NASA tropospheric ozone from EPIC, OMI, and OMPS satellite measurements: Current status and science results

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Tropospheric Column Ozone Satellite Products from NASA GSFC Code 614

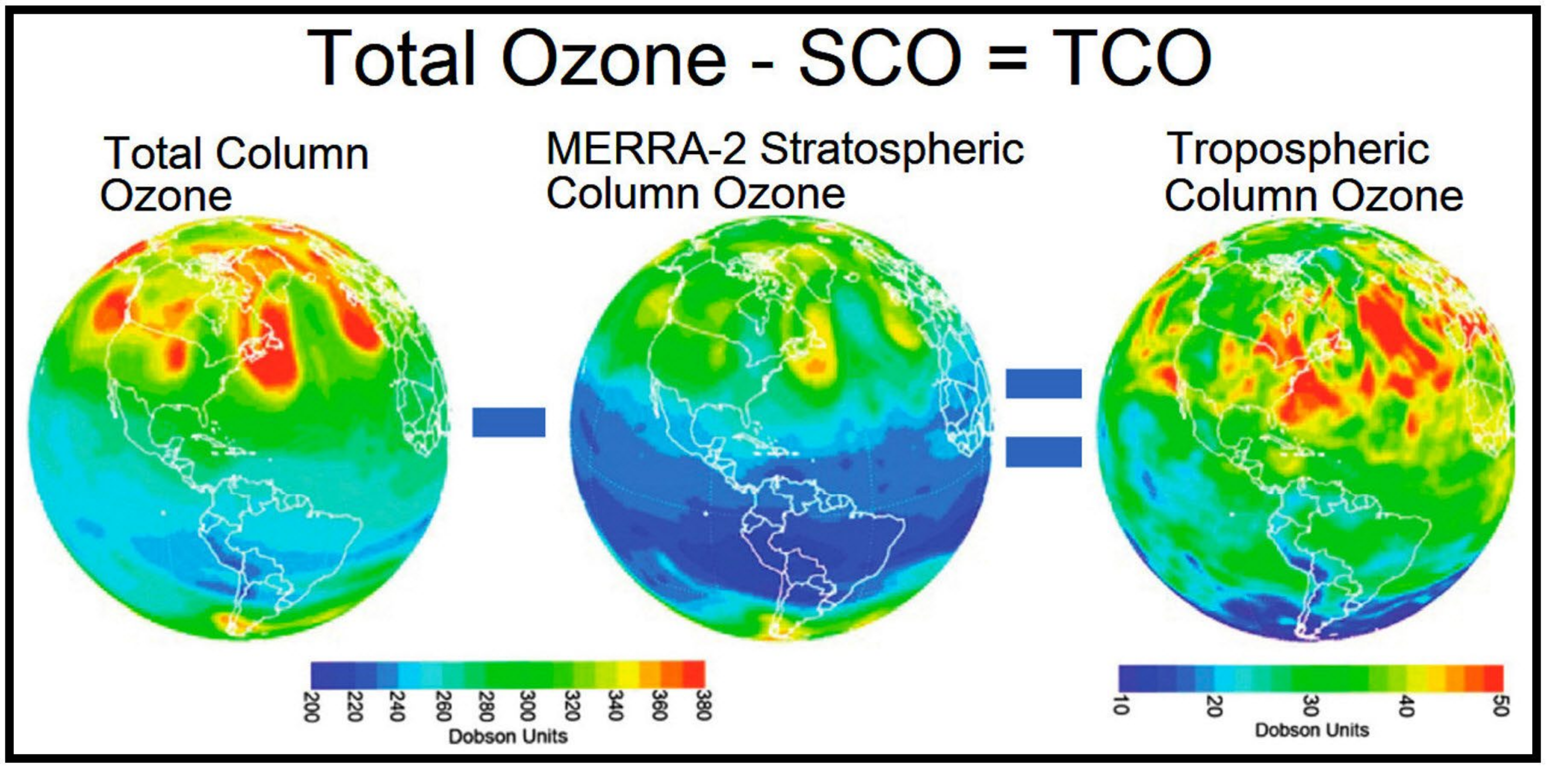
Online products (https://asdc.larc.nasa.gov, and https://acp-ext.gsfc.nasa.gov/Data_services/cloud_slice):

- TOMS CCD: 1979-2005, monthly, 30S-30N, $5^{o}\times5^{o}$
- OMI/MLS: October 2004-recent, monthly, 60S-60N, $1^{o}\times1.25^{o}$ and $5^{o}\times5^{o}$
- EPIC/MERRA2: June 2015-recent, hourly-to-monthly, 90S-90N, $1^{o}\times1^{o}$
- OMPS/MERRA2: January 2015-recent, daily-to-monthly, 90S-90N, $1^{o}\times1^{o}$

Research Products:

- OMI CCD: October 2004-recent, monthly, 30S-30N, $5^{o}\times5^{o}$
- OMI/MLS Cloud Ozone: October 2004-recent, monthly, 30S-30N, $1^{o}\times1^{o}$
- OMPS NM-LP: January 2012 – recent, monthly, 40S-40N, $1^{o}\times1^{o}$

General Residual Method to Derive Tropospheric Column Ozone

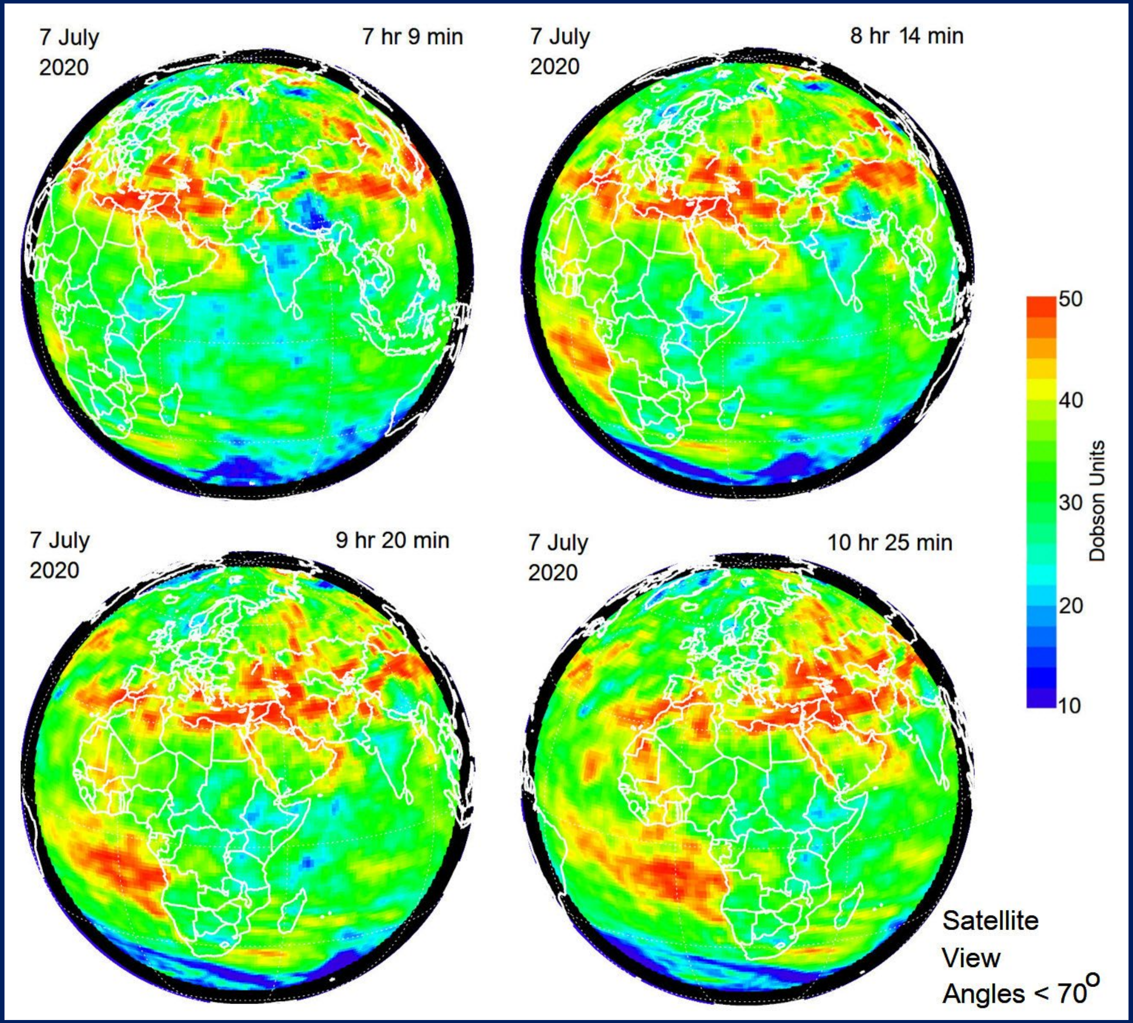


Hourly and daily maps: Collocated MERRA-2 SCO and PV-θ (2.5 PVU, 380K) tropopause pressure

