Visualizing, Exploring, and Communicating Environmental Effects of COVID-19 Using Earth Observation Dashboard



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IGARSS 2021

NASA-ESA-JAXA Cooperation in response to COVID-19

- COVID-19 pandemic has caused changes in socio-economic activities and some of the activities have impacted the environment.
- In April, JAXA, NASA and ESA launched a collaboration to analyze the changes in the global environment and socio-economic activities due to the pandemic using Earth observation data from the three agencies.
- Dashboard is a consolidated display of related information in a single place to compare and monitor a variety of data simultaneously.
- Integration of multiple data records with analytical tools to allows user-friendly tracking of changes in air and water quality, climate change, economic activity, and agriculture.



Goals

- ESA-NASA-JAXA collaborative response to COVID-19 using complementary EO assets
- EO data-driven dashboard to clearly communicate various indicators:

    Before the COVID-19 (baseline)

    Current situation

    Trend analysis

- Inform the public (Scientists, Policymakers, Journalists, Citizens) on impact of the pandemic on environment

Dashboards

- A dashboard is a consolidated display of related information in a single place.
- It is used to compare and monitor a variety of data simultaneously.
- Data driven insights - Different data views are displayed all at once.



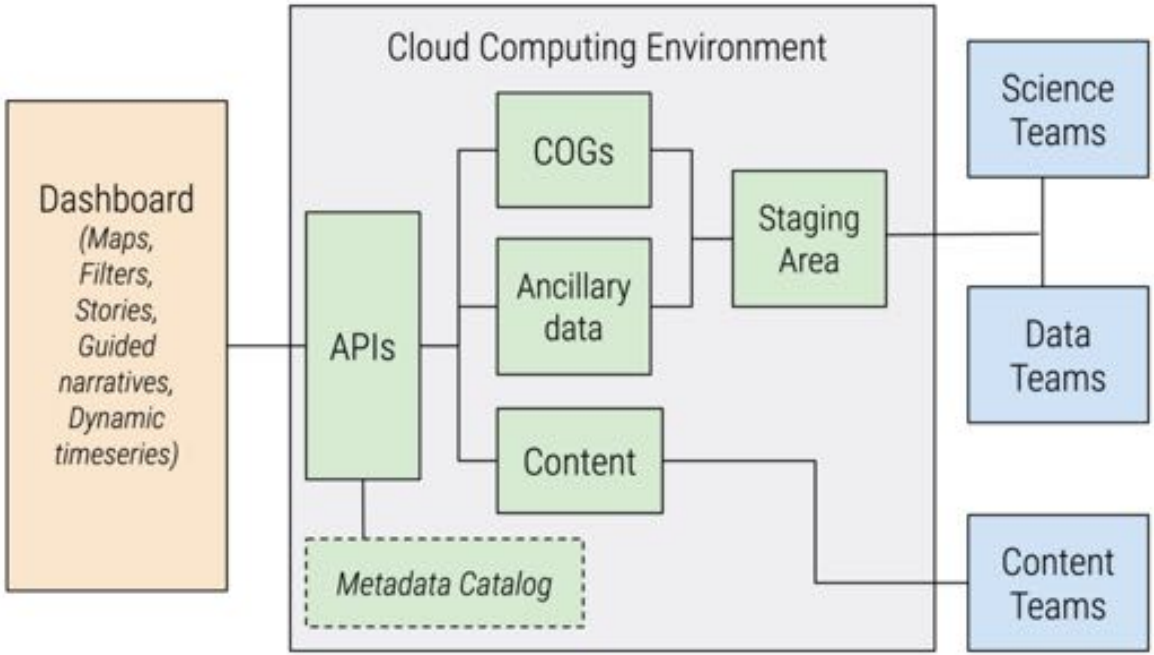
Indicators

- Air quality
- Greenhouse gases
- Water quality
- Agricultural activity
- Economic activity
  - Mobility activity
  - Energy and transportation use at night
  - Transport of people and goods

Challenges

- Integration of heterogenous datasets from different satellite remote sensing sensors
- Collection of data at a range of spatial and temporal scales
- Gaps in satellite data due to sensor design and sensor's inability to capture useful data during certain atmospheric conditions
- Inconsistent metadata and different metadata profiles
- Complex analytical techniques and data fusion to derive environmental indicators
- Accelerated timeline and resources for timely release of dashboard

