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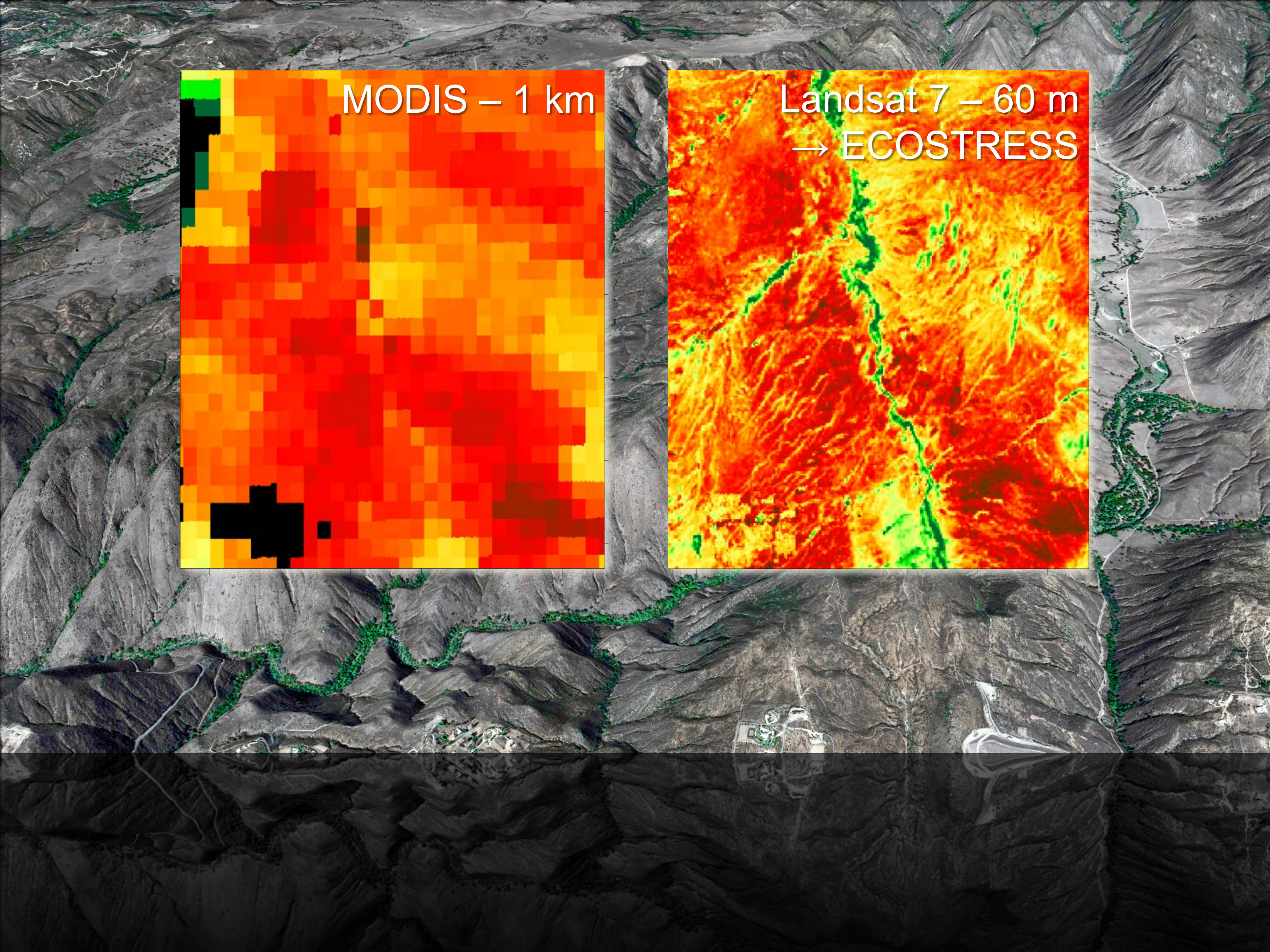
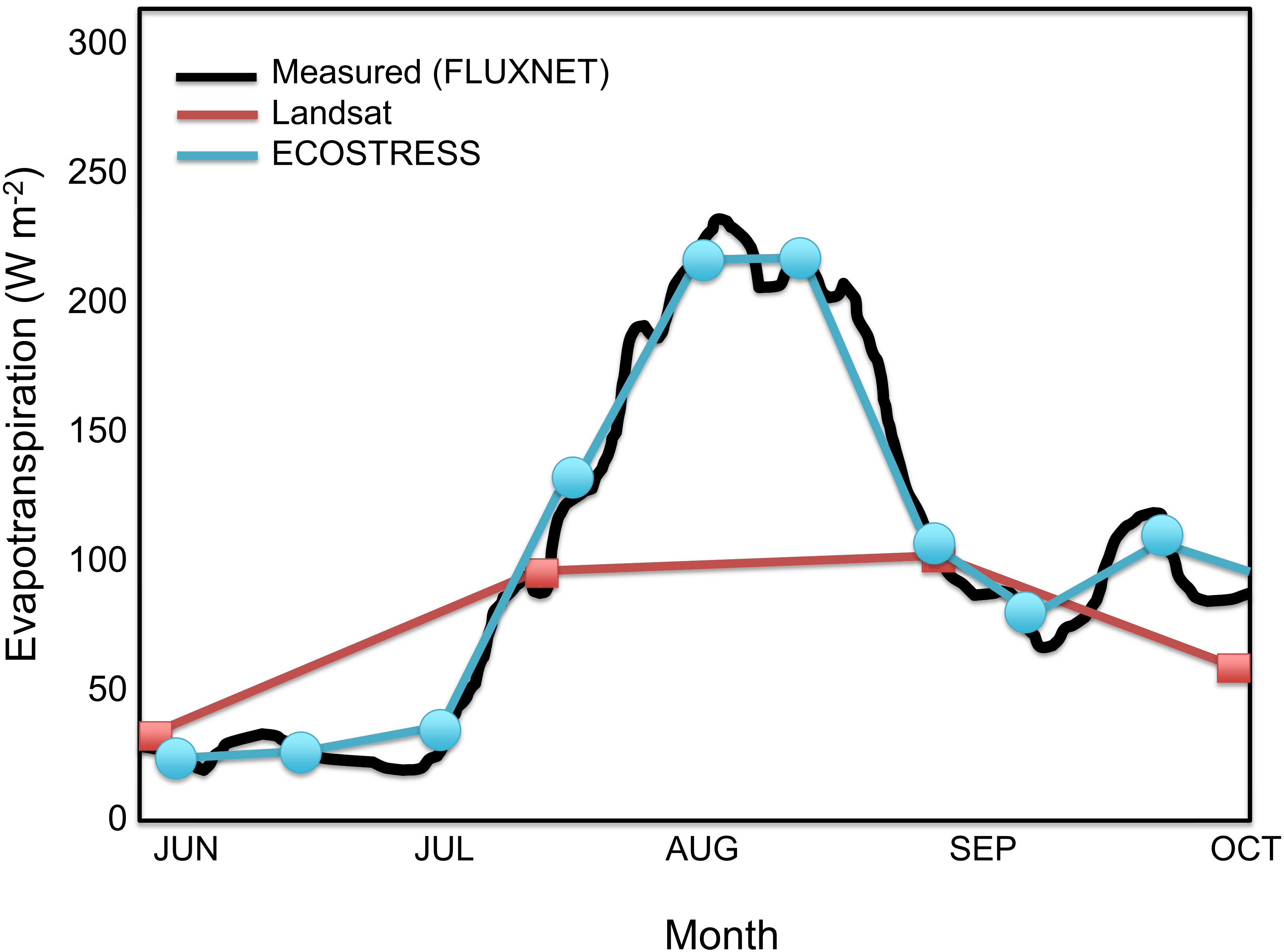
HOW DO DIFFERENT PLANTS RESPOND TO CHANGES IN WATER AVAILABILITY?

