Applications of Satellite Remote Sensing Products to Enhance and Evaluate the AIRPACT Regional Air Quality Modeling System

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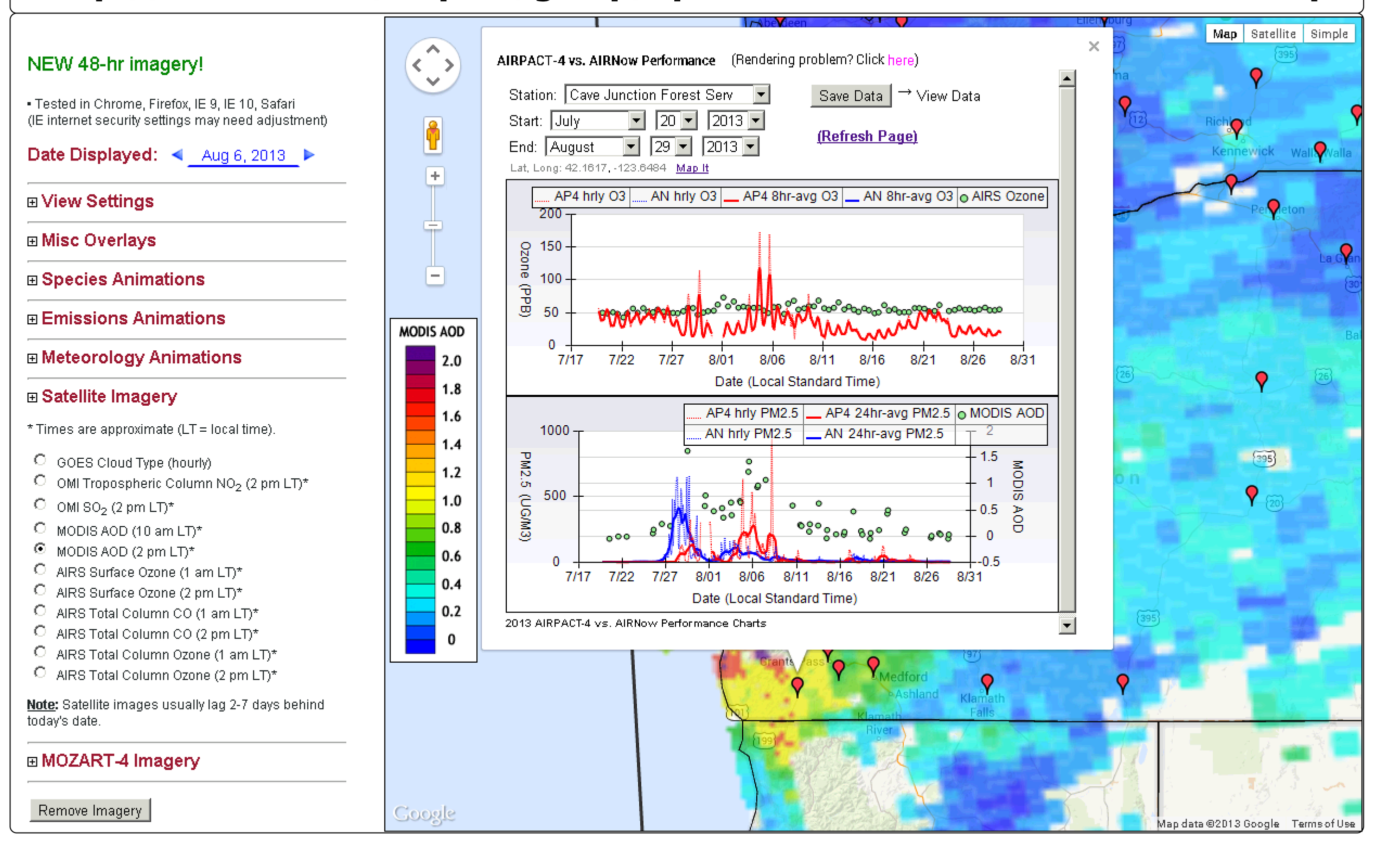
Introduction: The WSU AIRPACT air quality modeling system for the Pacific Northwest forecasts hourly levels of aerosols and atmospheric trace gases for use in determining potential health and ecosystem impacts by air quality managers. AIRPACT uses the WRF/SMOKE/CMAQ modeling framework, derives dynamic boundary conditions from MOZART-4 forecast simulations with assimilated MOPITT CO, and uses the BlueSky framework to derive fire emissions. Currently, there are two versions of AIRPACT available on the web (http://lar.wsu.edu/airpact/). AIRPACT-3 has 12-km grid cells and anthropogenic emissions from 2005 while AIRPACT-4 has 4-km grid cells and uses 2008 anthropogenic emissions. Presented here are features of the AIRPACT web-interface and comparisons of AIRPACT with satellite products.

