Oceans

California Wildfires

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California Wildfires

Every year, extensive wildfires break out across California, costing the state over $1 billion per year. In 2008, the wildfire outbursts came earlier than in previous years and caused substantial damage. However, as fires have become more damaging, the technology to mitigate the effects has also improved. Firefighters can now use real-time satellite data and other NASA instruments to fight fires across the state.

Questions to Explore:

- How can wildfires be detected through satellites?
- What are the parameters that show air pollution from wildfires?

Data Frames for this Chapter:

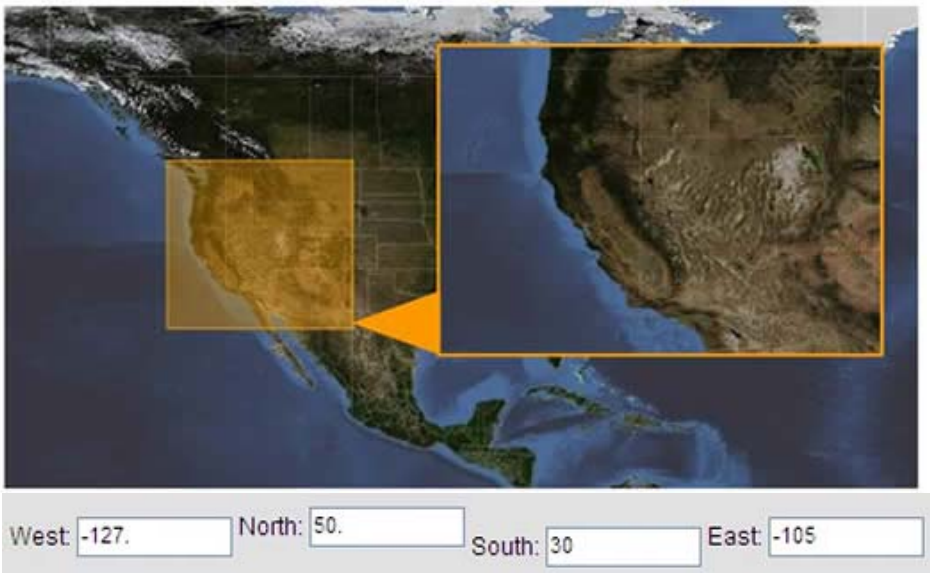
Giovanni Air Quality Instance

- Fine Particulate Matter (Air Quality, Giovanni)
- Aerosol Optical Depth (Air Quality, Giovanni)
- UV-Aerosol Absorbing Index (Air Quality, Giovanni)
- CO total column depth (AIRS, Giovanni)
- CO mixing ratio (AIRS, Giovanni)
- True Color Image (MODIS)
- Google Earth visualization

Visualizations for this Chapter:

- True Color Image (MODIS)
- Animation (Air Quality)
- Area Plot (Air Quality)
- Google Earth Visualization
- Area Plot (AIRS)
- Vertical Profile (AIRS)

Location Map and Coordinates:



Extensive wildfires broke out in several locations in Northern California in July 2008, consuming vegetation on thousands of acres. These fires resulted in extensive evacuations and some property damage, and some of the fires encroached on the scenic Big Sur coast and Yosemite National Park.

