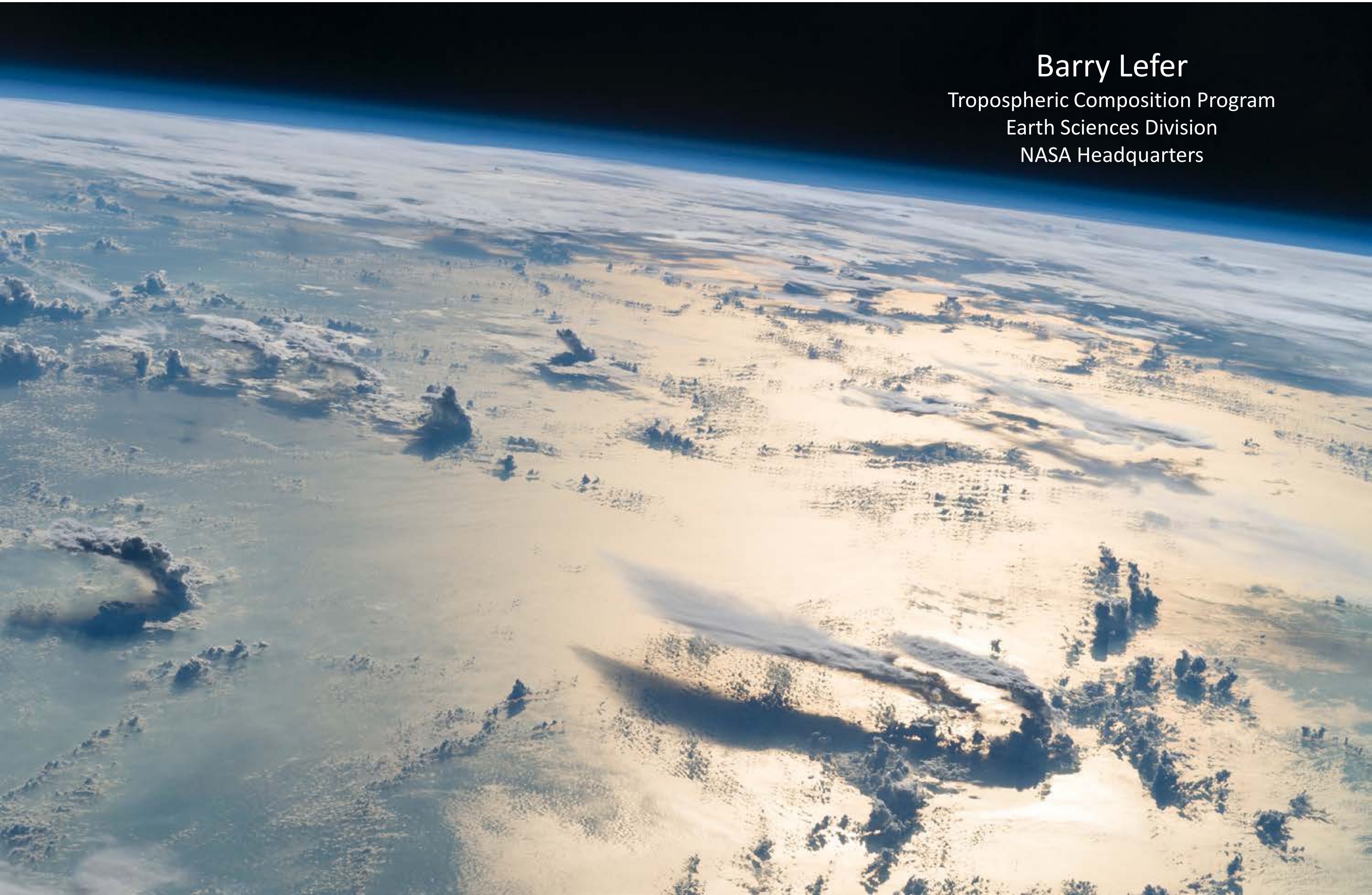
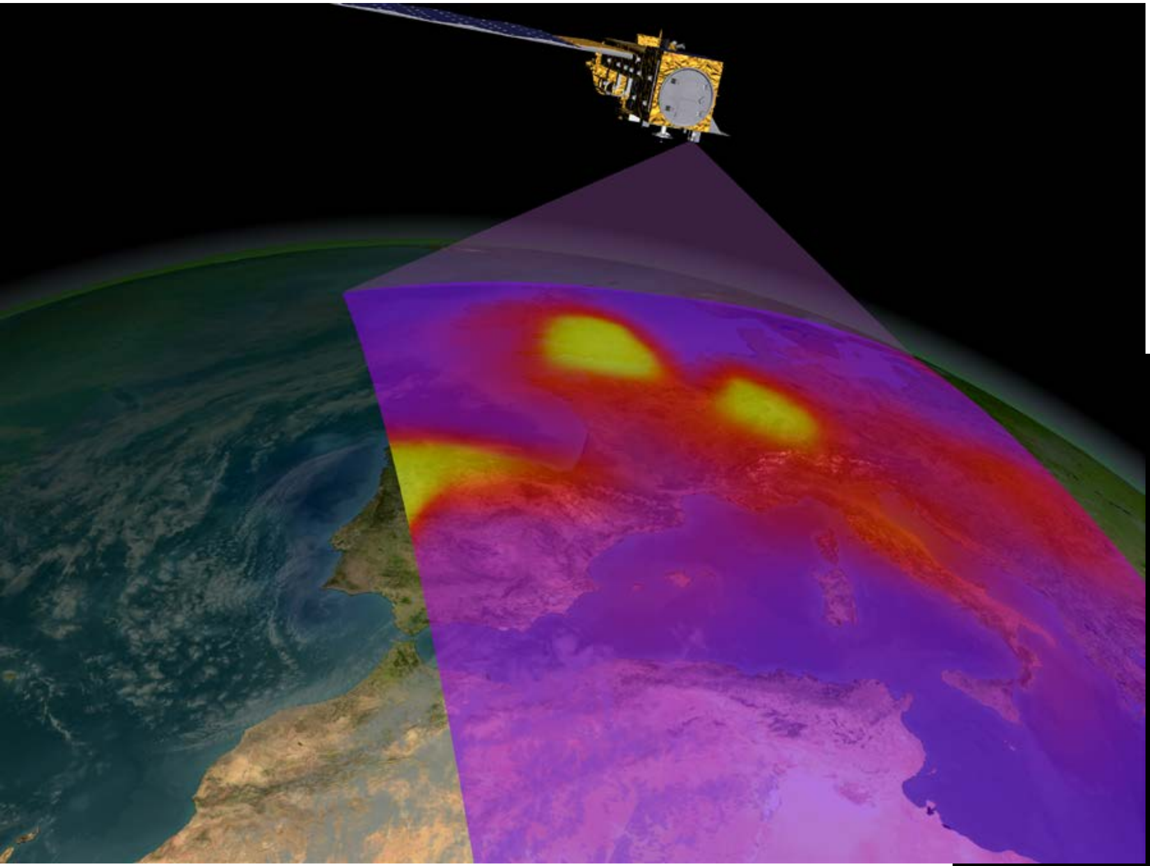
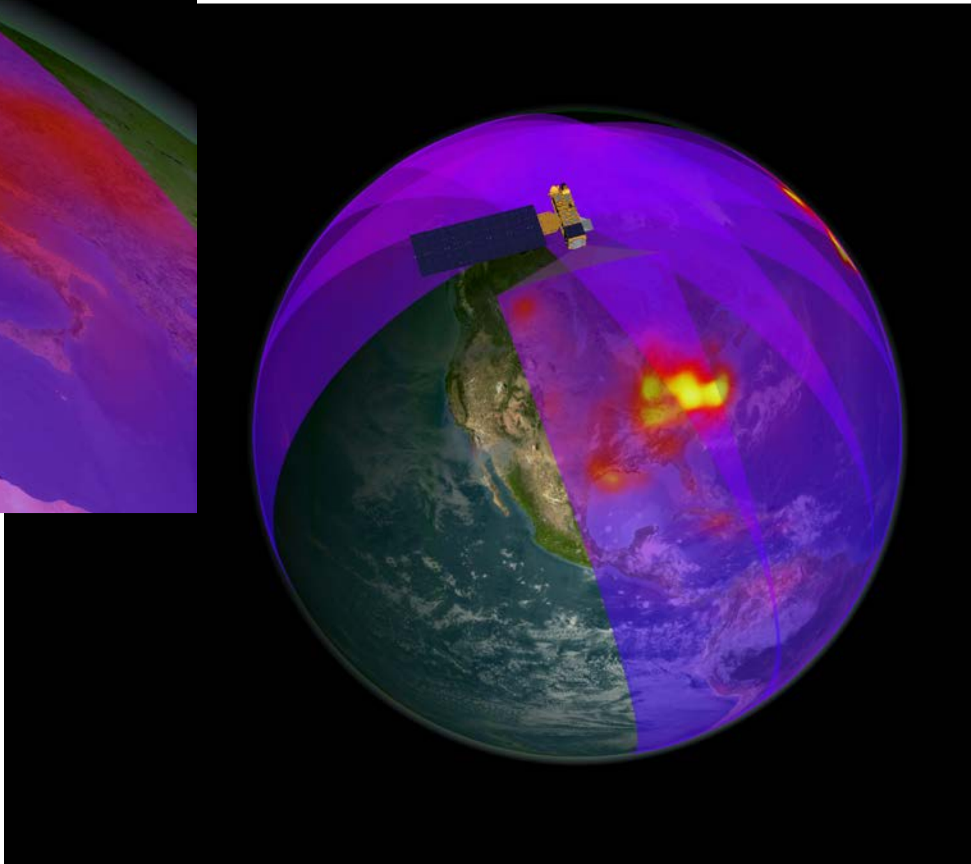
KORUS-AQ and an Integrated Observing System for Air Quality



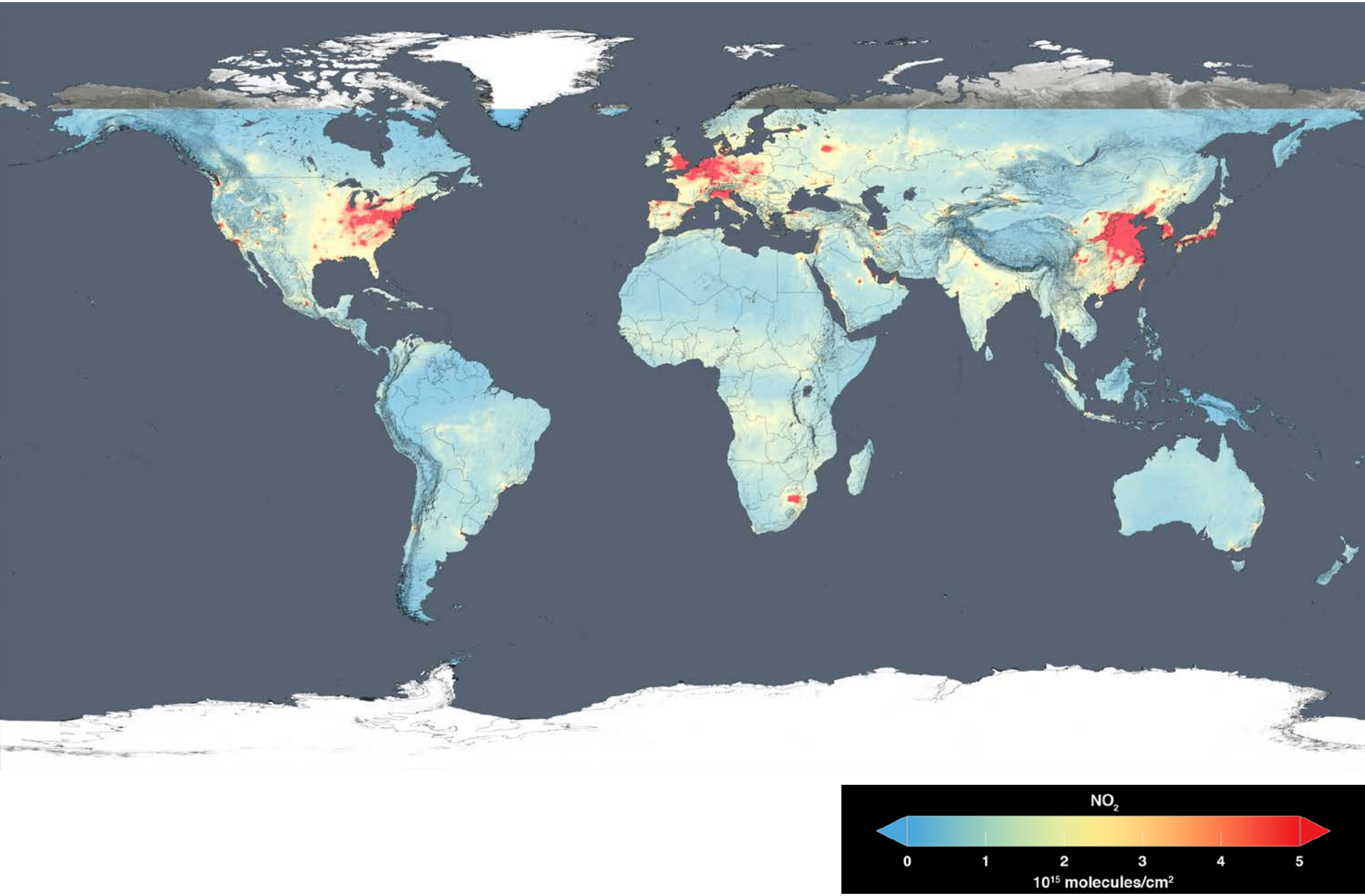
Barry Lefer
Tropospheric Composition Program
Earth Sciences Division
NASA Headquarters

NASA's OMI Satellite instrument mapping Nitrogen Dioxide (NO_2)

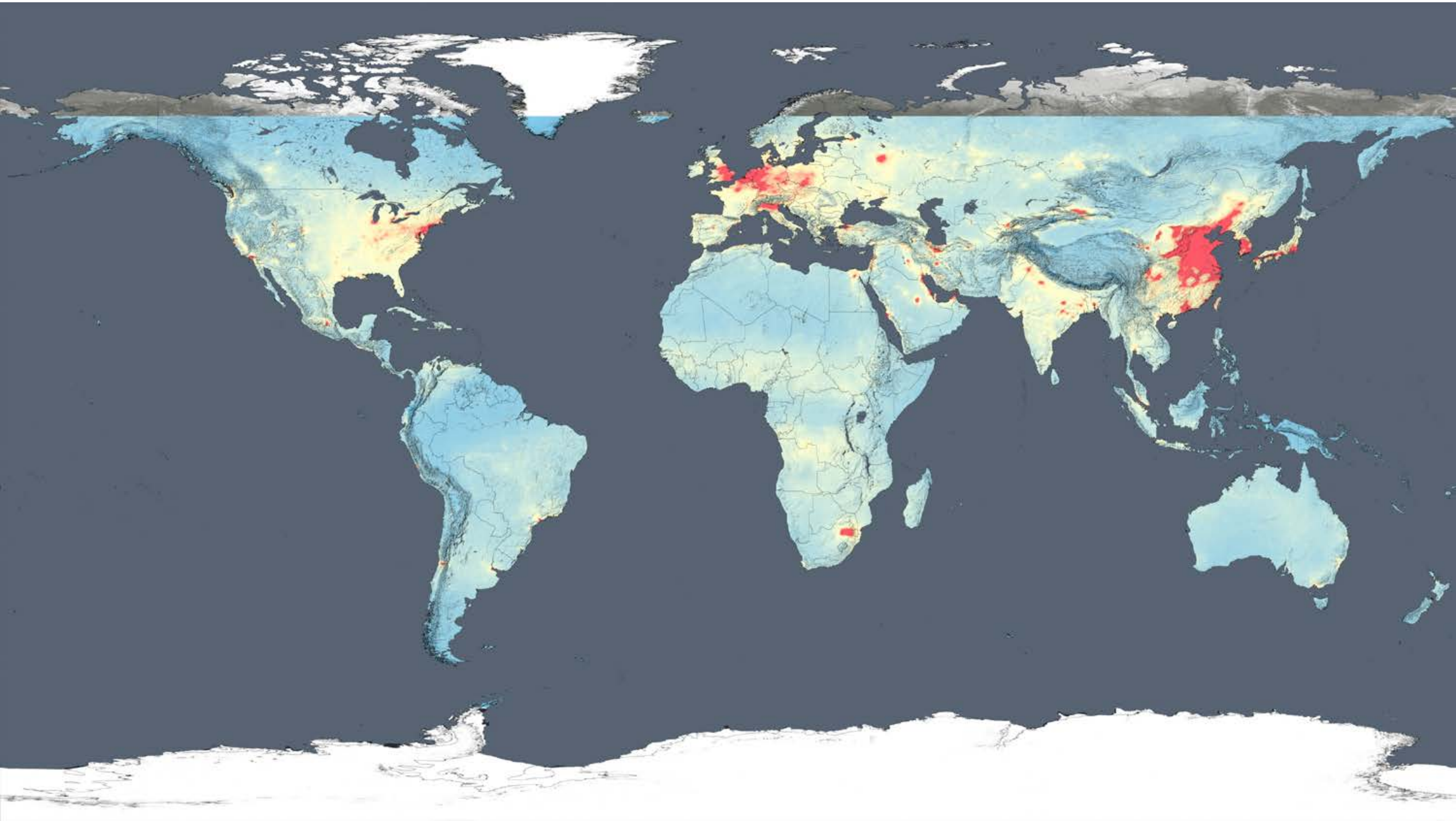


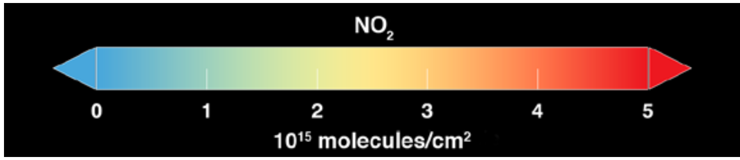


NASA's OMI NO_2 (2005)

