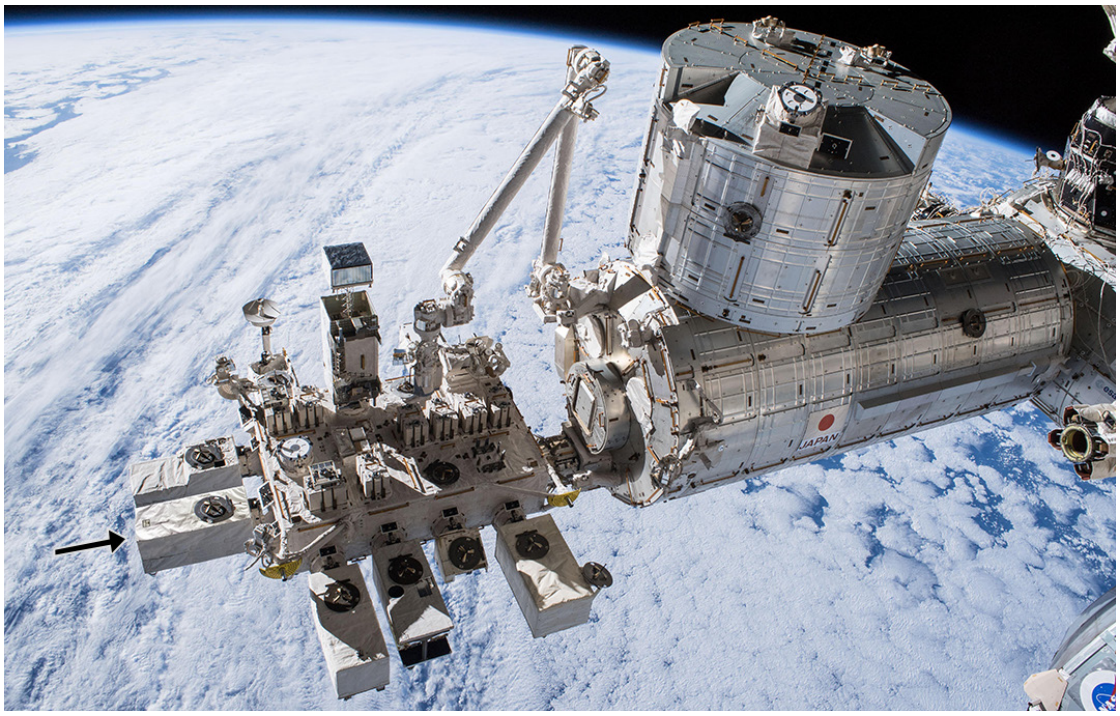
National Aeronautics and Space Administration

ECOSTRESS

ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

NASAfacts



NASA/JPL-Caltech

JPL's ECOSTRESS will launch aboard a SpaceX Falcon 9 rocket as part of a NASA-contracted commercial resupply mission to the International Space Station. It will be robotically installed on the exterior of the station's Japanese Experiment Module Exposed Facility Unit (JEM-EFU).

Humans and other animals depend on plants for their well-being. Besides supplying the oxygen we need to breathe, they provide our food, either directly or indirectly. Plants on land help keep our climate habitable by absorbing about a quarter of human-produced carbon dioxide emissions during photosynthesis.

But as Earth's climate warms and parts of the world become drier, how will plants respond to changes in water availability? Which ecosystems are most vulnerable to the impact of more frequent, longer droughts? What varieties of crops will enable farmers to keep feeding the world?

NASA's ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission is designed to provide new insights into these questions by detecting how plants are coping with heat and water stress.