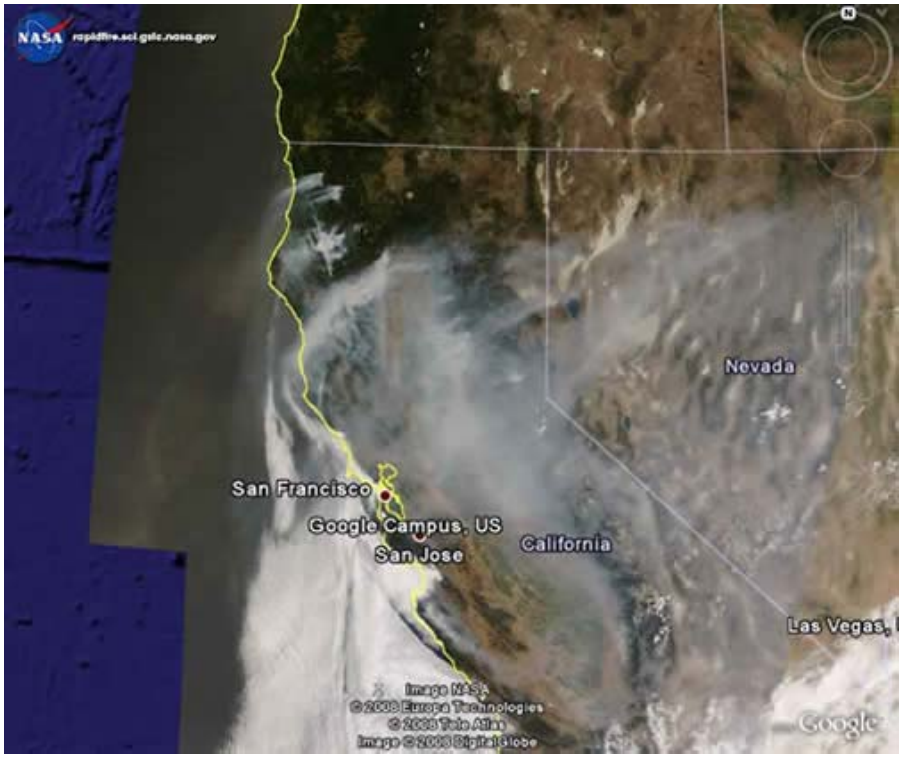
One NASA instrument, Ikhana, an instrument that senses infrared signals which is deployed on an unmanned plane,, was used to detect the outbreaks and extent of wildfires in the July 2008 event. Arnold Schwarzenegger called this instrument a "superstar," which helped to save the town of Paradise, California. Although Ikhana maps infrared radiation from the Earth's surface to detect wildfires, we can use other tools from space to see air quality changes due to the smoke and ash created by wildfires. The MODIS instrument also has fire detection bands that indicate the exact location of the hot spots associated with fires. (These bands also detect hot spots indicative of volcanic activity.)

By looking at a true color image, we can see the smoke plumes over Northern California on July 11, 2007.

(Note: all of the images in this chapter are linked to larger versions. Click the picture to see the larger version.)

True Color Image (MODIS)

1. Go to the website: http://rapidfire.sci.gsfc.nasa.gov/subsets/
2. Scroll down and click on a subset over California.
3. In the next window, click 'Display alternative dates available for this dataset (may load slowly)'
4. Scroll down and choose July 11, 2008.
5. Choose the 250 m resolution for the MODIS Terra True Color Image
6. Click 'Download KMZ file for GoogleEarth'
7. Open in Google Earth.
8. Choose more California subsets to see a whole extent of the smoke on July 11. (The two best datasets are "AERONET_Fresno" and "USA1".)



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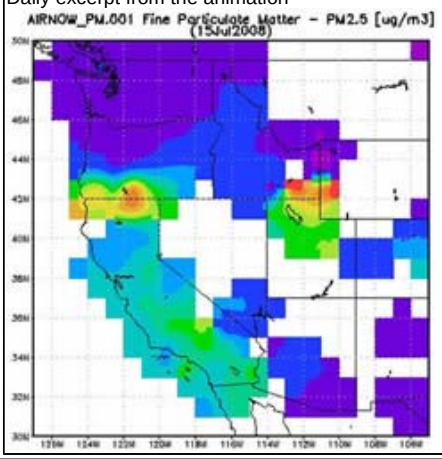
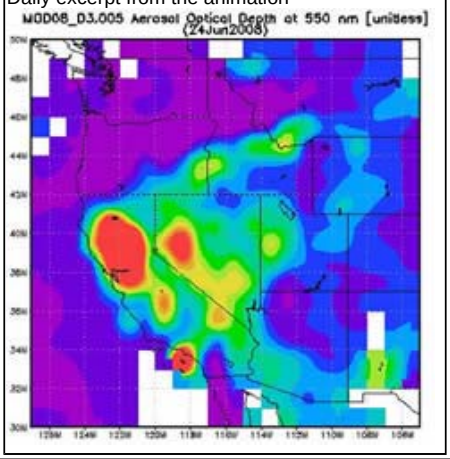
Animation (Air Quality)

An animation of the Aerosol Optical Depth (AOD) and Fine Particulate Matter (PM-2.5) data products over the period from June 20 – July 20 will show the changing location of the smoke plume as the fires evolve. In addition, smoke from Canadian fires can be seen across the northwestern US.

