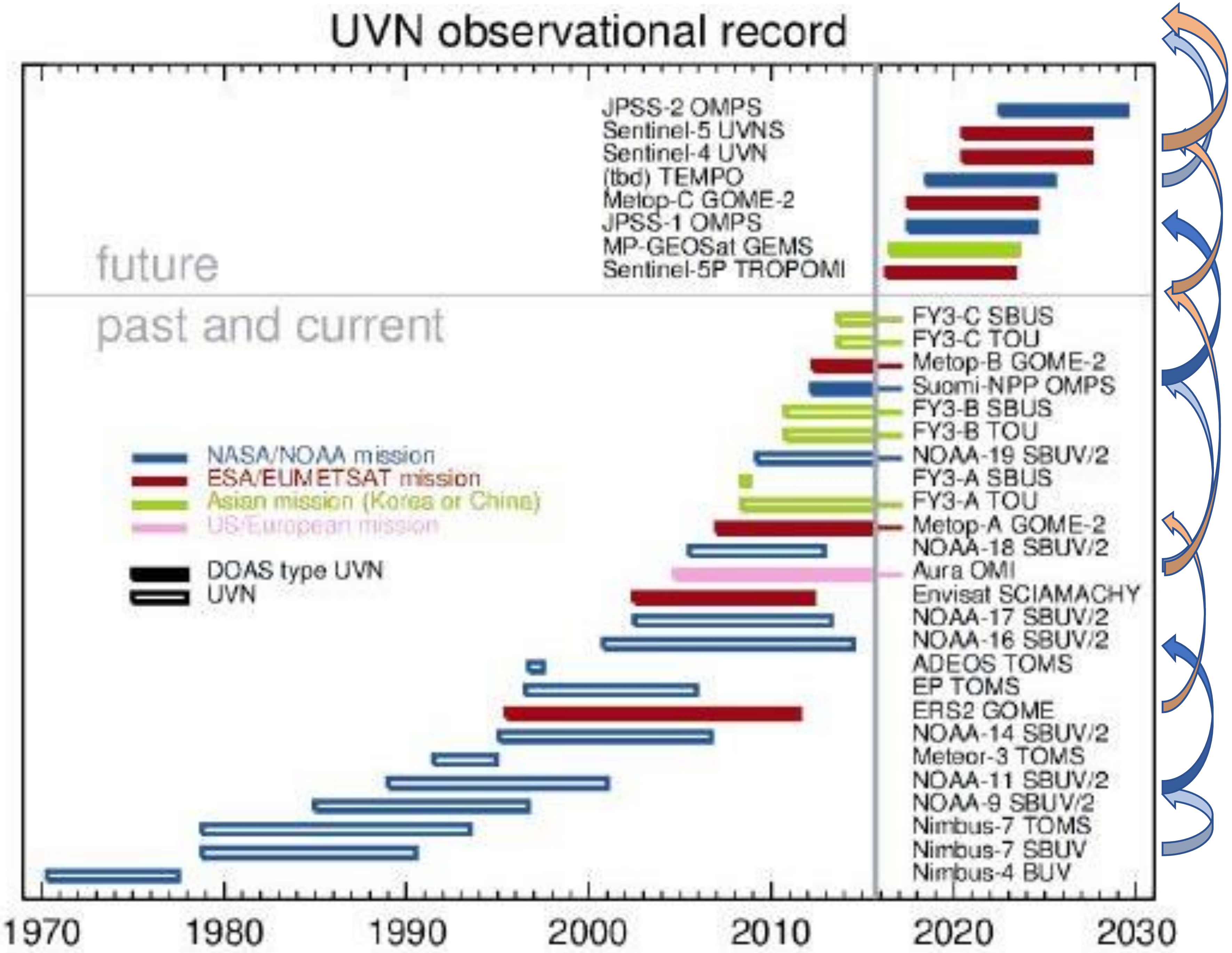
Transitioning NASA Capabilities to NOAA GEO-XO ACX

Joanna Joiner with contributions from many others

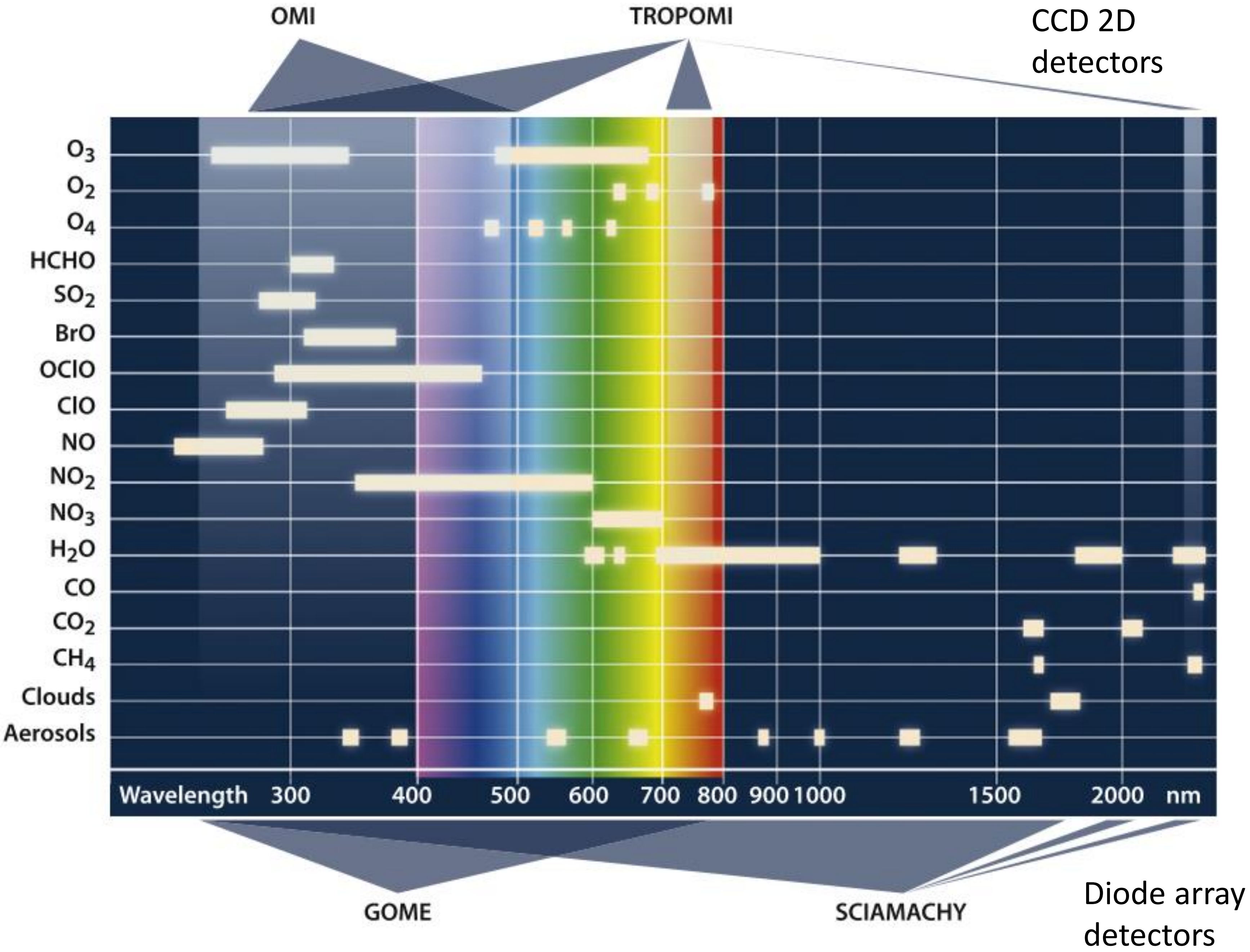
Outline

- Historical context of UV/Vis/NIR/SWIR atmospheric composition sensors
- Examples of applications and science developed with OMI and OMPS
- Importance of high spatial resolution
- What’s next with TEMPO?



