A New Tropospheric Ozone Data Product Derived from DSCOVR EPIC v3 Measurements

J. R. Ziemke, N. A. Kramarova, L. K. Huang, J. R. Herman,
P. K. Bhartia, and K. Wargan

NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

DSCOVR EPIC and NISTAR STM 28-30 September 2021

Data Details

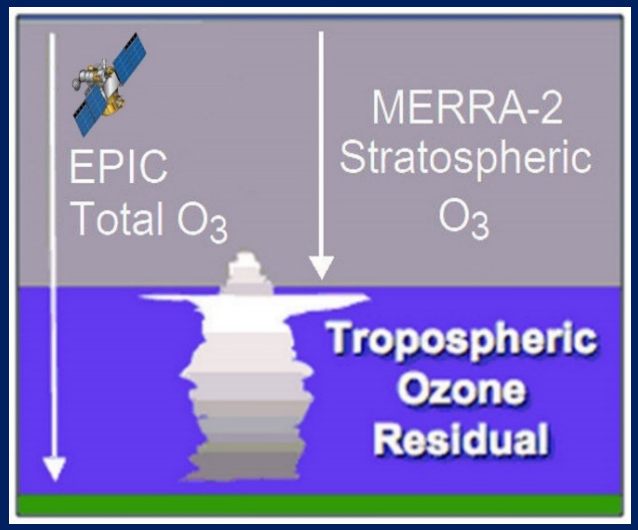
- Synoptic gridded v3 maps every 1-2 hours @ $1^{o} \times 1^{o}$ binning over sunlit disk of Earth

- File variables (HDF5 file format): Tropospheric column ozone (both corrected and not corrected arrays for reduced BL sensitivity to ozone), stratospheric column ozone, tropopause pressure, cloud pressure, radiative cloud fraction, reflectivity, data quality flags, etc.

- Time record: June 2015-August 2021 (~1 month lag due to MERRA2 vetting)

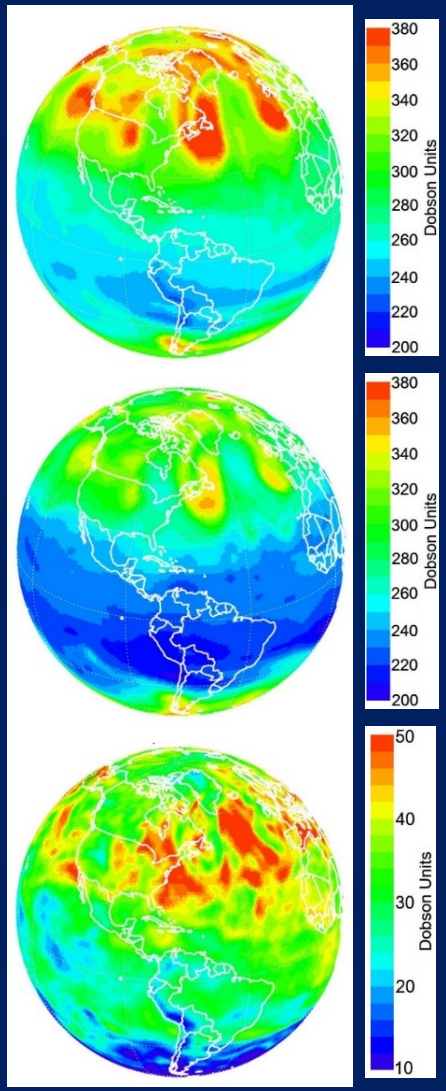
- Status: Data on NCCS ready for upload to ASDC

Tropospheric Ozone Residual (TOR) Method



Residual Method:

Tropo Column O_3
Residual =
EPIC Total O_3 -
MERRA2 Strat O_3



EPIC
Total O_3

−

MERRA2
Strat O_3
(assimilated
MLS)

=

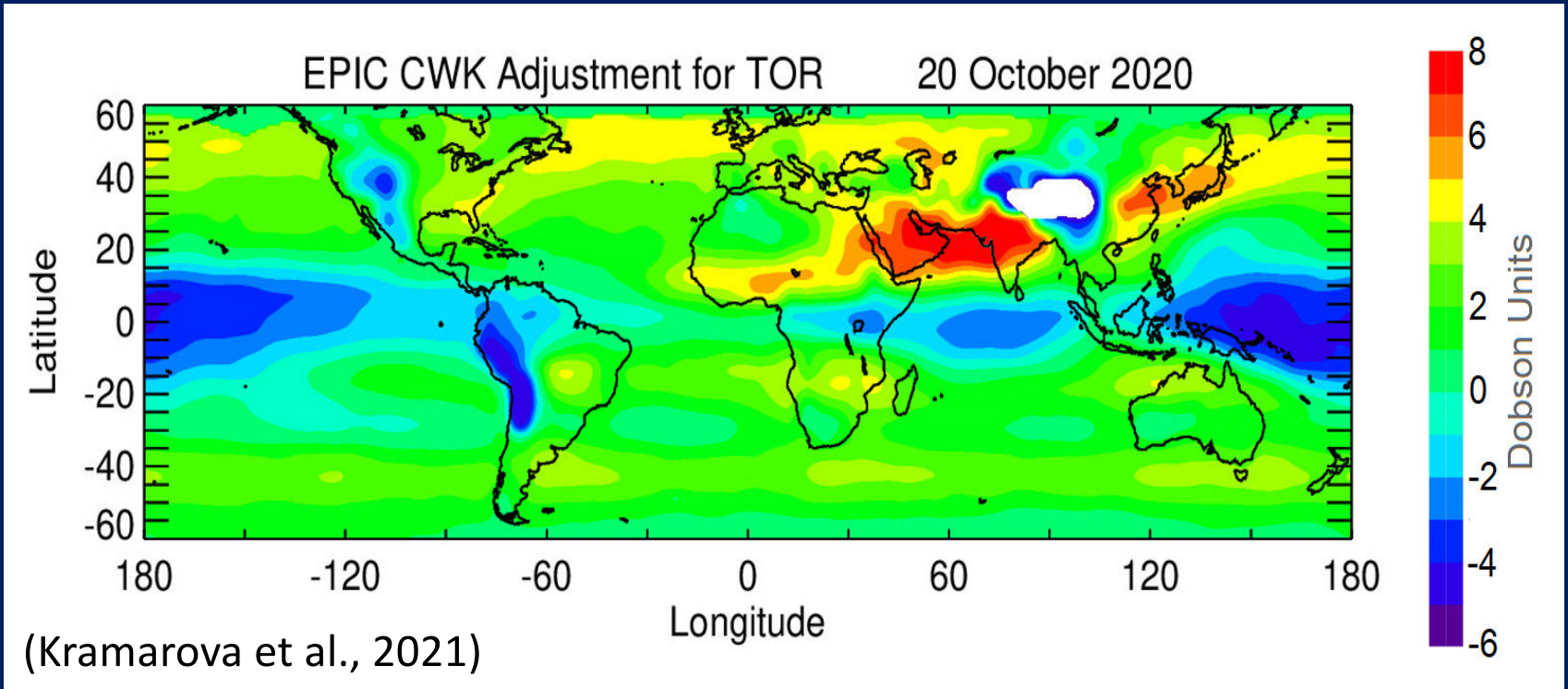
Tropo O_3
Residual

Tropopause pressure: From combining MERRA-2 potential vorticity (2.5 PVU) and potential temperature (380 K)

MERRA2 Strat O_3: Co-located to exact time and location of EPIC L2 footprints (accuracy & precision ~2-3 DU & 2-5 DU)

EPIC: All satellite zenith angles < 70°

EPIC Column-Weighting Function Daily Adjustments for BL O_3



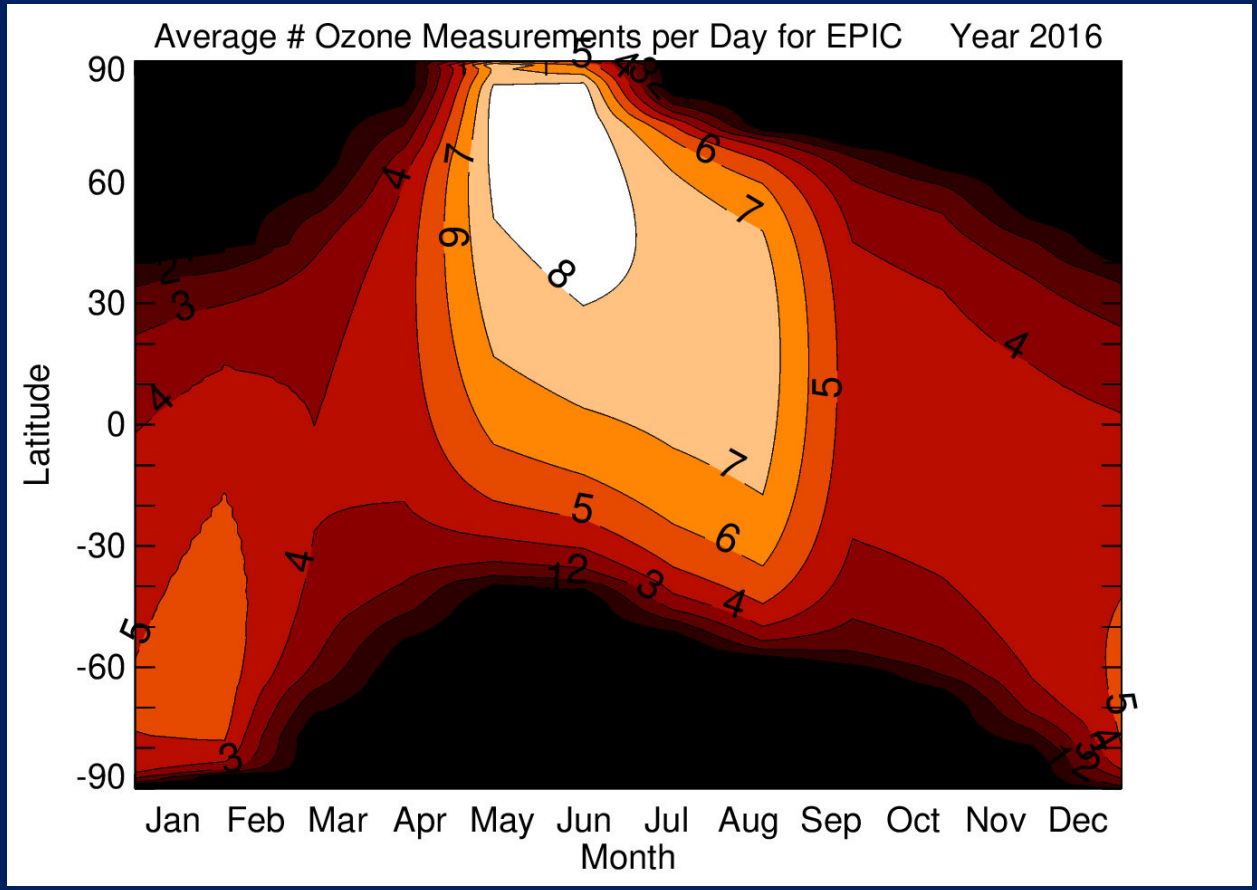
(Kramarova et al., 2021)

$$\Delta\Omega = [1 - CWF(0)] \cdot [GMI(0) - AP(0)]$$

where GMI(0) = daily 2015-2020 climatological layer 0 (gnd-to-506hPa) column O_3, and AP(0) = apriori layer 0 column O_3

EPIC Provides Many Measurements at a Given Location Per Day Compared to Polar Orbiters

Important for cross-validating geostationary satellite measurements such as current GEMS, and upcoming TEMPO and Sentenel-4