1. Select the area specified above. 2. Parameter: Fine Particulate Matter –PM2.5 3. Temporal: Begin Date = 2008, June 20 End Date = 2008, July 20 4. Select Visualization: Animation 5. Generate Plot Daily excerpt from the animation  	1. Select the area specified above. 2. Parameter: Aerosol Optical Depth at 550 nm 3. Temporal: Begin Date = 2008, June 20 End Date = 2008, July 20 4. Select Visualization: Animation 5. Generate Plot Daily excerpt from the animation 

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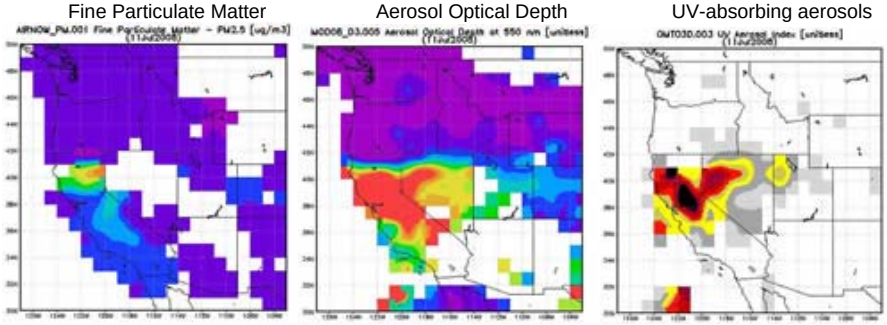
Area Plot (Air Quality)

Now examine the data products acquired the same day that the true color MODIS image was acquired.

1. Select the area specified above.
2. Parameter: Fine Particulate Matter – PM2.5 (AIRNOW)
   Aerosol Optical Depth at 550 nm
   UV Aerosol Index
3. Temporal: Begin Date = 2008, July 11
   End Date = 2008, July 11
4. Select Visualization: Lat-Lon Map, Time-Averaged
5. Generate Plot

Fine Particulate Matter | Aerosol Optical Depth | UV-absorbing aerosols



Compare the particulate matter graph (left) to the graph of aerosol optical depth (center). Aerosol optical depth will correlate better with particulate matter when the majority of the particles are found in the lowest part of the troposphere – which is called the Planetary Boundary Layer (PBL). The UV Aerosol Index shows the aerosols that absorb UV light. These include carbonaceous aerosols from fire, which are often transported by the wind to other locations, as observed here from the smoke being transported east into Nevada. There are areas in the images above, such as central and southern California, where both the MODIS and OMI satellite aerosol column concentrations are large , but the PM2.5 concentration is small. This may indicate that the aerosols are suspended above the PBL, where the satellites can detect them but the surface PM2.5 monitors cannot.

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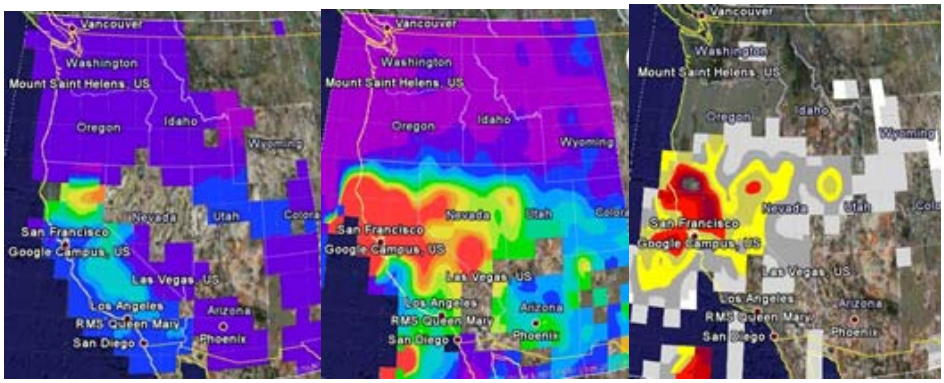
Google Earth with Giovanni output files