EPIC Hourly Maps of Tropospheric Ozone

EPIC tropospheric ozone maps (every 1-2 hours for June 2015 – present)

Available from Langley ASDC: https://asdc.larc.nasa.gov/



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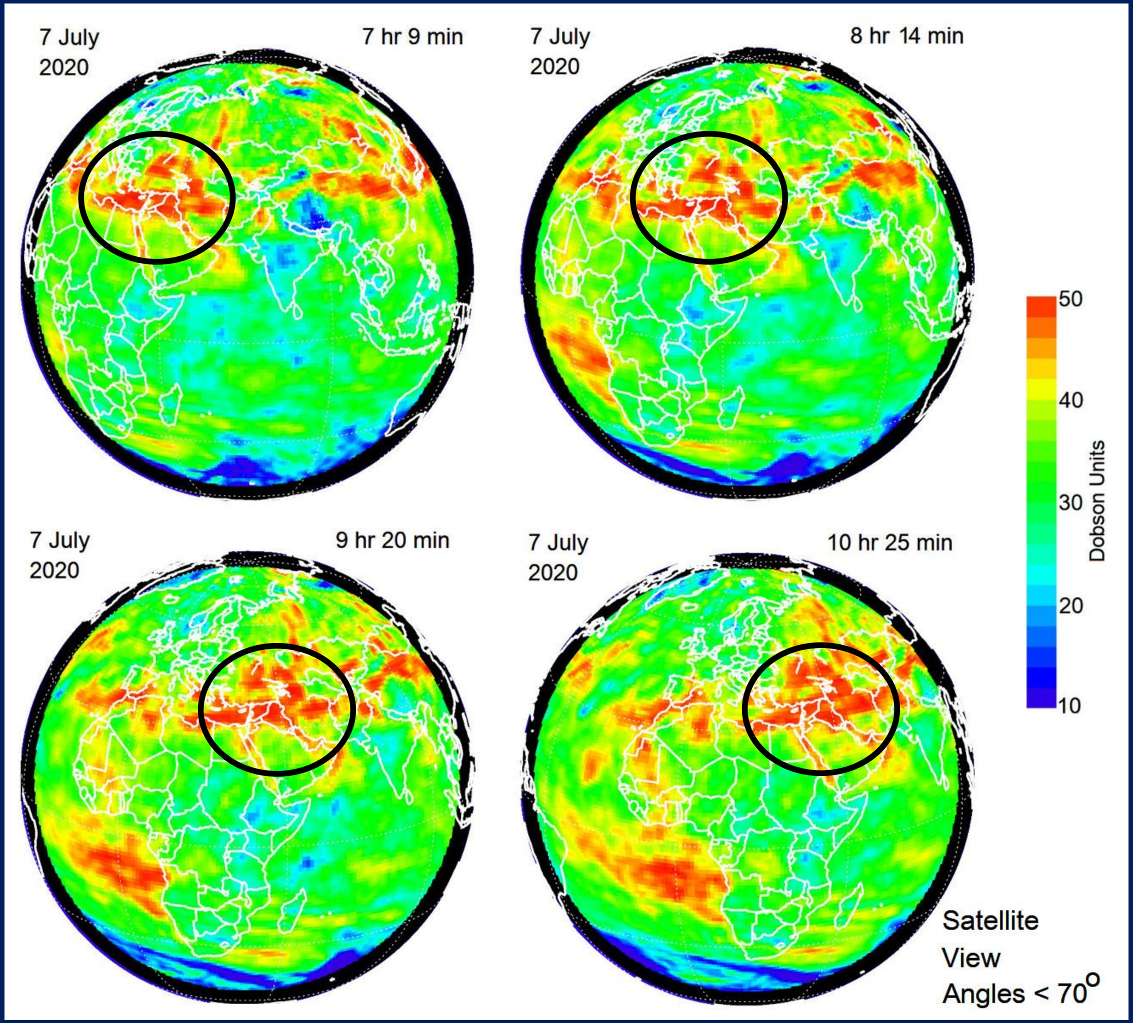
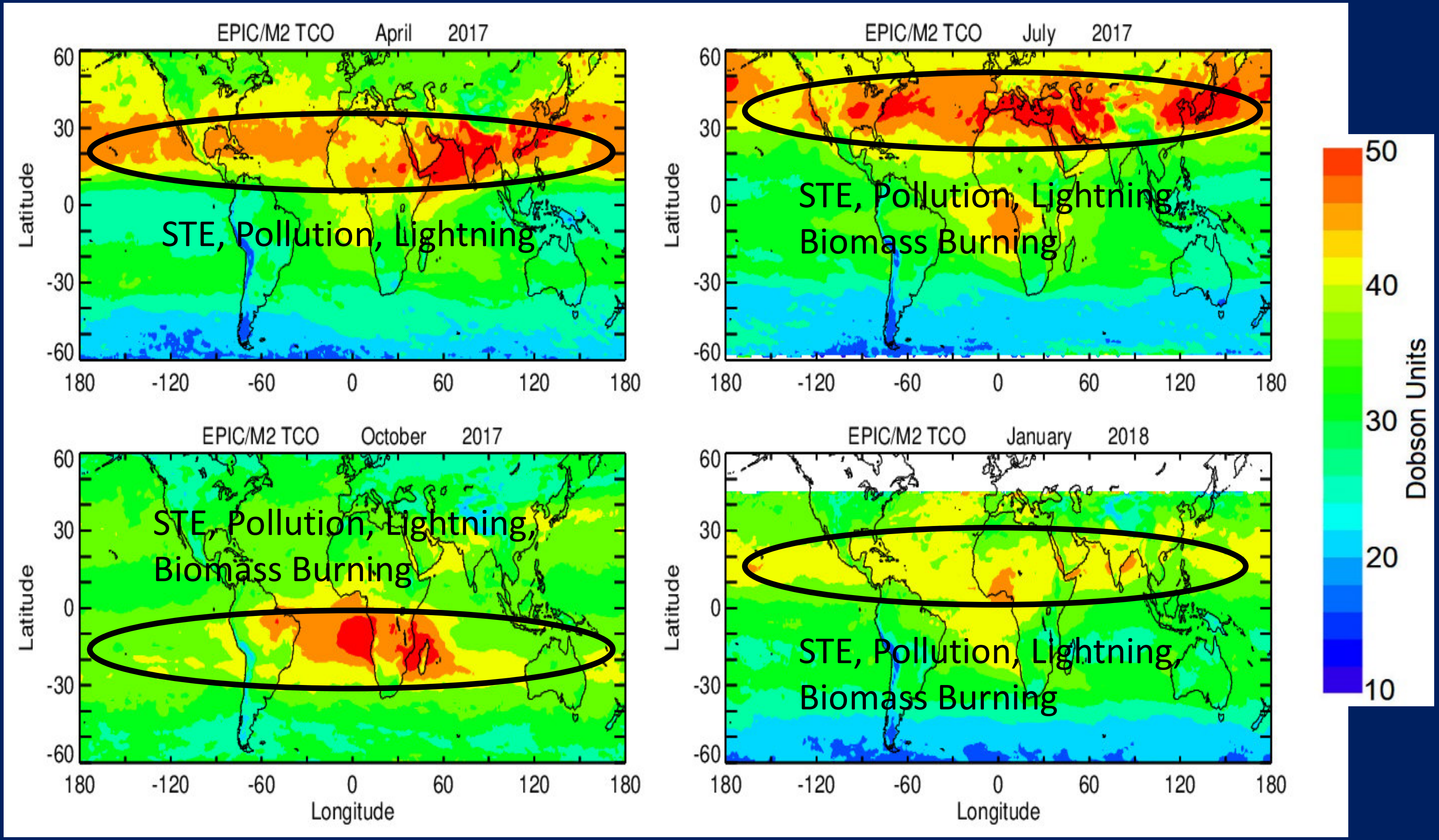
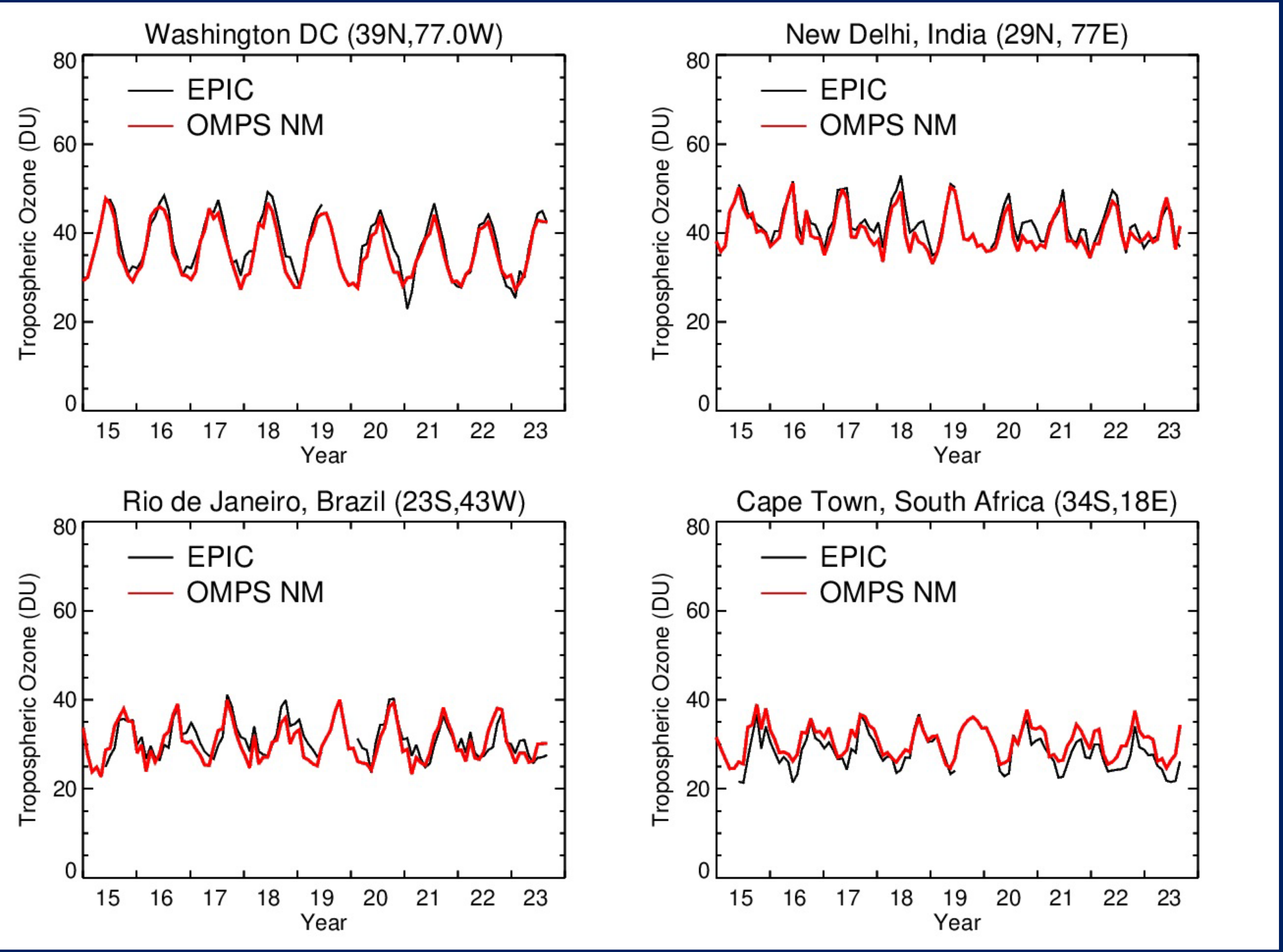


