Session 3B: Comparing Models and Observations: Strengths and Limitations of Satellite Data

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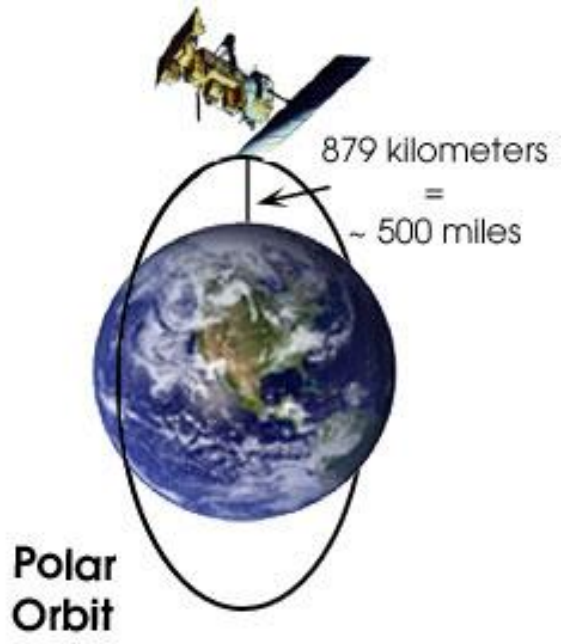
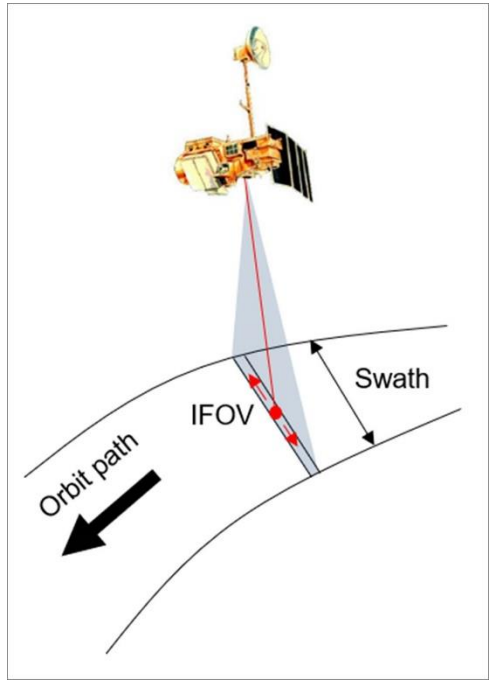
Earth Observations from Polar orbiting Satellites

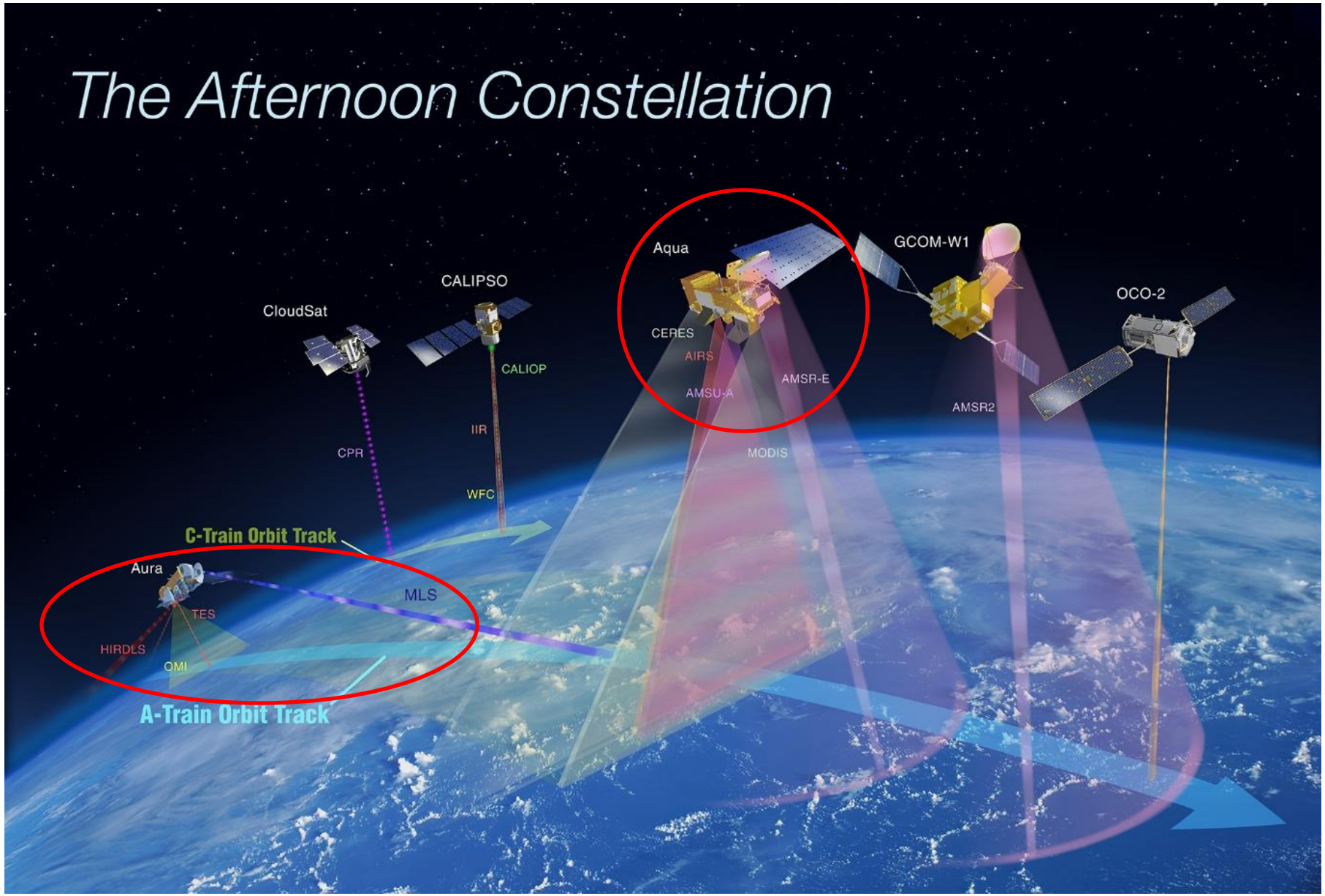


- **Polar orbiting** satellites travel in a circular orbit moving from pole to pole. These satellites collect data in a **swath** beneath them as the earth rotates on its axis. In this way, a polar orbiting satellite can "see" the entire planet twice in a 24 hour period.

