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

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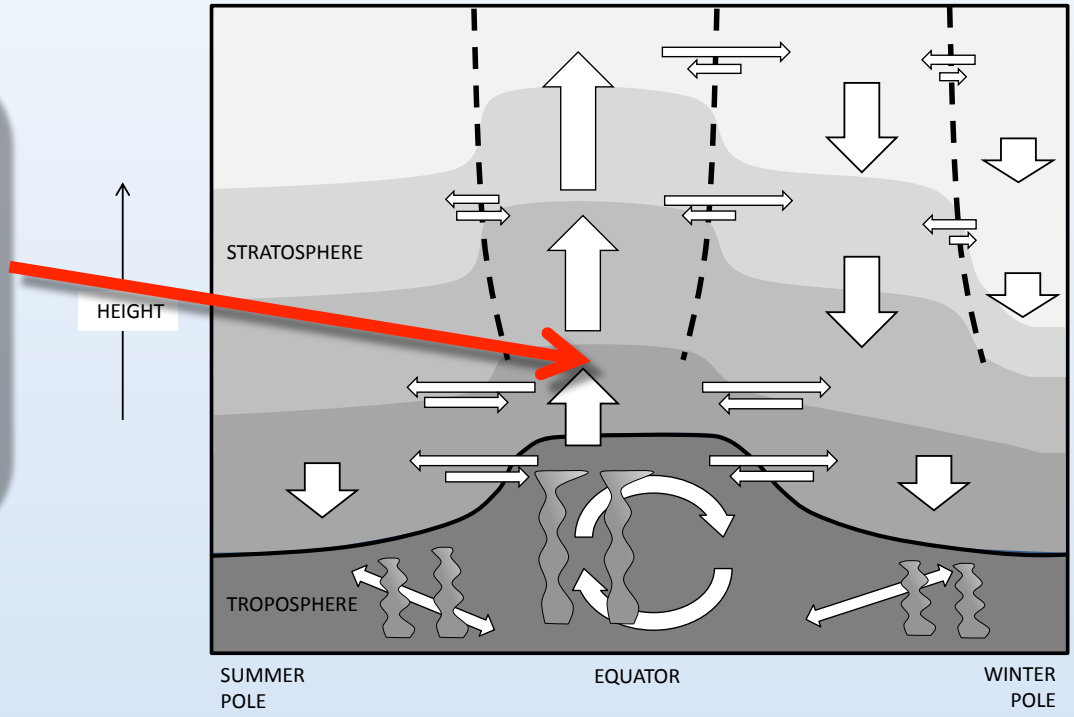
The Problem:
Models predict a speed-up of the Brewer-Dobson circulation with increasing greenhouse gases

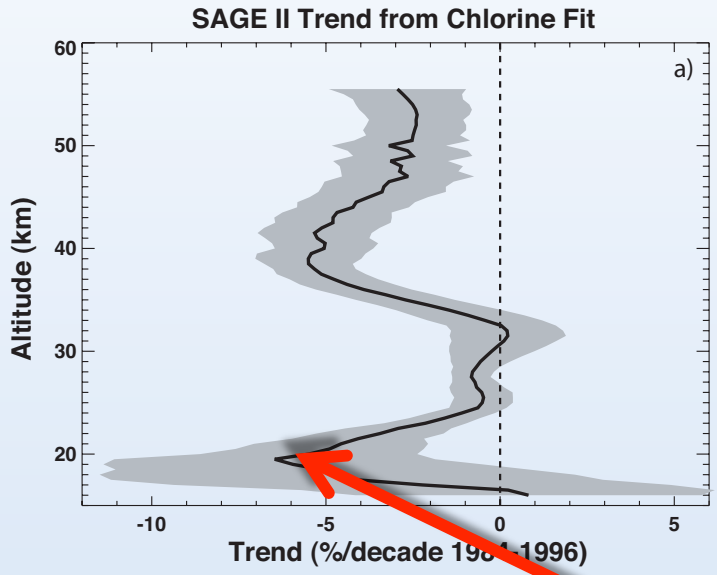
How can we test this prediction?

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



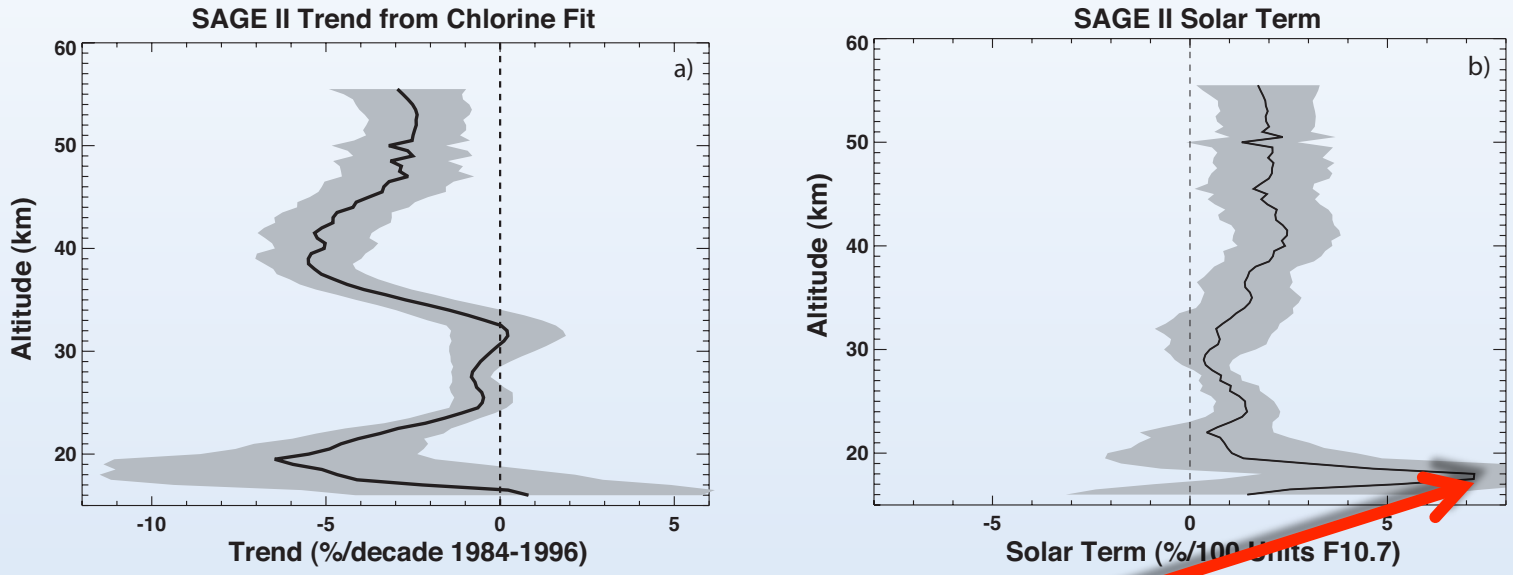
Updated stratospheric transport diagram by Alan Plumb