Architecture



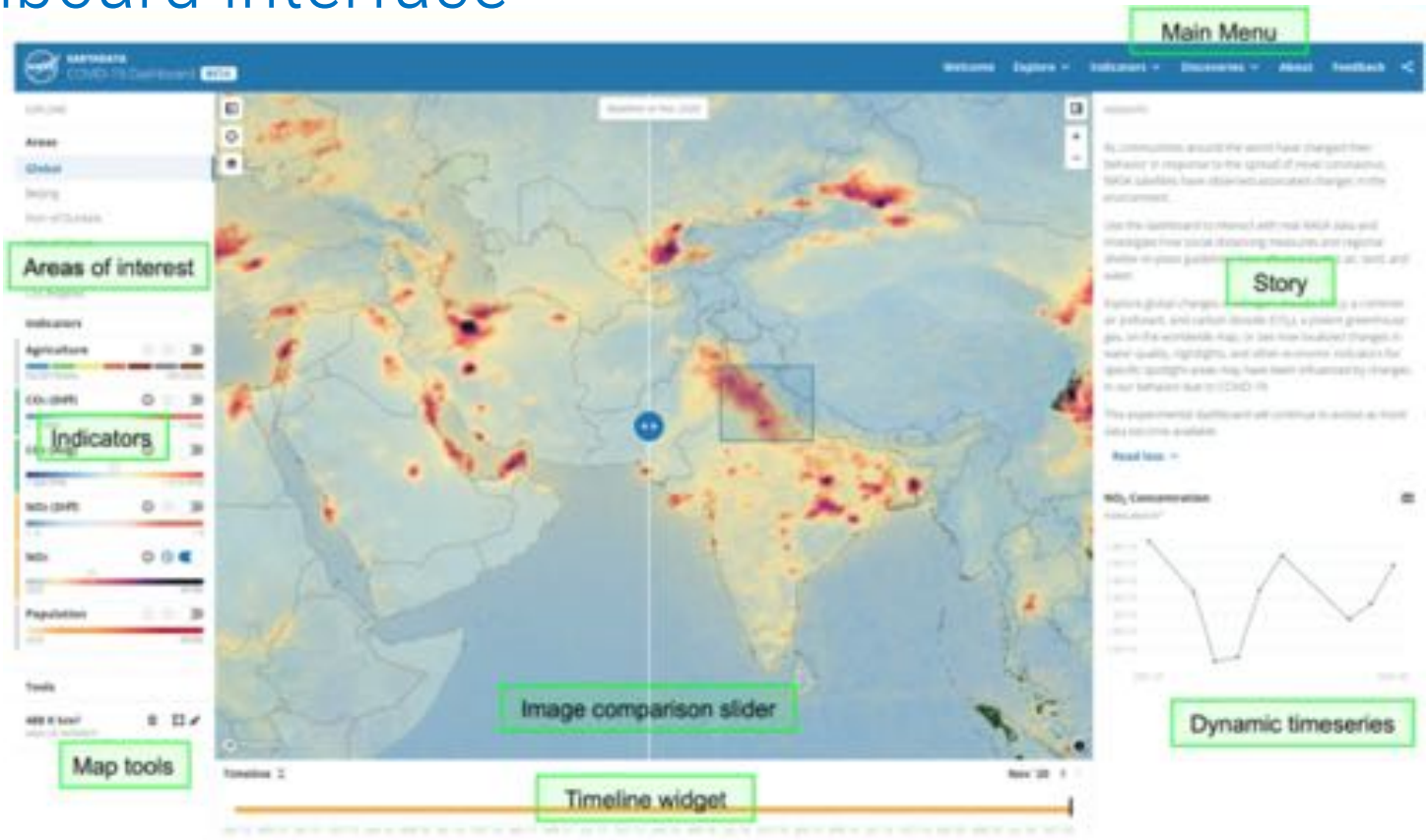
Dashboard system architecture

Indicator visualization

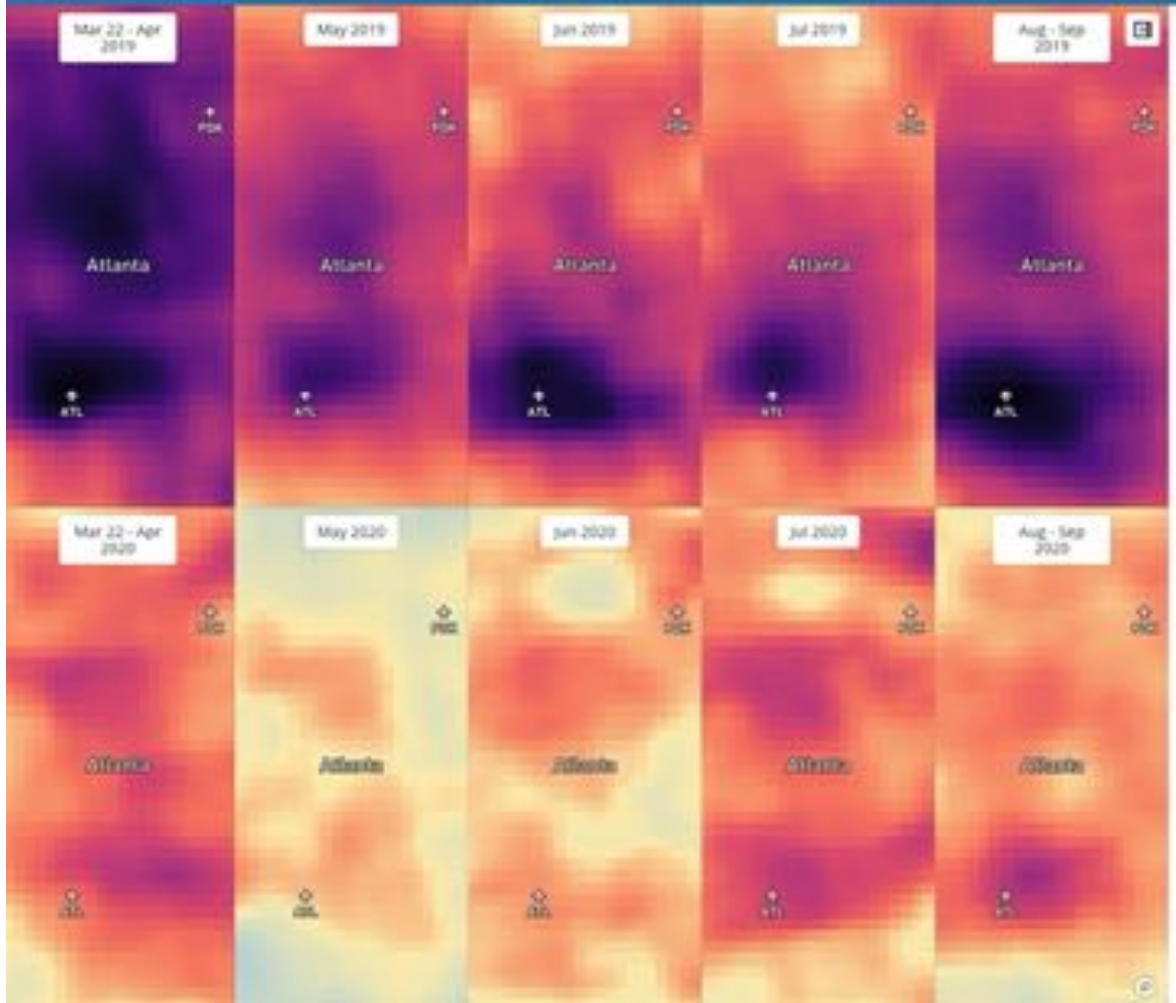
Indicator	Parameter	Data Sources	Display/Interaction	Area of Interest	Frequency
Air quality	NO_2 Concentration	OMI	COGs, Map, Timeline, Comparison slider, Dynamic Timeseries	Global	Monthly
Greenhouse Gas/Climate	Atmospheric CO_2 Level	OCO-2, GOSAT, GOSAT-2	COGs, Map, Timeline, Comparison slider, Dynamic Timeseries	Global	Daily
Water quality	Chlorophyll-a concentration, Turbidity	Landsat-8, MODIS,VIIRS,GCOM-C	Map, Timeline	Great Lakes, New York, San Francisco	Weekly
Agriculture activity	Crop outlook, Planting and harvest status	MODIS, GPM, Landsat-8, Sentinel-2, GCOM-C, ALOS-2	Map, Timeline	Global, Togo	Monthly
Economic activity	Shipping activity (Ship counts)	PlanetScope	Detection Polygons, Bar Chart	New York, San Francisco, Los Angeles	Monthly
	Car activity (parked car density)	Sentinel-1, ALOS-2, SkySat	Map, Bounding polygons	Beijing, Port of Dunkirk, Port of Ghent, New York, San Francisco, Los Angeles, Tokyo, Togo	Lockdown Recovery period
	Night Lights	VIIRS, Landsat-8	Map, GeoTiff	Beijing, Port of Dunkirk, Port of Ghent, New York, San Francisco, Los Angeles, Tokyo	Daily/Monthly
	Airport throughput (airplane counts)	PlanetScope	Detection Polygons, Count Line Chart	New York, San Francisco, Los Angeles, Tokyo	Selected dates

COVID-19 dashboard indicators, data sources, visual attributes, spatial extents, and temporal frequencies

