

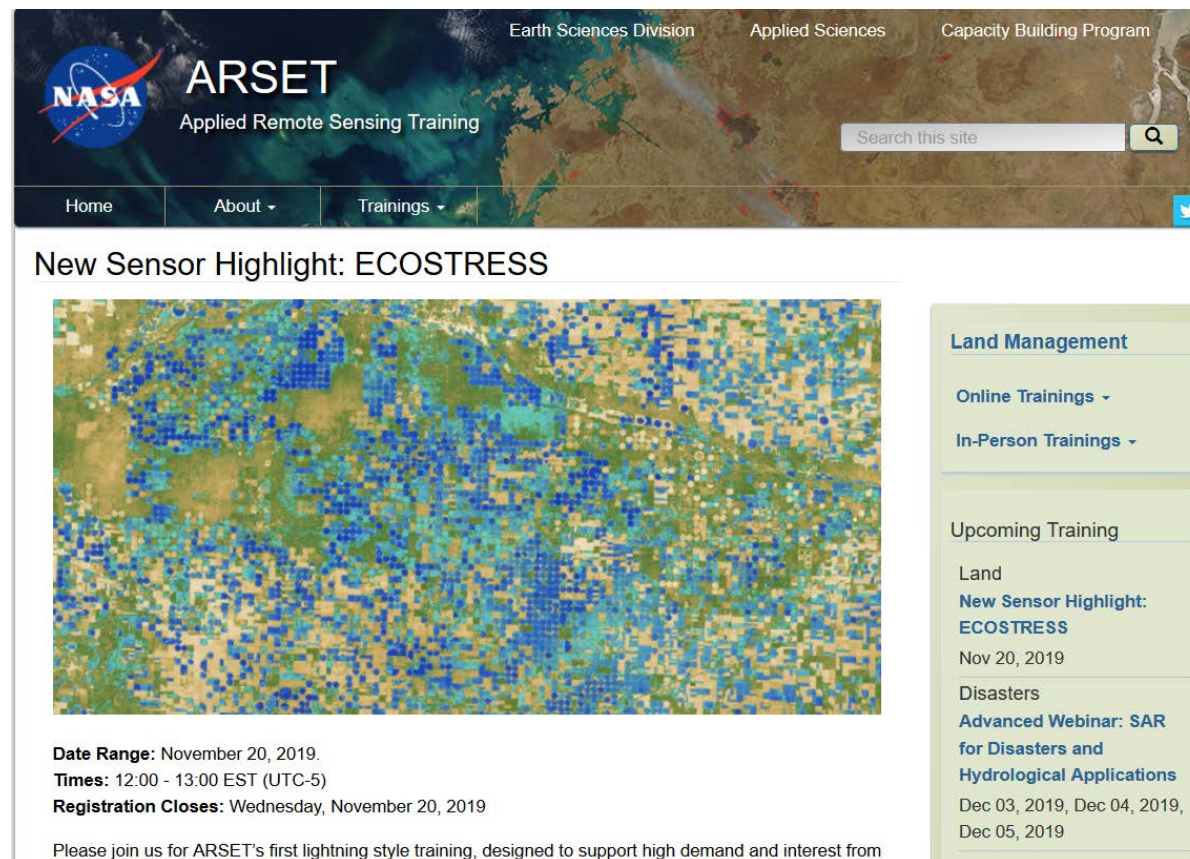
New Sensor Highlight: ECOSTRESS

Amber McCullum, Christine Lee (JPL), Cole Krehbiel (LP DAAC)

November 20, 2019

Course Structure

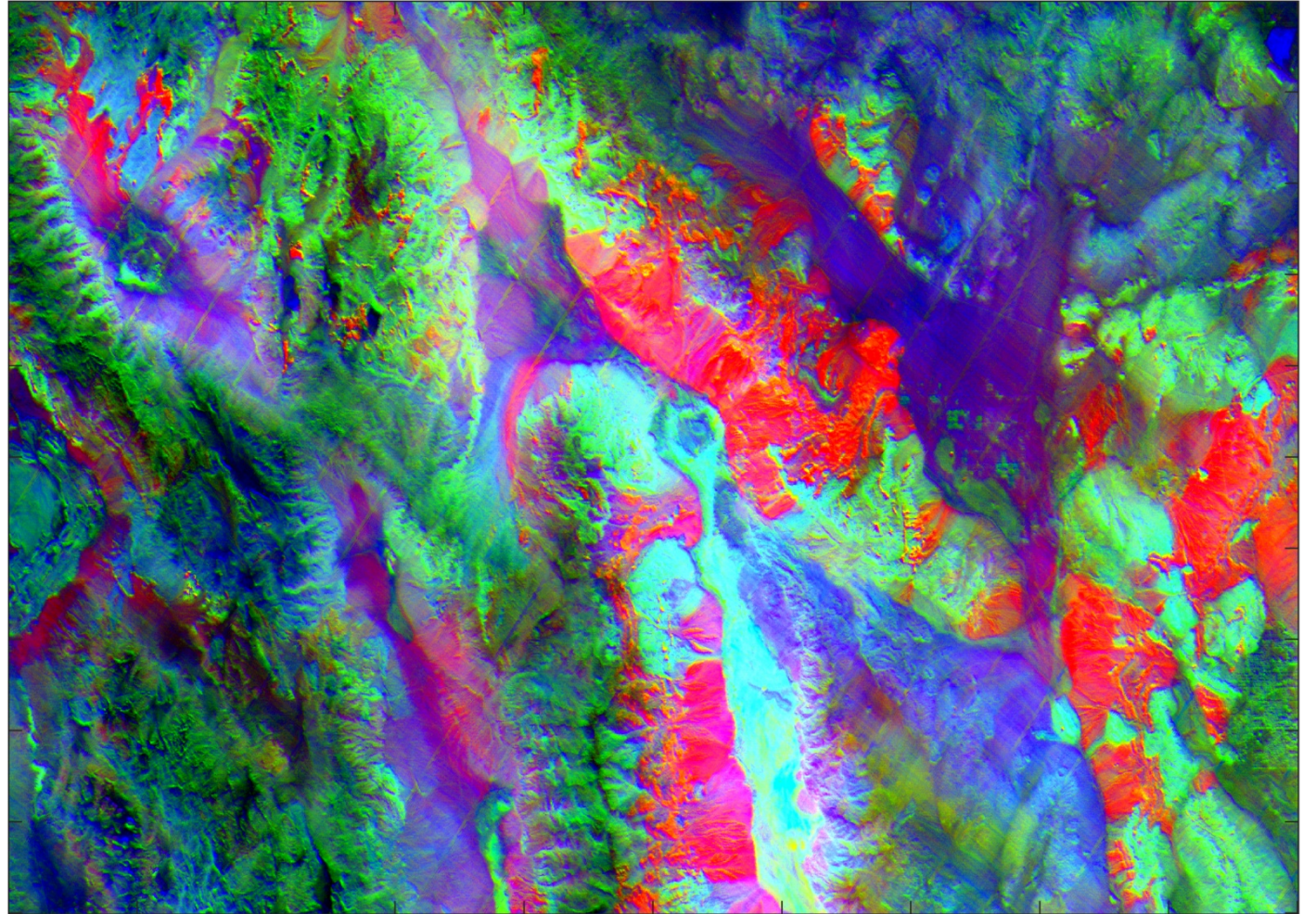
- New Lightning format: One 1-hr session
- The webinar recording and PowerPoint presentation can be found at:
 - <https://arset.gsfc.nasa.gov/land/webinars/ECOSTRESS>
- No homework or certificate
- Q&A: Following today's session and/or by email
 - amberjean.mccullum@nasa.gov
 - Or juan.l.torresperez@nasa.gov



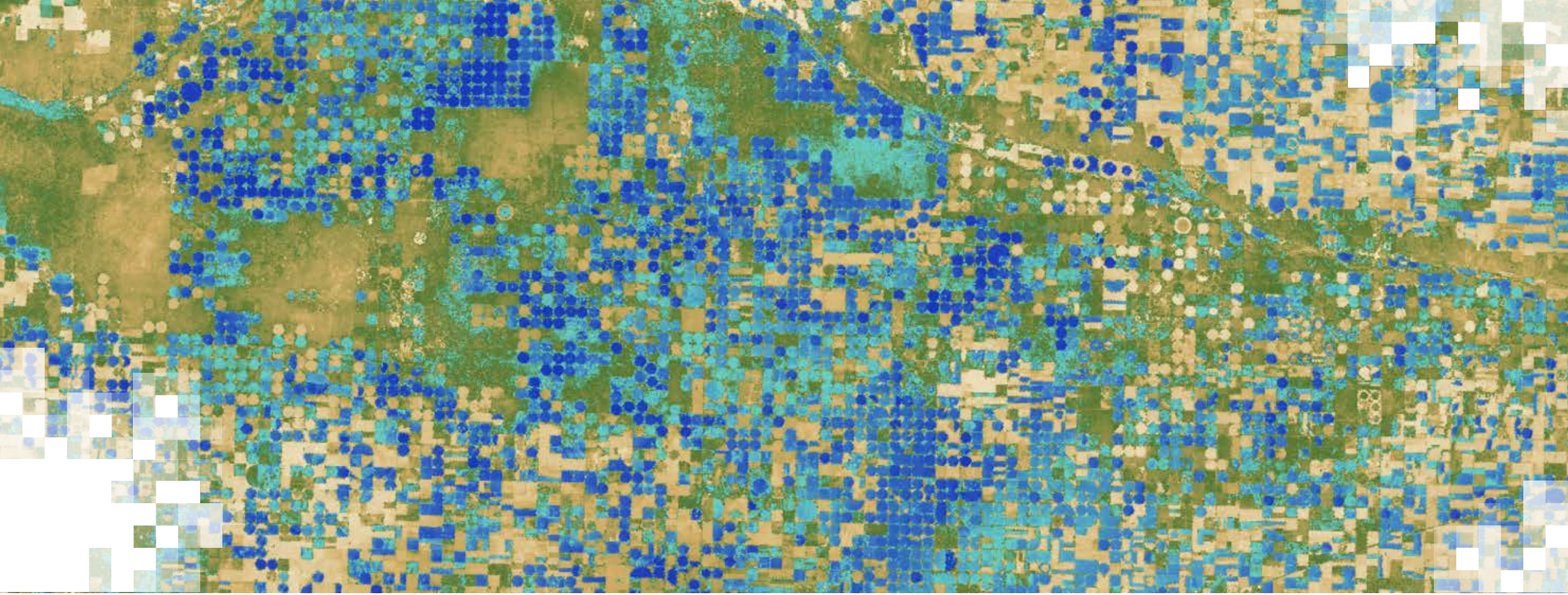
The screenshot shows the ARSET (Applied Remote Sensing Training) website. The header includes the NASA logo, the text "ARSET Applied Remote Sensing Training", and navigation links for "Earth Sciences Division", "Applied Sciences", and "Capacity Building Program". A search bar is present on the right. Below the header is a navigation menu with "Home", "About", and "Trainings". The main content area features a "New Sensor Highlight: ECOSTRESS" section with a satellite image of a forested area. To the right is a sidebar with navigation links for "Land Management", "Online Trainings", and "In-Person Trainings". Below the sidebar is an "Upcoming Training" section listing a "New Sensor Highlight: ECOSTRESS" on Nov 20, 2019, and an "Advanced Webinar: SAR for Disasters and Hydrological Applications" from Dec 03, 2019, to Dec 05, 2019. The main content area also includes details for the ECOSTRESS training: "Date Range: November 20, 2019", "Times: 12:00 - 13:00 EST (UTC-5)", and "Registration Closes: Wednesday, November 20, 2019". A final line of text reads: "Please join us for ARSET's first lightning style training, designed to support high demand and interest from".

Agenda

- ECOSTRESS at a glance
- Data and products
- Applications and case study examples
- An introduction to the LP DAAC
- Resources for working with ECOSTRESS data
- Question and Answer Session



ECOSTRESS image of Death Valley, California, acquired on 17 September at 12:13 UTC. The image has been processed with a decorrelation stretch algorithm with bands 5, 3, 2 displayed in RGB. Image Credit: [NASA](#)

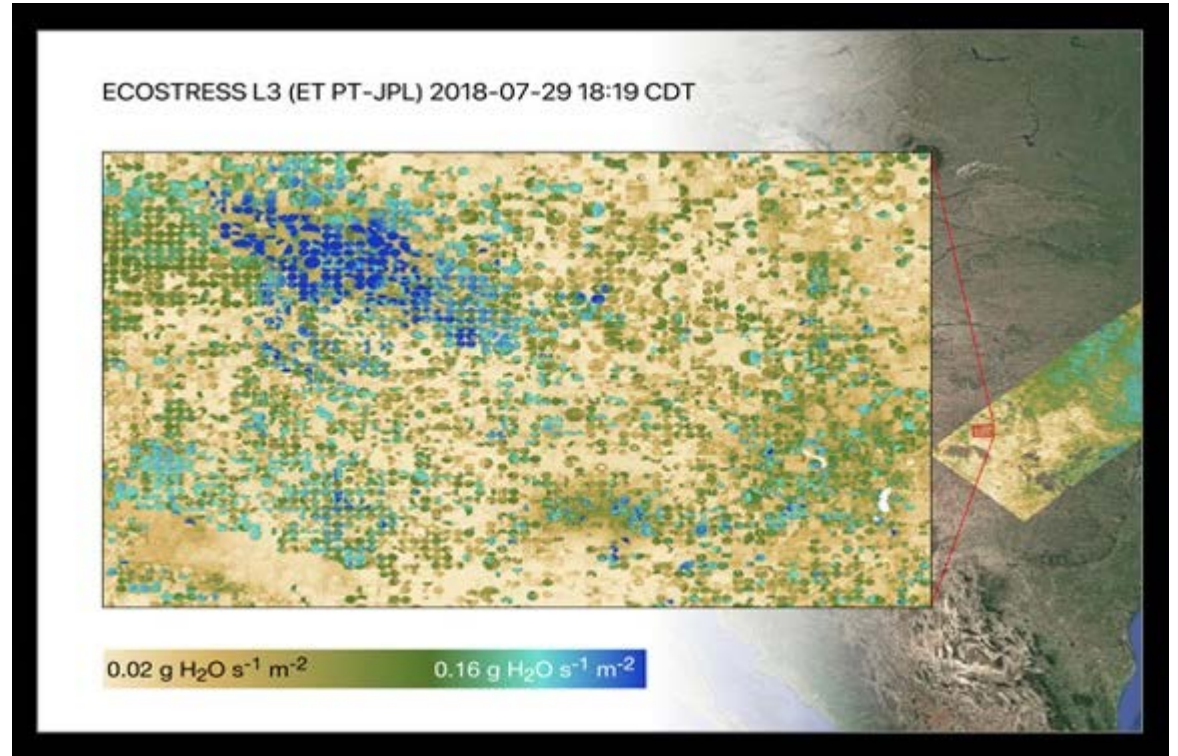


Guest Speaker: Christine Lee (JPL)

ECOSTRESS at a Glance



N



- Selected July 30, 2014
- Launched June 29, 2018 to the ISS
- Began operations August 20, 2018
- 30 M\$ Cost Capped, on schedule, on budget

- Has acquired 37,000 x 400x400 km scenes to date
- First use of Wi-Fi for a science mission
- Delivers L1-L4 products
- More information at: <https://ecostress.jpl.nasa.gov>

Image Credits: Provided by Dr. Joshua Fisher

ECOSTRESS

Maximizing Earth's Precious Resources

The ECOSystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) will measure the temperature of plants and use that information to better understand how plants respond to heat and water stress. This stress is detectable from space at the scale of an individual farmer's field, and we can use this information to manage water resources and monitor droughts. Evapotranspiration (ET) derived from ECOSTRESS can infer plant stress before any physical degradation is observed with the naked eye.

