

*ECOsysteM Spaceborne Thermal  
Radiometer Experiment on Space Station*

 **ECOSTRESS**

Simon J. Hook and the  
ECOSTRESS Team

Jet Propulsion Laboratory,  
California Institute of Technology,  
Pasadena, CA

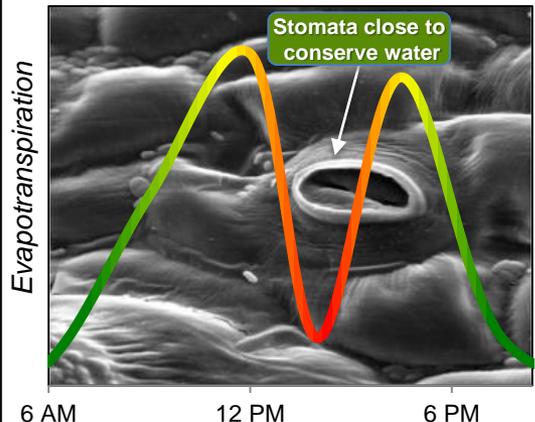


## ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

Dr. Simon J. Hook, JPL, Principal Investigator

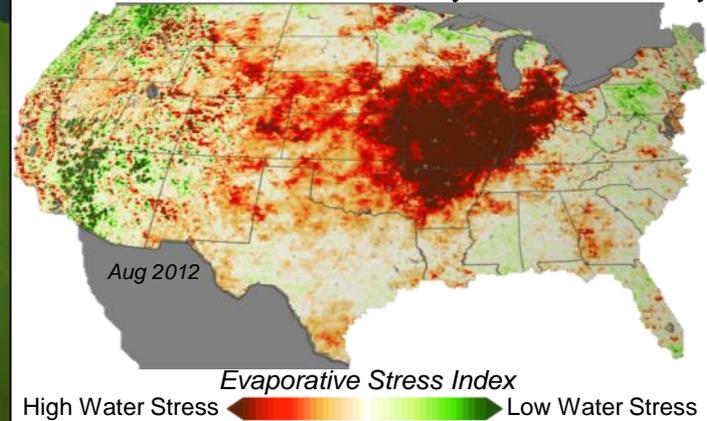
ECOSTRESS will provide critical insight into **plant-water dynamics** and how **ecosystems change with climate** via **high spatiotemporal** resolution thermal infrared radiometer measurements of evapotranspiration from the International Space Station (ISS).

### Water Stress Drives Plant Behavior



When stomata close, CO<sub>2</sub> uptake and evapotranspiration are halted and plants risk starvation, overheating and death.

### Water Stress Threatens Ecosystem Productivity



Water stress is quantified by the Evaporative Stress Index, which relies on evapotranspiration measurements.

### Science Objectives

- Identify **critical thresholds of water use and water stress** in key climate-sensitive biomes
- Detect the timing, location, and predictive factors leading to plant **water uptake decline** and/or cessation over the **diurnal cycle**
- Measure **agricultural water consumptive use** over the contiguous United States (CONUS) at spatiotemporal scales applicable to improve drought estimation accuracy



