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NOAA
National Satellite and
Information Service

***Center for Satellite Applications and Research***

# Current NOAA Atmospheric Composition (AC) Capabilities

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# Suite of NOAA Satellite Sensors for AC

**Polar-orbiting satellites: Suomi NPP and NOAA-20**

- Trace gases
  - Ozone Mapping and Profiler Suite (OMPS): ozone, sulfur dioxide, nitrogen dioxide*, formaldehyde*
  - Cross-track Infrared Sounder (CrIS): carbon monoxide, carbon dioxide, methane, sulfur dioxide
- Aerosols
  - Ozone Mapping and Profiler Suite (OMPS): Absorbing Aerosol Index
  - Visible Infrared Imaging Radiometer Suite (VIIRS): Aerosol Optical Depth, Aerosol Detection, true color RGB, dustRGB

**Geostationary satellites: GOES-16 and GOES-17**

- Aerosols
  - Advanced Baseline Imager: Aerosol Optical Depth, Aerosol Detection, GeoColor, dustRGB

*research

# NOAA's National/International Partnerships

**With NASA**

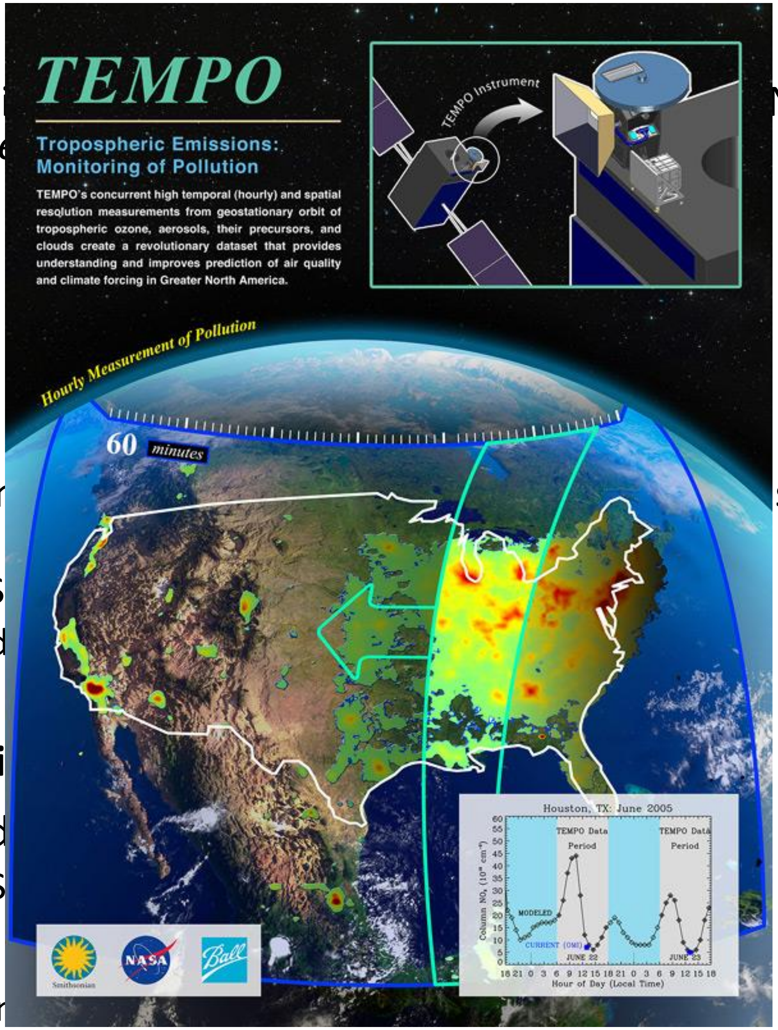
- NASA launches research missi NOAA transitions those capabilities into operational missions. *NOAA e*
  - OMI → OMPS
  - MODIS → VIIRS
  - AIRS → CrIS
  - Etc.

**With EUMETSAT**

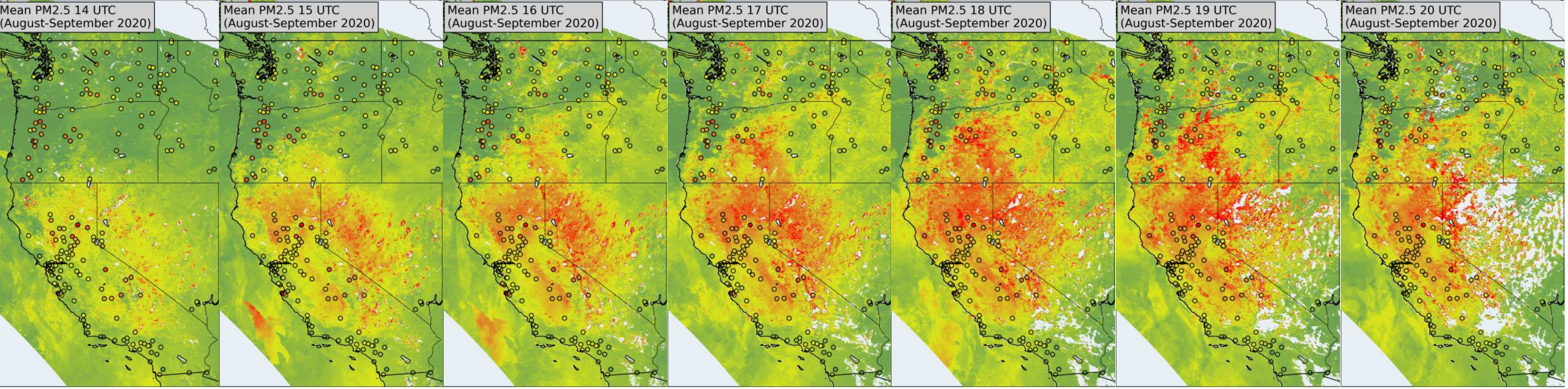
- NOAA and EUMETSAT have ar struments in afternoon and mid-morning orbits respectively
  - IASI (9:30 AM ECT) and CrIS
  - GOME-2 (9:30 AM ECT) and
  - Etc.