WHICH PLANTS DIE FIRST?

How plants respond to changes in water availability can be expressed in terms of Water Use Efficiency (WUE), defined as the amount of carbon fixed per unit water used (gross primary production, GPP, divided by ET). Some plants have high WUE and can fix a large amount of carbon using a small amount of water; other plants are less efficient. Low WUE plants risk replacement with increasing droughts.

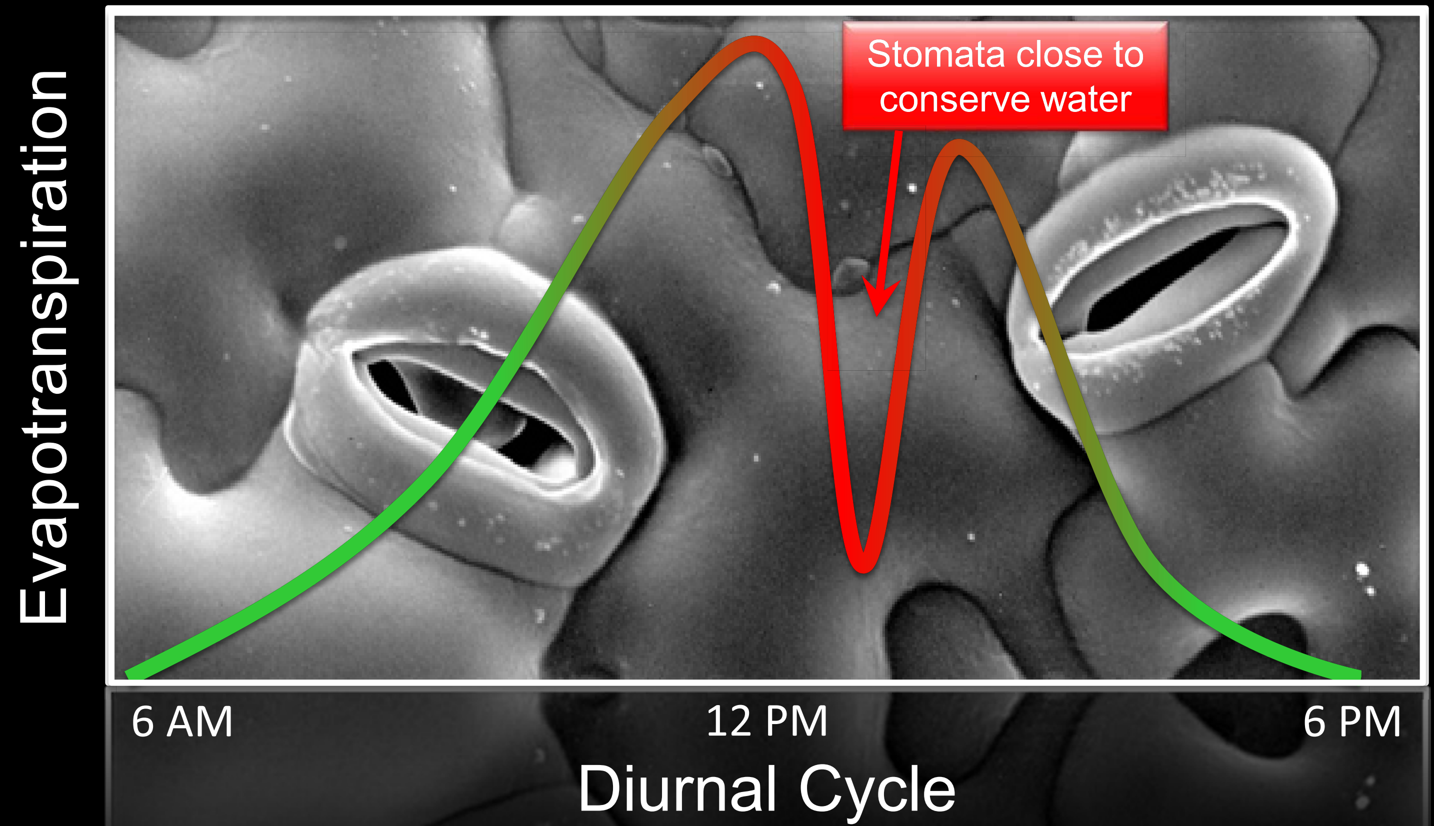
What we need: accurate, high spatial, high temporal, diurnal cycle, global, ET.