AIRPACT-4 Web Tool

http://lar.wsu.edu/airpact/gmap/ap4.html – AIRPACT-4 Interactive Map



The AIRPACT-4 Interactive Map (above) enables users to visualize emissions, meteorology, air quality simulations, satellite retrievals, and surface monitor results all within one web-tool. The imagery displayed is hosted within a Google Maps framework that allows users to pan, zoom, select background imagery, and search for locations of interest.

Main Tools and Functions Available:

Miscellaneous Overlays
- Air Quality Monitor Sites; satellite retrievals, air quality predictions, and surface observations
- Boundaries of states, counties, National Forests, Class I Federal Areas, etc.
- Fire Radiative Power and the latest information from the Hazards Mapping System
- Industrial emissions reported by the US EPA NEI

Air Quality Forecast Animations
- Hourly forecasts (O_3, PM2.5, CO, HCHO, NOx, VOCs, AOD, etc.)
- EPA averaging periods (24-hr avg. PM2.5 and 8-hr avg. O_3)

Meteorology Animations
- Hourly animations for PBL Height, Precipitation, Surface Wind, Surface Temperature, etc.
- Image overlays of AIRPACT-4 Elevation and Dominant Land Use

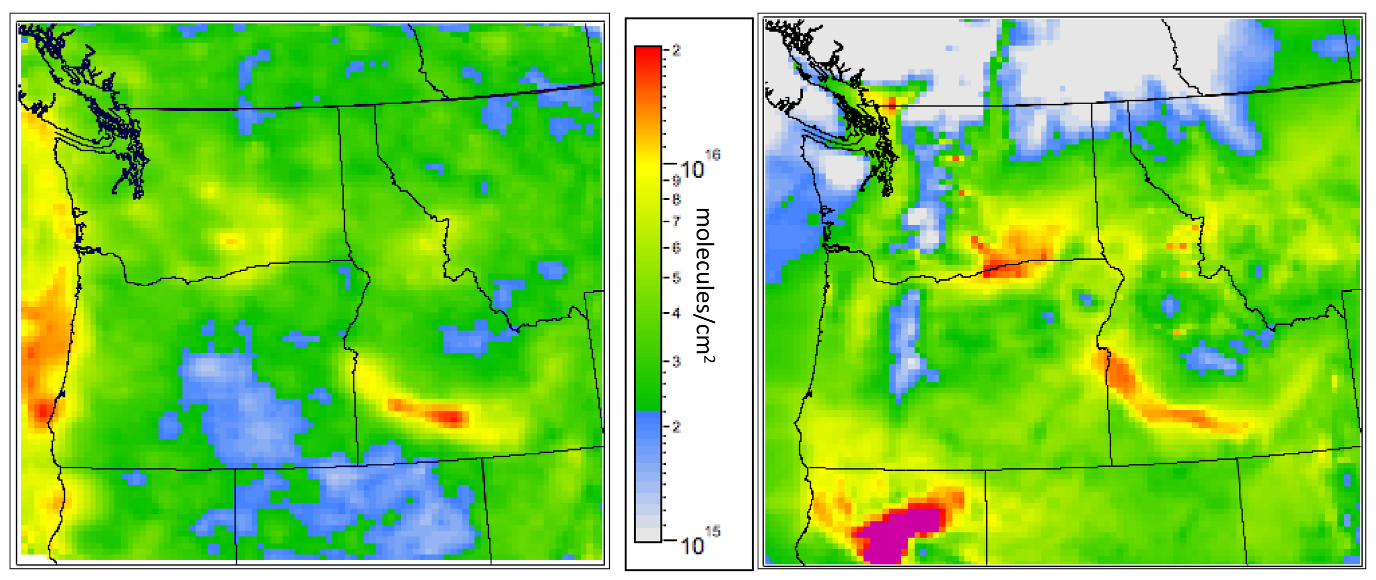
Satellite Imagery
- Image overlays of AIRS, MODIS, and OMI level-2 retrievals (CO, O_3, NO_2, SO_2, AOD)
- Hourly animations of GOES Cloud Type
- Continental US and bordering regions

