Observing OH Response to the Solar Cycle

— Over 5-year Aura MLS OH Measurements in Combination With the 13-year Ground-based FTUVS OH Measurement

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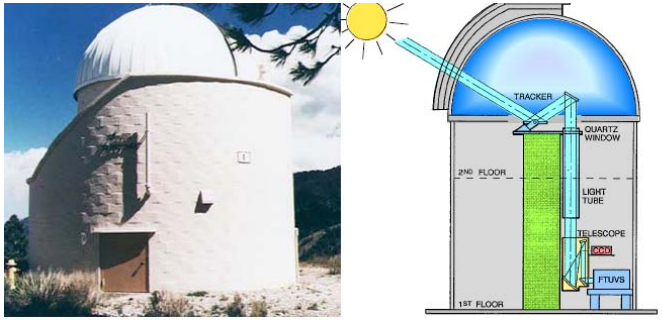


MLS OH —[Pickett et al., 2008; Wang et al., 2008]
FTUVS OH — [Cageao et al., 2001; Cheung et al., 2008]

Introduction - OH

- OH (together with HO_2) plays a key role in the HO_x catalytic reaction cycle leading to O_3 destruction in the middle atmosphere.

- Primary sources of OH

  Stratosphere

  $O_3 + h\nu \rightarrow O(^1D) + O_2$

  $O(^1D) + H_2O \rightarrow 2\ OH$

  Mesosphere

  $H_2O + h\nu \rightarrow OH + H$

- OH variability

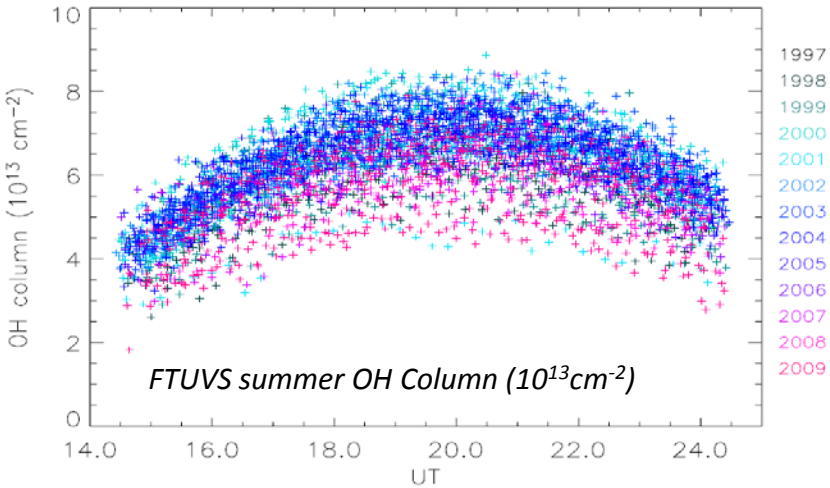
  Diurnal variation

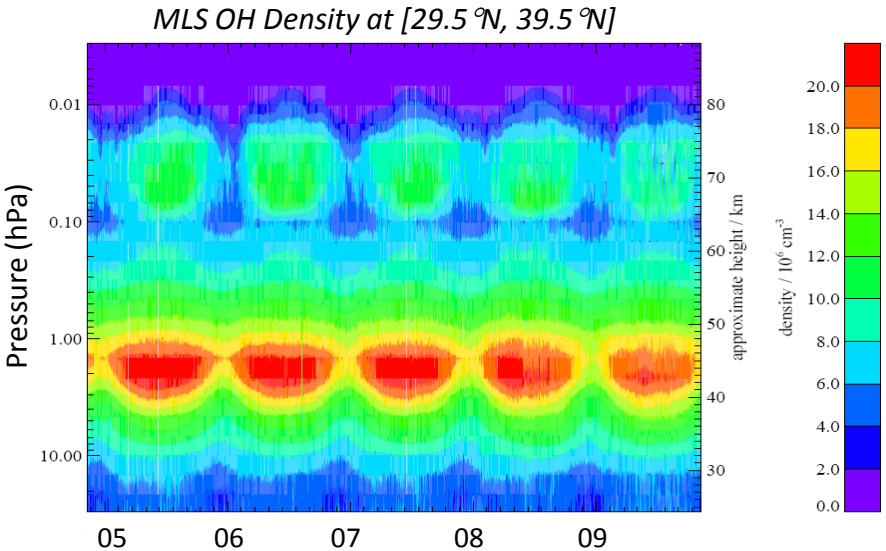
  Seasonal variation

  Solar cycles

  —11-year cycle (sunspot)

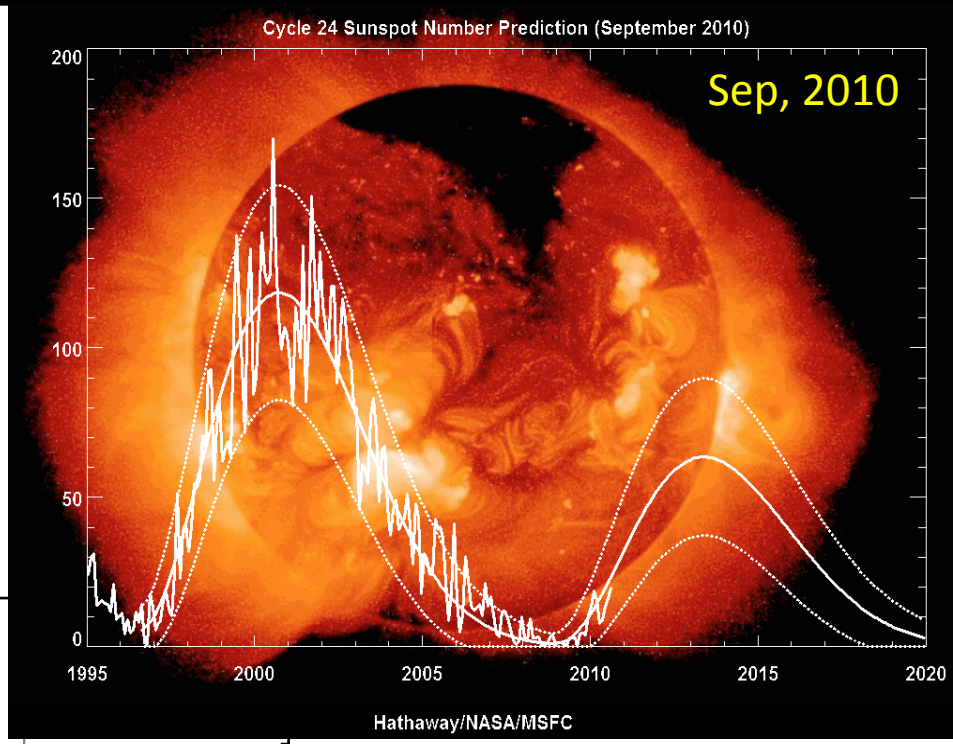
  — 27-day cycle (rotation)