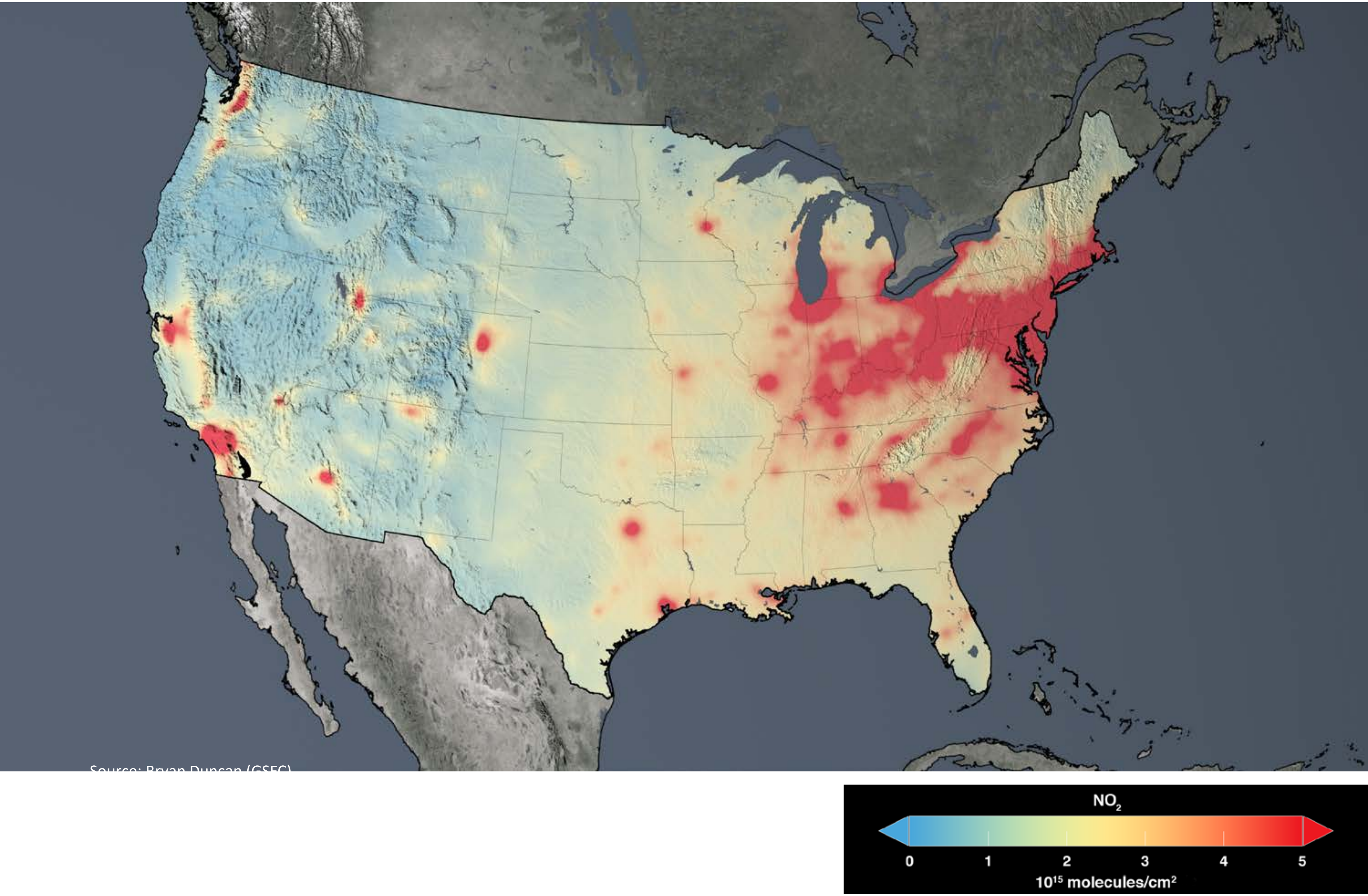


NASA's OMI NO_2 (2014)

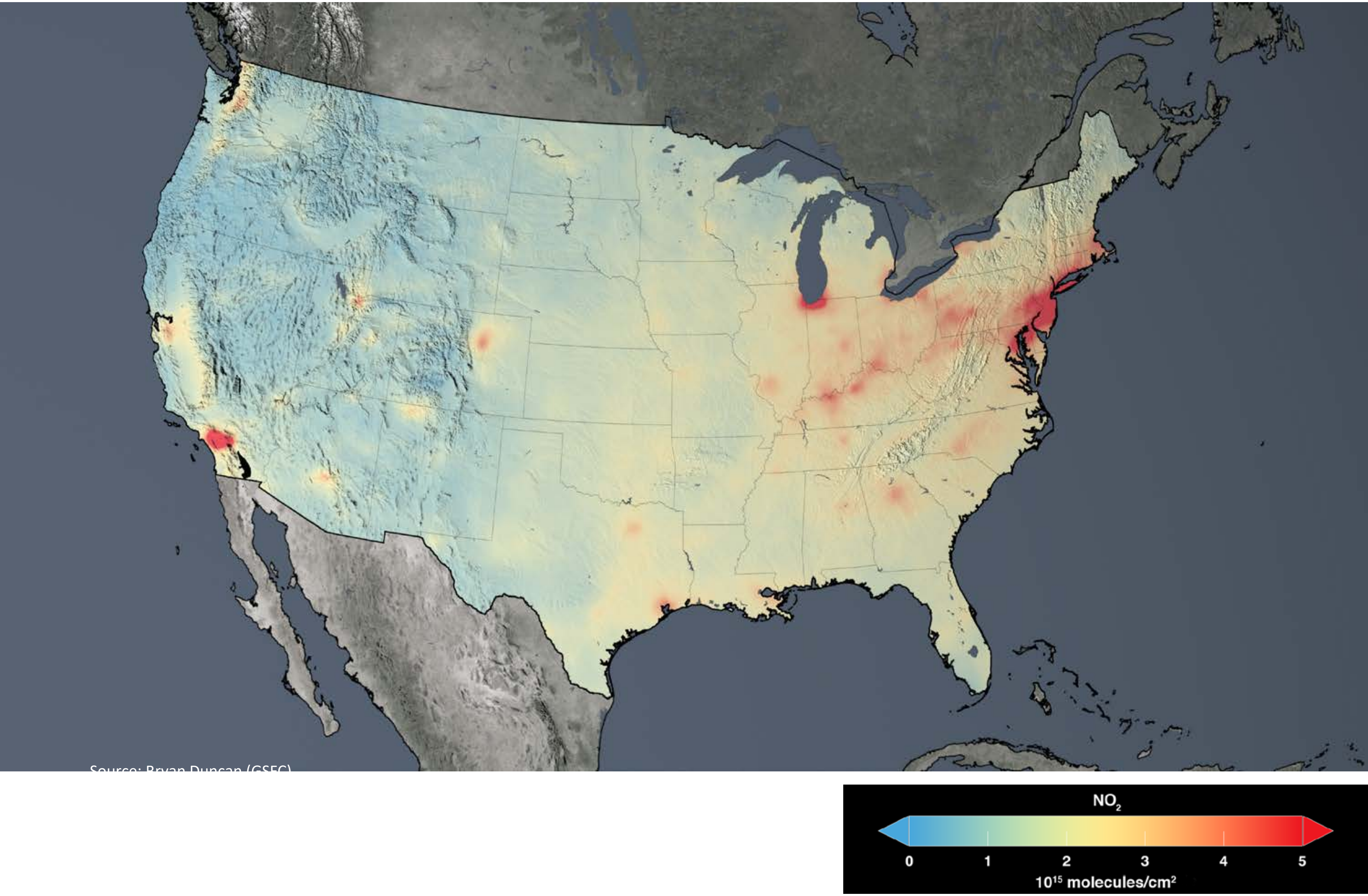




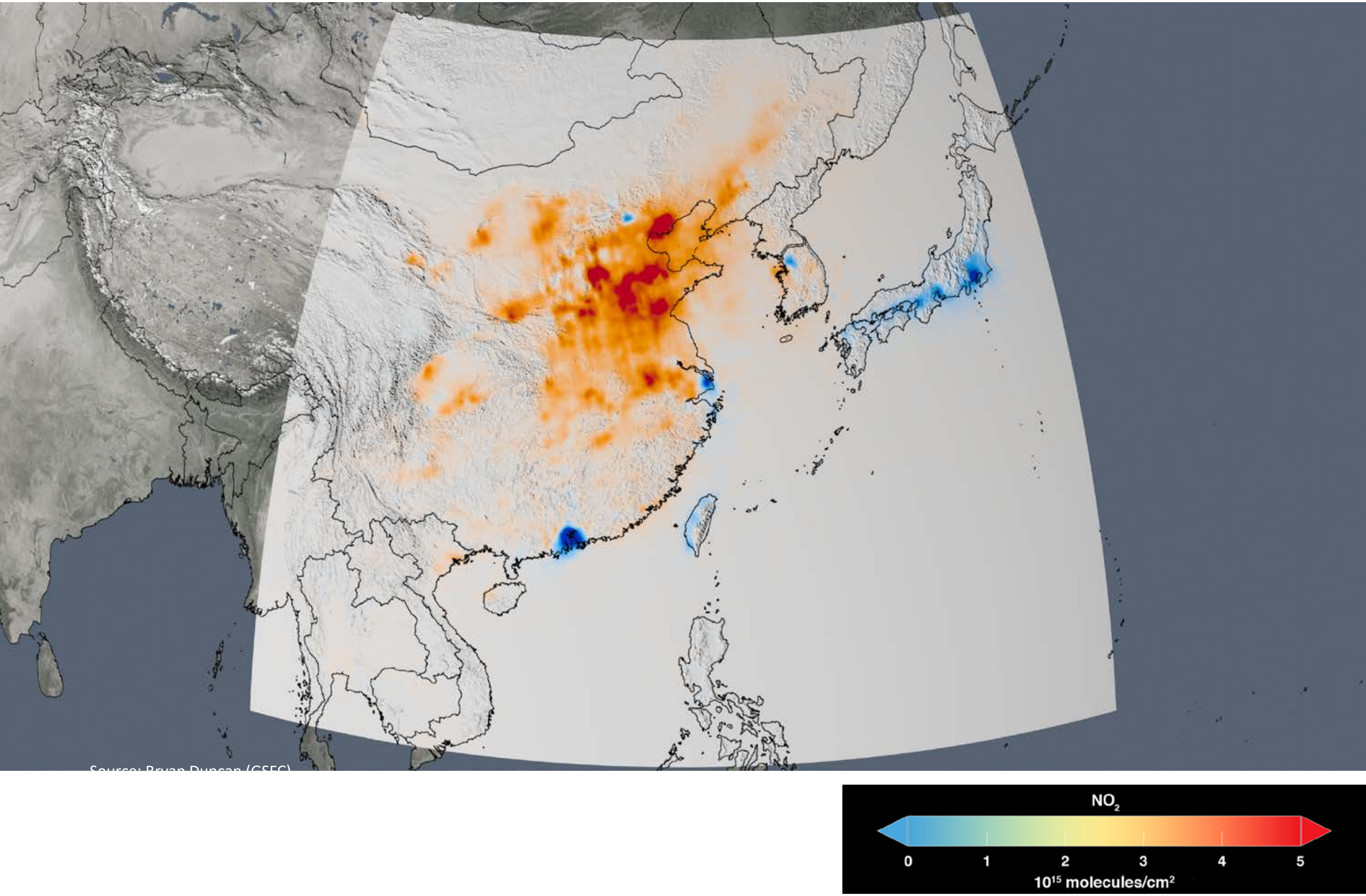
OMI NO_2 for United States (2005)



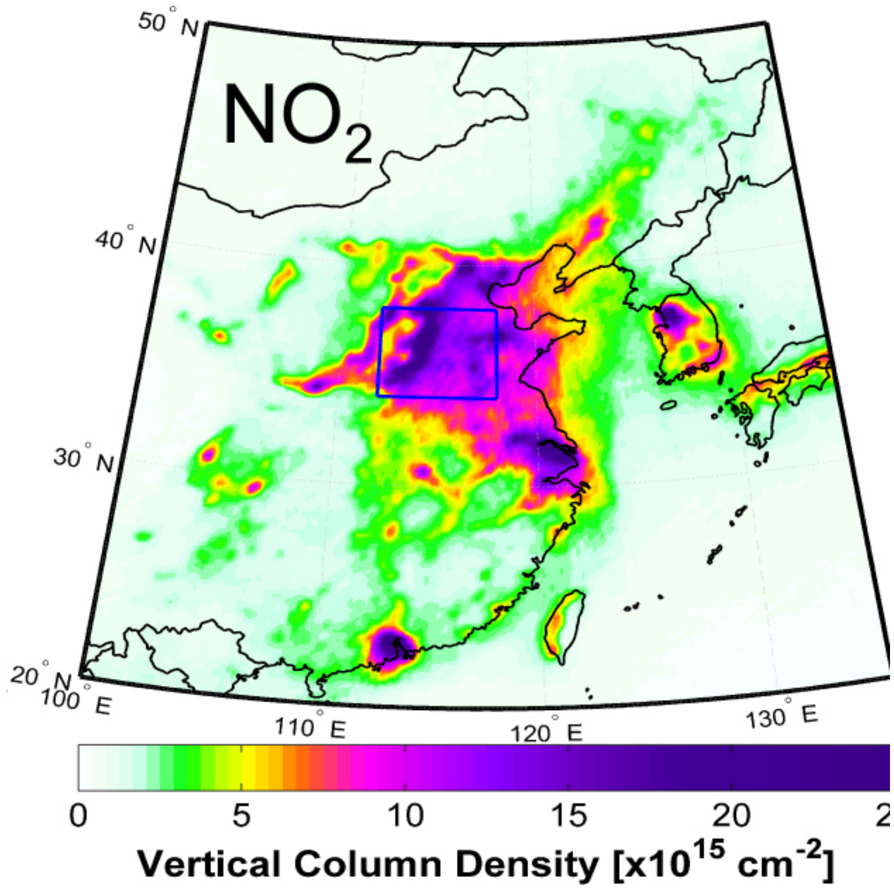
OMI NO_2 for United States (2014)

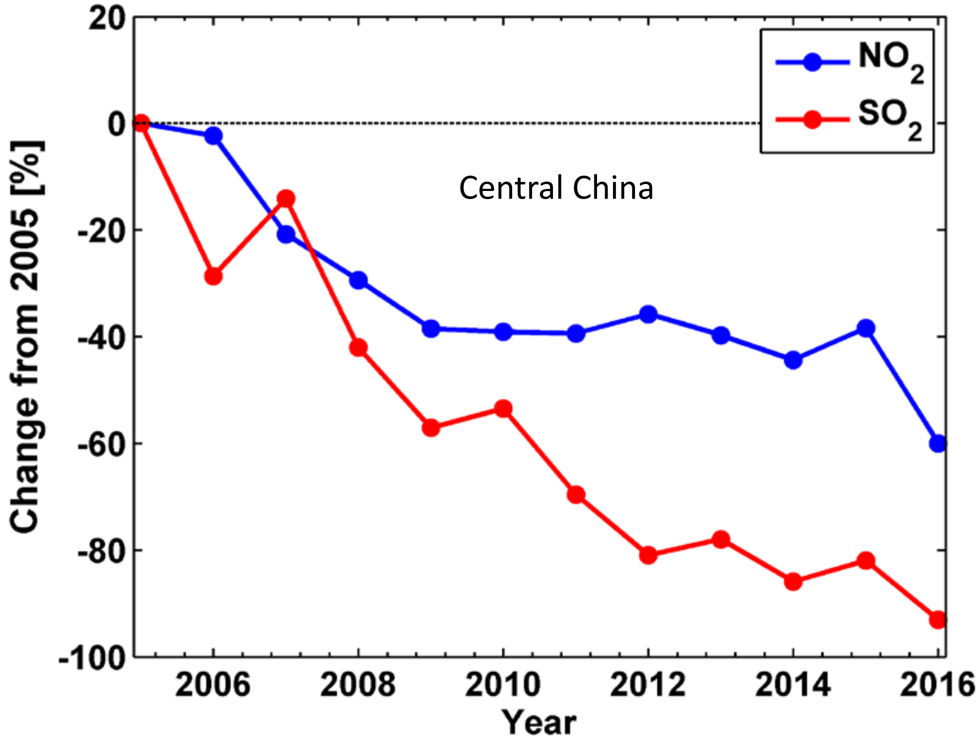


OMI NO_2 for East Asia (2005 to 2014)



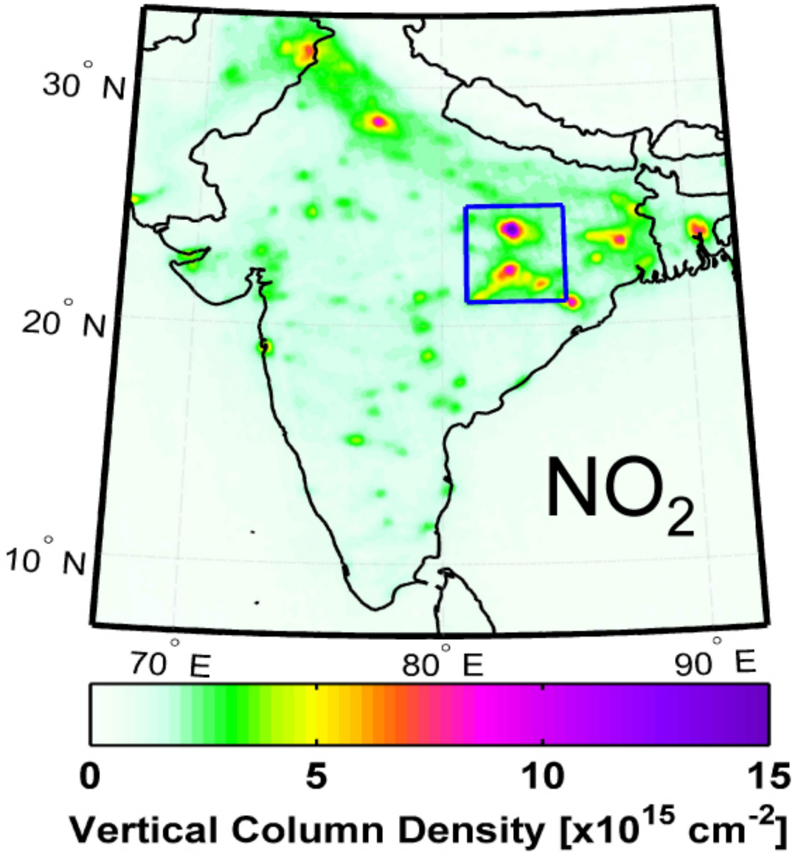
OMI NO_2 Trends (Annual 2005 to 2016)
Central China

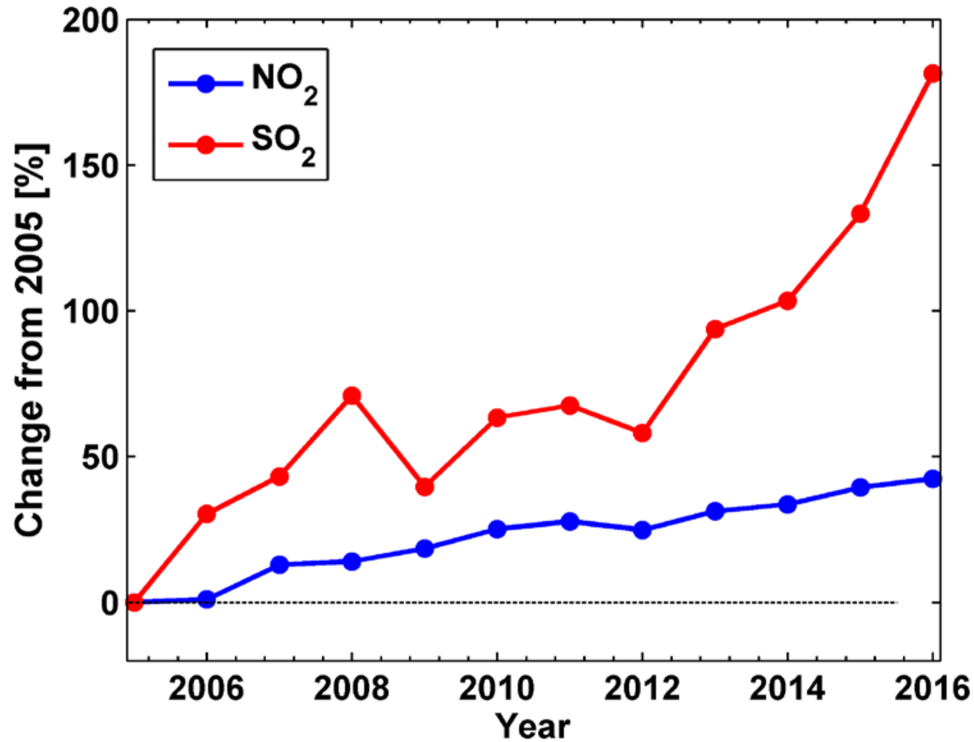




Source: Chris McLinden (ECCC)

