Three Tropospheric Ozone Products from NASA GSFC as a Pathway for the New Geostationary Platforms

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Why Three Different Tropospheric Ozone Products?

- **Aura OMI/MLS** (monthly, 2004-present, developed product):

→ Trends

- **SNPP OMPS/MERRA2** (daily, 2012-present, in development):

→ Continuing the OMI/MLS trend record

→ Daily maps

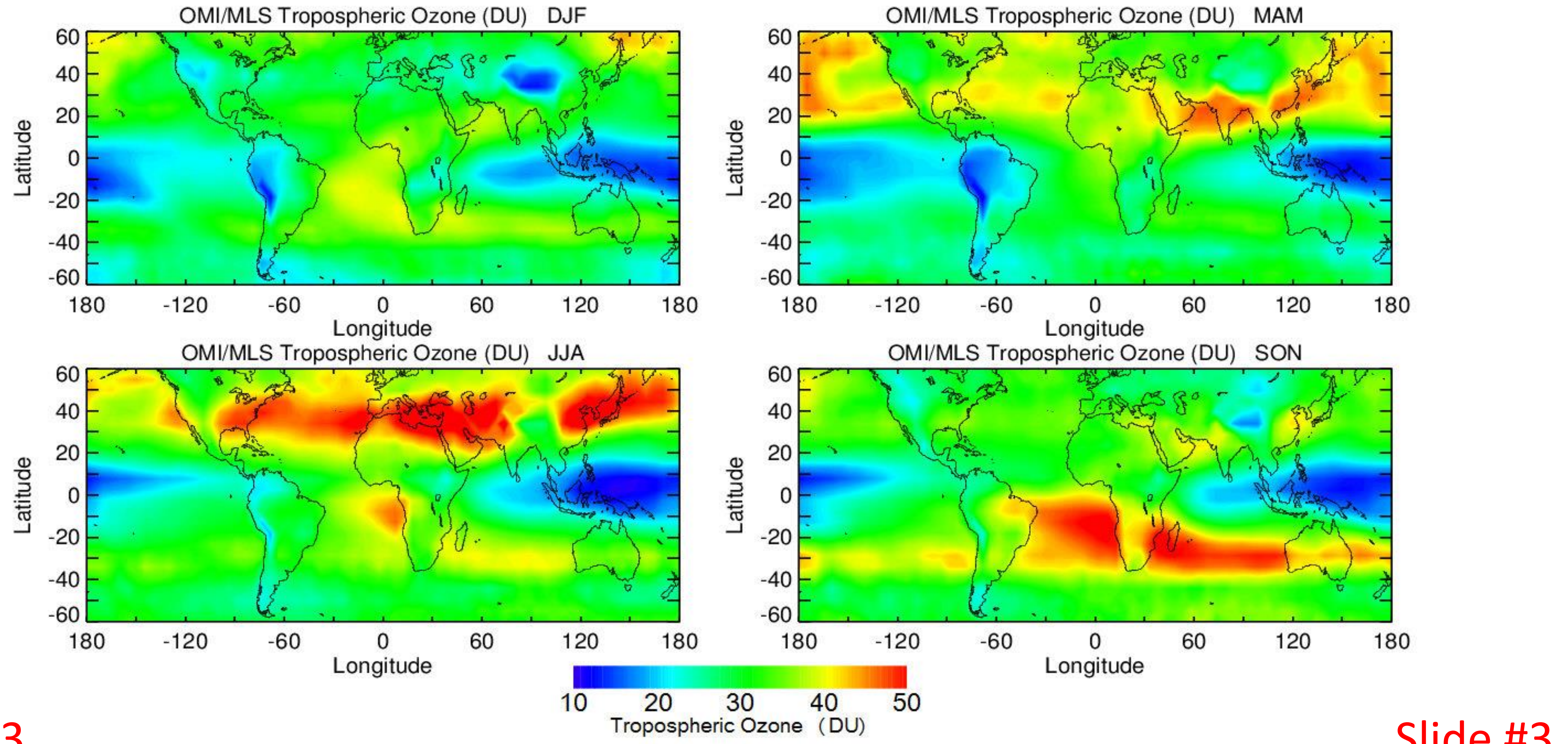
- **DSCOVR EPIC/MERRA2** (1-2 hours, 2015-present, in development):