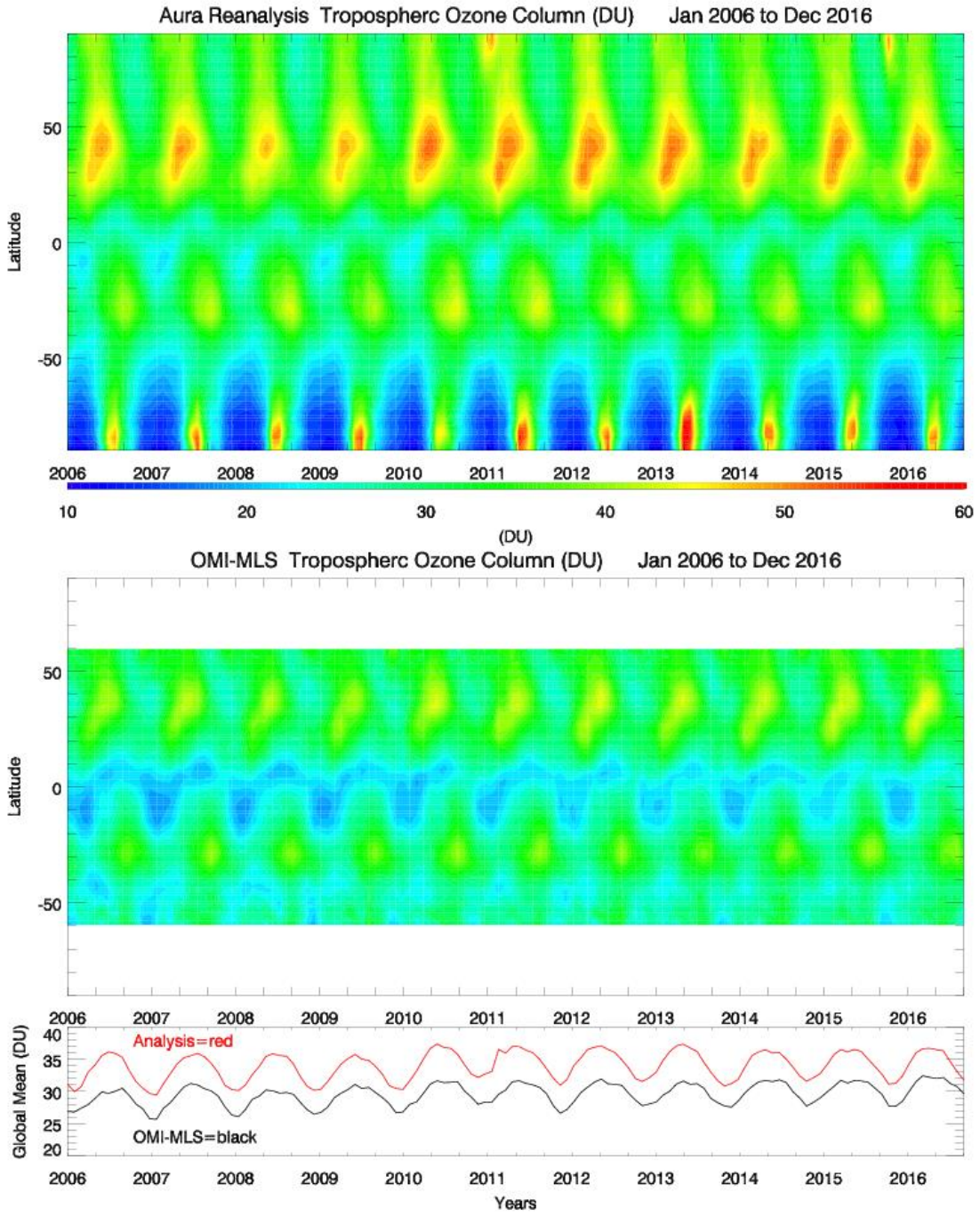
- Polar Orbiting Satellites are inserted into **sun-synchronous orbits** which place the spacecraft in a relatively constant relationship to the sun so that the ascending node will remain at a constant solar time.



This talk will focus on NASA Aura (OMI, MLS) and Aqua (AIRS) satellites



Aura OMI-MLS Tropospheric Ozone Column



Aura Microwave Limb Sounder (MLS) measures profiles of stratospheric O3 (and other species)

The Aura Ozone Monitoring Instrument (OMI) measures total column ozone (and other species)