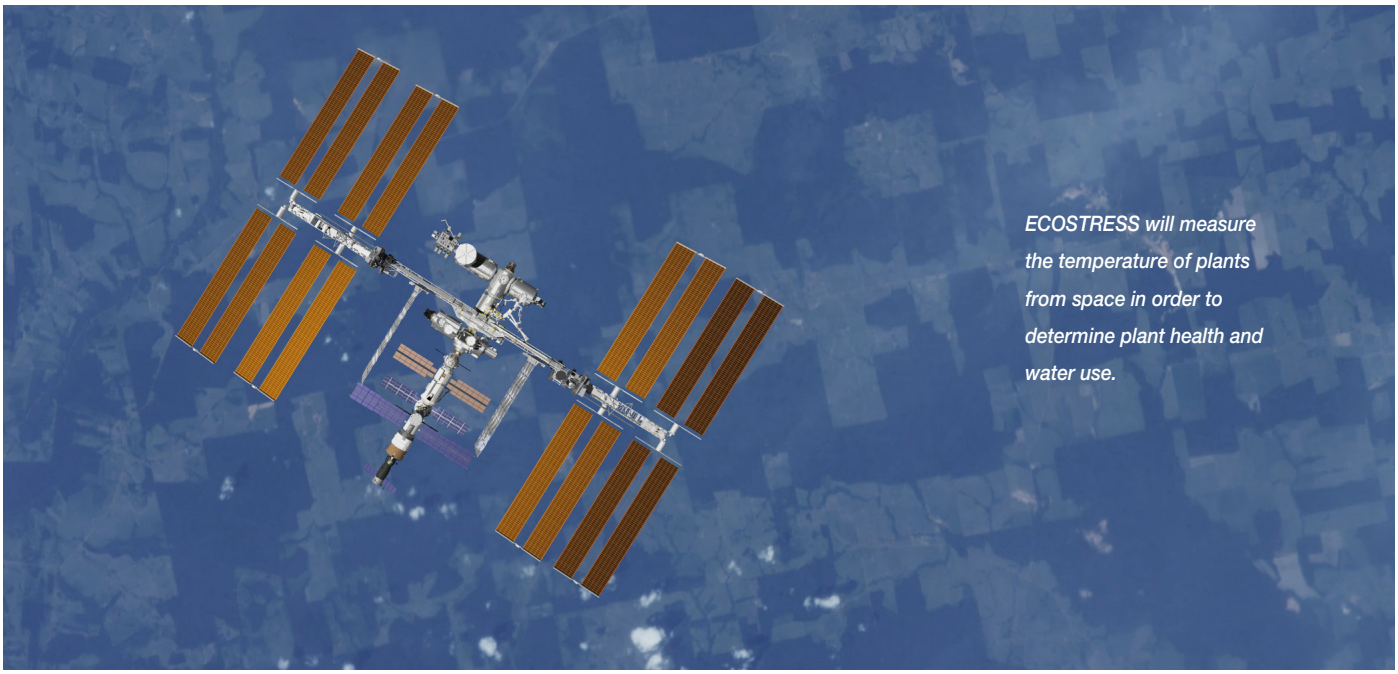
Plants draw in water from the soil through their roots, and some of that water is released through pores on their leaves. This water cools plants down -- much as humans sweat to stay cool. In hot or dry weather, plants may close these pores to conserve the water they have, causing their temperatures to rise.

This natural process has consequences. Plants use the same pores to absorb carbon dioxide from the atmosphere — to help make the "food" they need to survive. When their pores are closed, they stop absorbing carbon dioxide. If they continue to keep their pores closed due to too much heat, they will both starve from a lack of carbon dioxide, and overheat by not releasing water to stay cool.

Mission Overview

ECOSTRESS, managed by NASA's Jet Propulsion Laboratory in Pasadena, California, will measure Earth's surface temperature from the International Space Station at various times of day. ECOSTRESS will measure variations in ground temperatures to within a few tenths of a degree.

These measurements should indicate how plants respond to water shortages and how certain regions are likely to respond to future changes in climate.



ECOSTRESS will measure the temperature of plants from space in order to determine plant health and water use.

NASA/JPL-Caltech

The scientific objectives of ECOSTRESS are to:

- Identify the critical thresholds of water use and water stress in key climate-sensitive biomes -- typically by observing the transition zones between biomes;
- Identify when plants stop taking up water over the course of a day;
- Improve the accuracy of drought estimates based on agricultural water use in the continental United States.

To achieve these objectives, scientists need a complete picture of how plant temperatures and water use vary throughout the day, and they need to be able to gather data from small plots of land with relative clarity. ECOSTRESS is designed to do both.

ECOSTRESS will use the vantage point of the space station to measure the temperature of plants at the same location on Earth every few days on average at different times of day. It will do so at a resolution detailed enough to allow it to detect temperature variations within a farmer's field throughout much of the world. Other currently operating spaceborne sensors can make measurements with either the same spatial detail or with similar frequency, but not both.

ECOSTRESS data will help researchers determine how much water plants use and need, and whether the plants are healthy or suffering from environmental stresses caused by water shortages at a given time.