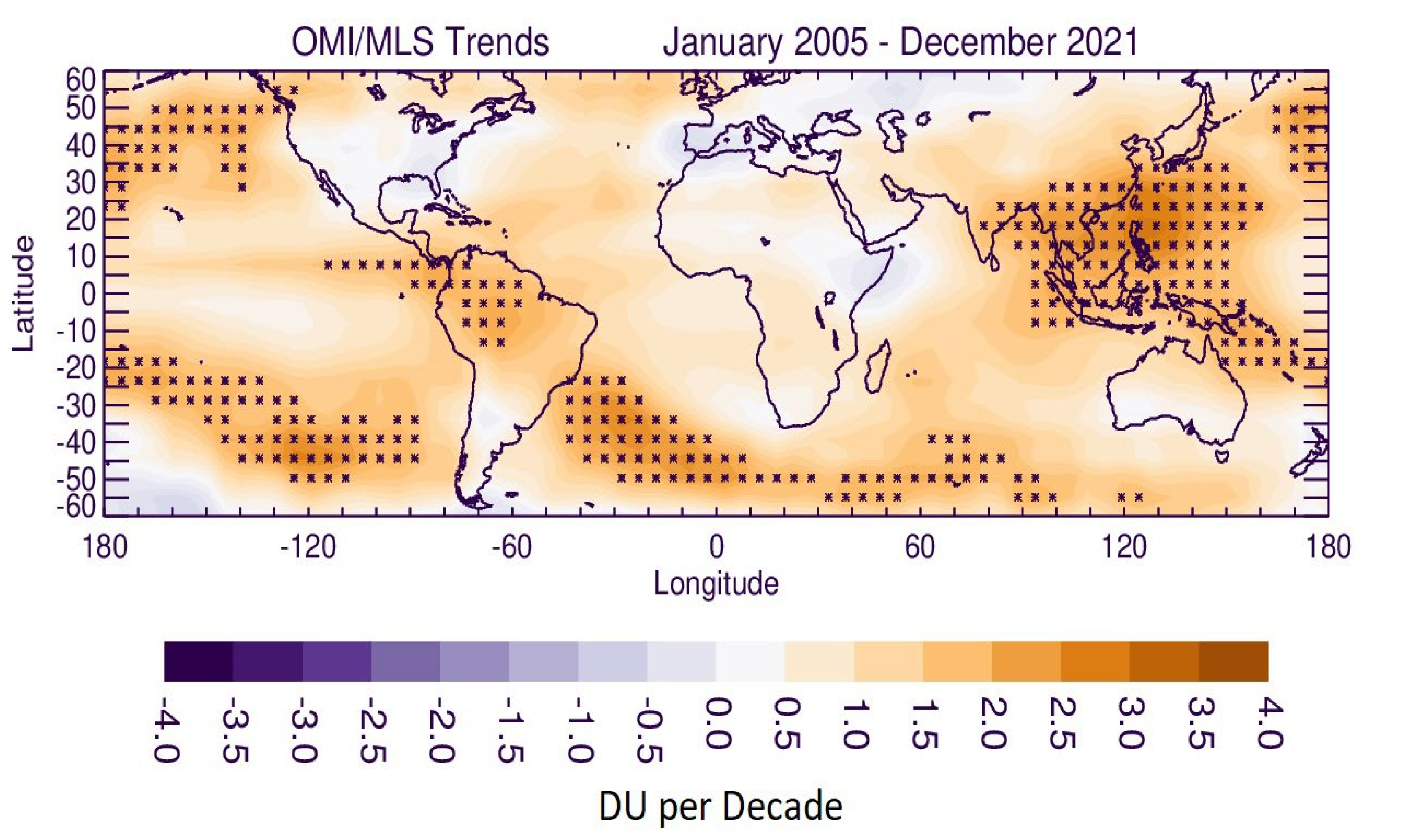
EPIC Global Tropospheric Ozone Maps



EPIC and OMPS TCO



Trends: OMI/MLS for 60S-60N
(includes a new drift correction)



