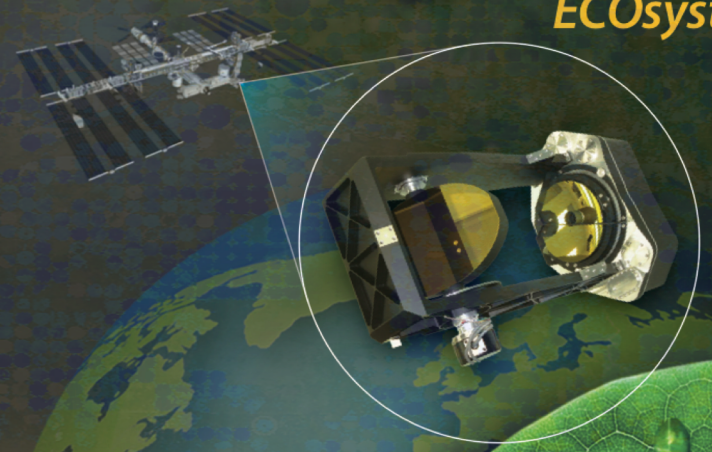
National Aeronautics and Space Administration

ECOSTRESS

ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station



An Earth Venture Instrument-2 Proposal

Submitted in response to

AO NNH12ZDA006O EVI2

Prepared for

National Aeronautics and Space Administration
Science Mission Directorate

Joshua B. Fisher (Science Lead)

Prime Mission Science Team

Simon Hook (PI), Kerry Cawse-Nicholson, Christine Lee, Glynn Hulley, Martha Anderson, Chris Hain, Rick Allen, Andy French, Eric Wood, Woody Turner

Extended Mission Science and Applications Team

Dennis Baldocchi, Nicholas De Felice, Christopher Doughty, Christian Frankenberg, Christoph Hecker, Chuanmin Hu, Soe Myint, Daniel Otis, Helen Poulos, David Wethey, Mary Whelan, Jingfeng Xiao

Data Contributors and Analysts

Brian Lee, Adam J. Purdy, Gregory H. Halverson, Audrey Wang, Ray G. Anderson, Bruno Aragon, M. Altaf Arain, John M. Baker, Hélène Barral, Carl J. Bernacchi, Christian Bernhofer, Sébastien C. Biraud, Gil Bohrer, Nathaniel Brunsell, Bernard Cappelaere, Saulo Castro-Contreras, Junghwa Chun, Bryan J. Conrad, Edoardo Cremonese, Jérôme Demarty, Ankur R. Desai, Anne De Ligne, Lenka Foltýnová, Michael L. Goulden, Timothy J. Griffis, Thomas Grünwald, Mark S. Johnson, Minseok Kang, Dave Kelbe, Natalia Kowalska, Jong-Hwan Lim, Ibrahim Maïnassara, Matthew F. McCabe, Justine E.C. Missik, Binayak P. Mohanty, Caitlin E. Moore, Laura Morillas, Ross Morrison, J. William Munger, Gabriela Posse, Andrew D. Richardson, Eric S. Russell, Youngryel Ryu, Arturo Sanchez-Azofeifa, Marius Schmidt, Efrat Schwartz, Iain Sharp, Ladislav Šigut, Yao Tang

November 25, 2013

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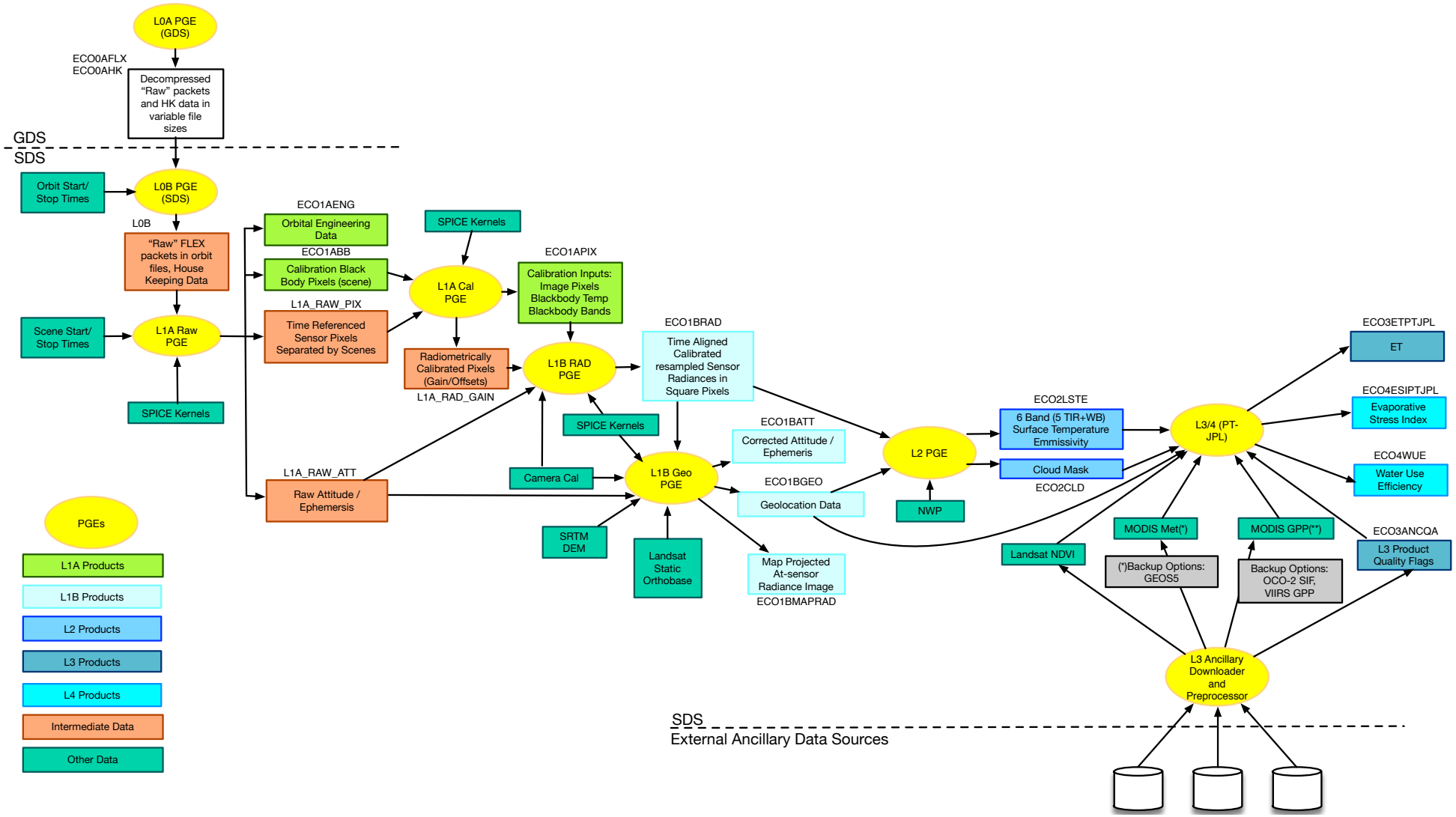
National Aeronautics and Space Administration

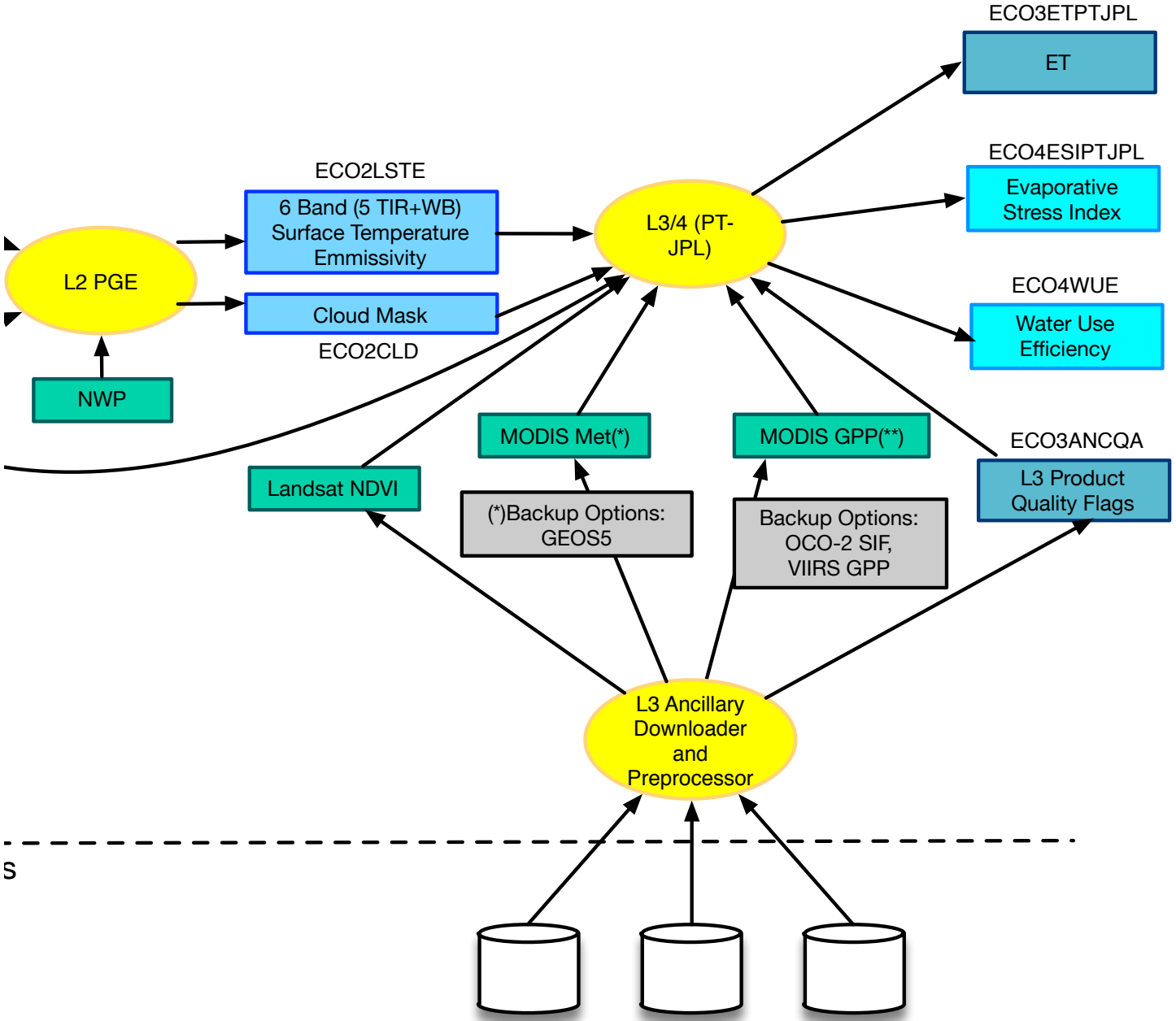
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

SDS L1 – L4 Product Generation



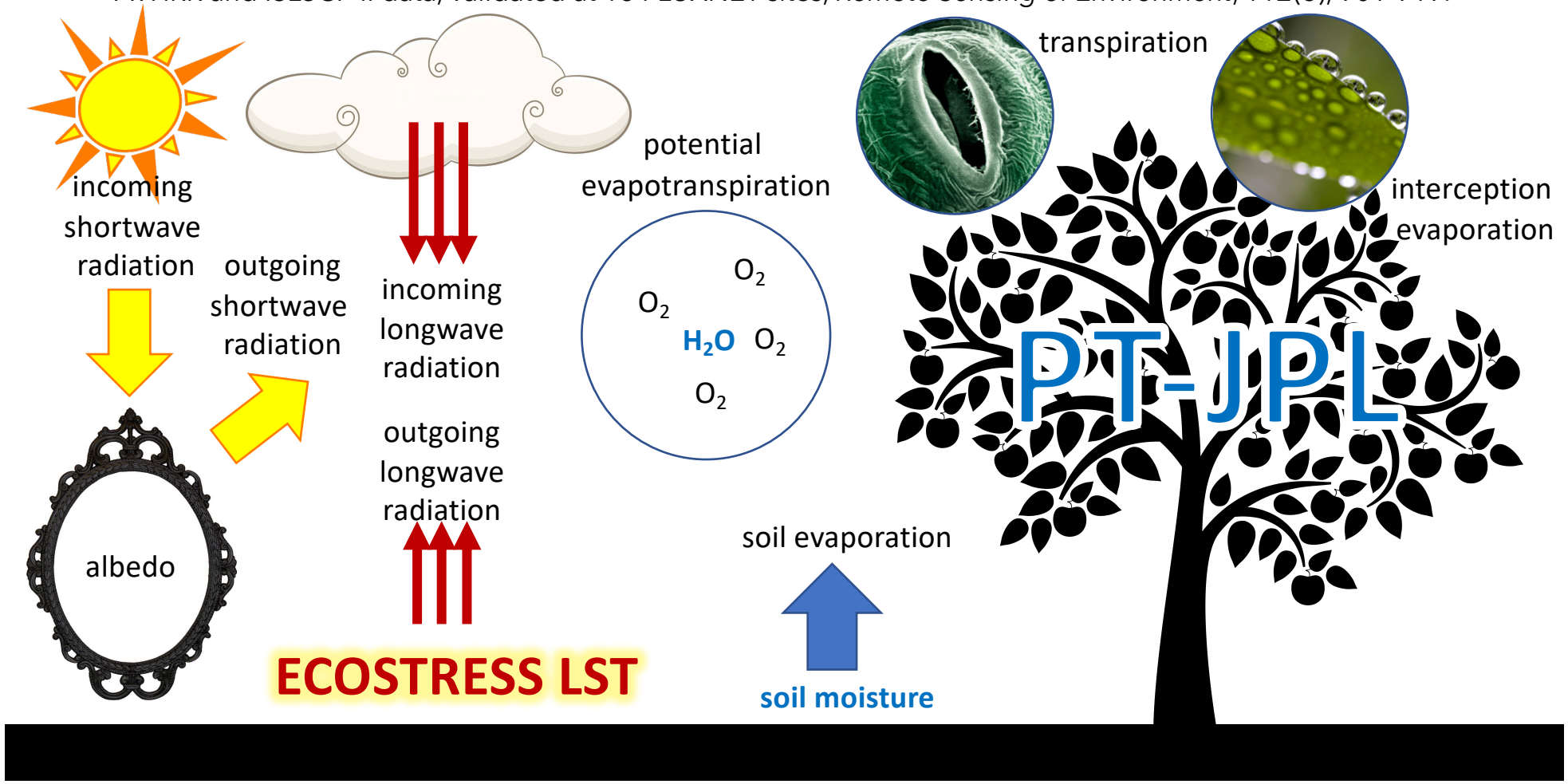
SDS L1 – L4 Product Generation



Science Algorithms: L3(ET_PT-JPL)

The Priestley-Taylor Jet Propulsion Laboratory (PT-JPL) Algorithm

Fisher, J. B., K. Tu, and D. D. Baldocchi (2008), Global estimates of the land-atmosphere water flux based on monthly AVHRR and ISLSCP-II data, validated at 16 FLUXNET sites, *Remote Sensing of Environment*, *112*(3), 901-919.