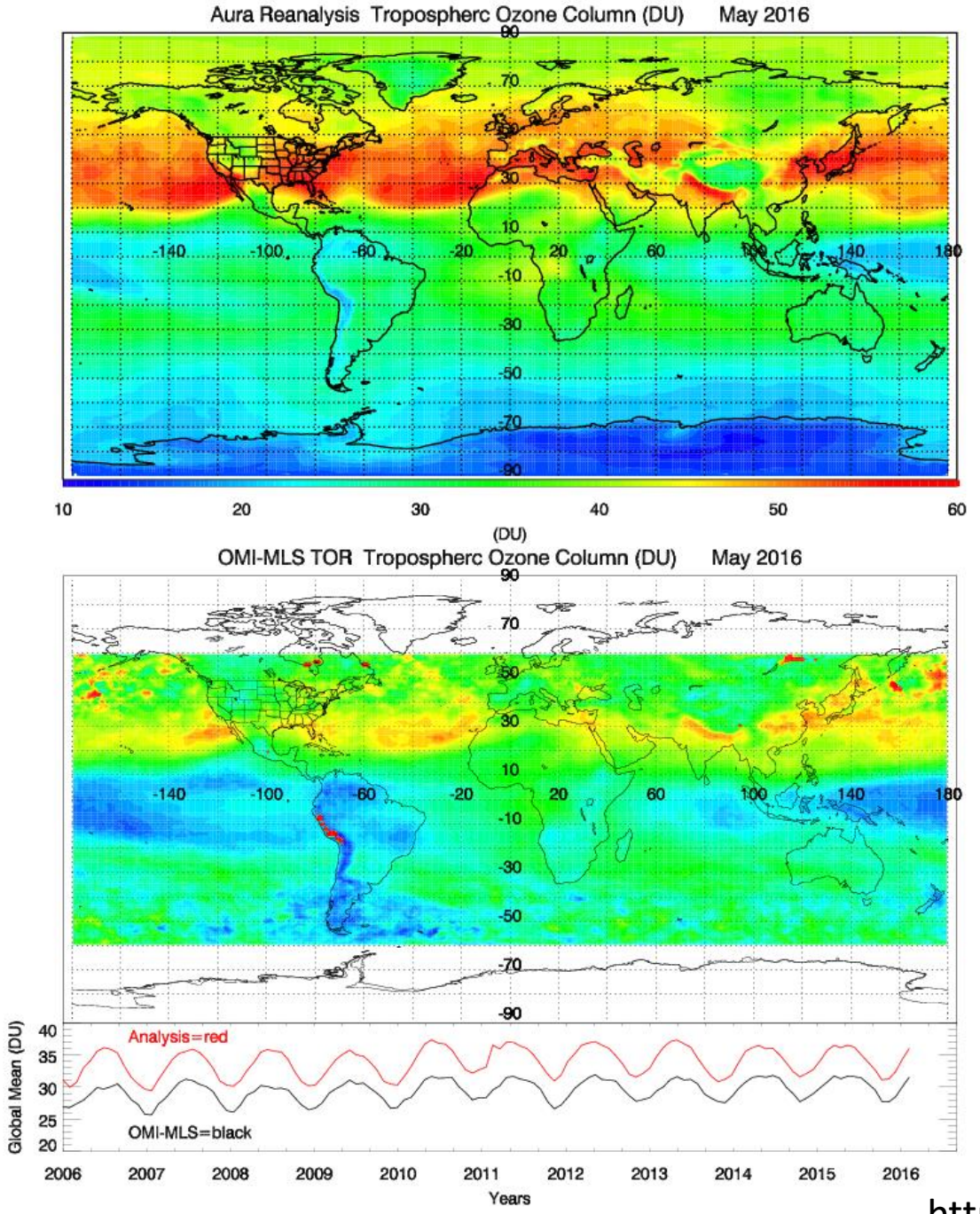
The difference (OMI-MLS, or total – stratospheric column) is called the Tropospheric Ozone Residual (TOR[1])

The long term records of OMI-MLS TOR are useful in evaluating chemical reanalyses such as the Real-time Air Quality Modeling System (RAQMS) Aura reanalysis which assimilates OMI and MLS O3 retrievals

Comparisons between RAQMS Aura and OMI-MLS TOR show that RAQMS is systematically high by ~4 Dobson Units (DU)

[1]Ziemke, J. R., S. Chandra, B. N. Duncan, L. Froidevaux, P. K. Bhartia, P. F. Levelt, and J. W. Waters (2006), Tropospheric ozone determined from Aura OMI and MLS: Evaluation of measurements and comparison with the Global Modeling Initiative's Chemical Transport Model, J. Geophys. Res., 111, D19303, doi:10.1029/2006JD007089.