Historical context of UV/Vis/NIR measurements and transitions from research to operational instruments

Courtesy: earth.esa.int, M. Weber, editor



LEO UV-Vis-NIR-SWIR instruments and what they measure

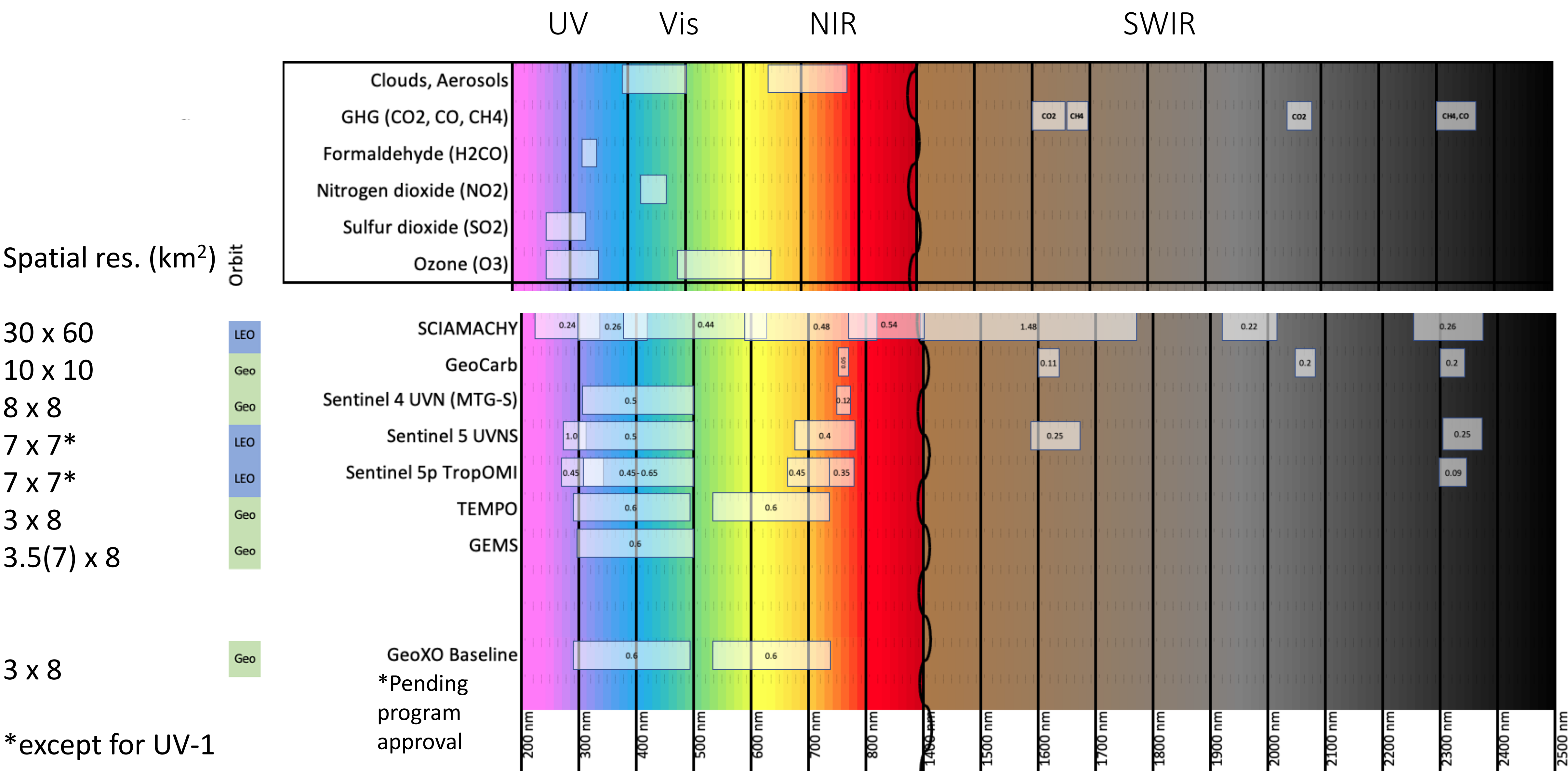
NASA’s role in developing pathfinder GEO missions: 2007 Decadal survey and GEO-CAPE

- The GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission was recommended by the National Research Council’s (NRC) 2007 Earth Science Decadal Survey
- GEO-CAPE was to measure tropospheric trace gases, aerosols, coastal ocean phytoplankton, water quality and biogeochemistry from GEO with multiple daily observations over greater North America
- These measurements are needed to explore physical, chemical, and dynamical processes that determine tropospheric composition and air quality at high temporal and spatial scales (similarly for coastal ocean).
- Final report delivered in 2018 following studies of a mission team from 2009-2018
- Commercial hosted payload strategy allowed for separation into smaller pieces suitable for NASA’s Earth Venture class of missions (the GEO-CAPE Mission Study Team legacy)
    - TEMPO (air quality): awaiting 2022 launch
    - GeoCARB (greenhouse gases): passed KDP-C, planned for 2022-2023 launch
    - GLIMR (coastal oceans): in pre-forumulation, planned for launch in late 2020s

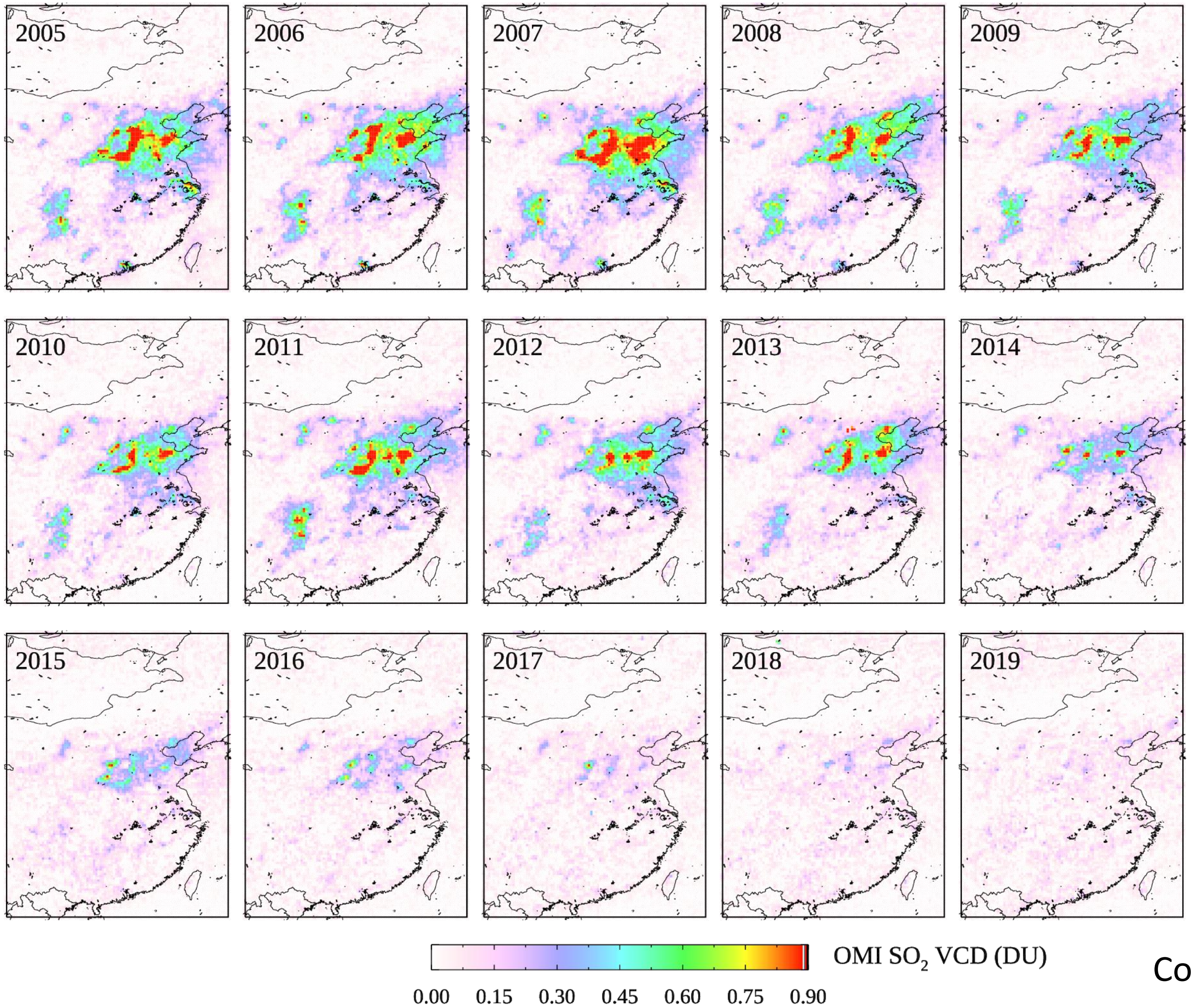
NASA's role in developing pathfinder missions: Earth Ventures Class

