1
P	7	60	241	242	245	246	257	275	295	307	314	317	-1
P	7	65	122	123	123	122	128	139	152	159	163	165	-1
P	7	70	577	578	573	562	595	654	730	779	808	818	-2
P	7	75	255	256	253	245	257	284	322	348	364	369	-2
P	7	80	110	110	109	104	104	111	126	137	144	146	-2
P	7	85	471	471	460	423	395	393	425	452	468	474	-3
P	7	90	197	198	191	170	145	131	131	135	137	138	-3
P	7	95	803	812	793	688	569	479	458	456	455	454	-4
P	7	100	350	357	354	317	262	218	198	191	187	185	-4
P	7	105	168	170	168	153	132	110	101	98	96	96	-4
P	7	110	898	903	895	835	725	626	576	559	549	545	-5
P	8	25	250	253	257	260	264	265	270	276	280	281	1
P	8	30	118	120	122	123	126	128	130	132	133	134	1
P	8	35	581	592	595	606	623	640	648	650	651	652	0
P	8	40	298	301	303	307	319	330	335	332	330	330	0
P	8	45	157	158	158	161	169	175	178	177	176	176	0
P	8	50	848	844	852	863	907	946	971	963	958	957	-1
P	8	55	458	457	454	462	485	509	526	525	524	524	-1
P	8	60	243	240	240	241	252	266	280	281	282	282	-1
P	8	65	122	123	121	120	124	132	141	145	147	148	-1
P	8	70	577	584	579	563	571	615	676	709	729	735	-2
P	8	75	256	268	261	251	250	268	295	316	329	333	-2
P	8	80	111	116	116	109	104	106	115	125	131	133	-2
P	8	85	469	506	501	459	408	390	397	430	450	456	-3

P	8	90	200	214	214	189	158	140	134	138	140	141	-3
P	8	95	855	931	902	796	660	567	504	489	480	477	-4
P	8	100	395	421	412	359	301	255	216	199	189	185	-4
P	8	105	199	213	199	171	145	122	102	91	84	82	-4
P	8	110	113	117	109	90	75	63	52	45	41	39	-4
P	9	25	251	253	254	257	259	260	260	262	263	264	1
P	9	30	118	120	121	122	124	124	124	124	124	124	1
P	9	35	582	589	596	597	607	613	610	599	592	590	0
P	9	40	299	301	303	302	307	313	310	301	296	294	0
P	9	45	159	159	160	158	162	165	163	157	153	152	0
P	9	50	860	858	858	845	865	883	875	840	819	812	-1
P	9	55	465	464	461	451	461	471	467	450	440	436	-1
P	9	60	244	245	242	234	235	241	243	237	233	232	-1
P	9	65	121	124	125	118	115	117	121	120	119	119	-1
P	9	70	569	600	606	560	528	537	573	582	587	589	-2
P	9	75	255	275	283	255	233	234	252	262	268	270	-2
P	9	80	110	122	126	112	98	96	103	110	114	116	-2
P	9	85	476	527	550	477	405	378	399	430	449	455	-3
P	9	90	206	230	236	200	166	150	153	164	171	173	-3
P	9	95	90	101	104	87	72	63	62	64	65	66	-3
P	9	100	419	480	487	404	328	280	265	261	259	258	-4
P	9	105	213	246	247	199	158	131	119	110	105	103	-4
P	9	110	122	141	138	107	82	66	56	48	43	42	-4
P	10	25	251	250	251	253	254	254	250	243	239	237	1
P	10	30	119	119	119	120	119	118	116	113	111	111	1
P	10	35	590	588	585	583	578	564	556	539	529	525	0
P	10	40	305	302	298	295	289	281	274	264	258	256	0
P	10	45	163	161	157	153	150	145	140	135	132	131	0
P	10	50	886	869	850	824	801	767	740	708	689	682	-1
P	10	55	478	468	457	439	426	403	389	374	365	362	-1
P	10	60	250	246	240	228	217	204	199	191	186	185	-1
P	10	65	123	123	122	113	106	99	99	95	93	92	-1
P	10	70	575	586	594	549	487	454	466	452	444	441	-2
P	10	75	253	265	274	248	217	202	213	207	203	202	-2
P	10	80	110	117	122	110	94	87	93	92	91	91	-2
P	10	85	479	515	533	471	402	371	398	400	401	402	-3
P	10	90	212	228	233	202	172	158	169	170	171	171	-3
P	10	95	92	99	102	88	75	69	74	74	74	74	-3
P	10	100	416	462	480	413	343	310	325	316	311	309	-4
P	10	105	202	230	242	207	172	151	150	139	132	130	-4
P	10	110	112	130	137	116	93	78	72	61	54	52	-4
P	11	25	251	250	248	247	246	245	244	239	236	235	1
P	11	30	120	119	118	116	115	113	111	109	108	107	1
P	11	35	595	589	578	562	546	529	518	511	507	505	0
P	11	40	309	303	294	283	270	255	247	244	242	242	0
P	11	45	164	161	155	148	139	129	123	122	121	121	0
P	11	50	889	869	838	792	736	666	633	632	631	631	-1
P	11	55	480	470	452	425	388	346	330	333	335	335	-1
P	11	60	253	248	239	221	200	177	168	169	170	170	-1
P	11	65	126	124	120	110	98	87	84	84	84	84	-1
P	11	70	582	576	571	525	464	413	404	396	391	390	-2
P	11	75	254	255	256	237	210	191	190	184	180	179	-2
P	11	80	111	112	113	104	93	86	87	84	82	82	-2
P	11	85	489	495	492	448	402	381	393	387	383	382	-3

P	11	90	213	216	212	192	175	169	178	176	175	174	-3
P	11	95	887	899	888	826	774	772	819	811	806	805	-4
P	11	100	379	395	405	384	365	364	386	372	364	361	-4
P	11	105	172	184	195	192	183	180	184	174	168	166	-4
P	11	110	91	100	109	106	99	93	91	81	75	73	-4
P	12	25	251	247	245	241	239	241	242	240	239	238	1
P	12	30	119	118	116	113	111	112	110	107	105	105	1
P	12	35	592	584	565	552	530	524	506	486	474	470	0
P	12	40	306	301	289	279	263	252	237	227	221	219	0
P	12	45	161	159	152	147	136	125	116	110	106	105	0
P	12	50	869	854	827	788	723	645	586	563	549	545	-1
P	12	55	468	460	442	422	382	336	303	294	289	287	-1
P	12	60	248	243	234	221	198	172	154	150	148	147	-1
P	12	65	125	122	117	111	99	86	78	75	73	73	-1
P	12	70	585	568	556	533	477	420	381	357	343	338	-2
P	12	75	255	250	245	239	220	199	183	167	157	154	-2
P	12	80	112	109	108	105	99	91	85	77	72	71	-2
P	12	85	486	477	459	449	433	411	388	353	332	325	-3
P	12	90	208	204	199	194	191	185	179	162	152	148	-3
P	12	95	853	833	807	822	849	867	841	764	718	702	-4
P	12	100	360	353	353	368	393	412	405	361	335	326	-4
P	12	105	162	161	161	173	188	201	195	172	158	154	-4
P	12	110	840	850	872	912	962	992	947	816	737	711	-5
P	13	25	251	250	249	248	249	250	251	249	248	248	1
P	13	30	119	119	118	118	117	118	118	116	115	115	1
P	13	35	588	588	583	576	570	570	567	555	550	549	0
P	13	40	303	302	298	292	288	286	282	273	271	271	0
P	13	45	161	160	157	154	151	149	145	139	138	138	0
P	13	50	865	861	848	824	808	792	769	734	730	729	-1
P	13	55	466	464	456	440	430	420	408	389	388	389	-1
P	13	60	246	244	239	229	223	218	212	202	201	201	-1
P	13	65	123	122	120	115	111	109	106	102	100	99	-1
P	13	70	576	576	570	545	525	518	513	489	462	453	-2
P	13	75	256	258	258	247	237	236	236	224	202	195	-2
P	13	80	111	112	113	108	103	102	103	98	88	85	-2
P	13	85	482	486	488	460	433	425	428	405	375	365	-3
P	13	90	206	208	207	193	178	173	174	164	152	147	-3
P	13	95	877	882	877	814	752	724	723	678	626	608	-4
P	13	100	384	386	385	359	334	322	321	300	276	268	-4
P	13	105	182	182	181	169	158	153	154	143	132	128	-4
P	13	110	960	959	943	873	811	792	801	748	690	669	-5
D	1	25	400	393	392	381	377	382	395	403	408	409	-4
D	1	30	178	175	173	171	171	176	179	176	174	174	-4
D	1	35	820	815	805	800	791	812	813	772	747	739	-5
D	1	40	404	400	386	374	367	371	361	338	324	320	-5
D	1	45	207	203	196	189	180	177	168	153	144	141	-5
D	1	50	108	107	104	100	94	89	81	72	67	65	-5
D	1	55	585	581	575	554	511	467	420	367	335	325	-6
D	1	60	327	325	320	302	277	248	218	192	176	171	-6
D	1	65	182	179	174	164	146	131	115	100	91	88	-6
D	1	70	952	926	906	837	755	661	581	497	447	430	-7
D	1	75	444	431	421	403	365	330	289	241	212	203	-7
D	1	80	195	190	187	180	171	157	137	110	94	88	-7
D	1	85	850	832	809	791	760	722	634	503	424	398	-8

D	1	90	370	365	349	339	333	320	283	225	190	179	-8
D	1	95	148	146	139	138	141	143	131	103	86	81	-8
D	1	100	580	574	560	571	622	645	593	474	403	379	-9
D	1	105	242	236	234	244	271	294	278	224	192	181	-9
D	1	110	108	106	104	107	119	128	124	101	87	83	-9
D	2	25	400	393	386	379	382	391	387	377	371	369	-4
D	2	30	178	174	172	171	173	178	175	168	164	162	-4
D	2	35	823	813	799	791	790	799	804	765	742	734	-5
D	2	40	403	393	386	375	368	366	366	348	337	334	-5
D	2	45	205	201	195	187	181	176	173	162	155	153	-5
D	2	50	108	106	104	99	95	90	85	77	72	71	-5
D	2	55	591	592	580	545	521	483	446	390	356	345	-6
D	2	60	334	332	325	303	284	261	235	203	184	177	-6
D	2	65	182	181	174	161	149	136	122	105	95	91	-6
D	2	70	943	914	873	809	760	694	612	516	458	439	-7
D	2	75	444	425	408	382	364	338	300	243	209	197	-7
D	2	80	198	189	185	177	171	160	141	111	93	87	-7
D	2	85	845	812	817	785	766	738	654	494	398	366	-8
D	2	90	360	343	347	342	341	331	295	222	178	164	-8
D	2	95	147	140	139	137	142	145	133	99	79	72	-8
D	2	100	610	571	574	574	598	619	578	439	356	328	-9
D	2	105	264	246	249	247	257	266	254	195	160	148	-9
D	2	110	125	114	114	113	116	118	114	89	74	69	-9
D	3	25	399	387	388	380	381	390	381	354	338	332	-4
D	3	30	178	175	174	172	174	177	173	162	155	153	-4
D	3	35	827	811	805	802	787	795	785	755	737	731	-5
D	3	40	400	397	390	382	371	368	365	356	351	349	-5
D	3	45	204	202	198	191	183	180	177	170	166	164	-5
D	3	50	109	109	106	101	96	94	90	84	80	79	-5
D	3	55	605	604	591	555	524	509	479	439	415	407	-6
D	3	60	340	343	331	305	288	276	258	233	218	213	-6
D	3	65	185	182	174	161	150	145	134	121	113	111	-6
D	3	70	931	912	863	800	760	735	668	594	550	535	-7
D	3	75	440	417	400	384	368	358	325	282	256	248	-7
D	3	80	195	186	183	177	174	172	155	129	113	108	-7
D	3	85	841	793	803	796	778	776	724	589	508	481	-8
D	3	90	361	345	350	345	340	346	323	255	214	201	-8
D	3	95	153	140	142	139	138	141	136	108	91	86	-8
D	3	100	644	591	583	574	578	589	559	451	386	365	-9
D	3	105	279	249	247	248	247	251	241	200	175	167	-9
D	3	110	131	117	114	110	110	112	111	94	84	80	-9
D	4	25	398	394	386	383	379	378	375	376	377	377	-4
D	4	30	178	178	174	174	173	173	173	174	175	175	-4
D	4	35	829	823	822	814	798	793	802	793	788	786	-5
D	4	40	406	406	402	396	384	381	377	364	356	354	-5
D	4	45	208	208	205	198	192	192	187	175	168	165	-5
D	4	50	112	112	110	106	103	103	98	89	84	82	-5
D	4	55	623	622	610	582	563	565	541	485	451	440	-6
D	4	60	352	350	340	323	311	314	294	264	246	240	-6
D	4	65	189	186	179	168	164	165	155	139	129	126	-6
D	4	70	958	942	903	864	838	846	788	697	642	624	-7
D	4	75	440	435	435	416	409	412	389	341	312	303	-7
D	4	80	193	190	196	196	195	200	186	162	148	143	-7
D	4	85	826	821	864	872	871	889	853	730	656	632	-8

D	4	90	368	364	382	388	373	374	353	301	270	259	-8
D	4	95	159	157	163	159	147	139	135	115	103	99	-8
D	4	100	673	648	669	654	603	560	522	445	399	383	-9
D	4	105	282	265	269	265	253	234	223	192	173	167	-9
D	4	110	126	116	115	114	108	107	106	95	88	86	-9
D	5	25	396	400	391	389	384	381	385	398	406	408	-4
D	5	30	178	180	177	177	177	176	178	181	183	183	-4
D	5	35	829	832	835	830	816	811	823	857	877	884	-5
D	5	40	411	414	411	402	396	395	399	399	399	399	-5
D	5	45	212	212	209	204	202	201	201	200	199	199	-5
D	5	50	113	114	112	109	109	110	109	104	101	100	-5
D	5	55	621	628	624	608	605	616	606	586	574	570	-6
D	5	60	350	351	344	334	338	344	341	324	314	310	-6
D	5	65	193	191	184	180	179	184	183	178	175	174	-6
D	5	70	984	985	958	930	935	957	945	906	883	875	-7
D	5	75	444	458	465	457	456	469	466	467	468	468	-7
D	5	80	191	200	208	207	211	221	225	224	223	223	-7
D	5	85	838	872	897	894	903	941	978	990	997	1000	-8
D	5	90	384	383	390	375	366	365	372	365	361	359	-8
D	5	95	163	166	166	151	131	119	119	122	124	124	-8
D	5	100	663	670	665	602	510	439	424	422	421	420	-9
D	5	105	262	266	270	246	210	178	173	178	181	182	-9
D	5	110	111	112	115	107	94	85	85	88	90	90	-9
D	6	25	397	400	395	392	396	399	397	403	407	408	-4
D	6	30	177	178	180	181	182	183	183	187	189	190	-4
D	6	35	828	835	845	848	848	851	870	897	913	919	-5
D	6	40	411	413	412	414	413	416	426	436	442	444	-5
D	6	45	210	211	209	209	210	215	219	223	225	226	-5
D	6	50	111	112	111	112	114	117	119	120	121	121	-5
D	6	55	606	617	619	622	631	649	669	673	675	676	-6
D	6	60	339	341	343	347	356	368	379	380	381	381	-6
D	6	65	187	189	188	188	193	202	209	213	215	216	-6
D	6	70	98	99	97	97	100	106	110	113	115	115	-6
D	6	75	447	463	458	461	474	511	547	580	600	606	-7
D	6	80	193	202	204	204	211	232	257	275	286	289	-7
D	6	85	85	87	87	86	87	94	104	113	118	120	-7
D	6	90	384	380	372	355	335	333	350	365	374	377	-8
D	6	95	160	158	152	134	109	96	99	105	109	110	-8
D	6	100	636	633	616	535	412	330	328	345	355	359	-9
D	6	105	252	256	252	224	171	136	132	140	145	146	-9
D	6	110	106	109	113	104	83	67	66	69	71	71	-9
D	7	25	400	399	401	402	408	407	407	413	417	418	-4
D	7	30	178	179	182	185	186	187	190	194	196	197	-4
D	7	35	820	840	856	863	881	891	903	919	929	932	-5
D	7	40	404	410	415	419	428	437	444	452	457	458	-5
D	7	45	207	208	209	211	217	226	230	231	232	232	-5
D	7	50	108	109	111	112	116	121	125	125	125	125	-5
D	7	55	585	591	609	615	641	672	695	700	703	704	-6
D	7	60	327	328	338	343	357	374	393	400	404	406	-6
D	7	65	182	183	186	188	195	207	219	225	229	230	-6
D	7	70	95	95	95	95	100	108	117	122	125	126	-6
D	7	75	444	446	440	434	468	524	587	625	648	655	-7
D	7	80	195	196	195	191	203	231	265	291	307	312	-7
D	7	85	85	85	84	80	82	89	103	113	119	121	-7

D	7	90	370	370	358	329	302	297	314	332	343	346	-8
D	7	95	148	148	142	122	102	90	91	94	96	96	-8
D	7	100	580	591	581	500	399	333	310	305	302	301	-9
D	7	105	242	247	245	215	178	143	130	125	122	121	-9
D	7	110	108	112	113	103	86	70	62	58	56	55	-9
D	8	25	400	403	406	406	408	403	411	423	430	433	-4
D	8	30	178	179	184	185	188	188	192	196	198	199	-4
D	8	35	823	845	853	872	882	895	907	924	934	938	-5
D	8	40	403	410	417	420	429	440	445	445	445	445	-5
D	8	45	205	208	206	210	219	225	227	225	224	223	-5
D	8	50	108	108	110	111	117	120	122	120	119	118	-5
D	8	55	591	593	594	609	642	666	673	665	660	659	-6
D	8	60	334	326	330	336	353	370	379	373	369	368	-6
D	8	65	182	182	179	182	192	201	208	207	206	206	-6
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D	8	75	444	455	440	431	445	488	542	568	584	589	-7
D	8	80	198	203	202	194	197	216	244	261	271	275	-7
D	8	85	85	90	89	85	82	84	91	101	107	109	-7
D	8	90	360	384	390	351	305	287	293	321	338	343	-8
D	8	95	147	161	158	139	114	101	96	99	101	101	-8
D	8	100	610	658	659	583	479	408	360	349	342	340	-9
D	8	105	264	287	281	252	214	182	154	142	135	132	-9
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D	9	25	399	400	399	400	401	403	401	407	411	412	-4
D	9	30	178	180	181	185	185	185	186	188	189	190	-4
D	9	35	827	841	854	863	873	872	871	873	874	875	-5
D	9	40	400	406	412	415	418	424	422	416	412	411	-5
D	9	45	204	206	208	208	211	214	212	205	201	199	-5
D	9	50	109	109	110	109	112	114	113	108	105	104	-5
D	9	55	605	600	606	600	620	631	616	587	570	564	-6
D	9	60	340	336	328	326	340	347	339	323	313	310	-6
D	9	65	185	181	179	175	178	183	182	175	171	169	-6
D	9	70	931	945	939	895	880	903	932	922	916	914	-7
D	9	75	440	460	468	432	409	419	451	454	456	456	-7
D	9	80	195	212	217	196	180	184	200	209	214	216	-7
D	9	85	841	922	967	865	762	744	809	865	899	910	-8
D	9	90	361	403	417	361	302	282	300	329	346	352	-8
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D	9	100	644	721	741	633	526	464	459	479	491	495	-9
D	9	105	279	318	332	280	233	202	196	197	198	198	-9
D	9	110	131	151	154	127	104	88	83	80	78	78	-9
D	10	25	398	394	391	395	400	402	395	382	374	372	-4
D	10	30	178	178	179	181	182	184	180	175	172	171	-4
D	10	35	829	832	839	843	845	836	827	810	800	796	-5
D	10	40	406	405	404	408	402	393	390	378	371	368	-5
D	10	45	208	206	204	202	199	193	189	183	179	178	-5
D	10	50	112	110	108	106	104	101	97	93	91	90	-5
D	10	55	623	611	598	584	574	550	529	505	491	486	-6
D	10	60	352	341	329	321	313	297	282	271	264	262	-6
D	10	65	189	184	177	167	164	155	149	142	138	136	-6
D	10	70	958	945	928	873	808	754	745	719	703	698	-7
D	10	75	440	448	455	418	372	349	358	345	337	335	-7
D	10	80	193	202	211	192	167	155	164	157	153	151	-7
D	10	85	826	883	928	842	722	669	714	706	701	700	-8

D	10	90	368	396	409	361	303	277	298	302	304	305	-8
D	10	95	159	169	170	147	128	119	128	130	131	132	-8
D	10	100	673	719	731	631	534	502	546	553	557	559	-9
D	10	105	282	310	322	276	237	220	239	241	242	243	-9
D	10	110	126	142	150	132	110	100	104	101	99	99	-9
D	11	25	396	394	389	391	391	392	393	387	383	382	-4
D	11	30	178	177	177	178	178	179	178	173	170	169	-4
D	11	35	829	831	828	823	816	815	805	792	784	782	-5
D	11	40	411	406	399	389	382	372	367	361	357	356	-5
D	11	45	212	208	201	194	185	178	173	169	167	166	-5
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D	11	55	621	609	585	560	522	473	451	453	454	455	-6
D	11	60	350	343	329	309	286	253	239	241	242	243	-6
D	11	65	193	188	179	165	149	132	124	127	129	129	-6
D	11	70	984	960	926	846	749	654	625	627	628	629	-7
D	11	75	444	439	436	401	354	313	303	299	297	296	-7
D	11	80	191	192	197	183	160	144	144	137	133	131	-7
D	11	85	838	849	861	796	703	654	655	633	620	615	-8
D	11	90	384	390	386	345	304	283	294	288	284	283	-8
D	11	95	163	162	156	141	128	124	131	132	133	133	-8
D	11	100	663	668	651	593	555	559	606	602	600	599	-9
D	11	105	262	270	272	260	252	259	282	281	280	280	-9
D	11	110	111	116	125	123	119	121	129	125	123	122	-9
D	12	25	397	390	385	384	384	380	390	399	404	406	-4
D	12	30	177	175	177	172	172	177	178	176	175	174	-4
D	12	35	828	821	809	801	789	811	805	776	759	753	-5
D	12	40	411	405	392	381	369	372	362	348	340	337	-5
D	12	45	210	207	196	191	180	176	166	158	153	152	-5
D	12	50	111	109	105	101	95	87	80	76	74	73	-5
D	12	55	606	598	576	555	510	458	418	400	389	386	-6
D	12	60	339	332	321	305	279	242	218	214	212	211	-6
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D	12	70	980	951	918	859	749	642	575	555	543	539	-7
D	12	75	447	435	422	409	361	318	287	269	258	255	-7
D	12	80	193	189	189	184	169	150	138	125	117	115	-7
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D	13	25	398	396	392	390	391	392	393	394	396	397	-4
D	13	30	178	178	178	178	179	180	181	180	179	178	-4
D	13	35	828	830	831	831	829	834	838	831	820	816	-5
D	13	40	406	406	403	399	395	396	396	389	387	386	-5
D	13	45	208	207	203	200	197	197	194	188	187	187	-5
D	13	50	110	110	108	106	104	100	100	96	94	94	-5
D	13	55	604	603	597	581	571	559	541	515	514	514	-6
D	13	60	339	336	331	320	314	305	294	281	283	284	-6
D	13	65	186	184	179	172	167	162	157	150	151	151	-6
D	13	70	956	946	921	878	846	824	803	768	776	779	-7
D	13	75	446	445	439	420	404	399	395	377	357	350	-7
D	13	80	195	197	198	191	185	184	185	175	150	142	-7
D	13	85	848	858	868	835	802	802	810	767	711	693	-8

D	13	90	373	377	378	356	333	326	329	311	288	281	-8
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D	13	100	649	652	648	600	551	528	523	491	453	440	-9
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T	1	25	218	219	217	219	219	220	215	207	204	203	0
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T	7	50	271	271	273	272	274	276	281	285	293	296 .	0
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T	7	65	234	234	230	226	229	234	241	246	244	243	0
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T	7	85	193	194	191	183	167	153	144	140	138	137	0
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T	7	95	187	189	193	195	192	184	174	168	164	163	0
T	7	100	204	204	206	214	222	221	216	212	210	209	0
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T	7	110	273	265	260	265	276	293	306	314	319	320	0
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STATIONARY PERTURBATIONS, CODE S

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S	1	30	190	15	28	87	169	0	19	22	43	86	0	-1	6	43	78	0
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S	1	30	280	15	11	-39	-82	0	2	0	-38	-66	0	7	6	3	-12	0
S	1	30	310	-1	-6	-48	-104	0	2	-11	-38	-66	0	-1	2	-11	-40	0
S	1	30	340	-1	-15	-48	-104	0	2	-11	-26	-46	0	-6	-3	-24	-55	0
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S	1	40	70	21	25	-70	-93	0	17	4	-102	-96	0	5	19	32	2	0
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S	1	84	310	10	-55	-195	-222	0	8	-39	-166	-207	0	3	-16	-32	-19	0

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S	1	90	10	66	15	-132	-217	0	58	38	-91	-195	0	7	-26	-42	-25	0
S	1	90	40	77	91	-62	-108	0	64	101	-25	-105	0	7	-10	-32	-1	0
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S	1	90	190	-54	9	122	300	0	-50	-19	104	267	0	-4	28	17	32	0
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S	1	90	310	14	-74	-218	-244	0	10	-54	-199	-216	0	1	-20	-22	-30	0
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S	5	84	70	5	24	24	5	0	7	15	17	2	0	-6	4	7	4	0
S	5	84	100	-5	22	15	5	0	7	15	8	2	0	-6	4	7	4	0
S	5	84	130	-1	1	26	-7	0	-4	6	17	-6	0	-1	-1	7	-1	[illegible]

S	5	84	160	3	-1	2	-31	0	7	-4	-1	-22	0	-1	-1	1	-7	0
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S	5	84	220	3	-13	-34	-16	0	-4	-13	-28	-6	0	4	-1	-4	-7	0
S	5	84	250	-1	-20	-18	-1	0	-4	-13	-10	2	0	-1	-6	-10	-7	0
S	5	84	280	-11	-27	-27	-6	0	-14	-23	-19	2	0	-1	-6	-10	-7	0
S	5	84	310	-21	-16	-7	26	0	-14	-13	-1	18	0	-1	-1	-4	4	0
S	5	84	340	-3	39	10	32	0	-4	34	8	18	0	4	10	1	10	0
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S	6	84	100	-3	-16	-18	-4	0	-6	-15	-10	-4	0	-1	-4	-9	-1	0
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S	6	90	100	-4	-17	-24	-3	0	-6	-18	-23	-6	0	8	0	-1	6	0
S	6	90	130	-4	-23	-16	-3	0	-9	-18	-16	-6	0	3	0	-1	-1	0

S	6	90	160	-4	-17	-1	-10	0	-9	-18	-7	-4	0	3	0	6	-1	0
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S	13	52	70	11	27	5	-18	0	7	26	3	-18	0	3	1	1	0	0
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S	13	52	160	-4	-4	21	50	0	-2	-1	26	53	0	-1	-2	-3	-1	0
S	13	52	190	-3	-4	26	56	0	-1	-4	29	57	0	0	0	-2	0	0
S	13	52	220	-7	-12	18	40	0	-5	-11	19	40	0	0	0	0	1	0
S	13	52	250	-10	-18	0	7	0	-9	-17	-1	5	0	-1	0	1	2	0
S	13	52	280	-10	-15	-19	-21	0	-10	-15	-20	-23	0	0	0	1	2	0
S	13	52	310	-4	-15	-26	-36	0	-3	-16	-27	-38	0	0	1	2	2	0
S	13	52	340	6	0	-24	-40	0	5	-1	-25	-38	0	1	1	1	-1	0
S	13	60	10	10	19	-1	-42	0	14	24	7	-34	0	-3	-3	-7	-7	0
S	13	60	40	17	28	1	-32	0	15	31	12	-26	0	2	-3	-10	-6	0
S	13	60	70	14	27	3	-19	0.	10	27	8	-17	0	4	0	-5	-2	0
S	13	60	100	4	8	-4	8	0	1	6	-7	4	0	4	1	2	4	0
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S	13	60	160	-5	-4	20	50	0	-4	-7	18	46	0	0	2	2	6	0
S	13	60	190	-4	-2	25	62	0	-3	-7	24	49	0	0	6	2	12	0
S	13	60	220	-6	-11	25	45	0	-7	-13	12	39	0	0	3	13	6	0
S	13	60	250	-12	-18	6	9	0	-11	-18	-4	7	0	-1	1	11	1	0
S	13	60	280	-10	-16	-19	-22	0	-10	-15	-17	-19	0	0	0	0	-2	0
S	13	60	310	-5	-16	-25	-38	0	-3	-13	-24	-32	0	-2	-1	-1	-6	0
S	13	60	340	7	-1	-28	-46	0	6	2	-20	-37	0	0	-4	-8	-8	0
S	13	68	10	7	16	-9	-54	0	8	17	-3	-39	0	0	0	-6	-14	0
S	13	68	40	18	27	-10	-43	0	17	27	-1	-29	0	1	0	-8	-13	0
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S	13	68	100	7	8	-5	9	0	7	9	-3	10	0	2	0	-1	1	0
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S	13	68	160	-7	-3	23	60	0	-4	-3	20	51	0	0	1	3	9	0
S	13	68	190	-3	3	32	81	0	-5	0	22	62	0	0	3	8	17	0
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S	13	68	250	-13	-19	19	12	0	-14	-17	8	6	0	0	0	12	7	0
S	13	68	280	-9	-14	-19	-25	0	-12	-15	-17	-23	0	3	1	1	0	0
S	13	68	310	-8	-18	-28	-47	0	-6	-14	-25	-40	0	-2	-1	-2	-7	0
S	13	68	340	7	-5	-36	-58	0	9	-4	-27	-45	0	0	-1	-7	-14	0
S	13	76	10	9	21	-12	-66	0	6	13	-15	-61	0	2	8	3	-6	0
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S	13	76	160	-10	-7	19	67	0	-7	0	28	66	0	-2	-6	-8	0	0
S	13	76	190	-5	0	33	94	0	-3	6	38	90	0	-1	-4	-4	4	0
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S	13	76	280	-6	-14	-17	-23	0	-8	-13	-21	-26	0	2	0	4	4	0
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S	13	84	10	12	28	-8	-71	0	10	24	-9	-70	0	2	3	1	-1	0
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S	13	84	160	-14	-14	9	64	0	-10	-11	15	67	0	-2	-3	-5	-2	0
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S	13	84	220	-10	-13	49	79	0	-10	-12	50	78	0	-1	0	0	1	0
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----- END OF FILE WRITTEN -----

RANDOM PERTURBATIONS, CODE R

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R	1	35	28	36	56	112	125	24	34	55	103	117	20	27	42	57	61
R	1	40	33	46	77	134	149	31	39	61	114	128	18	29	61	64	65
R	1	45	36	54	103	161	177	38	51	84	136	151	20	26	55	58	59
R	1	50	40	60	119	183	201	40	57	108	164	181	21	23	42	47	47
R	1	55	44	65	125	189	207	42	61	133	200	219	18	29	43	46	46
R	1	60	48	72	123	179	194	46	72	130	198	217	23	34	39	51	54
R	1	65	55	74	115	166	180	51	86	134	191	205	34	39	44	52	54
R	1	70	67	75	106	150	162	66	89	131	185	199	44	46	50	55	57
R	1	75	74	74	95	123	131	86	93	123	171	177	52	69	76	73	72
R	1	80	92	93	102	99	99	81	92	117	150	160	52	60	76	96	101
R	1	85	110	114	115	93	84	102	95	112	131	137	65	70	69	83	86
R	1	90	146	134	119	83	62	130	167	162	116	96	106	108	110	104	101
R	1	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	1	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	1	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	1	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	1	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81

R	1	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	2	25	13	19	35	37	35	18	21	26	28	27	14	16	35	41	42
R	2	30	19	24	52	64	67	12	23	40	59	64	17	22	33	58	62
R	2	35	29	32	68	81	82	24	31	53	83	92	22	26	36	58	62
R	2	40	35	41	84	99	101	33	36	70	85	91	21	28	39	62	66
R	2	45	40	50	98	122	127	39	42	99	106	110	21	27	40	58	63
R	2	50	44	59	106	138	144	42	52	100	136	146	20	24	35	71	80
R	2	55	48	67	112	152	159	47	60	113	164	176	16	30	42	95	109
R	2	60	51	75	117	166	177	49	73	113	171	183	23	34	35	102	120
R	2	65	57	79	117	170	184	53	86	128	182	194	32	37	45	53	56
R	2	70	69	79	112	161	176	68	93	133	188	202	44	45	49	54	55
R	2	75	75	78	103	141	152	86	97	130	181	195	52	67	73	70	69
R	2	80	93	93	106	118	122	81	95	123	166	178	52	61	75	92	97
R	2	85	110	111	114	104	100	103	96	118	147	156	65	70	70	84	88
R	2	90	146	133	118	88	72	130	163	159	127	114	106	111	114	107	105
R	2	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	2	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	2	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	2	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	2	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	2	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	3	25	22	27	32	74	82	26	27	44	67	72	14	16	33	38	39
R	3	30	27	34	42	84	94	20	28	36	82	93	16	19	35	44	46
R	3	35	38	42	58	95	105	25	37	46	87	96	22	22	32	47	50
R	3	40	50	50	70	112	124	32	39	66	97	105	25	24	34	46	50
R	3	45	64	64	78	130	145	41	43	66	105	115	34	27	35	43	45
R	3	50	86	79	91	150	165	66	58	77	127	140	27	28	32	38	40
R	3	55	96	93	103	163	177	93	76	88	152	167	20	29	36	37	38
R	3	60	95	101	115	175	189	104	106	99	161	176	25	31	35	43	46
R	3	65	70	94	128	187	203	79	104	126	182	196	24	32	40	46	48
R	3	70	75	92	128	190	207	77	105	141	199	215	39	41	44	48	49
R	3	75	78	89	122	181	198	91	109	146	208	225	49	62	64	61	60
R	3	80	92	92	114	158	170	83	104	139	204	221	52	63	71	81	83
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R	3	90	145	129	112	97	91	128	151	153	153	153	108	121	122	116	114
R	3	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	3	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	3	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	3	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	3	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	3	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	4	25	17	20	20	29	32	22	17	16	27	29	14	13	15	23	25
R	4	30	22	26	30	42	47	15	22	18	28	30	15	16	20	26	29
R	4	35	30	33	43	58	64	25	28	29	37	40	18	20	28	27	31
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R	4	45	38	48	77	103	113	39	38	52	67	70	19	20	33	46	53
R	4	50	41	57	94	127	138	38	43	71	100	108	19	21	32	40	44
R	4	55	47	68	109	143	155	41	51	88	126	136	16	23	31	30	31
R	4	60	54	81	125	157	161	48	63	105	137	152	24	26	32	34	35
R	4	65	62	96	140	176	190	56	83	126	143	155	30	28	31	48	51
R	4	70	73	101	146	201	219	72	109	150	177	196	43	38	36	44	45
R	4	75	79	100	143	216	233	91	120	164	225	245	49	56	50	48	46
R	4	80	92	90	124	198	215	85	115	157	235	251	53	66	66	63	59
R	4	85	108	94	104	162	178	103	103	146	227	243	66	72	75	86	88

R	4	90	144	122	102	110	118	125	134	143	183	196	110	133	132	126	123
R	4	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	4	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	4	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	4	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	4	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	4	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	5	25	12	16	21	20	21	16	18	17	22	23	15	13	12	20	22
R	5	30	20	21	29	29	30	10	17	19	23	23	17	17	17	24	26
R	5	35	33	30	38	41	43	17	23	29	27	26	22	19	19	24	27
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R	5	45	62	48	60	72	77	48	34	42	48	50	26	20	23	31	35
R	5	50	70	59	72	90	97	65	45	55	67	71	28	22	24	31	34
R	5	55	76	68	83	102	110	74	59	67	87	95	26	23	24	24	25
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R	5	65	66	87	111	127	134	70	81	101	98	105	26	31	31	39	41
R	5	70	74	90	116	148	155	74	99	120	128	135	40	40	35	36	36
R	5	75	78	91	116	162	172	90	107	131	164	170	48	54	50	41	36
R	5	80	92	92	109	152	163	82	99	126	177	189	52	62	62	53	48
R	5	85	109	105	108	128	134	105	115	133	171	181	65	70	70	73	74
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R	5	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	5	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	5	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
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R	6	30	22	24	20	24	26	16	18	14	21	23	16	14	12	18	19
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R	6	40	36	36	37	42	45	34	32	28	37	40	18	17	19	22	23
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R	6	50	43	48	56	62	65	40	39	41	51	54	20	20	22	17	17
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R	6	85	110	113	110	99	95	106	122	124	119	118	65	68	66	58	56
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R	7	80	92	95	91	78	73	79	81	84	78	74	51	58	56	37	28
R	7	85	110	116	111	85	74	106	125	120	94	84	65	67	64	51	46
R	7	90	146	133	114	76	62	124	125	137	132	126	103	89	89	86	87
R	7	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	7	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	7	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	7	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	7	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	7	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	8	25	15	23	16	43	47	19	20	16	16	15	15	15	11	32	38
R	8	30	19	30	20	56	63	16	21	16	55	61	16	16	13	30	34
R	8	35	28	41	27	62	70	24	24	18	61	68	19	23	17	31	35
R	8	40	33	60	36	69	78	31	28	27	62	69	18	37	19	28	31
R	8	45	37	69	44	77	87	36	50	33	67	76	19	32	20	21	21
R	8	50	42	106	54	83	91	40	91	40	77	86	19	32	22	15	13
R	8	55	45	124	63	88	95	43	112	53	82	89	18	30	22	16	15
R	8	60	50	126	73	94	100	48	136	62	87	96	26	31	29	21	19
R	8	65	58	98	84	97	100	53	110	79	93	96	32	22	31	23	21
R	8	70	69	89	87	103	107	67	103	93	99	100	43	34	34	23	19
R	8	75	77	87	90	107	112	87	101	100	110	113	49	51	48	31	22
R	8	80	94	95	96	105	107	79	87	97	115	120	52	58	58	42	34
R	8	85	110	113	110	99	95	106	123	124	120	118	65	68	66	58	55
R	8	90	145	131	113	81	68	124	126	138	139	140	104	96	96	93	91
R	8	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	8	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	8	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	8	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	8	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	8	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	9	25	21	19	17	25	27	23	20	17	22	24	14	15	13	15	16
R	9	30	24	24	23	32	35	23	19	15	25	26	15	17	15	17	17
R	9	35	28	34	34	40	43	28	25	20	35	37	16	21	21	24	26
R	9	40	31	43	46	52	55	32	33	31	37	39	19	19	26	32	34
R	9	45	34	52	60	66	71	35	39	40	46	48	19	20	25	29	31
R	9	50	38	63	74	81	86	36	51	55	62	65	21	26	25	27	28
R	9	55	43	69	86	93	95	39	58	69	77	86	19	26	25	24	24
R	9	60	50	78	99	109	115	42	70	81	85	90	25	32	29	35	34
R	9	65	60	88	113	124	137	53	85	104	104	107	31	33	31	40	41
R	9	70	71	90	117	151	160	69	99	122	129	141	43	40	35	35	34
R	9	75	77	91	116	163	174	88	107	131	167	177	49	54	49	40	35
R	9	80	92	92	109	152	163	82	99	126	178	188	52	62	62	52	47
R	9	85	109	106	108	128	135	105	115	133	171	184	66	70	70	73	73
R	9	90	144	127	108	93	88	124	129	140	159	165	107	113	112	108	107
R	9	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	9	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	9	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	9	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	9	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	9	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	10	25	15	28	32	39	41	17	27	23	46	51	14	17	17	20	21

R	10	30	19	33	42	43	43	18	29	30	36	37	15	20	21	21	21
R	10	35	26	42	55	56	56	21	33	40	36	34	16	21	26	30	35
R	10	40	31	52	69	76	81	28	39	53	50	52	18	24	31	40	44
R	10	45	35	65	84	100	107	35	47	63	66	70	18	29	34	43	47
R	10	50	39	83	100	123	133	36	53	80	92	99	19	38	30	41	45
R	10	55	44	104	114	143	155	41	76	95	117	129	19	36	30	38	38
R	10	60	50	120	128	165	178	44	129	111	132	147	25	39	34	45	45
R	10	65	61	110	144	188	204	53	119	133	160	175	32	27	31	46	49
R	10	70	72	106	148	209	228	71	120	153	189	209	43	35	35	42	42
R	10	75	79	102	144	218	233	90	123	165	233	255	50	54	50	47	45
R	10	80	92	90	124	198	213	84	116	157	238	246	53	65	66	62	58
R	10	85	108	94	104	162	181	103	104	146	224	243	66	72	75	86	86
R	10	90	143	122	102	113	124	125	133	143	184	197	110	133	132	126	123
R	10	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	10	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	10	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	10	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	10	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	10	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	11	25	16	36	24	54	60	17	16	19	43	49	15	26	18	28	30
R	11	30	20	55	34	65	71	19	34	25	56	64	16	28	19	30	33
R	11	35	28	75	44	77	84	24	45	38	66	73	18	38	26	40	42
R	11	40	33	97	53	98	107	30	72	45	75	83	18	41	31	52	56
R	11	45	37	122	66	123	134	36	109	54	97	108	19	33	35	52	56
R	11	50	40	124	80	146	160	39	129	65	117	129	20	24	31	48	52
R	11	55	46	117	93	166	181	40	118	77	146	161	19	20	35	41	41
R	11	60	52	104	108	179	194	48	116	86	164	178	24	23	37	43	44
R	11	65	58	98	125	189	205	55	108	120	188	203	32	27	41	46	48
R	11	70	70	94	127	190	209	69	108	139	200	215	43	39	45	47	49
R	11	75	77	89	121	181	200	88	110	145	209	222	51	61	65	61	60
R	11	80	92	92	114	158	169	82	104	139	204	221	52	63	71	80	83
R	11	85	109	105	111	130	134	102	100	130	185	199	66	71	72	85	90
R	11	90	145	129	112	98	92	128	151	153	153	154	108	121	122	115	113
R	11	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75
R	11	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	11	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	11	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	11	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	11	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	12	25	21	18	45	34	30	21	22	31	31	32	16	17	22	33	35
R	12	30	24	24	57	55	53	24	21	51	40	36	18	21	24	39	42
R	12	35	31	33	62	71	73	29	29	64	60	61	19	24	29	52	58
R	12	40	36	43	67	99	105	35	40	65	64	65	19	29	38	58	63
R	12	45	39	52	79	129	138	39	49	73	98	104	20	29	41	52	54
R	12	50	42	61	89	153	165	41	49	82	127	137	21	24	35	46	48
R	12	55	47	69	97	168	182	44	64	92	161	173	18	27	38	48	49
R	12	60	51	76	107	175	189	50	73	94	175	188	23	36	39	50	53
R	12	65	57	80	114	171	186	53	90	121	187	203	31	39	47	51	54
R	12	70	69	79	111	161	176	68	93	131	189	203	44	45	49	53	55
R	12	75	76	78	103	141	152	86	97	129	182	195	52	67	73	70	69
R	12	80	94	93	106	118	121	80	95	123	167	179	52	61	75	92	97
R	12	85	110	112	114	104	100	102	96	117	147	156	65	70	70	84	87
R	12	90	146	133	118	88	72	130	163	159	127	114	106	111	114	107	105
R	12	100	132	132	132	132	132	154	154	154	154	154	75	75	75	75	75

R	12	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	12	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	12	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	12	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	12	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69
R	13	25	20	38	46	77	95	22	30	35	58	77	15	19	30	43	98
R	13	30	24	46	63	104	126	21	39	40	74	92	17	24	38	53	104
R	13	35	33	56	90	136	159	28	45	57	92	113	21	26	49	62	110
R	13	40	40	67	118	177	202	34	57	82	120	139	21	28	71	85	114
R	13	45	46	76	145	220	250	41	67	111	161	183	23	27	50	70	122
R	13	50	54	88	167	255	289	49	78	138	209	236	22	26	41	60	75
R	13	55	59	96	184	282	321	56	86	162	244	277	20	28	39	56	63
R	13	60	63	104	199	309	353	66	102	183	272	306	29	33	39	58	92
R	13	65	65	104	209	331	386	61	108	208	304	342	35	35	44	50	77
R	13	70	77	102	203	349	416	74	116	226	342	391	46	44	54	44	67
R	13	75	86	100	182	341	422	94	120	227	377	441	52	62	80	65	59
R	13	80	102	102	152	290	377	90	111	212	385	469	54	65	106	116	94
R	13	85	121	116	135	195	281	112	118	181	332	423	68	74	128	164	171
R	13	90	158	140	173	134	194	135	149	180	219	298	109	117	165	185	189
R	13	100	192	192	192	192	192	224	224	224	224	224	97	97	97	97	97
R	13	120	183	183	183	183	183	79	79	79	79	79	211	211	211	211	211
R	13	140	125	125	125	125	125	72	72	72	72	72	146	146	146	146	146
R	13	160	90	90	90	90	90	65	65	65	65	65	105	105	105	105	105
R	13	180	71	71	71	71	71	58	58	58	58	58	81	81	81	81	81
R	13	200	61	61	61	61	61	52	52	52	52	52	69	69	69	69	69