Dashboard interface



https://earthdata.nasa.gov/covid19/



MEASURING AIR POLLUTION ON THE GROUND AT AIRPORTS

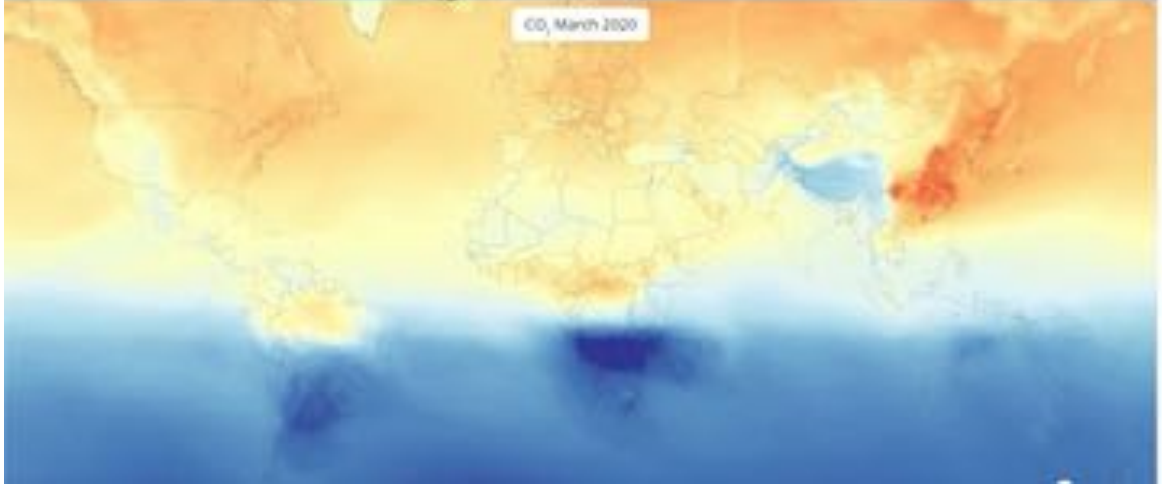
New research during the pandemic is also looking at how COVID-related travel bans are impacting air quality around airports. Current conditions create a unique opportunity to study airport-related pollutants, especially nitrogen dioxide and formaldehyde. While travel bans and strict regulations around air travel have been in place, air traffic has yet to return to previous levels, and many planes remain grounded. Scientists have installed two sensors at the Baltimore-Washington International Airport and two sensors at the Hartsfield-Jackson Atlanta International Airport to better characterize how airplanes contribute to air pollution. They are comparing the on-the-ground sensor information from NASA's Pandora Project with satellite information from TROPOMI. So far, they have found that nitrogen dioxide hotspots in Atlanta shifted from the airport, shown here, to the city center from April-June 2020. By September, however, satellites revealed the airport had reemerged as a dominant nitrogen dioxide emission source.

About the data

NO_2 levels

Levels in 10^{15} molecules cm^{-2}. Darker colors indicate higher nitrogen dioxide (NO_2) levels associated and more activity. Lighter colors indicate lower levels of NO_2 and less activity.