**How do plants
respond to
changing water
availability?**

**How do changes in
evapotranspiration (ET)
throughout the day
affect vegetation growth?**

**Can we use ET
measurements to
optimize agricultural
water use?**

ECOSTRESS Data Products

(higher level products resampled to 70 x 70-m)

- Level 1 – Calibrated Radiance and Geolocation
 - Level 2 – Land Surface Temperature and Emissivity
 - Level 3 -- Evapotranspiration
 - Level 4 – Water Use Efficiency
 - Level 4 – Evaporative Stress Index
-
- Land Surface Temperature, along with other ancillary inputs, are used to derive ET at high spatial resolution and accuracy using two ET models (PT-JPL and ALEXI)
 - L3 and L4 products will be used to address the mission science objectives

ECOSTRESS

Maximizing Earth's Precious Resources

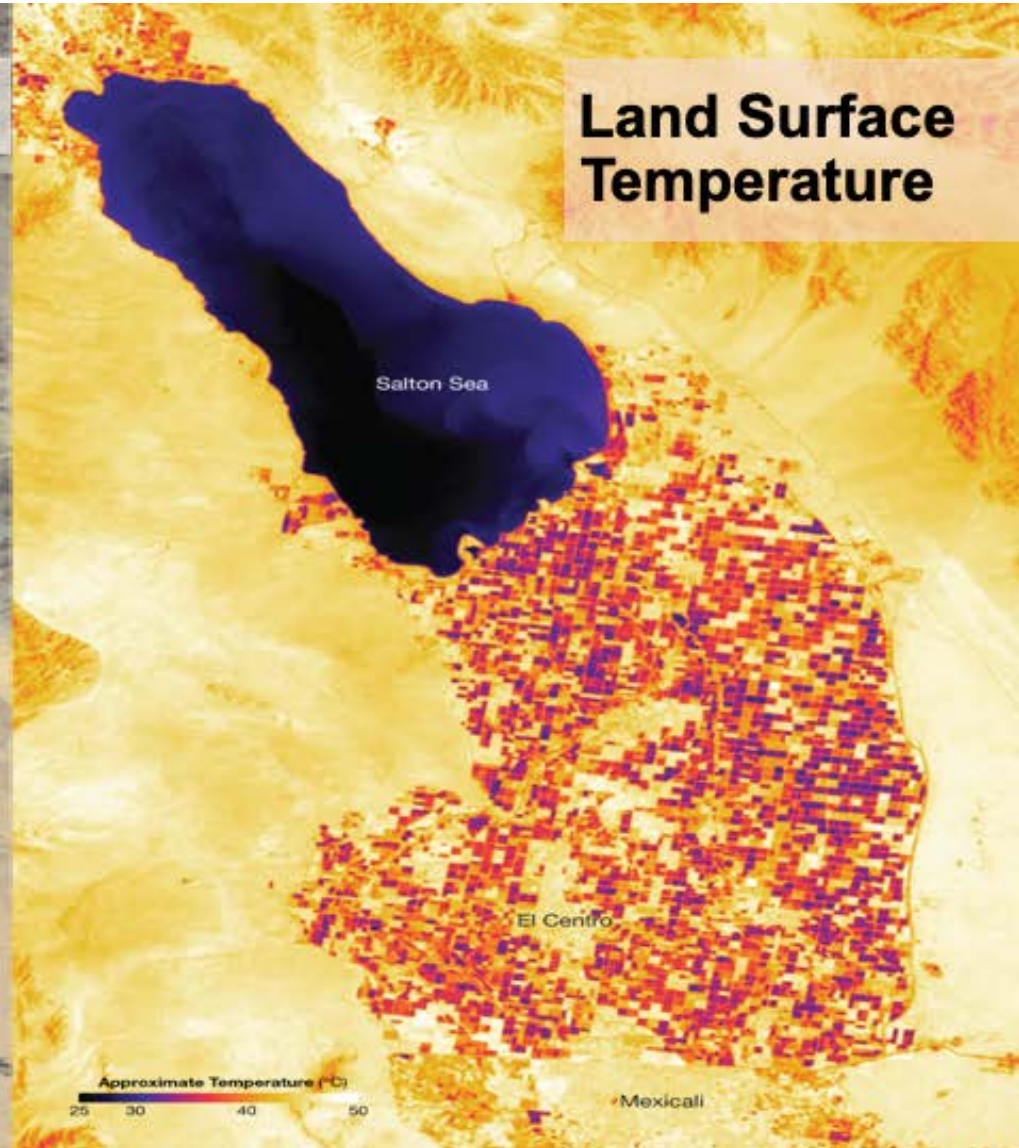
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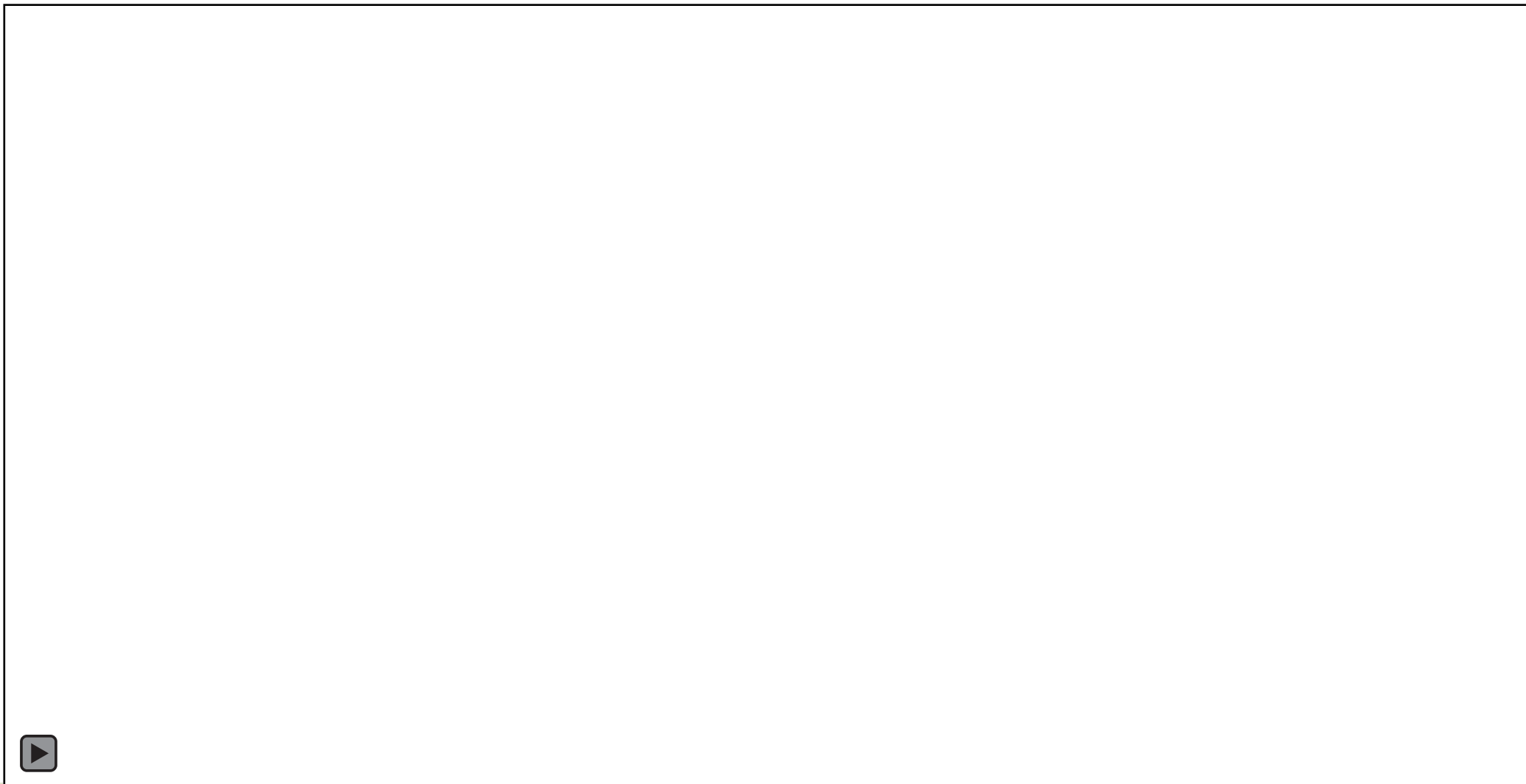
**How do changes in
evapotranspiration (ET)
throughout the day
affect vegetation growth?**

**Can we use ET
measurements to
optimize agricultural
water use?**

Natural Color vs. Thermal Images



Evapotranspiration



What Is Evapotranspiration?

Evapotranspiration is the key climate variable linking the water, energy, and carbon cycles

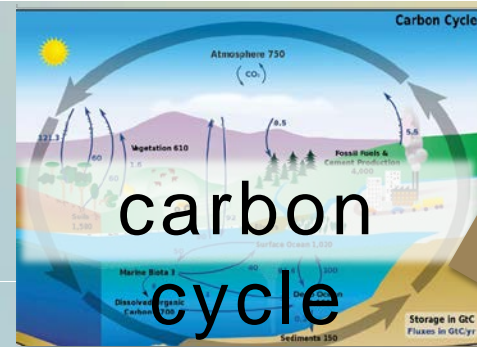


Figure credits: Wikipedia. CC 2.0 Creative Commons License

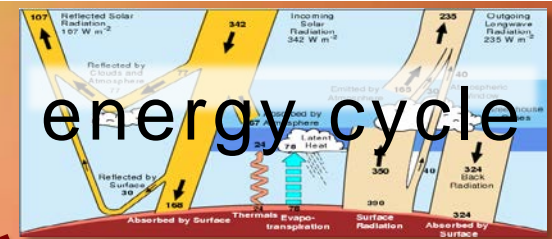
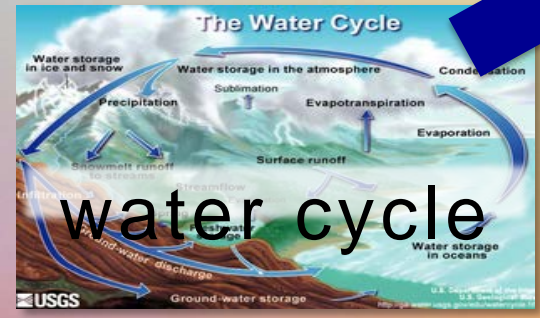


Figure credits: Wikipedia. CC 2.0 Creative Commons License



What Is Evapotranspiration?

Evapotranspiration is the key climate variable linking the water, energy, and carbon cycles

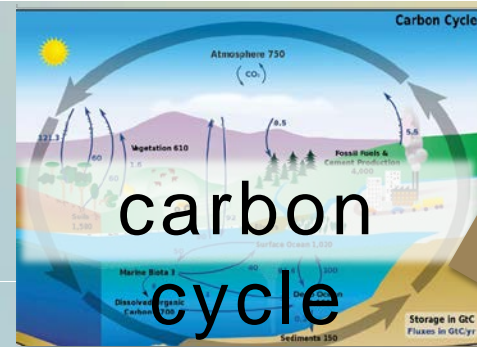


Figure credits: Wikipedia. CC 2.0 Creative Commons License

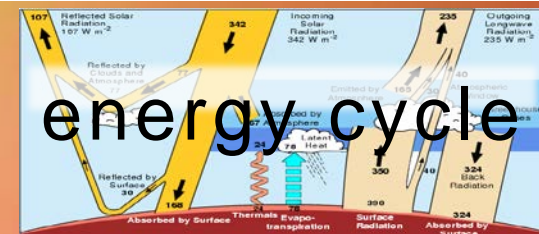
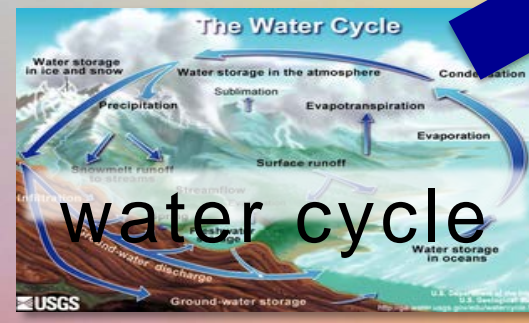


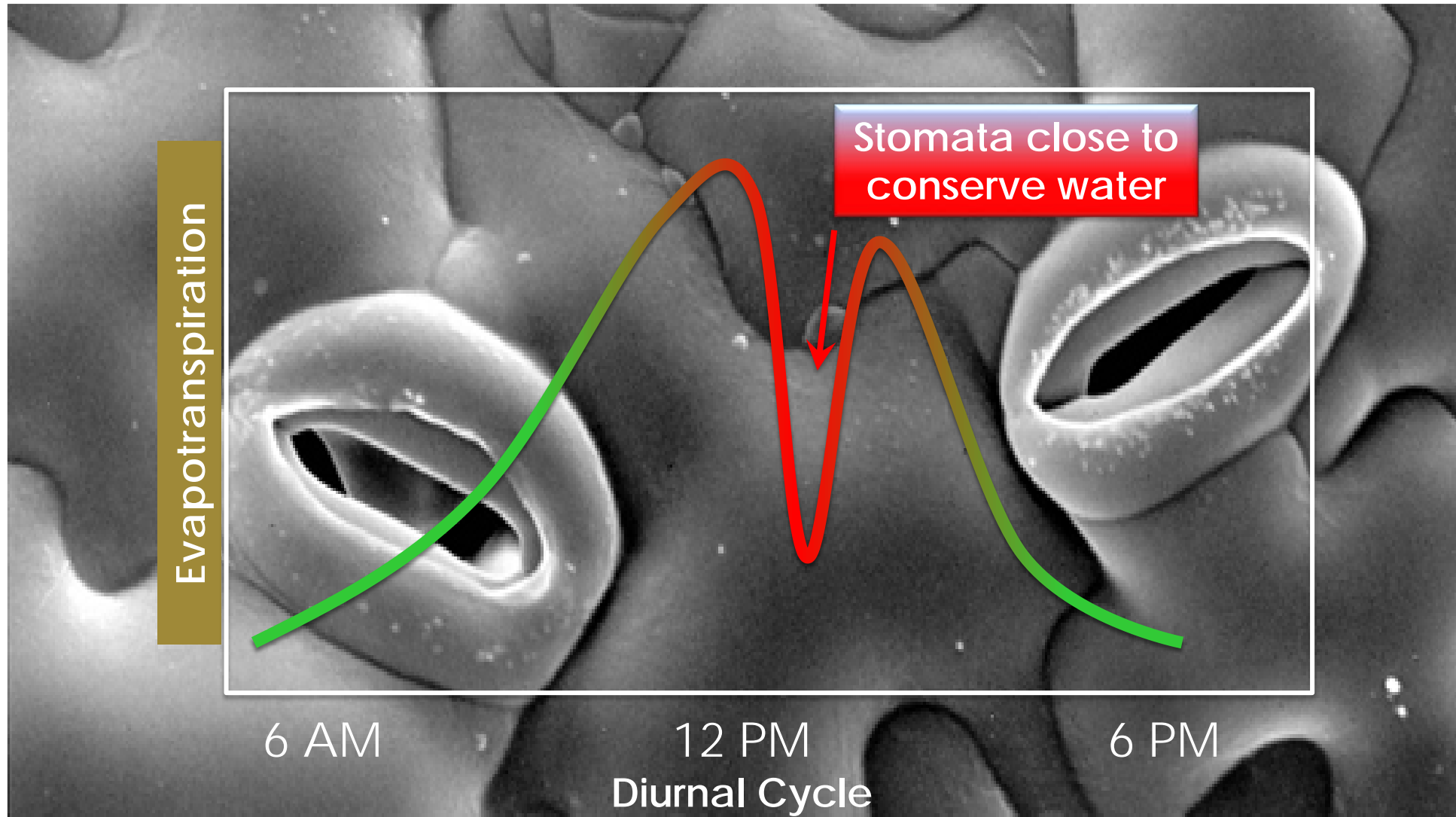
Figure credits: Wikipedia. CC 2.0 Creative Commons License



