

Microwave Limb Sounding

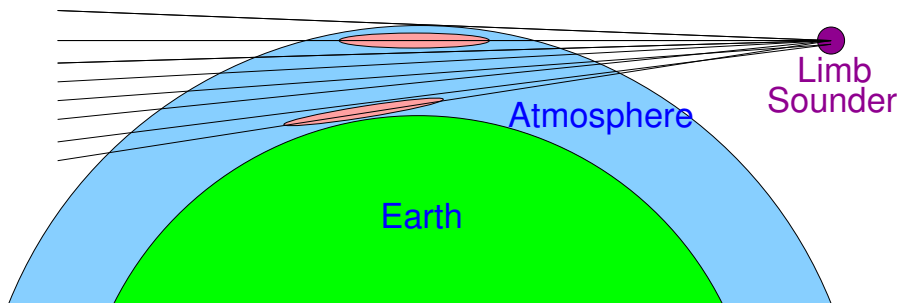
Hugh Pumphrey

The University of Edinburgh

November 6, 2012



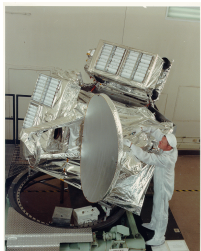
Limb Sounding



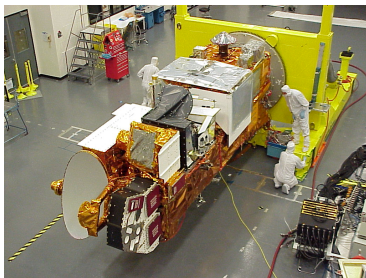
- Advantages:
 - ▶ Long path
 - ▶ Dark background
 - ▶ Good vertical resolution (limited by scan step and antenna beamwidth)
- Disadvantages:
 - ▶ Low horizontal resolution
 - ▶ Troposphere too opaque to see into



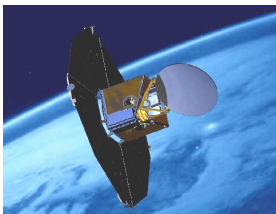
Some microwave limb-sounding missions



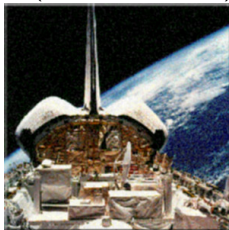
UARS MLS (1991-2001)



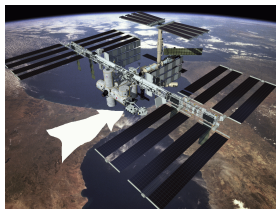
EOS MLS (Aura: 2004-current)



Odin SMR (2001-current)



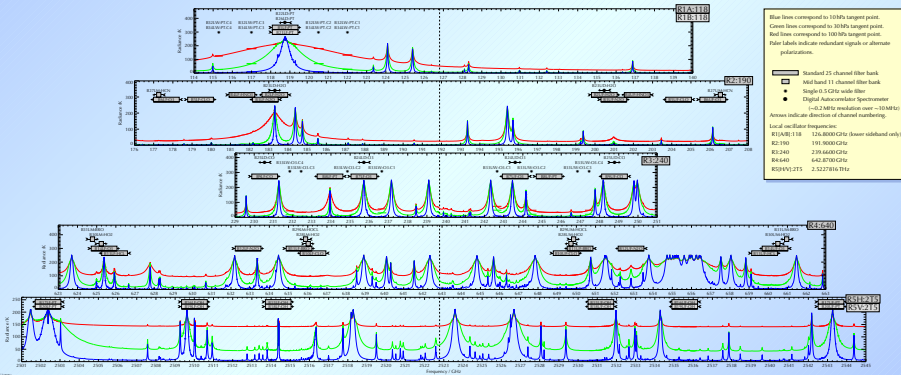
MAS (shuttle, 1991)



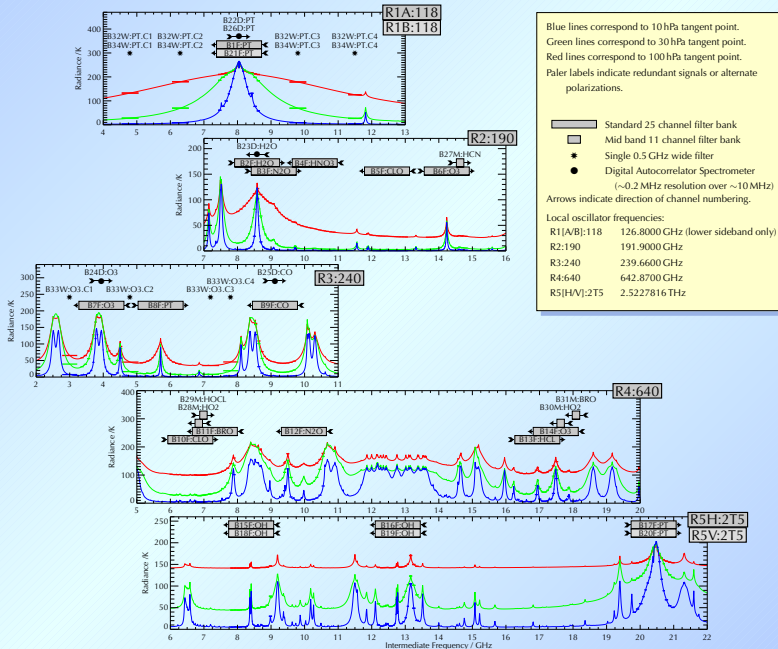
SMILES (ISS, 2009)



