USING PCDS TO STUDY THE INFLUENCE OF UV FLUX VARIATION ON THE MIDDLE ATMOSPHERE

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The value of the PCDS in examining the influences of short-period solar flux variations on the middle atmosphere was demonstrated. Several Nimbus satellite data sets proposed for the study exist in the PCDS. Planned for retrieval through the PCDS are ozone mixing ratios and cumulative ozone profiles available from the Backscatter Ultraviolet Spectrophotometer (BUV) on Nimbus-4. Also to be accessed are Nimbus-7 data sets that will provide ozone and nitrogen dioxide mixing ratios, temperature profiles from the Limb Infrared Monitor of the Stratosphere (LIMS), and ozone mixing ratio profiles from the Solar Backscatter Ultraviolet Spectrophotometer (SBUV).

Bypassing the time-consuming process of reading raw data tapes, the researchers plan to transfer the PCDS processed data to an IBM PC at Iowa State University. The IBM PC will serve as an intermediate vehicle for transferring the data to the NOAA CYBER 840 at Boulder, Colorado, where research will continue on both an eight-layer radiative-photochemical numerical model and on a nonlinear dynamical model, with the hope of understanding how motions take place in the stratosphere. All the graphics will be done at Boulder, where NCAR graphics packages are available for plotting.

Also being contemplated for possible utilization in this research are the FGGE and ERB data sets. These relevant data sets also reside in the PCDS. Problems associated with remote access to the PCDS were discussed in regard to all the PCDS data sets.

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I. RESEARCH WORK - THE INFLUENCE OF ULTRAVIOLET FLUX VARIATIONS ON THE MIDDLE ATMOSPHERE

II. OBJECTIVES

A. TO USE NIMBUS 4 AND NIMBUS 7 DATA WITH A RADIATIVE-PHOTOCHEMICAL NUMERICAL MODEL TO UNDERSTAND HOW OZONE AND TEMPERATURE FIELDS IN THE STRATOSPHERE RESPOND TO ACTUAL SHORT-PERIOD (13-27 DAYS) VARIATIONS IN THE SOLAR FLUX.

B. TO COUPLE THE OZONE AND TEMPERATURE VARIATIONS, DUE IN PART TO SOLAR FORCING, TO THE STRATOSPHERIC DYNAMICS IN A NONLINEAR MODEL TO GAIN SOME UNDERSTANDING AS TO HOW RADIATION, PHOTOCHEMISTRY, AND DYNAMICS INTERACT IN THE STRATOSPHERE.

III. RATIONALE FOR THE RESEARCH

* MOST STUDIES TO DATE HAVE BEEN STATISTICAL.
* AMPLITUDE AND PHASE OF OZONE AND TEMPERATURE VARIATIONS DEPEND UPON PERIOD OF SOLAR FORCING.
* STATISTICAL STUDIES MAY NOT SHOW A RELATIONSHIP BETWEEN OZONE AND SOLAR FORCING EXCEPT IN VERY SPECIAL CASES.
* COUPLING OF DYNAMICS, RADIATION, AND PHOTOCHEMISTRY IN PROPOSED MODEL SHOULD GIVE SOME INSIGHT INTO THE EFFECTS OF TIME DEPENDENT SOLAR/THERMAL FORCING AND NONLINEARITY.

IV. PHOTOCHEMICAL REACTIONS

$O_2 + H\nu \rightarrow O + O$	J_2
$O + O_2 + M \rightarrow O_3 + M$	K_{12}
$O_3 + O \rightarrow 2O_2$	K_{13}
$O_3 + H\nu \rightarrow O_2 + O$	J_3
$H + O_3 \rightarrow OH + O_2$	α_{10}
$OH + O_3 \rightarrow HO_2 + O_2$	α_{11}
$HO_2 + O_3 \rightarrow OH + 2O_2$	α_{12}
$OH + O \rightarrow H + O_2$	α_{13}
$HO_2 + O \rightarrow OH + O_2$	α_{14}
$OH + OH \rightarrow H_2O + O$	α_{16}
$NO + O_3 \rightarrow NO_2 + O_2$	β_{27}
$NO_2 + O \rightarrow NO + O_2$	β_{28}
$NO_2 + H\nu \rightarrow NO + O$	J_{29}
$CL + O_3 \rightarrow CLO + O_2$	γ_{56}
$CLO + O \rightarrow CL + O_2$	γ_{57}

J'S ARE PHOTODISSOCIATION RATES.

α'S, β'S, AND γ'S ARE TEMPERATURE DEPENDENT REACTION RATES.

V. RADIATIVE-PHOTOCHEMICAL MODEL

A. OZONE PROGNOSTIC EQUATION WHICH INCLUDES NITROGEN, HYDROGEN, AND CHLORINE PHOTOCHEMISTRY

1. TIME AND WAVELENGTH-DEPENDENT SOLAR FORCING
2. TEMPERATURE DEPENDENT REACTION RATES
3. ADVECTION IGNORED

B. TEMPERATURE PROGNOSTIC EQUATION

1. HEATING RATE DEPENDENT ON SOLAR FLUX AND OZONE AMOUNT
2. NEWTONIAN COOLING
3. ADVECTION IGNORED

$$\frac{d\phi}{dt} = \frac{-2J_3K_{13}}{K_{12}\eta_{O_2}}\phi^2 - (\alpha_{13}\eta_{OH} + \alpha_{14}\eta_{HO_2} + \beta_{28}\eta_{NO_2} + \gamma_{57}\eta_{ClO})\frac{J_3}{K_{12}\eta_{O_2}\eta_m}\phi$$

$$-(\alpha_{10}\eta_H + \alpha_{11}\eta_{OH} + \alpha_{12}\eta_{HO_2} + \beta_{27}\eta_{NO} + \gamma_{56}\eta_{Cl})\phi + 2J_2\frac{\eta_{O_2}}{\eta_m}$$

