

Satellite Data Visualization with NASA Worldview and NOAA JSTAR Mapper

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NASA Air Quality Remote Sensing Training for EPA, March 21-23, 2023

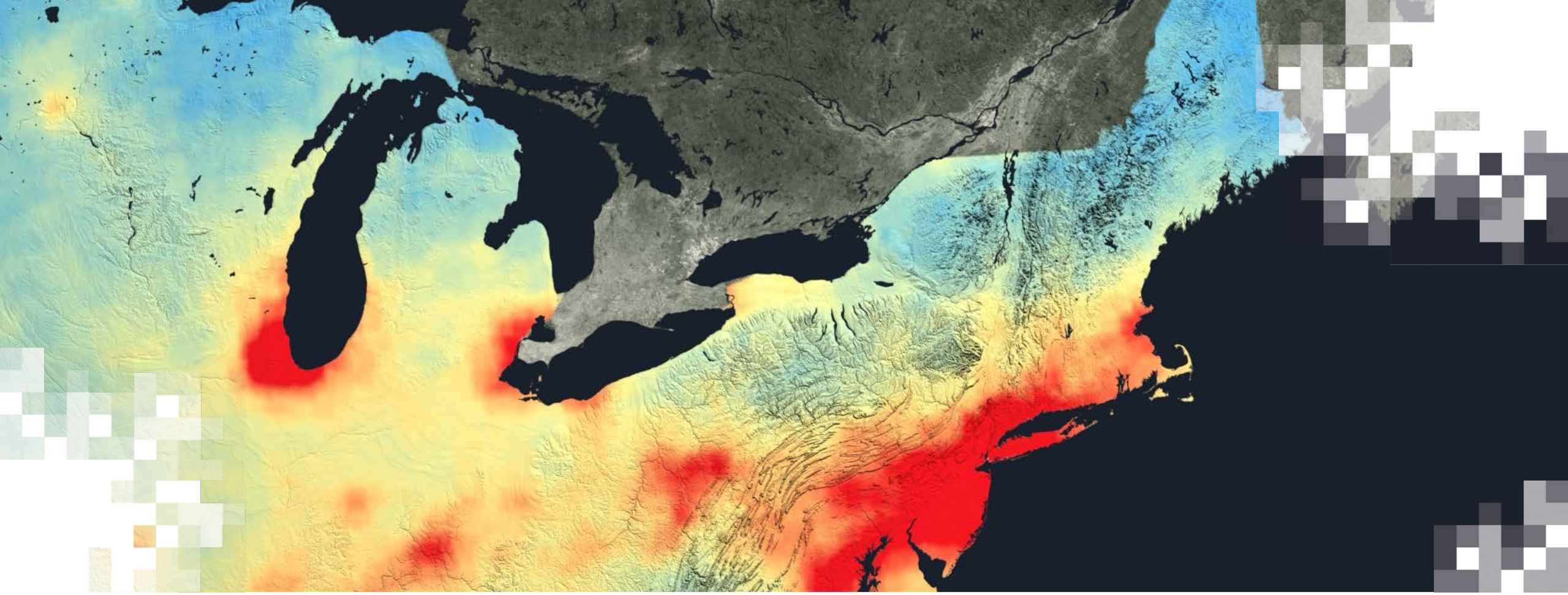


Learning Objectives

By the end of this exercise, you will be:

- Familiar with the NASA Worldview and NOAA JSTAR Mapper websites
- Able to generate and download imagery/animations for an event in Worldview
- Able to visualize NOAA satellite data products in JSTAR Mapper