RANDOM WINDS, CODE RW

RW	1	0	2	5	7	6	6	3	5	6	5	5
RW	1	5	6	10	13	11	11	4	9	12	11	11
RW	1	10	8	15	15	12	11	7	14	15	12	11
RW	1	15	9	11	11	10	10	7	10	10	11	11
RW	1	20	10	8	11	12	13	5	5	9	13	14
RW	1	25	12	9	20	21	21	2	4	11	17	18
RW	1	30	15	13	25	27	27	4	6	15	20	21
RW	1	35	17	18	29	29	28	7	10	17	27	29
RW	1	40	18	22	36	30	27	6	11	20	33	37
RW	1	45	24	27	46	33	27	11	14	22	40	45
RW	1	50	23	29	50	36	29	13	16	28	45	50
RW	1	55	21	29	44	38	35	16	16	25	42	46
RW	1	60	21	29	37	38	38	16	19	26	39	43
RW	1	65	21	38	45	37	35	21	25	38	47	49
RW	1	70	30	42	44	34	30	17	22	32	47	50
RW	1	75	35	38	45	51	52	32	43	46	42	40
RW	1	80	31	33	45	61	66	37	47	62	64	65
RW	1	85	41	33	46	73	80	56	61	76	81	82
RW	1	90	76	54	63	81	87	79	118	121	115	112
RW	1	100	74	59	58	53	53	75	102	87	53	53
RW	1	120	72	64	62	52	52	72	85	52	52	52
RW	1	140	69	69	69	69	69	69	69	69	69	69
RW	1	160	87	87	87	87	87	87	87	87	87	87
RW	1	180	87	87	87	87	87	87	87	87	87	87
RW	1	200	87	87	87	87	87	87	87	87	87	87
RW	2	0	2	5	6	6	6	2	6	5	6	6
RW	2	5	6	10	12	11	10	4	9	12	11	11

RW	2	10	8	16	15	12	11	7	15	14	12	12
RW	2	15	9	12	10	11	11	7	11	9	11	12
RW	2	20	10	8	10	13	14	4	5	7	13	14
RW	2	25	12	9	14	16	17	3	3	12	12	13
RW	2	30	14	12	17	20	21	4	6	15	21	23
RW	2	35	16	19	22	21	20	7	8	17	25	27
RW	2	40	19	23	29	25	24	6	10	19	28	31
RW	2	45	24	26	35	31	30	10	13	21	33	36
RW	2	50	22	27	38	33	31	11	13	24	33	36
RW	2	55	20	27	39	39	38	16	15	21	31	34
RW	2	60	21	27	35	35	34	16	17	23	30	32
RW	2	65	20	37	44	36	34	21	24	36	44	47
RW	2	70	30	41	43	34	30	17	22	31	44	48
RW	2	75	35	38	45	49	50	32	41	45	42	41
RW	2	80	31	33	44	59	63	37	47	61	63	64
RW	2	85	41	35	46	57	60	56	61	74	60	61
RW	2	90	76	54	62	55	57	78	113	118	57	56
RW	2	100	63	44	57	53	53	63	44	57	53	53
RW	2	120	50	57	52	52	52	50	57	52	52	52
RW	2	140	69	69	69	69	69	69	69	69	69	69
RW	2	160	87	87	87	87	87	87	87	87	87	87
RW	2	180	87	87	87	87	87	87	87	87	87	87
RW	2	200	87	87	87	87	87	87	87	87	87	87
RW	3	0	2	5	6	5	5	3	5	6	5	5
RW	3	5	6	9	11	11	11	4	9	11	11	11
RW	3	10	8	15	14	11	10	7	14	14	11	10
RW	3	15	9	12	9	9	9	7	10	9	10	10
RW	3	20	10	7	9	11	11	4	5	7	10	11
RW	3	25	13	7	13	14	14	3	3	8	19	21
RW	3	30	13	11	13	15	15	4	4	8	19	22
RW	3	35	16	18	20	20	20	7	8	12	20	22
RW	3	40	19	19	26	24	23	6	8	13	21	24
RW	3	45	24	22	31	30	29	9	10	14	23	25
RW	3	50	21	22	32	29	28	10	11	17	23	25
RW	3	55	20	23	32	32	32	16	14	19	23	24
RW	3	60	22	26	31	32	32	15	16	20	25	27
RW	3	65	20	36	40	34	31	20	22	30	36	38
RW	3	70	29	38	40	32	29	17	21	28	38	40
RW	3	75	35	39	43	44	44	32	37	41	42	42
RW	3	80	31	34	41	52	55	37	47	59	60	61
RW	3	85	42	39	46	52	54	56	61	71	58	58
RW	3	90	76	56	56	53	54	76	100	109	55	56
RW	3	100	73	60	54	53	53	73	90	81	53	53
RW	3	120	71	65	52	52	52	71	79	52	52	52
RW	3	140	69	69	69	69	69	69	69	69	69	69
RW	3	160	87	87	87	87	87	87	87	87	87	87
RW	3	180	87	87	87	87	87	87	87	87	87	87
RW	3	200	87	87	87	87	87	87	87	87	87	87
RW	4	0	2	4	5	5	5	2	5	6	5	5
RW	4	5	5	8	11	10	10	4	8	12	11	10
RW	4	10	7	14	15	11	9	6	13	16	11	9
RW	4	15	7	11	9	9	10	6	10	9	8	8
RW	4	20	9	7	8	11	11	4	5	6	8	9
RW	4	25	12	5	5	7	8	3	3	3	5	5

RW	4	30	12	8	8	9	10	4	4	4	6	7
RW	4	35	17	14	14	11	11	8	6	8	8	9
RW	4	40	17	15	16	13	12	5	7	9	11	12
RW	4	45	23	19	20	16	15	9	8	9	10	10
RW	4	50	20	20	22	18	17	11	8	10	11	12
RW	4	55	21	22	25	21	20	16	12	15	14	14
RW	4	60	21	26	29	25	23	15	13	15	16	16
RW	4	65	20	34	35	29	27	20	19	20	21	21
RW	4	70	28	35	35	30	28	17	19	24	26	26
RW	4	75	36	40	41	35	33	31	31	36	42	44
RW	4	80	31	34	38	41	42	37	47	54	56	57
RW	4	85	43	45	46	45	46	56	62	65	55	56
RW	4	90	77	59	48	49	49	72	77	95	54	54
RW	4	100	74	65	50	53	53	71	74	74	53	53
RW	4	120	72	71	52	52	52	70	71	52	52	52
RW	4	140	69	69	69	69	69	69	69	69	69	69
RW	4	160	87	87	87	87	87	87	87	87	87	87
RW	4	180	87	87	87	87	87	87	87	87	87	87
RW	4	200	87	87	87	87	87	87	87	87	87	87
RW	5	0	2	4	5	5	5	2	4	6	5	5
RW	5	5	5	7	11	10	9	4	7	11	10	9
RW	5	10	6	12	15	11	9	5	11	15	11	9
RW	5	15	8	10	9	6	5	6	10	9	6	5
RW	5	20	7	6	7	5	4	4	5	5	5	5
RW	5	25	12	4	3	3	3	3	2	2	3	4
RW	5	30	14	8	6	5	4	8	3	3	3	3
RW	5	35	15	10	10	8	8	9	6	7	5	5
RW	5	40	16	11	10	11	11	6	6	7	7	7
RW	5	45	22	15	14	18	19	19	8	8	8	8
RW	5	50	20	13	14	20	22	21	8	8	10	11
RW	5	55	19	15	16	28	31	23	10	12	11	11
RW	5	60	22	19	20	17	17	29	14	15	15	15
RW	5	65	18	28	29	23	21	20	20	20	18	18
RW	5	70	28	30	30	25	23	18	25	26	21	19
RW	5	75	35	39	41	35	33	31	32	42	45	46
RW	5	80	31	38	43	43	43	37	48	52	49	48
RW	5	85	44	52	55	46	46	56	61	61	50	50
RW	5	90	79	82	72	50	50	73	86	98	52	51
RW	5	100	76	78	62	53	53	72	80	75	53	53
RW	5	120	72	73	52	52	52	70	75	52	52	52
RW	5	140	69	69	69	69	69	69	69	69	69	69
RW	5	160	87	87	87	87	87	87	87	87	87	87
RW	5	180	87	87	87	87	87	87	87	87	87	87
RW	5	200	87	87	87	87	87	87	87	87	87	87
RW	6	0	2	4	5	4	4	2	4	5	5	4
RW	6	5	5	8	11	11	11	3	6	9	9	9
RW	6	10	6	11	14	12	11	5	9	14	12	11
RW	6	15	7	10	9	6	5	6	8	8	6	6
RW	6	20	7	6	6	5	4	4	5	5	4	4
RW	6	25	11	5	3	3	3	3	8	2	2	2
RW	6	30	12	7	4	3	3	3	8	2	2	2
RW	6	35	13	8	7	5	5	7	8	6	4	4
RW	6	40	17	9	8	6	6	6	8	6	5	4
RW	6	45	23	13	10	8	8	10	9	8	5	4

RW	6	50	20	13	41	10	10	10	10	10	7	5
RW	6	55	20	15	13	15	16	15	13	10	8	8
RW	6	60	20	16	15	15	16	15	13	17	13	14
RW	6	65	17	22	23	18	16	20	20	20	16	15
RW	6	70	27	26	26	21	20	18	28	27	17	12
RW	6	75	35	38	41	35	33	31	32	46	47	48
RW	6	80	32	41	47	44	43	37	49	51	43	40
RW	6	85	45	57	61	47	46	56	61	58	46	44
RW	6	90	81	95	86	50	50	75	92	100	50	49
RW	6	100	77	86	69	53	53	73	85	76	53	53
RW	6	120	73	77	52	52	52	71	79	52	52	52
RW	6	140	69	69	69	69	69	69	69	69	69	69
RW	6	160	87	87	87	87	87	87	87	87	87	87
RW	6	180	87	87	87	87	87	87	87	87	87	87
RW	6	200	87	87	87	87	87	87	87	87	87	87
RW	7	0	2	3	4	4	4	2	3	5	4	4
RW	7	5	5	6	8	9	9	4	5	8	8	8
RW	7	10	6	8	14	12	11	4	7	14	12	11
RW	7	15	7	8	9	7	5	5	7	9	6	5
RW	7	20	7	5	6	4	4	4	4	5	4	3
RW	7	25	11	3	2	2	2	4	3	2	2	2
RW	7	30	12	4	3	2	2	4	3	2	2	2
RW	7	35	12	6	5	5	5	7	5	4	3	2
RW	7	40	14	7	8	6	6	7	6	6	4	3
RW	7	45	20	11	10	5	4	9	8	8	4	4
RW	7	50	24	9	9	6	4	11	8	7	5	5
RW	7	55	20	12	12	9	7	14	11	10	8	7
RW	7	60	25	17	12	8	7	19	15	18	13	11
RW	7	65	17	20	20	15	13	20	20	20	16	14
RW	7	70	27	24	24	20	18	18	29	27	15	8
RW	7	75	35	38	41	35	33	31	33	47	48	48
RW	7	80	32	42	48	45	44	37	49	50	41	37
RW	7	85	45	59	63	55	53	56	61	57	46	42
RW	7	90	82	100	91	76	70	75	94	101	80	72
RW	7	100	78	84	72	53	53	73	81	77	53	53
RW	7	120	73	67	52	52	52	71	67	52	52	52
RW	7	140	69	69	69	69	69	69	69	69	69	69
RW	7	160	87	87	87	87	87	87	87	87	87	87
RW	7	180	87	87	87	87	87	87	87	87	87	87
RW	7	200	87	87	87	87	87	87	87	87	87	87
RW	8	0	2	3	5	5	5	2	3	4	4	4
RW	8	5	5	5	8	9	9	4	5	9	8	8
RW	8	10	6	8	13	12	11	5	8	14	12	11
RW	8	15	7	8	10	7	6	5	7	10	7	5
RW	8	20	7	5	6	5	4	4	4	5	4	4
RW	8	25	10	3	3	3	3	3	2	2	2	2
RW	8	30	13	4	4	5	5	5	3	2	2	2
RW	8	35	14	7	6	6	7	7	6	5	3	3
RW	8	40	17	10	8	8	8	6	6	6	4	3
RW	8	45	24	13	11	8	7	9	9	8	5	4
RW	8	50	21	13	11	9	8	10	10	8	6	6
RW	8	55	17	17	13	12	11	13	12	11	8	7
RW	8	60	18	19	19	15	14	16	14	17	14	14
RW	8	65	17	22	23	18	16	20	20	20	16	15

RW	8	70	27	26	26	21	20	18	28	27	17	12
RW	8	75	35	38	41	35	33	31	32	46	47	48
RW	8	80	32	41	47	44	43	37	49	51	43	40
RW	8	85	45	57	61	47	46	56	61	58	46	44
RW	8	90	81	95	86	50	50	75	92	100	50	49
RW	8	100	100	87	69	53	53	100	85	76	53	53
RW	8	120	90	78	52	52	52	90	77	52	52	52
RW	8	140	69	69	69	69	69	69	69	69	69	69
RW	8	160	87	87	87	87	87	87	87	87	87	87
RW	8	180	87	87	87	87	87	87	87	87	87	87
RW	8	200	87	87	87	87	87	87	87	87	87	87
RW	9	0	2	4	5	6	6	2	3	5	5	5
RW	9	5	4	6	10	9	9	3	6	10	9	9
RW	9	10	5	10	15	12	10	4	9	16	12	10
RW	9	15	7	9	10	7	5	5	8	10	7	6
RW	9	20	8	6	7	5	5	4	4	6	5	5
RW	9	25	11	4	4	5	6	3	3	3	3	3
RW	9	30	13	6	5	7	8	3	5	3	5	5
RW	9	35	14	10	10	9	10	6	6	7	6	7
RW	9	40	19	12	11	12	13	5	7	7	8	9
RW	9	45	22	15	15	13	13	8	8	9	7	7
RW	9	50	16	15	15	15	15	8	8	9	9	9
RW	9	55	16	16	18	18	18	13	12	12	9	8
RW	9	60	18	20	22	21	21	14	13	16	17	17
RW	9	65	18	28	29	23	21	20	20	20	18	18
RW	9	70	28	30	30	25	23	18	25	26	21	19
RW	9	75	35	39	41	35	33	31	32	42	45	46
RW	9	80	31	38	43	43	43	37	48	52	49	48
RW	9	85	44	52	55	46	46	56	61	61	50	50
RW	9	90	79	82	72	50	50	73	86	98	51	51
RW	9	100	71	67	62	53	53	71	55	56	53	53
RW	9	120	64	51	52	52	52	64	51	52	52	52
RW	9	140	69	69	69	69	69	69	69	69	69	69
RW	9	160	87	87	87	87	87	87	87	87	87	87
RW	9	180	87	87	87	87	87	87	87	87	87	87
RW	9	200	87	87	87	87	87	87	87	87	87	87
RW	10	0	3	4	6	5	5	2	4	6	5	5
RW	10	5	5	7	11	10	9	4	7	12	10	9
RW	10	10	6	12	15	13	13	5	11	16	12	10
RW	10	15	7	11	10	9	8	5	9	11	8	7
RW	10	20	8	7	7	8	8	4	5	7	8	8
RW	10	25	12	6	7	9	9	4	3	6	9	9
RW	10	30	15	8	9	9	9	4	4	7	11	12
RW	10	35	16	15	14	12	11	6	6	9	13	15
RW	10	40	17	19	16	13	12	6	6	11	14	15
RW	10	45	19	22	21	15	13	8	8	12	14	15
RW	10	50	16	22	23	19	16	9	9	12	16	17
RW	10	55	17	22	26	23	22	13	13	16	18	18
RW	10	60	21	26	29	29	27	16	13	16	22	24
RW	10	65	20	34	35	29	27	20	19	20	21	21
RW	10	70	28	35	35	30	28	17	19	24	26	26
RW	10	75	36	40	41	35	33	31	31	36	42	44
RW	10	80	31	34	38	41	42	37	47	54	56	57
RW	10	85	43	45	46	45	46	56	62	65	55	56

RW	10	90	77	59	48	49	49	72	77	95	54	54
RW	10	100	74	60	50	53	53	71	69	50	53	53
RW	10	120	72	60	52	52	52	70	60	52	52	52
RW	10	140	69	69	69	69	69	69	69	69	69	69
RW	10	160	87	87	87	87	87	87	87	87	87	87
RW	10	180	87	87	87	87	87	87	87	87	87	87
RW	10	200	87	87	87	87	87	87	87	87	87	87
RW	11	0	3	5	6	6	6	2	5	6	6	5
RW	11	5	5	8	11	11	10	4	8	12	11	11
RW	11	10	7	13	15	12	10	6	12	16	12	11
RW	11	15	8	11	10	8	8	6	10	10	9	9
RW	11	20	9	7	8	9	9	4	5	7	10	10
RW	11	25	11	7	8	11	12	3	4	7	13	15
RW	11	30	16	12	12	12	11	4	6	9	17	18
RW	11	35	15	26	18	15	15	7	8	12	19	21
RW	11	40	16	18	19	20	21	5	9	13	19	21
RW	11	45	22	20	23	25	26	9	12	14	20	22
RW	11	50	20	22	27	25	24	10	13	18	24	26
RW	11	55	21	23	29	32	32	14	15	20	23	24
RW	11	60	21	24	31	32	31	15	17	21	26	27
RW	11	65	20	36	40	34	31	20	22	30	36	38
RW	11	70	29	38	40	32	29	17	21	28	38	40
RW	11	75	35	39	43	44	44	32	37	41	42	42
RW	11	80	31	34	41	52	55	37	47	59	60	61
RW	11	85	42	39	46	52	54	56	61	71	58	58
RW	11	90	76	56	56	53	54	76	100	109	55	56
RW	11	100	74	60	54	53	53	74	90	81	53	53
RW	11	120	71	65	52	52	52	71	79	52	52	52
RW	11	140	69	69	69	69	69	69	69	69	69	69
RW	11	160	87	87	87	87	87	87	87	87	87	87
RW	11	180	87	87	87	87	87	87	87	87	87	87
RW	11	200	87	87	87	87	87	87	87	87	87	87
RW	12	0	2	5	7	6	6	3	5	6	6	6
RW	12	5	5	9	12	11	11	4	9	12	11	11
RW	12	10	8	15	15	11	10	7	15	15	12	10
RW	12	15	9	12	10	9	9	7	12	10	10	10
RW	12	20	10	8	10	10	11	4	6	9	11	12
RW	12	25	10	34	14	14	13	2	34	10	12	13
RW	12	30	17	13	19	18	18	4	6	14	19	21
RW	12	35	17	20	22	22	23	8	9	18	23	25
RW	12	40	20	24	23	27	28	7	13	22	28	30
RW	12	45	27	29	27	30	30	11	14	23	29	31
RW	12	50	25	31	31	32	31	12	15	25	30	30
RW	12	55	23	32	33	35	35	17	17	23	31	33
RW	12	60	23	29	34	35	35	18	21	23	30	32
RW	12	65	20	37	44	36	34	21	24	36	44	47
RW	12	70	30	41	43	34	30	17	22	31	44	48
RW	12	75	35	38	45	49	50	32	41	45	42	41
RW	12	80	31	33	44	59	63	37	47	61	63	64
RW	12	85	41	35	46	57	60	56	61	74	60	60
RW	12	90	76	54	62	55	56	78	113	118	56	57
RW	12	100	74	59	57	53	53	75	99	85	53	53
RW	12	120	72	64	52	52	52	72	84	52	52	52
RW	12	140	69	69	69	69	69	69	69	69	69	69

RW	12	160	87	87	87	87	87	87	87	87	87	87
RW	12	180	87	87	87	87	87	87	87	87	67	87
RW	12	200	87	87	87	87	87	87	87	87	87	87
RW	13	0	3	5	6	5	5	3	5	6	5	5
RW	13	5	6	10	11	10	10	4	8	11	10	10
RW	13	10	8	18	15	12	11	6	12	15	12	11
RW	13	15	10	16	10	9	9	6	10	10	9	9
RW	13	20	10	11	10	11	11	4	5	7	9	10
RW	13	25	11	11	10	11	11	3	10	7	10	11
RW	13	30	14	9	12	13	13	4	5	9	13	14
RW	13	35	15	15	16	16	15	7	7	11	16	17
RW	13	40	17	17	20	18	18	6	8	13	18	20
RW	13	45	23	20	24	22	21	11	10	14	20	22
RW	13	50	21	21	29	23	22	12	11	16	22	24
RW	13	55	20	22	27	27	27	16	13	17	22	23
RW	13	60	21	24	27	27	26	17	16	19	23	25
RW	13	65	19	32	35	29	27	20	21	27	30	31
RW	13	70	28	34	35	29	26	17	24	28	32	33
RW	13	75	35	39	42	41	40	31	35	43	44	44
RW	13	80	31	36	43	49	51	37	48	56	55	54
RW	13	85	43	47	52	52	54	56	61	66	56	56
RW	13	90	78	73	68	57	57	75	97	106	63	62
RW	13	100	76	69	60	53	53	75	81	74	53	53
RW	13	120	72	76	52	52	52	71	72	52	52	52
RW	13	140	69	69	69	69	69	69	69	69	69	69
RW	13	160	87	87	87	87	87	87	87	87	87	87
RW	13	180	87	87	87	87	87	87	87	87	87	87
RW	13	200	87	87	87	87	87	87	87	87	87	87

----- END OF FILE WRITTEN -----

P, D, T ANNUAL PERCENTS, CODE P

P	13	0	761	599	498	435	415	633	504	414	361	341	485	495	762	829	852
P	13	5	734	610	535	488	473	617	522	455	417	401	472	495	758	827	851
P	13	10	707	622	572	540	530	601	540	497	472	461	459	496	753	825	850
P	13	15	679	633	608	592	587	586	557	538	527	522	447	496	749	824	849
P	13	20	652	644	645	644	645	570	575	579	582	582	434	497	745	822	848
P	13	25	621	643	663	673	677	616	613	611	611	610	445	519	732	803	827
P	13	30	607	672	719	747	757	500	591	656	695	707	390	454	740	828	857
P	13	35	571	696	784	838	856	459	613	722	788	810	362	520	752	850	883
P	13	40	531	692	808	877	900	508	654	758	821	841	412	588	714	790	815
P	13	45	523	690	802	869	892	534	670	766	824	844	440	551	630	678	693
P	13	50	495	667	789	863	887	491	649	762	830	853	418	493	545	577	588
P	13	55	471	646	770	846	871	483	636	746	812	834	430	472	502	520	526
P	13	60	517	655	753	813	832	587	673	734	771	784	544	570	588	600	604
P	13	65	550	642	707	747	760	681	710	730	742	747	677	703	722	733	737
P	13	70	583	629	662	682	688	648	663	673	679	681	574	587	597	602	604
P	13	75	616	616	616	616	616	615	615	615	615	615	471	471	471	471	471
P	13	80	637	637	637	637	637	571	571	571	571	571	455	455	455	455	455
P	13	85	657	657	657	657	657	526	526	526	526	526	439	439	439	439	439
P	13	90	678	678	678	678	678	482	482	482	482	482	422	422	422	422	422
P	13	100	719	719	719	719	719	393	393	393	393	393	390	390	390	390	390
P	13	120	599	599	599	599	599	328	328	328	328	328	325	325	325	325	325
P	13	140	479	479	479	479	479	262	262	262	262	262	260	260	260	260	260

P	13	160	360	360	360	360	360	197	197	197	197	197	195	195	195	195	195
P	13	180	240	240	240	240	240	131	131	131	131	131	130	130	130	130	130
P	13	200	120	120	120	120	120	66	66	66	66	66	65	65	65	65	65
PW	13	0	961	911	866	873	828	320	606	921	693	733					
PW	13	5	941	904	869	847	840	321	599	892	721	759					
PW	13	10	922	897	873	857	852	323	591	864	748	785					
PW	13	15	903	890	876	867	864	324	583	835	775	810					
PW	13	20	884	883	880	877	876	327	575	806	803	836					
PW	13	25	864	878	887	892	894	344	575	739	839	872					
PW	13	30	854	872	885	892	895	324	552	751	832	859					
PW	13	35	821	858	885	901	906	304	545	786	890	918					
PW	13	40	794	854	896	921	930	328	550	706	944	974					
PW	13	45	798	853	899	927	937	349	537	618	920	943					
PW	13	50	768	831	876	903	912	339	489	650	856	889					
PW	13	55	734	761	781	793	797	366	450	649	771	811					
PW	13	60	721	686	662	647	642	469	550	674	749	773					
PW	13	65	743	720	704	694	690	601	713	794	842	858					
PW	13	70	765	753	745	740	739	694	750	790	814	822					
PW	13	75	787	787	787	787	787	787	787	787	787	787					
PW	13	80	760	760	760	760	760	760	760	760	760	760					
PW	13	85	734	734	734	734	734	734	734	734	734	734					
PW	13	90	707	707	707	707	707	707	707	707	707	707					
PW	13	100	654	654	654	654	654	654	654	654	654	654					
PW	13	120	615	615	615	615	615	615	615	615	615	615					
PW	13	140	575	575	575	575	575	575	575	575	575	575					
PW	13	160	536	536	536	536	536	536	536	536	536	536					
PW	13	180	496	496	496	496	496	496	496	496	496	496					
PW	13	200	457	457	457	457	457	457	457	457	457	457					

SMALL & LARGE SCALE U-D AND V-D ANNUAL CORRELATIONS, CODE CS, CL

CS	13	0	-55	-17	-47	-65	-70	108	-27	-122	-181	-201
CS	13	5	-61	-22	-42	-54	-58	82	-29	-107	-156	-173
CS	13	10	-67	-26	-38	-44	-46	56	-32	-93	-131	-144
CS	13	15	-74	-31	-33	-34	-34	30	-34	-78	-106	-116
CS	13	20	-80	-36	-28	-24	-22	4	-36	-64	-82	-88
CS	13	25	-86	-71	-60	-54	-52	1	-73	-125	-157	-168
CS	13	30	-122	-67	-28	-4	4	-56	-75	-88	-97	-100
CS	13	35	-113	-46	2	30	40	-75	-25	11	32	39
CS	13	40	-72	-8	37	65	75	-101	15	98	147	163
CS	13	45	-51	-9	22	40	46	-152	-8	95	157	177
CS	13	50	-107	-52	-12	10	18	-169	-38	55	111	129
CS	13	55	-213	-89	0	52	70	-183	-72	8	56	72
CS	13	60	-102	-108	-15	41	60	-173	-93	-37	-2	9
CS	13	65	-137	-77	15	68	87	-231	-56	68	143	168
CS	13	70	-143	-82	19	79	99	-256	-58	82	168	196
CS	13	75	-149	-86	24	89	112	-283	-61	97	193	225
CS	13	80	-155	-91	29	99	124	-309	-63	112	218	253
CS	13	85	-162	-96	34	110	136	-335	-65	126	243	281
CS	13	90	-168	-100	38	120	148	-361	-67	141	268	310
CS	13	100	-181	-109	48	140	172	-413	-72	170	318	366
CS	13	120	-181	-109	48	140	172	-413	-72	170	318	366
CS	13	140	-181	-109	48	140	172	-413	-72	170	318	366
CS	13	160	-181	-109	48	140	172	-413	-72	170	318	366
CS	13	180	-181	-109	48	140	172	-413	-72	170	318	366

CS	13	200	-181	-109	48	140	172	-413	-72	170	318	366
CL	13	0	308	-207	-576	-796	-869	23	145	235	289	309
CL	13	5	289	-202	-553	-763	-832	23	136	218	268	287
CL	13	10	270	-197	-530	-729	-795	23	126	202	248	265
CL	13	15	251	-191	-507	-696	-759	24	117	185	227	242
CL	13	20	232	-186	-484	-663	-722	24	107	169	207	220
CL	13	25	283	-150	-459	-644	-705	-18	69	131	169	182
CL	13	30	223	-159	-432	-595	-650	74	116	147	165	172
CL	13	35	56	-202	-385	-495	-532	30	107	163	196	207
CL	13	40	96	-183	-382	-502	-542	-4	40	71	90	96
CL	13	45	163	-170	-407	-549	-596	34	-30	-76	-102	-111
CL	13	50	137	-180	-405	-540	-586	50	-47	-116	-157	-171
CL	13	55	126	-144	-335	-450	-489	36	-50	-110	-146	-159
CL	13	60	79	-108	-240	-320	-347	-2	-84	-143	-178	-190
CL	13	65	60	-138	-277	-361	-390	26	-94	-160	-200	-214
CL	13	70	41	-133	-254	-328	-353	26	-111	-180	-222	-237
CL	13	75	22	-127	-231	-294	-316	27	-127	-199	-243	-259
CL	13	80	3	-122	-208	-261	-280	27	-144	-219	-265	-282
CL	13	85	-16	-117	-185	-227	-243	27	-160	-238	-287	-304
CL	13	90	-36	-111	-162	-194	-206	27	-177	-258	-309	-327
CL	13	100	-74	-101	-116	-127	-132	28	-210	-297	-352	-372
CL	13	120	-74	-101	-116	-127	-132	28	-210	-297	-352	-372
CL	13	140	-74	-101	-116	-127	-132	28	-210	-297	-352	-372
CL	13	160	-74	-101	-116	-127	-132	28	-210	-297	-352	-372
CL	13	180	-74	-101	-116	-127	-132	28	-210	-297	-352	-372
CL	13	200	-74	-101	-116	-127	-132	28	-210	-297	-352	-372

----- END OF FILE WRITTEN -----

QUASI-BIENNIAL OSCILLATIONS, CODE QP, QD, QT, QU, OR QV

QP	15	1	291	1	807	1	554	1	404	1	353
QP	20	2	248	2	778	2	537	2	392	2	344
QP	25	3	369	3	811	3	506	3	323	3	262
QP	30	6	63	8	675	10	491	11	381	12	344
QP	35	8	49	15	669	20	491	23	385	24	349
QP	40	9	39	22	665	31	491	37	387	39	352
QP	45	8	27	26	645	39	465	47	357	49	321
QP	50	9	839	27	595	40	422	48	317	50	282
QP	55	11	825	26	574	37	395	43	288	45	251
QP	60	16	837	31	580	42	396	49	285	51	249
QP	65	13	732	26	525	35	378	41	289	43	259
QP	70	11	689	21	497	28	360	33	277	34	250
QP	75	8	646	16	469	21	342	25	266	26	240
QP	80	5	603	10	441	14	325	16	254	17	231
QP	85	3	560	5	413	7	307	8	243	9	222
QP	90	0	517	0	384	0	289	0	231	0	212
QD	15	5	428	2	151	1	823	0	704	0	665
QD	20	10	368	5	95	1	770	1	653	1	614
QD	25	15	410	7	189	2	30	1	805	1	773
QD	30	6	287	5	807	4	557	4	407	3	357
QD	35	6	76	9	699	11	523	12	417	13	382
QD	40	8	66	15	695	20	522	23	419	24	384
QD	45	9	40	24	668	35	496	42	393	44	358
QD	50	8	869	28	625	43	450	52	346	55	311

QD	55	8	842	26	589	38	408	46	299	48	263
QD	60	15	829	19	584	22	409	24	304	24	269
QD	65	13	704	16	466	18	296	20	194	20	160
QD	70	10	645	13	411	15	243	16	143	16	110
QD	75	8	585	10	355	11	191	12	92	12	59
QD	80	5	526	6	300	7	138	8	41	8	9
QD	85	3	466	3	244	4	85	4	860	4	828
QD	90	0	407	0	189	0	33	0	809	0	778
QT	15	4	10	3	695	2	563	2	483	2	457
QT	20	6	4	6	673	4	529	4	443	4	414
QT	25	11	18	9	626	7	439	6	327	6	290
QT	30	9	9	10	636	10	462	11	357	11	322
QT	35	3	853	9	631	14	473	17	378	18	346
QT	40	1	810	9	603	16	455	19	367	21	337
QT	45	4	3	8	580	10	370	12	245	12	203
QT	50	1	784	2	492	3	283	4	157	4	115
QT	55	2	811	4	514	4	302	5	175	5	132
QT	60	6	18	6	513	5	245	5	85	5	31
QT	65	5	822	5	476	4	228	4	80	4	29
QT	70	4	817	4	454	3	194	3	40	3	856
QT	75	3	811	3	432	3	161	3	869	3	814
QT	80	2	805	2	410	2	128	2	829	2	771
QT	85	1	799	1	388	1	94	1	788	1	728
QT	90	0	794	0	366	0	61	0	748	0	685
QU	15	42	655	25	586	14	537	6	507	4	497
QU	20	84	504	51	505	27	505	13	506	8	505
QU	25	126	325	76	390	41	436	19	463	12	472
QU	30	158	205	99	355	57	462	31	526	23	547
QU	35	146	79	93	280	56	424	33	511	25	539
QU	40	56	843	47	221	40	398	37	505	35	540
QU	45	21	591	24	102	26	374	27	537	28	591
QU	50	49	289	43	793	39	282	36	498	35	570
QU	55	61	421	55	845	51	278	48	460	47	520
QU	60	52	159	47	721	44	253	41	494	40	574
QU	65	44	7	39	640	36	221	34	493	34	583
QU	70	35	725	31	558	29	190	27	492	27	592
QU	75	26	573	24	476	22	158	21	490	20	600
QU	80	17	421	16	395	15	127	14	489	13	609
QU	85	9	269	8	313	7	95	7	488	7	618
QU	90	0	118	0	231	0	63	0	486	0	626
QV	15	1	226	3	91	5	866	7	809	7	790
QV	20	1	264	6	140	11	53	13	0	14	853
QV	25	1	438	9	246	16	109	20	27	21	0
QV	30	1	404	9	270	15	175	19	117	20	98
QV	35	8	274	13	245	17	225	20	213	20	209
QV	40	6	174	16	238	22	284	26	312	28	321
QV	45	7	441	11	363	14	308	16	275	16	264
QV	50	1	544	19	453	31	389	39	350	41	337
QV	55	5	647	11	543	15	469	17	424	18	409
QV	60	4	571	9	533	13	507	15	491	15	485
QV	65	4	609	8	582	11	564	12	552	13	548
QV	70	3	648	6	632	9	621	10	614	10	611
QV	75	2	686	5	681	6	678	7	675	8	674
QV	80	1	724	3	730	4	734	5	737	5	737

QV	85	1	763	2	779	2	791	2	798	3	800
QV	90	0	801	0	828	0	849	0	859	0	863

----- END OF FILE WRITTEN -----

SPHERICAL HARMONICS COEFFICIENTS, CODE SP

SP	25	1	-711	840	245	675	1188	-20	245	86	62
SP	30	1	-881	1246	272	770	1010	87	347	140	3
SP	35	1	-1051	1566	160	1006	1014	351	393	46	-221
SP	40	1	-1302	1834	85	1243	1499	416	288	-12	-475
SP	45	1	-1367	2771	-88	1384	2240	768	-131	-166	-642
SP	50	1	-1242	3707	-117	1218	2056	850	-298	-202	-783
SP	55	1	-591	3511	-638	2072	-255	1210	-447	-98	-920
SP	60	1	221	3594	-379	2791	-2082	1333	-683	-44	-1075
SP	65	1	-1197	4623	-66	3334	-4594	-355	2211	574	-442
SP	70	1	559	3331	-237	2488	0	0	0	0	0
SP	75	1	641	2705	16	2047	0	0	0	0	0
SP	80	1	607	2290	29	507	0	0	0	0	0
SP	85	1	1206	933	-595	139	0	0	0	0	0
SP	90	1	986	-566	-3359	-250	0	0	0	0	0
SP	25	1	10	-240	-76	-67	-212	160	-223	-42	-16
SP	30	1	-35	-355	-61	-52	-346	233	-242	-47	-29
SP	35	1	-92	-541	-37	38	-480	304	-226	-66	-37
SP	40	1	-4	-698	46	290	-713	350	-312	-110	-78
SP	45	1	137	-260	-117	150	-543	686	-271	-157	-132
SP	50	1	125	-490	-231	316	-743	649	18	-159	-264
SP	55	1	142	-781	-220	414	-368	222	235	-84	-167
SP	60	1	106	-1023	-101	728	-226	-145	334	-12	-59
SP	65	1	-317	-1126	531	250	24	-658	924	274	-140
SP	70	1	-350	-512	582	-375	0	0	0	0	0
SP	75	1	9	324	350	-237	0	0	0	0	0
SP	80	1	109	1667	603	-290	0	0	0	0	0
SP	85	1	-50	-1062	-237	1865	0	0	0	0	0
SP	90	1	-157	735	-2659	704	0	0	0	0	0
SP	25	2	-576	761	0	619	1379	-144	159	23	72
SP	30	2	-625	1125	215	724	1673	-177	296	110	33
SP	35	2	-396	1332	139	1073	1976	159	510	29	-218
SP	40	2	-1096	1658	201	1197	2355	375	626	-4	-451
SP	45	2	-844	2425	-38	1476	2520	739	310	-118	-581
SP	50	2	-250	2920	-136	1515	1211	270	433	-21	-375
SP	55	2	61	2993	155	1962	-1220	-63	884	243	-370
SP	60	2	501	2825	346	2292	-2378	504	903	320	-384
SP	65	2	-761	2642	197	2929	-4014	-181	3096	556	-313
SP	70	2	1532	3063	-587	1289	0	0	0	0	0
SP	75	2	690	2086	-273	816	0	0	0	0	0
SP	80	2	37	1593	-1908	385	0	0	0	0	0
SP	85	2	-16	1431	-1589	-888	0	0	0	0	0
SP	90	2	630	-60	-3774	-1464	0	0	0	0	0
SP	25	2	101	-41	-138	-184	-170	149	-326	-52	-25
SP	30	2	176	222	-175	-366	-189	403	-530	-89	-28
SP	35	2	235	70	-160	-324	-113	350	-669	-114	-11
SP	40	2	336	135	-135	-339	-282	489	-805	-171	-48
SP	45	2	357	-75	-31	47	-304	555	-629	-155	-153
SP	50	2	432	-416	-181	209	-343	348	-537	-223	-72

SP	55	2	194	-486	-338	478	-662	580	-44	-165	-175
SP	60	2	386	-762	83	642	-665	799	-83	-164	-277
SP	65	2	-72	-321	337	-42	-515	51	123	52	-114
SP	70	2	-471	-453	575	2	0	0	0	0	0
SP	75	2	113	156	597	-55	0	0	0	0	0
SP	80	2	293	1331	-320	-76	0	0	0	0	0
SP	85	2	576	-841	-1548	1420	0	0	0	0	0
SP	90	2	-446	1008	-2070	-1156	0	0	0	0	0
SP	25	3	-327	312	23	274	1498	194	-167	-32	28
SP	30	3	-522	274	415	676	1906	320	285	114	-69
SP	35	3	-580	211	535	887	2146	459	612	15	-215
SP	40	3	-256	173	108	1070	2035	538	472	-83	-433
SP	45	3	420	375	-291	1092	1076	232	286	-135	-210
SP	50	3	1029	852	-115	964	515	500	208	-82	-217
SP	55	3	1670	865	-401	952	-112	260	80	39	-82
SP	60	3	1550	544	218	1108	-693	-154	682	240	-141
SP	65	3	96	271	769	1527	-865	-490	2872	852	-46
SP	70	3	1418	2048	-33	-300	0	0	0	0	0
SP	75	3	269	1289	804	-434	0	0	0	0	0
SP	80	3	-71	1299	474	-409	0	0	0	0	0
SP	85	3	209	467	276	-540	0	0	0	0	0
SP	90	3	1088	-155	-4063	-761	0	0	0	0	0
SP	25	3	90	-56	-94	-100	-81	27	-189	-20	-1
SP	30	3	56	-130	-126	-78	-188	87	-190	-33	-32
SP	35	3	129	-238	-62	-92	-264	-7	-243	-37	-2
SP	40	3	128	-197	-73	-23	-320	-38	-257	-53	-33
SP	45	3	127	-278	-16	138	-495	112	-59	-39	-156
SP	50	3	169	-208	-175	63	-121	-94	93	-55	-62
SP	55	3	257	-79	-399	85	-182	297	55	-119	-182
SP	60	3	216	-49	-34	259	-292	-58	381	37	-17
SP	65	3	126	422	220	-359	-705	371	-49	-67	-105
SP	70	3	-288	80	-22	-187	0	0	0	0	0
SP	75	3	-238	530	-135	408	0	0	0	0	0
SP	80	3	162	1723	-518	-777	0	0	0	0	0
SP	85	3	1130	-427	-1869	431	0	0	0	0	0
SP	90	3	-304	430	-2055	200	0	0	0	0	0
SP	25	4	-459	-592	112	322	1273	10	234	30	117
SP	30	4	-319	-819	472	499	1488	121	533	95	-50
SP	35	4	14	-1099	449	473	1576	177	551	-42	-17
SP	40	4	599	-1216	250	98	1190	249	397	-110	-17
SP	45	4	1314	-1392	-96	-213	820	115	138	-192	136
SP	50	4	1637	-1969	-73	-198	-92	-94	334	-108	170
SP	55	4	2596	-1601	-364	-1082	331	-343	-438	-121	345
SP	60	4	2774	-2098	122	-764	343	307	-336	59	236
SP	65	4	2621	-3036	495	-284	760	-92	-30	221	204
SP	70	4	1634	-2286	-31	140	0	0	0	0	0
SP	75	4	90	-1584	355	638	0	0	0	0	0
SP	80	4	-169	-2090	-40	756	0	0	0	0	0
SP	85	4	334	52	-982	-1153	0	0	0	0	0
SP	90	4	900	439	-3888	-1663	0	0	0	0	0
SP	25	4	-10	-73	-55	-22	-181	-182	57	14	10
SP	30	4	-44	213	-31	-116	-206	-151	40	-2	73
SP	35	4	41	78	124	-120	-231	-309	-34	17	114
SP	40	4	8	296	127	-231	-304	-270	-53	11	130

SP	45	4	15	27	301	10	-516	-580	252	77	117
SP	50	4	358	336	203	-369	-187	-687	-103	-45	254
SP	55	4	475	388	-23	-307	-157	-287	-165	-107	171
SP	60	4	140	70	0	-148	-194	-396	356	-6	142
SP	65	4	387	503	447	-536	272	150	-23	-56	-14
SP	70	4	16	704	181	-504	0	0	0	0	0
SP	75	4	-88	679	269	-775	0	0	0	0	0
SP	80	4	139	1645	-278	-1611	0	0	0	0	0
SP	85	4	1084	-32	-1414	-66	0	0	0	0	0
SP	90	4	234	149	-2049	-472	0	0	0	0	0
SP	25	5	-461	-827	-193	21	1236	46	115	-87	120
SP	30	5	-405	-1138	201	-89	1062	167	435	-31	-43
SP	35	5	-83	-1761	207	-266	1067	-47	548	-81	134
SP	40	5	505	-2029	246	-892	211	-135	569	-47	270
SP	45	5	820	-2363	-1	-1575	-64	-223	440	-147	428
SP	50	5	1257	-3345	153	-1889	135	-538	459	-87	439
SP	55	5	2076	-2684	-104	-3002	369	-366	-829	-409	788
SP	60	5	2429	-4467	-650	-1679	446	404	-1180	-326	402
SP	65	5	3059	-5203	478	-1232	1932	420	-1539	-42	317
SP	70	5	941	-3887	249	-847	0	0	0	0	0
SP	75	5	421	-4788	50	316	0	0	0	0	0
SP	80	5	849	-4199	-179	1288	0	0	0	0	0
SP	85	5	719	-676	-992	-420	0	0	0	0	0
SP	90	5	901	-278	-2890	1279	0	0	0	0	0
SP	25	5	-35	185	-111	31	-265	-31	4	-18	16
SP	30	5	-46	301	-74	-95	-232	-117	21	3	42
SP	35	5	70	178	55	-50	-230	-234	-108	-19	38
SP	40	5	99	261	197	-78	-137	-317	-168	-8	62
SP	45	5	220	212	206	-170	-429	-538	-53	-22	80
SP	50	5	269	354	-189	-206	-550	-447	-90	-139	184
SP	55	5	168	831	-170	-581	-596	-344	170	-102	187
SP	60	5	213	962	-103	-587	-737	-331	108	-57	209
SP	65	5	289	1171	290	-673	-573	194	-203	-172	7
SP	70	5	37	522	308	-681	0	0	0	0	0
SP	75	5	-176	498	693	-1183	0	0	0	0	0
SP	80	5	-280	1163	-25	-1525	0	0	0	0	0
SP	85	5	231	439	-813	-487	0	0	0	0	0
SP	90	5	411	-673	-1671	960	0	0	0	0	0
SP	25	6	-433	-1575	84	15	1535	116	119	-22	-8
SP	30	6	-198	-2625	221	134	1958	137	217	61	-261
SP	35	6	66	-3324	271	-292	1993	-209	316	38	36
SP	40	6	384	-3602	441	-1109	1744	-342	312	74	322
SP	45	6	294	-4194	89	-1700	1736	-749	298	-26	784
SP	50	6	117	-4549	-56	-2116	1806	-891	201	-97	952
SP	55	6	723	-4788	-194	-2134	879	-704	-313	-1	808
SP	60	6	1306	-3750	-699	-2945	-512	-10	-1143	-301	892
SP	65	6	2527	-6108	334	-2552	887	469	-1842	-110	442
SP	70	6	1425	-4104	595	-2907	0	0	0	0	0
SP	75	6	1331	-5958	328	-733	0	0	0	0	0
SP	80	6	965	-4838	21	1085	0	0	0	0	0
SP	85	6	939	-1013	-1067	124	0	0	0	0	0
SP	90	6	672	204	-3358	1253	0	0	0	0	0
SP	25	6	-57	412	-111	-94	-364	-26	-18	-34	40
SP	30	6	-192	836	35	-246	-656	-201	15	-5	66