Trends: OMI/MLS for 60S-60N
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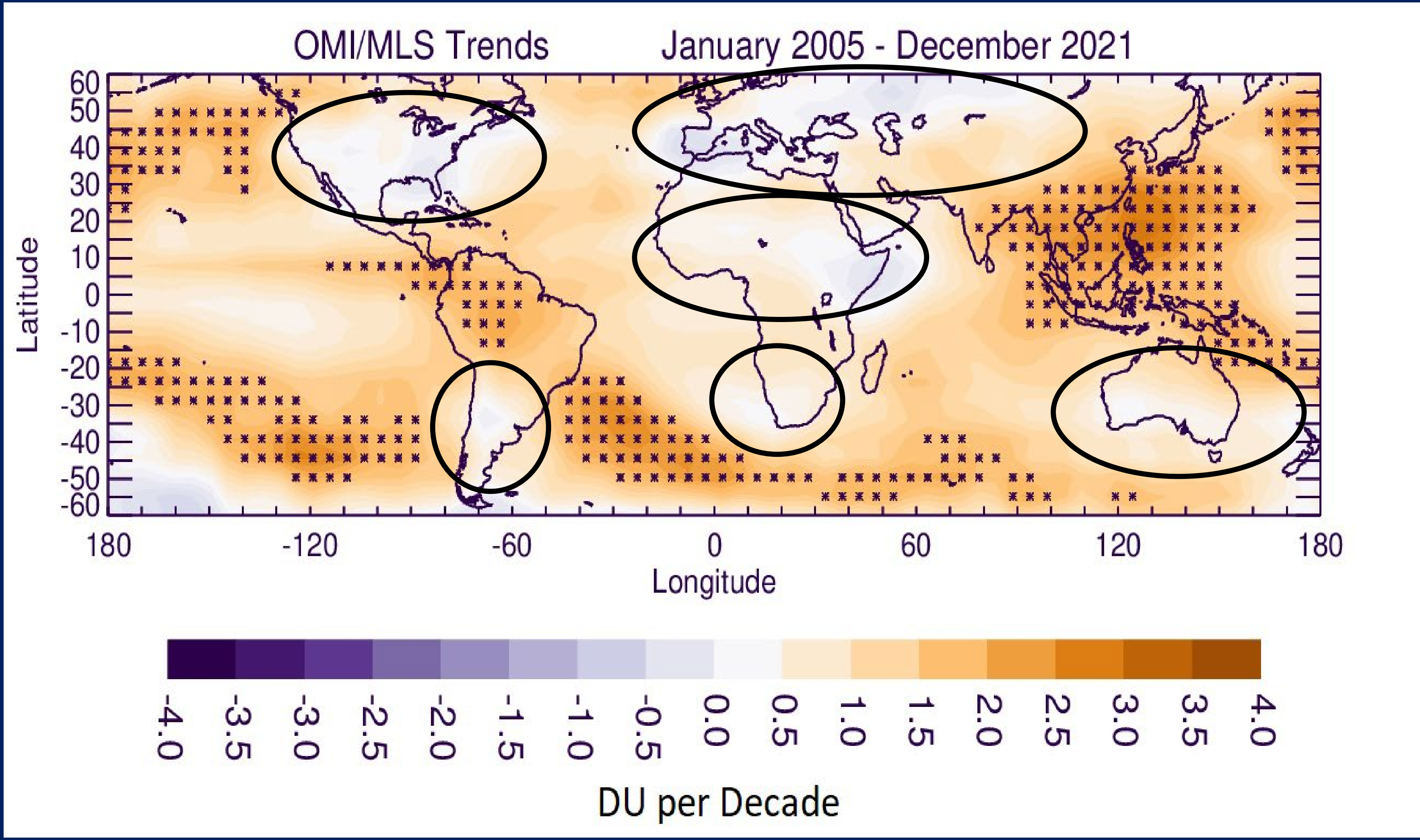
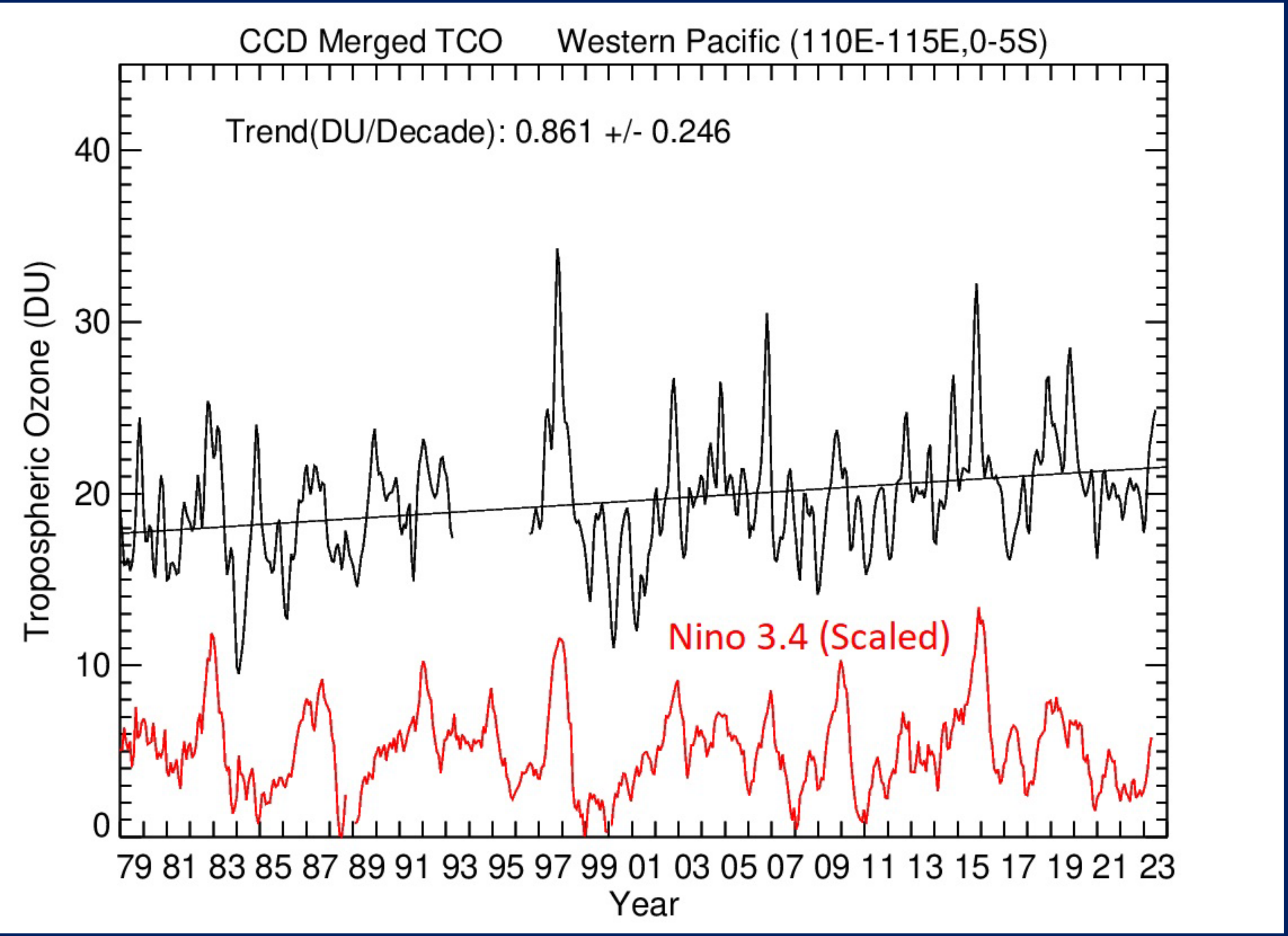
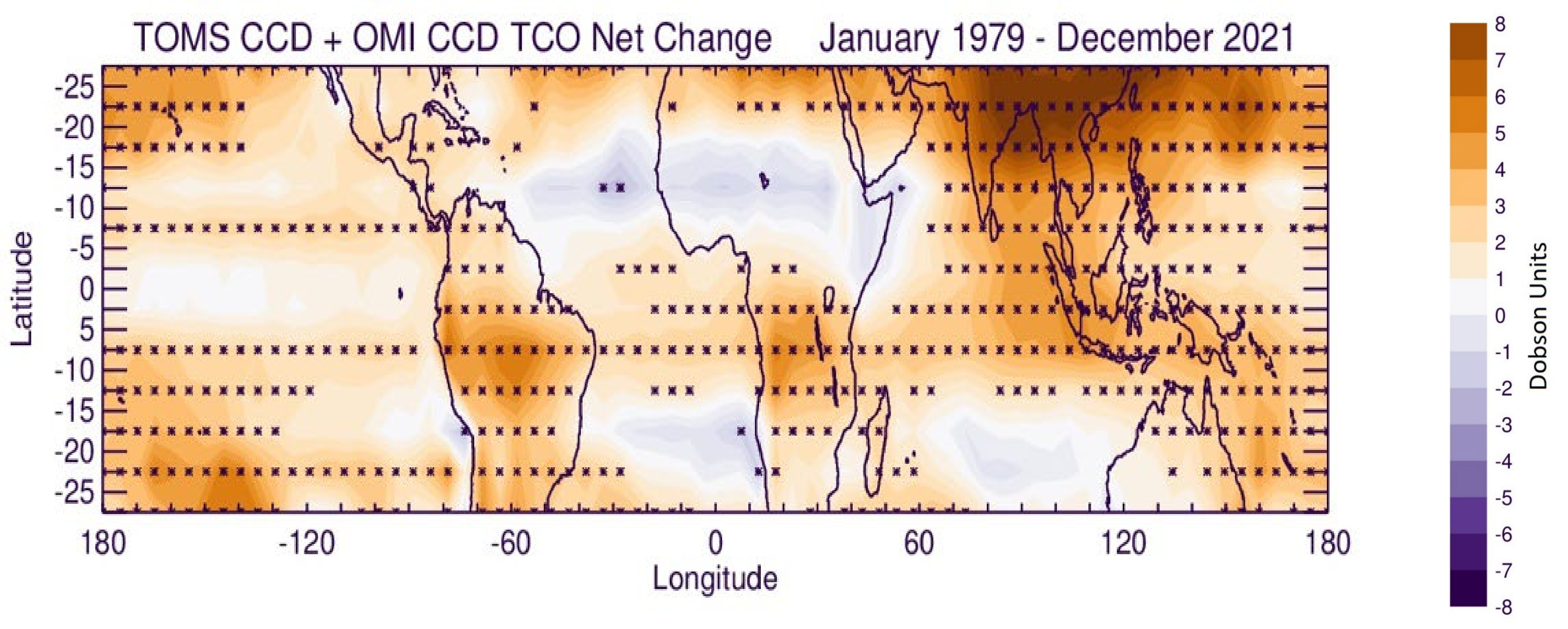