water cycle

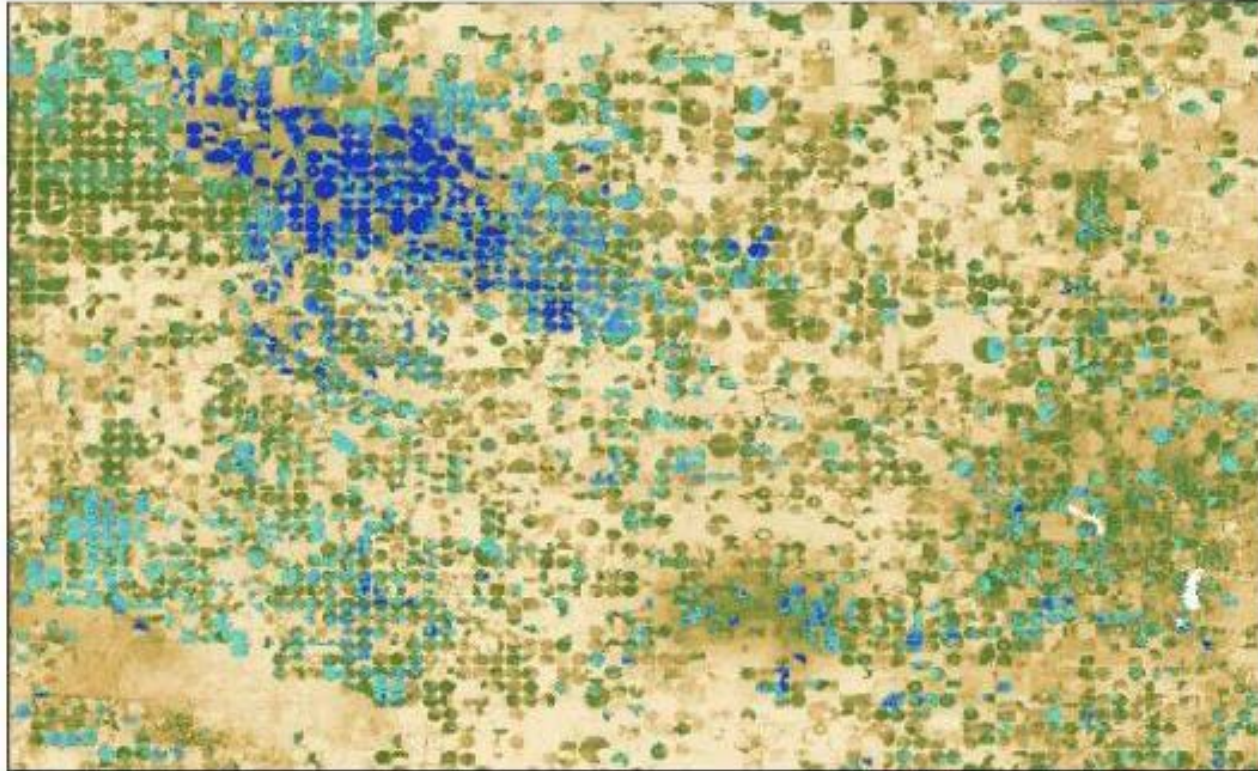


Water Stress Drives Plant Behavior



ECOSTRESS Has a Large Swath (400km) + High Spatial Resolution (70m)

ECOSTRESS L3 (ET PT-JPL) 2018-07-29 18:19 CDT



0.02 g H₂O s⁻¹ m⁻²

0.16 g H₂O s⁻¹ m⁻²

Image Credits: Provided by Dr. Joshua Fisher

[NASA's Applied Remote Sensing Training Program](#)

Plot-scale Insights into Plant Water Use

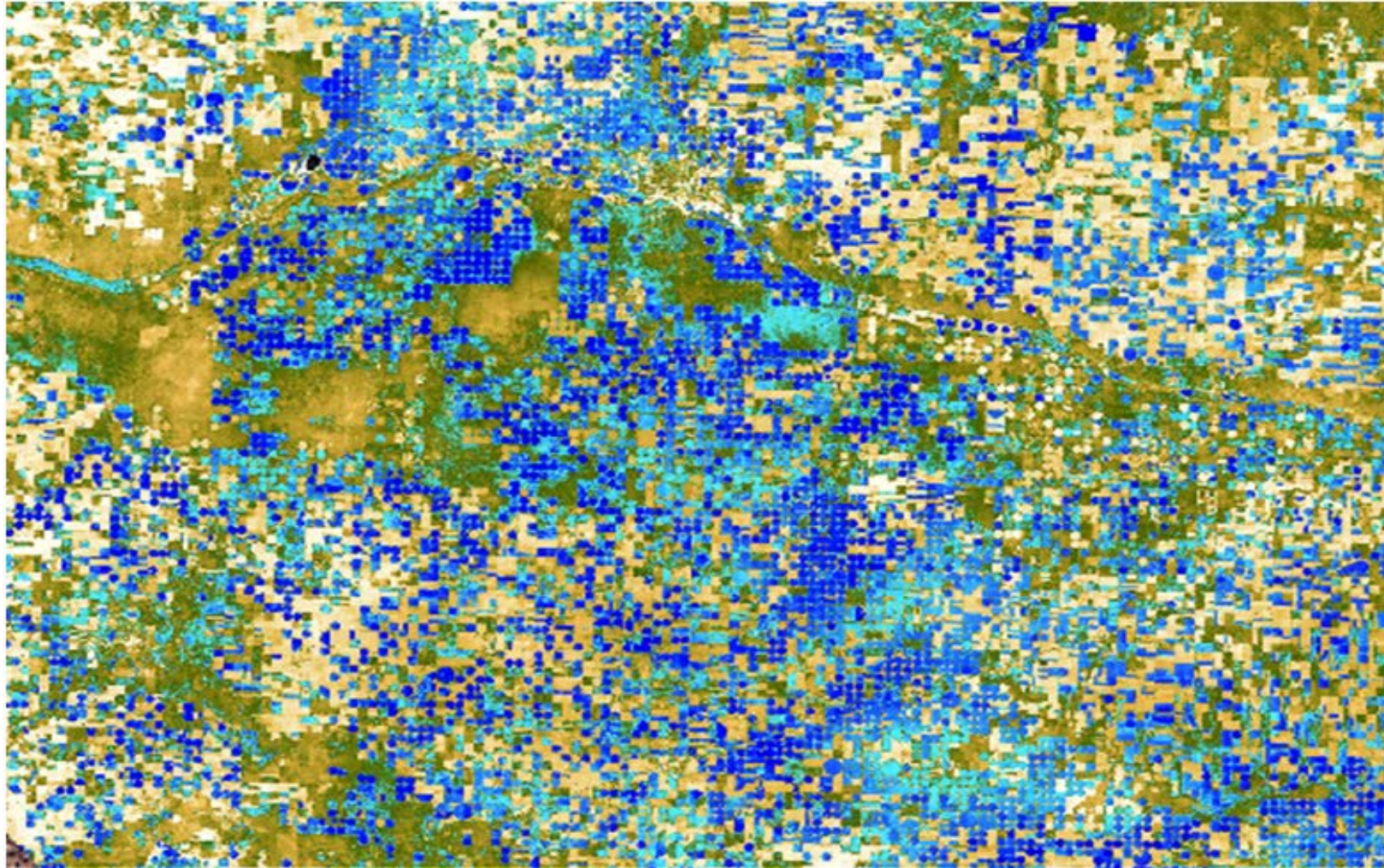


Image Credits: Provided by Dr. Joshua Fisher

[NASA's Applied Remote Sensing Training Program](#)

Contrasting Snapshots of Water Use

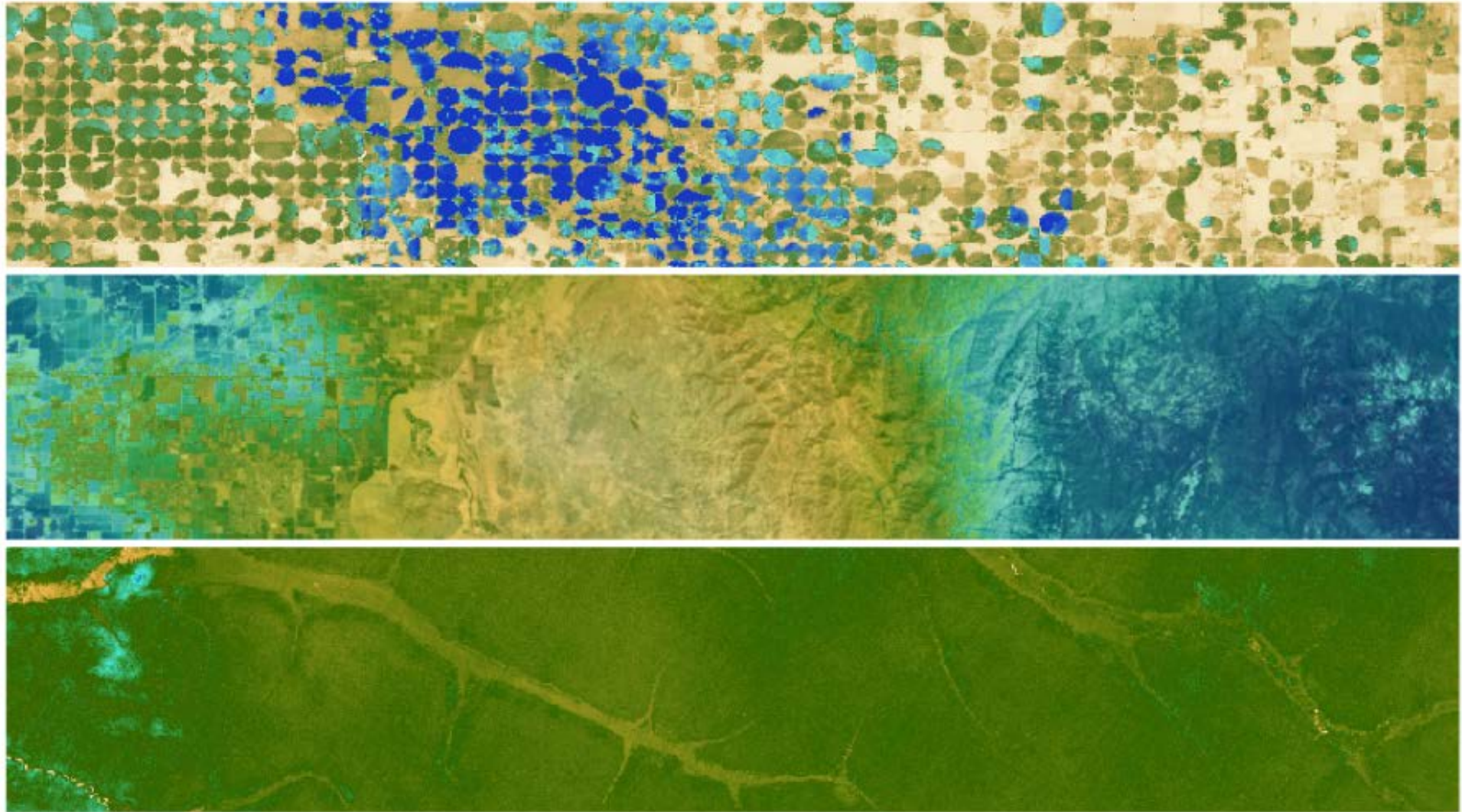


Image Credits: Provided by Dr. Joshua Fisher

[NASA's Applied Remote Sensing Training Program](#)