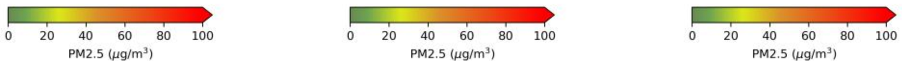
**With other international agenci**

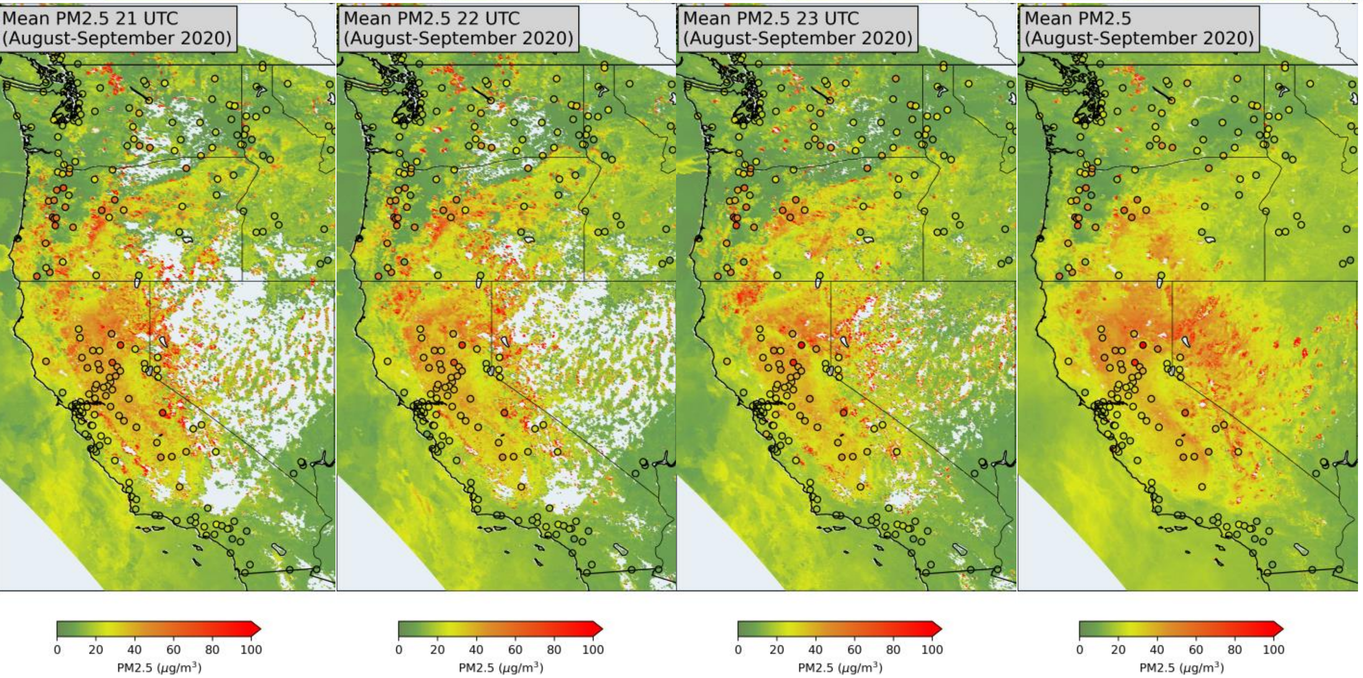
- NOAA scientists serve as valid
  - E.g., GeoKompsat-2B GEMS
- Access data in near real time
  - E.g., Himawari-8 AHI; Sentir




EUMETSAT does fly some advanced sensors that NOAA has no plans for. One example is the 3MI polarimeter slated for Metop-SG series.




**Western US fires impacting surface $PM_{2.5}$ concentrations from August to September 2020**

- Human exposure to surface $PM_{2.5}$ on hourly time scales can be examined from geostationary satellites
- Current NOAA statistical model (Geographically Weighted Regression method) that uses ABI AOD does not use aerosol layer height information
- GEO-XO ACX $O_2$-$O_2$ or $O_2$ A/B-band absorption features could help improve the $PM_{2.5}$ estimates. The valuation studies we are starting soon will explore this using EPIC/DSCOVR aerosol height information (as proxy for ACX) to isolate $AOD_{PBL}$ from ABI AOD

$$AOD = PM_{2.5}\, H\, f(RH)\, \frac{3Q_{ext,dry}}{4\rho\, r_{eff}} = PM_{2.5}\, H\, S$$

Time series of GOES-17 hourly composite $PM_{2.5}$ except the last panel which is the average of all hours (14 to 23 UTC) for August to September 2020

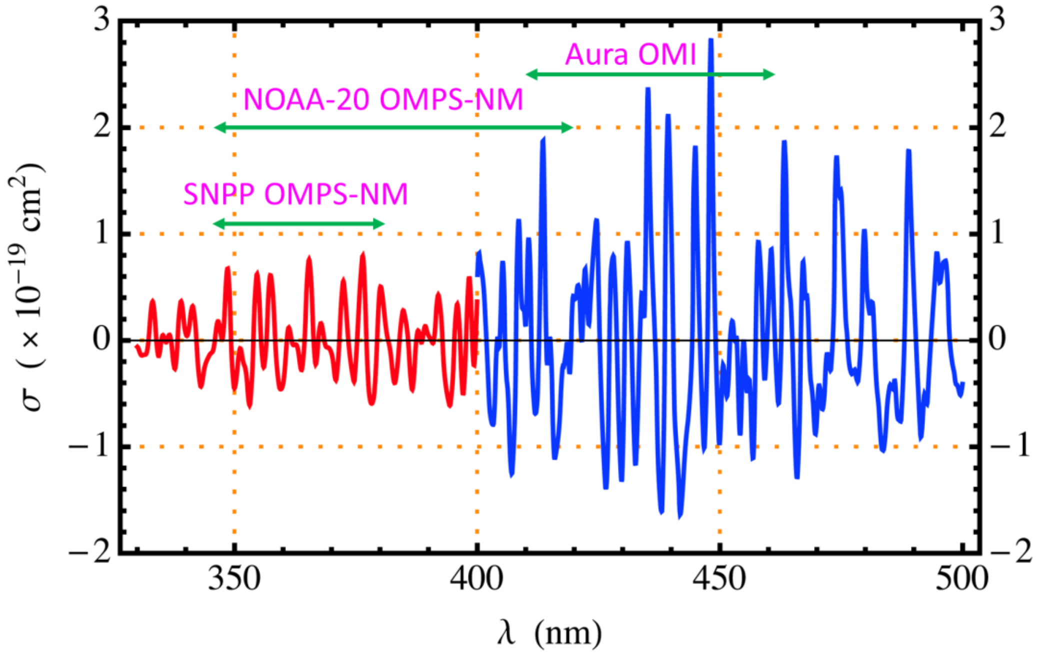
# Gap Analysis of NOAA Aerosol Capabilities

