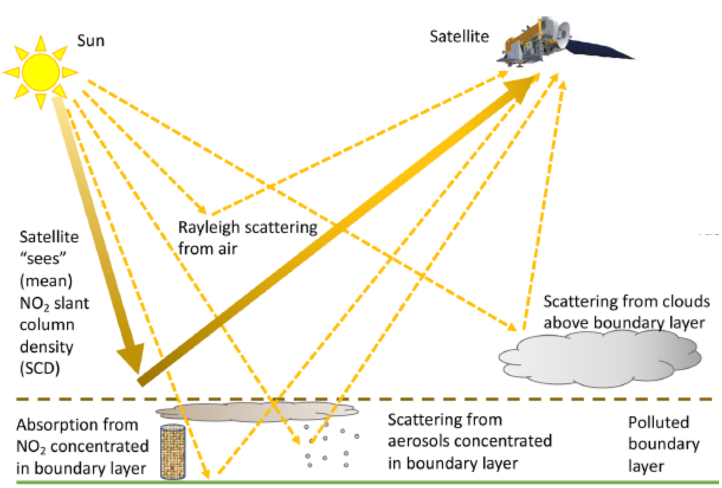
Quick Guide: Understanding Uncertainty in TEMPO Data

What is the Current State of TEMPO Data?

- TEMPO is a geostationary satellite instrument launched on April 7, 2023 designed to monitor air quality across North America with hourly or more frequent observations during daytime (1). TEMPO measurements of radiances (spectrally-resolved sunlight backscattered from Earth) have a spatial resolution (footprint) of 2 km x 4.75 km at the center of the field of regard.
- TEMPO data are currently Provisional which indicates that the products are “potentially ready for testing by operational users and may be suitable for scientific publication”.
- Data quality is expected to improve as known issues as described in the TEMPO data product user guides are addressed and implementation of the validation plan is continued.

Documentation

TEMPO data product user guides are available for Level 1 radiances, Level 2 and 3 NO_2 and HCHO, and Level 2 and 3 Total Ozone. A validation plan is available (2). A validation document is forthcoming.
https://asdc.larc.nasa.gov/project/TEMPO

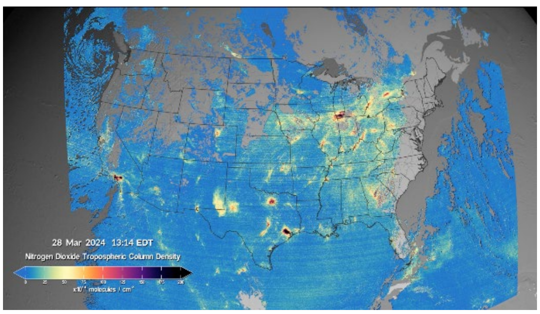


TEMPO measures scattered sunlight. TEMPO retrieval algorithms relate those measurements to trace gas vertical columns. Adapted from (3).

TEMPO field of regard. Adapted from TEMPO image gallery.

How do TEMPO Retrieval Algorithms Work?

- TEMPO retrieval algorithms calculate the trace gas abundance needed to reproduce measured radiances measured by the TEMPO instrument. Level 2 data contain cloud and trace gas products at the native ground-pixel footprint. Level 3 data contain cloud and trace gas products on a regular grid.
- TEMPO NO_2 and HCHO retrieval algorithms include a spectral fit to produce line-of-sight “slant columns” and an air mass factor, which accounts for the vertically-varying sensitivity of the observation and the relative vertical profile of the trace gas, to relate these slant columns to vertical columns. NO_2 algorithms also include a stratosphere-troposphere separation algorithm that uses observations over clean regions to separate tropospheric and stratospheric columns (4).
- TEMPO total ozone algorithms retrieve total column ozone from measured radiances using an inverse model that calculates the ozone abundance needed to simulate the measured radiance.
- Additional data products including an ozone profile are expected in future TEMPO releases.



(Top) Earth from space. Clouds, snow, and ice are challenging for retrievals. (Bottom) Example of TEMPO data for NO_2. Image from Trent Schindler/NASA's Scientific Visualization Studio.

What are the Main Sources of Uncertainty in TEMPO Data?

- TEMPO builds upon the heritage of prior satellite instruments such as OMI that observe solar backscatter at ultraviolet and visible wavelengths, and thus has related sources of uncertainty. Current major sources of uncertainty include 1) absolute accuracy of the geolocated Earth radiance that affects inferred cloud fraction, and 2) accuracy of representing geophysical fields such as surface reflectance, clouds, aerosols, and trace gas vertical profile that affect the path of sunlight through the atmosphere and the absorption of solar radiation by the trace gas along that path (5). TEMPO uncertainties tend to be larger in the morning and evening when radiance contributions from the lower troposphere are reduced.
- If the user is comparing TEMPO NO_2 or HCHO data with a chemical transport model, it is recommended to replace the assumed relative vertical profile with that from the users chemical transport model, so the comparison is not affected by differences between the vertical profile in the user's model and the assumed profile (6, 7).

References

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