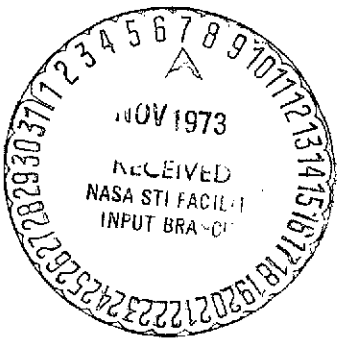
NASA CR-135790

THE UNIVERSITY OF MICHIGAN
COLLEGE OF ENGINEERING
Department of Electrical and Computer Engineering
Space Physics Research Laboratory

OGO-VI NEUTRAL ATMOSPHERIC COMPOSITION EXPERIMENT: FINAL REPORT

Prepared on behalf of the project by

D. R. Taeusch



under contract with:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
GRANT NO. NGR23-005-561
GREENBELT, MARYLAND

ADMINISTERED THROUGH:

OFFICE OF RESEARCH ADMINISTRATION ANN ARBOR

September 1973

This report summarizes the results of the effort under NASA Grant NGR-23-005-561. The subject grant provided support for the continued analysis of data obtained from the Neutral Atmospheric Composition Experiment (NACE) flown on OGO-VI. The effort was directed toward the study of five specific areas of interest for which we felt the OGO-VI data were especially useful. The results of these efforts are discussed in the following paragraphs.

LONGITUDE-UNIVERSAL TIME BEHAVIOR

Certain physical processes expected to take place in the atmosphere are not fully represented in the OGO-6 model (Hedin et al., 1972). One such class of phenomena, being studied in cooperation with personnel at Goddard Space Flight Center (GSFC), includes the longitude-universal time variations of the constituents N_2, O, and He. The effects seen so far are significant enough to have a noticeable effect on the thermospheric tidal winds. These are also functions of universal time and longitude, independent of the usual local solar time variation. Furthermore, the effects are persistent enough that, when considered as a function of longitude alone, there should be planetary circulation effects. The longitude and

universal time variations quite likely have a relationship to the magnetic storm response referred to above. That is, there may be no class distinction between a daily disturbance variation and a storm variation. The same physical mechanisms are thought to operate in both cases. A paper dealing with these results was presented at the 1973 Spring Meeting of the American Geophysical Union (Hinton, 1973), and is being prepared for publication in the Journal of Geophysical Research.

This work is the nucleus for a Ph.D. thesis which is currently being undertaken by one of our graduate students in the Aeronomy Program.

LONG TERM BEHAVIOR OF CONSTITUENT DENSITIES

A paper on this subject was published in the Journal of Geophysical Research (Taeusch and Carignan, 1972). In this paper, data obtained from the OGO-6 NAC experiment for a period of more than one year are used to compare the average constituent composition at an altitude of 400 km with that predicted by the Jacchia 1965 and 1971 models. The comparison shows that the Jacchia 1971 model underestimates the molecular nitrogen densities at 400 km by a factor of 2. An atmosphere is constructed down to 120 km by means of the Stein and Walker technique. A fit is made with (1) the 400 km total densities from drag measurements and the composition from OGO-6 NAC, (2) the 250 km measured molecular nitrogen densities, and (3) the 150 km total densities from drag. This fit shows that the Jacchia 1971 model overestimates the atomic oxygen content at 150 km.

SUMMARY OF ATMOSPHERIC BEHAVIOR DURING GEOMAGNETIC DISTURBANCES

We suggested that a publication summarizing our knowledge of atmospheric behavior during geomagnetic disturbances be written during the contract period, and efforts have progressed toward that end. A paper discussing the July 1969 magnetic storm data (Taeusch et al., 1971a,b), and their implication in light of the September 1969 and March 1970 data previously studied, was prepared for publication. During the ensuing discussions and internal editing it was apparent that many questions were unanswered concerning time lags, latitudinal dependence of energy input and longitudinal-universal time effects during magnetically disturbed periods. Subsequent to this, a new set of questions regarding the neutral atmosphere were generated. First, it was decided that the polar regions were of primary importance and that the atmospheric behavior during magnetically quiet periods should be established. Then, the atmospheric behavior in the polar regions during magnetically disturbed periods could be studied and differentiated from the quiet behavior.

For this purpose six polar-perigee passes were available with good data coverage, three north and three south polar passes in the period between late August 1969 to mid-June 1970. We were not interested here in a statistical study since we wanted to see the various types of perturbations which occur and can be expected. It has already been established to our

satisification that there is a longitude-universal time effect which is approximately symmetrical around the magnetic poles, and the global quiescent statistical behavior has been reported and will be published in the near future. Hundreds of orbits were studied on an individual basis. The conclusions to date of this study are listed below.

Magnetically Quiet Periods ($K_p < 3_0$)

Energy deposition in the neutral atmosphere in the polar regions is characterized above 400 km by a ring of enhanced N_2 densities and depressed He densities located approximately 11° from the magnetic dipole.

It is conventient to divide this ring into local time quadrants, which we will call sunward, antisunward, morning and evening. The sunward quadrant, which contains the polar cusp, is the most predictable in terms of N_2 enhancement. At all low altitudes of magnetic activity, there is almost always an N_2 enhancement, with rather narrow latitudinal boundaries, 11° from and sunward of the magneti dipole.

The antisunward quadrant contains N_2 enhancement also approximately 11° from the magnetic dipole, which are normally less well-defined latitudinally and are usually smaller in amplitude.

The morning and evening quadrants contain broad, less intense N_2 enhancements which cover approximately 10° to 20° of latitude, with the morning quadrant typically more disturbed

and broader in extent than the evening quadrant. Also the antisunward-morning area appears more extended in longitude that the antisunward-evening.

Magnetically Disturbed Periods ($K_p < 4o$)

During magnetically disturbed periods, the N_2 enhancements increase in amplitude and expand equatorwards, with broad, multiple, large amplitude peaks down to midlatitude.

There is strong evidence that the equatorward expansion is dependent on the local time position of the magnetic dipole. If the magnetic dipole is antisunward of the geographic pole the equatorward expansion is antisunward or toward the magnetic midnight quadrant. If the magnetic dipole is sunward of the geographic pole the equatorward expansion is toward the magnetic moon quadrant.

The above summaries of neutral atmospheric behavior in the polar regions provide a warning about viewing satellite data which are fixed in local time geographic coordinate. The magnetic control of the polar energy deposition in the neutral atmosphere, when viewed at low to midlatitude from a satellite, can appear to provide time lag information and latitudinal dependence which are erroneous due to the geometrical differences between the invariants of the satellite orbit and the neutral atmosphere.

More work is required before the results of this study are ready for publication, but the results to date have already provided new directions for future work.

REFERENCES

Hedin, A. E., H. G. Mayr, C. A. Reber, N. W. Spencer and G. R. Carignan, Empirical model of global thermospheric temperature and composition based on data from the OGO-6 quadrupole mass spectrometer, Goddard Space Flight Center Report X-621-73-37, December 1972.

Hinton, B. B., High latitude heating on ordinary and quiet days, EOS, 54, 398, April 1973.

Taeusch, D. R., G. R. Carignan and C. A. Reber, Neutral composition variation above 400 kilometers during a magnetic storm, J. Geophys. Res., 76, 8318, December 1971a.

Taeusch, D. R., G. R. Carignan and C. A. Reber, Response of the neutral atmosphere to geomagnetic disturbances, Space Res. XI, 995, 1971b.

Taeusch, D. R. and G. R. Carignan, Neutral composition in the thermosphere, J. Geophys. Res., 77, 4870, September 1972.