ECOSTRESS
ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

An Earth Venture Instrument-2 Proposal Submitted in response to AO NNH12ZDA006O EV12

L3/4 (PT-JPL) PROCESSING AND PRODUCTS

JOSHUA B. FISHER
LAURA JEWELL | GREGORY HALVERSON

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SDS High Level Processing Data Flow

ISS

L0A PACKETS

L0B PGE

L1A PGE

L1B PGE

L2 PGE

PT-JPL L3/L4 PGEs

DAAC

DAAC I/F (format)

USDA

ALEXI L3/L4 PGEs

Validated Products

ISS

SCF/testbed

Data Portal

Co-Investigators

SDS

LO packets: time codes, ephemeris, attitude, black body temperatures

Time referenced annotated data, radiometric calibration coeff

Calibrated Sensor Radiances & geolocation parameters

Land Surface Temperature & Emissivity, Cloud

Evapotranspiration, Evaporative Stress Index, Water Use Efficiency (PT-JPL)

ET, ESI (ALEXI)

L0A PACKETS

SRTM

Landsat

NWP

MODIS

Landsat

Static Ortho Base

Atmos Profile

Atm

Surface

Surface

Geo, LSTE, Cloud

Time referenced annotated data, radiometric calibration coeff

Calibrated Sensor Radiances & geolocation parameters

Land Surface Temperature & Emissivity, Cloud

Evapotranspiration, Evaporative Stress Index, Water Use Efficiency (PT-JPL)
L3/4 PT-JPL Processing Data Flow

**L3 (ET_PT-JPL) Evapotranspiration Retrieval**
- Geolocation Data
- Cloud Mask
- 6 band (5 TIR+WB) Surface Temperature Surface Emissivity

**L3 Ancillary Downloader**
- Landsat
- MODIS (*)
  - (*Backup Options: GEOS-FP)

**L4 (ESI_PT-JPL)**
- ET, ETs, ETc, ETi, Potential ET
- MODIS GPP(**)
  - (**Backup Options: OCO-2 SIF, VIIRS GPP)

**L4 (WUE)**
- Water Use Efficiency

**PGEs**
- L1B Products
- L2 Products
- L3 Products
- L4 Products
- Intermediate data
- Other data
Preprocessing pipeline (Python)

Find ancillary data product files for time and location

Download ancillary data

Pre-process (quality control, scale, offset)

Reproject onto ECOSTRESS scene

Science code
BESSION/FLIES → PT-JPL (Matlab → C++)

Ancillary data products (MODIS, Landsat, NWP)

Fetch data (DAACs)

ECOSTRESS L1 data products
Fetch data (local)

If no L2 produced → no L3/L4 product

ECOSTRESS L2 data products
Fetch data (local)

ECOSTRESS L3, L4 products

Scene geolocation data
LST & Emissivity

Find ancillary data product files for time and location

Download ancillary data

Pre-process (quality control, scale, offset)

Reproject onto ECOSTRESS scene
L3/4 PT-JPL Science Data Flow

Evapotranspiration
ET, PET, ESI

Radiation
Landcover
Atmospheric Transmissivity
Surface Temperature
Near-Surface Meteorology
Vegetation