Trends: Long Record of TOMS+OMI CCD Tropospheric Ozone for 30S-30N



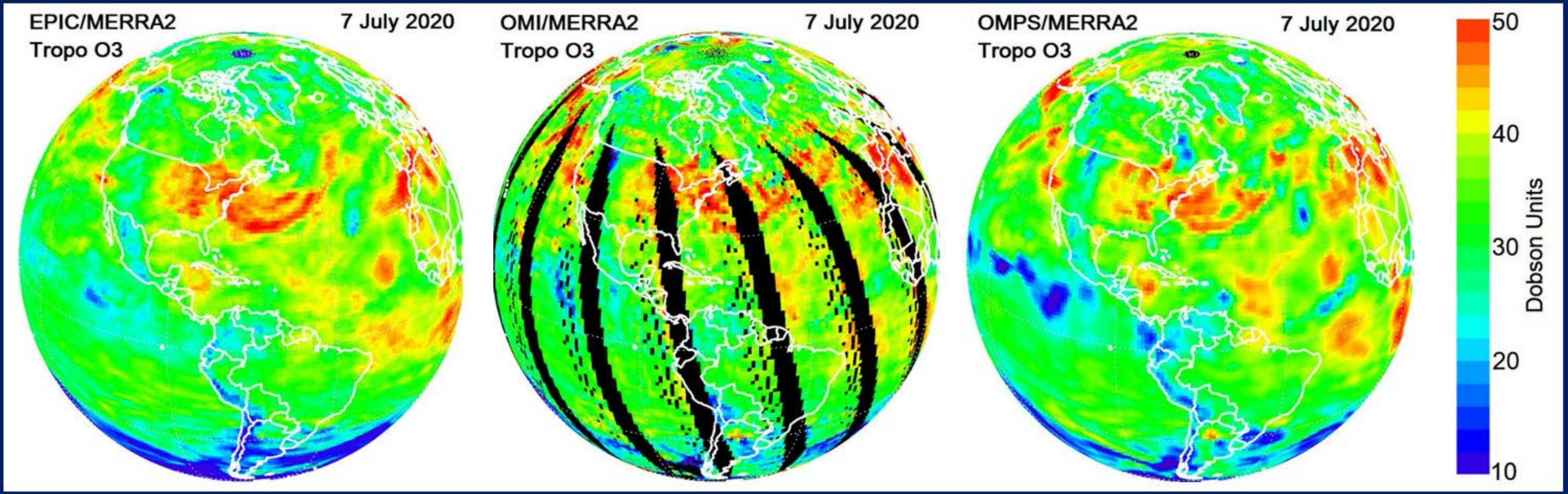
Trends: 43-Year Record Changes in TOMS+OMI CCD Tropospheric Ozone for 30S-30N



- Total change (in DU) = TOMS trend (DU/decade) · 2.6 decades + Trend_OMIMLS (DU/decade) · 1.6 decades
- Total change variance = $2.6^2 \cdot$ var(Trend_TOMS) + $1.6^2 \cdot$ var(Trend_OMIMLS)

To Investigate TCO Anomalies During the COVID Period We Derive a "Merged" Tropospheric Column Ozone Dataset from Combining EPIC with OMI and OMPS nadir mappers

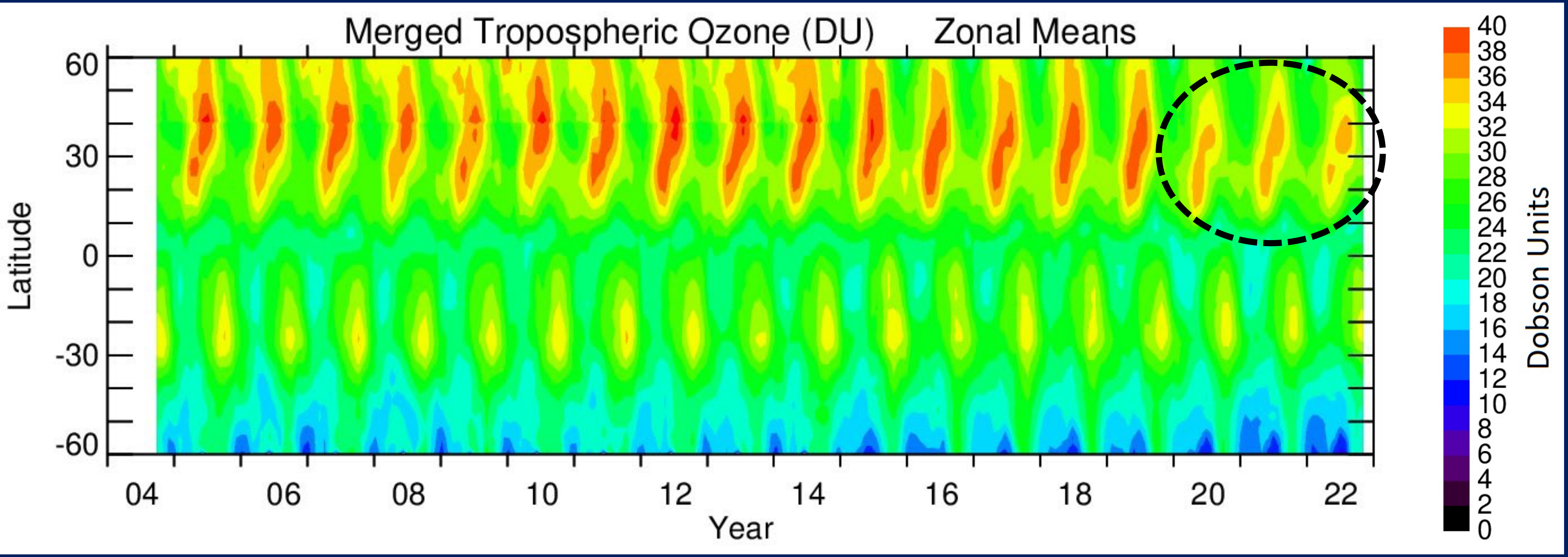
EPIC OMI OMPS



All three use co-located MERRA-2 SCO with PV-θ tropopause (2.5 PVU, 380 K) to derive tropospheric column ozone

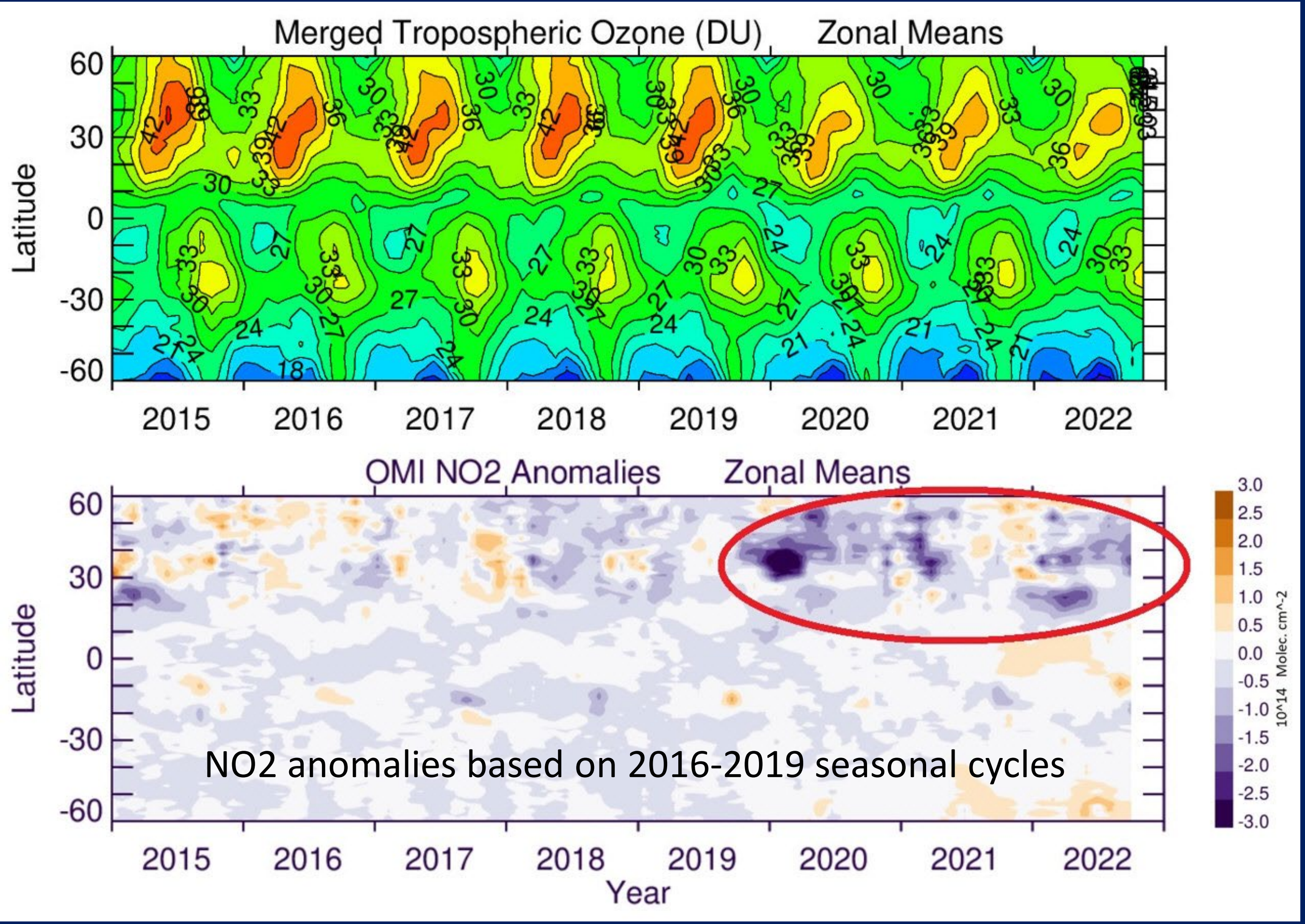
EPIC+OMPS+OMI "Merged" long record: Global-scale reductions in NH TOR in 2020, 2021, 2022