- Recommended by the NRC's Decadal Survey 2007
- New science-driven (innovative Earth science to enhance capabilities)
- Competitively selected
- Low cost, cost capped
- 3 classes: 1) EVI: Instrument only; 2) EVM: Mission; 3) EVS: Sub-orbital
- TEMPO (Tropospheric Emissions: Monitoring of Pollution) was selected as the first EVI (EVI-1)
    - PI: Kelly Chance – Harvard Smithsonian Astrophysical Observatory
    - Geostationary UV-Vis grating spectrometer
    - Measures pollutants (O_3, NO_2, SO_2, HCHO, aerosol, clouds, etc.) hourly over greater North America

Capabilities of current and near-term UV-Vis-NIR-SWIR instruments



Courtesy: Joel McCorkel, NASA



OMI Long-term Monitoring of Anthropogenic SO_2 Pollution

Mean warm season (April to October) OMI SO_2 vertical column densities (VCDs) over eastern China from 2005-2019 [*Li et al., AMT* 2020].

Continued but slower decrease in SO_2 pollution over China since 2016 (figure on left).

Courtesy: Can Li (ESSIC) and OMI SO_2 group at GSFC

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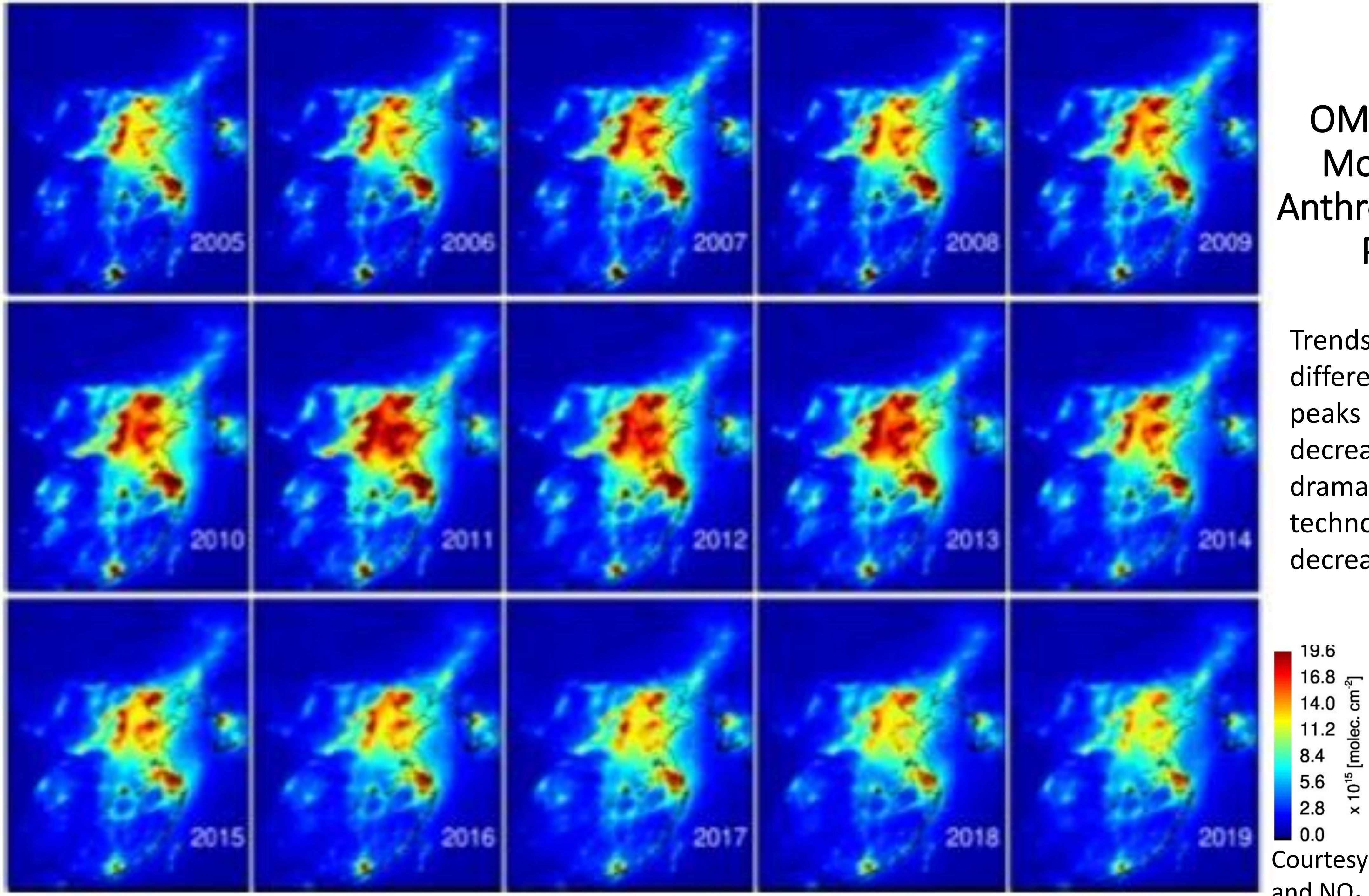
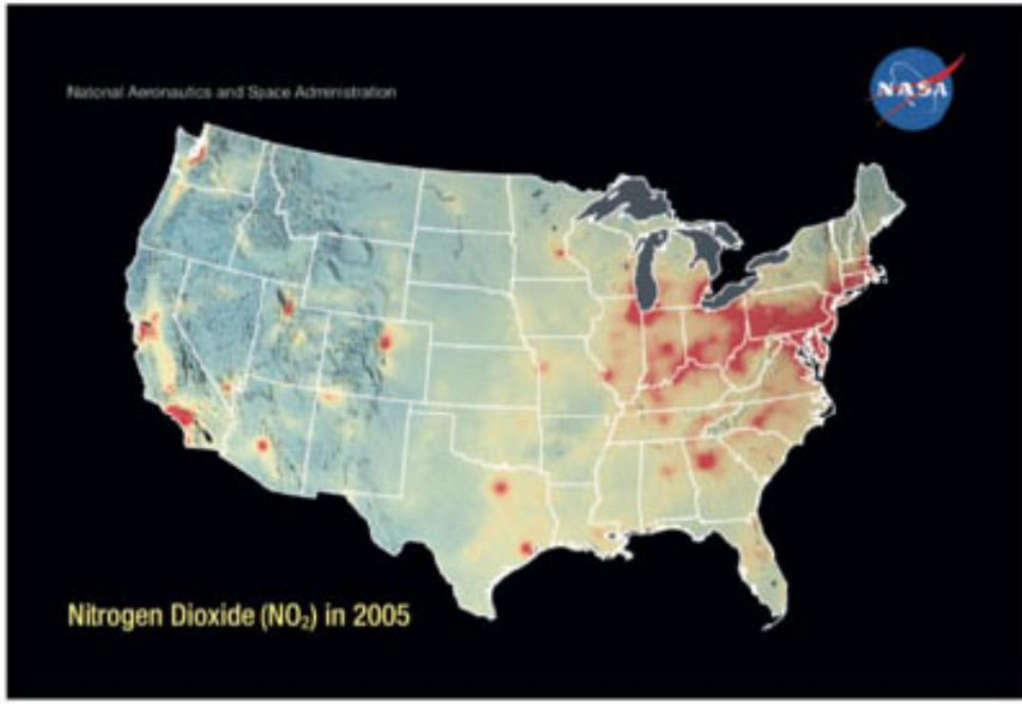