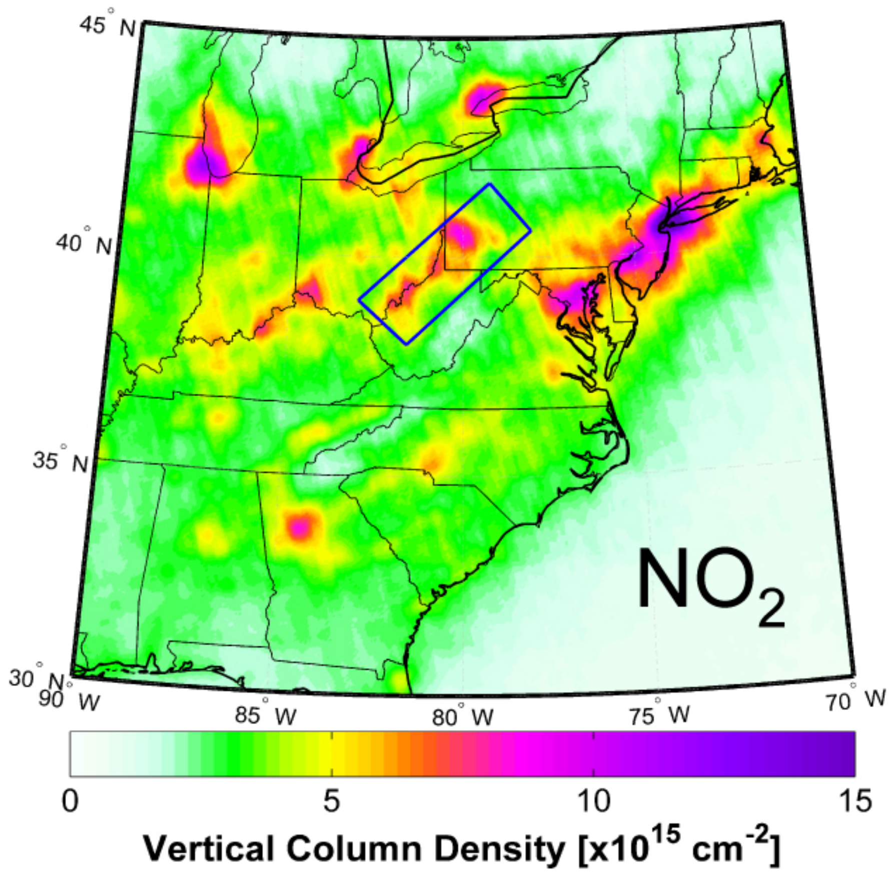
OMI NO_2 Trends (Annual 2005 to 2016)
Northeast India

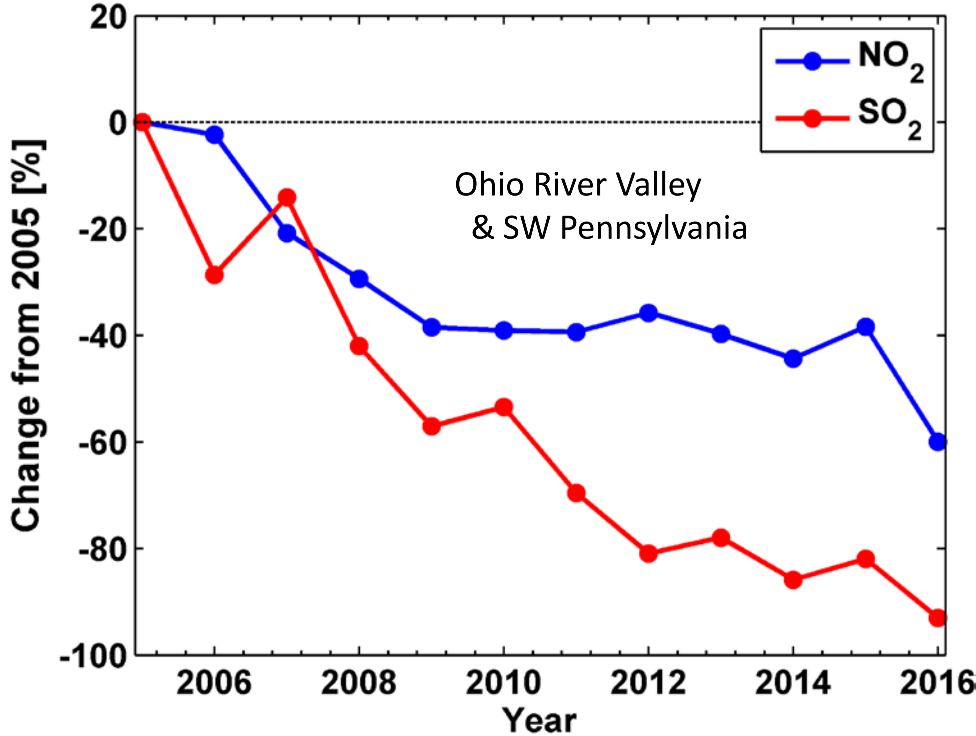




Source: Chris McLinden (ECCC)

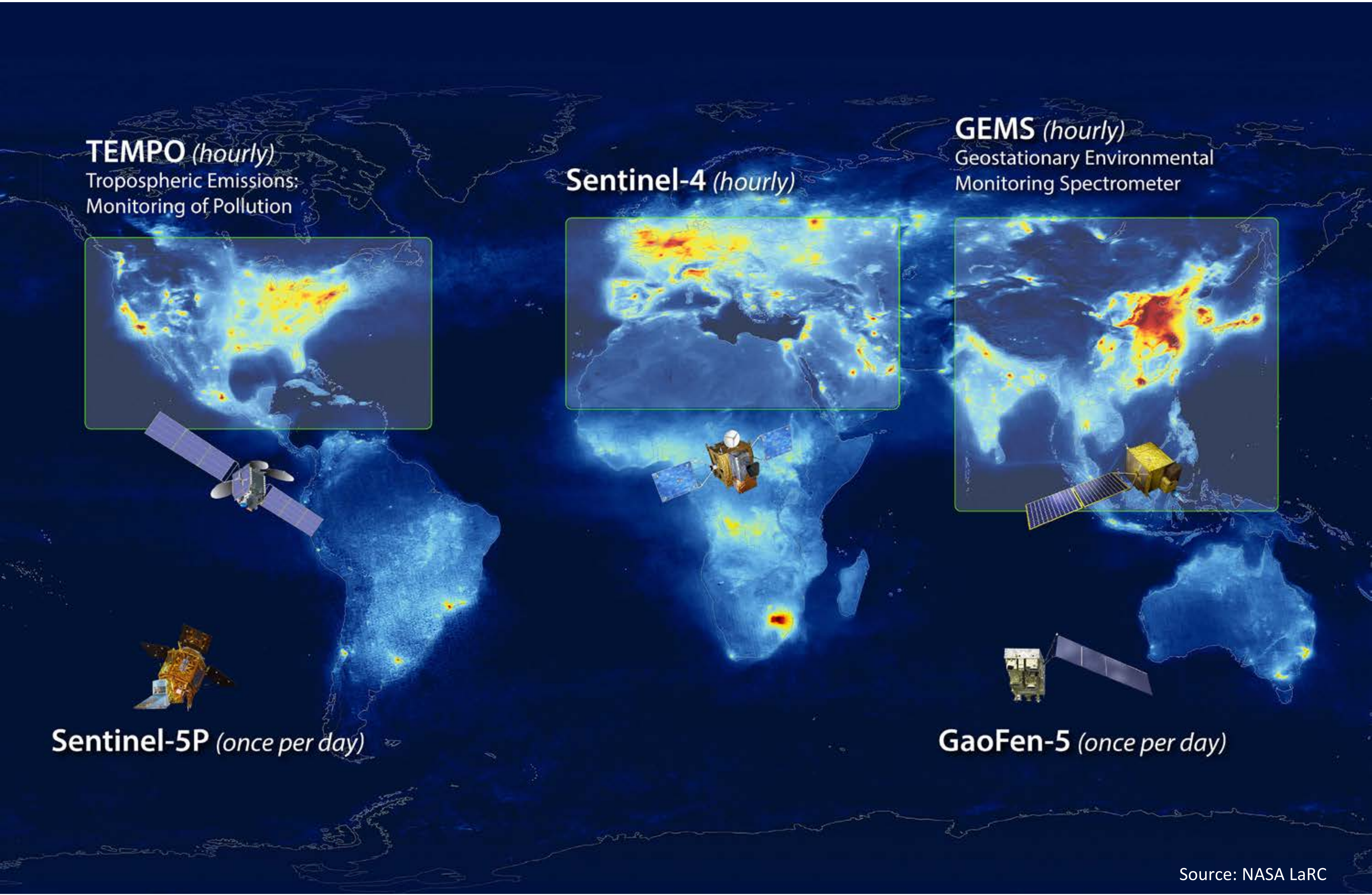
OMI NO_2 Trends (Annual 2005 to 2016)
Ohio River Valley and Southwestern Pennsylvania





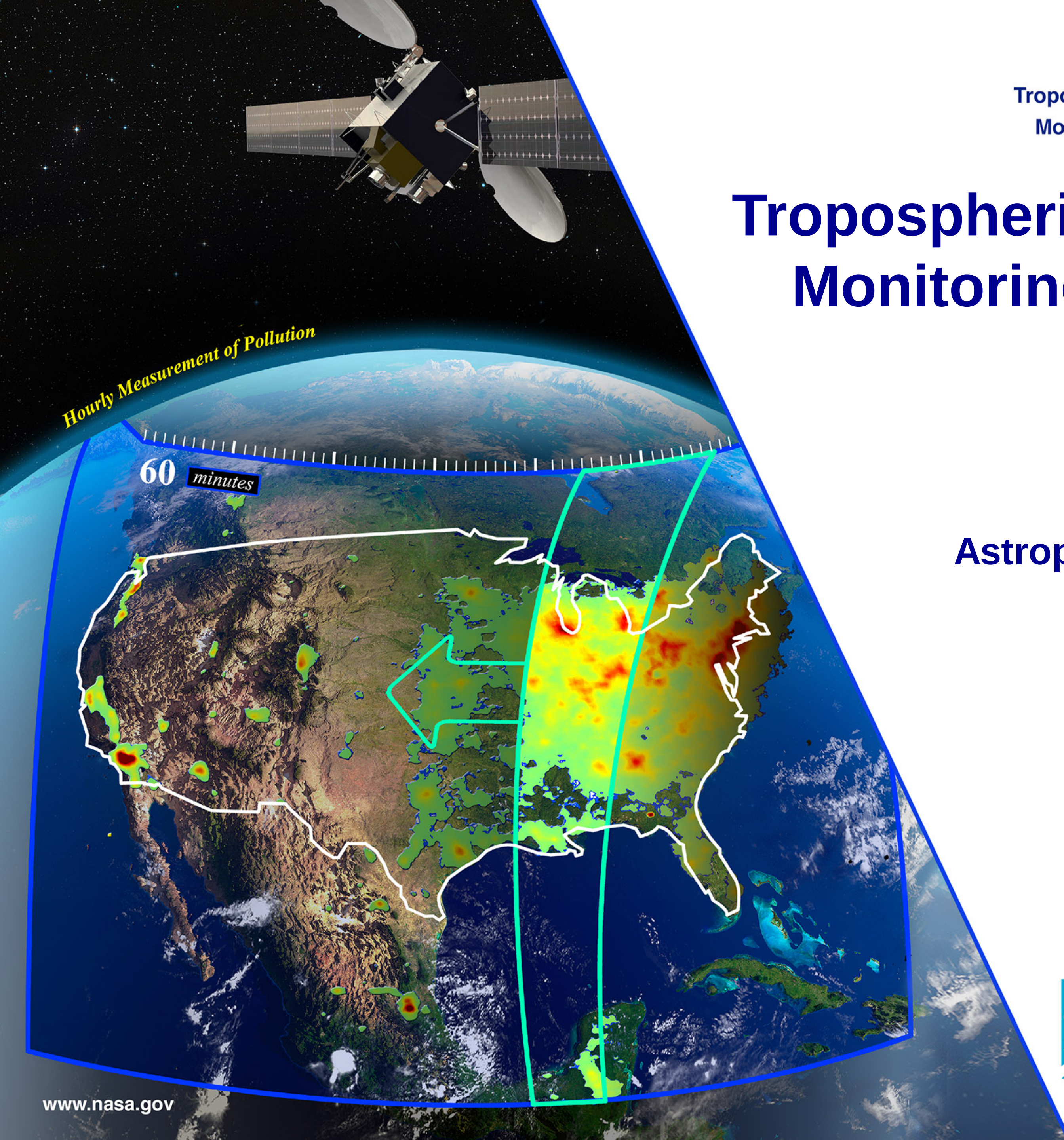
Source: Chris McLinden (ECCC)

2018 – 2022 Atmospheric Composition Virtual Constellation (AC-VC)



Tropospheric Emissions: Monitoring of Pollution (TEMPO)

Kelly Chance
Smithsonian
Astrophysical Observatory



Smithsonian

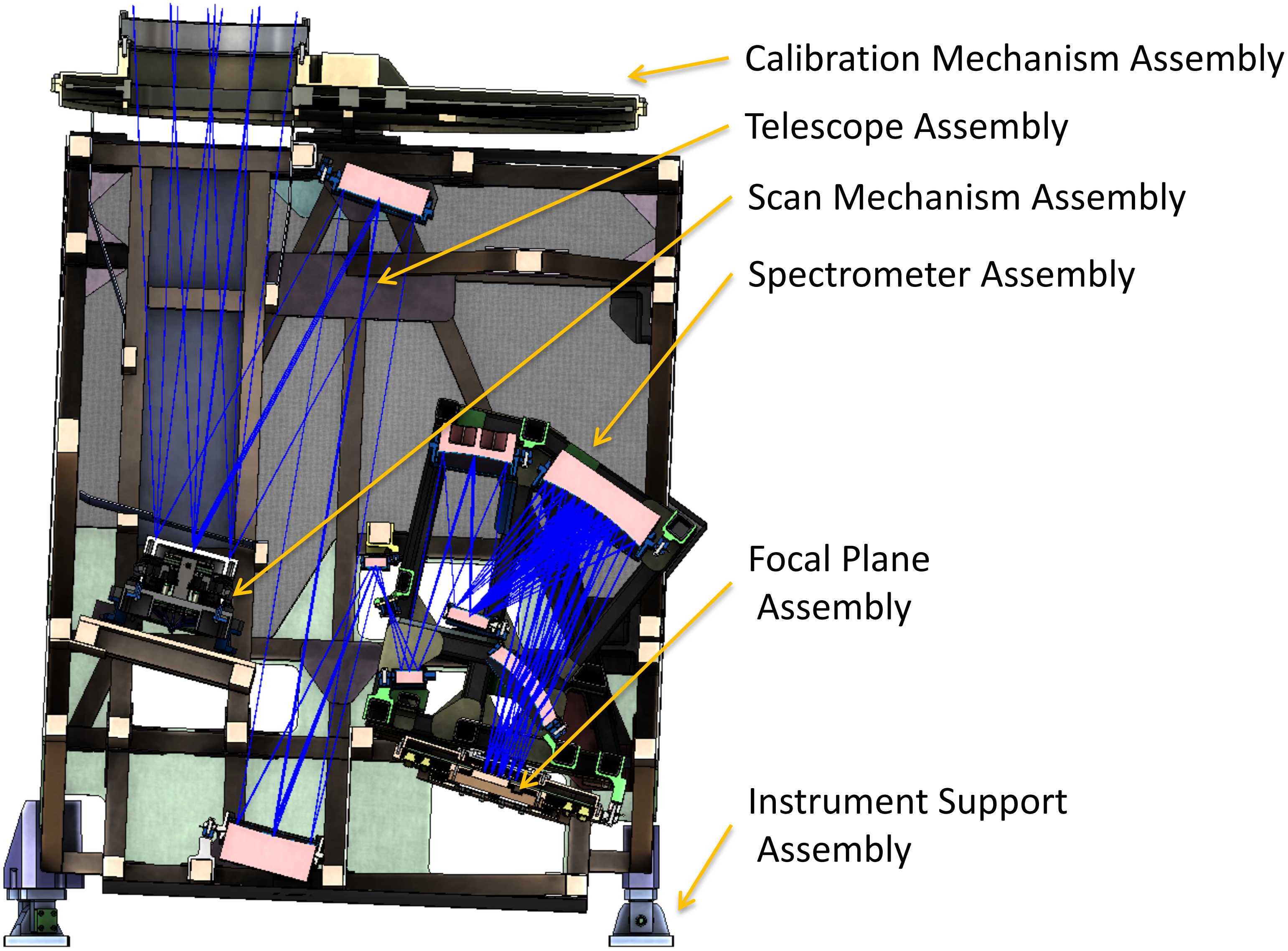
TEMPO instrument concept

- **Measurement technique**
  - Imaging grating spectrometer measuring solar backscattered Earth radiance
  - Spectral band & resolution: 290-490 + 540-740 nm @ 0.6 nm FWHM, 0.2 nm sampling
  - 2 2-D, 2k×1k, detectors image the full spectral range for each geospatial scene
  - Geostationary Orbit (22,236 miles) on a commercial telecom satellite
  - Expected launch by 2021.

