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:
• No homework or certificate
• Q&A: Following today’s session and/or by email
  • amberjean.mccullum@nasa.gov
  • Or juan.l.torresperez@nasa.gov
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

- 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

Image Credits: Provided by Dr. Joshua Fisher
ECOSTRESS
Maximizing Earth’s Precious Resources

The ECOfytem 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-J PL 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 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?
Natural Color vs. Thermal Images
Evapotranspiration
What Is Evapotranspiration?

Evapotranspiration is the key climate variable linking the water, energy, and carbon cycles.
What Is Evapotranspiration?

Evapotranspiration is the key climate variable linking the water, energy, and carbon cycles.
Water Stress Drives Plant Behavior

Evapotranspiration

Stomata close to conserve water

6 AM 12 PM 6 PM
Diurnal Cycle

NASA’s Applied Remote Sensing Training Program
ECOSTRESS Has a Large Swath (400km) + High Spatial Resolution (70m)

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

Capturing Water Use Efficiency in the Amazon
2018-07-21 ECOSTRESS Orbit 234 Scene 10
0 g C kg⁻¹ H₂O 1.1

Image Credits: Provided by Dr. Joshua Fisher

NASA’s Applied Remote Sensing Training Program
Drought in Costa Rica

Image Credits: Provided by Dr. Joshua Fisher

NASA’s Applied Remote Sensing Training Program
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

NASA’s Applied Remote Sensing Training Program
USDA is Using ECOSTRESS to Bridge Temporal Gaps in ET Assessments in Support of Agricultural Applications

Image Credits: Provided by Dr. Martha Anderson

NASA’s Applied Remote Sensing Training Program
Other Applications of ECOSTRESS Data
ECOSTRESS Observes Fires in the Amazon

Image Credits: Provided by Dr. Kerry Cawse-Nicholson

NASA’s Applied Remote Sensing Training Program
Examining the Relation Between Biodiversity and Surface Temperature Regimes in Localized Coastal Upwelling Zones

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

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

Image Credits: Provided by Dr. Daniel Otis

NASA’s Applied Remote Sensing Training Program
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

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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
Pl. 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)
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 (EO SDIS) DAAC
- [https://lpdaac.usgs.gov](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
- S-NPP VIIRS
- Terra and Aqua MODIS
- Terra ASTER
- NASA MEaSUREs
- Community
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Description</th>
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<tbody>
<tr>
<td>Temporal Coverage</td>
<td>July 09, 2018 – Present</td>
</tr>
<tr>
<td>Spatial Coverage</td>
<td>CONUS, key biomes/agricultural zones, selected FLUXNET sites</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>~ 70 m (USDA dis-ALEXI 30 m)</td>
</tr>
<tr>
<td>Temporal Resolution</td>
<td>Variable, dependent on ISS</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>5 (3) bands spanning TIR</td>
</tr>
<tr>
<td>Data Types</td>
<td>Swath</td>
</tr>
<tr>
<td>File Type</td>
<td>HDF-EOS</td>
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<tr>
<td>Unique Products</td>
<td>12</td>
</tr>
<tr>
<td>Version</td>
<td>001</td>
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**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

**LEVEL 1**
**LEVEL 2**
**LEVEL 3**
**LEVEL 4**
Using ECOSTRESS Data
ECOSTRESS Data in AppEEARS

Subset data-

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

Visualizations

Swath to Grid

Decoded QC

Outputs
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](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

Description


This collection of R and Python scripts can be used to download data and perform basic data processing functions such as georeferencing, reprojecting, convoluting, and reformatting data. Scripts are available in Python and/or R, and each has a README that provides additional information. For downloading the LP DAAC User Resources BitBucket Code Repository, visit NASA’s Applied Remote Sensing Training Program.

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 LIT Radiance to Top of Atmosphere Reflectance
  - Reproject and Georeference ASTER LIT HDF Files

Visible Infrared Imaging Radiometer Suite (VIIRS)
- Reproject and Georeference VIIRS Surface Reflectance HDF-EOS5 Files

ASTER Global Emissivity Dataset (GED)
- Convert ASTER GED v1.3 Science Datasets to Georeferenced GeoTiffs using R and Python
- Convert ASTER GED v1.1 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

NASA’s Applied Remote Sensing Training Program
LP DAAC E-Learning

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

- **User Services**
  - [https://lpdaac.usgs.gov/lpdaac-contact-us/](https://lpdaac.usgs.gov/lpdaac-contact-us/)

- **Try out AppEEARS:**
  - [https://lpdaacsvc.cr.usgs.gov/app/ears](https://lpdaacsvc.cr.usgs.gov/app/ears)

- **Subscribe to the LP DAAC Listserv:**
  - [https://lists.nasa.gov/mailman/listinfo/lpdaac]
Contacts

• ARSET Land Management & Wildfire Contacts
  – Amber McCullum: AmberJean.Mccullum@nasa.gov
  – Juan Torres-Perez: juan.l.torresperez@nasa.gov

• General ARSET Inquiries
  – Ana Prados: aprados@umbc.edu

• ARSET Website:
  – http://arset.gsfc.nasa.gov
Thank You!