Aura OMI-MLS Tropospheric Ozone Column



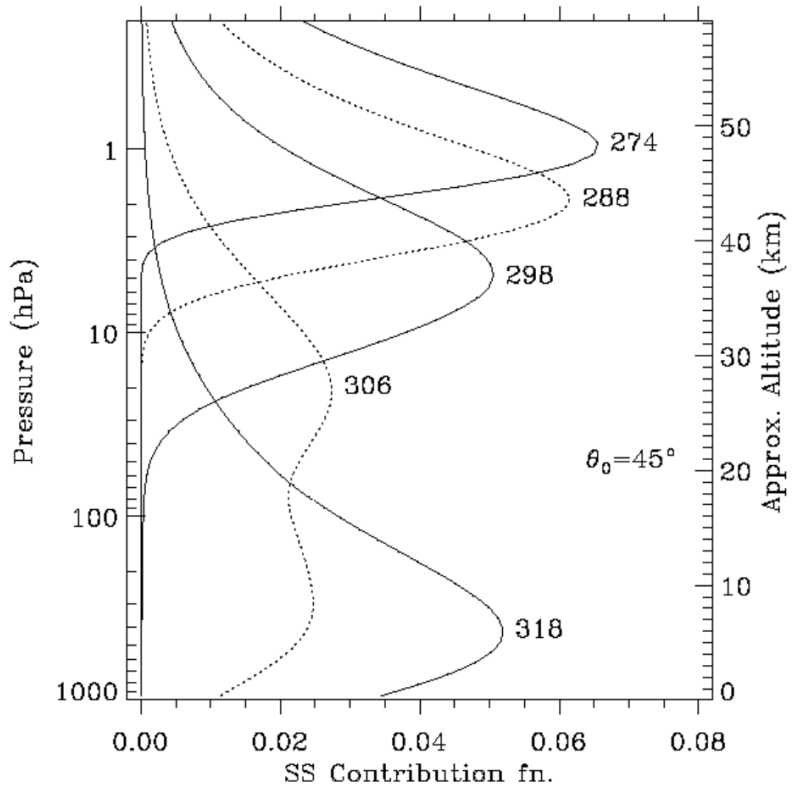


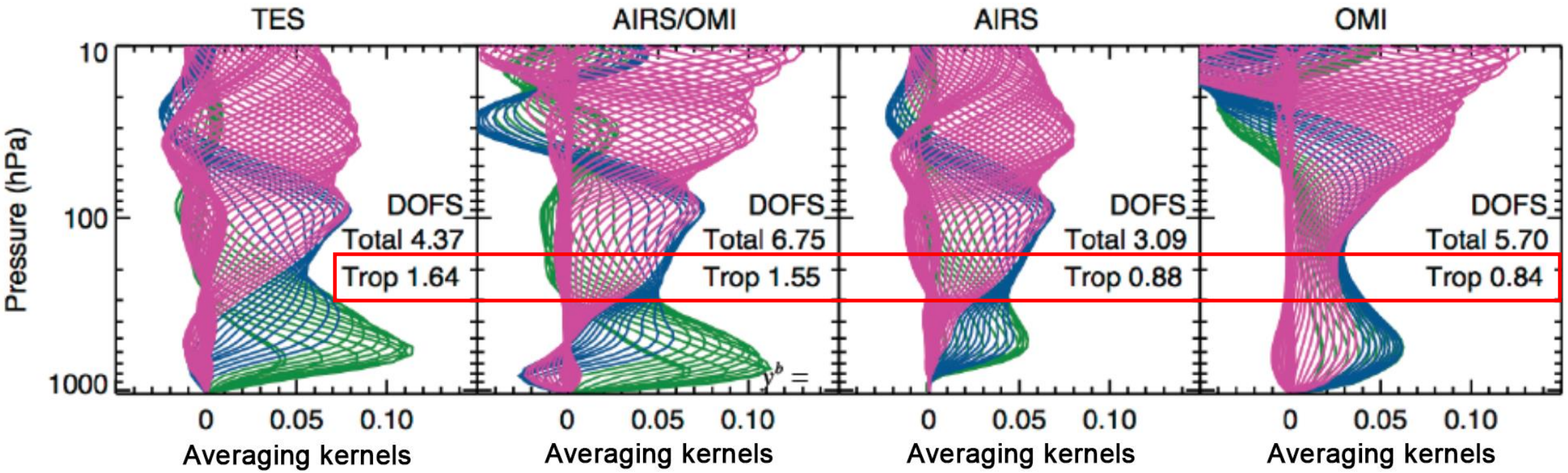
Figure 1-2: Radiance Contribution Functions

- The Aura OMI instrument is less sensitive to tropospheric ozone than to stratospheric ozone.
- Because the OMI-MLS TOR is a monthly product, this sensitivity cannot be accounted for in the comparison

https://eospso.nasa.gov/sites/default/files/atbd/ATBD-OMI-02.pdf

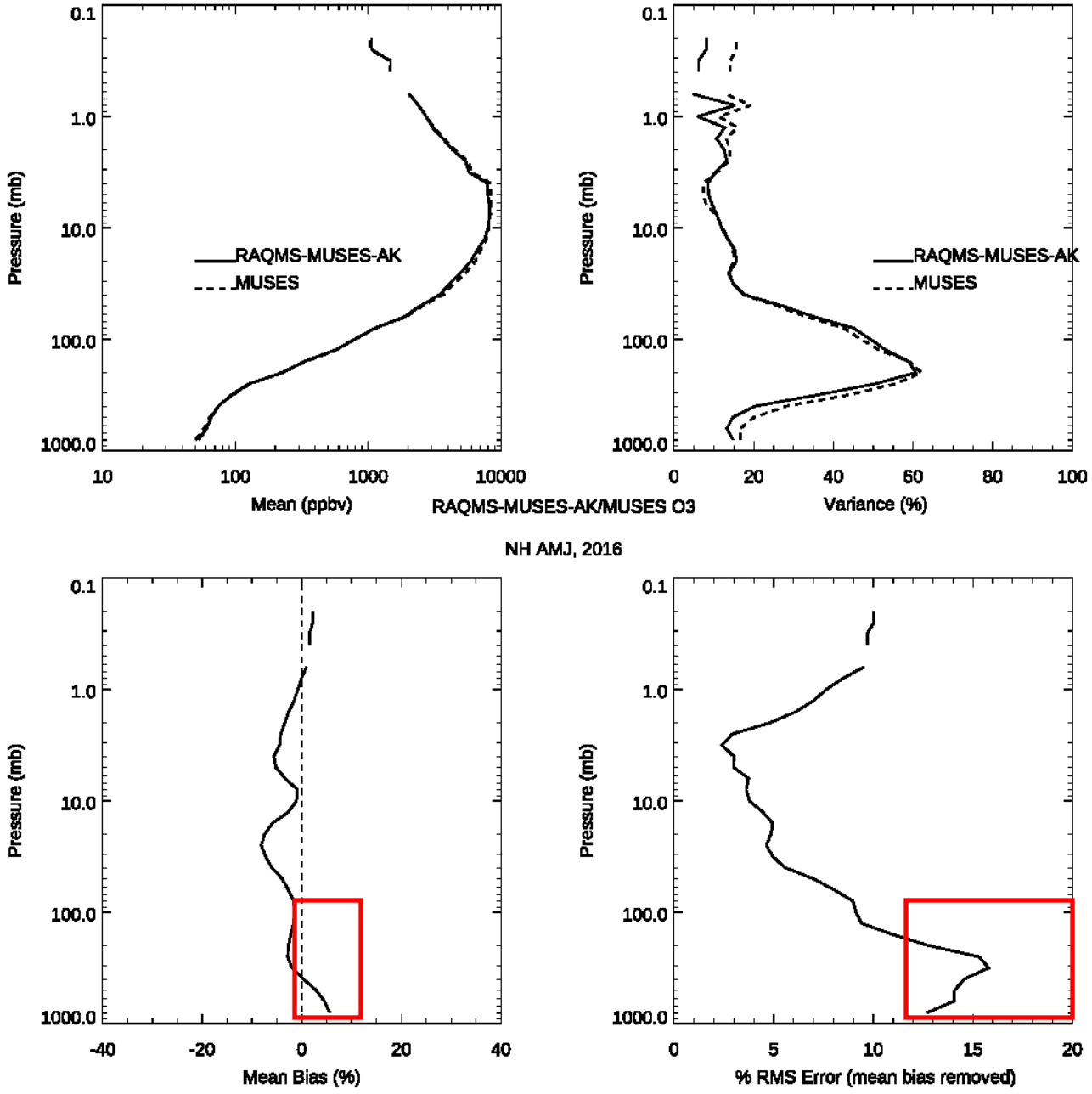
MUlti-SpEctra, MUlti-SpEcies, MUlti-SEnsors (MUSES) AIRS/OMI retrieval algorithm.