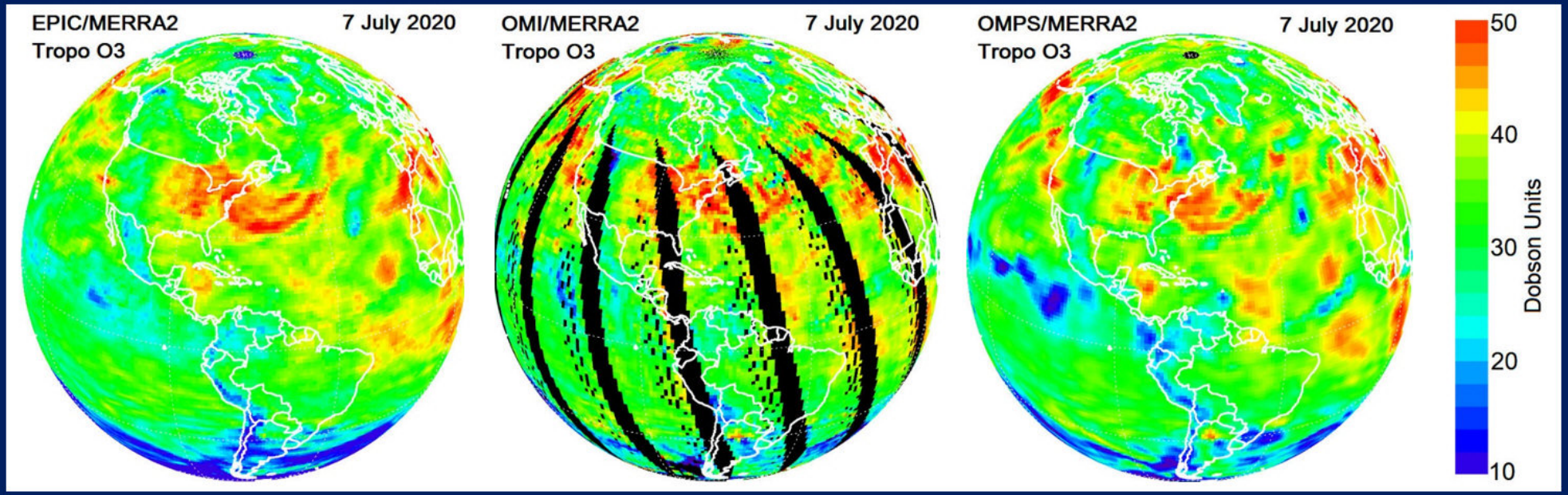


(Missing/bad data not included in averaging)

(Kramarova et al., 2021)

Validation: EPIC vs OMI and OMPS Daily TOR

EPIC OMI OMPS



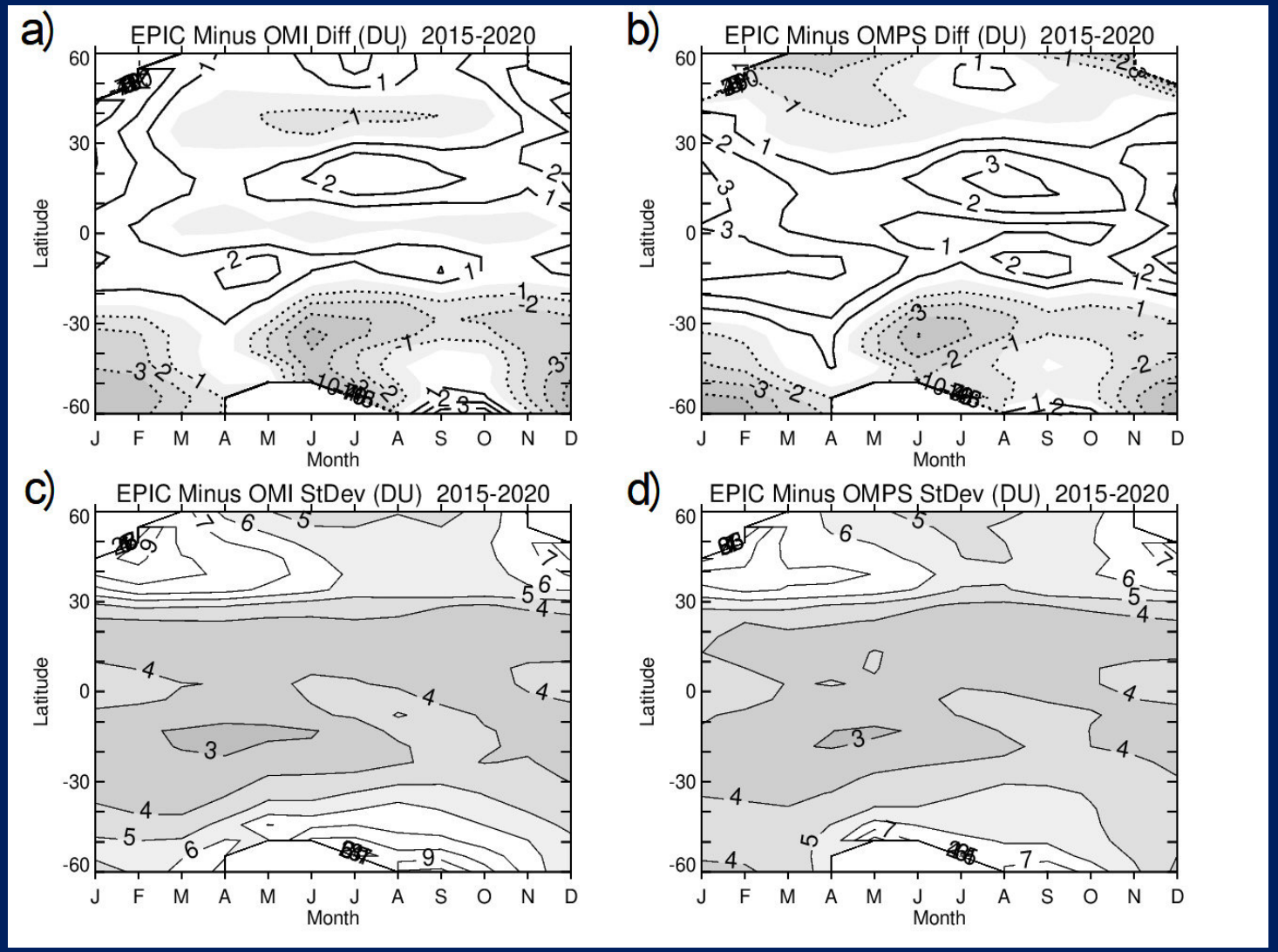
(Kramarova et al., 2021)

All Three: Use co-located MERRA2 assimilated MLS ozone for Strat O_3

Validation: EPIC vs OMI and OMPS Daily TOR

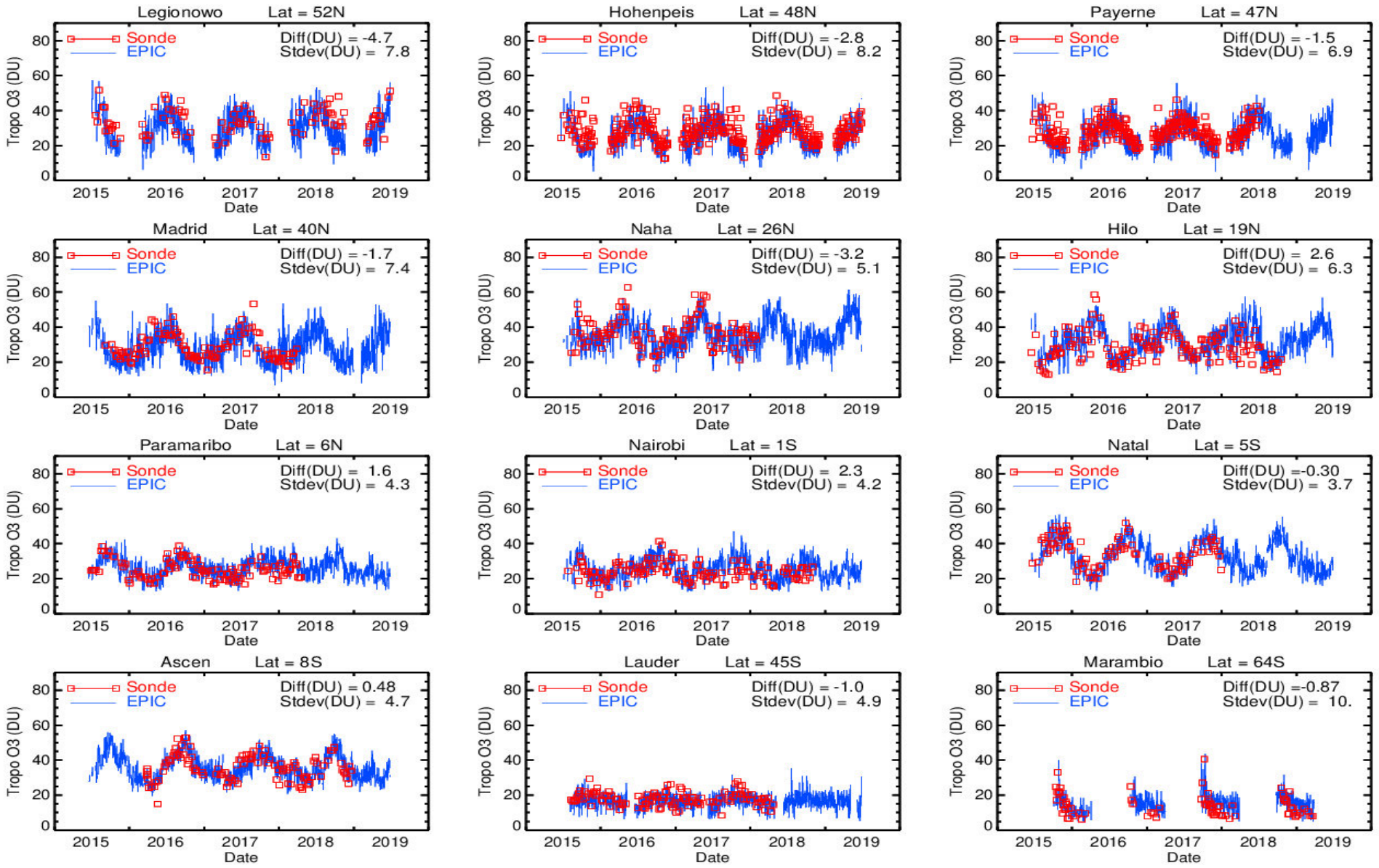
Offsets with OMI and OMPS

Standard Deviations with OMI and OMPS



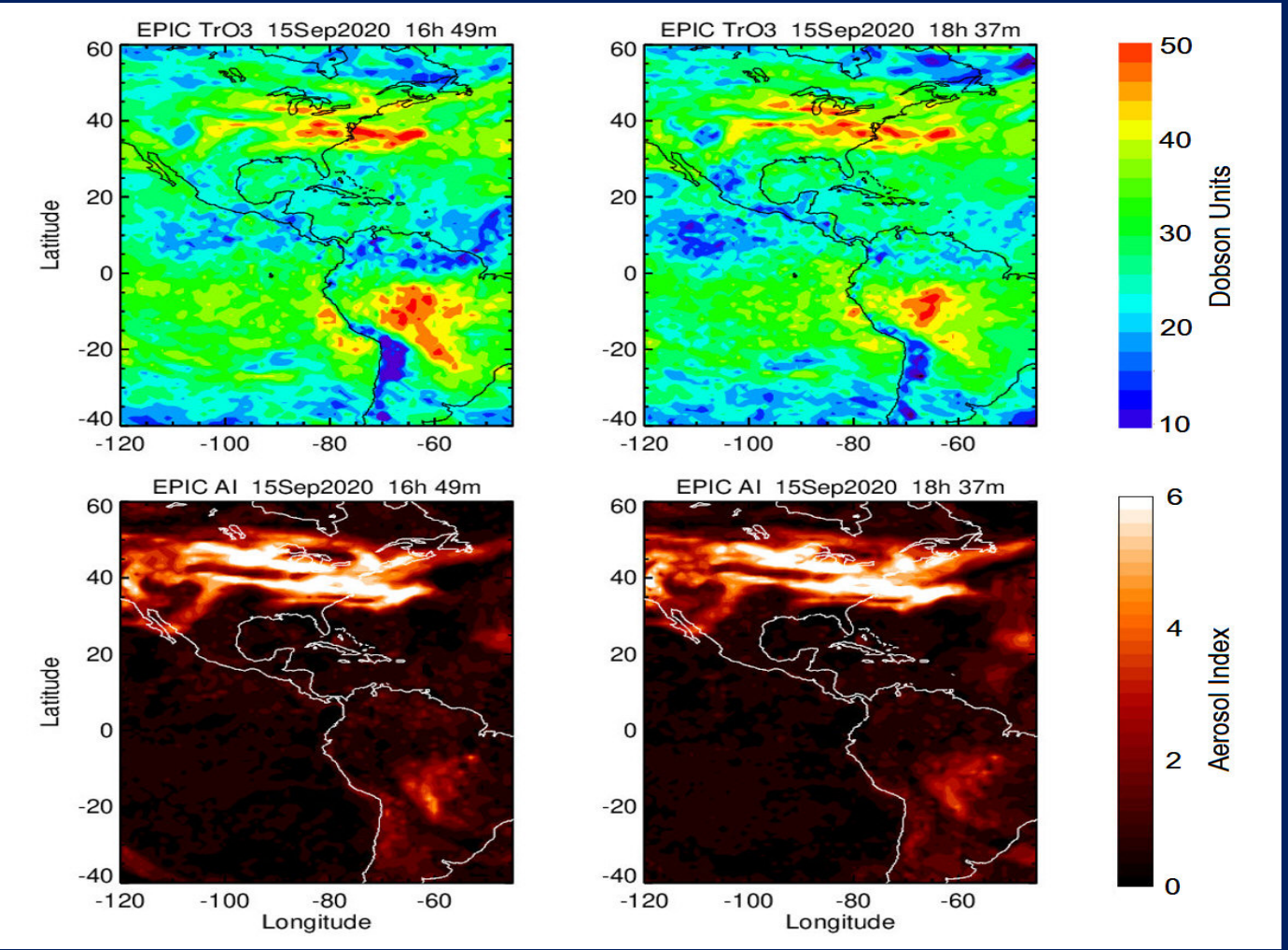
(Kramarova et al., 2021)