SP	85	10	334	-52	-982	1153	0	0	0	0	0
SP	90	10	900	-438	-3888	1663	0	0	0	0	0
SP	25	10	2	-6	-39	60	-84	148	54	14	-8
SP	30	10	12	-66	-15	30	8	175	-34	-20	-58
SP	35	10	18	58	96	34	-57	337	-30	10	-94
SP	40	10	59	-89	97	82	-163	351	-145	-14	-107
SP	45	10	179	140	312	-52	-356	629	5	24	-122
SP	50	10	450	-9	276	178	-176	849	-218	-59	-276
SP	55	10	679	-380	14	321	40	425	-357	-131	-270
SP	60	10	323	-351	-5	301	49	361	157	-55	-99
SP	65	10	85	109	510	172	-322	-17	297	-9	2
SP	70	10	-68	-36	300	154	0	0	0	0	0
SP	75	10	-35	589	151	117	0	0	0	0	0
SP	80	10	589	-459	-403	931	0	0	0	0	0
SP	85	10	1084	32	-1414	66	0	0	0	0	0
SP	90	10	234	-149	-2049	472	0	0	0	0	0
SP	25	11	-481	648	-167	131	1300	-212	186	-51	-32
SP	30	11	-408	1089	158	137	1413	-370	464	-20	114
SP	35	11	-109	1610	282	374	1268	-244	629	-4	95
SP	40	11	519	2112	268	853	508	-84	530	6	-56
SP	45	11	800	2554	33	1340	256	96	461	-55	-155
SP	50	11	1000	3016	273	1903	-60	250	765	71	-186
SP	55	11	973	2377	-120	2930	-871	316	554	-64	-583
SP	60	11	661	2208	-111	2959	-1655	280	502	-56	-728
SP	65	11	-539	2535	783	2808	-1888	-286	2335	559	-363
SP	70	11	321	2900	87	1592	0	0	0	0	0
SP	75	11	-486	2952	676	1088	0	0	0	0	0
SP	80	11	-302	1562	179	1170	0	0	0	0	0
SP	85	11	719	676	-992	420	0	0	0	0	0
SP	90	11	901	278	-2890	-1279	0	0	0	0	0
SP	25	11	2	-102	-83	-57	-146	61	-24	-16	-5
SP	30	11	21	-179	-65	13	-197	146	-85	-9	-36
SP	35	11	116	-66	32	-76	-287	296	-249	-48	-48
SP	40	11	182	-144	174	-117	-272	413	-386	-56	-59
SP	45	11	275	5	160	-50	-644	643	-273	-73	-84
SP	50	11	315	-218	-223	61	-524	523	-281	-186	-198
SP	55	11	210	-655	-112	436	-579	481	61	-124	-180
SP	60	11	301	-781	88	500	-658	494	76	-35	-88
SP	65	11	-178	-161	461	81	-1029	231	316	-68	-75
SP	70	11	-119	-240	422	374	0	0	0	0	0
SP	75	11	45	580	261	374	0	0	0	0	0
SP	80	11	247	193	-378	741	0	0	0	0	0
SP	85	11	231	-439	-813	487	0	0	0	0	0
SP	90	11	411	673	-1671	-960	0	0	0	0	0
SP	25	12	-477	1433	108	116	1639	-239	211	11	56
SP	30	12	-391	2297	148	44	1631	-321	440	105	282
SP	35	12	-190	2904	231	538	1481	-34	648	126	54
SP	40	12	-67	3051	442	1389	1093	156	899	222	-307
SP	45	12	-143	3594	125	1885	1107	590	818	113	-642
SP	50	12	-723	3746	-8	2408	403	851	1182	94	-815
SP	55	12	-201	3969	295	2394	26	835	490	-47	-763
SP	60	12	-492	2533	7	3708	-1961	477	835	97	-993
SP	65	12	-582	5098	-124	3359	-3499	682	1094	203	-640
SP	70	12	-28	3114	-282	3238	0	0	0	0	0

SP	35	6	-157	1006	155	-462	-879	-436	-9	-47	136
SP	40	6	-318	1645	209	-946	-1241	-614	135	-63	298
SP	45	6	246	864	148	-699	-914	-791	-206	-143	278
SP	50	6	384	337	-14	-370	-561	-785	-116	-143	250
SP	55	6	333	388	-103	-316	-249	-480	107	-46	261
SP	60	6	202	780	-290	-888	-500	-499	326	-32	246
SP	65	6	331	1407	63	-1012	-259	-1	178	-65	177
SP	70	6	-382	851	367	-166	0	0	0	0	0
SP	75	6	-779	494	336	-520	0	0	0	0	0
SP	80	6	-825	748	514	-1044	0	0	0	0	0
SP	85	6	-101	1061	-624	-1611	0	0	0	0	0
SP	90	6	-475	-1188	-2589	1459	0	0	0	0	0
SP	25	7	-505	-1126	67	-458	1185	-176	-182	-58	-20
SP	30	7	-470	-1820	187	-476	1450	-282	-214	-13	-35
SP	35	7	-467	-2415	194	-502	1719	-637	-352	-119	259
SP	40	7	-653	-2654	95	-868	2154	-453	-431	-160	371
SP	45	7	-1023	-3505	-561	-1244	2744	-831	-599	-370	755
SP	50	7	-769	-4327	-227	-1226	2755	-630	-660	-281	832
SP	55	7	358	-4608	-523	-1668	1009	-1045	-1133	-159	837
SP	60	7	1613	-3206	-525	-3314	-440	-1038	-2134	-342	1225
SP	65	7	2712	-6106	-124	-2458	1206	1016	-1677	37	217
SP	70	7	1877	-6369	-331	-1201	0	0	0	0	0
SP	75	7	1200	-7179	21	-123	0	0	0	0	0
SP	80	7	662	-5700	233	1133	0	0	0	0	0
SP	85	7	1206	-933	-595	-139	0	0	0	0	0
SP	90	7	986	566	-3359	250	0	0	0	0	0
SP	25	7	-100	522	-44	-130	-392	-98	-54	-11	44
SP	30	7	-109	625	0	-199	-454	-157	-41	-3	68
SP	35	7	-37	502	8	-68	-476	-336	-230	-64	80
SP	40	7	-57	889	64	-446	-809	-313	-165	-81	99
SP	45	7	-46	929	-17	-522	-841	-568	120	-68	156
SP	50	7	4	712	-125	-432	-608	-566	299	-81	189
SP	55	7	-95	1052	-110	-616	-516	-237	568	-13	135
SP	60	7	-77	1186	-51	-831	-843	149	556	10	46
SP	65	7	-121	-1178	912	966	1939	301	1394	547	-73
SP	70	7	-433	379	357	310	0	0	0	0	0
SP	75	7	-365	-67	251	-101	0	0	0	0	0
SP	80	7	-382	-158	818	-819	0	0	0	0	0
SP	85	7	-50	1062	-237	-1865	0	0	0	0	0
SP	90	7	-157	-735	-2659	-704	0	0	0	0	0
SP	25	8	-503	-907	-61	-516	1300	64	3	-32	-69
SP	30	8	-505	-1429	98	-575	1529	11	17	-4	-82
SP	35	8	-764	-1731	108	-833	2151	-403	158	-107	242
SP	40	8	-818	-2281	267	-918	2610	-565	214	-121	359
SP	45	8	-748	-3038	-391	-1373	2830	-1013	-10	-333	721
SP	50	8	155	-3256	-185	-1596	1214	-397	-74	-198	525
SP	55	8	1177	-4372	-84	-1196	297	121	-320	-48	320
SP	60	8	1988	-3365	-63	-2127	-521	-276	-728	-32	480
SP	65	8	3314	-4647	-191	-1687	746	663	-1323	-164	154
SP	70	8	1986	-4586	-244	-725	0	0	0	0	0
SP	75	8	1094	-7017	-537	1277	0	0	0	0	0
SP	80	8	445	-6044	-1835	2684	0	0	0	0	0
SP	85	8	-16	-1431	-1589	888	0	0	0	0	0
SP	90	8	630	60	-3774	1464	0	0	0	0	0

SP	25	8	83	127	-103	116	-187	-85	-277	-32	11
SP	30	8	196	-164	-67	205	74	-318	-364	-35	40
SP	35	8	264	-160	-2	258	127	-281	-525	-51	-7
SP	40	8	352	-65	33	209	42	-370	-600	-88	21
SP	45	8	358	247	35	-205	5	-428	-473	-102	93
SP	50	8	371	553	-148	-322	-461	-208	-382	-191	-20
SP	55	8	74	722	-201	-616	-506	-412	201	-74	131
SP	60	8	202	722	229	-622	-636	-614	212	-73	267
SP	65	8	-9	946	476	-356	-307	83	132	92	91
SP	70	8	-581	768	486	-311	0	0	0	0	0
SP	75	8	-386	340	375	-702	0	0	0	0	0
SP	80	8	-150	-277	-35	-867	0	0	0	0	0
SP	85	8	576	841	-1549	-1420	0	0	0	0	0
SP	90	8	-446	-1008	-2070	1156	0	0	0	0	0
SP	25	9	-269	-356	27	-243	1470	-207	-255	-54	-35
SP	30	9	-405	-511	409	-570	1975	-468	88	42	58
SP	35	9	-559	-561	546	-677	2290	-734	434	-76	321
SP	40	9	-119	-499	228	-926	2151	-755	241	-155	443
SP	45	9	538	-453	-556	-1153	1473	-529	-146	-367	479
SP	50	9	1386	-1205	-76	-785	932	-711	-240	-215	412
SP	55	9	2083	-1673	-427	-471	-212	-318	-355	-94	89
SP	60	9	2545	-1784	-167	-455	30	188	-566	-86	70
SP	65	9	2982	-3117	508	145	2456	-226	-273	354	136
SP	70	9	1774	-3800	-109	1306	0	0	0	0	0
SP	75	9	295	-4635	715	2044	0	0	0	0	0
SP	80	9	-14	-4175	481	2512	0	0	0	0	0
SP	85	9	209	-467	276	540	0	0	0	0	0
SP	90	9	1088	155	-4063	761	0	0	0	0	0
SP	25	9	80	101	-85	58	-101	2	-168	-12	-6
SP	30	9	83	131	-122	5	-51	-66	-174	-31	21
SP	35	9	164	199	-27	30	-69	31	-238	-29	-20
SP	40	9	164	180	-55	-44	-82	83	-260	-53	-19
SP	45	9	177	96	-57	-47	-143	-148	-70	-41	76
SP	50	9	73	387	-251	-183	-158	116	182	-66	57
SP	55	9	123	260	-246	-224	-258	-281	324	-37	167
SP	60	9	217	-290	44	-104	186	226	467	87	-82
SP	65	9	9	731	268	-314	-684	152	171	5	8
SP	70	9	-363	590	-31	-302	0	0	0	0	0
SP	75	9	-458	427	-51	-1171	0	0	0	0	0
SP	80	9	42	-666	-593	-147	0	0	0	0	0
SP	85	9	1130	427	-1869	-431	0	0	0	0	0
SP	90	9	-304	-430	-2055	-200	0	0	0	0	0
SP	25	10	-421	413	75	-150	1225	-149	143	2	-53
SP	30	10	-381	690	360	-380	1334	-390	485	17	134
SP	35	10	-189	836	352	-244	1362	-571	665	-77	262
SP	40	10	448	1119	240	43	727	-511	558	-93	146
SP	45	10	1179	1153	-73	290	62	-438	365	-118	37
SP	50	10	1433	1438	-56	492	-669	-290	636	-10	-64
SP	55	10	1898	1051	-332	1338	-880	126	463	68	-302
SP	60	10	1841	396	209	1752	-1305	-36	606	215	-502
SP	65	10	1295	1441	423	1174	-226	-742	1498	481	-110
SP	70	10	712	-130	-424	1418	0	0	0	0	0
SP	75	10	-782	1499.	296	89	0	0	0	0	0
SP	80	10	-991	198	35	1168	0	0	0	0	0

SP	75	12	-84	3674	-23	1902	0	0	0	0	0
SP	80	12	-85	2077	-160	1227	0	0	0	0	0
SP	85	12	939	1013	-1067	-124	0	0	0	0	0
SP	90	12	672	-204	-3358	-1253	0	0	0	0	0
SP	25	12	8	-250	-112	-23	-196	46	-105	-42	-23
SP	30	12	-74	-412	19	-37	-348	239	-182	-42	4
SP	35	12	-70	-665	134	220	-607	454	-167	-73	-56
SP	40	12	-112	-873	139	432	-796	710	-204	-135	-168
SP	45	12	315	-546	-12	473	-925	929	-451	-241	-278
SP	50	12	538	-184	-124	211	-468	911	-484	-259	-299
SP	55	12	450	-404	-18	284	-33	524	-118	-113	-313
SP	60	12	345	-749	-328	881	-265	535	142	-74	-283
SP	65	12	-50	-1017	-31	812	-191	540	529	-27	-407
SP	70	12	-194	-186	563	-300	0	0	0	0	0
SP	75	12	-260	645	351	-250	0	0	0	0	0
SP	80	12	-345	1191	409	12	0	0	0	0	0
SP	85	12	-101	-1061	-624	1611	0	0	0	0	0
SP	90	12	-475	1188	-2589	-1459	0	0	0	0	0

----- END OF FILE WRITTEN -----

APPENDIX C

SAMPLE INPUT AND OUTPUT FOR THE GRAM PROGRAM

Input to GRAM is as follows:

(All input data cards are in free field format.)

INITIAL HEIGHT	-	Height of starting position, km
INITIAL LATITUDE	-	Latitude of starting position (degrees, southern latitudes negative)
INITIAL WEST LONGITUDE	-	West longitude of starting position (degrees, 0 to 360 degrees, or east longitudes negative)
F10.7	-	Solar 10.7 cm radio noise flux (10^{-22} watts/m^2) at time of calculations. Use zero if height does not go over 90 km. Use 230 for design applications or consult Aerospace Environment Division (AED) of Marshall Space Flight Center (MSFC) for monthly predictions.
MEAN F10.7	-	81 day mean solar 10.7 cm flux. Use zero if height does not go over 90 km. Use 230 for design applications or consult AED, MSFC for monthly predictions.
AP	-	Geomagnetic index a_p. Use zero if height does not go over 90 km. Use 20.3 for design steady state conditions, or 400 for maximum conditions, or consult AED, MSFC.
DATE	-	Date for starting time of calculations (month, date, two digit year). Use month 13 for annual reference period.
GREENWICH TIME	-	Time for starting position (hours, minutes, seconds). Use time corresponding to local time - 0900 for design steady state, or 1400 maximum conditions.
LAT INCREMENT	-	Latitude displacement (degrees) between successive positions (new lat = old lat + lat increment). Use zero if trajectory positions are to be read in.
WEST LON INCREMENT	-	West longitude displacement (degrees) between successive positions (new long = old lon + lon increment). Use zero if trajectory positions are to be read in.
HEIGHT INCREMENT	-	Height decrease (km) between successive positions (new height = old height - height increment). Normal profiles are generated downward. If an upward generated profile id desired set height increment negative.

CARD 1

MAXIMUM NUMBER OF POSITIONS	-	Number of positions to be computed, not including initial position. Use zero if trajectory positions are to be read in.
TIME INCREMENT	-	Time displacement (seconds) between successive positions for automatically generated profiles (new time = old time + time increment)
TRAJECTORY OPTION	-	0 for linear profile generated automatically internal to the program, or value equal to unit number (e.g. 5 for card input) for a trajectory with each position to read in.
OUTPUT OPTION	-	0 for no non-print output of atmospheric parameter values, or value equal to unit number to get non-print output.
MIN. GEOSTROPH. LAT.	-	Lowest latitude (magnitude) for which geostrophic winds are to be used in 4-D (0-25 km) and Jacchia (above 90 km) height segments. Otherwise, interpolation is used to fill in winds. In middle heights (25-90 km), the spherical harmonic model is used at all latitudes.

CARD 2

GROVES INPUT UNIT	-	Unit number for tape containing Groves and stationary perturbations (SCIDAT tape in Appendix A). Use any available unit number.
RANDOM INPUT UNIT	-	Unit number of file from which random perturbation data are to be read. If same as Groves input unit, these are read from SCIDAT tape. If card input, use 5.
QBO INPUT UNIT	-	Unit number of file from which QBO parameters are to be read. If same as Groves input unit, these are read from SCIDAT tape. If card input, use 5.
4-D INPUT UNIT	-	Unit number for 4-D input data tape. Use any available unit number.
RANDOM OPTION	-	1 means compute random perturbation output, 2 means do not compute random perturbation output.
QBO OPTION	-	1 means compute QBO output, 2 means do not compute QBO output.
FIRST RANDOM NUMBER	-	Initial number for random number generator used to compute random perturbations (can be any odd positive integer). Use 1 for standard design applications.
NMC READ OPTION	-	0 means read NMC grid data from SCIDAT tape, otherwise these data are read from cards.
4-D, P, D, T, SCRATCH UNIT	-	Unit number for scratch file for 4-D grid profiles required in computations. Use any available unit number. This normally is a temporary drum file.

CARD 2 (cont'd.)	NMC GRID POINTS SCRATCH UNIT -	Unit number for scratch file to store NMC grid point data. Use any available unit number. This normally is a temporary drum file.
(OPTIONAL)*	INITIAL PL, DL, TL, PS, DS, TS -	Initial values of large scale and small scale random relative pressure, density, and temperature perturbations, percent. Use zeros for standard design applications.
	INITIAL UL, VL, US, VS -	Initial values of large scale and small scale random wind components, m/s. Use zeros for standard design applications.

* - Include card 3 only if random option = 1.

TRAJECTORY INPUT -	Use only if linear profile is not to be generated automatically. Each record has time (seconds), height (km), latitude (degrees), and west longitude (degrees).
TRAJECTORY BACKUP RECORD -	Only if trajectory input is used. Same form as a trajectory position but with any negative height value.

The trajectory input records are optional, in free field format. If included, use as many records (e.g. cards), as necessary.

Input for the following sample output listing is as follows:

CARD1: 92.0, 28.45, 80.53, .0, .0, .0, 1, 1, 75, 0, 0, 0, .0, .0, 2., 47, 0, 0, 0, 20,

CARD2: 3, 3, 3, 4, 1, 1, 1, 0, 12, 13

CARD3: 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,

A SUMMARY OF THE ORGANIZATION OF AN INPUT DATA DECK IS AS FOLLOWS

Initial Data

Card 1, as described at the beginning of this Appendix

Card 2, as described at the beginning of this Appendix

Card 3, optional, included only if random option = 1

NMC Grid Data

Optional. Include as card input only if this is not to be read from the SCIDAT data tape.

Random Perturbation Data

Optional. Include as card input only if the random input unit is 5 and these data are not to be read from the SCIDAT data tape or some other input file. Do not include if random option = 2.

QBO Parameters

Optional. Include as card input only if the QBO input unit is 5 and these data are not to be read from the SCIDAT data tape or some other file. Do not include if QBO option = 2.

Trajectory Position Data and Backup Card

Optional. Include if trajectory, rather than linear profile generated by the program is to be evaluated, and if trajectory option is 5. Trajectory data is on other file if trajectory unit is not 0 or 5.

More Data of the Same Kind (Starting with Initial Data, Card 1)

If additional trajectories or profiles are to be evaluated, the data may be input one set immediately after the other. The program is actually more efficient for such multiple runs if the month remains the same. This is because as long as the month remains the same the SCIDAT data tape read can be avoided for each subsequent data set.

OUTPUT TO GRAM IS AS FOLLOWS

JULIAN DATE	-	Computed from input date, set equal to zero for month 13 (annual average)
INITIAL STANDARD DEVIATIONS IN P, D, T, U, V FOR LARGE SCALE AND SMALL SCALE	-	Computed for initial position on input data

HEIGHT, LAT, LON, TIME	-	Position and time where atmospheric parameters are evaluated
UNPERTURBED PRESSURE DENSITY, TEMPERATURE AND GEOSTROPHIC WIND (monthly mean values)	-	Computed from Jacchia, 4-D, or Groves - plus - stationary perturbations, depending on height.
TOTAL PRESSURE, DENSITY, TEMPERATURE, AND WIND	-	Monthly means plus random perturbations and QBO perturbations
THERMAL WIND SHEAR		From thermal wind equations using finite differences of Jacchia, 4-D, or Groves - plus - stationary perturbations, depending on height.
MEAN VERTICAL WIND	-	From mean isentropic surface slopes
PERTURBATION VALUES	-	Stationary perturbations, QBO perturbations and amplitudes, and random perturbations and magnitudes for the small scale (S), large scale (L), and total (T) perturbations. Perturbations are those which are added to monthly means to produce total results output.

Following is a listing of sample output from the GRAM program. Initial lines of output are merely listings of the input data for easy reference. These listings are provided to indicate formats and kinds of input and output data. For a listing of the input cards for these sample outputs, see earlier in the Appendix.

1 ****** GLOBAL REFERENCE ATMOSPHERE - MOD 3 ******

INITIAL HEIGHT = 92.00 KM
F10.7 = 0.00
DATE = 1/ 1/75
LAT INCREMENT = 0.00 DEG
MAXIMUM NUMBER OF POSITIONS = 47
TRAJECTORY OPTION = 0

INITIAL LAT = 28.45 DEG
MEAN F10.7 = 0.00
GREENWICH TIME = 0: 0: 0
WEST LON INCREMENT = 0.00 DEG
TIME INCREMENT = 0 SEC
OUTPUT OPTION = 0

INITIAL WEST LON = 80.53 DEG
AP = 0.00
HEIGHT INCREMENT = 2.00 KM
MIN GEOSTROPH LAT = 18.0

GROVES INPUT UNIT = 3
4-D INPUT UNIT = 4
FIRST RANDOM NUMBER = 1
NMC READ OPTION = 0
NMC GRID POINTS SCRATCH UNIT = 13

RANDOM INPUT UNIT = 3
RANDOM OPTION = 1
4-D P,D,T DATA SCRATCH UNIT = 12
JULIAN DATE = 2442414.0

QBO INPUT UNIT = 3
QBO OPTION = 1

INITIAL P,D,T = 0.00 % 0.00 % 0.00 %
INITIAL U,V = 0.00 M/S 0.00 M/S

SIGMA P,D,T = 11.13 % 11.06 % 6.58 %
SIGMA U,V = 47.48 M/S 93.93 M/S LARGE SCALE

INITIAL P,D,T = 0.00 % 0.00 % 0.00 %
INITIAL U,V = 0.00 M/S 0.00 M/S

SIGMA P,D,T = 7.53 % 11.89 % 7.81 %
SIGMA U,V = 31.35 M/S 62.02 M/S SMALL SCALE

INITIAL UDL,VDL = -10.39 % -16.73 %

INITIAL UDS,VDS = -10.71 % -9.15 %

** PERCENT DEVIATIONS FROM 1962 US STANDARD ATMOSPHERE APPEAR BELOW PRESSURE, DENSITY AND TEMPERATURE VALUES **

			UNPERTURBED (MONTHLY MEAN)					MEAN PLUS PERTURBATIONS					THERMAL WIND SHEAR (M/S/KM)		PERTURBATION VALUES						
HEIGHT (KM) TIME (SEC)	LAT (DEG)	WEST LON (DEG)	PRES. (NT/ M**2)	DENS. (KG/ M**3)	TEMP (DEG KEL-VIN)	GEOSTROPH. WIND (M/S) E-W	N-S	PRES. (NT/ M**2)	DENS. (KG/ M**3)	TEMP (DEG KEL-VIN)	TOTAL WIND (M/S) E-W	N-S	E-W	N-S	P (%)	D (%)	T (%)	U M/S	V M/S	W CM/S	
90.00	28.45	80.53	.199E+00	.367E-05	189.	0.	4.	.230E+00	.390E-05	207.	-30.	66.	-.8	-.4						-.06	
0			21.0%	15.8%	4.5%			40.1%	23.0%	14.3%					7.9	7.8	.1				SP
															0.0	0.0	0.0	0.	0.		QBO
															0.0	0.0	0.0	0.	0.		MAG
															9.4	2.6	6.7	-4.	7.		RANS
															7.7	11.8	8.2	30.	62.		SIGS
															6.3	3.6	2.7	-26.	54.		RANL
															11.1	11.4	7.0	47.	97.		SIGL
															15.7	6.3	9.4	-30.	62.		RANT
															13.5	16.4	10.8	56.	115.		SIGT
88.00	28.45	80.53	.281E+00	.513E-05	191.	7.	7.	.331E+00	.556E-05	209.	13.	60.	-3.3	-1.2						-.09	
0			18.5%	12.0%	5.9%			39.4%	21.3%	15.6%					7.7	7.3	.4				SP
															-.1	-.1	-.0	-0.	0.		QBO
															.2	.1	.0	0.	0.		MAG
															7.6	-.5	8.1	14.	25.		RANS
															7.3	10.0	7.1	26.	52.		SIGS
															10.1	9.1	1.1	-8.	28.		RANL
															10.4	10.0	6.2	41.	82.		SIGL
															17.7	8.5	9.2	6.	53.		RANT

```
                                                                                          12.7 14.1  9.4  48.  97. SIGT
84.00  28.45  80.53 .398E+00 .716E-05  194.   14.    9. .455E+00 .747E-05  213.   22.    5. -3.3 -1.2                    -.16
 0                   16.0%     8.2%   7.4%                32.7%     12.9%  18.0%                  7.5  6.8   .7            SP
                                                                                          -.1  -.2  -.0  -1.    0. QBO
                                                                                           .4   .2   .1   1.    0. MAG
                                                                                          3.6 -2.0  5.6  22.  -13. RAMS
                                                                                          6.9  7.8  5.9  20.   39. SIGS
                                                                                         10.9  6.6  4.4 -13.    9. RAML
                                                                                          9.6  8.1  5.2  33.   64. SIGL
                                                                                         14.5  4.6  9.9   9.   -4. RAMT
                                                                                         11.8 11.3  7.9  39.   75. SIGT
84.00  28.45  80.53 .560E+00 .996E-05  196.   18.   10. .637E+00 .104E-04  214.    5.    5.  -.9   .6                    -.25
 0                   12.9%     4.1%   8.7%                28.5%      8.8%  18.6%                  7.3  6.4  1.0            SP
                                                                                          -.1  -.4  -.0  -1.    0. QBO
                                                                                           .6   .4   .1   1.    0. MAG
                                                                                          6.4  1.1  5.3  28.   -1. RAMS
                                                                                          6.5  6.5  5.1  17.   30. SIGS
                                                                                          7.5  3.7  3.8 -40.   -4. RAML
                                                                                          8.9  6.9  4.5  29.   50. SIGL
                                                                                         14.0  4.8  9.1 -12.   -5. RAMT
                                                                                         11.0  9.5  6.8  34.   58. SIGT
82.00  28.45  80.53 .782E+00 .138E-04  198.   20.    9. .868E+00 .146E-04  208.   -3.   -9.  -.9   .6                    -.28
 0                    9.1%     -.4%   9.8%                21.1%      5.3%  15.2%                  6.9  5.8  1.1            SP
                                                                                          -.1  -.4  -.0  -1.    0. QBO
                                                                                           .8   .5   .2   1.    0. MAG
                                                                                         10.6  4.7  5.9  19.    0. RAMS
                                                                                          6.1  6.2  4.7  17.   26. SIGS
                                                                                           .5  1.4  -.8 -40.  -18. RAML
                                                                                          8.2  6.9  4.3  29.   45. SIGL
                                                                                         11.1  6.1  5.0 -21.  -18. RAMT
                                                                                         10.2  9.3  6.4  33.   53. SIGT
80.00  28.45  80.53 .109E+01 .191E-04  200.   21.    7. .120E+01 .207E-04  202.  -14.   -2.  -.9   .6                    -.31
 0                    5.3%    -4.7%  10.8%                15.8%      3.3%  12.0%                  6.5  5.2  1.3            SP
                                                                                          -.0  -.5  -.0  -1.    0. QBO
                                                                                          1.0   .6   .2   2.    0. MAG
                                                                                          6.8  4.5  2.3   3.    3. RAMS
                                                                                          5.6  6.0  4.4  16.   23. SIGS
                                                                                          3.2  4.5 -1.3 -37.  -13. RAML
                                                                                          7.4  6.9  4.0  29.   40. SIGL
                                                                                         10.0  9.0  1.1 -35.  -10. RAMT
                                                                                          9.3  9.1  5.9  33.   46. SIGT
78.00  28.45  80.53 .152E+01 .262E-04  203.   28.    4. .163E+01 .279E-04  203.    2.  -28. -3.1  1.5                    -.36
 0                    2.2%    -4.8%   7.7%                 9.7%      1.3%   7.9%                  6.1  4.7  1.4            SP
                                                                                           .0  -.6  -.0  -0.    0. QBO
                                                                                          1.2   .7   .2   2.    0. MAG
                                                                                          3.2  4.1  -.9   1.   -1. RAMS
                                                                                          5.2  5.9  4.6  17.   21. SIGS
                                                                                          4.1  2.9  1.1 -26.  -32. RAML
                                                                                          6.8  7.0  4.3  31.   39. SIGL
```

```
                                                                                          7.3  7.1   .2 -25.  -33. RANT
                                                                                          8.6  9.2  6.3  35.   45. SIGT

76.00  28.45  80.53 .212E+01 .359E-04  206.   34.    2. .225E+01 .382E-04  204.   11.  -44. -3.1  1.5                  -.37
  0                       .7%    -3.8%   4.7%                 7.0%      2.2%   3.9%                  5.7  4.1  1.6            SP
                                                                                           .2  -.6  -.0   0.    0. QBO
                                                                                          1.4   .9   .3   2.    0. MAG
                                                                                         -2.4   .5 -2.9   2.   -3. RANS
                                                                                          4.8  5.8  4.8  17.   20. SIGS
                                                                                          8.5  6.4  2.1 -25.  -43. RANL
                                                                                          6.2  7.2  4.5  33.   38. SIGL
                                                                                          6.1  6.9  -.8 -23.  -46. RANT
                                                                                          7.8  9.2  6.6  37.   43. SIGT

74.00  28.45  80.53 .293E+01 .490E-04  208.   38.   -2. .289E+01 .527E-04  188.   -2.  -23. -1.1  1.7                  -.28
  0                      -.3%    -2.2%   2.0%                -1.8%      5.0%  -8.0%                  5.4  4.3  1.1            SP
                                                                                           .3  -.5   .0   1.    0. QBO
                                                                                          1.6  1.0   .3   3.    0. MAG
                                                                                         -7.4  1.6 -9.0  -6.    4. RANS
                                                                                          4.6  5.6  4.6  18.   18. SIGS
                                                                                          5.5  6.4  -.9 -35.  -26. RANL
                                                                                          5.8  7.2  4.5  34.   34. SIGL
                                                                                         -1.9  8.0 -9.9 -41.  -21. RANT
                                                                                          7.4  9.1  6.4  38.   39. SIGT

72.00  28.45  80.53 .401E+01 .659E-04  212.   40.   -5. .441E+01 .760E-04  199.    1.    9. -1.1  1.7                  -.14
  0                      -.9%    -1.0%    .1%                 8.9%     14.1%  -6.3%                  5.2  4.4   .7            SP
                                                                                           .5  -.4   .0   1.    1. QBO
                                                                                          1.8  1.2   .4   3.    1. MAG
                                                                                         -1.9  4.2 -6.0  -8.   15. RANS
                                                                                          4.6  5.3  3.8  19.   15. SIGS
                                                                                         11.2 11.6  -.4 -32.   -2. RANL
                                                                                          5.9  7.2  4.1  35.   28. SIGL
                                                                                          9.3 15.7 -6.4 -41.   13. RANT
                                                                                          7.4  8.9  5.6  40.   32. SIGT

70.00  28.45  80.53 .550E+01 .887E-04  216.   43.   -8. .586E+01 .974E-04  207.  -14.   -5. -1.1  1.7                  -.00
  0                      -.4%     1.3%  -1.7%                 6.1%     11.3%  -6.0%                  5.0  4.6   .3            SP
                                                                                           .7  -.3   .1   2.    1. QBO
                                                                                          2.0  1.3   .4   3.    1. MAG
                                                                                          -.8  1.9 -2.7 -16.    4. RANS
                                                                                          4.6  5.1  3.0  20.   11. SIGS
                                                                                          6.6  8.3 -1.7 -43.   -1. RANL
                                                                                          5.9  7.1  3.5  36.   19. SIGL
                                                                                          5.8 10.1 -4.4 -59.    3. RANT
                                                                                          7.4  8.7  4.6  41.   22. SIGT

68.00  28.45  80.53 .742E+01 .116E-03  222.   48.   -6. .737E+01 .122E-03  207.   30.  -29. -2.9 -1.1                  -.39
  0                      -.4%     1.9%  -2.2%                -1.0%      7.1%  -8.8%                  4.7  4.8  -.1            SP
                                                                                          1.0  -.1   .1   3.    1. QBO
                                                                                          2.2  1.4   .4   3.    1. MAG
                                                                                         -4.7  -.8 -3.9  -7.    1. RANS
                                                                                          4.5  4.9  2.6  20.   12. SIGS
                                                                                          3.1  6.0 -2.9 -14.  -25. RAML
```

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                                                                                                   5.8  7.1  3.4  34.   20. SIGL
                                                                                                  -1.6  5.2 -6.8 -22.  -24. RANT
                                                                                                   7.4  8.6  4.3  40.   23. SIGT

66.00  28.45  80.53 .100E+02 .152E-03  230.   54.   -4. .105E+02 .161E-03  225.   28.  -21.  -2.9 -1.1                       -.33
  0                      .8%      3.2%  -2.3%               5.8%      9.7%  -4.6%                      4.8  4.8  -.1            SP
                                                                                                   1.2   .1   .1   4.    1. QBO
                                                                                                   2.4  1.5   .5   4.    1. MAG
                                                                                                  -4.7 -3.4 -1.2  -3.    8. RANS
                                                                                                   4.4  4.6  2.3  20.   13. SIGS
                                                                                                   8.4  9.6 -1.2 -27.  -26. RANL
                                                                                                   5.8  7.1  3.3  32.   20. SIGL
                                                                                                   3.7  6.2 -2.5 -30.  -18. RANT
                                                                                                   7.3  8.5  4.0  38.   24. SIGT

64.00  28.45  80.53 .133E+02 .196E-03  237.   52.   -1. .136E+02 .202E-03  233.   -3.  -21.   4.7 -1.8                        .01
  0                     1.5%      4.1%  -2.5%               3.6%      7.4%  -4.4%                      4.8  4.9  -.1            SP
                                                                                                   1.6   .6   .2   4.    1. QBO
                                                                                                   2.6  1.6   .5   4.    1. MAG
                                                                                                  -2.4 -2.1  -.3 -26.   14. RANS
                                                                                                   4.4  4.5  2.1  19.   14. SIGS
                                                                                                   2.9  4.8 -1.8 -33.  -34. RANL
                                                                                                   5.8  6.8  3.1  30.   19. SIGL
                                                                                                    .5  2.6 -2.1 -59.  -20. RANT
                                                                                                   7.2  8.1  3.8  35.   24. SIGT

62.00  28.45  80.53 .175E+02 .250E-03  244.   43.    3. .184E+02 .264E-03  241.   -5.  -19.   4.7 -1.8                        .39
  0                     1.6%      4.6%  -2.8%               6.4%     10.4%  -4.2%                      4.8  4.9  -.1            SP
                                                                                                   2.1  1.1   .3   4.    1. QBO
                                                                                                   2.8  1.8   .6   4.    1. MAG
                                                                                                  -1.7 -1.2  -.5 -27.   13. RANS
                                                                                                   4.3  4.3  2.2  18.   13. SIGS
                                                                                                   4.3  5.5 -1.2 -25.  -35. RANL
                                                                                                   5.7  6.3  2.8  27.   17. SIGL
                                                                                                   2.6  4.3 -1.7 -52.  -22. RANT
                                                                                                   7.1  7.6  3.6  32.   21. SIGT

60.00  28.45  80.53 .230E+02 .320E-03  251.   33.    6. .229E+02 .323E-03  246.   -9.   -7.   4.7 -1.8                        .74
  0                     2.4%      4.5%  -1.9%               1.8%      5.6%  -3.9%                      4.8  4.9  -.1            SP
                                                                                                   2.5  1.6   .3   4.    0. QBO
                                                                                                   3.0  1.9   .6   5.    1. MAG
                                                                                                  -6.1 -3.6 -2.5 -17.    9. RANS
                                                                                                   4.2  4.1  2.2  16.   13. SIGS
                                                                                                   3.1  3.0   .1 -31.  -23. RANL
                                                                                                   5.7  5.7  2.5  24.   14. SIGL
                                                                                                  -3.0  -.6 -2.4 -47.  -14. RANT
                                                                                                   7.0  7.0  3.3  28.   19. SIGT

58.00  28.45  80.53 .299E+02 .406E-03  257.   28.    6. .298E+02 .417E-03  249.  -36.    3.   2.6   .2                        .58
  0                     2.6%      3.9%  -1.1%               2.3%      6.7%  -4.2%                      4.7  4.6   .1            SP
                                                                                                   2.3  1.8   .3   4.    1. QBO
                                                                                                   2.8  2.1   .5   5.    1. MAG
                                                                                                  -5.3 -3.1 -2.2 -25.   16. RANS
                                                                                                   4.1  3.9  2.2  15.   12. SIGS
```

```
                                                                                       2.8  4.0 -1.2 -43. -20. RAML
                                                                                       5.4  5.3  2.3  24.  13. SIGL
                                                                                      -2.5   .9 -3.5 -68.  -4. RANT
                                                                                       6.8  6.6  3.1  28.  18. SIGT

56.00  28.45  80.53 .388E+02 .515E-03  263.   23.   6. .432E+02 .575E-03  262.  -36.   10.  2.6   .2                .48
  0                    3.2%     3.6%   -.3%                14.6%    15.5%   -.6%                   4.6  4.3   .3            SP
                                                                                       2.1  2.0   .2   3.   1. QBO
                                                                                       2.6  2.3   .4   5.   1. MAG
                                                                                      -1.0   .4 -1.4 -15.  29. RAMS
                                                                                       3.9  3.8  2.1  14.  12. SIGS
                                                                                       9.8  8.9   .9 -48. -26. RAML
                                                                                       5.2  4.9  2.1  25.  11. SIGL
                                                                                       8.8  9.3  -.5 -63.   4. RANT
                                                                                       6.5  6.2  2.9  28.  17. SIGT

54.00  28.45  80.53 .501E+02 .652E-03  267.   18.   6. .525E+02 .696E-03  264.  -17.    8.  2.3  -.0                .30
  0                    3.2%     3.3%   -.0%                 8.3%    10.3%  -1.5%                   4.5  4.0   .5            SP
                                                                                       2.1  2.2   .2   3.   1. QBO
                                                                                       2.5  2.5   .3   5.   1. MAG
                                                                                      -2.7  -.3 -2.4  -9.  19. RAMS
                                                                                       3.8  3.6  2.0  14.  12. SIGS
                                                                                       5.4  4.6   .8 -29. -17. RAML
                                                                                       5.0  4.7  1.9  25.  11. SIGL
                                                                                       2.7  4.4 -1.6 -38.   2. RANT
                                                                                       6.3  5.9  2.7  28.  16. SIGT

52.00  28.45  80.53 .640E+02 .824E-03  271.   14.   6. .711E+02 .920E-03  271.  -18.   17.  2.3  -.0                .15
  0                    2.8%     2.9%    .2%                14.3%    14.9%    .0%                   4.4  3.7   .7            SP
                                                                                       2.2  2.4   .1   3.   0. QBO
                                                                                       2.5  2.6   .3   5.   1. MAG
                                                                                      -1.1  1.8 -2.8  -8.  20. RAMS
                                                                                       3.6  3.5  1.8  13.  12. SIGS
                                                                                       9.8  7.2  2.6 -26.  -9. RAML
                                                                                       4.9  4.6  1.7  26.  11. SIGL
                                                                                       8.8  9.0  -.2 -34.  11. RANT
                                                                                       6.1  5.7  2.5  29.  16. SIGT

50.00  28.45  80.53 .811E+02 .103E-02  275.    9.   6. .848E+02 .111E-02  268.  -27.   14.  2.3  -.0                .05
  0                    1.7%      .5%   1.5%                 6.3%     8.1%  -1.1%                   3.5  2.6   .9            SP
                                                                                       2.3  2.6   .1   2.  -0. QBO
                                                                                       2.6  2.6   .2   4.   2. MAG
                                                                                      -4.5   .9 -5.4 -23.  15. RAMS
                                                                                       3.5  3.4  1.6  12.  11. SIGS
                                                                                       6.6  3.9  2.7 -15.  -6. RAML
                                                                                       4.7  4.5  1.6  26.  11. SIGL
                                                                                       2.1  4.8 -2.7 -38.   9. RANT
                                                                                       5.9  5.6  2.3  29.  16. SIGT