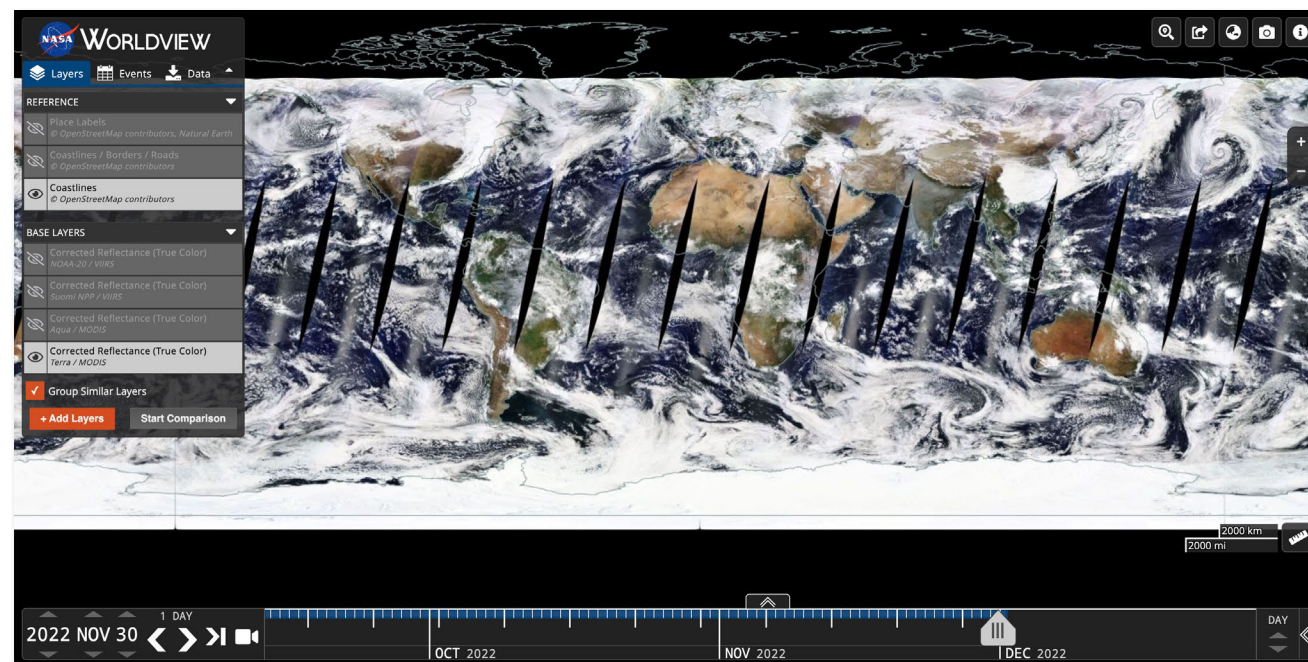


NASA Worldview

NASA Worldview

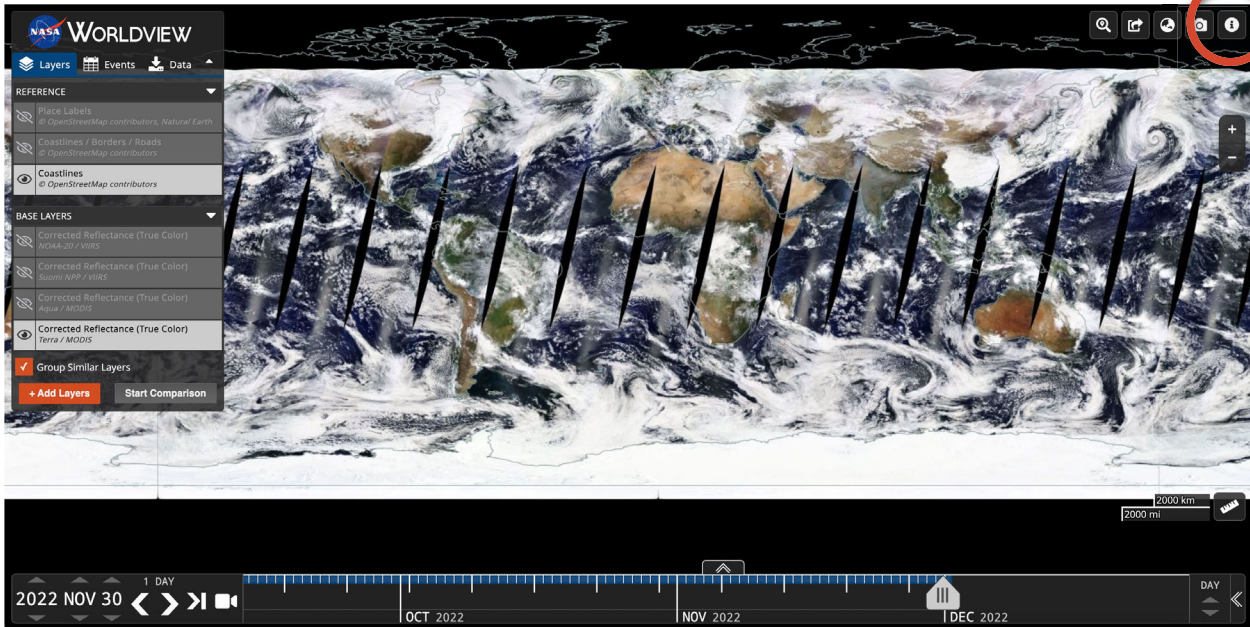
<https://worldview.earthdata.nasa.gov/>

- Application that allows the user to:
 - Interactively browse, save, or share satellite imagery layers
 - Download the data
- Some imagery available in near real time (NRT) or within three hours of observation



Worldview Tutorials

- Worldview tour can be accessed here



- HAQAST Tutorial Video, Written Tutorial (With Downloadable PDF):
 - <https://haqast.org/nasa-tools/>
- Earthdata Webinar:
 - <https://www.youtube.com/watch?v=96Nt36euLJY>
- Getting Started with NASA Worldview:
 - <https://www.youtube.com/watch?v=uMkuiRjr-E>



Worldview Controls

The image shows the NASA Worldview web application interface. The main display is a satellite image of Earth. On the left, there is a sidebar with a 'Layers' panel containing 'REFERENCE' and 'BASE LAYERS' sections. At the top right, there is a toolbar with icons for search, share, projection, zoom, and help. At the bottom, there is a timeline for selecting dates and creating animations. Several callout boxes with arrows point to specific features:

- Take a Snapshot and Download Image**: Points to the camera icon in the toolbar.
- Share Image**: Points to the share icon in the toolbar.
- Search by Location**: Points to the search icon in the toolbar.
- Change Projection**: Points to the projection icon in the toolbar.
- Help /Info**: Points to the help/info icon in the toolbar.
- View Layers, Events, or Download Data**: Points to the 'Layers', 'Events', and 'Data' tabs in the top left.
- Add Image Layers**: Points to the '+ Add Layers' button in the layers panel.
- Zoom In/Out**: Points to the zoom in (+) and zoom out (-) buttons in the toolbar.
- Choose Date and Time**: Points to the date selection controls in the timeline.
- Create an Animation**: Points to the animation controls in the timeline.