Validation: EPIC vs Ozonesonde Daily TOR



(Kramarova et al., 2021)

EPIC Measures Hourly Maps of TOR

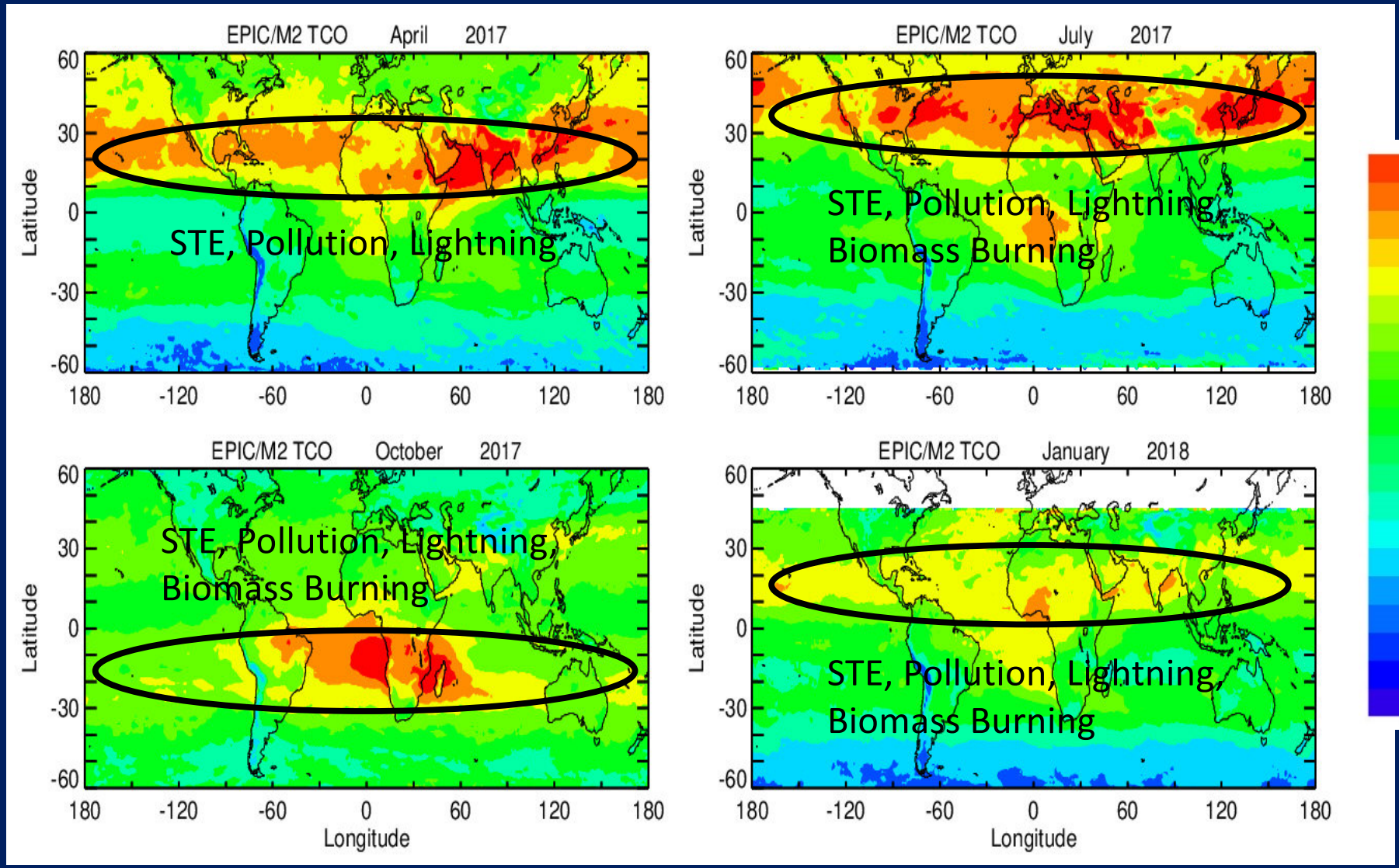


EPIC Tropospheric Ozone Maps 1 h 48 min apart

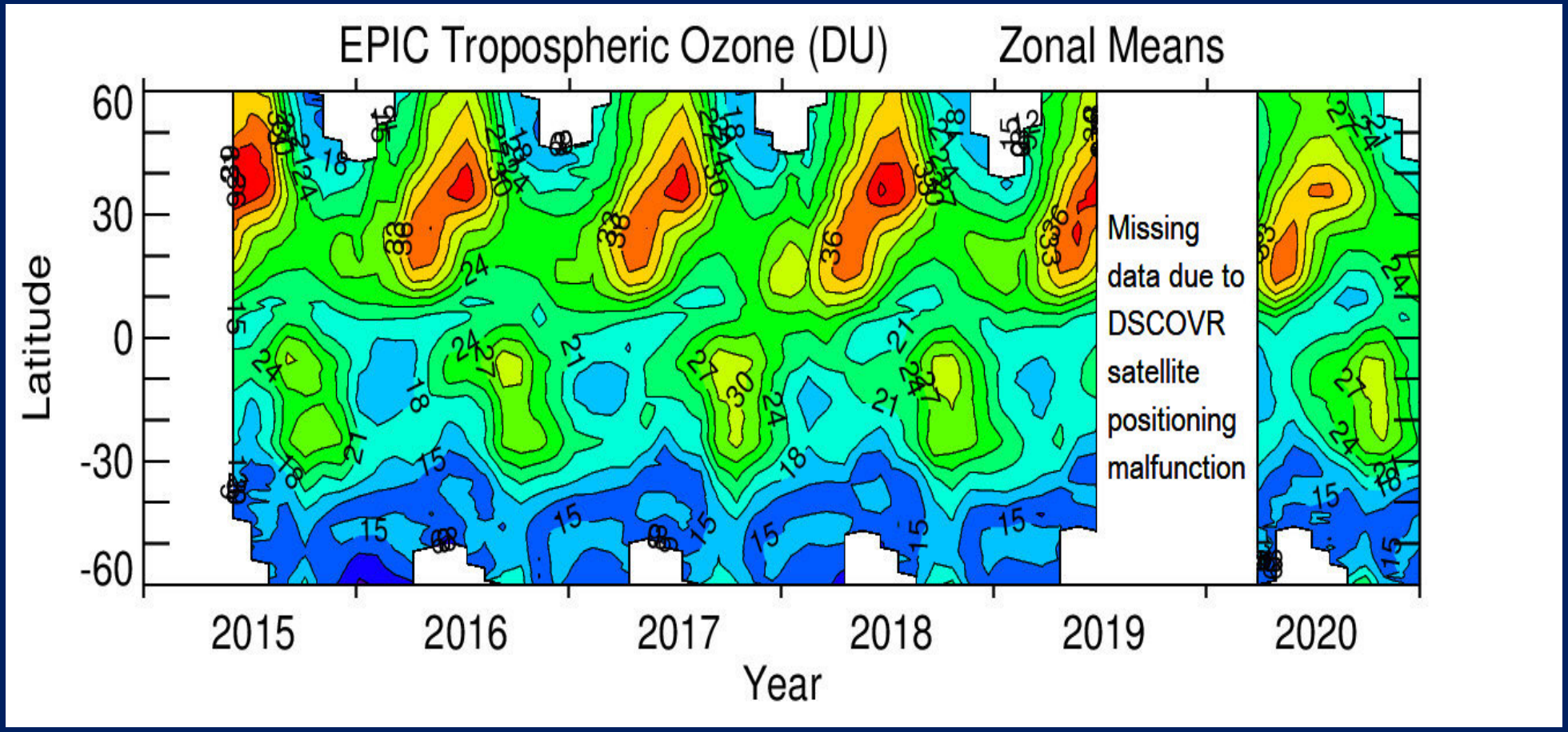
EPIC Aerosol Index Maps 1 h 48 min apart

Biomass burning in California and Brazil in September 2020 produced ozone in the troposphere