48.00  28.45  80.53 .103E+03 .132E-02  273.    8.   4. .106E+03 .135E-02  274.  -12.    3.   .5   .6               -.03
  0                    1.1%      .0%   1.0%                 3.5%     2.4%   1.3%                   2.6  1.5  1.0            SP
                                                                                       2.4  2.5   .3   1.  -0. QBO
                                                                                       2.5  2.5   .4   4.   1. MAG
                                                                                      -4.5 -1.3 -3.3  -8.   6. RAMS
```

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                                                                                                3.3  3.2  1.7  11.   11. SIGS
                                                                                                4.6  1.2  3.3 -13.   -8. RAML
                                                                                                4.6  4.3  1.7  25.   11. SIGL
                                                                                                 .0  -.1   .1 -21.   -1. RANT
                                                                                                5.6  5.4  2.4  28.   15. SIGT

46.00  28.45  80.53 .132E+03 .168E-02  272.    7.    3. .134E+03 .174E-02  268.  -35.    9.   .5   .6                   -.07
  0                      .3%    -2.0%  2.0%                1.7%     1.3%    .5%                  1.6   .3  1.2             SP
                                                                                                2.4  2.4   .5  -0.   -1. QBO
                                                                                                2.5  2.4   .7   3.    1. MAG
                                                                                               -3.2  -.5 -2.7  -3.   17. RANS
                                                                                                3.1  3.0  1.7  11.   10. SIGS
                                                                                                2.2  1.4   .7 -39.  -10. RAML
                                                                                                4.4  4.2  1.8  25.   10. SIGL
                                                                                               -1.0  1.0 -2.0 -41.    7. RANT
                                                                                                5.4  5.1  2.5  27.   14. SIGT

44.00  28.45  80.53 .168E+03 .216E-02  269.    6.    2. .164E+03 .214E-02  267.  -23.    7.   .3   .7                   -.07
  0                     -.9%    -4.3%  3.1%               -3.1%    -5.2%   2.3%                   .7  -.8  1.4             SP
                                                                                                2.4  2.1   .7  -1.   -1. QBO
                                                                                                2.4  2.1   .8   3.    1. MAG
                                                                                               -4.5 -2.4 -2.2  -3.   16. RANS
                                                                                                2.9  2.8  1.8  10.    9. SIGS
                                                                                                 .1  -.6   .7 -25.  -10. RAML
                                                                                                4.2  3.9  1.9  24.   10. SIGL
                                                                                               -4.4 -3.0 -1.4 -28.    6. RANT
                                                                                                5.1  4.8  2.6  26.   13. SIGT

42.00  28.45  80.53 .218E+03 .286E-02  264.    6.    0. .213E+03 .283E-02  262.  -14.    7.   .3   .7                   -.05
  0                    -1.0%    -4.5%  3.3%               -3.1%    -5.4%   2.3%                  1.3  -.0  1.3             SP
                                                                                                2.2  1.8   .7  -3.   -1. QBO
                                                                                                2.2  1.8   .8   4.    1. MAG
                                                                                               -8.0 -3.3 -4.7  -4.   11. RANS
                                                                                                2.7  2.6  1.8   9.    8. SIGS
                                                                                                3.8   .7  3.1 -13.   -3. RAML
                                                                                                4.0  3.5  2.0  22.    9. SIGL
                                                                                               -4.3 -2.6 -1.6 -17.    8. RANT
                                                                                                4.8  4.3  2.7  24.   12. SIGT

40.00  28.45  80.53 .279E+03 .373E-02  260.    5.   -1. .287E+03 .380E-02  263.  -11.   -2.   .3   .7                   -.05
  0                    -3.0%    -6.7%  3.8%                -.0%    -5.0%   5.1%                   .7  -.8  1.4             SP
                                                                                                2.1  1.4   .8  -5.   -2. QBO
                                                                                                2.1  1.4   .8   5.    2. MAG
                                                                                               -2.0 -1.5  -.6   4.    6. RANS
                                                                                                2.6  2.3  1.8   8.    7. SIGS
                                                                                                2.9  1.8  1.1 -16.   -5. RAML
                                                                                                3.7  3.1  2.1  20.    8. SIGL
                                                                                                 .9   .4   .5 -12.    0. RANT
                                                                                                4.5  3.8  2.8  22.   11. SIGT

38.00  28.45  80.53 .365E+03 .504E-02  252.    6.   -2. .380E+03 .521E-02  254.  -17.    7.  -.4   .5                   -.07
  0                    -3.3%    -6.1%  2.9%                 .8%    -2.9%   3.9%                   .2  -.9  1.1             SP
                                                                                                1.8  1.2   .8  -7.   -1. QBO
                                                                                                1.8  1.2   .8   7.    1. MAG
```

```
                                                                                                   -1.4 -1.5   .0  -0.   10. RANS
                                                                                                    2.3  2.2  1.9   8.    7. SIGS
                                                                                                    3.8  3.7   .1 -16.    1. RANL
                                                                                                    3.4  2.9  2.0  19.    8. SIGL
                                                                                                    2.4  2.2   .1 -17.   11. RANT
                                                                                                    4.2  3.6  2.8  20.   10. SIGT

36.00  28.45  80.53 .477E+03 .681E-02  244.    7.   -3. .510E+03 .700E-02  255.  -15.    -5.  -.4   .5                          -.13
  0                   -4.3%    -6.2%   2.0%                 2.4%    -3.5%   6.4%                    -.3 -1.1   .8               SP
                                                                                                    1.6  1.0   .8  -9.   -1. QBO
                                                                                                    1.6  1.0   .9   9.    1. MAG
                                                                                                     .8 -1.8  2.5   2.    0. RANS
                                                                                                    2.1  2.2  1.9   7.    7. SIGS
                                                                                                    4.5  3.6   .9 -15.   -1. RANL
                                                                                                    3.1  2.7  1.9  17.    7. SIGL
                                                                                                    5.3  1.8  3.4 -13.   -1. RANT
                                                                                                    3.8  3.4  2.7  19.   10. SIGT

34.00  28.45  80.53 .628E+03 .921E-02  238.    7.   -4. .657E+03 .949E-02  242.  -19.     5.   .6   .1                          -.18
  0                   -5.3%    -6.9%   1.8%                 -.9%    -4.0%   3.7%                    -.8 -1.2   .5               SP
                                                                                                    1.3   .7   .9  -9.   -1. QBO
                                                                                                    1.3   .8   .9  10.    1. MAG
                                                                                                     .3  -.1   .4   6.    9. RANS
                                                                                                    1.9  2.1  1.8   6.    6. SIGS
                                                                                                    2.9  2.4   .5 -21.    1. RANL
                                                                                                    2.8  2.5  1.8  16.    7. SIGL
                                                                                                    3.2  2.3   .9 -16.   10. RANT
                                                                                                    3.4  3.2  2.6  17.    9. SIGT

32.00  28.45  80.53 .833E+03 .125E-01  233.    5.   -4. .833E+03 .124E-01  235.   -3.    -3.   .6   .1                          -.15
  0                   -6.3%    -8.1%   2.2%                -6.3%    -8.3%   2.7%                   -1.2 -1.4   .2               SP
                                                                                                    1.0   .5   .9  -9.   -1. QBO
                                                                                                    1.0   .7   .9  10.    1. MAG
                                                                                                   -1.9  -.9  -.9  10.    3. RANS
                                                                                                    1.8  1.9  1.8   6.    5. SIGS
                                                                                                     .8   .2   .6  -9.   -2. RANL
                                                                                                    2.5  2.3  1.7  14.    6. SIGL
                                                                                                   -1.0  -.7  -.3   1.    2. RANT
                                                                                                    3.1  3.0  2.4  15.    8. SIGT

30.00  28.45  80.53 .110E+04 .169E-01  229.    4.   -4. .114E+04 .169E-01  236.    1.    -8.   .6   .1                          -.11
  0                   -7.8%    -8.4%   1.0%                -5.0%    -8.2%   4.4%                   -1.7 -1.5  -.1               SP
                                                                                                     .8   .2  1.0  -8.   -1. QBO
                                                                                                     .8   .5  1.0  10.    1. MAG
                                                                                                    -.0 -1.2  1.2  10.   -3. RANS
                                                                                                    1.6  1.8  1.7   5.    4. SIGS
                                                                                                    2.3  1.2  1.1  -4.   -1. RANL
                                                                                                    2.2  2.1  1.5  12.    4. SIGL
                                                                                                    2.3  -.0  2.3   5.   -4. RANT
                                                                                                    2.7  2.8  2.3  13.    6. SIGT

28.00  28.45  80.53 .151E+04 .235E-01  225.    4.   -3. .151E+04 .228E-01  231.    6.    -8.   .2  -.1                          -.09
  0                   -6.4%    -6.2%    .1%                -6.8%    -9.1%   3.1%                    0.0  0.0  0.0               SP
                                                                                                     .5  -.2   .9  -6.   -1. QBO
```

```
                                                                               .6   .6  1.0   9.    1. MAG
                                                                              -.8 -2.7  1.9   3.   -3. RANS
                                                                              1.5  1.6  1.5   4.    3. SIGS
                                                                              -.0  -.2   .1   6.   -0. RANL
                                                                              2.0  1.9  1.4  11.    4. SIGL
                                                                              -.9 -2.9  2.1   9.   -3. RANT
                                                                              2.5  2.4  2.1  12.    5. SIGT
26.00  28.45  80.53 .207E+04 .328E-01  220.   3.  -3. .208E+04 .316E-01  230.   5.   0.   .2  -.1
  0                   -5.3%    -4.3%  -1.0%              -4.8%    -7.7%  3.3%                          -.07
                                                                              0.0  0.0  0.0             SP
                                                                               .2  -.6   .9  -5.   -1. OBO
                                                                               .4   .7   .9   8.    1. MAG
                                                                               .8 -1.5  2.4   7.    2. RANS
                                                                              1.3  1.3  1.3   4.    3. SIGS
                                                                              -.5 -1.5  1.0  -0.    2. RANL
                                                                              1.8  1.6  1.3  10.    3. SIGL
                                                                               .3 -3.0  3.3   7.    4. RANT
                                                                              2.2  2.0  1.9  10.    4. SIGT
24.00  28.45  80.53 .284E+04 .457E-01  216.   4.  -2. .285E+04 .449E-01  221.   1.  -2.  1.1   .3
  0                   -4.6%    -2.6%  -1.9%              -4.2%    -4.4%   .3%                          -.05
                                                                              0.0  0.0  0.0             SP
                                                                               .1  -.7   .8  -3.   -1. OBO
                                                                               .3   .7   .9   7.    1. MAG
                                                                               .2  -.2   .3   0.    2. RANS
                                                                               .5   .6   .6   3.    3. SIGS
                                                                               .1 -1.0  1.2  -0.   -1. RANL
                                                                               .6   .7   .6   8.    3. SIGL
                                                                               .3 -1.2  1.5  -0.    1. RANT
                                                                               .8   .9   .8   9.    4. SIGT
22.00  28.45  80.53 .391E+04 .643E-01  212.   6.  -1. .389E+04 .636E-01  213.   5.  -5.  -.1  -.0
  0                   -3.5%     -.3%  -3.2%              -3.9%    -1.4%  -2.5%                          .00
                                                                              0.0  0.0  0.0             SP
                                                                               .1  -.5   .7  -0.   -1. OBO
                                                                               .2   .6   .7   6.    1. MAG
                                                                               .0  -.2   .2   3.    1. RANS
                                                                               .4   .6   .5   3.    3. SIGS
                                                                              -.6  -.4  -.2  -3.   -4. RANL
                                                                               .6   .7   .5   8.    3. SIGL
                                                                              -.6  -.5  -.0  -0.   -3. RANT
                                                                               .7  1.0   .8   9.    5. SIGT
20.00  28.45  80.53 .545E+04 .914E-01  207.  16.   3. .546E+04 .916E-01  208.   6.  -3. -1.6  -.3
  0                   -1.5%     2.8%  -4.2%              -1.3%     3.0%  -4.0%                         -.00
                                                                              0.0  0.0  0.0             SP
                                                                               .1  -.3   .6   2.   -0. OBO
                                                                               .2   .5   .6   5.    1. MAG
                                                                              -.6  -.6  -.0   0.    1. RANS
                                                                               .4   .7   .5   3.    3. SIGS
                                                                               .7  1.1  -.4 -12.   -6. RANL
                                                                               .6   .9   .5   8.    4. SIGL
                                                                               .1   .5  -.4 -11.   -5. RANT
                                                                               .7  1.1   .8   8.    5. SIGT
18.00  28.45  80.53 .759E+04 .129E+00  205.  19.   4. .759E+04 .128E+00  206.  12.  -0. -3.3  -.4
  0                     .3%     6.0%  -5.4%                .3%     5.6%  -5.0%                         -.07
                                                                              0.0  0.0  0.0             SP
```

															.1	-.3	.5	2.	-0.	QBO
															.2	.4	.5	4.	0.	MAG
															-.1	-.5	.3	2.	3.	RAMS
															.5	.9	.6	3.	5.	SIGS
															.0	.4	-.3	-11.	-8.	RAML
															.6	1.0	.6	9.	5.	SIGL
															-.1	-.1	-.0	-9.	-4.	RAMT
															.8	1.3	.8	9.	7.	SIGT
16.00	28.45	80.53	.107E+05	.183E+00	204.	30.	3.	.107E+05	.181E+00	207.	16.	-15.	-4.1	-.3						-.09
0			3.5%	9.8%	-5.8%			3.7%	8.7%	-4.6%					0.0	0.0	0.0			SP
															.1	-.2	.4	2.	-0.	QBO
															.1	.3	.4	3.	0.	MAG
															-.4	-1.2	.8	2.	-8.	RAMS
															.6	1.1	.7	3.	6.	SIGS
															.5	.5	.0	-18.	-10.	RAML
															.7	1.2	.6	10.	7.	SIGL
															.2	-.7	.9	-16.	-18.	RAMT
															.9	1.6	.9	10.	9.	SIGT
14.00	28.45	80.53	.149E+05	.246E+00	210.	37.	4.	.148E+05	.244E+00	212.	22.	-6.	-1.1	-.1						-.04
0			5.0%	8.1%	-2.9%			4.7%	7.2%	-2.3%					0.0	0.0	0.0			SP
															.0	-.2	.2	2.	-0.	QBO
															.1	.2	.2	2.	0.	MAG
															-.8	-1.2	.4	-6.	1.	RAMS
															.7	1.1	.7	4.	7.	SIGS
															.5	.5	.0	-11.	-10.	RAML
															.9	1.3	.7	11.	8.	SIGL
															-.3	-.7	.4	-17.	-9.	RAMT
															1.1	1.7	1.0	12.	11.	SIGT
12.00	28.45	80.53	.205E+05	.328E+00	217.	35.	3.	.204E+05	.335E+00	212.	20.	-11.	2.1	.1						.07
0			5.5%	5.2%	.3%			5.2%	7.3%	-2.0%					0.0	0.0	0.0			SP
															.0	-.1	.1	1.	-0.	QBO
															.0	.1	.1	1.	0.	MAG
															-.4	.6	-1.0	4.	-8.	RAMS
															.7	1.0	.8	4.	8.	SIGS
															.1	1.5	-1.3	-20.	-6.	RAML
															.9	1.1	.7	13.	9.	SIGL
															-.3	2.1	-2.4	-16.	-15.	RAMT
															1.1	1.5	1.1	13.	12.	SIGT
10.00	28.45	80.53	.278E+05	.421E+00	230.	32.	3.	.282E+05	.423E+00	232.	11.	-1.	3.5	.2						.16
0			4.8%	1.8%	3.0%			6.6%	2.4%	4.1%					0.0	0.0	0.0			SP
															0.0	0.0	0.0	0.	0.	QBO
															0.0	0.0	0.0	0.	0.	MAG
															.1	-.7	.7	-5.	-4.	RAMS
															.7	.9	.8	5.	9.	SIGS
															1.6	1.2	.3	-17.	-0.	RAML
															.9	1.0	.8	14.	10.	SIGL
															1.7	.6	1.1	-22.	-4.	RAMT
															1.1	1.3	1.1	15.	14.	SIGT
8.00	28.45	80.53	.370E+05	.529E+00	244.	26.	3.	.367E+05	.526E+00	243.	4.	-9.	3.9	.2						.46

```
 0                  3.9%      .6%   3.3%            3.1%      .0%   3.0%
                                                                              0.0  0.0  0.0          SP
                                                                              0.0  0.0  0.0   0.   0. QBO
                                                                              0.0  0.0  0.0   0.   0. MAG
                                                                              -.3  -.0  -.3  -4.  -2. RAMS
                                                                               .6   .8   .8   4.   8. SIGS
                                                                              -.5  -.5   .0 -18. -10. RAML
                                                                               .8   .8   .8  12.   9. SIGL
                                                                              -.8  -.5  -.3 -22. -13. RAMT
                                                                              1.0  1.1  1.1  13.  12. SIGT
6.00  28.45  80.53 .486E+05 .654E+00  259.   20.   3. .479E+05 .655E+00  255.   4.  -14.  3.6   .3        .27
 0                  2.9%     -.9%   3.8%            1.5%     -.7%   2.3%
                                                                              0.0  0.0  0.0          SP
                                                                              0.0  0.0  0.0   0.   0. QBO
                                                                              0.0  0.0  0.0   0.   0. MAG
                                                                              -.7   .5 -1.3   0.  -9. RAMS
                                                                               .5   .7   .7   3.   6. SIGS
                                                                              -.6  -.4  -.2 -16.  -8. RAML
                                                                               .7   .7   .7  10.   8. SIGL
                                                                             -1.3   .1 -1.4 -15. -17. RAMT
                                                                               .9  1.0  1.0  11.  10. SIGT
4.00  28.45  80.53 .628E+05 .808E+00  271.   12.   3. .631E+05 .808E+00  272.  15.   -2.  3.5   .3        .28
 0                  1.9%    -1.4%   3.3%            2.3%    -1.4%   3.8%
                                                                              0.0  0.0  0.0          SP
                                                                              0.0  0.0  0.0   0.   0. QBO
                                                                              0.0  0.0  0.0   0.   0. MAG
                                                                               .2  -.3   .6  -1.  -6. RAMS
                                                                               .5   .6   .7   3.   5. SIGS
                                                                               .2   .3  -.1   3.   1. RAML
                                                                               .6   .7   .7   9.   6. SIGL
                                                                               .4  -.1   .5   2.  -5. RAMT
                                                                               .7   .9  1.0   9.   8. SIGT
2.00  28.45  80.53 .804E+05 .996E+00  281.    6.   2. .807E+05 .989E+00  284.   5.    2.  3.5  1.0       -.00
 0                  1.1%    -1.1%   2.2%            1.5%    -1.7%   3.2%
                                                                              0.0  0.0  0.0          SP
                                                                              0.0  0.0  0.0   0.   0. QBO
                                                                              0.0  0.0  0.0   0.   0. MAG
                                                                               .2  -.6   .7  -3.  -3. RAMS
                                                                               .4   .8   .8   2.   4. SIGS
                                                                               .2  -.1   .3   2.   3. RAML
                                                                               .5   .8   .8   7.   5. SIGL
                                                                               .4  -.7  1.0  -1.   0. RAMT
                                                                               .6  1.1  1.2   7.   7. SIGT
0.00  28.45  80.53 .102E+06 .123E+01  288.   -1.  -1. .102E+06 .124E+01  287.  -4.    4.  5.6  1.4       -.14
 0                   .8%      .7%    .1%             .7%     1.2%   -.5%
                                                                              0.0  0.0  0.0          SP
                                                                              0.0  0.0  0.0   0.   0. QBO
                                                                              0.0  0.0  0.0   0.   0. MAG
                                                                              -.3  -.0  -.3   0.   1. RAMS
                                                                               .3  1.4  1.4   1.   3. SIGS
                                                                               .3   .6  -.3  -3.   4. RAML
                                                                               .4  1.4  1.4   5.   4. SIGL
                                                                              -.1   .5  -.6  -3.   5. RAMT
                                                                               .5  1.9  2.0   5.   5. SIGT
```

