Hemispheric Differences in Tropical Lower Stratospheric Constituent Seasonal Cycles

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1. We published a paper (Stolarski, et al. JGR 10.1002/2013JD021294) in which we pointed out the differences in the seasonal cycle of ozone in the tropical lower stratosphere. We noted that the seasonal cycle in the northern tropics was stronger than that in the southern tropics. This behavior was clearly seen in 21 years of SAGE II data and similarly in Aura MLS data. The figures from that paper are below:

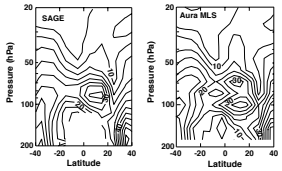


Figure 1. Amplitude of annual cycle of ozone (%) in SAGE and MLS data as a function of latitude and altitude.

2. While these data from both satellites show the asymmetric maximum in ozone annual cycle, the MLS data seem to indicate a double peak with maxima at both 68 and 100 hPa. We have examined this by comparing MLS data to the OMPS Limb Sounder data (see Kramarova et al poster A33I-3311). OMPS Limb has a little over 2 years of data. We have fit the annual cycle to each year as shown in the figure below:

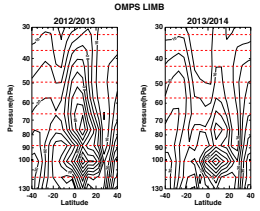


Figure 2. Amplitude of annual cycle of ozone (%) in OMPS Limb data. Two individual years are shown; from 2012.7 to 2013.7 on the left and 2013.7 to 2014.7 on the right. Red dashed lines indicate the levels on which data is retrieved.

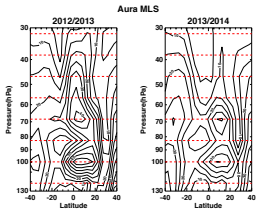


Figure 3. Amplitude of annual cycle of ozone (%) in Aura MLS data. Two individual years are shown; from 2012.7 to 2013.7 on the left and 2013.7 to 2014.7 on the right. Red dashed lines indicate the levels on which data is retrieved.

3. OMPS Limb data clearly shows a double-peaked structure similar to that in Aura MLS. The data further exhibit significant differences between the two years. The same two years are shown in Figure 3 for annual cycles deduced from Aura MLS data.

Conclusion: Double-peaked structure in tropical lower stratospheric annual cycle of ozone observed by Aura MLS is consistent with data from OMPS Limb sounder.

4. Examination of the longitude structure of the annual cycle reveals strong differences. Notice the major difference between the Western Pacific (120E – 180E) and the Eastern Pacific (180W – 120W). The figure below shows the annual cycle calculated from 10 years of Aura MLS data divided into six 60-degree longitude sections. The locations are indicated on the world map below the graphs.

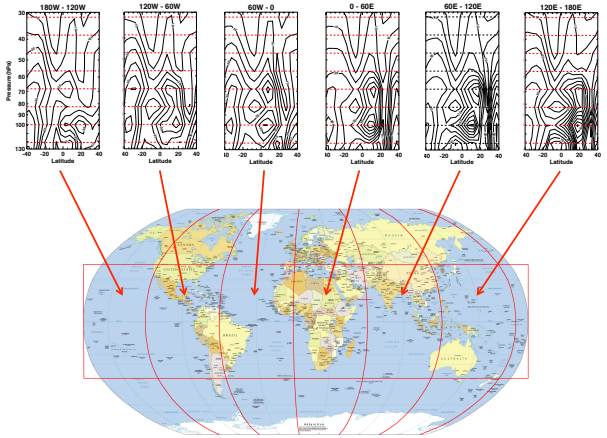


Figure 4. Top: Annual amplitude (%) as a function of latitude and altitude from Aura MLS data calculated for six longitudinal sectors. Bottom: World map illustrating location of each longitude sector.

5. The contrast between the Western and Eastern Pacific is particularly interesting (Panels 1 and 6 above). Below we show the time series for the southern tropics (20°S-Equator) and the northern tropics (Equator-20°N) at three pressure levels for the Eastern Pacific and for the Western Pacific.

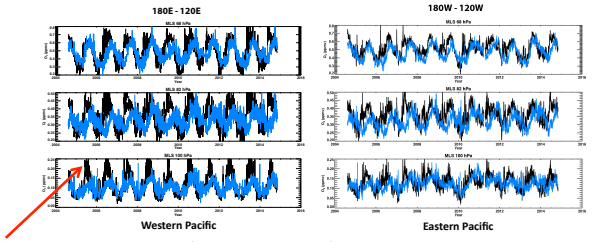
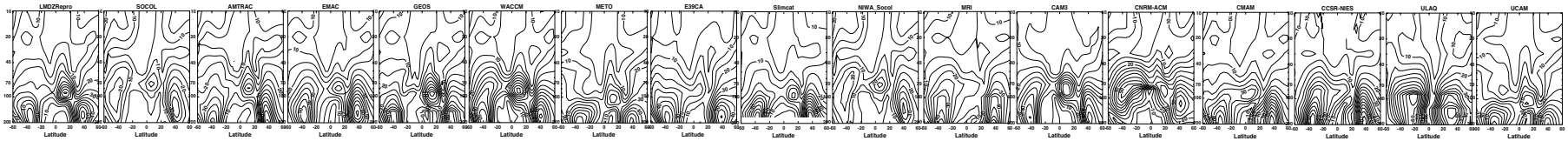


Figure 5. Time series of Aura MLS measurements of ozone mixing ratio at three pressure levels (68, 82, 100) for the Western Pacific (left) and Eastern Pacific (right). Black lines are the northern tropics (0-20N); blue lines are the southern tropics (0-20S).

6. Western Pacific seasonal cycle is sinusoidal in southern tropics at 100 hPa but show sharp peaks in JJA in the northern tropics. Eastern Pacific seasonal cycle does not show sharp peaks leading to smaller annual amplitude.

Conclusion: Longitudinal structure of ozone annual cycle indicates possible role of monsoon circulations in determining balance between upwelling and mixing.



Model Results from CCMVal2: Most show hemispheric asymmetry, but not double-peaked structure.