MODIS – 1 km
Landsat 7 – 60 m
→ ECOSTRESS

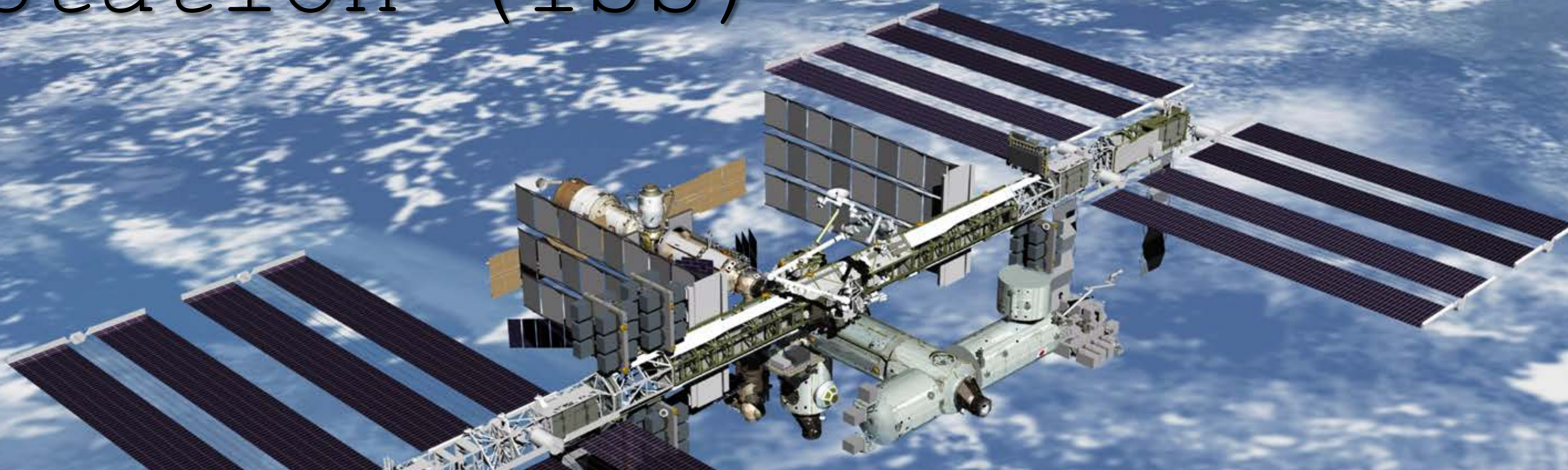


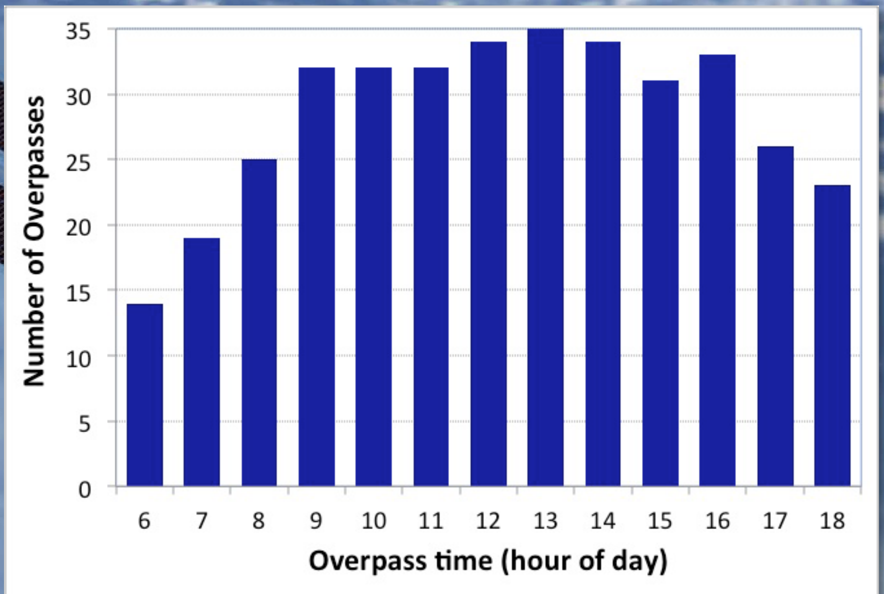
Measured (FLUXNET)
Landsat
ECOSTRESS
Evapotranspiration (W m-2)
300
250
200
150
100
50
0
JUN
JUL
AUG
SEP
OCT
Month

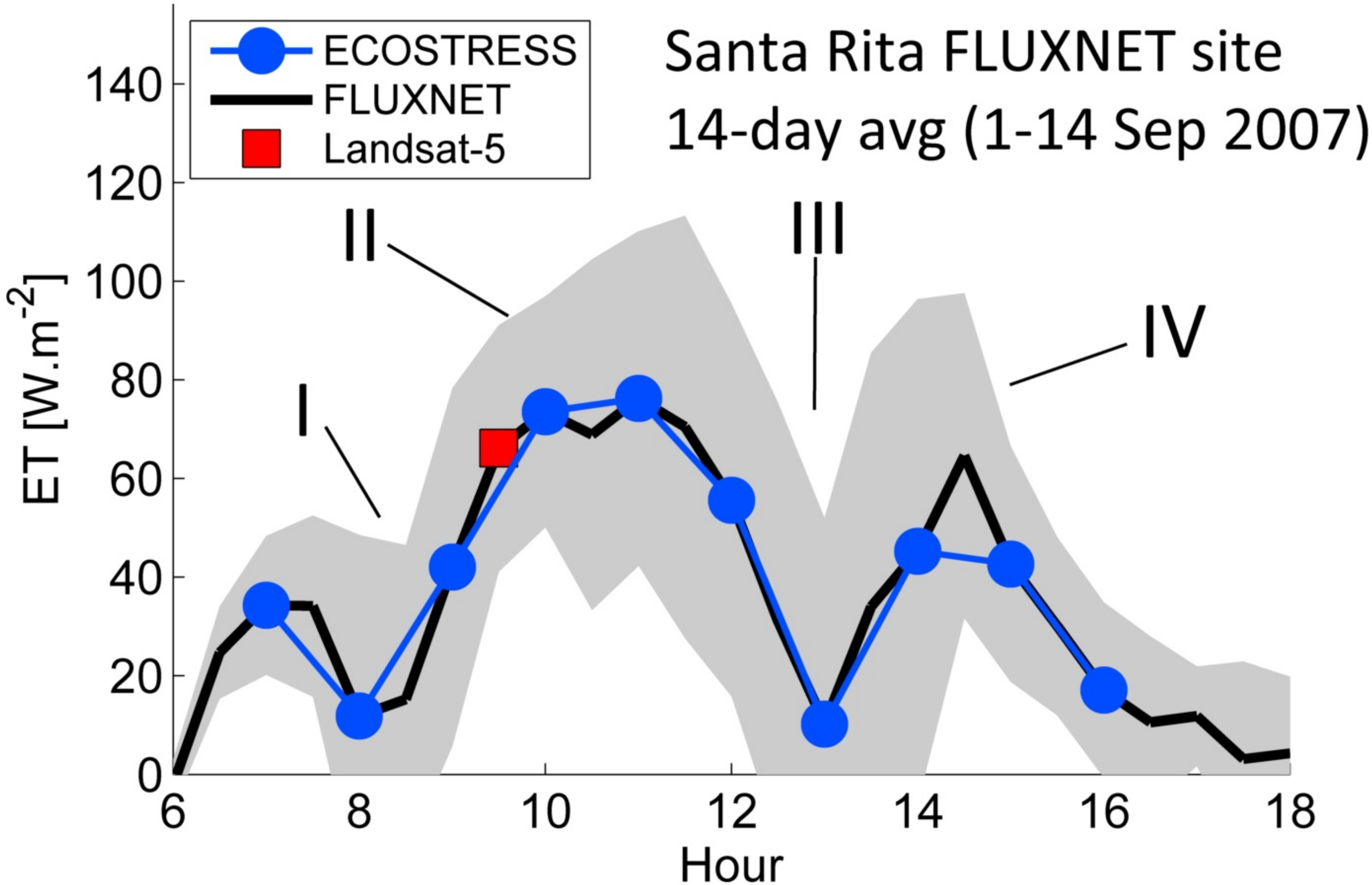
Water Stress Drives Plant Behavior



The International Space Station (ISS)





