Improved Tropospheric Ozone Residual and Comparisons to the GMI Model

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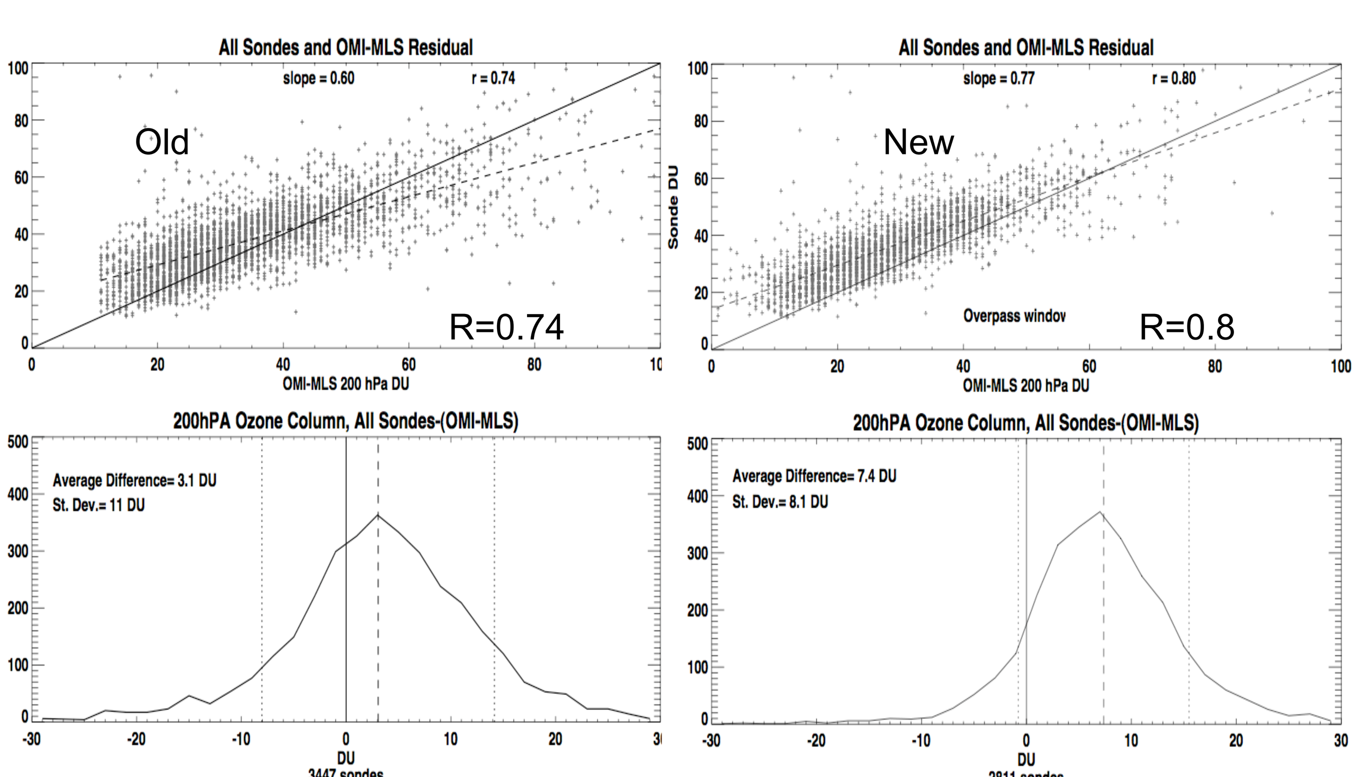
Abstract. **The tropospheric ozone residual (TOR) is produced by subtracting the stratospheric ozone measured by MLS and the tropospheric ozone column measured by OMI. The key to producing a good extra-tropical TOR is a relatively high resolution stratosphere. In our approach we use backward and forward trajectories from four days of MLS data to boost the horizontal resolution of the stratospheric ozone field. The TOR estimates are validated by comparing them to sondes . The residual is converted an equivalent ozone mixing ratio using the lower bound pressure. High reflectivity scenes are no longer discarded – the OMI cloud pressure and radiative cloud fraction is used to modify the surface pressure. OMI-MLS TOR from 2005 and 2006 are also compared with the GMI derived TOR. The results show that the OMI-MLS TOR is an underestimate due to lack of boundary layer sensitivity of the OMI instrument.**