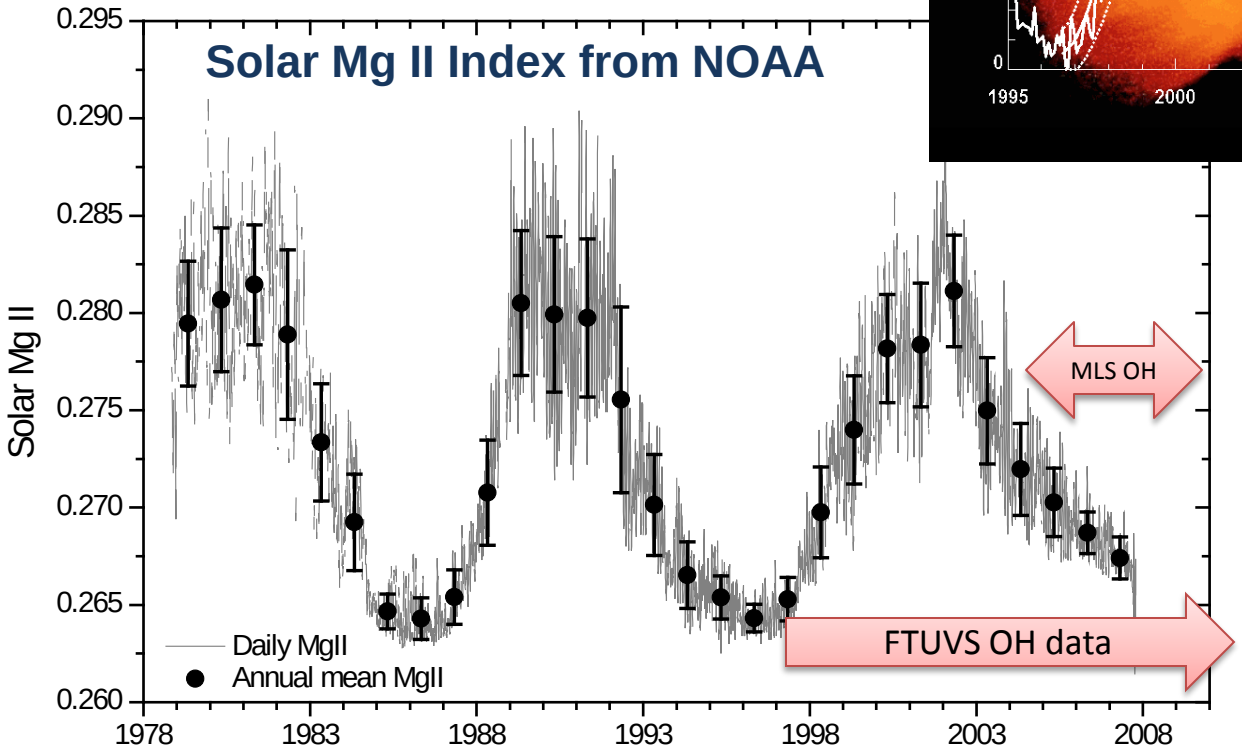




Introduction – Solar Cycle

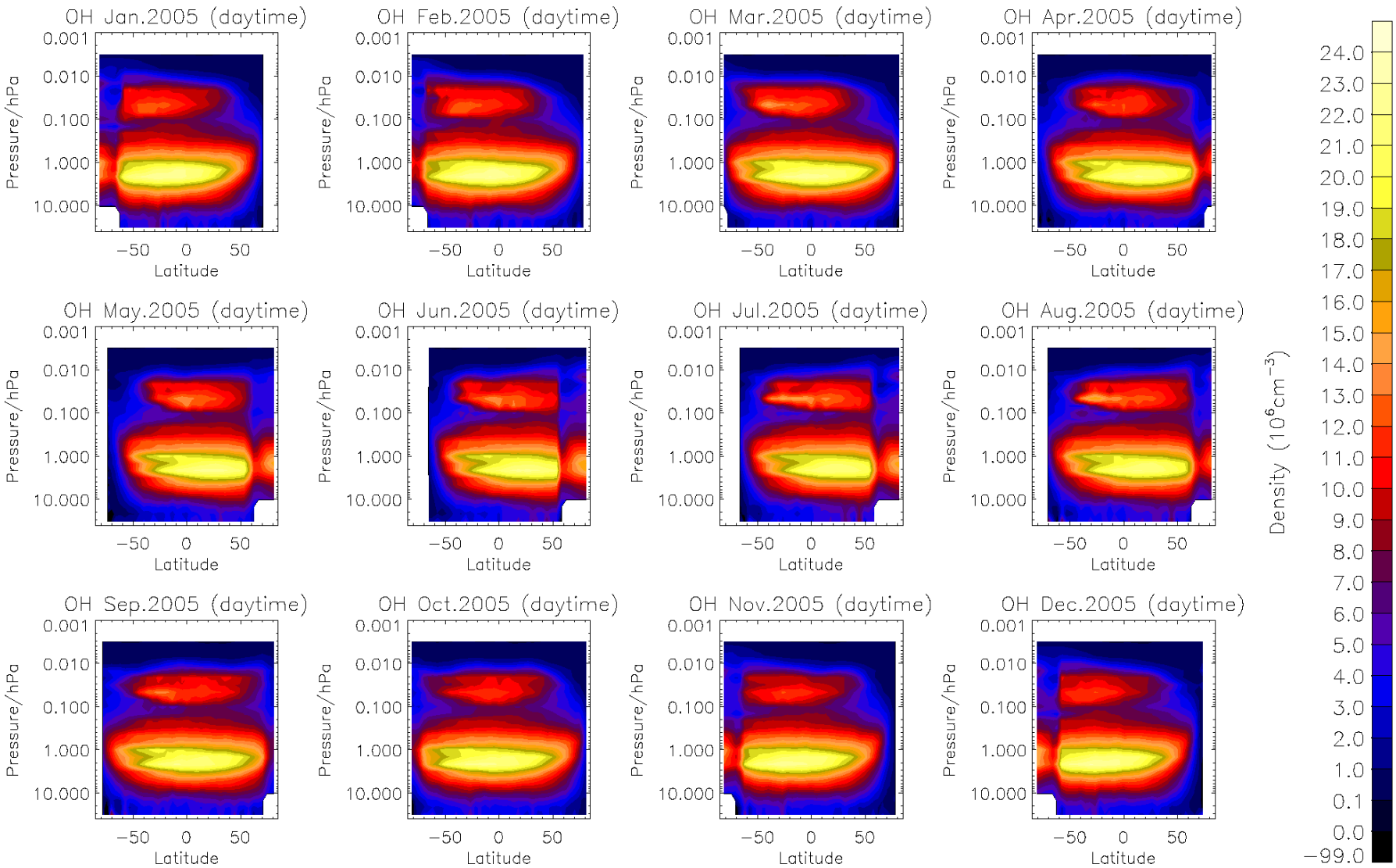
- The 11-year solar cycle is also known as the "sunspot cycle".
- The Sun has just came out of an extended solar minimum and entered the solar cycle 24 (max predicted to be in 2013).