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



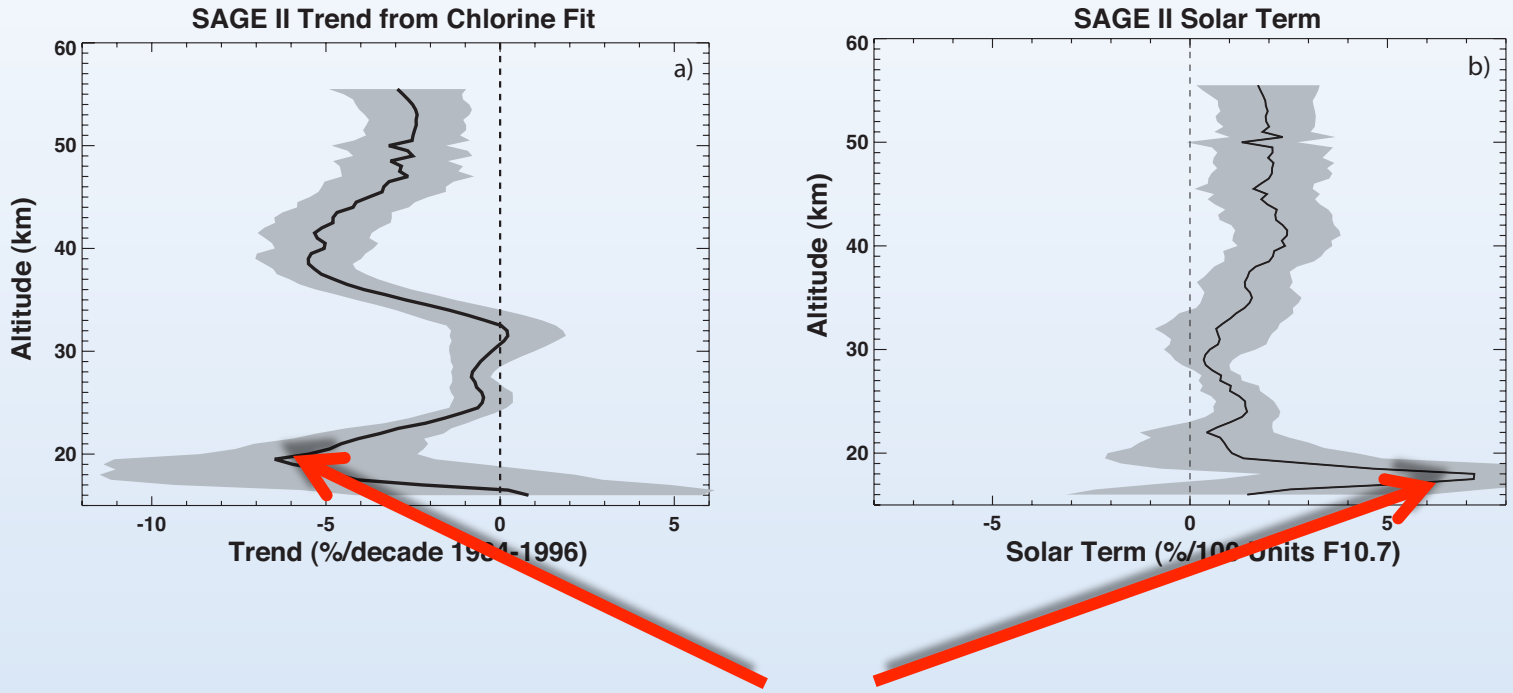
Significant negative trend

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



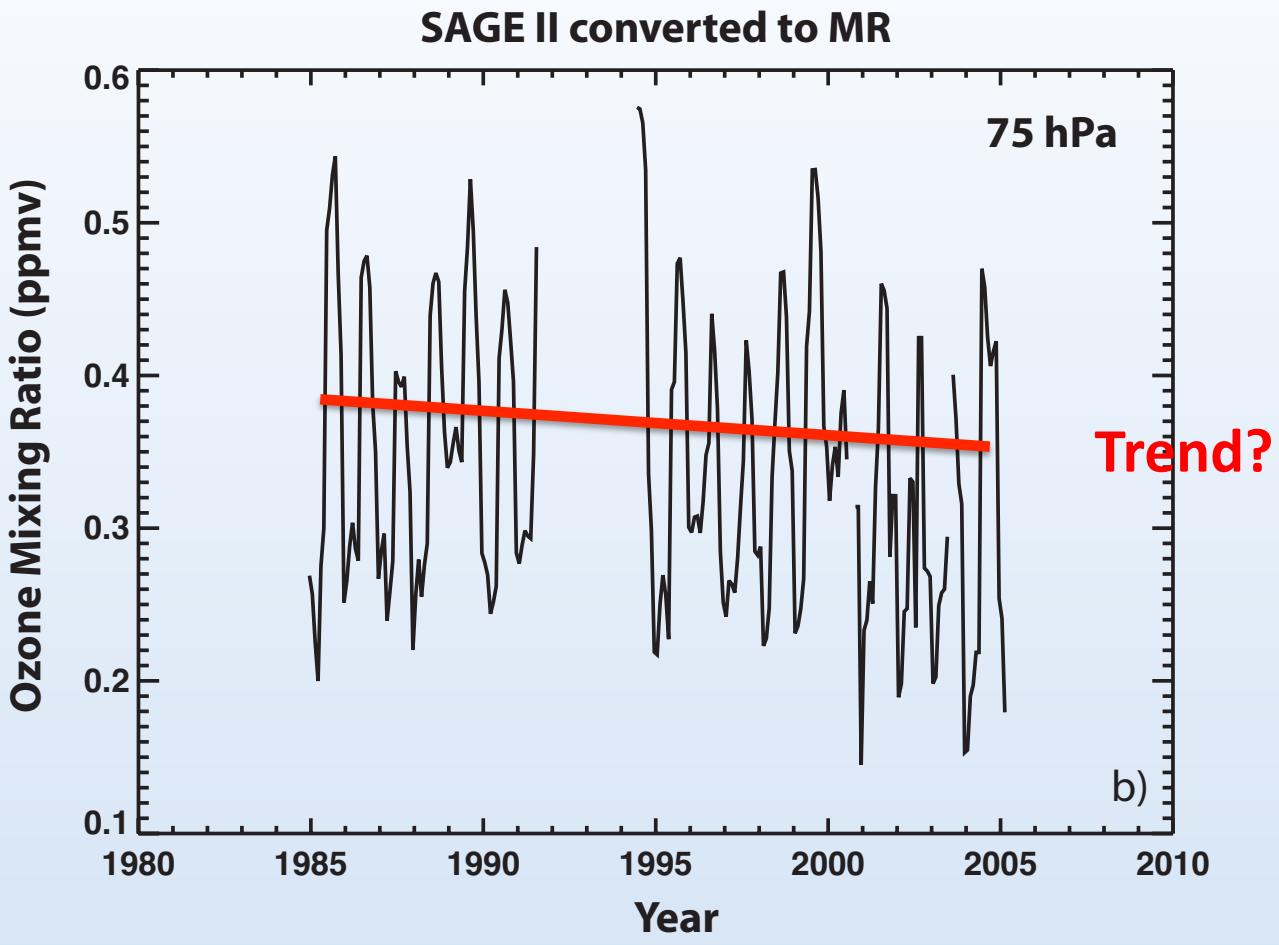
Also significant solar term

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

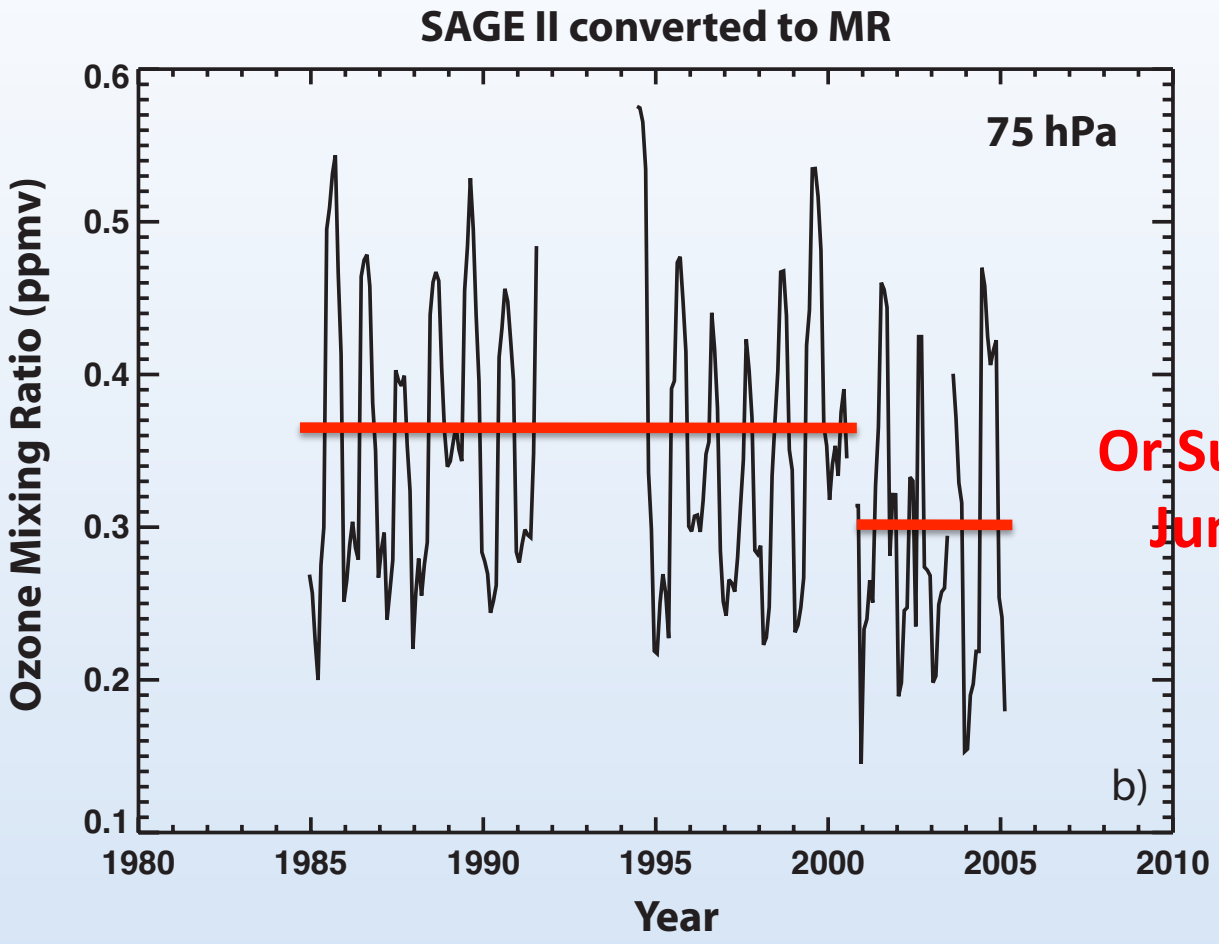


Are these just artifacts of the time series analysis?

SAGE II Data

