Under the High Patronage of His Majesty King Mohammed VI

International Water Resources Association
IWRA

XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco | 1 - 5 December 2025

Kingdom of Morocco
Ministry of Equipment and Water

Global Daily Evapotranspiration Estimation Using VIIRS and Atmosphere-Land Exchange Inverse Energy Balance Model

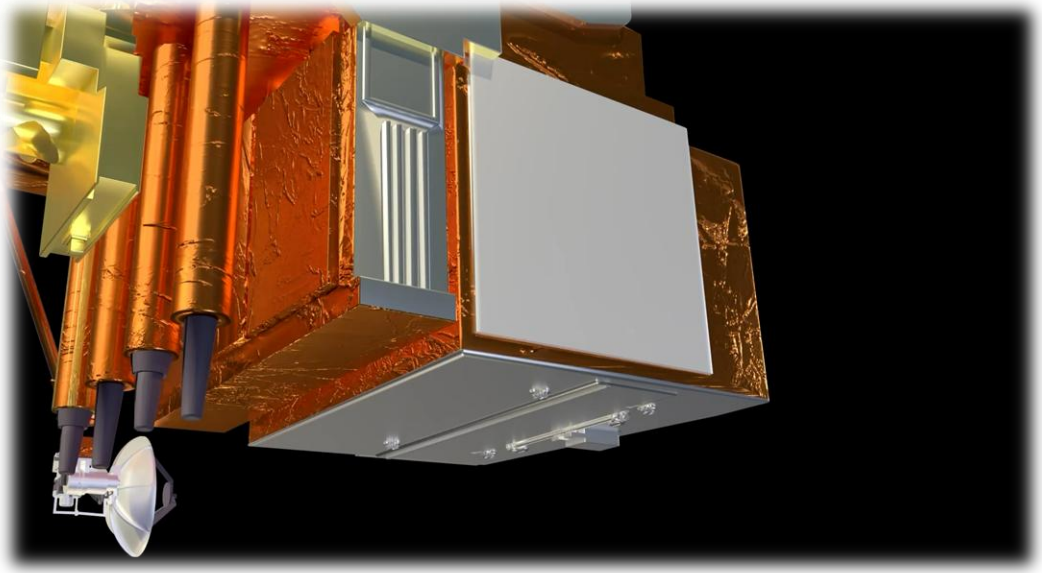
Sammy Z. Akasheh, Christopher M.U. Neale, Martha C. Anderson, Christopher R. Hain, Debora R. Roberti, Vanessa A. Souza, Andy E. Suyker and Mitchell A. Schull

THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE
at the University of Nebraska

Why VIIRS*?

- Higher Resolution “thermal band” (375m) compared to other Polar Orbiting Satellites like MODIS and the geostationary GOES.
- Highter temporal resolution than Landsat (every 16th day).
- MODIS is retiring soon due to declining fuel reserves.
- Offers Day/Night Brightness Temperature, Band I5, needed for ALEXI model.
- VIIRS has improved band-to-band registration

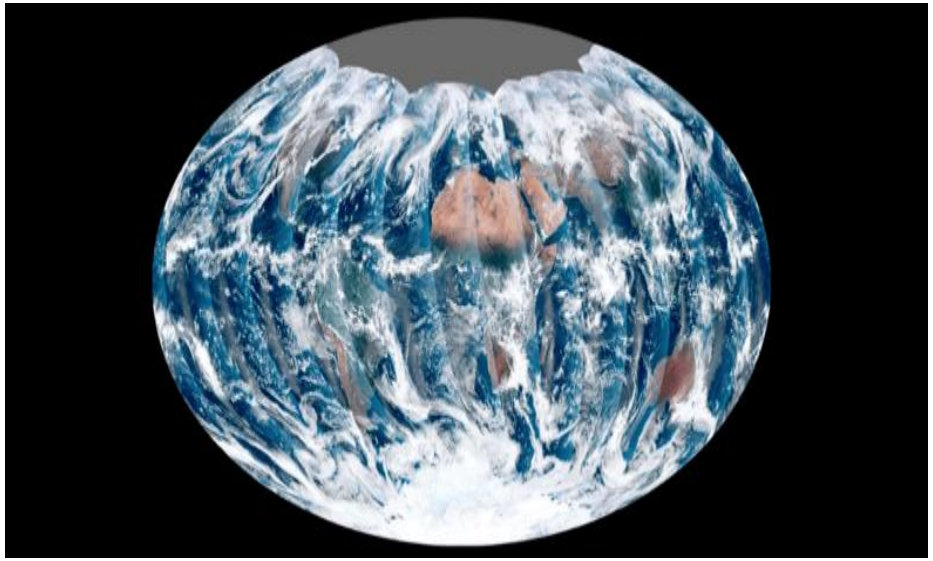
*Visible Infrared Imaging Radiometer Suite