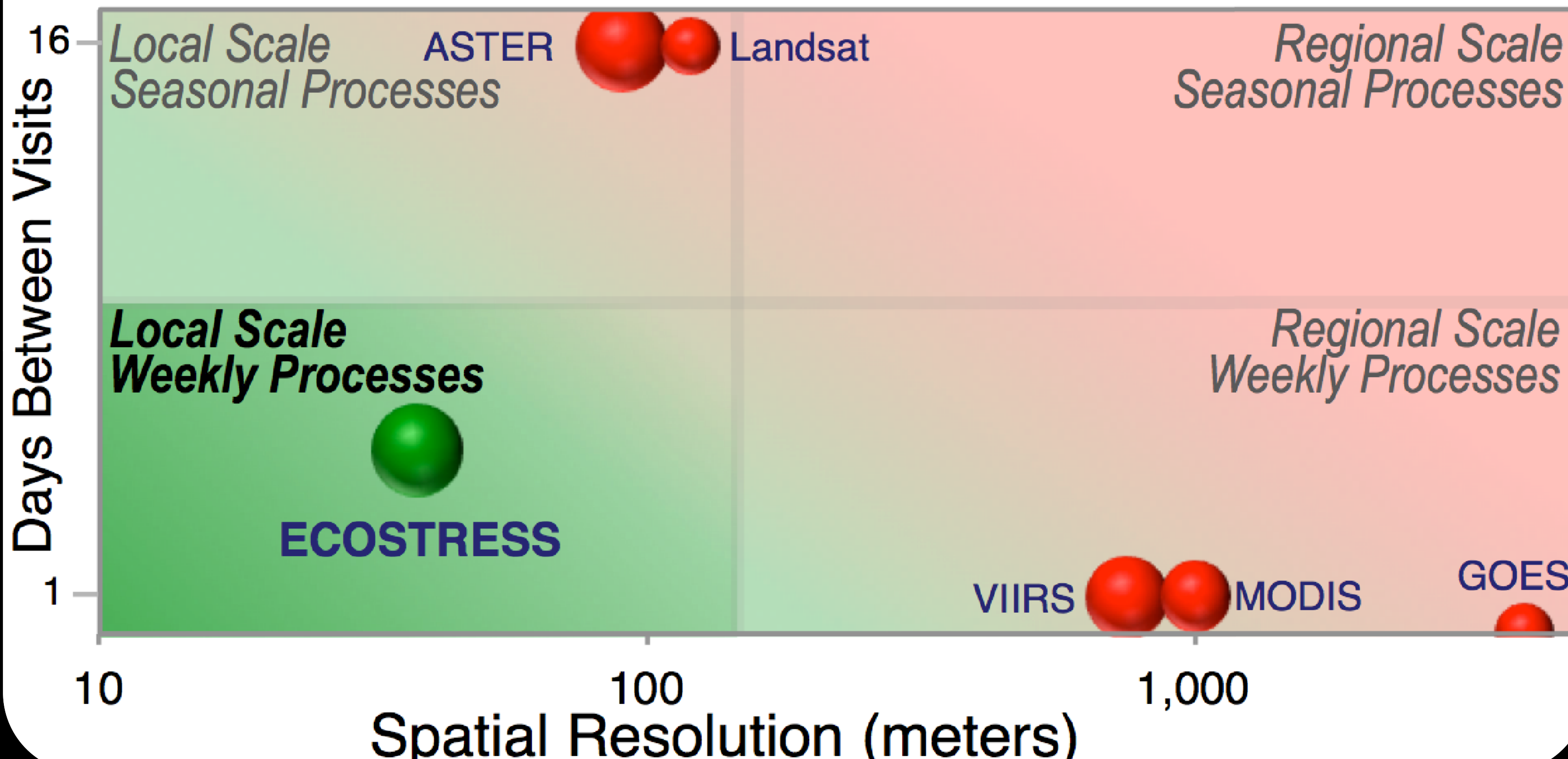


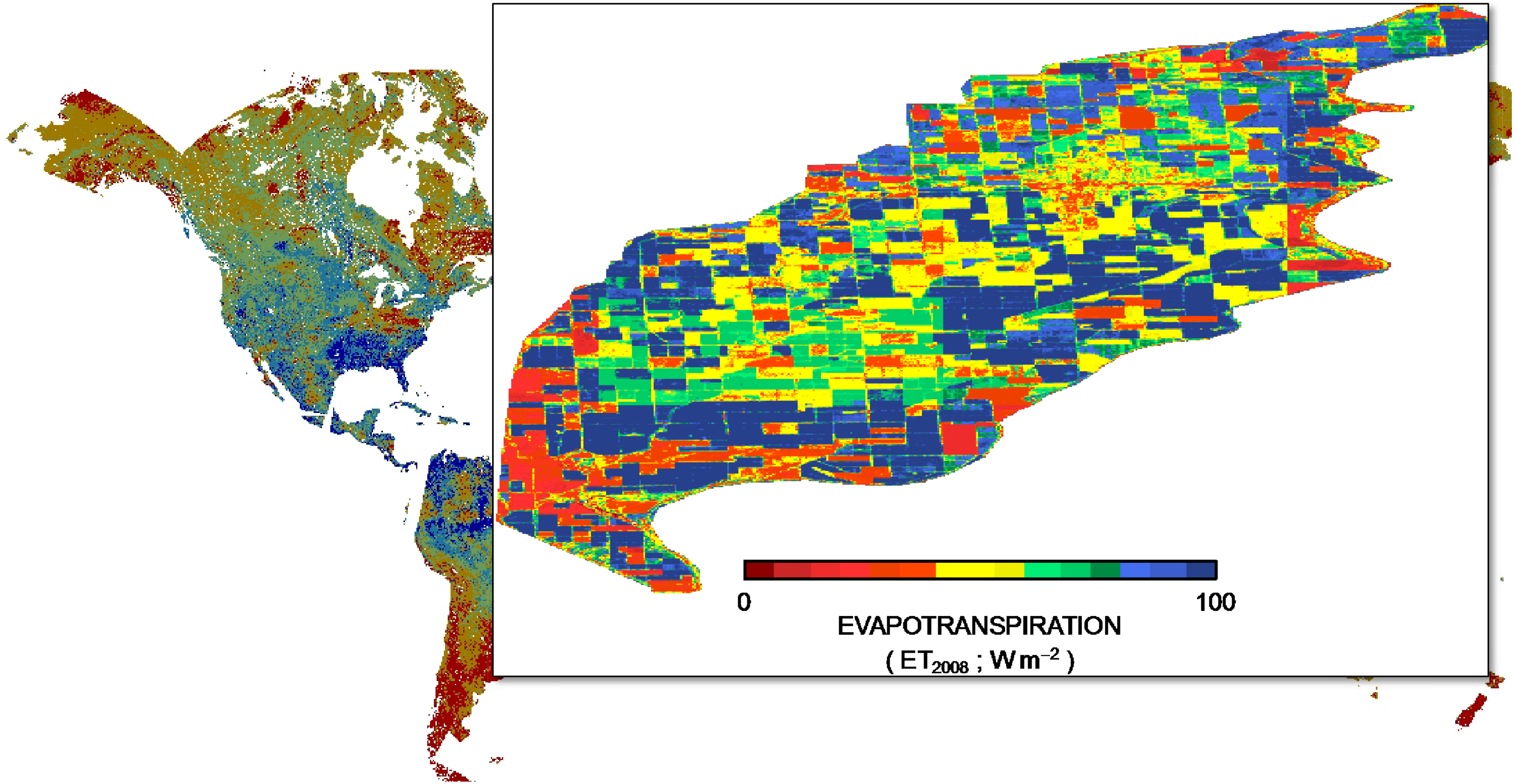
Gray shading represents mean **diurnal variation** in ET over 14-days. The afternoon decline in ET is related to water stress (clear day).

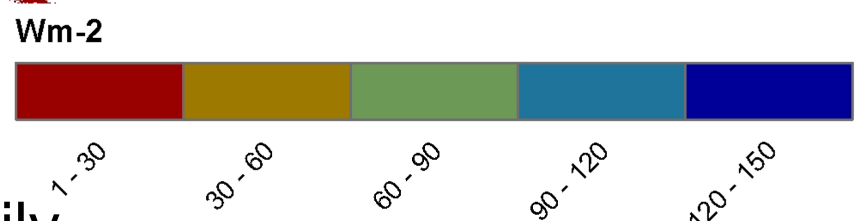
- **I** Xylem refilling after initial water release.
- **II** ET at maximum/potential rate in the morning.
- **III** Stomata shut down water flux in the afternoon.
- **IV** ET resumes at maximum/potential in early evening when demand is reduced.