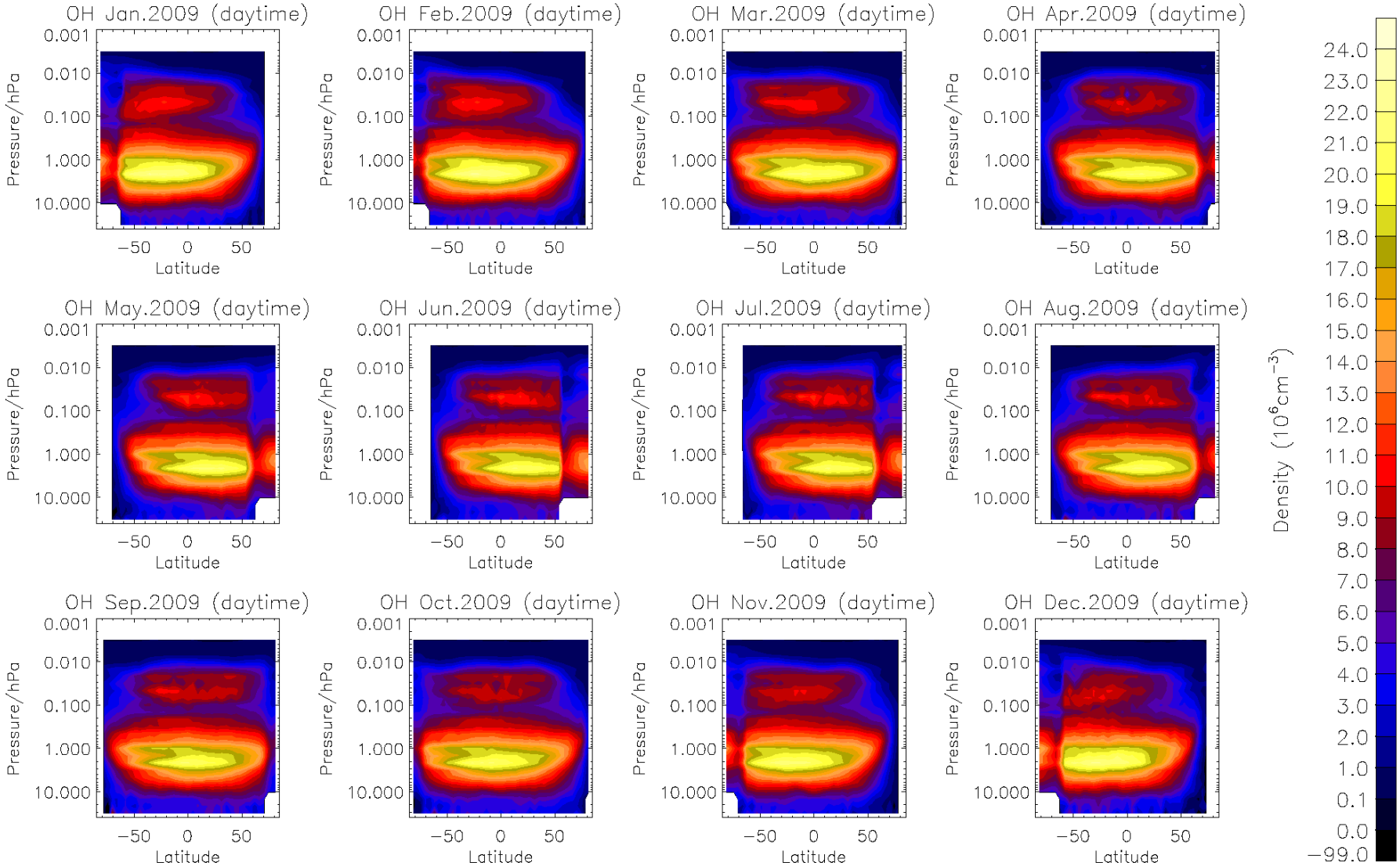


- Mg II core-to-wing ratio (~280nm) is a robust measure of chromospheric activity and a very reliable indicator of solar UV variability.
- OH, produced through photolysis, is expected to show variability during the solar cycle.

