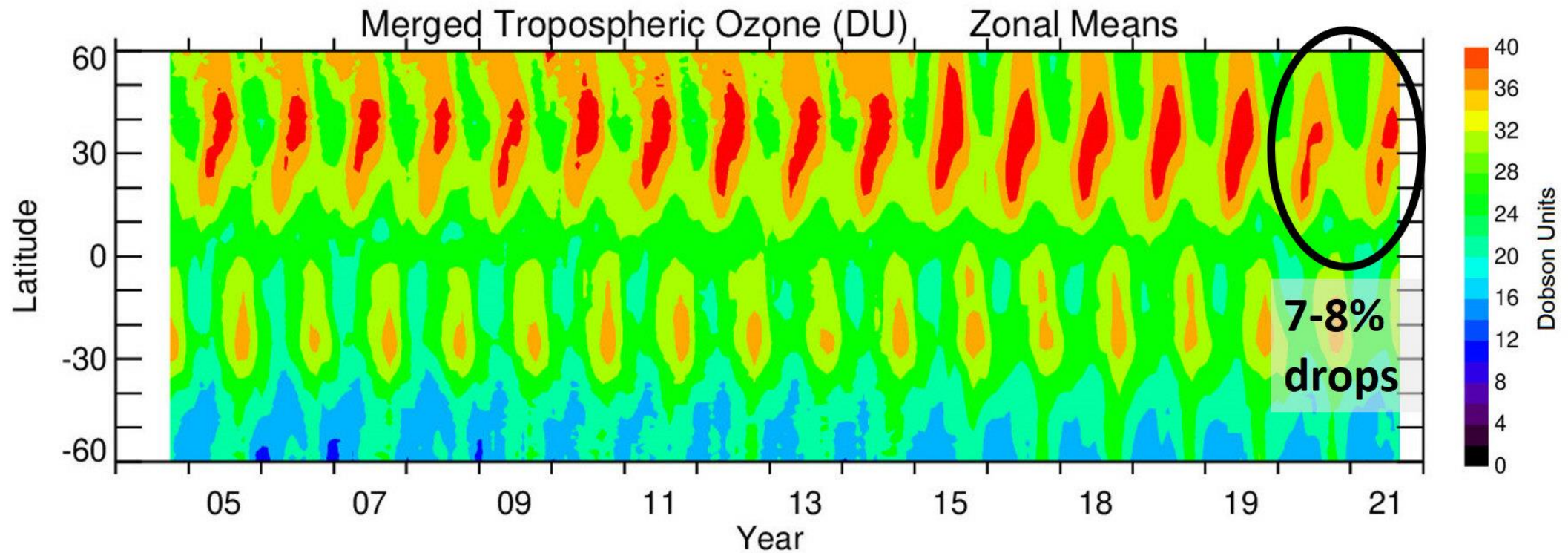




# Global-scale reductions in free tropospheric ozone in 2020-2022 associated with decreased pollution due to COVID-19 and impact on trends



Jerry R. Ziemke, Natalya A. Kramarova, Stacey M. Frith, Liang-Kang Huang  
NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