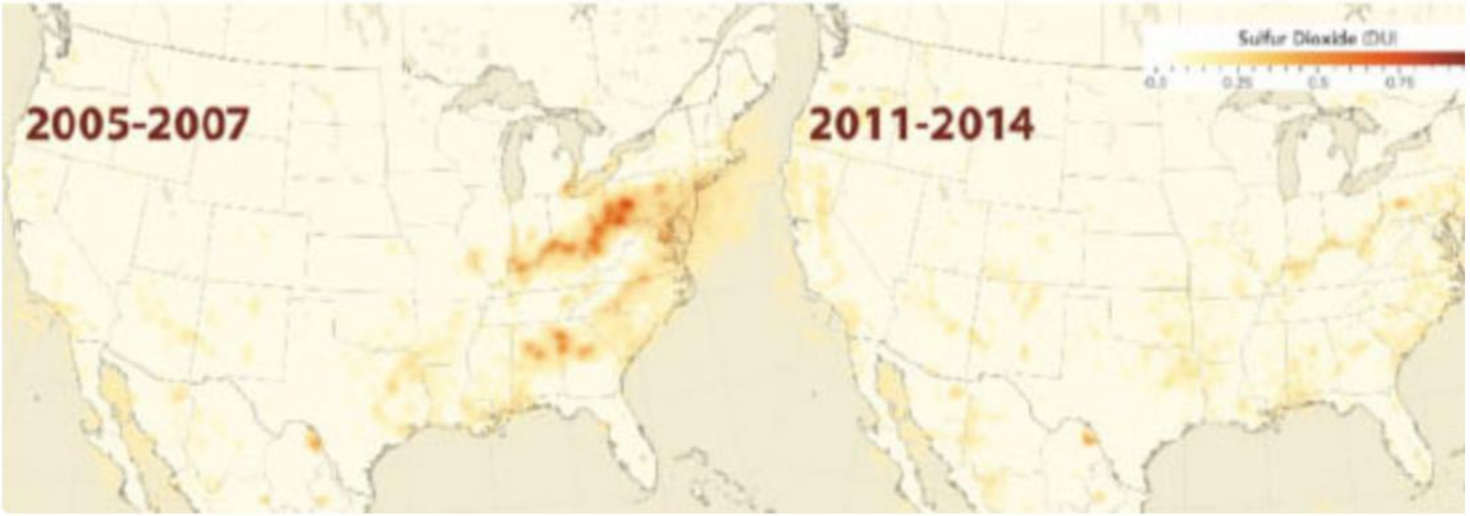
Trends somewhat different from SO_2, peaks later in time and decrease is not as dramatic (different technologies used to decrease emissions).

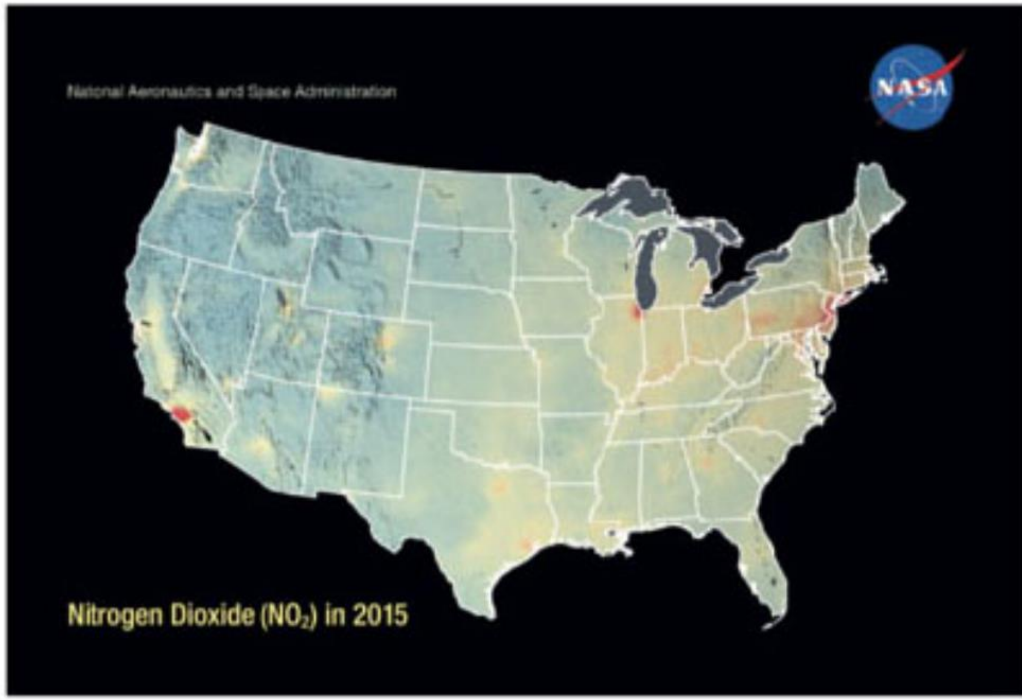
Courtesy: Lok Lamsal, USRA, and NO_2 group at GSFC

OMI data highlighted in 2018 Decadal Survey as examples of satellite observations used as a monitoring system for air quality and health



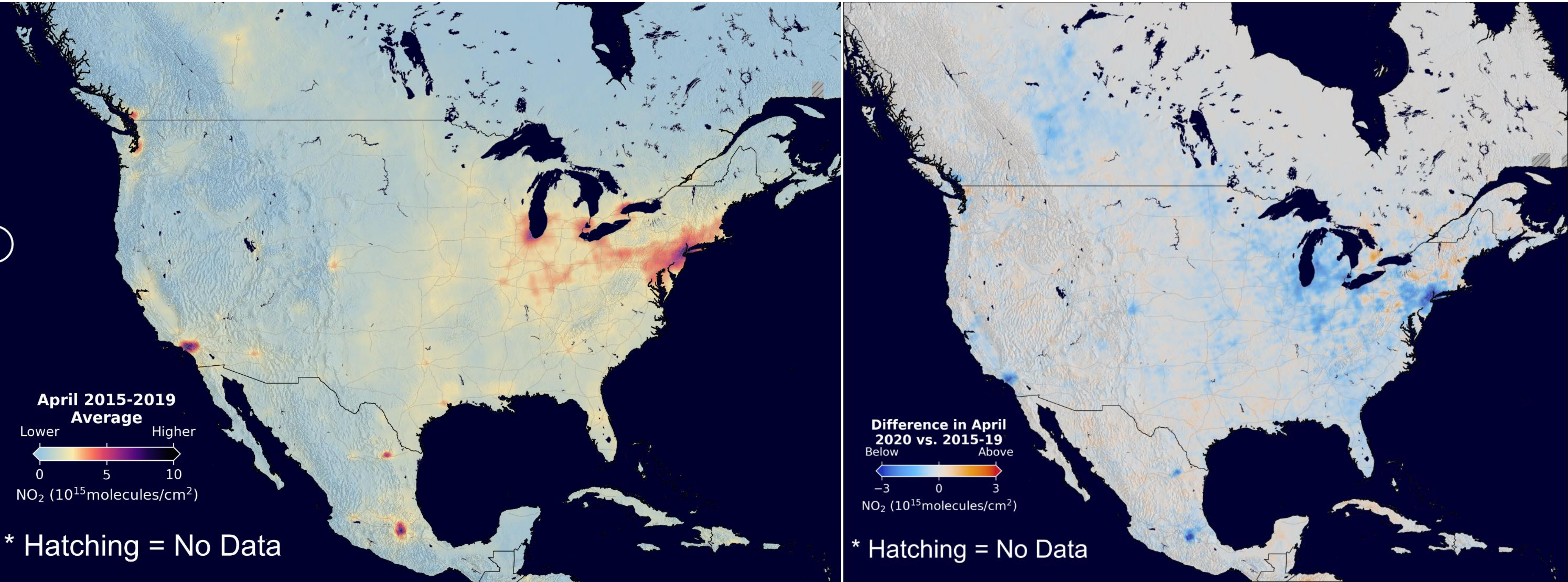
Courtesy: NASA Earth Observatory and Aura OMI science team at GSFC



