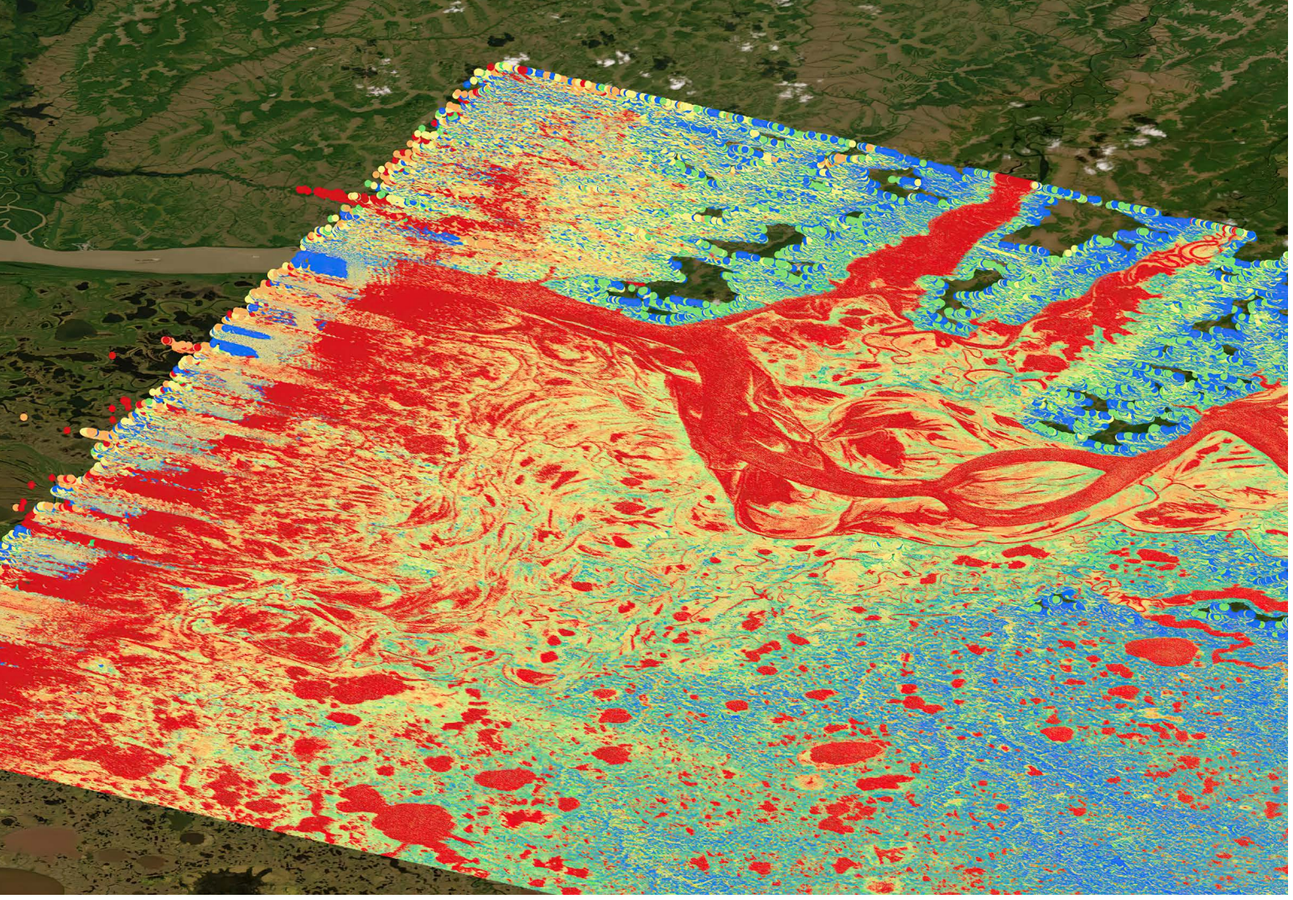
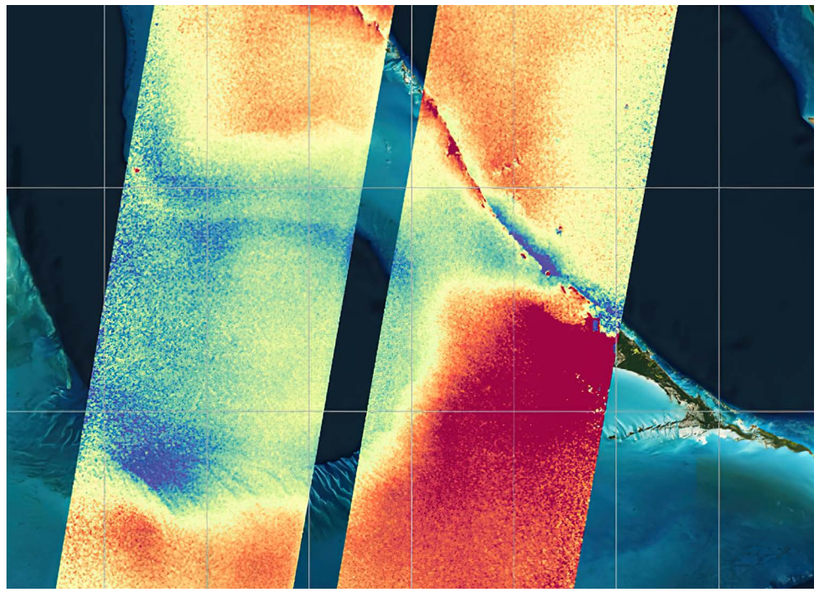
EARTH SCIENCE