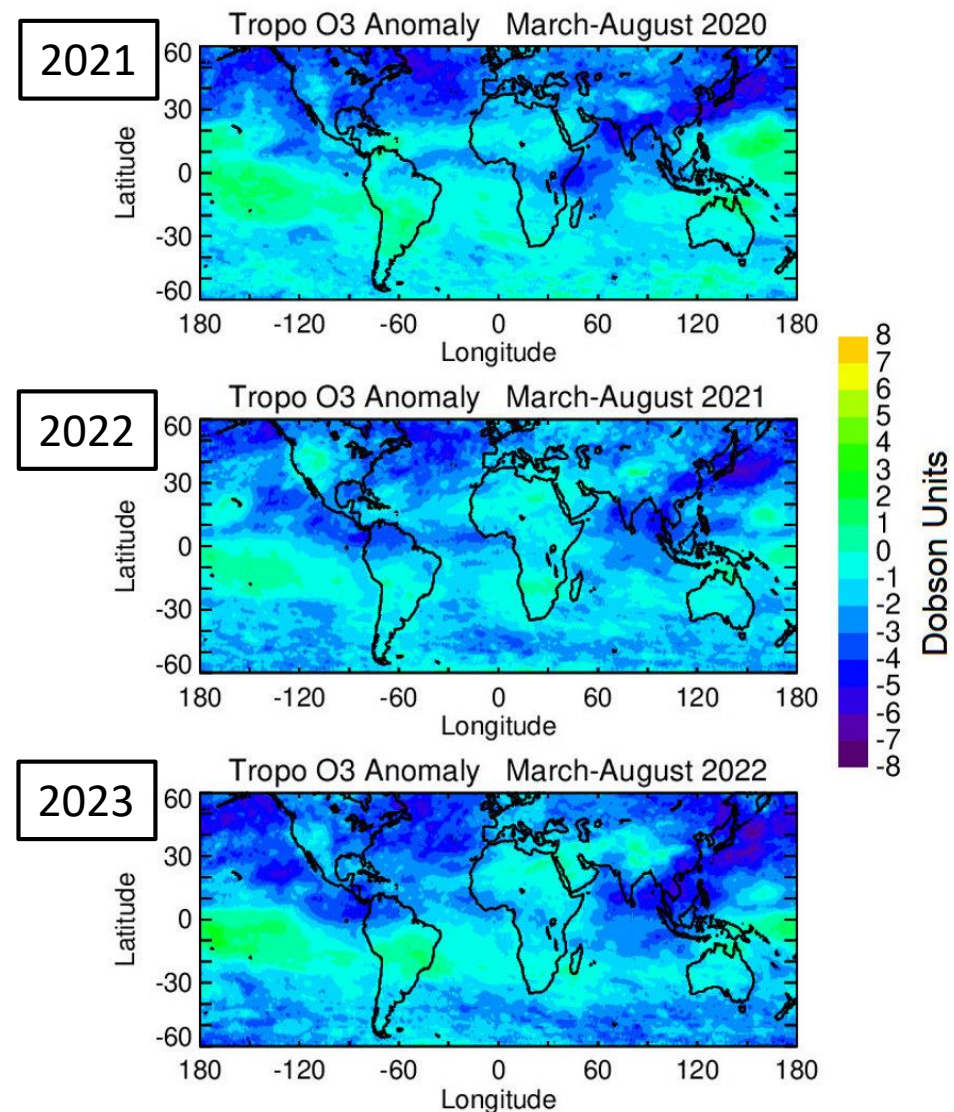
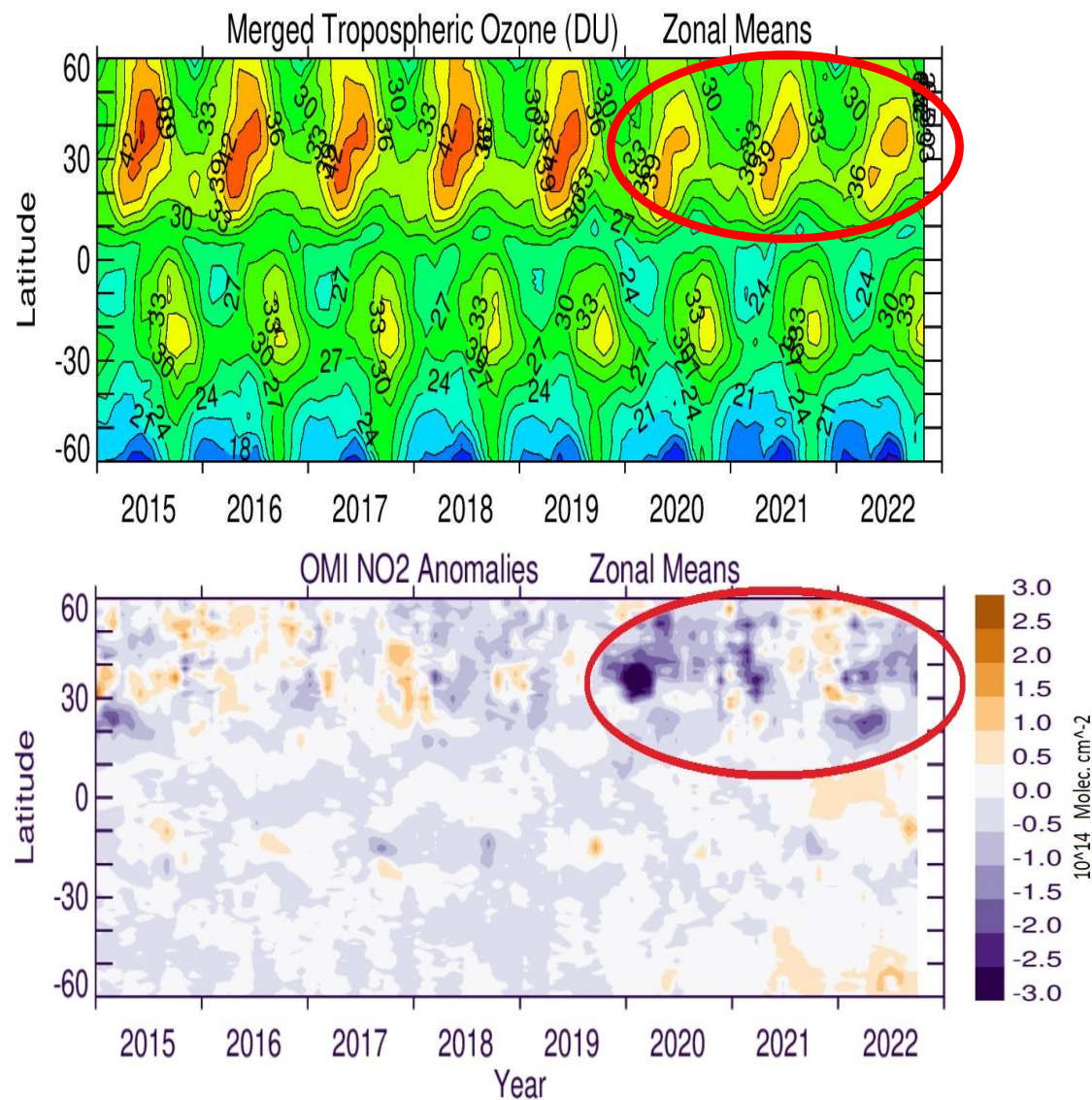


(Ziemke et al., 2022, Geophys. Res. Lett.)