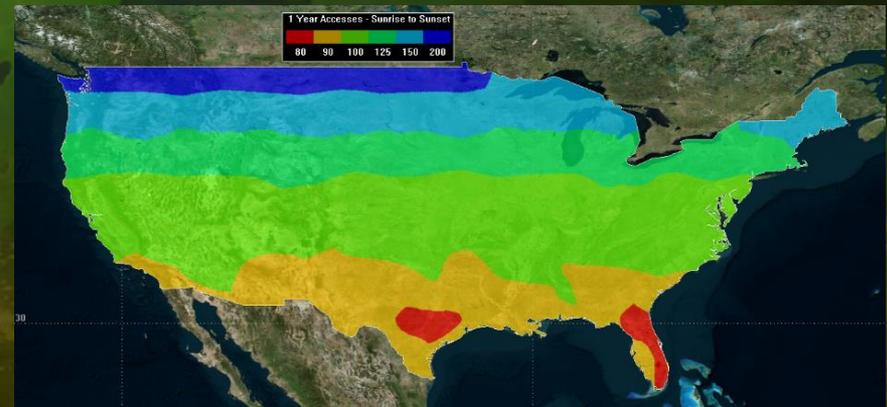
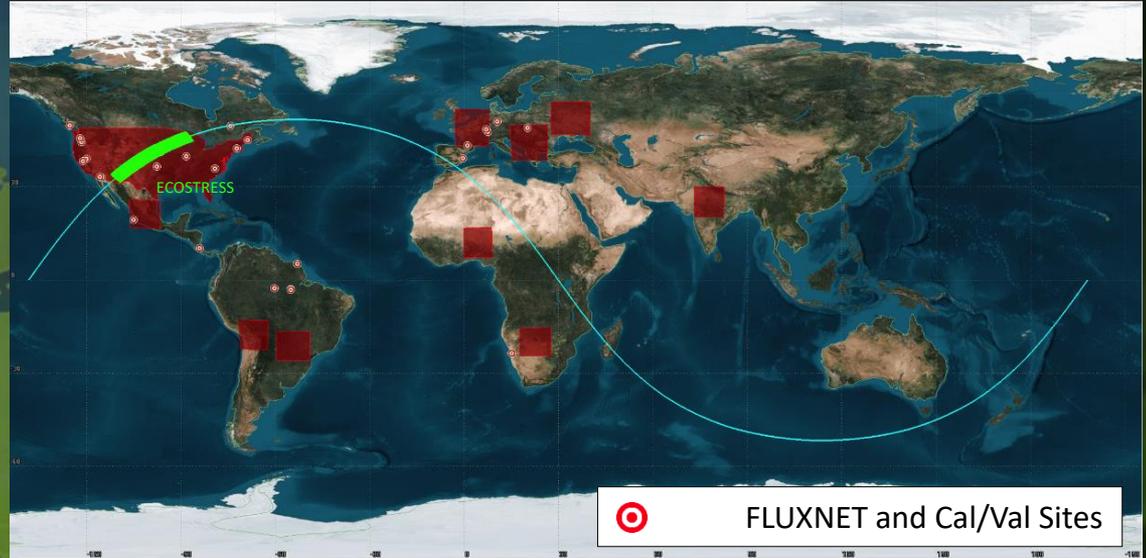
# ECOSTRESS Target List

## Operational Phases per Orbit

- **Science Collection Mode**
  - Science Data
  - Calibration Data
- **Scanning Mode**
  - Data discarded

## ECOSTRESS Targets:

- CONUS + Canada
  - Day-time data only
- Climate hotspot and agricultural regions
  - 12 predefined 1000km x 1000km regions
  - Day-time data only
- FLUXNET sites
  - 400km x 400km images at 23 sites
  - Day-time data only (~120 visits/year)
- Calibration/Validation sites
  - 400km x 400km images at 4 sites
  - Day-time and night-time data (~180 visits/year)





# Project Overview

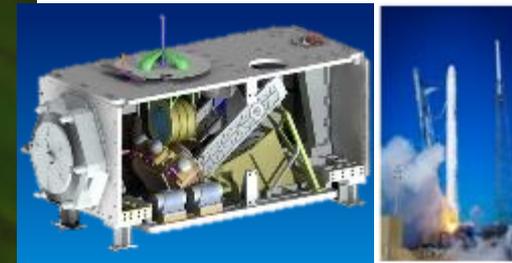
*ECOSTRESS is an Earth Venture Instrument-2 on the ISS*

## Overview:

- Cost-Capped, \$29.942M Cat 3/Risk class D per NPR 7120.5E/ NPR 8705.4
  - Type II project with tailoring of the JPL flight practices, single string with limited redundancy using COTS hardware
- 8–12.5  $\mu\text{m}$  radiometer with a 400km swath, 69 x 38 m resolution
- Measure brightness temperatures of Earth at selected locations
- June 2018 planned launch date
- Launch on SpX-15 and deployed on the ISS on JEM-EFU 10
- Baseline operations: 1 year after 30 days on-orbit checkout