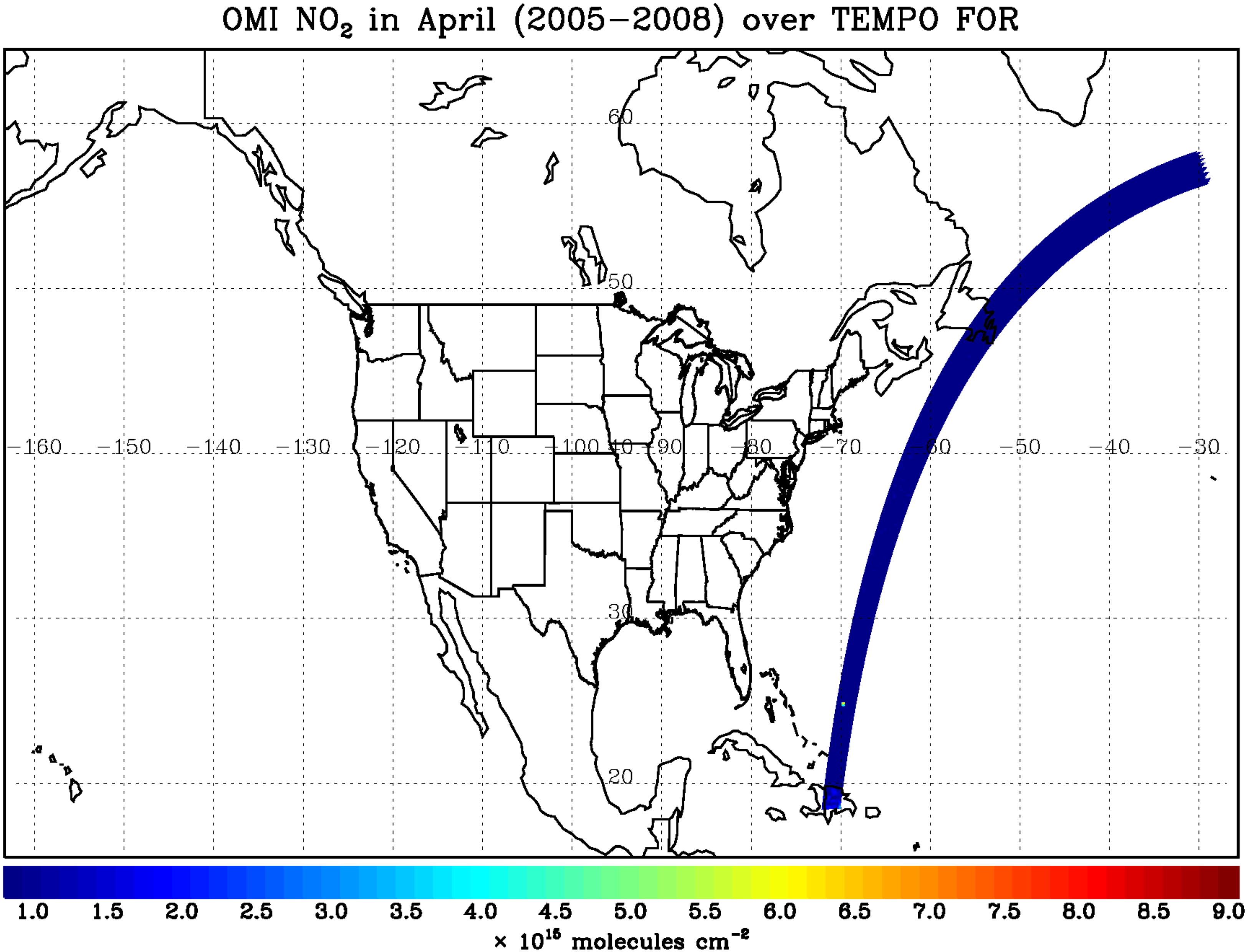
- **Spatial resolution**
  - 2.1 km N/S × 4.7 km E/W native pixel resolution (9.8 km^2)
  - Co-add/cloud clear as needed for specific data products

- **Standard data products and sampling rates**
  - Hourly NO_2 and O_3 (troposphere, PBL). O_3 for selected conditions*
  - HCHO, $C_2H_2O_2$, SO_2 sampled hourly (average results for ≥ 3/day if needed)
  - Aerosol Optical Depth (AOD) at UV/VIS
  - Nominal spatial resolution 8.4 km N/S × 4.7 km E/W at center of domain (can often measure 2.1 km N/S × 4.7 km E/W)

Instrument layout

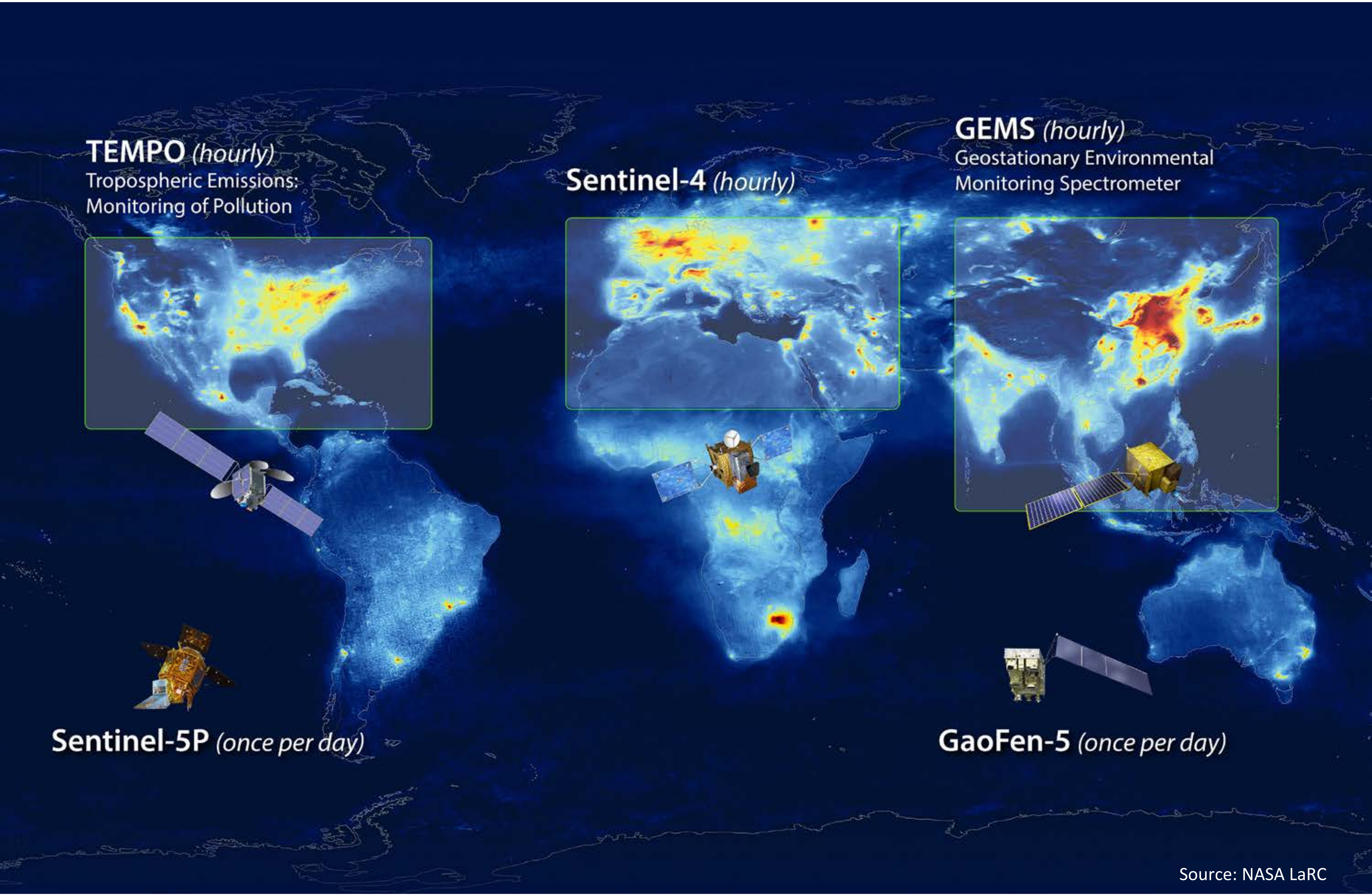


TEMPO Hourly Scanning



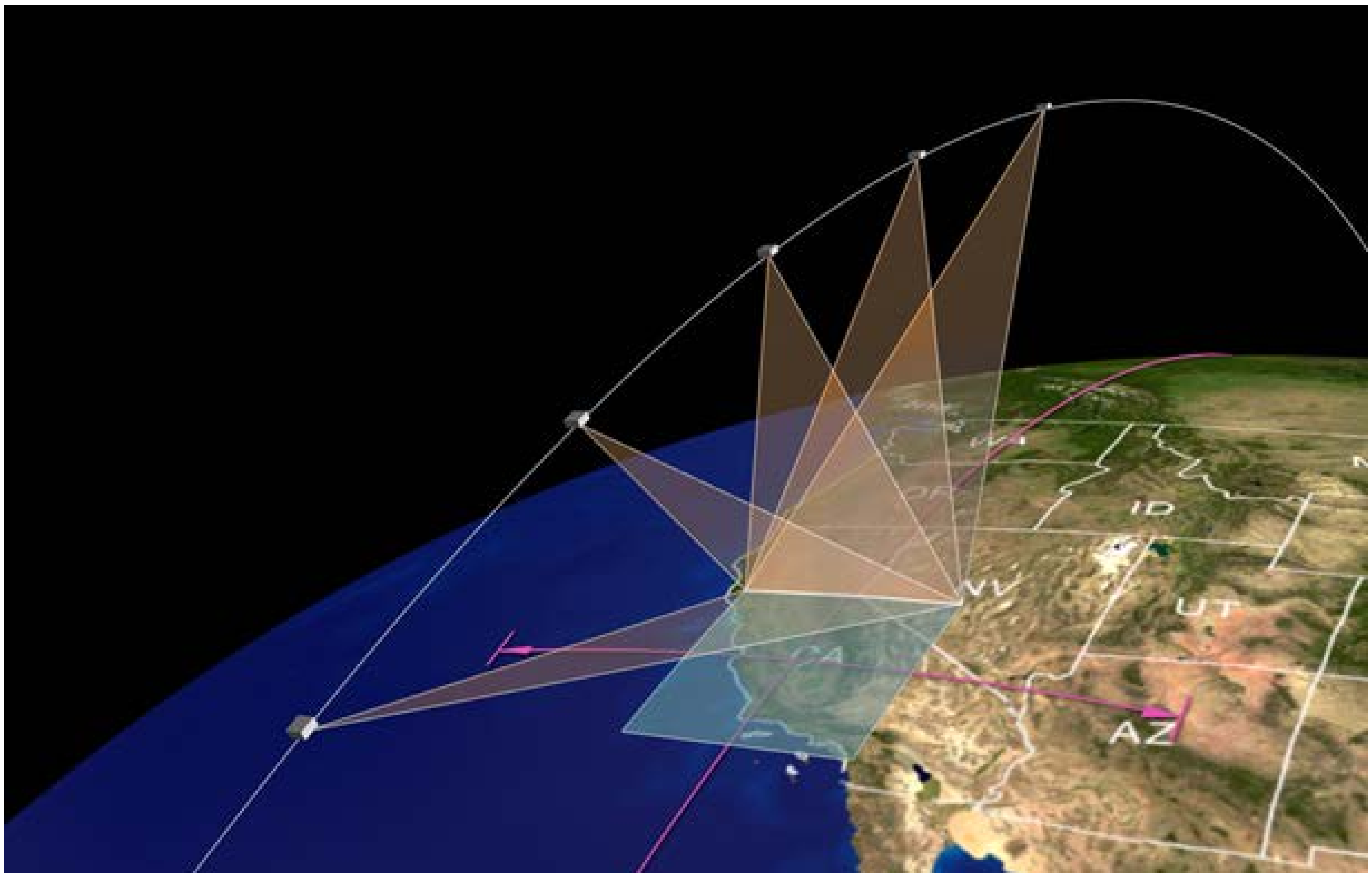
Source: Kelly Chance (SAO)

2018-2022 Atmospheric Composition Virtual Constellation (AC-VC)



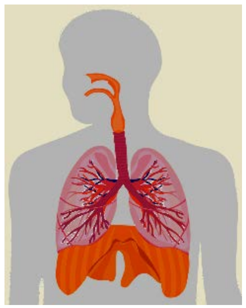
Multi-Angle Imager for Aerosols (MAIA)

MAIA uses a twin-camera instrument that will make radiometric and polarimetric measurements needed to characterize the sizes, compositions and quantities of particulate matter in air pollution. As part of the MAIA investigation, researchers will combine MAIA measurements with population health records to better understand the connections between aerosol pollutants and health problems such as adverse birth outcomes, cardiovascular and respiratory diseases and premature deaths.

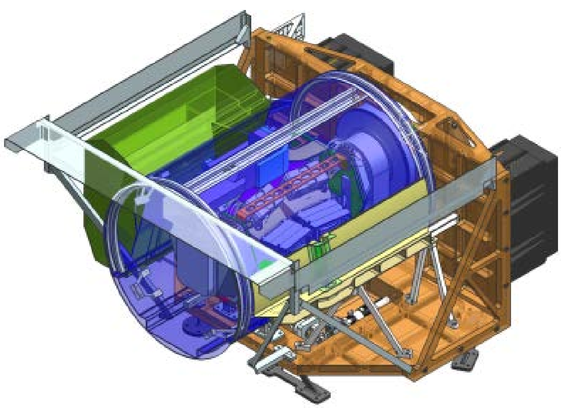


Multi-Angle Imager for Aerosols (MAIA)

- MAIA's objective is to assess the impacts of different size/compositional mixtures of airborne particulate matter (PM) on adverse birth outcomes, premature deaths, and cardiovascular/respiratory disease.



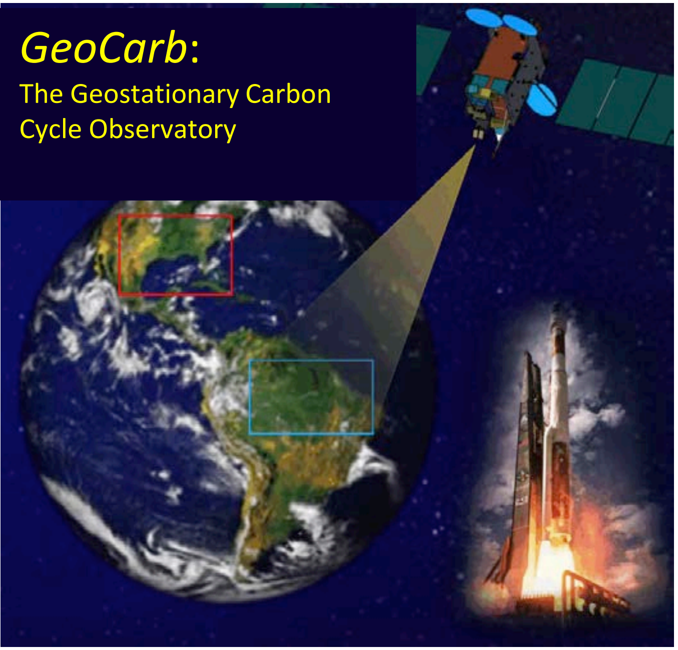
The investigation integrates chemical transport model, surface monitor, and satellite instrument data to map speciated PM at ~1 km scale.



- The MAIA instrument is being built at JPL
  - UV/VNIR/SWIR spectropolarimetric imager on a 2-axis gimbal to routinely observe a set of globally-distributed cities (e.g., Boston, Atlanta, LA, Rome, Tel Aviv, Johannesburg, Taipei, Delhi, Beijing)
- Launch into polar orbit (~2021, 3-year mission)
- Data products include aerosol optical depth, PM_{10}, $PM_{2.5}$, and $PM_{2.5}$ for sulfates, nitrates, black carbon, organic carbon, dust

- Epidemiologists on the MAIA team will use birth, death, and hospital records to associate PM exposure with human health impacts.

Geostationary Carbon Cycle Observatory (GeoCarb)



GeoCarb Products:

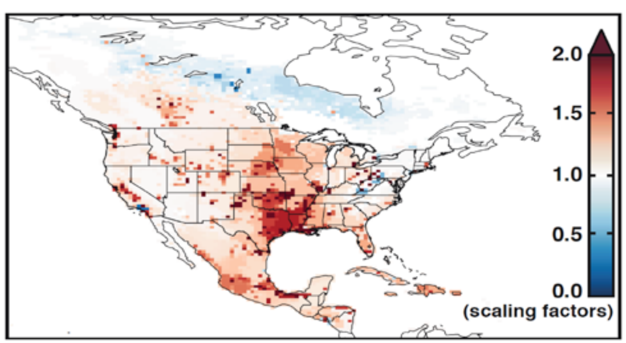
Geostationary measurements of North, Central, South America showing column CO_2, CH_4, CO and Solar Induced Fluorescence (SIF).

GeoCarb accuracy:
0.6% for CH_4 , 0.3% for CO_2 , and 10% for CO

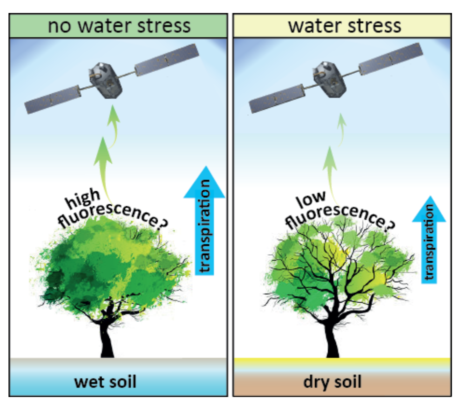
3km x 6km pixel size

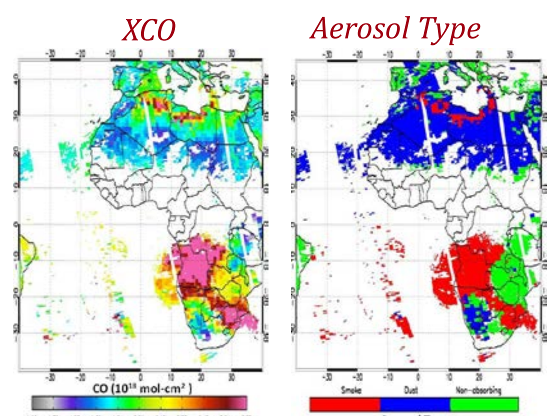
Launch: 2022.

Correction factors for North America



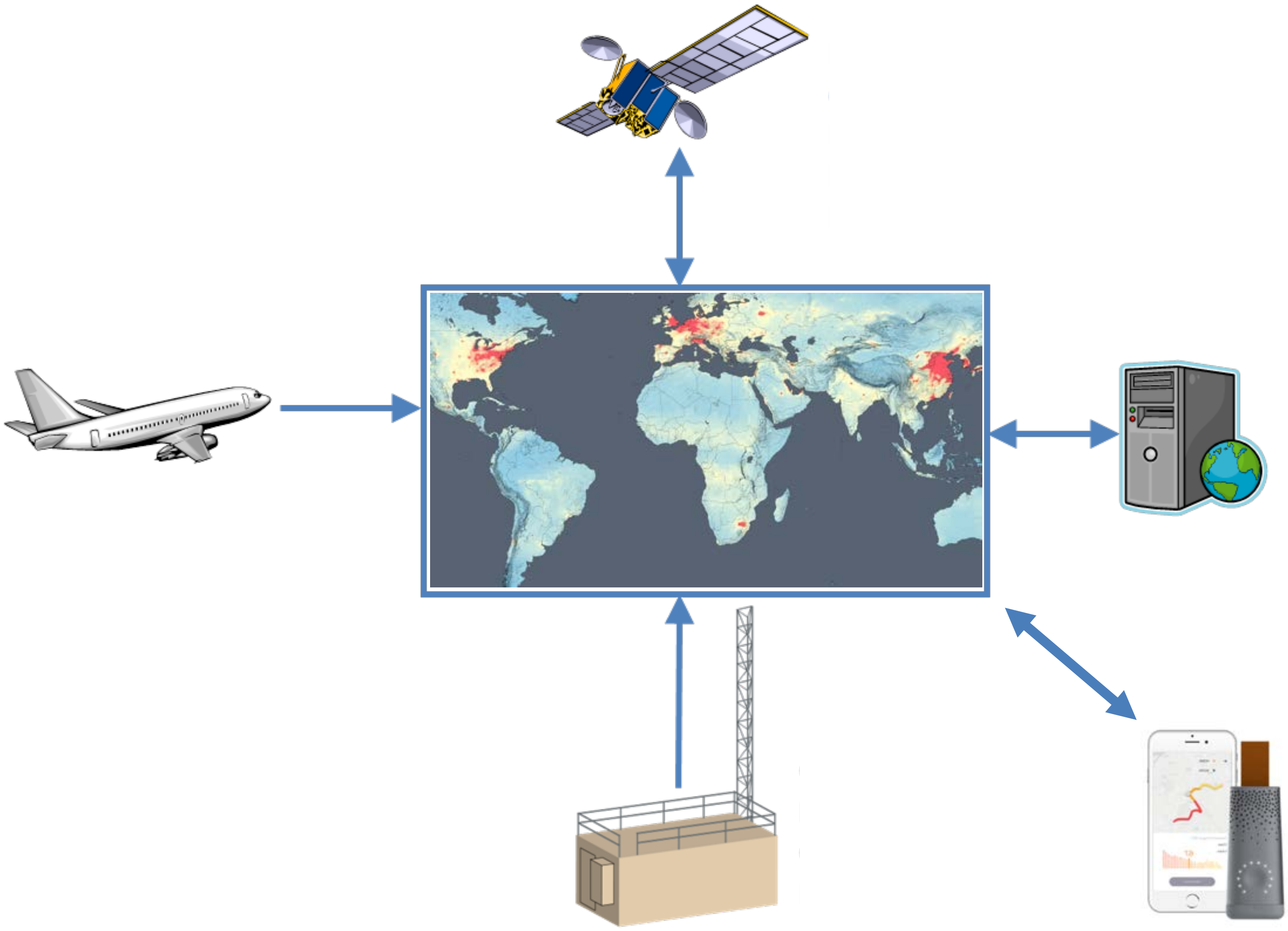
- CONUS anthropogenic emission of 40-43 Tg a^{-1} vs. EPA value of 27 Tg a^{-1}
- Is the underestimate in livestock or oil/gas emissions or both? *Turner et al. [2015]*