APPENDIX D - GRAM PROGRAM LISTING

Following is a listing of the Global Reference Atmospheric Model (GRAM) - Mod 3. Sequence numbers containing a four character subroutine code and a four digit number appear on the right of the printout.

```
C     FIRST DATA CARD READS INITIAL HEIGHT (KM), INITIAL LATITUDE (DEG)
C        INITIAL LONGITUDE (DEG), F10.7, MEAN F10.7, AP, MONTH, DAY,
C        YEAR (TOTAL YEAR - 1900), GREENWICH HOUR, MINUTES, SECONDS,
C        LATITUDE INCREMENT (DEG), LONGITUDE INCREMENT (DEG),
C        HEIGHT DECREASE (KM), MAXIMUM NUMBER OF POSITIONS (EXCLUDING
C        INITIAL POSITION) TO BE COMPUTED, TIME INCREMENT BETWEEN
C        POSITIONS, TRAJECTORY OPTION, OUTPUT OPTION,MINIMUM GEOSTROPHIC
C         LATITUDE
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI
     .          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS,IOPP,LOOK,IET,GLAT,
     1RP1S,RD1S,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,
     2UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2
      COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
      COMMON/WINCOM/ DUMSTF(17),UPRE,VPRE,DUPRE,DVPRE
 9090 FORMAT('1 ****** GLOBAL REFERENCE ATMOSPHERE - MOD 3 ******'/)
      PI=3.1415927
      FAC=0.017453293
      LOOK=0
      MONTH = 0
      IOPT=0
       H=0.
    5 IF(IOPT.EQ.0.OR.(IOPT.GT.0.AND.H.LT.0.)) GO TO 6
      READ(IOPT,10) IET,H,PHI,THET
10    FORMAT( )
      GO TO 5
    6 MN = MONTH
      NSAME = 0
      READ(5,10,END=90) H1,PHI1,THET1,F10,F10B,AP,MN,IDA ,IYR,IHRO,MINO,
     1 ISECO,DPHI,DTHET,DH,NMAX,INCT,IOPT,IOPP,GLAT
   91 REWIND 4
      WRITE(6,9090)
      IF(ABS(PHI1).LE.90.)GO TO 7
      PHI1=SIGN(180.-ABS(PHI1),PHI1)
      THET1=THET1+180.
      IF(THET1.GT.360.)THET1=THET1-360.
    7 IF(THET1.LT.0.) THET1=THET1+360
      GLAT = ABS(GLAT)
      IF (GLAT.LT. 5.) GLAT =  5.
      IF (GLAT.GE.18.) GLAT = 17.999
      GLATF=GLAT*FAC
      WRITE(6,9010) H1,PHI1,THET1,F10,F10B,AP,MN,IDA ,IYR,IHRO,MINO,
     $ ISECO,DPHI,DTHET,DH,NMAX,INCT,IOPT,IOPP,GLAT
C      SET NSAME TO AVOID SETUP
   15 IF (MN.EQ.MONTH) NSAME = 1
C     LOOKUP ON MULTIPLE PASSES
      MONTH = MN
C      CONVERT LATITUDE TO RADIANS
      PHI1R=PHI1*FAC
C     CONVERT LONGITUDE TO RADIANS
      THET1R=THET1*FAC
C     CONVERT LATITUDE INCREMENT TO RADIANS
      DPHIR=DPHI*FAC
```

```
C     CONVERT LONGITUDE INCREMENT TO RADIANS
      DTHETR=DTHET*FAC
C     READ DATA TAPE TO INITIALISE ARRAYS
      CALL SETUP
      NT = 1
      IF(IOPT.EQ.0) GO TO 18
      READ(IOPT,10) IET,H,PHI,THET
      IF(ABS(PHI).LE.90.) GO TO 16
      PHI = SIGN(180.-ABS(PHI),PHI)
      THET = THET + 180.
   16 IF(THET.LT.0.)THET=THET+360.
      IF(THET.GT.360.) THET = THET - 360.
      PHIR=PHI*FAC
      THETR=THET*FAC
      GO TO 19
   18 H = H1 - DH
C.....DISPLACES POSITION BEFORE EVALUATION OF ATMOSPHERIC PARAMETERS
      IET = INCT
      PHIR=PHI1R+DPHIR
      THETR=THET1R+DTHETR
      IF (ABS(PHIR).LE.PI/2.) GO TO 17
      PHIR = SIGN(PI-ABS(PHIR),PHIR)
      THETR = THETR + PI
17    IF (THETR.GT.2.*PI) THETR = THETR - 2.*PI
      IF (THETR.LT.0.) THETR = THETR + 2.*PI
C      A=FQUATORIAL EARTH RADIUS, B = POLAR EARTH RADIUS
C      EPS= EARTH ECCENTRICITY
   19 A = 6378.160
      B = 6356.7747
      EPS=(1.-(B*B)/(A*A))
C.....COMPUTES RADIUS TO HEIGHT H, AND GRAVITY AT HEIGHT AND
C          LATITUDE PHIR
      CALL RIG
      ISEC=ISEC0+IET
      ISEC=MOD(ISEC,60)
      MIN = MIN0 + IET/60
      IHR = IHR0 + MIN / 60
      MIN = MOD(MIN,60)
C.....COMPUTES P,D,T,U,V AT FIRST POSITION AFTER INITILL POSITION
      IF(H1.LE.30.) LOOK=1
      IF(ABS(PHIR).GT.GLATF) GO TO 195
      PHIS=PHIR
      DPHIS=(PHIR+GLATF)/(2.*GLATF)
      PHIR=GLATF
      CALL SCIMOD(0)
      UP2=UPRE
      VP2=VPRE
      DUP2=DUPRE
      DVP2=DVPRE
      PHIR=-GLATF
      CALL SCIMOD(0)
      UP1=UPRE
      VP1=VPRE
      DUP1=DUPRE
```

```
      DVP1=DVPRE
      UPRE=UP1+(UP2-UP1)*DPHIS
      VPRE=VP1+(VP2-VP1)*DPHIS
      DUPRE=DUP1+(DUP2-DUP1)*DPHIS
      DVPRE=DVP1+(DVP2-DVP1)*DPHIS
      PHIR=PHIS
195   CALL SCIMOD(1)
   20 NT = NT + 1
      IF (IOPT.EQ.0) GO TO 22
      READ(IOPT,10) IET,H,PHI,THET
      IF(H.LT.0.)GO TO 5
      IF(ABS(PHI).LE.90.)GO TO 21
      PHI=SIGN(180.-ABS(PHI),PHI)
      THET=THET+180.
   21 IF(THET.LT.0.)THET=THET+360.
      IF(THET.GT.360.)THET=THET-360.
      PHIR=PHI*FAC
      THETR=THET*FAC
      GO TO 25
C     INCREMENT THE HEIGHT
 22   H = H1 - DH
      IF (H .LT. 0.0) GO TO 5
C     INCREMENT THE LATITUDE
      PHIR=PHIR+DPHIR
C     INCREMENT THE LONGITUDE
      THETR=THETR+DTHETR
C.....READS NEW INPUT IF ABS(LAT) GTR 90 DEG
      IF (ABS(PHIR).LE.PI/2) GO TO 23
      PHIR=SIGN(PI-ABS(PHIR),PHIR)
      THETR=THETR+PI
   23 IF (THETR.GT.2.*PI) THETR = THETR - 2. * PI
      IF (THETR.LT.0.) THETR = THETR + 2. * PI
C      INCREMENT THE TIME
      IET=IET+INCT
   25 MIN=MINO+IET/60
      ISEC=ISECO+IET
      ISEC=MOD(ISEC,60)
      IHR=IHRO+MIN/60
      MIN=MOD(MIN,60)
C     COMPUTE RADIUS AND GRAVITY AT NEW POSITION
      CALL RIG
C     COMPUTE P,D,T,U,V, AT NEW POSITION
      IF(ABS(PHIR).GT.GLATF) GO TO 80
      PHIS=PHIR
      DPHIS=(PHIR+GLATF)/(2.*GLATF)
      PHIR=GLATF
      CALL SCIMOD(0)
      UP2=UPRE
      VP2=VPRE
      DUP2=DUPRE
      DVP2=DVPRE
      PHIR=-GLATF
      CALL SCIMOD(0)
      UP1=UPRE
```

```
      VP1=VPRE
      DUP1=DUPRE
      DVP1=DVPRE
      UPRE=UP1+(UP2-UP1)*DPHIS
      VPRE=VP1+(VP2-VP1)*DPHIS
      DUPRE=DUP1+(DUP2-DUP1)*DPHIS
      DVPRE=DVP1+(DVP2-DVP1)*DPHIS
      PHIR=PHIS
80    CALL SCIMOD(1)

C.....READS NEW INPUT IF NMORE = 0 OR MAX POINTS COMPUTED
      IF(NMORE.EQ.0.OR.(IOPT.EQ.0.AND.NT.GE.NMAX)) GO TO 5
C     CYCLE TO NEW POSITION
      GO TO 20
   90 STOP
 9010 FORMAT('  INITIAL HEIGHT = ',F7.2,' KM',T43,'INITIAL LAT = ',
     1F6.2,' DEG',T83,'INITIAL WEST LON = ',F6.2,' DEG',/,'  F10.7 = ',F
     $8.2,
     2T43,'MEAN F10.7 = ',F7.2,T83,'AP = ',F8.2,/,'  DATE = ',I2,'/',I2,
     3'/',I2,T43,'GREENWICH TIME = ',I2,':',I2,':',I2/,'  LAT INCREMENT
     4= ',F6.2,' DEG',T43,'WEST LON INCREMENT = ',F6.2,' DEG',T83,'HEI',
     $'GHT INCR',
     5'EMENT = ',F7.2,' KM',/,'  MAXIMUM NUMBER OF POSITIONS = ',I4,T43,
     6'TIME INCREMENT = ',I4,' SEC',/2X,'TRAJECTORY OPTION = ',I4,
     7T43,'OUTPUT OPTION = ',I2,T83,'MIN GEOSTROPH LAT = ',F5.1,/)
      END
      SUBROUTINE ADJUST
      COMMON/C4/DUM1(32),NG,P(16,26),D(16,26),T(16,26),SP(16,26)
     $,SD(16,26),ST(16,26),DU1,DU2,HS
      COMMON/ADJCOM/A(26,3), B(26), X(26), KOUNT
      DIMENSION PQ(26), QQ(26), UC(26), VC(26), WC(26), U(26), V(26),
     $ W(26)
C     ASSUMPTIONS@
C       HS IS THE SURFACE LEVEL
C       ALL DATA VALUES ABOVE SURFACE LEVEL ARE IN 1 KM INCREMENTS
      E1=0.075
      E2=0.150
      MAXIT=3
      KSMAX=10
      HSJ = HS
      IF (HS.LT.0.) HSJ = 0.
      JJ=INT(HSJ+2.)
      STEST=0.05
      ISS=1
      CONST=28703./980.665
      N=26
      ITER=0
      UC(1)=SQRT(SP(KOUNT,1))
      VC(1)=SQRT(SD(KOUNT,1))
      WC(1)=SQRT(ST(KOUNT,1))
      DO 5 I=JJ,N
      UC(I)=SQRT(SP(KOUNT,I))
      VC(I)=SQRT(SD(KOUNT,I))
    5 WC(I)=SQRT(ST(KOUNT,I))
```

```
      NM=N-1
      NP=N+1
C.....SETS UP QUADRATURE FACTORS
      PQ(1)=500.*(FLOAT(INT(HSJ+1.))-HS)/(CONST*T(KOUNT,1))
      QQ(1)=500.*(FLOAT(INT(HSJ+1.))-HS)/(CONST*T(KOUNT,JJ))
      DO 15 I=JJ,NM
      IP=I+1
      PQ(I)=500./(CONST*T(KOUNT,I))
   15 QQ(I)=500./(CONST*T(KOUNT,IP))
      GO TO 58
   12 NM=N-1
      NP=N+1
      DO 14 I=1,26
      U(I)=UC(I)*UC(I)
      V(I)=VC(I)*VC(I)
      W(I)=WC(I)*WC(I)
   14 CONTINUE
C.....INITIALIZE A(I,J)
      DO 20 I=1,26
      DO 20 J=1,3
   20 A(I,J)=0.
C.....SETS UP COEFFICIENTS
      I2=0
      DO 35 I=1,NM
      IF(I.GT.1.AND.I.LT.JJ) GO TO 35
      AW=1./SP(KOUNT,I)
      BW=1./SD(KOUNT,I)
      CW=1./ST(KOUNT,I)
      IM=I-1
      IF(I.EQ.JJ) IM=1
      IP=I+1
      IF (I.EQ.1) IP=JJ
      I2=I2+1
      AW1=1./SP(KOUNT,IP)
      BW1=1./SD(KOUNT,IP)
      CW1=1./ST(KOUNT,IP)
      IF(I.EQ.1) GO TO 25
      A(I2,1)=-(1.-QQ(IM))*(1.+PQ(I))/AW+(1./BW+1./CW)*PQ(I)*QQ(IM)
   25 A(I2,2)=((1.-QQ(I))**2)/AW1+((1.+PQ(I))**2)/AW+(1./BW+1./CW)
     $ *(PQ(I)**2)+(1./BW1+1./CW1)*QQ(I)**2
      IF(I.EQ.NM) GO TO 30
      A(I2,3)=-(1.-QQ(I))*(1.+PQ(IP))/AW1+(1./BW1+1./CW1)*
     $ PQ(IP)*QQ(IP)
   30 B(I2)=U(IP)-U(I)-(U(I)-V(I)+W(I))*PQ(I)-(U(IP)-V(IP)+W(IP))*QQ(I)
   35 CONTINUE
      CALL DIAGEQ(I2)
C.....FINDS CORRECTIONS
      AW=1./SP(KOUNT,1)
      BW=1./SD(KOUNT,1)
      CW=1./ST(KOUNT,1)
      UC(1)=SQRT(U(1)+X(1)*(1.+PQ(1))/AW)
      VC(1)=SQRT(V(1)-X(1)*PQ(1)/BW)
      WC(1)=SQRT(W(1)+X(1)*PQ(1)/CW)
      AW=1./SP(KOUNT,N)
```

```
      BW=1./SD(KOUNT,N)
      CW=1./ST(KOUNT,N)
      UC(N)=SQRT(U(N)-X(I2)*(1.-QQ(NM))/AW)
      VC(N)=SQRT(V(N)-X(I2)*QQ(NM)/BW)
      WC(N)=SQRT(W(N)+X(I2)*QQ(NM)/CW)
      I2=1
      DO 40 I=JJ,NM
      I2=I2+1
      I2M=I2-1
      AW=1./SP(KOUNT,I)
      BW=1./SD(KOUNT,I)
      CW=1./ST(KOUNT,I)
      IM=I-1
      IF(I.EQ.JJ)IM=1
      UC(I)=ABS(U(I)          +(-X(I2M)*(1.-QQ(IM))+X(I2)*(1.+PQ(I)))/AW)
      UC(I)=SQRT(UC(I))
      VC(I)=ABS(V(I)          -(X(I2M)*QQ(IM)+X(I2)*PQ(I))/BW)
      VC(I)=SQRT(VC(I))
      WC(I)=ABS(W(I)          +(X(I2M)*QQ(IM)+X(I2)*PQ(I))/CW)
   40 WC(I)=SQRT(WC(I))
C.....GETS ADJUSTED VALUES
C.....   ADJUSTS ON TRIANGLE INEQUALITIES
   58 K=0
      DO 68 I=1,N
      IF(I.GT.1.AND.I.LT.JJ) GO TO 68
      AU=UC(I)
      AV=VC(I)
      AM=WC(I)
      AMAX=AMAX1(AU,AV,AM)
      EE=E1*AMAX
      EF=E2*AMAX
      AW=SP(KOUNT,I)
      BW=SD(KOUNT,I)
      CW=ST(KOUNT,I)
      COR=AU+AV-AM-EE
      DIV=AW+BW+CW
      IF(COR.GT.0.) GO TO 60
      COR=(AU+AV-AM-EF)/DIV
      AU=AU-COR*AW
      AV=AV-COR*BW
      AM=AM+COR*CW
      GO TO 64
   60 COR=AU-AV+AM-EE
      IF(COR.GT.0.) GO TO 62
      COR=(AU-AV+AM-EF)/DIV
      AU=AU-COR*AW
      AV=AV+COR*BW
      AM=AM-COR*CW
      GO TO 64
   62 COR=-AU+AV+AM-EE
      IF(COR.GT.0.) GO TO 66
      COR=(-AU+AV+AM-EF)/DIV
      AU=AU+COR*AW
      AV=AV-COR*BW
```

```
      AW=AW-COR*CW
   64 K=K+1
   66 UC(I)=AU
      VC(I)=AV
      WC(I)=AW
   68 CONTINUE
      KMAX=K
  100 IF((ITER.EQ.0).OR.(KMAX.NE.0)) GO TO 110
      GO TO 112
  110 ITER=ITER+1
      IF(ITER.LE.MAXIT) GO TO 12
  112 IF (ISS.NE.1) GO TO 999
  114 ITER=1
      ISS=2
      VTA=VC(1)
      WTA=WC(1)
      DO 120 I=JJ,NM
      IM=I-1
      IF(I.EQ.JJ)IM=1
      VTB=VC(I)
      WTB=WC(I)
      VC(I)=(VC(I+1)+2.*VTB+VTA)*0.25
      WC(I)=(WC(I+1)+2.*WTB+WTA)*0.25
      VTA=VTB
      WTA=WTB
  120 CONTINUE
      GO TO 12
C.....CALCULATE THE CORRECTED VARIANCES
  999 DO 1010 I=1,N
      IF(I.GT.1.AND.I.LT.JJ) GO TO 1010
      SP(KOUNT,I)=UC(I)**2
      SD(KOUNT,I)=VC(I)**2
      ST(KOUNT,I)=WC(I)**2
 1010 CONTINUE
      RETURN
      END
      SUBROUTINE CHECK
      COMMON/CHK/P(4,4,3),RHO(4,4,3),NO(2)
      COMMON/WINCOM/DGH,FCORY,DX5,DY5
      COMMON/CHIC/LA(16),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
      NB(1) = 0
      NB(2) = 0
      CALL GROUP
      NS=0
      NR=1
      IF(NO(1).EQ.0.AND.NO(2).EQ.0) GO TO 1000
      DO 640 KL=1,2
      IF (NO(KL).EQ.0) GO TO 640
  450 CONTINUE
      NNR=4*NR
      IF(NO(KL).LE.NNR) GO TO 500
      NR=NR+1
      GO TO 450
  500 CONTINUE
```

```
      I1=NR
      J1=NO(KL)-(NR-1)*4
      SH1 = 6.
      SH2 = 6.
      DP = P(I1,J1,2) - P(I1,J1,1)
      IF (DP) 510,520,510
  510 SH1 = ABS(P(I1,J1,2)/DP)
  520 DP = P(I1,J1,2) - P(I1,J1,3)
      IF (DP) 530,540,530
  530 SH2 = ABS(P(I1,J1,2)/DP)
  540 IF(SH1.LT.4.0.OR.SH2.LT.4.0) GO TO 640
      IF(SH1.GT.9.0.OR.SH2.GT.9.0) GO TO 640
      NR=1
      NS=NS+1
  640 CONTINUE
      RETURN
 1000 IWSYM = '*'
      RETURN
      END
      SUBROUTINE CORLAT(A,B,C,D,E,F,G,H,AI,AJ,AK,SP1,SP2,SD1,SD2,ST1,
     1 ST2,SU1,SU2,SV1,SV2,UD1,UD2,VD1,VD2,RD,RT,RV)
      IF(SD1*ST1*SD2*ST2.GT.0.) GO TO 5
C.....DEFAULT VALUES AVOID DIVISION BY ZERO
      IF(SD1.LE.0.) SD1=0.001
      IF(ST1.LE.0.) ST1=0.001
      IF(SD2.LE.0.) SD2=0.001
      IF(ST2.LE.0.) ST2=0.001
      IF(RD.LE.0.) RD = .00001
      IF(RT.LE.0.) RT = .00001
      IF(RV.LE.0.) RV = .00001
 5    CONTINUE
      IF(ABS(TD1).LE.0.) TD1 = 0.001
      IF (ABS(UD1).LE.0.) UD1 = 0.001
      IF (ABS(VD1).LE.0.) VD1 = 0.001
      IF (ABS(SU1).LE.0.) SU1 = 0.001
      IF (ABS(SV1).LE.0.) SV1 = 0.001
      IF (ABS(UD1).GE.1.) UD1 = 0.99*UD1/ABS(UD1)
      IF (ABS(VD1).GE.1.) VD1 = 0.99*VD1/ABS(VD1)
      A=RD*SD2/SD1
      B=SD2*SQRT(1-RD*RD)
      TD2=(SP2*SP2-SD2*SD2-ST2*ST2)/(2*SD2*ST2)
      TD1=(SP1*SP1-SD1*SD1-ST1*ST1)/(2*SD1*ST1)
      IF(ABS(TD2).GE.1.0) TD2=0.99*TD2/ABS(TD2)
      IF(ABS(TD1).GE.1.0) TD1=0.99*TD1/ABS(TD1)
      C=(ST2/ST1)*(RT-RD*TD2*TD1)/(1-TD1*TD1*RD*RD)
      D=(RT*ST2*ST1-C*ST1*ST1)/(A*TD1*SD1*ST1)
      E=     ST2*ST2-C*C*ST1*ST1-D*D*SD2*SD2-2*C*D*RD*TD1*ST1*SD2
      IF(E.GE.0.) GO TO 10
      E=0.
   10 E=SQRT(E)
      F=(SU2/SU1)*(RV-RD*UD2*UD1)/(1-RD*RD*UD1*UD1)
      G=(RV*SU2-F*SU1)/(RD*UD1*SD2)
      H=     SU2*SU2-F*F*SU1*SU1-G*G*SD2*SD2-2*F*G*RD*UD1*SD2*SU1
      IF(H.GE.0.) GO TO 15
```

```
      H=0.                                                              CORL  36
   15 H=SQRT(H)                                                         CORL  37
      AI=(SV2/SV1)*(RV-RD*VD2*VD1)/(1-RD*RD*VD1*VD1)                    CORL  38
      AJ=(RV*SV2-AI*SV1)/(RD*VD1*SD2)                                   CORL  39
      AK=      SV2*SV2-AI*AI*SV1*SV1-AJ*AJ*SD2*SD2-2*AI*AJ*RD*VD1*SD2*SV1CORL  40
      IF(AK.GE.0.) GO TO 25                                             CORL  41
      AK=0.                                                             CORL  42
   25 AK=SQRT(AK)                                                       CORL  43
      RETURN                                                            CORL  44
      END                                                               CORL  45
      SUBROUTINE DIAGEQ(N)                                              DIAG   1
C     A(I,J)=DIAG. TERMS, I=ROW NO., J=DIAG. NO.                        DIAG   2
C     B(I)=RIGHT SIDE TERMS                                             DIAG   3
C     N=NO. OF ROWS                                                     DIAG   4
C     K=NO. OF BORDER DIAGONALS, M=K+1=INDES OF PRIN. DIAG              DIAG   5
C             2KM=TOTAL NO. OF DIAGS.                                   DIAG   6
C     X(I)=SOLUTION                                                     DIAG   7
      COMMON/ADJCOM/A(26,3), B(26), X(26)                               DIAG   8
      K = 1                                                             DIAG   9
      M=K+1                                                             DIAG  10
      DO 30 L=1,N                                                       DIAG  11
      ALM=A(L,M)                                                        DIAG  12
      A(L,M)=1.                                                         DIAG  13
      IF(L.EQ.N) GO TO 15                                               DIAG  14
      I2=MIN0(K,N-L)                                                    DIAG  15
      DO 10 I=1,I2                                                      DIAG  16
      MPI=M+I                                                           DIAG  17
   10 A(L,MPI)=A(L,MPI)/ALM                                             DIAG  18
   15 B(L)=B(L)/ALM                                                     DIAG  19
      IF(L.EQ.N) GO TO 30                                               DIAG  20
      DO 25 I=1,I2                                                      DIAG  21
      LPI=L+I                                                           DIAG  22
      FACT=A(LPI,M-I)                                                   DIAG  23
      DO 20 J=1,I2                                                      DIAG  24
      MJI=M+J-I                                                         DIAG  25
   20 A(LPI,MJI)=A(LPI,MJI)-A(L,M+J)*FACT                               DIAG  26
   25 B(LPI)=B(LPI)-B(L)*FACT                                           DIAG  27
   30 CONTINUE                                                          DIAG  28
      X(N)=B(N)                                                         DIAG  29
      NM1=N-1                                                           DIAG  30
      DO 50 L=1,NM1                                                     DIAG  31
      NML=N-L                                                           DIAG  32
      SUM=0.                                                            DIAG  33
      I2=MIN0(K,L)                                                      DIAG  34
      DO 40 I=1,I2                                                      DIAG  35
   40 SUM=SUM+A(NML,M+I)*X(NML+I)                                       DIAG  36
   50 X(NML)=B(NML)-SUM                                                 DIAG  37
      RETURN                                                            DIAG  38
      END                                                               DIAG  39
      SUBROUTINE FAIR (PG, DG, TG, PJ, DJ, TJ, IH, P, D, T,             FAIR   1
     $ DPYG, DPXJ, DPYJ, DPX, DPY,       DTYG, DTXJ, DTYJ, DTX, DTY)    FAIR   2
C.....FAIRS BETWEEN GROVES AND JACCHIA VALUES 90 LE HEIGHT LE 115 KM    FAIR   3
      DIMENSION CZ(6)                                                   FAIR   4
C.....FAIRING VALUES                                                    FAIR   5
```

```
      DATA CZ /1.0,0.9045085,0.6545085,0.3454915,0.0954915,0.0/
C     HEIGHT INDEX
      I =(IH - 85)/5
C     GROVES FAIRING COEFFICIENT
      CZI = CZ(I)
C     JACCHIA FAIRING COEFFICIENT
      SZI = 1.0 - CZI
C     FAIRED TEMPERATURE
      T = TG*CZI + TJ*SZI
C     FAIRED PRESSURE
      P = EXP(ALOG(PG)*CZI + ALOG(PJ)*SZI)
C     FAIRED DENSITY
      D = EXP(ALOG(DG)*CZI + ALOG(DJ)*SZI)
      DPX = DPXJ
C     DP/DY FOR GEOSTROPHIC WINDS
      DPY=DPYG*CZI+DPYJ*SZI
      DTX = DTXJ
C      DT/DY FOR THERMAL WINDS
      DTY = DTYG * CZI + DTYJ * SZI
      RETURN
      END
      SUBROUTINE GEN4D
C.....GENERATES NG = 9 OR 16 4D PROFILES P,D,T AND SIGMAS SP,SD,ST AT
C        GRID OF LATITUDES AND LONGITUDES GLAT,GLON. CURRENT LATITUDE,
C        LONGITUDE=CLAT,CLON. PREVIOUS LATITUDE,LONGITUDE=PLAT,PLON.
      COMMON/C4/GLAT(16),GLON(16),NG,P(16,26),D(16,26),T(16,26),
     $ SP(16,26),SD(16,26),ST(16,26),PLON,CLON,HS
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DDD,XMJD,PLAT,CLAT,
     $ NSAME,RP1,RD1,RT1,SP1,SD1,ST1,RU1,RV1,SU1,SV1,
     $ MN,IDA,IYR,H1,PHI1R,THET1R,GZ,RI,Z,PHIR,THETR,F10,F10B,AP,
     $ IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS,IOPP,LOOK,DUMMY(20)
      COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19),
     1      PSP(8,10,12),DSP(8,10,12),TSP(8,10,12)
     2,PAQ(17,5),DAQ(17,5),TAQ(17,5),
     3PDQ(17,5),DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),
     4UAQ(17,5),VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10),
     5PQ,DQ,TQ,UQ,VQ,PQA,DQA,TQA,UA,VA,IOPQ
     * ,PLP(25,10),DLP(25,10),TLP(25,10),ULP(25,10),VLP(25,10),UDL(25,
     * 10),VDL(25,10),UDS(25,10),VDS(25,10)
      COMMON/ADJCOM/DUM(130),KOUNT
      COMMON/IPRTP/ IPRT
      IF(NSAME.EQ.1) RETURN
      IPRT=0
      LOOK=0
      F = 0.017453293
      NG = 16
      DX = PLON - CLON
C.....LONGITUDE DISPLACEMENT FROM PREVIOUS TO CURRENT POSITION
      DY = CLAT - PLAT
C.....LATITUDE DISPLACEMENT FROM PREVIOUS TO CURRENT POSITION
      IF (DY) 20,10,20
 10   IF (DX) 15,12,15
 12   K = 0
      GO TO 40
```

```
   15 THETA = 180. + SIGN(90.,DX)
      GO TO 30
   20 THETA = ATAN(DX/DY)/F
      IF (DY.GT.0.) THETA = THETA + 180.
      IF (THETA.LT.0.) THETA = THETA + 360.
C.....THETA = AZIMUTH ANGLE OF TRÀJECTORY, USED TO ORIENT LAT-LON GRID
   30 K = INT((THETA + 67.5)/45.)
C     INDEX USED IN COMPUTED GO TO FOR 110 THRU 180
      IF (K.GT.8) K=K-8
C     NORTH POLAR GRID
      IF (CLAT.GT.75.0.AND.K.GE.3.AND.K.LE.7)GO TO 200
C     SOUTH POLAR GRID
      IF (CLAT.LT.-75.0.AND.(K.GE.7.OR.K.LE.3))GO TO 200
C.....INITIAL ESTIMATE OF REFERNCE LATITUDE (LOWER LEFT GRID POINT)
 40   LAT0 = 5*INT(CLAT/5.)
      IF (CLAT.LT.0.) LAT0 = LAT0 - 5
C.....INITIAL ESTIMATE OF REFERENCE LONGITUDE (LOWER LEFT GRID POINT)
      LON0=5*INT(CLON/5.)
C.....ADJUSTS LAT0,LON0 ACCORDING TO DIRECTION OF TRAJECTORY AZIMUTH
      IF (K.GT.0) GO TO 100
      LAT0 = LAT0 - 5
      LON0= LON0 + 10
      GO TO 190
 100  GO TO (110,120,130,140,150,160,170,180),K
  110 LAT0 = LAT0-10
      LON0 = LON0 + 10
      GO TO 190
  120 LAT0 = LAT0-10
      LON0 = LON0+15
      GO TO 190
  130 LAT0 = LAT0-5
      LON0 = LON0+15
      GO TO 190
  140 LON0 = LON0+15
      GO TO 190
  150 LON0 = LON0+10
      GO TO 190
  160 LON0 = LON0+5
      GO TO 190
  170 LAT0 = LAT0-5
      LON0 = LON0+5
      GO TO 190
  180 LAT0 = LAT0-10
      LON0 = LON0+5
  190 IF (LON0.GT.360) LON0 = LON0 - 360
      DLI=1.25
      IF(ABS(CLAT).GE.18) GO TO 192
      DLI=3.0
      LAT0=-18
  192 DO 195 I=1,4
      I12 = I+12
      DO 195 J=I,I12,4
      GLAT(J) = LAT0 + 1.25*(J-I)
C.....LATITUDE, LONGITUDE GRID AT 5 DEGREE INTERVALS
```

```
  195 GLON(J) = LONO - 5. * (I - 1)
      GO TO 400
C     POLAR GRID
  200 NG = 9
      DO 210 J=1,8
C.....POLAR GRID LATITUDES 1-8 = +75 (N) OR -75 (N)
      GLAT(J) = SIGN(75.,CLAT)
C.....POLAR GRID LONGITUDES 1-8 AT 45 DEG INTERVALS
  210 GLON(J) = 45.*(J-1)
C.....POLAR GRID LATITUDE 9 = POLE +93 OR -90
      GLAT(9) = SIGN(90.,CLAT)
C.....POLAR GRID LONGITUDE 9 = 0
      GLON(9) = 0.
C.....GENERATES 16 PROFILES (OR 9 PROFILES FOR POLAR GRID)
  400 CALL GRID4D
      DO 600 I=1,NG
      CHECK=P(I,26)*D(I,26)*T(I,26)*SP(I,26)*SD(I,26)*ST(I,26)
C     CHECK FOR ZERO DATA AT HEIGHT 25
      IHV=26
      SPR=SP(I,26)
      SDR=SD(I,26)
      STR=ST(I,26)
      IF (CHECK.GT.0.) GO TO 491
      DO 420 J1=1,25,1
      J=26-J1
      CHECK = P(I,J) * D(I,J) * T(I,J) * SP(I,J) * SD(I,J) * ST(I,J)
C      FINDS INDEX IHV OF HIGHEST HEIGHT WITH NON-ZERO DATA
      IHV = J
      IF (CHECK.GT.0.) GO TO 440
  420 CONTINUE
C     HEIGHT = HEIGHT INDEX - 1
  440 Z1 = IHV -1.
C     SPR,SDR,STR=SIGMAS AT HEIGHT Z1
      SPR = SP(I,IHV)
      SDR=SD(I,IHV)
      STR=ST(I,IHV)
C.....IF HEIGHT Z1 GEQ 20 KM, USE GROVES AT 30 KM FOR INTERPOLATION,
C          OTHERWISE USE GROVES AT 25 KM
      IF (IHV.GE.21) GO TO 480
C.....EVALUATES GROVES AT 25 KM FOR INTERPOLATION AND
C          FILL IN OF ZERO DATA
      CALL GTERP(25,GLAT(I),P2,D2,T2,PG,DG,TG,DPY,DTY,DP2Y)
      IHP = IHV + 1
      DO 450 K=IHP,26
C.....AVOIDS INTERPOLATION OF P,D,T IF ONLY SIGMAS ARE ZERO
      IF ((P(I,K)*D(I,K)*T(I,K)).GT.0.) GO TO 445
      H=K-1
C.....INTERPOLATES BETWEEN 4D AT HEIGHT Z1 AND GROVES AT 25 TO FILL
C          IN MISSING DATA
      CALL INTER2(P(I,IHV),D(I,IHV),T(I,IHV),Z1,P2,D2,T2,25.,PH,DH,TH,H)
      P(I,K)=PH
      D(I,K)=DH
      T(I,K)=TH
  445 SP(I,K) = SPR
```

```
      SD(I,K)=SDR
C.....SETS MISSING SIGMAS EQUAL TO SIGMAS AT HEIGHT Z1
  450 ST(I,K)=STR
      GO TO 500
C.....EVALUATES GROVES AT 30 KM FOR INTERPOLATION AND FILL IN OF
C          ZERO DATA
  480 CALL GTERP(30,GLAT(I),P2,D2,T2,PG,DG,TG,DPY,DTY,DP2Y)
      CALL PDTUV(PSP,DSP,TSP,GLAT(I),GLON(I),30,DP,DD,DT,DPX,DPY,DTX,DTY
C     COMPUTE PERTURBATIONS TO GROVES MODEL
     $ ,DP2X,DP2Y,DPXY)
C.....ADD STATIONARY PERTURBATIONS TO GROVES MODEL
      P2 = P2*(1. + DP)
      D2 = D2*(1. + DD)
      T2 = T2*(1. + DT)
      IHP = IHV + 1
      DO 490 K=IHP,26
C.....AVOIDS INTERPOLATING P,D,T IF ONLY SIGMAS ARE ZERO
      IF ((P(I,K)*D(I,K)*T(I,K)).GT.0.) GO TO 485
      H=K-1
C.....INTERPOLATES BETWEEN 4D AT HEIGHT Z1 AND GROVES AT 30 KM TO
C          FILL IN MISSING DATA
      CALL INTER2(P(I,IHV),D(I,IHV),T(I,IHV),Z1,P2,D2,T2,30.,PH,DH,TH,H)
      P(I,K)=PH
      D(I,K)=DH
      T(I,K)=TH
  485 SP(I,K) = SPR
      SD(I,K)=SDR
C     SET MISSING SIGMAS AT HEIGHT 1
  490 ST(I,K) = STR
  491 CONTINUE
      IHP = IHV - 1
      DO 492 K=2,9
      IF (SP(I,K) .LE . 0.) SP(I,K) = SP(I,1)
      IF (SD(I,K) .LE. 0.) SD(I,K)= SD(I,1)
  492 IF (ST(I,K) .LE. 0.) ST(I,K) = ST(I,1)
      DO 495 K=10,IHP
C......SETS ALL ZERO SIGMAS TO SIGMA AT HEIGHT Z1
      IF (SP(I,K).LE.0.0.AND.P(I,K).GT.0.) SP(I,K) = SPR
      IF (SD(I,K).LE.0.0.AND.D(I,K).GT.0.) SD(I,K) = SDR
  495 IF (ST(I,K).LE.0.0.AND.T(I,K).GT.0.) ST(I,K) = STR
  500 PA = P(I,1)
      TA = T(I,1)
      R =287.05
      G=GZ*(1.+(Z/(RI-Z))**2)
      K = 2
  510 PB = P(I,K)
      TB = T(I,K)
      IF ((PB*TB) .GT. 0.) GO TO 520
      K = K + 1
      GO TO 510
  520 IF (TA-TB) 560, 570, 560
  560 TZ = (TA-TB) / ALOG(TA/TB)
      GO TO 575
  570 TZ = TA
```

```
  575 HS = K-1.+0.001*R*TZ*ALOG(PB/PA)/G
      KM=K-2
      IF(ABS(K-1-HS).GT.0.1) GO TO 578
      GAM=TB-T(I,K+1)
      IF(GAM) 582,590,582
  578 IF(TA-TB) 580,590,580
  580 GAM=(TA-TB)/(K-1-HS)
  582 KM1=KM+1
      IF(ABS(GAM).GT.G) GAM=SIGN(G,GAM)
      DO 585 JD=1,KM1,1
      J=JD-1
      TJ=TA-GAM*(J-HS)
      PJ=PA*(TJ/TA)**(G/(R*GAM*0.001))
      DJ=PJ/(R*TJ)
      P(I,J+1)=PJ
      D(I,J+1)=DJ
  585 T(I,J+1)=TJ
      GO TO 599
  590 KM1=KM+1
      DO 595 JD=1,KM1,1
      J=JD-1
      TJ=TA
      PJ=PA*EXP(-G*(J-HS)/(R*0.001*TJ))
      DJ=PJ/(R*TJ)
      P(I,J+1)=PJ
      D(I,J+1)=DJ
  595 T(I,J+1)=TJ
      IF(NSAME.EQ.2) NSAME=1
  599 HS=0.
      KOUNT = I
      CALL ADJUST
  600 CONTINUE
      RETURN
      END
      SUBROUTINE GETNMC
C
C     READS 'SETUP' DATA TAPE, OR NMC GRID DATA CARDS,
C     AND WRITES SCRATCH FILE FOR USE BY SELEC4.
C
      DIMENSION IP(15)
C
      COMMON /IOTEMP/ IOTEM1,IUTEM2,IUG,NMCOP,IDUM(60)
C
      NREC=0
      IF(NMCOP.NE.0) GO TO 2
C
1     READ(IUG,300,END=90) N,IP
300   FORMAT(A2,19I7)
      IF(N.NE.'N') GO TO 6
      GO TO 3
    2 READ(5,100) (IP(I),I=1,15)
  100 FORMAT(15I5)
    3 DO 4 I=1,15,3
      M=IP(I)
```

```
      IF(M.LT.1) GO TO 5
      IJ=IP(I+1)*1000+IP(I+2)
      WRITE(IOTEM2) IJ
      NREC=NREC+1
    4 CONTINUE
      IF(NMCOP.NE.0) GO TO 2
      GO TO 1
    5 IF(NREC.NE.1977) GO TO 6
C     MOVES PAST FIRST EOF ON UNIT IUG
41    READ(IUG,9999,END=42) IDUMMY
9999  FORMAT(A10)
      GO TO 41
42    RETURN
    6 WRITE(6,200) NREC,IOTEM2
  200 FORMAT(1H1/1X,I6,' RECORDS WRITTEN BY GETNMC IN SCRATCH FILE',I3)
      STOP
90    WRITE(6,400) IUG
400   FORMAT('1  PREMATURE END-OF-FILE FOUND ON UNIT ',I2/
     %'0  CALLED FROM SUBROUTINE GETNMC.')
      STOP
      END
      SUBROUTINE GRID4D
      INTEGER FLD
      REAL LAT,LON
      COMMON/C4/LAT(16),LON(16),NP,P(16,26),R(16,26),T(16,26),SP(16,26),
     $ SR(16,26),ST(16,26)
      COMMON /PDTCOM/ IT,MONTH
C
C     S
C     SUBROUTINE TO SELECT PRESSURE, TEMPERATURE, AND DENSITY PROFILES (
C     TOGETHER WITH THE NORMALIZED VARIANCES IN EACH, AT UP TO 16 'GRID
C     AT LAT/LONS SELECTED BY CALLING PROGRAM.
C
C     USES NASA HUNTSVILLE MSFC 4-D DATA TAPES
C
      DIMENSION IN(107),BUFFER(64)
C
      COMMON /IOTEMP/ IOTEM1,IOTEM2
      COMMON /POINT/ IPT(16,5),LL(16),DXY(16,2)
      COMMON /ORDER/ IPTN(16,5),IREAD(65,3)
      COMMON /INT/ D(208,5),IG(5),DYX(2),DLA(4),DLO(4)
C
      INTEGER IOTEM1,READ,WRITE
C
C
C     INITIALIZE
C
      ZERO=0.0
      ONE=1.0
      TEN=10.0
      HUNDR=100.0
      THOU=1000.0
      READ=6H READ
      WRITE=6H WRITE
```

```
C
      N=MONTH-1-((2*MONTH)/9)*4
      IF(MONTH.EQ.13) N=0
      NUMEOF = 0
      CALL NTRAN(IT,10,22)
      IF (N.EQ.0) GO TO 20
      CALL NTRAN(IT,8,N,22)
C
C     APPROPRIATE 4-D INPUT TAPE NOW POSITIONED - FILE NEEDED PROFILES
C
C
   20 CALL SELEC4
C
      IRC=0
      IRN=1
      IF(IREAD(IRN,3).EQ.0) GO TO 39
   21 JT=IT
      N=READ
   22 CALL NTRAN(IT,2,106,IN,L,22)
      IRC =IRC +1
      IF (L.EQ.-2) GO TO 39
      IF (L.LT.0) WRITE(6,23) IT,L,IRC
   23 FORMAT(' INPUT UNIT NO.',I3,' IN ERROR (',I2,') FOR RECORD NO.',I5
     1)
      IF(IRC.LT.IREAD(IRN,3)) GO TO 22
      IF(IRC.GT.IREAD(IRN,3)) GO TO 39
   24 I=IREAD(IRN,1)
      J=IREAD(IRN,2)
      IF(IRN.EQ.1) GO TO 25
      IF(IREAD(IRN,3).EQ.IREAD(IRN-1,3)) GO TO 27
   25 IP=FLD(12,12,IN(106))
      MP=FLD(24,12,IN(106))
      IF((MP.NE.MONTH).OR.(IP.NE.IPT(I,J))) GO TO 39
      DO 26 IK=1,106,1
      K=107-IK
      IN(K+1)=IN(K)
   26 CONTINUE
   27 FLD(0,18,IN(1)) = I
      FLD(18,18,IN(1)) = J
      JT=IOTEM1
      N=WRITE
      WRITE(IOTEM1) IN
      IRN=IRN+1
      IF(IREAD(IRN,3).EQ.IRC) GO TO 24
      IF(IREAD(IRN,3).EQ.0) GO TO 28
      GO TO 21
C
C     INTERPOLATE TO GIVEN LAT/LON FROM GRID DATA
C
   28 N=READ
      DO 38 II=1,NP
      DO 29 I=1,208
      DO 29 J=1,5
      D(I,J)=0.0
```

```
   29 CONTINUE
      DO 32 J=1,4
      IF(IPT(II,J).EQ.0) GO TO 32
      FLD(0,18,INDEX) = II
      FLD(18,18,INDEX) = J
      REWIND IOTEM1
30    READ(IOTEM1,END=39) IN
      IF(IN(1).NE.INDEX) GO TO 30
      DO 31 I=2,105
      J2=2*I-2
      J1=J2-1
      D(J1,J)=FLD(0,18,IN(I))/HUNDR
      D(J2,J)=FLD(18,18,IN(I))/HUNDR
   31 CONTINUE
      DLA(J)=FLD(0,18,IN(106))/TEN
      DLO(J)=FLD(18,18,IN(106))/TEN
   32 CONTINUE
C
C     IF NECESSARY, INTERPOLATE
C
      LALO=LL(II)
      DO 33 I=1,5
      IG(I)=IPT(II,I)
   33 CONTINUE
      IF(IG(2).NE.0) GO TO 35
      DO 34 I=1,208
      D(I,5)=D(I,1)
   34 CONTINUE
      GO TO 37
   35 IF(IG(5).NE.2) GO TO 36
      DYX(1)=DXY(II,1)
      DYX(2)=DXY(II,2)
C
   36 CALL INTRP4 (LALO)
C
   37 DO 38 I=1,26
      P(II,I)=D(I,5)*HUNDR
      R(II,I)=D(I+156,5)/THOU
      T(II,I) =D(I+52,5)
      DIVIDE=ONE
      IF(P(II,I).GT.ZERO) DIVIDE=(P(II,I)/HUNDR)**2
      SP(II,I)=D(I+26,5)/DIVIDE
      DIVIDE=ONE
      IF(R(II,I).GT.ZERO) DIVIDE=(THOU*R(II,I))**2
      SR(II,I)=D(I+182,5)/DIVIDE
      DIVIDE=ONE
      IF(T(II,I).GT.ZERO) DIVIDE=T(II,I)**2
      ST(II,I)=D(I+78,5)/DIVIDE
   38 CONTINUE
      RETURN
   39 WRITE(6,40) JT,IRC,IREAD(IRN,3),MP,MONTH,IP,I,J,IPT(I,J),IRN,M,L
   40 FORMAT(' ***** UNIT NO.',I3,' IN ERROR',I7,' RECORDS READ'/
     1' IREAD(IRN,3) =',I5,' MP =',I3,' MONTH =',I3,
     2' IP =',I5,' IPT(',I2,',',I1,') =',I5,' IRN =',I3/A6,' STATUS',I5)
```

```
      STOP
      END
      SUBROUTINE GROUP
      DIMENSION KOU(2)
      COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
      COMMON /CHK/P(4,4,3),DEN(4,4,3),NO(2)
      COMMON /WINCOM/DGH,FCORY,DX5,DY5
      FCORX = FCORY*DX5/DY5
      KK=1
      DO 100 I=1,4
      DO 100 J=1,4
      LA(I,J)=4*(I-1)+J
  100 CONTINUE
  200 CONTINUE
      DO 250 M=1,4
      DO 250 N=1,4
      IF (KK.EQ.1) GO TO 210
      I=5-M
      J=5-N
      NN=-1
      N4=-1
      GO TO 220
  210 CONTINUE
      I=M
      J=N
      NN=1
      N4=1
  220 CONTINUE
      IF (N.EQ.4) GO TO 225
      DINX=FCORX* (DEN(I,J+NN,2)+DEN(I,J,2))/2
      VY=(P(I,J+NN,2)-P(I,J,2))/DINX
      IF(ABS(VY).GT.100) GO TO 225
      LA(I,J)=MINO(LA(I,J),LA(I,J+NN))
      LA(I,J+NN)=LA(I,J)
  225 CONTINUE
      IF(M.EQ.4) GO TO 250
      DINY=FCORY* (DEN(I+N4,J,2)+DEN(I,J,2))/2
      VX=(P(I+N4,J,2)-P(I,J,2))/DINY
      IF(ABS(VX).GT.100) GO TO 250
      LA(I,J)=MINO(LA(I,J),LA(I+N4,J))
      LA(I+N4,J)=LA(I,J)
  250 CONTINUE
      KK=KK+1
      IF(KK.EQ.2) GO TO 200
      NO(1)=0
      NO(2)=0
      II=1
      DO 400 LL=1,11
      KOU(II)=1
      DO 300 I=1,4
      DO 300 J=1,4
      IF(LA(I,J).EQ.LL) KOU(II)=KOU(II)+1
  300 CONTINUE
      IF (KOU(II).GE.7) NO(II)=LL
```

```
      IF (KOU(II).GE.7) II=2
  400 CONTINUE
      RETURN
      END
      SUBROUTINE GTERP(IH,PHI,P,D,T,PG,DG,TG,DPY,DTY,DP2Y)
C.....INTERPOLATES GROVES DATA TO HEIGHT IH AND LATITUDE PHI
      DIMENSION PG(18,19),TG(18,19),DG(18,19)
C     HEIGHT INDEX
      I =(IH - 20)/5
C     LOWER LATITUDE INDEX
      J = INT((PHI + 100.)/10.)
      IF (J.LT.1) J = 1
      IF (J.GT.18) J = 18
C     UPPER LATITUDE INDEX
      JP = J + 1
C.....CHECK FOR DENSITY OR TEMPERATURE LEQ 0
      CHK = DG(I,J) * TG(I,J) * DG(I,JP) * TG(I,JP)
      IF (CHK) 10,10,20
 10   P = PG(I,J)
      D = DG(I,J)
      T = TG(I,J)
      GO TO 30
C.....LATITUDE DEVIATION FROM GROVES ARRAY POSITION
 20   PHIF = (PHI + 100. - 10.*J)/10.
      TL= TG(I,J) + (TG(I,JP ) - TG(I,J))*PHIF
C      LATITUDE INTERPOLATION
      DL= DG(I,J) + (DG(I,JP ) - DG(I,J)) *PHIF
      R1 = PG(I,J)/(DG(I,J)*TG(I,J))
      R2 = PG(I,JP)/(DG(I,JP)*TG(I,JP))
C     INTERPOLATED GAS CONSTANT
      R = R1 + (R2 - R1)*PHIF
C     PRESSURE COMPUTED FROM INTERPOLATED GAS CONSTANT
      P =DL*R*TL
      D = DL
      T = TL
C     DP/DY FOR GEOSTOPHIC WINDS
 30   DPY = (PG(I,JP) - PG(I,J)) * 0.5
C     DT/DY FOR THERMAL WINDS
      DTY = (TG(I,JP) - TG(I,J)) * 0.5
      JM = J - 1
      IF (JM.LT.1) JM = JP
      DP2Y = (PG(I,JP) - PG(I,JM ))*0.5
      IF (ABS(PHI)-90.) 50,40,40
 40   DPY = 0.
      DTY = 0.
      DP2Y = 0.
 50   CONTINUE
      RETURN
      END
      SUBROUTINE INTERW(U1,V1,Z1,U2,V2,Z2,U,V,Z)
      IF ( Z1 - Z2 ) 20,10,20
   10 U = U1
C     SETS U,V = U1,V1 IF Z1 = Z2
      V = V1
```

```
      RETURN
   20 A = (Z-Z1)/(Z2-Z1)
      U = U1 + (U2-U1) * A
      V = V1 + (V2-V1) * A
C.....LINEAR INTERPOLATION BETWEEN U1,V1 AT HEIGHT Z1 AND U2,V2 AT
C          HEIGHT Z2.  OUTPUT IS U,V AT HEIGHT Z
      RETURN
      END
      SUBROUTINE INTERZ(P1,D1,T1,Z1,P2,D2,T2,Z2,P,D,T,Z)
    5 IF (Z1 - Z2)  20,10,20
 10   P = P1
      D = D1
C     SETS P, D, T = P1,D1,T1, IF Z1 = Z2
      T =T1
      RETURN
 20   A = (Z - Z1)/ (Z2 - Z1)
      T = T1 + (T2 - T1)*A
      D = D1 + (D2 - D1)*A
      P = P1 + (P2 - P1) * A
C.....LINEAR INTERPOLATION BETWEEN P1,D1,T1 AT HEIGHT Z1 AND P2,D2,T2
C          AT HEIGHT Z2 TO OUTPUT VALUES OF P,D,T AT HEIGHT Z
      RETURN
      END
      SUBROUTINE INTER2(P1,D1,T1,Z1,P2,D2,T2,Z2,P,D,T,Z)
C.....INTERPOLATES BETWEEN P1,D1,T1 AT HEIGHT Z1 AND P2,D2,T2 AT
C          HEIGHT Z2 TO OUTPUT VALUES OF P,D,T AT HEIGHT Z
C.....CHECKS FOR T1,D1,T2,D2 PRODUCT = 0, FOR GAS CONSTANT INTERPOLATION
      CHK=T1*D1*T2*D2
      IF (CHK) 10,10,5
    5 IF (Z1 - Z2)  20,10,20
 10   P = P1
      D = D1
C        SETS P,D,T = P1,D1,T1 IF Z1=Z2
      T = T1
      RETURN
   20 IF(P1*D1*T1*P2*D2*T2.LE.0.)GO TO 30
      A=ALOG(D2/D1)/(Z2-Z1)
C       LINEAR INTERPOLATION ON LOG D
      DZ= D1*EXP(A*(Z - Z1))
      A=(Z-Z1)/(Z2-Z1)
C       LINEAR INTERPOLATION ON T
      TZ= T1 + A*(T2-T1)
      R1=P1/(D1*T1)
      R2=P2/(D2*T2)
C       LINEAR INTERPOLATION ON GAS CONSTANT R
      R=(R2-R1)*A+R1
C        PRESSURE FROM PERFECT GAS LAW
      P = DZ * R * TZ
      D = DZ
      T = TZ
      RETURN
   30 P=0.
      D=0.
      T=0.
```

```
      RETURN
      END
      SUBROUTINE INTER4 (             CLAT, CLON, IZ,     P, D, T,
     $ P4, D4, T4, DPX, DPY, DTX, DTY,DPXX,DPYY,DPXY)
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .NSAME
C.....INTERPOLATES BETWEEN 4D ARRAYS P(I,IH),D(I,IH),T(I,IH) AT GRID
C        LOCATIONS LATITUDE GLAT(I) LONGITUDE GLON(I).
C        CLAT,CLON = CURRENT LATITUDE,LONGITUDE
C        IZ = HEIGHT                      NG = NUMBER OF 4D GRID POSITIONS
C        OUTPUT = P4,D4,T4, AND DERIVATIVES DPX,DPY,DTX,DTY
      COMMON /C4/ GLAT(16),GLON(16),NG
      COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
      DIMENSION                  P(16,26),D(16,26),T(16,26),LAX(16)
      IWSYM = ' '
      ICHK = 0
C     HEIGHT INDEX = HEIGHT + 1
      IH = IZ + 1
    5 IF (ICHK.GT.1) GO TO 220
      IF (NG.GT.9) GO TO 100
C     NG = 9 MEANS POLAR GRID
      DO 10 I=10,16,1
      P(I,IH) = P(9,IH)
      D(I,IH) = D(9,IH)
      T(I,IH) = T(9,IH)
      GLAT(I) = GLAT(9)
C     I=10-16 ALL AT 90 DEG
   10 GLON(I) = GLON(I-8)
C     LOWER RIGHT INTERPOLATION INDEX
      IB = INT(CLON/45) + 1
C     LOWER LEFT INTERPOLATION INDEX
      IA =IB+1
      IF (IA.GT.8) IA = IA-8
C     POSITION OUTSIDE POLAR GRID
      IF (ABS(CLAT).LT.75.) GO TO 20
C     UPPER LEFT INTERPOLATION INDEX
      IC = IA +8
C     UPPER RIGHT INTERPOLATION INDEX
      ID = IB + 8
      GO TO 300
   20 IF(NSAME.EQ.1) NSAME=2
      CALL GEN4D
      IWSYM = '*'
      ICHK = ICHK + 1
      GO TO 5
  100 XLON = CLON
      DO 105 I = 1,4
      DO 105 J = 1,4
      I16 = 4*(I-1) + J
      LAX(I16) = LA(I,J)
  105  CONTINUE
      IF (CLON.GT.345) XLON = CLON - 360.
C.....CHECKS FOR POSITION WITHIN 16 POINT GRID 110=GOOD.  200=POSITION
C        OUTSIDE GRID.
```

```
      IF (CLAT.GE.GLAT(1) .AND. CLAT.LT.GLAT(16) .AND. XLON.LE.GLON(1)
     $  .AND.XLON.GT.GLON(16)) GO TO 110
      GO TO 200
  110 NDL=5
      IF(ABS(CLAT).LT.18) NDL=12
      IA = 1 + INT((GLON(1) - XLON) / 5)
C.....IA = LOWER LEFT (REFERENCE) INTERPOLATION INDEX
      IA = IA + 4 * INT((CLAT - GLAT(1)) / NDL)
C     LOWER RIGHT INTERPOLATION INDEX
      IB = IA + 1
C     UPPER LEFT INTERPOLATION INDEX
      IC = IA + 4
C     UPPER RIGHT INTERPOLATION INDEX
      ID = IA + 5
      IF(LAX(IA).EQ.NB(1).OR.LAX(IA).EQ.NB(2).OR.LAX(IB).NE.LAX(IA).
     *  OR.LAX(IC).NE.LAX(IA).OR.LAX(ID).NE.LAX(IA))IWSYM='*'
      GO TO 300
  200 IF(NSAME.EQ.1)NSAME=2
      CALL GEN4D
      IWSYM = '*'
      ICHK = ICHK + 1
      GO TO 5
  220 WRITE(6,250)
  250 FORMAT('  UNABLE TO GENERATE 4-D GRID')
      P4=0.
      D4=0.
      T4=0.
      RETURN
C.....INTERPOLZTION FOR POSITION INSIDE 16 POINT GRID OR POLAR GRID
  300 CALL INTLL(P,IA,IB,IC,ID,P4,GLAT,GLON,CLAT,CLON,IH)
      CALL INTLL(D,IA,IB,IC,ID,D4,GLAT,GLON,CLAT,CLON,IH)
      CALL INTLL(T,IA,IB,IC,ID,T4,GLAT,GLON,CLAT,CLON,IH)
C.....RELATIVE LONGITUDE DISPLACEMENT FROM REFERENCE POSITION (IA)
      DLON = (CLON - GLON(IA))/(GLON(IB) - GLON(IA))
C.....RELATIVE LATITUDE DISPLACEMENT FROM REFERENCE POSITION(IA)
      DLAT = (CLAT - GLAT(IA))/(GLAT(IC) - GLAT(IA))
      DPX=P(IB,IH)-P(IA,IH)
C.....DP/DX FOR GEOSTROPHIC WIND EQUATIONS
      DPX = DPX + (P(ID,IH) - P(IC,IH) - DPX)*DLAT
      DTX = T(IB,IH) - T(IA,IH)
C.....DT/DX FOR THERMAL WIND EQUATIONS
      DTX = DTX + (T(ID,IH) - T(IC,IH) - DTX)*DLAT
      DPY = P(IC,IH) - P(IA,IH)
C.....DP/DY FOR GEOSTROPHIC WIND EQUATIONS
      DPY = DPY + (P(ID,IH) - P(IB,IH) - DPY)*DLON
      DTY = T(IC,IH) - T(IA,IH)
C.....DT/DY FOR THERMAL WIND EQUATIONS
      DTY = DTY + (T(ID,IH) - T(IB,IH) - DTY)*DLON
      IF(NG.GT.9) GO TO 315
      DPX=DPX/9.
      DTX=DTX/9.
      DPY=DPY/3.
      DTY=DTY/3.
  315 IF(ABS(CLAT).GT.18) GO TO 312
```

```
      DPY=DPY*5./12
      DTY=DTY*5./12
  312 IF (NG.GT.9) GO TO 310
      DPXX = 0.
      DPYY = 0.
      DPXY = 0.
      RETURN
  310 DPXY = P(ID,IH) - P(IC,IH) - P(IB,IH) + P(IA,IH)
      IF (MOD(IB,4) .EQ.0) GO TO 320
      I1 = IA
      I2 = IB + 1
      I3 = IC
      I4 = ID + 1
      SX=1.
      GO TO 330
  320 I1 = IA - 1
      I2 = IB
      I3 = IC - 1
      I4 = ID
      SX=-1.
  330 IF(LAX(I1).NE.LAX(IA).OR.LAX(I2).NE.LAX(IA).OR.LAX(I3).NE.
     * LAX(IA).OR.LAX(I4).NE.LAX(IA)) GO TO 360
      DPXX = P(I2,IH) - P(I1,IH)
      DPXX = DPXX + (P(I4,IH) - P(I3,IH) - DPXX)*DLAT
      IF (IC.GT.12) GO TO 340
      I1 = IA
      I2 = IC + 4
      I3 = IB
      I4 = ID + 4
      SY=1.
      GO TO 350
  340 I1 = IA - 4
      I2 = IC
      I3 = IB - 4
      I4 = ID
      SY=-1.
  350 IF(LAX(I1).NE.LAX(IA).OR.LAX(I2).NE.LAX(IA).OR.LAX(I3).NE.
     * LAX(IA).OR.LAX(I4).NE.LAX(IA)) GO TO 360
      DPYY = P(I2,IH) - P(I1,IH)
      DPYY = DPYY + (P(I4,IH) - P(I3,IH) - DPYY)*DLON
      DPXX =(DPXX - 2.*DPX )*SX
      DPYY =(DPYY - 2.*DPY )*SY
      RETURN
  360 DPXX = 0.
      DPYY = 0.
      DPXY = 0.
      IWSYM = '*'
      RETURN
      END
      SUBROUTINE INTLL(F,IA,IB,IC,ID,FLL,GLAT,GLON,CLAT,CLON,IH)
C.....INTERPOLATES FUNCTION (ARRAY) F FROM VALUES OF GLAT AND GLON AT
C        INDEX VALUES IA, IB, IC, ID TO OUTPUT VALUE FLL AT HEIGHT IH
C        AND POSITION CLAT, CLON
      DIMENSION F(16,26),GLAT(16),GLON(16)
```

```
C.....NORMALIZES LONGITUDE DISPLACEMENT
      IF(F(IA,IH)*F(IB,IH)*F(IC,IH)*F(ID,IH)) 20,10,20
   10 FLL=0.
      RETURN
   20 X=(CLON-GLON(IB))/(GLON(IA)-GLON(IB))
C.....NORMALIZES LATITUDE DISPLACEMENT
      Y=(CLAT-GLAT(IA))/(GLAT(IC)-GLAT(IA))
C.....TWO DIMENSIONAL INTERPOLATION
      FLL=F(IB,IH)+(F(ID,IH)-F(IB,IH))*Y+(F(IA,IH)-F(IB,IH))*X
     1  +(F(IC,IH)-F(IA,IH)-F(ID,IH)+F(IB,IH))*X*Y
      RETURN
      END
      SUBROUTINE INTRP4 (LALON)
C
C         SUBROUTINE TO INTERPOLATE VALUES
C
      DIMENSION XLL(4),YLL(4),XC(4),YC(4)
C
      COMMON/INT/D(208,5),IG(5),DXY(2),DLA(4),DLO(4)
C
      DEGRAD=3.14159/180.
      LALO=IABS(LALON)
      L1=LALO/10000
      L2=LALO-L1*10000
      XL=L1/10.
      YL=L2/10.
      IF (IG(5)-2) 30,20,10
   10 IF (IG(5)-3) 30,30,50
C
C         INTERPOLATE FROM NMC GRID
C
   20 CONTINUE
      DO 25 L=1,26
      DO 22 J=1,4
   22 IF (D(L,J).LT.0.01) GO TO 25
      DO 24 K=1,8
      I=(K-1)*26+L
      D(I,5)=(1.-DXY(2))*((1.-DXY(1))*D(I,1)+DXY(1)*D(I,2))
     1 +DXY(2)*(((1.-DXY(1))*D(I,3))+DXY(1)*D(I,4))
   24 CONTINUE
   25 CONTINUE
      RETURN
C
C     INTERPOLATE FROM EQUATION FOR SOUTHERN HEMISPHERE GRID
C
   30 CONTINUE
      DO 32 J=1,2
      XLL(J)=DLA(J)
      YLL(J)=DLO(J)
      IF ((YL.GE.355.).AND.(YLL(J).LT.0.01)) YLL(J)=360.
   32 CONTINUE
      X=(YLL(1)-YL)/5.
      Y=(XL-XLL(1))/5.
      IF (IG(5).EQ.3) Y=-Y
```

```
      DO 38 L=1,26
      DO 36 J=1,4
   36 IF (D(L,J).LT.0.01) GO TO 38
      DO 37 K=1,8
      I=(K-1)*26+L
      D(I,5)=D(I,1)+X*(D(I,2)-D(I,1))+Y*(D(I,3)-D(I,1))+X*Y*
     1 (D(I,4)-D(I,3)-D(I,2)+D(I,1))
   37 CONTINUE
   38 CONTINUE
      RETURN
C
C        INTERPOLATE FROM ACROSS GRIDS
C
   50 CONTINUE
      IF (IG(5).NE.1133) GO TO 55
      IG(5)=3
      GO TO 30
   55 CONTINUE
      IF (IG(5).NE.333) GO TO 60
      DLO(1)=(DLO(2)+DLO(3))/2.
      DO 52 I=1,208
   52 D(I,4)=D(I,3)
      DLA(4)=DLA(3)
      DLO(4)=DLO(3)
   60 CONTINUE
      DO 62 I=1,4
      XLL(I)=DLA(I)
      YLL(I)=DLO(I)
      IF ((YL.GT.350.).AND.(YLL(I).LT.0.01)) YLL(I)=360.
   62 CONTINUE
      ITH=0
      X=YLL(1)-YL
      Y=XL-XLL(1)
   63 CONTINUE
      DO 65 I=2,4
      XC(I)=YLL(1)-YLL(I)
   65 YC(I)=XLL(I)-XLL(1)
      TH2=3.14159/4
      TH3=3.14159/4
      IF (ABS(XC(2)).GT.0.01) TH2=ATAN(YC(2)/XC(2))
      IF (ABS(YC(3)).GT.0.01) TH3=ATAN(XC(3)/YC(3))
      IF (XC(2).LT.0.) TH2=3.14159+TH2
      IF (XC(3).LT.0.) TH3=3.14159+TH3
      DNN=COS(TH2+TH3)
      IF (ABS(DNN).GT.0.001) GO TO 66
      ITH=ITH+1
      IF (ITH.EQ.2) GO TO 66
      XLL(3)=XLL(4)
      YLL(3)=YLL(4)
      DO 61 I=1,208
   61 D(I,3)=D(I,4)
      GO TO 63
   66 CONTINUE
      ZA=SQRT(XC(2)**2+YC(2)**2)
```

```
      IF (ITH.LT.2) GO TO 69
      Z=SQRT(X**2+Y**2)
      E=0.
      Z4=0.
      GO TO 71
   69 CONTINUE
      EB=SQRT(XC(3)**2+YC(3)**2)
      Z4=(XC(4)*COS(TH3)-YC(4)*SIN(TH3))/DNN
      E4=(YC(4)*COS(TH2)-XC(4)*SIN(TH2))/DNN
      Z=(X*COS(TH3)-Y*SIN(TH3))/DNN
      E=(Y*COS(TH2)-X*SIN(TH2))/DNN
      B=0.
      C=0.
      DD=0.
C
   71 CONTINUE
      DO 70 L=1,26
      DO 68 J=1,4
   68 IF (D(L,J).LT.0.01) GO TO 70
      DO 67 K=1,8
      I=(K-1)*26+L
      A=D(I,1)
      IF (ZA.GT.0.01) B=(D(I,2)-D(I,1))/ZA
      IF (EB.GT.0.01) C=(D(I,3)-D(I,1))/EB
      IF ((ABS(Z4).GT.0.01).AND.(ABS(E4).GT.0.01))
     1 DD=(D(I,4)-A-B*Z4-C*E4)/(Z4*E4)
      D(I,5)=A+B*Z+C*E+DD*Z*E
   67 CONTINUE
   70 CONTINUE
      RETURN
      END
      SUBROUTINE INTRUV(UR,VR,H,PHI,SUH,SVH)
C.....FINDS RANDOM WIND STANDARD DEVIATION AT HEIGHT H (KM), LATITUDE
C        PHI (DEGREES), FROM UR AND VR ARRAYS
      DIMENSION UR(25,10),VR(25,10)
C.....I - LOWER HEIGHT INDEX
      IF (H.LT.95.) I = 1 + INT(H) / 5
      IF (H.GE.95.) I=19+(INT(H)-80)/20
      IF (I.GT.25) I = 25
C     UPPER HEIGHT INDEX
      IP=I+1
      IF (IP.GT.25) IP=25
C     LOWER LATITUDE INDEX
      J=INT(PHI+110.)/20
C      UPPER LATITUDE INDEX
      JP=J+1
      IF (JP.GT.10) JP=10
C.....PHI1 - LOWER LATITUDE FOR UR AND VR ARRAY VALUES
      PHI1=-110.+20.*J
C.....PHI2 - UPPER LATITUDE FOR UR AND VR ARRAY VALUES
      PHI2=-110.+20.*JP
      IF (I.GT.19) GO TO 10
C      LOWER HEIGHT FOR UR AND VR ARRAY VALUES
      Z1=5.*(I-1)
```

```
      GO TO 20
10    Z1=20.*(I-15)
20    IF (IP.GT.19) GO TO 30
C       UPPER HEIGHT FOR UR AND VR ARRAY VALUES
      Z2=5.*(IP-1)
      GO TO 40
   30 Z2 = 20. * (IP - 15)
C     INTERPOLATE ON LATITUDE AT LOWER HEIGHT
   40 CALL INTERW(UR(I,J),VR(I,J),PHI1,UR(I,JP),VR(I,JP),PHI2,U1,V1,
     $PHI)
C       INTERPOLATE ON LATITUDE AT UPPER HEIGHT
      CALL INTERW(UR(IP,J),VR(IP,J),PHI1,UR(IP,JP),VR(IP,JP),PHI2,U2,V2,
     $PHI)
C       INTERPOLATE ON HEIGHT
      CALL INTERW(U1,V1,Z1,U2,V2,Z2,SUH,SVH,H)
      RETURN
      END
      SUBROUTINE JAC(Z,TZ,DENS)
      COMMON/IOTEMP/IOTEM1,IOTEM2,IU6,NMCOP,DD,XMJD,PHI1,PHI,
     .           NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,Y,T,EM
      DIMENSION ALPHA(6),EI(6),DI(6),     B(7),DIT(6)
      QQ = 100.
      DATA ALPHA/0.0,0.0,0.0,0.0,-0.38,0.0/
      DATA EI/28.0134,31.9988,15.9994,39.948,4.0026,1.00797/
      DATA B/28.15204,-0.085586,1.284E-04,-1.0056E-05,-1.021E-05,
     11.5044E-06,9.9826E-08/
      AV=6.02257E23
      QN=.78110
      QO2=.20955
      QA=.009343
      QHE = 1.289E-5
      FK=8.31432
C
C     TEMPERATURE AT Z = 125 KM, EQ. 9
C
      TX=444.3807+.02385*T -392.8292*EXP(-.0021357*T)
      A2=2.*(T-TX)/3.14159265
C
C
      DIT(6)=0.
      M=10
      EPS=.0001
C
C     TEMPERATURE FOR 90%Z%125, EQ. 10
C
      T1=1.9*(TX-183.)/35.
      T4=3.*(TX-183.-2.*T1*35./3.)/(35.**4)
      T3=-T1/(3.*35.**2)+4.*T4*35./3.
      TZ=TX+T1*(Z-125.)+T3*(Z-125.)**3+T4*(Z-125.)**4
      IF (Z-105.) 43,43,40
C
```

```
C     MEAN MOLECULAR WEIGHT FOR 90%Z%105, EQ. 1
C
   43 Z2 = Z - QQ
      EM=B(1)+B(2)*Z2+B(3)*Z2**2+B(4)*Z2**3+B(5)*Z2**4+B(6)*Z2**5
     1+B(7)*Z2**6
      D=Z
   70 CONTINUE
C
C     INTEGRATION OF EQ. 5 FOR DENSITY BETWEEN 90%Z%105
C
      A=90.
      FA=B(1)+B(2)*(A-QQ)+B(3)*(A-QQ)**2+B(4)*(A-QQ)**3+B(5)*(A-QQ)**4
     1+B(6)*(A-QQ)**5 +B(7)*(A-QQ)**6
      FA=FA*9.80655/((1.+A/6.356766E+3)**2)
      FA=FA/(TX+T1*(A-125.)+T3*(A-125.)**3 +T4*(A-125.)**4)
      FD=B(1)+B(2)*(D-QQ)+B(3)*(D-QQ)**2+B(4)*(D-QQ)**3+B(5)*(D-QQ)**4
     1+B(6)*(D-QQ)**5 +B(7)*(D-QQ)**6
      FD=FD*9.80665/((1.+D/6.356766E+3)**2)
      FD=FD/(TX+T1*(D-125.)+T3*(D-125.)**3 +T4*(D-125.)**4)
C     SRQ4, SIMPSONS RULE QUADRATURE  -  G.F.KUNCIR
C     DEFINITIONS  -
C       A = LOWER LIMIT OF INTEGRATION
C       D = UPPER LIMIT OF INTEGRATION
C       FUNC = INTEGRAND FUNCTION SUBPROGRAM
C       EPS = RELATIVE ERROR CONVERGENCE CRITERION
C       M = MAXIMUM NUMBER OF INTEGRATIONS
C       R = RESULT OF INTEGRATION
C       N = NUMBER OF INTEGRATIONS9RIQ8IRID TO FIND R
C
      NINT = 1
      N=0
      PREV=0.
      SONE=(D-A)*(FA+FD)/2.
   71 N=N+1
      IF (N-M) 72,72,75
   72 NINT = 2 * NINT
      STWO=0.
      DEL=(D-A)/FLOAT(NINT)
      DO 73 I=1,NINT,2
      X=A+DEL*FLOAT(I)
      FX=B(1)+B(2)*(X-QQ)+B(3)*(X-QQ)**2+B(4)*(X-QQ)**3+B(5)*(X-QQ)**4
     1+B(6)*(X-QQ)**5 +B(7)*(X-QQ)**6
      FX=FX*9.80665/((1.+X/6.356766E+3)**2)
      FX=FX/(TX+T1*(X-125.)+T3*(X-125.)**3 +T4*(X-125.)**4)
   73 STWO=STWO+FX
      CUR=SONE+4.*DEL*STWO
      IF (EPS*ABS(CUR)-ABS(CUR-PREV)) 74,75,75
   74 PREV=CUR
      SONE=(SONE+CUR)/4.
      GO TO 71
   75 R=CUR/3
      IF (Z-105.) 44,76,44
   44 IF (D-105.) 76,55,76
C
```

```
C      DENSITY FOR 90%Z%105
C
76     DENS=3.46E-9*183.*EM*EXP(-R/FK)/(TZ*28.878)
       DL=ALOG10(DENS)
       PAR=AV*DENS/EM
       AN=ALOG10(QN*EM*PAR/28.96)
       AA=ALOG10(QA*EM*PAR/28.96)
       AHE=ALOG10(QHE*EM*PAR/28.96)
       AO=ALOG10(2.*PAR*(1.-EM/28.96))
       AO2=ALOG10(PAR*(EM*(1.+QO2)/28.96-1.))
       AH=-0.
       RETURN
C
C      TEMPERATURE AND MEAN MOLECULAR WEIGHT AT Z=105 KM
C
   40  Z3=105.
       TZ3=TX+T1*(Z3'125.)+T3*(Z3-125)**3+T4*(Z3-125)**4
       ZM3=B(1)+B(2)* 5.+B(3)* 25.+B(4)* 125.+B(5)* 5.**4.+B(6)* 5.**5.
      1+B(7)* 5.**6.
       D=105.
       GO TO 70
C
C      DENSITY  AT Z=105 KM
C
55     DEN1=3.46E-9*183.*ZM3*EXP(-R/FK)/(TZ3*28.878)
       PAR=AV*DEN1/ZM3
       DI(1)=QN*ZM3*PAR/28.96
       DI(2)=PAR*(ZM3*(1.+QO2)/28.96-1.)
       DI(3)=2.*PAR*(1.-ZM3/28.96)
       DI(4)=QA*ZM3*PAR/28.96
       DI(5)=QHE*ZM3*PAR/28.96
       IF(Z-125.) 56,56,90
56     CONTINUE
C
C      INTEGRATION OF EQ. 6 FOR DENSITY ABOVE 105 KM
C
       R=0.
       D1=125.
       A1=105.
  400  CONTINUE
       FA1=9.80665/((1.+A1/6.356766E+3)**2)
       FA1=FA1/(TX+T1*(A1-125.)+T3*(A1-125.)**3+T4*(A1-125.)**4)
       FD1=9.80665/((1.+D1/6.356766E+3)**2)
       IF(D1-125.) 45,45,50
   45  FD1=FD1/(TX+T1*(D1-125.)+T3*(D1-125.)**3+T4*(D1-125.)**4)
       GO TO 51
50     FD1=FD1/(TX+A2*ATAN(T1*(D1-125.)*(1.+4.5E-6*(D1-125.)**2.5)/A2))
       TZ=TX+A2*ATAN(T1*(Z-125.)*(1.+4.5E-6*(Z-125.)**2.5)/A2)
51     N=0
       NINT = 1
       PREV=0
       SONE=(D1-A1)*(FA1+FD1)/2.
81     N=N+1
       IF (N-M) 82,82,85
```

```
82    NINT = 2 * NINT
      STWO=0.
      DEL=(D1-A1)/FLOAT(NINT)
      DO 83 I=1,NINT,2
      X1=A1+DEL*FLOAT(I)
      FX1=9.80665/((1.+X1/6.356766E+3)**2)
      IF(X1-125.) 46,46,52
   46 FX1=FX1/(TX+T1*(X1-125.)+T3*(X1-125.)**3+T4*(X1-125.)**4)
      GO TO 83
52    FX1=FX1/(TX+A2*ATAN(T1*(X1-125.)*(1.+4.5E-6*(X1-125.)**2.5)/A2))
83    STWO=STWO+FX1
      CUR=SONE+4.*DEL*STWO
      IF (EPS*ABS(CUR)-ABS(CUR-PREV)) 84,85,85
84    PREV=CUR
      SONE=(SONE+CUR)/4.
      GO TO 81
85    R=CUR/3.+R
      IF(A1.EQ.125.) GO TO 430
      D1=Z
      A1=125.
      GO TO 400
 430  CONTINUE
C
C     DENSITY ABOVE 105 KM
C
      DO 41  I=1,5
      DIT(I)=DI(I)*(TZ3/TZ)**(1.+ALPHA(I))*EXP(-EI(I)*R/FK)
   41 CONTINUE
      DENS=0
      DO 42 I=1,6
      DENS=DENS+EI(I)*DIT(I)/AV
42    CONTINUE
C
C     MEAN MOLECULAR WEIGHT FOR Z 105 KM
C
      EM=DENS*AV/(DIT(1)+DIT(2)+DIT(3)+DIT(4)+DIT(5)+DIT(6))
C
C     LOG DENSITY
C
      DL=ALOG10(DENS)
      AN =ALOG10(DIT(1))
      AO2=ALOG10(DIT(2))
      AO =ALOG10(DIT(3))
      AA =ALOG10(DIT(4))
      AHE=ALOG10(DIT(5))
      IF(Z-500.) 47,48,48
   47 DIT(6)=10.**(-6)
   48 AH=ALOG10(DIT(6))
      AN =AMAX1(-0., AN)
      AO2=AMAX1(-0.,AO2)
      AO =AMAX1(-0., AO)
      AA =AMAX1(-0., AA)
      AHE=AMAX1(-0.,AHE)
      AH =AMAX1(-0., AH)
```

```
      RETURN
C
C     TEMPERATURE AND DENSITY AT Z=500 KM
C
90    S=TX+A2*ATAN(T1*375.*(1.+4.5E-6*375.**2.5)/A2)
      DI(6)=10.**(73.13-39.4*ALOG10(S)+5.5*ALOG10(S)*ALOG10(S))
      A1=500.
      IF(Z-500.) 49,60,60
C
C     INTEGRATION OF EQ. 6 FOR DENSITY FOR Z 125 KM
C
   49 A1=Z
   60 FA1=9.80665/((1.+A1/6.356766E+3)**2)
      FA1=FA1/(TX+A2*ATAN(T1*(A1-125.)*(1.+4.5E-6*(A1-125.)**2.5)/A2))
      D1=Z
      IF(Z-500.) 61,62,62
   61 D1=500.
   62 FD1=9.80665/((1.+D1/6.356766E+3)**2)
      FD1=FD1/(TX+A2*ATAN(T1*(D1-125.)*(1.+4.5E-6*(D1-125.)**2.5)/A2))
      N=0
      NINT = 1
      PREV=0
      SONE=(D1-A1)*(FA1+FD1)/2.
91    N=N+1
      IF (N-M) 92,92,95
92    NINT = 2 * NINT
      STWO=0.
      DEL=(D1-A1)/FLOAT(NINT)
      DO 93 I=1,NINT,2
      X1=A1+DEL*FLOAT(I)
      FX1=9.80665/((1.+X1/6.356766E+3)**2)
      FX1=FX1/(TX+A2*ATAN(T1*(X1-125.)*(1.+4.5E-6*(X1-125.)**2.5)/A2))