MOZART-4 Imagery
- 6-hourly image overlays of CO, NOx, O_3, and PAN
- Continental US and bordering regions

Anthropogenic Emissions

The IASI ammonia research product is one example of satellite retrievals that have been used to evaluate AIRPACT emissions. The IASI ammonia retrievals provide valuable information about regional emissions from agriculture, fires, and urban areas. Although the IASI retrievals have high errors over the ocean, there is good sensitivity over land. Errors in AIRPACT ammonia emissions from California were recently detected (below) and subsequently corrected for future simulations.

IASI Ammonia — Sept. 26 to Oct. 11, 2012 | AIRPACT-3 Ammonia — Sept. 26 to Oct. 11, 2012



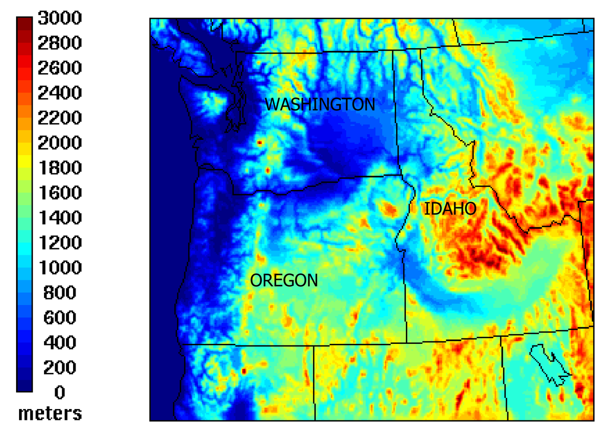
Long-Range Transport

The AIRPACT boundary conditions are derived from global simulations from NCAR that assimilate MOPITT carbon monoxide into MOZART-4. This methodology provides good estimates of the O_3 and CO inflow that affects air quality in the Pacific Northwest.

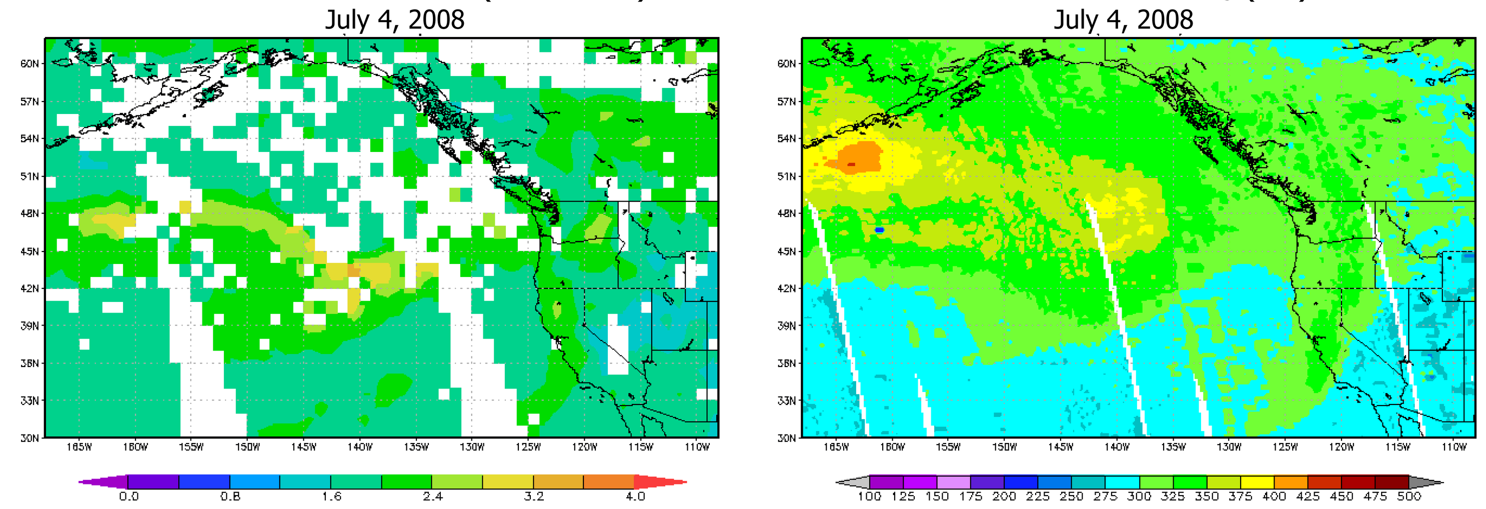
The Cascade Range and Rocky Mountains are particularly susceptible to increased ozone at the surface due to long-range transport (LRT) of Asian emissions and upper-troposphere/lower-stratosphere (UT/LS) exchange.

