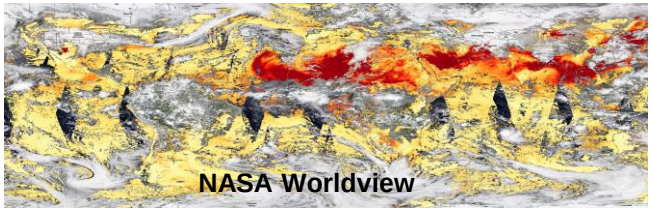
Overview of Current & Future Program of Record

with special attention on aerosol observations & applications

Aaron Naeger (MSFC), Bryan Duncan (GSFC), Ali Omar (LaRC), Amber Soja (LaRC), Melanie Follette-Cook (GSFC)

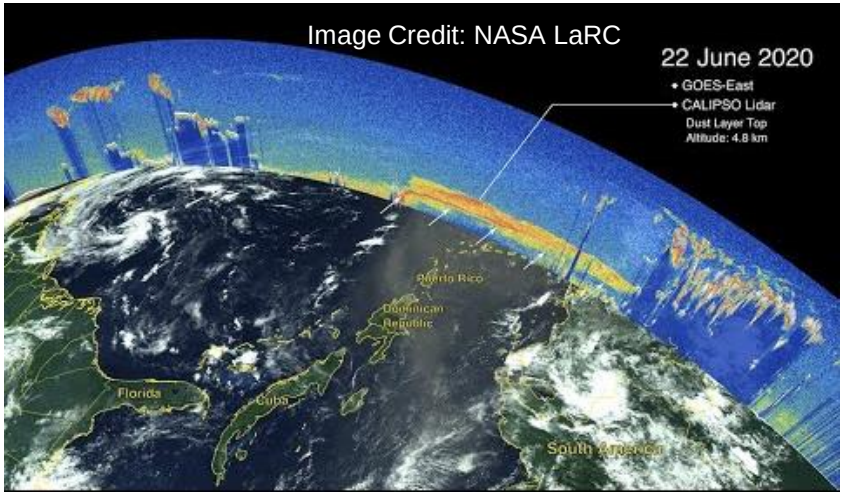
Current: LEO & GEO Radiometers for Aerosols

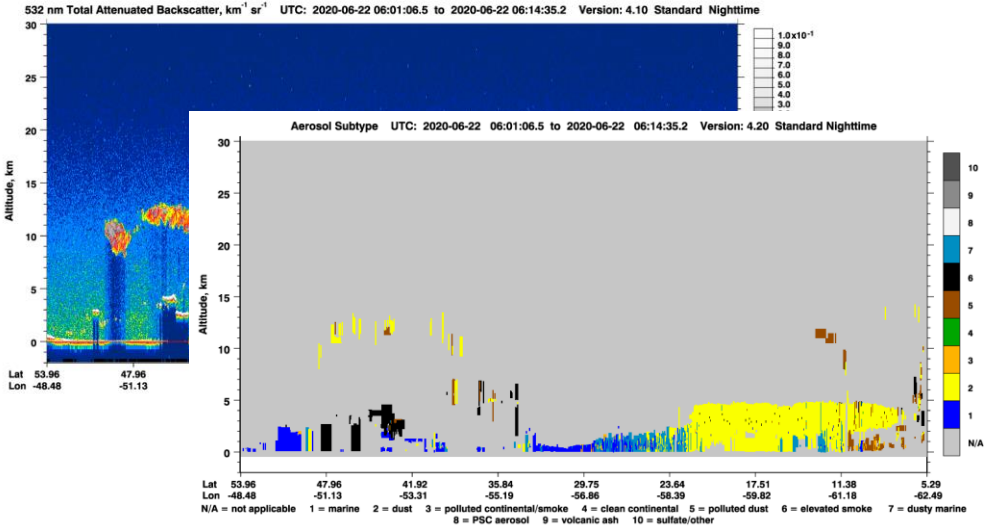
- Low-earth orbit (LEO)
  - **NASA's A-Train**: Terra MODIS (1999-present), Aqua MODIS (2002-present), Terra MISR (2000-present)
  - SNPP VIIRS (2012-present), NOAA-20 VIIRS (2017-present)
- Geostationary orbit (GEO)
  - GOES-16 / -17 ABI (2016- present), Himawari 8/ 9 AHI (2014-present) , MSG SEVIRI (2005-present)
- Lagrange point
  - DSCOVR EPIC (2015-present)