(Ziemke et al., 2022, GRL)

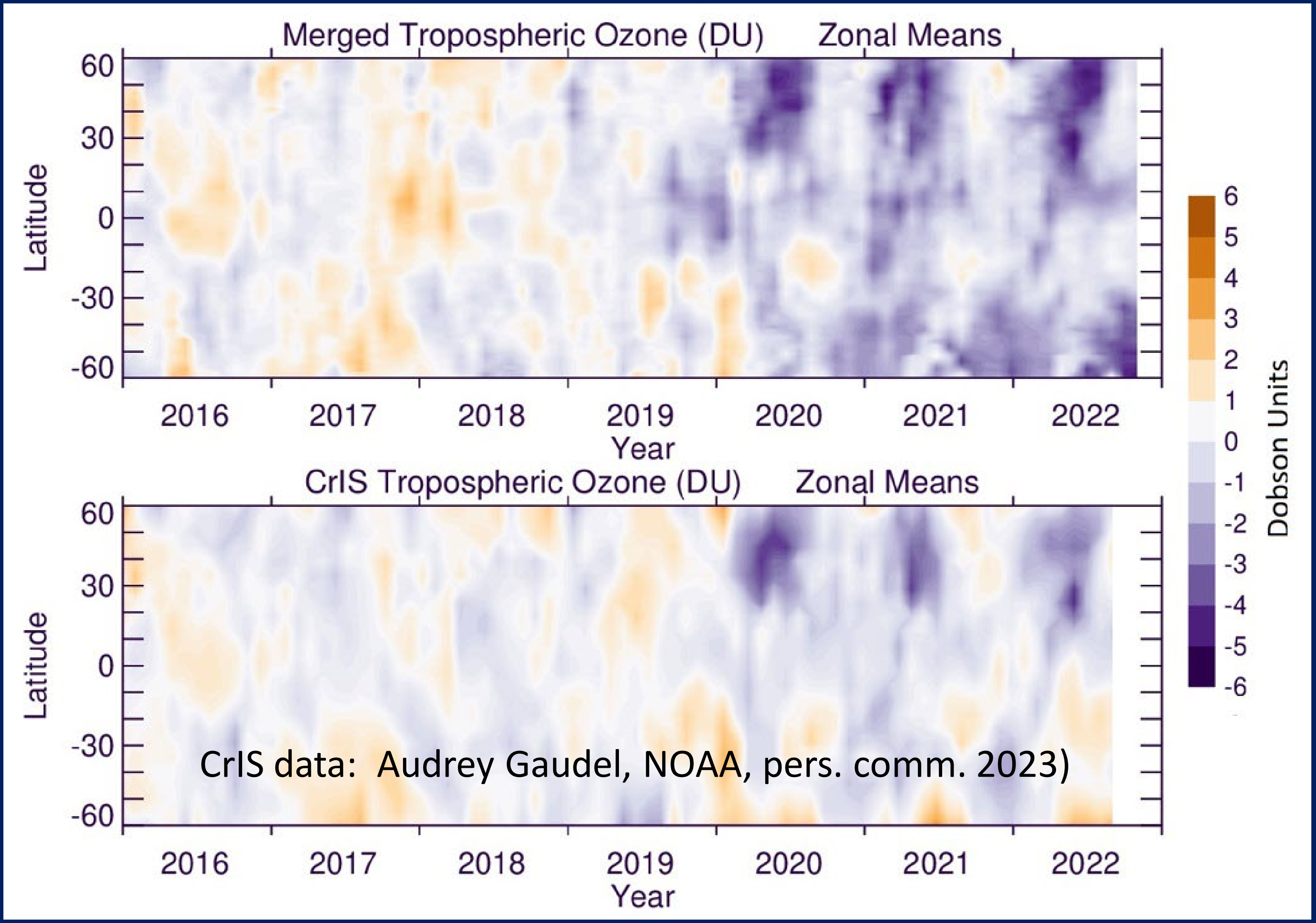


- Drops in TCO in spring-summer of ~3 DU each year 2020-2022
- May be driven largely by decrease in NH pollution during and after COVID-19 (OMI NO_2 also shows anomalous drops in spring-summer 2020-2022)

Anomalous Drops in NH Tropospheric Ozone and NO2 in 2020, 2021, and 2022 (More Than Just COVID-Related?)

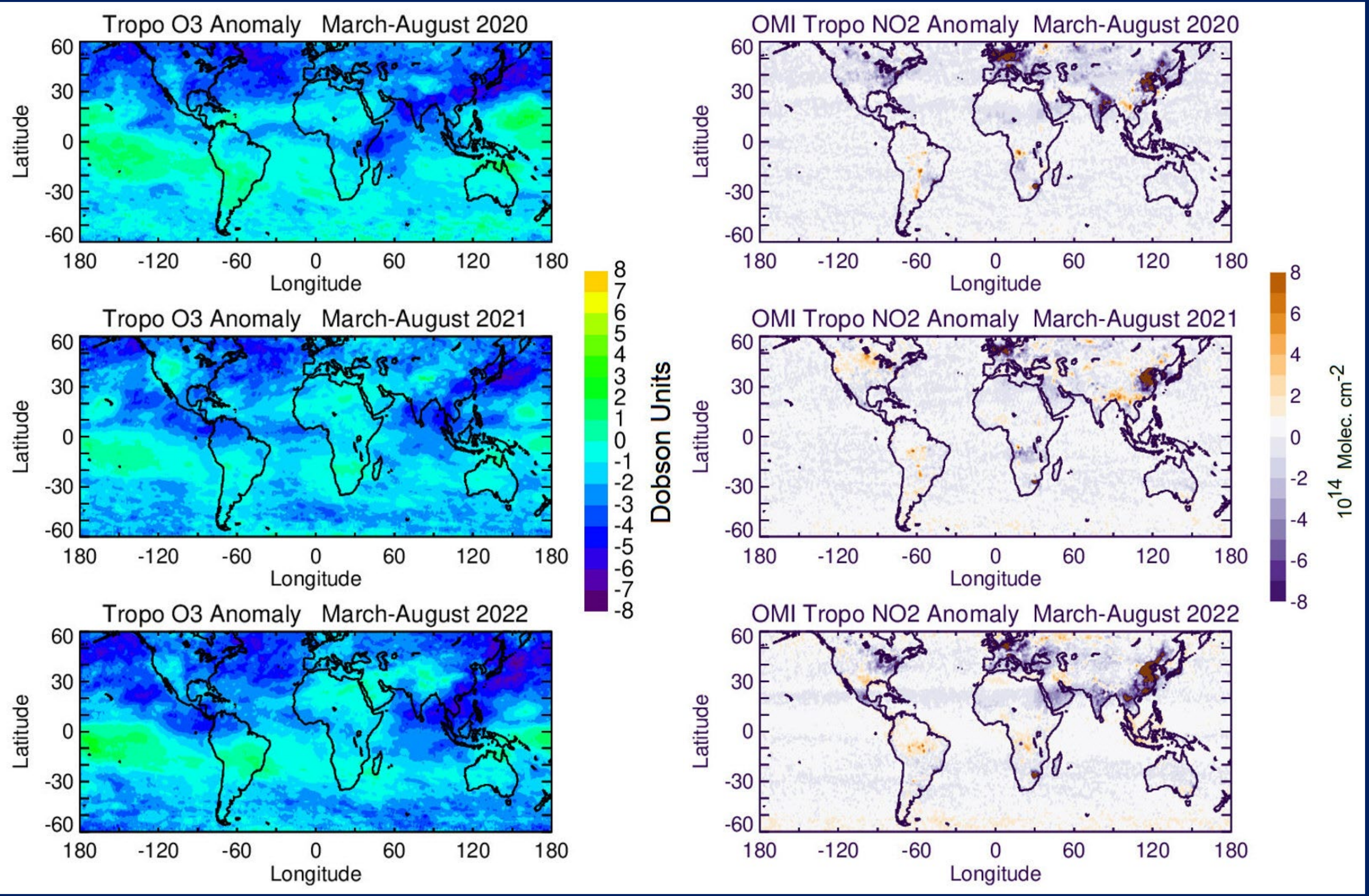


Anomalous Reductions in Tropospheric Ozone in 2020, 2021, 2022



(Anomalies based on 2016-2019 average seasonal cycles)