93    STWO=STWO+FX1
      CUR=SONE+4.*DEL*STWO
      IF (EPS*ABS(CUR)-ABS(CUR-PREV)) 94,95,95
94    PREV=CUR
      SONE=(SONE+CUR)/4.
      GO TO 91
95    R=CUR/3.
C
C     TEMPERATURE AT Z 500 KM
C
      TZ=TX+A2*ATAN(T1*(Z-125.)*(1.+4.5E-6*(Z-125.)**2.5)/A2)
      IF(Z-500.) 63,64,64
   63 R=-R
C
C     DENSITY OF HYDROGEN FOR Z 500 KM
C
   64 DIT(6)=DI(6)*(S/TZ)*EXP(-EI(6)*R/FK)
      GO TO 56
      END
      SUBROUTINE JACCH(Z,PHIR,THET,PH,DH,TH)
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,R,T,EM
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
```

```
     .           NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ M , IDA, IYR, H1, PHI1R,THET1R,G,RI,H,CLAT,CLON ,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
C
C     JACCH CALCULATES THE PRESSURE, DENSITY, AND TEMPERATURE AT A
C     POINT IN SPACE ABOVE 90 KM FOR A PARTICULAR TIME
C
C     INPUT
C     Z = HEIGHT IN KM
C     PHIR = LATITUDE IN RADIANS
C     THET = LONGITUDE IN DEGREES  (0 TO 360 DEGREES TURNING WESTWARD)
C     F10 = SOLAR RADIO NOISE FLUX (XE - 22 WATTS/M**2)
C     F10B = 81-DAY AVERAGE F10
C     AP = GEOMAGNETIC INDEX
C     M  = MONTH (FOR YEARLY MEAN VARIABLES M IS SET TO 13)
C     IDA = DAY OF MONTH
C     IYR = YEAR
C     IHR = HOUR OF DAY  (UNIVERSAL TIME)
C     MIN = MINUTE  (UNIVERSAL TIME)
C     XMJD = MEAN JULIAN DAY  (SET EQUAL TO ZERO FOR ANNUAL MEAN)
C     DD = DAY NUMBER WITH RESPECT TO JAN 0 OF YEAR IYR
C
C     OUTPUT
C     PH = PRESSURE IN UNITS OF NT/M**2
C     DH = DENSITY IN UNITS OF KG/M**3
C     TH = TEMPERATURE IN KELVIN DEGREES
C
C     DD = DAY NUMBER WITH RESPECT TO JAN 1 OF YEAR IYR
C
C     REPLACEMENT OF SUBROUTINE VARIABLES TO INSURE NO CHANGES IN THEM
C
      R = 0.31
      XLAT = PHIR
      XLONG = THET
      IF (M.EQ.13) GO TO 50
C
C     CALCULATE SOLAR DEC. AND HOUR ANGLE
C
      CALL TME
C
C     EXOSPHERIC TEMPERATURE
C
      CALL TINF
      GO TO 75
   50 T = 1000.0
C
C     TEMPERATURE, MOLECULAR WEIGHT, AND DENSITY WITHOUT SEASONAL
C        VARIATIONS
C
   75 CALL JAC(Z,TH,DH)
      IF (M.EQ.13) GO TO 300
      YDA = 365.0
      J1 = MOD(IYR,4)
      IF (J1.EQ.0) YDA = 366.0
```

```
      C1 = SIN((360. / YDA) * 0.0174532925 * (DD + 100.0))
      IF (PHIR) 80,70,80
   70 C2 = 0.0
      GO TO 90
   80 C2 = (SIN(PHIR) ** 2) * (PHIR / ABS(PHIR))
C
C     DENSITY WITH SEASONAL VARIATIONS
C
   90 Z90 = Z - 90.0
      DLRHO = 0.02 * Z90 * EXP(-0.045 * Z90) * C1 * C2
      DH = DH * EXP(DLRHO)
C
C     MOLECULAR WEIGHT WITH SEASONAL VARIATION
C
      IF (Z - 120.0) 100,100,150
  100 EM = EM + 0.006 * Z90 * C1
      GO TO 250
  150 IF (Z - 230.0) 200,250,250
  200 DEM = EXP(-0.02424 * Z90) * (0.0316 * Z90 - 0.0002257 * Z90 * Z90)
      EM = EM + DEM * C1*0.5
C
C     TEMPERATURE WITH SEASONAL VARIATIONS
C
  250 IF (Z-260.0) 270,300,300
  270 Z110 = Z - 110.0
      DTH = -2.291753 * Z110 + 0.02154336 * Z110*Z110- 4.1766671E-05 *
     $ (Z110 ** 3)
      DTH = EXP(-0.290655 * SQRT(ABS(Z110)))* DTH
      TH = TH +(DTH * C1 * C2 *TH) / 100.0
C
C     DENSITY IN METRIC UNITS AND PRESSURE CALCULATED
C
  300 DH = DH * 1000.0
      PH =((DH * 8.31432 * TH) / EM) * 1000.0
      RETURN
      END
      SUBROUTINE NORMAL(D1,D2)
C.....PRODUCES 2 RANDOM NUMBERS, D1, D2, PICKED FROM A NORMAL DIST.
C     WITH ZERO MEAN AND UNIT VARIANCE
      REAL L
   50 X = RAND(0)
      Y = 2*RAND(0) - 1
      XX = X**2
      YY = Y**2
      S = XX + YY
      IF (S-1) 51,51,50
   51 L = SQRT(-2*ALOG(RAND(0)))/S
      D1 = (XX-YY)*L
      D2 = 2*X*Y*L
      RETURN
      END
      SUBROUTINE PDTUV (PSP, DSP, TSP, CLAT, CLON, IH, PS, DS, TS,
     $ DPX, DPY, DTX, DTY,DP2X,DP2Y,DPXY)
C.....INTERPOLATES STATIONARY PERTURBATIONS ON LATITUDE AND LONGITUDE
```

```
C        AT HEIGHT IH
      DIMENSION PSP(8,10,12),DSP(8,10,12),TSP(8,10,12)
      IF (IH.LT.52) GO TO 10
      IF (IH.GT.84) GO TO 20
C     HEIGHT INDEX K
      K = ((IH+4)/8) - 4
      GO TO 30
   10 K = (IH-20)/10
      GO TO 30
   20 K = 8
   30 XLON = CLON
      IF (CLON.LT.10.) XLON = 360. + CLON
C     LOWER LONGITUDE INDEX J
      J = INT((XLON + 20.)/30.)
C.....DLON - RELATIVE LONGITUDE DEVIATION FROM CORNER REFERENCE LOCATION
      DLON = (XLON - 30.*J + 20.)/30.
C     UPPER LONGITUDE INDEX JP
      JP = J+1
      IF (JP.GT.12) JP=1
C     LOWER LATITUDE INDEX I
      I = INT((CLAT + 110.)/20.)
C      UPPER LATITUDE INDEX IP
      IP = I+1
      IF (IP.GT.10) IP=10
C.....DLAT - RELATIVE LATITUDE DEVIATION FROM CORNER REFERENCE LOCATION
      DLAT = (CLAT-20.*I + 110.)/20.
C     PRESSURE LAT-LON INTERPOLATION
      PS=PSP(K,I,J)+(PSP(K,IP,J)-PSP(K,I,J))*DLAT+(PSP(K,I,JP)-PSP(K,I,J
     1))*DLON+(PSP(K,IP,JP)-PSP(K,I,JP)-PSP(K,IP,J)+PSP(K,I,J))*DLAT*
     2DLON
C     DENSITY LAT-LON INTERPOLATION
      DS=DSP(K,I,J)+(DSP(K,IP,J)-DSP(K,I,J))*DLAT+(DSP(K,I,JP)-DSP(K,I,J
     1))*DLON+(DSP(K,IP,JP)-DSP(K,I,JP)-DSP(K,IP,J)+DSP(K,I,J))*DLAT*
     2DLON
C     TEMPERATURE LAT-LON INTERPOLATION
      TS=TSP(K,I,J)+(TSP(K,IP,J)-TSP(K,I,J))*DLAT+(TSP(K,I,JP)-TSP(K,I,J
     1))*DLON+(TSP(K,IP,JP)-TSP(K,I,JP)-TSP(K,IP,J)+TSP(K,I,J))*DLAT*
     2DLON
C.....DPX - DP/DX FOR GEOSTROPHIC WINDS
      DPX = (PSP(K,I,J) - PSP(K,I,JP)) / 6.
      DPX = DPX + ((PSP(K,IP,J) - PSP(K,IP,JP))/6. - DPX)*DLAT
C.....DPY - DP/DY FOR GEOSTROPHIC WINDS
      DPY=(PSP(K,IP,J)-PSP(K,I,J))/4.
      DPY = DPY + ((PSP(K,IP,JP) - PSP(K,I,JP))/4. - DPY)*DLON
C.....DTX - DT/DX FOR THERMAL WINDS
      DTX = (TSP(K,I,J) - TSP(K,I,JP)) / 6.
      DTX = DTX + ((TSP(K,IP,J) - TSP(K,IP,JP))/6. - DTX)*DLAT
C.....DTY - DT/DY FOR THERMAL WINDS
      DTY = (TSP(K,IP,J) - TSP(K,I,J)) / 4.
      DTY = DTY + ((TSP(K,IP,JP) - TSP(K,I,JP))/4. - DTY)*DLON
      IF (IP.GT.9) GO TO 90
      DPXY = (PSP(K,IP,J) - PSP(K,IP,JP) - PSP(K,I,J) + PSP(K,I,JP))/24.
      JX = J - 1
      IF (JX.LT.1) JX = JX + 12
```

```
      IY = I -  1
      DP2X = (PSP(K,I,JX) - PSP(K,I,JP))/6.
      DP2X = DP2X + ((PSP(K,IP,JX) - PSP(K,IP,JP))/6. - DP2X)*DLAT
      DP2Y = (PSP(K,IP,J) - PSP(K,IY,J))/4.
      DP2Y = DP2Y + ((PSP(K,IP,JP) - PSP(K,IY,JP))/4.- DP2Y)*DLON
      RETURN
90    DP2X = 0.
      DP2Y = 0.
      DPXY = 0.
      RETURN
      END
      SUBROUTINE PERTRB
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,NSAME,
     *PL1,DL1,TL1,SPL1,SDL1,STL1,UL1,VL1,SUL1,SVL1,MN,IDA,IYR,
     1PH,FLAT,
     * PLON,G,R,CH,CLAT,CLON,F10,F10B,AP,IHR,MIN,NMORE,DX,HL,VL,DZ,
     2B,EPS,IOPP,LOOK,IET,FLAT,PS1,DS1,TS1,US1,VS1,SPS1,SDS1,
     3STS1,SUS1,SVS1,UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2
      COMMON /COMPER/SP2,SD2,ST2,P2,D2,T2,U2,V2,SU2,SV2,CP,
     1PS2,DS2,TS2,US2,VS2,
     2PL2,DL2,TL2,UL2,VL2,
     3SPS2,SDS2,STS2,SUS2,SVS2,
     4SPL2,SDL2,STL2,SUL2,SVL2
      COMMON/WINCOM/ DUM(11),T
      DLON = ABS(CLON-PLON)
      PI = 3.1415927
      IF(DLON.GT.PI) DLON = 2.*PI - DLON
      DX  =     R*SQRT((CLAT-PLAT)**2 + (COS(CLAT)*(DLON     ))**2)
C.....DX IS HORIZONTAL DISTANCE BETWEEN POSITIONS PLAT,PLON AND CLAT,CLO
      AH = 900.
      BH = 6.
C     HORIZONTAL WAVELENGTH, KM
      HLL= AH + BH*CH
      DPHI = (90. - ABS(PHI1))**2
      DHGT = 0.22 + 0.0025B*(SQRT(ABS(CH)**3))
      IF (DHGT.GT.5.) DHGT = 5.
      VDS = (11.0 - 2.102E-4*DPHI)*DHGT
      VTS = (3.0 + 5.146E-4*DPHI)*DHGT
      VUS = (6.2 - 3.615E-4*DPHI)*DHGT
      VDL = (20.7 - 1.346E-3*DPHI)*DHGT
      VTL = 7.3*DHGT
      VUL = (31.2 - 3.503E-3*DPHI)*DHGT
      HLS = 20. + .0125*CH*CH
      IF(HLS.GT.400.) HLS = 400.
      HLS = (DX/HLS)**2
      HLL = (DX/HLL)**2
      RDS=SQRT(HLS+(DZ/VDS)**2)
      IF(RDS.LE.100.)GO TO 10
      RDS=0.
      GO TO 20
10     RDS=1./EXP(RDS)
20    RTS=SQRT(HLS+(DZ/VTS)**2)
      IF(RTS.LE.100.)GO TO 30
      RTS=0.
```

```
      GO TO 40                                                         PERT  44
 30   RTS=1./EXP(RTS)                                                  PERT  45
 40   RVS=SQRT(HLS+(DZ/VUS)**2)                                        PERT  46
      IF(RVS.LE.100.)GO TO 50                                          PERT  47
      RVS=0.                                                           PERT  48
      GO TO 60                                                         PERT  49
 50   RVS=1./EXP(RVS)                                                  PERT  50
 60   RDL=SQRT(HLL+(DZ/VTL)**2)                                        PERT  51
      IF(RDL.LE.100.)GO TO 70                                          PERT  52
      RDL=0.                                                           PERT  53
      GO TO 80                                                         PERT  54
 70   RDL=1./EXP(RDL)                                                  PERT  55
 80   RTL=SQRT(HLL+(DZ/VTL)**2)                                        PERT  56
      IF(RTL.LE.100.)GO TO 90                                          PERT  57
      RTL=0.                                                           PERT  58
      GO TO 100                                                        PERT  59
 90   RTL=1./EXP(RTL)                                                  PERT  60
100   RVL=SQRT(HLL+(DZ/VUL)**2)                                        PERT  61
      IF(RVL.LE.100.)GO TO 110                                         PERT  62
      RVL=0.                                                           PERT  63
      GO TO 120                                                        PERT  64
110   RVL=1./EXP(RVL)                                                  PERT  65
120   CONTINUE                                                         PERT  66
      CALL CORLAT(AS,BS,CS,DS,ES,FS,GS,HS,AIS,AJS,AKS,SPS1,SPS2,SDS1,  PERT  67
     1 SDS2,STS1,STS2,SUS1,SUS2,SVS1,SVS2,UDS1,UDS2,VDS1,VDS2,RDS,RTS, PERT  68
     2RVS)                                                             PERT  69
      CALL CORLAT(AL,BL,CL,DL,EL,FL,GL,HL,AIL,AJL,AKL,SPL1,SPL2,SDL1,  PERT  70
     1 SDL2,STL1,STL2,SUL1,SUL2,SVL1,SVL2,UDL1,UDL2,VDL1,VDL2,         PERT  71
     2RDL,RTL,RVL)                                                     PERT  72
      CALL NORMAL(ZD,ZT)                                               PERT  73
      DS2=AS*DS1+BS*ZD                                                 PERT  74
      TS2=CS*TS1+DS*DS2+ES*ZT                                          PERT  75
      PS2=DS2+TS2                                                      PERT  76
      CALL NORMAL(ZD,ZT)                                               PERT  77
      US2=FS*US1+GS*DS2+HS*ZD                                          PERT  78
      VS2=AIS*VS1+AJS*DS2+AKS*ZT                                       PERT  79
      CALL NORMAL(ZD,ZT)                                               PERT  80
      DL2=AL*DL1+BL*ZD                                                 PERT  81
      TL2=CL*TL1+DL*DL2+EL*ZT                                          PERT  82
      PL2=DL2+TL2                                                      PERT  83
      CALL NORMAL(ZD,ZT)                                               PERT  84
      UL2=FL*UL1+GL*DL2+HL*ZD                                          PERT  85
      VL2=AIL*VL1+AJL*DL2+AKL*ZT                                       PERT  86
      P2=PS2+PL2                                                       PERT  87
      D2=DS2+DL2                                                       PERT  88
      T2=TS2+TL2                                                       PERT  89
      U2=US2+UL2                                                       PERT  90
      V2=VS2+VL2                                                       PERT  91
      UDL1=UDL2                                                        PERT  92
      UDS1=UDS2                                                        PERT  93
      VDL1=VDL2                                                        PERT  94
      VDS1=VDS2                                                        PERT  95
      RETURN                                                           PERT  96
      END                                                              PERT  97
```

```
      SUBROUTINE PHASE(D1,X1,D2,X2,D,X)
      PER = 870.
      IF (X2-X1) 20,10,20
10    D = D1
      RETURN
20    DA = D1
      DB = D2
      PER2 = PER/2.
      IF(ABS(DB-DA).LE.PER2)GO TO 30
      IF (DA.LT.PER2) DA = DA + PER
      IF (DB.LT.PER2) DB = DB + PER
   30 DA = DA + (DB - DA)*(X - X1)/(X2 - X1)
      IF (DA.GT.PER) DA = DA - PER
      IF(DA.LT.0.)DA=DA+PER
      D = DA
      RETURN
      END
      SUBROUTINE QBOGEN
C.....COMPUTES QBO VALUES PQ,DQ,TQ,UQ,VQ AT HEIGHT H, LATITUDE PHI
C        ON JULIAN DAY XMJD FROM ARRAYS OF AMPLITUDES PAQ,DAQ,TAQ,
C        UAQ,VAQ AND PHASES PDQ,DDQ,TDQ,UDQ,VDQ.
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DDD,XMJD,PHI1,PHI,
     ,           NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
      COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19)
     , ,PSP(8,10,12)
     , ,DSP(8,10,12),TSP(8,10,12),PAQ(17,5),DAQ(17,5),TAQ(17,5),
     , PDQ(17,5),DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),
     ,UAQ(17,5),VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10)
     , ,PQ,DQ,TQ,UQ,VQ
     , ,PA,DA,TA,UA,VA,IOPQ
      IF (XMJD.GT.0.AND.IOPQ.EQ.1) GO TO 10
C     SETS QBO VALUES TO ZERO FOR ANNUAL MEAN
      PQ =0.
      DQ=0.
      TQ=0.
      UQ=0.
      VQ=0.
      RETURN
C     LOWER HEIGHT INDEX
   10 IH = INT((H-5.)/5.)
      IF (IH.LT.1) IH=1
C     UPPER HEIGHT INDEX
      IP = IH + 1
      IF (IP.GT.17) IP = 17
      PHA = ABS(PHI)
C     LOWER LATITUDE INDEX

      JL = INT((  PHA    + 10.)/20.)
C     UPPER LATITUDE INDEX
      JP = JL + 1
      IF (JL.LE.0) JL=1
      IF (JP.GT.5) JP=5
```

```
C     JULIAN DAY FOR JAN 0, 1966
      XMJDO = 2439126
C     TIME RELATIVE TO JAN 0, 1966
      TMJD = XMJD-XMJDO
C     2*PI/PERIOD,PERIOD = 870 DAYS
      PER = 870.
      TP = 6.2831853/PER
C     LOWER HEIGHT
      HI = 5. + 5.*IH
C     LOWER LATITUDE
      PHIJ = 20.*JL - 10.
C     UPPER LATITUDE
      PHIP = 20.*JP-10.
C.....INTERPOLATES QBO P,D,T AMPLITUDE ON LATITUDE AT LOWER HEIGHT
      CALL INTERZ(PAQ(IH,JL),DAQ(IH,JL),TAQ(IH,JL),PHIJ,PAQ(IH,JP),
     1DAQ(IH,JP),TAQ(IH,JP),PHIP,PA1,DA1,TA1,PHA)
C     UPPER HEIGHT
      HP = 5.+5.*IP
C.....INTERPOLATES QBO P,D,T AMPLITUDE ON LATITUDE AT UPPER HEIGHT
      CALL INTERZ(PAQ(IP,JL),DAQ(IP,JL),TAQ(IP,JL),PHIJ,PAQ(IP,JP),
     2DAQ(IP,JP),TAQ(IP,JP),PHIP,PA2,DA2,TA2,PHA)
C.....INTERPOLATES QBO P,D,T AMPLITUDE ON HEIGHT AT LATITUDE PHI
      CALL INTERZ(PA1,DA1,TA1,HI,PA2,DA2,TA2,HP,PA,DA,TA,H)
C.....INTERPOLATES QBO P,D,T,U,V PHASE ON LATITUDE AND HEIGHT
      CALL PHASE(PDQ(IH,JL),PHIJ,PDQ(IH,JP),PHIP,PD1,PHA)
      CALL PHASE(DDQ(IH,JL),PHIJ,DDQ(IH,JP),PHIP,DD1,PHA)
      CALL PHASE(TDQ(IH,JL),PHIJ,TDQ(IH,JP),PHIP,TD1,PHA)
      CALL PHASE(PDQ(IP,JL),PHIJ,PDQ(IP,JP),PHIP,PD2,PHA)
      CALL PHASE(DDQ(IP,JL),PHIJ,DDQ(IP,JP),PHIP,DD2,PHA)
      CALL PHASE(TDQ(IP,JL),PHIJ,TDQ(IP,JP),PHIP,TD2,PHA)
      CALL PHASE(PD1,HI,PD2,HP,PD,H)
      CALL PHASE(DD1,HI,DD2,HP,DD,H)
      CALL PHASE(TD1,HI,TD2,HP,TD,H)
      CALL PHASE(UDQ(IH,JL),PHIJ,UDQ(IH,JP),PHIP,UD1,PHA)
      CALL PHASE(VDQ(IH,JL),PHIJ,VDQ(IH,JP),PHIP,VD1,PHA)
      CALL PHASE(UDQ(IP,JL),PHIJ,UDQ(IP,JP),PHIP,UD2,PHA)
      CALL PHASE(VDQ(IP,JL),PHIJ,VDQ(IP,JP),PHIP,VD2,PHA)
      CALL PHASE(UD1,HI,UD2,HP,UD,H)
      CALL PHASE(VD1,HI,VD2,HP,VD,H)
C.....INTERPOLATES QBO WIND AMPLITUDE ON LATITUDE AT LOWER HEIGHT
      CALL INTERW(UAQ(IH,JL),VAQ(IH,JL),PHIJ,UAQ(IH,JP),VAQ(IH,JP),
     5PHIP,UA1,VA1,PHA)
C.....INTERPOLATES QBO WIND AMPLITUDES ON LATITUDE AT UPPER HEIGHT
      CALL INTERW(UAQ(IP,JL),VAQ(IP,JL),PHIJ,UAQ(IP,JP),VAQ(IP,JP),
     6PHIP,UA2,VA2,PHA)
C.....INTERPOLATES QBO WIND AMPLITUDES ON HEIGHT AT LATITUDE PHI
      CALL INTERW(UA1,VA1,HI,UA2,VA2,HP,UA,VA,H)
C.....EVALUATES QBO VALUES FROM INTERPOLATED AMPLITUDES AND PHASES
      PQ=PA*COS(TP*(TMJD-PD))
      DQ=DA*COS(TP*(TMJD-DD))
      TQ=TA*COS(TP*(TMJD-TD))
      UQ=UA*COS(TP*(TMJD-UD))
      VQ=VA*COS(TP*(TMJD-VD))
      RETURN
```

```
      END
      FUNCTION RAND(X0)
C.....PRODUCES A RANDOM NUMBER FROM A UNIFORM DIST. FROM 0 TO +1
      INTEGER X0
      IF (X0.NE.0) X = X0/262144.
      X = X*509
      X = X - INT(X)
      RAND = X
      RETURN
      END
      SUBROUTINE RIG
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     ,          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS
     1RP1S,RD1S,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,
     2UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2
C.....GRAVITY G AT H, LATITUDE PHIR (RADIANS)
C.....RADIUS RI FROM CENTER OF EARTH TO HEIGHT H
C.....B = POLAR EARTH RADIUS, EPS = ECCENTRICITY
      CPHI2 = COS(PHIR) ** 2
C      EARTH RADIUS
      RI = B / SQRT(1. - EPS * CPHI2)
C     C2PHI = COS(2*PHIR)
      C2PHI = 2. * CPHI2 - 1.
C     C4PHI = COS(4*PHIR)
      C4PHI = 8. * CPHI2 * (CPHI2 - 1.) + 1.
C.....G AT SURFACE
      G = 9.80616 * (1. - 0.0026373 * C2PHI + 0.0000059 * C2PHI * C2PHI)
C.....EFFECTIVE RADIUS
      RE = 2. * G / (3.085462E-3 + C2PHI * 2.27E-6 - C4PHI * 2.E-9)
C      G AT HEIGHT H
      G = G / (1. + (H / RE)) ** 2
C      RADIUS AT HEIGHT H
      RI = RI + H
      END
      SUBROUTINE RTERP(H,PHI,PR,DR,TR,P,D,T)
C.....COMPUTES RANDOM PERTURBATION STANDARD DEVIATIONS P,D,T AT
C         HEIGHT H (KM), LATITUDE PHI(DEGREES) FROM SIGMA ARRAYS
C         PR,DR,AND TR
      DIMENSION PR(20,10),DR(20,10),TR(20,10)
C.....I = LOWER HEIGHT INDEX
      IF (H.LT.95.) I = INT((H-20.)/5.)
      IF (H.GE.95.) I = 14 + INT((H-80.)/20.)
      IP = I+1
      IF (IP.GT.20) IP = 20
C      LOWER LATITUDE INDEX
      J = INT((PHI + 110.)/20.)
      JP = J+1
      IF (JP.GT.10) JP=10
      IF (I.GT.14) GO TO 10
C     LOWER HEIGHT FOR PR,TR,DR  ARRAYS
      Z1=5.*I+20.
      GO TO 20
```

```
   10 Z1=20.*(I-10)
   20 IF (IP.GT.14) GO TO 30
C     UPPER HEIGHT FOR PR,DR,TR ARRAYS
      Z2=5.*IP+20.
      GO TO 40
   30 Z2=20.*(IP-10)
   40 PHI1=-110.+20.*J
      PHI2=-110.+20.*JP
C.....INTERPOLATE ON LATITUDE AT LOWER HEIGHT
      CALL INTERZ(PR(I,J),DR(I,J),TR(I,J),PHI1,PR(I,JP),DR(I,JP),
     1            TR(I,JP),PHI2,P1,D1,T1,PHI)
C.....INTERPOLATE ON LATITUDE AT UPPER HEIGHT
      CALL INTERZ(PR(IP,J),DR(IP,J),TR(IP,J),PHI1,PR(IP,JP),DR(IP,JP),
     1            TR(IP,JP),PHI2,P2,D2,T2,PHI)
C.....INTERPOLATION ON HEIGHT USING LATITUDE INTERPOLATED VALUES
      CALL INTERZ(P1,D1,T1,Z1,P2,D2,T2,Z2,P,D,T,H)
      RETURN
      END
      SUBROUTINE RTRAN
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG
      COMMON/COTRAN/NDATA(19),I1,I2,I3,I4(10),I5
C.....ENTRY POINT TO READ STATIONARY PERTURBATION DATA, AND
C        RANDOM PERTURBATION DATA IN SETUP
      IWHERE=2H.
      READ(IUG,100,END=3) NDATA
  100 FORMAT(A2,19I7)
      RETURN
      ENTRY RTRAN1
C.....ENTRY POINT TO READ GROVES DATA IN SETUP
      IWHERE=2H1.
      READ(IUG,100,END=3) NDATA
      I1=NDATA(1)
      I2=NDATA(2)
      I3=NDATA(3)
      I5=NDATA(14)
      DO 1 I=1,10
    1 I4(I)=NDATA(I+3)
      RETURN
      ENTRY RTRAN2
C.....ENTRY POINT TO READ QBO PARAMETERS IN SETUP
      IWHERE=2H2.
      READ(IUG,100,END=3) NDATA
      I1=NDATA(1)
      I3=NDATA(2)
      DO 2 I=1,10
    2 I4(I)=NDATA(2+I)
      RETURN
    3 WRITE(6,200) IUG,IWHERE
  200 FORMAT('1  PREMATURE END-OF-FILE FOUND ON UNIT ',I2/
     %'0  CALLED FROM SUBROUTINE RTRAN',A2)
      STOP
      END
      SUBROUTINE SCIMOD(NPOP)
C.....COMPUTES VALUES P,D,T,U,V AND SHEAR DUH,DVH FROM INPUT AND
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C        ARRAYS IN COMMON PDTCOM.  INPUT TO SCIMOD IS%
C        G = GRAVITY AT POSITION         RI = RADIUS AT HEIGHT H
C        PHIR = LATITUDE (RADIANS)       THETR = LONGITUDE (RADIANS)
C        F10 = F10.7 SOLAR FLUX          F10B = MEAN F10.7 FLUX
C        AP = SOLAR-GEOMAGNETIC A SUB P INDEX
C        MN/IDA/IYR = DATA (IYR = FULL YEAR-1900)
C        IHR%MIN = TIME                  H1 = PREVIOUS HEIGHT
C        PHI1R = PREVIOUS LATITUDE       THET1R = PREVIOUS LONGITUDE
C        RP1,RD1,RT1 = PREVIOUS RANDOM PERTURBATIONS
C        SP1,SD1,ST1 = PREVIOUS RANDOM STANDARD DEVIATIONS (SIGMAS)
C        RU1,RV1 = PREVIOUS RANDOM WINDS
C        SU1,SV1 = PREVIOUS RANDOM WIND SIGMAS
      COMMON/IPRTP/ IPRT
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     ,NSAME,RP1L,RD1L,RT1L,SP1L,SD1L,ST1L,RU1L,RV1L,SU1L,SV1L,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     ,   IHR,MIN,NMORE,DX,HL,VL,DZ,B,EPS,IOPP,LOOK,IET,FLAT,
     1RP1S,RD1S,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,
     2UDS1,VDS1,UDL1,VDL1,UDS2,VDS2,UDL2,VDL2
      COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19)
     , ,PSP(8,10,12)
     , ,DSP(8,10,12),TSP(8,10,12),PAQ(17,5),DAQ(17,5),TAQ(17,5),
     , PDQ(17,5),DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),
     ,UAQ(17,5),VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10),  PQ
     , ,DQ,TQ,UQ,VQ,PQA,DQA,TQA,UA,VA,IOPQ,
     1PLP(25,10),DLP(25,10),TLP(25,10),
     2ULP(25,10),VLP(25,10),UDL(25,10),
     3VDL(25,10),UDS(25,10),VDS(25,10)
      COMMON /C4/ GLAT(16),GLON(16),NG,P4D(16,26),D4D(16,26),T4D(16,26),
     ,  SP4(16,26),SD4(16,26),ST4(16,26),THET1,THET,DUMMY
      COMMON/COMPER/SPH,SDH,STH,PRH,DRH,TRH,URH,VRH,SUH,SVH,CP,
     1PRHS,DRHS,TRHS,URHS,VRHS,PRHL,DRHL,TRHL,URHL,VRHL,
     2SPHS,SDHS,STHS,SUHS,SVHS,SPHL,SDHL,STHL,SUHL,SVHL
       COMMON/WINCOM/DH,FCORY,DX5,DY5,DPX,DPY,DPXX,DPXY,DPYY,UGH,VGH,
     $     TH,DTX,DTY,DUH,DVH,PH ,UPRE,VPRE,DUPRE,DVPRE
      COMMON/CHK/PCK(4,4,3),DCK(4,4,3),NO(2)
      COMMON/CHIC/LA(4,4),NB(2),IWSYM,UCOEF(14,9),VCOEF(14,9)
C        FACTOR FOR RADIANS TO DEGREES
      FAC = 57.2957795
      IWSYM = ' '
      IF(NPOP.NE.0) GO TO 6
      UPRE=0.
      VPRE=0.
      DUPRE=0.
      DVPRE=0.
    6 PQ=0.
      DQ=0.
      TQ=0.
      PRH=0.
      DRH=0.
      TRH=0.
      URH=0.
      VRH=0.
      UQ=0.
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      VQ=0.
      PQA=0.
      DQA=0.
      TQA=0.
      UA=0.
      VA=0.
      PSH=0.
      DSH=0.
      TSH=0.
      MONTH=MN
C     PRESENT LATITUDE, DEG
      PHI = PHIR*FAC
C     PRESENT LONGITUDE, DEG
      THET = THETR*FAC
C     PREVIOUS LATITUDE, DEG
      PHI1 = PHI1R*FAC
C     PREVIOUS LONGITUDE, DEG
      THET1 = THET1R*FAC
C.....FCORY = NORTH COMPONENT CORIOLIS FACTOR TIMES DISTANCE FOR
C          5 DEGREES OF LATITUDE
      DY5 = 5000.*RI/FAC
      DX5 = DY5*COS(PHIR)
      FCORY = DY5*SIN(PHIR)/(120.*FAC)
C.....IN JACCHIA OR MIXED GROVES-JACCHIA HEIGHT RANGE
    8 IF(H.GT.90.0) GO TO 10
C.....IN 4-D DATA HEIGHT RANGE
      IF (H.LE.25.0) GO TO 500
C      IN GROVES OR MIXED GROVES 4D HEIGHT RANGE
      GO TO 200
C.....IN MIXED JACCHIA-GROVES RANGE, NEED TO FAIR DATA
 10   IF (H.LT.115.) GO TO 20
C.....FOLLOWING IS THE PURE JACCHIA HEIGHT RANGE SECTION
C.....JACCHIA VALUES AT CURRENT POSITION
      CALL JACCH(H,PHIR,THET,PH,DH,TH)
      PHIN = PHIR + 5. / FAC
      THETE = THET - 5.
C.....JACCHIA VALUES AT CURRENT POSITION+5 DEGREES LAT, FOR DP/DY AND
C         DT/DY
      CALL JACCH(H,PHIN,THET,PHN,DHN,THN)
C.....JACCHIA VALUES AT CURRENT POSITION-5 DEGREES LON, FOR DP/DX AND
C         DT/DX
      CALL JACCH(H,PHIR,THETE,PHE,DHE,THE)
C      DP/DY FOR GEOSTROPHIC WIND
      DPY=PHN-PH
C      DP/DX FOR GEOSTROPHIC WIND
      DPX=PHE-PH
C      DT/DX FOR THERMAL WIND SHEAR
      DTX = THE - TH
C      DT/DY FOR THERMAL WIND SHEAR
      DTY = THN - TH
C      CHANGE NOTATION FOR OUTPUT
      PGH=PH
      DGH=DH
      TGH=TH
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      CALL WIND
      UH = UGH
      VH = VGH
      HB = H + 5.
      CP = 7.*PH/(2.*DH*TH)
      CALL JACCH(HB,PHIR,THET,PB,DB,TB)
      DTZ = (TB - TH)/5000.
C.....VERTICAL MEAN WIND
      WGH = -CP*(UH*DTX/DX5 + VH*DTY/DY5)/(G + CP*DTZ + UH*DUH+VH*DVH)
C       GO TO RANDOM PERTURBATIONS SECTION
      GO TO 800
C.....FOLLOWING IS THE MIXED JACCHIA-GROVES HEIGHT RANGE SECTION
C       LOWER HEIGHT INDEX
 20   IHA = 5*(INT(H)/5)
C         UPPER HEIGHT INDEX
      IHB = IHA + 5
C     LOWER HEIGHT FOR INTERPOLATION
      HA = IHA*1.
C     UPPER HEIGHT FOR INTERPOLATION
      HB = IHB*1.
C.....JACCHIA VALUES AT LOWER HEIGHT, CURRENT LAT-LON
      CALL JACCH(HA,PHIR,THET,PJA,DJA,TJA)
      PHIN = PHIR + 5. / FAC
      THETE = THET - 5.
C.....JACCHIA VALUES AT LOWER HEIGHT, CURRENT LAT-LON+5 DEGREES
C          LAT, FOR DP/DY AND DT/DY
      CALL JACCH(HA,PHIN,THET,PJN,DJN,TJN)
C.....JACCHIA VALUES AT LOWER HEIGHT, CURRENT LAT-LON-5 DEGREES
C          LON, FOR DP/DX, AND DT/DX
      CALL JACCH(HA,PHIR,THETE,PJE,DJE,TJE)
C      JACCHIA DP/DY AT LOWER HEIGHT
      DPXJA=PJE-PJA
C       JACCHIA DP/DY AT LOWER HEIGHT
      DPYJA=PJN-PJA
C       JACCHIA DT/DX AT LOWER HEIGHT
      DTXJA = TJE - TJA
C       JACCHIA DT/DY AT LOWER HEIGHT
      DTYJA = TJN - TJA
C.....JACCHIA VALUES AT UPPER HEIGHT, CURRENT LAT-LON
      CALL JACCH(HB,PHIR,THET,PJB,DJB,TJB)
      PHIN = PHIR + 5. / FAC
      THETE=THETE-5
C.....JACCHIA VALUES AT UPPER HEIGHT, CURRENT LAT/LON+5 DEGREES
C          LAT, FOR DP/DY AND DT/DY
      CALL JACCH(HB,PHIN,THET,PJN,DJN,TJN)
C.....JACCHIA VALUES AT UPPER HEIGHT, CURRENT LAT-LON-5 DEGREES
C          LON, FOR DP/DX AND DT/DX
      CALL JACCH(HB,PHIR,THETE,PJE,DJE,TJE)
C      JACCHIA DP/DX FOR GEOSTROPHIC WINDS
      DPXJB = PJE - PJB
C       JACCHIA DP/DY FOR GEOSTOPHIC WINDS
      DPYJB = PJN - PJB
C      JACCHIA DT/DX FOR THERMAL WIND SHEAR
      DTXJB = TJE - TJB
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C        JACCHIA DT/DY FOR THERMAL WIND SHEAR
         DTYJB = TJN - TJB
C.....GROVES AT LOWER HEIGHT, TO BE FAIRED WITH JACCHIA
         CALL GTERP(IHA,PHI,PGA,DGA,TGA,PG,DG,TG,DPYGA,DTYGA,DP2YGA)
C.....GROVES AT UPPER HEIGHT, TO BE FAIRED WITH JACCHIA
         CALL GTERP(IHB,PHI,PGB,DGB,TGB,PG,DG,TG,DPYGB,DTYGB,DP2YGB)
C.....FAIRED RESULTS AT LOWER HEIGHT
         CALL FAIR(PGA,DGA,TGA,PJA,DJA,TJA,IHA,P1,D1,T1,      DPYGA,
      $ DPXJA,DPYJA,DPXA,DPYA,       DTYGA,DTXJA,DTYJA,DTXA,DTYA)
C.....FAIRED RESULTS AT UPPER HEIGHT
         CALL FAIR(PGB,DGB,TGB,PJB,DJB,TJB,IHB,P2,D2,T2,      DPYGB,
      $DPXJB,DPYJB,DPXB,DPYB,       DTYGB,DTXJB,DTYJB,DTXB,DTYB)
C.....HEIGHT INTERPOLATION ON FAIRED P,D,T
         CALL INTER2(P1,D1,T1,HA,P2,D2,T2,HB,PH,DH,TH,H)
C.....HEIGHT INTERPOLATION ON FAIRED DP/DX,DP/DY
         CALL INTERW(DPXA,DPYA,HA,DPXB,DPYB,HB,DPX,DPY,H)
C.....HEIGHT INTERPOLATION ON FAIRED DT/DX,DT/DY
         CALL INTERW(DTXA,DTYA,HA,DTXB,DTYB,HB,DTX,DTY,H)
C.....EASTWARD COMPONENT OF GEOSTROPHIC WIND
         CALL WIND
C        CHANGE OF VARIABLES FOR OUTPUT
         PGH=PH
         DGH=DH
         TGH=TH
         UH = UGH
         VH = VGH
         CP = 7.*PH/(2.*DH*TH)
         DTZ = (T2 - T1)/5000.
C.....VERTICAL MEAN WIND
         WGH = -CP*(UH*DTX/DX5 + VH*DTY/DY5)/(G + CP*DTZ + UH*DUH + VH*DVH)
C        GO TO RANDOM PERTURBATIONS SECTION
         GO TO 800
C.....THE FOLLOWING SECTION IS FOR GROVES OR MIXED GROVES 4D HEIGHTS
C        UPPER HEIGHT INDEX
  200    IHGB = 5*(INT(H)/5) + 5
         IF (IHGB.GT.90) IHGB=90
C        UPPER HEIGHT
         HGB = IHGB*1.
C.....GROVES AT UPPER HEIGHT
         CALL GTERP(IHGB,PHI,PGB,DGB,TGB,PG,DG,TG,DPYGB,DTYGB,DP2YGB)
C.....UPPER STATIONARY PERTURBATION HEIGHT = 40
         IF (H.LT.40.0) GO TO 210
C.....UPPER STATIONARY PERTURBATION HEIGHT = 90
         IF (H.GT.84.0) GO TO 220
C.....UPPER STATIONARY PERTURBATION HEIGHT = 52,60,68,76,OR 84
         IHSB = 8*((INT(H) + 4)/8) + 4
C.....UPPER STATIONARY PERTURBATION HEIGHT = 52
         IF (IHSB.LT.52.0) IHSB = 52
         GO TO 230
  210    IHSB = 10*(INT(H)/10) + 10
         GO TO 230
  220    IHSB = 90
C        UPPER STATIONARY PERTURBATION HEIGHT
  230    HSB = IHSB*1.
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C.....STATIONARY PERTURBATIONS AT UPPER HEIGHT
      CALL PDTUV(PSP,DSP,TSP,PHI,THET,IHSB,PSB,DSB,TSB,DPXSB,DPYSB,
     $ DTXSB,DTYSB,DP2XSB,DP2YSB,DPXYSB)
C      MIXED GROVES 4D SECTION
      IF (H.LT.30.0) GO TO 300
C     LOWER HEIGHT INDEX
      IHGA = IHGB - 5
C     LOWER HEIGHT INDEX
      HGA = IHGA*1.
C.....GROVES AT LOWER HEIGHT
      CALL GTERP(IHGA,PHI,PGA,DGA,TGA,PG,DG,TG,DPYGA,DTYGA,DP2YGA)
C.....LOWER STATIONARY PERTURBATION HEIGHT = 30
      IF (H.LT.40.0) GO TO 240
C.....LOWER STATIONARY PERTURBATION HEIGHT = 52,60,68,76, OR 84
      IHSA = 8*((INT(H) + 4)/8) - 4
C.....LOWER STATIONARY PERTURBATIONS HEIGHT = 40
      IF (IHSA.LT.40.0) IHSA = 40
      GO TO 250
  240 IHSA = 30
C     LOWER STATIONARY PERTURBATION HEIGHT
 250  HSA = IHSA*1.
C.....STATIONARY PERTURBATIONS AT LOWER HEIGHT
      CALL PDTUV(PSP,DSP,TSP,PHI,THET,IHSA,PSA,DSA,TSA,DPXSA,DPYSA,
     $ DTXSA,DTYSA,DP2XSA,DP2YSA,DPXYSA)
C.....GROVES VALUES HEIGHT INTERPOLATIONS
      CALL INTER2(PGA,DGA,TGA,HGA,PGB,DGB,TGB,HGB,PGH,DGH,TGH,H)
C.....STATIONARY PERTURBATION HEIGHT INTERPOLATION
      CALL INTERZ(PSA,DSA,TSA,HSA,PSB,DSB,TSB,HSB,PSH,DSH,TSH,H)
C     QUASI-BIENNIAL VALUES
      CALL QBOGEN
C.....HEIGHT INTERPOLATION OF GROVES DP/DY, DT/DY, AND D2P/DY2
      CALL INTERZ(DPYGA,DTYGA,DP2YGA,HGA,DPYGB,DTYGB,DP2YGB,HGB,DPYG,
     $   DTYG,DP2YG,H)
C.....HEIGHT INTERPOLATION OF STATIONARY PERTURBATION DP/DX AND DP/DY
      CALL INTERW(DPXSA,DPYSA,HSA,DPXSB,DPYSB,HSB,DPXS,DPYS,H)
C.....HEIGHT INTERPOLATION OF STATIONARY PERTURBATION DT/DX AND DT/DY
      CALL INTERW(DTXSA,DTYSA,HSA,DTXSB,DTYSB,HSB,DTXS,DTYS,H)
C.....HEIGHT INTERPOLATION OF STATIONARY PERTURBATION D2P/DX2,D2P/DY2,
C                AND D2P/DXDY
      CALL INTERZ(DP2XSA,DP2YSA,DPXYSA,HSA,DP2XSB,DP2YSB,DPXYSB,HSB,
     $       DP2XS,DP2YS,DPXYS,H)
C.....UNPERTURBED (MONTHLY MEAN) VALUES FOR OUTPUT
      TGH = TGH * (1. + TSH)
      PGH = PGH * (1. + PSH)
      DGH = DGH * (1. + DSH)
C     TOTAL DT/DX
      DTX =        DTXS * TGH
C     TOTAL DT/DY
      DTY = TGH*DTYS + DTYG*(1. + TSH + DTYS)
C     TOTAL DP/DX
      DPX =        DPXS * PGH
C     TOTAL DP/DY
      DPY = PGH*DPYS + DPYG*(1. + PSH + DPYS)
C     D2P/DX2
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      DPXX = PGH*(2.*DPXS - DP2XS)
      DPYY = PGH*(2.*DPYS - DP2YS) +  (2.*DPYG - DP2YG)*(1. +PSH+DPYS)
     $     - (DPYG - DP2YG)*DP2YS
C     D2P/DXDY
      DPXY = (PGH + DPYG)*DPXYS + DPYG*DPXS
C.....UNPERTURBED VALUES PLUS QBO PERTURBATIONS
      PH = (1. + PQ) * PGH
      DH = DGH * (1. + DQ)
      TH = (1. + TQ) * TGH
      CALL WIND
C     GEOSTROPHIC WIND PLUS QBO WIND PERTURBATIONS
      UH=UGH+UQ
      VH=VGH+VQ
      CP = 7.*PGH/(2.*DGH*TGH)
      DTZ = (TGB*(1.+TSB) - TGA*(1.+TSA))/5000.
C.....VERTICAL MEAN WIND
      WGH=-CP*(UGH*DTX/DX5+VGH*DTY/DY5)/(G+CP*DTZ+VGH*DUH+VGH*DVH)
C      GO TO RANDOM PERTURBATIONS SECTION
      GO TO 800
C.....THE FOLLOWING IS THE MIXED GROVES 4D SECTION
C.....GENERATE GRID OF 4D PROFILES IF PREVIOUS HEIGHT GE 30
300   IF (H1.GE.30..OR.LOOK.EQ.1) CALL GEN4D
      IHCK = 24
      DO 310 KND = 1,3
      IKND = IHCK + KND
      IF (IKND.GT.26)IKND=26
      DO 310 IND = 1,4
      DO 310 JND = 1,4
      PCK(IND,JND,KND) = P4D(4*(IND-1)+JND,IKND)
      DCK(IND,JND,KND) = D4D(4*(IND-1)+JND,IKND)
 310  CONTINUE
      CALL CHECK
C.....LAT-LON INTERPOLATION OF 4D DATA AT 25 KM
      CALL INTER4(          PHI,THET,25,   P4D,D4D,T4D,P4A,D4A,T4A,
     $ DPX4,DPY4,DTX4,DTY4,DPXXA,DPYYA,DPXYA)
C      GROVES PLUS STATIONARY PERTURBATIONS
      PB = PGB*(1. + PSB)
C      P,D,T
      DB = DGB*(1. + DSB)
      TB = TGB*(1. + TSB)
      DPXB = PGB*DPXSB
      DPYB = PGB*DPYSB + DPYGB*(1. + PSB + DPYSB)
      DPXXB = PGB*(2.*DPXSB - DP2XSB)
      DPYYB = PGB*(2.*DPYSB - DP2YSB) + (2.*DPYGB - DP2YGB)*
     $  (1. + PSB + DPYSB) - (DPYGB - DP2YGB)*DP2YSB
      DPXYB = (PGB + DPYGB)*DPXYSB + DPYGB*DPXSB
      DTXB = TGB*DTXSB
      DTYB = TGB*DTYSB + DTYGB*(1. + TSB + DTYSB)
C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 AND GROVES AT UPPER HEIGHT
C        DP/DX AND DP/DY
      CALL INTERW(DPX4,DPY4,25.,DPXB,DPYB,HSB,DPX,DPY,H)
C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 AND GROVES AT UPPER HEIGHT
C        P,D,T
      CALL INTER2(P4A,D4A,T4A,25.,PB,DB,TB,HGB,PGH,DGH,TGH,H)
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C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 AND GROVES AT UPPER HEIGHT
C        DT/DX AND DT/DY
      CALL INTERW(DTX4,DTY4,25.,DTXB,DTYB,HGB,DTX,DTY,H)
C.....HEIGHT INTERPOLATION BETWEEN 4D AT 25 KM AND GROVES AT UPPER
C     HEIGHT D2P/DX2, D2P/DY2, AND D2P/DXDY
      CALL INTERZ(DPXXA,DPYYA,DPXYA,25.,DPXXB,DPYYB,DPXYB,HGB,DPXX,
     $     DPYY,DPXY,H)
      IF (IOPQ.EQ.2) GO TO 350
C     QUASI BIENNIAL PERTURBATIONS
      CALL QBOGEN
C     ADD QBO PERTURBATIONS TO P,D,T
  350 PH=PGH*(1.+PQ)
      DH=DGH*(1.+DQ)
      TH=TGH*(1.+TQ)
      CALL WIND
C     ADD QBO WIND PERTURBATIONS
      UH=UGH+UQ
      VH=VGH+VQ
      CP = 7.*PGH/(2.*DGH*TGH)
      DTZ = (TB - T4A)/(1000.*(HGB - 25.))
C.....VERTICAL MEAN WIND
      WGH=-CP*(UGH*DTX/DX5+VGH*DTY/DY5)/(G+CP*DTZ+UGH*DUH+VGH*DVH)
C     GO TO RANDOM PERTURBATIONS SECTION
 2000 FORMAT(' LATITUDE',/16F8.3)
 2001 FORMAT(' LONGITUDE',/16F8.3,/' PRESSURE')
 2002 FORMAT(1X,I2,16F8.0)
      GO TO 800
  500 IF (H.GE.0.0) GO TO 510
      IF (H.LT.-0.015) GO TO 505
C     IF -15 METER LE H LT 0 , H IS SET TO 0
      H = 0.
      GO TO 510
C     NO MORE COMPUTATIONS TO BE MADE IF HEIGHT LT -5 M
  505 NMORE = 0
       RETURN
C.....GENERATE GRID OF 4D PROFILES IF PREVIOUS HEIGHT GE 30
510   IF (H1.GE.30..OR.LOOK.EQ.1) CALL GEN4D
C      LOWER HEIGHT INDEX
       IHA=INT(H)
C      LOWER HEIGHT INDEX
       HA = IHA*1.
      IWSX = IWSYM
      IHCK=IHA-1
      DO 511 KND=1,3
      IKND = IHCK + KND
      IF (IKND.LT.1)IKND = 1
      IF (IKND.GT.26)IKND = 26
      DO 511 IND=1,4
      DO 511 JND = 1,4
      PCK(IND,JND,KND)=P4D(4*(IND-1)+JND,IKND)
      DCK(IND,JND,KND)=D4D(4*(IND-1)+JND,IKND)
511   CONTINUE
      CALL CHECK
C      UPPER HEIGHT INDEX
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      IHB = IHA + 1
      IF(IHB.LE.25) GO TO 513
      IHA=24
      HA=24.
      IHB=25
C       UPPER HEIGHT
  513 HB = IHB*1.
C.....LAT-LON INTERPOLATION OF 4D VALUES AT UPPER HEIGHT
  515 CALL INTER4(          PHI,THET,IHB,    P4D,D4D,T4D,PB,DB,TB,
     $ DPX4B,DPY4B,DTX4B,DTY4B,DPXXB,DPYYB,DPXYB)
      IF(IHA.EQ.0.AND.PB*DB*TB.LE.0.)GO TO 520
      GO TO 540
  520 IHB=IHB+1
C.....LOOP TO FIND LOWEST VALID HEIGHT
      HB=HB+1.
      GO TO 515
  540 IF(IHA.GT.0)CALL INTER4(          PHI,THET,IHA,    P4D,D4D,T4D,
     1PA,DA,TA,DPX4A,DPY4A,DTX4A,DTY4A,DPXXA,DPYYA,DPXYA)
      IF(IWSYM.EQ.'*')IWSX = IWSYM
      IF(IHA.EQ.0.OR.(PA*DA*TA.LE.0.AND.IHA.LT.10.AND.PB*DB*TB.GT.0.))
     1GO TO 550
      GO TO 600
C.....LAT-LON INTERPOLATION OF 4D VALUES AT LOWER HEIGHT
  550 CALL INTER4(          PHI,THET,0,    P4D,D4D,T4D,
     ,PA,DA,TA,DPX4A,DPY4A,DTX4A,DTY4A,DPXXA,DPYYA,DPXYA)
      IF(IWSYM.EQ.'*')IWSX = IWSYM
      IF(TA-TB)560,570,560
  560 TZ=(TA-TB)/ALOG(TA/TB)
      GO TO 575
  570 TZ=TA
C ...COMPUTES HEIGHT OF SURFACE
  575 HA=HB+0.28705*TZ*ALOG(PB/PA)/G
      IF(H.GT.HA-.04) GO TO 600
      PH=0.
      DH=0.
      TH=0.
      PGH=0.
      DGH=0.
      TGH=0.
      GO TO 800
C.....HEIGHT INTERPOLATION OF P,D,T
  600 CALL INTER2(PA,DA,TA,HA,PB,DB,TB,HB,PGH,DGH,TGH,H)
C.....HEIGHT INTERPOLATION OF DP/DX AND DP/DY
      CALL INTERW(DPX4A,DPY4A,HA,DPX4B,DPY4B,HB,DPX,DPY,H)
C.....HEIGHT INTERPOLATION OF DT/DX AND DT/DY
      CALL INTERW(DTX4A,DTY4A,HA,DTX4B,DTY4B,HB,DTX,DTY,H)
C.....HEIGHT INTERPOLATION OF D2P/DX2, D2P/DY2, AND D2P/DXDY
      CALL INTERZ(DPXXA,DPYYA,DPXYA,HA,DPXXB,DPYYB,DPXYB,HB,DPXX,DPYY,
     $DPXY,H)
C       CHANGE OF NOTATION FOR OUTPUT
      PH = PGH
      DH = DGH
      TH = TGH
      IF(PH*DH*TH.LE.0.) GO TO 800
```

```
      CALL WIND
C       CHANGE OF NOTATION FOR OUTPUT
      UH = UGH
      VH = VGH
      CP = 7.*PGH/(2.*DGH*TGH)
      DTZ = (TB - TA)/(1000.*(HB - HA))
C.... VERTICAL MEAN WIND
      WGH = -CP*(UGH*DTX/DX5 + VGH*DTY/DY5)/(G+CP*DTZ+UH*DUH+VH*DVH)
C     QBO=0 IF H LT 10
      IF (H.LT.10.) GO TO 800
      IF (IOPQ.EQ.2) GO TO 650
C     COMPUTES QUASI BIENNIAL PERTURBATIONS
      CALL QBOGEN
C     ADDS QBO PERTURBATIONS TO P,D,T
  650 PH=PGH*(1.+PQ)
      DH=DGH*(1.+DQ)
      TH=TGH*(1.+TQ)
C     ADDS QBO WIND PERTURBATIONS TO U,V
      UH=UGH+UQ
      VH=VGH+VQ
C.....THE FOLLOWING IS THE RANDOM PERTURBATIONS SECTION
C.....NO RANDOM PERTURBATIONS IF IOPR GT 1
  800 CONTINUE
      IF(H.GT.30) GO TO 512
      IF(IPRT.NE.0.OR.IWSYM.NE.'*') GO TO 512
      WRITE(6,2000) (GLAT(I),I=1,16)
      WRITE(6,2001) (GLON(I),I=1,16)
      DO 504 I=1,26
      IH=I-1
      WRITE(6,2002) IH,(P4D(J,I),J=1,16)
  504 CONTINUE
      IPRT=IPRT+1
  512 CONTINUE
      IF (IOPR.GT.1) GO TO 830
C.....INTERPOLATES RANDOM WIND MAGNITUDES TO HEIGHT H, LATITUDE PHI
      CALL INTRUV(UR,VR,H,PHI,SUH,SVH)
      CALL INTRUV(PLP,DLP,H,PHI,PLPH,DLPH)
      CALL INTRUV(TLP,DLP,H,PHI,TLPH,DLPH)
      CALL INTRUV(ULP,VLP,H,PHI,ULPH,VLPH)
      CALL INTRUV(UDL,VDL,H,PHI,UDL2,VDL2)
      CALL INTRUV(UDS,VDS,H,PHI,UDS2,VDS2)
      SUHL=SQRT(ULPH*ABS(SUH))
      SUHS=SQRT((1.-ULPH)*ABS(SUH))
      SVHL=SQRT(VLPH*ABS(SVH))
      SVHS=SQRT((1.-VLPH)*ABS(SVH))
      SUH = SQRT(ABS(SUH))
      SVH = SQRT(ABS(SVH))
C.....IF H LE 25 USE 4D DATA RANDOM P,D,T SIGMAS
      IF (H.LE.25.) GO TO 810
C.....INTERPOLATE PR,DR,TR ARRAYS TO GET P,D,T SIGMAS AT HEIGHT H,
C         LATITUDE PHI
      CALL RTERP(H,PHI,PR,DR,TR,SPH,SDH,STH)
      GO TO 820
C.....LAT-LON INTERPOLATION ON P,D,T SIGMAS AT LOWER HEIGHT
```

```
  810 CALL INTER4(          PHI,THET,IHA,   SP4,SD4,ST4,PA,DA,TA,
     $ DPX,DPY,DTX,DTY,DPXX,DPYY,DPXY)
C.....LAT-LON INTERPOLATION ON P,D,T SIGMSA AT UPPER HEIGHT
      CALL INTER4(          PHI,THET,IHB,   SP4,SD4,ST4,PB,DB,TB,
     $ DPX,DPY,DTX,DTY,DPXX,DPYY,DPXY)
C.....HEIGHT INTERPOLATION OF SIGMAS
      CALL INTERZ(PA,DA,TA,   HA,PB,DB,TB,   HB,SPH,SDH,STH,H)
      IF(PH*DH*TH.LE.0.) GO TO 825
C.....HEIGHT DISPLACEMENT BETWEEN PREVIOUS AND CURRENT POSITION
  820 DZ = H1 - H
      SPHL=SQRT(PLPH*ABS(SPH))
      SPHS=SQRT((1.-PLPH)*ABS(SPH))
      SDHL=SQRT(DLPH*ABS(SDH))
      SDHS=SQRT((1.-DLPH)*ABS(SDH))
      STHL=SQRT(TLPH*ABS(STH))
      STHS=SQRT((1.-TLPH)*ABS(STH))
      SPH = SQRT(ABS(SPH))
      SDH = SQRT(ABS(SDH))
      STH = SQRT(ABS(STH))
C.....COMPUTES HORIZONTAL DIXPLACEMENT DX BETWEEN PREVIOUS AND CURRENT
C         POSITION, HORIZONTAL SCALE HL, AND VERTICAL SCALE VL
C.....COMPUTES PERTURBATION VALUES PRH,DRH,TRH,URH AND VRH
      CALL PERTRB
C     ADDS RANDOM PERTURBATIONS TO PH,DH,TH
      PH = PH*(1. + PRH)
      DH = DH*(1. + DRH)
      TH = TH*(1. + TRH)
C     ADDS RANDOM WINDS TO UH,VH
      UH=UH+URH
      VH=VH+VRH
C.....SETS PREVIOUS RANDOM PERTURBATION IN P,D,T TO CURRENT
C         PERTURBATIONS, FOR NEXT CYCLE
  825 RP1S= PRHS
      RD1S= DRHS
      RT1S= TRHS
      RP1L=PRHL
      RD1L=DRHL
      RT1L=TRHL
C.....SETS PREVIOUS MAGNITUDES FO CURRENT VALUES, FOR NEXT CYCLE
      SP1S=SPHS
      SD1S= SDHS
      ST1S=STHS
      SP1L=SPHL
      SD1L=SDHL
      ST1L=STHL
C.....SETS PREVIOUS WIND PERTURBATION VALUES TO CURRENT VALUES,
C         FOR NEXT CYCLE
      RU1S=URHS
      RV1S=VRHS
      RU1L=URHL
      RV1L=VRHL
C.....SETS PREVIOUS WIND PERTURBATION MAGNITUDES TO CURRENT VALUES,
C         FOR NEXT CYCLE
      SU1S=SUHS
```

```
      SV1S=SVHS
      SU1L=SUHL
      SV1L=SVHL
C.....SETS PREVIOUS HEIGHT TO CURRENT HEIGHT, FOR NEXT CYCLE
  830 H1 = H
C.....SETS PREVIOUS LATITUDE TO CURRENT LATITUDE, FOR NEXT CYCLE
      PHI1R=PHIR
C.....SETS PREVIOUS LONGITUDE TO CURRENT LONGITUDE, FOR NEXT CYCLE
      THET1R=THETR
C     SETS NMORE TO COMPUTE MORE DATA ON NEXT CYCLE
      NMORE = 1
C.....NO MORE DATA IF P, D, OR T LEQ 0
      IF(PH*DH*TH.LE.0.) RETURN
      CALL STDATM(H,TS,PS,DS)
      IF ((PS*DS*TS).GT.0.) GO TO 870
      PGHP=0.
      DGHP=0.
      TGHP=0.
      PHP=0.
      DHP=0.
      THP=0.
      GO TO 880
  870 PGHP=100.*(PGH-PS)/PS
      DGHP=100.*(DGH-DS)/DS
      TGHP=100.*(TGH-TS)/TS
      PHP=100.*(PH-PS)/PS
      DHP=100.*(DH-DS)/DS
      THP=100.*(TH-TS)/TS
C     CONVERTS QBO P,D,T TO PERCENT
  880 PQ=100.*PQ
      DQ=100.*DQ
      TQ=100.*TQ
C     CONVERTS RANDOM P,D,T TO PERCENT
      PRH=100.*PRH
      DRH=100.*DRH
      TRH=100.*TRH
      PRHS=100.*PRHS
      DRHS=100.*DRHS
      TRHS=100.*TRHS
      PRHL=100.*PRHL
      DRHL=100.*DRHL
      TRHL=100.*TRHL
      SPHS = 100.*SPHS
      SDHS = 100.*SDHS
      STHS = 100.*STHS
      SPHL = 100.*SPHL
      SDHL = 100.*SDHL
      STHL = 100.*STHL
C     CONVERTS WIND SHEAR TO M/S/KM
      DUH = DUH * 1000.
      DVH = DVH * 1000.
C      CONVERTS VERTICAL WIND TO CM/S
      WGH = WGH*100.
      PQA=PQA*100.
```

```
      DQA=DQA*100.
      TQA=TQA*100.
      SPH=SPH*100.
      SDH=SDH*100.
      STH=STH*100.
      PSH=PSH*100.
      DSH=DSH*100.
      TSH=TSH*100.
      IF(NPOP.NE.0) GO TO 920
      UPRE=UGH
      VPRE=VGH
      DUPRE=DUH/1000.
      DVPRE=DVH/1000.
      RETURN
  920 IF (IOPP.NE.0)
     * WRITE(IOPP,951) H,PHI,THET,PGHP,DGHP,TGH,UGH,VGH,SPH,SDH,STH,
     1SUH,SVH,PGH,DGH,FLOAT(IET),FLOAT(MN),TGHP
  951 FORMAT(F5.1,7F7.2,5F6.2,2E10.3,F5.0,F3.0,F7.2)
      WRITE(6,900) H,PHI,THET,PGH,DGH,TGH,UGH,IWSYM,VGH,PH,DH,TH,UH,
     * IWSYM,VH,DUH,
     $ DVH,WGH,IET,PGHP,DGHP,TGHP,PHP,DHP,THP,PSH,DSH,TSH,PQ,DQ,TQ,UQ,
     $ VQ,PQA,DQA,TQA,UA,VA,PRHS,DRHS,TRHS,URHS,VRHS,SPHS,SDHS,STHS,
     1SUHS,SVHS,PRHL,DRHL,TRHL,URHL,VRHL,SPHL,SDHL,STHL,SUHL,SVHL,
     2PRH,DRH,TRH,URH,VRH,SPH,SDH,STH,SUH,SVH
  900 FORMAT(1X,F6.2,2F7.2,2(2E9.3,2F6.0,A1,F5.0),2F5.1,23X,F6.2/1X,
     $ I5,14X,2(2( F8.1,'%'),F6.1,'%',11X),10X,
     $3F5.1,10X,' SP',/102X,3F5.1,2F5.0,' QBO'/102X,3F5.1,2F5.0,' MAG'/1
     $02X,3F5.1,2F5.0,' RANS',/102X,3F5.1,2F5.0,' SIGS',/
     2102X,3F5.1,2F5.0,' RANL',/
     3102X,3F5.1,2F5.0,' SIGL',/
     4102X,3F5.1,2F5.0,' RANT',/
     5102X,3F5.1,2F5.0,' SIGT',/)
      RETURN
      END
      SUBROUTINE SELEC4
      INTEGER IOTEM2
      COMMON/C4/XL(16),YL(16),NP
C
C     S
C     SUBROUTINE TO SELECT POINTS FOR INTERPOLATION
C
      COMMON /IOTEMP/ IOTEM1,IOTEM2
      COMMON /POINT/ IPT(16,5),LL(16),DXY(16,2)
      COMMON /ORDER/ IPTN(16,5),IREAD(65,3)
C
      DIMENSION            IC(4),IL(2),JL(2),LIML(51),LIMU(51)
C
      DATA  LIML/15,14,13,12,11,10,9,8,7,6,5,4,3,2,23*1,2,3,4,5,6,7,8,9,
     110,11,12,13,14,15/
      DATA  LIMU/33,34,35,36,37,38,39,40,41,42,43,44,45,46,23*47,46,45,
     144,43,42,41,40,39,38,37,36,35,34,33/
      DATA PI/3.14159/
C
C
```

```
C        INITIALIZE
C
      PI4=PI/4.
      DEGRAD=PI/180.
      DO 1 I=1,16
      DO 1 J=1,5
    1 IPT(I,J)=0
C
C        MAJOR LOOP FOR POINTS
C
      DO 100 II=1,NP
C
      LA=ABS(XL(II))*10.+.5
      LO=YL(II)*10.+.5
      LL(II)=LA*10000+LO
      IF (XL(II).LT.0.) LL(II)=-LL(II)
C
      IF (XL(II)-15.1) 15,30,30
   15 IF (XL(II)) 50,40,40
C
C        NMC GRID
C
   30 IPT(II,5)=2
      EL=(350-YL(II))*DEGRAD
      PHI=XL(II)*DEGRAD
      R=31.204359052*(SIN(PI4-PHI/2.)/COS(PI4-PHI/2.))
      XX=R*COS(EL)+24.
      YY=R*SIN(EL)+26.
      I=XX
      J=YY
      DX=XX-I
      DY=YY-J
      DXY(II,1)=DX
      DXY(II,2)=DY
      IF (XL(II).GT.17.18) GO TO 31
      IF ((J.LT.1).OR.(J.GT.51)) GO TO 70
      IF ((I.LT.LIML(J)).OR.(I.GT.LIMU(J))) GO TO 70
   31 IC(1)=I*1000+J
      IF ((ABS(DX).GT..1).OR.(ABS(DY).GT..1)) GO TO 32
      IP=1
      GO TO 35
   32 CONTINUE
      IF (XL(II).GT.17.18) GO TO 34
      IF (((I.GT.(LIMU(J)-1)).AND.((J.GE.15).AND.(J.LE.37)))
     1 .OR.(J.GT.50)) GO TO 70
      IF ((I+1.GT.LIMU(J+1)).OR.(I.LT.LIML(J+1))) GO TO 80
      IF ((I.EQ.LIMU(J)).OR.(I.EQ.LIML(J))) GO TO 80
   34 IP=4
      IC(2)=(I+1)*1000+J
      IC(3)=I*1000+J+1
      IC(4)=(I+1)*1000+J+1
   35 CONTINUE
      REWIND IOTEM2
      DO 38 IPG=1,1977
```

```
      READ(IOTEM2) IJ
      DO 38 K=1,IP
   38 IF(IC(K).EQ.IJ) IPT(II,K)=IPG
      GO TO 100
C
C        EQUATORIAL GRID
C
   40 IPT(II,5)=1
      L1=XL(II)
      L2=YL(II)
      IL(1)=L1/5
      IL(2)=IL(1)+1
      JL(1)=(L2/5)+1
      JL(2)=JL(1)-1
      DO 45 K1=1,2
      DO 45 K2=1,2
      IF ((ABS(XL(II)-IL(K1)*5).GT.0.1).OR.(ABS(YL(II)-JL(K2)*5).GT.0.1)
     1 ) GO TO 45
      IF (JL(K2).EQ.72) JL(K2)=0
      IPT(II,1)=JL(K2)*4+IL(K1)+1
      GO TO 100
   45 CONTINUE
      IF (JL(1).EQ.72) JL(1)=0
      IPT(II,1)=JL(1)*4+IL(1)+1
      IPT(II,2)=JL(2)*4+IL(1)+1
      IPT(II,3)=JL(1)*4+IL(2)+1
      IPT(II,4)=JL(2)*4+IL(2)+1
      GO TO 100
C
C        SOUTHERN HEMISPHERE
C
   50 IPT(II,5)=3
      L1=XL(II)
      L2=YL(II)
      IF (ABS(XL(II)).LT.85.0) GO TO 51
      IPT(II,1)=1
      IF (ABS(XL(II)+90.).LT.0.11) GO TO 100
   51 CONTINUE
      IL(1)=(L1/5)-1
      JL(1)=(L2/5)+1
      IL(2)=IL(1)+1
      JL(2)=JL(1)-1
      DO 52 K1=1,2
      DO 52 K2=1,2
      IF ((ABS(XL(II)-IL(K1)*5).GT.0.1).OR.(ABS(YL(II)-JL(K2)*5).GT.0.1)
     1  ) GO TO 52
      IF (JL(K2).EQ.72) JL(K2)=0
      IPT(II,1)=JL(K2)*17-IL(K1)+1
      IF (IL(K).NE.0) GO TO 100
      IPT(II,1)=JL(K2)*4+1
      IPT(II,5)=1
      GO TO 100
   52 CONTINUE
      IF (JL(1).EQ.72) JL(1)=0
```

```
      IF (IPT(II,1).EQ.1) GO TO 54
      IPT(II,1)=JL(1)*17-IL(1)+1
      IPT(II,2)=JL(2)*17-IL(1)+1
      IF (IL(2)) 55,53,55
   53 IPT(II,3)=JL(1)*4+1
      IPT(II,4)=JL(2)*4+1
      IPT(II,5)=1133
      GO TO 100
   54 IPT(II,2)=JL(1)*17-IL(2)+1
      IPT(II,3)=JL(2)*17-IL(2)+1
      IPT(II,5)=333
      GO TO 100
   55 CONTINUE
      IPT(II,3)=JL(1)*17-IL(2)+1
      IPT(II,4)=JL(2)*17-IL(2)+1
      GO TO 100
C
C     BODERLINE POINTS
C
   70 CONTINUE
C     TWO NMC, TWO EQUATORIAL
      IPT(II,5)=2211
      L=YL(II)
      IPT(II,1)=((L/5)+2)*4
      IPT(II,2)=IPT(II,1)-4
      IF (L.GE.355) IPT(II,1)=4
C
      IF (J.LT.1) J=1
      IF (J.GT.51) J=51
      IF (I.LT.LIML(J)) I=LIML(J)
      IF (I.GT.LIMU(J)) I=LIMU(J)
      IC(1)=I*1000+J
      IF ((J.LT.15).OR.(J.GT.37)) GO TO 72
      IC(2)=I*1000+J+1
      GO TO 76
   72 IF ((J.NE.1).AND.(J.NE.51)) GO TO 74
      IF (I.EQ.LIMU(J)) GO TO 73
      IC(2)=(I+1)*1000+J
      GO TO 76
   73 IC(2)=(I-1)*1000+J
      GO TO 76
   74 IF (I.EQ.LIML(J)) GO TO 75
      IC(2)=LIMU(J+1)*1000+J+1
      GO TO 76
   75 IC(2)=LIML(J+1)*1000+J+1
C
   76 REWIND IOTEM2
      DO 77 IPG=1,1977
      READ(IOTEM2) IJ
      DO 77 K=1,2
   77 IF(IC(K).EQ.IJ) IPT(II,K+2)=IPG
      GO TO 100
C
   80 CONTINUE
```

```
C     THREE NMC, ONE EQUATORIAL                                         SELE 183
      IPT(II,5)=2212                                                    SELE 184
      IC(2) = 0                                                         SELE 185
      L=YL(II)                                                          SELE 186
      IPT(II,2)=((L/5)+1)*4                                             SELE 187
      IF (L.GE.355) IPT(II,2)=4                                         SELE 188
      IF (I.EQ.LINL(J)) GO TO 84                                        SELE 189
      IF (J.GT.37) GO TO 82                                             SELE 190
      IC(1)=I*1000+J                                                    SELE 191
      IC(3)=I*1000+J+1                                                  SELE 192
      IC(4)=(I+1)*1000+J+1                                              SELE 193
      GO TO 88                                                          SELE 194
   82 IC(1)=(I+1)*1000+J                                                SELE 195
      IC(3)=I*1000+J                                                    SELE 196
      IC(4)=I*1000+J+1                                                  SELE 197
      GO TO 88                                                          SELE 198
   84 IF (J.GT.37) GO TO 86                                             SELE 199
      IC(1)=(I-1)*1000+J+1                                              SELE 200
      IC(3)=I*1000+J+1                                                  SELE 201
      IC(4)=I*1000+J                                                    SELE 202
      GO TO 88                                                          SELE 203
   86 IC(1)=(I+1)*1000+J+1                                              SELE 204
      IC(3)=(I+1)*1000+J                                                SELE 205
      IC(4)=I*1000+J                                                    SELE 206
C                                                                       SELE 207
   88 REWIND IOTEM2                                                     SELE 208
      DO 89 IPG=1,1977                                                  SELE 209
      READ(IOTEM2) IJ                                                   SELE 210
      DO 89 K=1,4                                                       SELE 211
      IF(IC(K).EQ.0) GO TO 89                                           SELE 212
      IF(IC(K).EQ.IJ) IPT(II,K)=IPG                                     SELE 213
   89 CONTINUE                                                          SELE 214
C                                                                       SELE 215
  100 CONTINUE                                                          SELE 216
      DO 150 I=1,16                                                     SELE 217
      DO 150 J=1,5                                                      SELE 218
  150 IPTN(I,J)=IPT(I,J)                                                SELE 219
      CALL SORT4(NP)                                                    SELE 220
      RETURN                                                            SELE 221
      END                                                               SELE 222
      SUBROUTINE SETUP                                                  SETU   1
      COMMON/COTRAN/NDATA(19),IC,MI,IH,IX(10),IEX                       SETU   2
      DIMENSION IP(5),ID(5),IT(5),IDAY(12),BUFFER(64)                   SETU   3
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,           SETU   4
     .NSAME,RP1L,RD1L,RT1L,SP1L,SD1L,ST1L,RU1L,RV1L,SU1L,SV1L,          SETU   5
     $ MN, IDD, IYR, H1, PHI1R,THETA1R,DUMS(21),RP1S,RD1S               SETU   6
     1,RT1S,RU1S,RV1S,SP1S,SD1S,ST1S,SU1S,SV1S,UDS1,VDS1,               SETU   7
     2UDL1,VDL1,UDS2,VDS2,UDL2,VDL2                                     SETU   8
      COMMON/PDTCOM/IU4,MONTH,IOPR,PG(18,19),TG(18,19),DG(18,19)        SETU   9
     , ,PSP(8,10,12)                                                    SETU  10
     1,DSP(8,10,12),TSP(8,10,12),PAQ(17,5),DAQ(17,5),TAQ(17,5),PDQ(17,5)SETU  11
     2 ,DDQ(17,5),TDQ(17,5),PR(20,10),DR(20,10),TR(20,10),UAQ(17,5)     SETU  12
     3 ,VAQ(17,5),UDQ(17,5),VDQ(17,5),UR(25,10),VR(25,10),              SETU  13
     * PQ,DQ,TQ,UQ,VQ,PQA,DQA,                                          SETU  14
```