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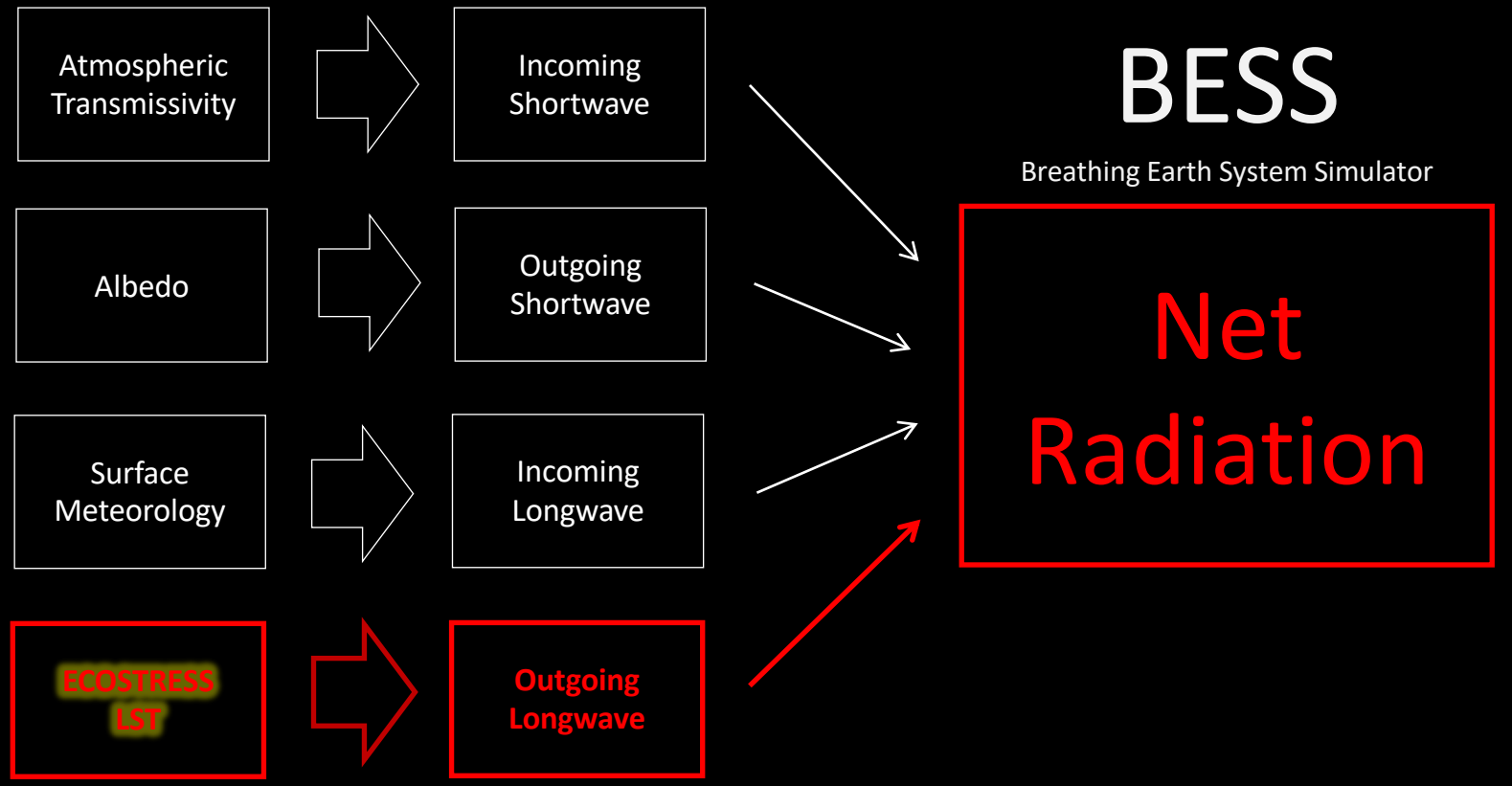

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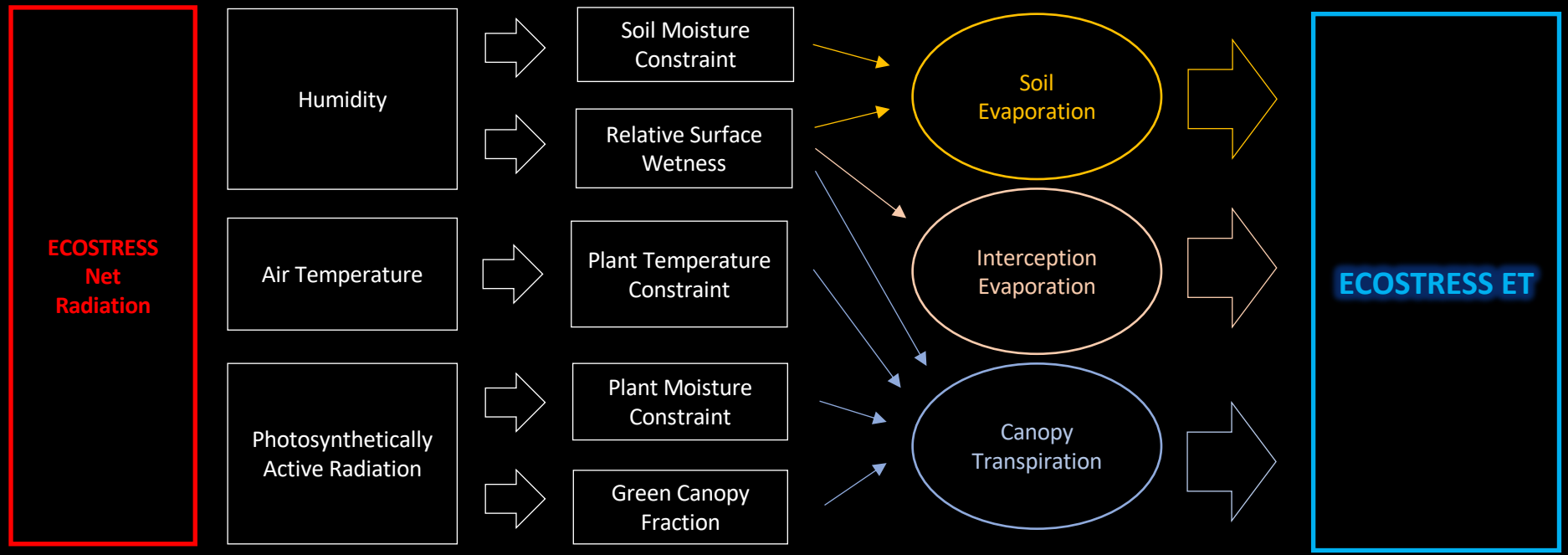
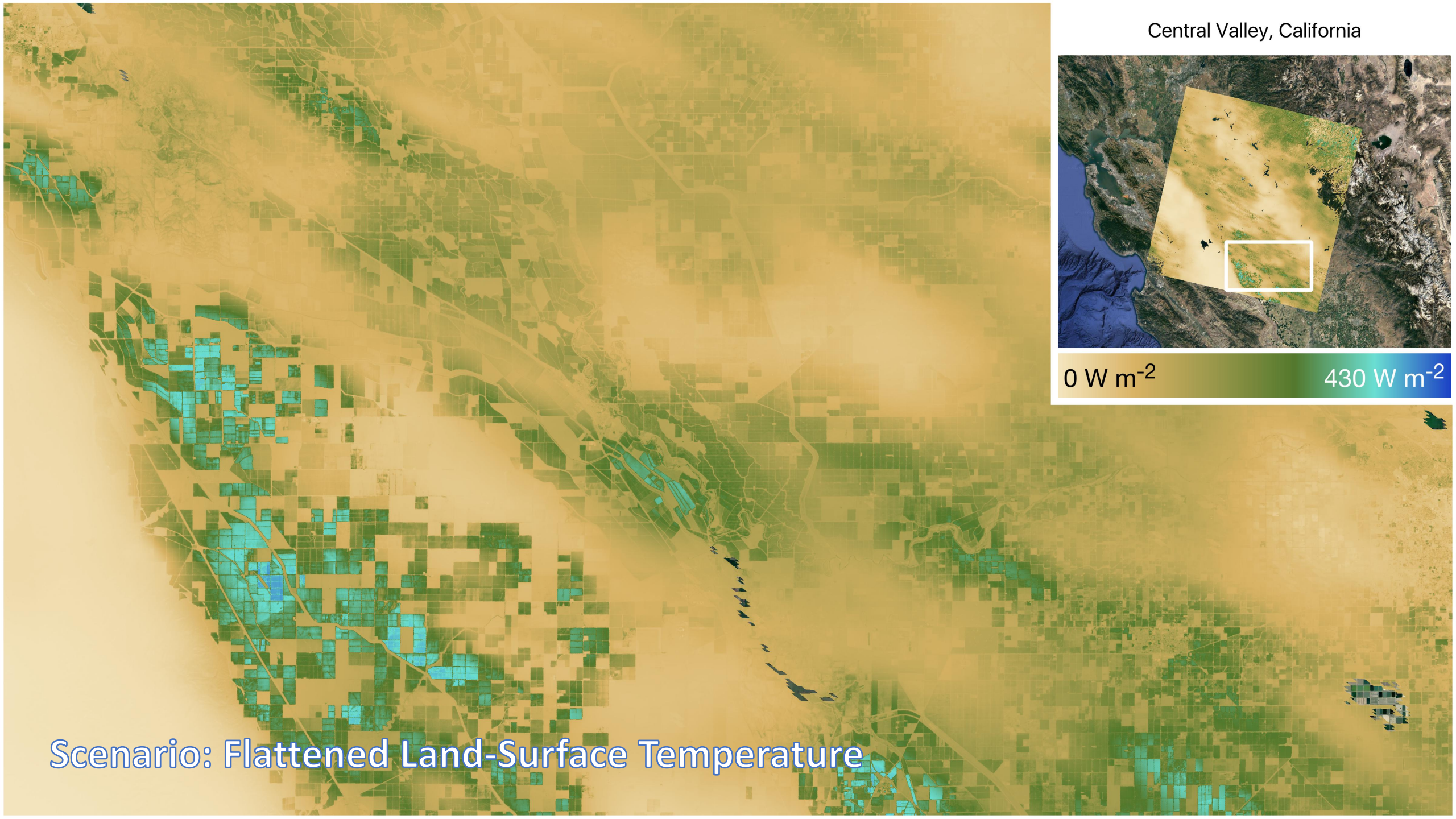
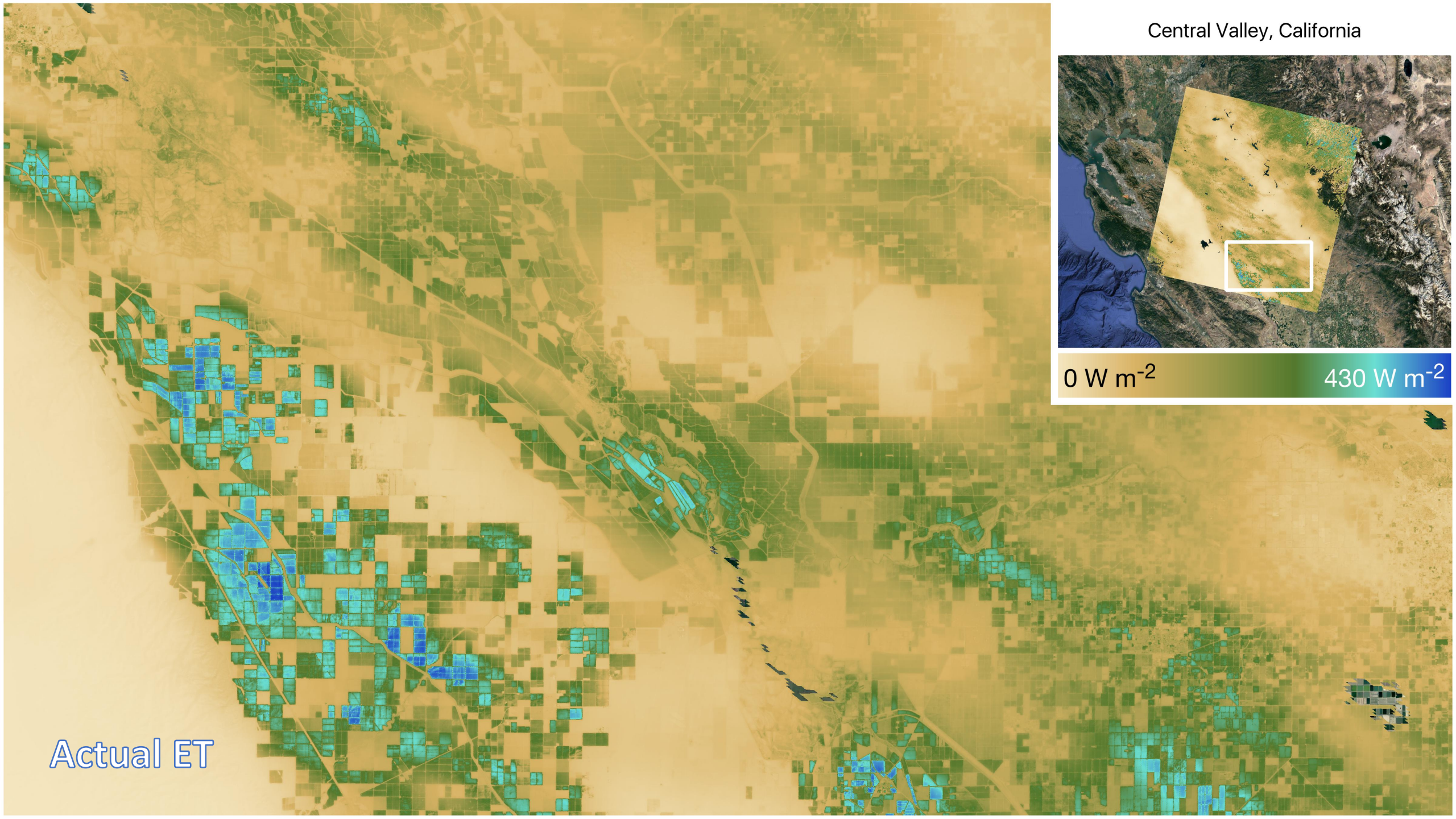
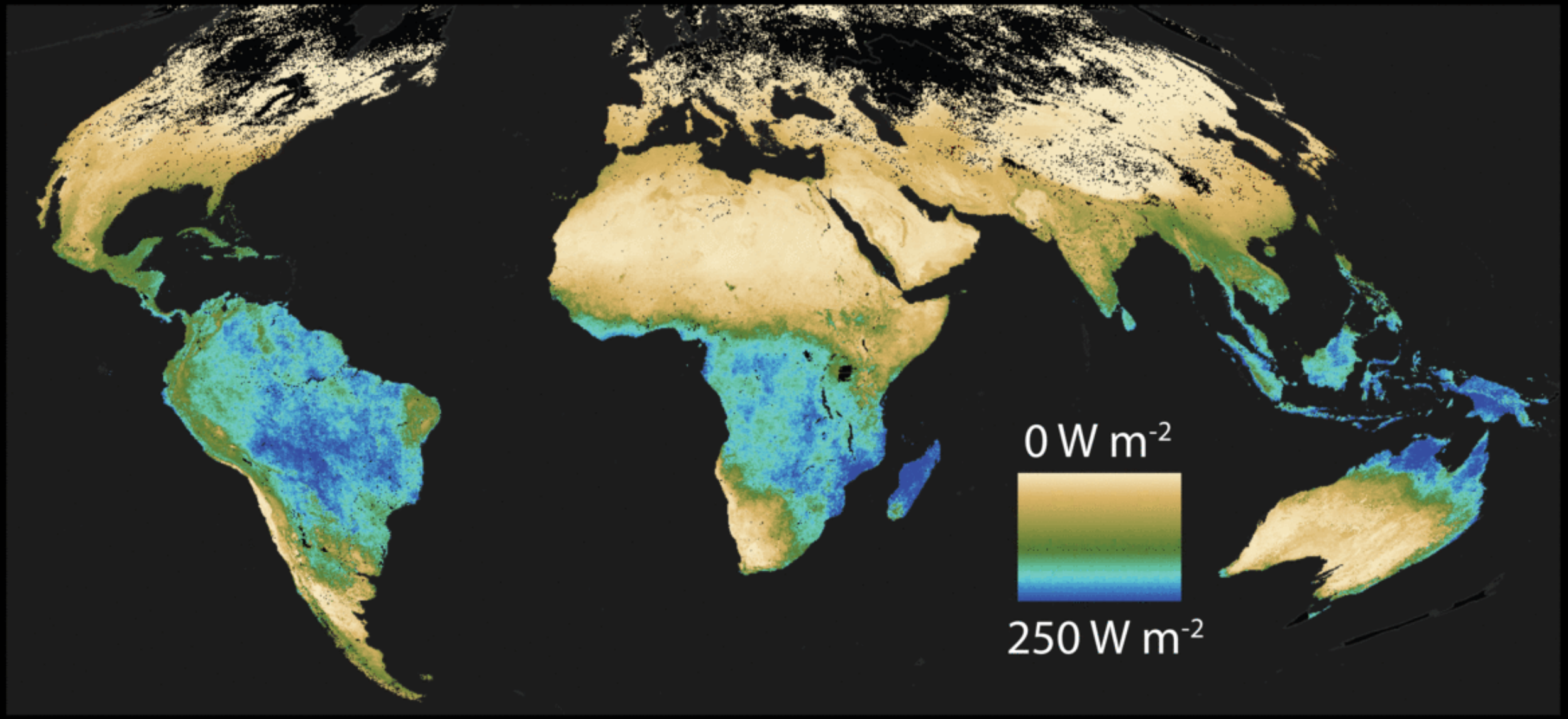


PT-JPL


Central Valley, California
0 W m-2
430 W m-2
Scenario: Flattened Land-Surface Temperature


Central Valley, California
0 W m-2
430 W m-2
Actual ET

Monthly Average of PT-JPL Daily Integrated Latent Heat Flux



1 2 3 4 5 6 7 8 9 10 12 13

J F M A M J J A S O N D

Science Algorithms: L3(ET_PT-JPL)

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

This discussion paper is/has been under review for the journal Geoscientific Model Development (GMD). Please refer to the corresponding final paper in GMD if available.