ISS JEM-EF



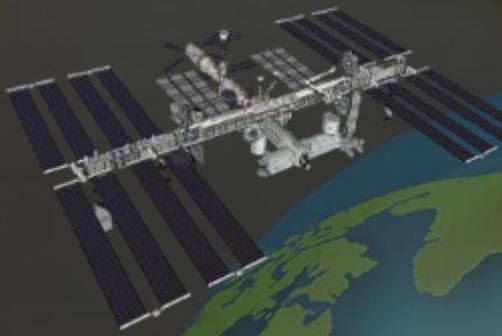
ECOSTRESS

Falcon-9

## Timeline:

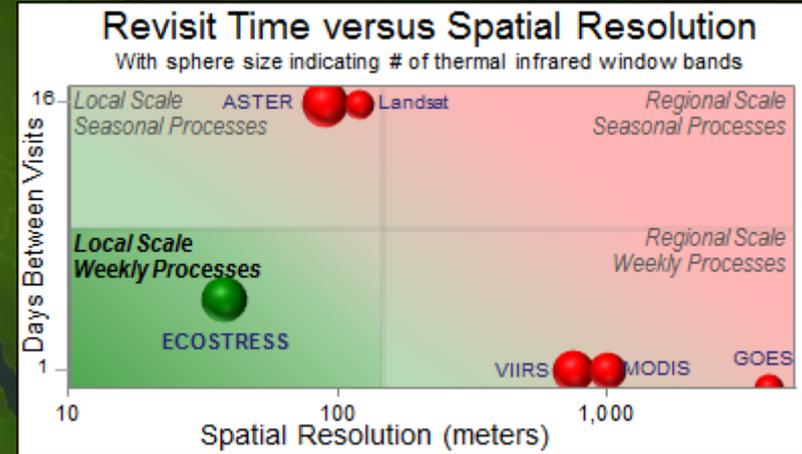
Cal Year	2014	2015	2016	2017	2018	2019	
KDP		B ▼	C ACC ▼▼		E ▼	F ▼	
Phase		A	B	C	D	E	F
Milestone	ATP Oct 1 ▲	SRR/ MDR ▲	PDR ▲	CDR ▲	ETRR ▲	HROR/ CoFR P-III ▲	PSR/ ORR SR ▲

PL Completion → (between 2017 and 2018)  
 Delivery → (at start of 2018)  
 Launch → (at start of 2018)



## Mission

- Class D \$30M cost cap
- 31-months from project start to delivery
- JPL implementation and management
- 69-month project duration (Phase A-F)
- On ISS-JEMS Module
- 12-month Science Operations (Phase E)



The inclined, precessing ISS orbit enables ECOSTRESS to sample the diurnal cycle in critical regions across the globe at spatiotemporal scales missed by current instruments in Sun-synchronous polar and high-altitude geostationary orbits.

## Instrument

- Leverages functionally-tested PHYTIR space-ready hardware developed under the NASA Instrument Incubator Program:
  - Spectral resolution: 5 bands in the thermal infrared window (8-12.5  $\mu\text{m}$ ) part of the electromagnetic spectrum
  - Noise equivalent delta temperature:  $\leq 0.3$  K
  - Spatial resolution: 38 m x 69 m
  - Swath width: 400 km @ 400 km altitude ( $51^\circ$ )
- Well understood measurement and algorithms based on prior missions, such as ASTER, MODIS, and Landsat

# ECOSTRESS Science Data Products



Data Product	Description	Initial Availability to NASA DAAC	Median Latency in Product Availability to NASA DAAC after Initial Delivery	NASA DAAC Location
<b>Level 0</b>	Raw collected telemetry	6 months after IOC	12 weeks	LP DAAC
<b>Level 1</b>	Calibrated Geolocated Radiances	6 months after IOC	12 weeks	LP DAAC
<b>Level 2</b>	Surface temperature and emissivity	6 months after Level 1 data products are available	12 weeks	LP DAAC
<b>Level 3</b>	Evapotranspiration	2 months after Level 2 data products are available	12 weeks	LP DAAC
<b>Level 4</b>	Water use efficiency and evaporative stress index	2 months after Level 3 data products are available	12 weeks	LP DAAC

The Land Processes Distributed Active Archive Center (*LP DAAC*) was assigned for ECOSTRESS since KDP-B.