Left: An artist's concept of the Surface Water and Ocean Topography spacecraft orbiting Earth

Climate change is here now, impacted by and impacting every population on the planet. Measurement and analysis are critical to adaptation and mitigation. A new JPL mission surveys nearly all the world's lakes and large rivers. Another has spotted hundreds of methane sources. And a future mission will monitor land movements with game-changing frequency.





Above: *SWOT passed over the Yukon River in Alaska and recorded this data during a period of calibration and validation, when a mission tests the reliability and precision of its instruments. The satellite aims radar beams at Earth and measures how they scatter off the surface. Backscatter from water tends to be stronger than from solid ground, enabling SWOT to distinguish the two with high accuracy.*

Left: *The mission also measures variation in sea surface height. These two swaths show the fine details of sea levels in the Caribbean Sea, with red areas representing higher elevations.*

Raise a Glass... of Water

As the Earth's climate changes, the distribution of water on the planet is also changing.

This is leading to changes in water availability, especially in areas subject to frequent drought or flooding.

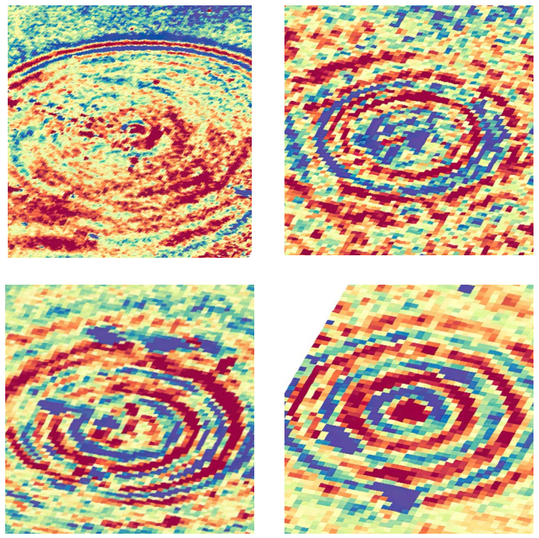
The Surface Water and Ocean Topography mission, a collaboration between NASA and the French Space Agency, launched in Dec. 2022 to achieve the first global survey of Earth's surface water, namely rivers, lakes, and oceans, with unprecedented accuracy. Surface water is essential for human consumption, household use, agriculture, hydroelectric power, and many industries.

SWOT's performance, as seen in images and data, is already exceeding expectations. Using radar technology, the solar-powered spacecraft scans over 90 percent of the planet every 21 days. It measures 95 percent of the world's lakes larger than 15 acres and gathers data on rivers wider than 330 feet, allowing researchers to better understand how climate change is affecting the planet's water cycle.

The mission's instruments also monitor the oceans, allowing scientists to better track sea level changes. The information will help societies better understand the consequences of sea level rise and develop strategies that support worldwide coastal community and ecosystem planning and management in the face of increasing tides and surges. With its enhanced spatial resolution, SWOT is also observing finer features in the ocean, providing oceanographers with profound new insights into the transport of energy and nutrients around the globe.

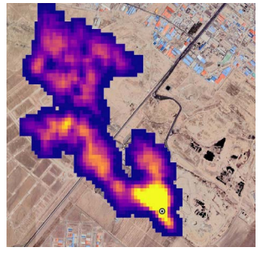
SWOT is expected to continue collecting data for at least three years, delivering the most comprehensive view of the world's surface water. The mission will help improve our ability to predict and respond to natural disasters, such as floods and droughts, and its findings will benefit all decision-making that involves water management.