Revisit Time versus Spatial Resolution

With sphere size indicating # of thermal infrared window bands







Current JPL ET:

- Global, 1 km, daily
- Running multiple algorithms: PT-JPL, PM-MOD16, SEBS, PMBL

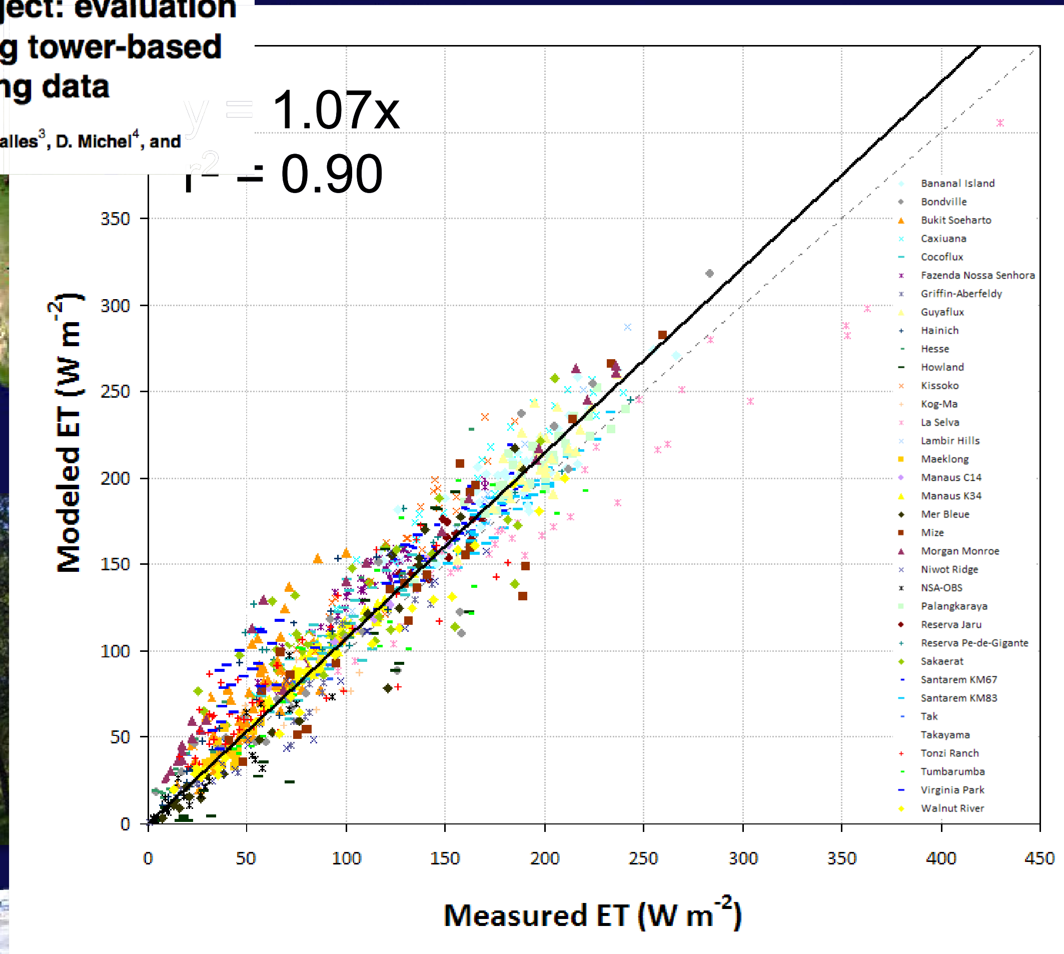
Geosci. Model Dev. Discuss., 8, 6809–6866, 2015
www.geosci-model-dev-discuss.net/8/6809/2015/
doi:10.5194/gmdd-8-6809-2015

Geoscientific Model Development Discussions

stations as independent metrics of performance, the tower-based analysis indicated that PT-JPL provided the highest overally statistical performance (0.72; 61 $W m^{-2}$; 0.65), followed closely by GLEAM (0.68; 64 $W m^{-2}$; 0.62), with values in parenthe-

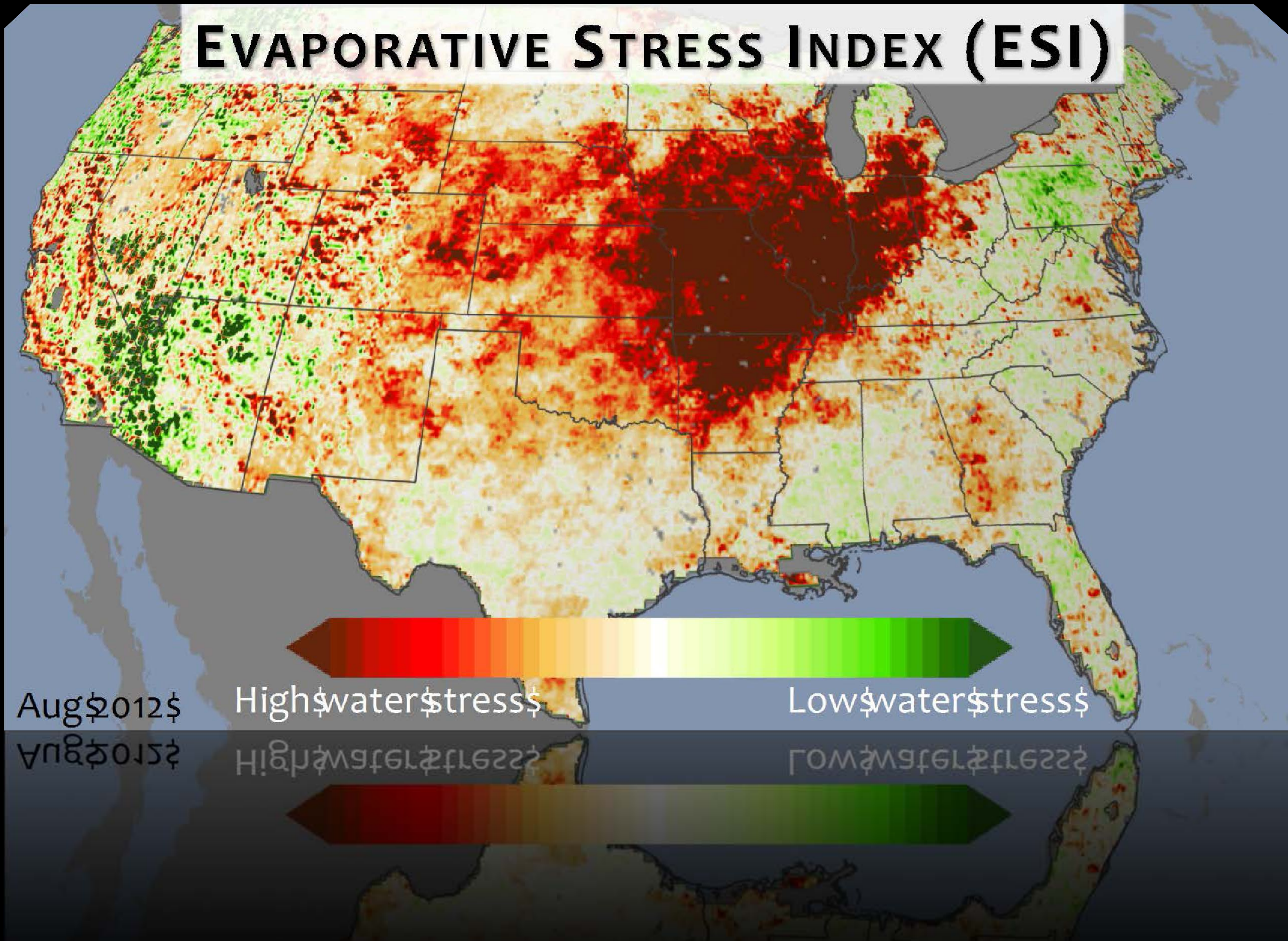
The GEWEX LandFlux project: evaluation of model evaporation using tower-based and globally-gridded forcing data