Improved TOR

A number of improvements have been made in the TOR product described in Schoeberl et al. [2007] (S07)

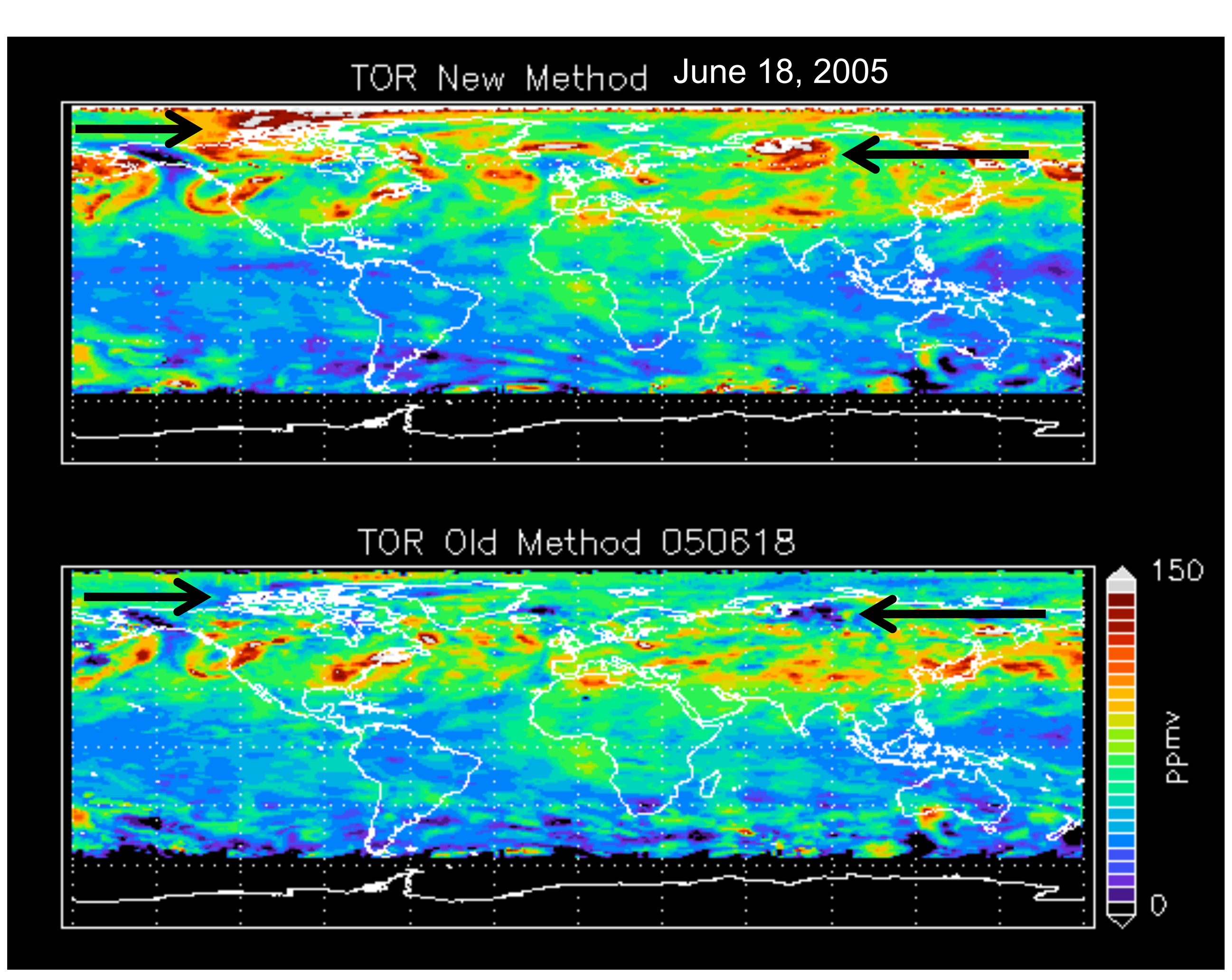
1. **Use of V2.2 MLS data which improves the lower stratospheric ozone [see Livesey et al. [2008]**
2. **Use of Collection 3 OMI column ozone data**
3. **2-day backward and forward trajectories (only forward were used in S07)**
4. **Use of the OMI cloud pressure and cloud fraction. This affects the TOR because the the column ozone uses climatology in high reflectivity scenes which increases noise – this climatology is now removed. Use of the cloud fraction and pressure also affects the average mixing ratio calculated from the tropospheric column depth – the effective surface pressure is now $P_{eff}= P_s\text{-}f(P_s\text{-}P_{cld})$ where f is the radiative cloud fraction and P_{cld} is the cloud centroid pressure.**