EPIC Also Measures Global TOR Each Day

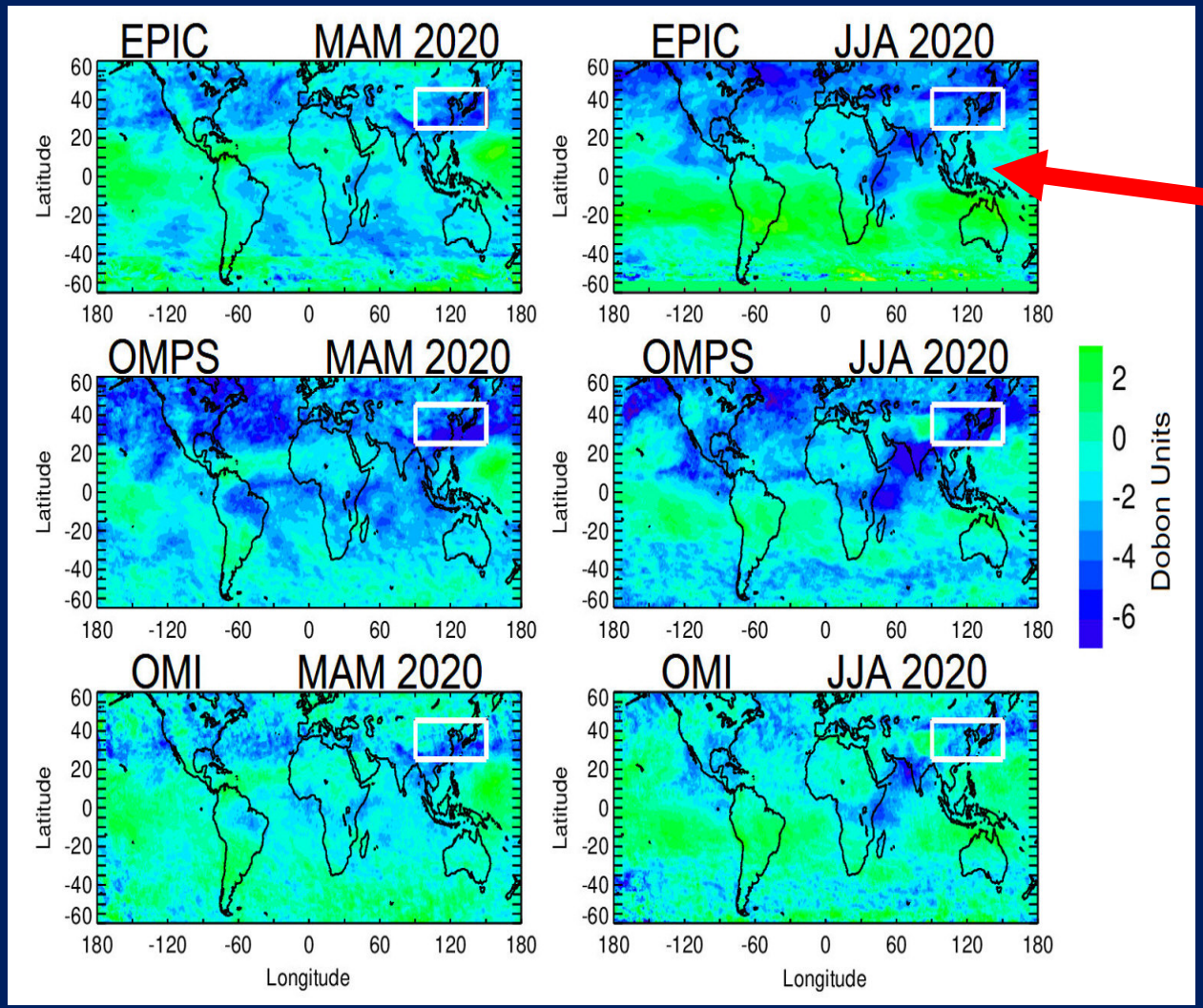


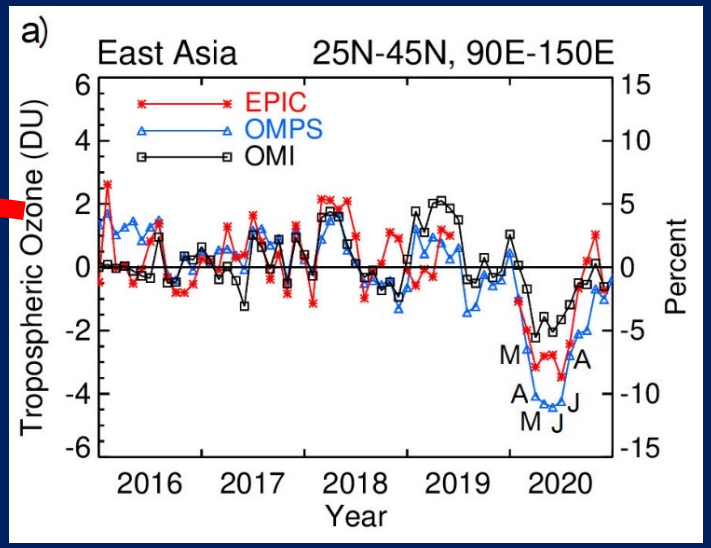
EPIC is now Developing a Long Record of TOR



(Kramarova et al., 2021)

Regional Patterns of the NH Tropospheric Ozone Reductions in 2020





Steinbrecht et al. (2021, GRL):
7% reduction throughout NH free troposphere in spring-summer 2020 from sondes, lidar, model

Bouarar et al. (2021, GRL):
5-15% reduction of zonal-mean tropospheric ozone in 2020 from theCAM-Chem model

(Anomalies: Relative to 2016-2019 Average Fields

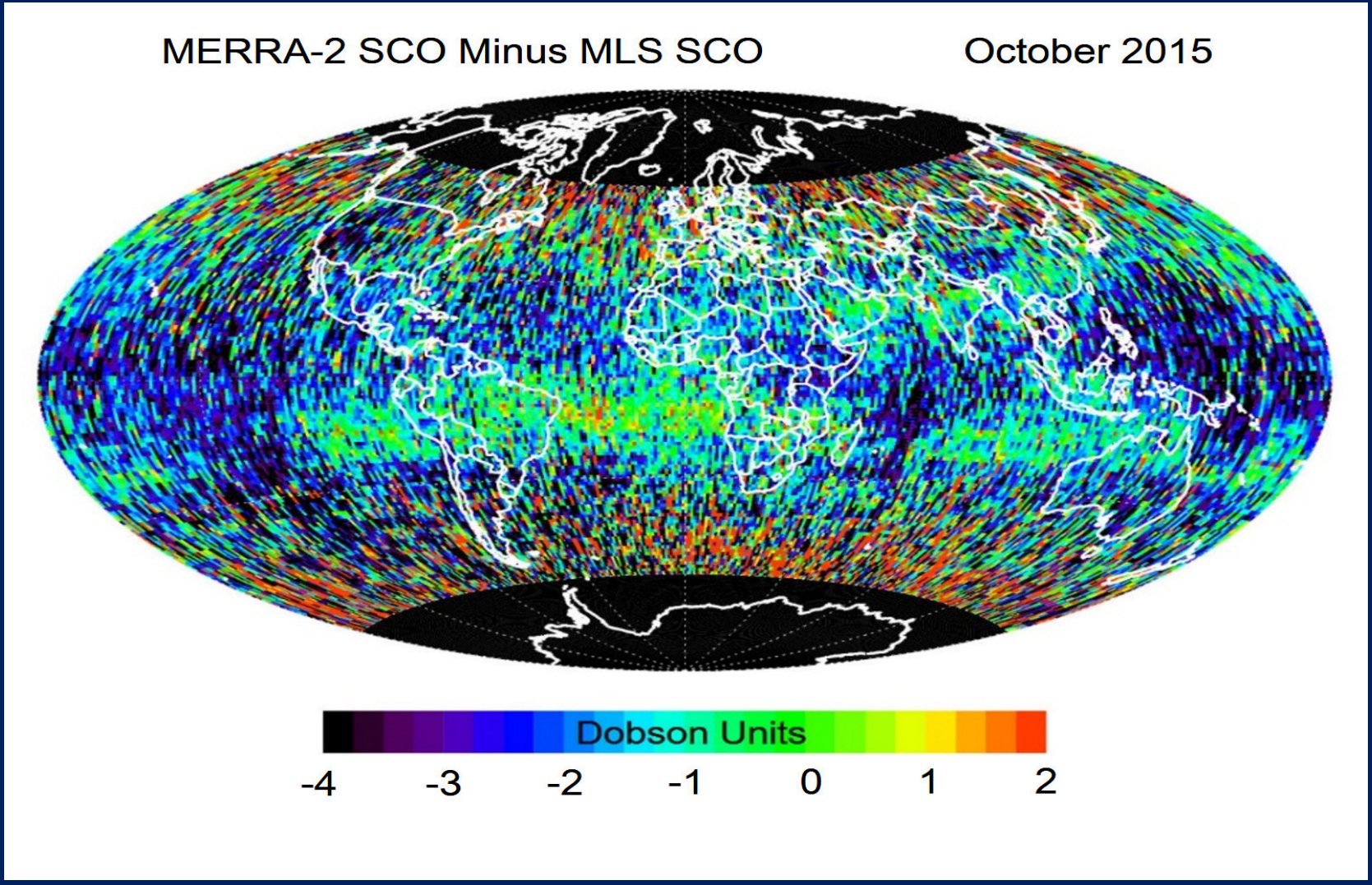
Conclusions

- EPIC provides maps of tropospheric ozone for studying variability from hourly to inter-annual timescales

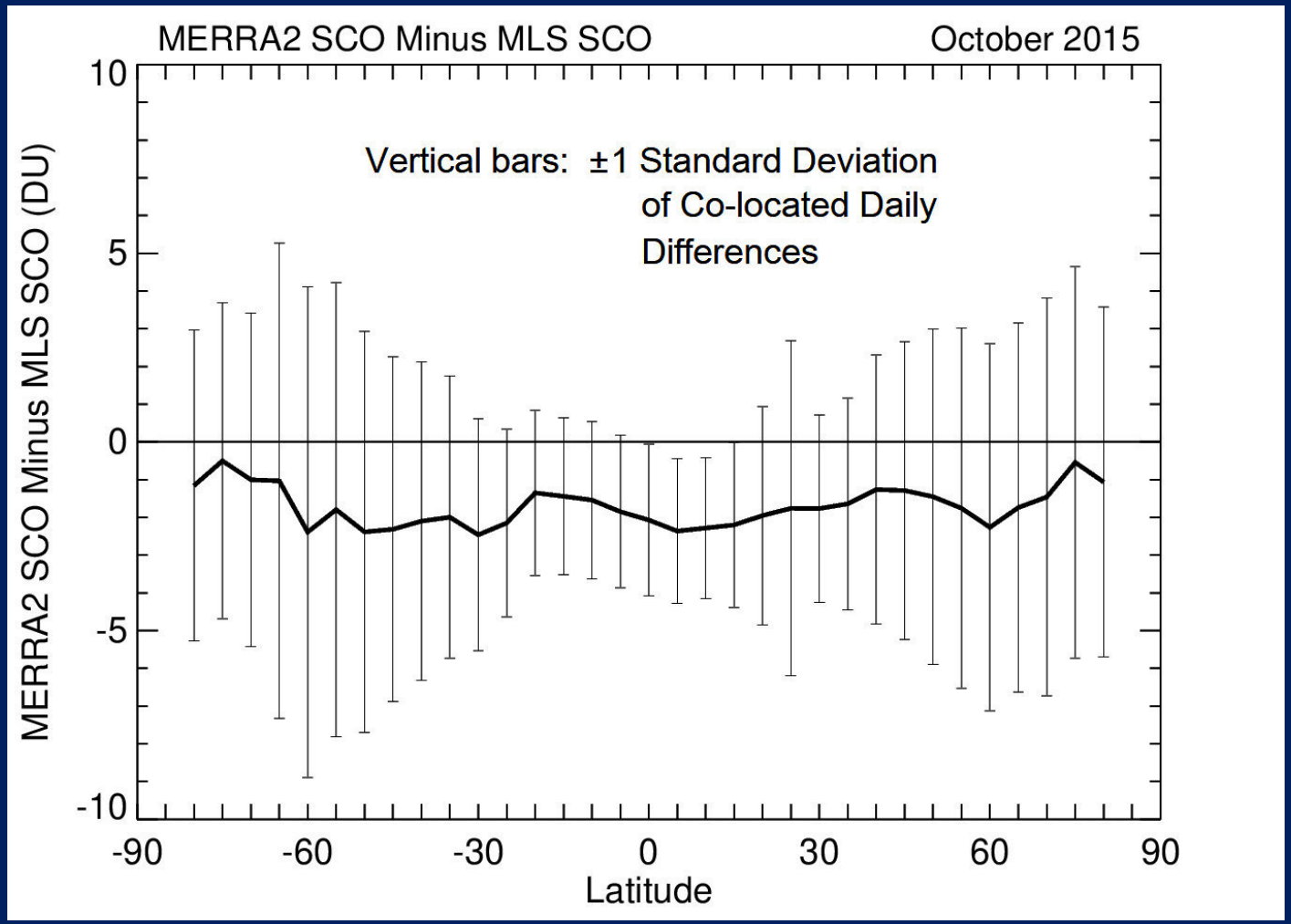
- EPIC TOR maps every 1-2 hours is unique and is useful as a "pathfinder" for new geostationary platforms (*e.g., current GEMS, and upcoming TEMPO and Sentenel-4*)