→ Quasi-hourly synoptic ("snapshot") maps

→ Pathfinder for new geostationary platforms like GEMS and TEMPO

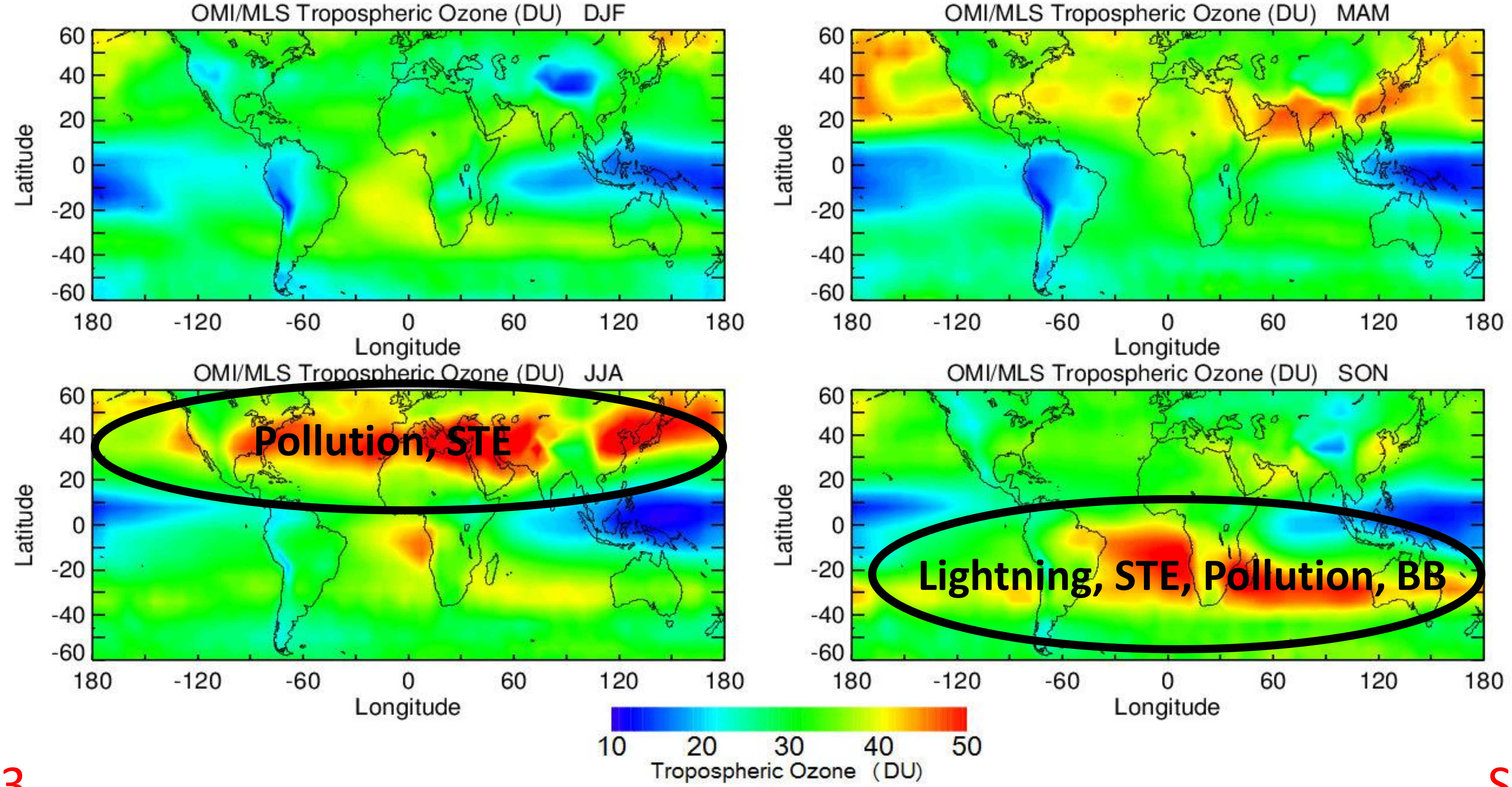
Slide #2

All Three Products Produce Useful Monthly Global Maps (OMI/MLS Shown)



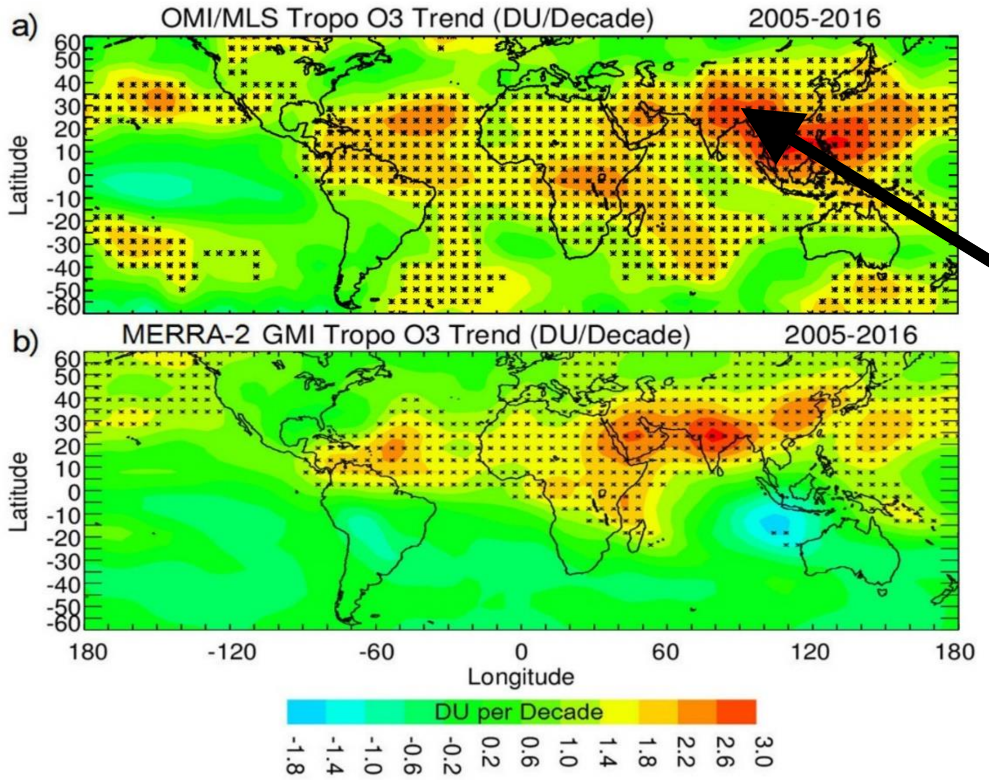
Slide #3

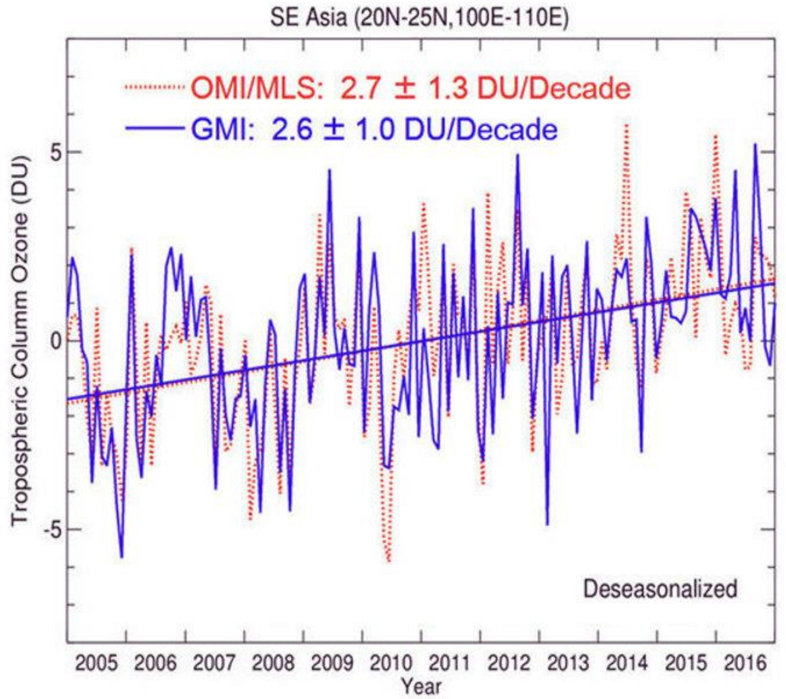
All Three Products Produce Useful Monthly Global Maps (OMI/MLS Shown)



Slide #3 Slide #3

Largest Increases in OMI/MLS Tropospheric Ozone are Measured over Saudi Arabia/India/Southeast Asia Extending Eastward Over Pacific Ocean