Validation of the 200 hPa column against sondes (below) show the improvement.



Daily Map

Below are two figures of daily maps of the average mixing ratio using the new cloud method and old method.



Overall the old and new methods show the greatest differences at high latitudes. The two regions indicated by arrows are cloudy regions. In the old method, the climatological ozone was substituted used in the OMI column. In the new method the climatological ozone is not used and the cloud top pressure and cloud fraction is used. Cloudiness at high latitudes produced a bias in the old TOR fields which is now reduced using the new method.

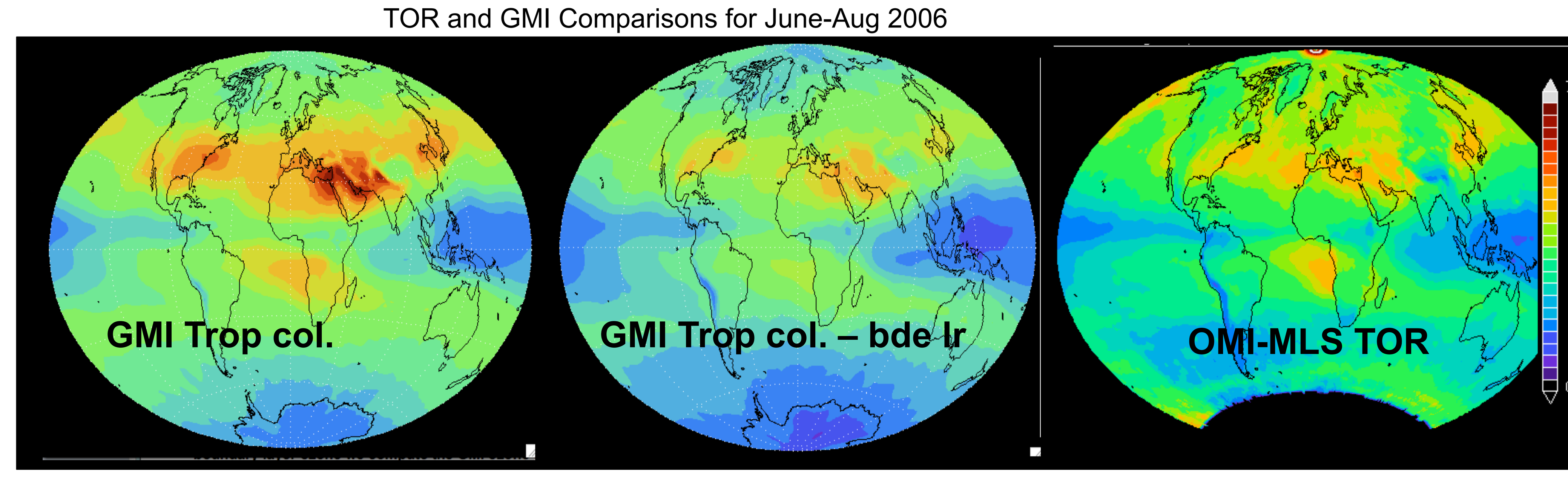
Summary

The OMI- MLS TOR is quantitatively improved using (1) MLS v2.2 (2) OMI cloud and cloud fraction (3) Trajectory enhancement of the stratospheric ozone field. Comparison to GMI model TOR show good agreement as well as some important differences best agreement appears when the lowest 1.5 km of the GMI model is not used. OMI is not very sensitive to the ozone in the boundary layer. Differences in the TOR distribution appears to be mostly due to the difference in the distribution of ozone in the lower stratosphere between the GMI model and the MLS observations.