Water Use Efficiency in the Amazon

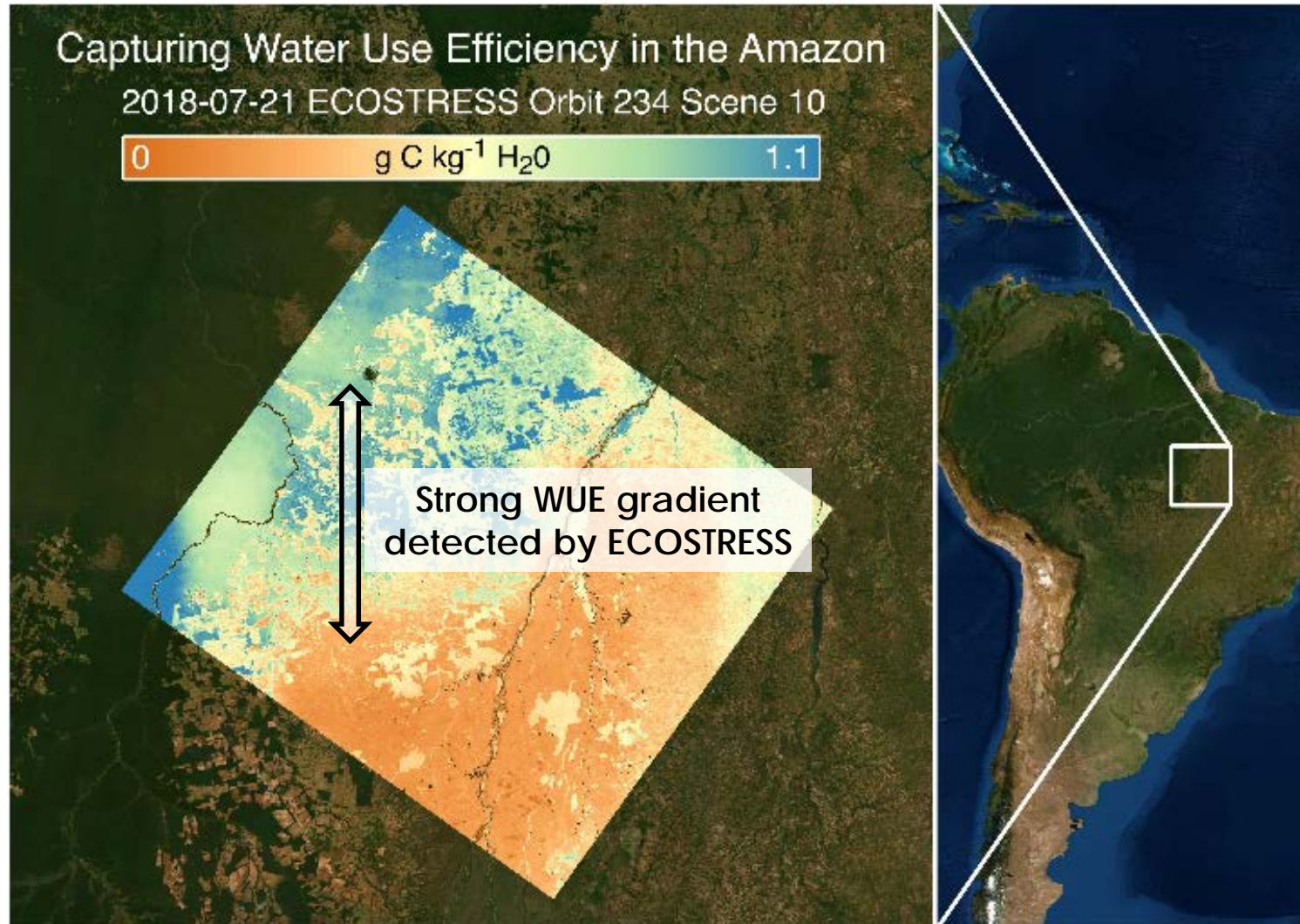


Image Credits: Provided by Dr. Joshua Fisher

Drought in Costa Rica

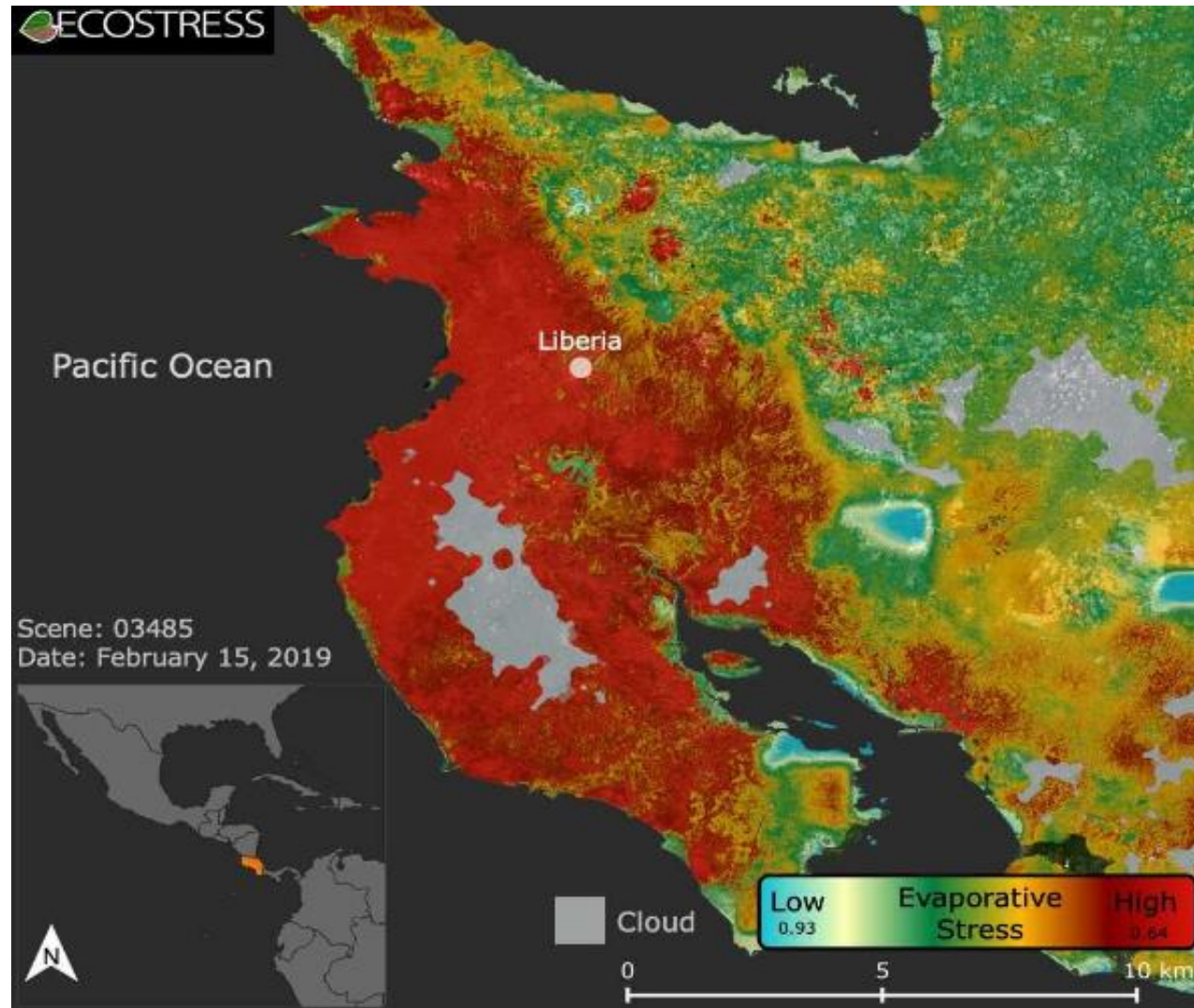
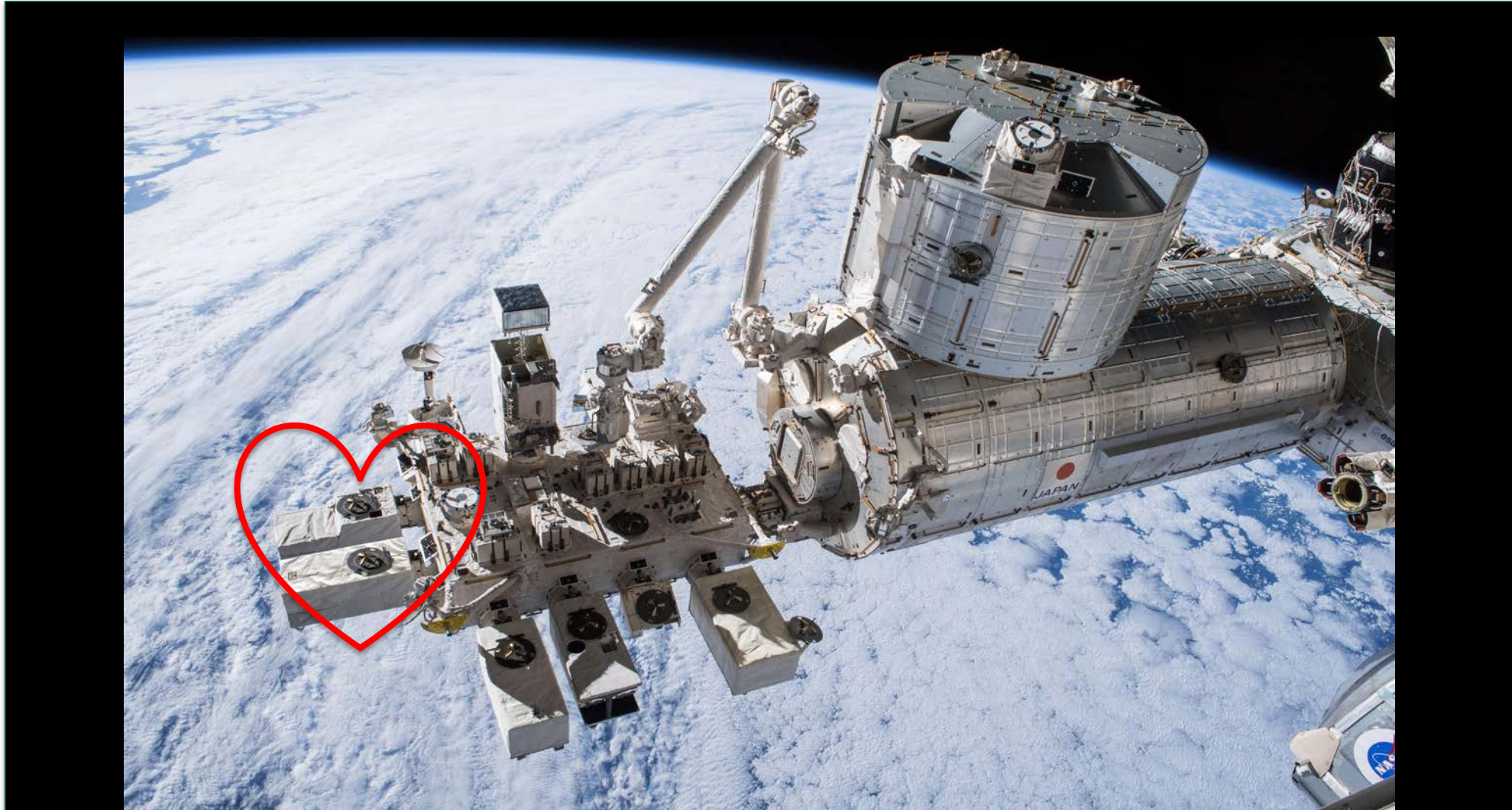


Image Credits: Provided by Dr. Joshua Fisher

ECOSTRESS Leverages the Variable Overpass of the ISS to Study How ET Varies at Different Times of Day



Diurnal Field-scale ET Now Seen, ISS Acquires Data at Different Times of Day

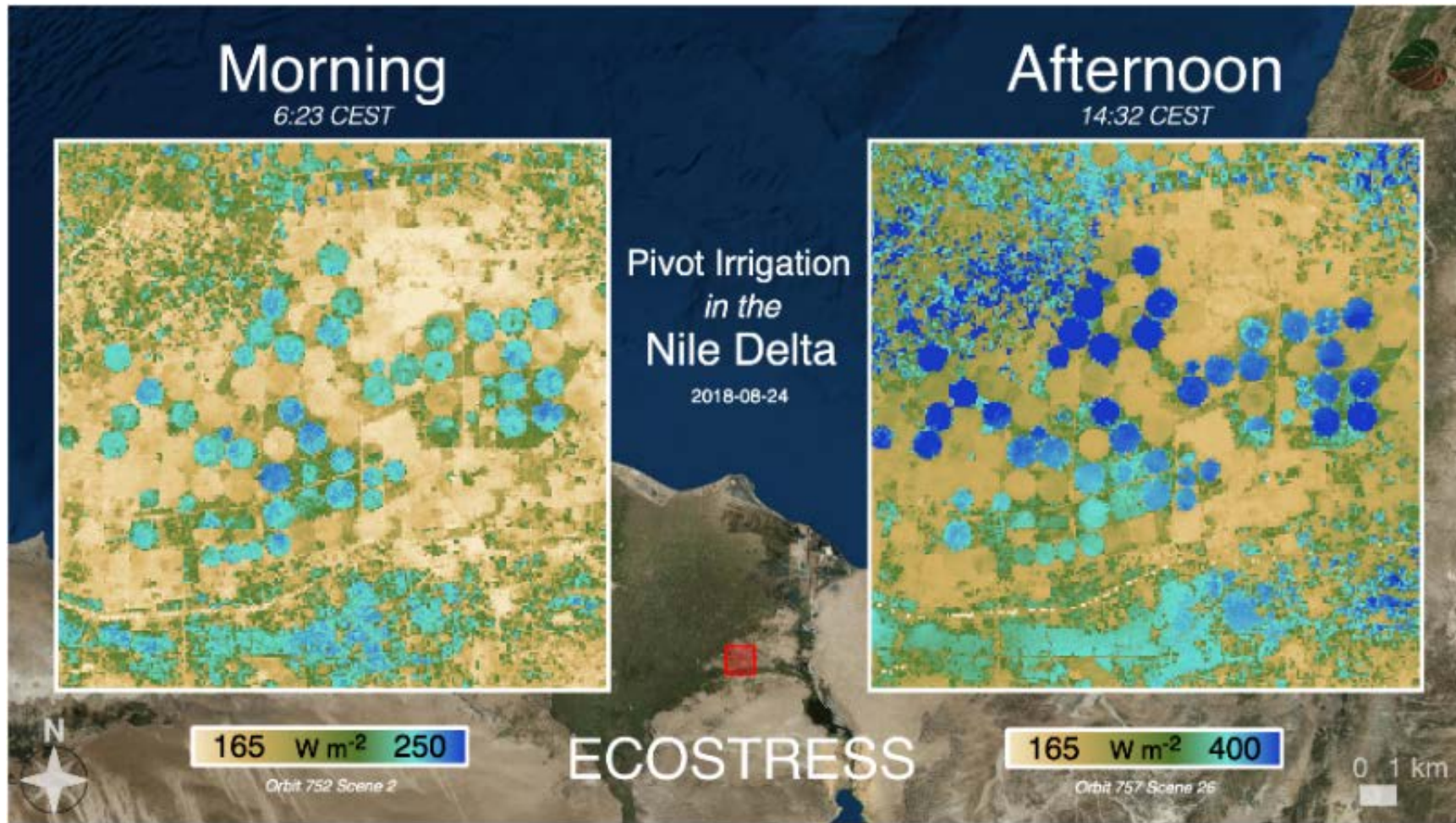


Image Credits: Provided by Dr. Joshua Fisher

[NASA's Applied Remote Sensing Training Program](#)

ECOSTRESS is Being Used to Advance Understanding of How ET Changes Throughout the Day, and How This Relates to Plant Health

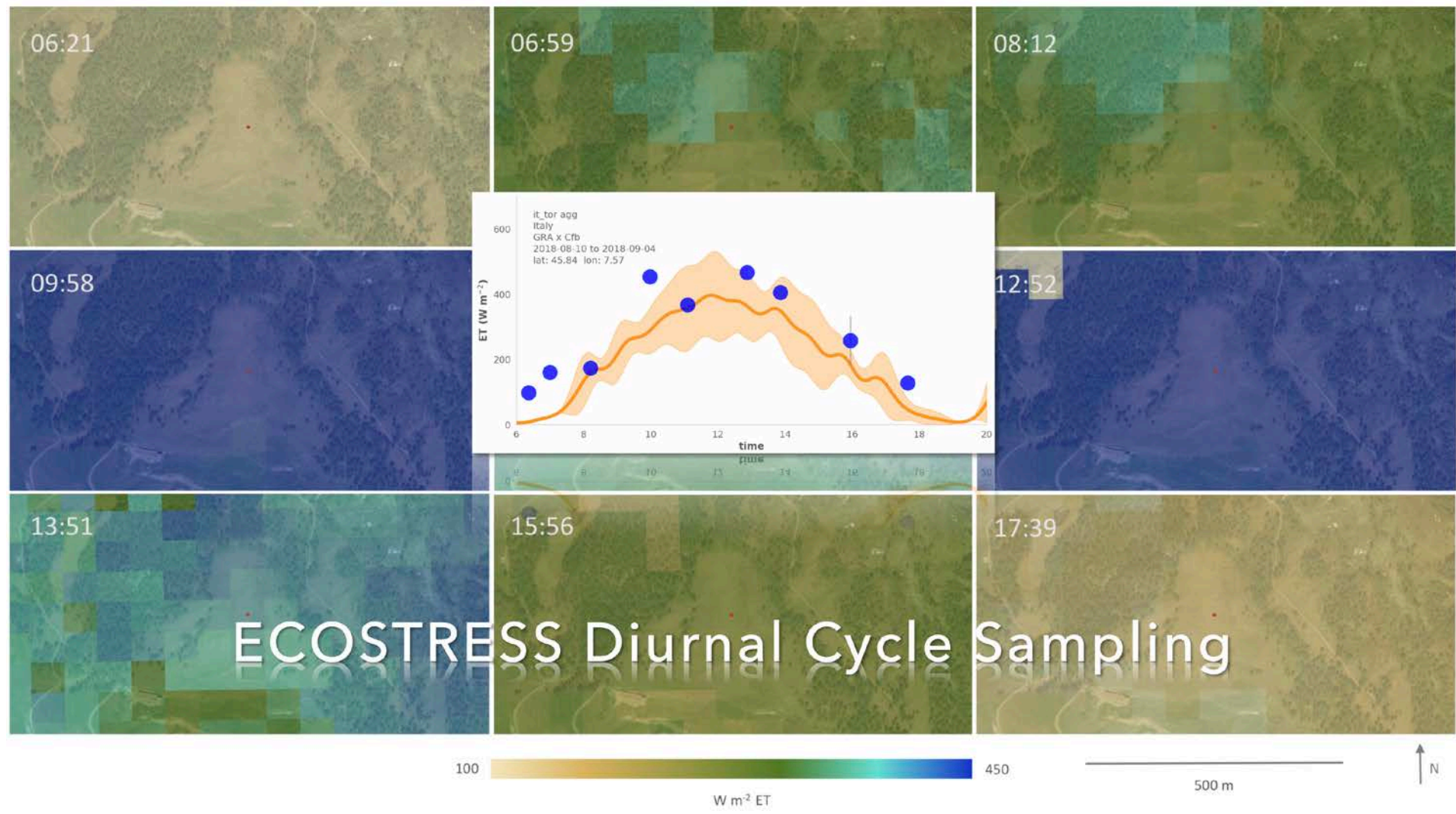


Image Credits: Provided by Dr. Joshua Fisher

USDA is Using ECOSTRESS to Bridge Temporal Gaps in ET Assessments in Support of Agricultural Applications