“Merged”: Aura OMI + DSCOVR EPIC + SNPP OMPS NM Average Tropospheric Column Ozone Fields



# Update: Anomalous Low NH Free Tropospheric Ozone and NO<sub>2</sub> for Three Consecutive Years 2020-2022



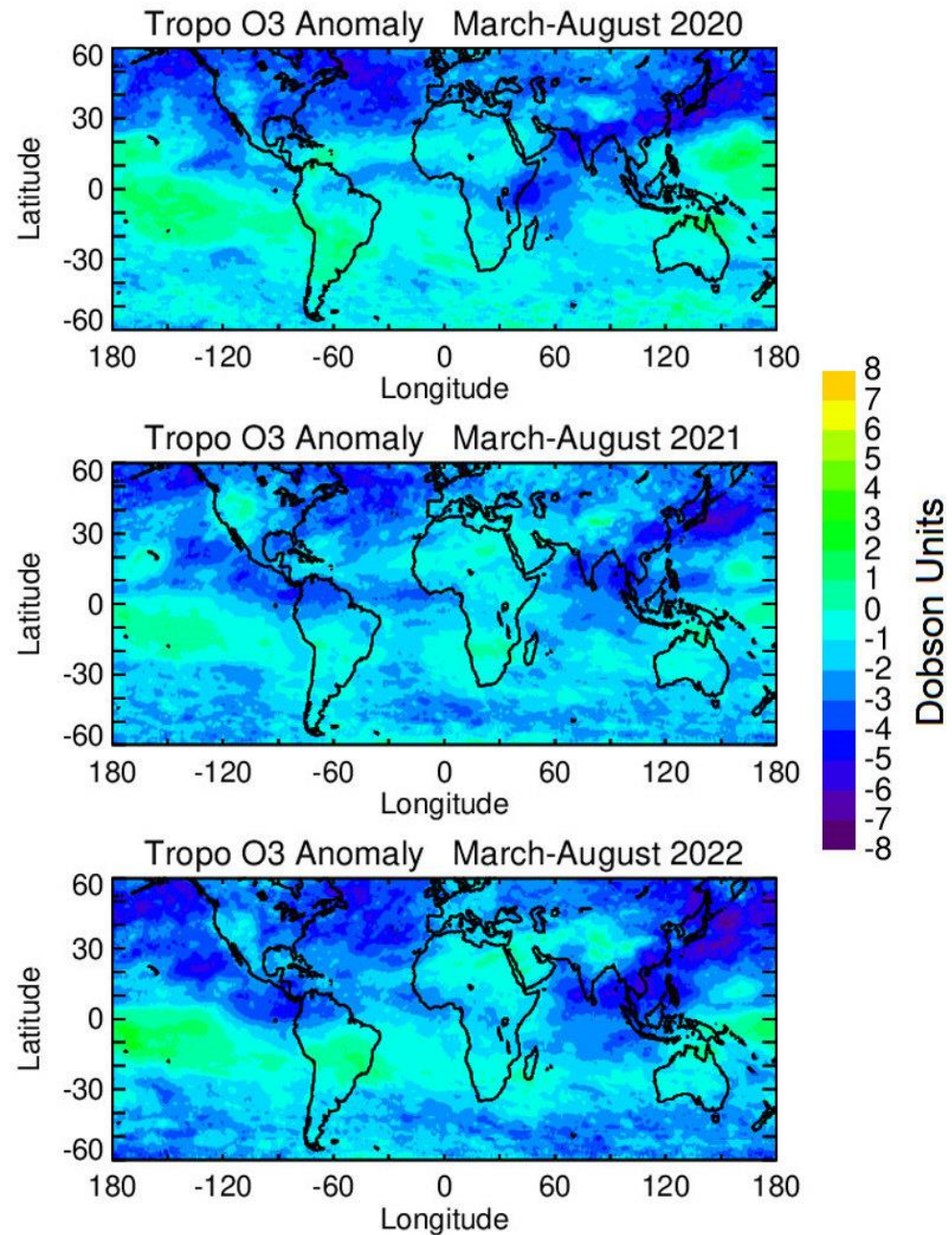
Anomalous decreases (in **BLUE**):