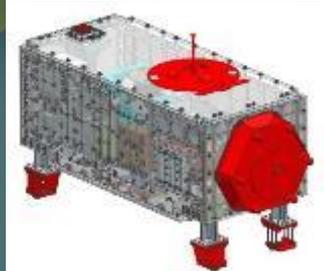
# Mission Concept



Radiometer Instrument



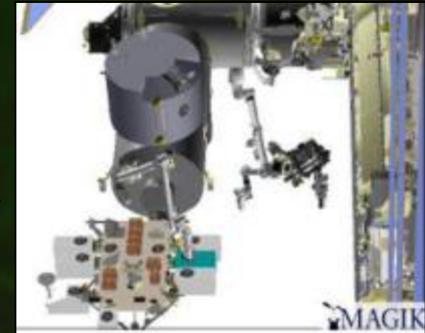
ECOSTRESS Payload



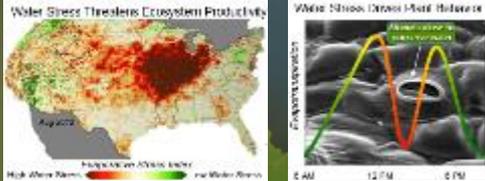
Dragon-Trunk Falcon-9 LV



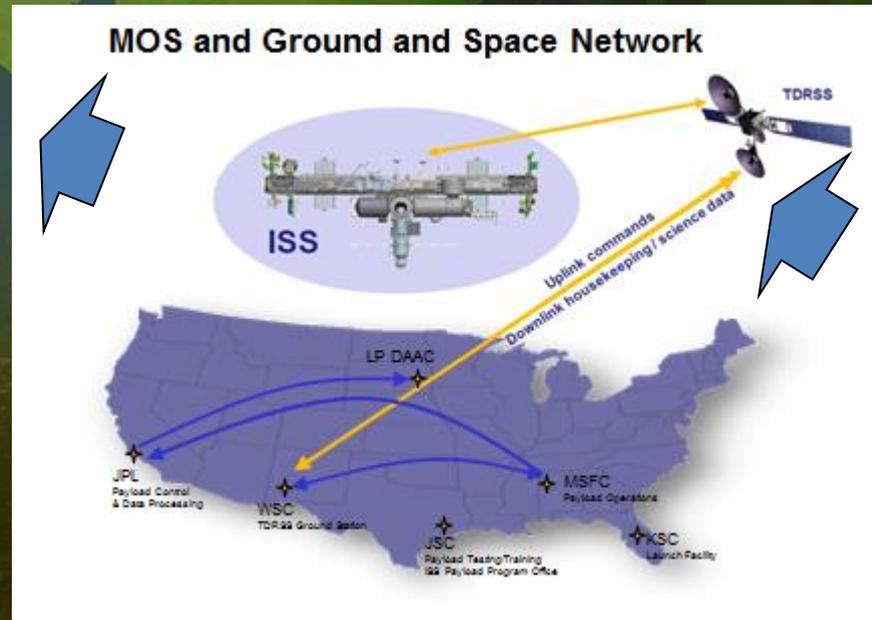
Installation on JEM-EF



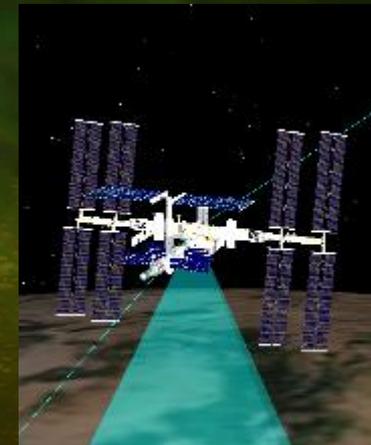
Science Data Processing and Archive



MOS and Ground and Space Network



Data Collection



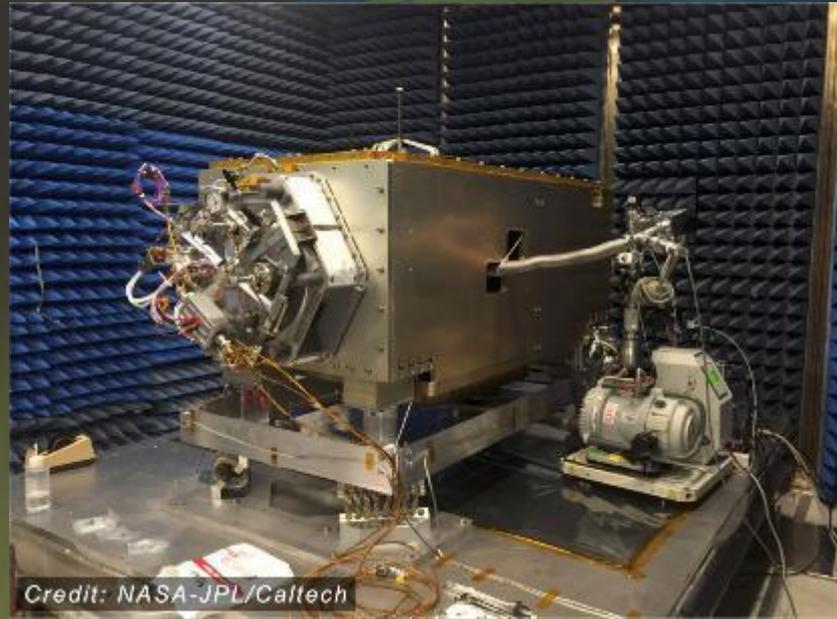
EOL Payload disposal via Dragon Trunk re-entry



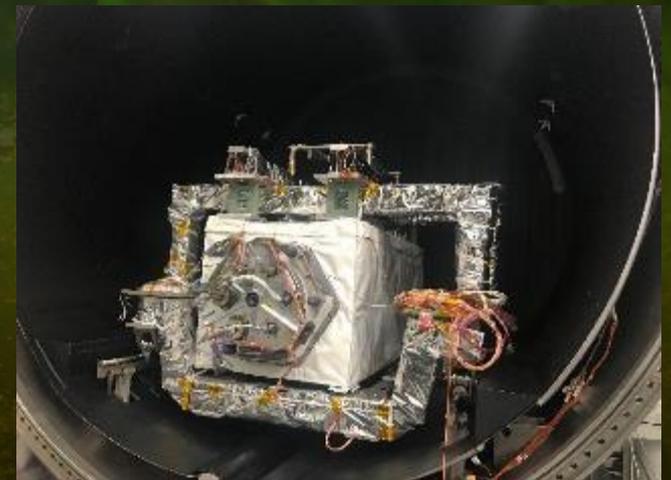
# Final Tests

EMC/EMI

Vibration



Thermal  
Vacuum





# Key Milestones

## Phase A/B/C

- ✓ 01/01/2014 ATP
- ✓ 02/10/2015 SRR and MDR
- ✓ 03/05/2015 Inheritance Review
- ✓ 03/24/2015 Phase 0 Safety Review
- ✓ 04/15/2015 KDP-B
- ✓ 06/23/2015 ISS Interface PDR
- ✓ 07/14/2015 Phase I Safety Review
- ✓ 07/28/2015 PDR
- ✓ 10/05/2015 DMC
- ✓ 10/23/2015 KDP-C
- ✓ 12/10/2015 KDP-C for Accommodation
- ✓ 02/09/2016 Phase II Safety Review
- ✓ 02/10/2016 ISS Interface CDR
- ✓ 03/08-09/16 CDR
- ✓ 03/29/2016 DMC
- ✓ 04/14/2016 Post-CDR briefing ESD DPMC
- ✓ 04/26/2017 ETRR
- ✓ 02/28/2018 Phase III Safety Review
- ✓ 03/12/2018 HRCR
- ✓ 03/29/2018 Pre-Ship Review
- ✓ 04/06/2018 Ship to KSC

