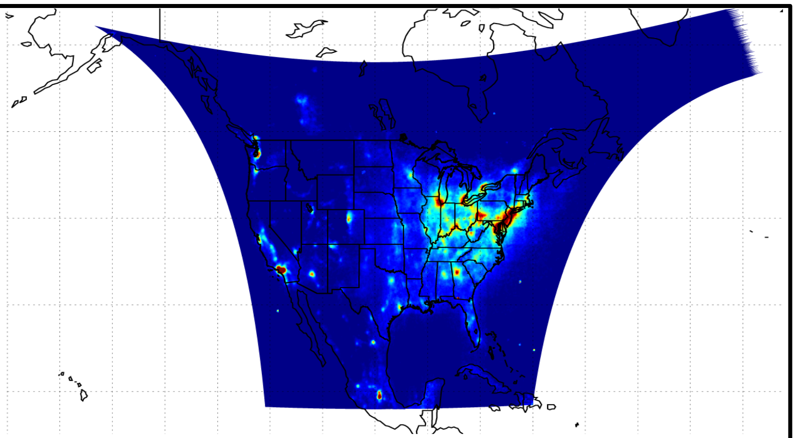
Tropospheric Emissions: Monitoring of Pollution



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- Smithsonian Astrophysical Observatory (SAO)/NASA mission to measure North American air pollution from geostationary orbit.
- Measures ultraviolet/visible/near-infrared spectra to determine key pollutants.
- Hourly measurements (shown above) of U.S., Canada, Mexico, Cuba, and The Bahamas at high (sub-urban) spatial resolution.
- Member of global air quality constellation, along with European and Asian instruments.
- Improves North American air quality and health.
- Instrument delivery to commercial host 2017 for 2019 or later launch.

Science questions addressed by TEMPO

1. What are the temporal and spatial variations of emissions of gases and aerosols important for air quality and climate?
2. How do physical, chemical, and dynamical processes determine tropospheric composition and air quality over scales ranging from urban to continental, diurnally to seasonally?
3. How does air pollution drive climate forcing and how does climate change affect air quality on a continental scale?
4. How can observations from space improve air quality forecasts and assessments?
5. How does intercontinental transport affect air quality?
6. How do episodic events, such as wild fires, dust outbreaks, and volcanic eruptions, affect atmospheric composition and air quality?

TEMPO provides measurements to help solve national and international challenges

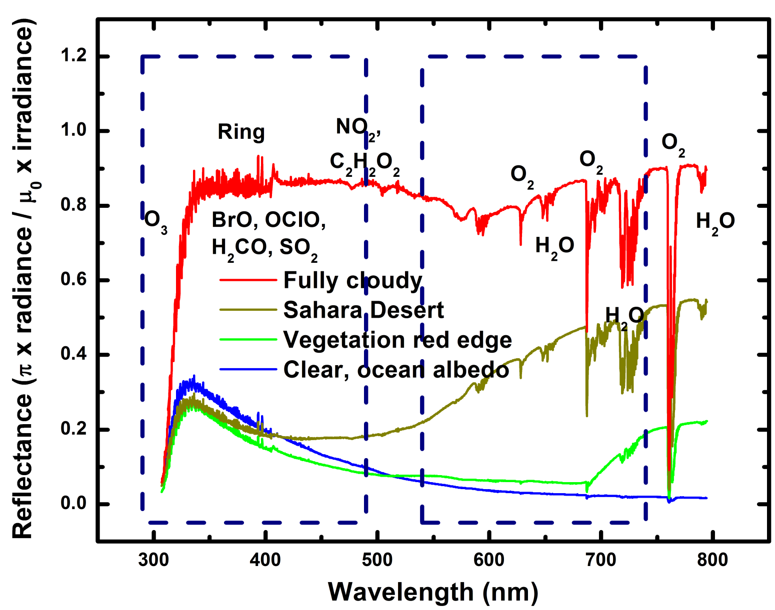
- US air quality standards continue to become more stringent to better protect human health.
- New and transient pollution sources (*e.g.*, vehicular traffic, oil and gas development, trans-boundary pollution) are growing in importance yet are very difficult to monitor from ground networks.
- Many areas that are not currently monitored are expected to violate proposed ozone standards.

TEMPO measures, directly or by proxy, the major elements of tropospheric ozone chemistry.

Measurements include lower tropospheric ozone, formaldehyde and nitrogen dioxide as the primary pollutant gases. TEMPO additionally measures sulfur dioxide, glyoxal, water vapor, halogen oxides, aerosols, clouds, ultraviolet-B radiation, and foliage properties.