Extra Plots

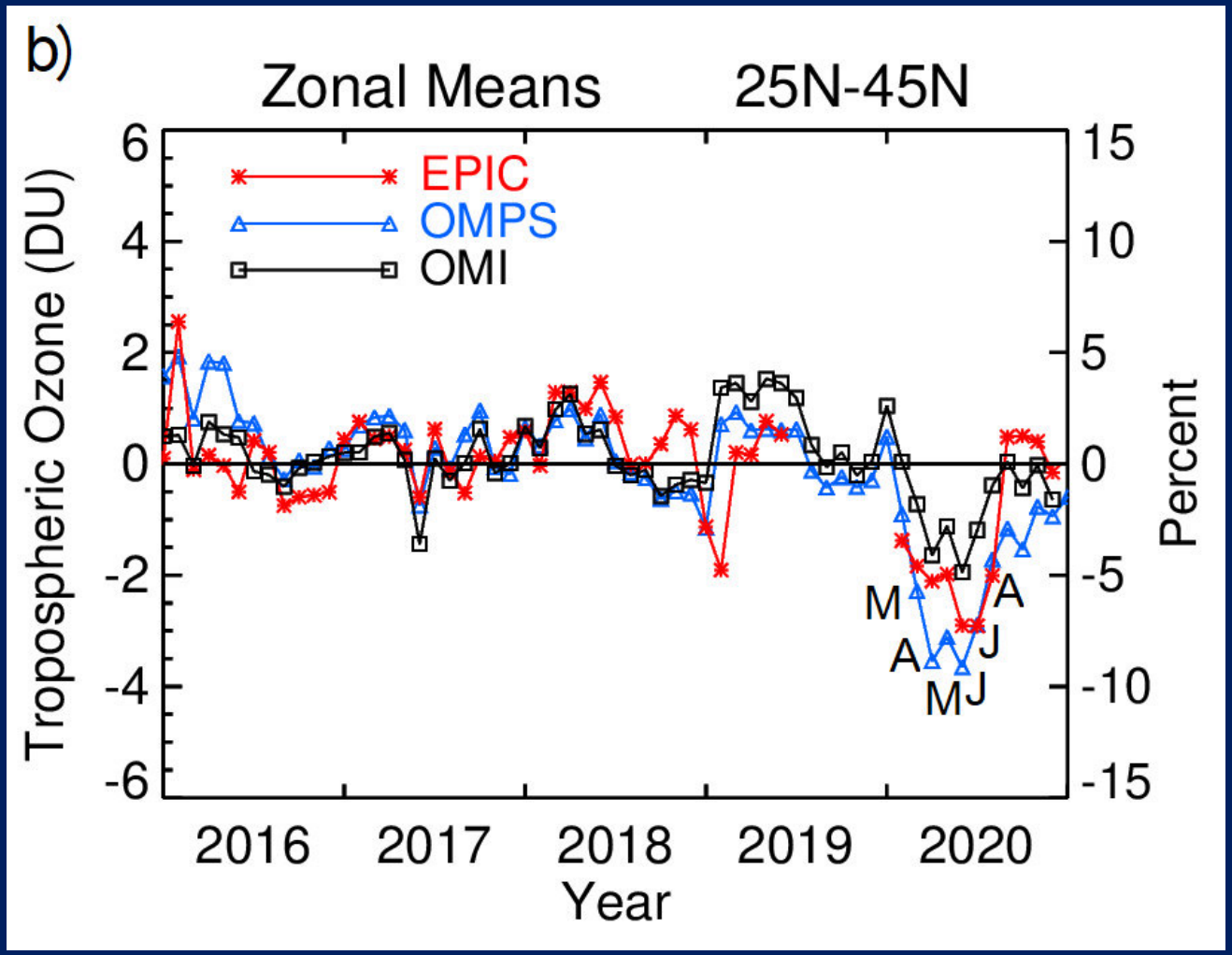
How Good is MERRA-2 Daily SCO?



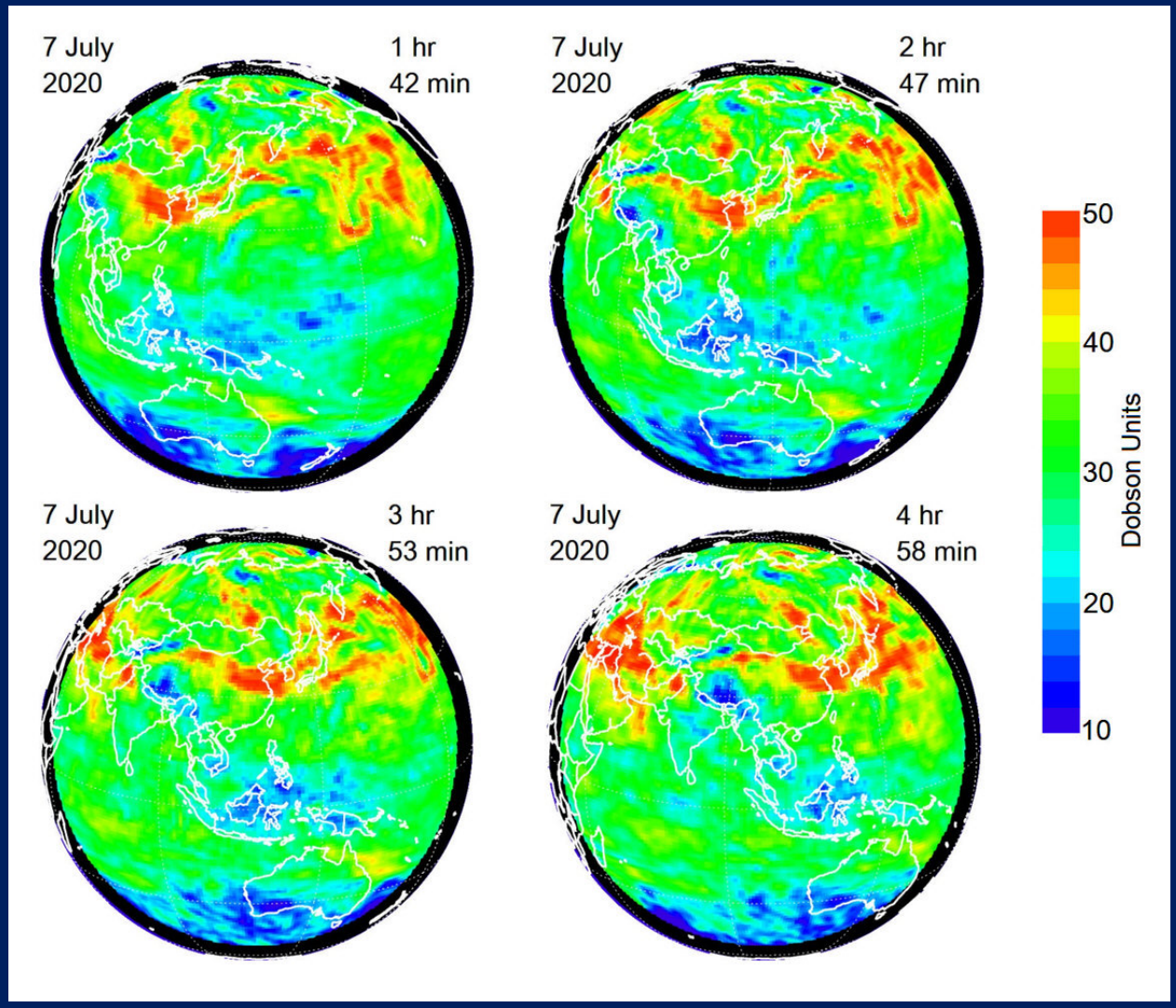
Answer: ~2-3 DU offsets from MLS SCO


MERRA2 SCO Minus MLS SCO
October 2015
Vertical bars: ±1 Standard Deviation
of Co-located Daily
Differences
MERRA2 SCO Minus MLS SCO (DU)
10
5
0
-5
-10
-90
-60
-30
0
30
60
90
Latitude

Zonal-Mean TOR from Satellite Shows 2-4 DU (~5-10%) Anomalous Reductions in 2020



EPIC Hourly Maps of TOR

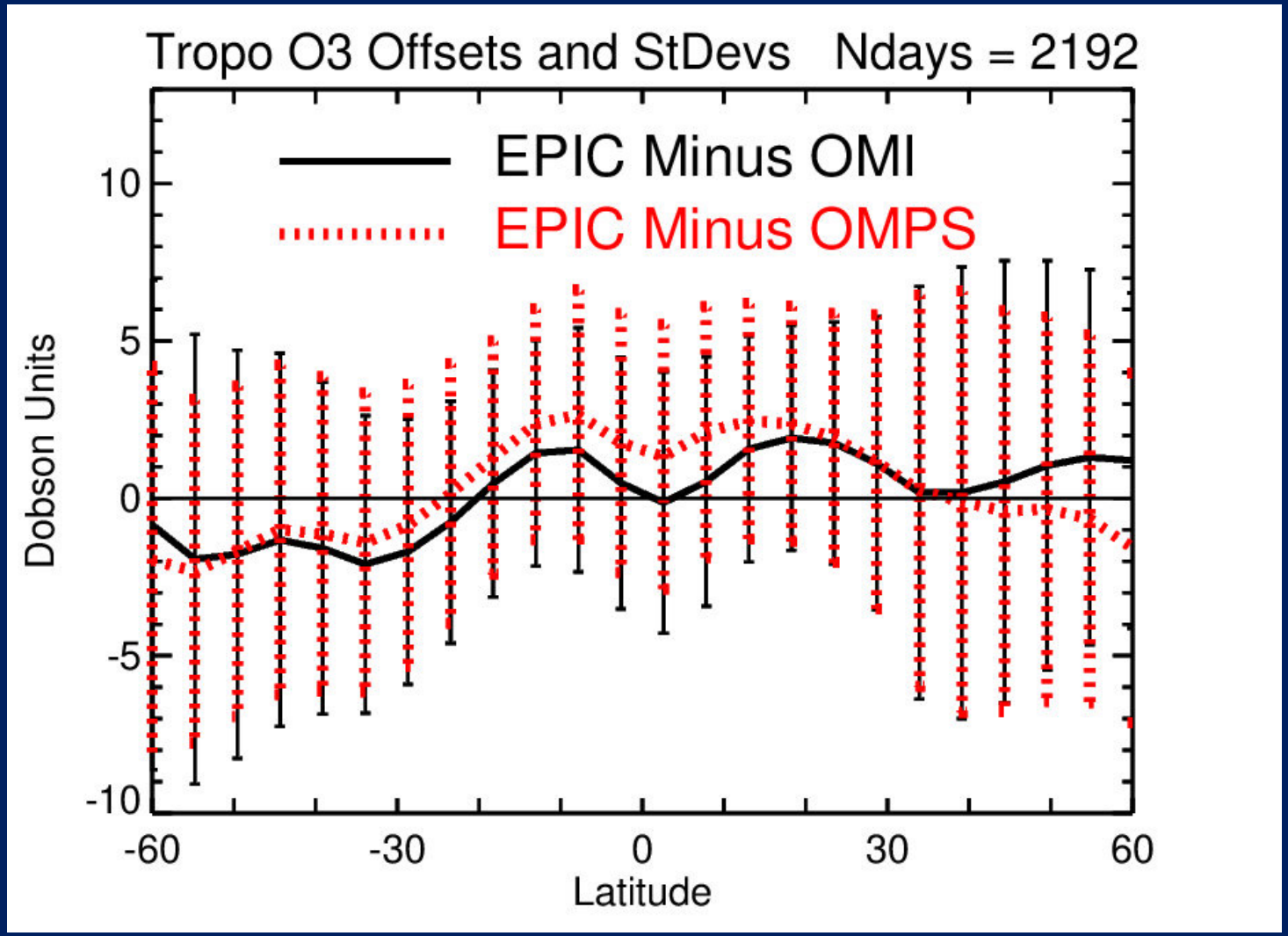


EPIC is "pathfinder" for current and upcoming geostationary ozone measurements such as from GEMS, TEMPO, and Sentinel-4