| WMO Ranking | Sensor Type | Spectral Coverage | Capability | Pros | Cons |
|---|---|---|---|---|---|
| Primary | Polarimeters | VIS-near IR | Aerosol optical depth, size, refractive index, concentration, and layer height | Full aerosol characterization | Reduced mapping capability |
| Very High | Spectrometers<br>Lidars | UV<br>UV-Deep blue<br>VIS-IR<br>UV-VIS | Aerosol vertical profile, atmospheric composition | Aerosol and trace gases relevant to air quality including aerosol layer height | No aerosol optical depth in the visible for spectrometers. Lidars have limited spatial coverage |
| High | Leo Imagers | VIS-IR | Aerosol Optical Depth<br>Aerosol Type | High spatial resolution and full global coverage | No aerosol layer height and no composition (i.e., single scattering albedo etc.) |
| Fair | Geo Imagers | VIS-IR | Aerosol Optical Depth<br>Aerosol Type | High temporal resolution | No aerosol layer height and no composition and only hemispheric coverage |

Until NOAA plans to launch a Lidar or GeoXO ACX instrument in 2030s, gaps in capabilities have to be filled with synergistic retrievals or with partner agency satellites

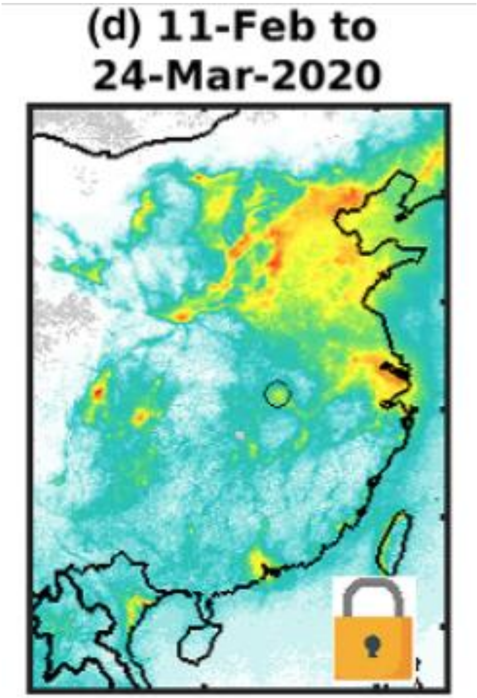
NOAA's current capabilities are ranked "Fair" or "High"