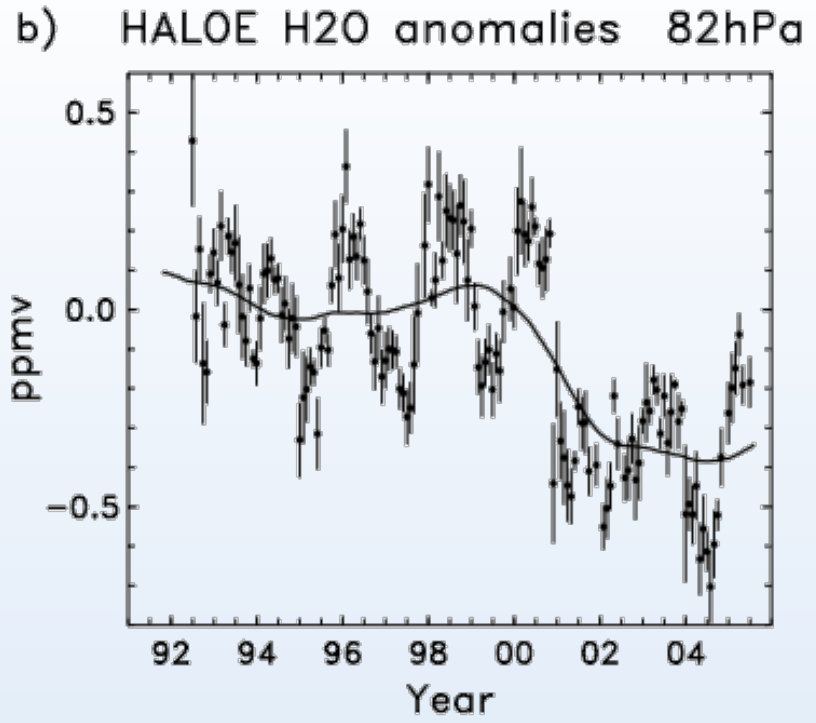

SAGE II converted to MR
75 hPa
Ozone Mixing Ratio (ppmv)
0.6
0.5
0.4
0.3
0.2
0.1
1980
1985
1990
1995
2000
2005
2010
Year
b)
Trend?

SAGE II Data



Or Sudden Jump?

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

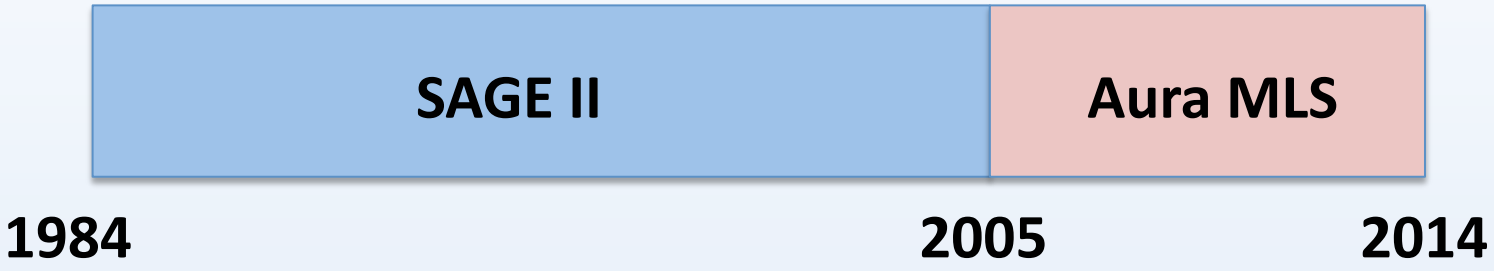


Decreases in stratospheric water vapor after 2001: Links to changes in the tropical tropopause and the Brewer-Dobson circulation