- **Advantages**: Daily global coverage of aerosol optical depth (AOD), high temporal frequency in GEO coverage areas
- **Limitations**: columnar measurements, aerosol type information

Current: Lidars for Aerosols

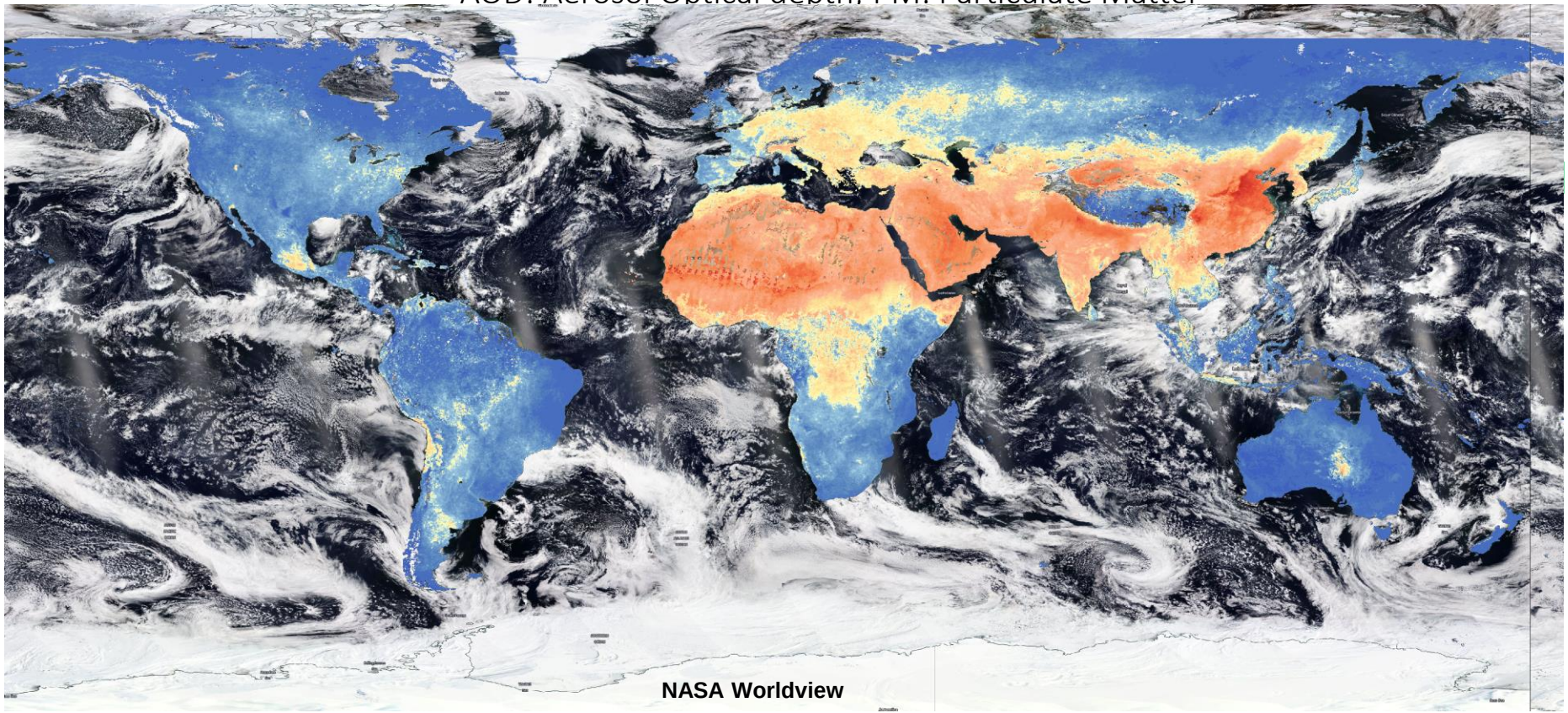




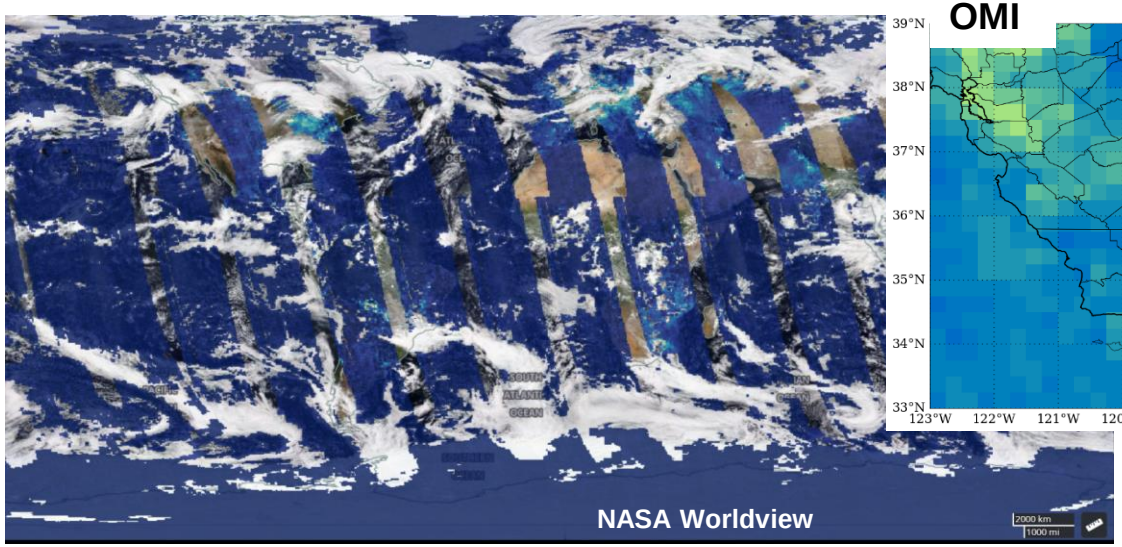
- CALIOP, flying in NASA A-Train, observes vertical structure of aerosols in atmosphere