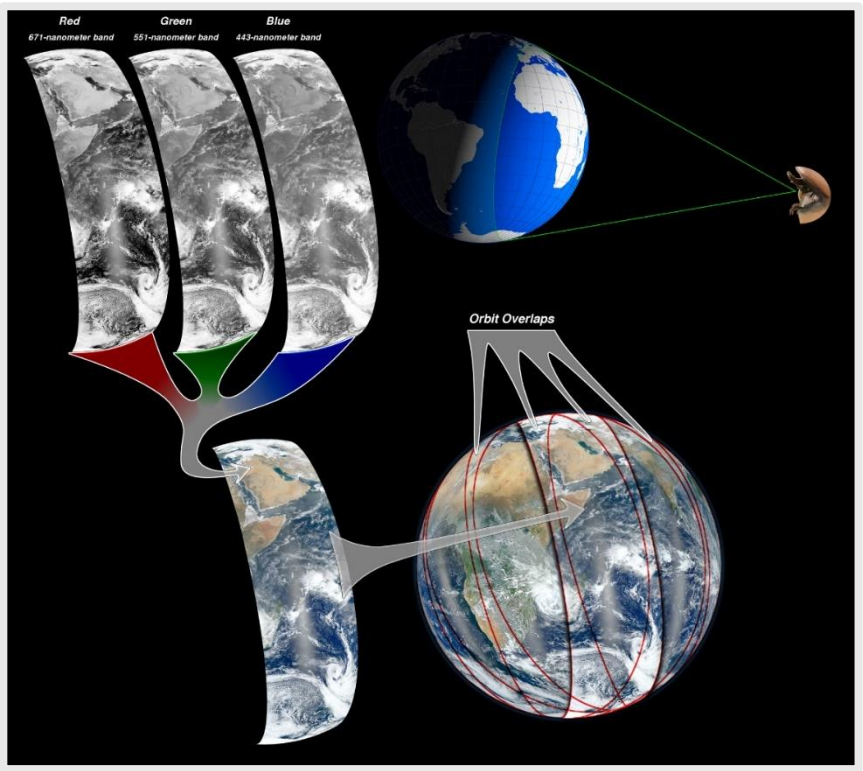
* From National Environmental Satellite, Data, and Information Servi (NESDIS) website

VIIRS

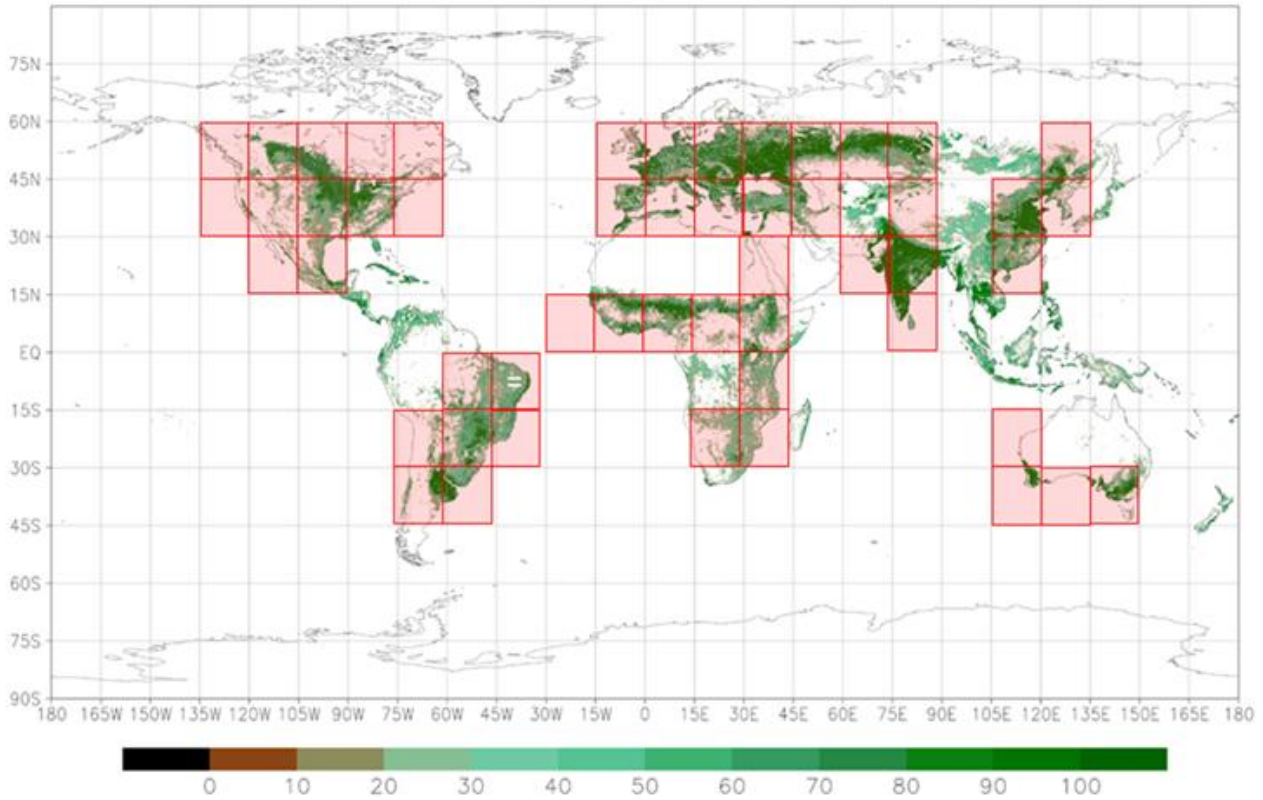
- VIIRS SWATH daytime coverage of the Globe (3040 km wide)