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     ,  TQA,UA,VA,IOPQ,PLP(25,10),DLP(25,10),TLP(25,10)
     1,ULP(25,10),VLP(25,10),UDL(25,10),VDL(25,10),UDS(25,10)
     2,VDS(25,10)
      COMMON/CHIC/DUM(18),IWSYM,UCOEF(14,9),VCOEF(14,9)
      DIMENSION IDUM(9)
      DATA IDAY/0,31,59,90,120,151,181,212,243,273,304,334/
      XMJD = 0.
      IF (MN.GT.12) GO TO 2
      IDA = IDAY(MN) + IDD
      DD = IDA
      IF (MOD(IYR,4).EQ.0.AND.MN.GT.2) IDA = IDA + 1
      XMJD = 2439856. + 365. * (IYR -   68.) + IDA + INT((IYR -   65.)
     $ / 4.)
C.....SECOND DATA CARD READS, FREE FIELD, THE FOLLOWING DATA:
C         IUG = UNIT NUMBER FOR GROVES DATA TAPE
C         IUR = UNIT NUMBER FOR RANDOM SIGMA DATA
C                  (IF IUR=IUG UNIT IUG WILL BE READ)
C         IUQ = UNIT NUMBER FOR QBO DATA
C                  (IF IUQ=IUG DATA ON TAPE ON UNIT IUG WILL BE READ)
C         IU4 = UNIT FOR 4-D INPUT P,D,T 0-25KM DATA
C         IOPR = RANDOM OUTPUT OPTION
C.....IOPR=1 RANDOM OUTPUT               IOPR=2 NO RANDOM OUTPUT
C         IOPQ = QBO OUTPUT OPTION
C.....IOPQ=1 QBO OUTPUT                  IOPQ=2 NO QBO OUTPUT
C         NR1 = STARTING RANDOM NUMBER
C         NMCOP = NMC GRID DATA READ OPTION
C.....NMCOP=0  READS NMC GRID DATA FROM UNIT IUG, OTHERWISE READS FORM
C         CARDS
C.....IOTEM1=UNIT FOR 4-D P, D, T DATA (SCRATCH FILE, DOES NOT NEED TO
C         BE ASSIGNED)
C.....IOTEM2=UNIT FOR NMC GRID POINTS (SCRATCH FILE, DOES NOT NEED TO
C         BE ASSIGNED)
    2 READ(5,10) IUG,IUR,IUQ,IU4,IOPR,IOPQ,NR1,NMCOP,IOTEM1,IOTEM2
   10 FORMAT( )
      WRITE(6,9000) IUG,IUR,IUQ,IU4,IOPR,IOPQ,NR1,NMCOP,IOTEM1,IOTEM2
     $ ,XMJD
      IF (IOPR.LT.1.OR.IOPR.GT.2) GO TO 666
      IF (IOPQ.LT.1.OR.IOPQ.GT.2) GO TO 666
      MONTH=MN
      IF (IOPR.EQ.2) GO TO 7
      R=RAND(NR1)
      R = RAND(0)
      R = RAND(0)
C.....THIRD DATA CARD READS FREE FIELD, THE FOLLOWING DATA%
C         RP1 = INITIAL RANDOM PRESSURE PERTURBAIIONS, PERCENT
C         RD1 = INITIAL RANDOM DENSITY PERTURBATION, PERCENT
C         RT1 = INITIAL RANDOM TEMPERATURE PERTURBATION, PERCENT
C         SD1 = INITIAL STANDARD DEVIATION FOR RANDOM DENSITY
C                  PERTURBATION, PERCENT
C         RU1 = INITIAL EASTWARD WIND PERTURBATION, M/S
C         RV1 = INITIAL NORTHWARD WIND PERTURBATION, M/S
C         SU1 = INITIAL STANDARD DEVIATION FOR RANDOM EASTWARD WIND, M/S
C         SV1 = INITIAL STANDARD DEVIATION FOR RANDOM NORTHWARD WIND, M/S
      READ(5,10) RP1L,RP1S,RD1L,RD1S,RT1L,RT1S,RU1L,RU1S,RV1L,RV1S
```

```
      RP1=RP1L+RP1S
      RD1=RD1S+RD1L
      RT1=RT1S+RT1L
      RU1=RU1L+RU1S
      RV1=RV1L+RV1S
C     AVOIDS TAPE SEARCH IF CURRENT MONTH IS SAME AS PREVIOUS MONTH
      IF(NSAME.GT.0) GO TO 621
    7 IF (NSAME.EQ.1) GO TO 621
      CALL GETNMC
C.....LOADS NMC GRID DATA FROM INPUT UNIT TO SCRATCHFILE UNIT IOTEM2
      IF (MONTH.LT.13) GO TO 12
      M1=13
      M2=13
C.....MONTH=13 IS ANNUAL AVERAGE CASE
      GO TO 13
   12 M1=MONTH
      M2=MONTH + 6
C.....SOUTHERN HEMISPHERE DATA IS 6 MONTHS DISPLACED FOR GROVES,
C          STATIONARY PERTURBATIONS, AND RANDOM PERTURBATIONS
      IF (M2.GT.12) M2=M2 - 12
   13 DO 100 I=1,234
      CALL RTRAN1
C.....READS GROVES PRESSURE DATA
      IF (IC.NE.'P') GO TO 666
      IF (MI.EQ.M1) GO TO 30
      IF (MI.EQ.M2) GO TO 40
      GO TO 100
   30 KS=1
      GO TO 50
   40 KS=-1
   50 IH=(IH-20)/5
      TENX=10.**IEX
      DO 60 J=1,10
      K=10+KS*(J-1)
   60 PG(IH,K) = IX(J)*TENX
C.....CONVERSION TO REAL AND STORAGE IN ARRAY COMPLETE
  100 CONTINUE
      DO 200 I=1,234
      CALL RTRAN1
C.....READS GROVES DENSITY DATA
      IF(IC.NE.'D') GO TO 666
      IF (MI.EQ.M1) GO TO 130
      IF (MI.EQ.M2) GO TO 140
      GO TO 200
  130 KS=1
      GO TO 150
  140 KS=-1
  150 IH=(IH-20)/5
      TENX=10.**IEX
      DO 160 J=1,10
      K=10+KS*(J-1)
  160 DG(IH,K) = IX(J)*TENX
C.....CONVERSION TO REAL AND STORAGE IN ARRAY COMPLETE
  200 CONTINUE
```

