TEMPO Data in Action: ASDC's Advanced Tools for Wildfire Monitoring and Impact Analysis

National Aeronautics and Space Administration

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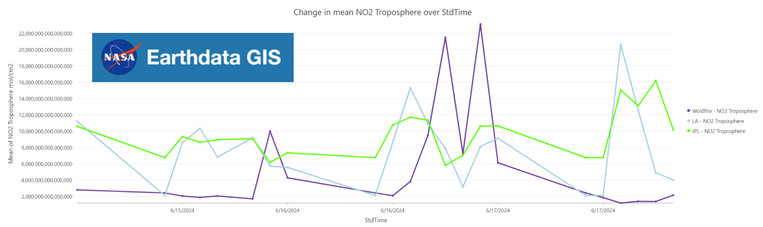
Wildfires are a significant environmental challenge in North America, profoundly impacting ecosystems, air quality, and human health. Effective monitoring and management are crucial for mitigating their effects and enhancing response strategies. The data from the Tropospheric Emissions: Monitoring of Pollution (TEMPO) instrument, hosted by the Atmospheric Science Data Center (ASDC), provides a novel dataset offering high temporal and spatial resolution of atmospheric pollutants across North America. This study explores the application of TEMPO data in wildfire monitoring, focusing on its potential to enhance detection, track the progression, and analyze the impact of wildfires. We detail the methods for leveraging TEMPO's temporal and spatial resolution to monitor key fire-related pollutants such as ozone (O_3), nitrogen dioxide (NO_2), and formaldehyde (HCHO). We integrate various tools and services to leverage TEMPO's capabilities, including the Remote Sensing Information Gateway (RSIG), NASA Worldview, Earth Geographic Information System (EGIS), Jupyter Notebooks, Earthdata Search, OPeNDAP, and Harmony. Additionally, we assess the integration of TEMPO observations with ground-based sensors and satellite data to improve wildfire detection and tracking accuracy and timeliness.

Overview of the June 16th, 2024, Excelsior Wildfire Event Using Earthdata GIS:

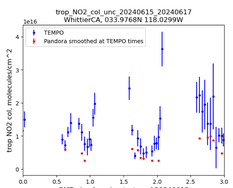
Excelsior wildfire burning northwest of Los Angeles on June 16th, 2024, has forced the evacuation of over 1,000 people from a popular outdoor recreation area and burned over 12,000 acres. The initial timeseries comparison of NO_2 tropospheric column (number of molecules in the column of air above 1 cm^2 of surface) over the wildfire shows, see figure to the right, maximum level of more than $2.2 \cdot 10^{16}$ mol/cm^2 on the same day, while the NO_2 tropospheric column is minimal at JPL and Los Angles. Using EGIS quick look analysis, we can see that the smokes moved over JPL and LA in less than 12 hours.



TEMPO Formaldehyde and Cloud Fraction Beta data on Worldview

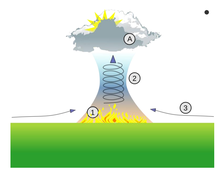
Formaldehyde Level 3 (L3) product provides trace gas retrievals on a regular grid. L3 files are derived by area-weighted re-gridding data from all L2 granules comprising a TEMPO scan. TEMPO performs one East-West scan in approximately one hour during daylight hours, with more frequent scans in the morning over the eastern portion of the FOR and in the evenings over the western portion of the FOR. The main retrieved parameters is formaldehyde total column. Figures below show formaldehyde temporal development of the Excelsior wildfire.

CLDO4 L3 product is derived from corresponding L2 product that employs the O_2-O_2 cloud retrieval algorithm. Main retrieved parameters include effective cloud fraction, f_{cld} (unitless), and optical centroid pressure for cloud (hPa). f_{cld} is derived by inverting Eq. (1) of Vasilkov et al. (2018), https://amt.copernicus.org/articles/11/4093/2018/amt-11-4093-2018.pdf, at 466 nm. Figures below show temporal development of NO2, HCHO and fcld in the area of the Excelsior wildfire.