Next time you raise a glass of drinking water, consider: SWOT has most likely surveyed it and will be back to check on its health.



Right: *SWOT observed circular waves forming around icebergs in polar oceans.*

A Side Hustle on the ISS



Above: *EMIT spotted a plume of methane rising from a landfill.*

Below: *EMIT attached to the ISS in the bottom left of the lattice framework in front of the solar panels*

NASA's plan for its Earth Surface Mineral Dust Source Investigation instrument was to focus on the climate impacts of lofted dust particles. But since docking to the International Space Station in July 2022, EMIT has become an unlikely climate hero for a different reason.

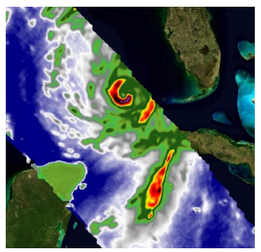
EMIT was born from a desire to track Earth's mineral dust cycle. Winds in our atmosphere kick up dust from arid regions and carry the particles elsewhere. These opaque air currents can have significant and predictable long-term climate effects on regions far from the dust source.

The spectrometer on EMIT detected the dust as expected. Unexpectedly, the instrument also showed extraordinary sensitivity to large and small methane emissions, from tens of thousands to just hundreds of pounds per hour. Within weeks of entering orbit, EMIT had become a "super-emitter" detector. It has already identified over 750 point-source emissions, including from landfills, agricultural sites, and oil and gas facilities.

Methane detection is crucial in addressing the climate crisis due to its potent greenhouse effect. Methane is up to 80 times more effective at trapping heat than carbon dioxide. By pinpointing methane emission sources, EMIT enables operators and agencies to mitigate the emissions.

EMIT is still performing its original duties, it's just picked up another climate change fighting side hustle.

Locking Eyes with Cyclones



Top: *COWVR weather instrument aboard the ISS*

Bottom: *COWVR's view of Hurricane Idalia as it approached Florida's Gulf Coast*

The Compact Ocean Wind Vector Radiometer instrument, launched to the International Space Station in late 2021, is delivering critical forecast information for the most devastating of storms: tropical cyclones.

COWVR, approximately the size and weight of a mini fridge, gathers data by measuring microwave emissions from the Earth's atmosphere and surface. The data lets forecasters peer inside the center of storms and understand the processes that generate them.

The eyewall packs the strongest winds within a storm, and as the eye dilates or contracts, the wind speed can change accordingly. Reliable, frequently updated information on wind speed is crucial to tracking storms as they move between Africa's east coast and the west coast of the Americas.

COWVR incorporates technology and designs developed at JPL for the Jason series of ocean-observing satellites. Like Jason, COWVR uses a radiometer built with spinning dishes to enable broader coverage than that provided by an instrument that points straight down. For COWVR, JPL engineers managed to simplify the design, making it more power-efficient without compromising its capabilities.

To date, COWVR data are available for evaluation by forecasters at the U.S. National Hurricane Center. In addition, the Joint Typhoon Warning Center intends to take a closer look at COWVR's surface wind speed and direction data to see how they may improve tropical cyclone forecasts.

All from staring a challenge right in the eye.

Ecosystem Equalizer

NASA and the Indian Space Research Organisation are putting the finishing touches on the NASA ISRO Synthetic Aperture Radar satellite.

NISAR will scan Earth's surface every 12 days, observing the many complex natural processes of our planet — including ecosystem changes, the movements and melting of glaciers and sea ice, and the motion of the land — to better understand earthquakes, volcanic eruptions, and landslides.

The satellite carries two different synthetic aperture radars: one by NASA (the L-band SAR), and one by ISRO (the S-band). NISAR marks the first time the two space agencies are collaborating to develop an Earth-observing mission.

A main focus for NISAR will be Earth's forests and wetlands as they serve as vital carbon sinks, hoarding carbon that might otherwise float in the atmosphere as carbon dioxide and other greenhouse gases.

Forests hold carbon in the wood of their trees. NISAR's data from often cloud-covered rainforests — such as those in the Congo and Amazon basins, which lose millions of wooded acres every year — will improve our understanding of how that loss contributes to global warming.

Wetlands present another carbon puzzle: Swamps, bogs, peatlands, inundated forests, marshes, and other wetlands hold 20 to 30 percent of the carbon in their soil, despite constituting only 5 to 8 percent of the land surface.

