Figure 1: ECOSTRESS Logo

ECOSTRESS Level-3 Evapotranspiration L3 (JET)

Algorithm Theoretical Basis Document

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Introduction

Purpose

Evapotranspiration (ET) is one of the main science outputs from the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS). ET is a Level-3 (L-3) product constructed from a combination of the ECOSTRESS Level-2 (L-2) Land Surface Temperature (LST) product and auxiliary data sources. The rate of ET is controlled by many environmental and biological factors, including:

- Incoming radiation
- Atmospheric water vapor deficit
- Soil water availability
- Vegetation physiology and phenology

Scope and Objectives

This document provides:

1. A description of the ET parameter characteristics and requirements.
2. An overview of the general form of the ET algorithms in the JET ensemble.
3. Algorithm-specific adaptations for the ECOSTRESS mission.
4. Required auxiliary data products and their sources.
5. A plan for calibration and validation (Cal/Val) of the ET retrieval.

Parameter Description and Requirements

Attributes of ET Data

- **Spatial resolution:** 70 m x 70 m
- **Temporal resolution:** Diurnally varying to match ISS overpass characteristics
- **Latency:** As required by the ECOSTRESS Science Data System (SDS)

Auxiliary Variables

Auxiliary Variable	Equation	Source
Near-surface air temp.	L3G MET	GEOS-5 FP tavg1_2d_slv_Nx
Near-surface dew point	Net radiation	GEOS-5 FP tavg1_2d_slv_Nx
Relative humidity (RH)	L3G MET	GEOS-5 FP tavg1_2d_slv_Nx
Soil moisture (SM)	L3G SM product	GEOS-5 FP tavg1_2d_lnd_Nx

Evapotranspiration Retrieval

PT-JPL$_{\mathbf{SM}}$: General Form

The PT-JPL$_{\mathrm{SM}}$ model relies on the Priestley-Taylor equation to resolve potential ET (PET):

$$PT = \alpha \frac{\Delta}{\Delta + \gamma} R_N - G$$

Where: - Δ: Slope of the saturation-to-vapor pressure curve - γ: Psychrometric constant - R_N: Net radiation (W/m²) - G: Ground heat flux (W/m²)

To reduce PET to actual ET (AET), ecophysiological constraint functions are applied based on atmospheric moisture and vegetation indices.

STIC: General Form

The Surface Temperature Initiated Closure (STIC) model integrates LST into the Penman-Monteith Shuttleworth-Wallace system of ET equations. The general approach involves:

1. Solving state equations to find analytical solutions for aerodynamic temperature (T_0) and conductances (g_a, g_{cs}).
2. Iteratively estimating unknowns using Penman-Monteith and Shuttleworth-Wallace equations.

MOD16: General Form

The MOD16 algorithm is based on the Penman-Monteith equation with environmental constraints from vegetation cover, temperature, and atmospheric moisture deficits. It resolves evaporative fluxes from the soil, canopy, and intercepted water separately.

BESS: General Form

The Breathing Earth System Simulator (BESS) couples atmospheric and canopy radiative transfer processes with photosynthesis, stomatal conductance, and transpiration. It uses a quadratic representation of the Penman-Monteith model to estimate transpiration.

Calibration/Validation

ET Evaluation

Eddy covariance (EC) towers provide year-round observations at frequencies (~30 minutes) and spatial scales (10s-100s m) necessary to evaluate the JET ensemble. This analysis uses EC data from the Ameriflux network.

Error Budget

The ECOSTRESS ET products target an error value of 1 mm/day, consistent with established literature. For example:

- PT-JPL ET: RMSE of 6%, $R^2 = 0.88$
- MOD16: RMSE of 0.84 mm/day

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