Combining Aura OMI Ultra Violet (UV) and Aqua Atmospheric Infrared Sounder (AIRS) hyper-spectral thermal infrared radiances provides an improve approach to measuring lower-tropospheric ozone



Dejian Fu et al, Retrievals of tropospheric ozone profiles from the synergism of AIRS and OMI: methodology and validation Atmos. Meas. Tech., 11, 5587–5605, 2018, https://doi.org/10.5194/amt-11-5587-2018

MUlti-SpEctra, MUlti-SpEcies, MUlti-SEnsors (MUSES) AIRS/OMI retrieval algorithm.

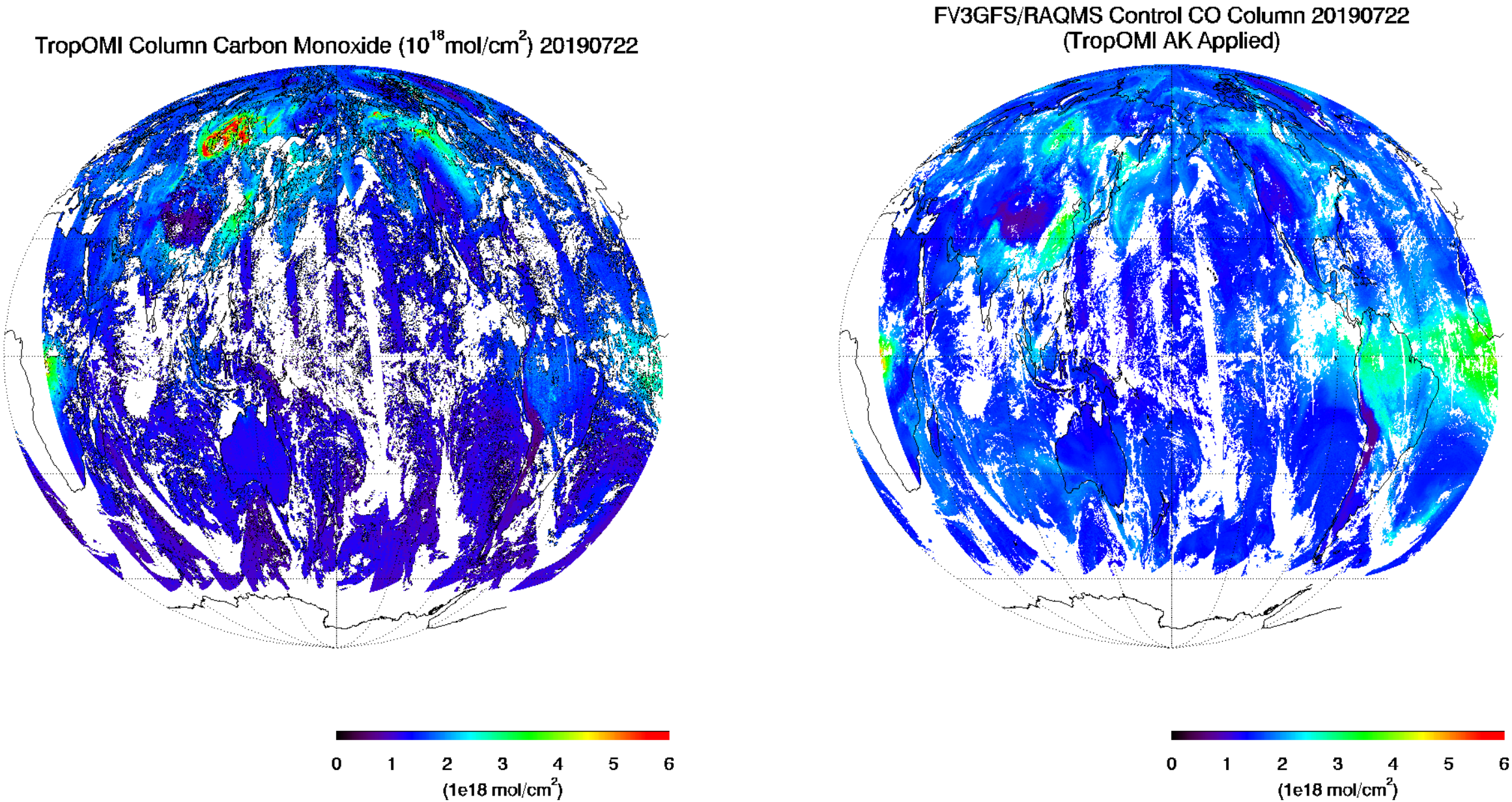


Comparison between RAQMS Aura OMI/MLS ozone analysis (with Averaging Kernels)

- RAQMS Aura Northern Hemisphere April-May-June, 2016 OMI/MLS O3 reanalysis is in very good agreement with MUSES O3 retrievals (mean bias within 5-10%, RMS Error within 15%) when averaging kernels are used