The AIRS CO and OMI O_3 products (below) are very useful for identifying these events and assessing AIRPACT performance in the free troposphere.

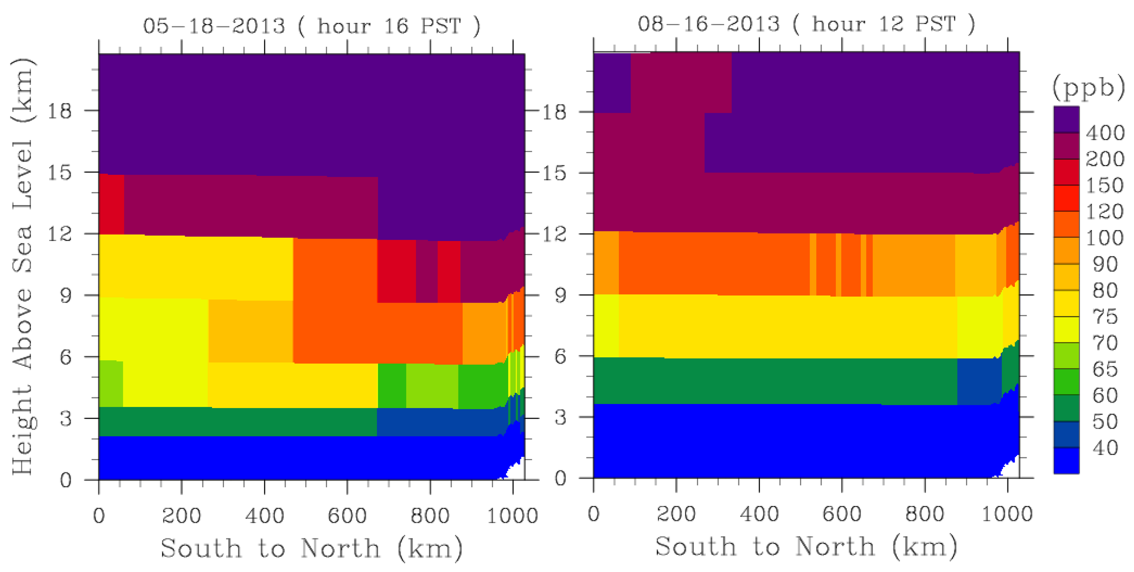
AIRPACT-4 Surface Elevation



AIRS Total Column CO (VCD E10[18]) — July 4, 2008 | OMI Total Column O_3 (DU) — July 4, 2008



AIRPACT-4 Western Ozone Boundary Conditions



LRT events often bring over 70 ppb of ozone and 200 ppb of CO into the Pacific Northwest.

