N92-14537

Stratospheric Dynamics

Richard E. Young, Prinicipal Investigator
NASA-Ames Research Center, M/S 245-3
Moffett Field, CA 94035

James B. Pollack
Owen B. Toon
(All same address as above)

Research Objectives

A global circulation model is being used to study the dynamical behavior of stratospheric planetary waves (waves having horizontal wavelengths of tens of thousands of kilometers) forced by growing cyclonic disturbances of intermediate scale, typically with wavelengths of a few thousand kilometers, which occur in the troposphere. Planetary scale waves are the dominant waves in the stratosphere, and are important for understanding the distribution of atmospheric trace constituents. Planetary wave forcing by intermediate scale tropospheric cyclonic disturbances is important for producing eastward travelling planetary waves of the sort which are prominent in the southern hemisphere during winter. The same global circulation model is also being used to simulate and understand the rate of dispersion and possible stratospheric climatic feedbacks of the El Chichon volcanic aerosol cloud. By comparing the results of the model calculations with an established data set now in existence for the volcanic cloud spatial and temporal distribution, stratospheric transport processes will be better understood, and the extent to which the cloud modified stratospheric wind and temperature fields can be assessed.

Summary of Progress and Results

A study has been completed, in which average wintertime conditions in the southern hemisphere have been used to study the interactions of cyclone disturbances and planetary scale waves. The results of this study indicate that the dynamics of eastward travelling planetary waves, which dominate the wave spectrum of the wintertime southern hemisphere stratosphere, cannot be properly understood without considering interactions of cyclone disturbances in the troposphere. In the model calculations, only cyclone forcing of planetary waves is allowed, but the general characteristics of the observed planetary wave features are produced: eastward progression with a speed of about 20 degrees of longitude per day, maximum amplitude occurring near 60° south latitude in the upper stratosphere, propagation time from troposphere to stratosphere of 1-3 days, depending on wavelength, and existence of intermitant periods of wave growth and decay. Computed maximum amplitudes of planetary waves are comparable to peak amplitudes observed for eastward traveling waves in southern hemisphere winter. The lack of coherence observed for planetary waves 1 and 2 between troposphere and stratosphere appears to be due, based on the computations, to nonlinear effects in the stratosphere. Zonal accelerations induced by the planetary wave momentum and heat transports are in the same qualitative sense as observed, such that the stratospheric jet tends to move downwards and polewards with time. There was no irreversible mixing across or outside the polar vortex by the computed waves.

The characteristics of transport processes in the lower stratosphere were illustrated by the behavior of the El Chichon volcanic cloud which was injected into the stratosphere in April of 1982. Because an extensive data set exists concerning cloud properties as functions of space and time, the El Chichon volcanic cloud represents a unique opportunity to study stratospheric transport processes and the climatic feedbacks of the cloud on the stratosphere. We are using a global circulation model coupled with an aerosol microphysical and transport model to compute the behvior of the volcanic cloud as a function of time and position. We have begun initial simulations treating the cloud as a passive tracer. All NMC data required to force the model at the lower boundary 300 mb pressure level have been acquired, spectrally analyzed, and incorporated into a forcing function which represents the coupling with the troposphere as a function of time. Numerical difficulties encountered with this procedure have been resolved, and stratospheric simulations are underway for the years immediately following the El Chichon eruption.

Journal Publications

Young, R. E., and H. Houben, 1989: Dynamics of Planetary-Scale Baroclinic Waves during Southern Hemisphere Winter. *Journal of the Atmospheric Sciences,* **46**, 1365-1383.