*Source: NASA website

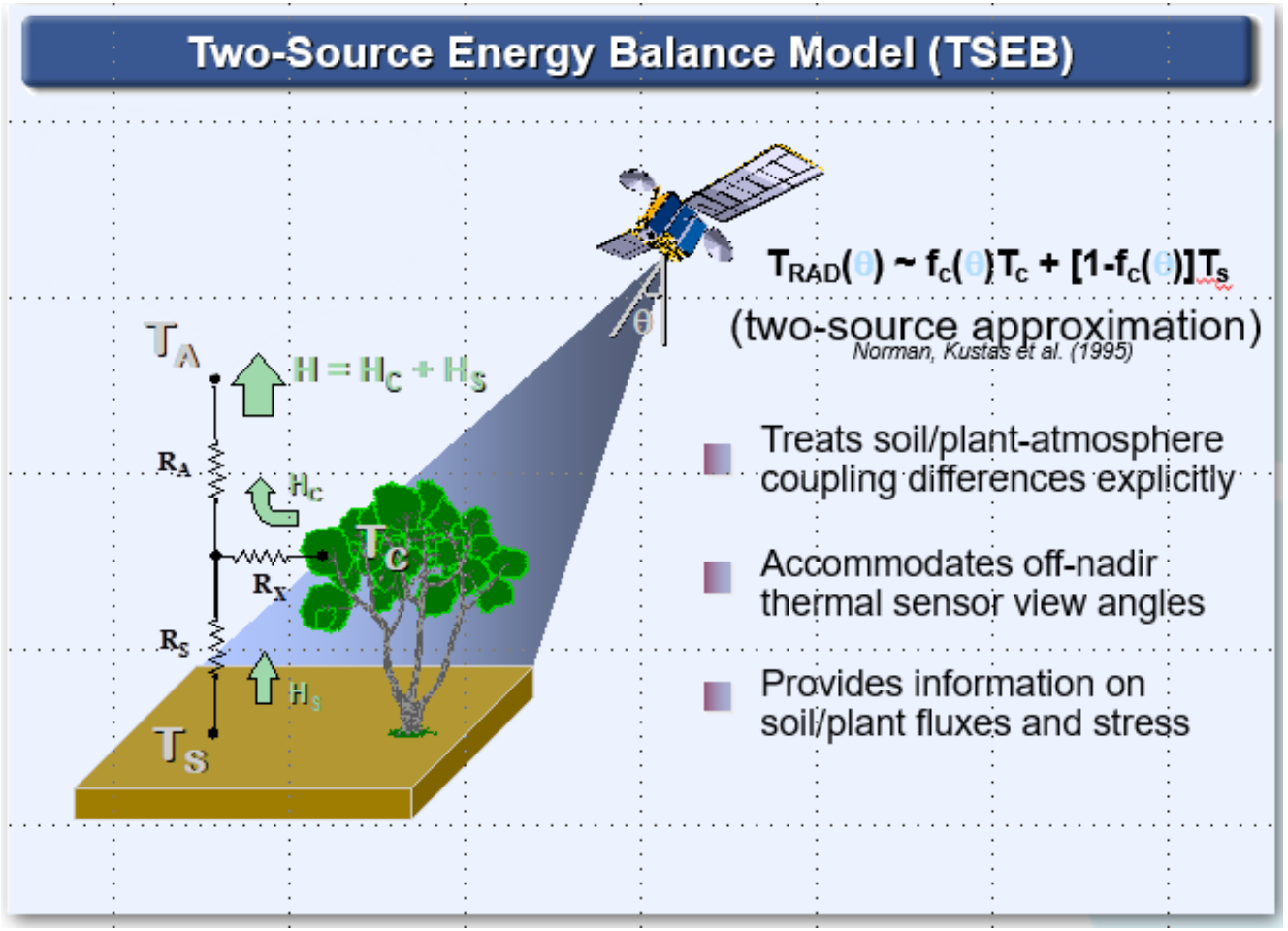


VIIRS processing



15 x 15-degree processing tiles (375-m) VIIRS ET Product for major food producing areas of the world