## Phase D (ATLO)

- ✓ 04/09/2018 Payload arrived KSC
- ✓ 04/11/2018 Limited Functional Test
- ✓ 04/13/2018 Interface Test with PRCU
- ✓ 04/18/2018 PPBE
- ✓ 05/01/2018 ORR
- ✓ 05/08/2018 DMC and RAR
- ✓ 05/11/2018 KDP-E
- ✓ 05/21/2018 Prep Payload for moving
- ✓ 05/28/2018 Move Payload to Dragon Land
- ✓ 05/29/2018 Integration with Dragon trunk
- ✓ 06/01/2018 delta-CoFR pre-launch
- 06/29/2018 Launch on SpX-15 at KSC
- 07/05/2018 Robotic Transfer
- 07/09/2018 IOC starts

## Phase E

- 08/09/2018 Flight Operations Start

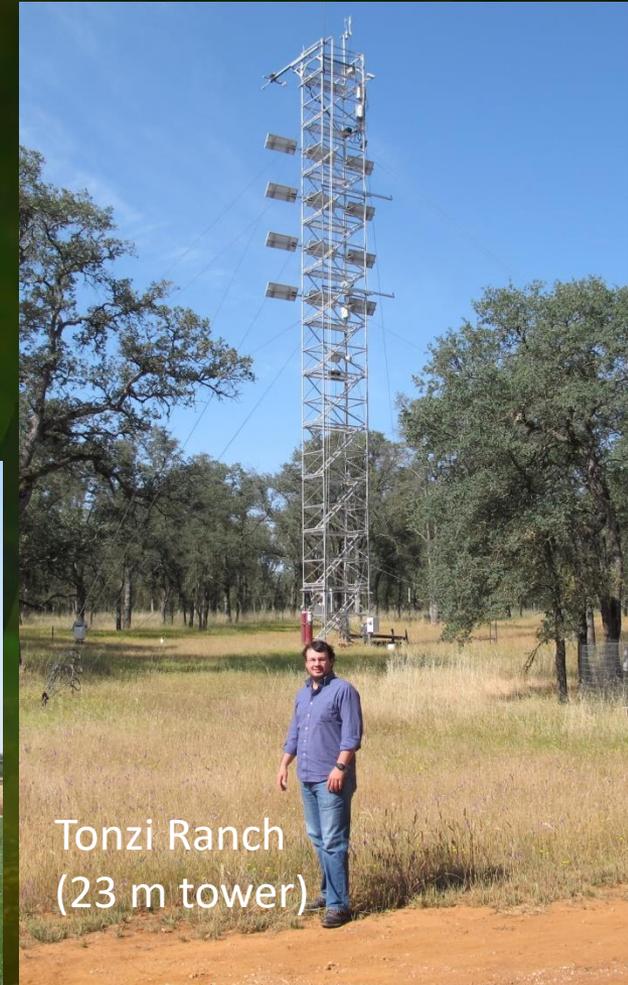
# Calibration and Validation

- On-board blackbodies
- Vicarious calibration sites
- Validation sites (FLUXNET)