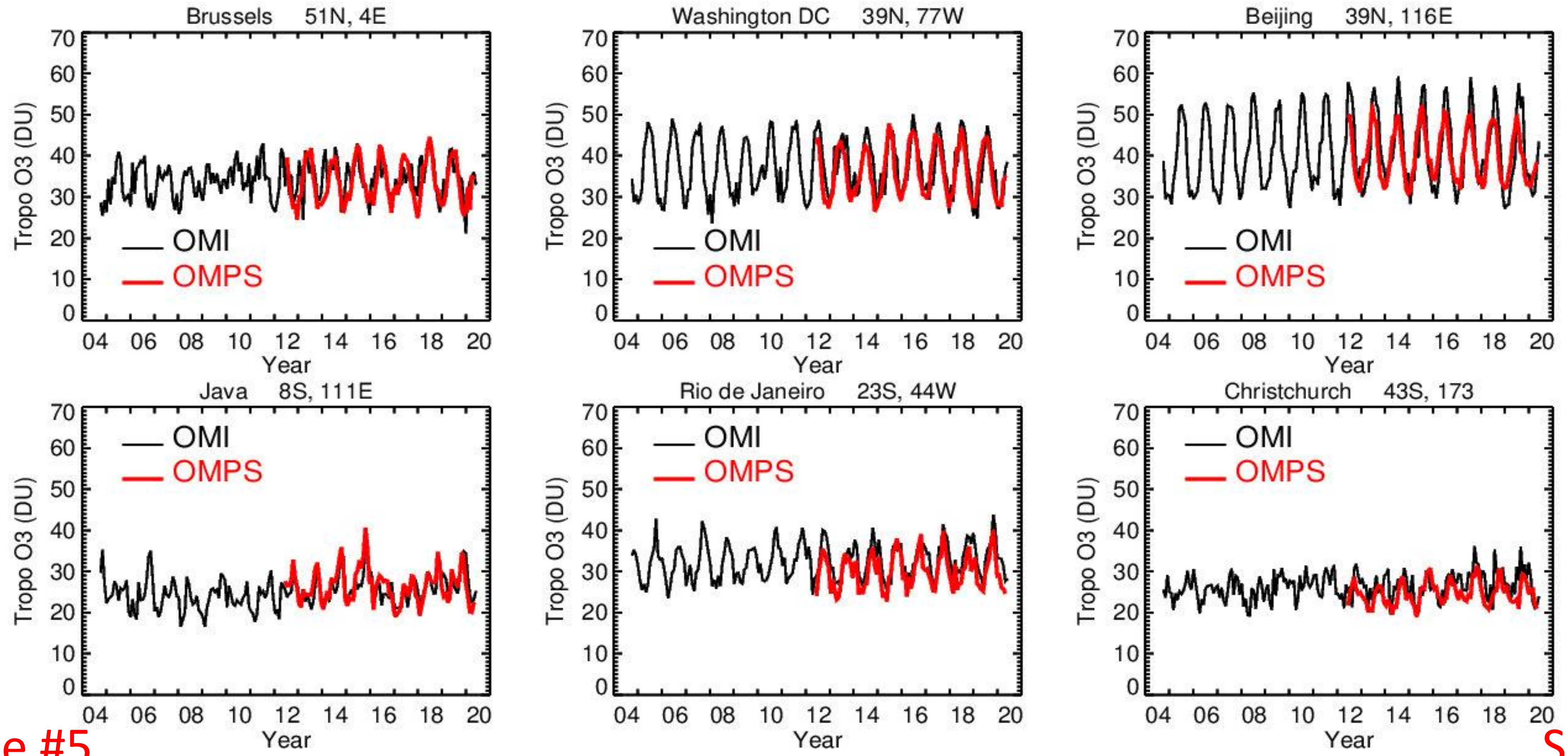


(Ziemke et al., 2019, ACP)

MERRA-2 GMI model indicates that these increases are due to increases in pollution

Slide #4

Trends: OMPS/MERRA2 Will Continue the OMI/MLS Long Record (No Cross-Calibration Applied)

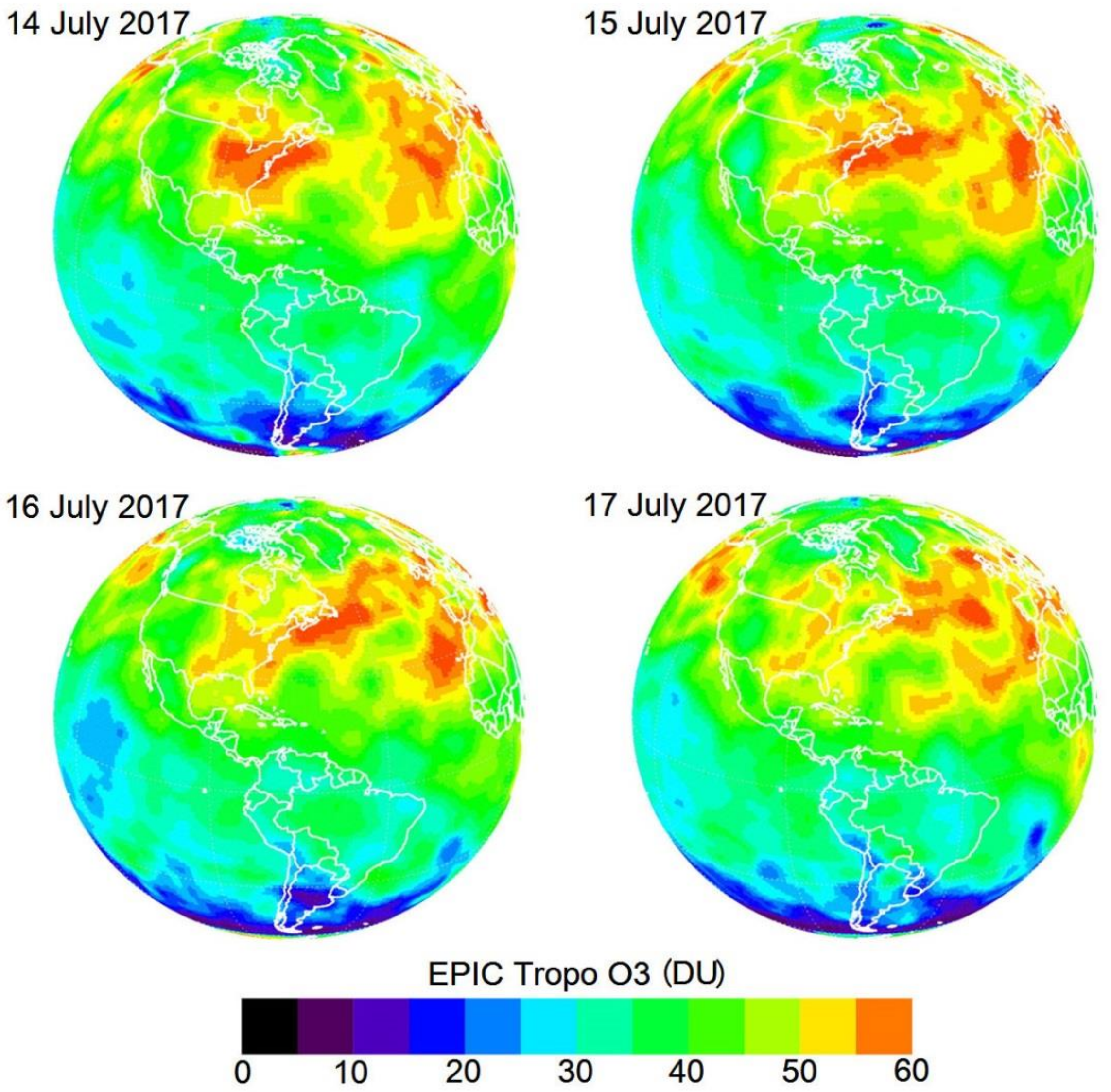


Slide #5

Slide #5

EPIC Synoptic Maps are Available Every 1-2 Hours: EPIC is a Pathfinder for Geostationary Missions