M. F. McCabe[1], A. Ershadi[1], C. Jimenez[2], D. G. Miralles[3], D. Michel[4], and E. F. Wood[5]



PT-JPL ET VALIDATION

Fisher, J.B., Tu, K.P., Baldocchi, D.D., 2008. *Remote Sensing of Environment*.



Anderson, M.C., et al., 2008: ALEXI. *Remote Sensing of Environment*.

GEOPHYSICAL RESEARCH LETTERS, VOL. 38, L17706, doi:10.1029/2011GL048738, 2011

New global observations of the terrestrial carbon cycle from GOSAT: Patterns of plant fluorescence with gross primary productivity

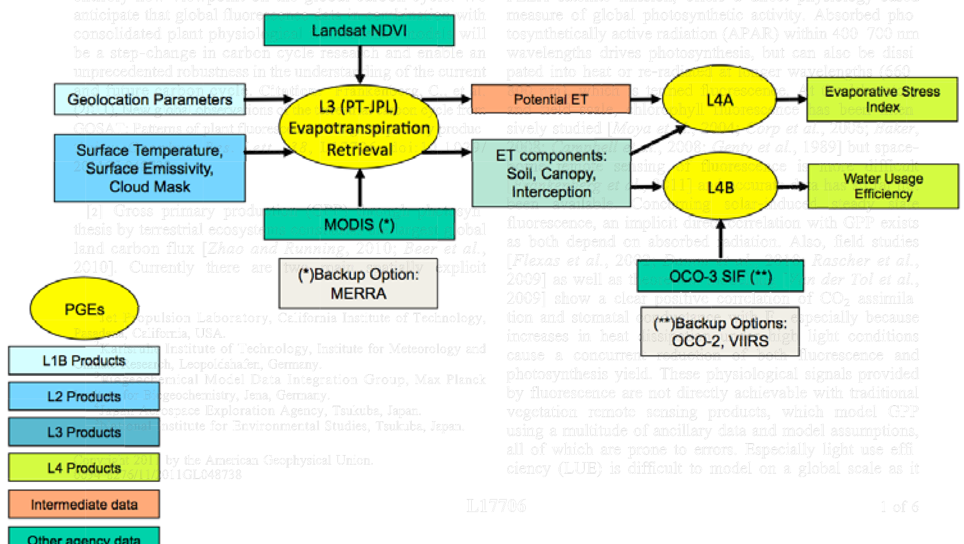
Christian Frankenberg,[1] Joshua B. Fisher,[1] John Worden,[1] Grayson Badgley,[1] Sassan S. Saatchi,[1] Jung-Eun Lee,[1] Geoffrey C. Toon,[1] André Butz,[2] Martin Jung,[3] Akihiko Kuze,[4] and Tatsuya Yokota[5]

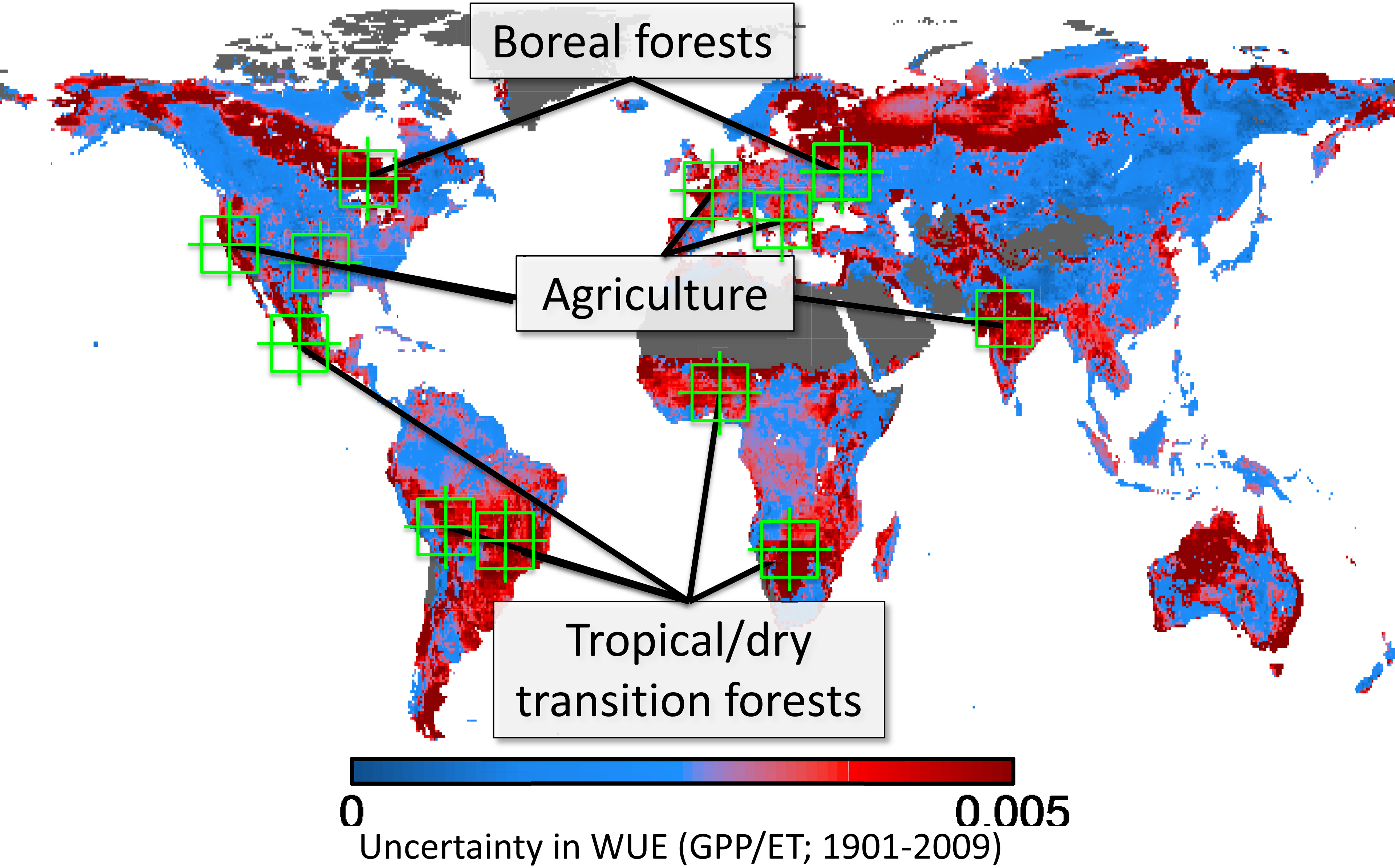
Received 30 June 2011; revised 11 August 2011; accepted 16 August 2011; published 14 September 2011.