# Trace Gases: $NO_2$



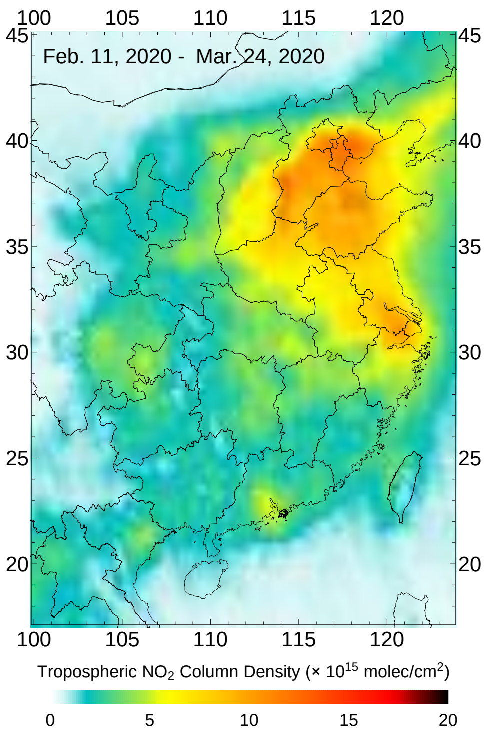

*OMPS wavelength window not optimal for $NO_2$ but capability exists*

**TROPOMI**

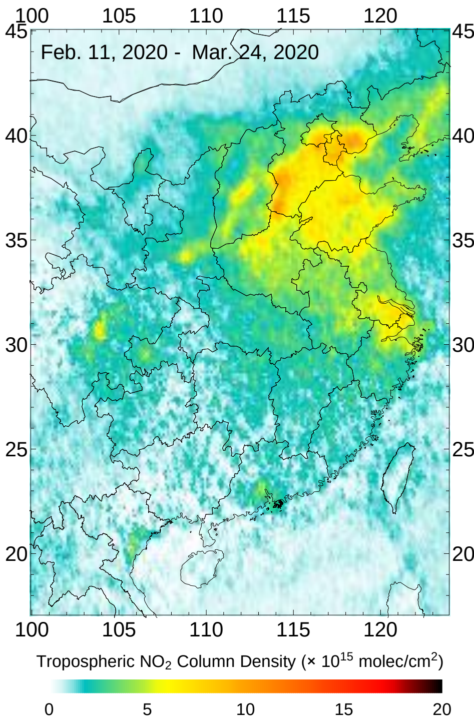



Bauwens et al., 2020

**SNPP OMPS**

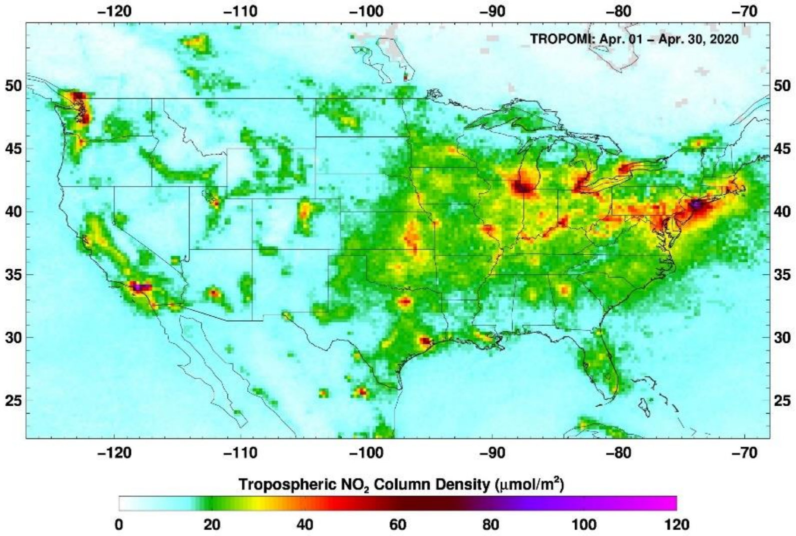


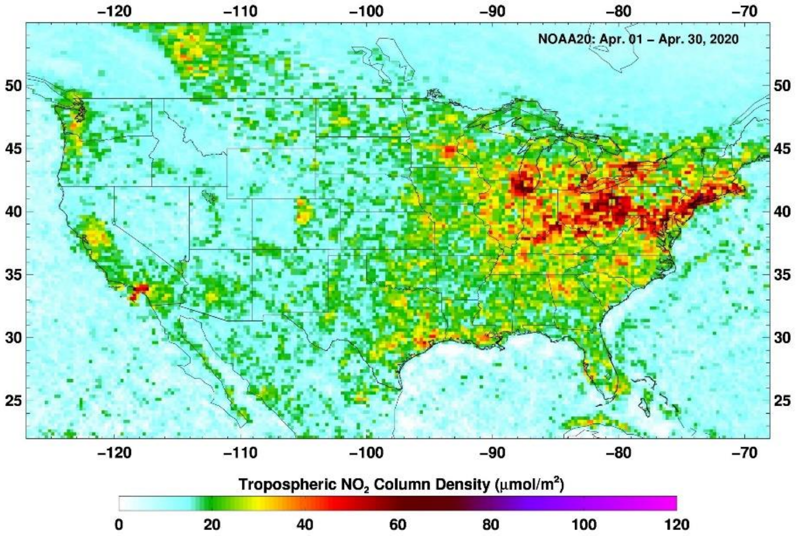

**NOAA20 OMPS**

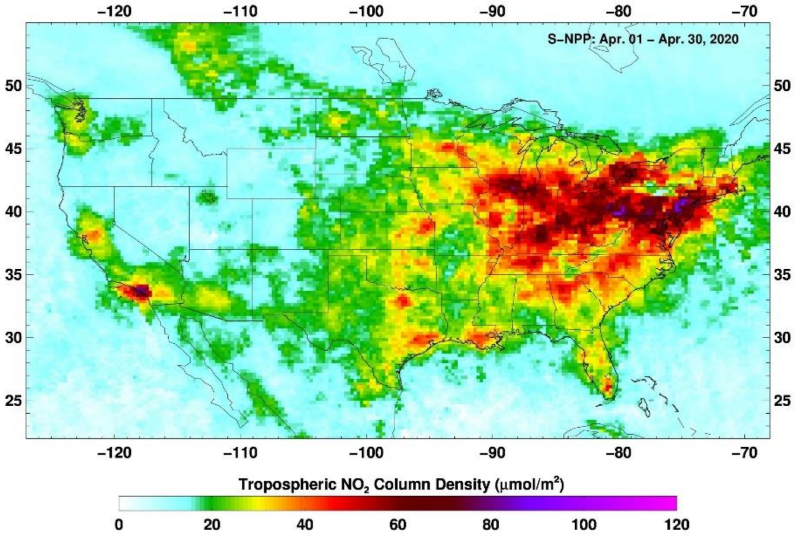


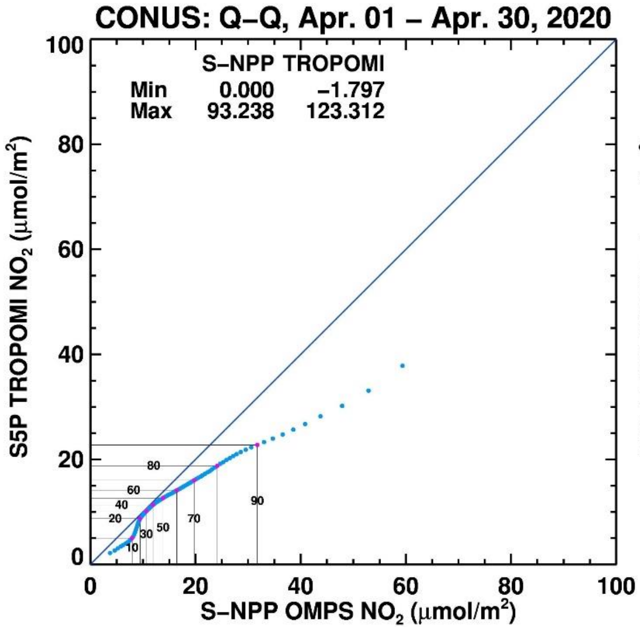

PI: Kai Yang (UMD)