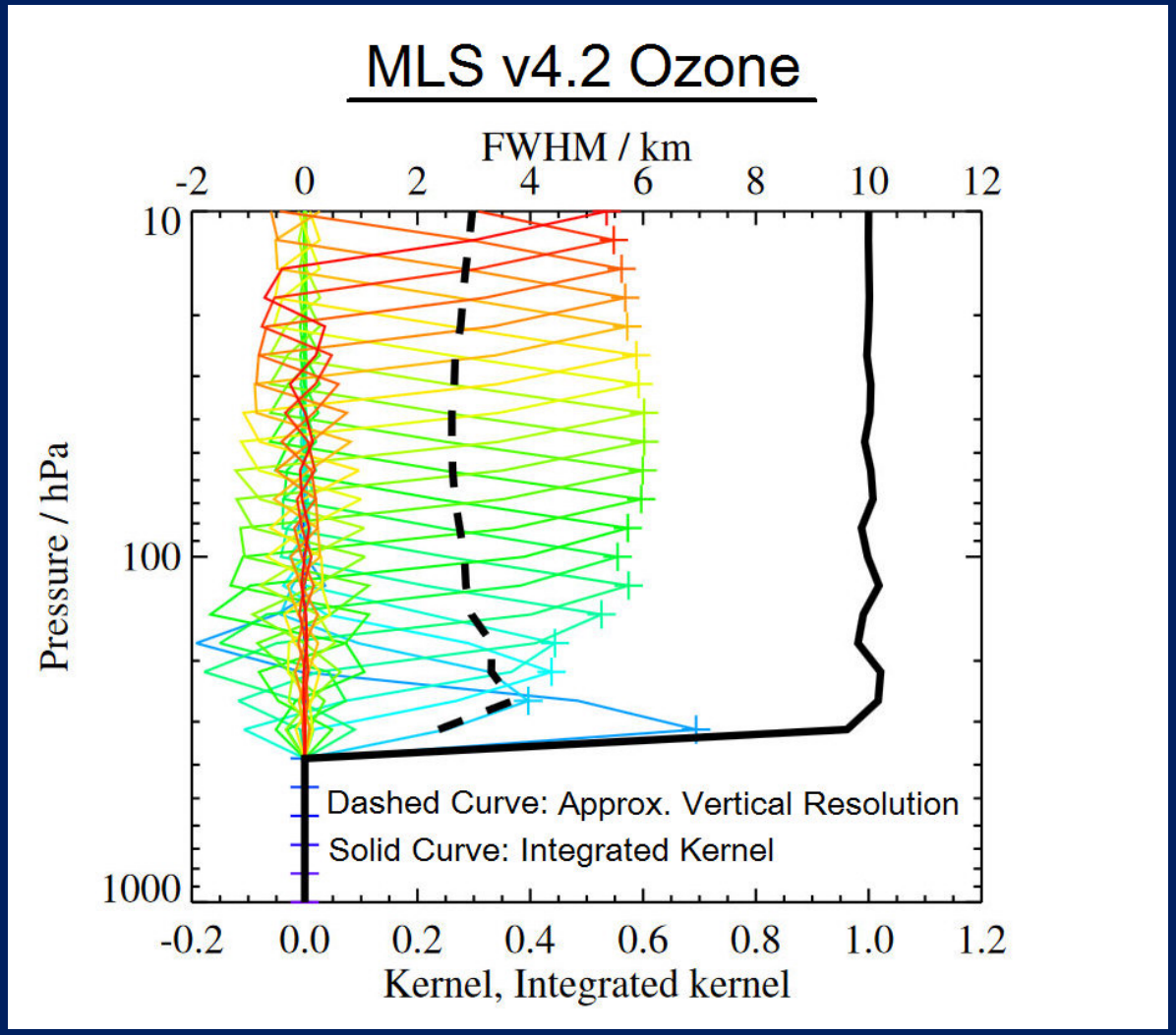
Satellite Zenith Angles < 70°

(Western Pacific, simulates GEMS)

Satellite TOR Inter-Comparisons



Why Use Assimilated MLS Ozone for the Stratosphere?



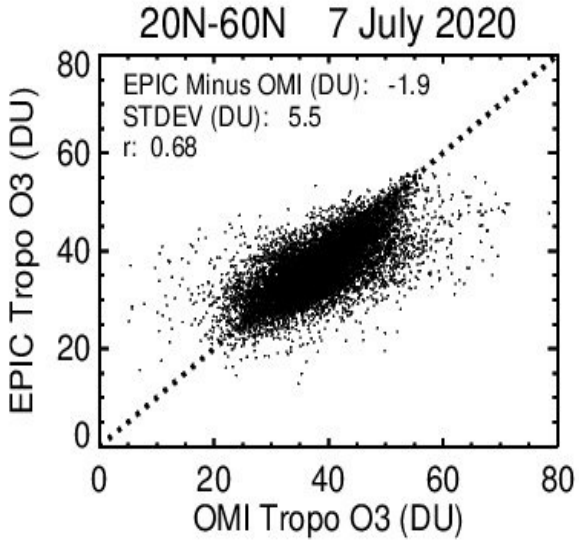
(MLS v4.2 Data Documentation User's Guide)

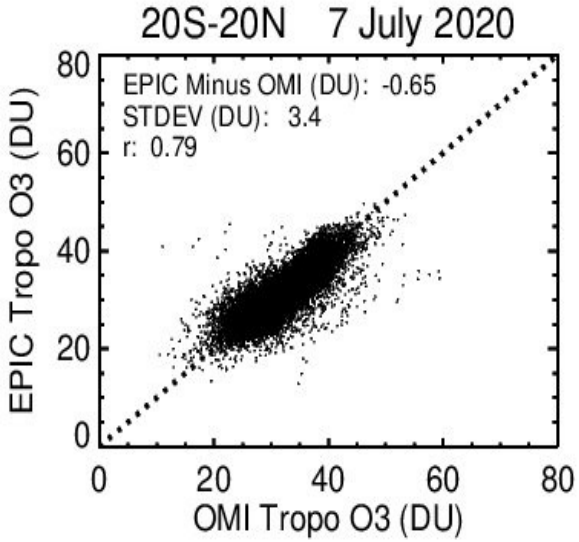
MLS vertical resolution for ozone is ~3 km including near the tropopause

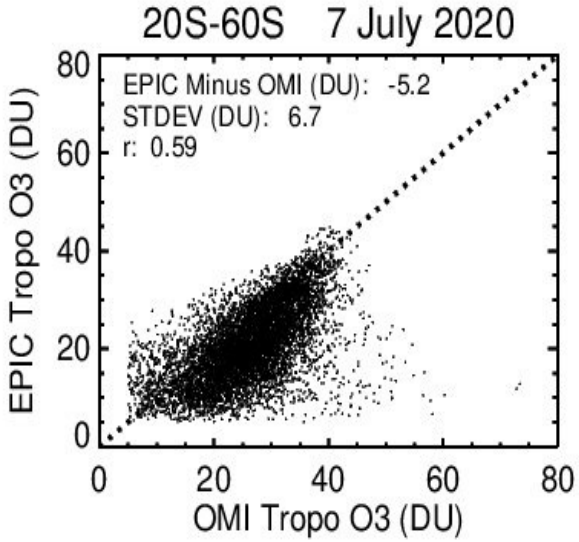
MERRA2 assimilated MLS ozone used for strat column O_3

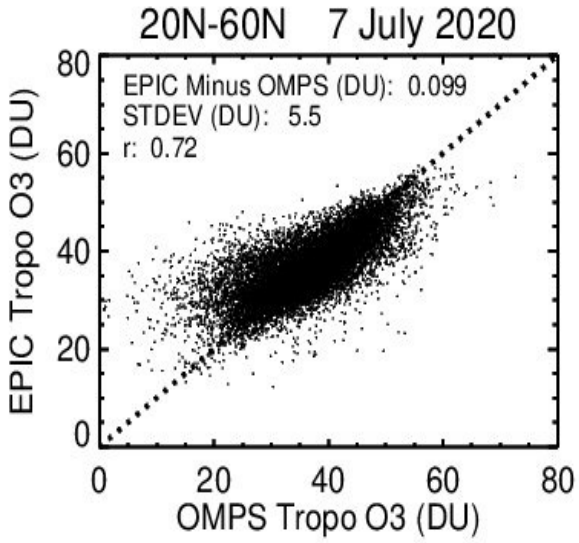
(Est. pixel accuracy and precision ~2-3 DU and 2-4 DU, resp.)

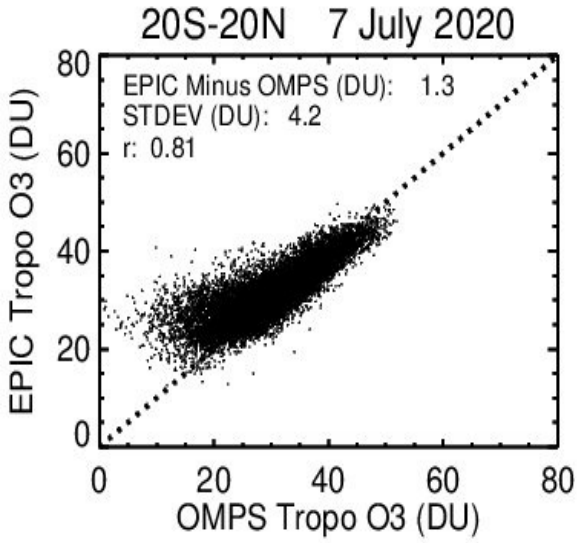
Satellite TOR Inter-Comparisons

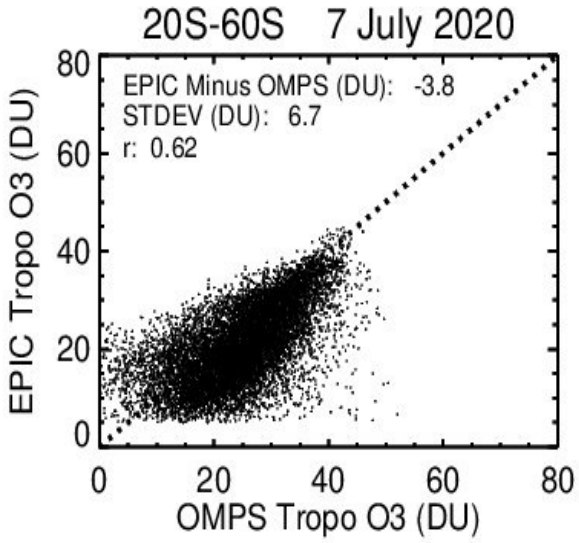


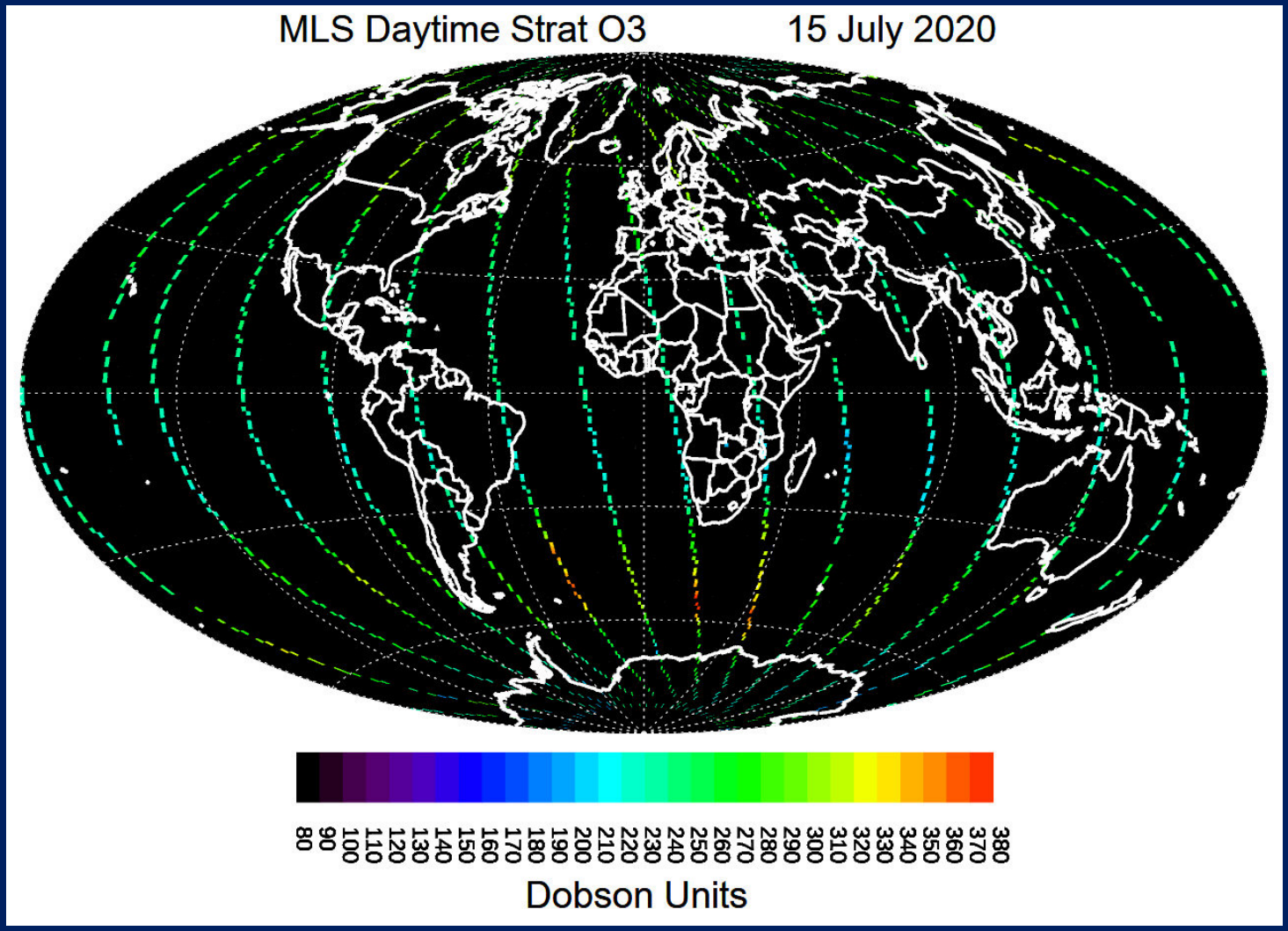











MLS Daytime Strat O3
15 July 2020
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
380
Dobson Units