Spring and Summer Anomalies For Tropospheric Ozone and NO2 during 2020-2022



Seasonal anomalies based on 2016-2019 average seasonal cycles

Conclusions

Several online products available from NASA GSFC Code 614:

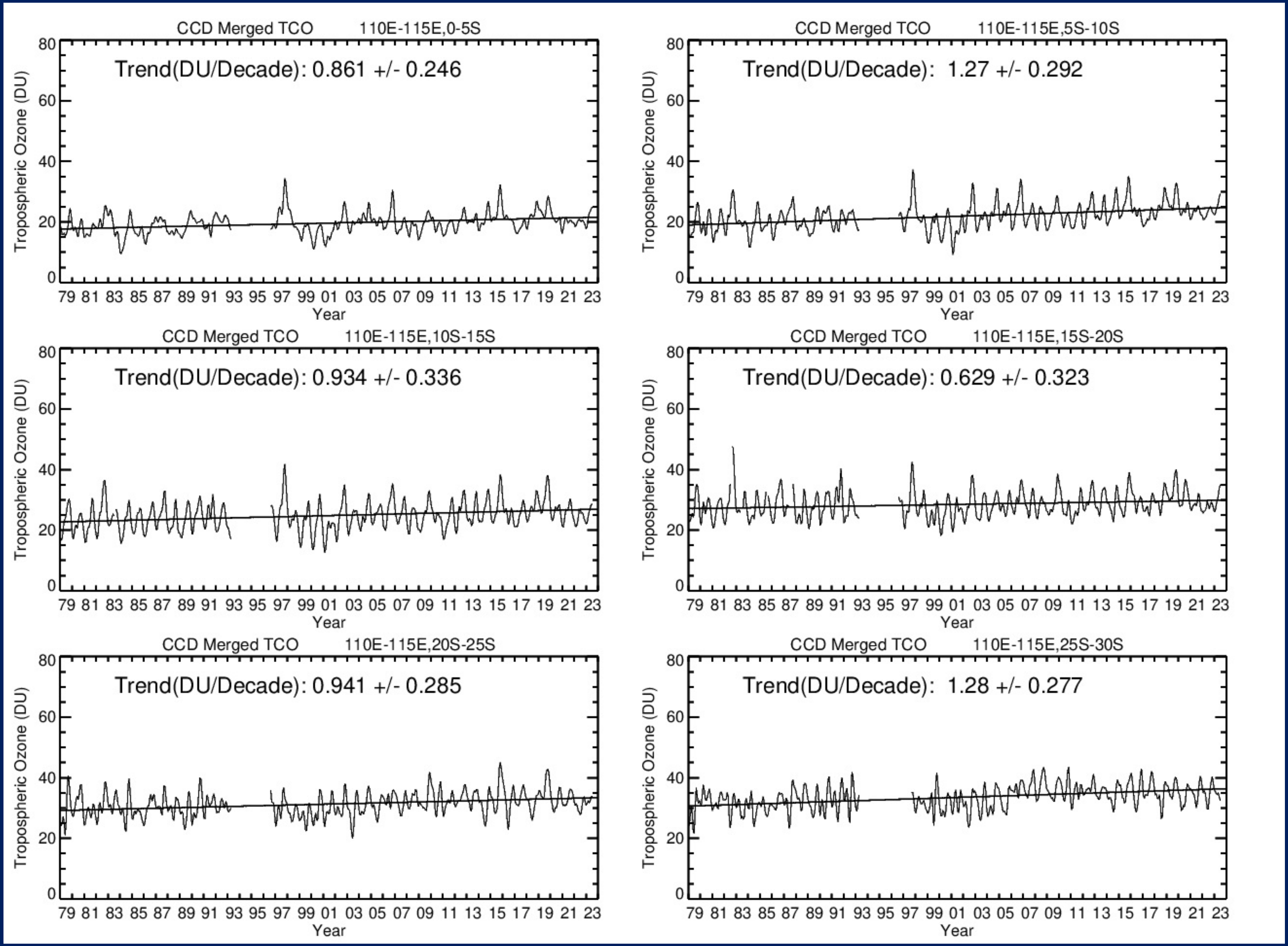
- EPIC/M2: Every 1-2 hours 2015-recent (data download from ASDC)
- OMI/MLS: Monthly 2004-recent
- TOMS: Monthly for 1979-2005 (limited to tropics)
- OMPS/M2: Daily 2012-recent

Science:

- Tropospheric ozone trends show overall increases for both OMI/MLS and TOMS with some regional negative trends and largest positive trends about SE Asia (~+7-8 DU increase for 1979-recent, ~+1.9 DU/decade avg)
- Ozone in free troposphere shows reductions of ~3 DU (~8%) in NH in spring-summer 2020-2022 (three-year drop also appears in OMI tropospheric NO2)

Extra Plots

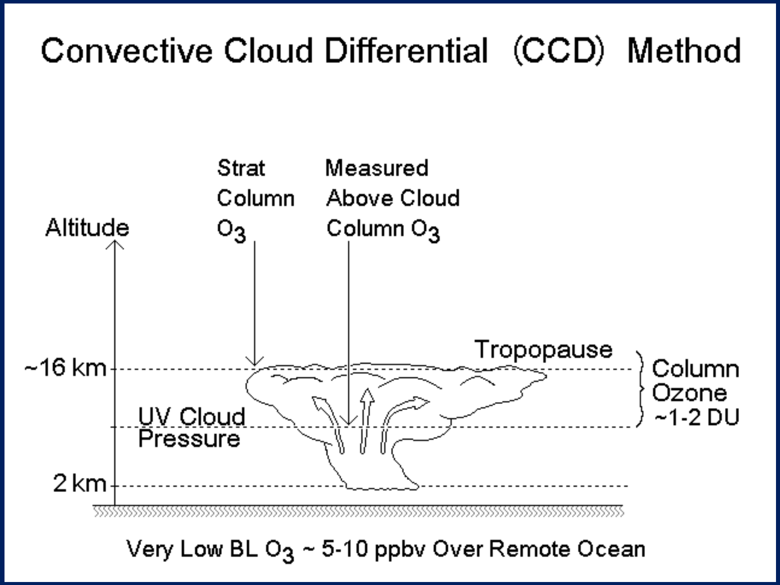
45-Year record of TOMS+OMI CCD Tropospheric Ozone for 30S-30N

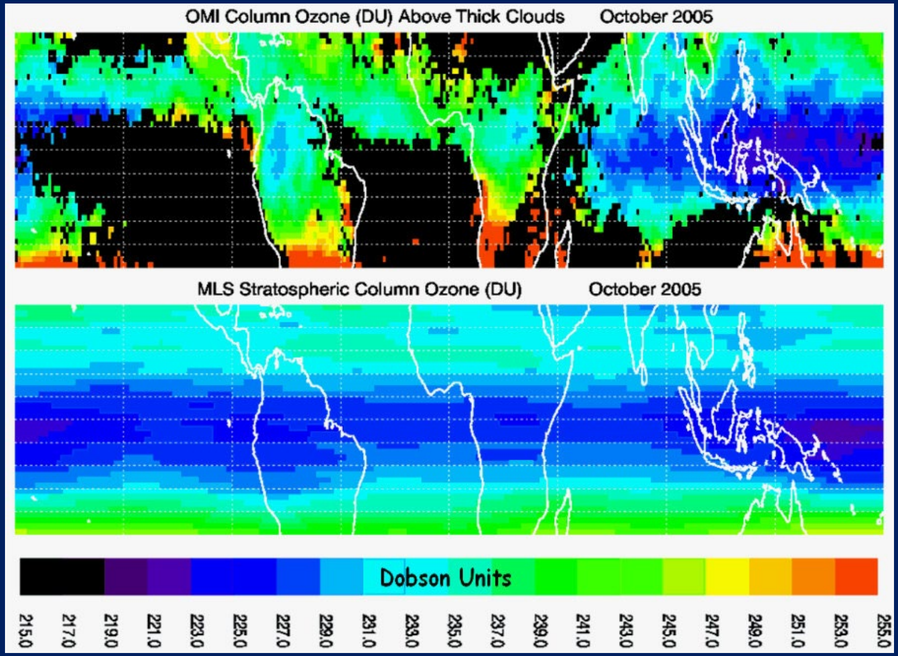


"Convective-Cloud Differential" (CCD) Method for deriving gridded tropical tropospheric column ozone