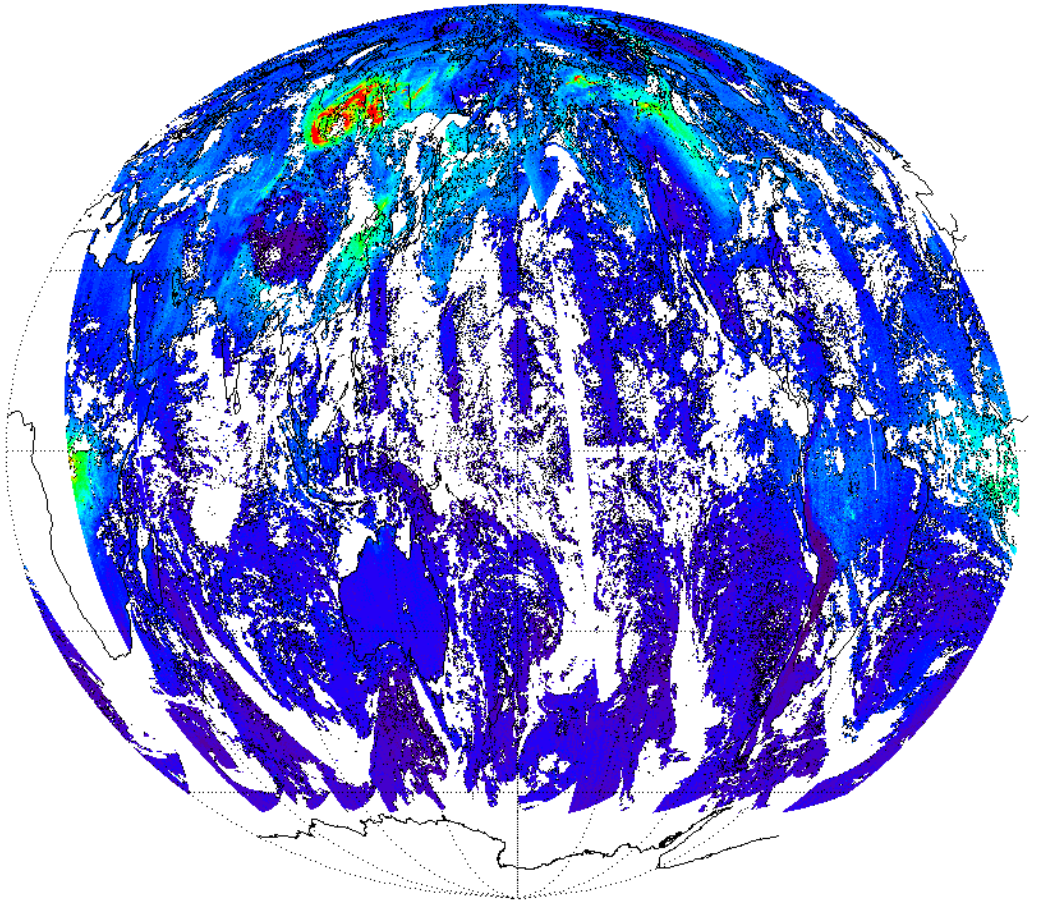
Comparisons between models and satellite data should be done at the orbital swath (L2) level so that the information content of the satellite retrieval can be accounted for

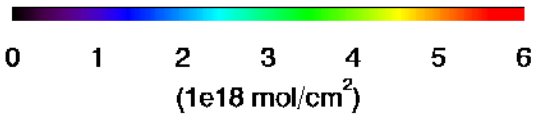
Column Averaging Kernels are also necessary for comparison with TropOMI CO!



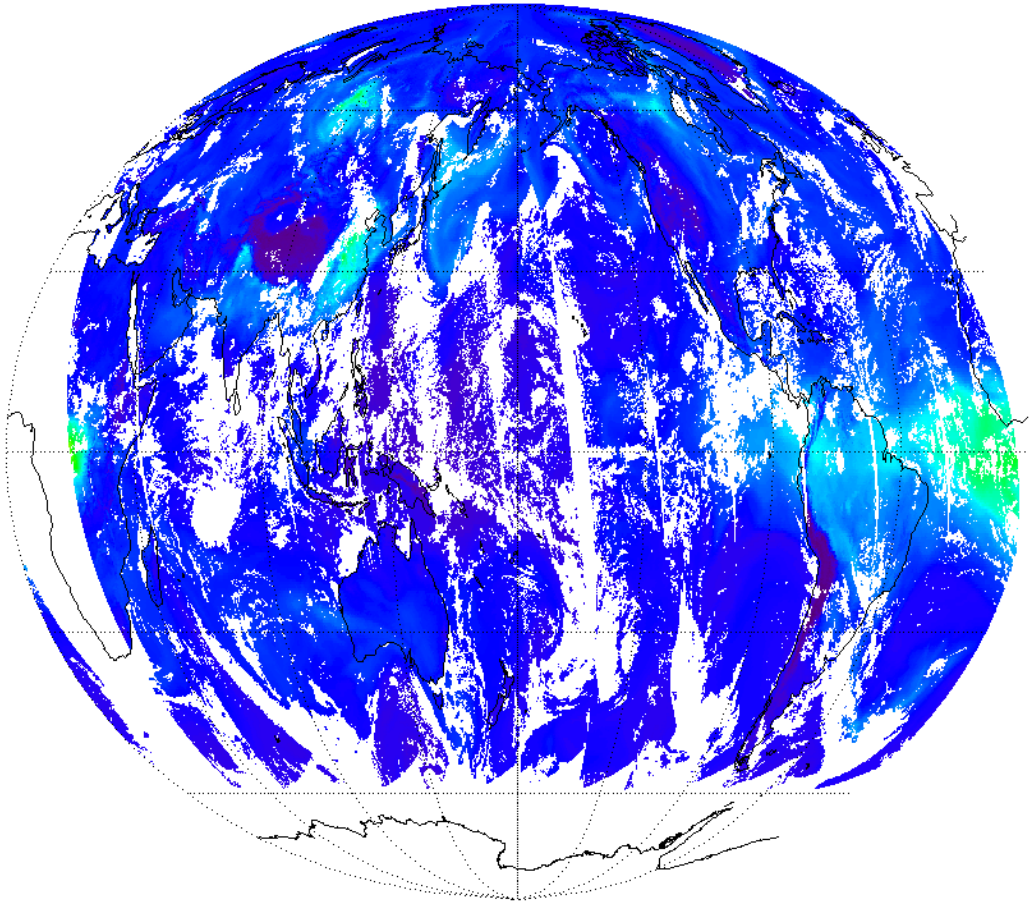
Column Averaging Kernels are also necessary for comparison with TropOMI CO!