Step 1: Select Date

The screenshot displays the NASA WorldView interface. On the left, a sidebar menu includes 'Layers', 'Events', and 'Data'. Under 'REFERENCE', there are options for 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines'. Under 'BASE LAYERS', there are four 'Corrected Reflectance (True Color)' options from different satellite sensors (NOAA-20 / VIIRS, Suomi NPP / VIIRS, Aqua / MODIS, Terra / MODIS) and a checked 'Group Similar Layers' option. A '+ Add Layers' button and a 'Start Comparison' button are at the bottom of the sidebar. The main area shows a satellite view of Earth with a timeline at the bottom. A yellow box highlights the timeline with the text 'Choose Date and Time'. The timeline shows the date '2022 NOV 30' and navigation controls for '1 DAY' intervals. The timeline is divided into months: 'OCT 2022', 'NOV 2022', and 'DEC 2022'. A scale bar at the bottom right indicates '2000 km' and '2000 mi'.



Step 2: Zoom in on the Region of Interest

The screenshot displays the NASA WorldView web application interface. On the left, a sidebar menu includes 'Layers', 'Events', and 'Data'. The 'Layers' panel is expanded, showing 'REFERENCE' layers like 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines', and 'BASE LAYERS' such as 'Corrected Reflectance (True Color)' from various satellite sensors (NOAA-20, Suomi NPP, Aqua, Terra). A 'Zoom In/Out' callout box highlights the zoom controls on the right side of the map. The main map area shows a satellite view of Earth with several black arrows pointing to specific regions. At the bottom, a timeline shows the date '2022 NOV 30' and navigation controls for '1 DAY' and 'DAY'. A scale bar indicates 2000 km and 2000 mi.



Step 3: Explore the Base Layer Options

The screenshot displays the NASA WorldView interface. On the left, a 'Layers' panel is open, showing two sections: 'REFERENCE' and 'BASE LAYERS'. The 'REFERENCE' section includes 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines'. The 'BASE LAYERS' section includes four 'Corrected Reflectance (True Color)' options from different satellite sensors: NOAA-20 / VIIRS, Suomi NPP / VIIRS, Aqua / MODIS, and Terra / MODIS. A yellow box highlights the eye icons next to the 'Coastlines / Borders / Roads' and 'Corrected Reflectance (True Color) Terra / MODIS' layers. A text box with a yellow border and orange text says 'Click on an Eye to View/Hide a Layer'. The main map area shows a satellite view of the Pacific Northwest coast of the United States. At the top right, there is a search bar and several utility icons. At the bottom, there is a timeline showing the date '2022 OCT 08' and a '1 DAY' time interval, along with navigation controls. A scale bar indicates 200 km and 100 mi. Coordinates '52.4827°, -120.6902° EPSG:4326' are displayed in the bottom right corner of the map area.



Step 3: Explore the Base Layer Options

The screenshot displays the NASA WorldView interface. On the left, a 'LAYERS' panel is visible, containing two sections: 'REFERENCE' and 'BASE LAYERS'. The 'REFERENCE' section includes 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines'. The 'BASE LAYERS' section includes four 'Corrected Reflectance (True Color)' options from different sensors: NOAA-20 / VIIRS, Suomi NPP / VIIRS, Aqua / MODIS, and Terra / MODIS. Each layer has an eye icon to its left. A yellow box highlights the eye icons for the 'Coastlines / Borders / Roads' and 'Coastlines' layers, with a text box below it stating 'Click on an Eye to View/Hide a Layer'. A red box on the right contains the text 'What are the differences in the features between each of the sensors?'. The main map area shows a satellite view of the Pacific Northwest coast of the United States. At the bottom, there is a timeline for October 2022, with a date selector set to '2022 OCT 08' and a '1 DAY' interval. A scale bar shows 200 km and 100 mi. The bottom right corner displays coordinates: 52.4827°, -120.6902° EPSG:4326.



Step 3: Explore the Base Layer Options

The screenshot displays the NASA WorldView web application interface. On the left, a sidebar menu includes 'Layers', 'Events', and 'Data'. Under the 'LAYERS' section, there are 'REFERENCE' layers like 'Place Labels', 'Coastlines / Borders / Roads', and 'Coastlines', and 'BASE LAYERS' such as 'Corrected Reflectance (True Color)' from various satellite sensors (NOAA-20, Suomi NPP, Aqua, Terra). A 'Create an Animation' button is highlighted with a yellow box. The main map area shows a satellite view of the western United States and the Pacific Ocean. At the bottom, a timeline shows the date '2022 OCT 08' and a '1 DAY' interval, with a video camera icon also highlighted by a yellow box. The interface includes a search bar at the top right, a scale bar (200 km / 100 mi), and coordinate information (52.4827°, -120.6902° EPSG:4326).



Step 3: Explore the Three Layer Options

The screenshot displays the NASA WorldView web application interface. The main map shows a satellite view of the United States and surrounding regions. On the left, a sidebar contains the following sections:

- NASA WORLDVIEW** logo and navigation tabs: Layers, Events, Data.
- REFERENCE** section:
 - Place Labels (© OpenStreetMap contributors, Natural Earth)
 - Coastlines / Borders / Roads (© OpenStreetMap contributors)
 - Coastlines (© OpenStreetMap contributors)
- BASE LAYERS** section:
 - Corrected Reflectance (True Color) NOAA-20 / VIIRS
 - Corrected Reflectance (True Color) Suomi NPP / VIIRS
 - Corrected Reflectance (True Color) Aqua / MODIS
 - Corrected Reflectance (True Color) Terra / MODIS
- Group Similar Layers (checked)
- + Add Layers (highlighted with a yellow box)
- Start Comparison

A yellow callout box with the text "Add Image Layers" is positioned over the "+ Add Layers" button.

At the top right, there is a search bar: "Search for places or enter coordinates" with icons for search, location, share, print, and info.