Lake Tahoe



Russell Ranch



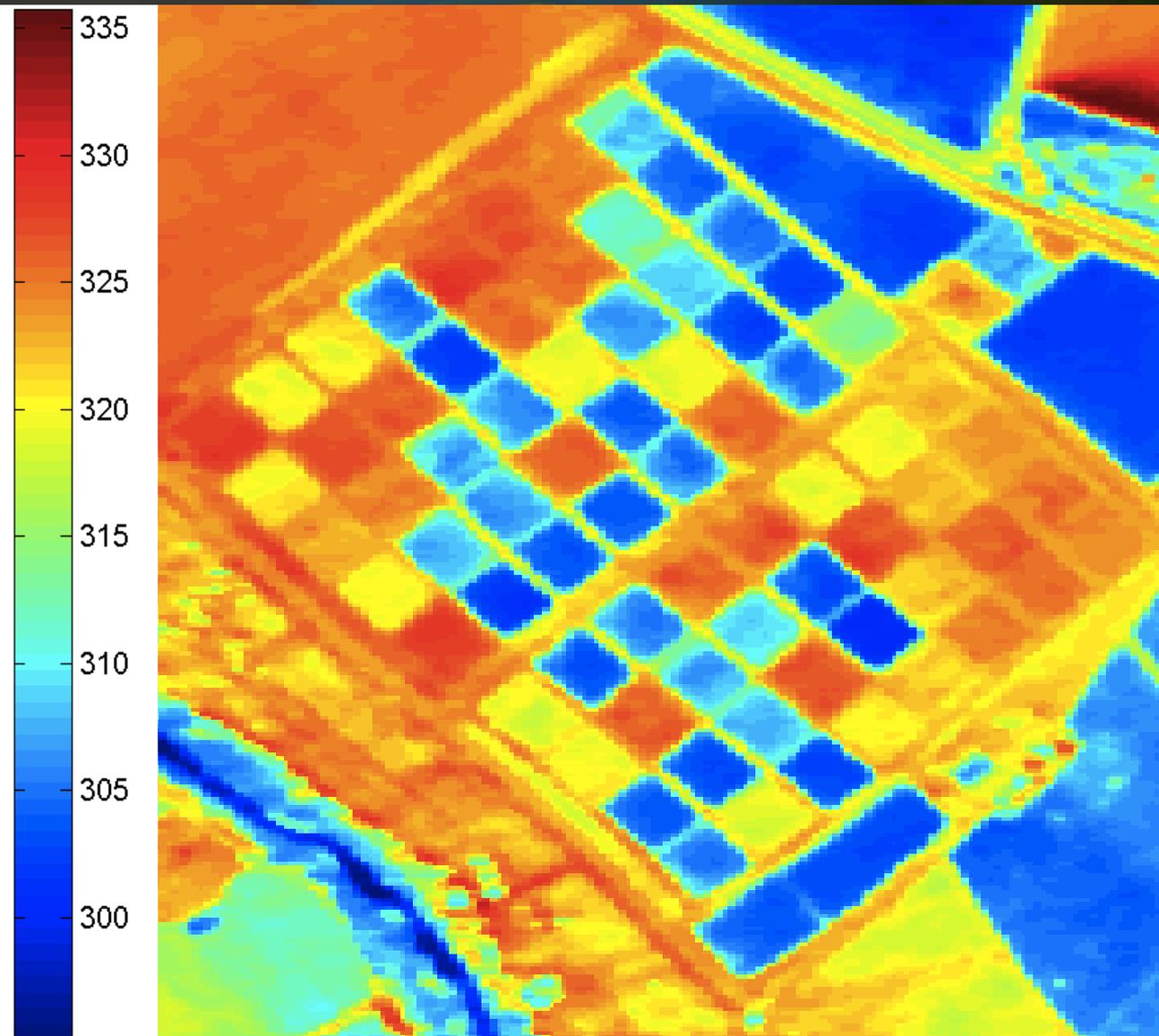
Tonzi Ranch  
(23 m tower)