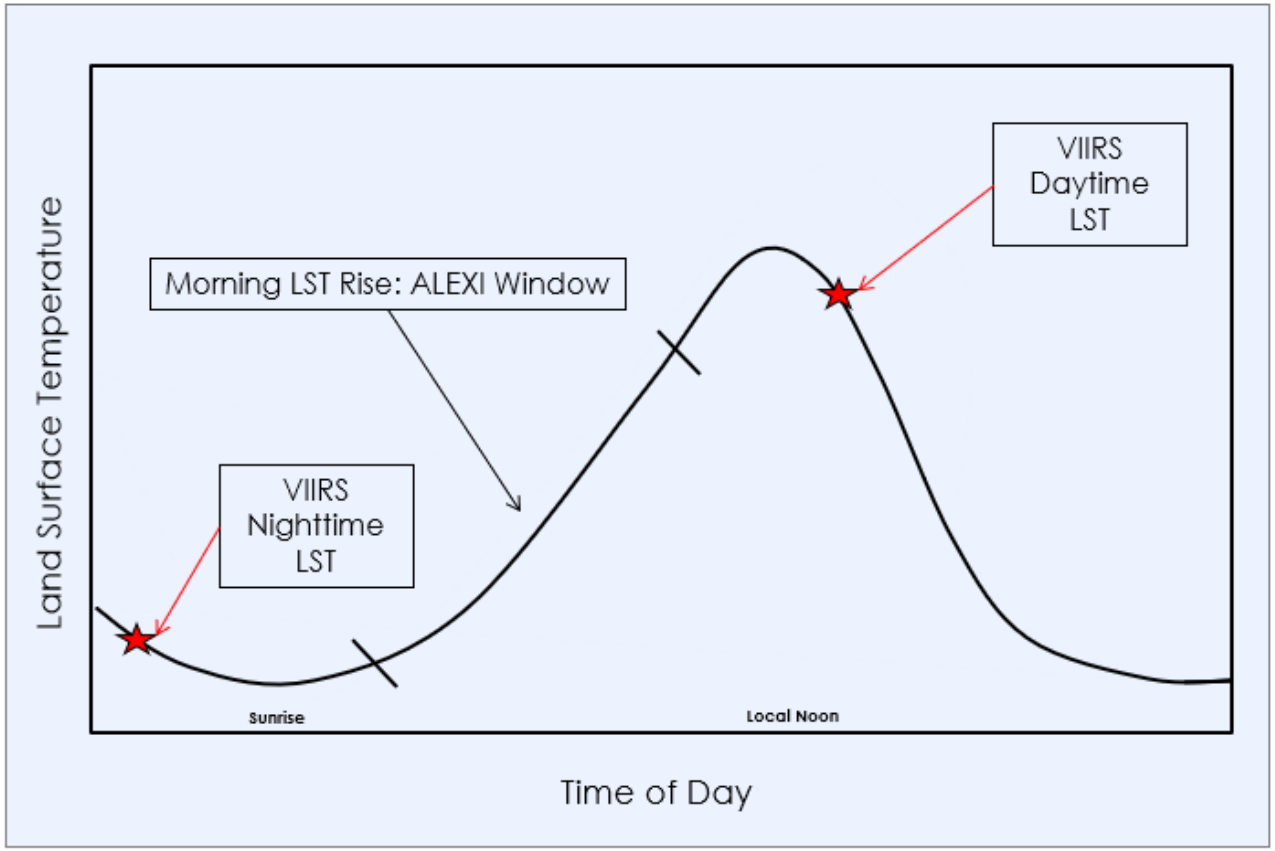
The Atmosphere-Land Exchange Inverse Model (ALEXI)



ALEXI Land Surface Temperature Rise

Making it possible to use Polar-Orbiting Sensors

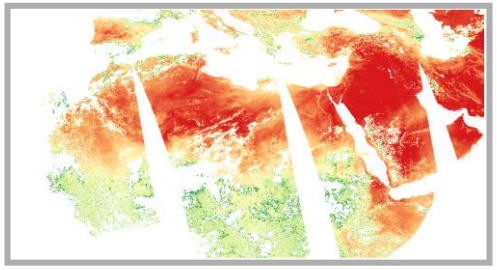
- A regression model was developed from GOES (Temporal Res~ 5-15 min) day-night LST differences. The regression model can provide reasonable estimates of the mid-morning rise in LST (RMSE ~ 5 to 8%) from the twice daily VIIRS LST observations.