Tracking Mid-latitude "Weather System" Variability of Tropospheric Ozone



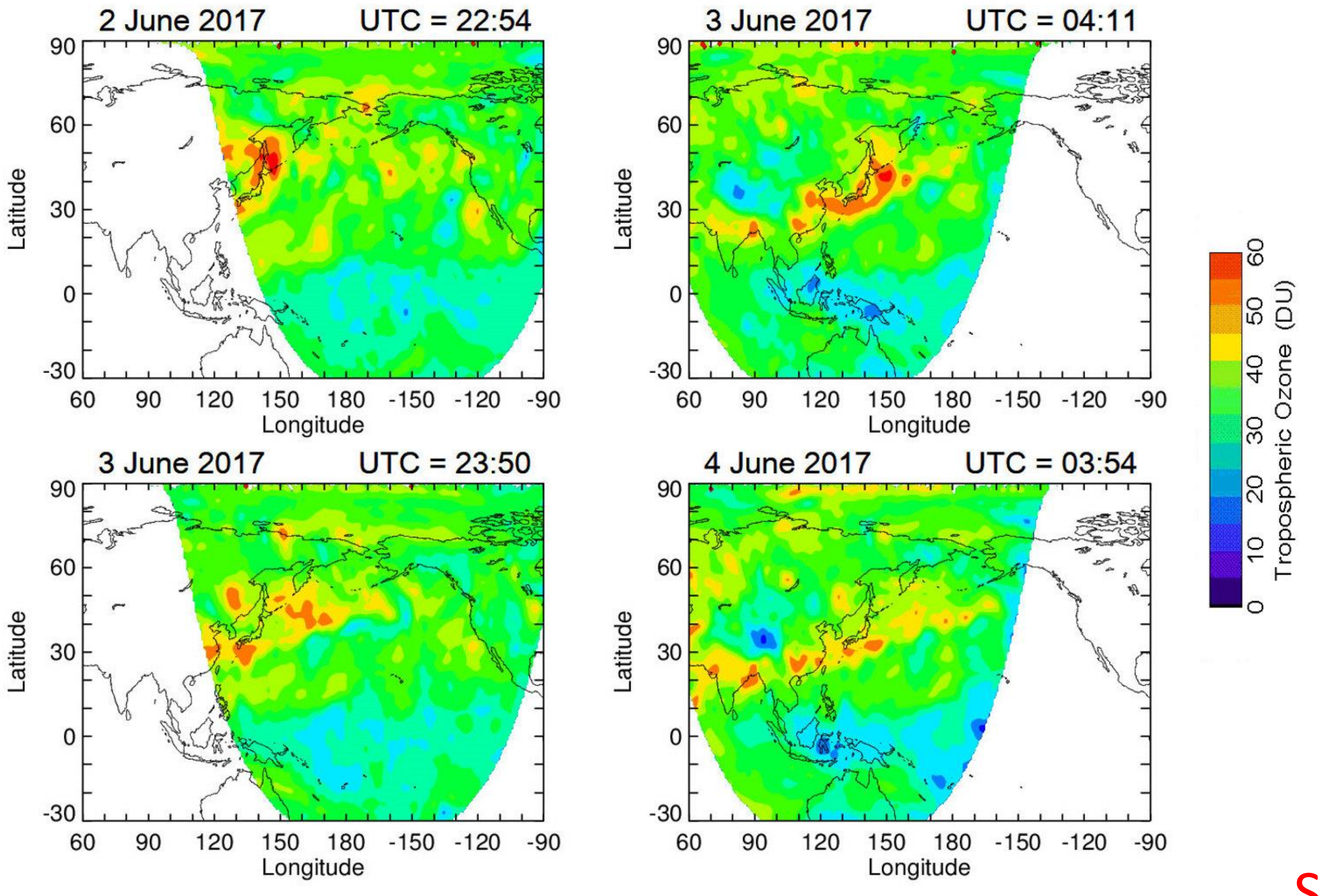
EPIC Daily Averages

Slide #6

EPIC Synoptic Maps are Available Every 1-2 Hours: EPIC is a Pathfinder for Geostationary Missions

Tracking Hourly Changes in Tropospheric Ozone

This is the Pacific Region Covered by GEMS



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Slide #7

Conclusions

Three NASA GSFC products:

1) OMI/MLS (monthly maps) used for monitoring trends

2) OMPS/MERRA2 (daily maps) used for continuing OMI/MLS trend record and producing daily maps

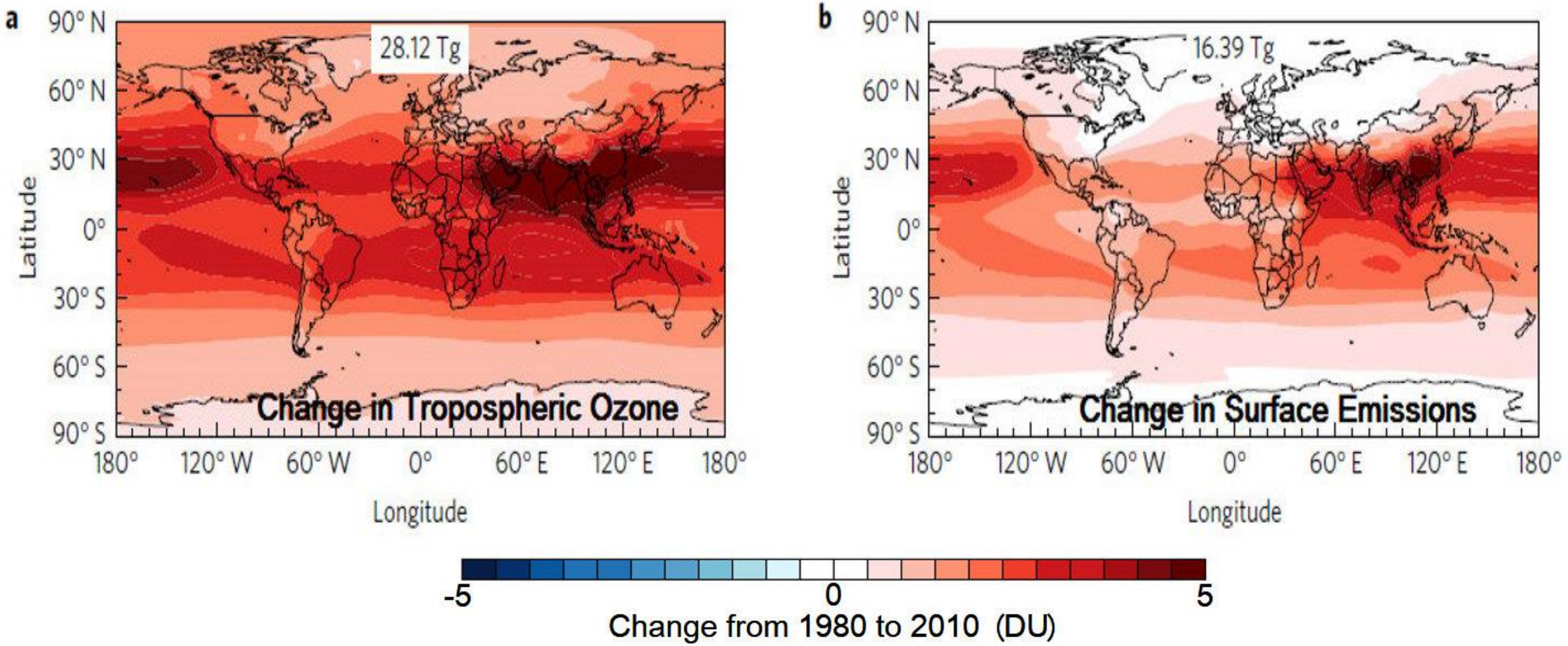
3) EPIC/MERRA2 (hourly maps) used for bridging OMPS/MERRA2 and useful as a pathway for geostationary platform measurements such as from GEMS and TEMPO

Slide #8

EXTRA SLIDES

CAM-Chem Model Simulated Increases in Global Tropospheric Ozone from 1980 to 2010

(Zhang et al. 2016, Nature Geosci.)