- Mostly NH
- Mostly over ocean

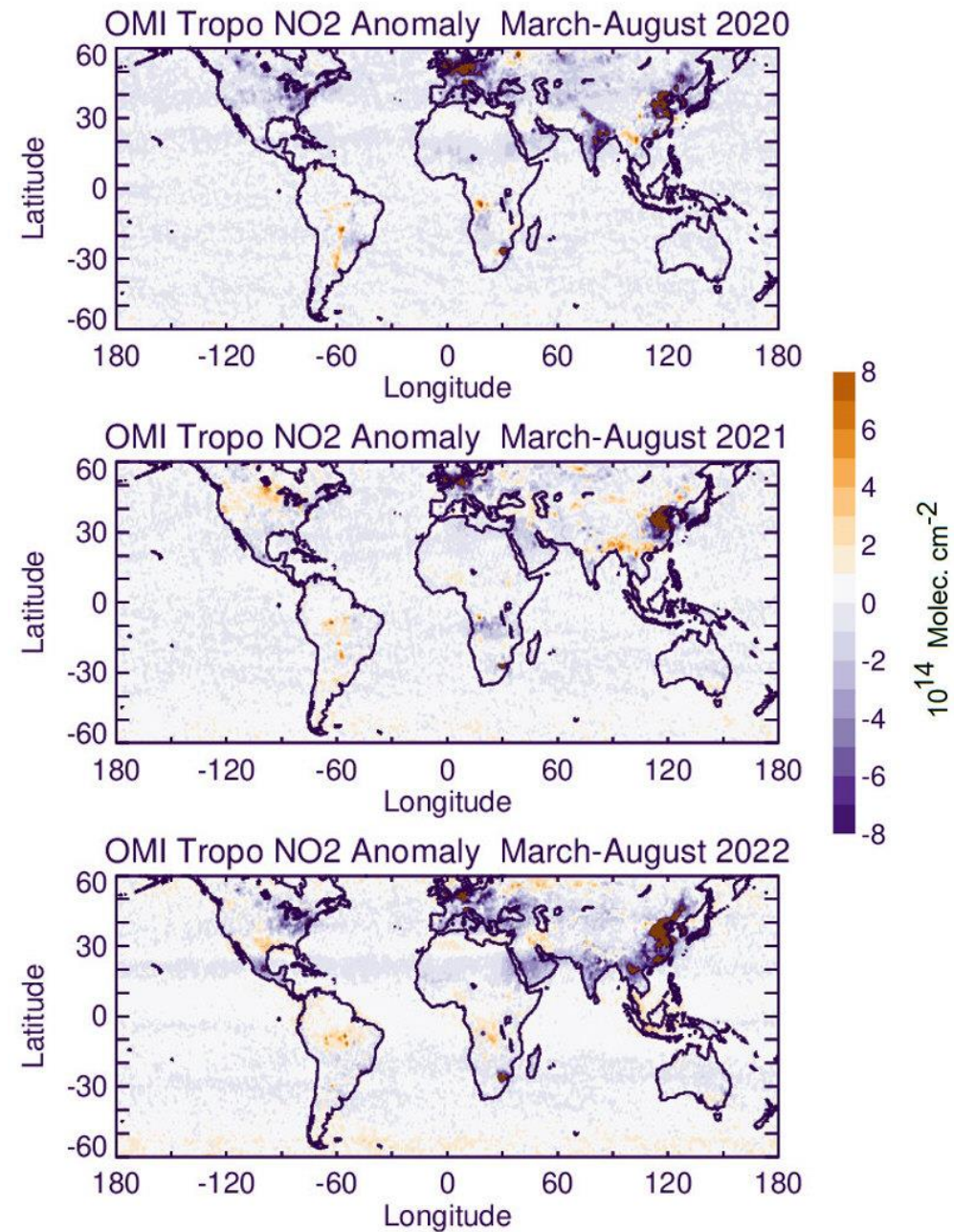
# Extra Plots



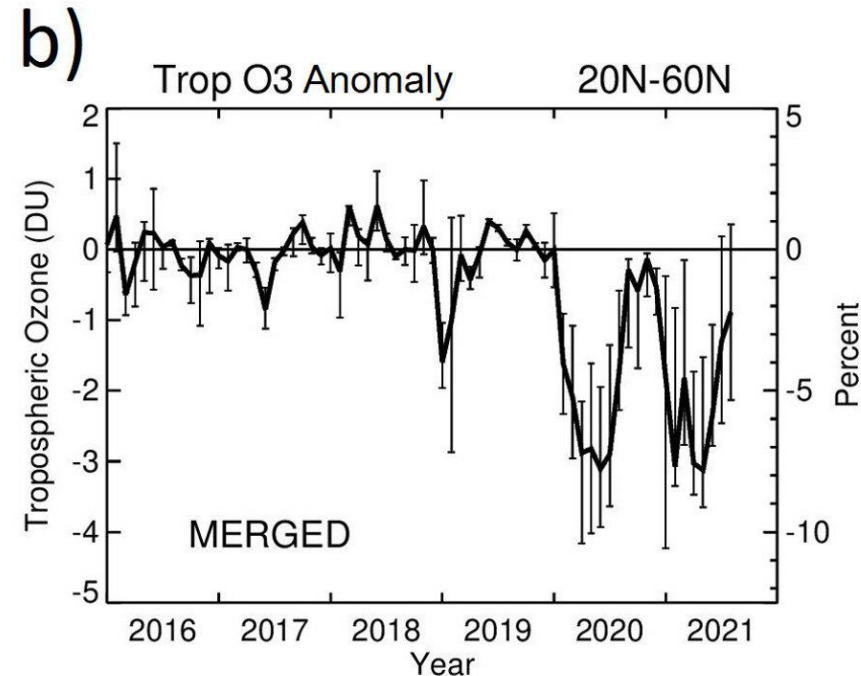
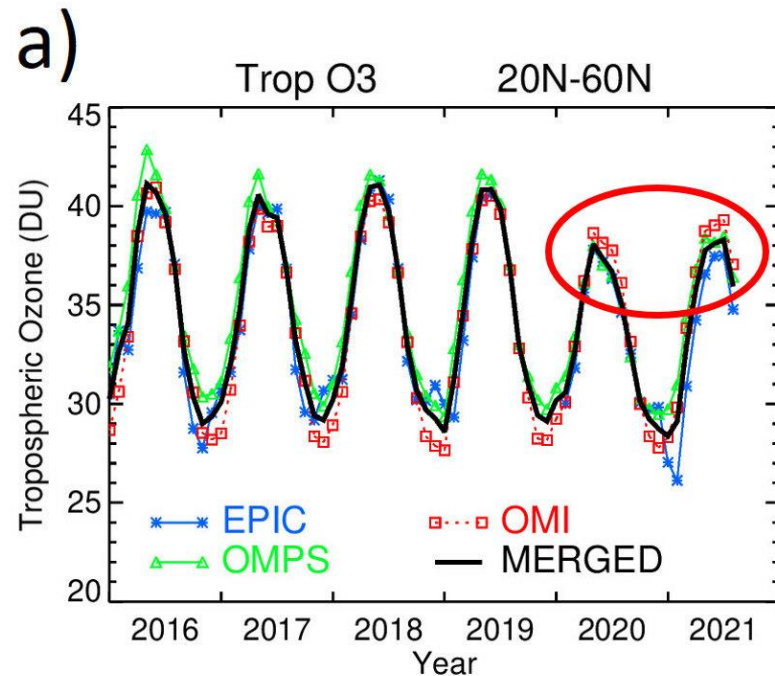
## Merged Tropo O3