William J. Randel,[1] Fei Wu,[1] Holger Vömel,[2] Gerald E. Nedoluha,[3] and Piers Forster[4]

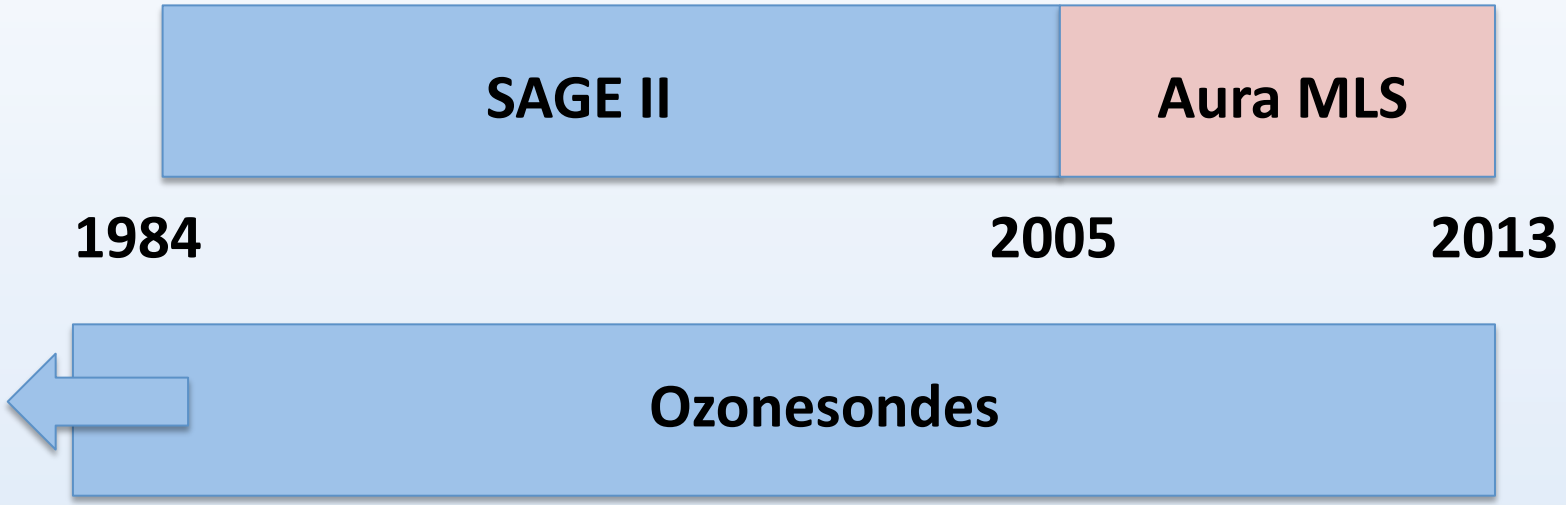
JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 111, D12312, doi:10.1029/2005JD006744, 2006

We need a longer data set



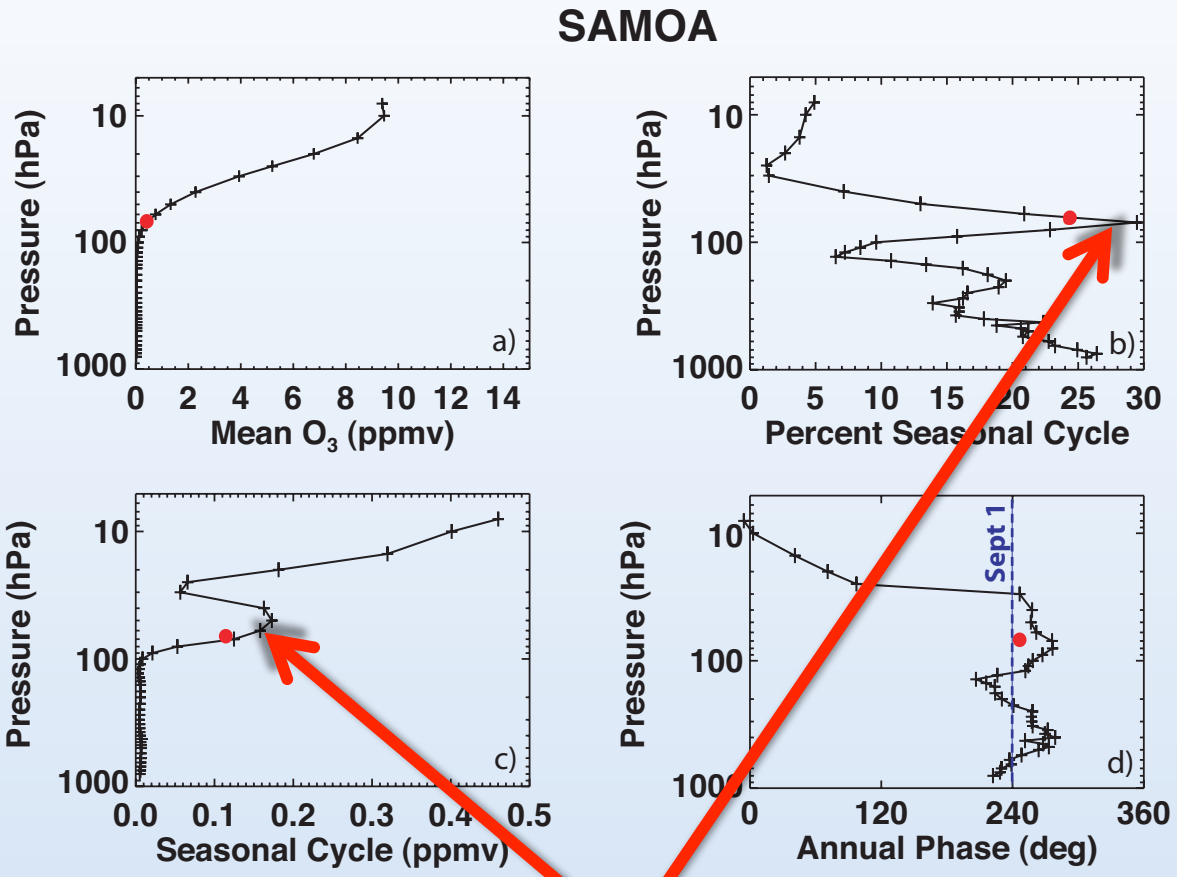
Aura MLS continues the profile data set, but with minimal overlap and differing vertical resolution and coverage