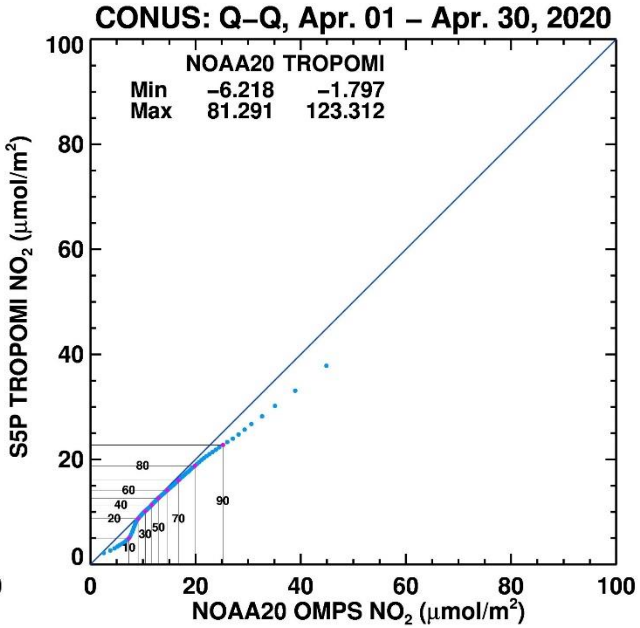
# Trace Gases: $NO_2$



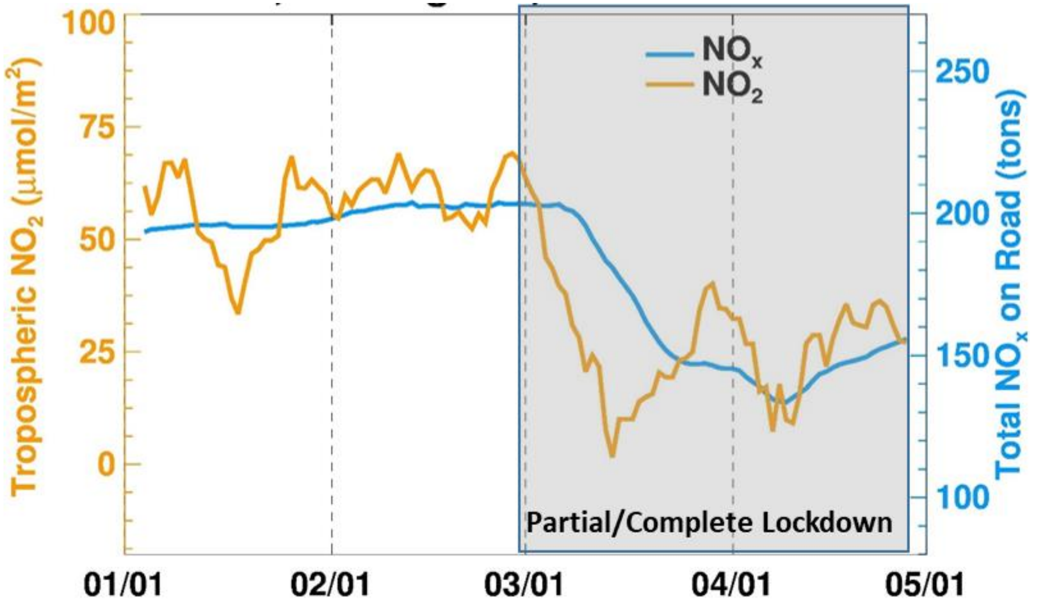



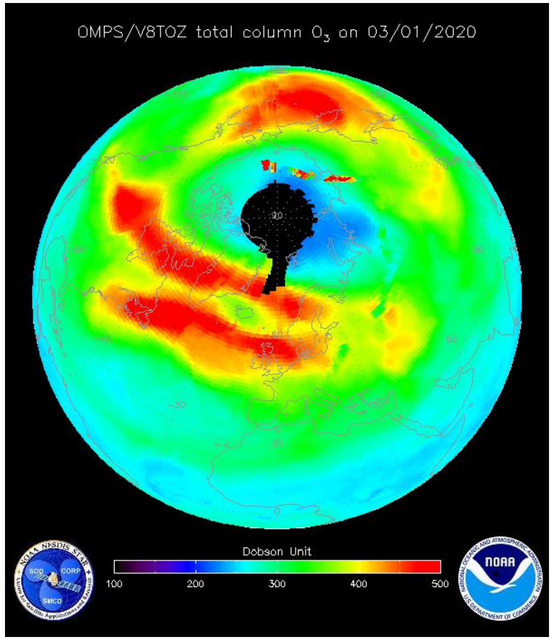



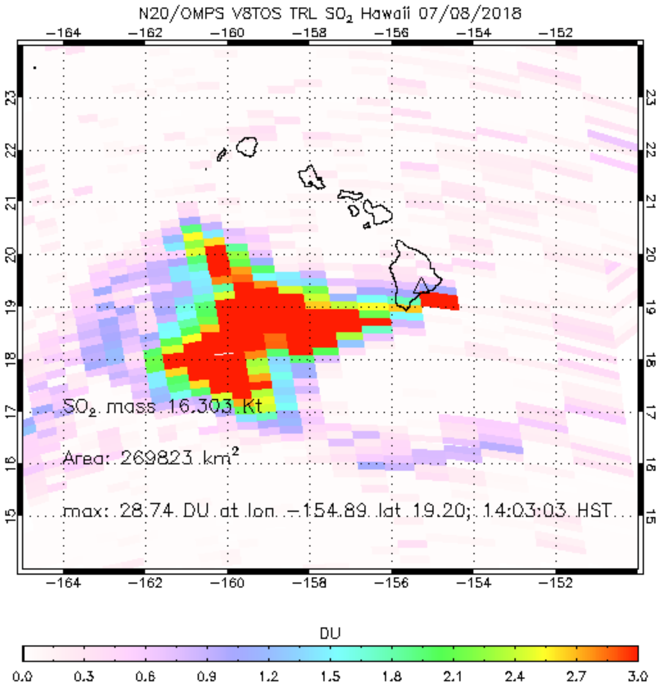

NOAA-20 OMPS for LA Basin

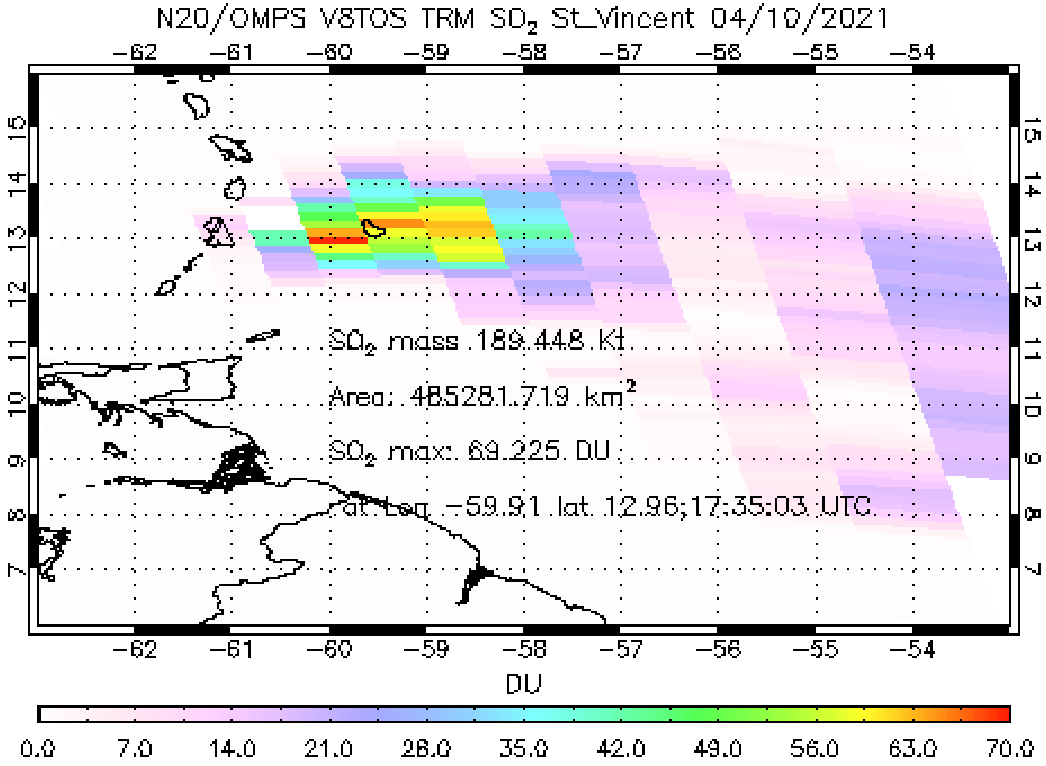



On-road NOx emissions data from Brian McDonald (NOAA/OAR)