At the bottom, there is a timeline and navigation controls:

- Timeline: 2022 OCT 08, 1 DAY, OCT 2022, NOV 2022, DEC 2022
- Navigation: Home, Back, Forward, Stop, Day/Week view toggle
- Scale: 200 km, 100 mi
- Coordinates: 52.4827°, -120.6902° EPSG:4326



Step 4: Add a Layer

The screenshot displays the NASA WorldView web application interface. On the left, a sidebar contains a 'Layers' panel with sections for 'REFERENCE' (Place Labels, Coastlines / Borders / Roads, Coastlines) and 'BASE LAYERS' (Corrected Reflectance from NOAA-20 / VIIRS, Suomi NPP / VIIRS, Aqua / MODIS, Terra / MODIS). A '+ Add Layers' button is visible. The main content area features a search bar and a grid of category tabs: 'Hazards And Disasters', 'Science Disciplines', 'Featured', and 'Recent'. The 'Recent' tab is active, showing a grid of layer categories: 'All', 'Air Quality', 'Ash Plumes', 'Drought', 'Dust Storms', 'Fires', 'Floods', 'Severe Storms', and 'Shipping'. The 'Fires' category is highlighted with a yellow box, and the 'Fires and Thermal Anomalies' layer is selected. The bottom of the interface includes a timeline for '2022 OCT 08' with navigation controls and a 'DAY' view selector.



Step 4: Add a Layer

The screenshot shows the NASA WorldView interface. On the left, a sidebar lists various layers under categories like 'REFERENCE', 'FIRES AND THERMAL ANOMALIES', and 'BASE LAYERS'. The 'Fires and Thermal Anomalies (Day, 375m)' layer under 'Suomi NPP/VIIRS' is highlighted with a yellow box. A detailed information panel for this layer is open on the right, showing a world map with red fire detections and a list of attributes. The attributes include Latitude, Longitude, Brightness Temperature, Fire Radiative Power, and Acquisition Date. The temporal coverage is set to '2012 JAN 20 - Present'. The interface also shows a search bar, navigation controls, and a timeline at the bottom.

Suomi NPP/VIIRS

The Fire and Thermal Anomalies layers are now vectors! Zoom in and click on a point to examine the attributes. Attribute information include Latitude, Longitude, Brightness Temperature (Channel I-4), Brightness Temperature (Channel I-5), Fire Radiative Power, Detection Confidence, Day/Night Flag, Along-Scan Pixel Size, Along-track Pixel Size, Acquisition Date, Acquisition Time, Satellite, Collection and Source, and Unique Identifier.

Fires and Thermal Anomalies (Day and Night, 375m)

Temporal Coverage: 2012 JAN 20 - Present*View Dates

The VIIRS (Visible Infrared Imaging Radiometer Suite) Fire and Thermal Anomalies (Day and Night, 375m) layer shows active fire detections and thermal anomalies, such as volcanoes, and gas flares. Fires can be set naturally, such as by lightning, or by humans, whether intentionally or accidentally. Fire is often thought of as a menace and detriment to life, but in some ecosystems it is necessary to maintain the equilibrium, for example, some plants only release seeds under high temperatures that can only be achieved by fire, fires can also clear undergrowth and brush to help restore forests to good health, humans use fire in slash and burn agriculture, to clear away last year's



Step 4: Add a Layer

The screenshot displays the NASA WorldView web application interface. On the left, a sidebar menu is open to the 'Layers' section. The 'FIRES AND THERMAL ANOMALIES' category is expanded, showing the 'Fires and Thermal Anomalies (Day, 375m)' layer selected. Below this, the 'BASE LAYERS' section is visible, listing various reflectance products. A red checkmark and the text '+ Add Layers' are visible at the bottom of the layer list. The main map area shows a satellite view of North America with numerous red dots indicating fire locations. A search bar at the top right contains the text 'Search for places or enter coordinates'. At the bottom, a timeline shows the date '2022 OCT 08' and navigation controls for time and zoom. A scale bar in the bottom right corner indicates 200 km and 100 mi.