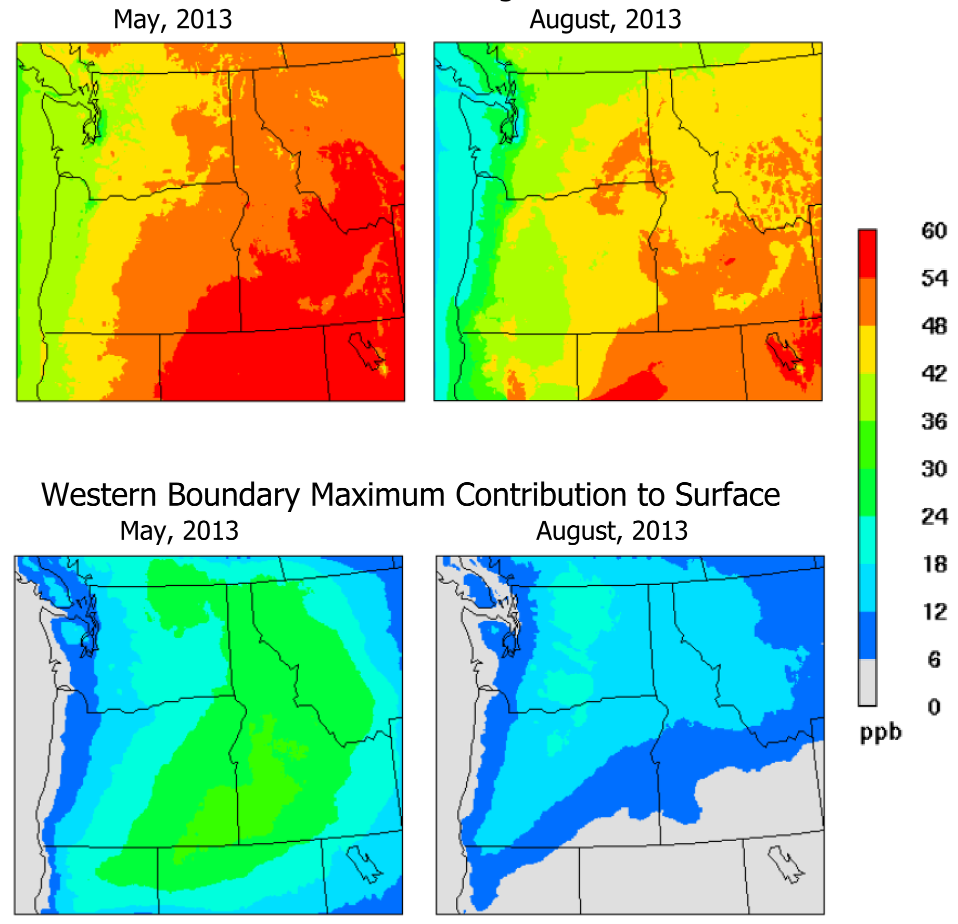
LRT pollutants from MOZART-4 typically enter the AIRPACT domain at the middle and upper troposphere on the western boundary (left).

The contribution of western boundary conditions to the predicted surface ozone varies by season.
The 8-hr average surface ozone in mountainous areas predicted by AIRPACT-4 is higher in spring than summer for mountainous areas (top), due to the meteorological conditions that maximize the LRT of Asian emissions during spring months.

A tracer-only build of CMAQ was used to track ozone from the western boundary to the surface of high elevation regions.
Cities in mountainous areas (e.g. Boise, ID) experienced over 25 ppb of surface ozone attributed to the western boundary during the spring (bottom left) and ~60% less contribution during the summer (bottom right).

