FINAL REPORT

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ABSTRACT

Our work has two primary scientific goals, the interannual variability (IAV) of stratospheric ozone and the hydrological cycle of the upper troposphere and lower stratosphere. Our efforts are aimed at integrating new information obtained by spacecraft and aircraft measurements to achieve a better understanding of the chemical and dynamical processes that are needed for realistic evaluations of human impact on the global environment. A primary motivation for studying the ozone layer is to separate the anthropogenic perturbations of the ozone layer from natural variability. Using the recently available merged ozone data (MOD), we have carried out an empirical orthogonal function (EOF) study of the temporal and spatial patterns of the IAV of total column ozone in the tropics. The outstanding problem about water in the stratosphere is its secular increase in the last few decades. The Caltech/JPL multi-dimensional chemical transport model (CTM) photochemical model is used to simulate the processes that control the water vapor and its isotopic composition in the stratosphere. Datasets we will use for comparison with model results include those obtained by the Total Ozone Mapping Spectrometer (TOMS), the Solar Backscatter Ultraviolet (SBUV and SBUV/2), Stratosphere Aerosol and Gas Experiment (SAGE I and II), the Halogen Occultation Experiment (HALOE), the Atmospheric Trace Molecular Spectroscopy (ATMOS) and those soon to be obtained by the Cirrus Regional Study of Tropical Anvils and Cirrus Layers Florida Area Cirrus Experiment (CRYSTAL-FACE) mission. The focus of the investigations is the exchange between the stratosphere and the troposphere, and between the troposphere and the biosphere.

ACCOMPLISHMENTS

Temporal and spatial patterns of the interannual variability of total ozone in the tropics

The recently constructed dataset, combining the monthly mean column abundances collected by the Total Ozone Mapping Spectrometer (TOMS) and the Solar Backscatter Ultraviolet (SBUV and SBUV/2) instruments, provides a nearly continuous record from late 1978 to 2000 on a 5° × 10° latitude-longitude grid. The precision and calibration of these measurements allow very small signals, ~1% of total column ozone, to be clearly seen. Using merged ozone data (MOD), we have carried out an empirical orthogonal
function (EOF) study of the temporal and spatial patterns of the interannual variability of total column ozone in the tropics. The first four EOFs of our study capture over 94% of the variance of the deseasonalized data. The leading two EOFs, respectively accounting for 54% and 25% of the variance, display structures attributable to the quasi-biennial oscillation (QBO), with influence from a decadal oscillation (most likely the solar cycle). The third EOF (11% of the variance) represents an interaction between the QBO and an annual cycle. The fourth EOF (4% of the variance) is related to the El Nino - Southern Oscillation. This is the first complete analysis of tropical ozone data using simultaneously the longitudinal, latitudinal and temporal patterns. A paper based on this work (Camp et al. 2003) is published in J. Geophys. Research. The preprint may be viewed in http://yly-mac.gps.caltech.edu/ under “O3 Paper”.

Isotope Compositions in the Upper Troposphere and Lower Stratosphere

Observations of the isotopic ratio in H2O vapor can provide unique tests of the atmospheric physics that control dehydration. With improved H2O linelists and retrieval methods, we are able to estimate the water isotope abundances in the upper troposphere/lower stratosphere, especially for the tropics, using Fourier Transform InfraRed (FTIR) Interferometer data from the Atmospheric Trace Molecule Spectroscopy (ATMOS) and the Mark IV balloon flights. The D/H ratio remains constant from 10 to 25 km (left panel), even though the mixing ratio of H2O changes by an order of magnitude (right panel). This provides definitive evidence for the tropical tropopause layer (TTL), first suggested by Sherwood and Dessler (2001). The details of this work may be viewed from our recent AGU presentation (Kuang et al., 2001; http://www.gps.caltech.edu/~kzm/HDO/). Simultaneous retrieval of CO from the same spectra yields vertical profiles for this short-lived molecule. From this an estimate of the time constant of mixing in the TTL can be made. A paper has appeared in Geophys. Res. Lett.

Publications related to this project


Conference Presentations


Yung, Y. L., “The mean isotopic composition of nitrous oxide inferred from atmospheric modeling.” Biogeosciences [B], 2002, B71A-0700 AGU Fall Meeting


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