Step 5: Compare Two Days

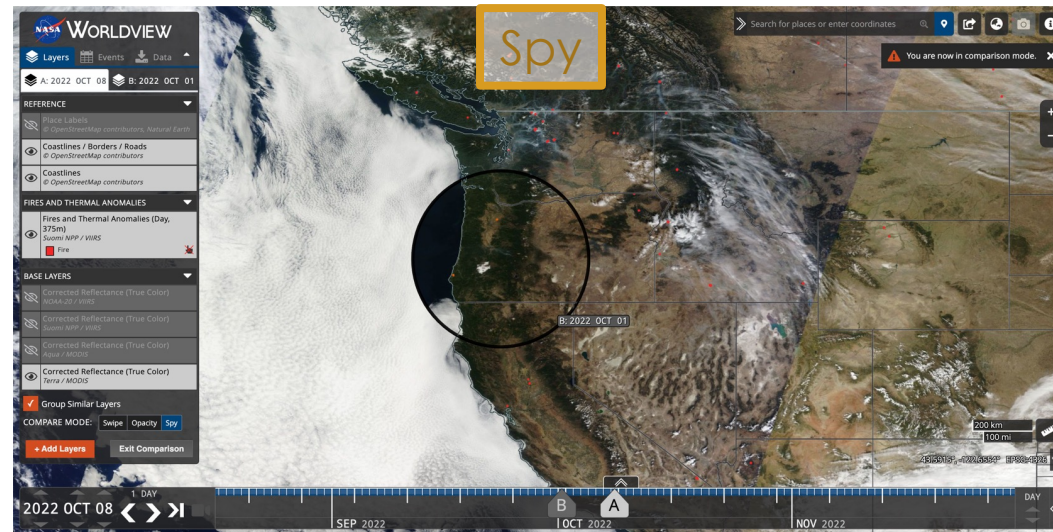
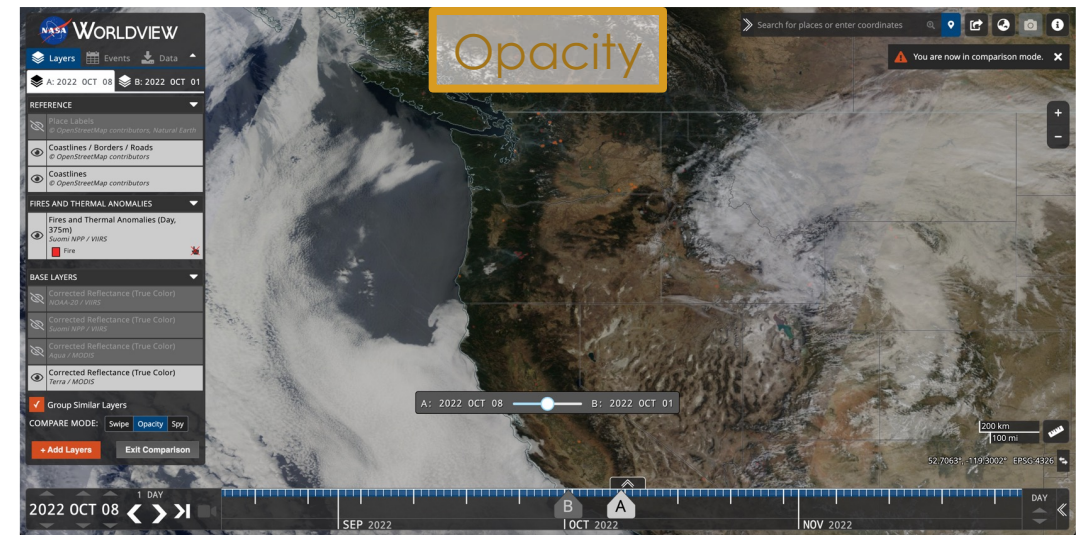
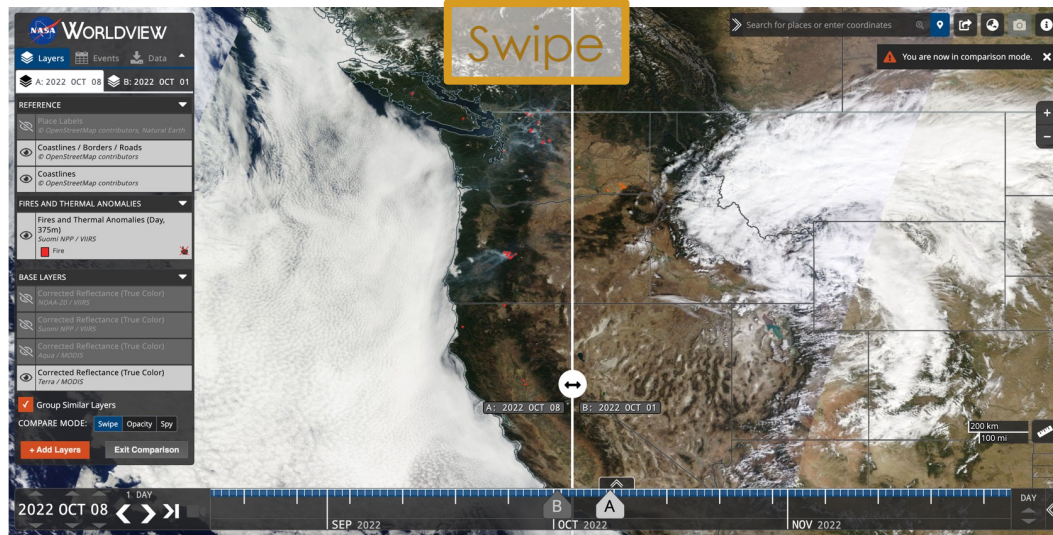
The screenshot displays the NASA WorldView web application interface. The main map shows a satellite view of the western United States, with red dots indicating fire locations. The interface includes a left-hand sidebar with a 'Layers' panel containing the following sections:

- REFERENCE**
 - Place Labels
 - Coastlines / Borders / Roads
 - Coastlines
- FIRES AND THERMAL ANOMALIES**
 - Fires and Thermal Anomalies (Day, 375m) - *Suomi NPP / VIIRS* (Active)
 - Fire (Legend icon)
- BASE LAYERS**
 - Corrected Reflectance (True Color) - *NOAA-20 / VIIRS*
 - Corrected Reflectance (True Color) - *Suomi NPP / VIIRS*
 - Corrected Reflectance (True Color) - *Aqua / MODIS*
 - Corrected Reflectance (True Color) - *Terra / MODIS*

At the bottom of the sidebar, there are buttons for '+ Add Layers' and 'Start Comparison'. The main map area includes a search bar at the top right, a scale bar (200 km / 100 mi) at the bottom right, and a timeline at the bottom. The timeline shows the date '2022 OCT 08' and a '1 DAY' interval, with navigation arrows and a home button. The current date is 'OCT 2022', and the next month is 'NOV 2022'. The map also displays coordinates: 52.3263°, -124.7733° EPSG:4326.