Hint of Solar Signal in MLS OH Climatology (2005)

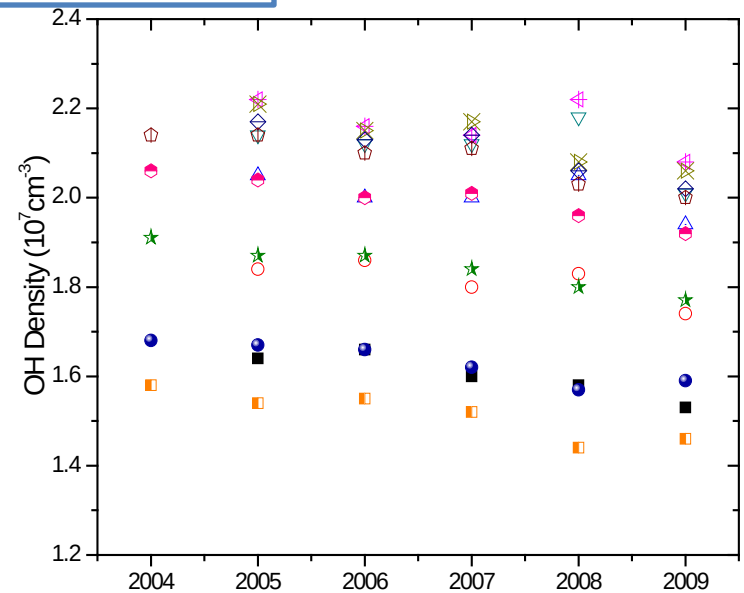


Hint of Solar Signal in MLS OH Climatology (2009)