# HyTES: Hyperspectral Thermal Emission Spectrome

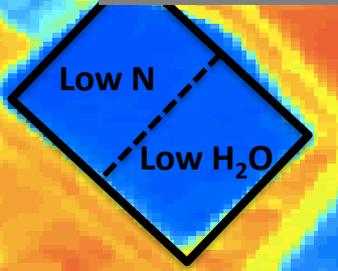
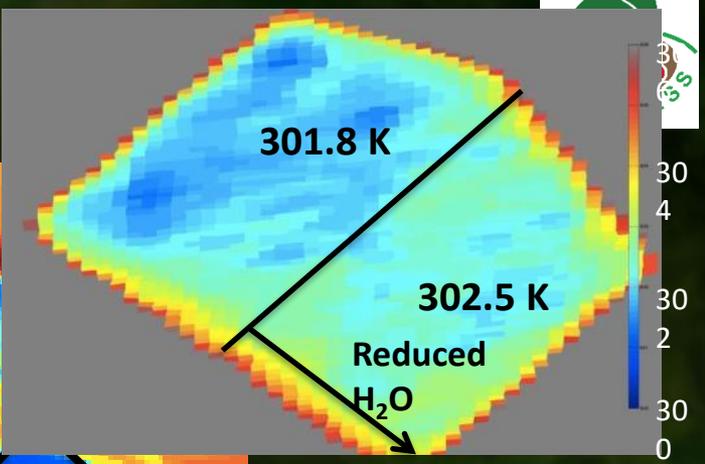
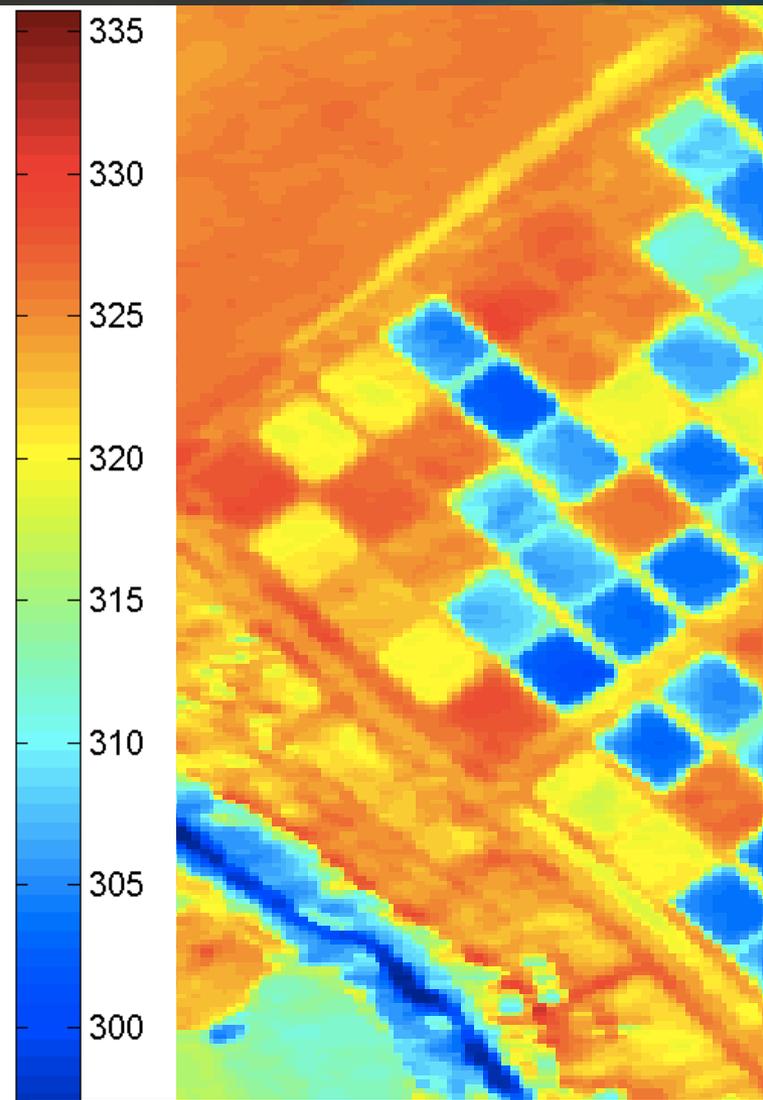


JPL Airborne Capability

Image Acquisition: 9 JUL 2014



# Using JPL Airborne Instruments for Precursor Studies:



**HyTES Acquisition: July 9, 2014**

# Summary



- ECOSTRESS is possible because of the development of the PHyTIR instrument for HypsIRI-TIR supported by ESTO
- ECOSTRESS will address a subset of the science associated with HypsIRI
- The ECOSTRESS mission will help answer three key science questions:
  - How is the terrestrial biosphere responding to changes in water availability?
  - How do changes in diurnal vegetation water stress impact the global carbon cycle?
  - Can agricultural vulnerability be reduced through advanced monitoring of agricultural water consumptive use and improved drought estimation?
- ECOSTRESS has a clearly defined set of data products and mature algorithms

ECOSTRESS is scheduled for launch on June 29th 2018. ECOSTRESS will provide highest spatial resolution thermal infrared data ever from the International Space Station.



# GO ECOSTRESS !!





BACKUP



# Movie Time