Step 5: Compare Two Days



Step 6: Explore Associated Layers (Orbit Tracks)

The screenshot displays the NASA WorldView interface. On the left, the 'Layers' panel is open, showing several categories: REFERENCE, ORBITAL TRACK, FIRES AND THERMAL ANOMALIES, and BASE LAYERS. The 'ORBITAL TRACK' section is highlighted with a yellow box, showing 'Suomi NPP - Orbit Track & Time' with a sub-layer 'Acquisition Time (UTC) - Ascending/Day'. The 'FIRES AND THERMAL ANOMALIES' section shows 'Fires and Thermal Anomalies (Day, 375m)' with a sub-layer 'Ascending/Day'. The main map area shows a satellite image of the western United States with an orange line representing the orbit track and red dots representing fire locations. A time slider at the bottom shows the date '2022 OCT 08' and a '1 DAY' interval. A search bar at the top right contains the text 'Search for places or enter coordinates'. A scale bar at the bottom right shows '200 km' and '100 mi'. The coordinates '47.5332°, -132.9617° EPSG:4326' are displayed at the bottom right.



Step 7: Explore Geostationary Layers

The screenshot shows the NASA WorldView interface. On the left, the 'Layers' panel is open to the 'Geostationary' category. The 'GOES-East' layer is selected and highlighted with a yellow box. Below it, the 'Clean Infrared (10.3 μm, Band 13, 10 minute)' variable is also highlighted with a yellow box. A yellow callout box with text is overlaid on the interface, stating: 'Click Add Layers and select Featured. Then select satellite and variable'. The '+ Add Layers' button is also highlighted with a yellow box. On the right, a pop-up window for the 'GOES-East' layer is open, showing a thumbnail of Earth and a list of variables. The 'Clean Infrared (10.3 μm, Band 13, 10 minute)' variable is checked. Below the thumbnail, the temporal coverage is shown as '2021 AUG 30 08:40Z - Present'. A note states: 'This layer is generally available for the most recent 90 days, though certain historical ranges are also preserved.' Below the note, a paragraph describes the GeoColor layer: 'The GeoColor (True Color (Day), Multispectral blended infrared (IR; at Night)) layer from the GOES-East Advanced Baseline Imager (ABI) provides an approximation to daytime True Color imagery. The combination of spectral bands yields an appearance similar to what the human eye would perceive for land surface, oceanic and atmospheric features, with atmospheric correction used to make the appearance of these features sharper. Thus it is used primarily for the intuitive interpretation of meteorological and surface-based features such as smoke, blowing dust, and vegetation types (forests, deserts, croplands, etc.). At night, the true color imagery gives way to IR-based blended multispectral imagery that provides differentiation between low liquid water clouds (shown in light blue) and higher ice clouds (shown in gray/white). It also includes a static city lights/night lights database derived from the VIIRS Day/Night Band, which aids in geo-referencing and can help determine the proximity of clouds (such as fog) or



Step 7: Explore Geostationary Layers

The screenshot displays the NASA WorldView interface. On the left, a sidebar contains a 'Layers' panel with the following sections:

- REFERENCE**
 - Place Labels (© OpenStreetMap contributors, Natural Earth)
 - Coastlines / Borders / Roads (© OpenStreetMap contributors)
 - Coastlines (© OpenStreetMap contributors)
- GEOSTATIONARY**
 - Clean Infrared (10.3 μm, Band 13, 10 minute) (GOES-East/ABI)
- BASE LAYERS**
 - Corrected Reflectance (True Color) (NOAA-20 / VIIRS)
 - Corrected Reflectance (True Color) (Suomi NPP / VIIRS)

The main map area shows a global view with a color-coded geostationary infrared layer overlaid on a grayscale base layer. A search bar at the top right contains the text 'Search for places or enter coordinates'. At the bottom, a timeline shows the date '2022 DEC 01 17:12Z' and a '10 MINUTE' interval. A scale bar indicates 2000 km and 1000 mi. Coordinates '65.7769°, -48.8922°' and 'EPSG:4326' are displayed in the bottom right corner.

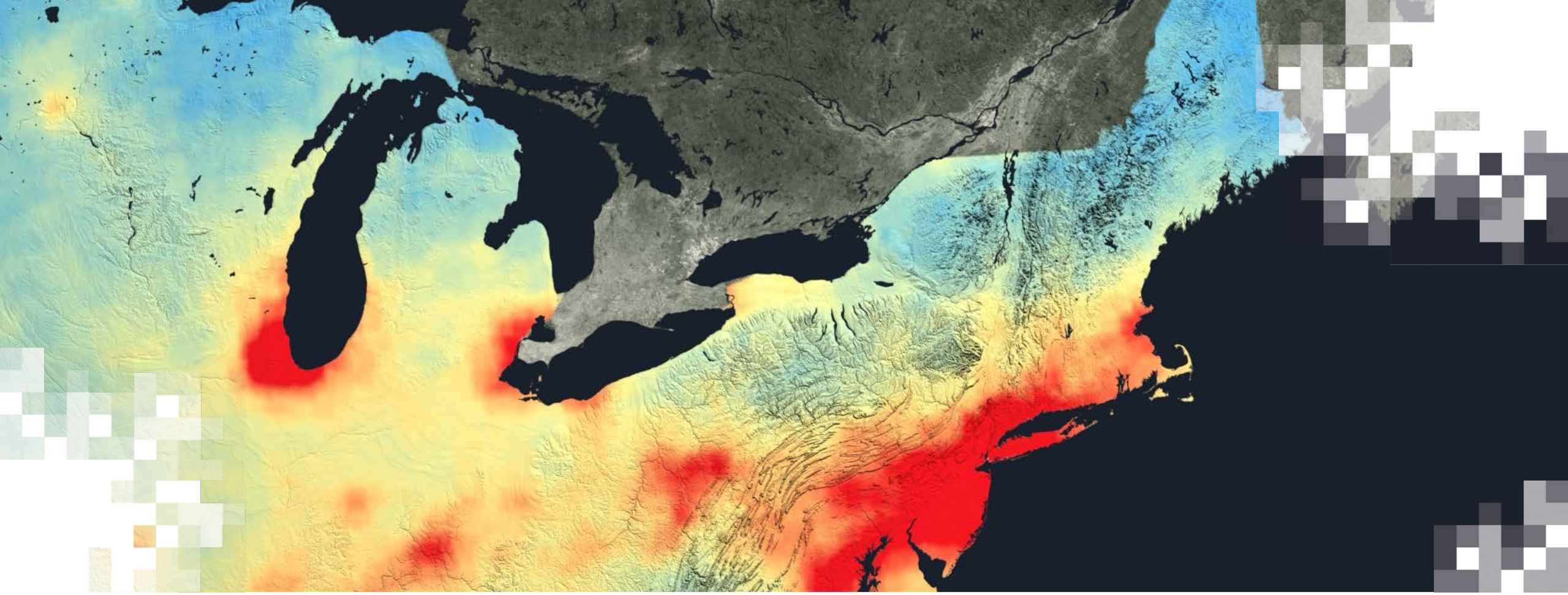
Higher temporal frequency available for creating maps and animations (every 10 minutes)



