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Automated Policy-based Scheduling for the ECOSTRESS Mission

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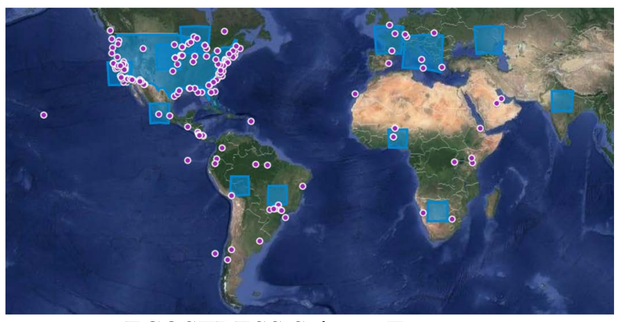
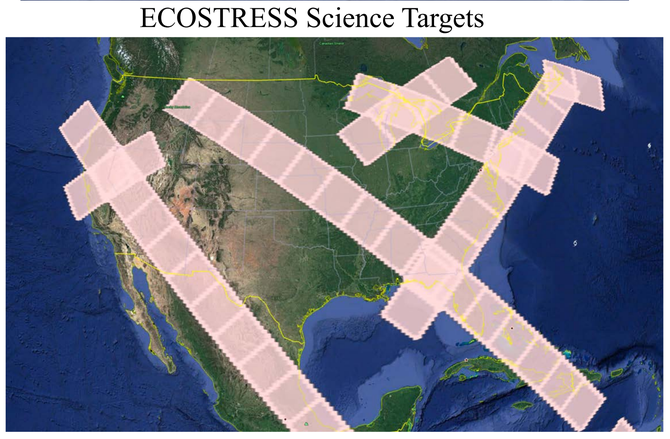
ECOSTRESS

The ECOSystem Thermal Radiometer Experiment on Space Station (ECOSTRESS) mission seeks to better understand how much water plants need and how they respond to stress. ECOSTRESS measures the temperature of plants to understand combined evaporation and transpiration, known as evapotranspiration.

ECOSTRESS launched on June 29, 2018 to the ISS (International Space Station) on a Space-X Falcon 9 rocket as part of a resupply mission. The instrument is attached to the Japanese Experiment Module – Exposed Facility (JEM-EF) on the ISS and targets key biomes on the Earth's surface, as well as calibration/validation sites. Other science targets include cities and volcanoes. From the orbit of the Space Station the instrument can see target regions at varying times throughout the day, rather than at a fixed time of day, allowing scientists to understand plant water use throughout the day. ECOSTRESS is expected to operate until mission end in Summer 2019.

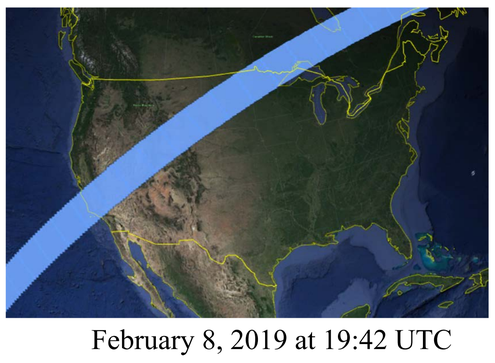


ECOSTRESS Science Targets



Observations scheduled over North America on February 28, 2019

January 26, 2019 at 1:15 UTC



February 8, 2019 at 19:42 UTC

Two Orbital Tracks of the ISS that view the same regions but at different illuminations

JPL Clearance CL 19-3109

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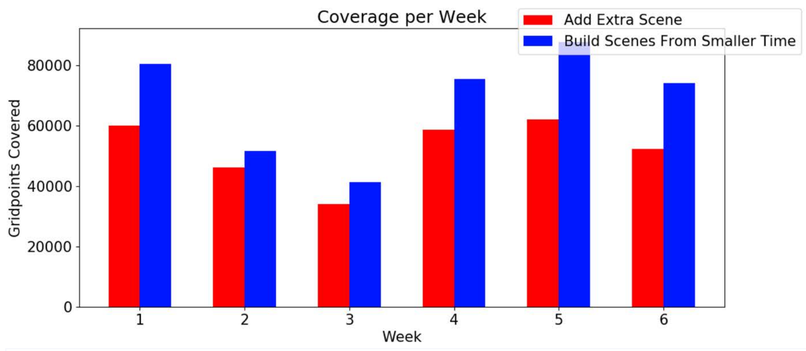
Orbit Uncertainty

Command sequences are uploaded weekly to ECOSTRESS. Being in Low Earth Orbit (LEO), the ISS experiences some drag from the atmosphere, causing it to drift over time from its predicted location at the beginning of the week. This can cause a planned observation to miss its intended target.