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]

Agricultural and Forest Meteorology 187 (2014) 46–61
Contents lists available at ScienceDirect
Agricultural and Forest Meteorology
journal homepage: www.elsevier.com/locate/agrformet

Multi-site evaluation of terrestrial evaporation models using FLUXNET data

A. Ershadi[a,*], M.F. McCabe[b], J.P. Evans[c,d], N.W. Chaney[e], E.F. Wood[e]

Remote Sensing of Environment 115 (2011) 801–823
Contents lists available at ScienceDirect
Remote Sensing of Environment
journal homepage: www.elsevier.com/locate/rse

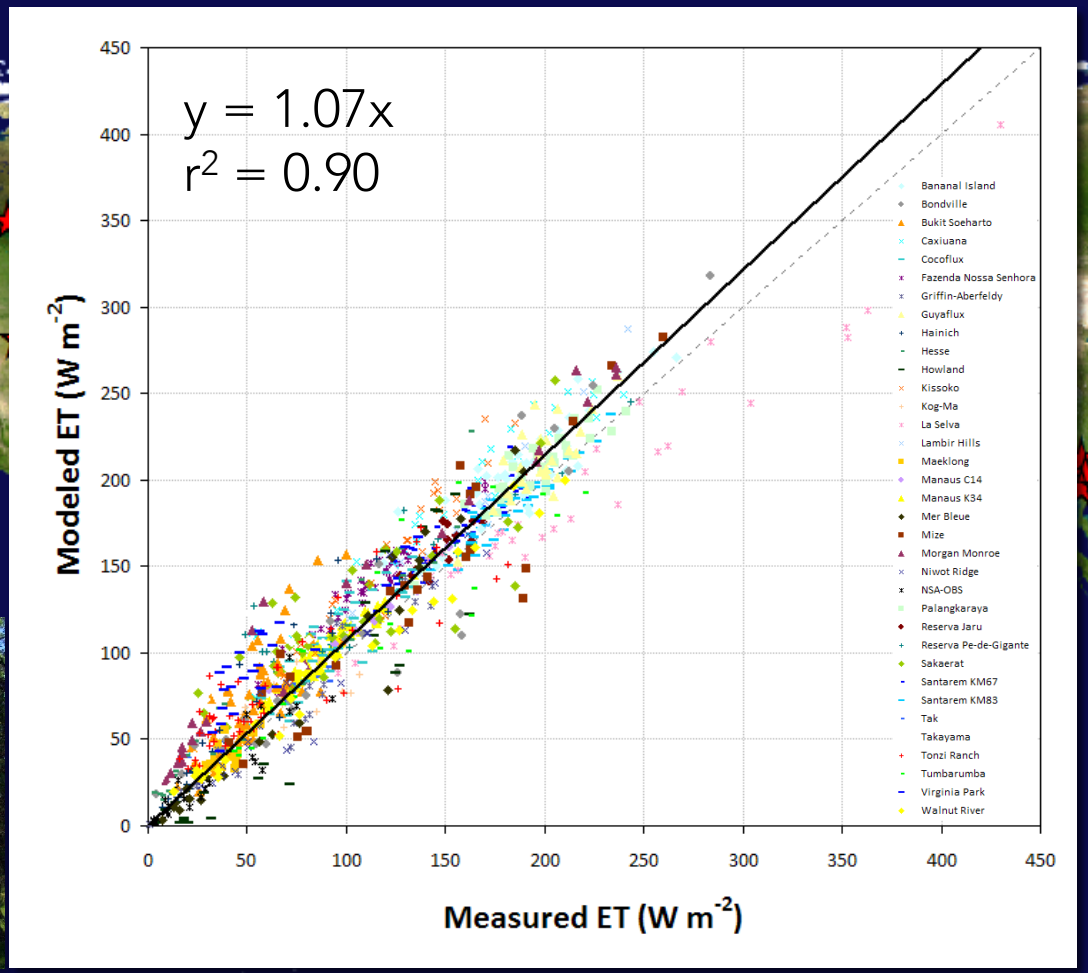
Global estimates of evapotranspiration for climate studies using multi-sensor remote sensing data: Evaluation of three process-based approaches

Raghuveer K. Vinukollu[a,*], Eric F. Wood[a], Craig R. Ferguson[a], Joshua B. Fisher[b]

Manuscript prepared for Hydrol. Earth Syst. Sci.
with version 2015/04/24 7.83 Copernicus papers of the LaTeX class copernicus.cls.
Date: 4 September 2015

The WACMOS-ET project - Part 1: Tower-scale evaluation of four observation-based evapotranspiration algorithms

D. Michel[1], C. Jiménez[2,3], D.M. Miralles[4,5], M. Jung[6], M. Hirschi[1], A. Ershadi[7], B. Martens[5], M.F. McCabe[7], J.B. Fisher[8], Q. Mu[9], Z. Su[10], S.I. Seneviratne[1], E.F. Wood[11], and D. Fernández-Prieto[12]

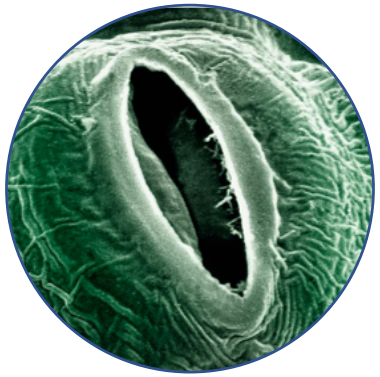


stations as independent metrics of performance, the tower-based analysis indicated that PT-JPL provided the highest overally statistical performance (0.72; 61 W m^{-2}; 0.65), followed closely by GLEAM (0.68; 64 W m^{-2}; 0.62), with values in parenthe-

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

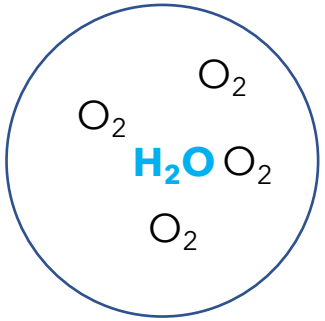
Science Algorithms: L4(ESI, WUE)

ECOSTRESS Water Use Efficiency (WUE) = Gross Primary Production (carbon in) / **ECOSTRESS Evapotranspiration (water out)**



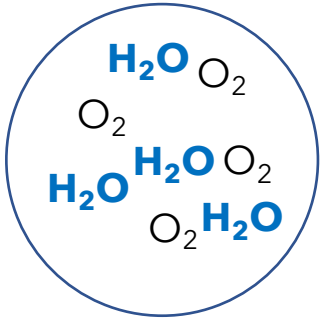
ECOSTRESS L4

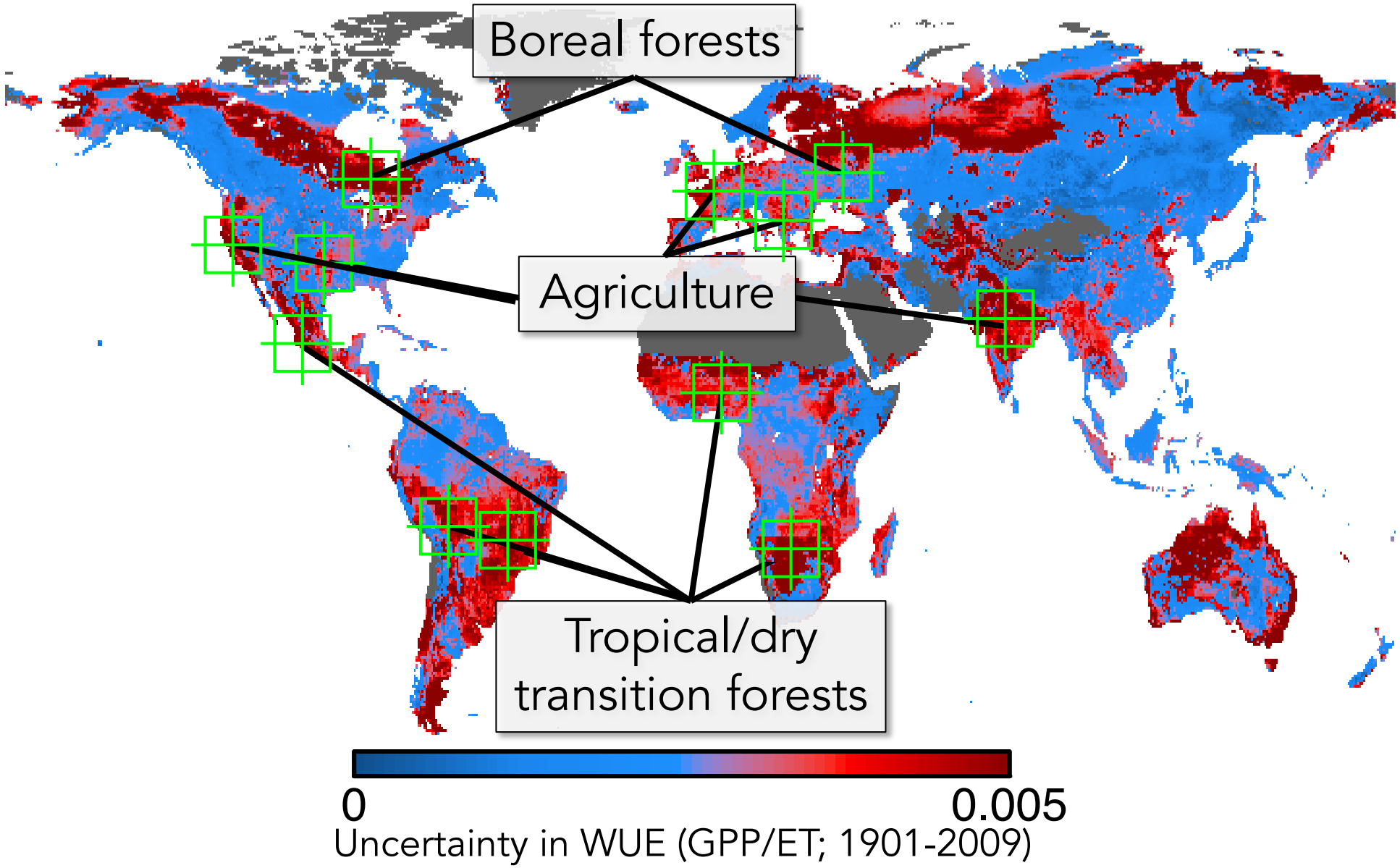
actual evapotranspiration



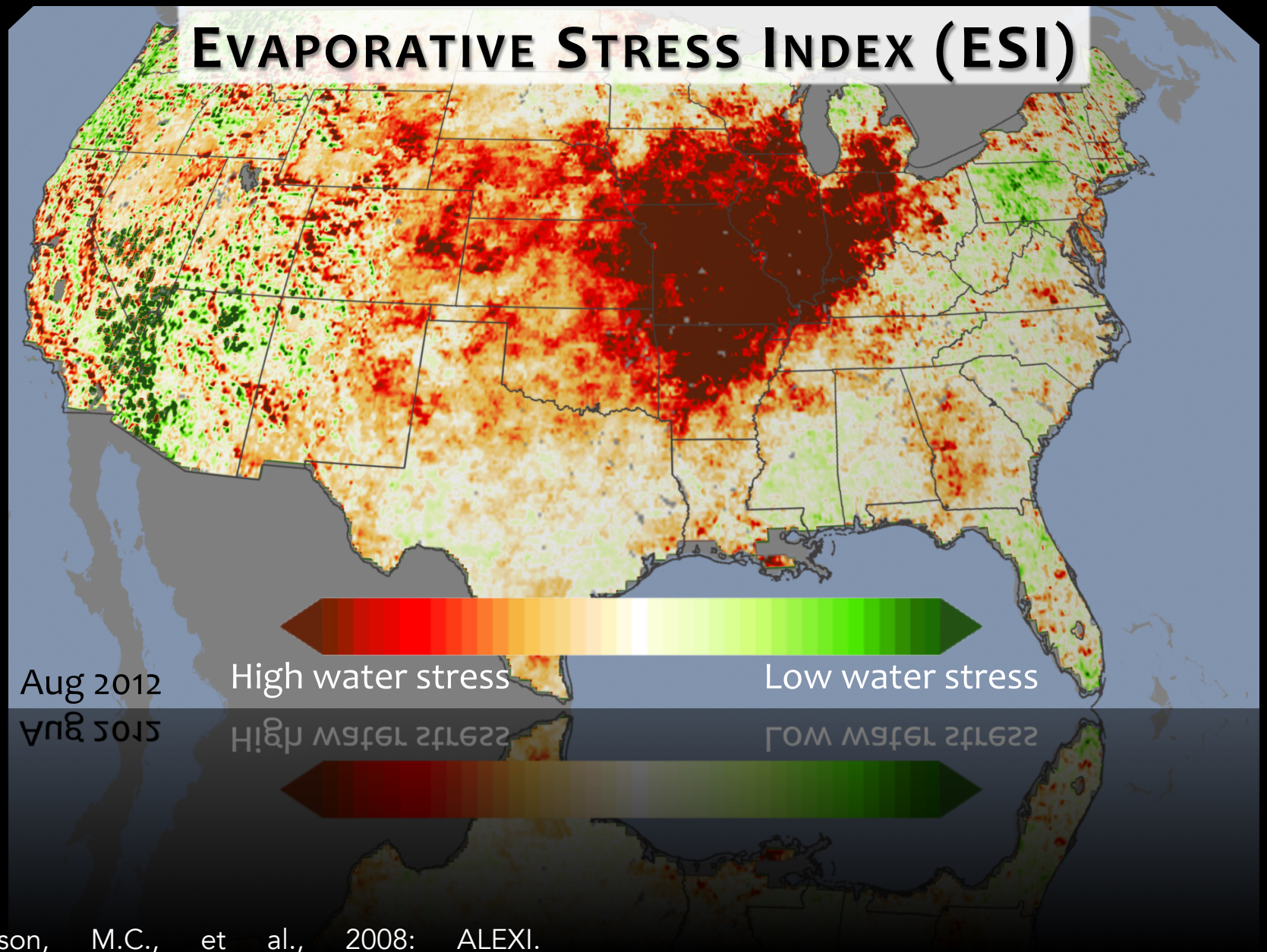
ECOSTRESS Evaporative Stress Index (ESI) = **actual evapotranspiration** / **potential evapotranspiration**

potential evapotranspiration



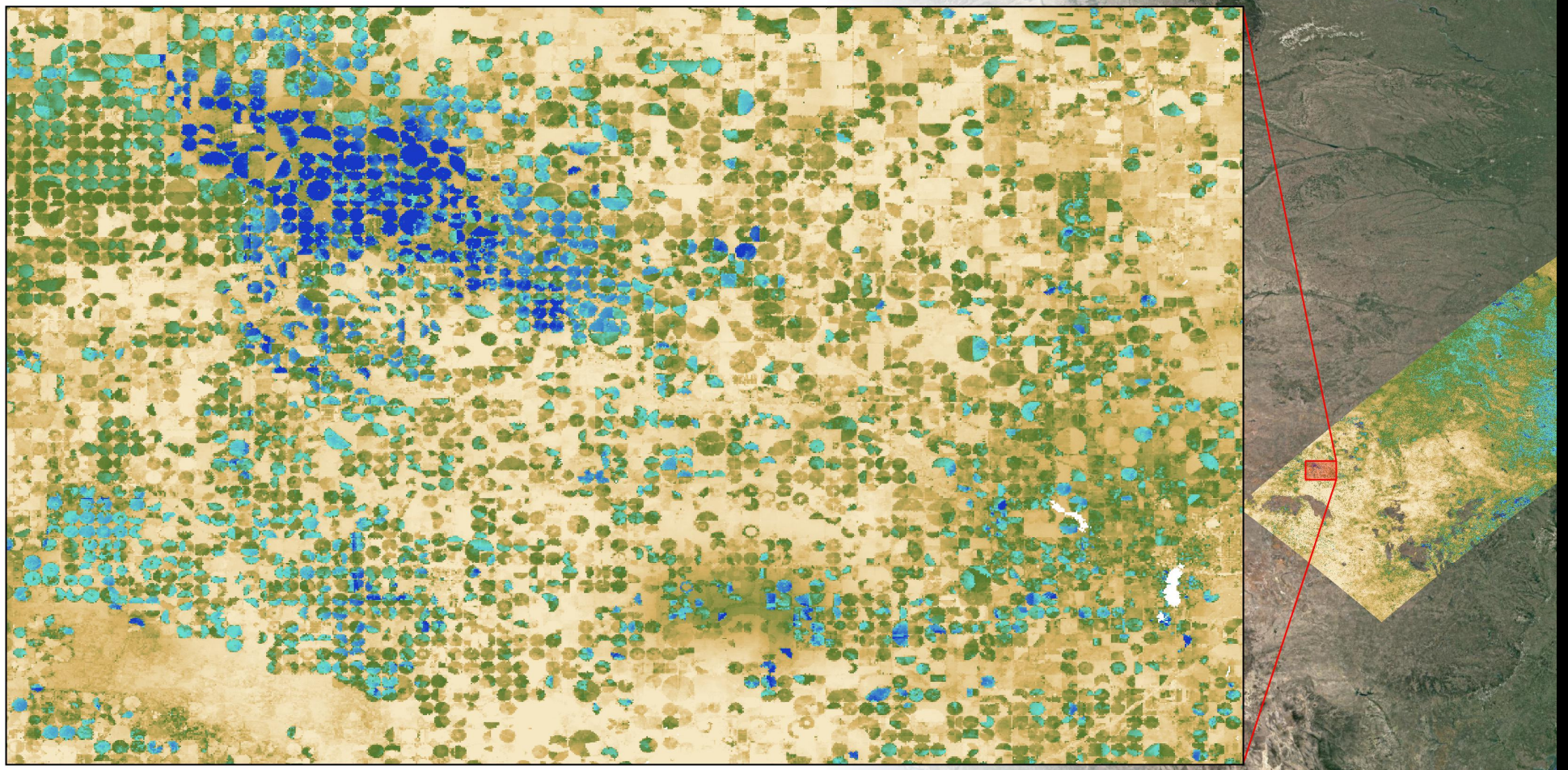


Nine land surface models were run with only a perturbed climate (i.e., CO_2, land use constant) over the 20th century, representing the g-response, or climate sensitivity to identify key *WUE uncertainty hotspots*.