## OMI Tropo NO2



# The Reductions in NH Tropospheric Ozone in Spring-Summer 2020 and 2021 were about 3 DU (~7-8%)

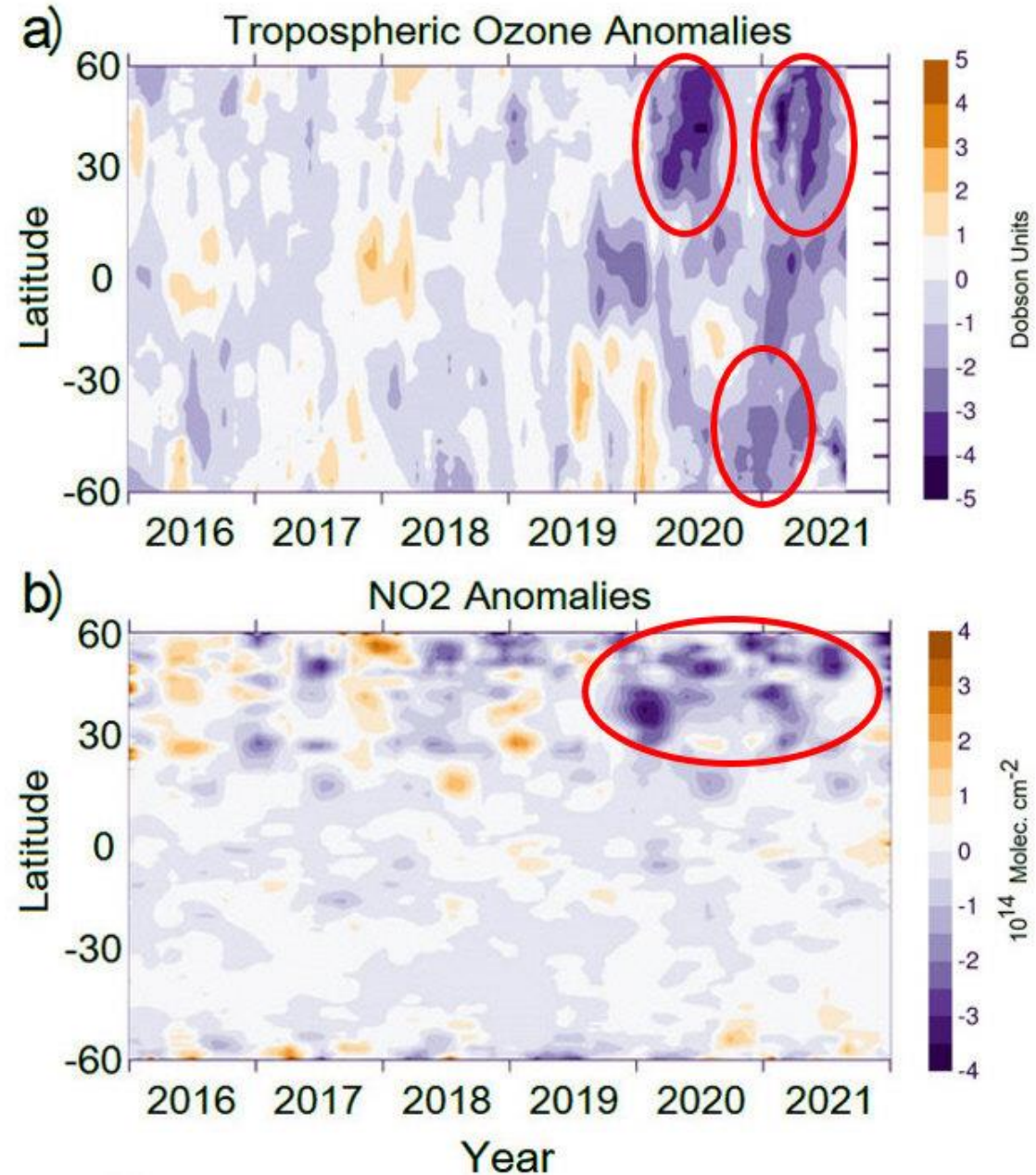




NH: Drops in tropospheric ozone in 2020 and 2021 coincided with drops in tropospheric NO<sub>2</sub>

Tropics: Drop in 2019 related to strong positive phase of the “Indian-Ocean Dipole”

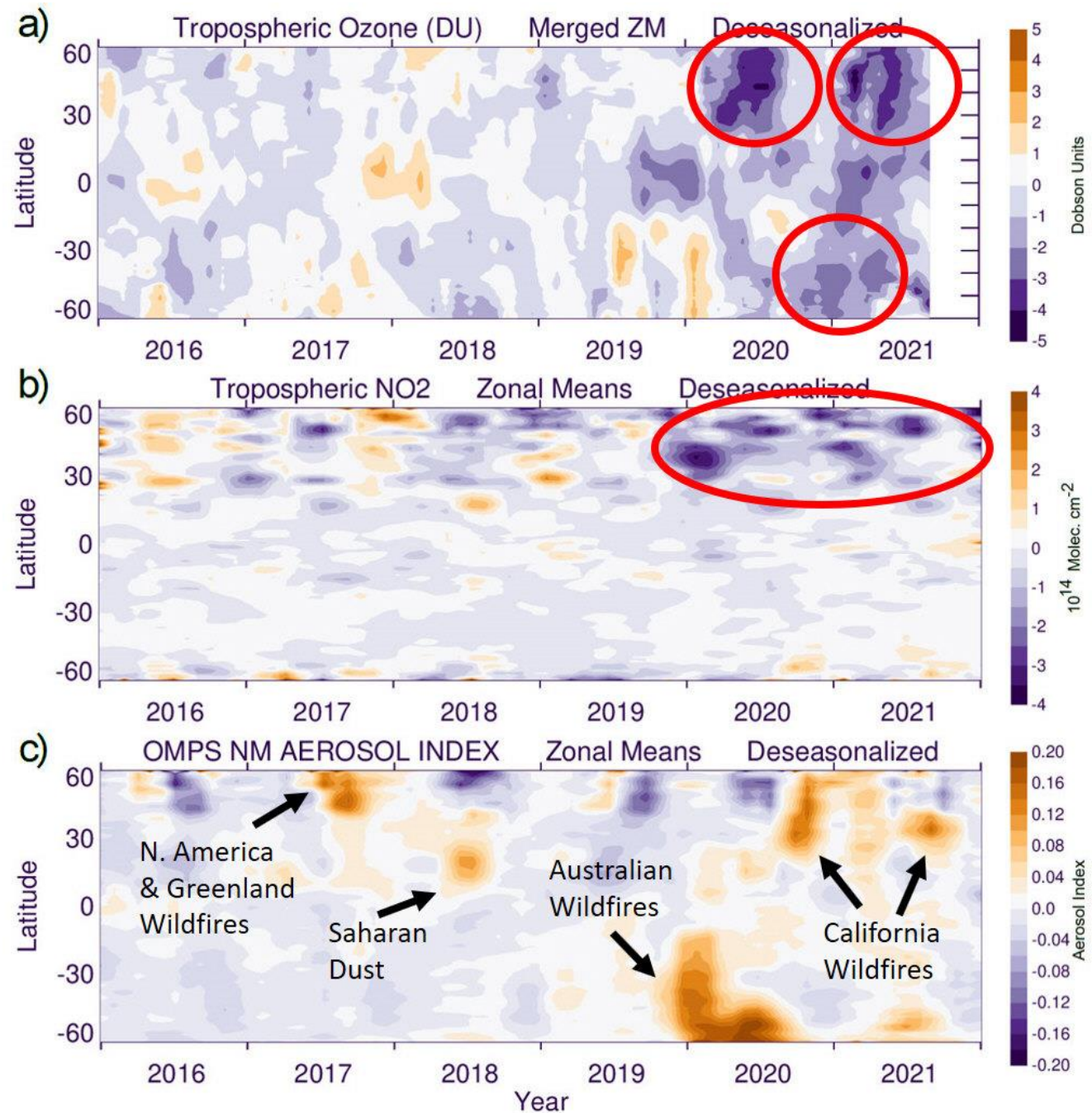
SH: Decrease may be related, but coincided with an anomalously deep and long-lasting Antarctic ozone hole



NH: Drops in tropospheric ozone in 2020 and 2021 coincided with drops in tropospheric  $\text{NO}_2$