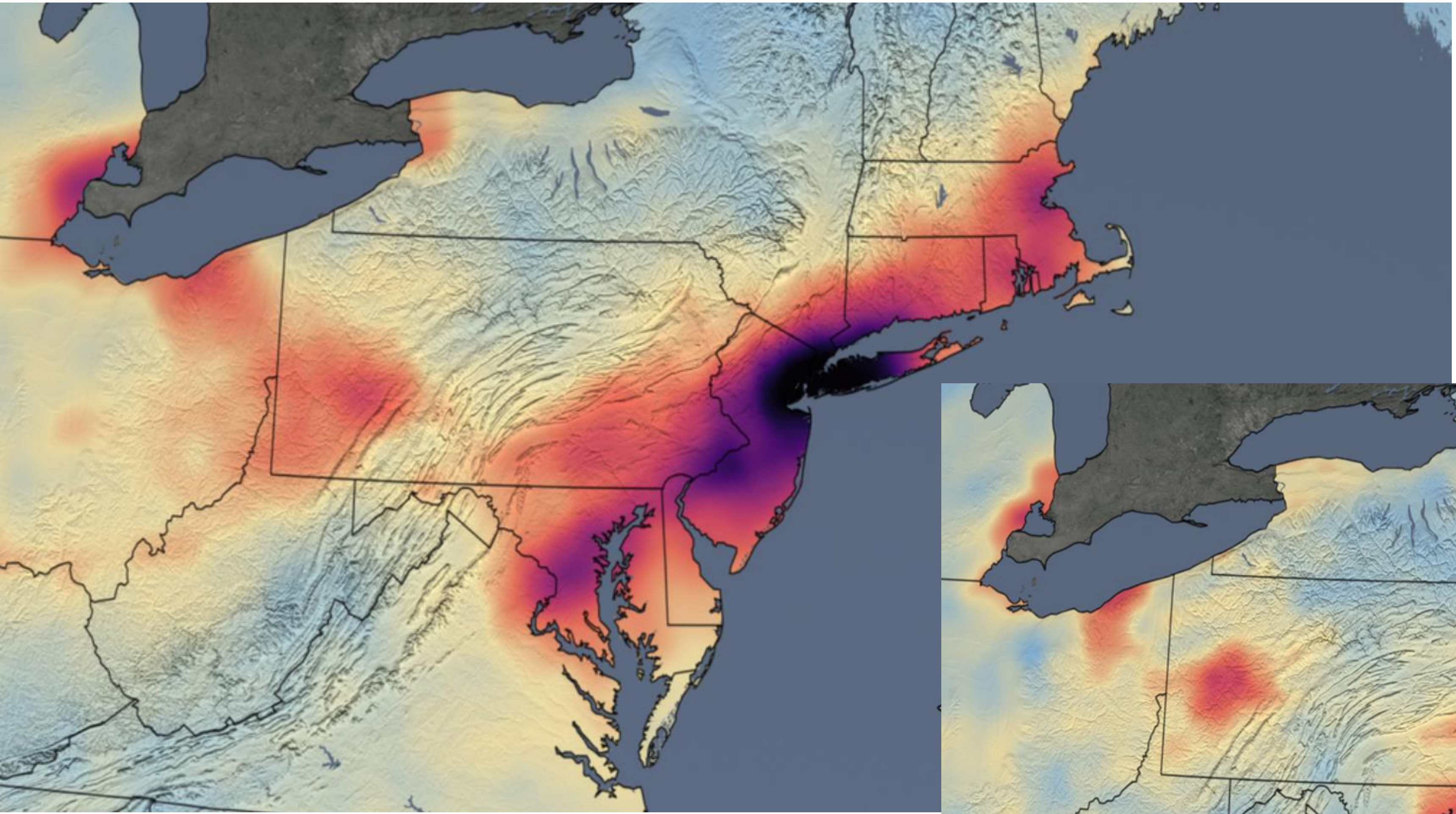


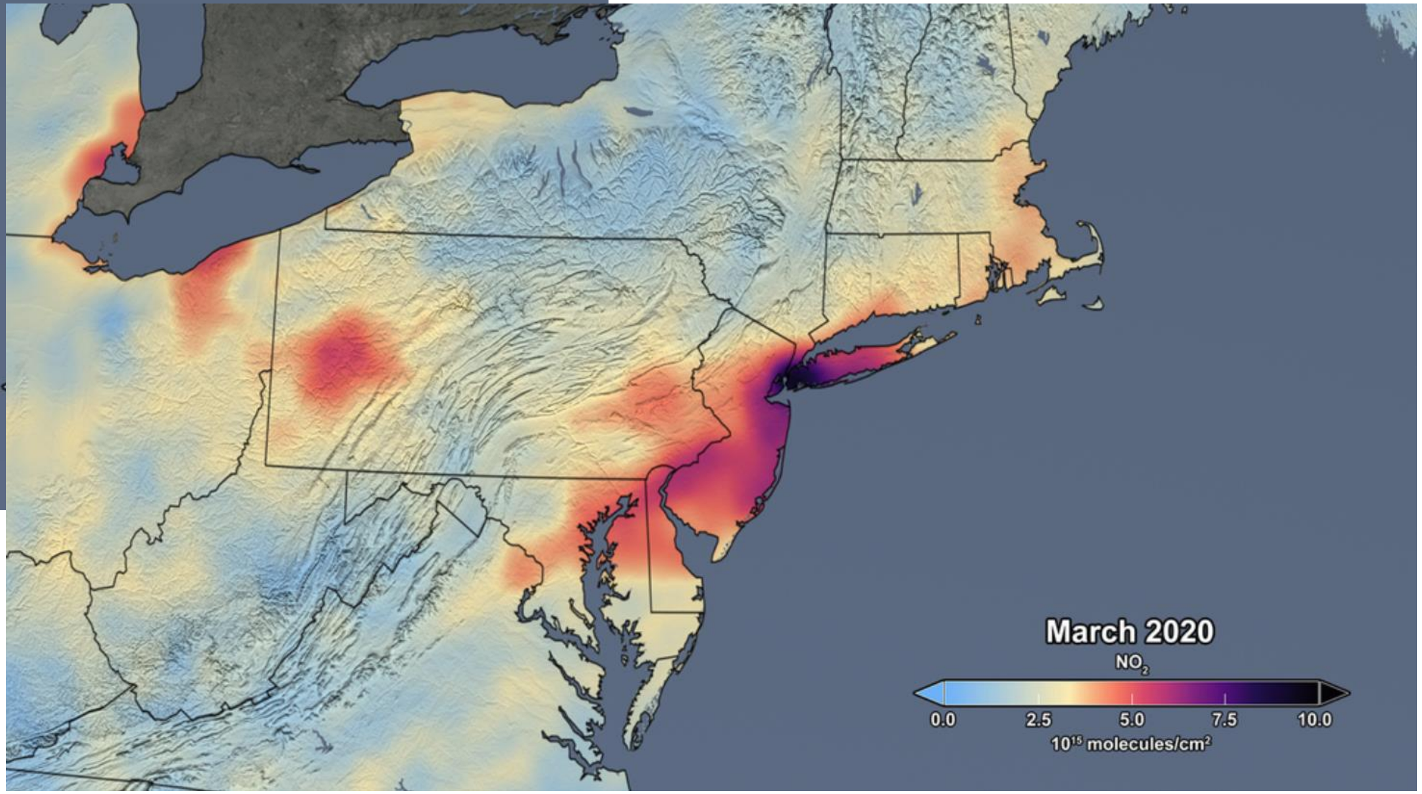
OMI NO_2 anomalies April 2020

Courtesy: Zachary Fasnacht and NASA GSFC OMI NO_2 COVID-19 task force



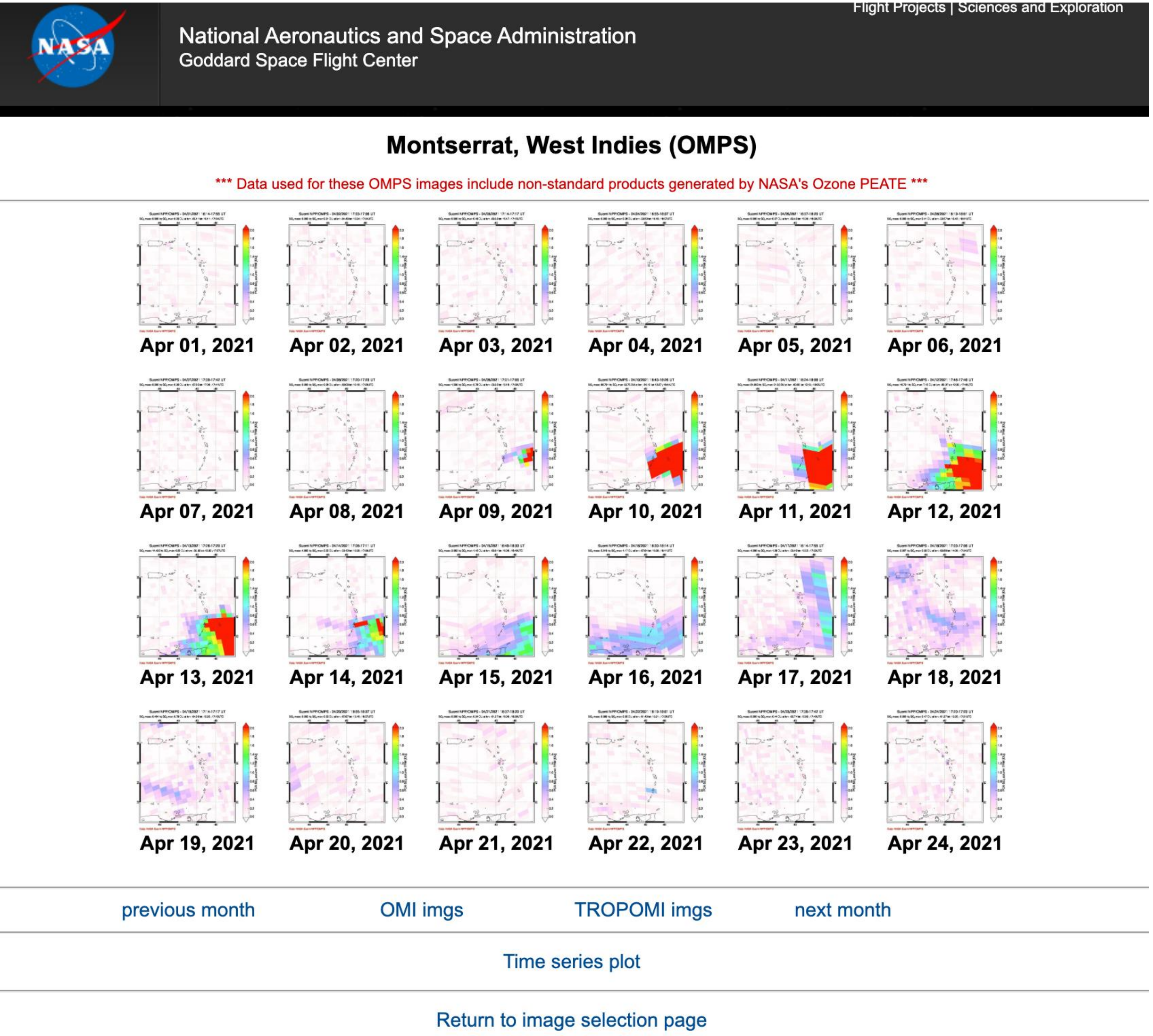
I-95 corridor 30% drop in regional total

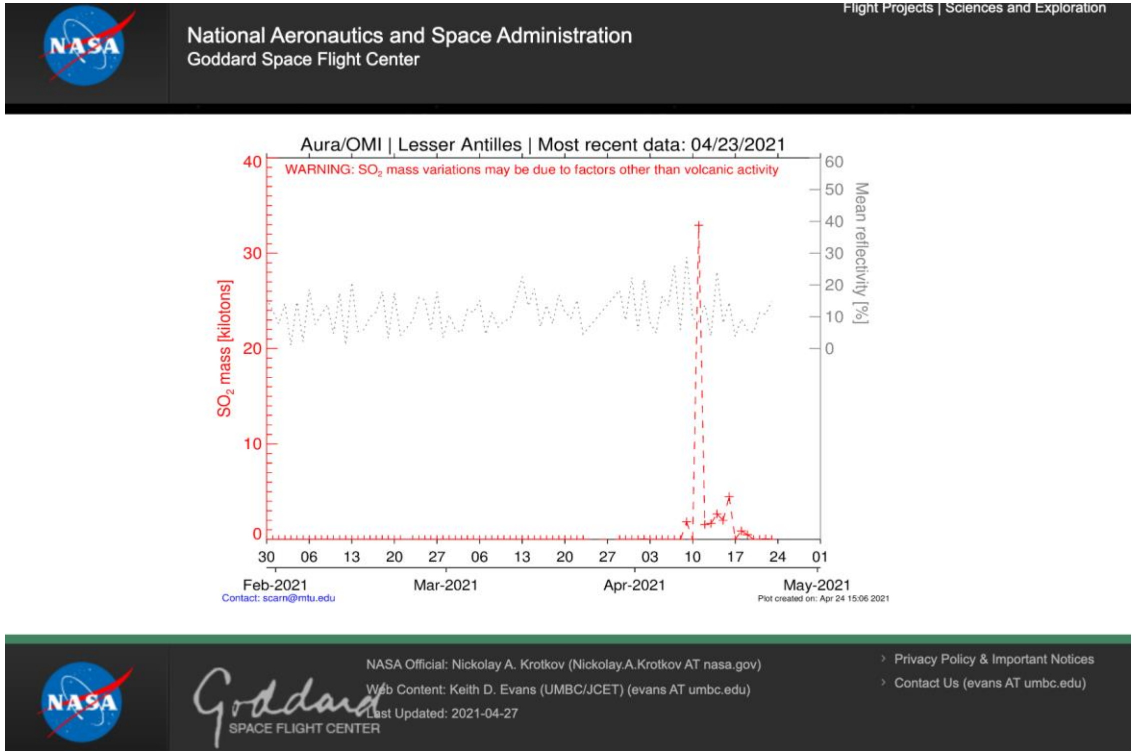