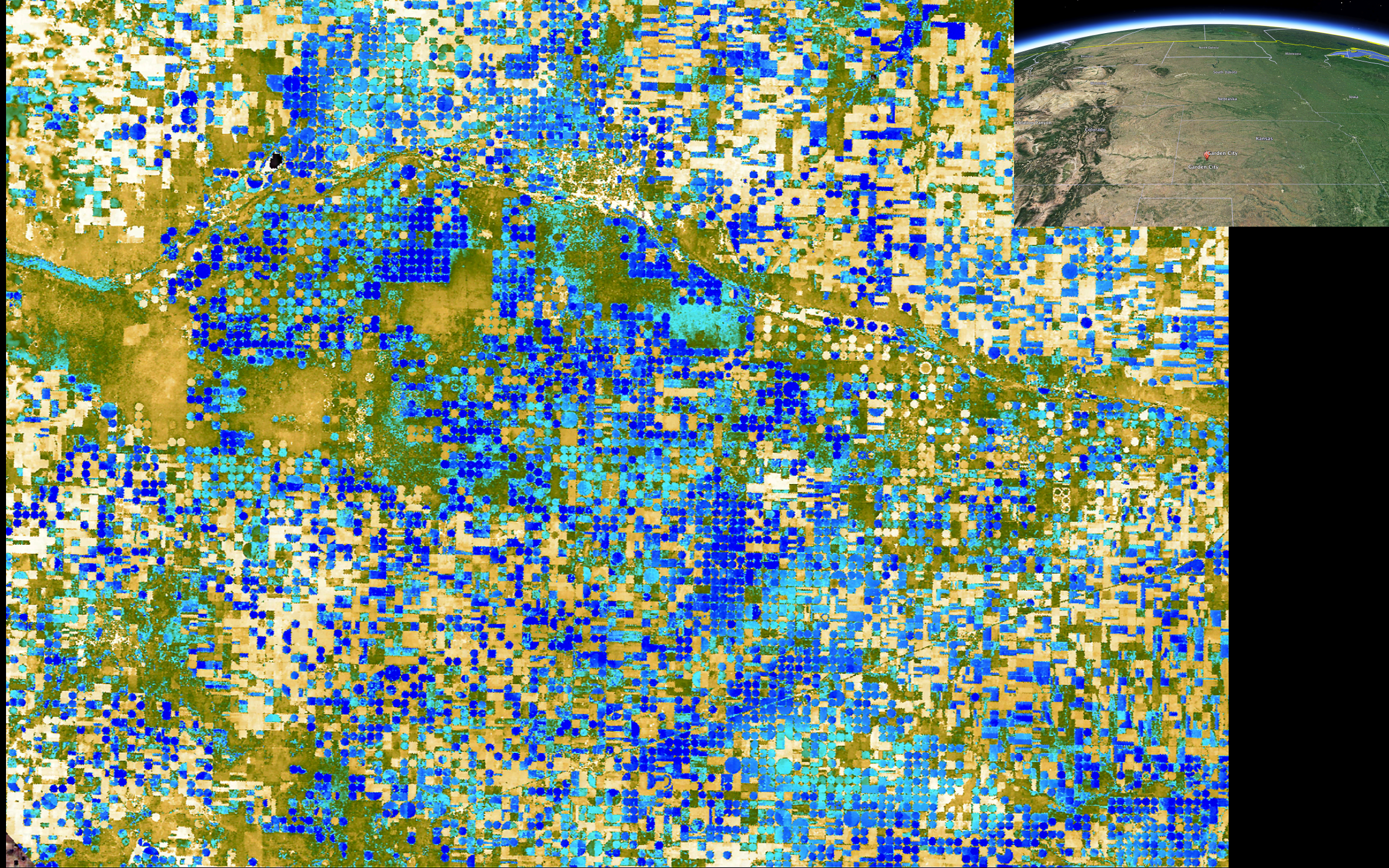


Anderson, M.C., et al., 2008: ALEXI. *Remote Sensing of Environment.*

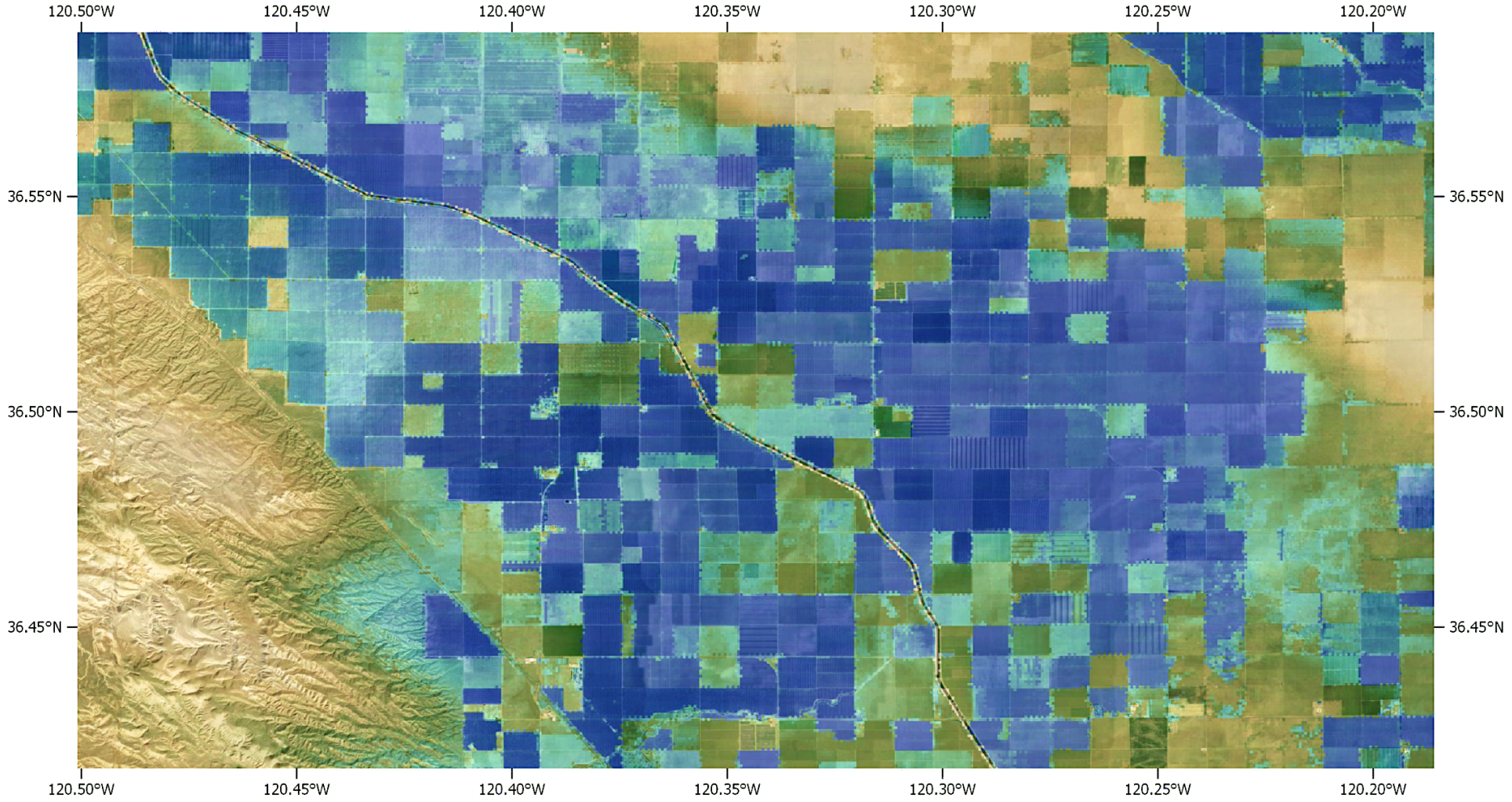
ECOSTRESS L3 (ET PT-JPL) 2018-07-29 18:19 CDT



0.02 g H_2O s^{-1} m^{-2} — 0.16 g H_2O s^{-1} m^{-2}

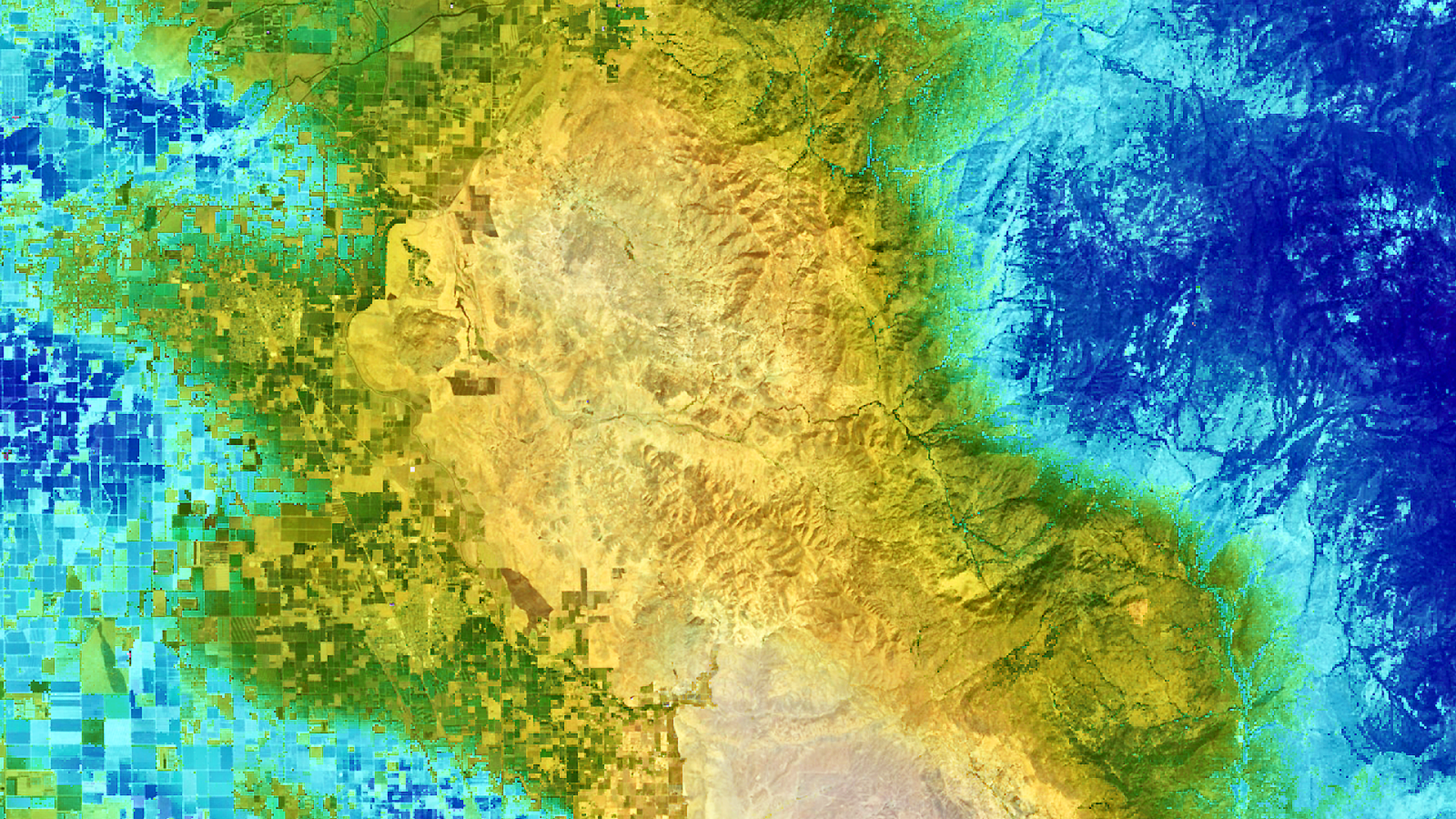

Colorado
Kansas
Garden City
Garden City

Variability in evapotranspiration detectable across and within fields, shown near Fresno, CA