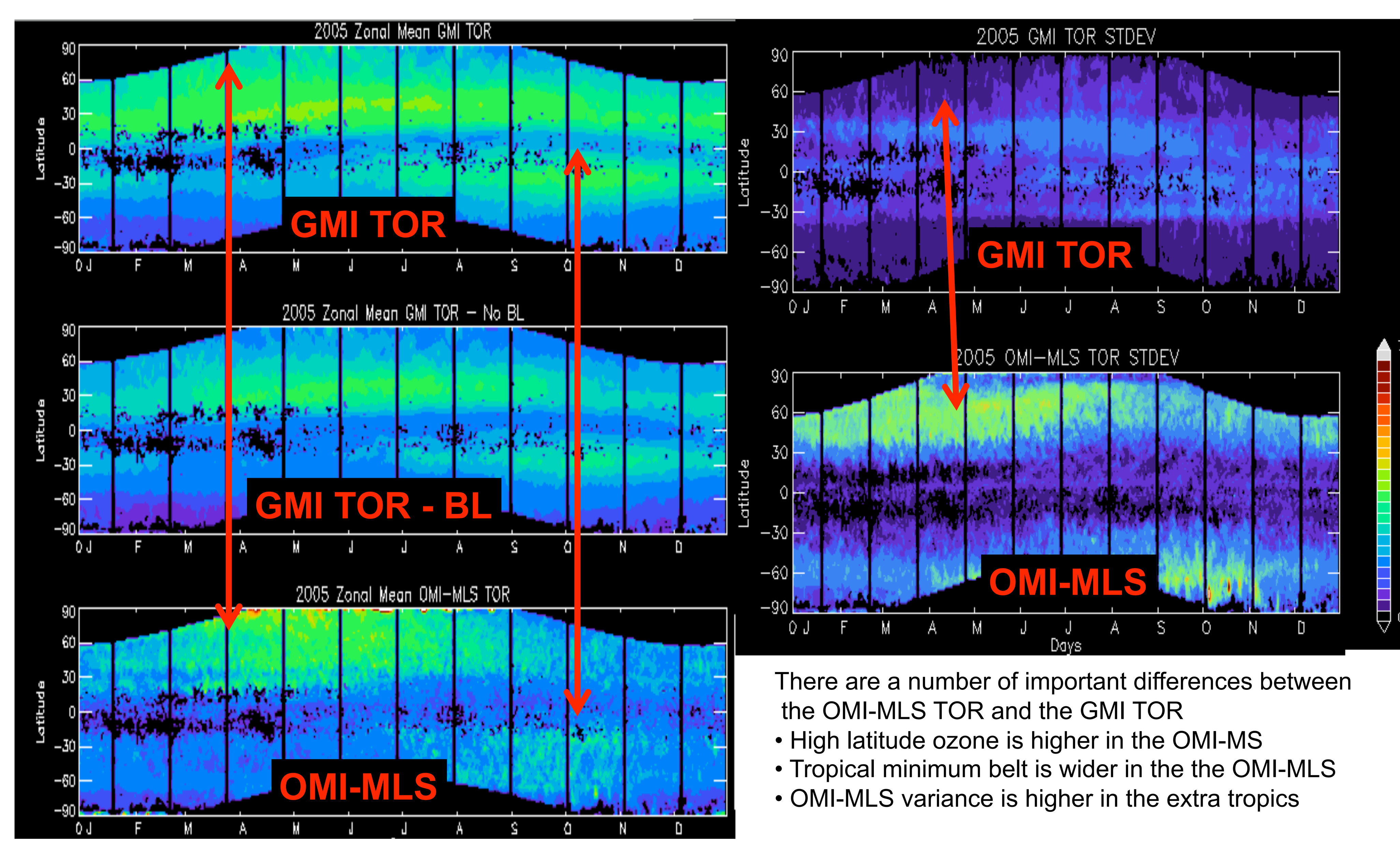
Comparison with the GMI Model

The GMI Model is described by Duncan et al. [2007]. It is a full stratosphere/troposphere chemistry model that uses the GEOS-4 assimilation winds for transport. The TOR can be computed for the GMI model ozone a comparison with the OMI-MLS TOR. Because the OMI instrument cannot see the boundary layer ozone we compute the GMI ozone column as well as the tropospheric ozone column minus the lowest 1.5 km layer, the boundary layer.