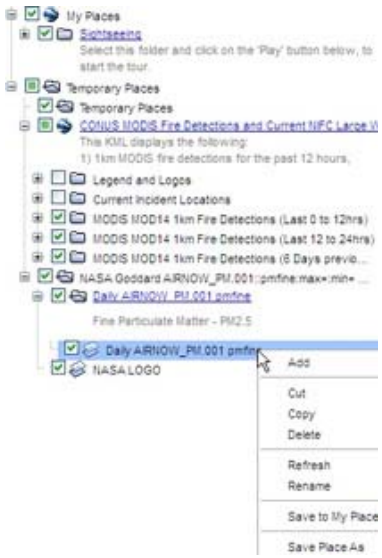
6. Make sure Google Earth is downloaded onto your computer
7. Click 'Download Data' above the map projection.
8. Choose the KMZ download option by clicking the icon.
9. The KMZ should directly import into Google Earth.



Analyze each image in relation to the fire and to each other.

One easy way to analyze each in succession is to play with the transparency for each image.

1. Go the Places Sidebar and click the AIRNOW folder to unzip all the files so they are visible.
2. Right-click on the Daily AIRNOW_PM.001 pmfine dataset (not the folder icon)



3. Click on Properties.
4. Above the Tabs, you will see a slider for Transparency.
5. Use the slider to compare between datasets.

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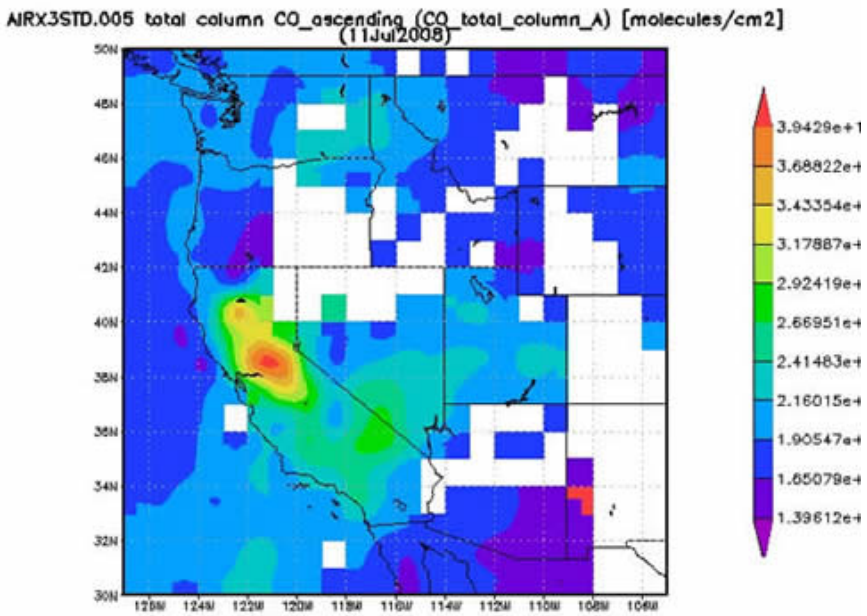
Area Plot (AIRS, daily)

Besides smoke and other air pollutants that are released during wildfires, carbon monoxide (CO) is a poisonous gas released by burning plant material. CO concentrations are available from the AIRS instrument, on NASA's Aqua Satellite.

First, let's compare this to other maps in Google Earth.

1. Choose the AIRS instance.
2. Select the area specified above.
3. Parameter: total column CO_ascending (CO_total_column_A) (Make sure you are in the last dataset according to date)
4. Temporal: Begin Date: 2008, July 11
   End Date: 2008, July 11
5. Select Visualization: Lat-Lon Map, Time-Averaged
6. Generate Plot



Now import into Google Earth:

1. Make sure Google Earth is downloaded onto your computer
2. Click 'Download Data' above the map projection.
3. Choose the KMZ download option by clicking the icon.
4. The KMZ should directly import into Google Earth.