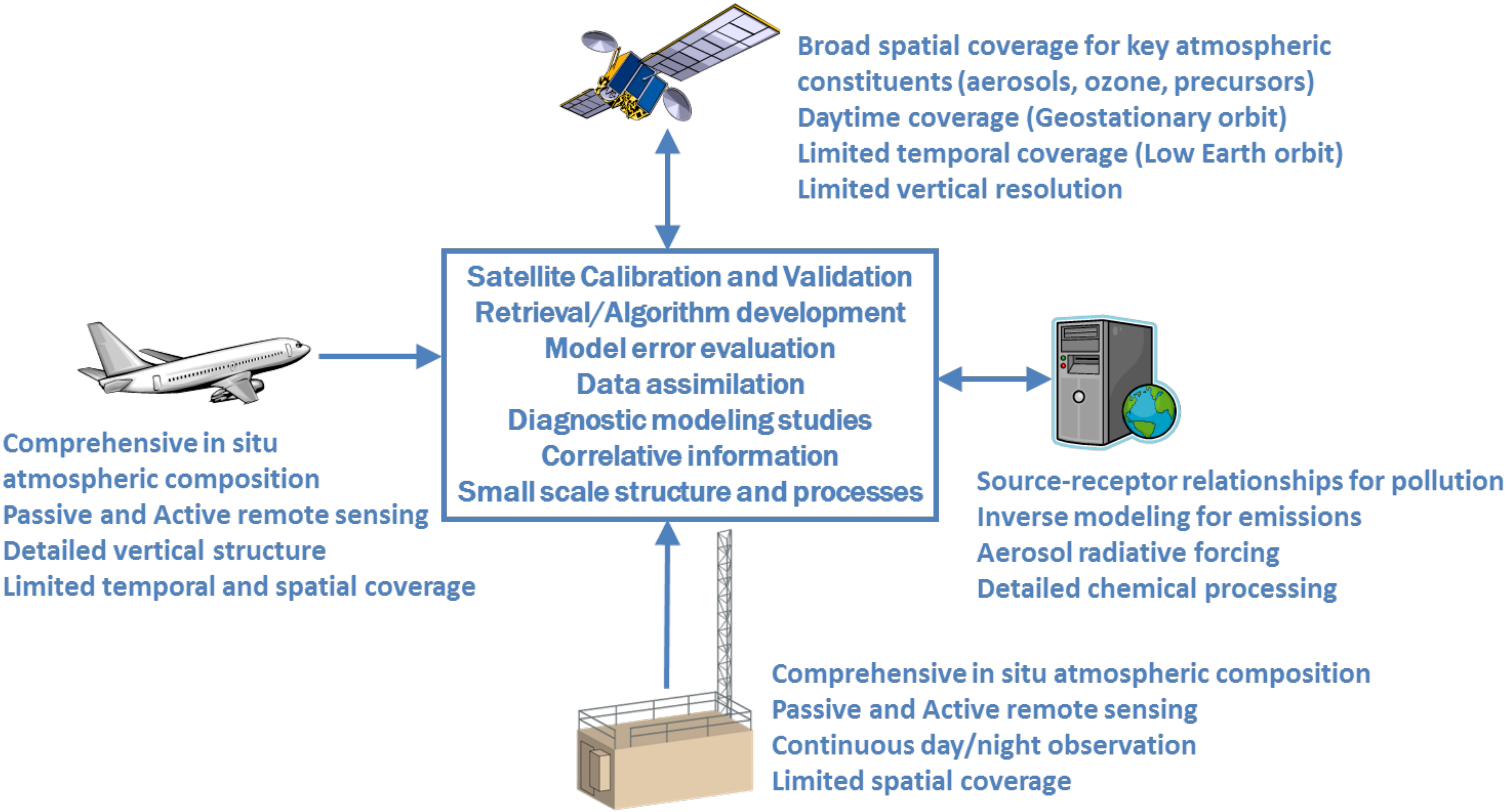
R. Chatfield, NASA Ames, Jan 2018

Integrated Observing System for Air Quality



Source: Jim Crawford

Field campaigns and the Integrated Observing System for Air Quality



Source: Jim Crawford

Ministry of Environment
National Institute of Environmental Research

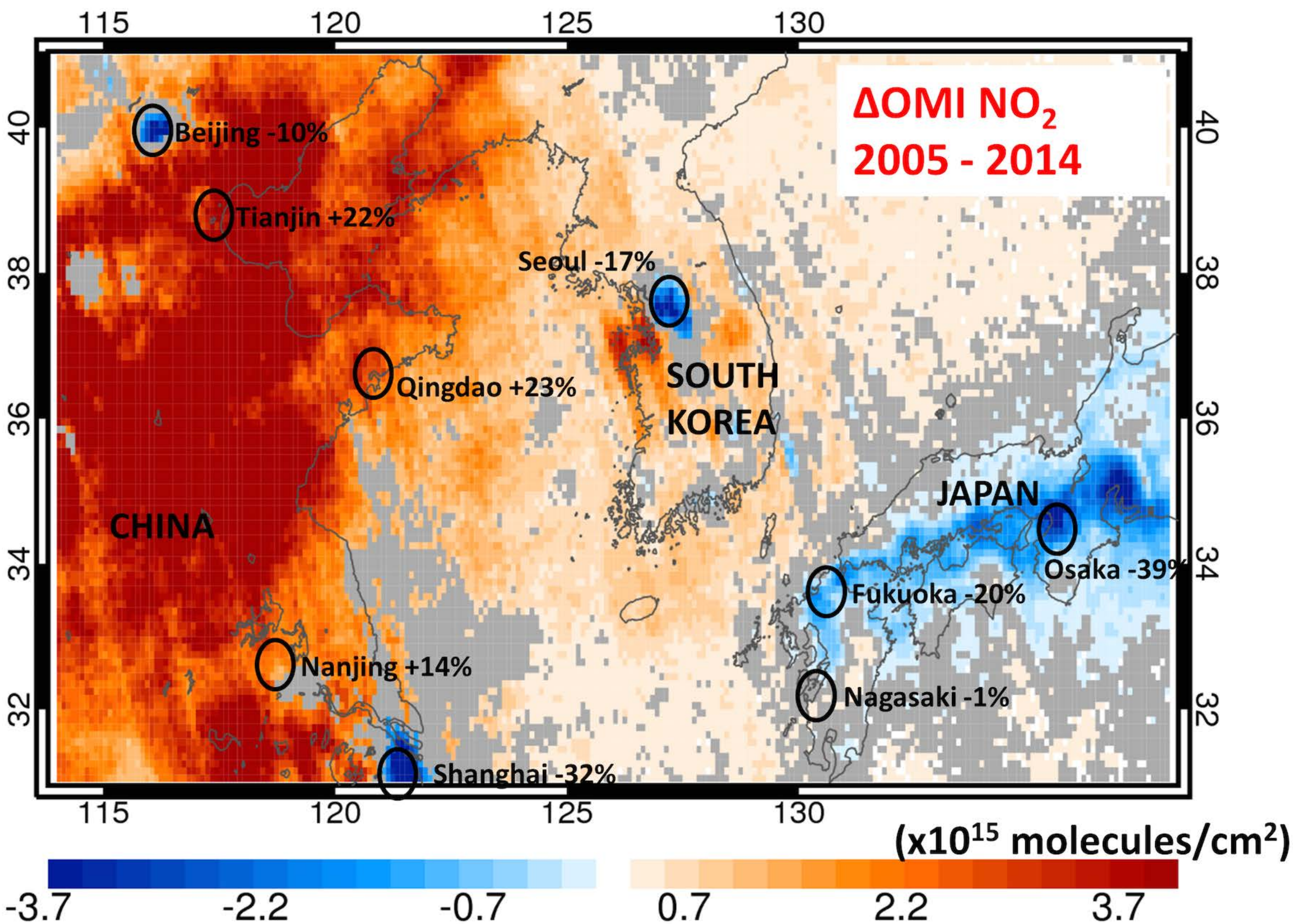
KOREA-UNITED STATES AIR QUALITY STUDY

KORUS-AQ

NIER • NASA

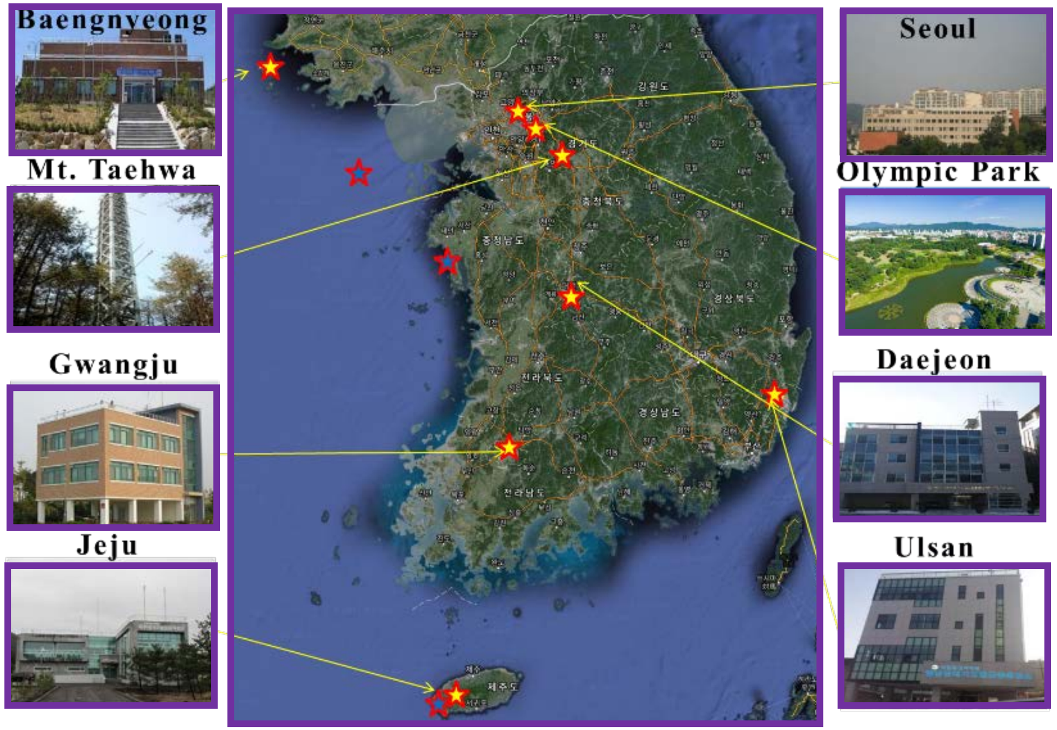
1 May – 14 June 2016

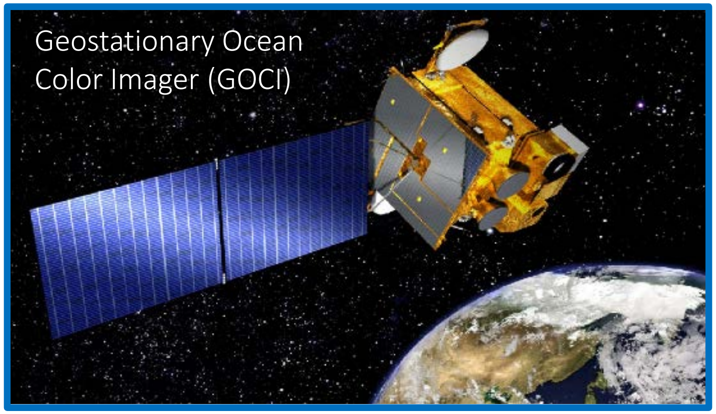
Area with changing emissions over past decade



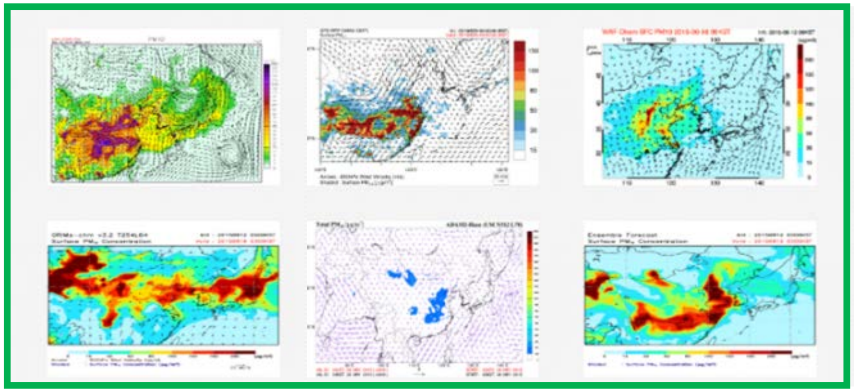
Source: Lok Lamsal

KORUS-AQ





Korean and US Air Quality Model Forecasts

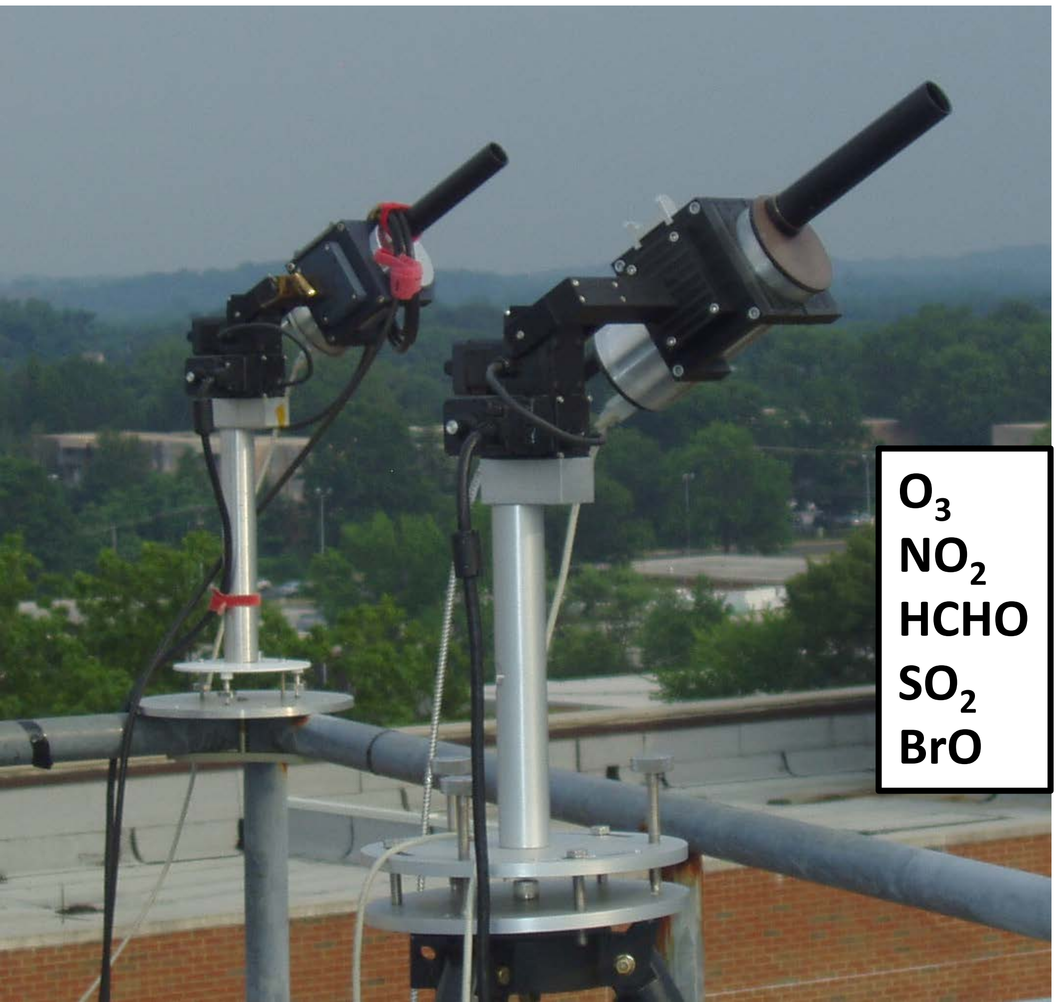


Pandora Sunphotometer

UV/VIS Ground Validation
Direct Sun & Sky-Scan Modes

Total Column every few minutes

Profiles every 20 minutes



NASA Pandora
ESA Pandonia

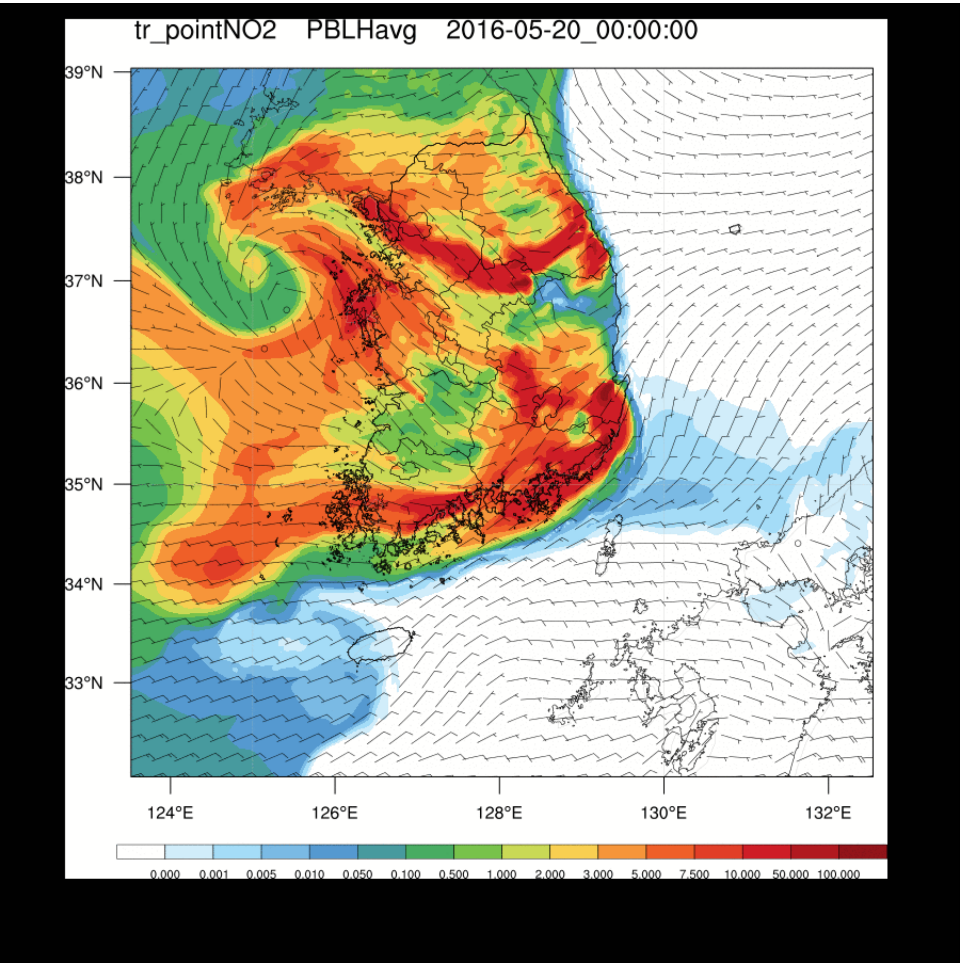
Pandonia Global Network (PGN)

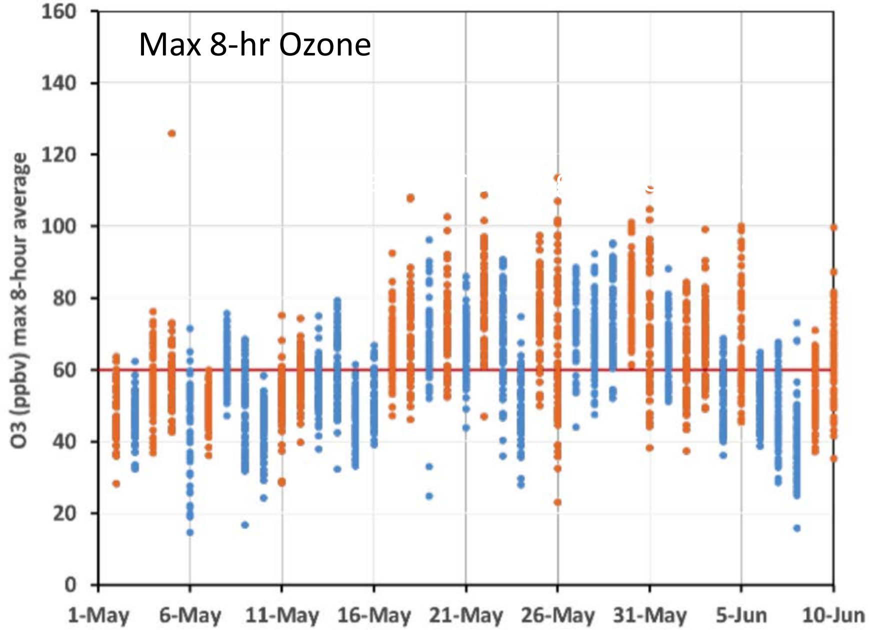
Approximately 40 in total worldwide.