- **Advantages**: Vertical distribution of aerosol types (i.e., coarse dust vs fine particles) and concentrations, including in lower troposphere where people live
- **Limitations**: Limited spatial coverage with lidar curtain, large uncertainties separating between fine mode aerosols (e.g., smoke) and aerosol mixtures

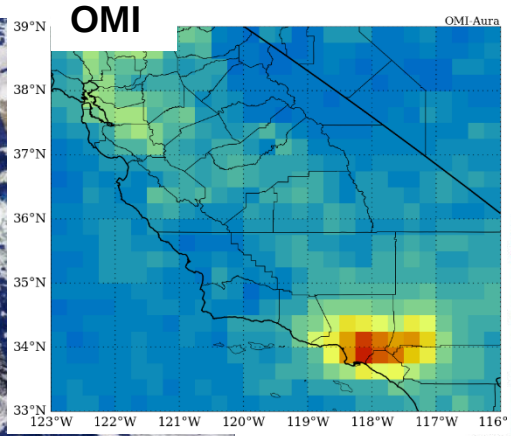
PoR: Relevant Literature on AOD to PM Conversion

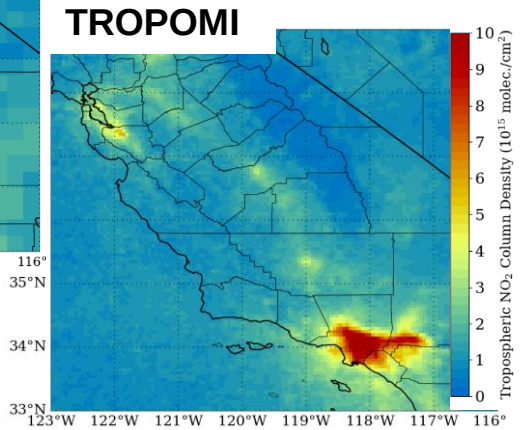
AOD: Aerosol Optical depth; PM: Particulate Matter