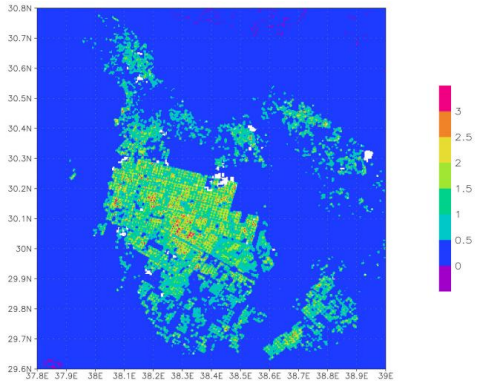
Input Data Needed to Develop a High-Resolution (375-m) ALEXI/VIIRS ET Product

Daily ET - Input Data

1. Clear Sky Land Surface Temperature-VIIRS I5 BT band.

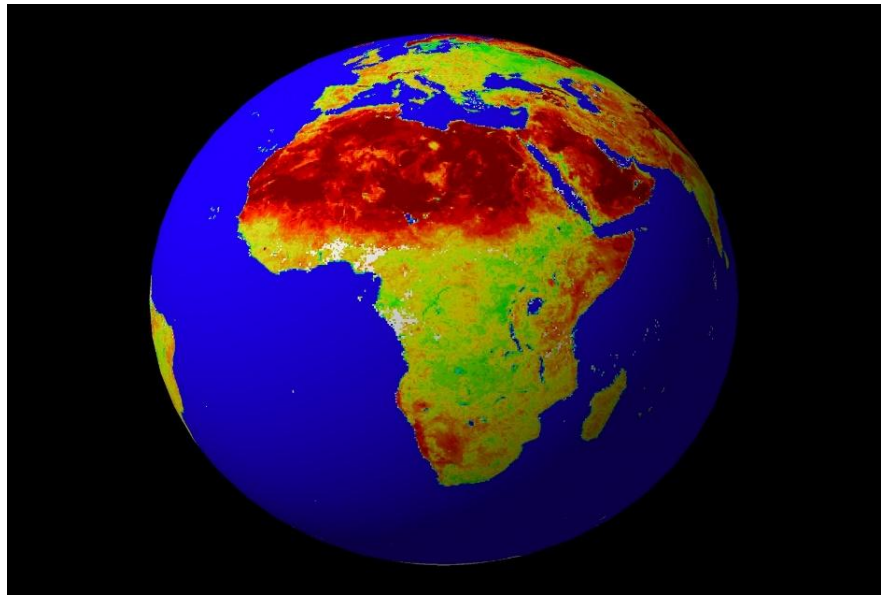


2. Leaf Area Index & Fraction of Vegetation-VIIRS Visible bands.



Cont.. Daily ET - Input Data

3. Land Surface Albedo
   - Only available VIIRS product is at 750-m – mapped to 375-m grid – used to calculate surface reflectivity in VIS/NIR spectrum as needed by ALEXI.