Step 1: Determine SCO in the tropical Pacific using ozone columns measured over deep convective clouds

Step 2: Apply natural zonal invariance of SCO in the tropics in 5-degree latitude bands to derive gridded SCO throughout the tropics

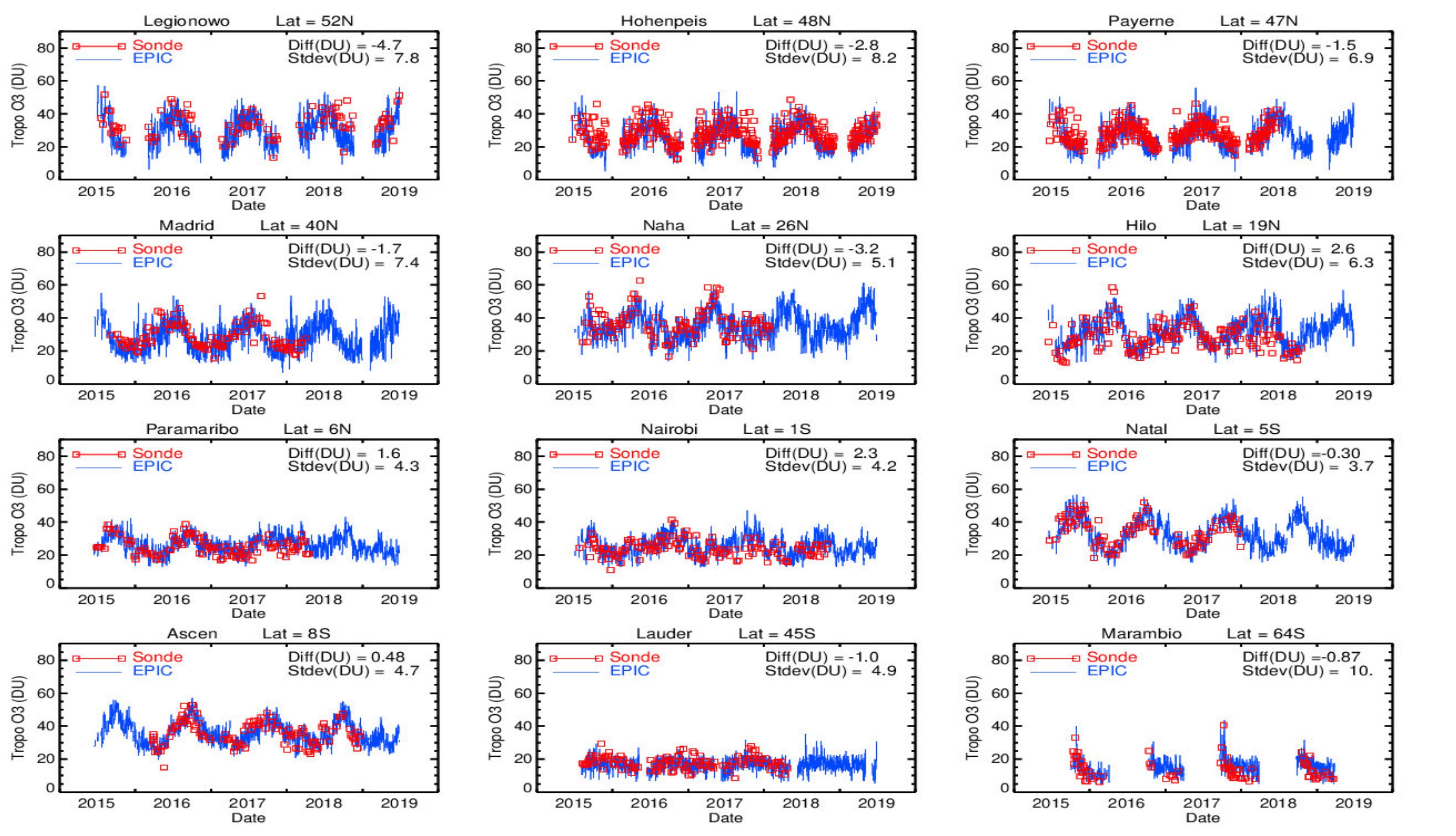




(Ziemke, J. R., J. Joiner, S. Chandra, et al., ACP, 2009)

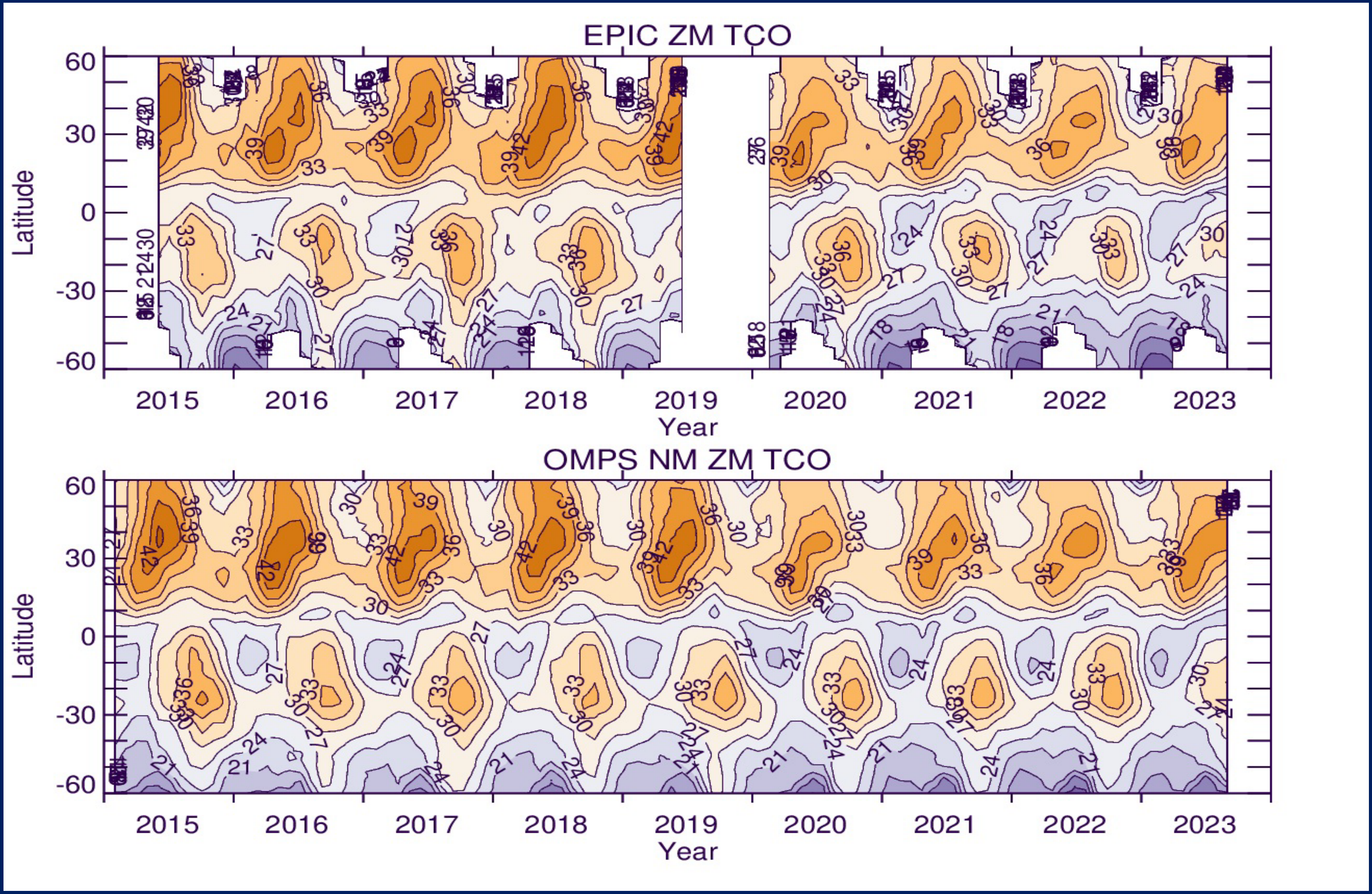
Validation: EPIC vs Ozonesonde Daily TOR

(Kramarova, et al., Front. Remote Sens., 2021)



Agreement within ±2.5 DU (or ~ ± 10%) after applying -3 DU global offset correction

TCO foor 2023 Remains Low by ~3 DU Compared to Previous Years



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