Two strategies were developed to deal with the uncertainty. They needed to account for the fixed size of observations that ECOSTRESS takes and at least a few seconds of extra time to ensure a target is not missed.

1) Static Padding - Add ½ of an observation to the start and end of each contiguous observation
2) Targeted Padding - analyzes the target regions and calculates padding around the targets



When working with the same fixed data volume constraints, Targeted Padding uses less data volume on padding, therefore enabling it to cover more science targets as seen above.

Mass Storage-less Operations

After further operations, both Mass Storage Units on ECOSTRESS became non-functioning. Updates to the instrument firmware were developed to allow data to be acquired and downlinked avoiding the MSU. CLASP was adapted again to be able to schedule with a new set of constraints.

New constraints included:

- Reduced onboard storage capability
- Greater downlink capability with removal of certain spectral bands
- All data onboard must be downlinked at once to regain use of storage

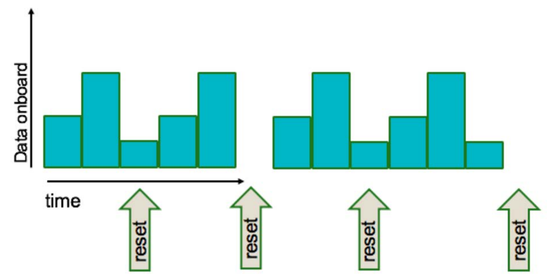
CLASP

The Compressed Large-scale Activity Scheduler and Planner (CLASP) has been in use in various ways for ECOSTRESS. Coverage planning technology in the CLASP scheduler has been used in the aid of:

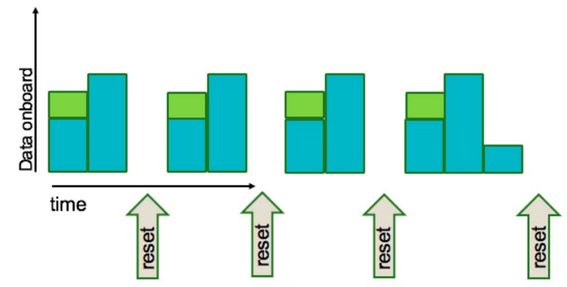
- evaluating designs of the overall science campaign implementation prior to launch
- Generating command sequences for operations
- designing new science coverage strategies
- updated scheduling approaches to address hardware challenges on orbit

Ring Buffer Issue

The Mass Storage Unit firmware onboard ECOSTRESS implemented a ring buffer. However, the read and write pointers did not correctly handle the buffer boundary, causing lost data. Rather than perform a firmware update to the instrument, CLASP was updated to automatically schedule resets of the ring buffer to avoid the issue.



High priority targets are initially scheduled to determine natural places where resets of the ring buffer should occur – when the amount of data onboard will be low and the end of the buffer has not been reached.



High and low priority targets are then scheduled, accounting for the times the ring buffer resets occur.

Radiation Sensitivity

One of the possible reasons for stalls of the Mass Storage Unit on ECOSTRESS was radiation sensitivity. It was found that most of the stalls were occurring in areas that had higher levels of radiation, like over the South Atlantic Anomaly and Low Latitudes. Many strategies for mitigating this were analyzed, and CLASP assessed the impact of the strategies on coverage.

Strategies included:

- Taking data and downlinking only on orbits overflying Australia
- Turning off the MSU over the South Atlantic Anomaly and Southern High Latitudes
- Not downlinking data over High Latitudes

Regions where the MSU needed to be powered down due to radiation

References

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