Courtesy: NASA GSFC visualization studio and NASA OMI NO_2 COVID-19 task force

UV/Vis instruments monitor hazards





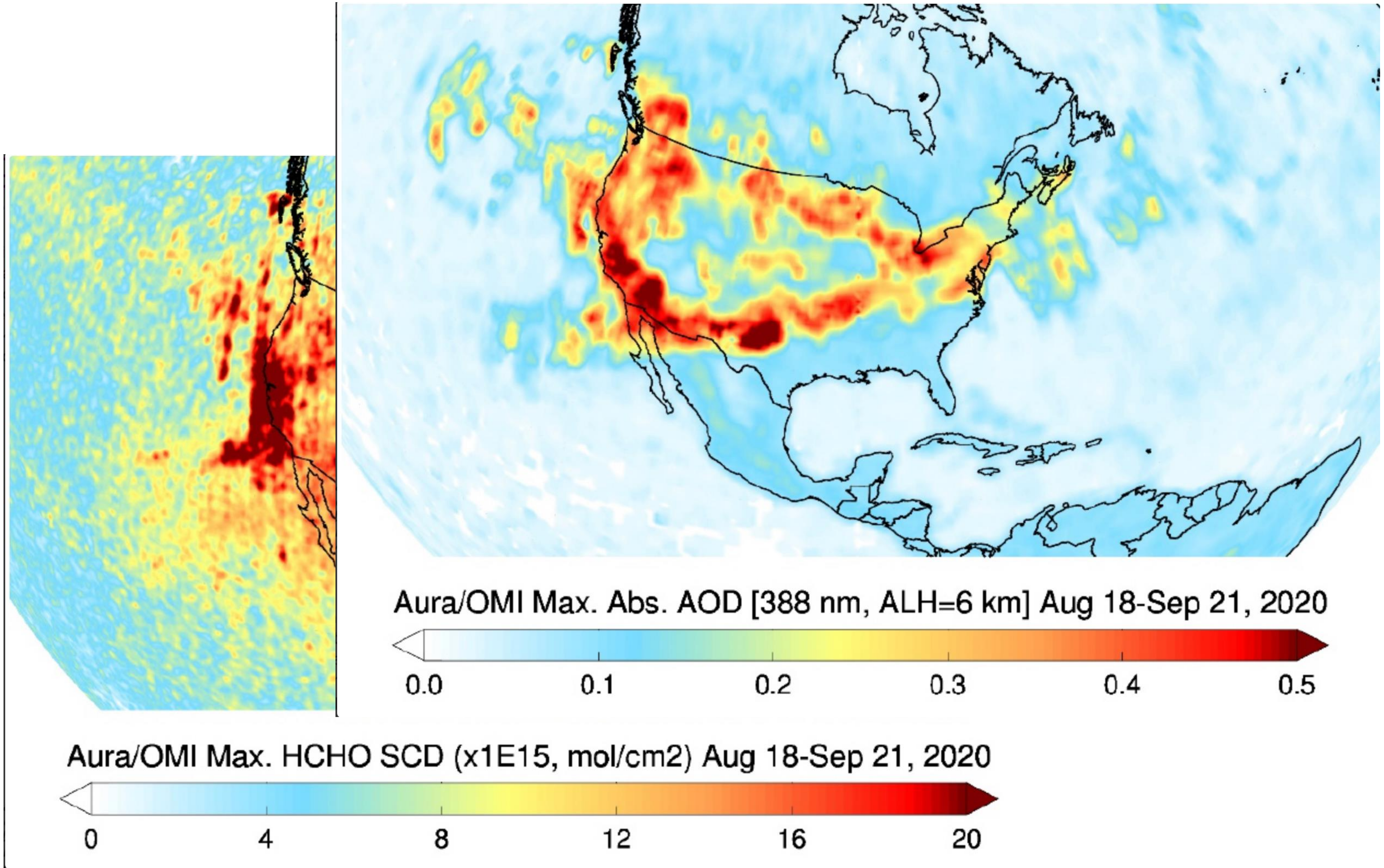
OMPS shows eruption of La Soufriere volcano on St. Vincent in the Caribbean earlier this month and spread of the SO_2 plume.