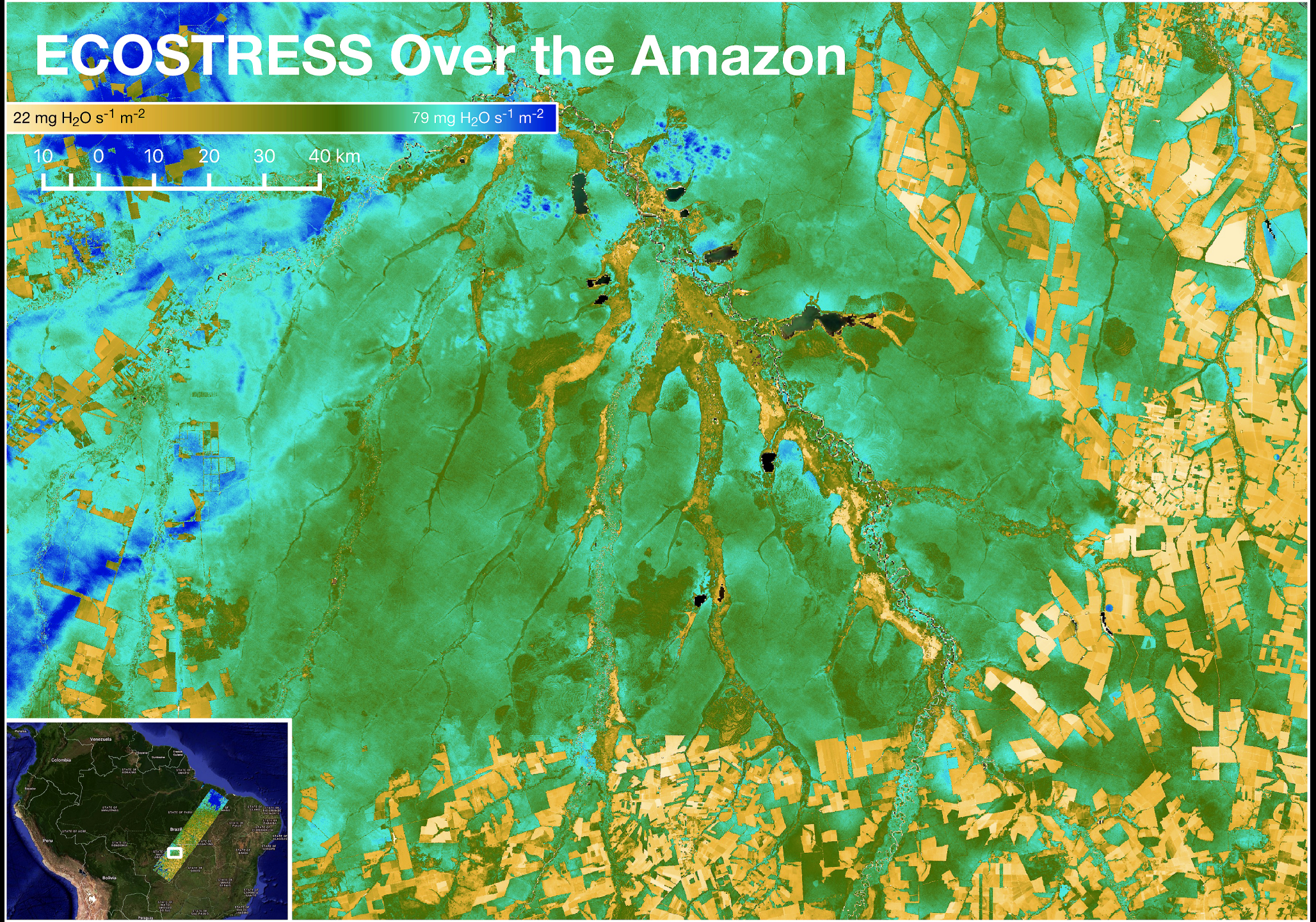


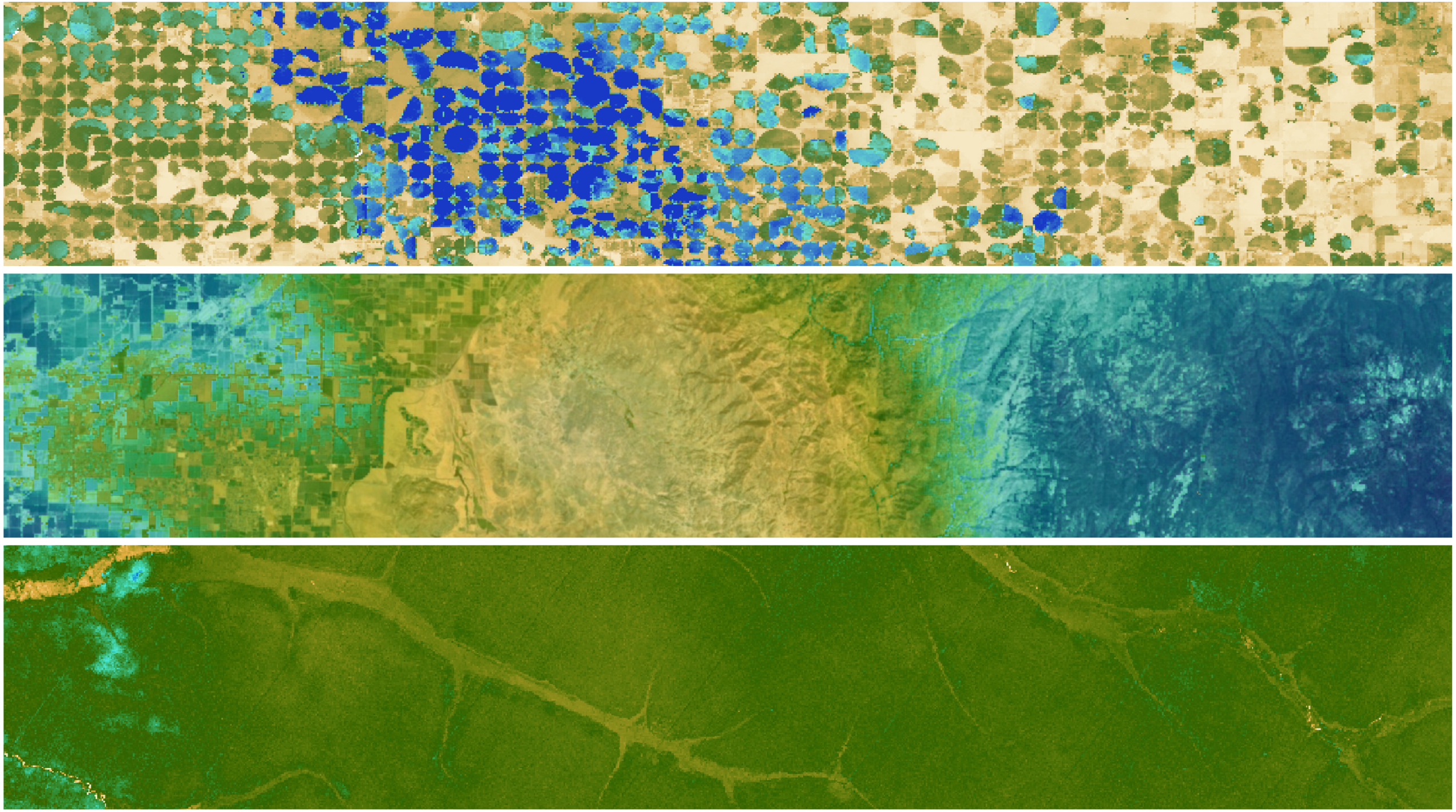
0 w m^{-2} — 200 w m^{-2}

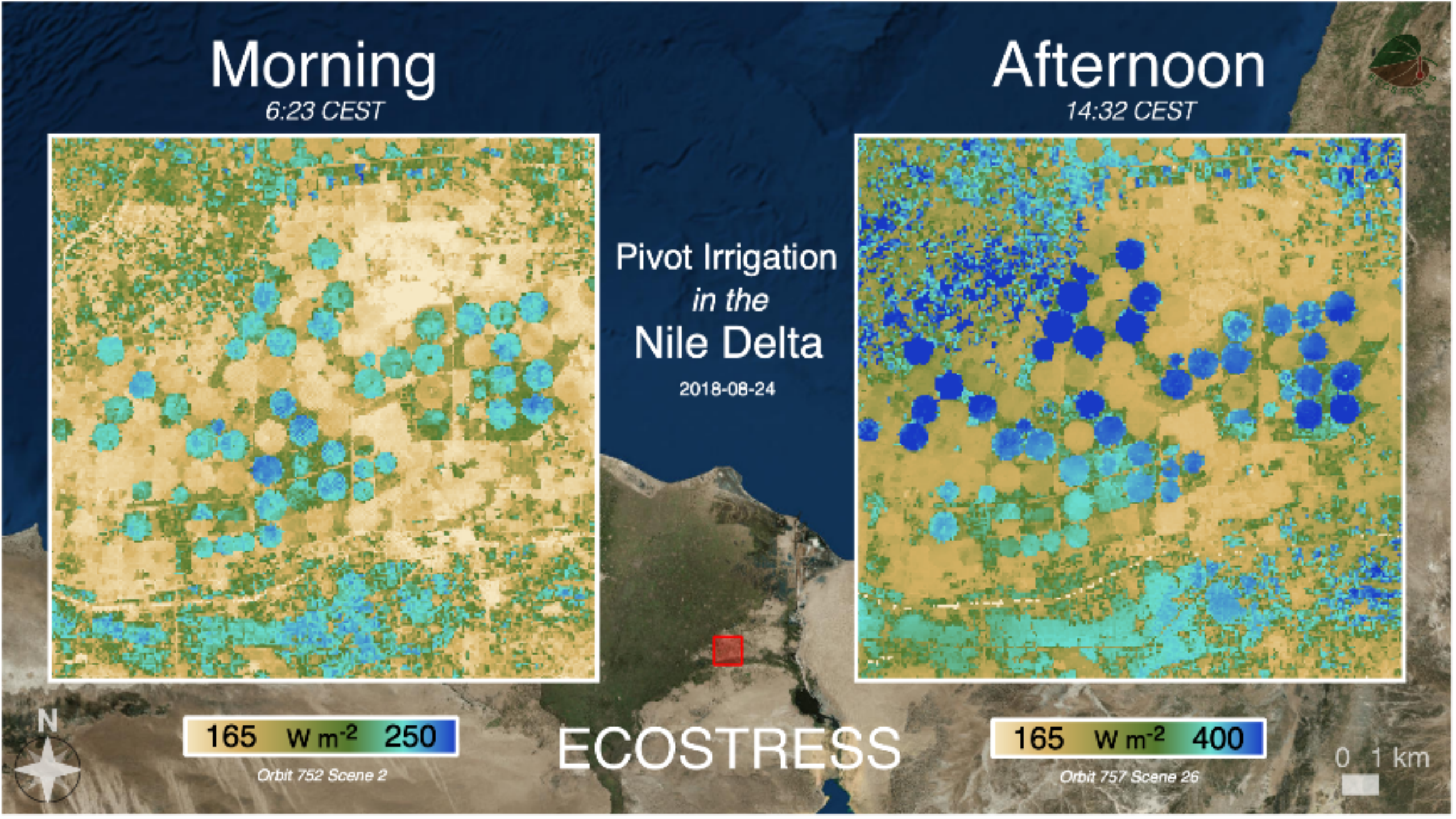
Credit: Early Adopter M. Ellen



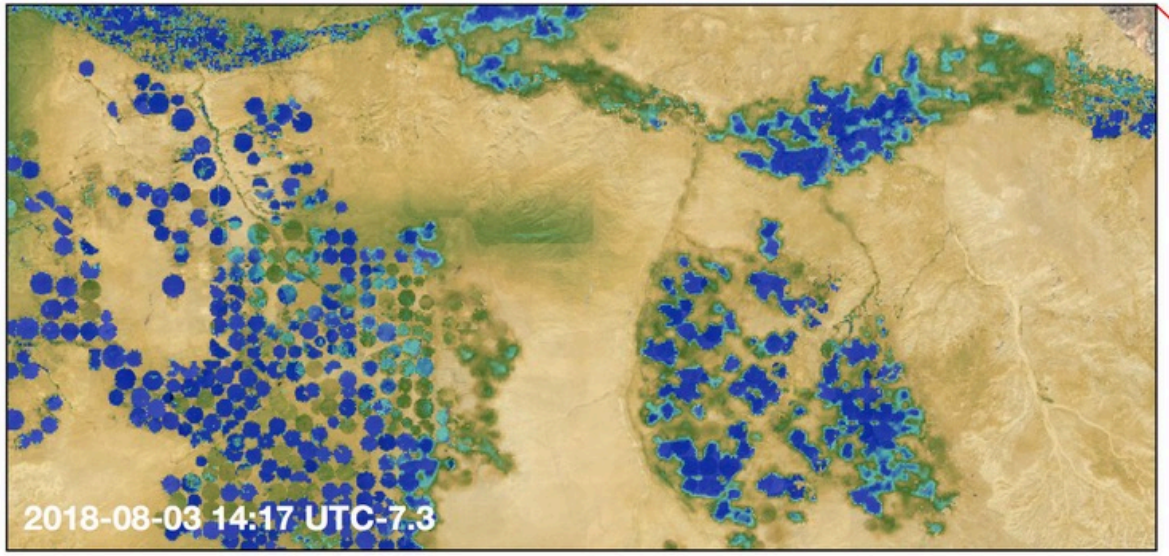
ECOSTRESS Over the Amazon

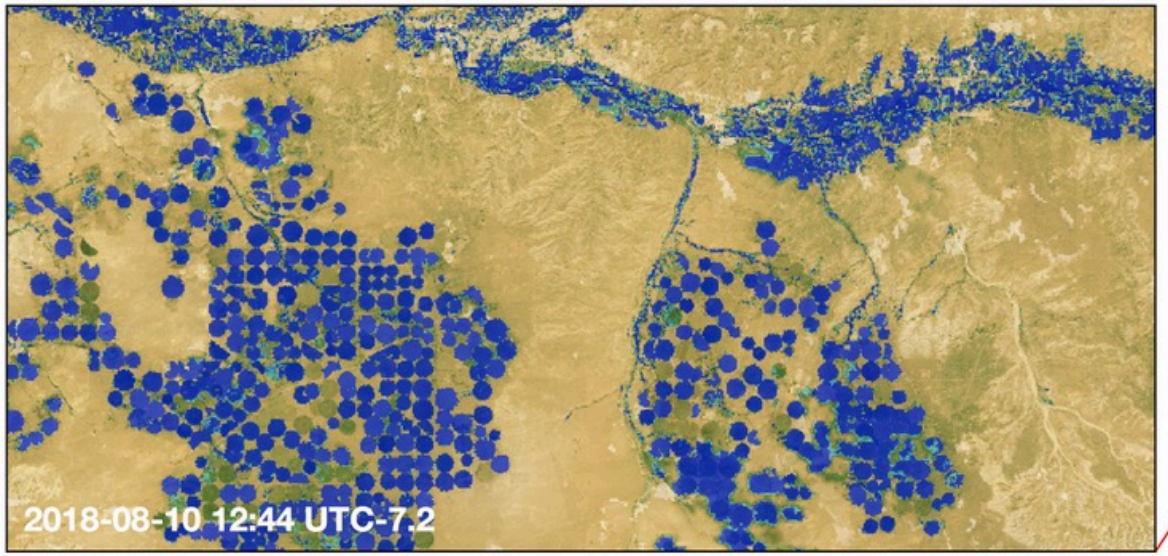




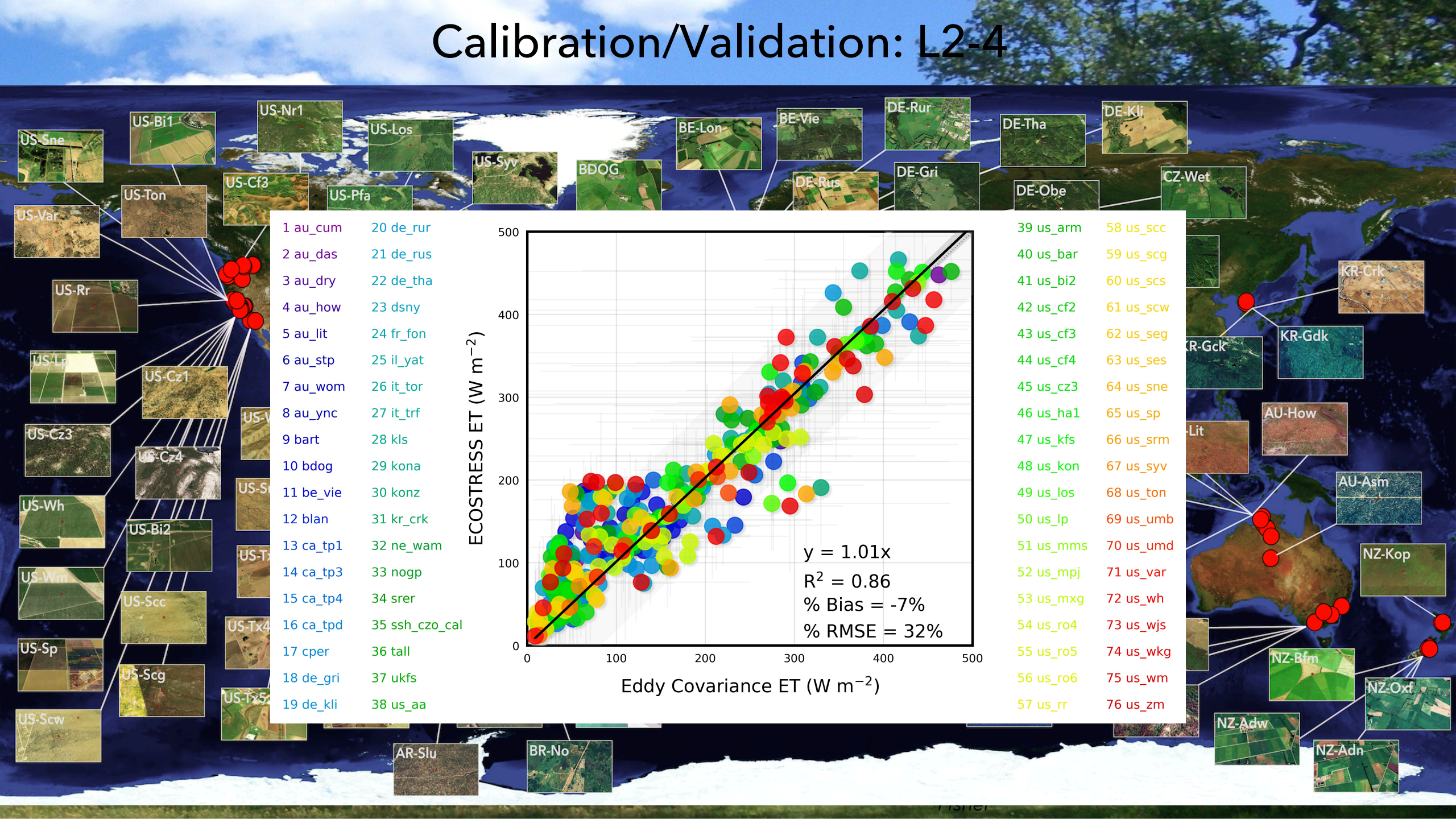

Morning
6:23 CEST
Afternoon
14:32 CEST
Pivot Irrigation
in the
Nile Delta
2018-08-24
N
165 W m-2 250
Orbit 752 Scene 2
ECOSTRESS
165 W m-2 400
Orbit 757 Scene 26
0 1 km