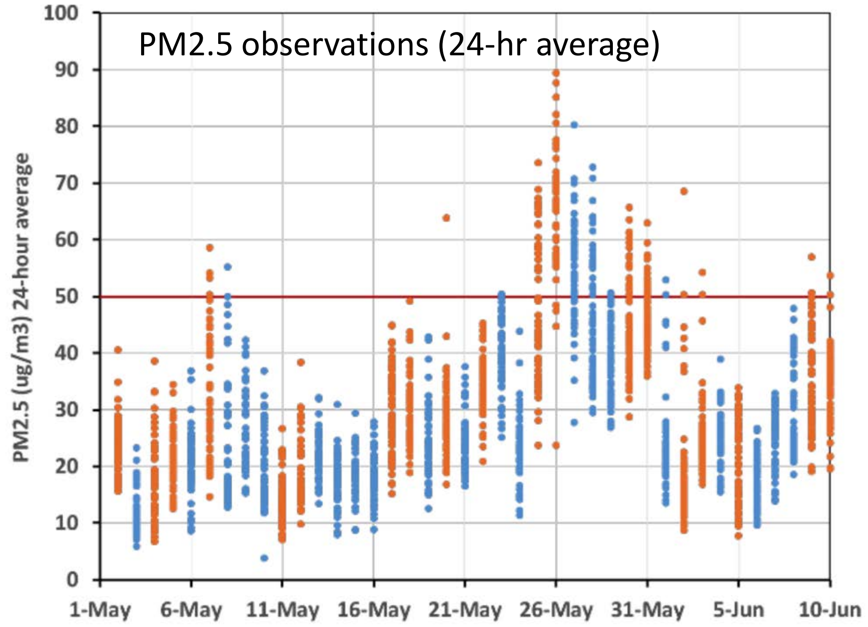
NASA working to have 25 new permanent sites in the U.S. in 2018.

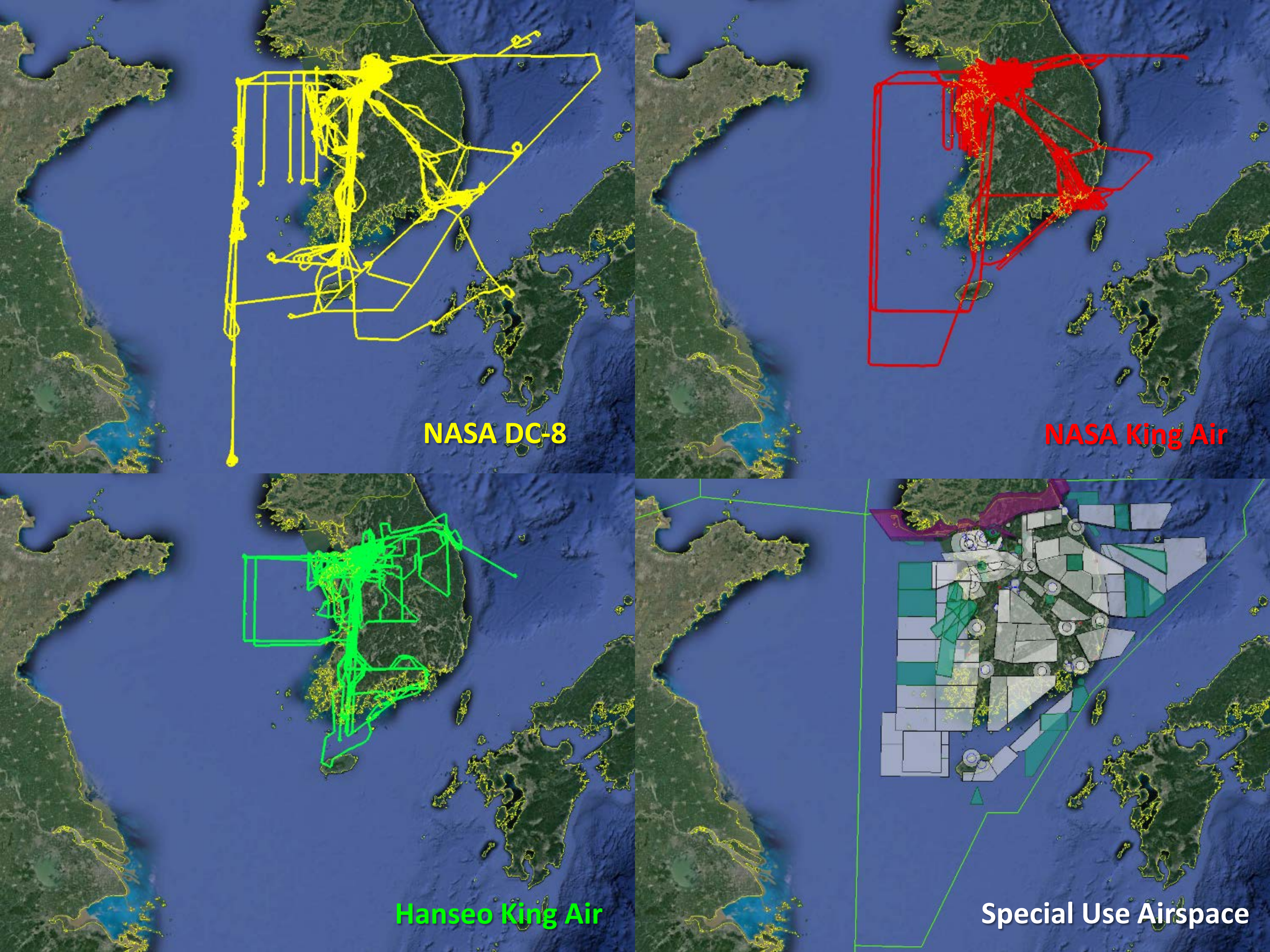
NASA Pandora Manager: Bob Swap (GSFC)

KORUS-AQ Flight Decision Tools

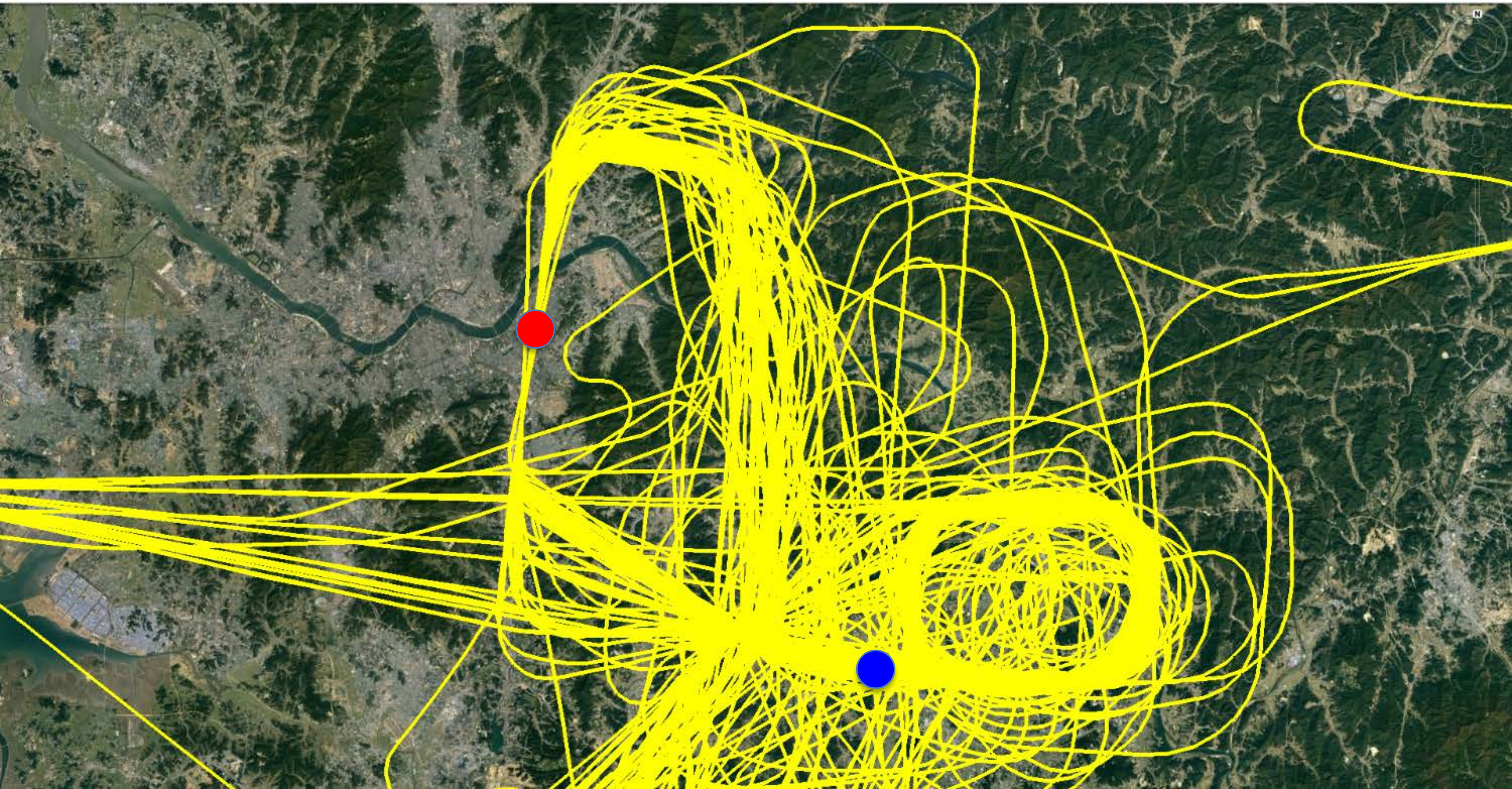




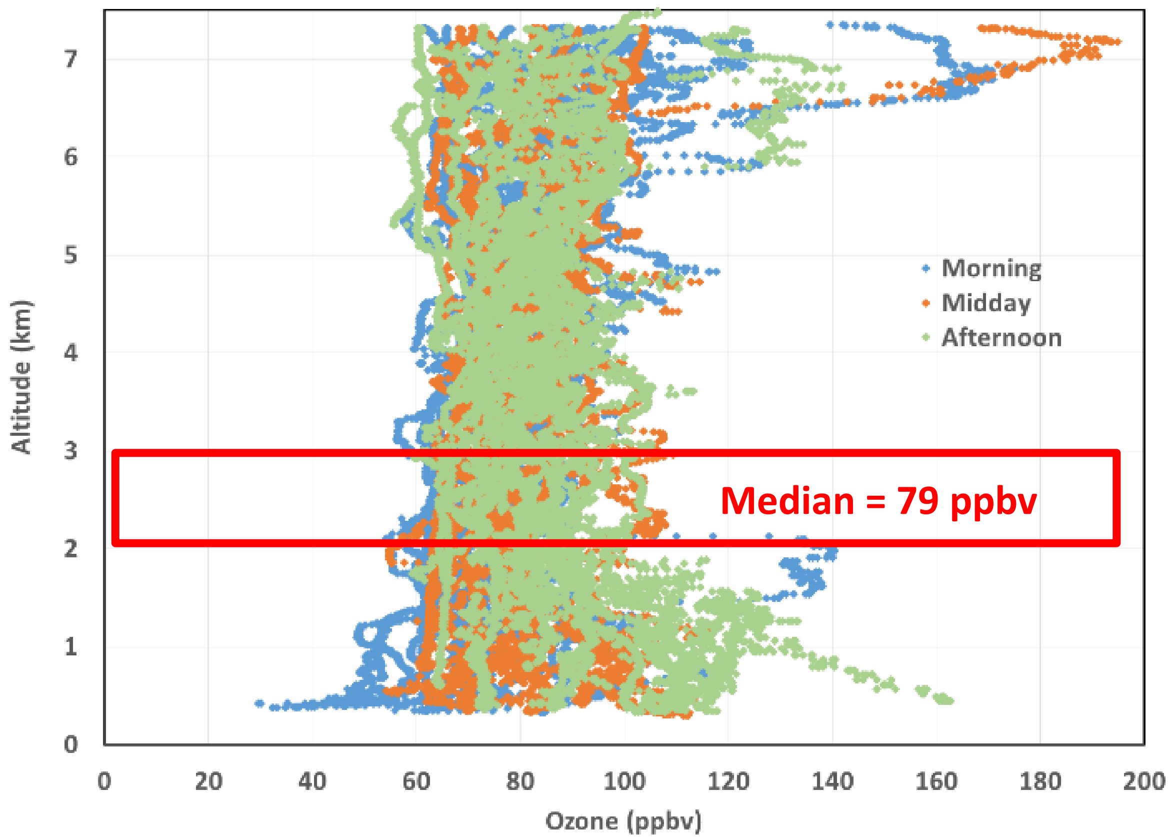


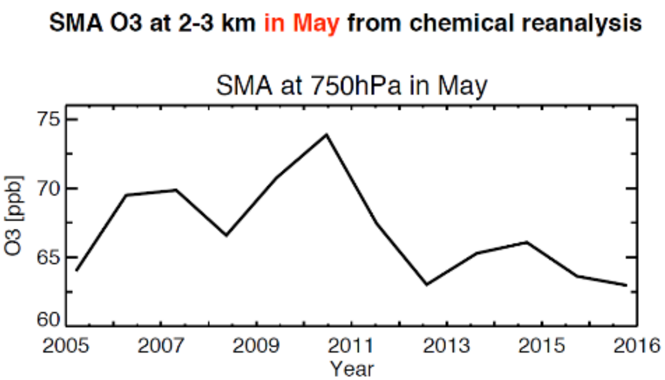

NASA DC-8
NASA King Air
Hanseo King Air
Special Use Airspace

Repetitive sampling by the DC-8 over research sites in Seoul and adjacent rural areas



Ozone in the lower free troposphere during KORUS-AQ was always greater than 60 ppbv. Thus, continued observations of ozone aloft over SMA are necessary for understanding future ozone changes at the surface and the effectiveness of local control strategies.





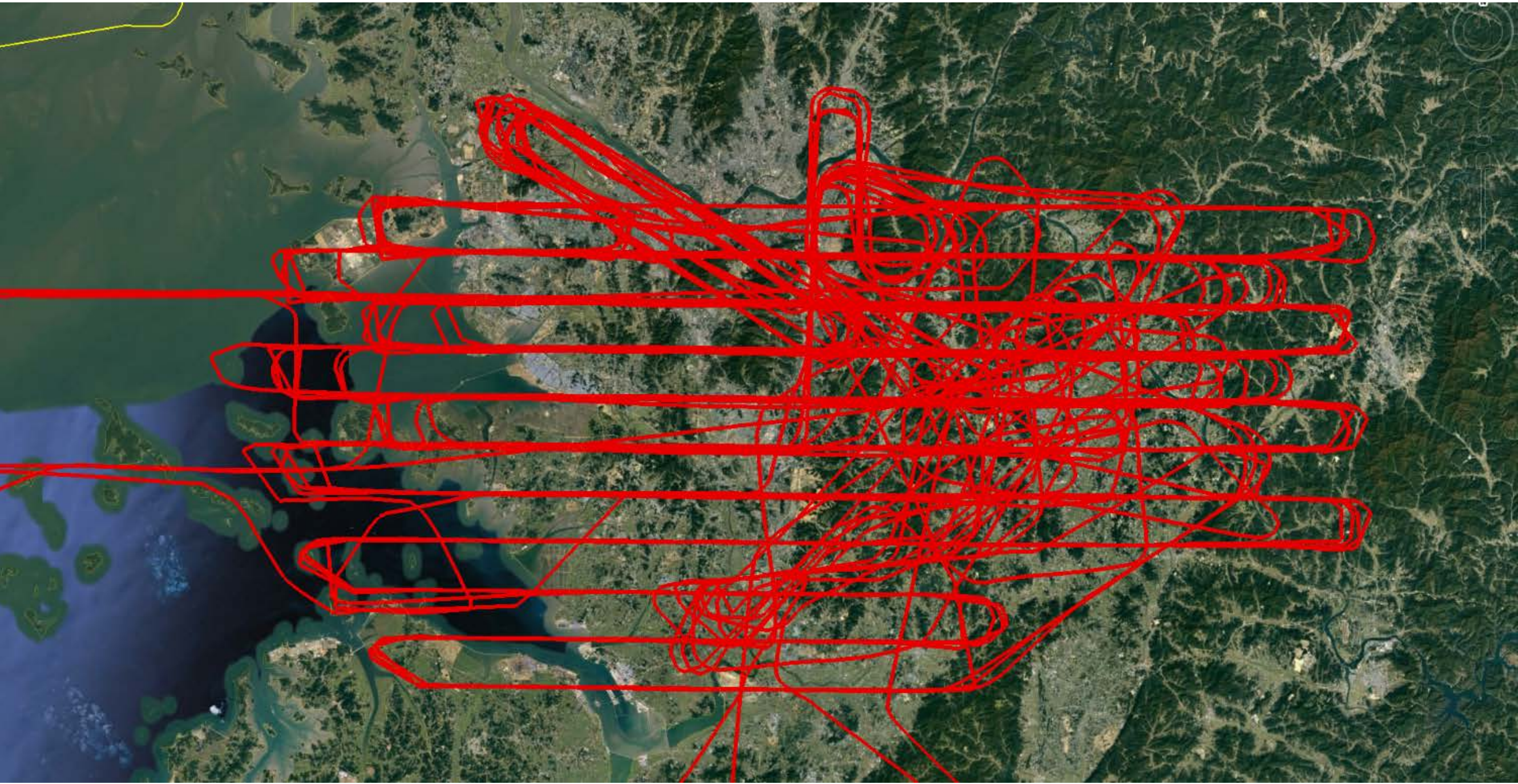
Figures contributed by Jim Crawford (NASA LaRC) and Kazuyuki Miyazaki (NASA/JPL)