It will provide key insights into how plants link Earth's carbon and water cycles. For example, the data will help scientists understand how plants take up carbon dioxide over the course of a typical day. Plants combine carbon dioxide with water and sunlight in a process known as photosynthesis to produce the "food" they use to survive. ECOSTRESS data will help determine how much carbon dioxide plants use based on which areas release more or less water.

ECOSTRESS data will also help society better manage agricultural water use. For example, water managers can adjust the timing and location of water releases for optimal crop yields. Similarly, the data will improve our understanding of how certain regions are impacted by drought, and which areas may be more susceptible to it.

ECOSTRESS is focused on studying plants; however, the temperature data can potentially be used for other studies, such as characterizing volcanoes, wildfires and heat waves.

Instrument Overview

ECOSTRESS was derived from a thermal infrared radiometer named PHyTIR (Prototype HyspIRI Thermal Infrared Radiometer) developed under NASA's Earth Science Technology Office Instrument Incubator Program to demonstrate the feasibility and reduce the cost and risk of developing these types of instruments for future NASA missions.

Radiometers work by measuring the radiation emitted from Earth's surface. From the space station's altitude of about 250 miles (400 kilometers), ECOSTRESS will provide Earth surface temperature data with a spatial resolution of 226 feet (69 meters) cross-track and 125 feet (38 meters) in-track with a temperature sensitivity of a few tenths of a degree. In a typical 24-hour period, it will observe an average of 22 target areas, or swaths, each measuring 250 by 250 miles (400 by 400 kilometers) for a duration of one to 11 minutes each.

ECOSTRESS uses a scanning mirror and telescope to focus the energy from a small spot on Earth onto a very sensitive mercury-