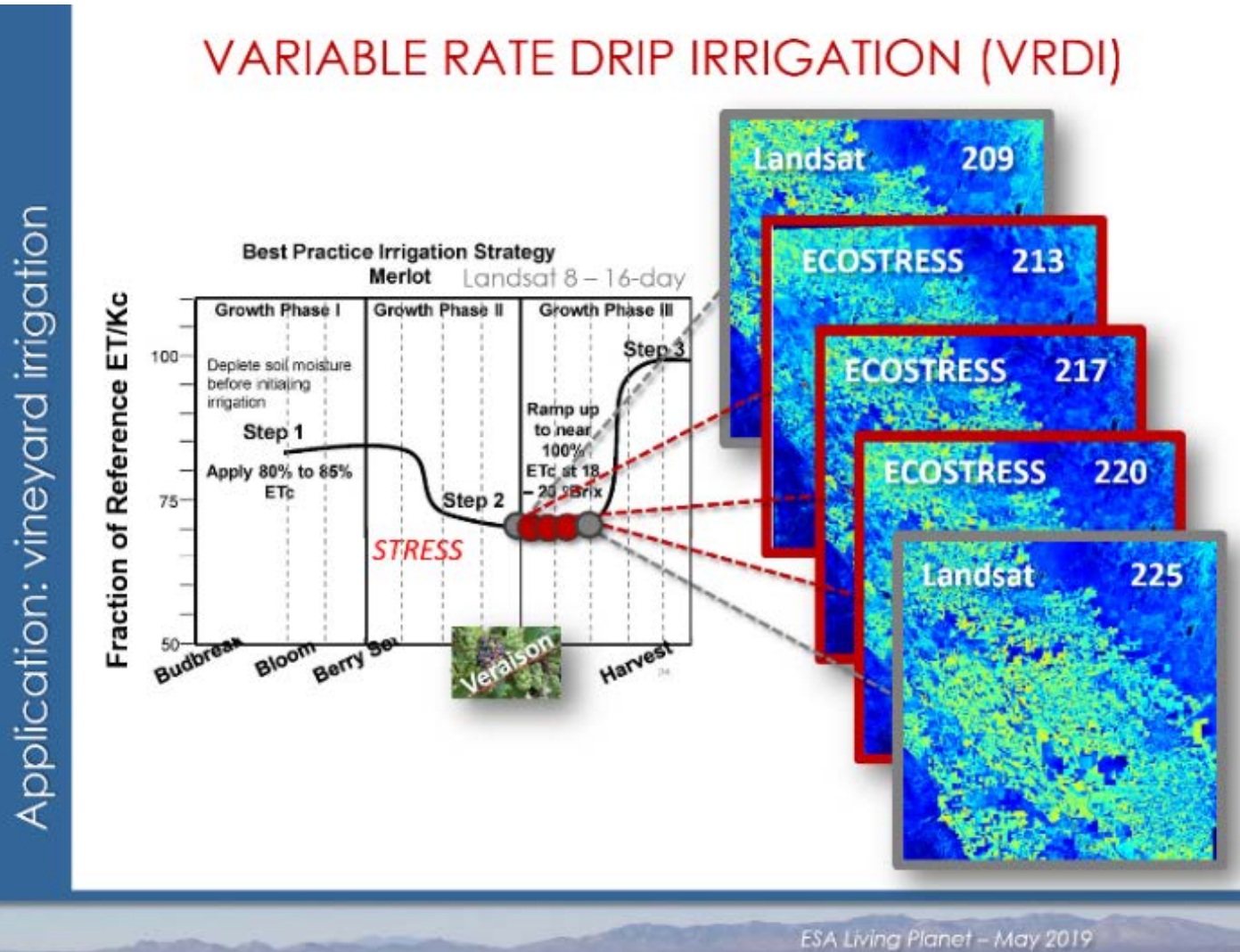
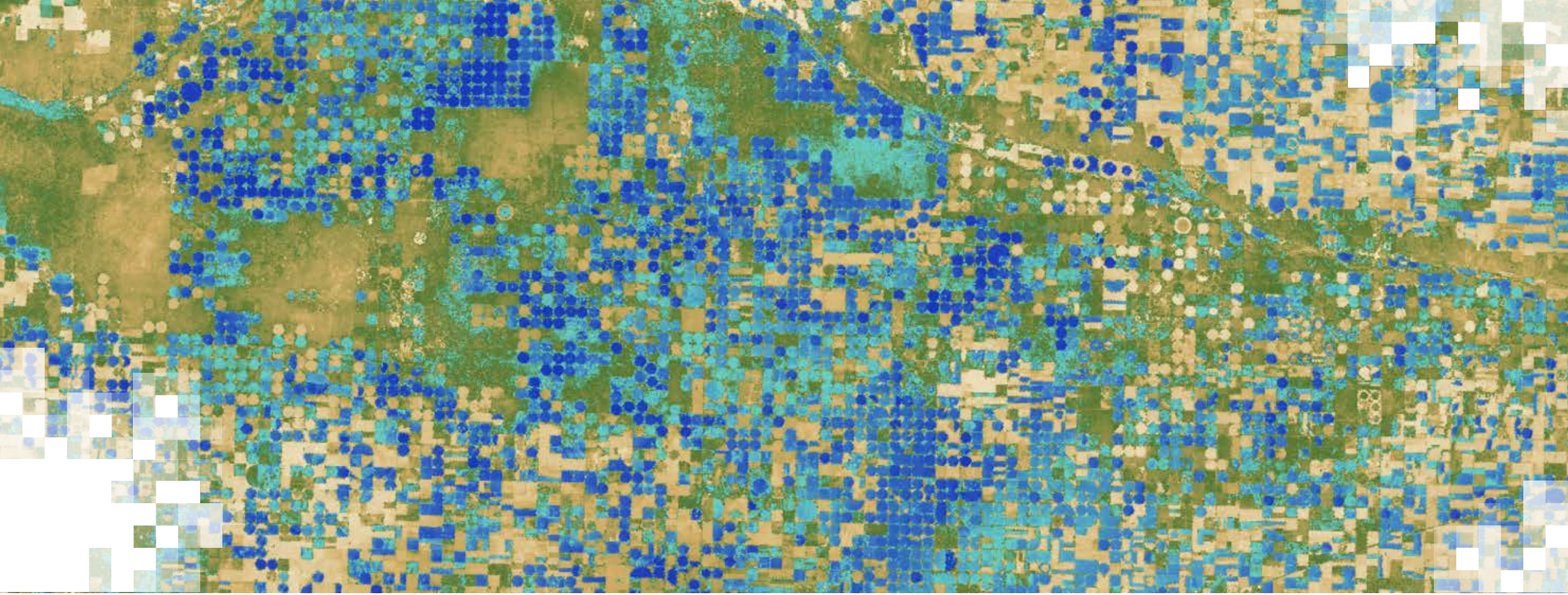


Image Credits: Provided by Dr. Martha Anderson



Other Applications of ECOSTRESS Data

ECOSTRESS Observes Fires in the Amazon

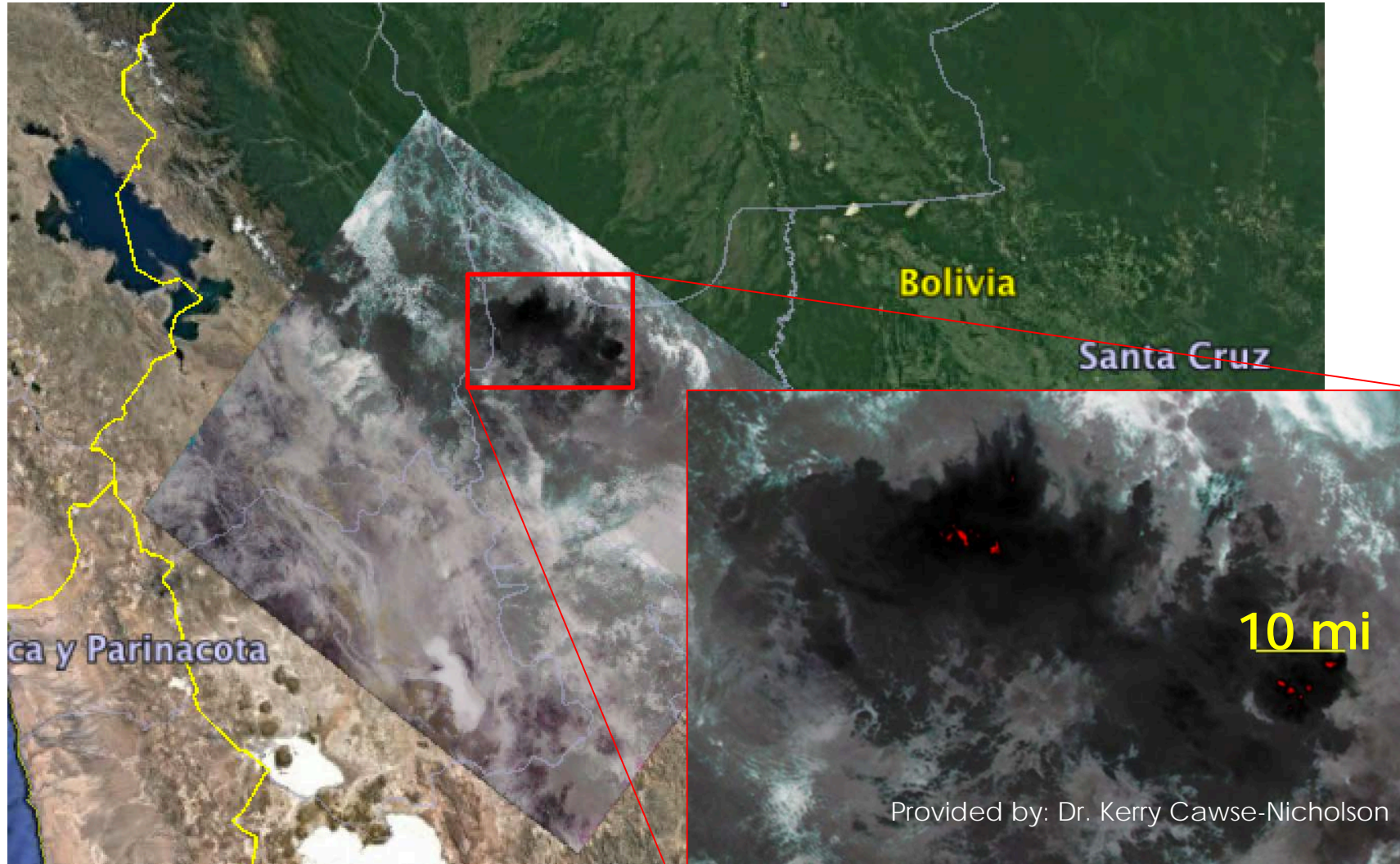


Image Credits: Provided by Dr. Kerry Cawse-Nicholson

Examining the Relation Between Biodiversity and Surface Temperature Regimes in Localized Coastal Upwelling Zones

Remote Sensing of Environment 233 (2019) 111366



Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse



Half a century of satellite remote sensing of sea-surface temperature

P.J. Minnett^{a,*}, A. Alvera-Azcárate^b, T.M. Chin^c, G.K. Corlett^d, C.L. Gentemann^e, I. Karagali^f, X. Li^g, A. Marsouin^h, S. Marulloⁱ, E. Maturi^j, R. Santoleri^k, S. Saux Picart^h, M. Steele^l, J. Vazquez-Cuervo^c

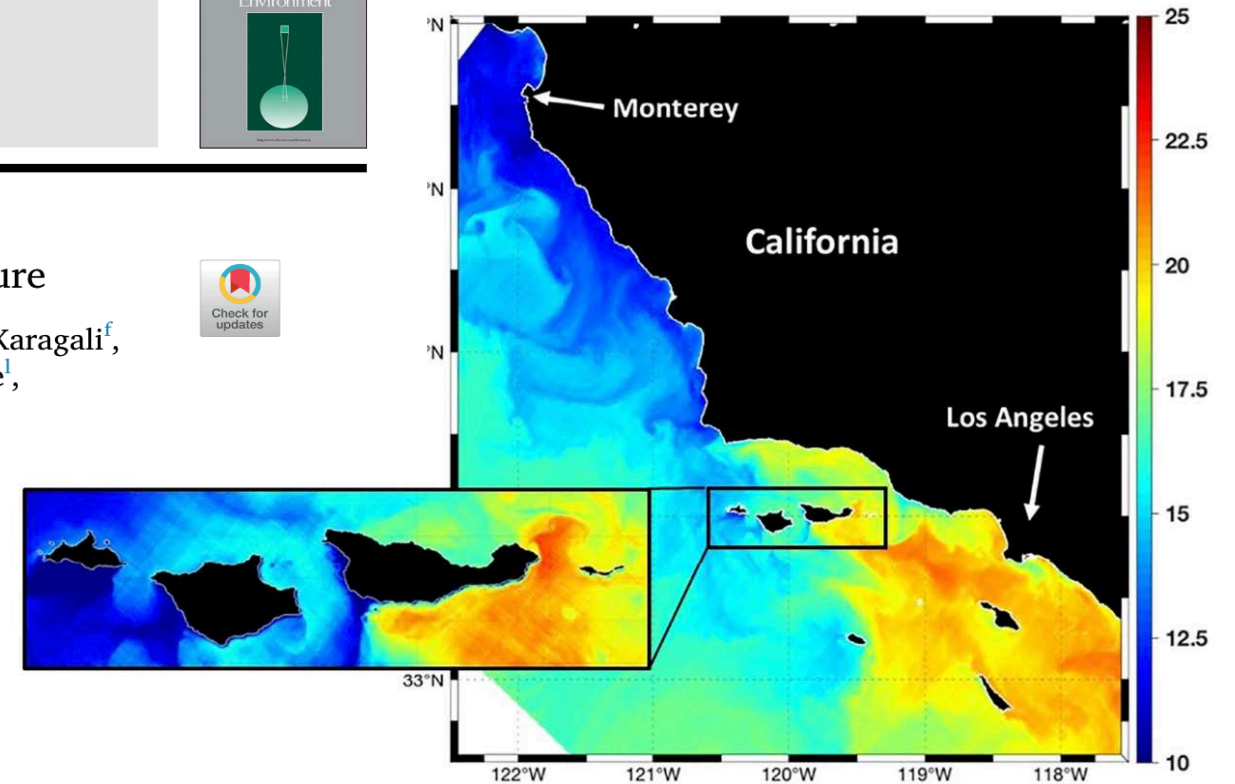


Image Credits: Provided by Dr. Daniel Otis

ECOSTRESS Used to Assess Heat Vulnerability in Urban Studies



Article

New ECOSTRESS and MODIS Land Surface Temperature Data Reveal Fine-Scale Heat Vulnerability in Cities: A Case Study for Los Angeles County, California

Glynn Hulley ^{1,*}, Sarah Shivers ², Erin Wetherley ² and Robert Cudd ³

- ¹ Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91109, USA
 - ² Department of Geography, University of California Santa Barbara, Santa Barbara, CA 93106, USA
 - ³ Institute of the Environment & Sustainability, University of California, Los Angeles, CA 90095, USA
- * Correspondence: Correspondence: glynn.hulley@jpl.nasa.gov; Tel.: +1-818-354-2979

Received: 17 July 2019; Accepted: 10 September 2019; Published: 13 September 2019



ECOSTRESS + Landsat 8 surface temperature (30m)

