Seasonal cycle of ozone in the tropical lower stratosphere: Implications for the relative importance of upwelling and mixing

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The Problem:
Models predict a speed-up of the Brewer-Dobson circulation with increasing greenhouse gases

How can we test this prediction?

Increased upwelling in tropics should give negative ozone trend where vertical gradient is largest: i.e. just above tropical tropopause

Updated stratospheric transport diagram by Alan Plumb
Time-series analysis of SAGE II data from 1984 to 2005 reveal a trend in the tropical lower stratosphere

Significant negative trend
Time-series analysis of SAGE II data from 1984 to 2005 reveal a trend in the tropical lower stratosphere.

Also significant solar term
Time-series analysis of SAGE II data from 1984 to 2005 reveal a trend in the tropical lower stratosphere.

Are these just artifacts of the time series analysis?
SAGE II Data

SAGE II converted to MR

Ozone Mixing Ratio (ppmv)

Year


0.1 0.2 0.3 0.4 0.5 0.6

75 hPa

Trend?
SAGE II Data

SAGE II converted to MR

Ozone Mixing Ratio (ppmv)

Year

Or Sudden Jump?
Could Ozone Change be Related to Water Vapor Change Seen by HALOE?

Decrees in stratospheric water vapor after 2001: Links to changes in the tropical tropopause and the Brewer-Dobson circulation

William J. Randel,1 Fei Wu,1 Holger Vömel,2 Gerald E. Nedoluha,3 and Piers Forster4

We need a longer data set

Aura MLS continues the profile data set, but with minimal overlap and differing vertical resolution and coverage
We need a longer data set

Ozonesondes provide the key to comparing the characteristics of SAGE II and MLS data

Ozonesondes

1984
2005
2013

SAGE II
Aura MLS
Characteristics of Tropical Lower Stratospheric Ozone Variation Determined by Ozonesondes

Note annual magnitude peak in lower stratosphere
Southern Tropics Appear to be Different from Northern Tropics

SAMOA (14° S)

COSTA RICA (10° N)
Seasonal Cycle of Southern and Northern Tropics from MLS data

Ozone Mixing Ratio (ppbv)

0-20 N
0-20 S

MLS @ 82 hPa

Year

Annual Magnitude Altitude/Latitude Structure

Larger Amplitude in Northern Tropics than in Southern Tropics
Extended seasonal magnitude feature in MLS with double peak
Is Double-Peaked Structure of Annual Cycle Magnitude Real?

OMPS Zonal Mean

MLS Zonal Mean

OMPS Limb sounder also shows double-peaked structure

Stolarski, AMS Phoenix
OMPS Limb and MLS Show Similar Differences Between Years

Year runs from mid-September to mid-September
Interannual variability of ozone annual amplitude in 10 years of MLS data

Stolarski, AMS Phoenix
Longitudinal Behavior of Ozone Annual Amplitude

10 Years of MLS Data

Stolarski, AMS Phoenix
Summary

- Ozone profile measurements provide potential to test predictions of a speed-up in the residual circulation.

- Extending the SAGE II data set in the tropical lower stratosphere is complicated by mis-matched seasonal cycles.

- Ozone seasonal cycles in the lower tropical stratosphere reveal differences between hemispheres that appear to be related to the interplay of upwelling and horizontal mixing (as discussed in more detail yesterday by D. Waugh).