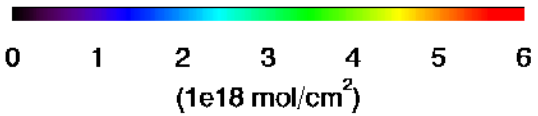
TropOMI Column Carbon Monoxide (10^{18}mol/cm^2) 20190722



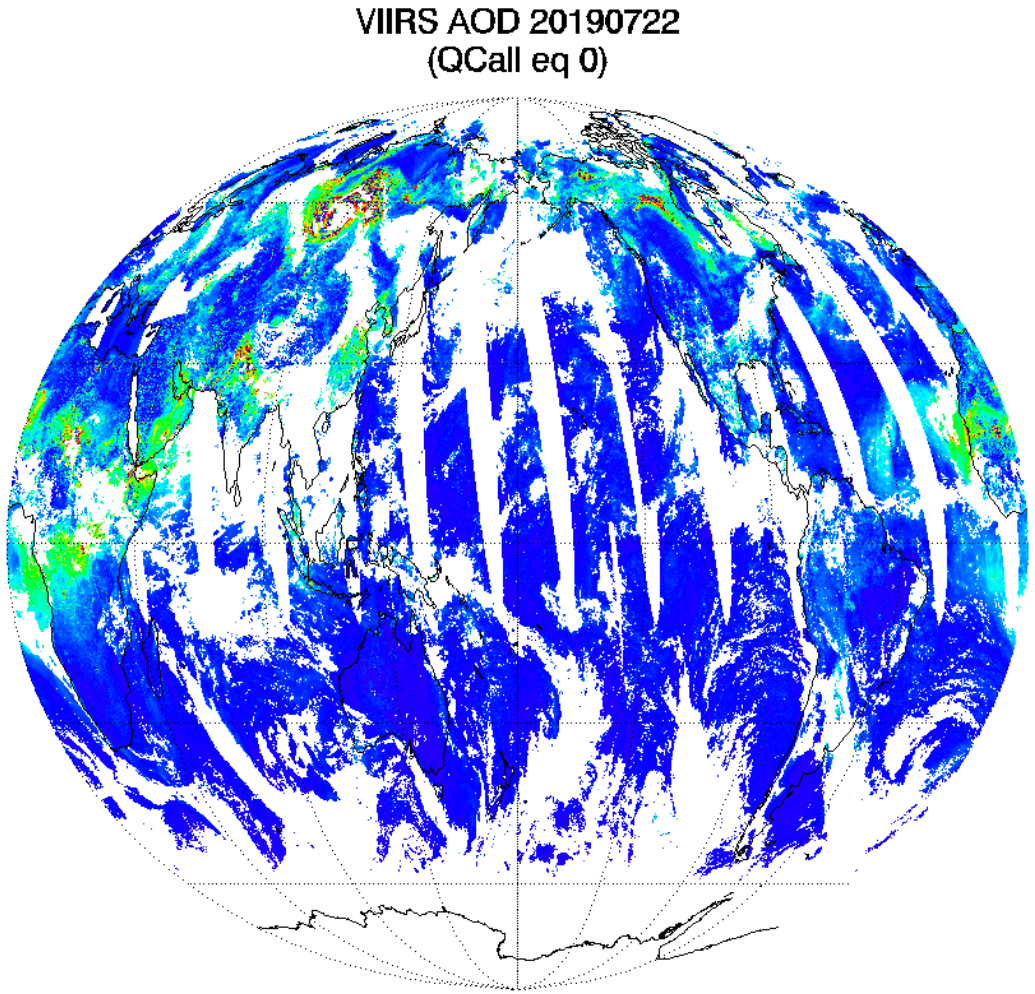


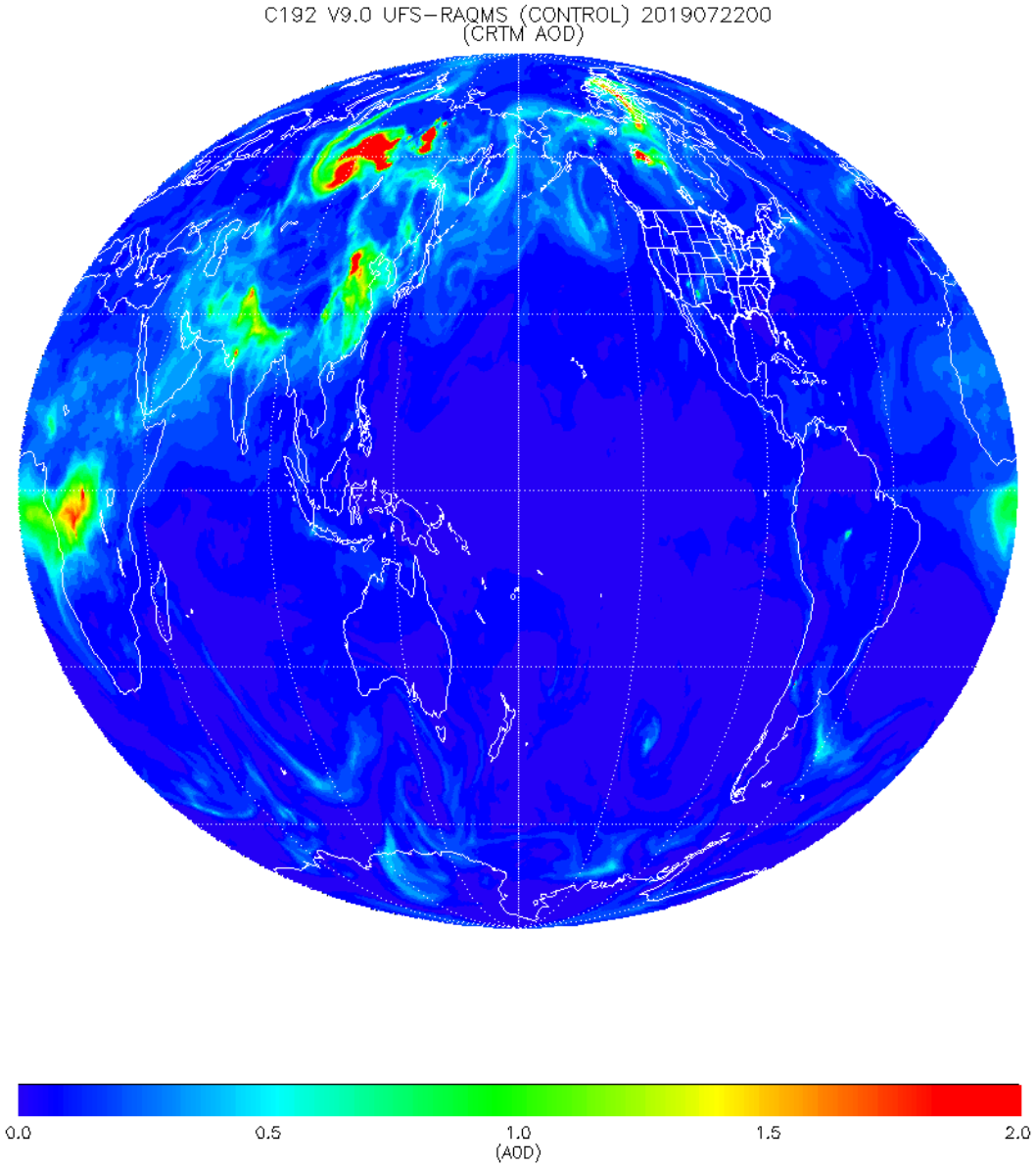
FV3GFS/RAQMS Control CO Column 20190722
(Without TropOMI AK Applied)