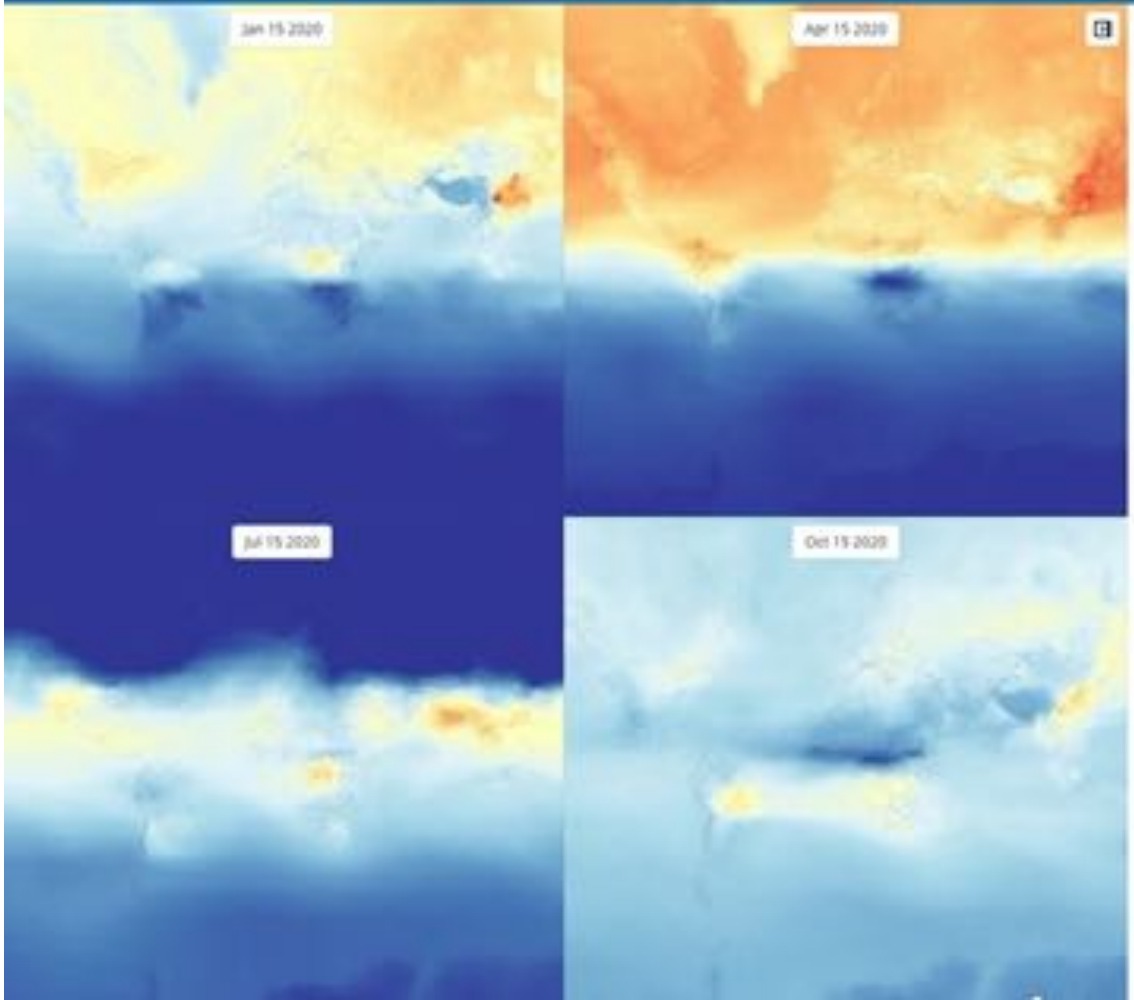


THE DIFFERENCE BETWEEN CO_2 AND NO_2

Unlike nitrogen dioxide, which dissipates in the atmosphere a few hours after emission, carbon dioxide can last for centuries. Because of this, nitrogen dioxide emissions are typically more localized, while winds can carry carbon dioxide emissions far from their original source. This creates a smooth, global distribution pattern for carbon dioxide, such as the one seen here, as new emissions mix with the surrounding air. As a result, atmospheric carbon dioxide concentrations are relatively steady over the entire planet. This makes it very difficult to discern the impact of temporary changes in carbon dioxide emissions during coronavirus-related shutdowns, as scientists expected that any observed fluctuations would be no larger than 0.1% below normal levels. Teasing out the impacts of such reductions for specific locations during the pandemic has required NASA and its partners in the Japan Aerospace Exploration Agency (JAXA) to use advanced modeling and develop new analysis techniques.

About the data

Top: darker colors indicate higher nitrogen dioxide (NO_2) levels associated and more activity. Lighter colors indicate lower levels of NO_2 and less activity. Bottom: redder colors indicate more CO_2. Blues colors indicate less CO_2.