We need a longer data set



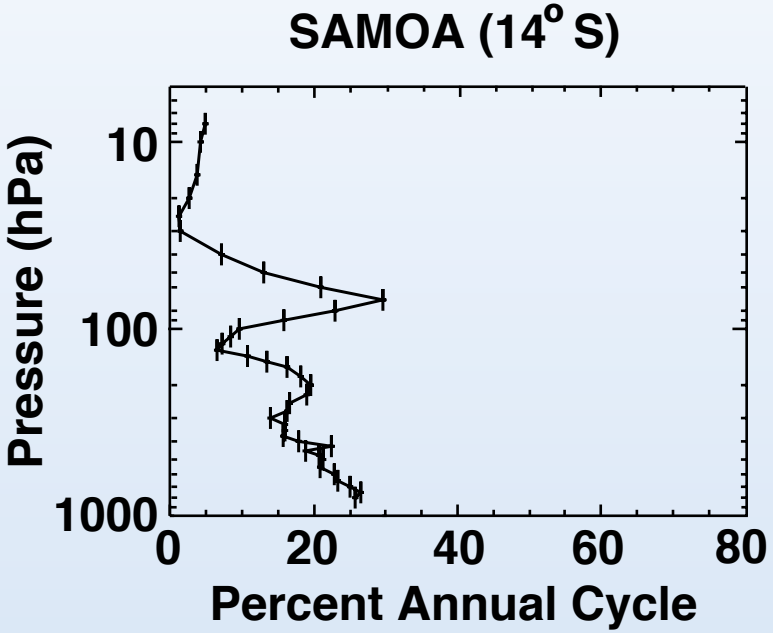
Ozonesondes provide the key to comparing the characteristics of SAGE II and MLS data

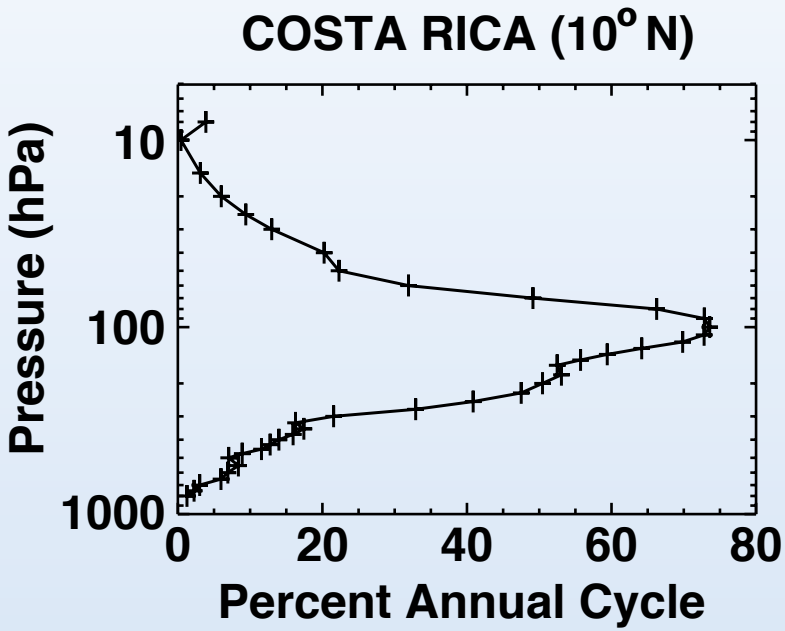
Characteristics of Tropical Lower Stratospheric Ozone Variation Determined by Ozonesondes



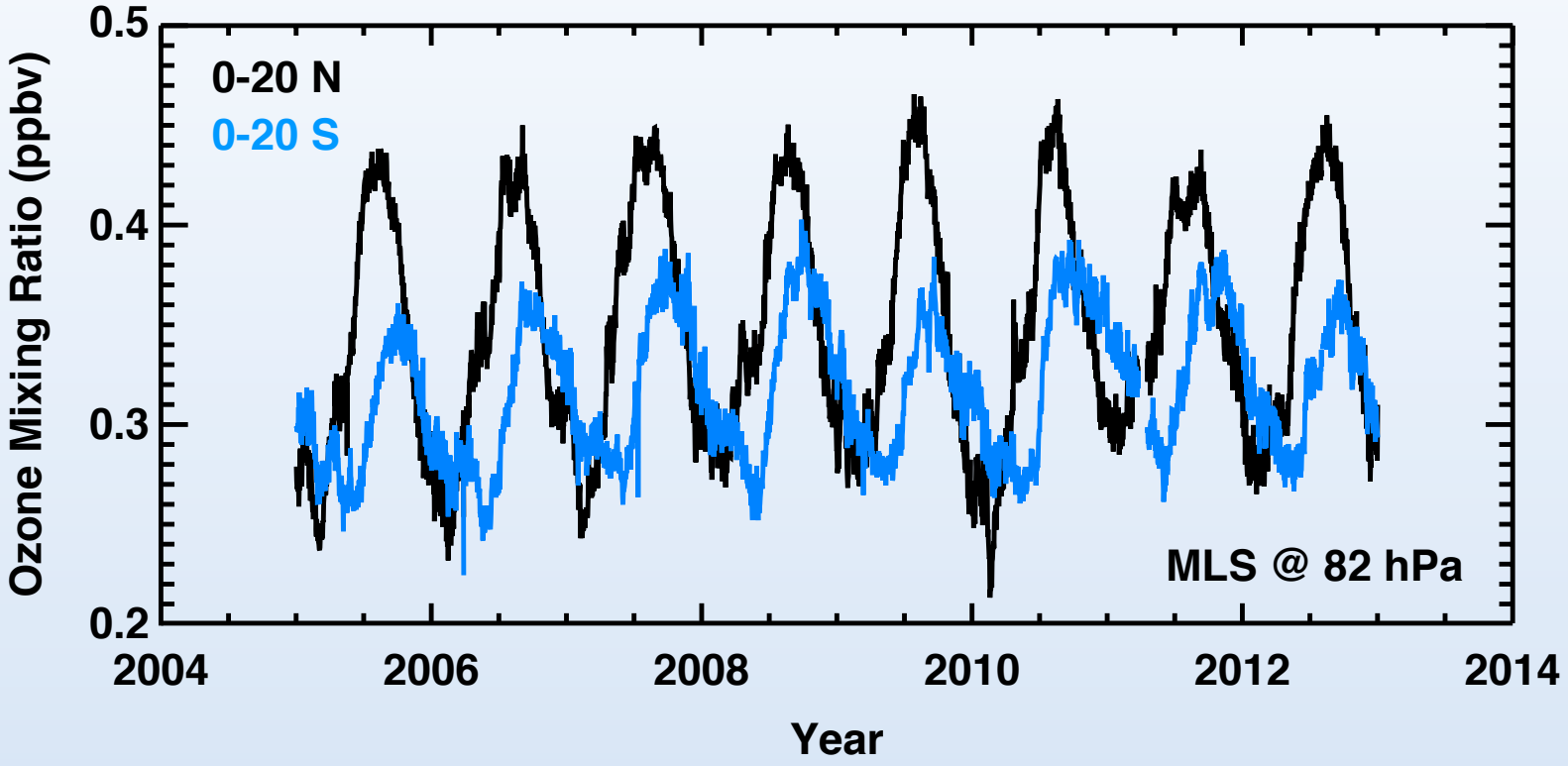
Note annual magnitude peak in lower stratosphere