Increases in tropospheric ozone throughout the SH from ozonesondes, surface and satellite data

(Lu et al. 2019, Sci. Bul.)

Lu et al. (2018, Science Bulletin)

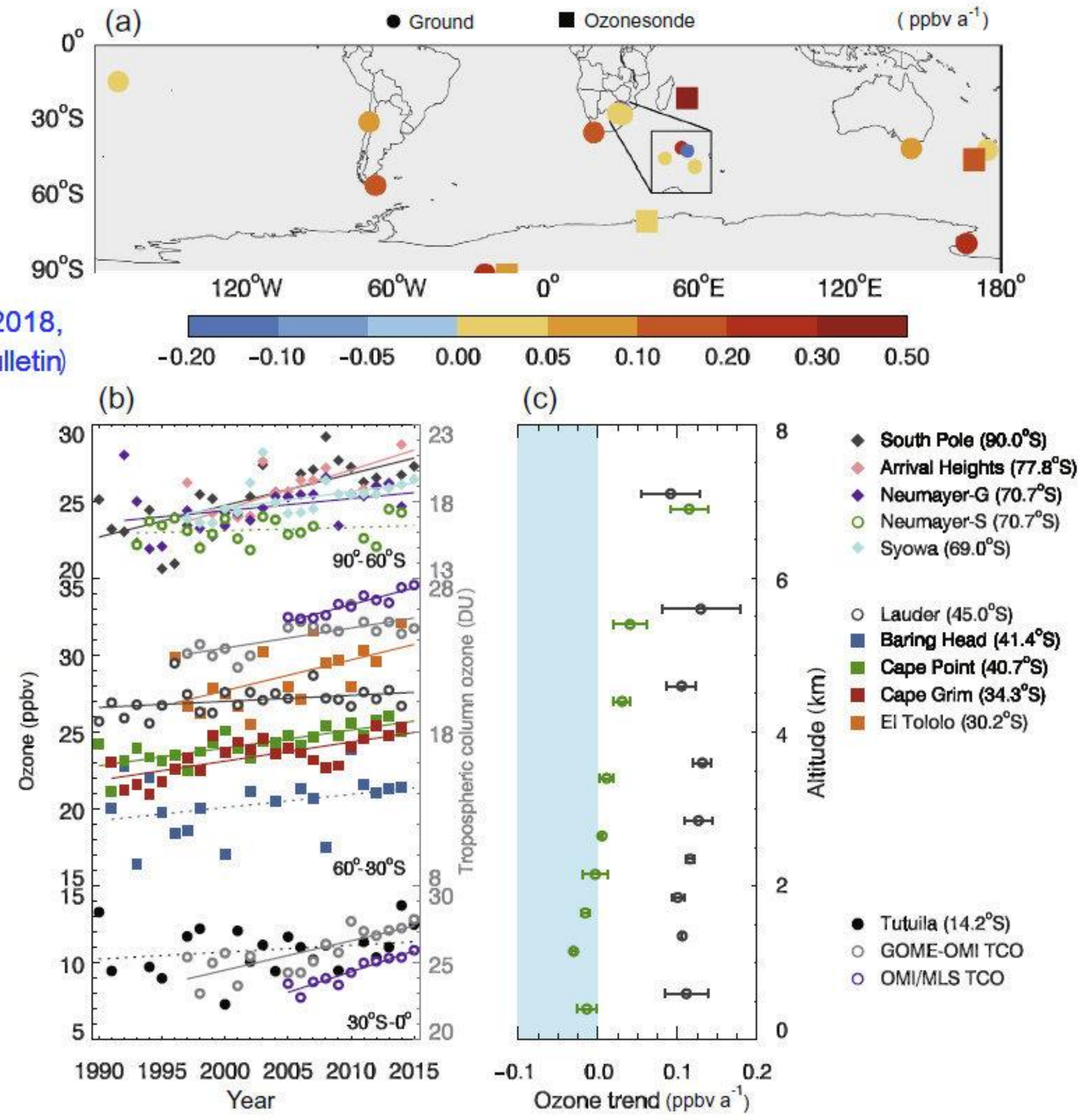


Fig. 1. Tropospheric ozone trends from the 1990s to 2015 in the Southern Hemisphere (SH). (a), A summary of observed ozone trends in the SH from recent publications. Circles denote ground observations and squares denote ozonesonde observations in the lower or middle troposphere. See Table S1 (online) for references and details. (b), Observed austral autumn mean ozone concentrations at nine surface sites, tropospheric column ozone (TCO) at two sonde sites, and satellite observed TCO from GOME-OMI and OMI/MLS over 1990–2015 grouped into three SH latitudinal bands (90°–60°S, 60°–30°S, and 30°S–0°). Filled symbols denote surface concentrations in unit of ppbv (left axes), and open circles denote TCO values in unit of DU (right axes). Solid and dashed lines represent statistically significant (at 90% confidence level) and insignificant linear trends, respectively. (c), Ozonesonde trends in austral autumn at Lauder (grey) and Neumayer-S (green). Horizontal bars are standard deviations.

The Harvard GEOS-Chem Model Prescribes Increases in Tropospheric Ozone Throughout the SH

(Lu et al. 2019, Nat. Bul.)

Lu et al. (2018, Science Bulletin)