CO_2 IN THE NATURAL CARBON CYCLE

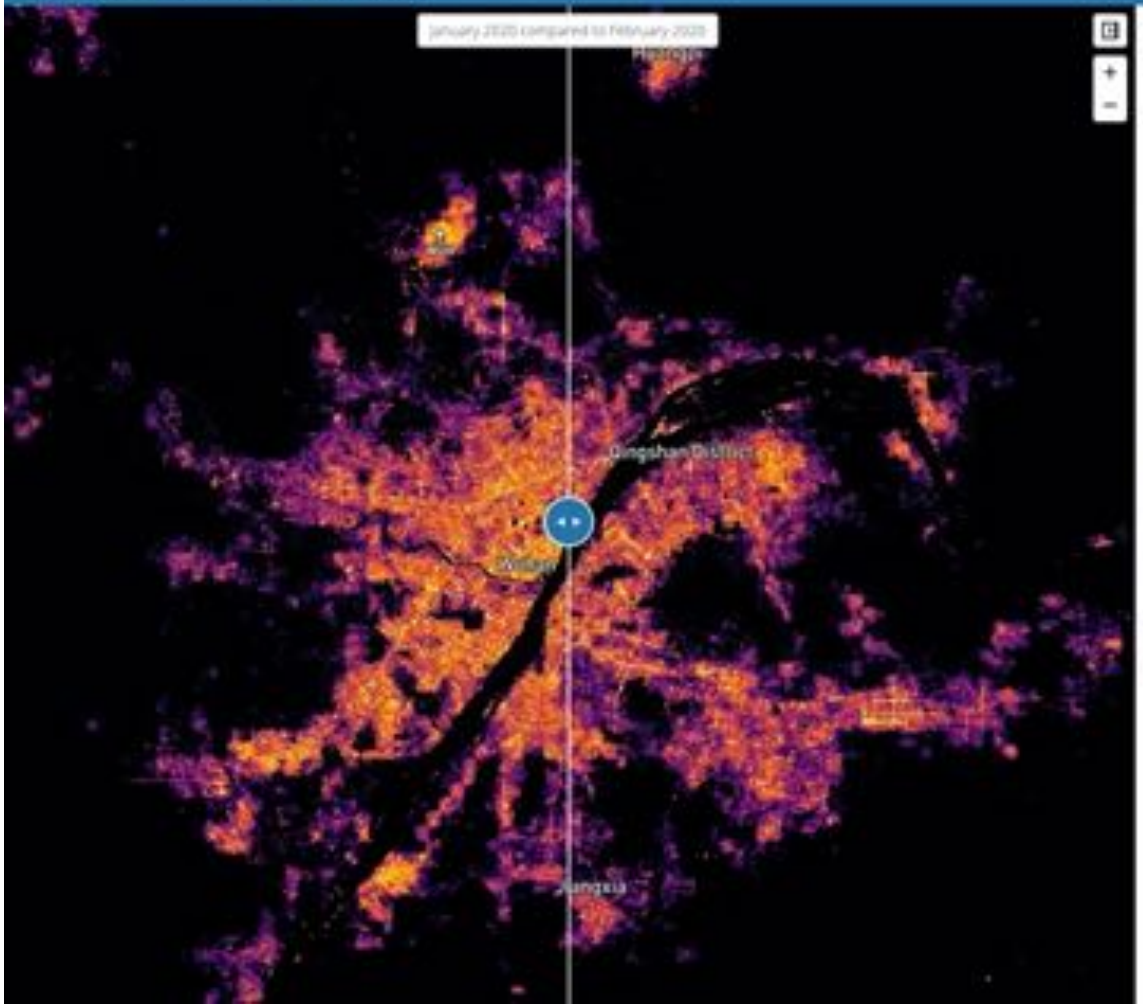
Further complicating the ability to discern pandemic-related changes in carbon dioxide concentrations is the fact that initial lockdowns corresponded with the beginning of spring in the Northern Hemisphere – when trees and other plants begin to rapidly absorb carbon dioxide from the atmosphere. Trees, grasslands, and other land ecosystems absorb billions of tons of carbon dioxide as they bloom in the spring and then release most of that carbon dioxide back into the atmosphere as they decay in the fall. The ocean also exchanges billions of tons of carbon dioxide with the atmosphere each year. Typically, these components of the natural carbon cycle are reasonably well balanced when averaged over the year: absorbing about as much carbon dioxide as the emit, along with about half of the carbon dioxide produced by human activities. However, seasonal swings in the uptake and release of carbon dioxide by plants on land, and temperature and rainfall changes associated with naturally occurring climatological phenomena such as the El Niño Southern Oscillation, can mask any smaller changes related to the COVID-19 pandemic.