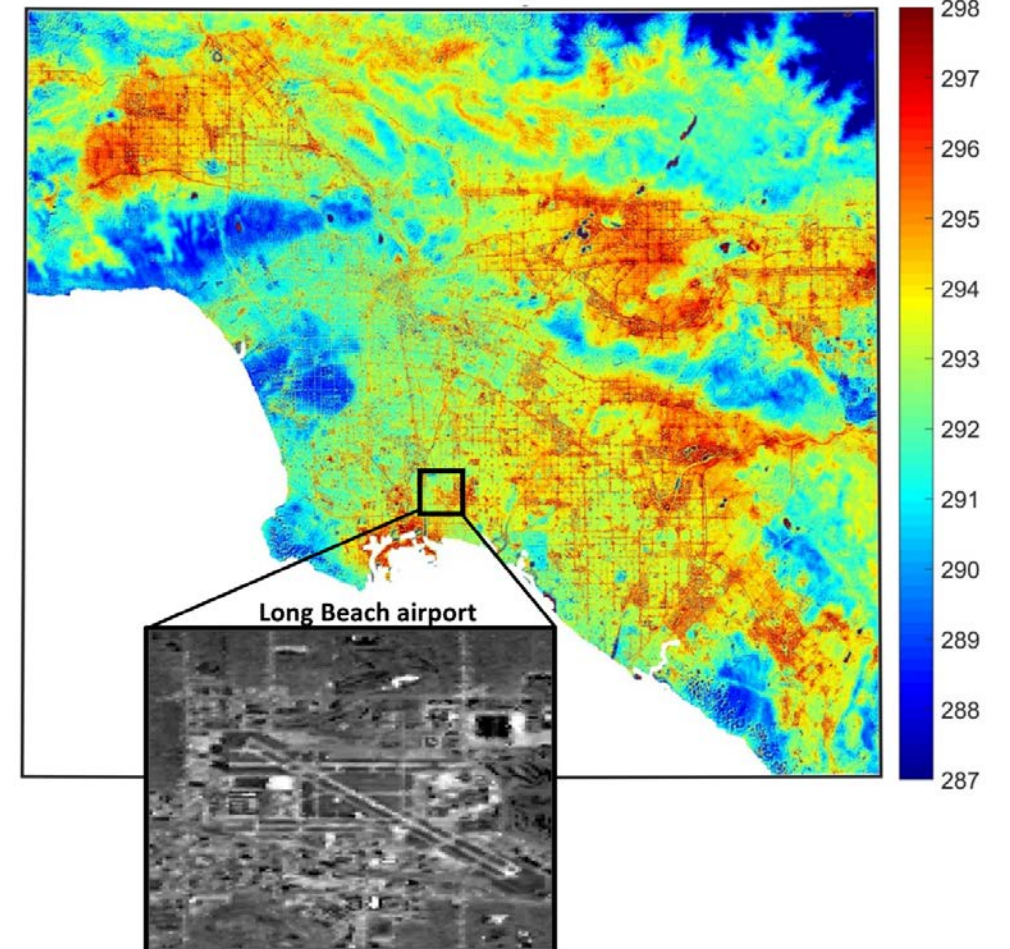


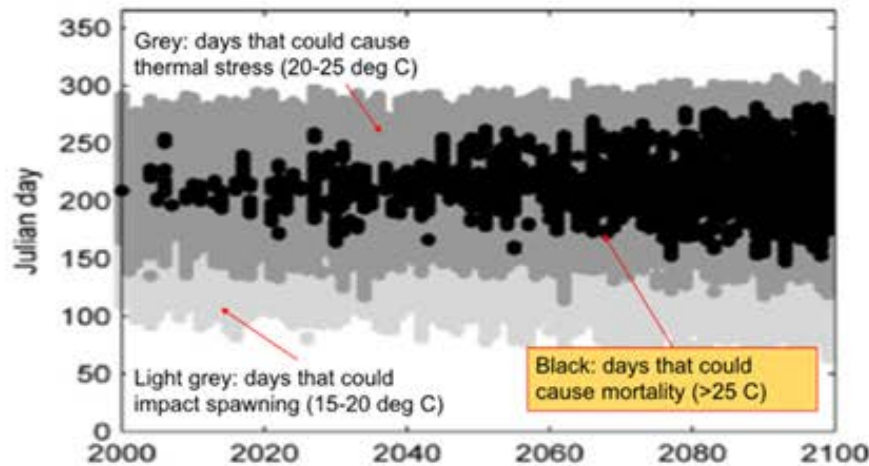
Image Credits: Provided by Dr. Glynn Hulley



Water Flow Operations Impacts on Turbidity and Temperature in San Francisco Bay and Delta Ecosystems Using Satellite Remote Sensing



Mapping thermal refuges of the delta smelt



WAGNER 2011

Agency Partners: California Department of Water Resources, Metropolitan Water District
PI. Christine Lee, Image: Gregory Halverson

ECOSTRESS Has over 260 Members in our Community of Practice (Formerly Early Adopters)

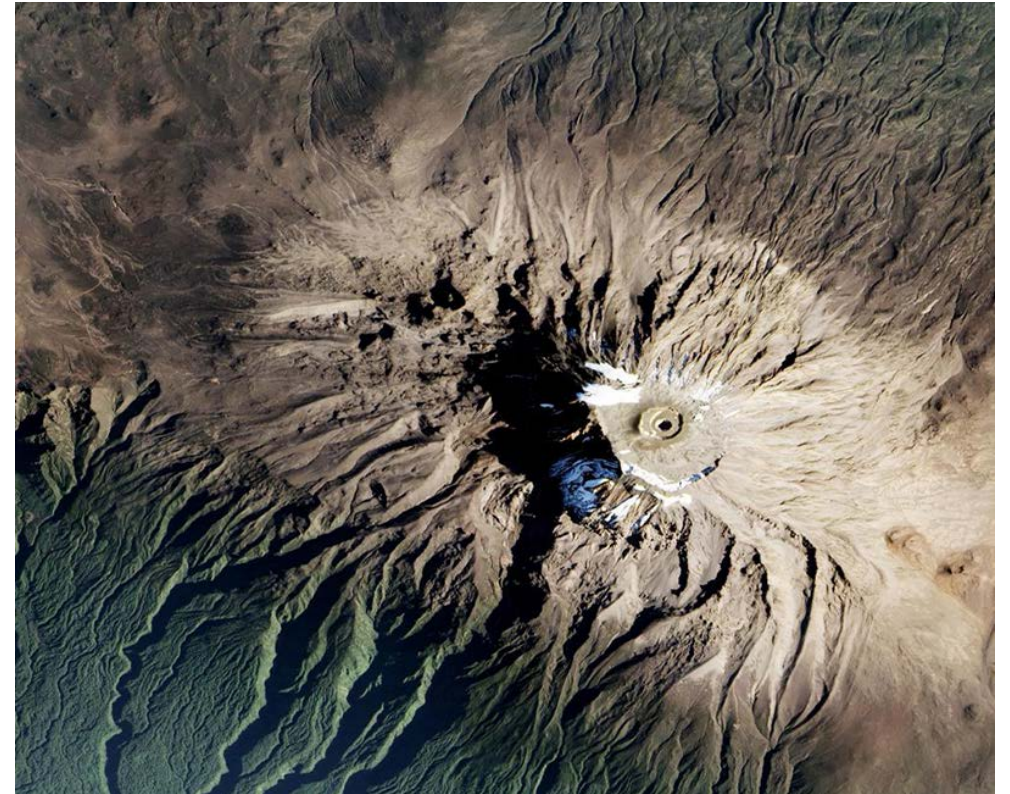
- To join our community, visit ecostress.jpl.nasa.gov/cop

ECOSTRESS Selected 15 New Members to Join the Science and Applications Team Family in 2019

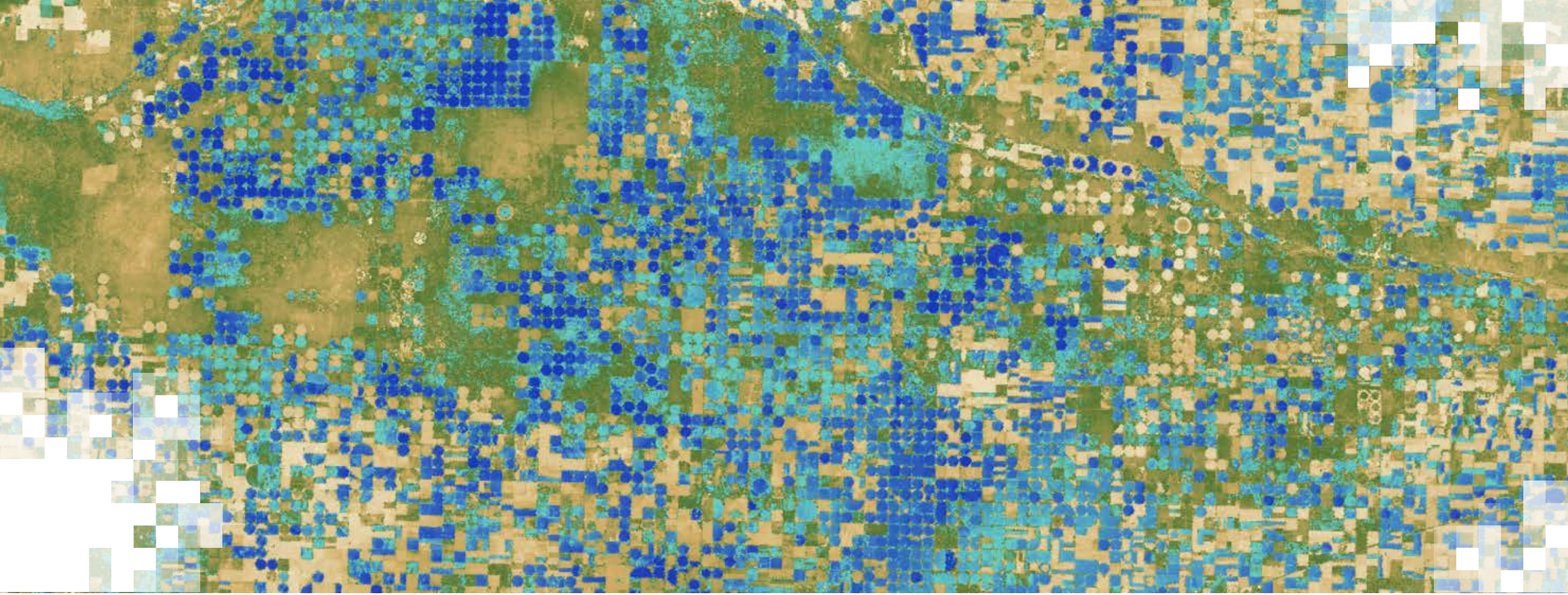
- See the updated team here: ecostress.jpl.nasa.gov/team
- Science and Applications investigations include agriculture, ecosystems, water quality, coastal systems and aquaculture, public health and urban heat, geothermal resources, and wildfire impacts!
- **Abstracts available here:** <https://tinyurl.com/ecostress-science-team-2019>
- There will be an open Science and Applications Team meeting in February 2020 in Southern California. A training with LP DAAC will likely be included. More information can be found here: ecostress.jpl.nasa.gov/cop

Surface Biology and Geology (SBG) Mission

- New instrument in development: Guidance from the [2018 Decadal Survey](#)
- Hyperspectral and thermal data under consideration
- Applications could include:
 - Water cycle and anthropogenic impacts
 - Biodiversity
 - Carbon fluxes
 - Land surface/atmosphere interactions
 - Volcanos
 - Landscape change
- The **Applications Working Group** is coordinating and integrating applications needs
 - Email list for updates: sbg@jpl.nasa.gov
- For more info: <https://sbg.jpl.nasa.gov/>



Mount Kilimanjaro Image Credit: [JPL SBG](#)

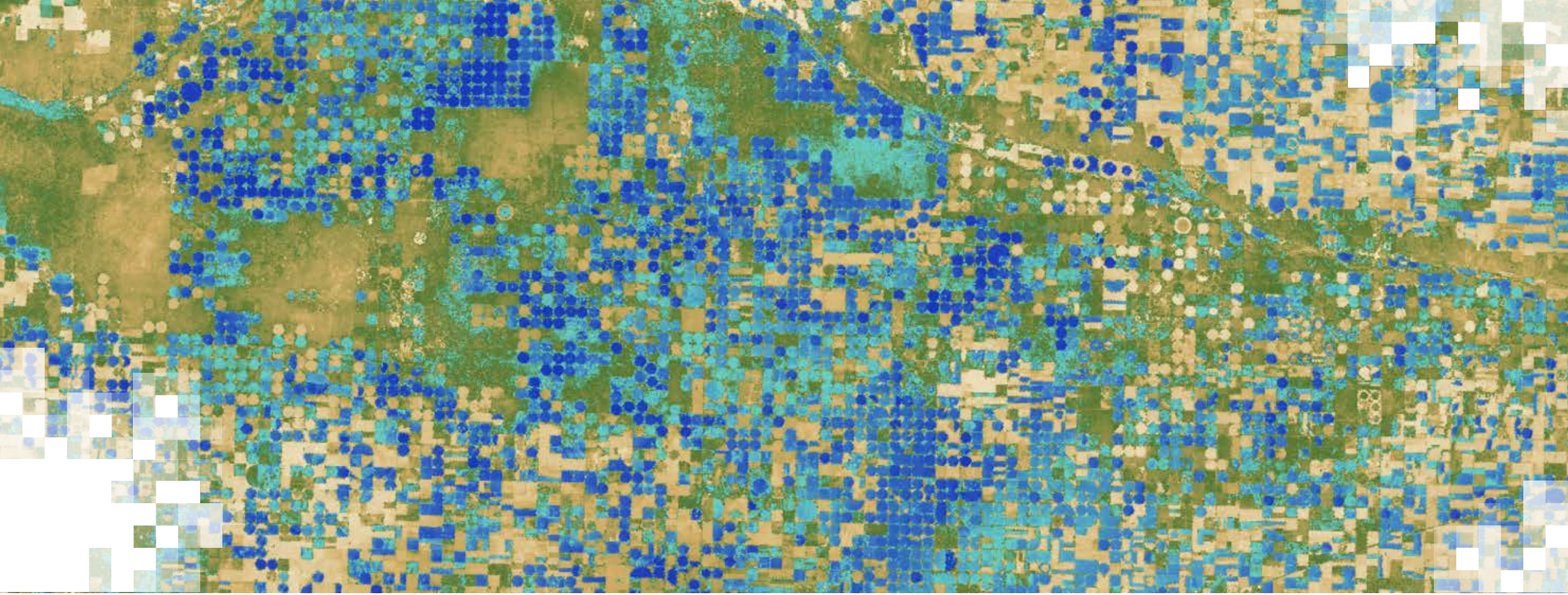


Guest Speaker: Cole Krehbiel (LP DAAC)

U.S. Department of the Interior
U.S. Geological Survey

LP DAAC Remote Sensing Scientist
KBR, contractor to USGS EROS
Sioux Falls, South Dakota
*Work performed under USGS contract G15PD00766

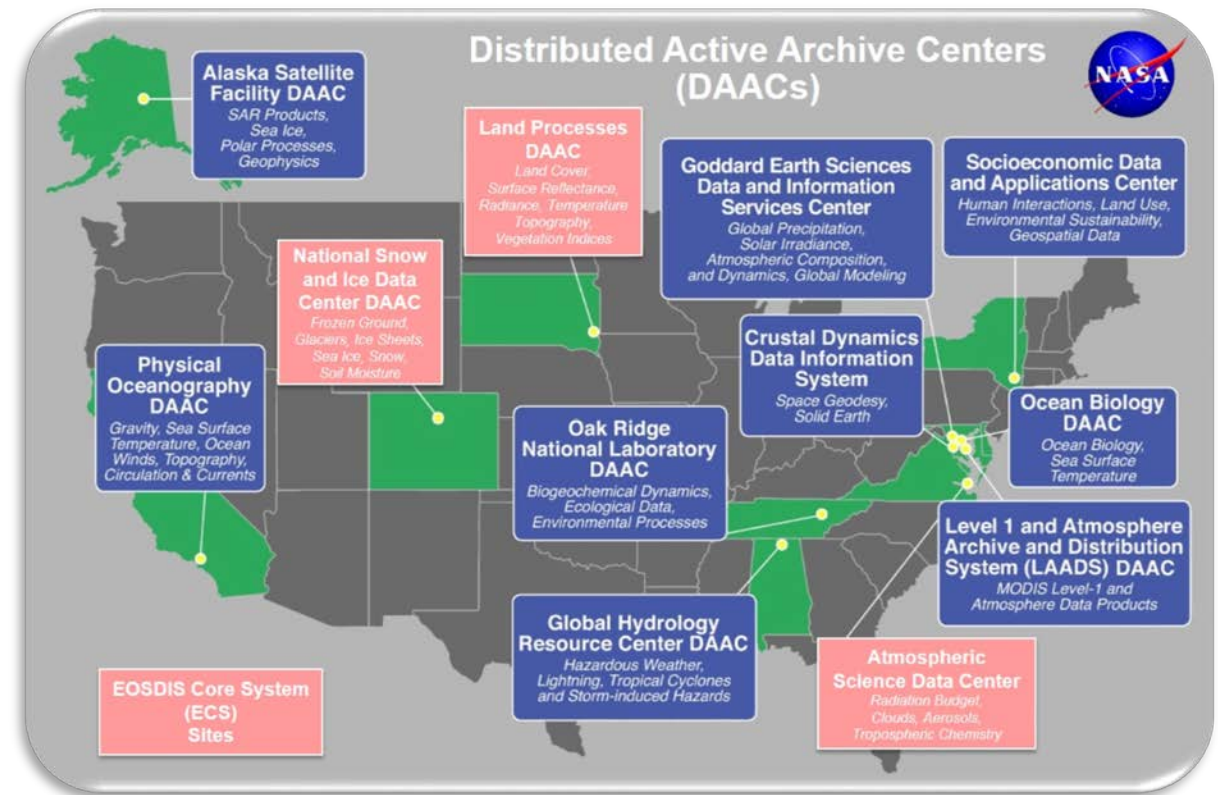




An Introduction to the LP DAAC, ECOSTRESS
Data, and Resources for Working with
ECOSTRESS Data