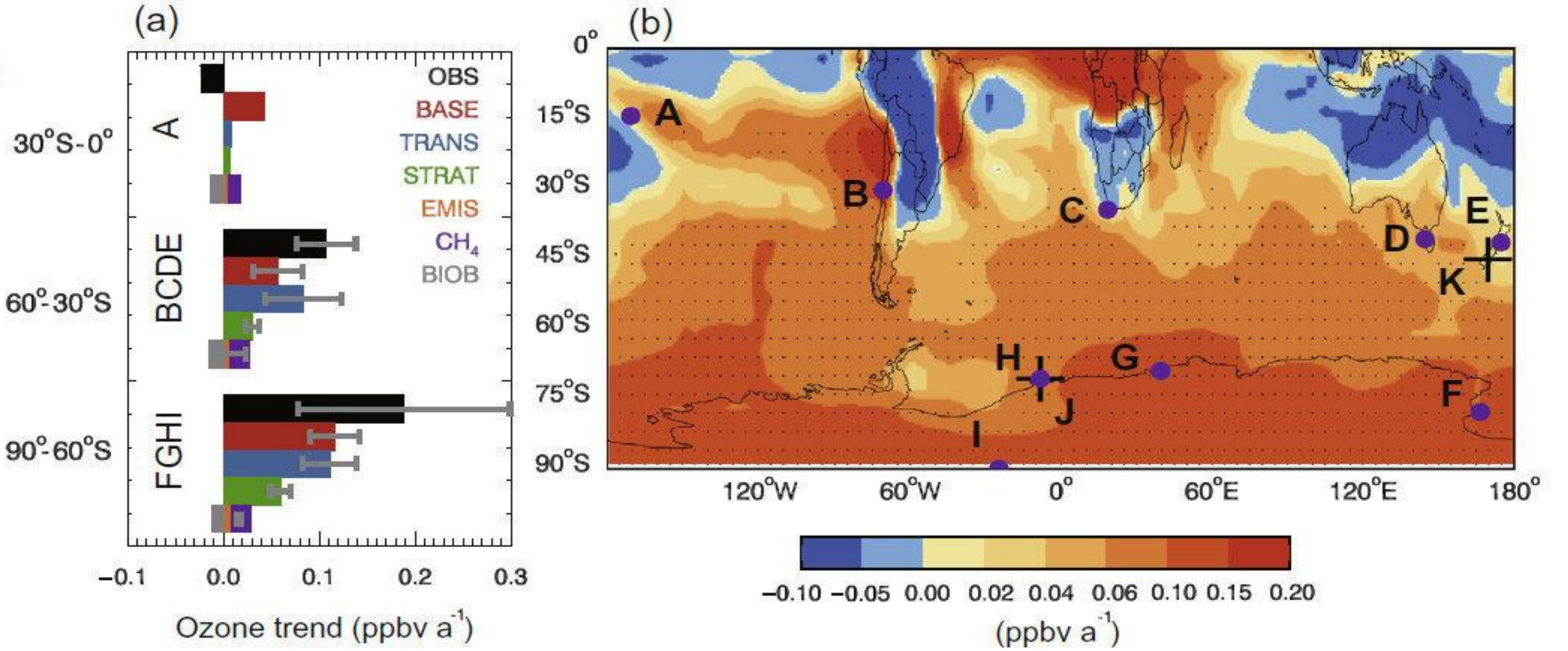
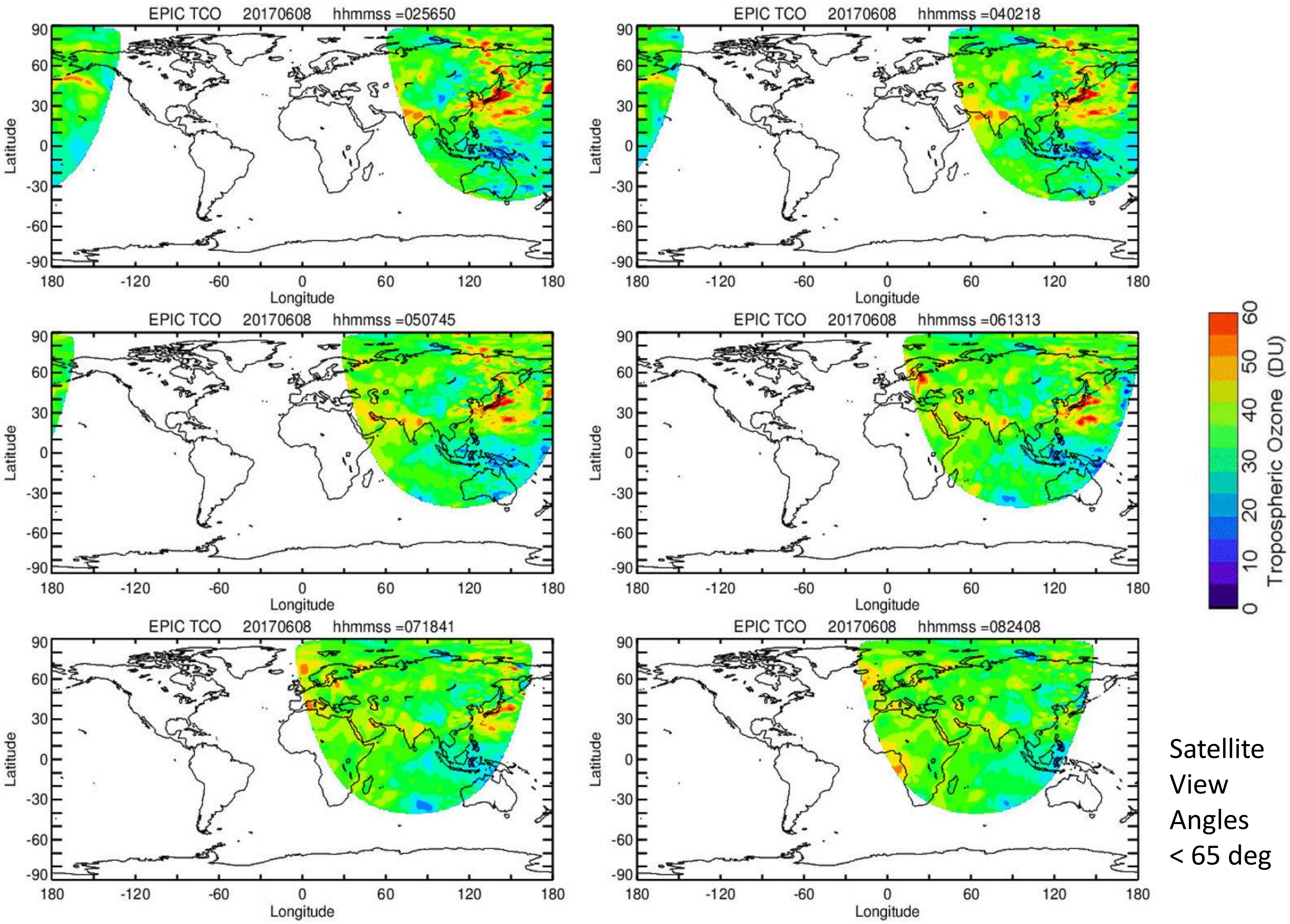