AIRPACT-4 Afternoon 8-hr Average Ozone at Surface — May, 2013 | August, 2013

Western Boundary Maximum Contribution to Surface — May, 2013 | August, 2013



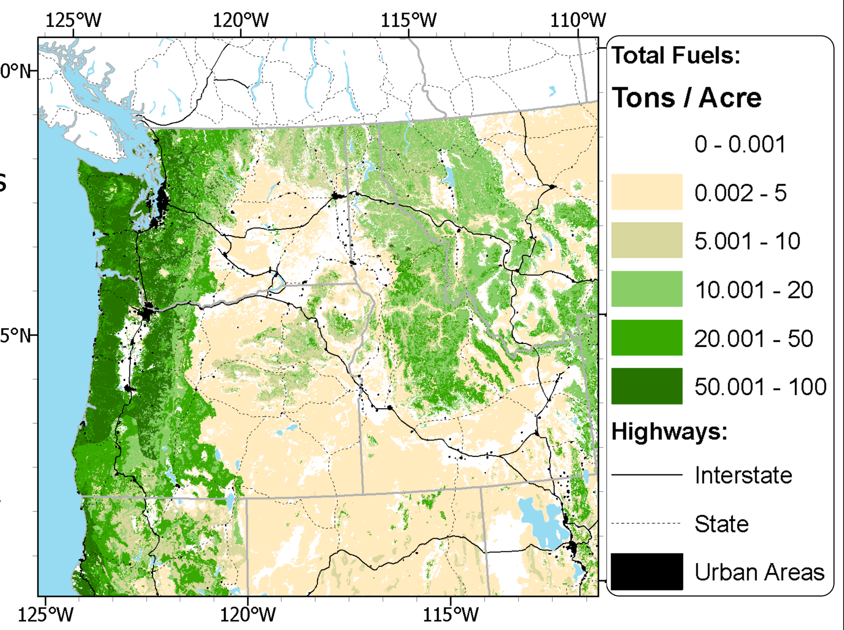
Wildfire Simulations

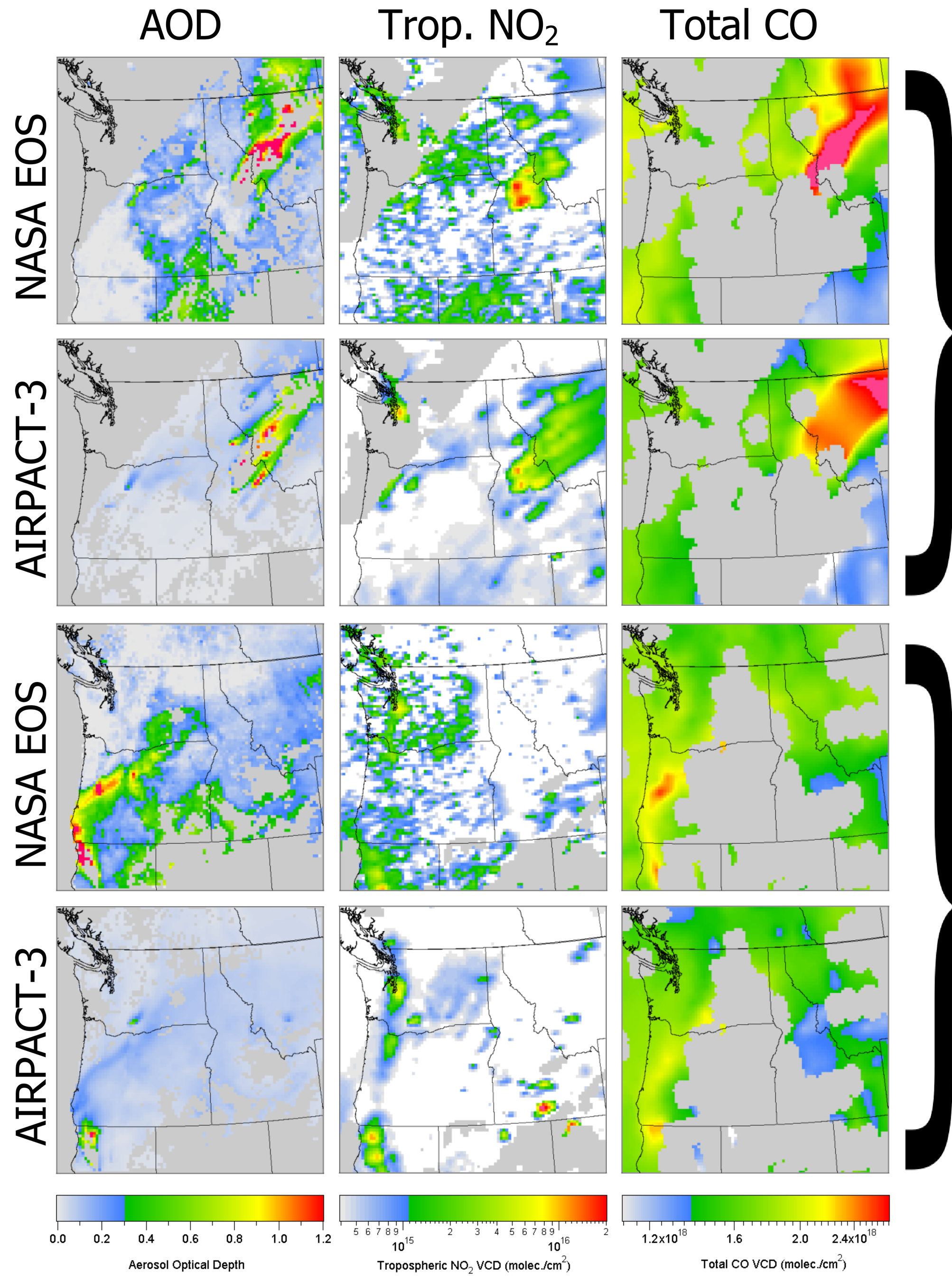
AIRPACT wildfire emissions are predicted with BlueSky (www.airfire.org/bluesky), using Consume, the Fuel Characteristic Classification System (FCCS), and the Fire Emission Production Simulator (FEPS).