Changes in Navajo Pivot Irrigation Field ET Seen in One Week by ECOSTRESS

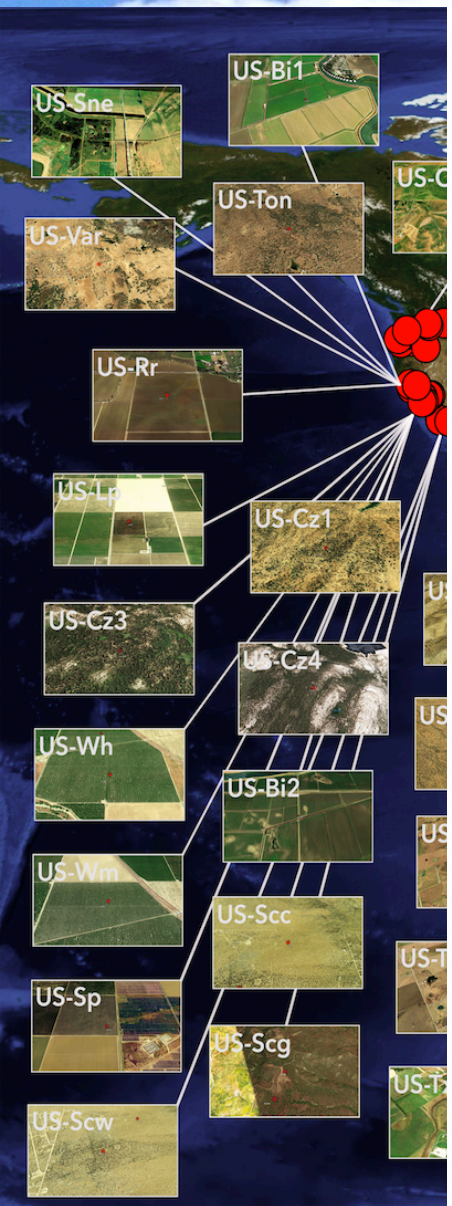


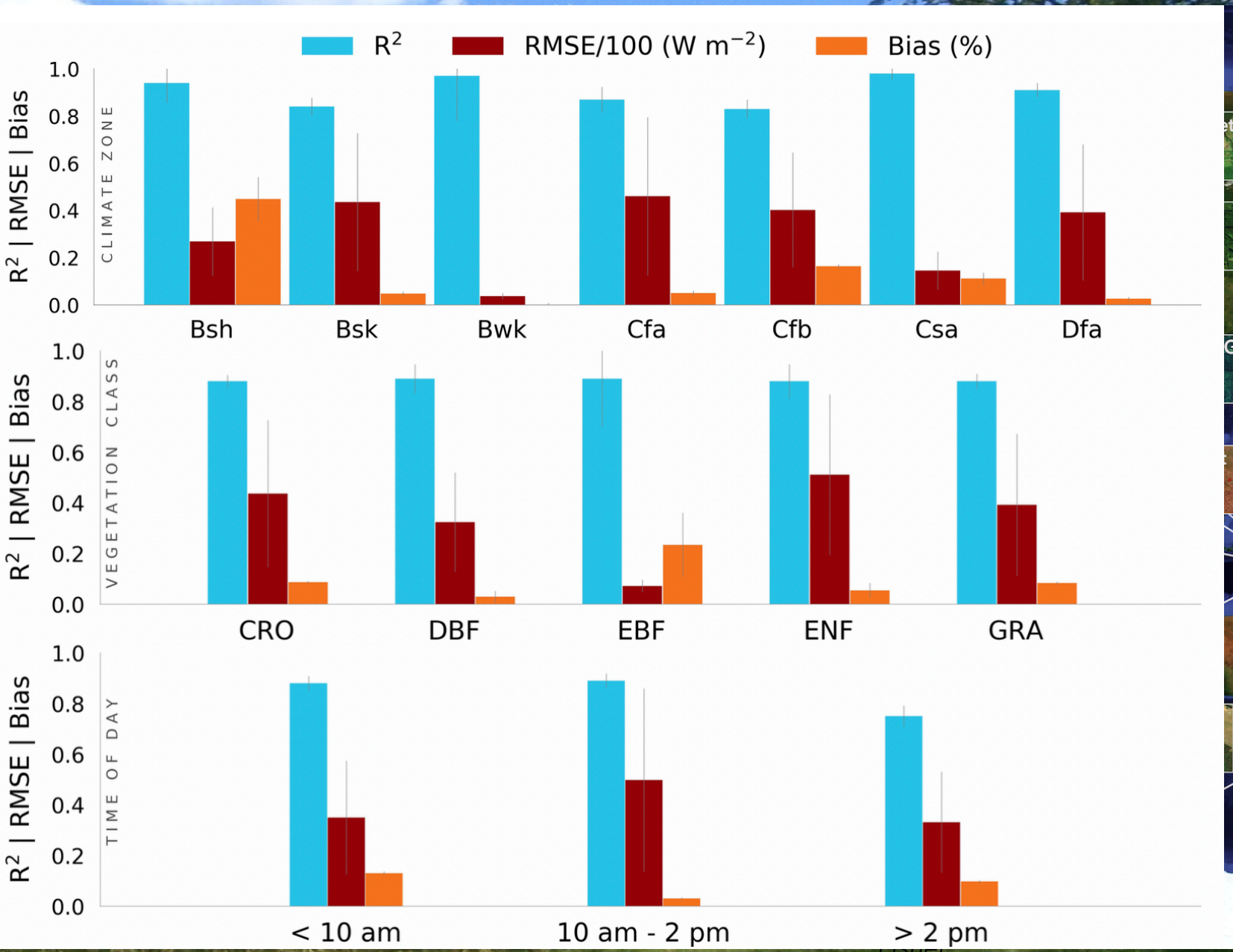


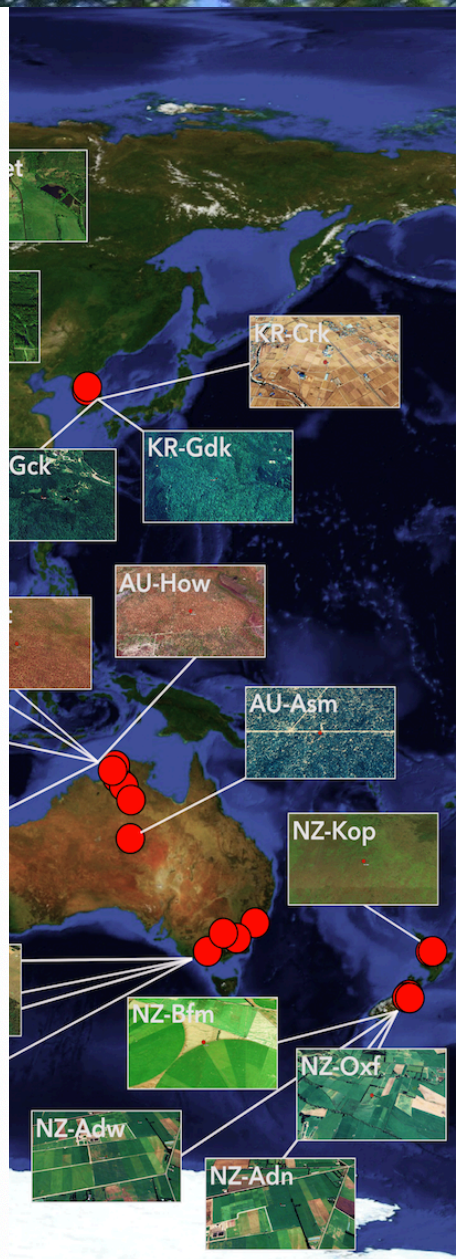
Calibration/Validation: L2-4

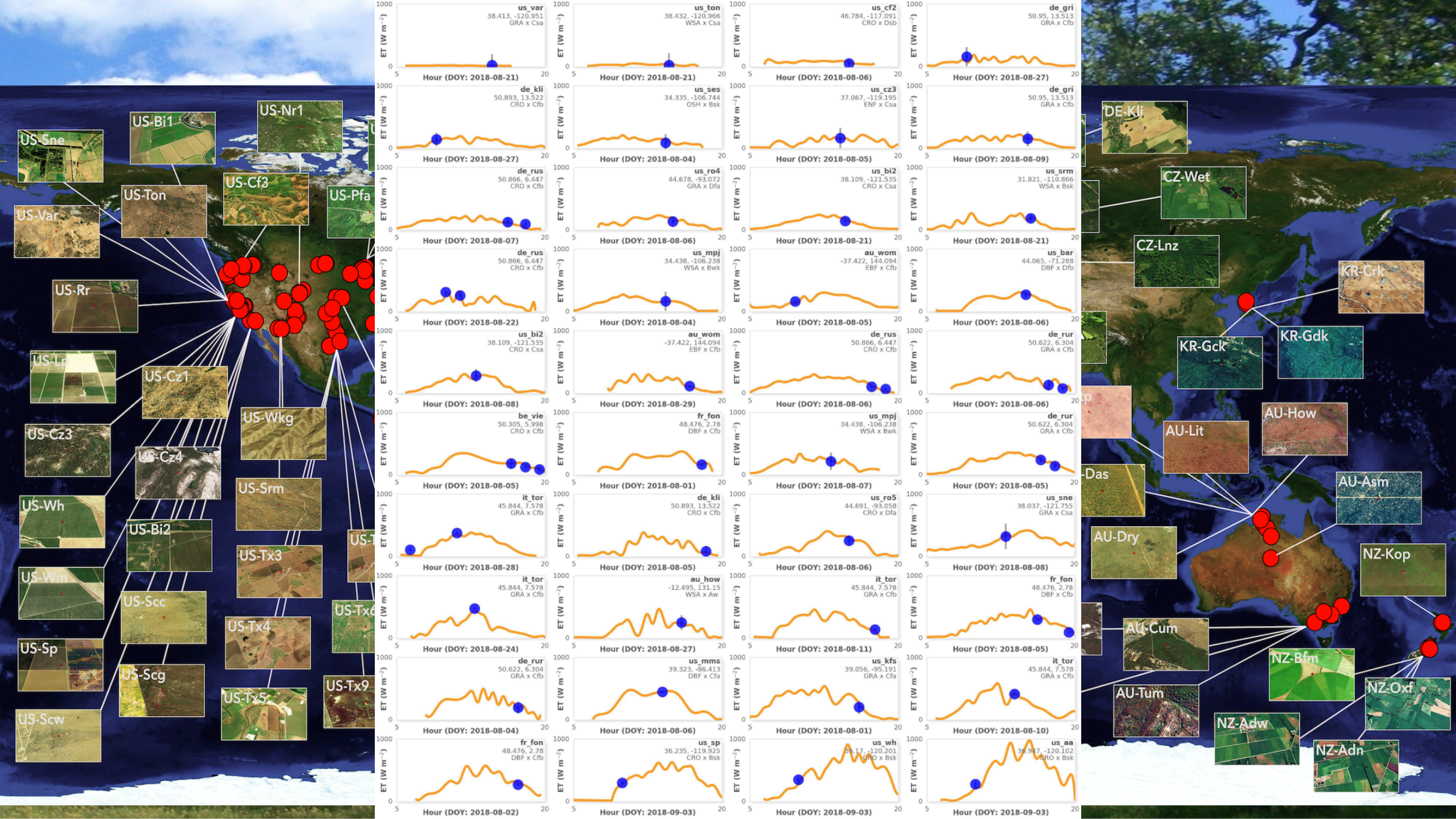


Calibration/Validation: L2-4








US-Sne
US-Bi1
US-Nr1
US-Ton
US-Cf3
US-Pfa
US-Var
US-Rr
US-Lp
US-Cz1
US-Wkg
US-Cz3
US-Cz4
US-Srm
US-Wh
US-Bi2
US-Tx3
US-Wm
US-Scc
US-Tx4
US-Sp
US-Scg
US-Tx5
US-Tx9
US-Scw
DE-Kli
CZ-Wet
CZ-Lnz
KR-Crk
KR-Gck
KR-Gdk
AU-How
AU-Lit
AU-Asm
AU-Dry
NZ-Kop
AU-Cum
NZ-Bfm
AU-Tum
NZ-Oxf
NZ-Adw
NZ-Adn
us_var 38.413, -120.951 GRA x Csa
us_ton 38.432, -120.966 WSA x Csa
us_cf2 46.784, -117.091 CRO x Dsb
de_gri 50.95, 13.513 GRA x Cfb
de_kli 50.893, 13.522 CRO x Cfb
us_ses 34.335, -106.744 OSH x Bsk
us_cz3 37.067, -119.195 ENF x Csa
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au_wom -37.422, 144.094 EBF x Cfb
us_bar 44.065, -71.288 DBF x Dfb
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de_rur 50.622, 6.304 GRA x Cfb
be_vie 50.305, 5.998 CRO x Cfb
fr_fon 48.476, 2.78 DBF x Cfb
it_tor 45.844, 7.578 GRA x Cfb
de_kli 50.893, 13.522 CRO x Cfb
us_ro5 44.691, -93.058 CRO x Dfa
us_sne 38.037, -121.755 GRA x Csa
au_how -12.495, 131.15 WSA x Aw
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us_kfs 39.056, -95.191 GRA x Cfa
us_sp 36.235, -119.925 CRO x Bsk
us_wh 38.17, -120.201 CRO x Bsk
us_aa 38.997, -120.102 CRO x Bsk
ET (W m⁻²)
Hour (DOY: 2018-08-21)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-27)
Hour (DOY: 2018-08-27)