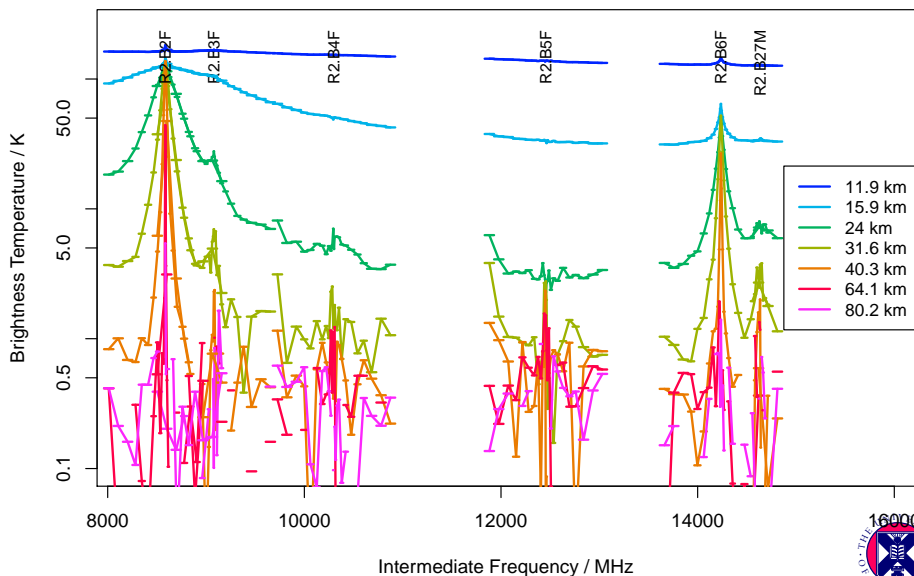
EOS MLS Spectral Coverage (split sideband)



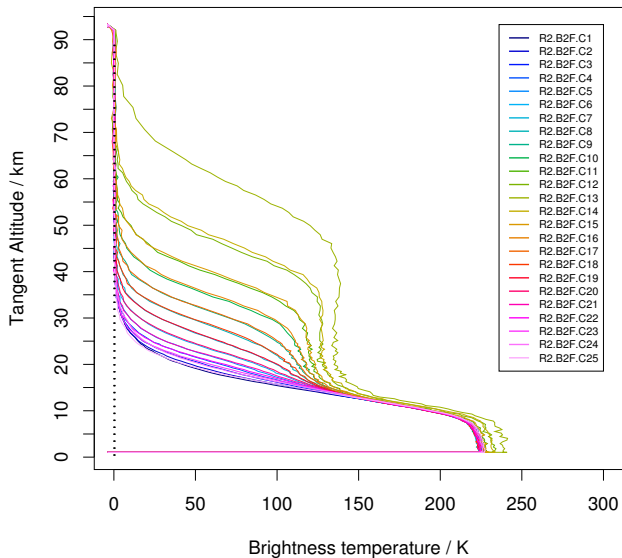
EOS MLS Spectral Coverage (folded sideband)



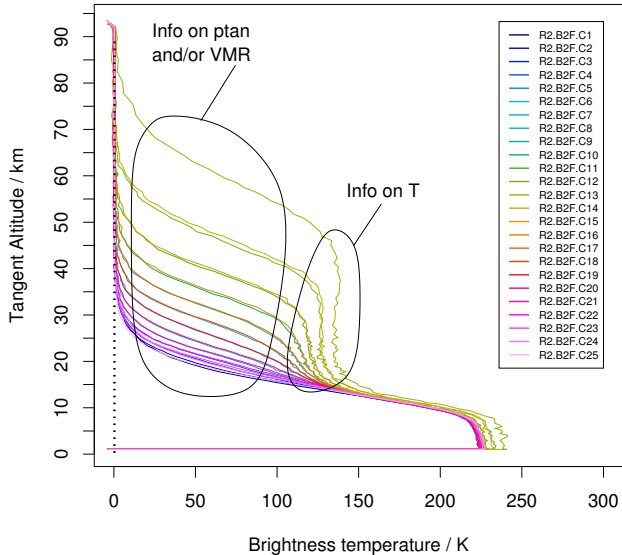
Spectrum from EMLS: single scan, 191 GHz radiometer