Exercise:

- Use the Date Selection at the bottom of the page and go to the date of an air quality event.
 - Suggestions:
 - Australian Fires, Jan 2-3, 2020
 - Dixie Fire, CA, July 14, 2021
 - Hunga Tonga-Hunga Ha'apai Eruption, Jan 15, 2022
 - Mauna Loa Eruption, Dec 4, 2022
- Zoom in on the region of the air quality event using the '+' and '-' sign on the top right side of the page.
- Explore the different base layer options (top, left side of the page).
- Change the date to see the progress of the event over several days. You can use the animation feature (camera sign on bottom left side) to create an animation.
- Add an additional interesting layer (e.g., MODIS/VIIRS AOD, fire detection, OMPS SO₂).





NOAA JSTAR Mapper

NOAA JSTAR Mapper

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

The screenshot displays the NOAA JSTAR Mapper web application. The main view is a satellite image of North America, showing two prominent storm systems: a large cyclone over the Gulf of Mexico and another over the Atlantic Ocean. The interface includes a left-hand control panel with the following elements:

- JSTAR Mapper** logo and NOAA logo.
- Navigation icons: back, zoom in (+), zoom out (-), and download.
- Projection** section: Date set to 08 Mar 2023, Projection set to Global Day.
- Layer 1** (Active):
 - NOAA-20 (selected)
 - Land (selected)
 - I-Band Fire Radiative Power (selected)
 - Opacity slider set to approximately 50%.
- Layer 2** (Inactive): Show
- Layer 3** (Inactive): Show
- Non-product layers** (Inactive): Show



NOAA JSTAR Mapper

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

The screenshot displays the NOAA JSTAR Mapper interface. On the left, a control panel includes a 'Date' field set to '08 Mar 2023', a 'Projection' dropdown set to 'Global Day', and a 'Layers' section with three active layers: 'NOAA-20', 'Land', and 'I-Band Fire Radiative Power'. The main map area shows a satellite view of North America with two large storm systems. Annotations with orange boxes and arrows point to the 'Download Snapshot' button (top right), the 'Zoom in/out' controls (center left), and the 'Layers' panel (left side).



Step 0: Change Background Layers (If Desired)

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

The screenshot displays the JSTAR Mapper web application interface. On the left, there is a control panel with the following elements:

- Projection:** 08 Mar 2023, Global Day
- Layer 1:** NOAA-20, Land, I-Band Fire Radiative Power, with an opacity slider.
- Layer 2:** (Collapsed)
- Layer 3:** (Collapsed)
- Non-product layers:** A list of checkboxes including N20 VIIRS True Color, N20 VIIRS granules, Road map, Surface type, Set background color, Borders (checked), and Title.

A yellow callout box labeled "Background Layers" is positioned over the "Non-product layers" section. The main map area shows a satellite-style view of North America and the surrounding oceans, with various geographical labels and a grid overlay.



Step 1: Select Satellite

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

The screenshot displays the JSTAR Mapper web application interface. The main map shows North America and the surrounding oceans. On the left side, there is a control panel with the following elements:

- Projection:** Global Day (dropdown menu)
- Satellite Selection:** A dropdown menu with options: NOAA-20, Suomi NPP, GCOM W-2, and Sentinel 5P (selected). A yellow box labeled "Select Satellite" highlights this menu.
- TROPOMI products:** Carbon Monoxide (dropdown menu)
- Opacity:** A slider control.
- Layer 2:** A button with a plus sign and a "Show" checkbox.
- Layer 3:** A button with a plus sign and a "Show" checkbox.
- Non-product layers:** A list of checkboxes:
 - No background image available
 - S5P TROPOMI granules
 - Road map
 - Surface type
 - Set background color
 - Borders
 - Title



Step 2: Select Product Category & Product

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

The screenshot displays the JSTAR Mapper web application interface. The main map shows North America with various geographical features and city labels. On the left side, there is a control panel with the following elements:

- JSTAR Mapper** logo and NOAA logo.
- Projection: 08 Mar 2023, Global Day.
- Layer 1** (expanded):
 - Carbon Monoxide
 - Methane
 - Nitrogen Dioxide** (highlighted with a blue bar and a yellow box labeled "Select Product")
 - Aerosol Index
- Layer 2** (collapsed)
- Layer 3** (collapsed)
- Non-product layers**:
 - No background image available
 - SSP TROPOMI granules
 - Road map
 - Surface type
 - Set background color
 - Borders
 - Title



Step 3: Toggle Layer to Display on Map

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

The screenshot displays the JSTAR Mapper web application interface. The main map shows a satellite view of North America with a Nitrogen Dioxide (NO₂) layer overlaid, showing concentrations in blue and red. The sidebar on the left contains the following controls:

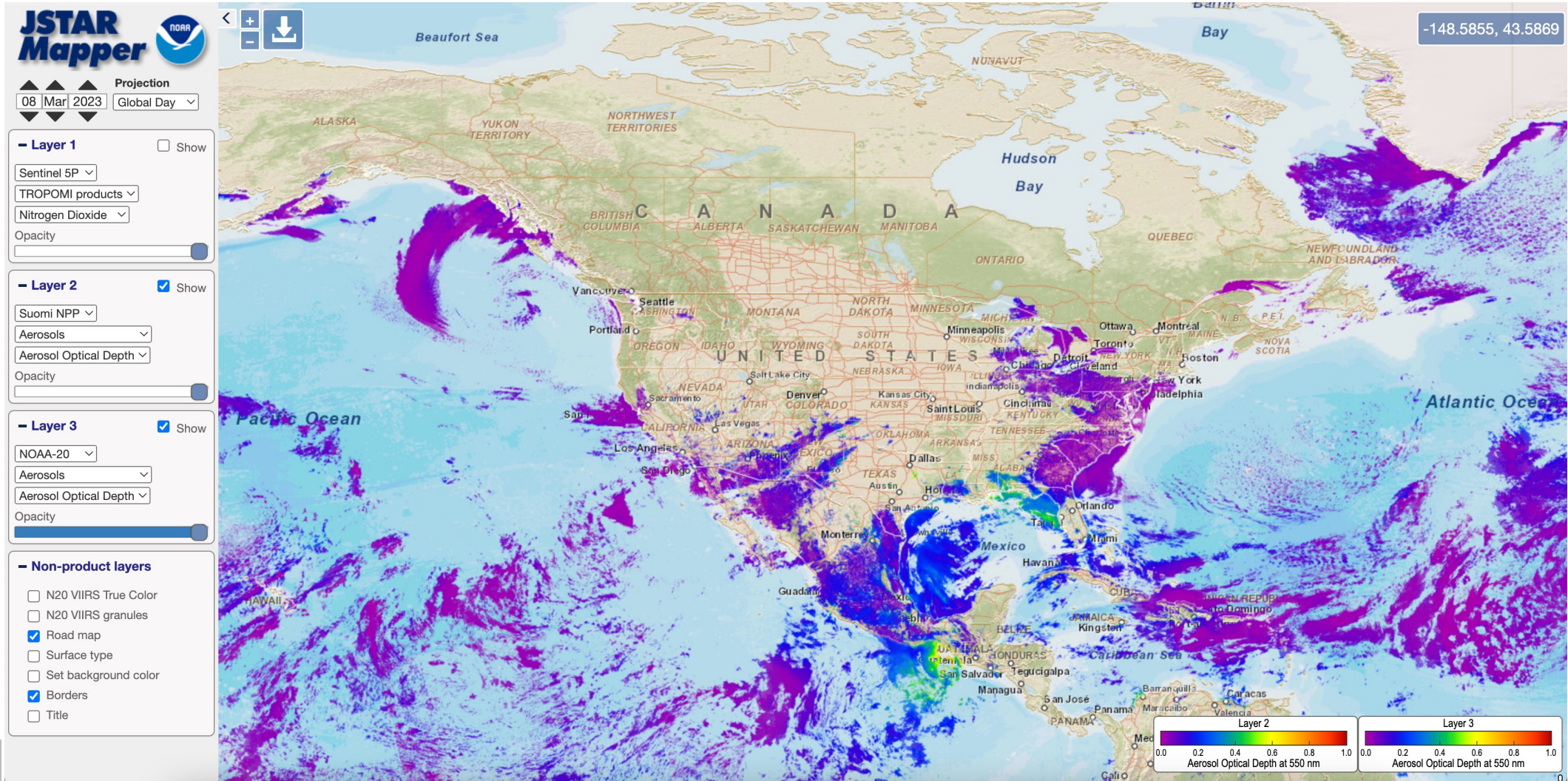
- Projection:** 08 Mar 2023, Global Day
- Layer 1:** Show. Includes dropdowns for Sentinel 5P, TROPOMI products, and Nitrogen Dioxide. An orange box labeled "Toggle Layer" highlights the "Show" checkbox.
- Layer 2:** Show
- Layer 3:** Show
- Non-product layers:**
 - No background image available
 - S5P TROPOMI granules
 - Road map
 - Surface type
 - Set background color
 - Borders
 - Title

The legend in the bottom right corner, titled "Layer Legend", shows a color scale for "Layer 1" representing Nitrogen Dioxide (10⁴ mol/m²) with values from 0 to 1.0.



Step 4: Compare Multiple Products in Different Layers

<https://www.star.nesdis.noaa.gov/jpss/mapper/>



Step 5: Visualize Trace Gas Sounding Products

<https://www.star.nesdis.noaa.gov/jpss/mapper/>