# Trace Gases: $O_3$, $SO_2$



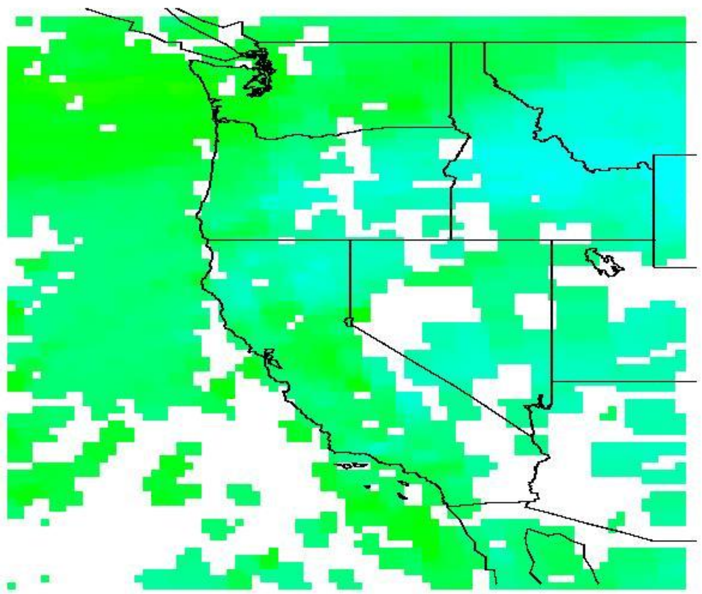



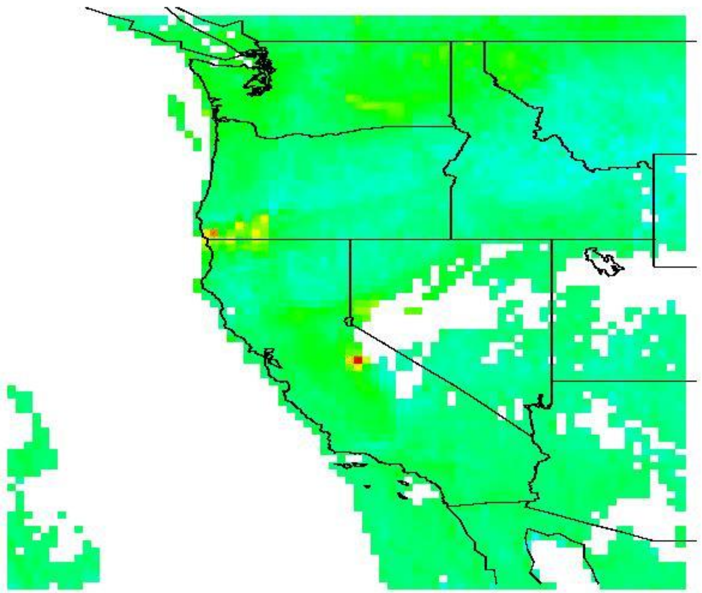



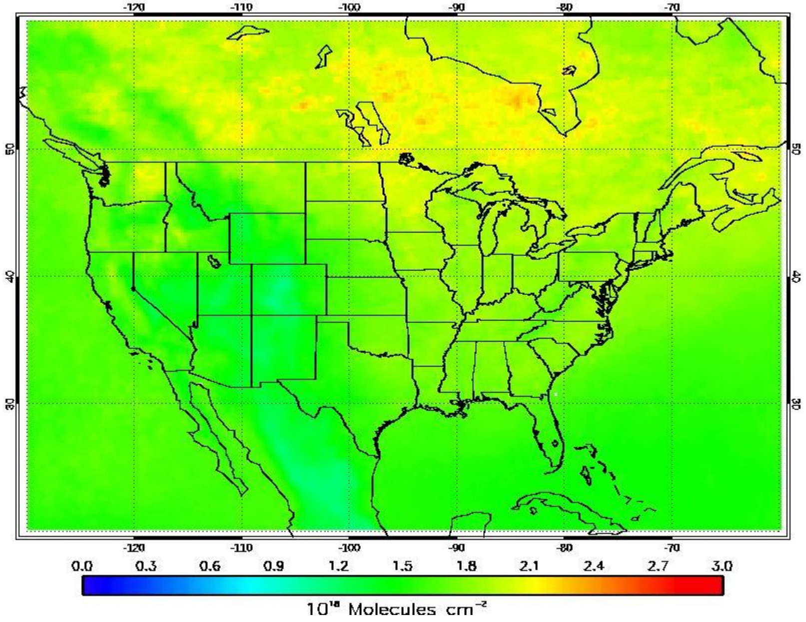

- Suomi NPP OMPS (50 km x 50 km) and NOAA-20 OMPS (50 km x 17 km) observe total/profile ozone and column $SO_2$
- NOAA-20 OMPS along with CrIS and IASI $SO_2$ retrievals support Volcanic Ash Advisory Centers activities
- Suomi NPP and NOAA-20 OMPS total ozone products used in annual ozone hole assessments