Hint of Solar Signal in MLS OH Climatology

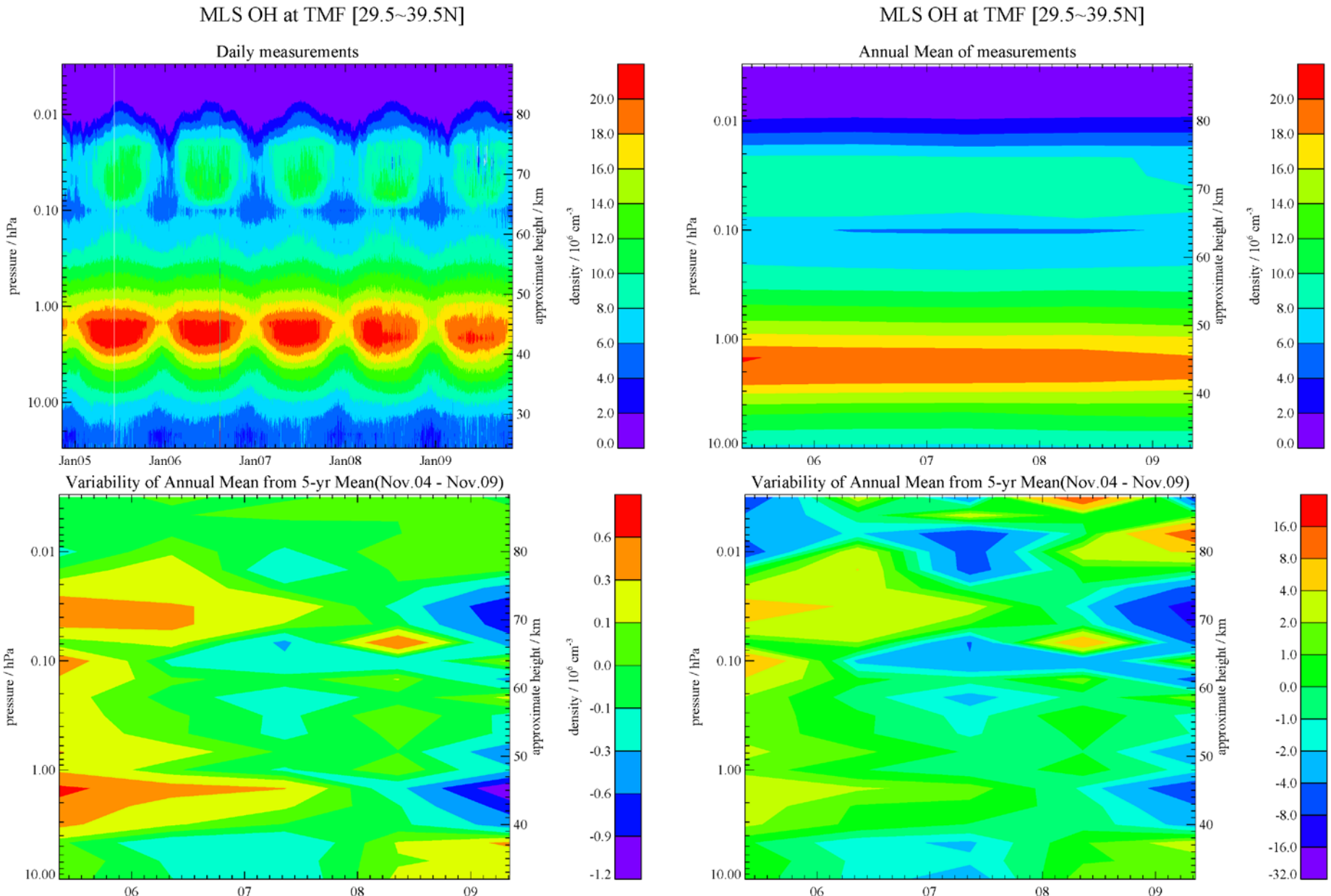
MLS Monthly Mean at ~2 hPa at ~34ºN



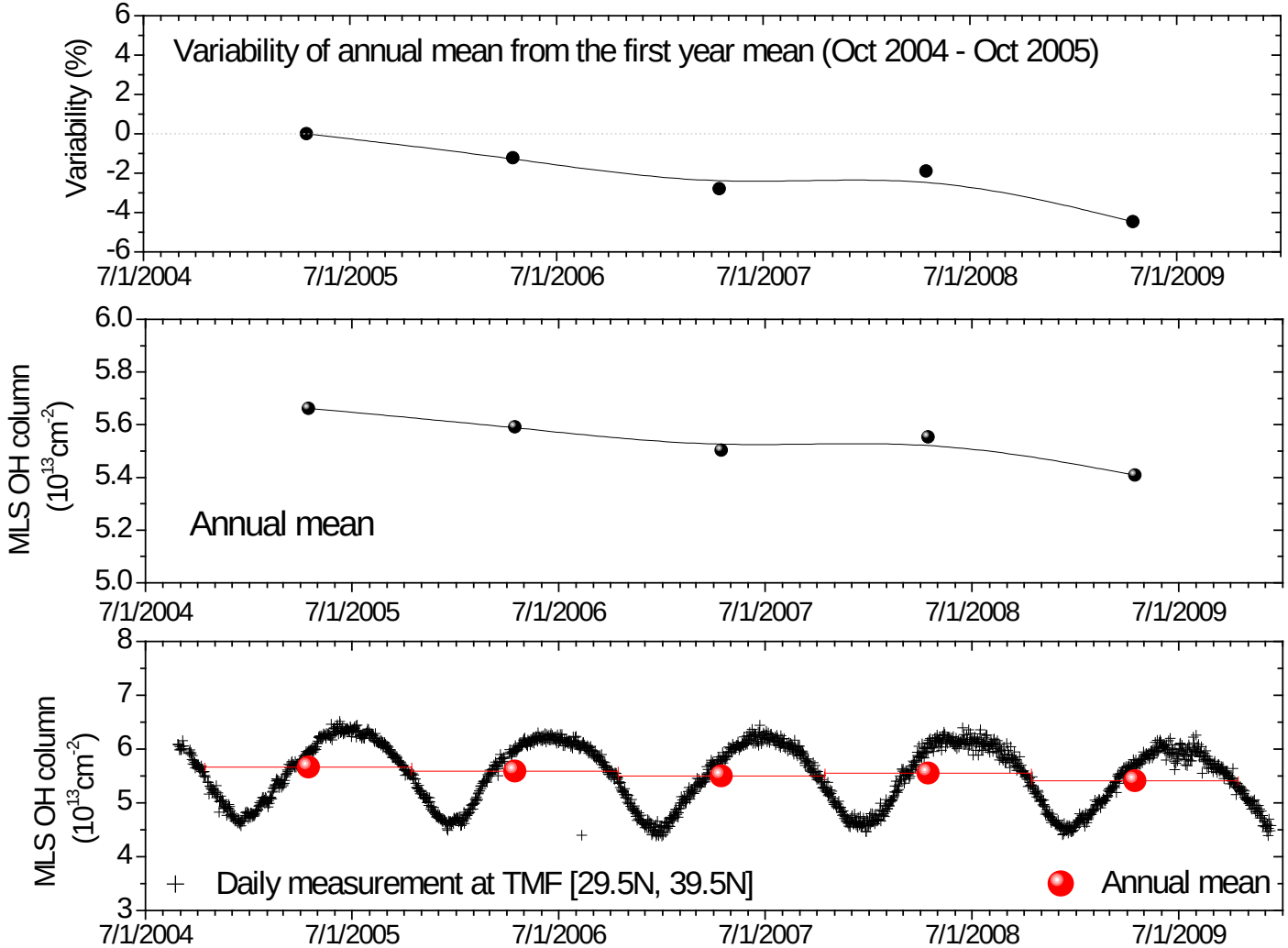
Data	Fit	-Slope(%)	R	Data	Fit	-Slope(%)	R
jan		1.8+0.4	-0.93				
feb		1.3+0.6	-0.78	feb2		1.6+0.5	-0.92
mar		0.8+0.7	-0.59	mar2		1.2+0.2	-0.96
apr		0.9+0.9	-0.50	apr2		1.4+0.4	-0.94
may		1.0+0.8	-0.59	may2		1.5+0.2	-0.98
jun		1.7+0.3	-0.93				
jul		1.7+0.3	-0.95				
aug		1.4+0.3	-0.93				
sep		1.3+0.2	-0.96				
oct		1.4+0.1	-0.98				
nov		1.4+0.3	-0.93				
dec		1.8+0.4	-0.92				

- MLS OH Climatology generally shows a clear decreasing trend during 2004-2009.
- Exceptions are seen in Feb-May, 2008.
- On average, OH decreases ~1.5% per year.