KORUS-AQ

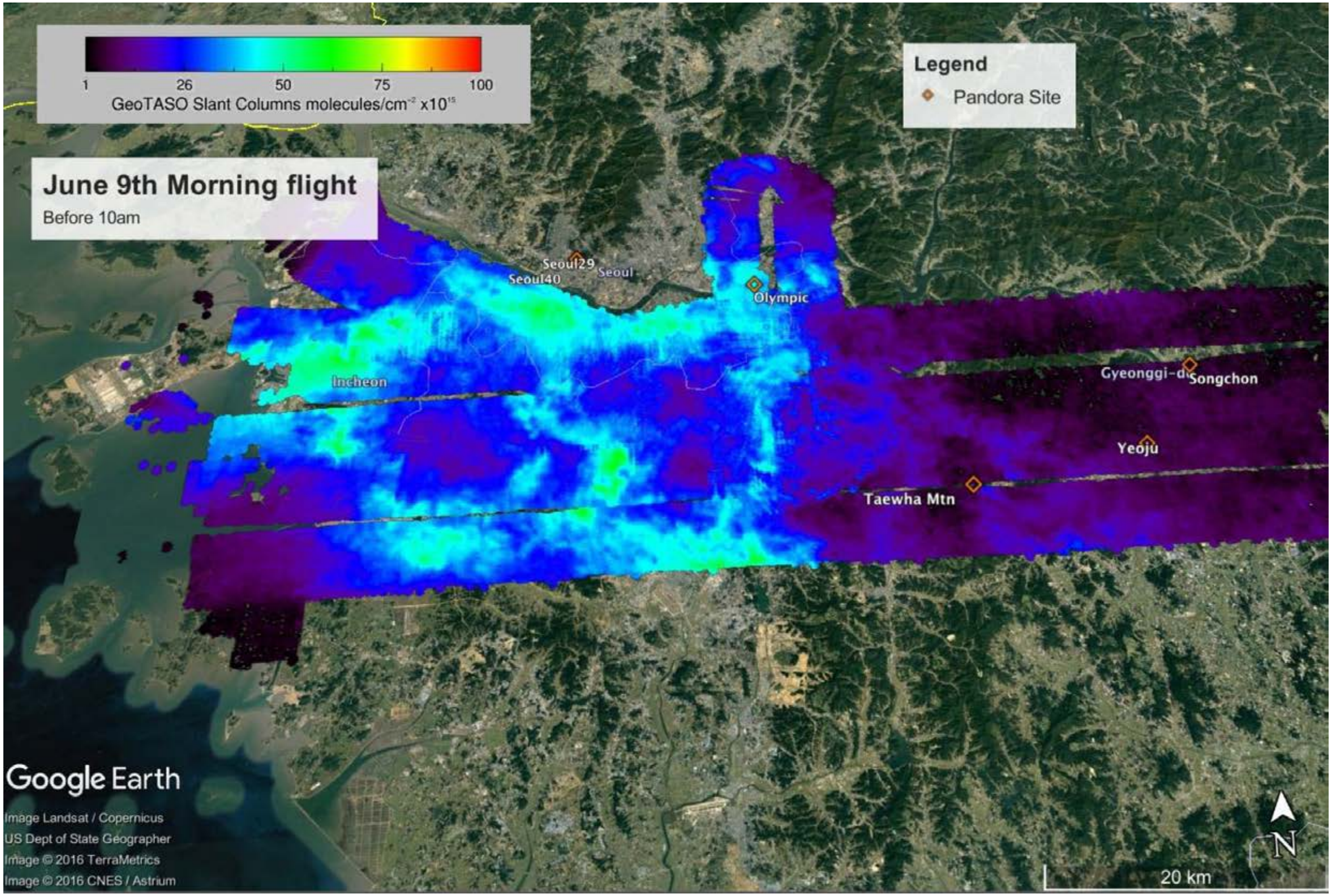
Ministry of Environment
National Institute of Environmental Research

NASA

Repetitive sampling by the NASA King Air to map emissions over the Seoul Metropolitan Area and adjacent rural areas

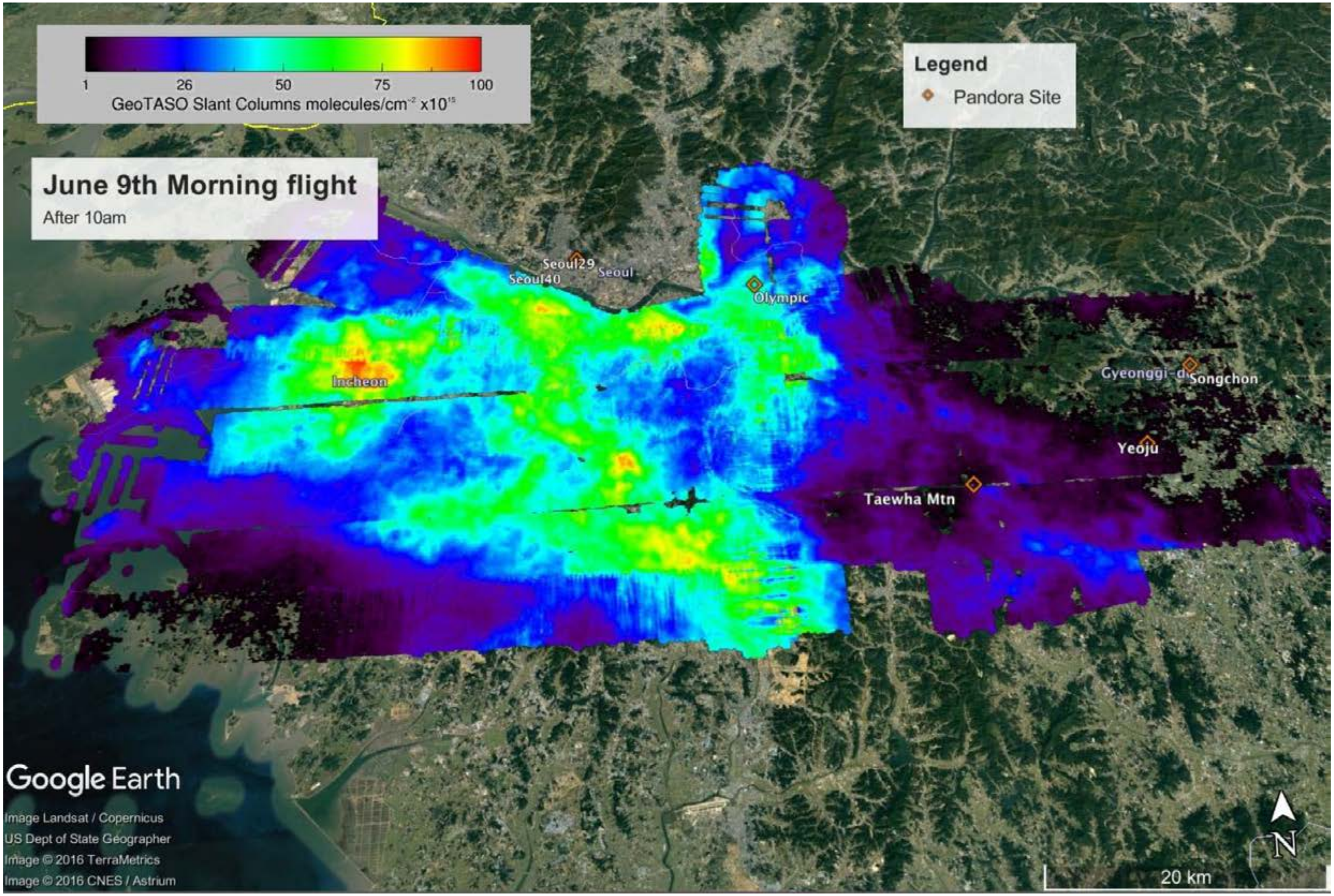


GeoTASO NO_2 Column Observations – KORUS-AQ



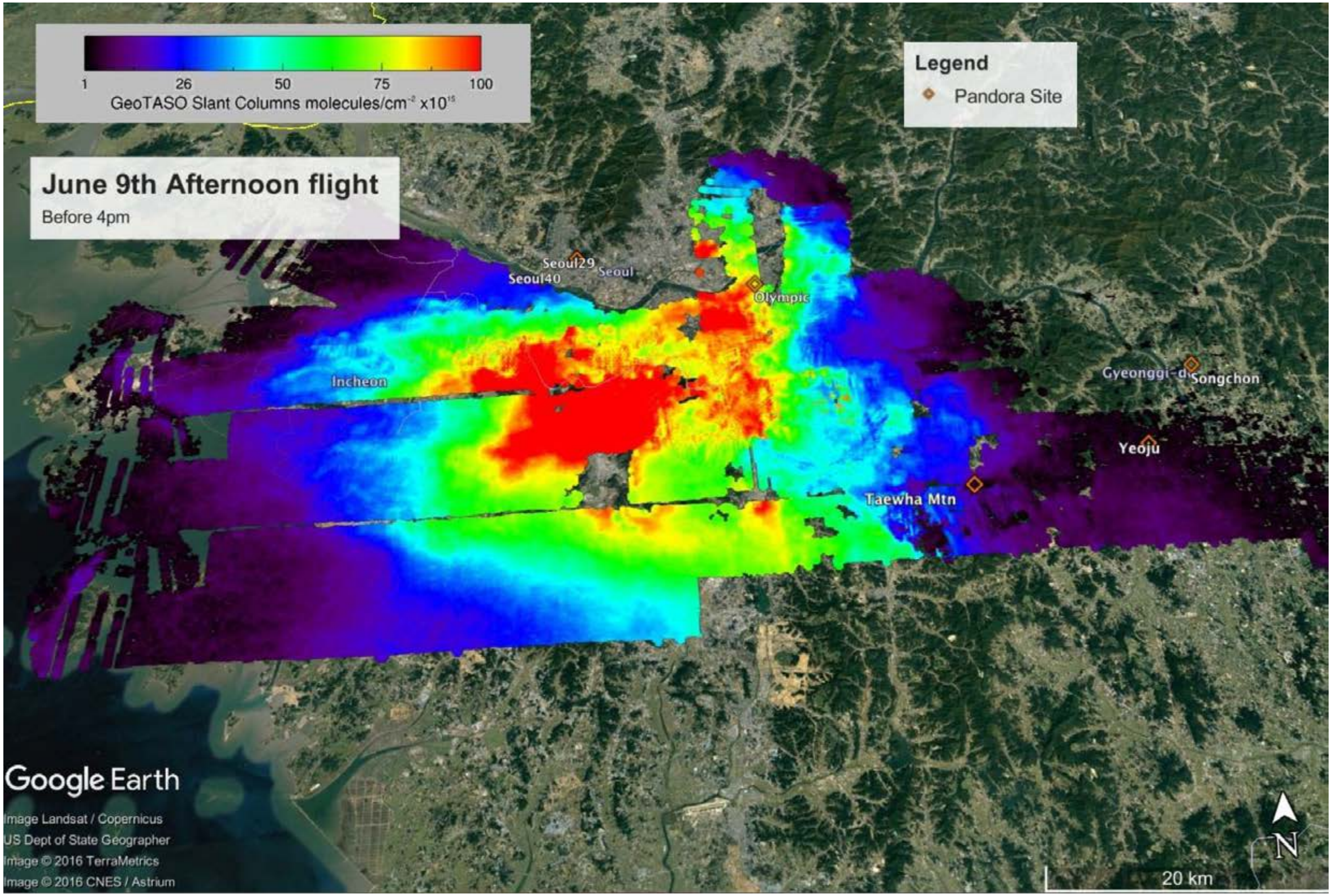
Source: Laura Judd

GeoTASO NO_2 Column Observations – KORUS-AQ



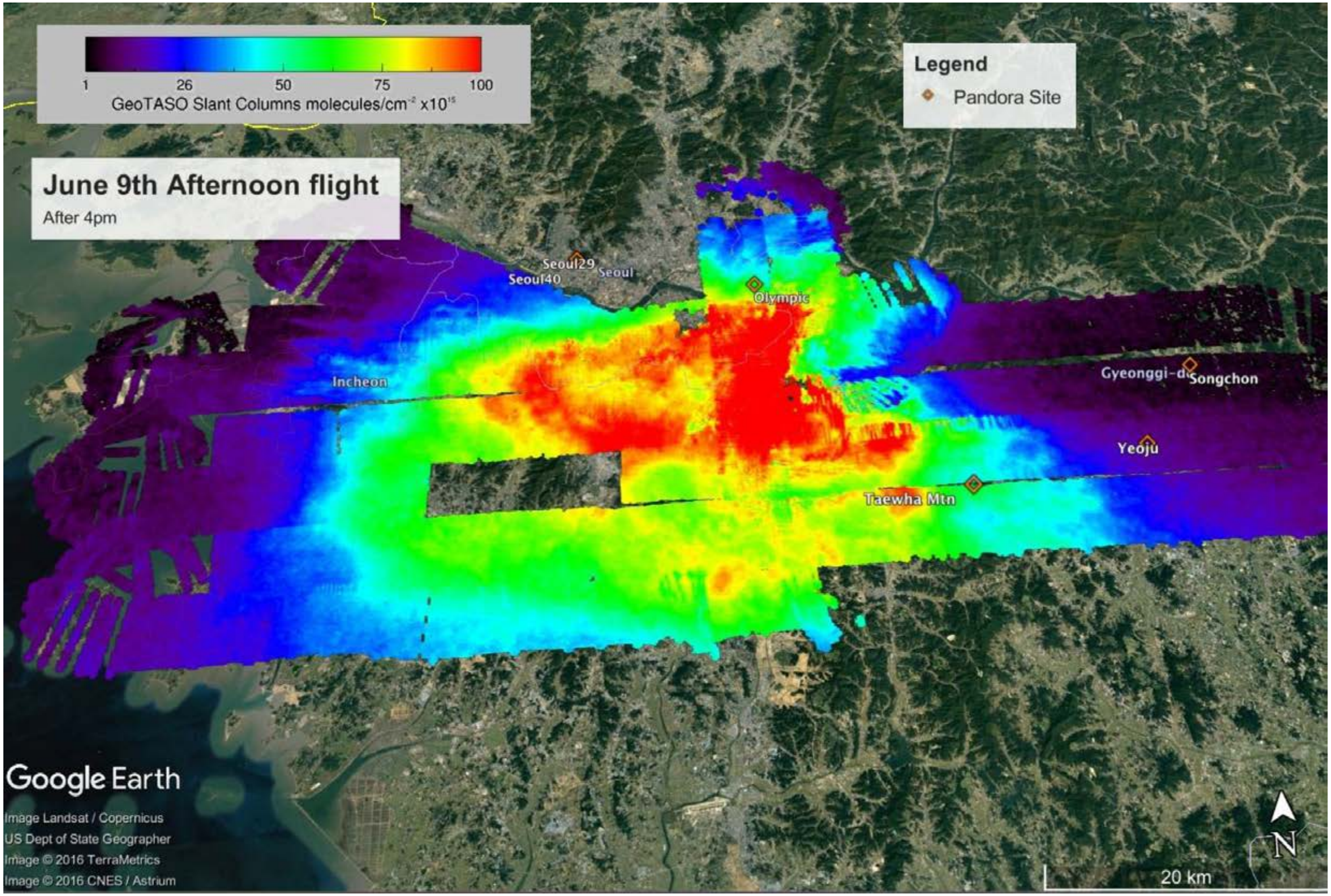
Source: Laura Judd

GeoTASO NO_2 Column Observations – KORUS-AQ



Source: Laura Judd

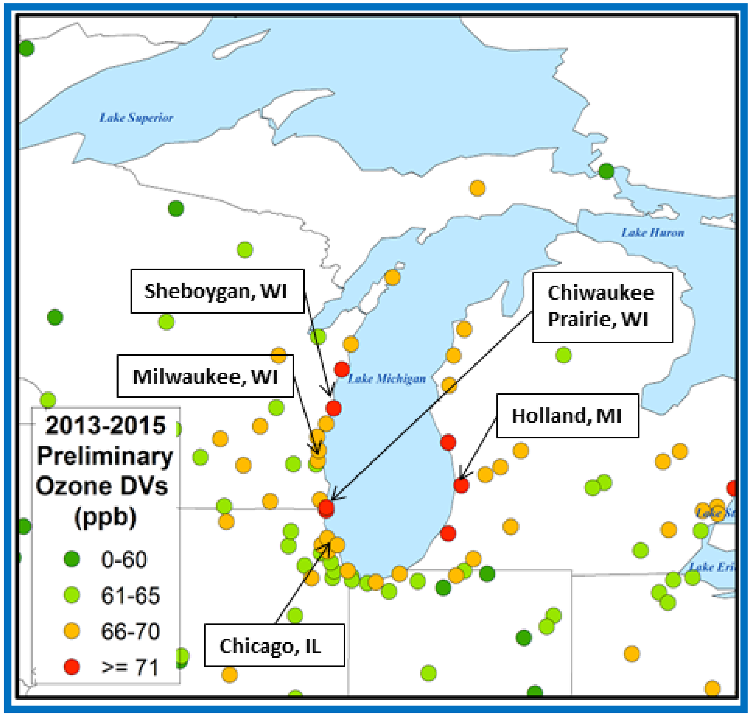
GeoTASO NO_2 Column Observations – KORUS-AQ

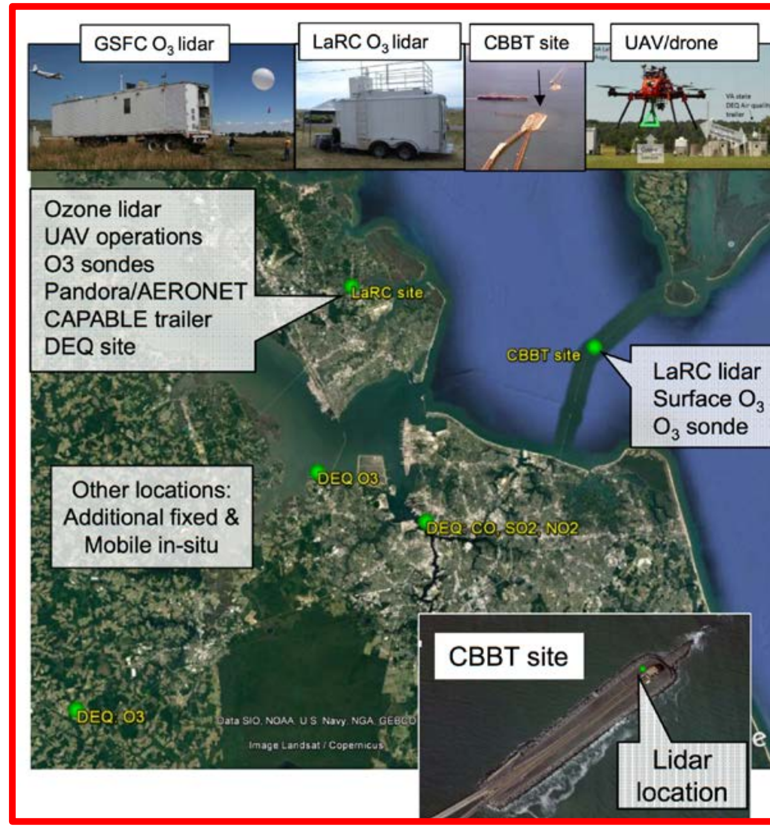


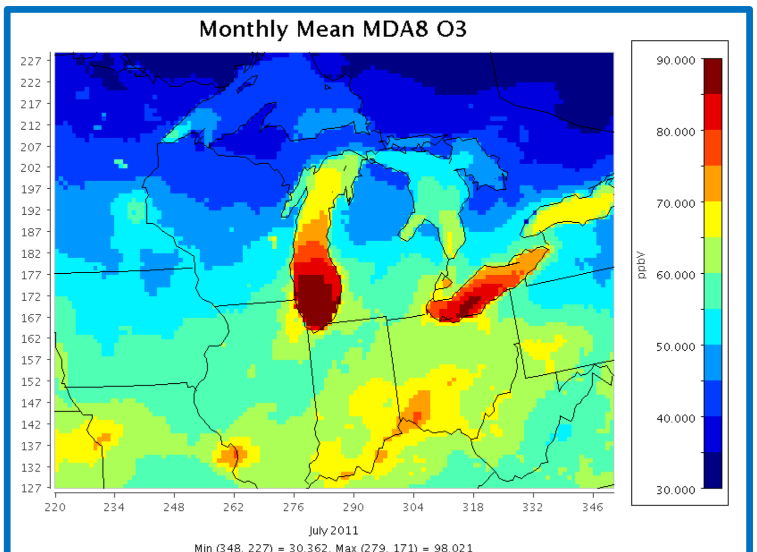
Source: Laura Judd

LMOS and OWLETS - 2017

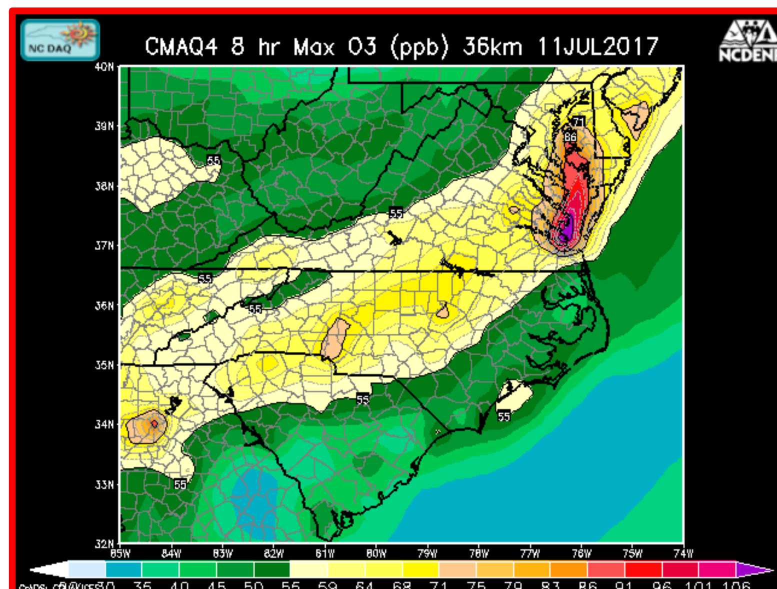
Lake Michigan Ozone Study (LMOS)