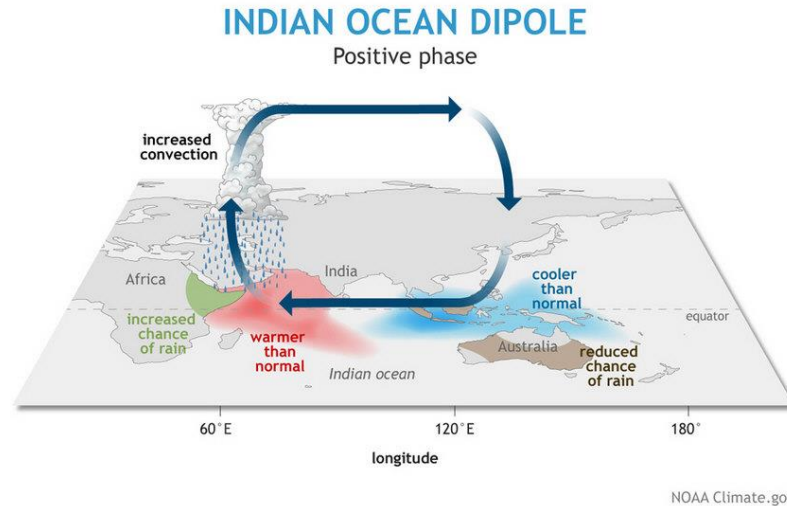
Tropics: Drop in 2019 related to strong positive phase of the “Indian-Ocean Dipole”

SH: Decrease may be related, but coincided with an anomalously deep and long-lasting Antarctic ozone hole