Vertical Stratification of Solar Cycle Signal

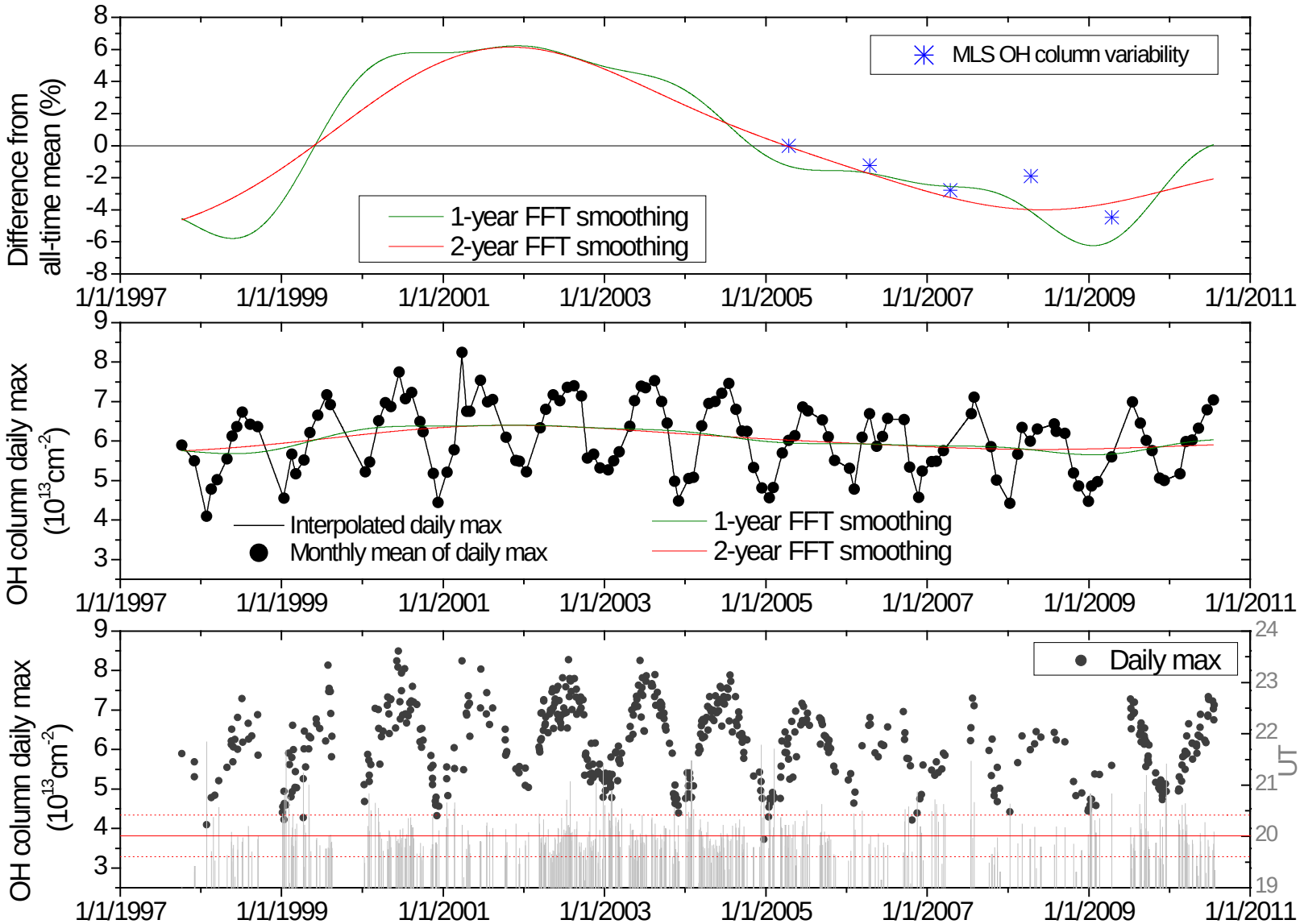


Solar Cycle Signal in 5-year MLS OH Partial Column at TMF

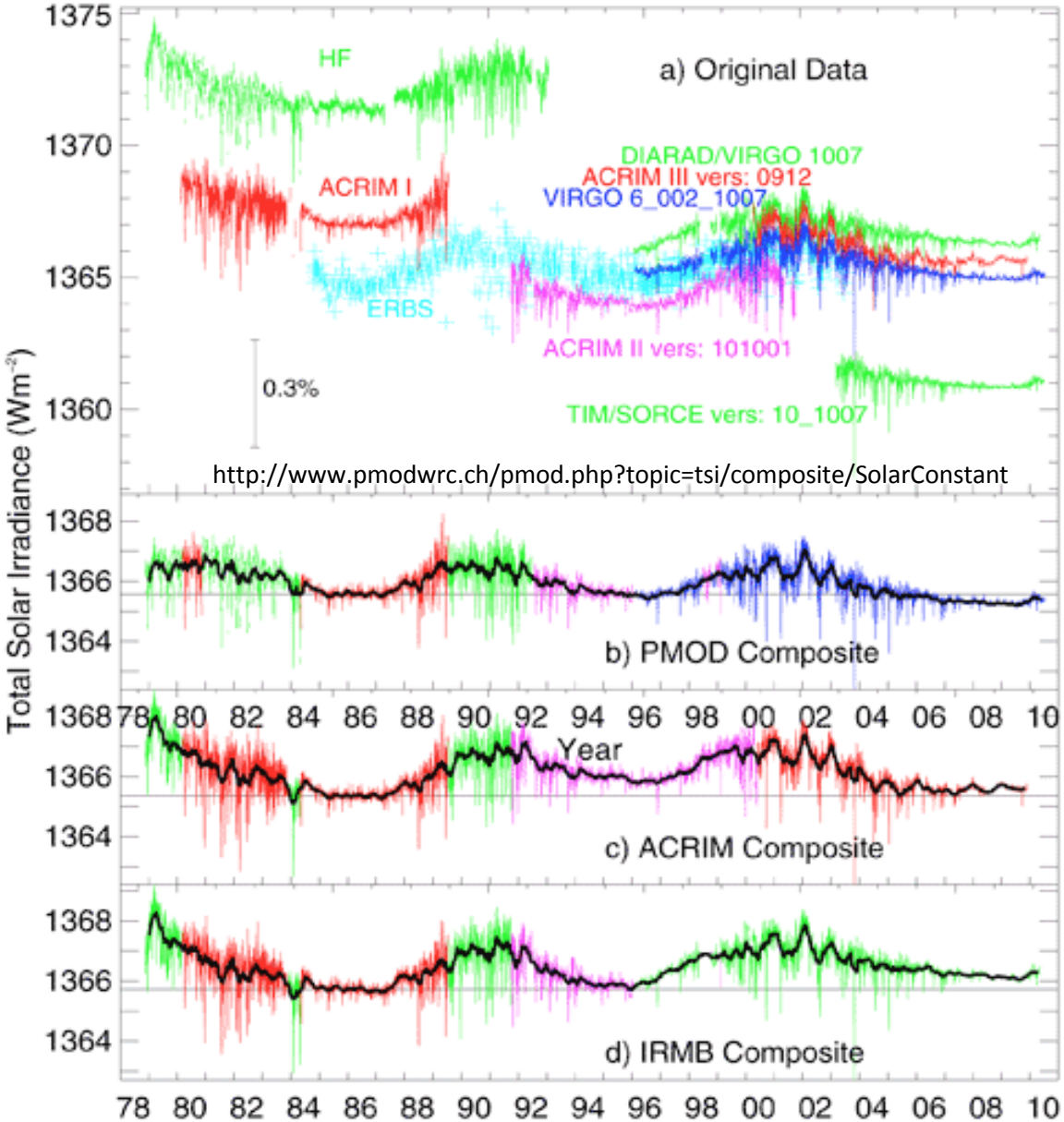


- The solar cycle response (column OH) from annual mean MLS data at TMF is ~ 4% decrease from 2004 to 2009.