Hour (DOY: 2018-08-04)
Hour (DOY: 2018-08-05)
Hour (DOY: 2018-08-09)
Hour (DOY: 2018-08-07)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-21)
Hour (DOY: 2018-08-21)
Hour (DOY: 2018-08-22)
Hour (DOY: 2018-08-04)
Hour (DOY: 2018-08-05)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-08)
Hour (DOY: 2018-08-29)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-05)
Hour (DOY: 2018-08-01)
Hour (DOY: 2018-08-07)
Hour (DOY: 2018-08-05)
Hour (DOY: 2018-08-28)
Hour (DOY: 2018-08-05)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-08)
Hour (DOY: 2018-08-24)
Hour (DOY: 2018-08-27)
Hour (DOY: 2018-08-11)
Hour (DOY: 2018-08-05)
Hour (DOY: 2018-08-04)
Hour (DOY: 2018-08-06)
Hour (DOY: 2018-08-01)
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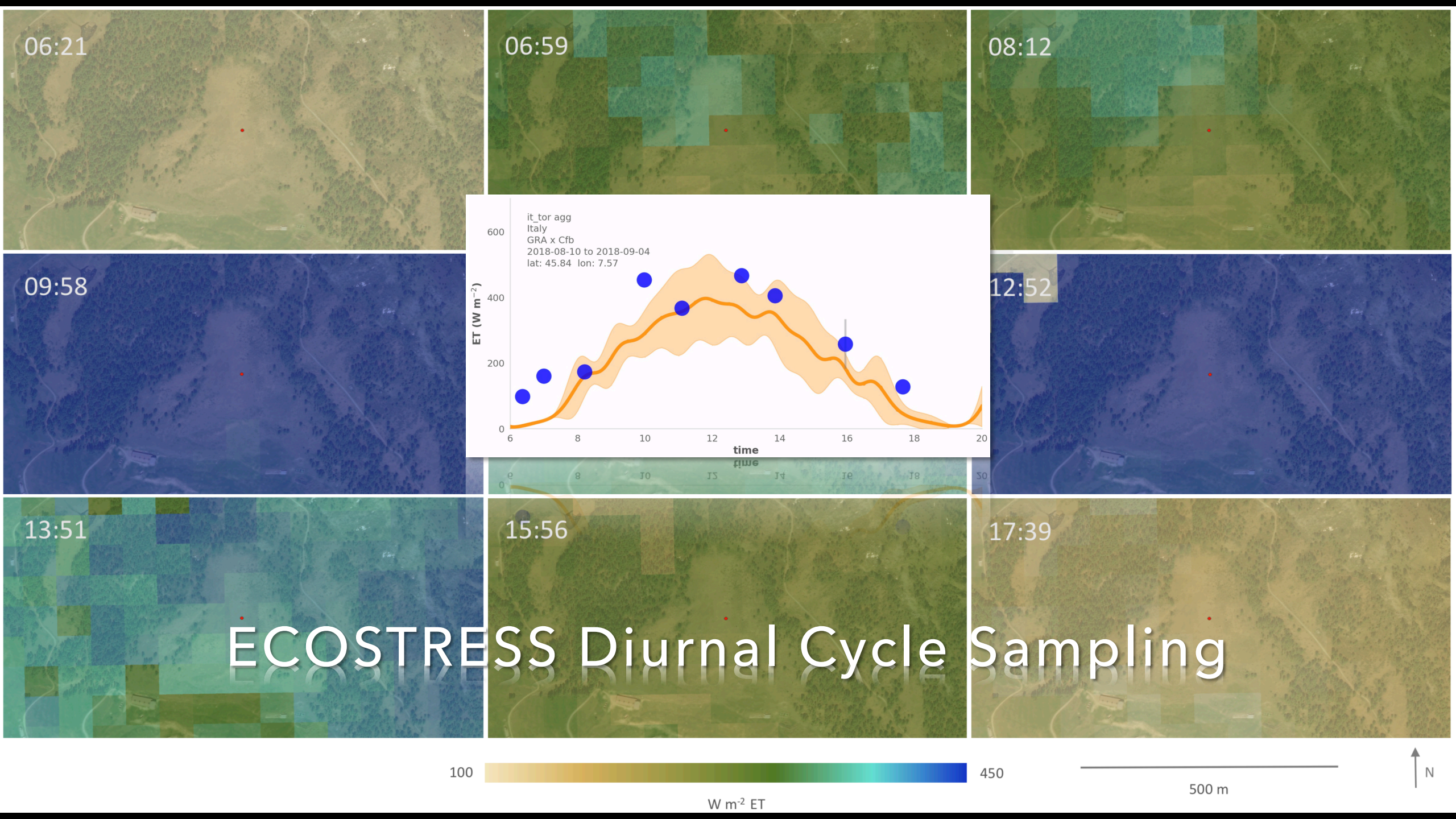
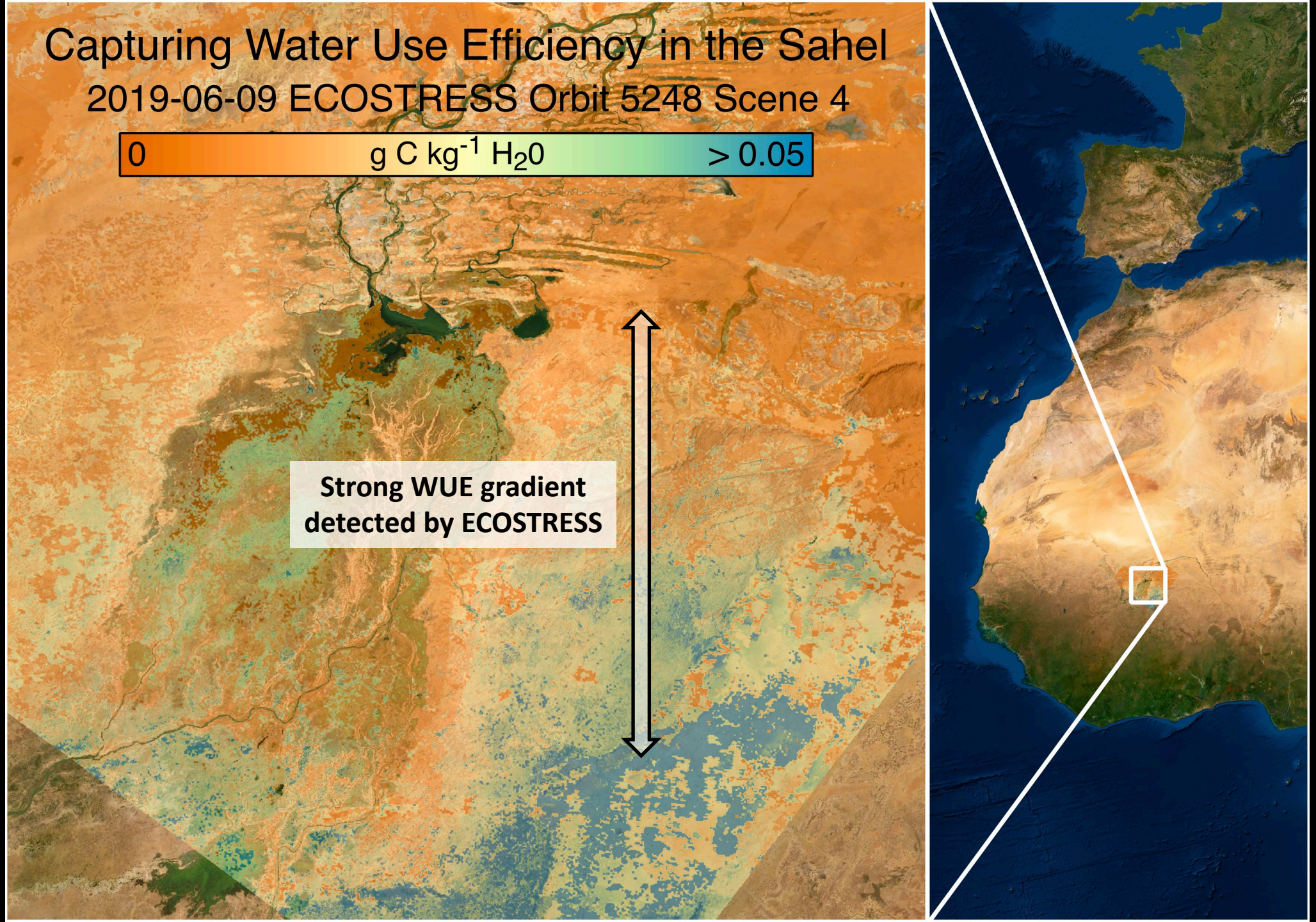
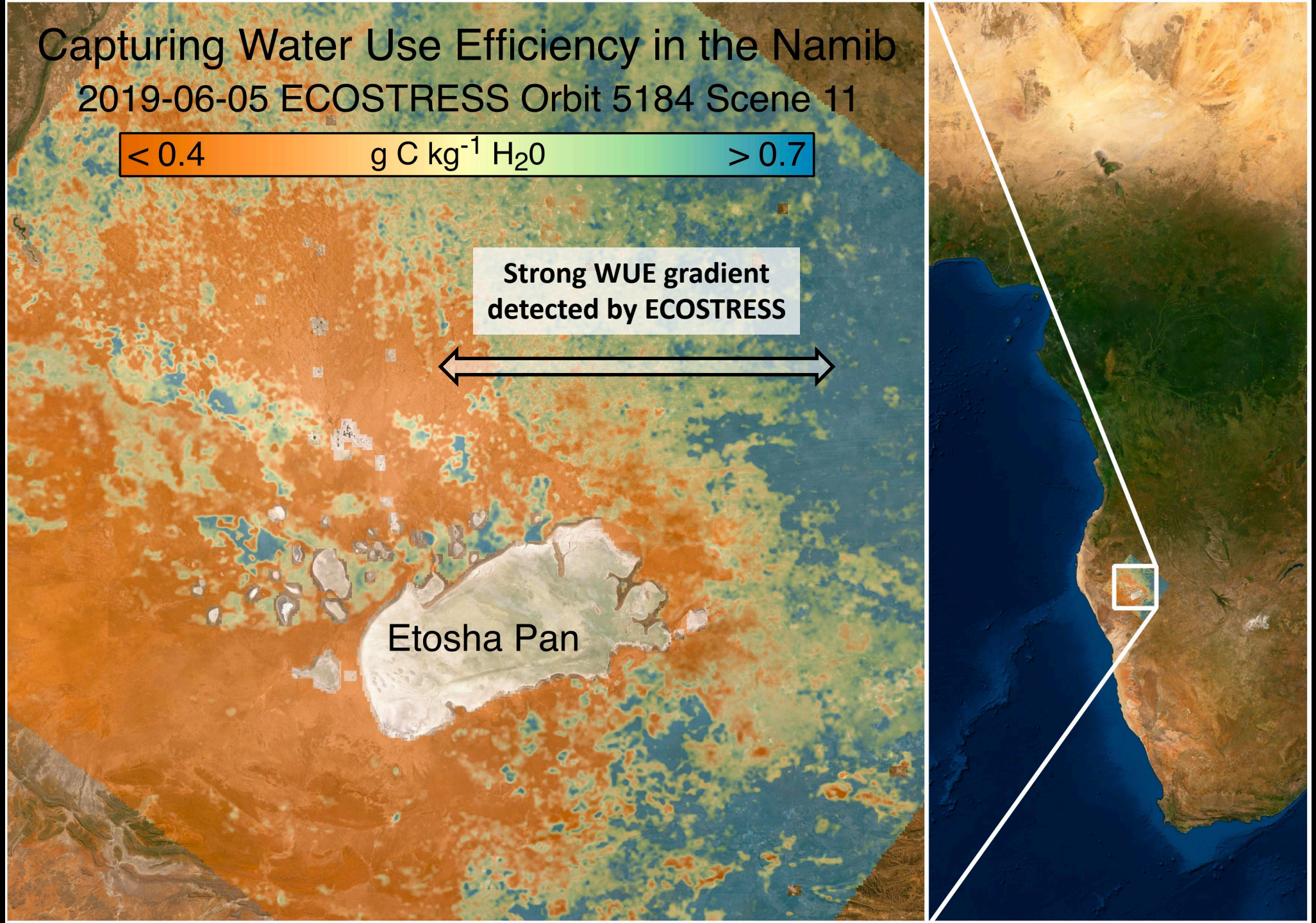
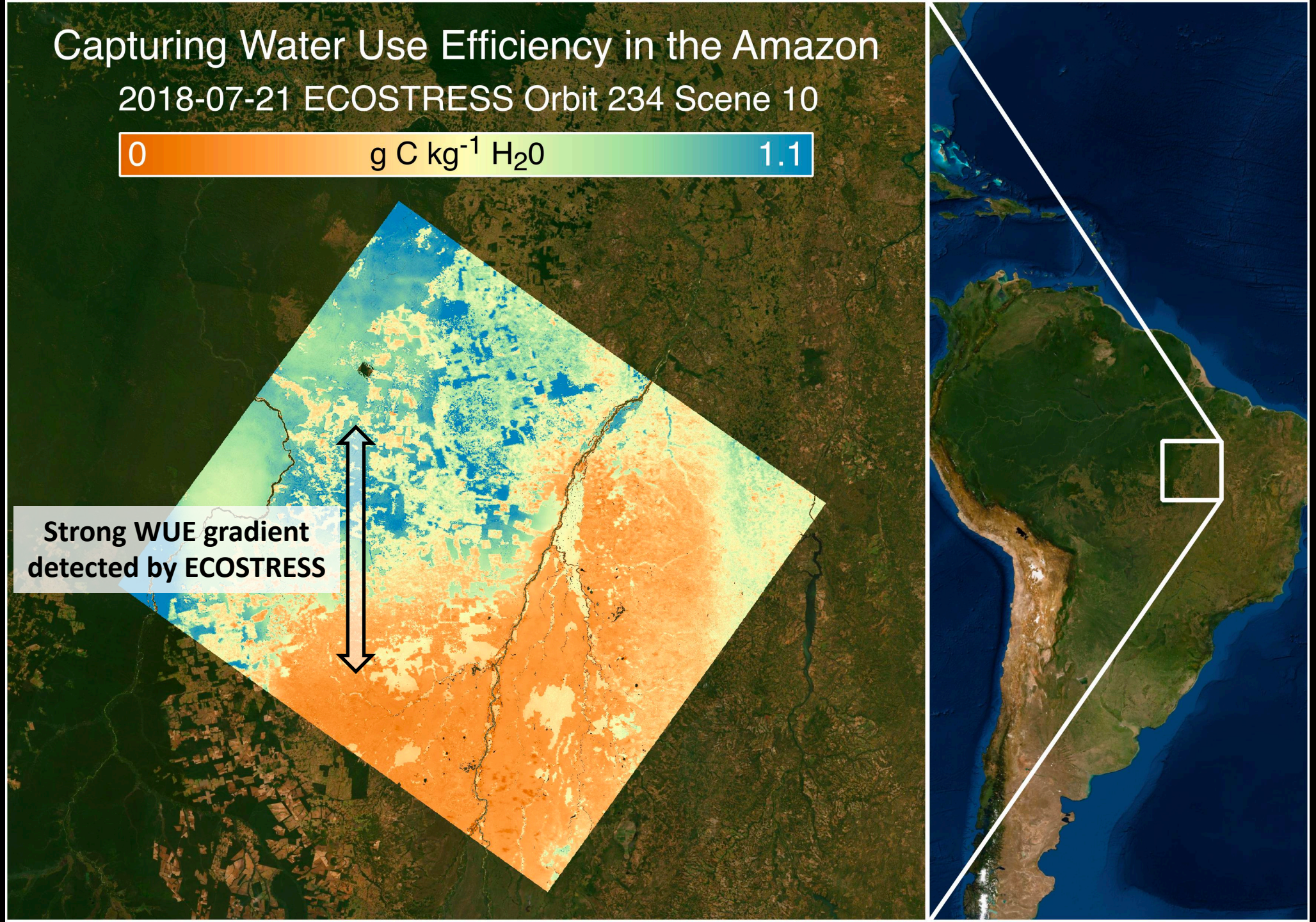
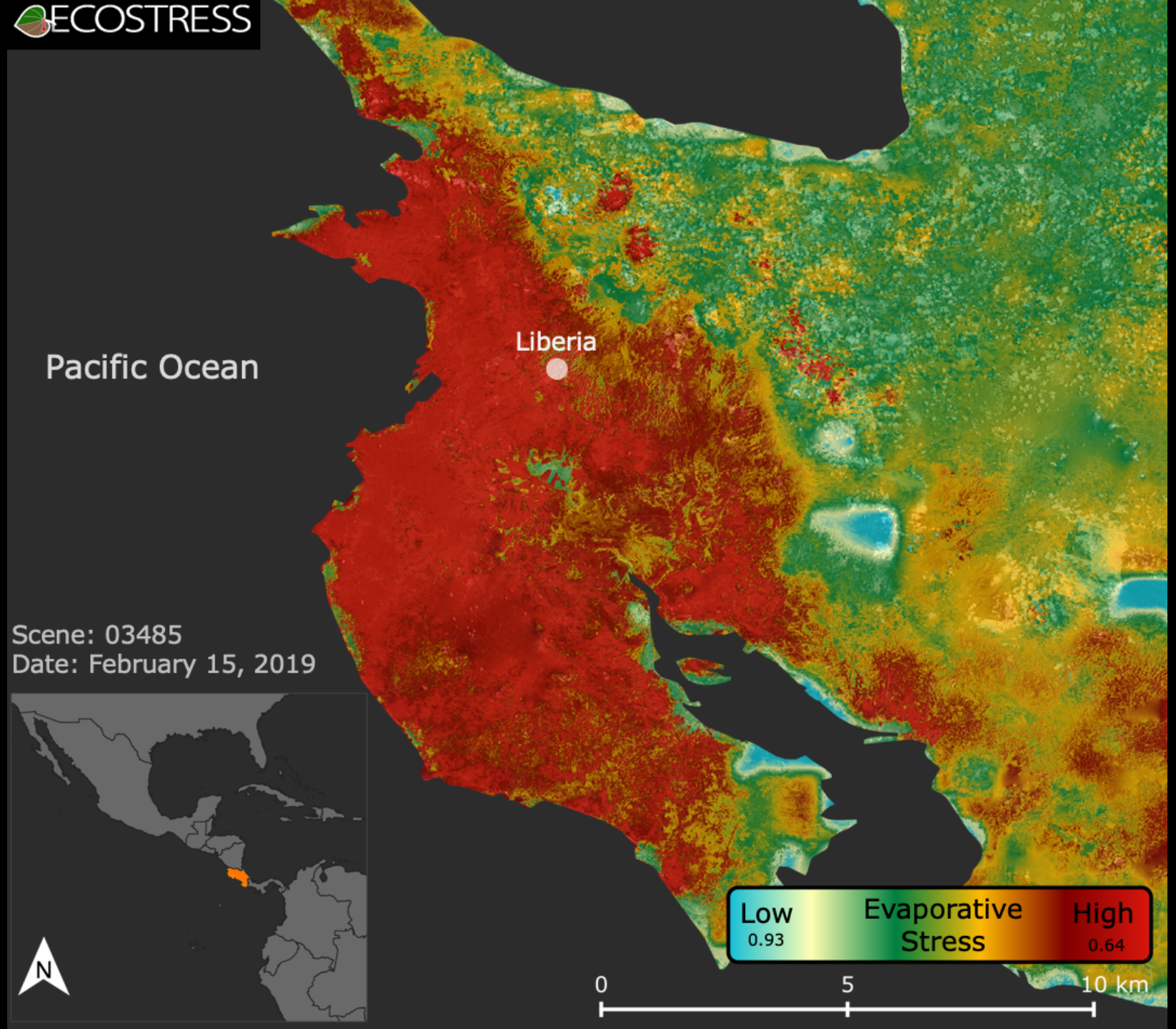

06:21
06:59
08:12
09:58
12:52
13:51
15:56
17:39
it_tor agg
Italy
GRA x Cfb
2018-08-10 to 2018-09-04
lat: 45.84 lon: 7.57
ET (W m^{-2})
600
400
200
0
6
8
10
12
14
16
18
20
time
ECOSTRESS Diurnal Cycle Sampling
100
450
W m^{-2} ET
500 m
N

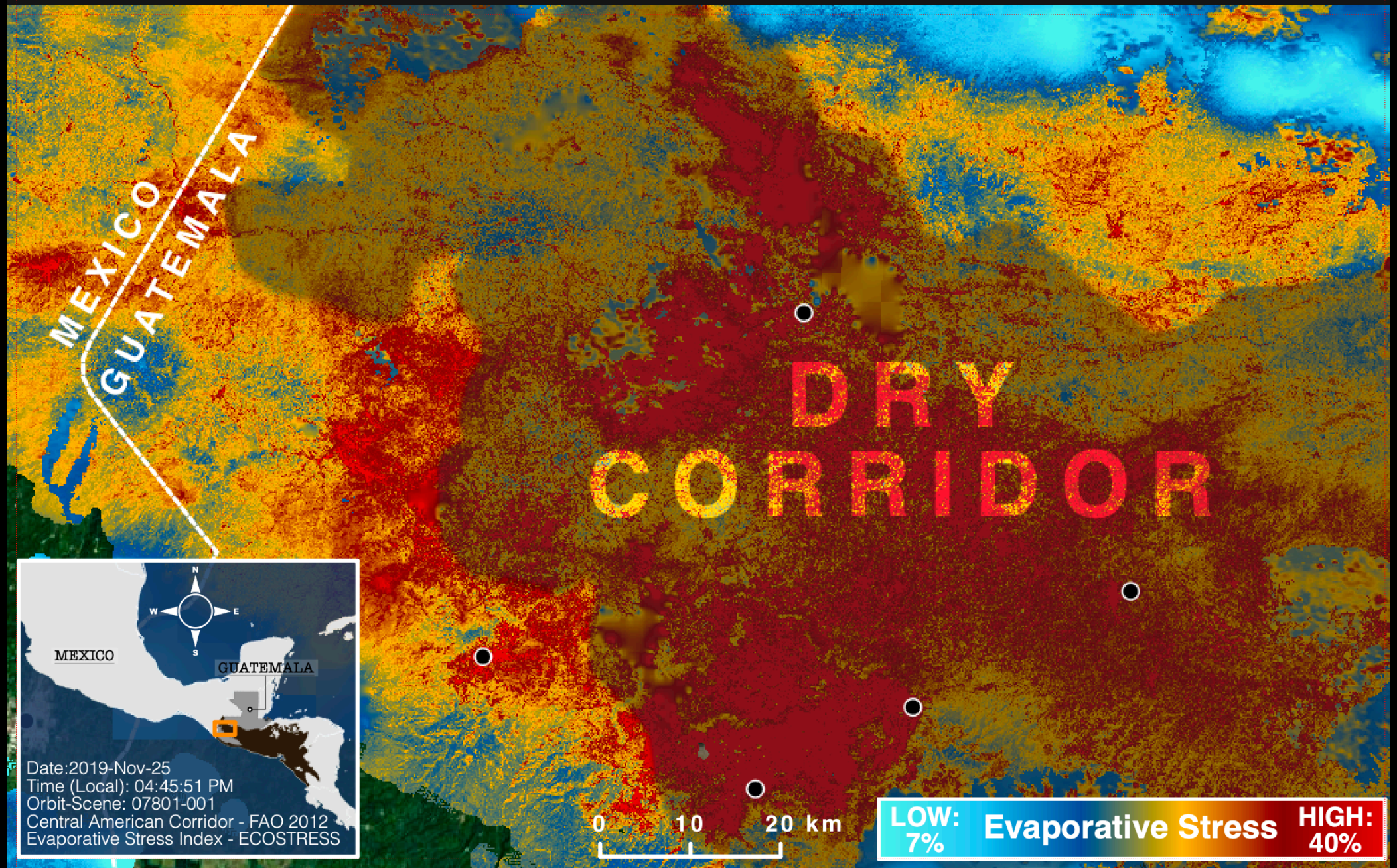

Capturing Water Use Efficiency in the Sahel
2019-06-09 ECOSTRESS Orbit 5248 Scene 4
0
g C kg-1 H20
> 0.05
Strong WUE gradient
detected by ECOSTRESS


Capturing Water Use Efficiency in the Namib
2019-06-05 ECOSTRESS Orbit 5184 Scene 11
< 0.4
g C kg-1 H20
> 0.7
Strong WUE gradient detected by ECOSTRESS
Etosha Pan