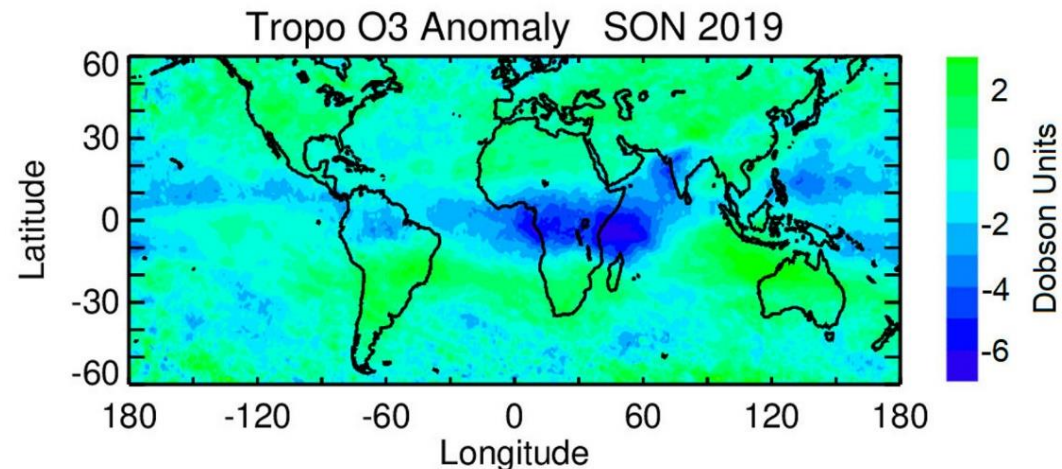


# Exceptionally Strong Positive Phase of Indian-Ocean Dipole in 2019



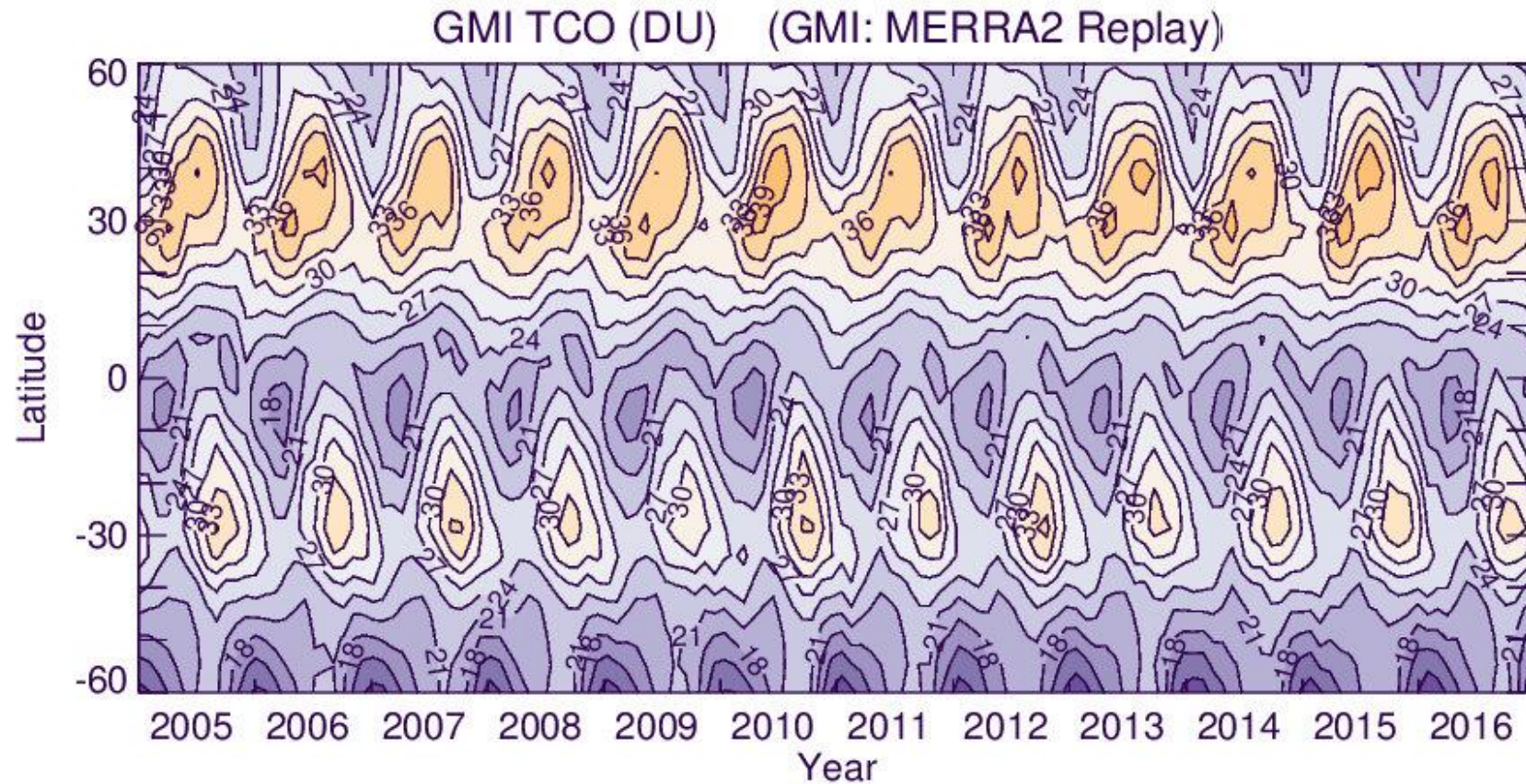
Deep convection just east of Africa injected LOW BL ozone into the clouds, reducing TCO

Strongest IOD since 2006