Mapping of the model to the satellite swath (L2) is important to capture pollution transport!!



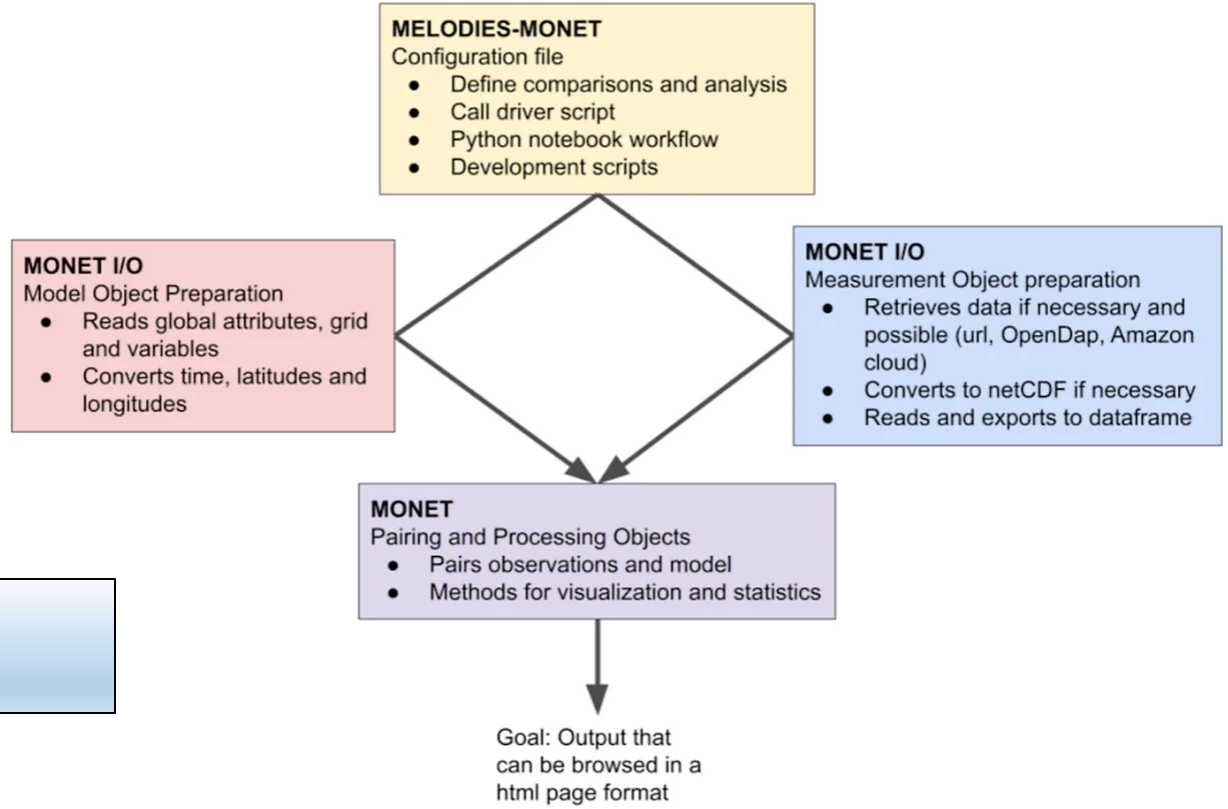



Way to complicated!
?
?
Do I really need to do this?
Where do I get data?
?
?
Where will I get the tools?

MELODIES MONET

A generic, portable, and model-agnostic software that can evaluate against a variety of observations including **surface, aircraft, and satellite data**

Model **E**va**L**uation using **O**bservations, **DI**agnostics and **E**xperiments **S**oftware (**MELODIES**) is being developed as an extension of the **M**odel and **O**bservatio**N** **E**valuation **T**oolkit (MONET) at NCAR in collaboration with scientists in the Air Resources Laboratory, Chemical Sciences Laboratory, and Global Systems Laboratory at NOAA.



Developed in Python (implementing Xarray, NumPy, SciPy, Pandas, and other packages)

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https://www.earthcube.org/melodies-for-musica

https://www2.acom.ucar.edu/modeling/melodies

https://www.arl.noaa.gov/research/surface-atmosphere-exchange-home/tools-and-products/monet/