Courtesy: Nick Krotkov and NASA GSFC SO_2 team

Smoke plumes from fires in the US West coast shows large spread.

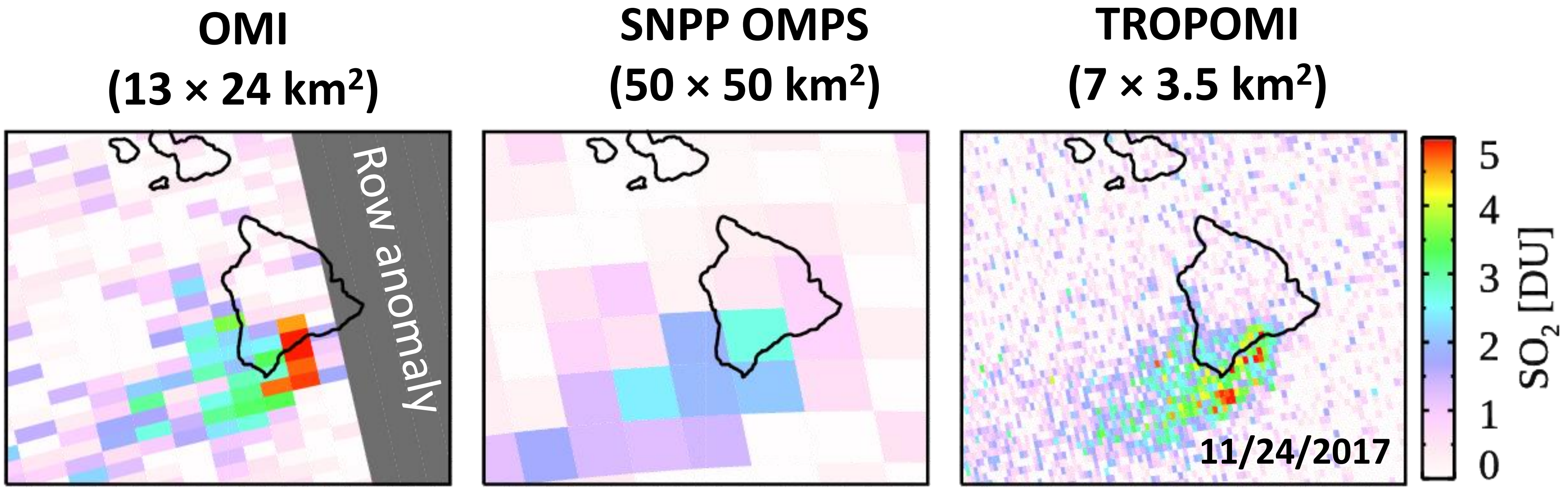
Determination of aerosol absorption optical depth requires information on aerosol layer height (ALH) in this case derived from space-borne lidar observations.

Formaldehyde (HCHO) comes from both fire and biogenic emissions and is relatively short lived.



Courtesy:Omar Torres (NASA GSFC), Can Li (ESSIC), and Hiren Jethva (USRA)

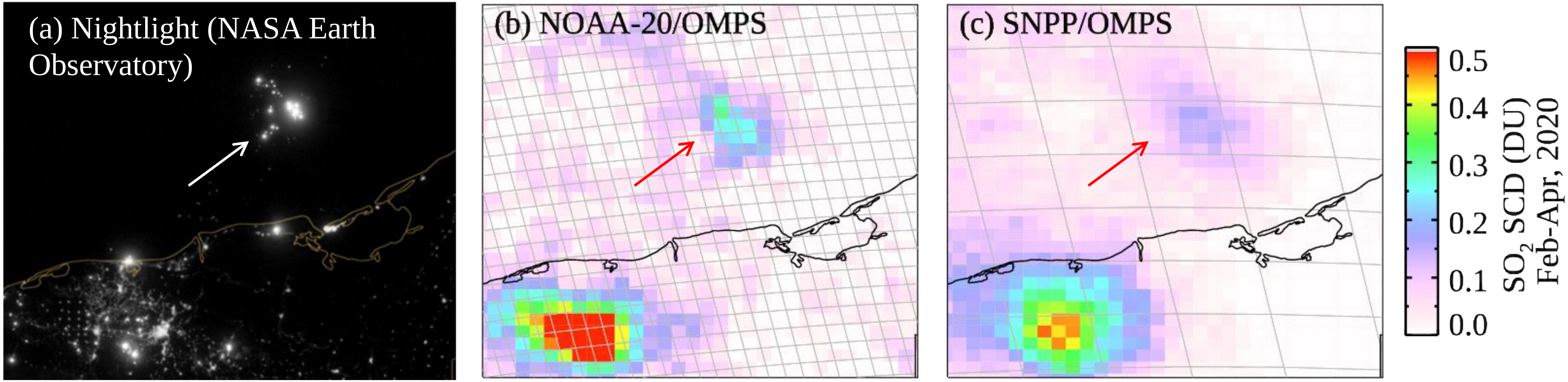
An example of instrument resolution: Kīlauea volcano



Total column SO_2 in Dobson Unit (DU, 1 DU = 2.69×10^{16} molec./cm^2)

Courtesy: Can Li, ESSIC, and NASA GSFC SO_2 team

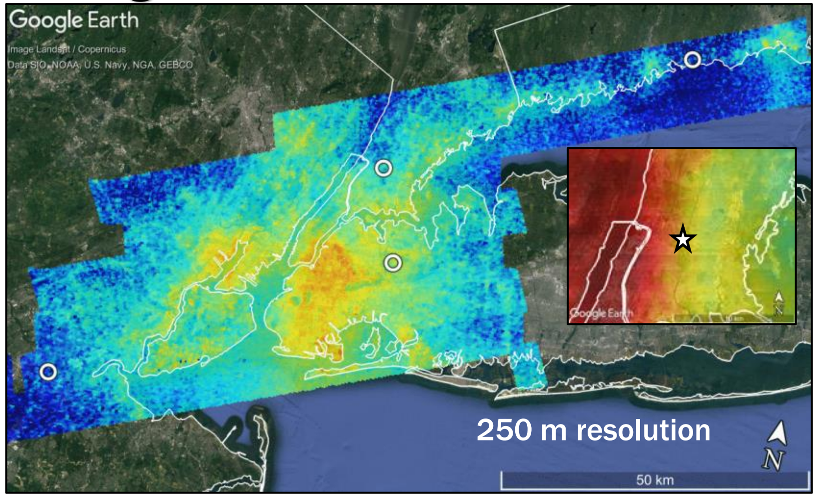
Impact of spatial resolution: NOAA-20 JPSS-1 and SNPP OMPS SO_2, Gas flaring emissions, Gulf of Mexico (Feb. - Apr, 2020)