NASA's Land Processes Distributed Active Archive Center (LP DAAC)

- Located in Sioux Falls, SD at the U.S. Geological Survey (USGS) Earth Resources Observation and Science (EROS) Center
- NASA Earth Observing System Data & Information System (EOSDIS) DAAC
- <https://lpdaac.usgs.gov>

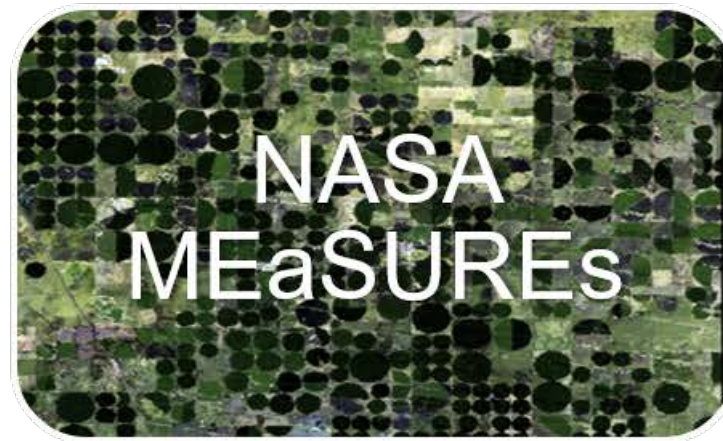


What does the LP DAAC do?



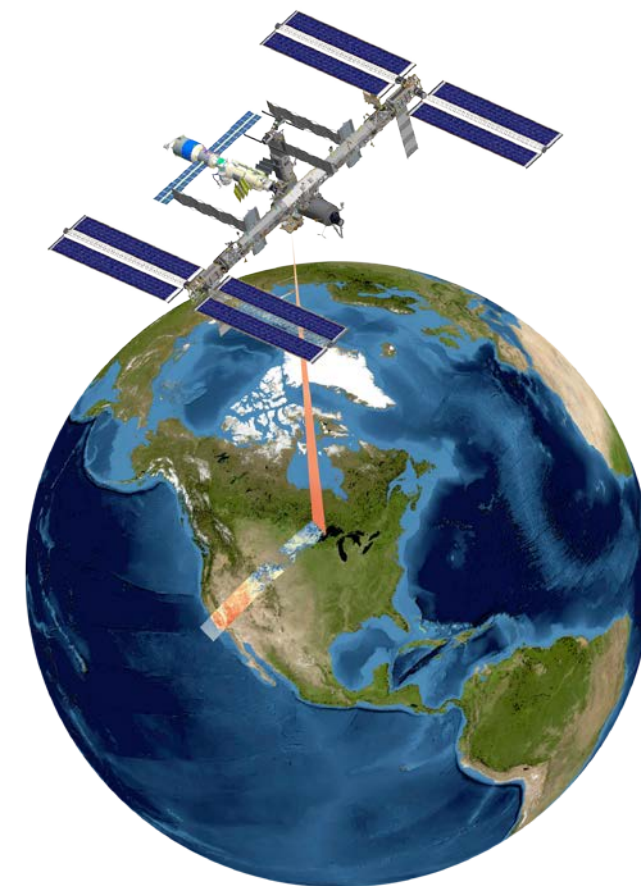
“Process, archive, and distribute publicly-available land-data products to advance the *access, understanding, and use* of data for large and diverse user communities”

LP DAAC Data Collections




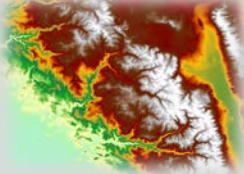

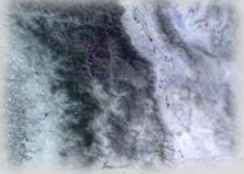
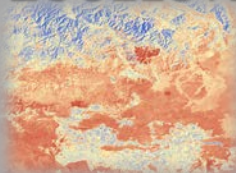
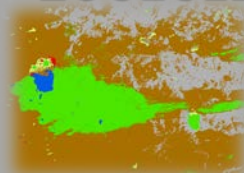


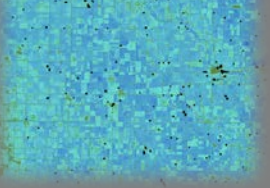
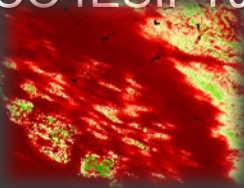


ECOSTRESS Characteristics

Characteristic	Description
Temporal Coverage	July 09, 2018 – Present
Spatial Coverage	CONUS, key biomes/agricultural zones, selected FLUXNET sites
Spatial Resolution	~ 70 m (USDA dis-ALEXI 30 m)
Temporal Resolution	Variable, dependent on ISS
Spectral Resolution	5 (3) bands spanning TIR
Data Types	Swath
File Type	HDF-EOS
Unique Products	12
Version	001

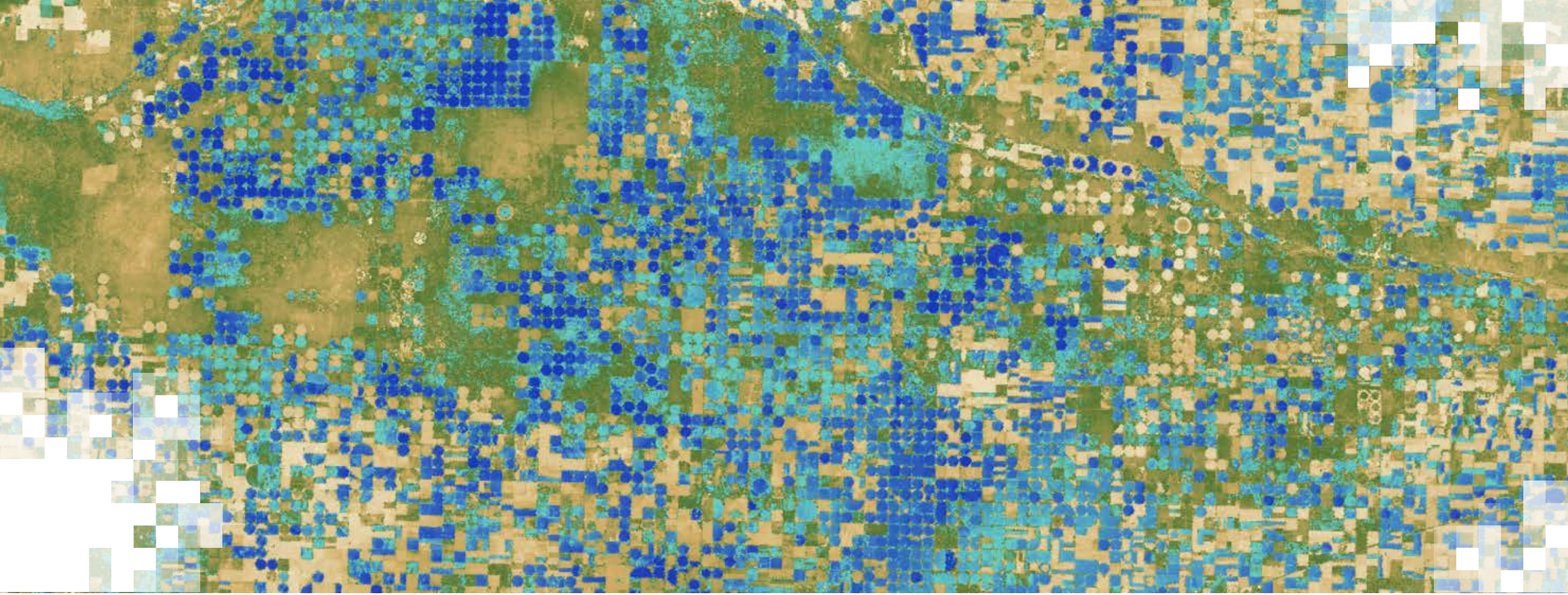


ECOSTRESS Products



ECO1BATT  Attitude/ephemeris data	ECO1BGEO  Geolocation parameters	ECO1BRAD  Calibrated Radiance	ECO1BMAPRAD  Resampled Radiance
ECO2LSTE  LST and Emissivity	ECO2CLD  Cloud Mask		
ECO3ETPTJPL  ET PT-JPL	ECO3ANCQA  Ancillary data QA flags	ECO3ETALEXIU  ET dis-ALEXI USDA	
ECO4ESIPTJPL  ESI PT-JPL	ECO4WUE  Water Use Efficiency	ECO4ESIALEXIU  ESI dis-ALEXI USDA	





Using ECOSTRESS Data

ECOSTRESS Data in AppEEARS

Subset data-

- Spatially
- Temporally
- By band/layer
- Output options

Extract Area Sample

Enter a name to identify your sample
Kings County, CA ECOSTRESS

Upload a file or draw a polygon using the or icon
Drop a vector polygon file containing the area features) to extract or click here to select the file.
Supported file formats:
• ESRI Shapefile (.shp including .shx, .dbf, .prj and .sbn files)
• GeoJSON (.json or .geojson)

Start Date: 07-01-2018 End Date: 06-04-2019

Is Data Recurring?

Select the layers to include in the sample

ECOSTRESS Land Surface Temperature & Emissivity (LST4E)
ECOSTRESS 6M, 70m, 655-dependent, (2018-07-09 to Present)

Selected layers: SOS_LST (70m, 655-dependent)

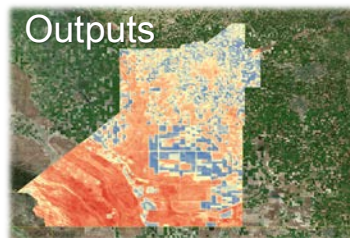
Output Options
File Format: GeoTIFF
Projection: Geographic
Datum: WGS84
PRJ4: EPSG:4326
PROJ4: +proj=latlong +datum=WGS84 +no_defs

NOTE: Be aware that any rejections of data from its source projection to a different projection will inherently change the data from its original format. All rejections use GDAL's `gdalwarp` function in combination with the PROJ4 + string listed above. For additional information, see the AppEEARS help documentation.

Submit Cancel

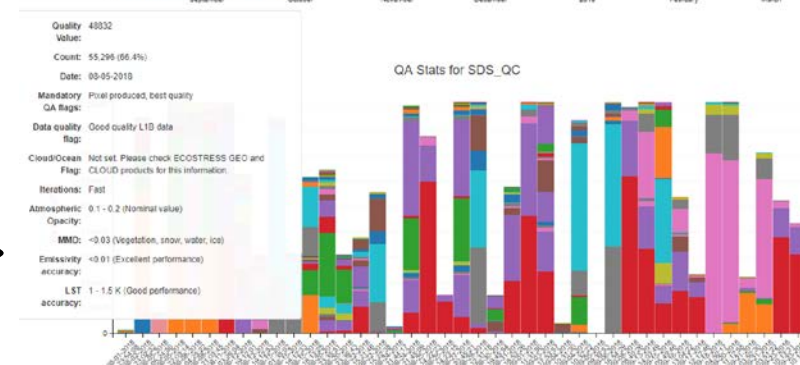
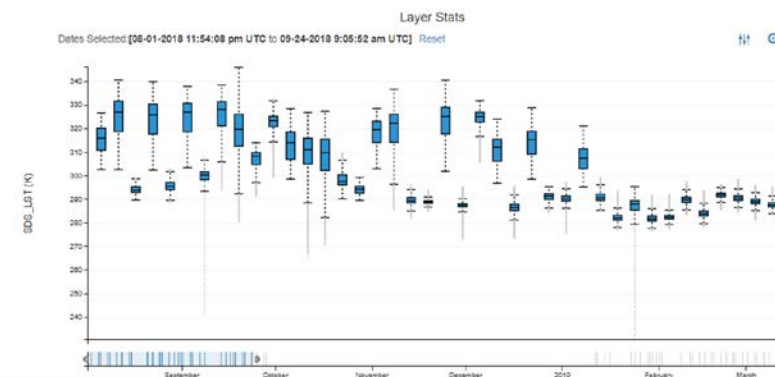
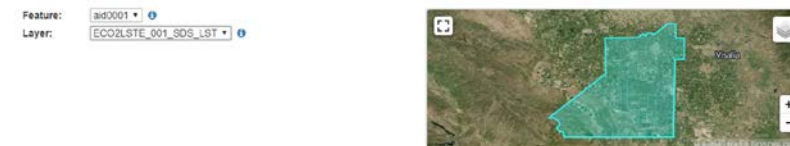


Swath to Grid



Outputs

Visualizations



Decoded QC

Tennessee Energy: Assessing the Hydrothermal Outputs of Nuclear Power Plants with ECOSTRESS

WHO: Staff from the TVA Hydrothermal Group

WHAT: Tasked with monitoring water temperature downstream from nuclear sites to ensure water temps meet federal regulations

WHERE: Upstream and downstream from TVA's three nuclear power plants (TN/AL)

WHY: Recent expansions in power production (spring 2018) potentially increased temp of river via thermal discharge in TN River, which can harm fluvial ecosystems

