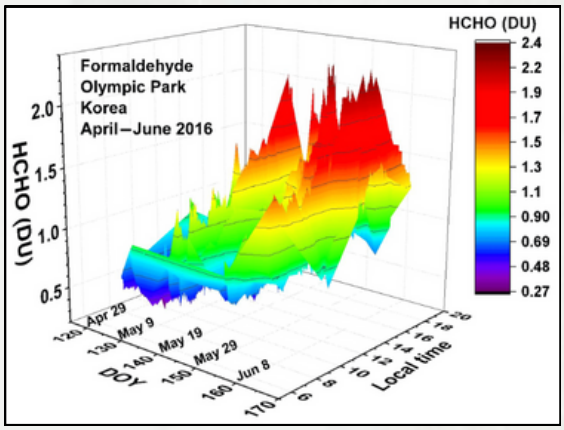
National Aeronautics and Space Administration

Air Quality Forecasts and Distributed Pandora Sensors

Satellite Needs Working Group - Solution Fact Sheet

Managing air quality requires a combined approach leveraging models, ground-based data, and remotely sensed Earth observation data. Further, consistent measurements and global-scale modeling are crucial for effective detection and prediction of key air quality parameters and their impact on human health. To meet these needs, and enhance detection and forecasting of these parameters in data-sparse regions, the Satellite Needs Working Group (SNWG) supports an Air Quality Forecasts and Distributed Pandora Sensors solution. The solution enables data collection from Pandora sites and U.S. embassies and the development of trace gas and PM2.5 products and forecasts. The NASA Pandora Spectrometer System is a ground-based platform providing total column measurements of trace gasses including ozone (O3), nitrogen dioxide (NO2), and formaldehyde (CH2O) present in the atmosphere. Using a network of these Pandora sensors, NASA and ESA established a Pandora Global Network (PGN) to initiate a long-term record of total column and vertically resolved trace gas concentrations at over 100 sites across the world. In addition, PM2.5 measurements are available through the U.S. EPA's AirNow network and U.S. embassy ground-based observations, and forecasts are available through NASA's Goddard Earth Observing System-forward processing (GEOS-FP) model. The PM2.5 forecasts from GEOS-FP are further bias corrected and calibrated at ground locations using advanced machine learning algorithms. Using these resources, this solution will provide three components to expand and improve existing air quality data:

- **Data from additional Pandora sites** - The existing Pandora network will be expanded to provide data in currently under-represented locations (10 instruments will be added in rural U.S. locations, and 10 instruments will be added at foreign U.S. embassies in regions with high levels of air pollution).
- **Access to GMAO air quality forecast products for Pandora locations** - NASA's Global Modeling and Assimilation Office (GMAO) will integrate Pandora observations with the GEOS Composition Forecast (GEOS-CF) modeling output to obtain tailored air quality forecasts at any Pandora location of interest.
- **Access to PM2.5 forecast products for cities worldwide** - The City Air quality foREcasting and analysis System (CARES) will apply a machine learning algorithm that uses U.S. embassy and other ground-based observations and GEOS-FP model output, which assimilates satellite data on aerosols and dust and uses satellite-informed fire emissions, to provide consistent and high quality PM2.5 forecasts at U.S. embassy locations and major global cities.



The figure (above) shows Pandora-measured formaldehyde amounts in Olympic Park, Korea from April to June 2016 at local times. With the expansion of the existing Pandora network, measurements of formaldehyde and other trace gasses will be available in data-sparse regions as well as existing sites.

Credit: (Jay Herman et al., 2018)

Societal Benefit

- **Support air quality monitoring for 20 additional locations in the rural U.S. and around the globe that currently lack ground observations**
- **Provide localized air quality forecasts at any Pandora site to better mitigate human exposure to harmful air pollution**
- **Initiate a long-term record of data collection at 20 new sites for historical analyses of trace gas concentrations**
- **Provide PM2.5 forecasts, up to 72 hours in advance, to monitor and anticipate the amount of fine particulate matter near the surface**
- **Support validation for emissions and air quality monitoring satellite platforms at additional sites through the expansion of the Pandora network**

Air Quality Forecasts and Distributed Pandora Sensors

Solution Component	Pandora Sensors	GMAO Forecasts	$PM_{2.5}$ Forecasts
Input Source	Ground-based Pandora Spectrometer System	Ground-based Pandora Spectrometer System and GEOS-CF model output	GEOS-FP, VIIRS, and available $PM_{2.5}$ measurements
Output Variables	• Total column ozone, nitrogen dioxide, formaldehyde • Tropospheric profiles of nitrogen dioxide and formaldehyde • Ground level concentrations of nitrogen dioxide and formaldehyde	Total column and surface ozone, nitrogen dioxide, formaldehyde	• Surface $PM_{2.5}$ concentration • U.S. EPA-defined Air Quality Index
Processing Level	2	4	4
Temporal Coverage	Dependent on sensor installation	January 2019 - TBD	May 2024 - present
Temporal Sampling	Hourly	Hourly	3-hour forecasts up to 72 hours in advance, updated daily
Latency	1 hour	Forecasts available NRT, historical data available with 24 hours latency	~2-4 hours (dependent on GEOS-FP latency)
Spatial Coverage	Select U.S. embassies (10) and agricultural sites (10)	Select U.S. embassies (10) and agricultural sites (10) with plans to scale to all operational Pandora Sensor locations	Select U.S. embassies (270) and cities (10,000+)
Spatial resolution	Point locations	Point locations	Point locations
Data format	Text files, HDF5	Text files, JSON files	ASCII (available via API)

How do I access the data?

Data for newly installed Pandora sensors within the PGN will be available through the PGN site. PM2.5 forecasts for global cities that host a U.S. diplomatic mission are available through the U.S. State Department's ZephAir application. GMAO forecasts are not yet available.

Pandonia Global Network

ZephAir Air Quality Forecasts

Where can I find more information?

More information on Air Quality Forecasts and Distributed Pandora Sensors can be found on the SNWG Solutions webpage and the official Pandora Project website.

SNWG Solutions

Pandora Project

Background image credit: NASA Earth Observatory