About the data

CO_2 - 16 day average

< 404 PPM > 415 PPM

This layer shows the average background concentration of carbon dioxide (CO_2) in our atmosphere for 2020. Redder colors indicate more CO_2. Bluer colors indicate less CO_2.



A DIMMER WORLD DURING THE PANDEMIC

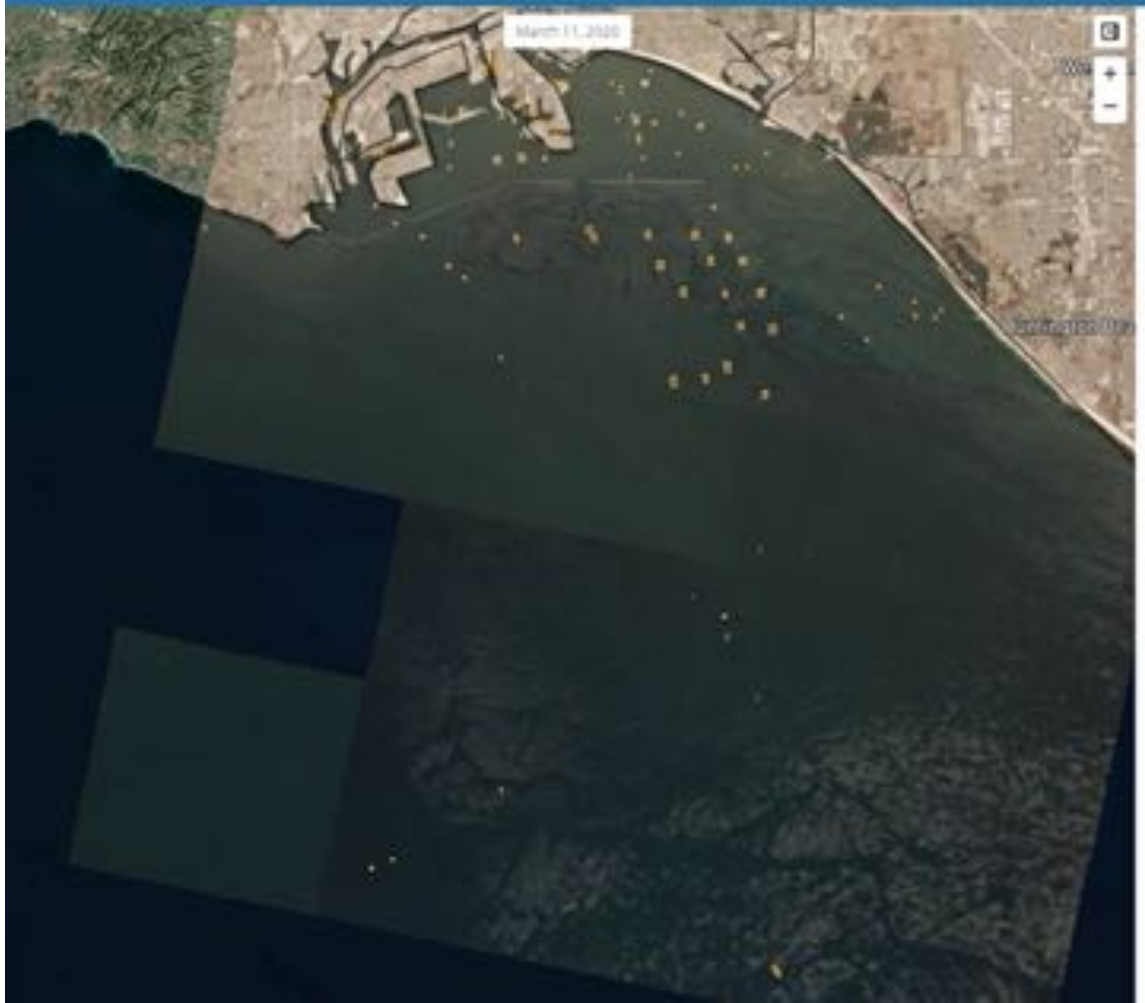
When China implemented restrictions on businesses in the early months of 2020, NASA researchers documented changes in nighttime lights throughout the region. Images of Earth at night provide an extraordinary view of how human activity changes over time. During the COVID-19 pandemic, scientists are using satellite observations to track variations in nighttime lights, which show changes in transportation, energy use, and migration as human response to the pandemic evolves. From January through February 2020, nighttime lights in the central commercial district of Wuhan dimmed as people stayed home instead of shopping or socializing. Even highways, represented by the bright lines in the satellite imagery, darkened with less activity during shutdown periods.