WHEN: January 2017 – July 2019

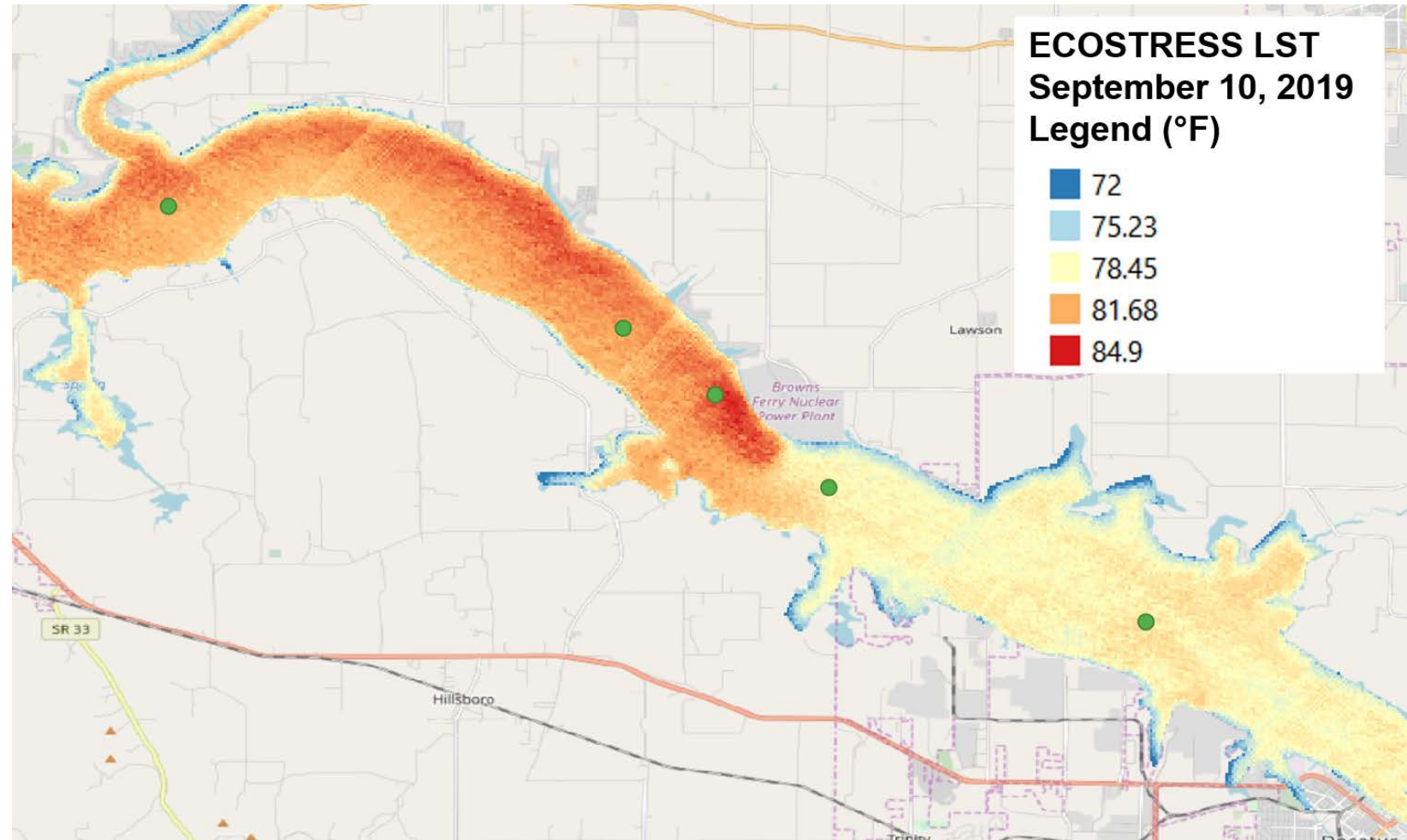
HOW: Supplement models with products assessing water surface temp before/after expansion at upstream and downstream locations (+ seasonal comparison) using Landsat 7 ETM+, Landsat 8 OLI, Aqua MODIS, Terra ASTER, and **ECOSTRESS LST**



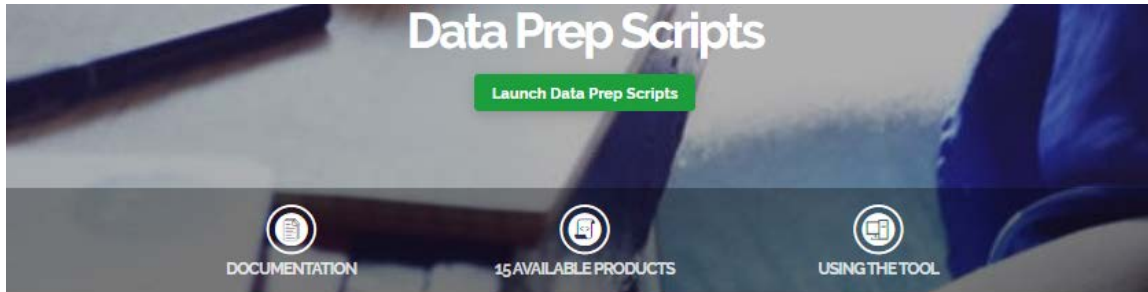
Problem: Many different data sources to blend together

Live Demos

1. LP DAAC Website Walk Through:
<https://lpdaac.usgs.gov>
2. Point Example Walk Through: Generating Hydrothermal Output Time Series
3. Area Example Walk Through: Extracting ECOSTRESS LST over the Tennessee River



LP DAAC Data Prep Scripts



Homepage / Tools / Data Prep Scripts

Description <https://lpdaac.usgs.gov/tools/data-prep-scripts/>

This collection of R and Python scripts can be used to download data and perform basic data processing functions such as georeferencing, reprojecting, converting, and reformatting data. Scripts are available in Python and/or R and each have a README that provides additional information for download from the LP DAAC User Resources BitBucket Code Repository.

Ecosystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS)

- ECOSTRESS Swath to Grid Conversion Script

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER)

- Convert ASTER L1T Radiance to Top of Atmosphere Reflectance
- Reformat and Georeference ASTER L1T HDF Files

Visible Infrared Imaging Radiometer Suite (VIIRS)

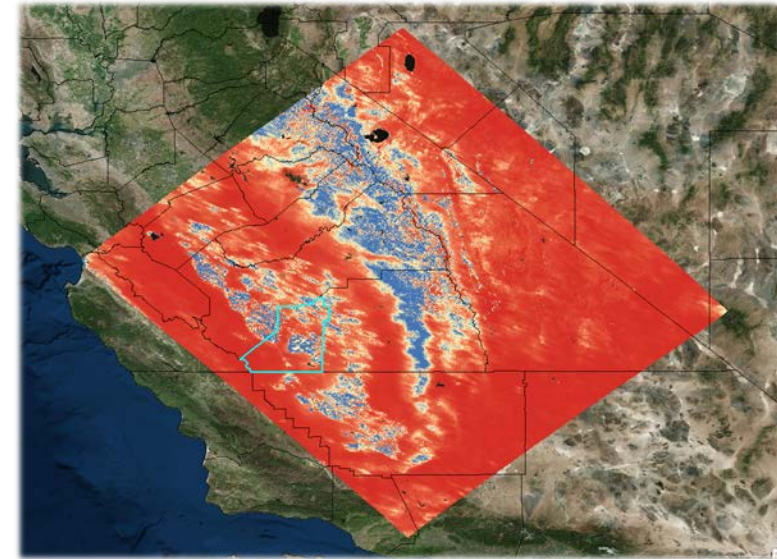
- Reformat and Georeference VIIRS Surface Reflectance HDF-EOS5 Files

ASTER Global Emissivity Dataset (GED)

- Convert ASTER GED V3 Science Datasets to Georeferenced GeoTIFFs using R and Python
- Convert ASTER GED V4.1 Science Datasets to Georeferenced GeoTIFFs using R and Python

How to Download LP DAAC Data

- How to Access the LP DAAC Data Pool with Python
- How to Access the LP DAAC Data Pool with R



Source	Description	Last Modified
ECOSTRESS_swath2grid.py	Updated package dependencies for Windows and corrected build 6.0 fill value issue	6 days ago
GDAL-2.3.2-cp36-cp36m-win_amd64.whl	New environment set up for windows	26 Oct 2018
h5py-2.8.0-cp36-cp36m-win_amd64.whl	New environment set up for windows	26 Oct 2018
mkdocs.yml	Changed mkdocs package version	12 Dec 2018
README.md	Updated list of layers for ECOANCCQA.001	08 May 2019
WindowsEnvironment.zip	Updated package dependencies for Windows and corrected build 6.0 fill value issue	6 days ago
windowsOS.yml	Updated package dependencies for Windows and corrected build 6.0 fill value issue	6 days ago

ECOSTRESS Swath to Grid Conversion Script

Objective:

The ECOSTRESS_swath2grid.py script converts ECOSTRESS swath data products, stored in Hierarchical Data Format version 5 (HDF5, .h5) into projected GeoTIFFs. When executing this script, a user will submit a desired output projection and input directory containing ECOSTRESS swath data products as command line arguments. The script begins by opening any of the ECOSTRESS products listed below that are contained in the input directory. Next, it uses the latitude and longitude arrays from the ECO1BGE0 product (except for L3/4 ALEX_USDA and ECO1BMAPRAD products) to resample the swath dataset to a grid using nearest neighbor resampling (Pyresample). Note that you will need to download the ECO1BGE0 files that correspond to your higher level product files. From there, the script defines the coordinate reference system (CRS) input by the user (options include UTM Zones and Geographic: EPSG:4326). There is an optional argument to override the default UTM zone selected by the script (see below) if needed. Ultimately, the script exports the gridded array as a GeoTIFF (GDAL). By default, the script will loop through and perform the aforementioned steps for each science dataset (SDS) in the HDF5 file. There is an optional argument that allows you to select a subset of SDS layers within a given product (see details below). The resulting GeoTIFF files can be imported with spatial reference into GIS and Remote Sensing software programs. The script also will batch process all ECOSTRESS swath files contained in the input directory provided. For ECOSTRESS products that include a scale factor in the metadata, the output will be scaled, and for products that include a fill value in the file metadata, this will be carried over into the GeoTIFF outputs. For layers that do not contain a fill value in the file metadata, the fill value will be defined as the highest possible value for the given datatype of an SDS.



LP DAAC E-Learning



Homepage / Resources / E-Learning

<https://lpdaac.usgs.gov/resources/e-learning/#ecostress>

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Q ecostress

ECOSTRESS: NASA's Next-Generation Mission to Measure Evapotranspiration from the ISS

APRIL 2, 2019

DATA POOL NASA EARTHDATA SEARCH

DATA PREP SCRIPTS ECOSTRESS

EVAPOTRANSPIRATION (ET)

LAND SURFACE TEMPERATURE (LST)

SURFACE RADIANCE

Video Tip

Hands-on Workshop for Accessing, Processing, and Analyzing ECOSTRESS Data

MARCH 27, 2019

NASA EARTHDATA SEARCH

DATA PREP SCRIPTS ECOSTRESS

EVAPOTRANSPIRATION (ET)

Materials

Working with ECOSTRESS Evapotranspiration Data

MARCH 14, 2019

DATA PREP SCRIPTS ECOSTRESS

EVAPOTRANSPIRATION (ET)

Tutorial Jupyter Notebook

Jupyter Notebook

Finally, compare the ECOSTRESS Evapotranspiration and uncertainty with the time series of observations from the flux tower.

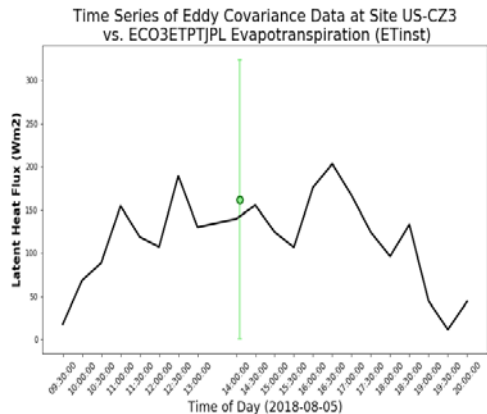
```
In [26]: # Set the figure size, create a subplot
fig = plt.figure(1, figsize=(12, 7))
ax = fig.add_subplot(111)

# Plot the flux tower observations followed by the ecostress median ET and median uncertainty
ax.plot(towerData.Time, towerData.LF, 'k', lw=2.5, color='black')
ax.plot(overpass, ETmedian, 'b', ms=18, color='darkgreen')
ax.errorbar(overpass, ETmedian, yerr=UMedian, lw=2.0, c='lightgreen', fml='o', capsiz=3, capthick=2)

# Set x/y axes and labels
ax.set_xlabel('Time of Day (date)', fontsize=18);
ax.set_ticks(np.array(overpass.Time));
ax.set_ylabel('Latent Heat Flux (Wm2)', fontsize=16, fontweight='bold');

# Add a title and export figure as png file
ax.set_title('Time Series of Eddy Covariance Data at Site US-CZ3 vs. [SDName]', fontsize=22)
figure_filename = join(outDir, '{}_{}_vs_fluxtower.png'.format(ecoName, SDName))
print('figure filename: {}'.format(figure_filename))
fig.savefig(figure_filename, bbox_inches='tight')

figure filename: C:\ECOSTRESS\output\ECOSTRESS_L3_ET_PT-JPL_00468_007_20180805T220314_0502_02_EtInst_vs_fluxtower.png
```



Workshop Materials

ECO3ETPTJPL Evapotranspiration (ETInst)
2018-08-05 at 14:06:00

Time Series of Eddy Covariance Data at Site US-CZ3 vs. ECO3ETPTJPL Evapotranspiration (ETInst)

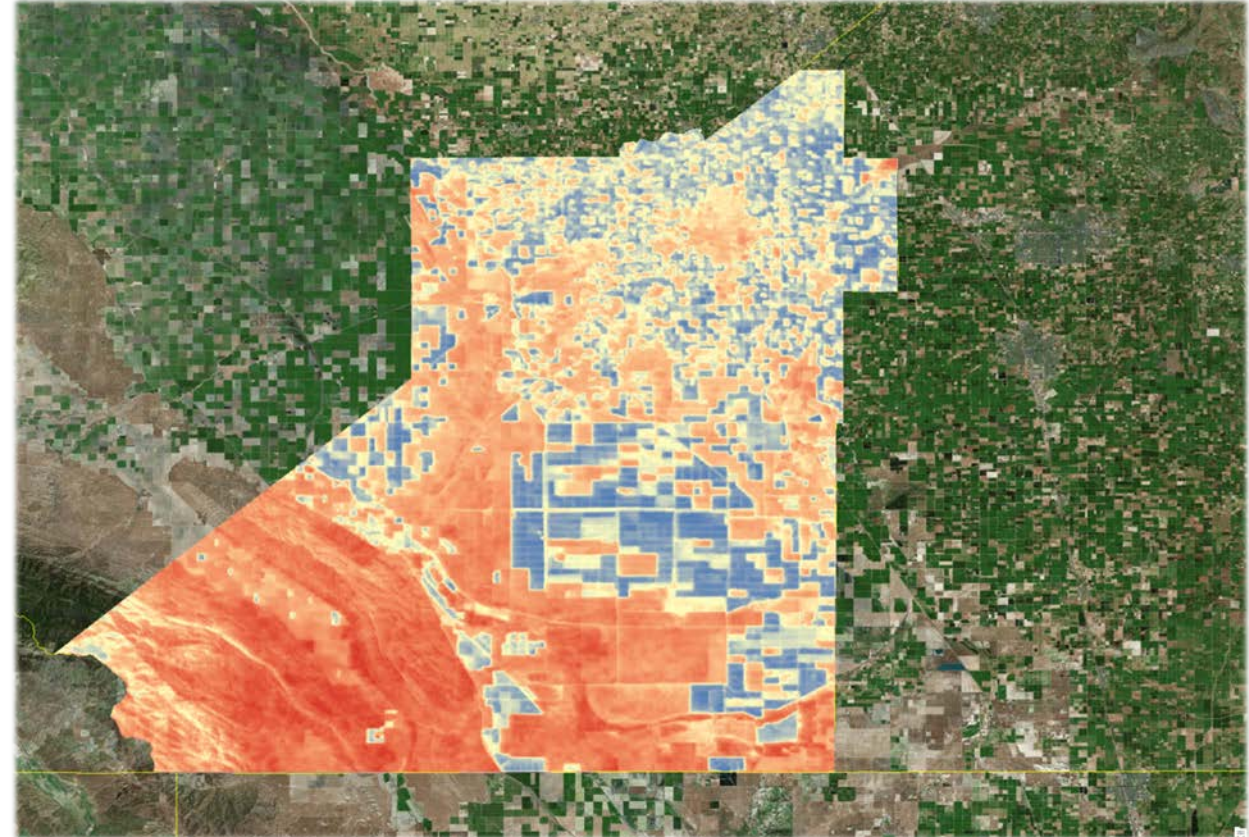
Provided in collaboration with the ECOSTRESS Science Team at JPL: <https://ecostress.jpl.nasa.gov/>

[NASA's Applied Remote Sensing Training Program](#)



Questions?

- User Services
 - <https://lpdaac.usgs.gov/lpdaac-contact-us/>
- Try out AppEEARS:
 - https://lpdaacsvc.cr.usgs.gov/app_eears
- Subscribe to the LP DAAC Listserv:
 - <https://lists.nasa.gov/mailman/listinfo/lpdaac>



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 - <http://arset.gsfc.nasa.gov>



Thank You!