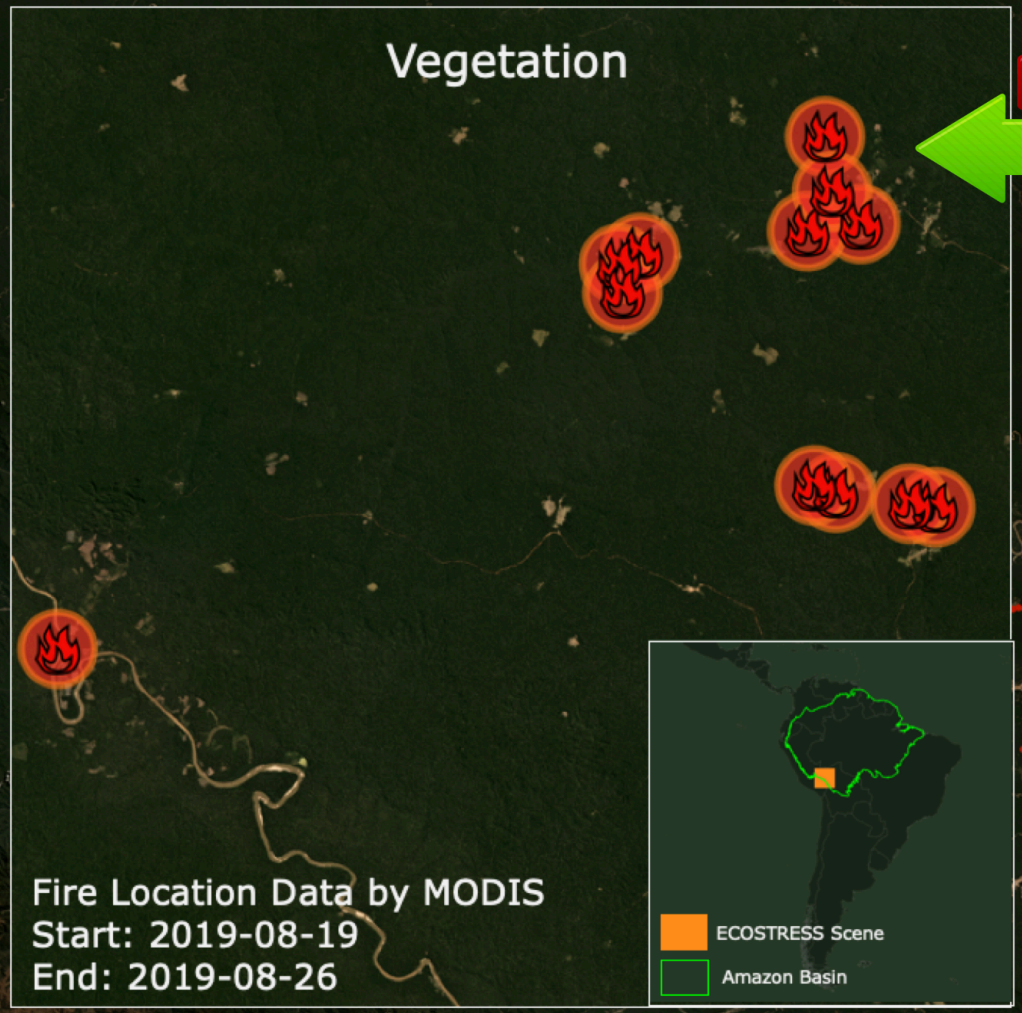

Capturing Water Use Efficiency in the Amazon
2018-07-21 ECOSTRESS Orbit 234 Scene 10
0
g C kg-1 H20
1.1
Strong WUE gradient detected by ECOSTRESS

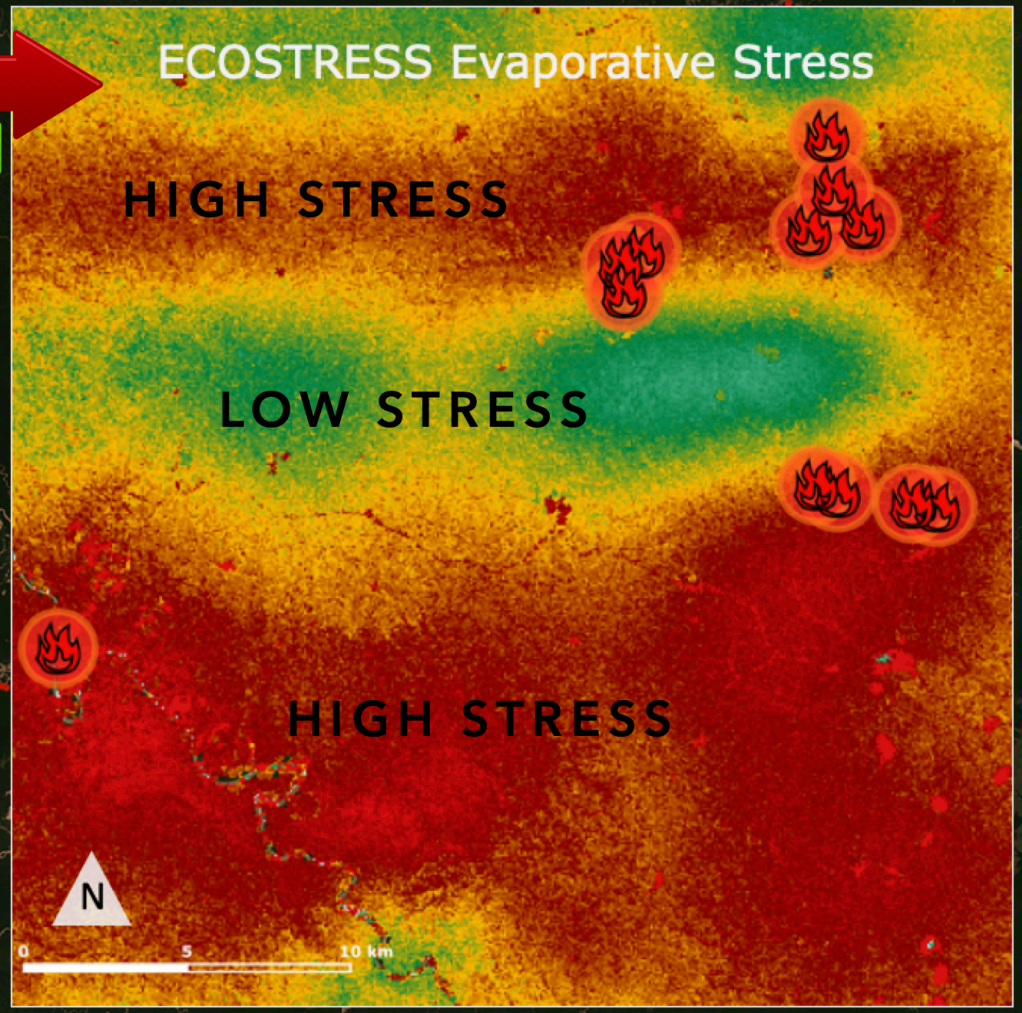

ECOSTRESS
Pacific Ocean
Liberia
Scene: 03485
Date: February 15, 2019
N
Low
0.93
Evaporative
Stress
High
0.64
0
5
10 km

The Expansion of the Central American Dry Corridor
as seen by ECOSTRESS



Amazon Rainforest Defends Itself Against Fires with Evapotranspiration

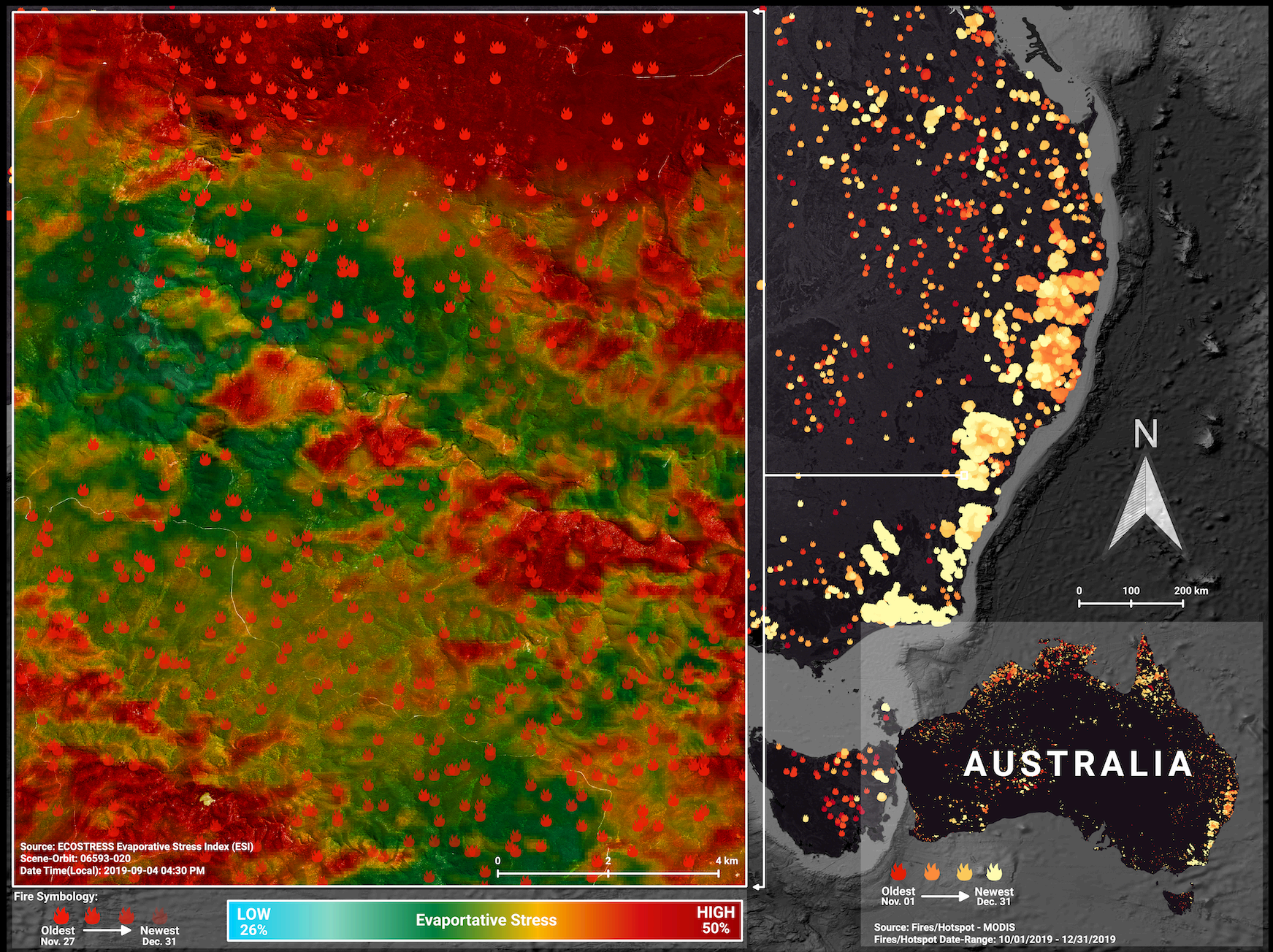


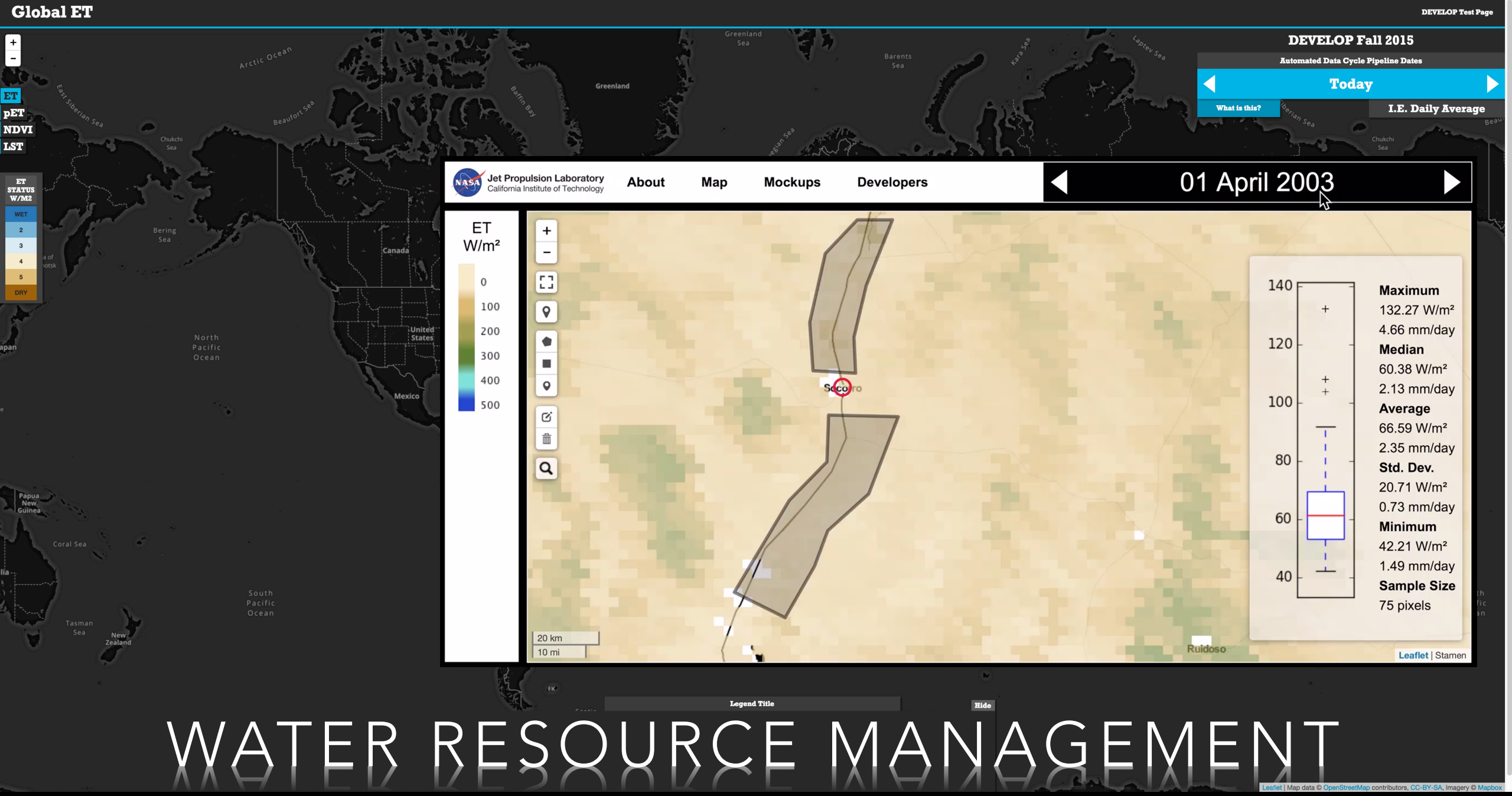


Orbit: 06165
Scene: 022
Date: 2019-08-07
Time: 13:55:26

Fuel for the Fires

ECOSTRESS shows Australian fires starting in high stress areas, but moving into low stress areas



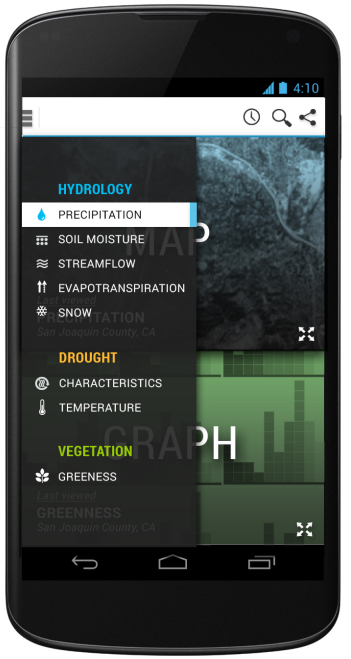


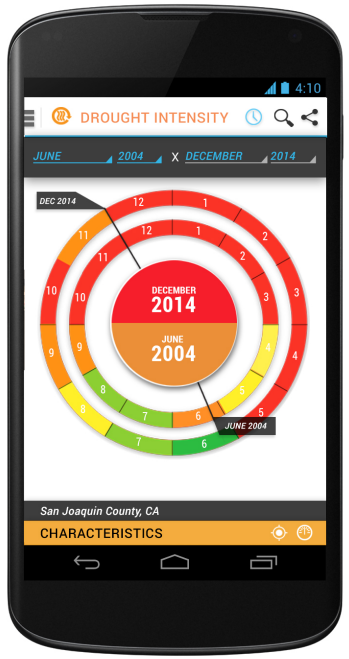
WATER RESOURCE MANAGEMENT

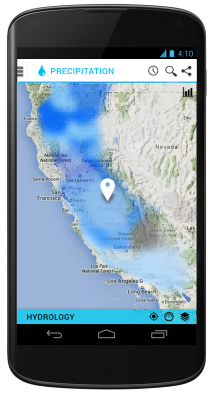
RHEAS DROUGHT MOBILE APPLICATION

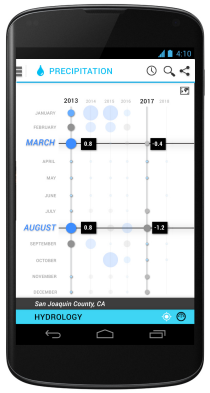
App Features:

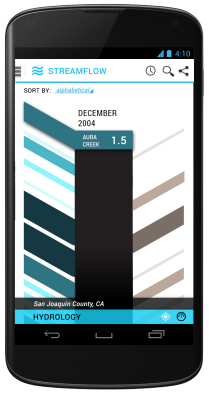
- Drought, hydrology, and vegetation products
- New and innovative visualization methods
- Current location enabled maps
- Form your own area of interest
- Location search
- Time and duration search
- Download and sharing of screenshots











THE FUTURE OF
EVAPOTRANSPIRATION
Global requirements for ecosystem functioning, carbon and climate feedbacks,
agricultural management, and water resources.