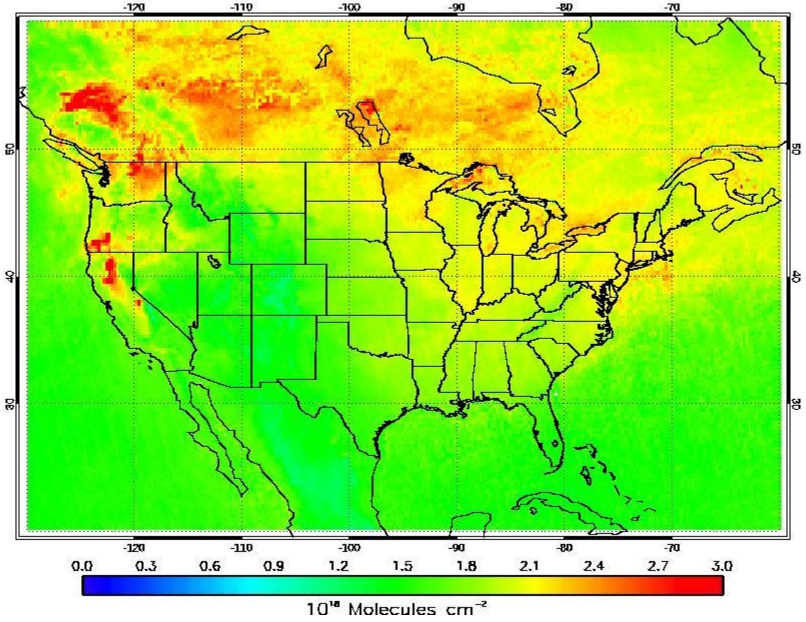
PI: Larry Flynn

# Trace Gases: CO



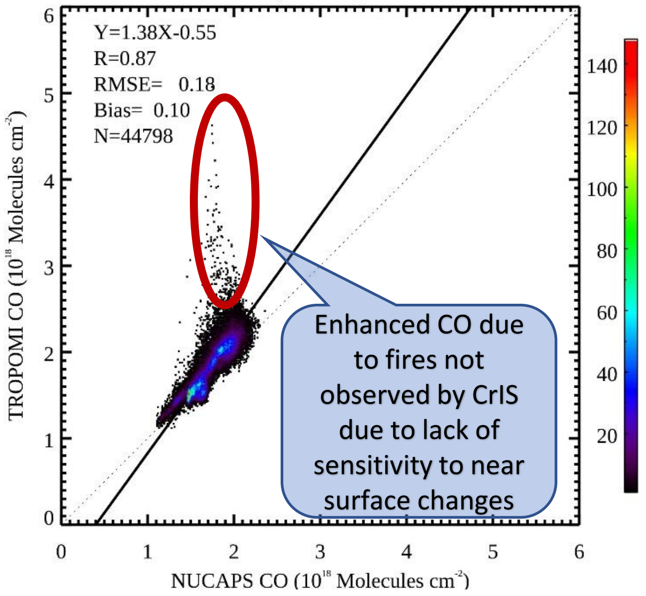



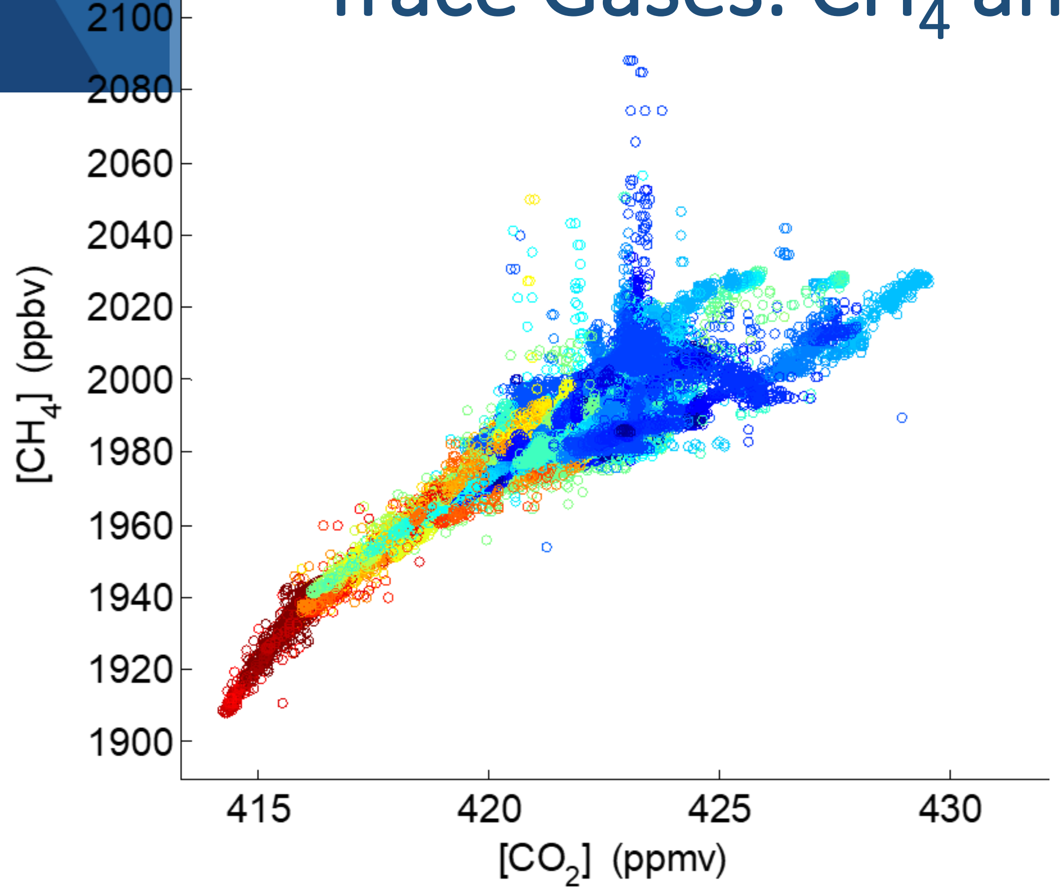



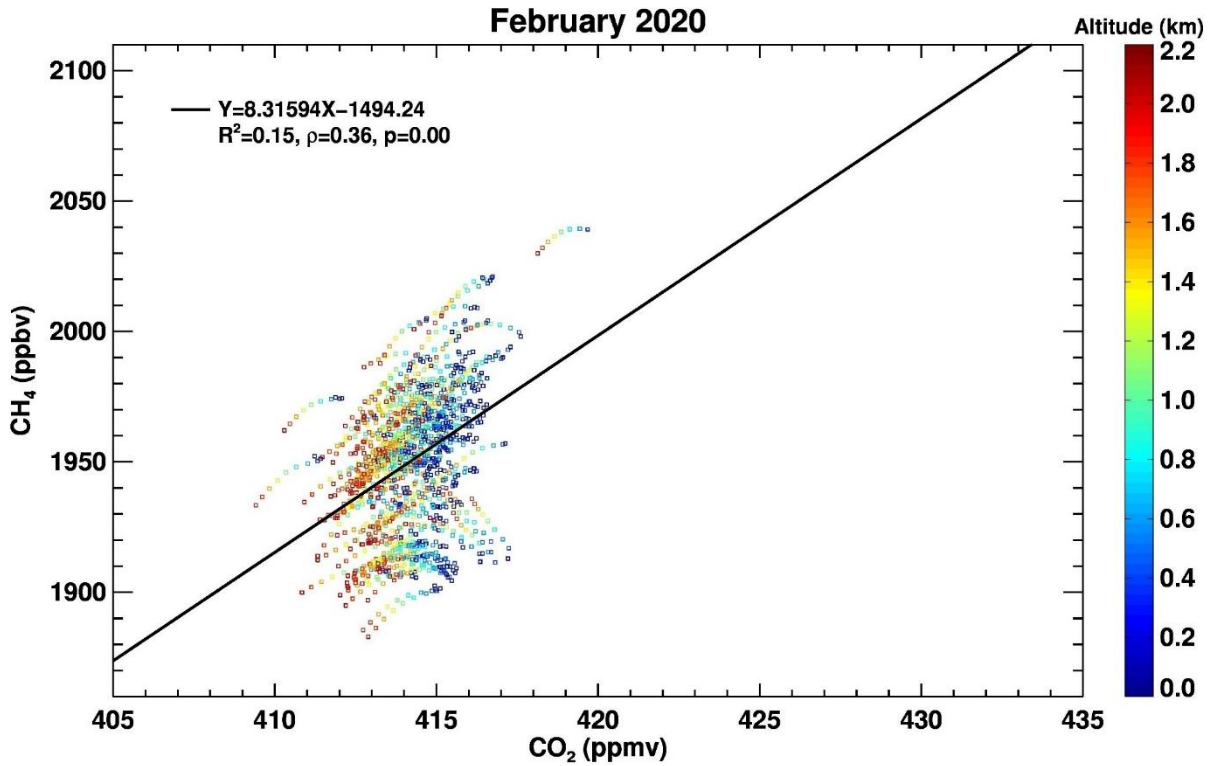

- TROPOMI CO retrievals are in the SWIR whereas CrIS CO retrievals use MWIR
- CrIS retrievals more sensitive to mid-tropospheric CO changes and less sensitive to near surface CO changes

NUCAPS: NOAA Unique Combined Atmospheric Processing System (developed by Chris Barnet now with STC)



# Trace Gases: $CH_4$ and $CO_2$




**Left panel:** aircraft measurements of greenhouse gases made from February 9 – 21, 2020 by UMD (Russ Dickerson) and NOAA (Xinrong Ren)
**Right panel:** SNPP CrIS measurements of greenhouse gases made from February 1 – 29, 2020

**Key features in the data:**

- In both satellite and aircraft observations, $CO_2$ and $CH_4$ higher near the surface and lower in free troposphere (> 2.0 km)
- Aircraft observations of $CH_4$ and $CO_2$ are correlated with good dynamic range from 415 to 430 ppmv for $CO_2$ whereas CrIS observations do not show the variability in $CO_2$
- SNPP CrIS retrievals are insensitive to near surface changes and are reliant on *a priori* profile; near the surface, retrievals are as good as *a priori* assumptions in the algorithm

# GEO-XO AC Capability

- Combination of Imager (AXI), Sounder (AXS), and Spectrometer (ACX) will deliver the AC Capability
  - Current constellation plans place ACX and AXS on the same platform in a Central position
  - Ideally, we prefer the ACI to be within 30º or less of longitude separation from AXI to do synergistic retrievals
  - ACX will be part of a constellation of satellite sensors for air quality and atmospheric composition
  - UVN and OMPS in polar orbit can cross calibrate ACX as recommended by CEOS ACVC

- **Aerosol layer height capability → accurate $PM_{2.5}$ estimates**
- **$NO_2$ hourly observational capability → quantitative applications (e.g., disease burden, environmental justice)**
- **Trace gas and aerosol hourly observational capability → timely updates of emissions in air quality forecast models**