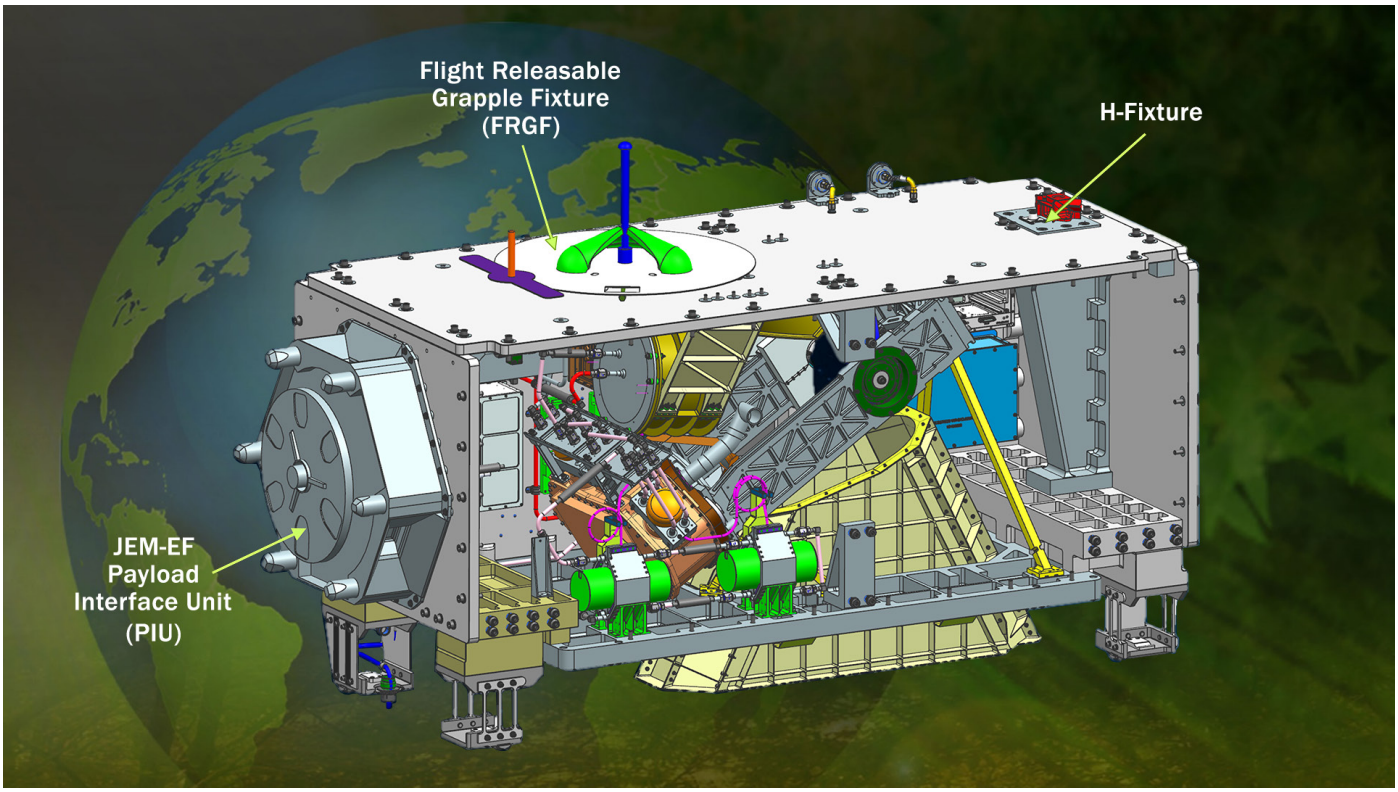


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Diagram of the ECOSTRESS instrument that will be installed on the International Space Station.

cadmium-telluride infrared detector array within the instrument. The mirror then sweeps back and forth using the forward motion of the spacecraft to build up an image. The image is 250 miles (400 kilometers) wide at right angles to the direction of flight. The instrument's field of view provides coverage from 53.6 degrees south latitude to 53.6 degrees north latitude around the entire Earth. This will allow ECOSTRESS to map 90 percent of the continental United States in less than four days.

The detector is cooled to minus 342.67 degrees Fahrenheit (minus 208.15 degrees Celsius, 65 Kelvin) using cryocoolers. The heat produced is removed by warming fluid that is then sent elsewhere on the space station along a fluid loop, where the fluid can radiate the heat to deep space. The cooled fluid is then returned to the instrument. The detector separates the energy from five different wavelengths, or spectral bands, using filters attached to the detector, thereby producing five separate image "colors" for each spot on the ground. The colors represent the intensity of thermal infrared radiation emitted by Earth's surface at each wavelength.

The ECOSTRESS payload fits within an enclosure measuring 6.1 feet by 2.6 feet by 2.9 feet (1.85 meters by 0.8 meters by 0.88 meters).

Launch and Orbit

ECOSTRESS will be launched in the SpaceX Dragon cargo trunk atop a Falcon 9 rocket from Cape Canaveral Air Force Station in Florida — part of the 15th NASA-contracted cargo resupply mission to the space station. Once it arrives at the station, it will be robotically installed on the exterior of the station's Japanese Experiment Module Exposed Facility Unit (JEM-EFU).

The space station's unique low-Earth orbit is especially useful to ECOSTRESS. The station orbits Earth about 16 times a day; and it flies over the same location on Earth approximately every few days at varying times. This orbit provides sufficient coverage for ECOSTRESS to produce data encompassing the complete daily cycle of plant water use.

Future missions will be able to use the space station in a similar way — and produce data that work in conjunction with ECOSTRESS data to answer additional Earth science questions.

Mission Duration

ECOSTRESS will provide temperature measurements for selected mid-latitude regions of the world for one year. The mission may be extended for an additional year, and possibly longer.

Partners and Collaborations

JPL built and manages the ECOSTRESS mission for NASA's Earth Science Division in the Science Mission Directorate in Washington. ECOSTRESS is one of NASA's Earth Venture-Instrument series of missions—small, targeted science investigations that complement NASA's larger missions. It is sponsored by NASA's Earth System Science Pathfinder program, managed by NASA's Langley Research Center in Hampton, Virginia. NASA's Human Exploration and Operations Mission Direc-

torate provides the access to space through the commercial resupply contract with Space X, the installation site and supporting interfaces on the station's JEM-EFU, robotic installation of the ECOSTRESS payload on the JEM-EFU, payload disposal at the end of the mission, and access to ground communication networks for uplink and downlink compatible with the ECOSTRESS mission. Japan Aerospace Exploration Agency's JEM-EFU is providing the cooling fluid and power to ECOSTRESS. The Marshall Space Flight Center Huntsville Operations Support Center is responsible for transmitting telemetry and science data. Science data products will be delivered to the Land Process Distributed Active Archive Center for archival and public distribution. The mission's co-investigators are from the United States Department of Agriculture, Princeton University, the University of Idaho and NASA's Marshall Space Flight Center.

National Aeronautics and Space Administration

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