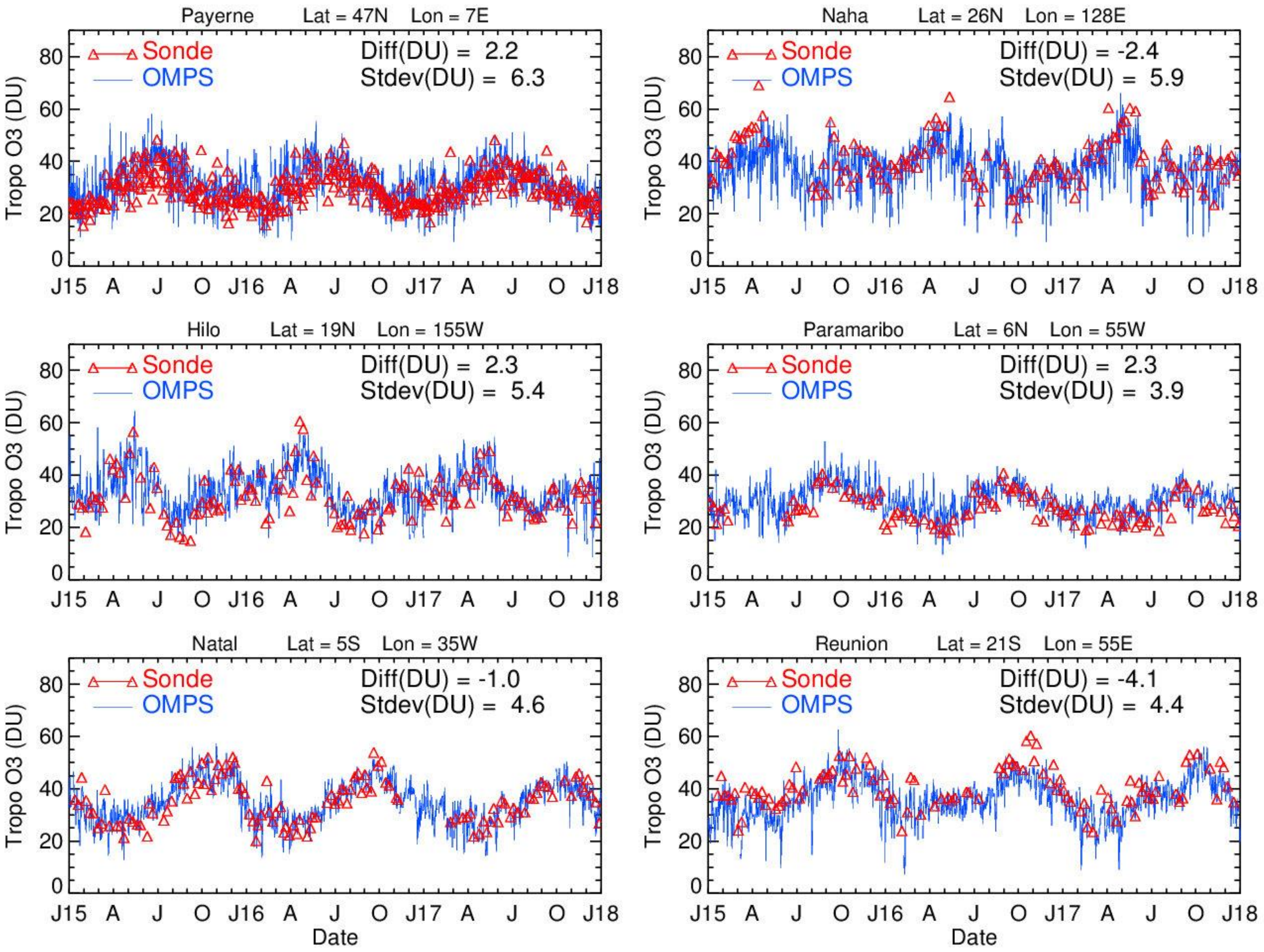
Fig. 2. Drivers of the tropospheric ozone trends in March–April–May (MAM) from the 1990s to 2010 in the SH. Observed trends (black bars) are compared with the BASE simulated results (red bars) at nine surface sites (circles in the right panel, A–I) averaged to three latitudinal bands. Also shown are contributions to the simulated trend from long-term changes in transport patterns (TRANS; blue bars), stratospheric ozone influences (STRAT; green bars), anthropogenic emissions (EMIS; orange bars), global methane levels (CH_4; purple bars), and biomass burning emissions (BIOB; grey bars) (Methods). Grey horizontal bars denote standard deviations over sites. The right panel shows the spatial distribution of surface ozone trends from the BASE simulation. Black dots denote statistically significant ($P < 0.05$). Pluses (J–K) denote the two sonde sites.

Tropospheric Ozone from EPIC at ~Hourly Increments



Satellite View Angles < 65 deg

Daily OMPS/MERRA2 and Sonde TCO

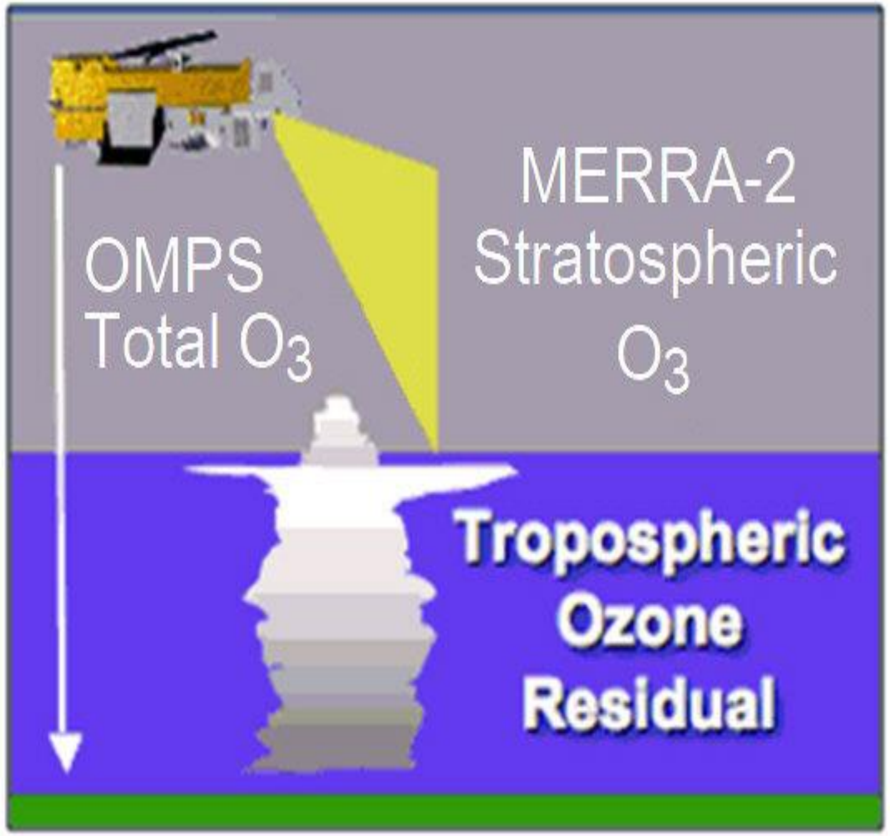


All Three Use a Residual Method

(Fishman and Larsen, JGR, 1987)