TOR and GMI Comparisons for June-Aug 2006

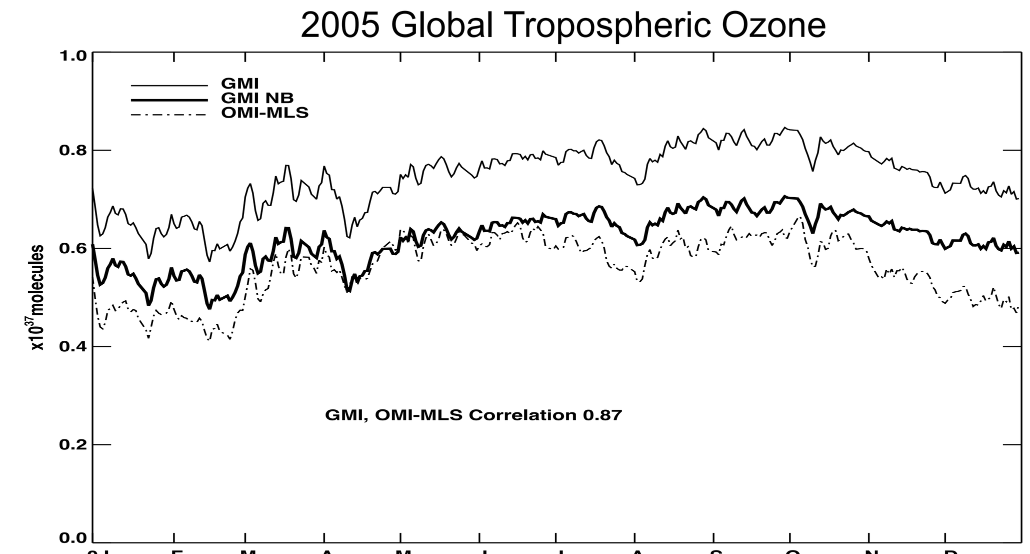


Below are the zonal mean time series of of the GMI and OMI-MLS TOR for 2005 and the standard deviation

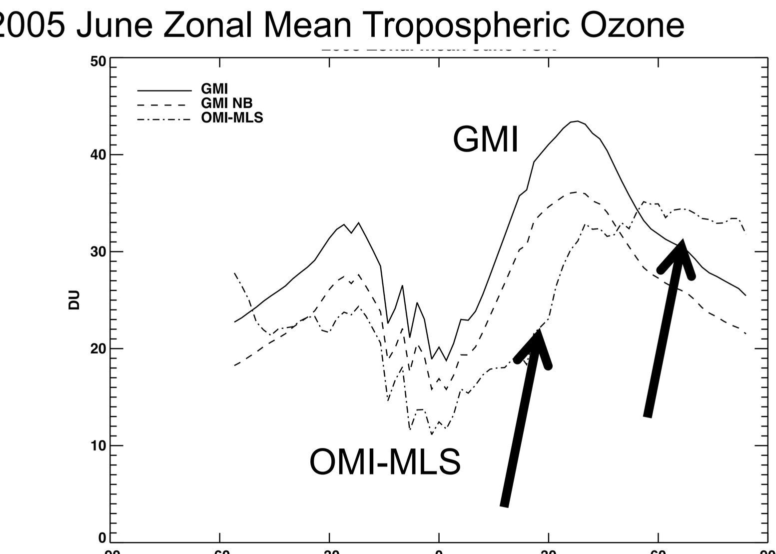


There are a number of important differences between the OMI-MLS TOR and the GMI TOR
- High latitude ozone is higher in the OMI-MS
- Tropical minimum belt is wider in the the OMI-MLS
- OMI-MLS variance is higher in the extra tropics