Radiance vs Height: 183 GHz H₂O Line



Radiance vs Height: 183 GHz H₂O Line

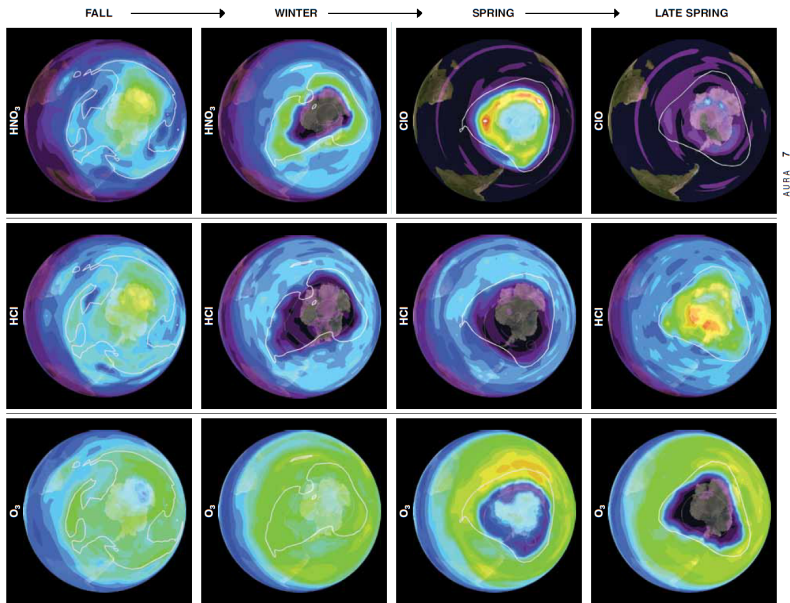


The inverse problem

Nadir Measurement	Nadir State	Limb Measurement	Limb State
Radiances	Temperature H ₂ O Clouds SST	Radiances Tan. Height	Temperature Ref. GPH Tan. Pressure Clouds H ₂ O O ₃ HCl, ClO N ₂ O Other Species



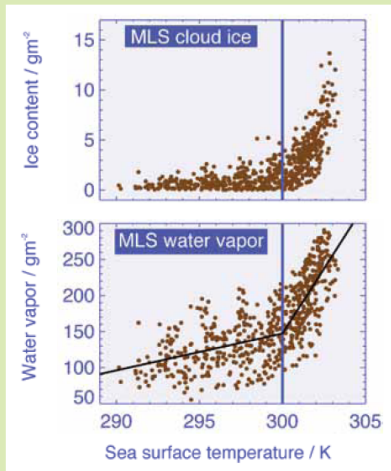
Results from EOS MLS: Ozone hole details



Results from EOS MLS: clouds / H₂O

Upper Troposphere

MLS measurements of cloud ice and water vapor over warm and cool parts of the tropical ocean. The increase in ice and water vapor as the ocean temperature increases suggests that as convection increases over warm seas, high cloud amounts [or cloud amounts] will increase. Sea surface temperatures are expected to rise as the planet warms and this result suggests that tropical high clouds will increase, amplifying the warming.

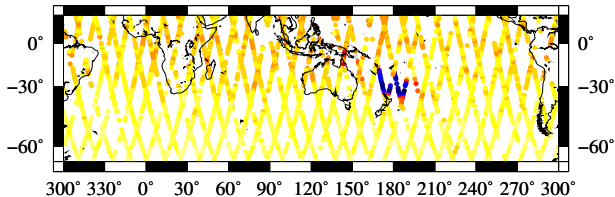


This figure and previous one from glossy NASA publication *Discoveries from EOS Aura* http://mls.jpl.nasa.gov/docs/aura_discoveries.pdf

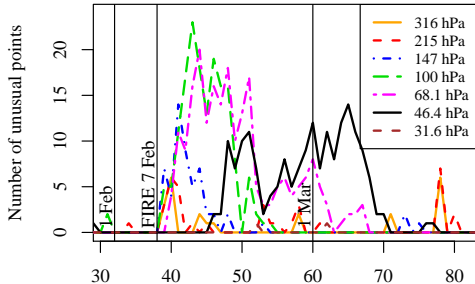
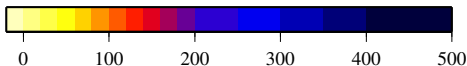


Results from EOS MLS: Black Saturday

300° 330° 0° 30° 60° 90° 120° 150° 180° 210° 240° 270° 300°



CO at 100 hPa on 12 and 13 February, 2009.