Solar Cycle Signal in 13-year FTUVS OH Column Data at TMF



Total Solar Irradiance (TSI) Records from Multiple Satellites



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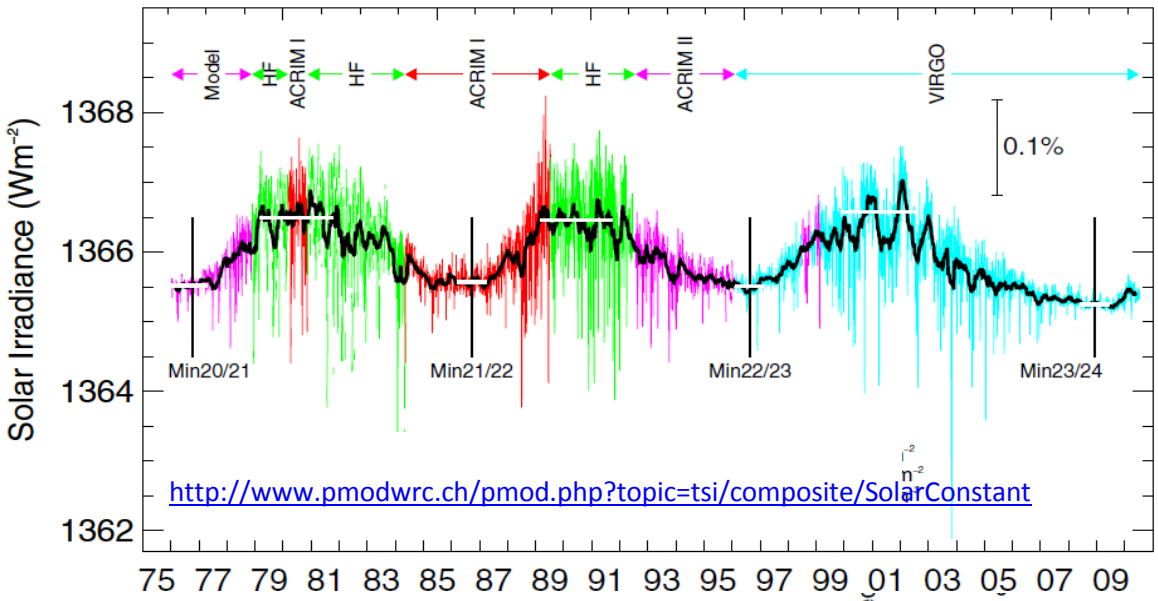
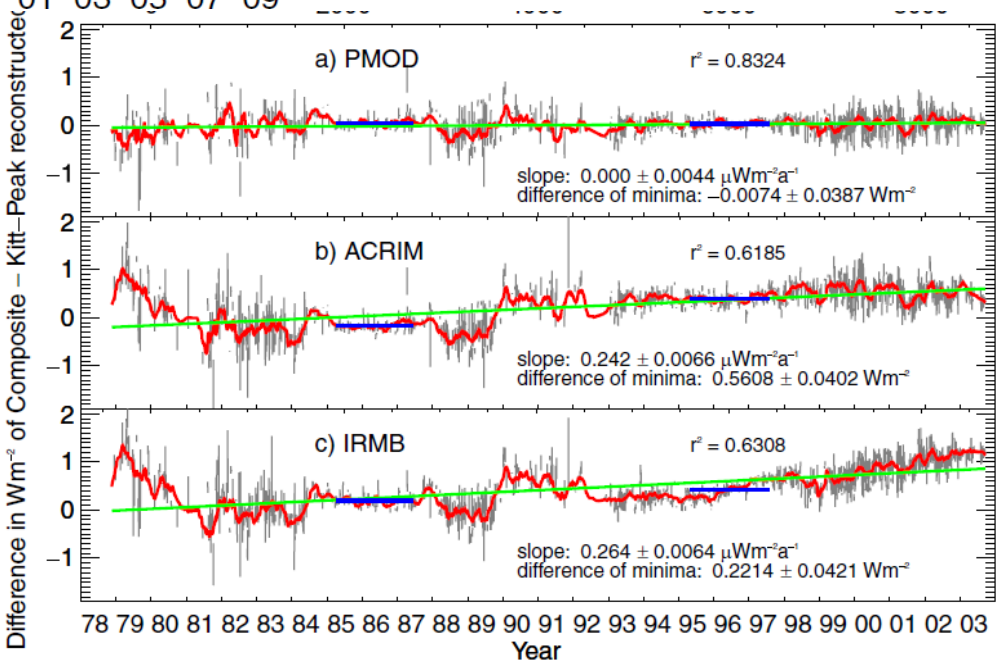


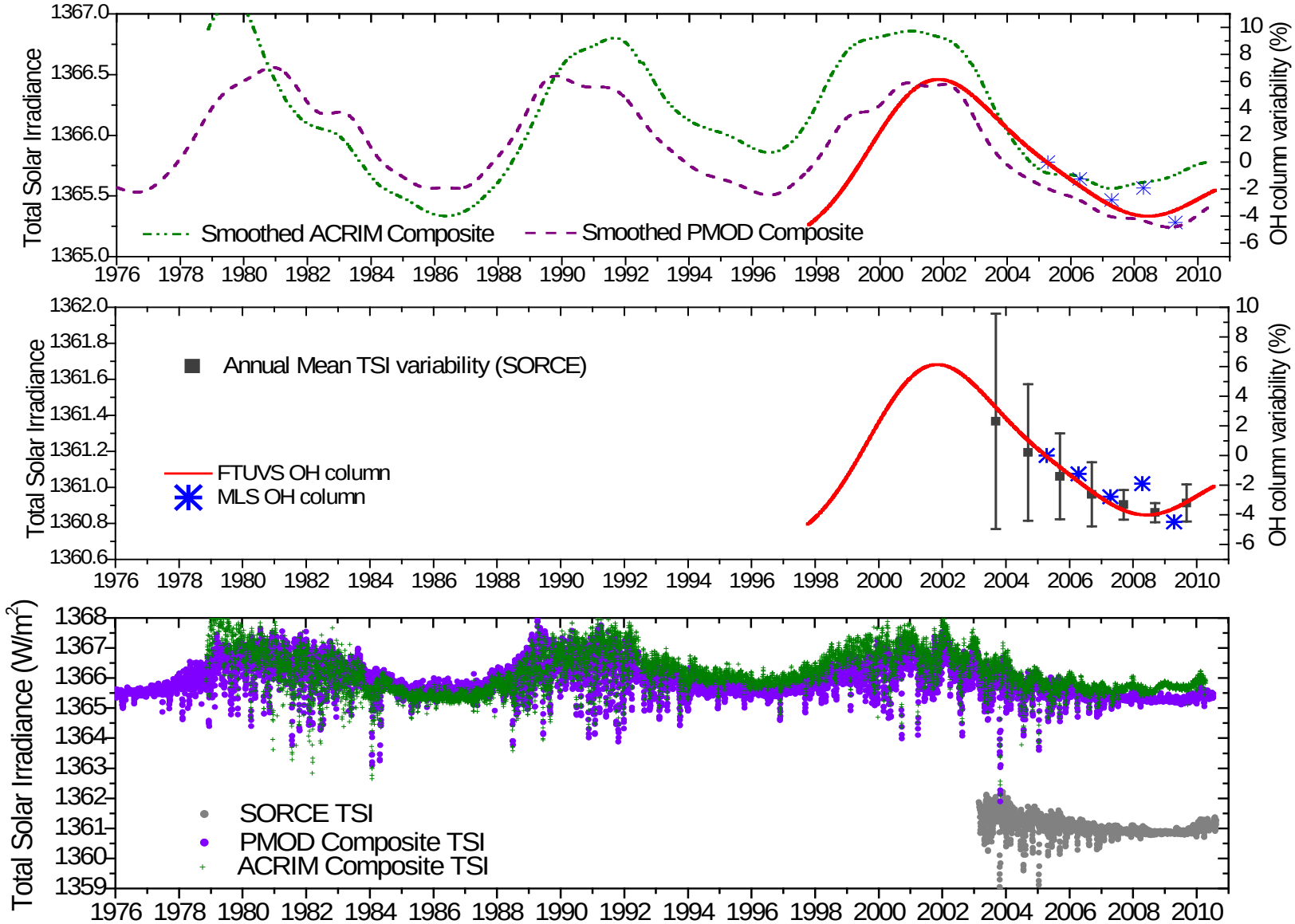
http://www.pmodwrc.ch/pmod.php?topic=tsi/composite/SolarConstant