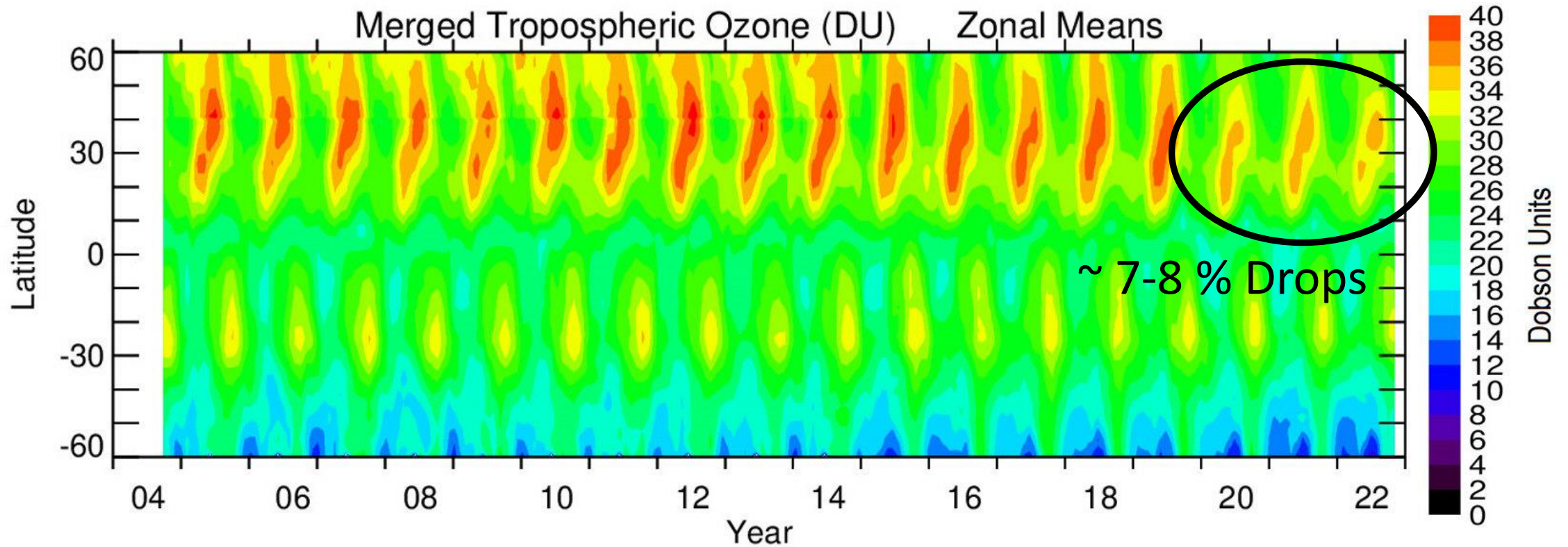


# GMI (MERRA-2 Replay) Modeled Tropospheric Ozone



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“Merged”: Aura OMI + DSCOVR EPIC + SNPP OMPS NM Average Tropospheric Column Ozone Fields

(Reference: Ziemke et al., 2022, Geophys. Res. Lett.)