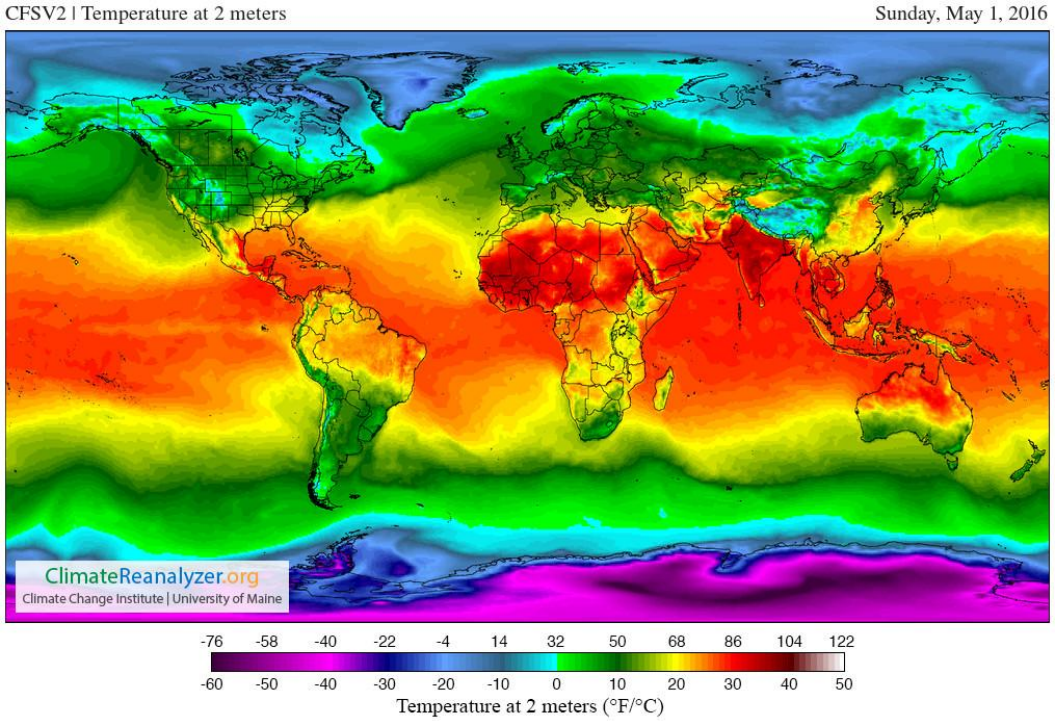


Cont.. Daily ET - Input Data

4. Climate Forecast System Reanalysis (CFSR, hourly; 0.50º)*

- Provides atmospheric correction-meteorological Surface Fields (e.g., air temperature; wind speed; surface atm pressure; incoming LW, incoming SW insol)

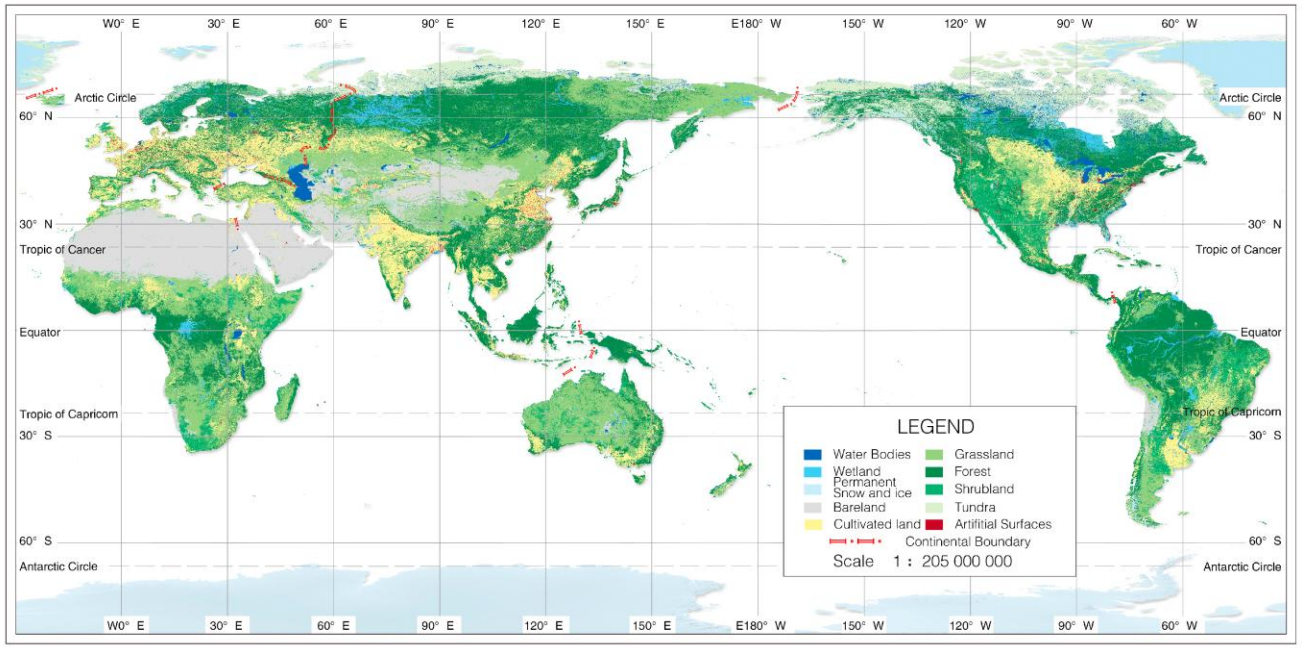
*From National Centers for Environmental Information (NCEI)