FCCS vegetation type and corresponding fuels (right) are used as input to Consume, which calculates fuel consumption and emissions by combustion phase (smoldering or flaming). FEPS then provides pollutant emissions, plume heights, and temporal profiles.

The Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation (SMARTFIRE) reports fire size and location by combining US Forest Service ICS-209 reports and hotspot detects reported by the Hazard Mapping System (HMS).

Canopy + Shrub + Grass + Dead Woody Fuel





August 12, 2007

Comparisons with MODIS (left), OMI (center), and AIRS (right) show that we have trouble predicting long-range transport from fires located outside the AIRPACT domain.

July 20, 2008

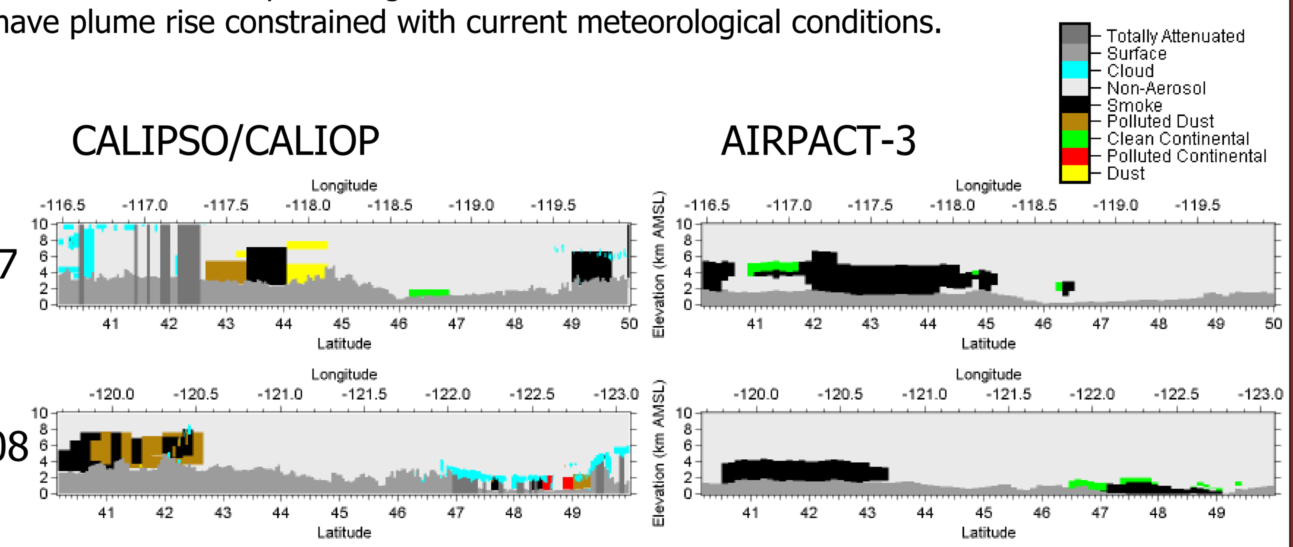
Simulations shown here used the finalized SMARTFIRE reports but AIRPACT wildfire forecasts are based upon reports from the previous day, which can cause temporal problems.

Plume rise is a significant source of uncertainty in AIRPACT predictions. Comparisons with Terra/MISR plume top heights (not shown) indicate that FEPS can over-predict plume rise in mountainous areas because the planetary boundary layer (PBL) is not considered. Comparisons with CALIPSO/CALIOP indicate that the underestimation of terrain height in AIRPACT-3 and the overestimation of plume-top heights from FEPS could be compensating errors in some instances. Future simulations of AIRPACT wildfires will have plume rise constrained with current meteorological conditions.

CALIPSO/CALIOP | AIRPACT-3

Aug. 3, 2007

July 18, 2008



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