$$+ J_{29}\eta_{NO_2} + \alpha_{16}\eta_{OH}^2$$

$$\frac{dT}{dt} = \eta\phi - aT + b$$

VI. DYNAMICAL MODEL

A. OZONE PROGNOSTIC EQUATION WHICH INCLUDES NITROGEN, HYDROGEN, AND CHLORINE PHOTOCHEMISTRY

1. TIME AND WAVELENGTH-DEPENDENT SOLAR FORCING
2. TEMPERATURE-DEPENDENT REACTION RATES
3. ADVECTION INCLUDED

B. TEMPERATURE PROGNOSTIC EQUATION

1. HEATING RATE DEPENDENT ON SOLAR FLUX AND OZONE AMOUNT
2. NEWTONIAN COOLING
3. ADVECTION INCLUDED

C. QUASI-GEOSTROPHIC POTENTIAL VORTICITY EQUATION

1. MOTION FIELD IS COUPLED TO TIME-DEPENDENT SOLAR FORCING THROUGH DIABATIC HEATING TERM

$$\left[\frac{\partial}{\partial t}+\frac{\partial\psi}{\partial x}\frac{\partial}{\partial y}-\frac{\partial\psi}{\partial y}\frac{\partial}{\partial x}\right]\left[\nabla^2\psi+\beta y+\frac{f_o^{\,2}}{\rho_s(z)}\frac{\partial}{\partial z}\left(\frac{\rho_s(z)}{N^2}\frac{\partial\psi}{\partial z}\right)\right]$$

$$=-\frac{Rf_o}{c_p h\rho_s(z)}\frac{\partial}{\partial z}\underbrace{\left[\frac{\rho_s(z)}{N^2}\,(H_f+H_d)\right]}_{\text{DIABATIC HEATING TERM}}$$

$H_f \alpha \eta \phi$

$H_d \alpha - aT + b$

VII. Proposed PCDS Usage

A. Ozone mixing ratio and cumulative ozone profiles from Backscatter Ultraviolet Spectrophotometer (BUV) on Nimbus 4

1. Data available from 1970-1977
2. 80°N-80°S spatial coverage
3. TAPE - Daily Zonal Means of Profile Ozone (DZP)
4. Profile data from 13 pressure levels (0.7, 1.0, 1.5, 2.0, 3.0, 4.0, 5.0, 7.0, 10, 15, 20, 30, and 40 mb)
5. Should get an idea of the impact and interaction of short-term UV flux variations on ozone and temperature

B. OZONE MIXING RATIO AND TEMPERATURE PROFILES FROM LIMB INFRARED MONITOR OF THE STRATOSPHERE (LIMS) ON NIMBUS 7

1. DATA AVAILABLE FROM OCTOBER 25, 1978 - MAY 29, 1979
2. 84°N-64°S SPATIAL COVERAGE
3. TAPE - MAP ARCHIVAL TAPES (LAMAT)
   * CONTAIN DAILY WORLD MAP GRIDS OF HARMONIC COEFFICIENTS FOR OZONE, NITRIC ACID, WATER VAPOR, NITROGEN DIOXIDE, AND TEMPERATURE AT STANDARD PRESSURE LEVELS AVERAGED INTO 38 FOUR DEGREE LATITUDE BANDS.
4. DATA IS GIVEN FOR BOTH THE ASCENDING AND DESCENDING PART OF THE NIMBUS 7 SATELLITE ORBIT.
5. HAS BETTER VERTICAL RESOLUTION THAN BUV AND ENABLES US TO LOOK FOR EFFECTS AS LOW AS 100 MB.

C. OZONE MIXING RATIO PROFILES FROM SOLAR BACKSCATTER ULTRAVIOLET SPECTROPHOTOMETER (SBUV) ON NIMBUS 7

1. DATA AVAILABLE FROM NOVEMBER 1978 - 1982
2. 80°N-80°S SPATIAL COVERAGE
3. TAPE - OZONE FROM SBUV (OZONE-S)
    * CONTAIN TOTAL OZONE, REFLECTIVITY, MIXING RATIOS, AND LAYER OZONE AMOUNTS, SCAN BY SCAN AND ORBIT BY ORBIT.
4. MIXING RATIOS GIVEN AT 16 PRESSURE LEVELS (0.3-40 MB)
5. POWER ON 3 DAYS OF 4

D. DATA USAGE

1. INITIAL CONDITIONS FOR RADIATIVE-PHOTOCHEMICAL MODEL AND DYNAMICAL MODEL
   * OZONE MIXING RATIO PROFILES
   * NITROGEN DIOXIDE MIXING RATIO PROFILES
   * TEMPERATURE PROFILES
   * CUMULATIVE OZONE PROFILES
   * GEOPOTENTIAL HEIGHTS FROM FGGE?
2. TEMPORAL VARIATION OF SOLAR FLUX IN DISCRETE WAVELENGTH BANDS FOR MODEL FORCINGS FROM ERB INSTRUMENT ON NIMBUS 7?
3. COMPARISON WITH MODEL RESULTS
4. DATA WILL BE TRANSFERRED FROM PCDS TO IBM-PC TO NOAA CYBER 840 AT BOULDER, CO, WHERE THE MODELS ARE/WILL BE RUN.

VIII. REMOTE USER PROBLEMS

A. COMMUNICATION WITH PCDS WITHOUT NETWORK ACCESS OR TOLL-FREE NUMBER IS PROHIBITIVELY EXPENSIVE.

B. ACCESSING DATA AT NIGHT

C. AVAILABILITY OF TAPE DRIVES

D. AVAILABILITY OF DOCUMENTATION ON ITEM DESCRIPTIONS