Current: Spectrometers & Sounders for Trace Gases

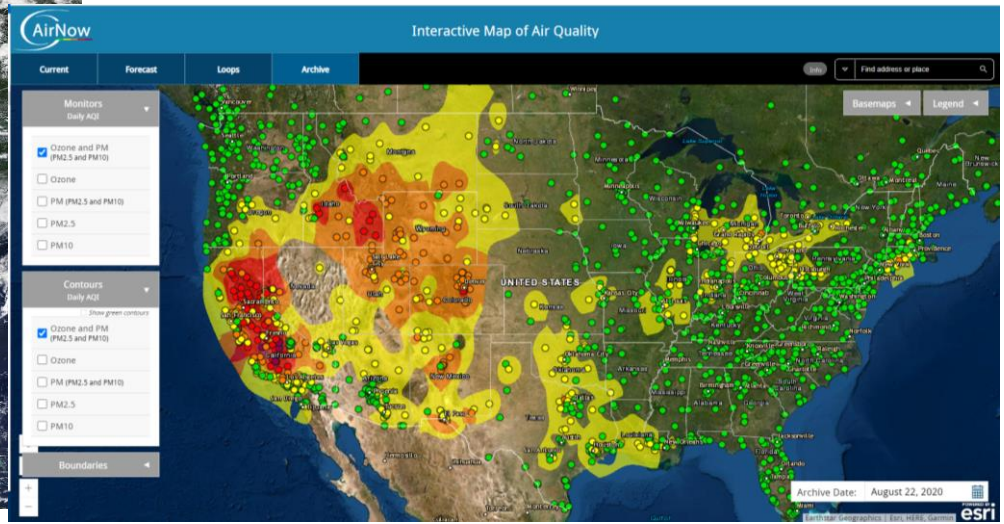






- OMI, TROPOMI, IASI, and CrIS provide daily global coverage of trace gas pollution (NO2, HCHO, SO2, CO, CH4, CHOCHO, NH3, O3) along with information on aerosols
- **Advantages**: High spatial resolution and sensitivity in troposphere, particularly TROPOMI.
- **Limitations**: Lack of diurnal information due to mid-day scans. Limited capabilities to separate gas concentrations in lower troposphere and PBL where people live.

Current: Ground-based AQ Instruments



- Suite of different ground-based AQ instruments
  - EPA reference-grade monitors for measuring trace gases and PM at surface-level, along with rapidly expanding low-cost sensors that can help fill gaps in reference-grade network
  - Expanding network of NASA Pandora spectrometers for columnar trace gas amounts
  - TOLNet lidars at key sites in U.S. and Canada and deployments in field campaigns for aerosol and O3 profiles
- **Ground-based monitors critical for AQ monitoring, validation, and complementing satellite and model-based products for improved AQ information in PBL and surface-layer**

Future: Tropospheric Emissions: Monitoring of Pollution (TEMPO)

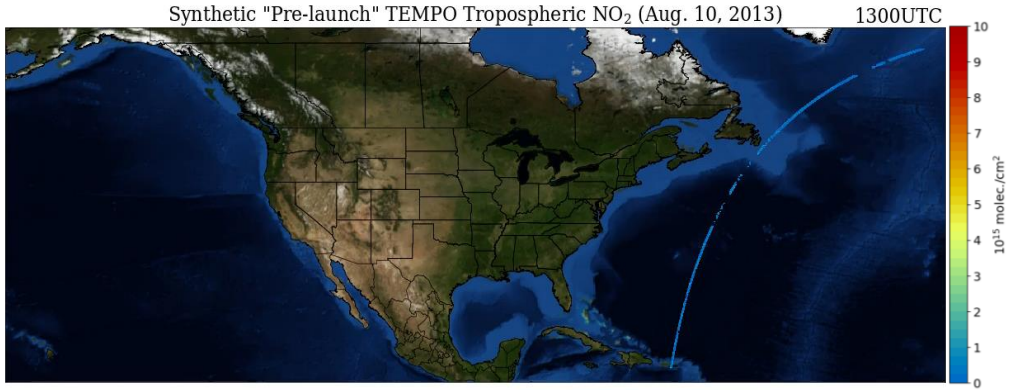
Expected launch October 2022

UV/VIS Imaging Spectrometer

TEMPO Baseline Products

Species/Products	Required Precision	Temporal Revisit
0-2 km O_3 (Selected Scenes) Baseline only	10 ppbv	2 hour
Tropospheric O_3	10 ppbv	1 hour
Total O_3	3%	1 hour
Tropospheric NO_2	1.0×10^{15} molecules cm^{-2}	1 hour
Tropospheric H_2CO	1.0×10^{16} molecules cm^{-2}	3 hour
Tropospheric SO_2	1.0×10^{16} molecules cm^{-2}	3 hour
Tropospheric $C_2H_2O_2$	4.0×10^{14} molecules cm^{-2}	3 hour
Aerosol Optical Depth	0.10	1 hour