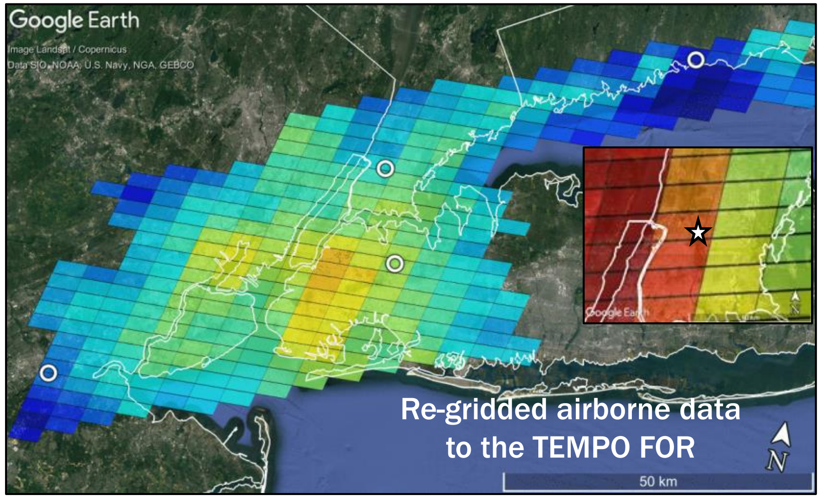


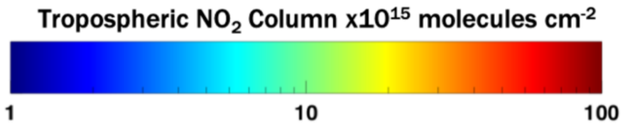
Courtesy: Can Li, ESSIC, and NASA GSFC SO_2 team

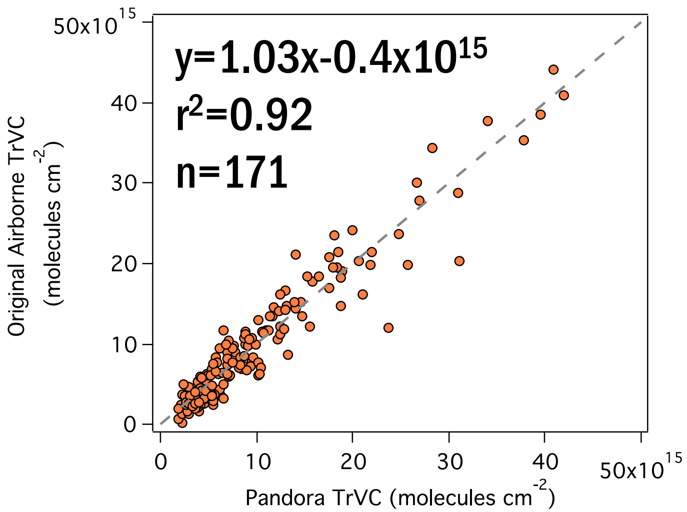
Pandora Comparisons at TEMPO Scales

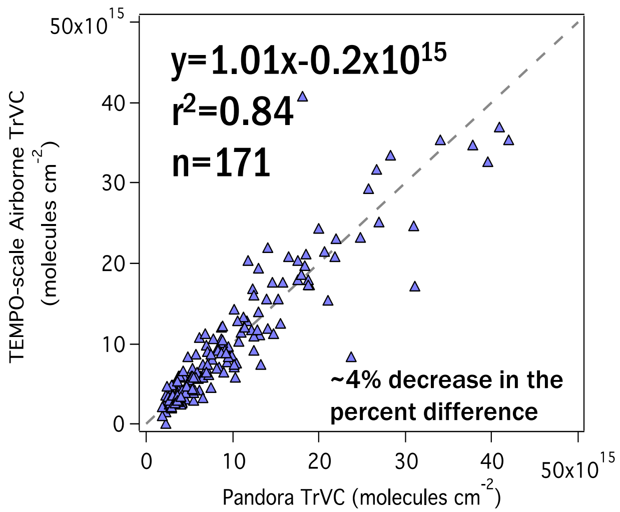
24 August 2018: 4 raster animation











Challenges

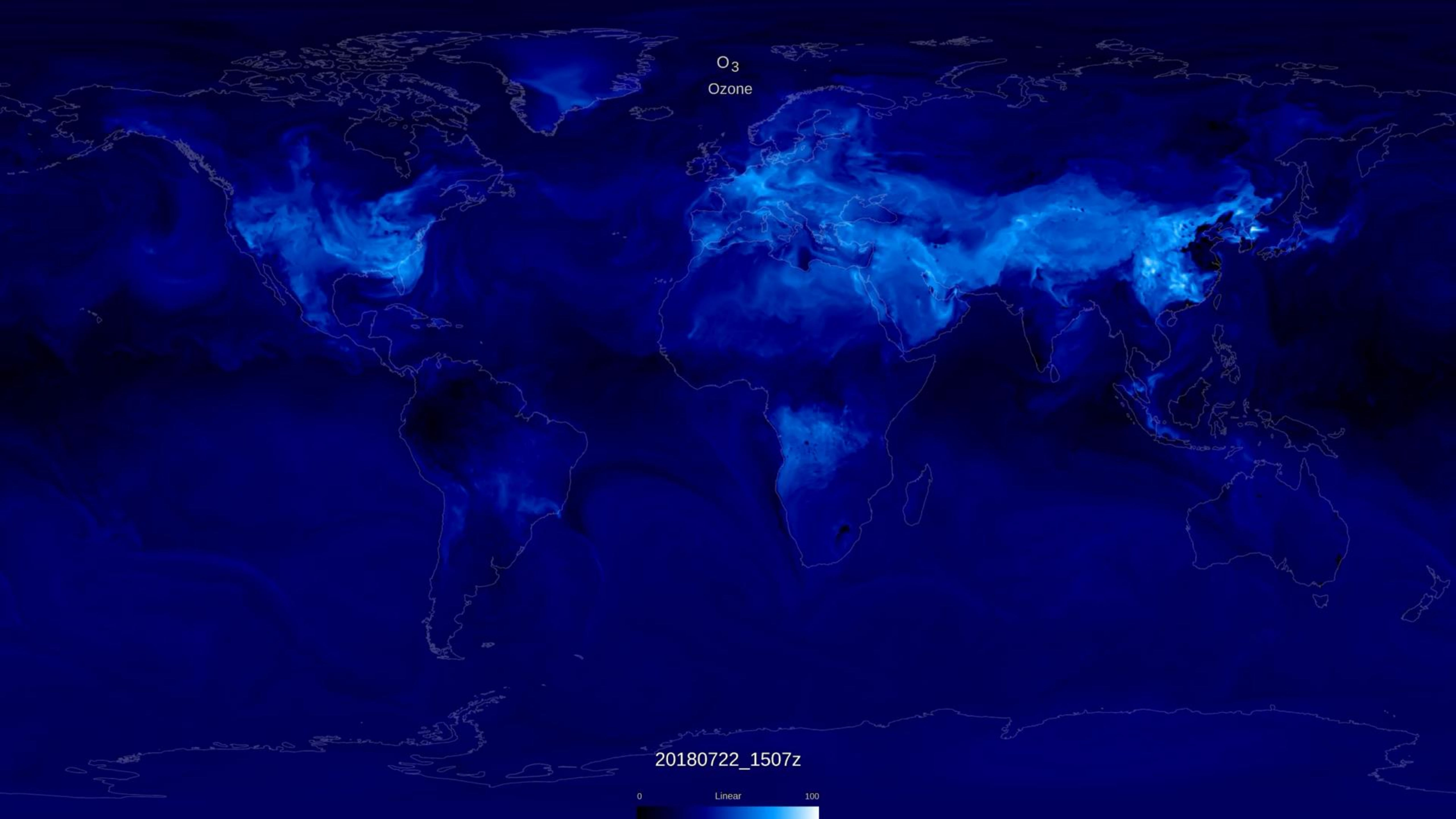
1. Spatial heterogeneity: Less of an issue than before but still can lead to mis-matches in areas with strong gradients
2. Temporal heterogeneity: the high temporal resolution of Pandora and the hourly measurements from TEMPO could help in identifying large changes over the hour time-frame

Courtesy: Laura Judd, LaRC and TEMPO team

What’s next for TEMPO, GEMS, Sentinel 4?

Estimation of diurnal emissions for use in Air Quality (AQ) and chemical weather models.

These sensors will measure ozone precursors (NO_2 and HCHO) and TEMPO will provide information on lower tropospheric ozone.


O_3
Ozone
20180722_1507z
0
Linear
100