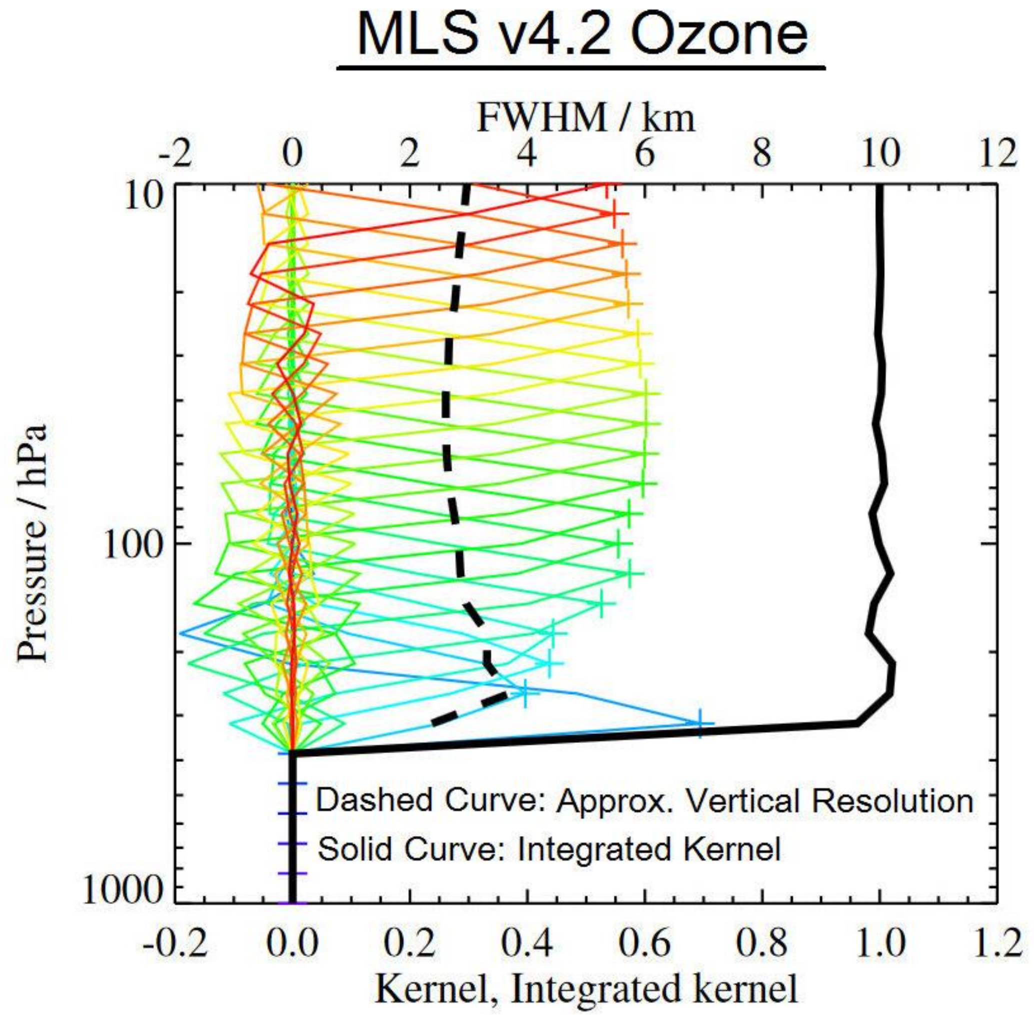
Tropospheric column ozone = OMPS nadir mapper total column ozone minus co-located MERRA-2 stratospheric column ozone

Tropopause pressure is derived from MERRA-2 potential vorticity (2.5 PVU) and potential temperature (380 K)



(Note: MERRA-2 is assimilated MLS ozone profiles)

All Three Products Use Aura MLS Measurements for Stratospheric Column Ozone

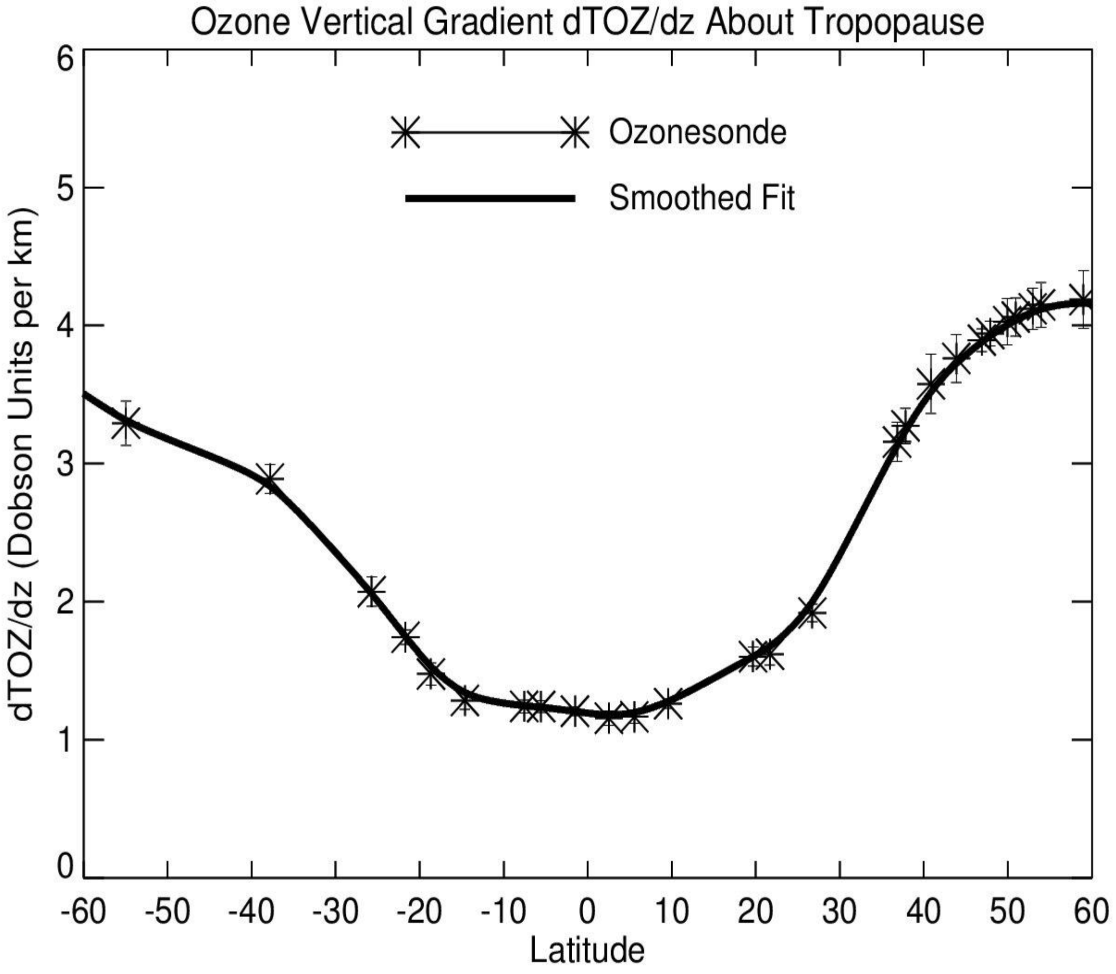


MLS has uncertainty of only ~3 km about the tropopause

(i.e., excellent for separating stratospheric from tropospheric ozone local measurements)

(MLS v4.2 Data Documentation User’s Guide)

Error in Tropopause Pressure/Height is Not a Major Source of Error in Tropospheric Ozone



Sondes:

Approximate error in tropospheric column ozone due to a ±1 km error in tropopause height

List of Errors and Uncertainties to Consider and/or Correct in the Data

- Systematic offsets/drifts between instruments
- Errors in TOZ at high satellite view angles
- Precision errors of TOZ and stratospheric column ozone
- Reduced sensitivity in measuring BL ozone
- Retrieval smoothing errors
- Errors due to aerosols, clouds, snow & ice
- Errors in applied tropopause pressure