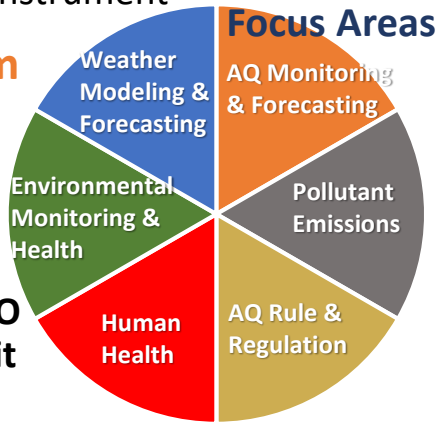
- Hourly daylight observations of trace gases and aerosols over Greater North America
- Suite of products at high spatiotemporal resolution will significantly advance capabilities to use satellite data for numerous science applications, particularly health and AQ applications
- First 0-2 km ozone product from space-based instrument



Early Adopters Program

- Expand user base of TEMPO data and tailor mission to user needs
- **Goal: Accelerate and maximize use of TEMPO data for societal benefit**

Application Focus Areas



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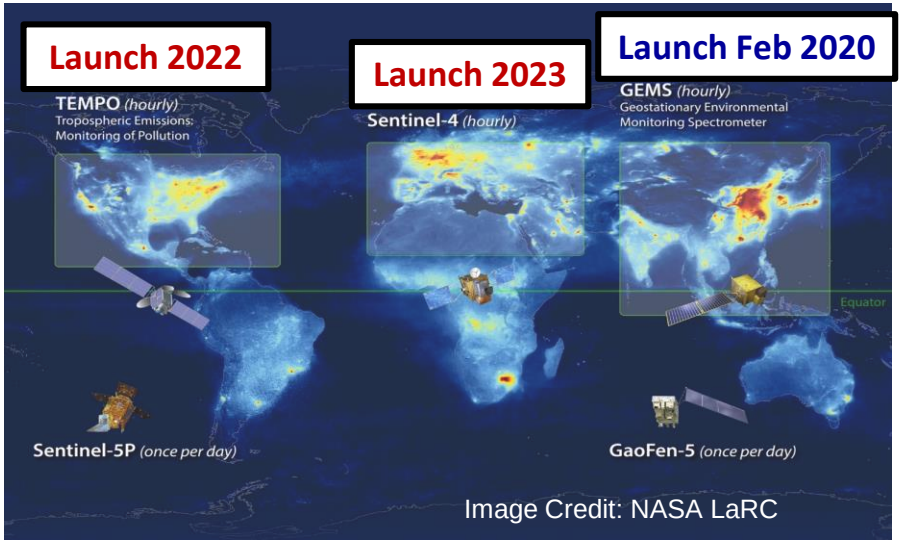
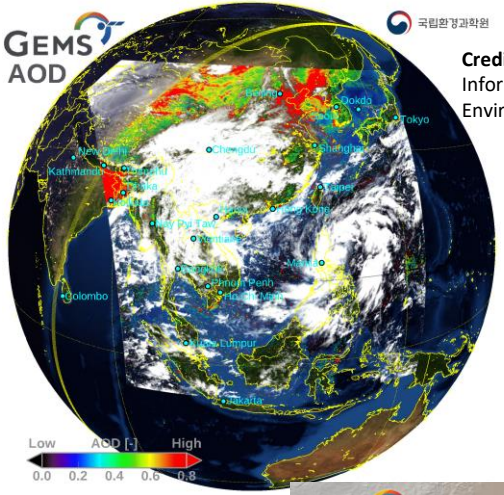
Future: Geostationary Constellation of AQ Observations



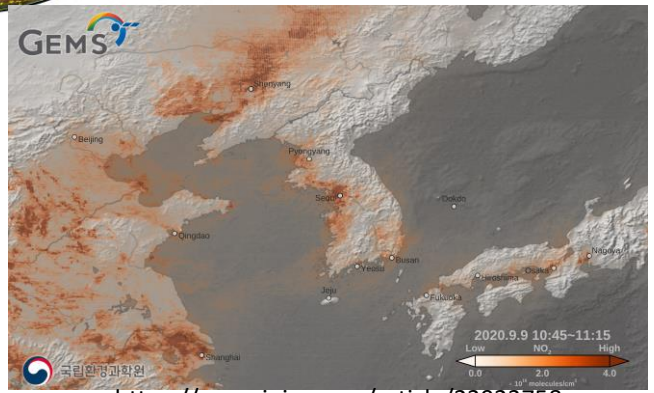
GEMS AOD



Credit: Ministry of Science and Technology Information and Communication·Ministry of Environment·Ministry of Oceans and Fisheries