[1] Our ability to close the Earth's carbon budget and predict feedbacks in a warming climate depends critically on knowing where, when and how carbon dioxide is exchanged between the land and atmosphere. Terrestrial gross primary production (GPP) constitutes the largest flux component in the global carbon budget, however significant uncertainties remain in GPP estimates and its seasonality. Empirically, we show that global spaceborne observations of solar induced chlorophyll fluorescence – occurring during photosynthesis – exhibit a strong linear correlation with GPP. We found that the fluorescence emission even without any additional climatic or model information has the same or better predictive skill in estimating GPP as those derived from traditional remotely-sensed vegetation indices using ancillary data and model assumptions. In boreal summer the generally

approaches to quantify GPP globally: 1) meteorology-driven full land surface carbon cycle models [*Friedlingstein et al.*, 2006; *Sitch et al.*, 2008]; and, 2) remote sensing-driven [*Zhao and Running*, 2010] and/or flux tower based [*Beer et al.*, 2010; *Jung et al.*, 2011] semi-empirical models focused on GPP or net primary production (NPP). Significant uncertainties related with the first approach are due to differing model sensitivities to meteorological parameters and uncertain global meteorological data sets [*Friedlingstein et al.*, 2006; *Sitch et al.*, 2008]. Uncertainties with the second approach exist because GPP cannot directly be estimated from the remote sensing measurements but is also modeled as a function of leaf area index (LAI) and fraction of absorbed photosynthetically active radiation (fAPAR) or greenness indices such as the normalized difference or

L3/L4 Data Flow





Nine land surface models were run with only a perturbed climate (i.e., CO_2, land use constant) over the 20[th] century, representing the γ-response, or climate sensitivity to identify key *WUE uncertainty hotspots*.


FLUXNET
A Global Network
NASA AirMOSS EV-1
Airborne Microwave Observatory of Subcanopy and Subsurface Project

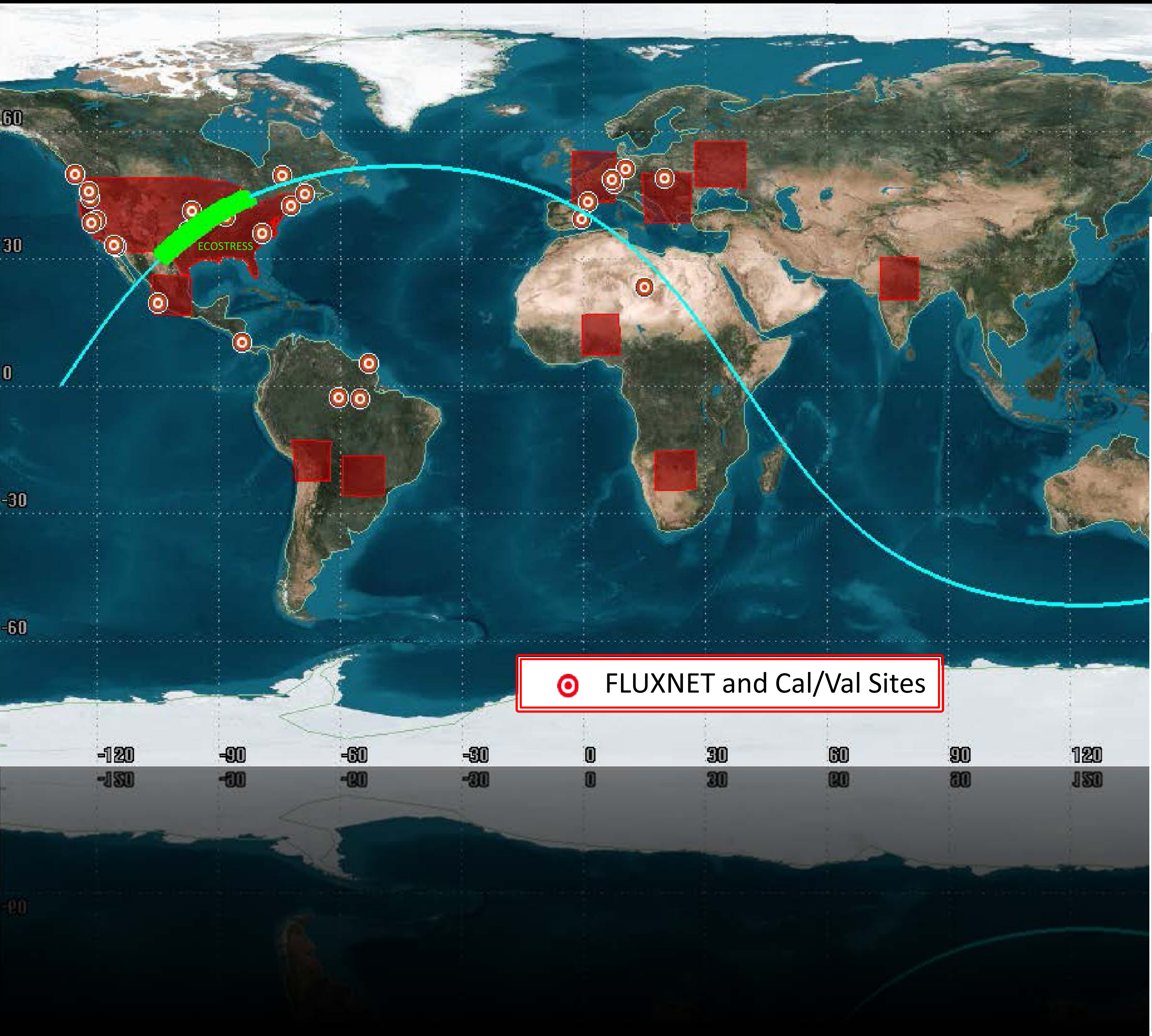


Table F.1-2. ECOSTRESS targets include all of CONUS, 1,000 km regions centered on climate hotspots and agricultural regions, and validation sites. ENF: Evergreen Needleleaf Forest; EBF: Evergreen Broadleaf Forest; WSA: Woody Savanna; SAV: Savanna; CRO: Cropland; DBF: Deciduous Broadleaf Forest; Cal/Val: Radiance at sensor, LST Calibration/Validation site.