Tracking these ecosystem changes on a global scale will help researchers understand the impacts on the carbon cycle — the processes by which carbon moves between the atmosphere, land, ocean, and living things.

NISAR is set to launch in 2024 from southern India.

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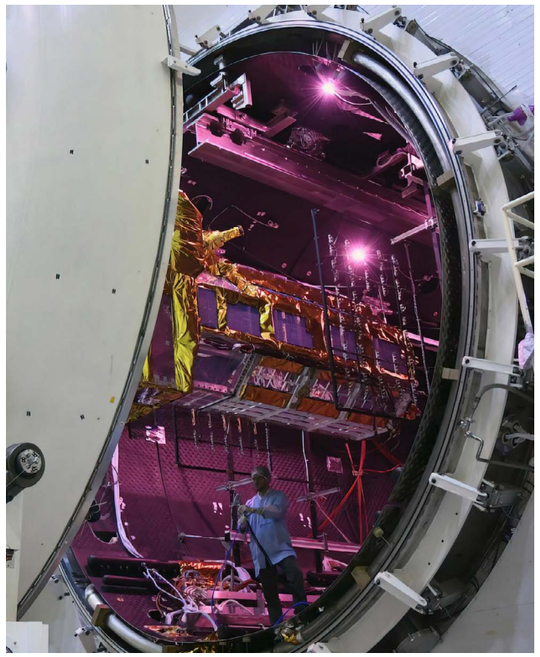
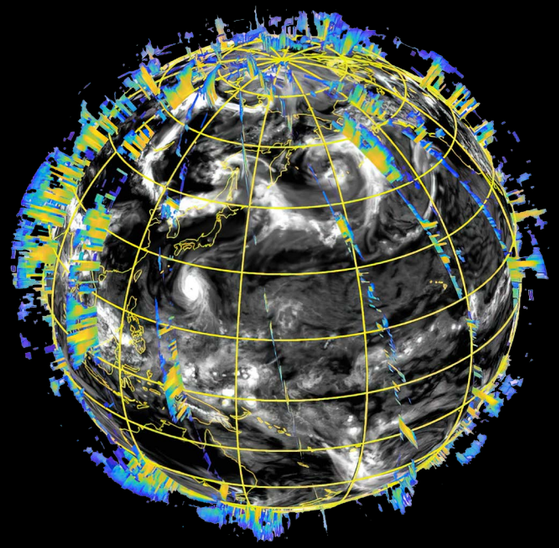


Right: *The NISAR satellite enters the thermal vacuum chamber for three weeks of testing at an ISRO facility in Bengaluru, India.*

Above: *At JPL, the NISAR science payload is packaged for shipment to ISRO headquarters in Bengaluru.*

Right: *A simulation showing the kind of images that data from the NISAR satellite will produce*



Skies Clear over Climate Change

Above: Radar data gathered by NASA's CloudSat satellite on July 31, 2007

Opposite, top: Rendering of the CloudSat spacecraft above Earth's surface

Opposite, bottom: Data collected by the CloudSat spacecraft, which was often combined with other satellites

Clouds once clouded our understanding of climate change.

Clouds exert an enormous influence on our weather and climate and represent a key element in Earth's water cycle, bringing water from the air to the ground and from one region of the globe to another. Clouds also dominate Earth's energy budget through their effect on the exchange of solar and thermal energy.

Because of these factors, even small changes in cloud abundance or distribution can influence the climate. The extent of that influence was a matter of significant scientific debate in the 1990s and early 2000s. Then came CloudSat.

Since 2006, CloudSat has been clearing the clouds on climate change by flying the first "cloud radar" — a millimeter-wavelength radar 1,000 times more sensitive to cloud properties than existing spaceborne radars — to provide the first direct global survey of cloud systems.

For 17 years, CloudSat has presented an unprecendented view of our Earth system that scientists had been long hoping for. Its observations have enabled climatologists to build more sophisticated models with better representations of clouds needed in predicting the effect of climate change and reducing uncertainty in forecasts of the global extent of warming.

CloudSat ran far past its design life, ending its run in Sept. 2023. The project delivered many firsts, including: determining how often clouds rain and snow, how much ice and water are contained in clouds globally, and how clouds heat or cool the atmosphere.

CloudSat has also fostered a global scientific community that will continue to clear our thoughts on how clouds influence the climate.

For 17 years, CloudSat has presented a view of our Earth system that scientists didn't have before.