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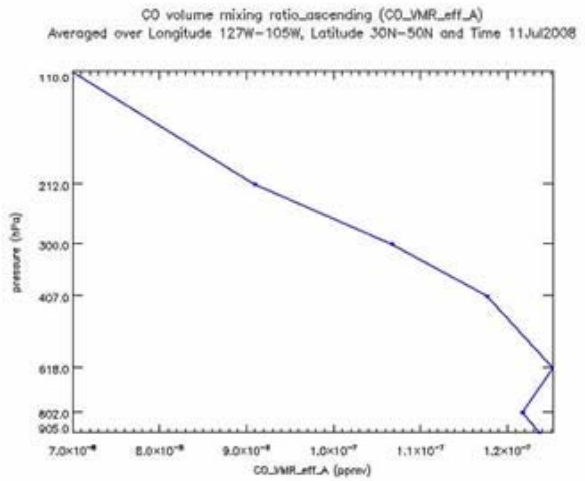
Vertical Profile (AIRS, Daily)

The CO mixing ratio is the ratio of the number of carbon monoxide molecules in a given volume of air to the total number of molecules in the given volume of air. The concentration is not related to the absolute number of CO molecules, but its numerical density. The mixing ratio is one unit that describes the concentration of CO in the air. To learn about other parameters, click each one for an explanation. Vertical profiles of CO concentrations are more informative than the total CO column concentration because they provide detailed information on the vertical structure of CO in the atmosphere.

Ascending/Descending refers to the type of orbit. These are specified because they are taken during different times of the day and use slightly different calculations.

1. Select area specified above.
2. Parameter: CO volume mixing ratio_ascending (CO_VMR_eff_A) (3D)
3. Vertical Profile: Upper Level: 905 hPa
   Lower Level: 110 hPa
4. Temporal: Begin Date: 2008, July 11
   End Date: 2008, July 11
5. Select Visualization: Vertical Profile
6. Generate Plot



This vertical profile shows how the average volume ratio is changing over lower pressures and greater heights above sea level. [The pressure units are hectopascals (hPa). Higher pressure values will be closer to the Earth surface.] The abrupt change in CO at 618hPa could be a result of dynamic atmospheric processes, such as temperature inversions, which can trap pollutants by preventing different air masses from mixing. This leads to different layers and variability in the vertical profile, such as in the figure above. Now let's look at the mixing levels for different altitudes.

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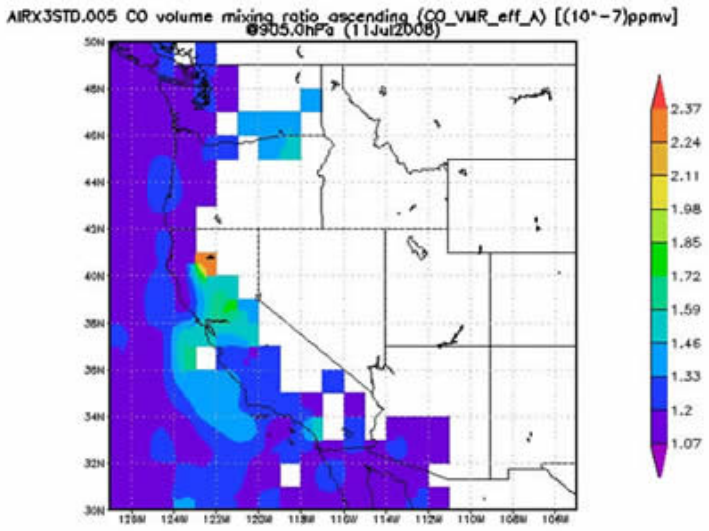
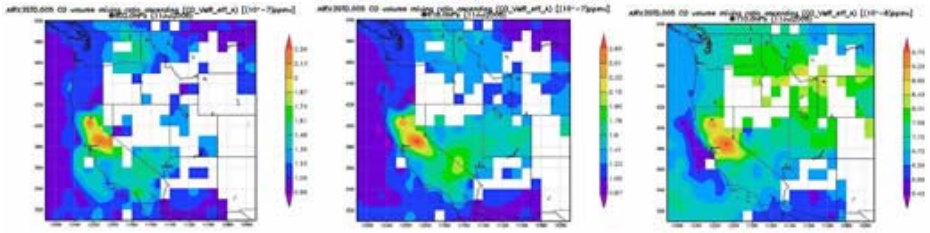
Area Plot (AIRS, daily)

1. Select area specified above.
2. Parameter: CO volume mixing ratio_ascending (CO_VMR_eff_A) (3D)
3. Vertical Profile: Upper Level: 905 hPa
   Lower Level: 905 hPa
4. Temporal: Begin Date: 2008, July 11
   End Date: 2008, July 11
5. Select Visualization: Lat-Lon Map, Time-Averaged
6. Generate Plot