UV/VIS Imaging Spectrometers

GEMS NO2



https://news.joins.com/article/23923758

- GEMS mission is first to provide hourly daytime observations of trace gases and aerosols from space, expected lifetime > 10 years
- AQ information at high spatiotemporal scales particularly important across Asia where large populations often exposed to hazardous AQ
- GEMS will be joined by TEMPO and Sentinel-4 for forming revolutionary geostationary constellation of air quality observations

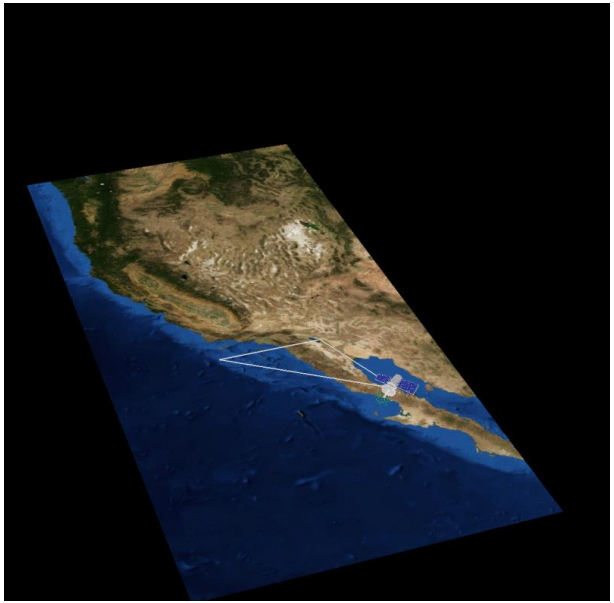
Future: Multi-Angle Imager of Aerosols (MAIA) Mission

Expected launch 2022

- MAIA will characterize the sizes, compositions, and quantities of particulate matter (PM) in air pollution
- **Primary purpose: Study how different types of PM affect our health over the world's major cities**

Key products:

- Total PM10
- Total PM2.5
- Sulfate PM2.5
- Nitrate PM2.5
- OC/EC PM2.5
- BC PM2.5
- Dust PM2.5



- Synergistic applications with TEMPO mission highlighted in MAIA-TEMPO Early Adopters Workshop

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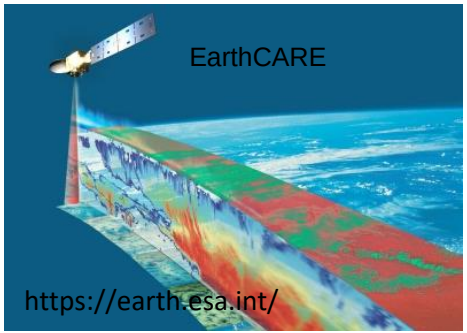
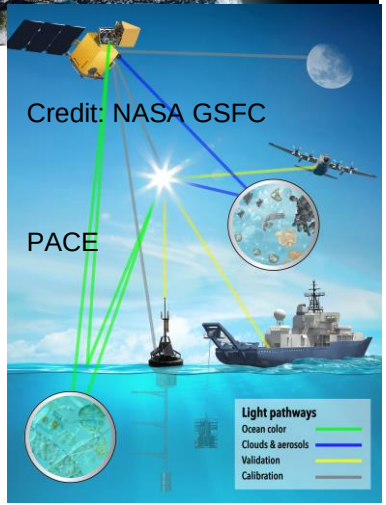
Future: Other Key Missions

- **Other key missions to advance AQ observations**
  - EarthCARE (2021; MSI, ATLID) – improve understanding of processes involving clouds, aerosols, and radiation
  - 3MI (2021) – provide aerosol characterization for climate monitoring, NWP, atmospheric chemistry and AQ
  - MethaneSAT (2022) – locate and quantify CH4 emissions at high spatial resolution throughout the globe
  - EMIT (2022) – improve mapping of surface mineralogy of arid dust regions to better account for dust in forecasts
  - PACE (2023; OCI, SPEXOne, HARP-2) new capabilities for aerosol characterization from space with near global daily coverage
  - **GEO-XO** (2030s) – improve monitoring of Earth's weather, oceans, and environment at high-resolution

How can the ACCP mission leverage the future PoR to further advance AQ products and applications?





Multi-channel/direction imaging radiometer, Atmospheric lidar

Multi-channel/direction/polarization imaging radiometer, VIS/SWIR imaging spectrometer