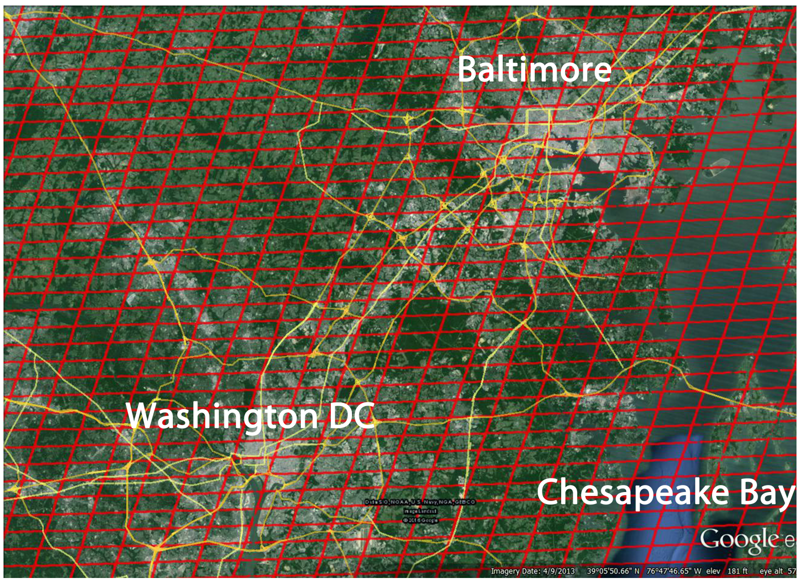
Science studies include: Air quality and health; lightning and soil NO_x emissions, biomass burning; halogen oxide, ozone and atmospheric oxidation in coastal regions and lakes; night lights; solar-induced fluorescence from chlorophyll for tropical dynamics, primary productivity, carbon uptake, drought responses, ocean red tides and the physiology and productivity of phytoplankton.

TEMPO's Canadian, Mexican and Cuban Science Teams conduct research and data validation for issues particular to their environmental needs.



TEMPO spectra (boxes) illustrated with European Space Agency GOME-1 reflectance measurements.

TEMPO instrument characteristics	
Wavelength range	290-490 + 540-740 nm
Spectral resolution	0.6 nm FWHM
Spectral sampling	0.2 nm
Maximum S/N	2700 @ 330-340 nm, EOL
Spatial resolution	2.1×4.5 km^2 @ 36.5N, 100W
Spectra per hour	2000 N/S × 1250 E/W



TEMPO hourly footprints overlaid on the Baltimore-Washington metropolitan area. The footprint size here is 2.4 km N/S × 5.4 km E/W. Map created using Google Earth/ Landsat Imagery.

Heritage and innovation

TEMPO builds on our experience with instrument and mission development and atmospheric spectroscopy at these wavelengths from low Earth orbit (LEO) by GOME, SCIAMACHY, GOME-2, OMI and OMPS. Instrument built by Ball Aerospace & Technologies Corporation (BATC).

The U.S. TEMPO Science Team includes SAO, NASA, NOAA, EPA, NCAR, universities and industry partners.

The measurement of lower tropospheric (0-2 km) ozone is revolutionary. All other products have been measured by the team from LEO to the precision required by TEMPO.

Pollution measurements from geostationary orbit are also revolutionary, giving the capability to resolve chemistry on hourly or better bases (down to 10 minutes for special studies) and providing superb spatial resolution.

Mission organization

TEMPO consists of the Instrument Project, competitively selected by NASA from the SAO proposal, and the Mission Project, directed to the NASA Langley Research Center (LaRC). The SAO Principal Investigator, Kelly Chance, has delegated Project Management, Systems Engineering, Safety and Mission Assurance, and management of the BATC prime contract to LaRC, led by Project Manager Wendy Pennington. The Mission Project provides the spacecraft, a commercial geostationary communications satellite host, integration, launch, and provision of telemetry data to the SAO. The host selection will occur once the instrument is completed in 2017.

The TEMPO Ground System, including the Instrument Operations Center and the Science Data Processing Center are at the SAO. Data distribution will include the EPA's Remote Sensing Information Gateway (RSIG).

Strategic communication, public engagement, and student collaboration

TEMPO includes a program of activities led by the SAO, and a synergistic effort at LaRC that involves students from Minority Serving Institutions in pursuing TEMPO-related research:

- Enhance interest in and public awareness of NASA's efforts to measure the distribution and temporal variation of air pollution across North America, and, specifically, the story of the TEMPO mission and its components (instrument, technology, team).
- Promote science literacy by using the TEMPO story to communicate the links between basic chemistry, physics, and geoscience concepts, and issues of human health and well-being.
- Empower students, citizen scientists and science communication professionals - including formal and informal educators - in using TEMPO data products to support authentic science engagement.
- Engage a diverse network of students and universities in contributing to TEMPO experimental validation and NASA air quality research.

The activities planned to accomplish these goals include the public-oriented website tempo.si.edu; news and social media activities; the development of a mobile app and user-friendly TEMPO data interfaces (*e.g.*, RSIG) to enable citizen science and broader general use of pollution data; collaborations with STEM education partners such as the Smithsonian Institution, the GLOBE project and My NASA DATA; public engagement events and programs at museums, anchored by a network of ozone gardens; and summer internships and research experiences for students and educators at LaRC.