Southern Tropics Appear to be Different from Northern Tropics

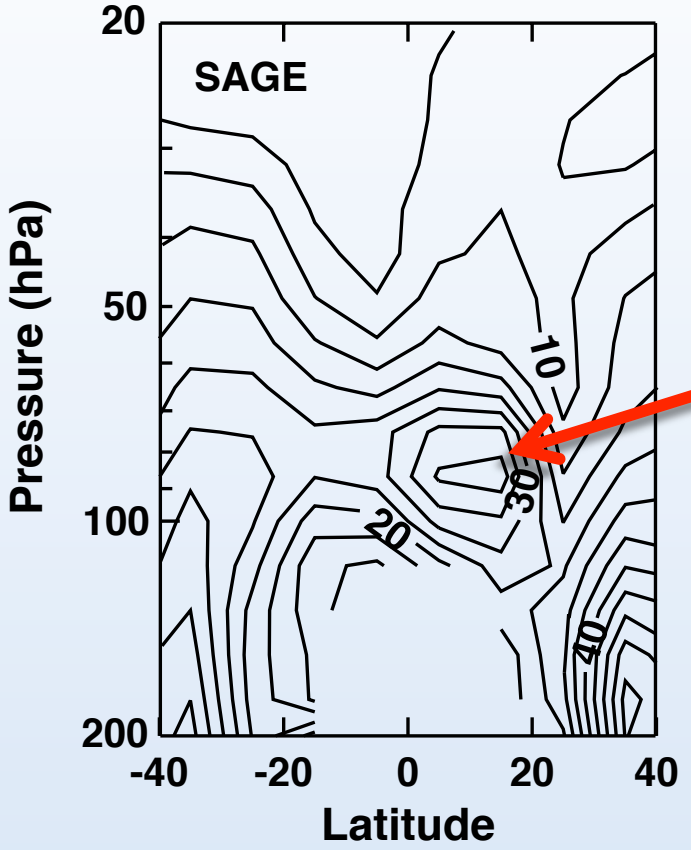




Seasonal Cycle of Southern and Northern Tropics from MLS data

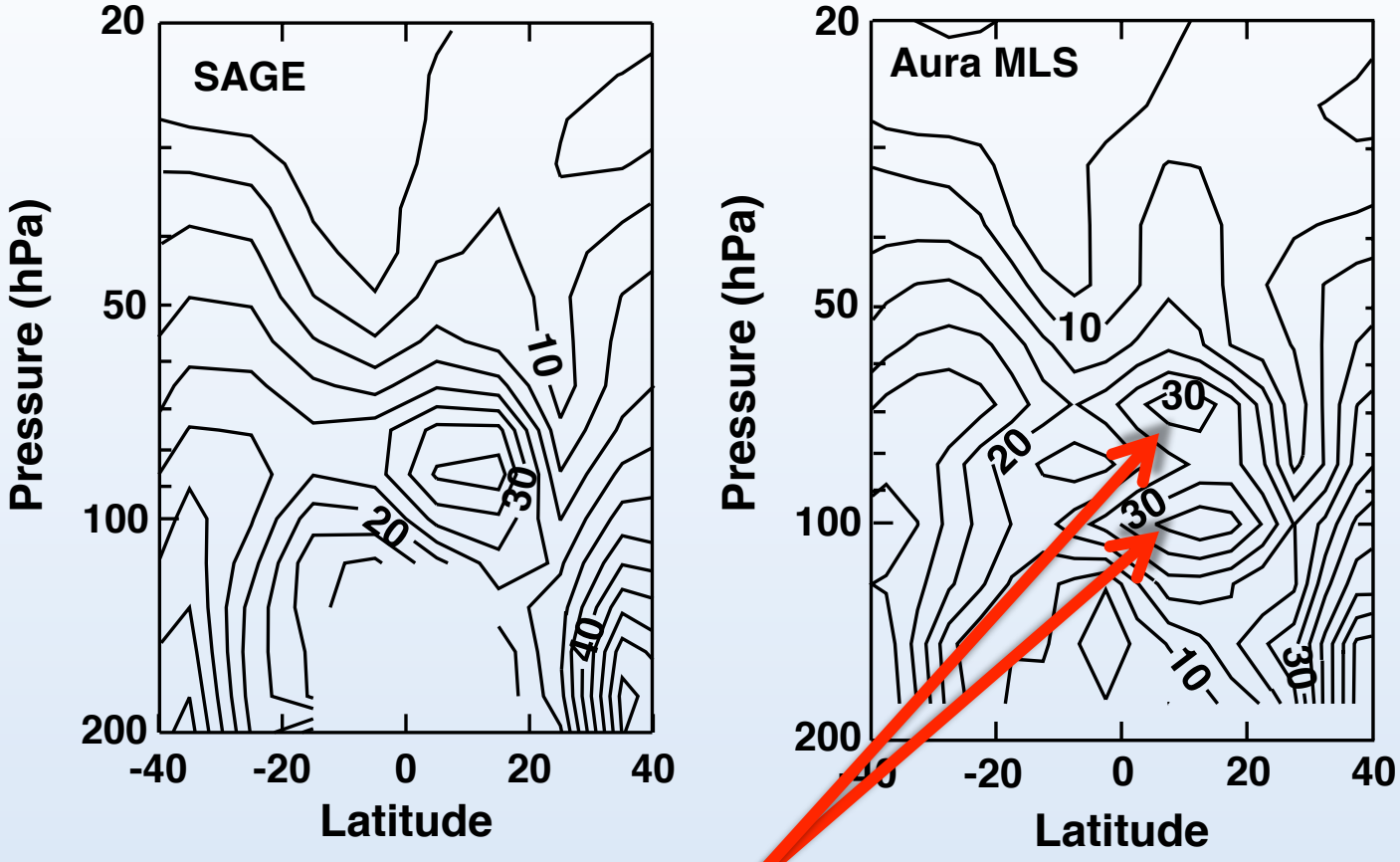


Annual Magnitude Altitude/Latitude Structure



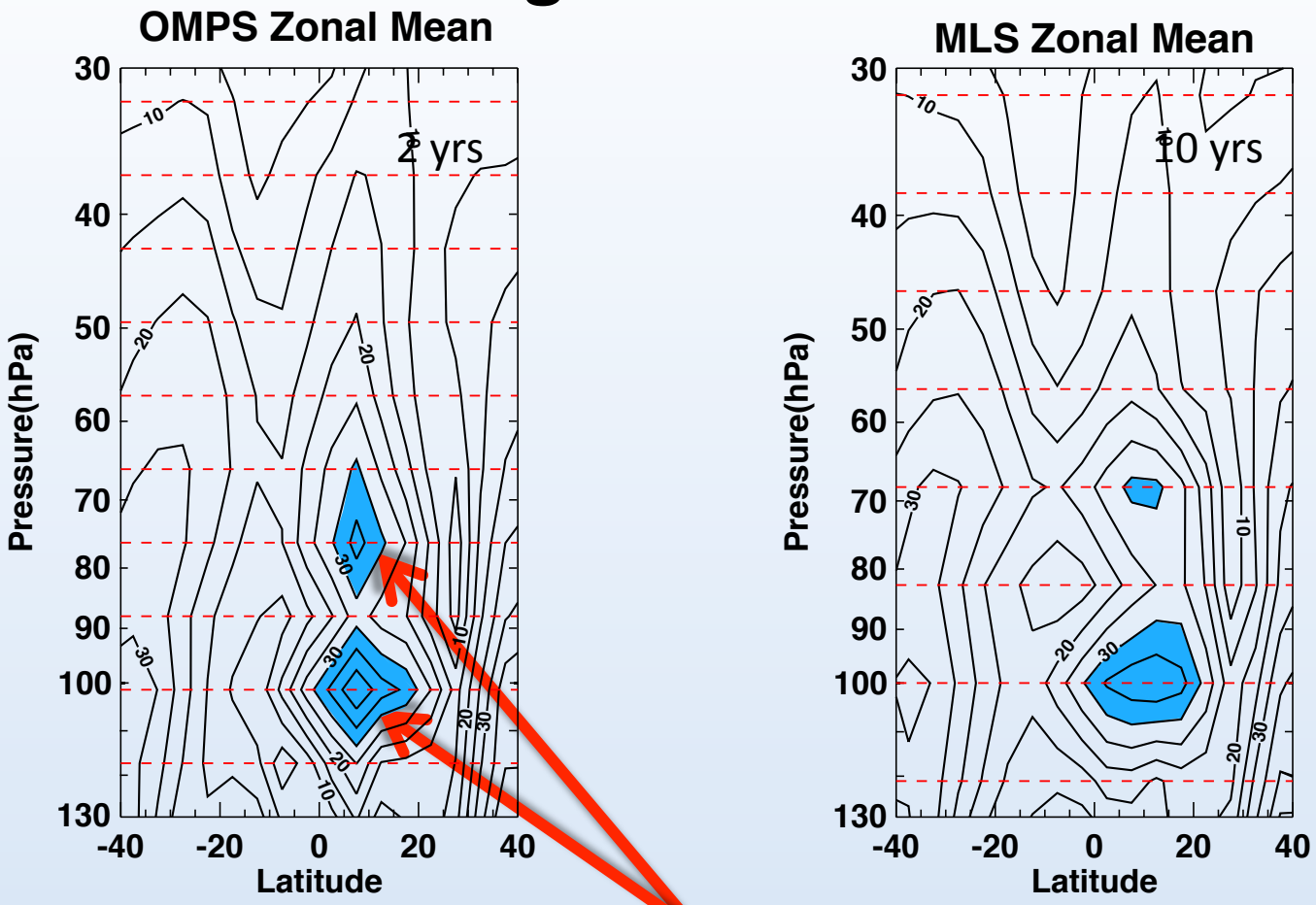