About the data

Nightlights HD

LESS MORE

The High Definition Nightlights dataset is processed to eliminate light sources, including moonlight reflectance and other interferences. Darker colors indicate fewer night lights and less activity. Lighter colors indicate more night lights and more activity.

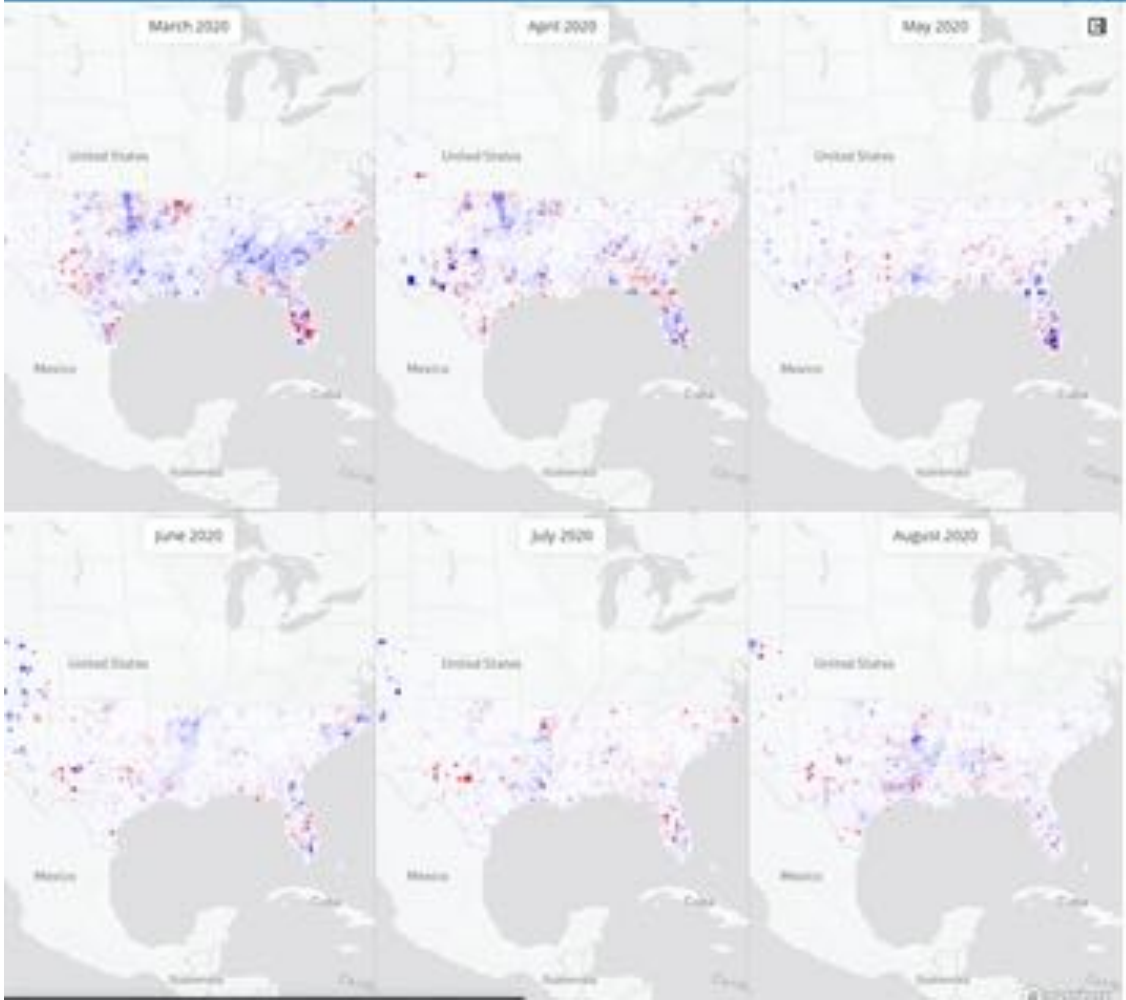


TRACKING CHANGES IN PORTS

It wasn't just ground transportation in Los Angeles that was affected by COVID-related shutdowns – its port also showed less activity. During the pandemic, supply chains around the world dependent on cargo shipping saw interruptions as many ports closed, shipments canceled, and in some locations, altered routes prevented the efficient movement of cargo. According to the Port of Los Angeles, its port saw a 19% reduction in shipping cargo volume during the early months of the pandemic, compared to the same time period in 2019. The image here shows a reduction in the number of ships at the port, which could potentially also affect the area's overall water quality.

About the data

Ships detected in PlanetScope imagery are shown in orange.



FEWER PRESCRIBED BURNS DURING THE PANDEMIC

Limits on work and travel during the pandemic also affected how humans interact with the natural environment. For example, satellites observed a reduction in managed forest fires, otherwise known as prescribed burns, on federal lands. Prescribed burns are an important way to reduce fuel loads and maintain biodiversity. In March 2020, the U.S. Forest Service and other federal agencies temporarily suspended all prescribed burns on federal lands in the Southeast United States. State agencies in Mississippi, South Carolina, and North Carolina also issued spring burning bans in response to the COVID-19 pandemic. The Forest Service's suspension aimed to prevent virus exposure to employees and to reduce smoke exposure to vulnerable communities, since COVID-19 is a respiratory illness. Using fire data from the Visible Infrared Imaging Radiometer Suite (VIIRS) on the Suomi NPP satellite, researchers at NASA's Goddard Space Flight Center detected a 42% reduction in active fires in the Southeastern U.S. this spring compared to previous years.

About the data

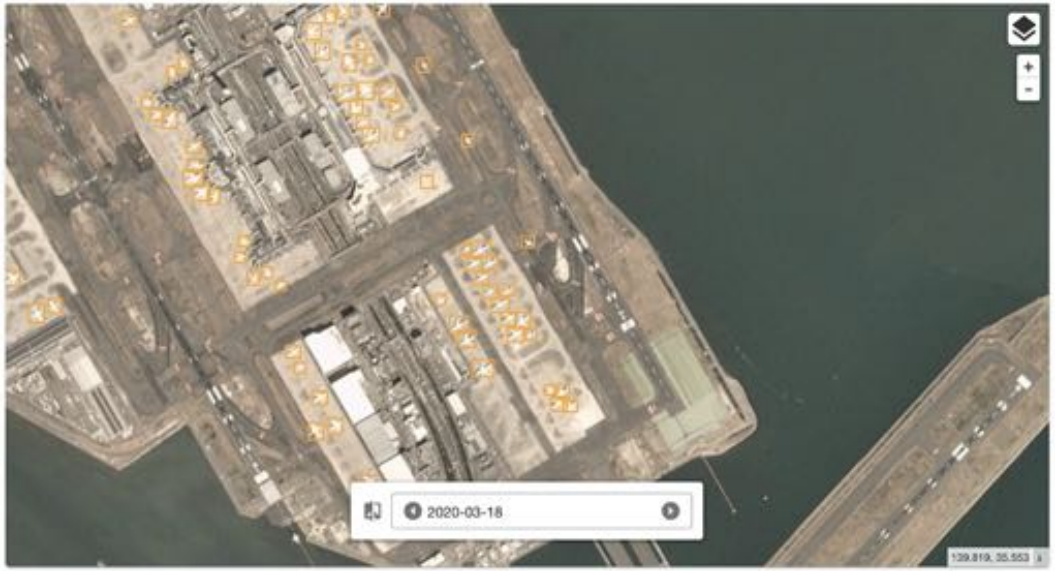
Fire anomalies

-100% +100%

This data shows the change in active fires compared to the baseline of 2012-2019.

Indicator example: Airport - throughput

Number of airplanes at parking areas in Tokyo International Airport based on ALOS-2 PALSAR-2, Sentinel-1 and Planet (with automatic plane detection in HR imagery)





Impacts

Enabling open science

- Space Apps COVID-19 challenge
- Maximizing the impact of science data
- Open source/Contribution
- Collaborative cloud infrastructure
- Collaboration Science/Communication/Data teams
- Reusable process and platform
- Hackathon



Lessons learned

- Swim lanes across the project teams to develop consensus and identify bottlenecks
- Synergy across virtual teams by hosting information and documents in shared location for ease of access and collaboration
- Tools for tracking issues and updates – allows data providers direct access to development team
- Metrics to explore new methods of presenting data
- Standardized data formats across teams to enable ease of data ingest into dashboard



Thank you.

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https://earthdata.nasa.gov/covid19/
https://github.com/NASA-IMPACT/covid-dashboard