2005 Global Tropospheric Ozone

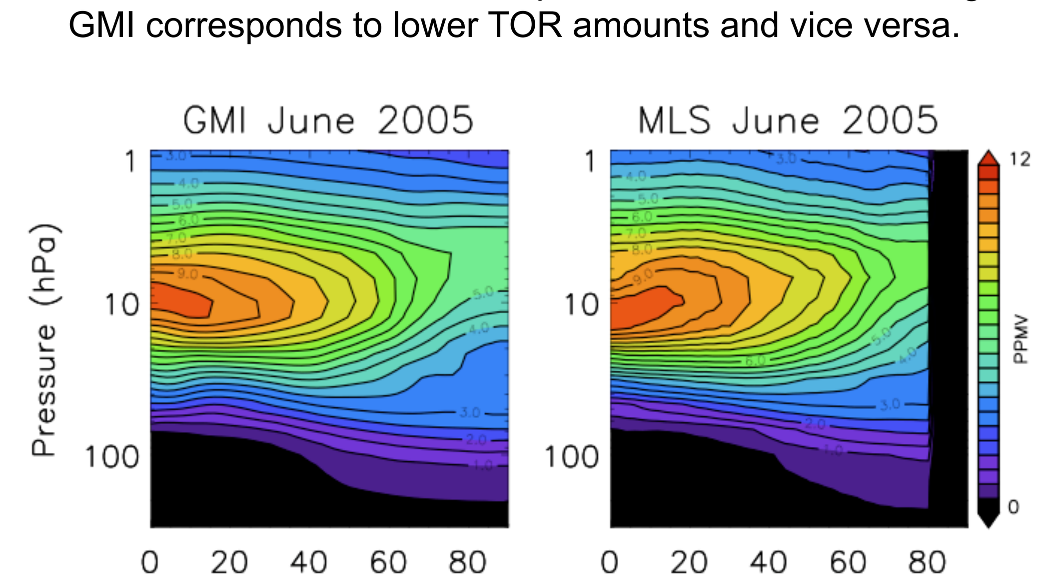


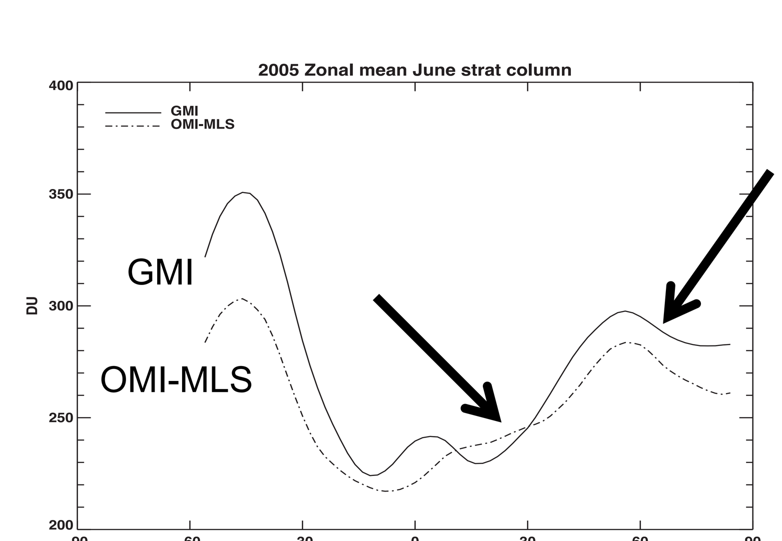
2005 June Zonal Mean Tropospheric Ozone



The GMI global tropospheric ozone time series on the left and agrees very will with the OMI-MLS time series when the lowest 1.5 km is excluded. The series have a 0.87 correlation coefficient.

The zonal mean ozone amount for June 2005 shows a discrepancy at high and low latitudes with GMI. Some of these differences can be traced to differences the stratospheric ozone. Below we show the stratosphere for MLS and GMI and the stratospheric column. Note the higher lower stratospheric column ozone for MLS vs GMI corresponds to lower TOR amounts and vice versa.





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Duncan, B. N., S. E. Strahan, Y. Yooshida, S. D. Steenrod, and N. Livesey, Model of the cross-tropopause transport of biomass burning pollution, Atmos. Chem. Phys., 7, 3713-3736, 2007.

Livesey, N.J., "Validation of Aura Microwave Limb Sounder O3 and CO observations in the upper troposphere and lower stratosphere," *JGR, 113, D15S02, doi:10.1029/2007JD008805,* 2008.

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