Site	Biome Type	Latitude	Longitude
Climate Hotspot Regions			
Boreal North America	ENF	47.0	-87.0
Boreal Eurasia	ENF	47.0	45.0
Tropical/Dry Transition 1	EBF	-12.0	-67.0
Tropical/Dry Transition 2	EBF/WSA	-16.0	-50.0
Tropical/Dry Transition 3	EBF/WSA	20.0	-103.0
Tropical/Dry Transition 4	WSA/SAV	9.0	4.0
Tropical/Dry Transition 5	WSA/SAV	-23.0	22.0
Agricultural Regions			
Agricultural North America 1	CRO	35.7	-121.0
Agricultural North America 2	CRO	41.5	-98.7
Agricultural Eurasia 1	CRO	44.2	18.0
Agricultural Eurasia 2	CRO	25.0	78.0
Agricultural Eurasia 3	CRO	47.0	0.0
FLUXNET and Calibration/Validation Sites			
Campbell River, Canada	ENF	49.9	-125.3
Hartheim, Germany	ENF	47.9	7.6
Howland Forest, ME, USA	ENF	45.2	-68.7
Metolius, OR, USA	ENF	44.5	-121.6
Quebec Boreal, Canada	ENF	49.7	-74.3
Tatra, Slovak Republic	ENF	49.1	20.2
Wind River Crane, WA, USA	ENF	45.8	-122.0
Guyaflux, French Guyana	EBF	5.3	-52.9
La Selva, Costa Rica	EBF	10.4	-84.0
Manaus K34, Brazil	EBF	-2.6	-60.2
Santarem KM67, Brazil	EBF	-2.9	-55.0
Santarem KM83, Brazil	DBF	-3.0	-55.0
Chamela, Mexico	DBF	19.5	-105.0
Duke Forest, NC, USA	DBF	36.0	-79.1
Hainich, Germany	DBF, Cal/Val	51.1	10.5
Harvard Forest, MA, USA	DBF	42.5	-72.2
Hesse Forest, France	DBF	48.7	7.1
Tonzi Ranch, CA, USA	DBF/WSA	38.4	-121.1
ARM S. Great Plains, OK, USA	CRO, Cal/Val	36.6	-97.5
Aurade, France	CRO	43.5	1.1
Bondville, IL, USA	CRO, Cal/Val	40.0	-88.3
El Saler-Sueca, Spain	CRO	39.3	-0.3
Mead 1, 2, 3 NE, USA	CRO	41.2	-96.5
Salton Sea, CA	Cal/Val	33.3	-115.7
Lake Tahoe, CA	Cal/Val	39.2	-120.0
Gobabeb, Namibia	Cal/Val	23.5	15.1
Algodones Dunes, CA	Cal/Val	33.0	-115.1

ECOSTRESS KEY SCIENCE QUESTIONS

1. HOW IS THE TERRESTRIAL BIOSPHERE RESPONDING TO CHANGES IN WATER AVAILABILITY?
1. HOW DO CHANGES IN DIURNAL VEGETATION WATER STRESS IMPACT THE GLOBAL CARBON CYCLE?
1. CAN AGRICULTURAL VULNERABILITY BE REDUCED THROUGH ADVANCED MONITORING OF AGRICULTURAL CONSUMPTIVE USE AND IMPROVED DROUGHT DETECTION?

ECOSTRESS SCIENCE OBJECTIVES

1. IDENTIFY **CRITICAL THRESHOLDS** OF WATER USE AND WATER STRESS IN KEY CLIMATE SENSITIVE BIOMES (E.G., TROPICAL/DRY TRANSITION FORESTS, BOREAL FORESTS);

1. DETECT THE TIMING, LOCATION, AND PREDICTIVE FACTORS LEADING TO PLANT WATER UPTAKE DECLINE AND/OR CESSATION OVER THE **DIURNAL CYCLE**;

1. MEASURE AGRICULTURAL WATER **CONSUMPTIVE USE** GLOBALLY AT SPATIOTEMPORAL SCALES APPLICABLE TO IMPROVING DROUGHT ESTIMATION ACCURACY.

NASA ROSES

COMMUNITY INVOLVEMENT

EARLY ADOPTERS

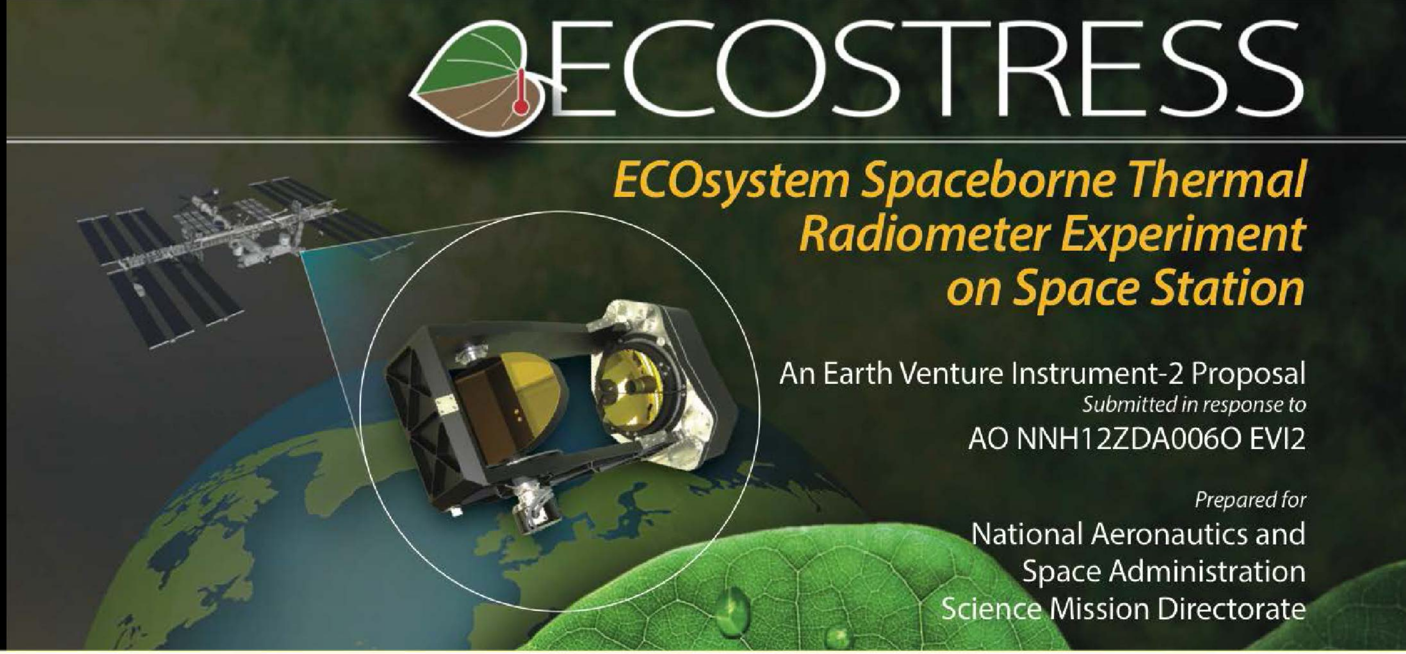
APPLIED SCIENCES

ECOSTRESS:

A technology that will help us understand how plants react to our changing planet

BROWN

Olivia Mansion



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).*

ECOSTRESS Science Data Products	
L2	Surface Temperature Surface Emissivity
L3	Evapotranspiration
L4	Water Use Efficiency Evaporative Stress Index

ECOSTRESS and Beyond…

- 2017
- → HyspIRI →
- → Landsat/SLI →