A. Title of Research Task:

Upper Atmosphere Dynamics

B. Investigators and Institutions:

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C. Research Objectives: The spatial distribution of stratospheric ozone is useful in diagnosis of some features of the large-scale atmospheric circulation, and the ozone may also interact with the atmospheric general circulation. Local maxima in the column ozone distribution are often associated with disturbances in the lower stratosphere and upper troposphere, which may herald cyclone development in the troposphere. One research objective is to explore these issues by means of time series analysis of a zonal index of total column ozone, to suggest the existence or nonexistence of relationships between column ozone and dynamical processes which are known to occur on various time scales. Another objective is to investigate the correlation between the ozone mixing ratio on the 350K isentropic surface and the column integrated ozone, and to investigate the use of an easily derived parameter as a proxy for ozone mixing ratio, which is conserved in the stratosphere for time scales shorter than the photochemical time scale. The source of data for these studies is the Total Ozone Mapping Spectrometer (TOMS) data set furnished by the National Space Science Data Center.

D. 1989 Accomplishments:

1. The zonal index of column ozone z_{O_3} is defined to be the difference between its average in 5-degree-wide bands centered at 60 N and at 30 N. Variations in this zonal index may be due to variations in the meridional transport of ozone in the stratosphere and may also be related to wave activity in the troposphere. A seven-year time series for z_{O_3} has been calculated from the TOMS data for 1981-1987. When the annual cycle is eliminated from the data, there remains evidence of signal from the quasibiennial oscillation, and also from periods of about 30 days, 12-16 days, and 4 to 5 days.
2. Analysis of a time period with a fairly clean wavenumber 1 signature in column ozone is planned. In order to find suitable episodes, video loops of TOMS data for the winters of 85-86, 86-87, and 87-88 have been prepared. The calculation of the pressure of the 350 K isentropic surface is now in progress.

E. Journal Publications: None to date.

A. Title of Research Task: Stratospheric Circulation from Remotely Sensed Temperatures

B. Investigators and Institutions:

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C. Abstract of Research Objectives:

The objective of the research is to develop an improved quantitative understanding of the large scale circulation of the lower stratosphere in the 15 to 30 km region. Included in the topics addressed are both free and forced waves along with the zonally-averaged component of the circulation. A major theme of the investigation is to examine traditional scaling approximations which have been applied to the stratosphere. Such approximations have been based mainly on tropospheric applications and are not always appropriate for stratospheric problems. When an approximation is found to be inappropriate, an alternative approach is developed. A second theme focuses on the detection and modeling of planetary waves. Both themes involve the use of high quality satellite data which provides both global coverage and good vertical resolution. For these applications, limb observations (Nimbus 7 Limb Infrared Monitor of the Stratosphere {LIMS}) have been found to be superior to other data sets.

D. Summary of Progress and Results:

The past year and a half has seen the development of a powerful spectral analysis tool. Although such techniques are not new, the use of this tool with the LIMS data set represents a significant step forward in our ability to analyse a large amount of high quality data. The tool provides global coverage of power, variance, coherence, and correlations as functions of latitude, longitude, height and frequency for temperature, height, ozone, nitric acid, water vapor, nitrogen dioxide and a wide variety of dynamical quantities which can be derived from these parameters. An immediate benefit has been the indentification of both previously documented and newly discovered large scale waves. Many of these features are extremely powerful and represent forces which produce change in the stratosphere. Some of these features appear in the spring in the southern polar regions and are present in both ozone and temperature fields. For example, the variances of temperature and ozone for zonal wavenumber 2 and an eastward period of 8 days are quite large during certain periods.

Simple display of the data does not provide an understanding of the processes which can be identified. Such an understanding can come through the use of models which are closely tied to the data. One such model has been developed to examine linearly unstable waves. Data from the LIMS experiment have been used to define zonally averaged basic state temperature and zonal wind fields in the middle atmosphere for several periods during the winter of 1978-79. This basic state has been used to calculate the phase speeds, growth rates and spatial structures of unstable modes using a linear, quasi-geostrophic model. These results have been compared with temperature and ozone variance amplitudes from the spectral analysis of the same LIMS data. The comparison indicates that there is a close match between phase speeds for the most rapidly growing modes predicted by the model and phase speeds for statistically significant temperature and ozone variances. Both calculated and observed modes tend to be limited in latitudinal extent to a few tens of degrees and in vertical extent to about 10 km. These modes also tend to be non-dispersive. Examples have been found in Southern Hemisphere near mb (30 km).

E. Journal Publications:

Elson, L. S., 1989: Three-dimensional linear instability modeling of the cloud level Venus atmosphere. *J. Atmos. Sci.*, to appear

Elson, L. S., 1989: Satellite observations of instability in the middle atmosphere. *J. Atmos. Sci.*, submitted.