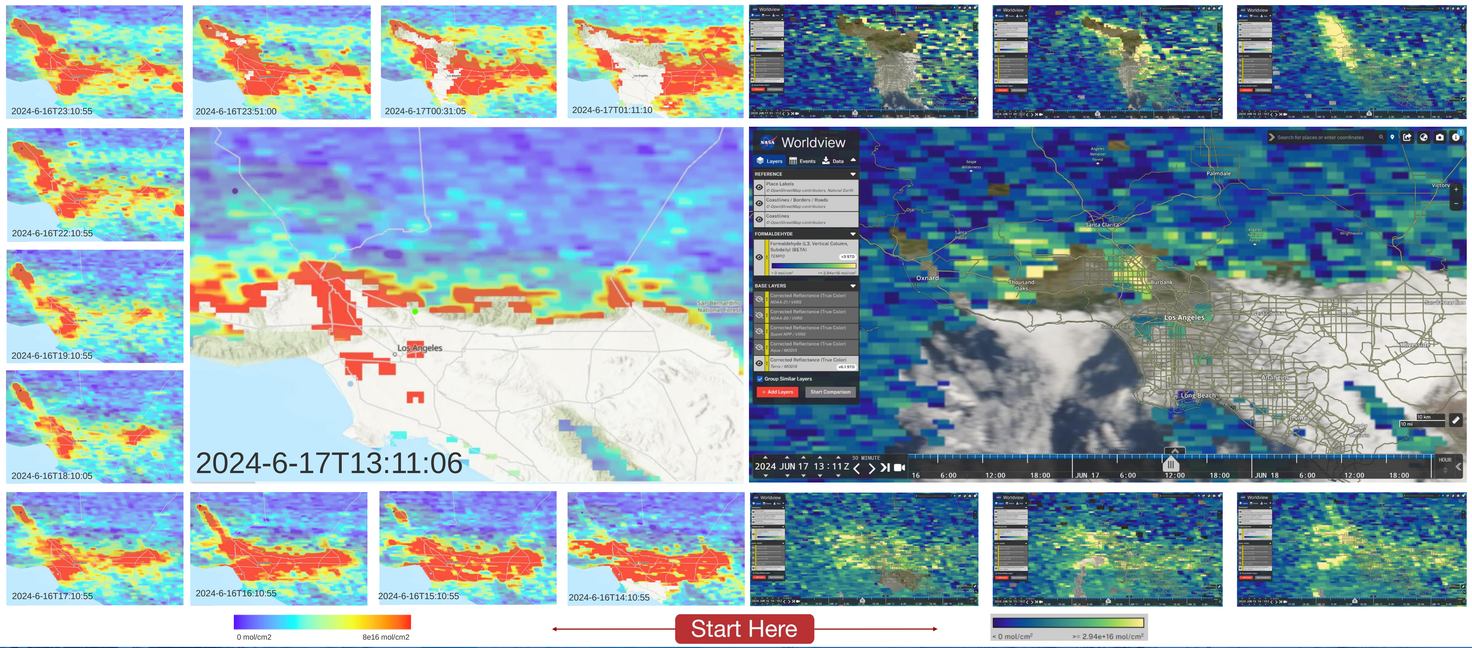


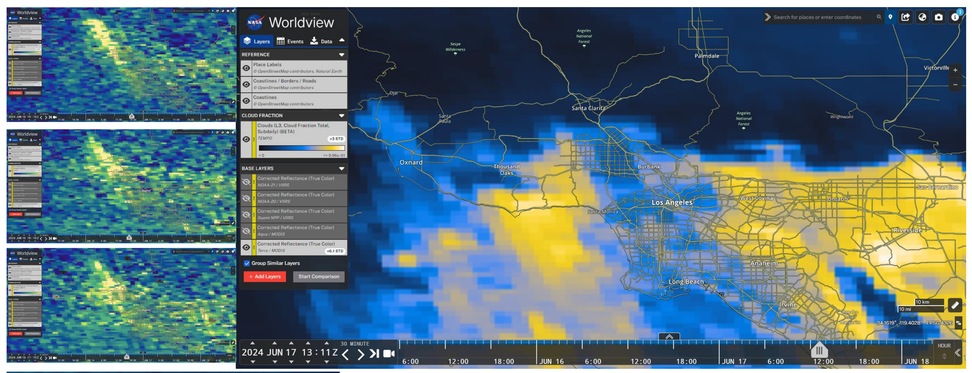
Pyrocumulonimbus clouds impact on Remote sensing measurements

TEMPO Imagery is available as approximately one-hour scans for daylight hours over North America. The sensor's native spatial resolution is ~2 km x 4.75 km at the center of TEMPO's field of regard (FOR), the Level 3 product resolution is 0.02 x 0.02 degrees, and the imagery resolution is 2 km. The layer is filtered to display high-quality pixels using the main data quality flag (QF), solar zenith angle (SZA), and effective cloud fraction variables. Gridboxes with QF > 1 and SZA > 80° are discarded to retain only high and moderate quality pixels, as well as those with f_{cld} > 0.5 which is filtering wildfire smokes from wildfire because the cloud fraction of the smokes is exceeding 0.85. There are 2 proposed solutions:



- Relax the cloud fraction threshold which must be accompanied by careful consideration of the increased uncertainty in NO_2/HCHO measurements due to cloud scattering. Pyrocumulonimbus cloud retrievals, Gatebe et al. 2012, considering the signal from plumes can still be strong enough to be detected under moderate cloud cover, see www.sciencedirect.com/science/article/pii/S1352231012000660;
- Using cloud type and aerosol type along with cloud thicknesses or some products differentiating smoke from dust from other sources such as DSCOVR EPIC, MODIS, and VIIRS products. Another solution can be using The Fire and Thermal Anomalies layers to relax the cloud filter by introducing a weighting system in the model.





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TEMPO

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Scan the QR code to learn more about TEMPO:
https://storymaps.arcgis.com/stories/01e82aefbc8b4d7a951fe089c818bc0c

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