[Fröhlich, 2006]

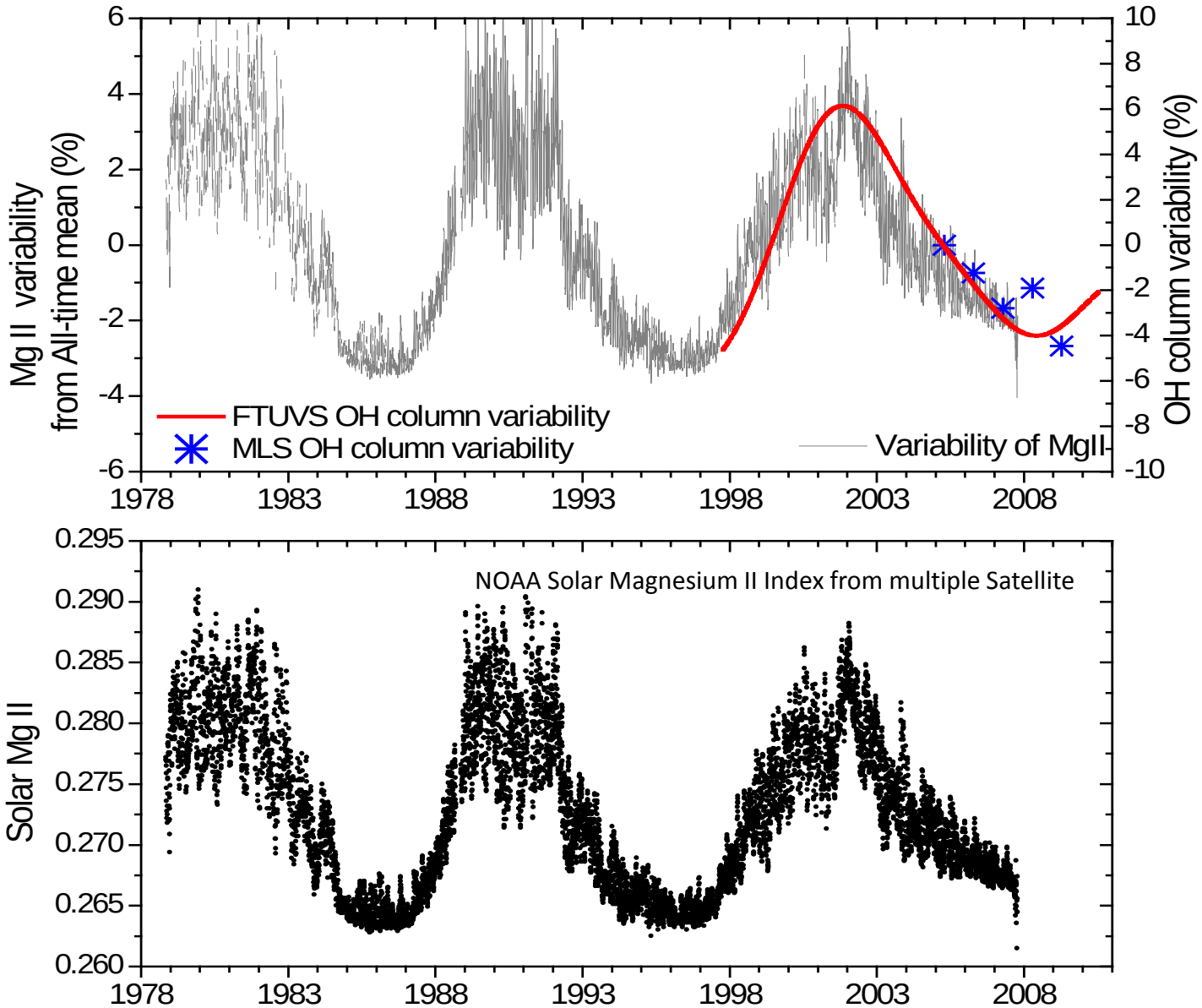
- The comparison of the three composites with a reconstruction of TSI (based on Kitt-Peak magnetograms [Wenzler, 2005]) shows that PMOD is the most reliable TSI composite.



Observed OH Variation is in Phase with the Solar Cycle (TSI)



Observed OH Variation is in Phase with the Solar Cycle (Mg II)



Summary

• The 5-year MLS global OH observations and the 13-year OH column data from FTUVS at TMF provide a great opportunity to study the hydrogen chemistry variation in the middle atmosphere, in particular, the response to the solar 11-year cycle.

• MLS OH climatology shows a clear decreasing trend during 2004-2009. The vertical profiles of such variability show two peaks at the two density peaks of OH. The integrated MLS OH columns show a decrease of ~4-5%.

• The FTUVS OH columns show a variability of ~10% (peak to valley) due to the solar 11-year cycle.

• The comparison of observed OH variability and with the TSI and Mg II records confirms that the 10% variability in OH column is associated with the solar cycle.

• **Ongoing work – Modeling the OH response to solar cycle:** Detailed modeling studies are required to fully understand the mechanisms through which solar variability governs the middle atmospheric chemistry. One of the largest uncertainties in such modeling work is the solar output variability.

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