Larger Amplitude in Northern Tropics than in Southern Tropics

Annual Magnitude Altitude/Latitude Structure



Extended seasonal magnitude feature in MLS with double peak

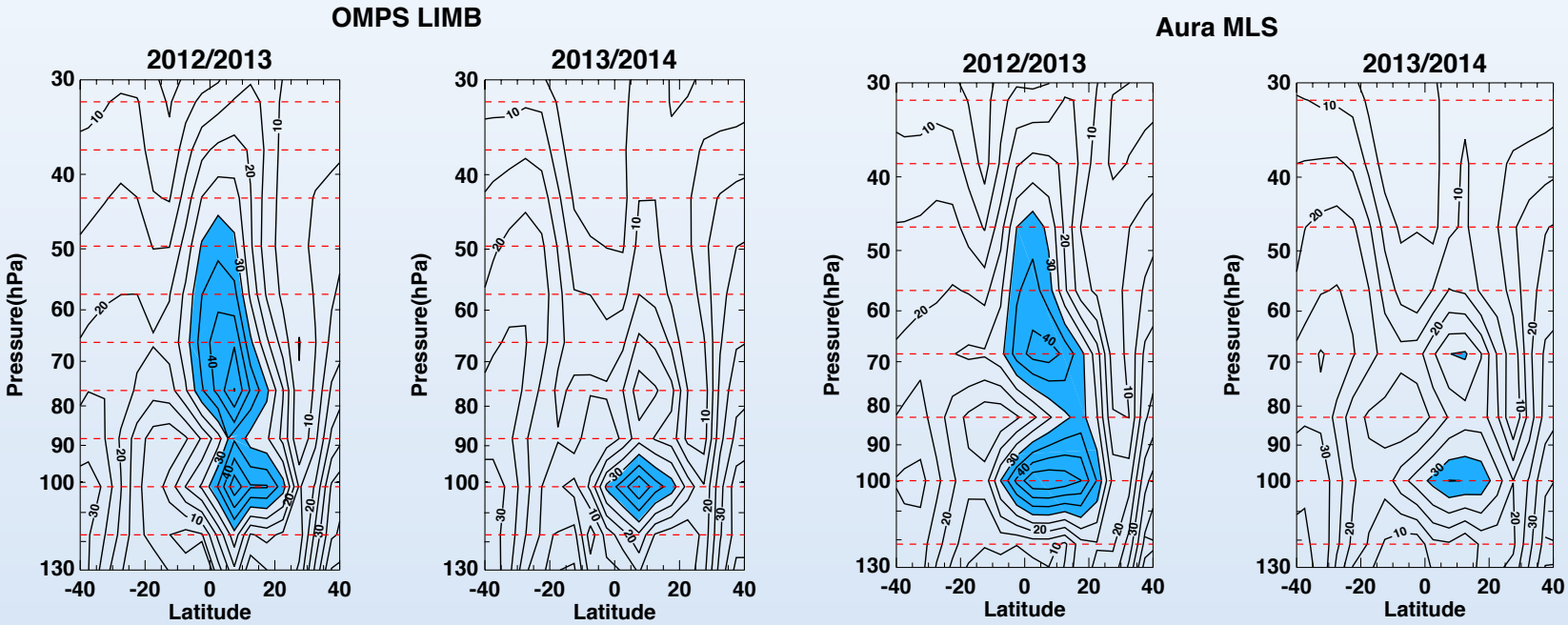
Is Double-Peaked Structure of Annual Cycle Magnitude Real?