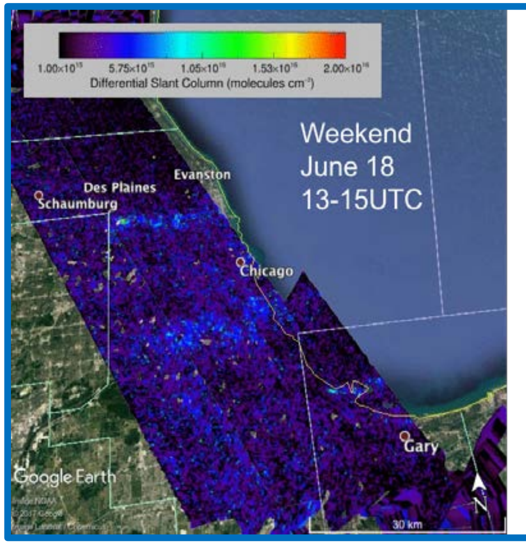


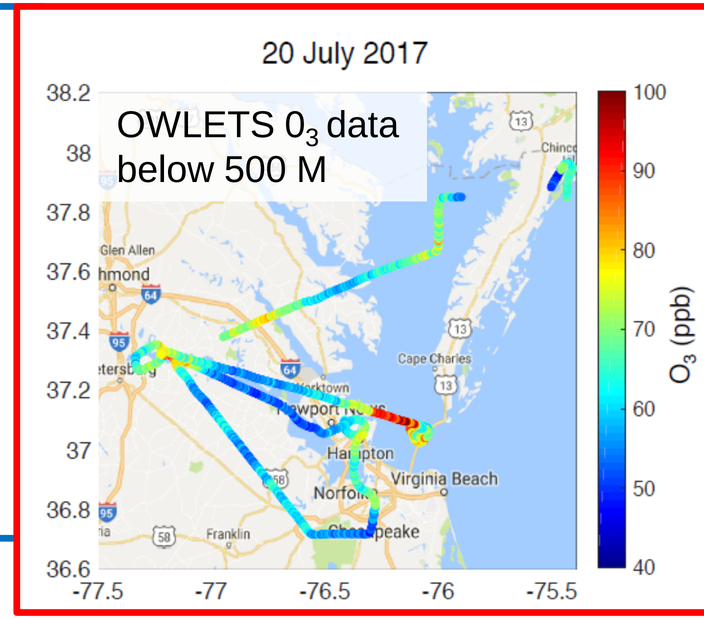


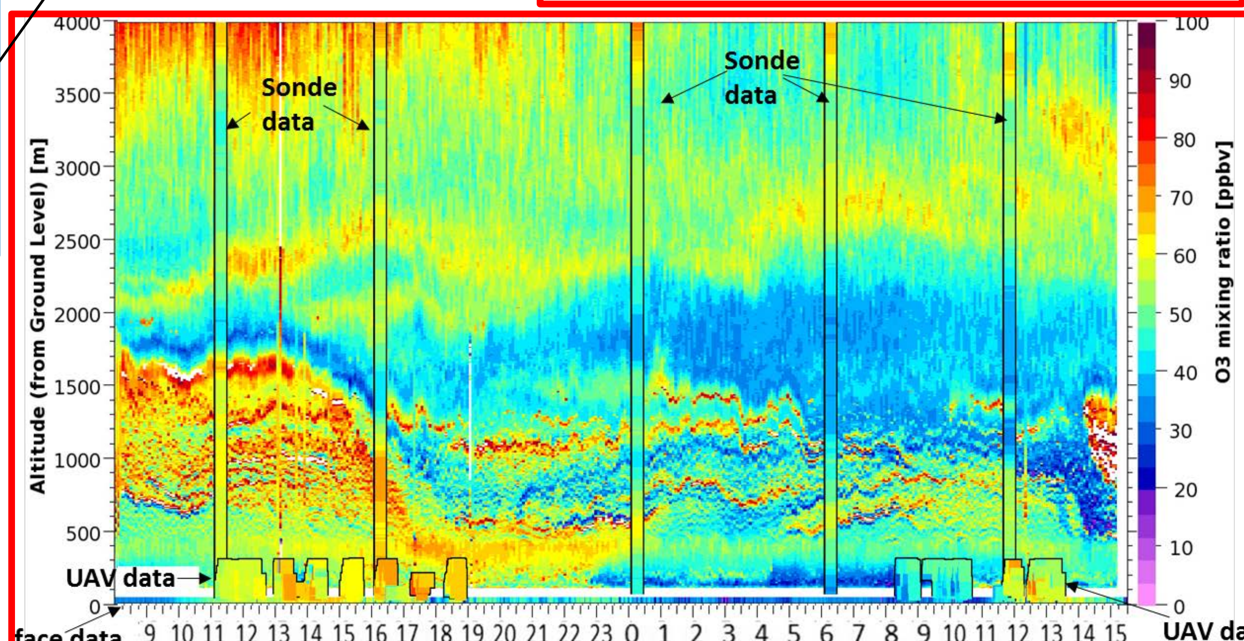
Ozone Water-Land Environmental Transition Study (OWLETS)



LMOS and OWLETS - 2017



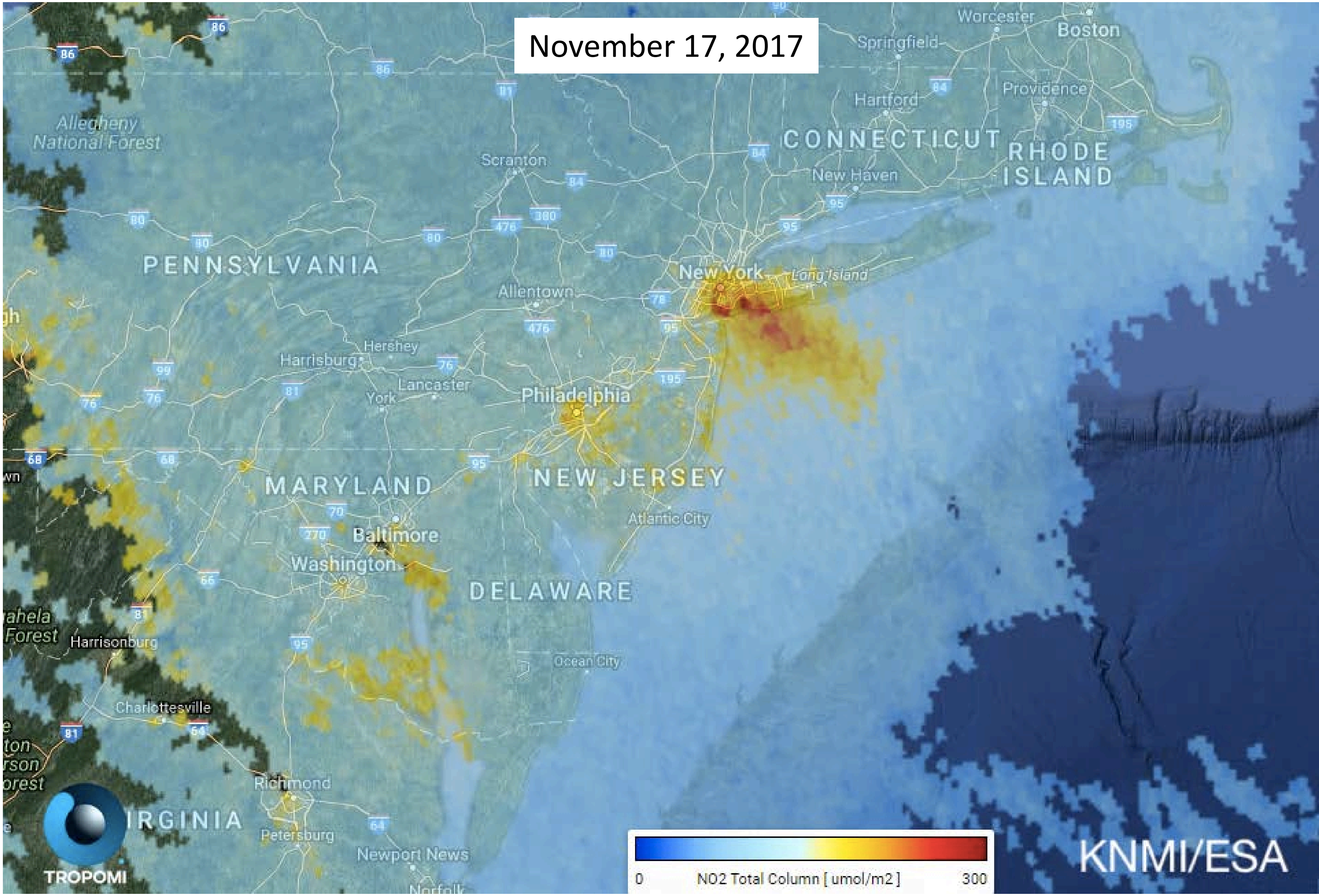




LMOS: Consistent mapping of NO_2 point sources over multiple days

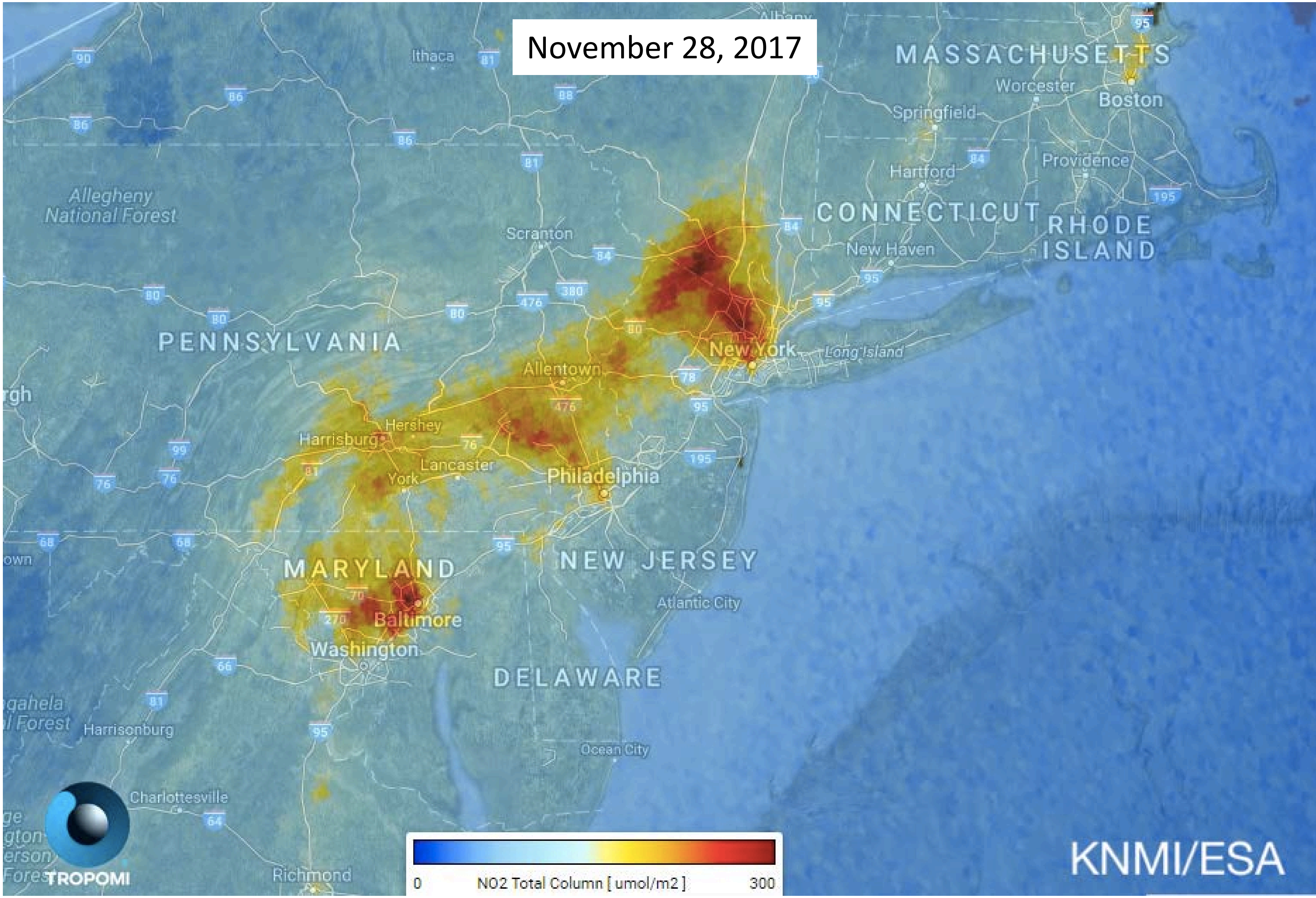
OWLETS Over-Water Ozone Lidar Data

2018 Field Campaigns (Baltimore and NYC)



Preliminary images courtesy of Pepijn Veefkind, KNMI

2018 Field Campaigns (Baltimore and NYC)

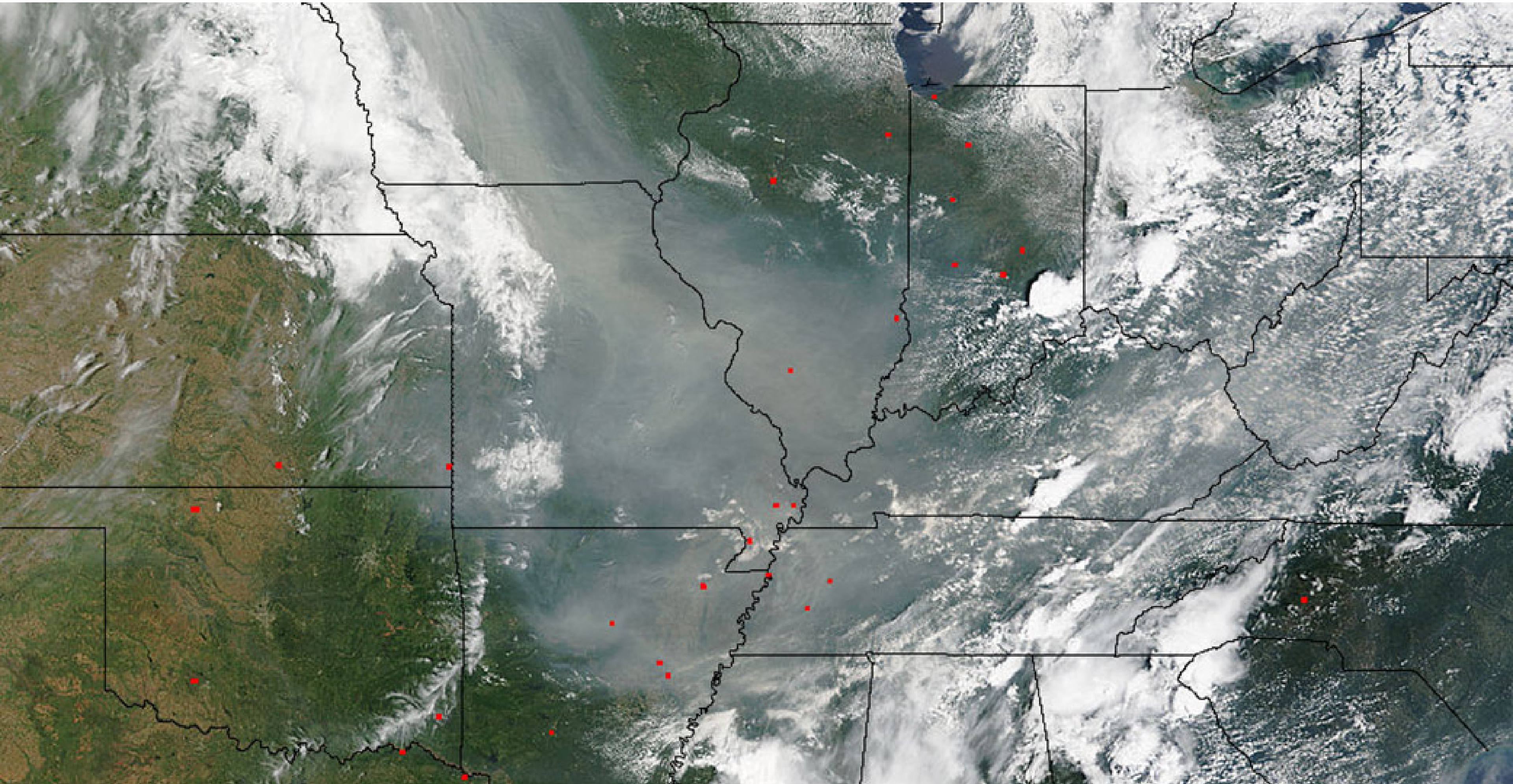


Preliminary images courtesy of Pepijn Veefkind, KNMI

NOAA/NASA FIREX-AQ

An interagency Investigation of Fire Impacts on Regional Emissions and Air Quality

Planned for 23 July to 15 September 2019



FIREX-AQ will also sample agricultural fires

Thank you!

You are invited to:
- Use NASA air quality data!
- TEMPO Satellite Data - Early Adopters Workshop focused on Western U.S. Air Quality Management on April 10-11, 2018 in Fort Collins.
- Other TEMPO Early Adopters Workshops for Air Quality Managers in planning stages.

barry.lefer@nasa.gov