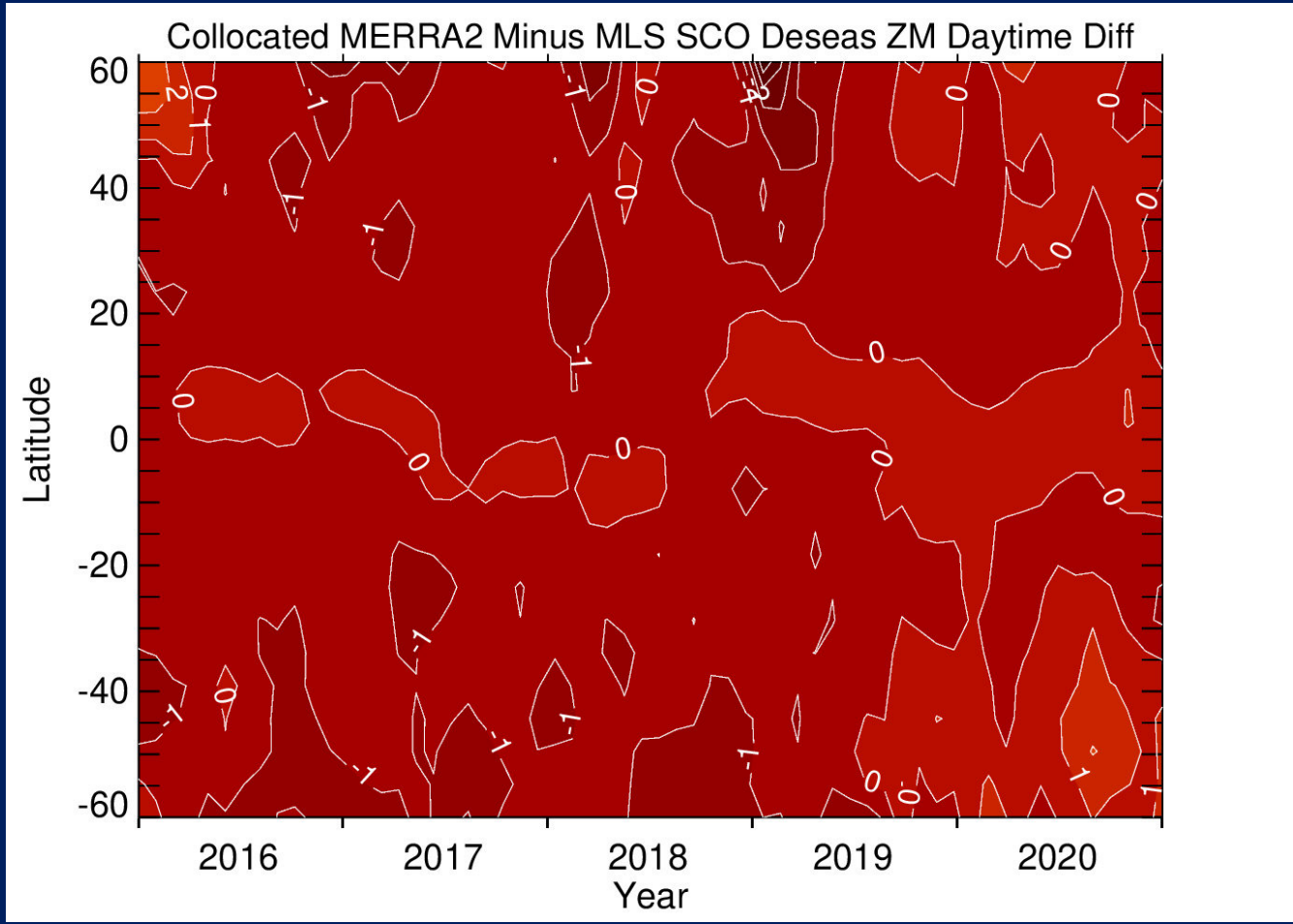
Inter-Annual Changes in MERRA2 SCO is Essentially Equivalent to Co-located MLS SCO to within ±1 DU

Daily along-track MLS SCO is space-time co-located with daily MERRA2 SCO pixels, which is then

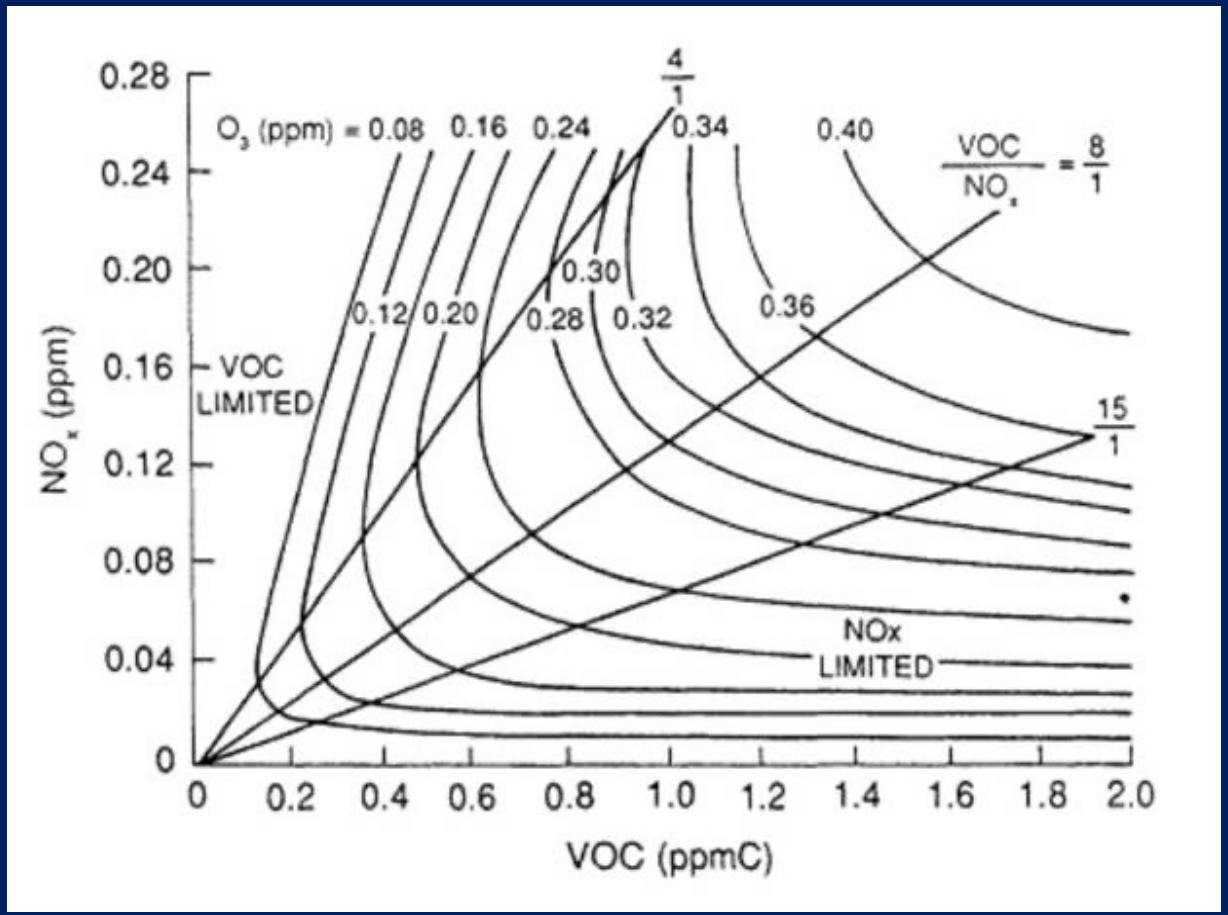
(1) Differenced

(2) Deseasonalized

(3) zonally averaged



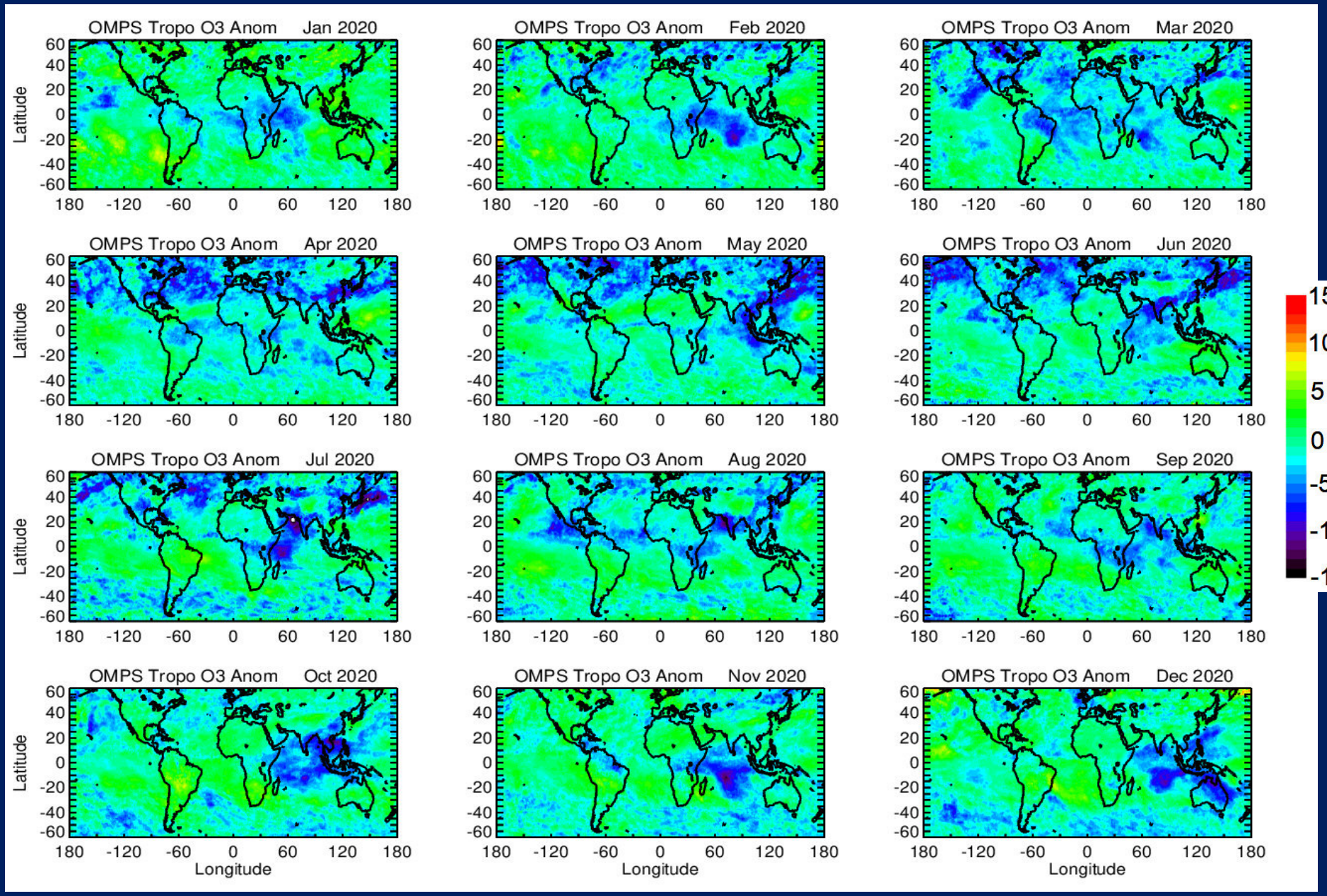
EKMA Diagram (Ozone Isopleth) Diagram for Summer Months



If "NO_x limited" in summertime:

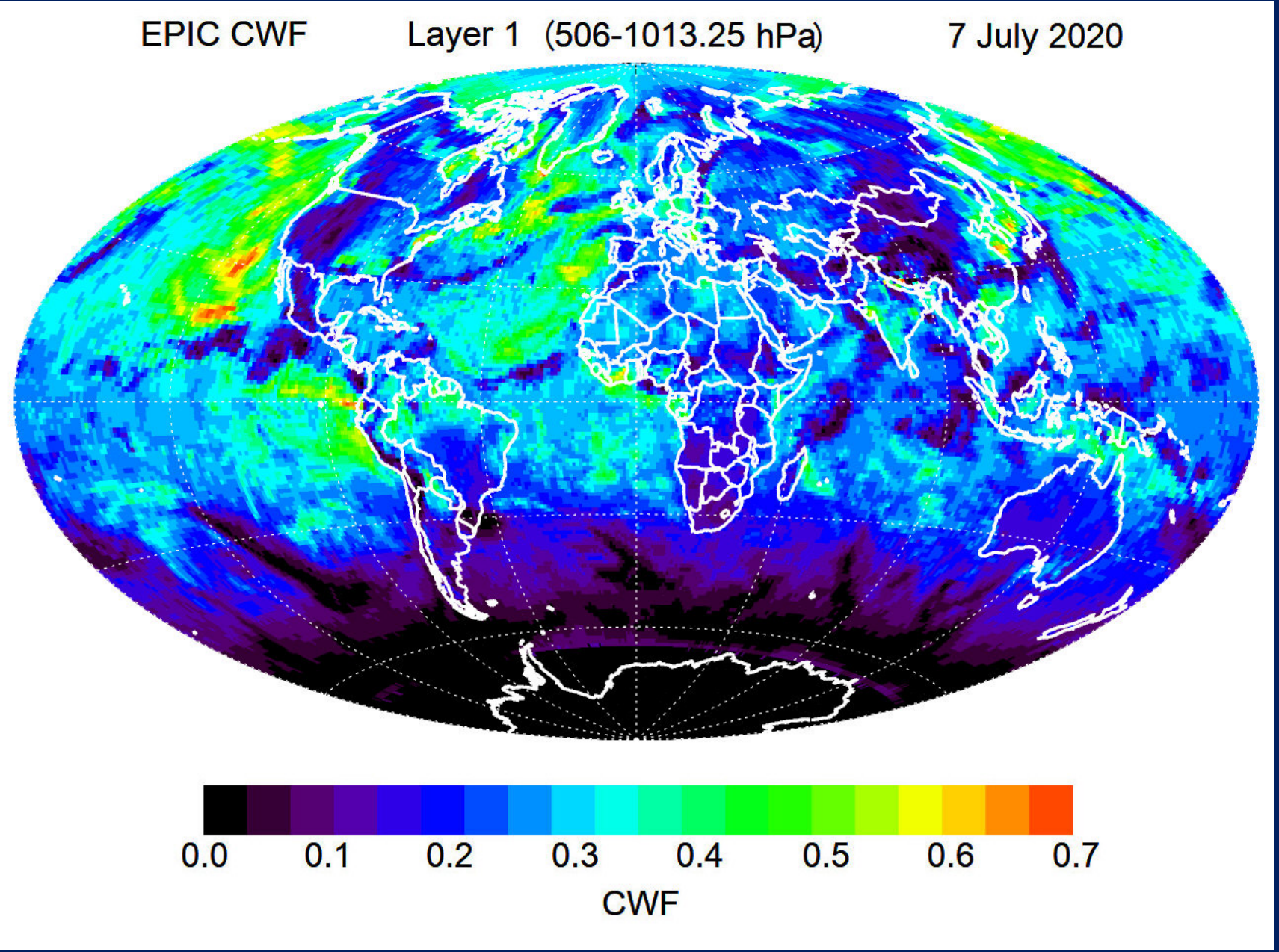
Reductions in pollution NO_x leads to reductions in ozone

OMPS: Reduced Tropospheric Ozone in NH/Tropics in 2020

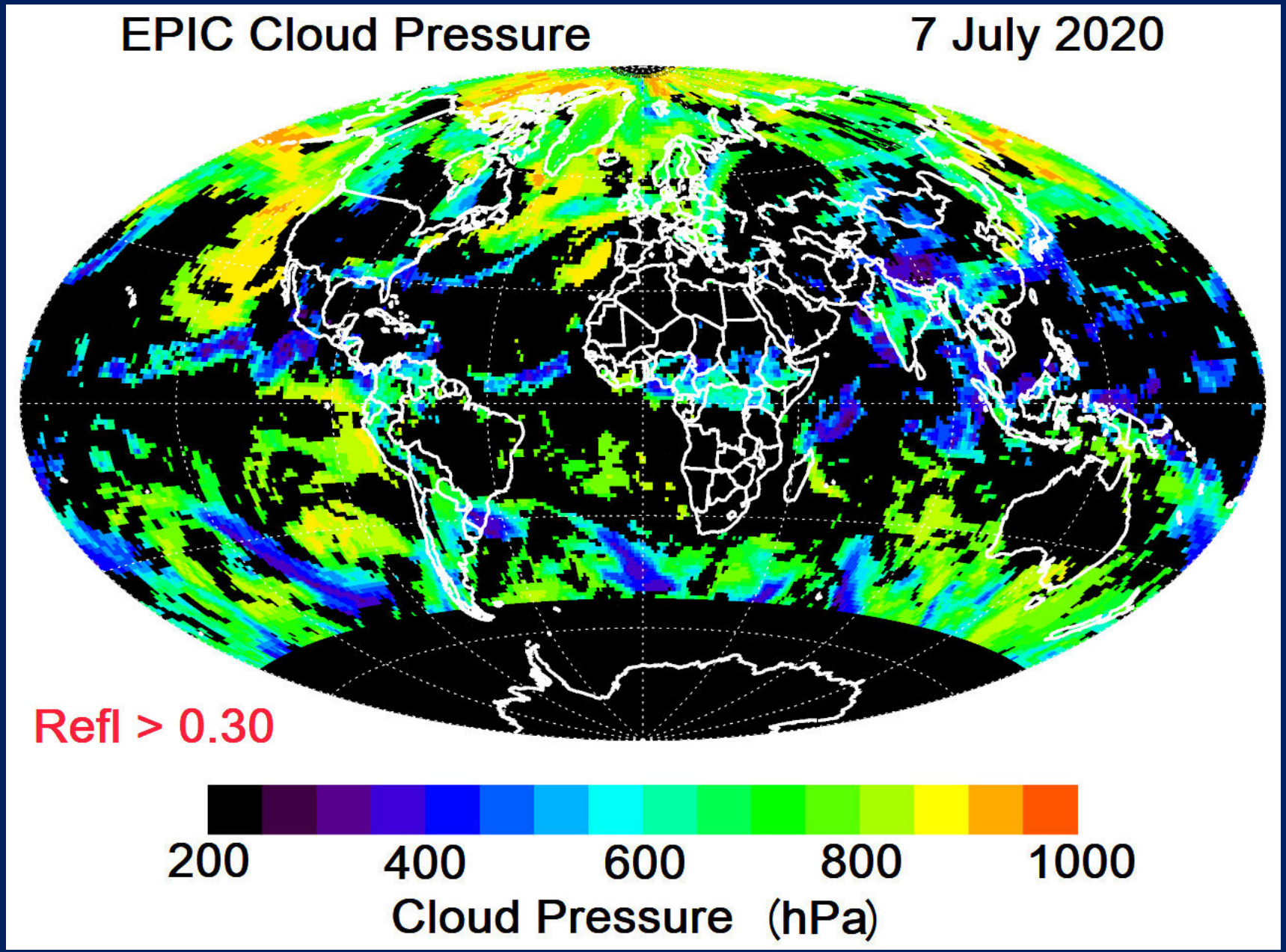


(Oct-Dec 2020 Was Strong La Nina: Produced LOW Tropo O_3 over west Pacific)

EPIC v3 Vertical Column Weighting Kernels

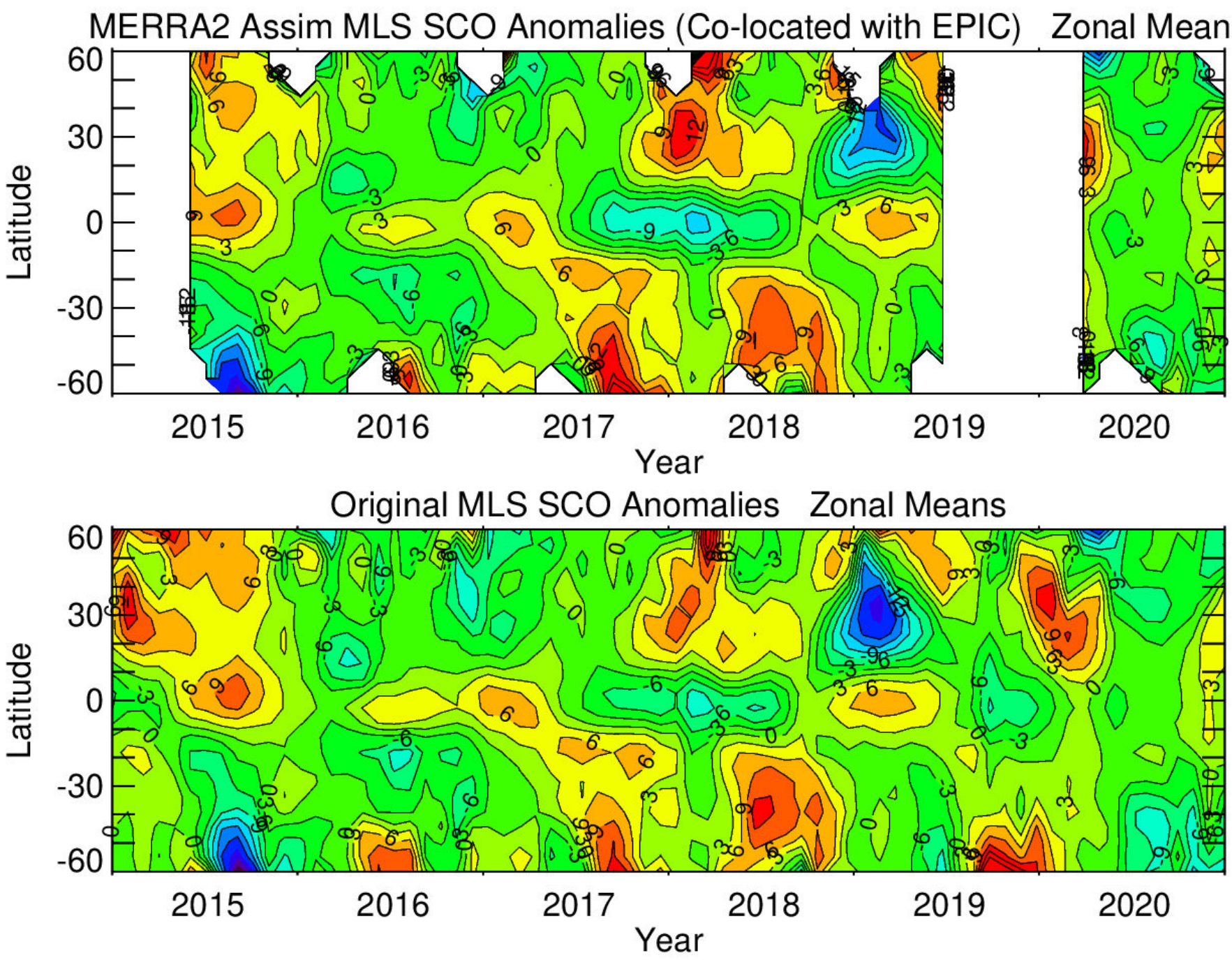


EPIC v3 in situ Cloud Pressure (A-band)



EPIC Retrieved Spectral Bands

Wavelength (nm)	Full Width (nm)	Primary Application
317.5 ± 0.1	1 ± 0.2	Ozone, SO_2
325 ± 0.1	2 ± 0.2	Ozone
340 ± 0.3	3 ± 0.6	Ozone, Aerosols
388 ± 0.3	3 ± 0.6	Aerosols, Clouds
443 ± 1.0	3 ± 0.6	Aerosols
551 ± 1.0	3 ± 0.6	Aerosols, Vegetation
680 ± 0.2	2 ± 0.4	Aerosols, Vegetation, Clouds
687.75 ± 0.2	0.8 ± 0.2	Clouds
764 ± 0.2	1.0 ± 0.2	Clouds
779.5 ± 0.3	2.0 ± 0.4	Clouds, Vegetation


MERRA2 Assim MLS SCO Anomalies (Co-located with EPIC) Zonal Means
Latitude
60
30
0
-30
-60
2015
2016
2017
2018
2019
2020
Year
Original MLS SCO Anomalies Zonal Means
Latitude
60
30
0
-30
-60
2015
2016
2017
2018
2019
2020
Year