```
      DO 300 I=1,234
      CALL RTRAN1
C.....READS GROVES TEMPERATURE DATA
      IF (IC.NE.'T') GO TO 666
      IF (MI.EQ.M1) GO TO 230
      IF (MI.EQ.M2) GO TO 240
      GO TO 300
  230 KS=1
      GO TO 250
  240 KS=-1
  250 IH=(IH-20)/5
      TENX=10.**IEX
      DO 260 J=1,10
      K=10+KS*(J-1)
  260 TG(IH,K) = IX(J)*TENX
C.....CONVERSION TO REAL AND STORAGE IN ARRAY COMPLETE
  300 CONTINUE
      IF (MONTH.LT.13) GO TO 308
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL
      DO 304 I=1,18
      DO 304 J=1,9
      J20=20-J
      PG(I,J)=PG(I,J20)
      DG(I,J)=DG(I,J20)
      TG(I,J)=TG(I,J20)
  304 CONTINUE
  308 DO 360 I=1,1248
      CALL RTRAN
C.....READS STATIONARY PERTURBATIONS DATA (TO BE STORED IN PSP, DSP, AND
C          TSP ARRAYS)
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      LON=NDATA(4)
      DO 311 K=1,5
      IP(K)=NDATA(4+K)
      ID(K)=NDATA(9+K)
  311 IT(K)=NDATA(14+K)
      IF (IC.NE.'S') GO TO 666
      IF (MI.EQ.M1) GO TO 320
      IF (MI.EQ.M2) GO TO 330
      GO TO 360
  320 KS=1
      GO TO 340
  330 KS=-1
  340 ISH=2+(IH-44)/8
      L=(LON+20)/30
      IF(IH.LT.52) ISH = (IH-20)/10
      IF (IH.GT.84) ISH=8
      DO 350 J=1,5
      K=5+KS*(J+(KS-1)/2)
      PSP(ISH,K,L) = IP(J)/1000.
      DSP(ISH,K,L) = ID(J)/1000.
  350 TSP(ISH,K,L) = IT(J)/1000.
```

```
C.....CONVERSION TO REAL AND STORAGE IN ARRAYS COMPLETE
  360 CONTINUE
      IF (MONTH.LT.13) GO TO 368
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL
      DO 364 I=1,8
      DO 364 K=1,12
      DO 364 J=1,5
      J10=11-J
      PSP(I,J,K)=PSP(I,J10,K)
      DSP(I,J,K)=DSP(I,J10,K)
      TSP(I,J,K)=TSP(I,J10,K)
  364 CONTINUE
C     MOVES PAST 2ND EOF ON UNIT IUG
368   READ(IUG,9999,END=369) IDUMMY
9999  FORMAT(A1)
      GO TO 368
369   CONTINUE
      IF(IOPR.EQ.2) GO TO 440
C.....IOPR=1 READS RANDOM SIGMAS,  IOPR=2 ZEROS RANDOM SIGMAS
      DO 430 I=1,260
      IF (IUR.EQ.IUG) GO TO 375
      READ (IUR,380) IC,MI,IH,IP,ID,IT
C.....USES FORTRAN READ ON UNIT IUR IF IUR NEQ IUG
  380 FORMAT (1X,A1,I2,I4,3(1X,5I4))
      GO TO 385
  375 CALL RTRAN
C.....READS FROM UNIT IUG IF IUG = IUR
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 381 K=1,5
      IP(K)=NDATA(3+K)
      ID(K)=NDATA(8+K)
  381 IT(K)=NDATA(13+K)
  385 IF (IC.NE.'R') GO TO 666
C     M1 = NORTHERN HEMISPHERE MONTH
      IF (MI.EQ.M1) GO TO 390
C      SOUTHERN HEMISPHERE MONTH
      IF (MI.EQ.M2) GO TO 400
C.....M2 = M1 + 6   UNLESS M1 = M2 = 13
      GO TO 430
  390 KS=1
      GO TO 410
  400 KS=-1
  410  IF (IH.LT.95) IHR=(IH-20)/5
C     IHR = HEIGHT INDEX
      IF (IH.GE.95) IHR = 14 + (IH - 80) / 20
      DO 420 J=1,5
      K = 5 + KS * (J + (KS - 1) / 2)
C.....K = LATITUDE INDEX 1-5 = LAT -90 TO -10, 6-10 = LAT +10 TO +90
      PR(IHR,K) =(IP(J)/1000.)**2
      DR(IHR,K) =(ID(J)/1000.)**2
  420 TR(IHR,K) =(IT(J)/1000.)**2
  430 CONTINUE
```

```
      IF (MONTH.LT.13) GO TO 460
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL
      DO 435 I=1,20
      DO 435 J=1,5
      J10=11-J
      PR(I,J)=PR(I,J10)
      DR(I,J)=DR(I,J10)
      TR(I,J)=TR(I,J10)
  435 CONTINUE
      GO TO 460
  440 DO 450 I=1,20
      DO 450 J=1,10
      PR(I,J) = 0.
      DR(I,J) = 0.
  450 TR(I,J) = 0.
C.....RANDOM SIGMAS ARE ZEROED IF IOPR=2
      DO 455 I=1,25
      DO 455 J=1,10
      UR(I,J)=0.
  455 VR(I,J) = 0.
      GO TO 500
  460 DO 490 I=1,325
      IF (IUR.EQ.IUG) GO TO 462
      READ(IUR,465) IC,MI,IH,IP,ID
C.....READS RANDOM WIND STANDARD DEVIATIONS WITH FORTRAN READ FROM
C          UNIT IUR IF IUR NEQ IUG
  465 FORMAT(1X,A2,I2,I4,2(1X,5I4))
      GO TO 467
  462 CALL RTRAN
C.....READS FROM UNIT IUG IF IUG = IUR
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 461 K=1,5
      IP(K)=NDATA(3+K)
  461 ID(K)=NDATA(8+K)
  467 IF (IC.NE.'RW') GO TO 666
C     NORTHERN HEMISPHERE MONTH
      IF (MI.EQ.M1) GO TO 470
C     SOUTHERN HEMISPHERE MONTH
      IF (MI.EQ.M2) GO TO 475
      GO TO 490
  470 KS=1
      GO TO 480
  475 KS=-1
  480 IF (IH.LT.95) IHR=1+IH/5
C     HEIGHT INDEX
      IF (IH.GE.95) IHR=19+(IH-80)/20
      DO 485 J=1,5
C     LATITUDE INDEX
      K=5+KS*(J+(KS-1)/2)
      UR(IHR,K)=(IP(J)**2)*1.
  485 VR(IHR,K)=(ID(J)**2)*1.
  490 CONTINUE
```

```
      IF (MONTH.LT.13) GO TO 500
C.....ANNUAL MEAN CASE - BOTH HEMISPHERES EQUAL
      DO 495 I=1,25
      DO 495 J=1,5
      J10=11-J
      UR(I,J)=UR(I,J10)
      VR(I,J)=VR(I,J10)
  495 CONTINUE
C     MOVES PAST 3RD EOF ON UNIT IUG
      IF(IOPR.EQ.2) GO TO 900
500   READ(IUG,9999,END=501) IDUMMY
      GO TO 500
501   CONTINUE
      DO 840 I=1,25
      IF(IUR.EQ.IUG) GO TO 800
      READ(IUR,380) IC,MI,IH,IP,ID,IT
C.....USES FORTRAN READ ON UNIT IUR IF IUR NEQ IUG
      GO TO 820
  800 CALL RTRAN
C.....READS FROM UNIT IUG IF IUR = IUG
      IC=NDATA(1)
       MI=NDATA(2)
      IH=NDATA(3)
      DO 810 K=1,5
      IP(K)=NDATA(3+K)
      ID(K)=NDATA(8+K)
  810 IT(K)=NDATA(13+K)
  820 IF(IH.GT.90) IH=70+(IH/4)
      IH=1+(IH/5)
      IF(IC.NE.'P'.OR.IH.NE.I) GO TO 666
      DO 830 J=1,5
      PLP(I,J+5)=IP(J)/1000.
       PLP(I,6-J)=IP(J)/1000.
      DLP(I,J+5)=ID(J)/1000.
      DLP(I,6-J)=ID(J)/1000.
      TLP(I,J+5)=IT(J)/1000.
  830 TLP(I,6-J)=IT(J)/1000.
  840 CONTINUE
      DO 865 I=1,25
      IF(IUR.EQ.IUG) GO TO 845
      READ(IUR,465) IC,MI,IH,IP,ID
      GO TO 855
  845 CALL RTRAN
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 850 K=1,5
      IP(K)=NDATA(3+K)
  850 ID(K)=NDATA(8+K)
  855 IF(IH.GT.90) IH=70+(IH/4)
      IH=1+(IH/5)
      IF(I.NE.IH.OR.IC.NE.'PW') GO TO 666
      DO 860 J=1,5
      ULP(I,J+5)=IP(J)/1000.
```

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      ULP(I,6-J)=IP(J)/1000.
      VLP(I,J+5)=ID(J)/1000.
  860 VLP(I,6-J)=ID(J)/1000.
  865 CONTINUE
      DO 888 I=1,25
      IF(IUR.EQ.IUG) GO TO 870
      READ(IUR,868)IC,MI,IH,IP,ID
  868 FORMAT(1X,A2,I2,I4,2(1X,5I5))
      GO TO 880
  870 CALL RTRAN
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 875 K=1,5
      IP(K)=NDATA(3+K)
  875 ID(K)=NDATA(8+K)
  880 IF(IH.GT.90) IH=70+(IH/4)
      IH=1+(IH/5)
      IF(IH.NE.I.OR.IC.NE.'CS')GO TO 666
      DO 885 J=1,5
      UDS(I,J+5)=(IP(J)/1000.)
      UDS(I,6-J)=(IP(J)/1000.)
      VDS(I,J+5)=(ID(J)/1000.)
  885 VDS(I,6-J)=(ID(J)/1000.)
  888 CONTINUE
      DO 898 I=1,25
      IF(IUR.EQ.IUG) GO TO 890
      READ(IUR,868)IC,MI,IH,IP,ID
      GO TO 894
  890 CALL RTRAN
      IC=NDATA(1)
      MI=NDATA(2)
      IH=NDATA(3)
      DO 892 K=1,5
      IP(K)=NDATA(3+K)
  892 ID(K)=NDATA(8+K)
  894 IF(IH.GT.90) IH= 70+(IH/4)
      IH=1+(IH/5)
      IF(IH.NE.I.OR.IC.NE.'CL') GO TO 666
      DO 896 J=1,5
      UDL(I,J+5)=(IP(J)/1000.)
      UDL(I,6-J)=(IP(J)/1000.)
      VDL(I,J+5)=(ID(J)/1000.)
  896 VDL(I,6-J)=(ID(J)/1000.)
  898 CONTINUE
      GO TO 910
  900 DO 905 I=1,25
      DO 905 J=1,10
      PLP(I,J)=0.
      DLP(I,J)=0.
      TLP(I,J)=0.
      ULP(I,J)=0.
      VLP(I,J)=0.
      UDS(I,J)=0.
```

```
      UDL(I,J)=0.
      VDS(I,J)=0.
      VDL(I,J)=0.
  905 CONTINUE
C.....MOVES PAST NEXT EOF ON TAPE
      IF (IOPQ.EQ.2) GO TO 600
910   READ(IUG,9999,END=911) IDUMMY
      GO TO 910
911   CONTINUE
C.....IOPQ=1 READS QBO PARAMETERS,  IOPQ=2 ZEROS THESE PARAMETERS
      DO 530 I=1,16
      IF (IUQ.EQ.IUG) GO TO 525
      READ(IUQ,520) IC,IH,IX
C.....READS WITH FORTRAN FROM UNIT IUQ IF IUQ NEQ IUG
  520 FORMAT (1X,A2,I3,5(I4,I5))
      GO TO 527
  525 CALL RTRAN2
C.....READS FROM UNIT IUG IF IUQ = IUG
  527 IF (IC.NE.'QP') GO TO 666
      IH = (IH-5)/5
      DO 530 J=1,5
C.....CONVERT FROM INTEGER PER MIL - QBO PRESSURE AMPLITUDE
      PAQ(IH,J) = IX(2*J-1)/1000.
C.....QBO PRESSURE PHASE (DAYS PAST JAN 0, 1966)
  530 PDQ(IH,J) = IX(2*J)*1.
      DO 531 I = 1,5
      PAQ(1,I) = 0.
 531  CALL PHASE(PDQ(2,I),15.,PDQ(3,I),20.,PDQ(1,I),10.)
      DO 540 I=1,16
      IF (IUQ.EQ.IUG) GO TO 535
      READ (IUQ,520) IC,IH,IX
      GO TO 537
  535 CALL RTRAN2
  537 IF (IC.NE.'QD') GO TO 666
      IH=(IH-5)/5
      DO 540 J=1,5
C...CONVERT FROM INTEGER PER MIL - QBO DENSITY AMPLITUDE
      DAQ(IH,J) = IX(2*J-1)/1000.
C.....QBO DENSITY PHASE (DAYS PAST JAN 0, 1966)
  540 DDQ(IH,J)=IX(2*J)*1.
      DO 541 I = 1,5
      DAQ(1,I) = 0.
 541  CALL PHASE(DDQ(2,I),15.,DDQ(3,I),20.,DDQ(1,I),10.)
      DO 550 I=1,16
      IF (IUQ.EQ.IUG) GO TO 545
      READ (IUQ,520) IC,IH,IX
      GO TO 547
  545 CALL RTRAN2
  547 IF (IC.NE.'QT') GO TO 666
      IH = (IH- 5)/5
      DO 550 J=1,5
C.....CONVERTS FROM INTEGER PER MIL - QBO TEMPERATURE AMPLITUDE
      TAQ(IH,J) = IX(2*J-1)/1000.
C.....QBO TEMPERATURE PHASE
```

```
  550 TDQ(IH,J) = IX(2*J)*1.
      DO 551 I = 1,5
      TAQ(1,I) = 0.
 551  CALL PHASE(TDQ(2,I),15.,TDQ(3,I),20.,TDQ(1,I),10.)
      DO 560 I=1,16
      IF (IUQ.EQ.IUG) GO TO 555
C.....READS WITH FORTRAN IF IUQ NEQ IUG
      READ(IUQ,520) IC,IH,IX
      GO TO 557
  555 CALL RTRAN2
C.....READS FROM UNIT IUG IF IUQ = IUG
  557 IF (IC.NE.'QU') GO TO 666
      IH=(IH- 5)/5
      DO 560 J=1,5
C.....EASTWARD WIND QBO AMPLITUDE - CONVERTED TO M/S
      UAQ(IH,J) = IX(2 * J - 1) / 10.
C.....EASTWARD WIND QBO PHASE (DAYS PAST JAN 0, 1966)
  560 UDQ(IH,J)=IX(2*J)*1.
      DO 561 I = 1,5
      UAQ(1,I) = 0.
 561  CALL PHASE(UDQ(2,I),15.,UDQ(3,I),20.,UDQ(1,I),10.)
      DO 570 I=1,16
       IF (IUQ.EQ.IUG) GO TO 565
      READ(IUQ,520) IC,IH,IX
      GO TO 567
  565 CALL RTRAN2
  567 IF (IC.NE.'QV') GO TO 666
      IH=(IH- 5)/5
      DO 570 J=1,5
C.....NORTHWARD WIND QBO AMPLITUDE - CONVERTED TO M/S
      VAQ(IH,J) = IX(2 * J - 1) / 10.
C.....NORTHWARD WIND QBO PHASE (DAYS PAST JAN 0,1966)
  570 VDQ(IH,J)=IX(2*J)*1.
      DO 571 I = 1,5
      VAQ(1,I) = 0.
 571  CALL PHASE(VDQ(2,I),15.,VDQ(3,I),20.,VDQ(1,I),10.)
      GO TO 611
  600 DO 610 I=1,IUG
      DO 610 J=1,5
      PAQ(I,J) = 0.
      DAQ(I,J) = 0.
      TAQ(I,J) = 0.
      PDQ(I,J) = 0.
      DDQ(I,J) = 0.
      TDQ(I,J) = 0.
      UAQ(I,J)=0.
      UDQ(I,J)=0.
      VAQ(I,J)=0.
      VDQ(I,J)=0.
  610 CONTINUE
C.....MOVE PAST NEXT EOF ON TAPE.
 611  READ(IUG,9999,END=609) IDUMMY
      GO TO 611
609   CONTINUE
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C...READ IN SPHERICAL HARMONICS COEFFICIENTS....................
      DO 615 IFR=1,MN
      DO 613 JFR=1,14
      READ(IUG,640)IF1,IF2,(IDUM(I),I=1,9)
  640 FORMAT(2X,19I7)
      DO 613 I=1,9
 613  UCOEF(JFR,I)=FLOAT(IDUM(I))/100.
      DO 612 JFR=1,14
      READ(IUG,640)IF1,IF2,(IDUM(I),I=1,9)
      DO 612 I=1,9
 612  VCOEF(JFR,I)=FLOAT(IDUM(I))/100.
 615  CONTINUE
C.....ZEROS QBO PARAMETERS IF IOPQ = 2
C.....REWINDS TAPE UNIT IUG
      REWIND IUG
C
 621  R=H1
      IF(H1.LT.25.) R=25.
      CALL RTERP(R ,PHI1,PR,DR,TR,SP1,SD1,ST1)
      CALL INTRUV(PLP,DLP,H1,PHI1,PLP1,DLP1)
      CALL INTRUV(TLP,DLP,H1,PHI1,TLP1,R)
      SP1L=SQRT(PLP1*ABS(SP1))*100.
      SP1S=SQRT((1.-PLP1)*ABS(SP1))*100.
      SD1L=SQRT(DLP1*ABS(SD1))*100.
      SD1S=SQRT((1.-DLP1)*ABS(SD1))*100.
      ST1L=SQRT(TLP1*ABS(ST1))*100.
      ST1S=SQRT((1.-TLP1)*ABS(ST1))*100.
      CALL INTRUV(UR,VR,H1,PHI1,SU1,SV1)
      CALL INTRUV(ULP,VLP,H1,PHI1,ULP1,VLP1)
      SU1L=SQRT(ULP1*ABS(SU1))
      SU1S=SQRT((1.-ULP1)*ABS(SU1))
      SV1L=SQRT(VLP1*ABS(SV1))
      SV1S=SQRT((1.-VLP1)*ABS(SV1))
      CALL INTRUV( UDL,VDL,H1,PHI1,UDL1,VDL1)
      CALL INTRUV(UDS,VDS,H1,PHI1,UDS1,VDS1)
      UDL1=UDL1*100.
      VDL1=VDL1*100.
      UDS1=UDS1*100.
      VDS1=VDS1*100.
      WRITE(6,9001) RP1L,RD1L,RT1L,SP1L,SD1L,ST1L,RU1L,RV1L,SU1L,SV1L,
     1'LARGE'
      WRITE(6,9001)RP1S,RD1S,RT1S,SP1S,SD1S,ST1S,RU1S,RV1S
     1,SU1S,SV1S,'SMALL'
      WRITE(6,9002)UDL1,VDL1,UDS1,VDS1
      WRITE(6,9003)
      RP1L=RP1L/100.
      RD1L=RD1L/100.
      RT1L=RT1L/100.
      SP1L=(SP1L/100.)
      SD1L=(SD1L/100.)
      ST1L=(ST1L/100.)
      RP1S=RP1S/100.
      RD1S=RD1S/100.
      RT1S=RT1S/100.
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      SP1S=SP1S/100.
      SD1S=SD1S/100.
      ST1S=ST1S/100.
      UDL1=UDL1/100.
      VDL1=VDL1/100.
      UDS1=UDS1/100.
      VDS1=VDS1/100.
      WRITE(6,630)
      RETURN
  666 WRITE(6,700) IUG,IUR,IUQ,IOPR,IOPO,NR1,NMCOP,IOTEM1,IOTEM2,
     $MONTH,IC,MI,IH,IX,IEX,IP,ID,IT,SD1
  700 FORMAT(' ERROR IN SETUP INPUT',/,1X,5I3,I10,4I3,A2,I3,I4,/,11I4,
     $/,15I4,/,F10.1)
      STOP
  630 FORMAT(27X,'UNPERTURBED (MONTHLY MEAN)',11X,'MEAN PLUS PERTURBATIO
     1NS',9X,'THERMAL',/,23X,2(34('-'),2X),3X,'WIND',6X,'PERTURBATION VA
     2LUES',/,' HEIGHT   LAT    WEST   PRES.    DENS.   TEMP  GEOSTROPH.
     3   PRES.    DENS.   TEMP      TOTAL       SHEAR',/,2X,'(KM)',11X,'LO
     4N',4X,'(NT/      (KG/     (DEG  WIND (M/S)    (NT/      (KG/     (DEG
     5WIND (M/S)  (M/S/KM) ',28('-'),/,' TIME     (DEG)   (DEG)',2('    M**
     62)     M**3)    KEL-  ',10('-')),2X,8('-'),'  P     D     T     U     V
     7  W'/' (SEC)',35X,'VIN)    E-W    N-S',20X,'VIN)    E-W   N-S  E-W  N
     8-S (%)  (%)   (%)  M/S  M/S CM/S'/)
 9000 FORMAT('  GROVES INPUT UNIT = ',I2,T43,'RANDOM INPUT UNIT = ',I2,
     1T83,'QBO INPUT UNIT = ',I2,/,'  4-D INPUT UNIT = ',I2,T43,'RANDOM
     2OPTION = ',I2,T83,'QBO OPTION = ',I2,/,'  FIRST RANDOM NUMBER = ',
     2I5,
     3/,'  NMC READ OPTION = ',I2,T43,'4-D P,D,T DATA SCRATCH UNIT = ',
     4I2,/,'  NMC GRID POINTS SCRATCH UNIT = ',I2,T43,'JULIAN DATE = ',
     5F9.1,/)
 9001 FORMAT('  INITIAL P,D,T = ',3(F6.2,' %   '),T60,'SIGMA P,D,T = ',
     13(F6.2,' %   '),/,'  INITIAL U,V = ',2(F7.2,' M/S   '),T60,'SIGMA
     2U,V = ',2(F7.2,' M/S   '),  7X,A5,1X,'SCALE'/)
 9003 FORMAT(//'  **  PERCENT DEVIATIONS FROM 1962 US STANDARD '
     1 ,'ATMOSPHERE APPEAR BELOW PRESSURE, DENSITY AND TEMPERATURE ',
     2 'VALUES  **'//)
 9002 FORMAT('  INITIAL UDL,VDL = ',2(F6.2,' % '),
     1T60,'INITIAL UDS,VDS = ',2(F6.2,' % '))
      END
      SUBROUTINE SORT4(NP)
C
C               SORTS POINTS FOR SEQUENTIAL TAPE READING
C
C          ASSIGNS POINT NUMBERS BY ORDER ON TAPE, NOT BY GRID
C
      COMMON /ORDER/ IPT (16,5),IREAD(65,3)
C
      DO 1 I=1,65
      DO 1 J=1,3
    1 IREAD(I,J)=0
      DO 9 I=1,NP
      IF(IPT(I,5).LT.1) GO TO 10
      IF(IPT(I,5).EQ.1) GO TO 9
      IF(IPT(I,5).EQ.2) GO TO 2
```

```
      IF(IPT(I,5).EQ.3) GO TO 4
      IF(IPT(I,5).EQ.1133)GO TO 6
      IF(IPT(I,5).EQ.2211) GO TO 7
      IF(IPT(I,5).EQ.2212)GO TO 8
      IF (IPT(I,5).EQ.333) GO TO 4
      GO TO 10
    2 DO 3 J=1,4
      IF(IPT(I,J).LT.1) GO TO 3
      IPT(I,J)=IPT(I,J)+288
    3 CONTINUE
      GO TO 9
    4 DO 5 J=1,4
      IF(IPT(I,J).LT.1) GO TO 5
      IPT(I,J)=IPT(I,J)+2265
    5 CONTINUE
      GO TO 9
    6 IF(IPT(I,1).GT.0)IPT(I,1)=IPT(I,1)+2265
      IF(IPT(I,2).GT.0)IPT(I,2)=IPT(I,2)+2265
      GO TO 9
    7 IF(IPT(I,3).GT.0)IPT(I,3)=IPT(I,3)+288
      IF(IPT(I,4).GT.0)IPT(I,4)=IPT(I,4)+288
      GO TO 9
    8 IF(IPT(I,1).GT.0)IPT(I,1)=IPT(I,1)+288
      IF(IPT(I,3).GT.0)IPT(I,3)=IPT(I,3)+288
      IF(IPT(I,4).GT.0)IPT(I,4)=IPT(I,4)+288
    9 CONTINUE
C
C          REORDERS POINT NUMBERS FOR READ
C
   10 IR=0
      DO 13 K=1,NP
      DO 13 L=1,4
      MP=IPT(K,L)
      IF(MP.LT.1) GO TO 13
   11 II=K
      JJ=L
      DO 12 I=1,NP
      DO 12 J=1,4
      IF (IPT(I,J).LT.1) GO TO 12
      IF(IPT(I,J).GT.3490) GO TO 12
      IF(IPT(I,J).GE.MP) GO TO 12
      II=I
      JJ=J
      MP=IPT(I,J)
   12 CONTINUE
      IF(IPT(II,JJ).GT.3490) GO TO 14
      IR=IR+1
      IREAD(IR,1)=II
      IREAD(IR,2)=JJ
      IREAD(IR,3)=IPT(II,JJ)
      IPT(II,JJ)=IPT(II,JJ)+9000
      MP=IPT(K,L)
      IF(MP.GT.3490) GO TO 13
      GO TO 11
```

```
 13 CONTINUE
 14 RETURN
    END
    SUBROUTINE SPHERE(MN,IH,PHIR,THETR,US,VS)
    COMMON/CHIC/DUM(18),IWSYM,UCOEF(14,9),VCOEF(14,9)
    DIMENSION Z(9)
    COSPHI=COS(PHIR)
    COSTHET=COS(THETR)
    SINPHI=SIN(PHIR)
    SINTHET=SIN(THETR)
    Z(1)=1.
    Z(2)=SINPHI
    Z(3)=COSTHET*COSPHI
    Z(4)=SINTHET*COSPHI
    Z(5)=(3*(SINPHI**2)-1)/2.
    Z(6)=COSTHET*(3*COSPHI*SINPHI)
    Z(7)=SINTHET*(3*COSPHI*SINPHI)
    Z(8)=(2*(COSTHET)**2-1)*(3*(COSPHI)**2)
    Z(9)=(2*SINTHET*COSTHET)*(3*(COSPHI)**2)
5   IH5=IH/5-4
    IFR=9
    IF(IH.GT.65)IFR=4
    US=0.
    VS=0.
    DO 10 I=1,IFR
    US=US+Z(I)*UCOEF(IH5,I)
    VS=VS+Z(I)*VCOEF(IH5,I)
10  CONTINUE
    RETURN
    END
    SUBROUTINE STDATM(Z,T,P,D)
    DIMENSION ZS(35),TMS(35),WMS(35),PS(35)
    DATA (ZS(I),I=1,35)/0., 11.019, 20.063, 32.162, 47.35,
   * 52.429, 61.591, 79.944, 90., 95., 100., 105., 110., 115.,
   * 120., 135., 150., 155., 160., 165., 170., 180., 190., 210.,
   * 230., 265., 300., 350., 400., 450., 500.,550.,600., 650., 700./
    DATA (TMS(I),I=1,35)/288.15, 216.65,216.65, 228.65, 270.65,270.65,
   * 252.65, 180.65, 180.65, 0., 210.65, 0., 260.65, 0., 360.65,
   * 0., 960.65, 0., 1110.65, 0., 1210.65, 0., 1350.65, 0., 1550.65,
   * 0., 1830.65, 0., 2160.65, 0., 2420.65, 0., 2590.65, 0.,
   * 2700.65/
    DATA (WMS(I),I=1,35)/28.9644, 28.9644, 28.9644, 28.9644, 28.9644,
   * 28.9644, 28.9644, 28.9644, 28.9644, 28.94, 28.88, 28.75, 28.56,
   * 28.32, 28.07, 27.37, 26.92, 26.79, 26.66, 26.52, 26.45, 26.15,
   * 25.85, 25.27, 24.69, 23.67, 22.66, 21.24, 19.94, 18.82, 17.94,
   * 17.29, 16.84, 16.50, 16.17/
    DATA (PS(I),I=1,35)/1013.25, 226.32, 54.7487, 8.68014, 1.10905,
   * .590005, .182099, 1.0377E-2, 1.6438E-3, 0., 3.0075E-4, 0.,
   * 7.3544E-5, 0., 2.5217E-5, 0., 5.0617E-6, 0., 3.6943E-6, 0.,
   * 2.7926E-6, 0., 1.6852E-6, 0., 6.9604E-7, 0., 1.8838E-7, 0.,
   * 4.0304E-8, 0., 1.0957E-8, 0., 3.4502E-9, 0., 1.1918E-9/
    IF(Z.LT.0.) GO TO 81
    R0=6356.36
    G0=9.8066
```

```
      WMO=28.9644
      RS=8314.32
      ZM=Z*1000.
      ROM=6356360.
      IF(Z.GE.90.) GO TO 6
      DO 3 I=1,8
      IF(ZS(I).LE.Z.AND.Z.LT.ZS(I+1)) GO TO 5
    3 CONTINUE
    5 ZL=INT(ZS(I))*1.
      ZU=INT(ZS(I+1))*1.
      ZLM=ZL*1000.
      ZUM=ZU*1000.
      IF(I.EQ.8) ZU=88.743
      WM=WMO
      HT=(RO*Z)/(RO+Z)
      HM=HT*1000.
      G=(TMS(I+1)-TMS(I))/(ZU-ZL)
      GM=G*.001
      IF(G.LT.0..OR.G.GT.0.) GO TO 12
      P=PS(I)*EXP(-(GO*WMO*(HM-ZLM))/(RS*TMS(I)))*100.
      GO TO 13
   12 P=PS(I)*((TMS(I)/(TMS(I)+G*(HT-ZL)))**((GO*WMO)/(RS*GM)))*100.
   13 T=TMS(I)+G*(HT-ZL)
      GO TO 25
    6 DO 7 I=9,33,2
      IF(ZS(I).LE.Z.AND.Z.LT.ZS(I+2)) GO TO 8
    7 CONTINUE
   81 T=0.
      P=0.
      D=0.
      RETURN
    8 ZL=ZS(I)
      ZU=ZS(I+2)
      ZLM=ZL*1000.
      ZUM=ZU*1000.
      ZMID=ZS(I+1)
      A0=WMS(I)
      A2=-2.*(2.*WMS(I+1)-WMS(I+2)-A0)/((ZU-ZL)**2.)
      A1=(WMS(I+2)-A0-A2*((ZU-ZL)**2.))/(ZU-ZL)
      WM=A0+A1*(Z-ZL)+A2*((Z-ZL)**2.)
      G=(TMS(I+2)-TMS(I))/(ZS(I+2)-ZS(I))
      GM=G*.001
      TK=ZLM-(TMS(I)/GM)
      S=(WMO*GO*ROM*ROM)/(RS*GM)
      A=((ROM+ZM)*(ZLM-TK)/((ZM-TK)*(ROM+ZLM)))
      B=(S/((TK+ROM)**2.))
      P=PS(I)*(((ROM+ZM)*(ZLM-TK)/((ZM-TK)*(ROM+ZLM)))**(S/((TK+ROM)
     1**2.)))*EXP((-S*(ZLM-ZM))/((TK+ROM)*(ZM+ROM)*(ZLM+ROM)))*100.
      TM=TMS(I)+G*(Z-ZS(I))
      T=(WM/WMO)*TM
   25 D=(WM*P)/(RS*T)
   26 RETURN
      END
      SUBROUTINE TINF
```

```
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .          NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,GI,
     .   IHR,MIN,NMORE,DX,HL,VL,DZ
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,R,TE,EM
C
C   SUROUTINE TINF CALCULATES THE EXOSPHERIC TEMPERATURE ACCORDING TO JA
C     SAO NO. 313 ,1970.
C
C LIST
C     F10 = SOLAR RADIO NOISE FLUX (XE-22 WATTS/M**2)
C     F10B= 81-DAY AVERAGE F10
C     GI  = GEOMAGNETIC ACTIVITY INDEX,AP
C     LAT = GEOGRAPHIC LATITUDE AT PERIGEE  (IN RAD)
C     SDA = SOLAR DECLINATION ANGLE         (IN RAD)
C     SHA = SOLAR HOUR ANGLE
C     DY  = D/Y (DAY NUMBER/TROPICAL YEAR)? 1
C     R = 0.31  (DIURNAL FACTOR)
C
C   CONSTANTS -- C=SOLAR ACTIVITY VARIATION, BETA,ETC. = DIURNAL VARIATI
C                D=GEOMAGNETIC VARIATION, E=SIMIANNUAL VARIATION.
C
      C1 = 383.0
      C2 =   3.32
      C3 =   1.80
C
      PI = 3.14159265
      CON = 0.01745329252
      BETA= -37.0*CON
      GAMMA= 43.0*CON
      P   =   6.0*CON
      XM  =   2.5
      XNN =   3.0
C
      D1 =  28.0
      D2 =   0.03
      D3 =   1.0
      D4 = 100.0
      D5 =  -0.08
C
      E1 =   2.41
      E2 =   0.349
      E3 =   0.206
      E4 = 360.*CON
      E5 = 226.5*CON
      E6 = 720.*CON
      E7 = 247.6*CON
      E8 =   0.1145
      E9 =   0.5
      E10= E4
      E11= 342.3*CON
      E12=  2.16
C
C SOLAR ACTIVITY VARIATION
```

```
C
      TC = C1 + C2*F10B + C3*(F10 - F10B)
C
C DIURNAL VARIATION
C
      ETA    = 0.5*ABS(XLAT - SDA)
      THETA  = 0.5*ABS(XLAT + SDA)
      TAU    = SHA + BETA + P*SIN(SHA + GAMMA)
      TPI=2*PI
      IF(TAU) 210,230,230
  210 IF(TAU+PI) 220,250,250
  220 TAU=TAU+TPI
      GO TO 210
  230 IF(TAU-PI) 250,250,240
  240 TAU=TAU-TPI
      GO TO 230
  250 CONTINUE
      A1 =(SIN(THETA))**XM
      A2 =(COS(ETA))**XM
      A3 =(COS(TAU/2.))**XMN
      B1 = 1.0 + R*A1
      B2 =(A2-A1)/B1
      TV = B1*( 1. + R*B2*A3)
      TL = TC*TV
C
C GEOMAGNETIC VARIATION
C
      TG = D3*GI + D4*(1-EXP(D5*GI))
C
C SEMIANNUAL VARIATION
C
      G3 = 0.5*(1.0 + SIN(E10*DY +E11) )
      G3 = G3**E12
      TAU1 = DY + E8*(G3 - E9)
      G1 = E2 + E3*(SIN(E4*TAU1 + E5))
      G2 = SIN(E6*TAU1+ E7)
      TS = E1 + F10B*G1*G2
C
C EXOSPHERIC TEMPERATURE
C
      TE = TL + TG + TS
      RETURN
      END
      SUBROUTINE TME
      COMMON/COMJAC/XLAT,XLONG,SDA,SHA,DY,R,T,EM
      COMMON/IOTEMP/IOTEM1,IOTEM2,IUG,NMCOP,DD,XMJD,PHI1,PHI,
     .           NSAME,RP1, RD1, RT1, SP1, SD1, ST1, RU1, RV1, SU1, SV1,
     $ MN, IDA, IYR, H1, PHI1R,THET1R,G,RI,H,PHIR,THETR,F10,F10B,AP,
     .    IHR,MIN,NMORE,DX,HL,VL,DZ
C
C LIST
C INPUT
C     MN=MONTH.  IDA=DAY. IYR=HEAR. HR = HOUR.  MIN = MINUTE
C     XLAT = LATITUDE (INPUT-GEOCENTRIC LATITUDE.)
```

```
C     XLONG= LONGITUDE(INPUT-GEOCENTRIC LONGITUDE. OUTPUT  -180 TO + 180)
C OUTPUT
C     SDA = SOLAR DECLINATION ANGLE (IN RAD)
C     SHA = SOLAR HOUR ANGLE (IN RAD)
C     DD  = DAY NUMBER FROM 1JAN.
C     DY  = DD/TROPICAL YEAR
C
C
C SET CONSTANTS
C
      YEAR = 365.2422
      YR=IYR
    6 DY = DD/YEAR
   30 FMJD = XMJD - 2435839.
C
C  CO,PUTE GREENWICH MEAN TIME IN MINUTES GMT
C
      XHR =IHR
      XMIN = MIN
      GMT = 60*XHR + XMIN
C
C  COMPUTE GREENWICH MEAN POSITION - GP (IN DEG)
C
      XJ = (XMJD - 2415020.0)/(36525.0)
      A1=99.6909833
      A2 = 36000.76854
      A3 = 0.00038708
      A4 = 0.25068447
      GP = A1 + A2*XJ + A3*XJ*XJ + A4*GMT
      N = GP/360.
      XN = N
      GP = GP - XN*360.
C
C  COMPUTE RIGHT ASCENSION POINT - RAP (IN DEG)
C
C     1ST CONVERT GEOCENTRIC LONGITUDE TO DEG LONGITUDE - WEST NEG $ EAS
C
      IFACT = XLONG/180.
      XFACT = IFACT
      XLONG = 360. * XFACT - XLONG
C
      RAP = GP + XLONG
      N = RAP/360.
      XN = N
      RAP = RAP - XN*360.
C
C  COMPUTE CELESTIAL LONGITUDE - XLS (IN RAD) - -PI/2 TO +PI/2
C
      B1 = 0.017203
      B2 = 0.0335
      B3 = 1.410
      Y1 = B1*FMJD
      XLS = Y1 + B2*SIN(Y1) - B3
      TPI = 6.28318
```

```
      N = XLS/TPI
      XN = N
      XLS = XLS - XN*TPI
C
C  COMPUTE SOLAR DECLINATION ANGLE - SDA (IN RAD)
C
      B4 = (TPI/360.)*23.45
      SDA = ASIN(SIN(XLS)*SIN(B4))
C
C  COMPUTE RIGHT ASCENSION OF SUN - RAS (IN RAD) - -PI/2 TO +PI/2
C
      RAS = ASIN(TAN(SDA)/TAN(B4))
C
C  PUT RAS IN SAME QUADRANT AS XLS
C
      PI = 3.14159265
      PI2 = PI/2.
      PI32= 3.*PI2
      RAS = ABS(RAS)
      TEMP = ABS(XLS)
      IF(TEMP - PI2) 130,130,100
  100 IF(TEMP - PI) 105,105,110
  105 RAS = PI - RAS
      GO TO 130
  110 IF(TEMP - PI32) 115,115,120
  115 RAS = PI + RAS
      GO TO 130
  120 RAS = TPI - RAS
  130 IF (XLS) 135,140,140
  135 RAS = -RAS
  140 CONTINUE
C
C  COMPUTE SOLAR HOUR ANGLE - SHA (IN DEG) - -
C
      SHA = RAP*(PI/180.) - RAS
      IF(SHA) 210,230,230
  210 IF(SHA+PI) 220,250,250
  220 SHA=SHA+TPI
      GO TO 210
  230 IF(SHA-PI) 250,250,240
  240 SHA=SHA-TPI
      GO TO 230
  250 CONTINUE
C
      RETURN
      END
      SUBROUTINE WIND
      COMMON /WINCOM/RHO,FCORY,DX5,DY5,PX,PY,PXX,PXY,PYY,U,V,  T,TX,TY,
     $   DU,DV,P,UPRE,VPRE,DUPRE,DVPRE
      COMMON /IOTEMP/DUM1(7),PHI,DUM2(11),MN,DM2A(5),G,R,H,PHIR,
     $THETR,DUM3(15),FLAT
      COMMON/CHIC/DUM(18),IWSYM,UCOEF(14,9),VCOEF(14,9)
      ABSPHI=ABS(PHI)
      IF (RHO.GT.0..AND.ABSPHI  .GT.0.) GO TO 20
```

```
      U = 0.
      V = 0.
      IF(ABSPHI  .LE.0) GO TO 31
      RETURN
 20   FCORX = FCORY*DX5/DY5
      U = - PY/(FCORY*RHO)
      V =   PX/(FCORX*RHO)
      DU = -(G*TY)/(FCORY*T)
      DV =  (G*TX)/(FCORX*T)
  31  IF(H.GT.20.AND.H.LT.95.)GOTO 99
      IF(ABSPHI.GE.FLAT) RETURN
      U=UPRE
      V=VPRE
      DU=DUPRE
      DV=DVPRE
      RETURN
C...SPHERICAL HARMONICS SECTION.....................................
  99  IH=INT(H)
      IF(IH.LE.25)GOTO 130
      IF(IH.GE.90)GOTO 140
      IH1=5*INT(H/5.)
      IH2=IH1+5
      CALL SPHERE(MN,IH1,PHIR,THETR,US,VS)
      CALL SPHERE(MN,IH2,PHIR,THETR,US2,VS2)
      FACS=(H-IH1)/5.
      U=US+(US2-US)*FACS
      V=VS+(VS2-VS)*FACS
      DU=(US2-US)/5000.
      DV=(VS2-VS)/5000.
      RETURN
C...LOW ALTITUDE FAIRING
  130 CALL SPHERE(MN,25,PHIR,THETR,US,VS)
      FACS=(H-20.)/5.
      FACG=1.-FACS
      U=FACG*U+FACS*US
      V=FACG*V+FACS*VS
      CALL SPHERE(MN,30,PHIR,THETR,US2,VS2)
      DUS=(US2-US)/5000.
      DVS=(VS2-VS)/5000.
      RETURN
C...HIGH ALTITUDE FAIRING
  140 CALL SPHERE(MN,90,PHIR,THETR,US,VS)
      FACS=(H-90.)/5.
      FACG=1.-FACS
      U=FACS*U+FACG*US
      V=FACS*V+FACG*VS
      CALL SPHERE(MN,85,PHIR,THETR,US2,VS2)
      DUS=(US-US2)/5000.
      DVS=(VS-VS2)/5000.
      DU=FACG*DU+FACS*DUS
      DV=FACG*DV+FACS*DVS
      RETURN
      END
```

APPENDIX E

SUMMARY OF PROGRAM CHARACTERISTICS
(Program Operating Environment)

1. Hardware

   a. Computer - Univac 1108 (implemented at Georgia Tech on the CDC Cyber 74 System)

   b. Core Requirements - Approximately 80K on the Georgia Tech CDC. The CDC System routines require more core than the Univac routine so there is no comparison between the system. See Section 5.1.

   c. Mangetic Tapes - All 4-D data tapes are 7 tracks. Proper and SCIDAT data tapes are 9 track. Tapes required are:

      1 program tape (if the program is stored in UNIVAC COPOUT tape format), 1 "SCIDAT" data tape (see Section 4.2), from 1 to 4 4-D data tapes, depending on the number of months to be used under control of one run card (see Section 4.1 and Appendix B).

   d. Card Punch - not required unless optional card output is desired.

   e. Plotter - none required

   f. Drum or Disk - 2 temporary drum or disk files are required. No permanent drum or disk files are created by a program run unless optional non-print output is generated as a permanent disk or drum file.

   g. Other Hardware - none

2. Software

   a. Operating System - UNIVAC EXEC 8 (Georgia Tech version is CDC Nos 1.3)

   b. Language - FORTRAN IV (UNIVAC FORTRAN V)

   c. Type of Run - Batch

   d. Library Subroutines - NTRAN and FLD are UNIVAC subroutines. NTRAN reads 36 bit binary integer woods records. FLD manipulates word bits and is used to break up 4-D data tape 36 bit words into two 18 bit integer words.

   e. Program Overlays - (Optional) - see Section 5.1

3. Program Specifications

   a. Common - See Sections 5.2 - 5.4

3. Program Specifications (cont'd.)

   b. Program Segments - See Sections 5.2 - 5.4

   c. Program Subroutines - See Section 5.1

   d. Listing - See Appendix D

   e. Flow Charts - See Figures 5.1, 5.2, 5.3

   f. Sample Input - See Appendix C.

   g. Sample Output - See Appendix C.

   h. Diagnostic Messages - See Section 4.5

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16. ABSTRACT

This report describes recent improvements in the Global Reference Atmospheric Model (NASA TM X-64871 and 64872), originally developed as a global scale (all latitudes and longitudes) model from surface to orbital altitudes. The basic model includes monthly mean values of pressure, density, temperature, and geostrophic winds, as well as quasi-biennial and small-scale and large-scale random perturbations. The newer version reported here incorporates a spherical harmonic wind model for the height range 25-90 km. Parameters for the model were determined from wind data determined by Meteorological Rocket Network soundings, and by grenade releases at higher altitudes. For all latitudes and longitudes in the 25-90 km height range, winds are evaluated by the new spherical harmonic model. Below 25 km and above 90 km, the GRAM program continues to use the geostrophic wind equations and data for pressure, in order to compute the mean wind. Another new feature of the program is that, in the altitudes where the geostrophic wind relations are used, an interpolation scheme is employed for estimating winds at low latitudes, where the geostrophic wind relations begin to mesh down. Several sample wind profiles are given, as computed by the new spherical harmonic wind model.

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