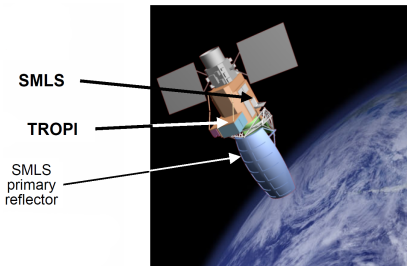
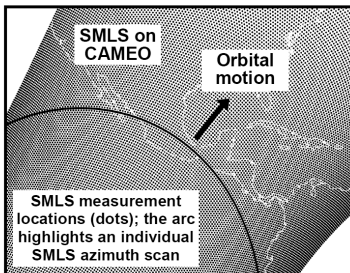
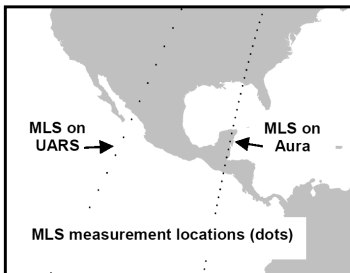
Time series of statistically-unusual CO ($> 4.2\sigma$)

Figures from Pumphrey et al, ACP 11, 6285-6296, (2011)

Time / Day of 2009



The future: horizontal scanning and bigger antennas



The future: horizontal scanning and bigger antennas

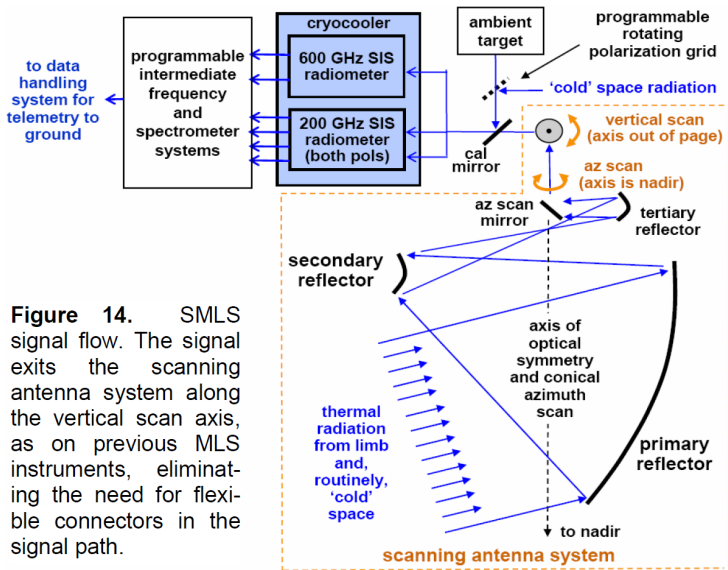
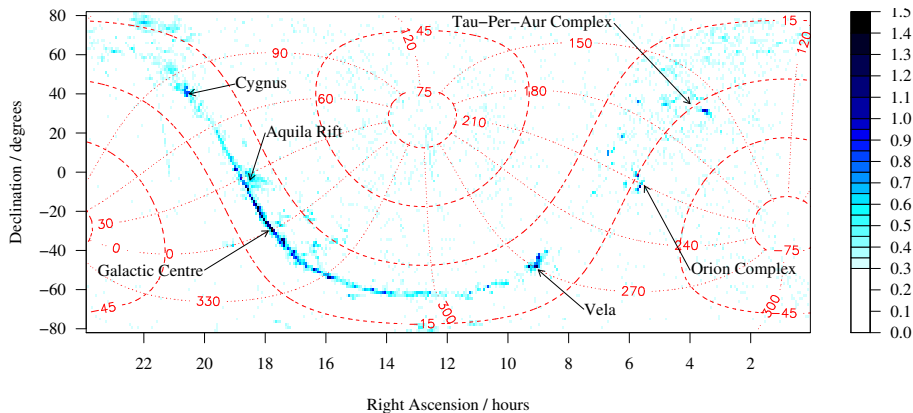


Figure 14. SMLS signal flow. The signal exits the scanning antenna system along the vertical scan axis, as on previous MLS instruments, eliminating the need for flexible connectors in the signal path.

That dark background ...



- ... not so dark if you are looking for CO
- Sky map shows brightness temperature in K, as measured by EOS MLS

From Pumphrey et al., Adv Space Res 43, 342-348 (2009)



Summary

- Microwave Limb sounding mostly used to measure chemistry of the upper troposphere, stratosphere and mesosphere.
 - ▶ but also gives quite good temperature/GPH data and interesting cloud data in the upper troposphere.
- Long path length → larger signal against simple, dark background, but limited horizontal resolution
- Future instruments may use
 - ▶ Larger antennae → better vertical resolution
 - ▶ Cross-track scanning → better horizontal resolution between orbits (requires much lower noise)
 - ▶ Superconducting detectors to get that lower noise