OMPS Limb sounder also shows double-peaked structure

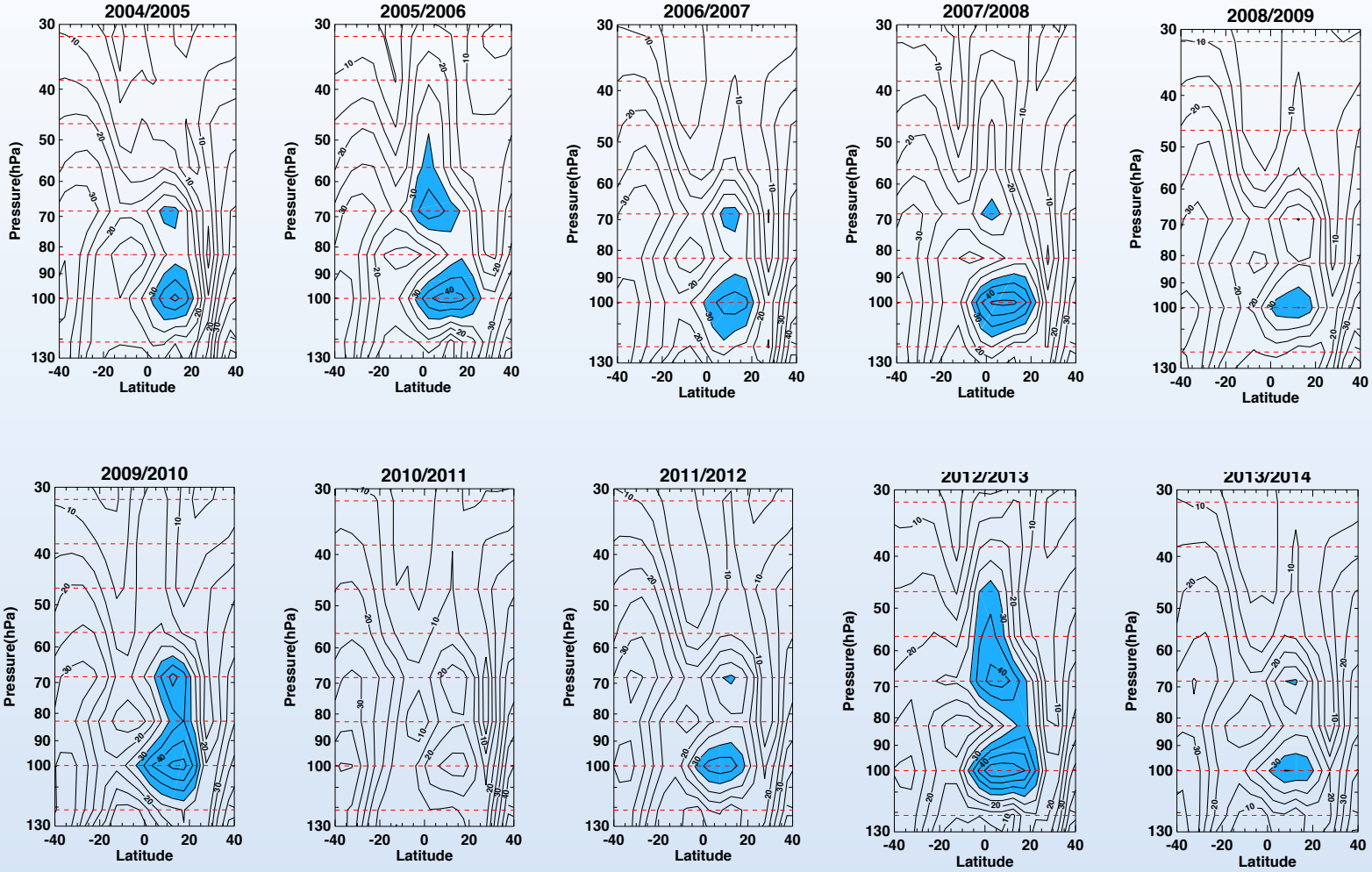
OMPS Limb and MLS Show Similar Differences Between Years

Year runs from mid-September to mid-September

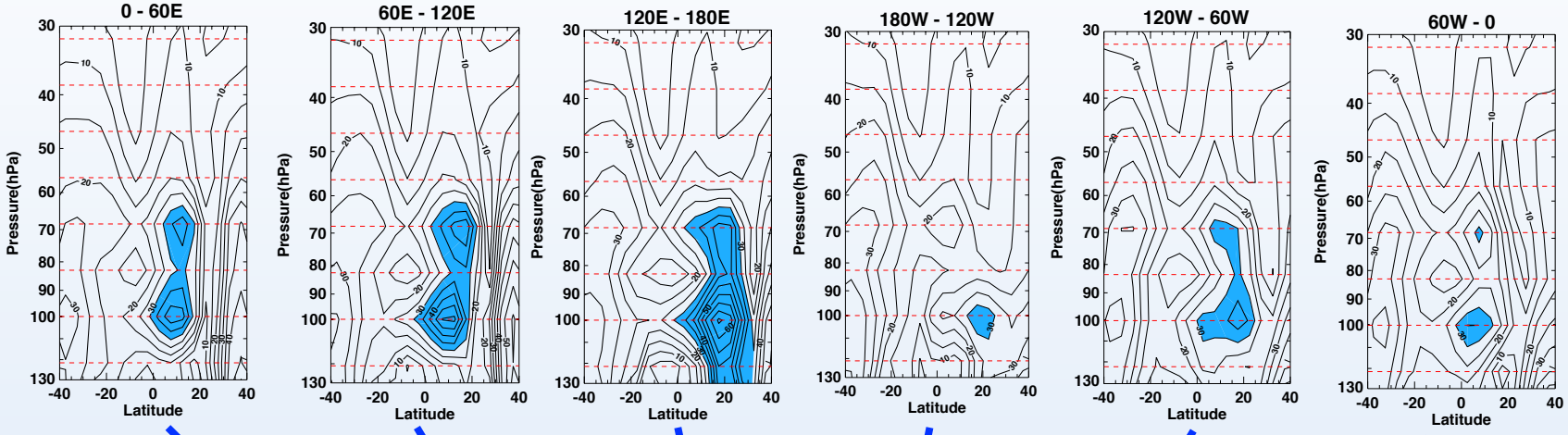


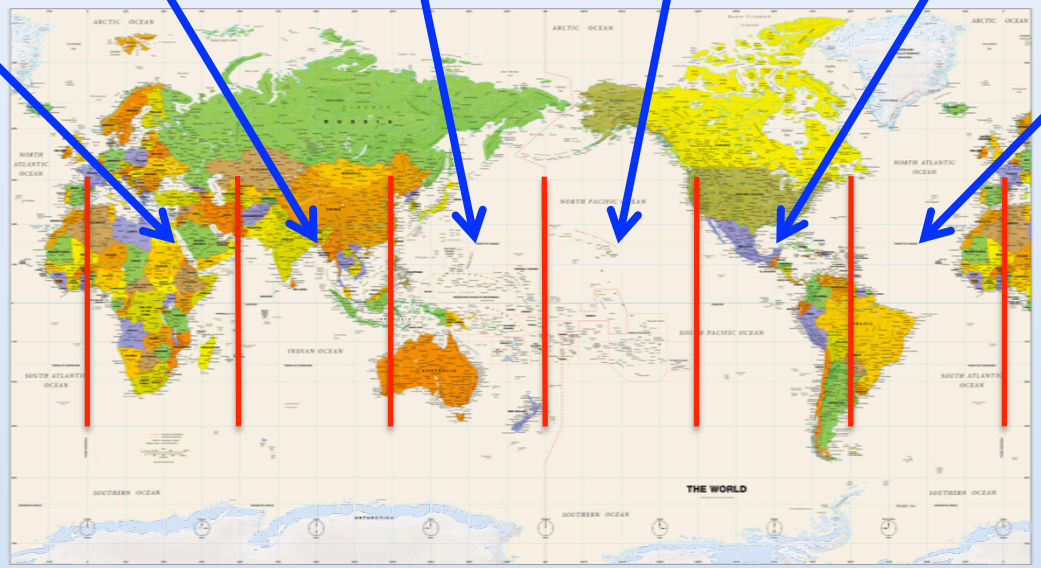
Stolarski, AMS Phoenix

Interannual variability of ozone annual amplitude in 10 years of MLS data



Longitudinal Behavior of Ozone Annual Amplitude





10 Years of MLS Data

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**