Remote Sensing
Operational Data Ingestion
Reanalysis
# MODIS Ancillary Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Product</th>
<th>Resolution</th>
<th>Projection</th>
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<tbody>
<tr>
<td>LST</td>
<td>Land-Surface Temperature</td>
<td>ECOSTRESS</td>
<td>70 m</td>
<td>Swath</td>
</tr>
<tr>
<td>ε</td>
<td>Emissivity</td>
<td>ECOSTRESS</td>
<td>70 m</td>
<td>Swath</td>
</tr>
<tr>
<td>NDVI</td>
<td>Vegetation Index</td>
<td>Landsat</td>
<td>30 m</td>
<td>UTM</td>
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<td>MOD13</td>
<td>500 m</td>
<td>Sinusoidal</td>
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<tr>
<td>α</td>
<td>Albedo</td>
<td>Landsat</td>
<td>30 m</td>
<td>UTM</td>
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<td></td>
<td></td>
<td>MOD43</td>
<td>1 km</td>
<td>Sinusoidal</td>
</tr>
<tr>
<td>LAI</td>
<td>Leaf-Area Index</td>
<td>MOD15</td>
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<tr>
<td>fAPAR</td>
<td>Fraction of Absorbed Photosynthetically Active Radiation</td>
<td>MOD15</td>
<td>1 km</td>
<td>Sinusoidal</td>
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<tr>
<td>SZV</td>
<td>Solar Zenith Angle</td>
<td>MOD07</td>
<td>5 km</td>
<td>Swath</td>
</tr>
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<td>LC</td>
<td>Land-Cover Type</td>
<td>MCD12</td>
<td>500 m</td>
<td>Sinusoidal</td>
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<td>KG</td>
<td>Climate Classification</td>
<td>Köppen-Geiger</td>
<td>30°</td>
<td>Geographic</td>
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<tr>
<td>AOT</td>
<td>Aerosol Optical Thickness</td>
<td>MOD04</td>
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<tr>
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<td>Cloud Optical Thickness</td>
<td>MOD06</td>
<td>5 km</td>
<td>Swath</td>
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<tr>
<td>Z_{top}</td>
<td>Cloud Top Height</td>
<td>MOD06</td>
<td>5 km</td>
<td>Swath</td>
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<tr>
<td>CF</td>
<td>Cloud Fraction</td>
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<td>5 km</td>
<td>Swath</td>
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<td>P_{surface}</td>
<td>Surface Pressure</td>
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<td>Swath</td>
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<td>Air Temperature</td>
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<td>Swath</td>
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<tr>
<td>f_{APAR}max</td>
<td>Photosynthetically Active Radiation</td>
<td>MOD07</td>
<td>5 km</td>
<td>Swath</td>
</tr>
</tbody>
</table>
Ancillary Data Re-projection (MODIS)

Calculate Daytime Swath Ground Track of Source Satellite in Temporal Search Radius
Ancillary Data Re-projection (MODIS)

Intersect Source Data Regions with ECOSTRESS Scene
Water Stress Drives Plant Behavior

Diurnal Cycle

Terra
~10:30

ISS
different
times of the day

Stomata close to conserve water
Diurnal PT-JPL Inputs

- Air Temperature
- Dew-Point Temperature
- Incoming Shortwave Radiation
- Incoming Longwave Radiation
Merging with NWP for $T_a$

$\rho = 0.96, R^2 = 0.91, \text{RMSE} = 3.51^\circ \text{C}$

\[
f(T_a, t_1, t_2) = T_a + \frac{1}{2}(T_{\text{max}} - T_{\text{min}}) \left( \sin \left( \frac{DL \pi t_2}{12} + 2.33 + \frac{t_2}{12} \right) - \sin \left( \frac{DL \pi t_1}{12} + 2.33 + \frac{t_1}{12} \right) \right)
\]
Merging with NWP for $T_d$

Dew point is similar to $T_{\text{min}}$ (almost constant)
Diurnal Testing

MERRA-2

Diurnal processing

PT-JPL

ρ = 0.98
$R^2 = 0.97$
RMSE = 6.65 W/m²

PT-JPL ET using MODIS and MERRA2 compared to La Thuile FLUXNET aggregated by hour at all sites with absolute and percentage bias.
SIMULATED DATA
PT-JPL: 30 m (MODIS/Landsat)

Mexicali: 23 March 2017
PT-JPL: 30 m (MODIS/Landsat)

Mexicali: 23 March 2017
ET Partitioning

Soil Evaporation
Transpiration
Interception
ET Uncertainty

Evapotranspiration Uncertainty

PM - MOD16

PT - JPL

SEBS
Quality Flags

- Collect quality flags from all input ancillary files;
- Place in pixel-based concatenated QualityFlag data field in output HDF5 file;
- Retain original conventions for quality flag usage and meaning from ancillary data sources;
- Original quality flags can have different lengths; padded to uniform length in concatenated file (ensure compatibility with secondary data sources).

As part of preprocessing pipeline:
Loop over 23 ancillary datasets

- From downloaded ancillary data, get quality field
- Resample onto ECOSTRESS scene, using Nearest Neighbor
- Re-open cumulative QualityFlag file per ECOSTRESS scene, concatenate new flag on pixel level, with padding if needed

L3 PT-JPL ET, L4 ESI, L4 WUE output from Science code

QualityFlag added to L3 PT-JPL ET, L4 ESI, L4 WUE output HDF5 files
Remaining Tasks

1. Swath boundaries correction. [1 week]
2. Diurnal cycle incorporation. [2 weeks]
3. Merge Landsat branch into Main branch. [3 weeks]
4. Finish quality flags coding. [3 weeks]
5. Back-up ancillary data incorporation. [3 weeks]
6. Validation of C++ code against Matlab version. [3 weeks]
7. Incorporation into automated ECOSTRESS SDS pipeline. [3 weeks]