Look at the CO volume mixing ratio for 802hPa, 618hPa, and 110hPa by changing the vertical profile levels

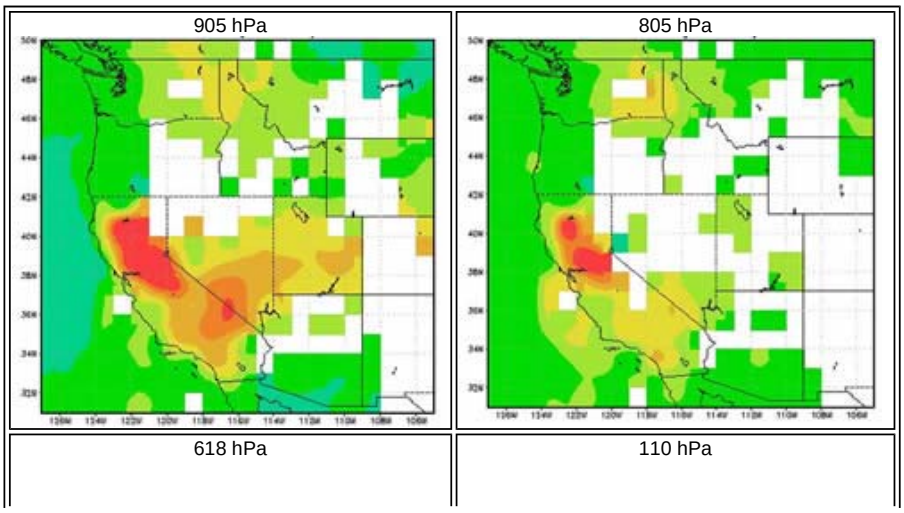
802 hPa 618 hPa 110 hPa

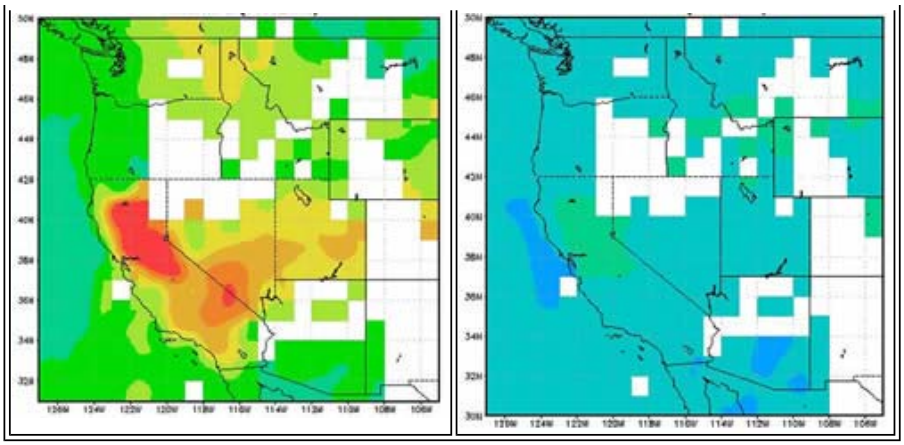


Notice the scale difference: 110 hPa, which is high in the atmosphere above the wildfire, has a maximum concentration of 8ppmv, whereas the other three have 7ppmv.

Now set the color scales to the same limits. This helps in plot interpretation and for better detection of differences between the plots. The greatest CO concentrations are found in the lower atmosphere. Automobiles are the major source of CO in the atmosphere, but industrial processes and biomass burning, such as wildfires, also contribute to carbon monoxide. Industry and cars tend to concentrate CO in the lower atmosphere, but forest fires can cause large quantities to rise into the upper atmosphere as well.

1. Under each plot, scroll down to Plot Preferences
2. Choose 'Custom' under Color Bar.
3. Change the value axes: Min Value: 0
   Max Value: .0000002 (or 2* 10-7)
4. Click 'Submit Refinements'





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Questions for Further Investigation

- How do the smoke plumes relate to the actual fire locations? Can you tell the predominant wind direction from this comparison?
- How do the four datasets – Aerosol Optical Depth, Fine Particulate Matter, UV-absorbing aerosols, and Carbon Monoxide – correlate? Which datasets correlate more closely? Why is this?
- How do Carbon Monoxide Concentrations change with height? Why does this occur?

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