Cont.. Daily ET - Input Data

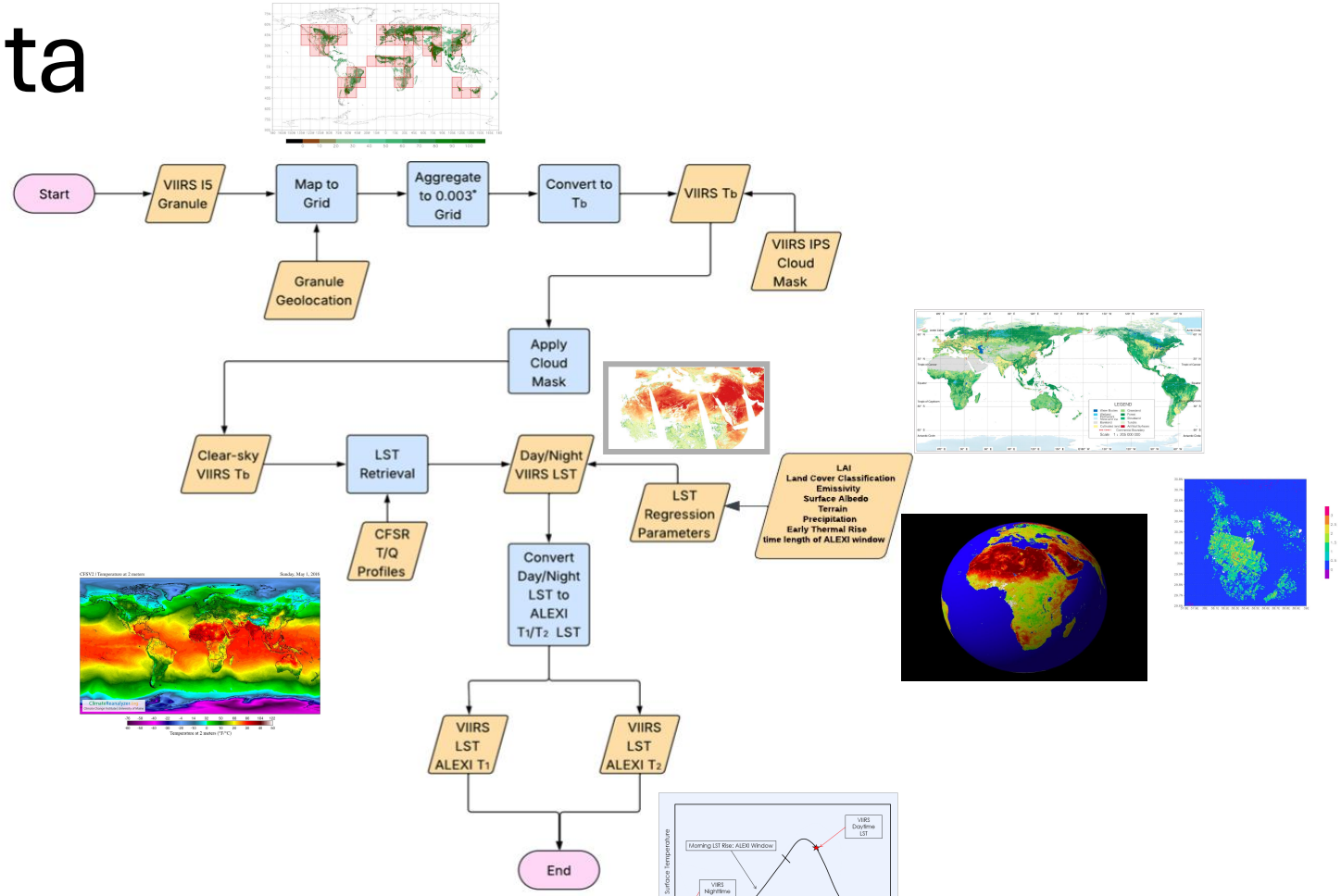
5. Landcover / Vegetation Type

NLCD a Landsat product or GlobeLand30



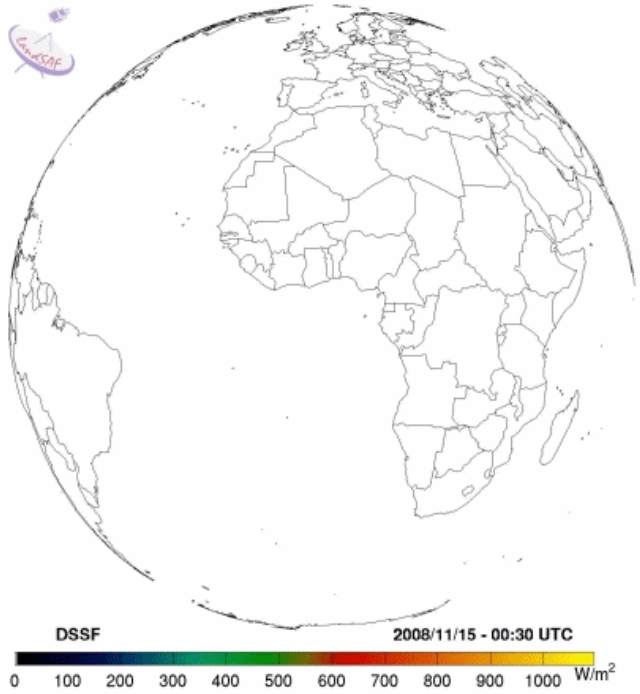
*GlobeLand30

Input Data

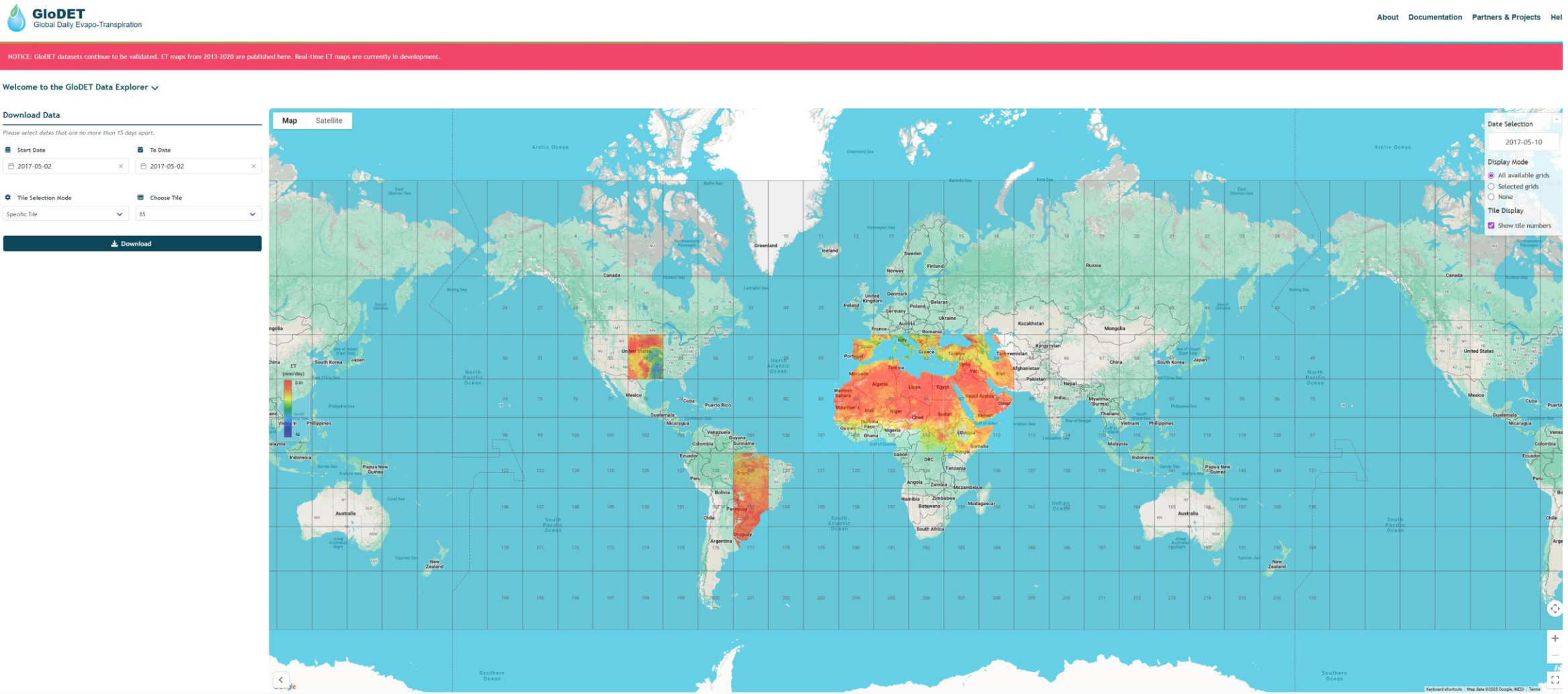

Start
VIIRS I5 Granule
Map to Grid
Aggregate to 0.003° Grid
Convert to Tb
VIIRS Tb
VIIRS IPS Cloud Mask
Granule Geolocation
Apply Cloud Mask
Clear-sky VIIRS Tb
LST Retrieval
Day/Night VIIRS LST
LST Regression Parameters
LAI
Land Cover Classification
Emissivity
Surface Albedo
Terrain
Precipitation
Early Thermal Rise
time length of ALEXI window
CFSR T/Q Profiles
Convert Day/Night LST to ALEXI T1/T2 LST
VIIRS LST ALEXI T1
VIIRS LST ALEXI T2
End
Morning LST Rise: ALEXI Window
VIIRS Nighttime LST
VIIRS Daytime LST
Land Surface Temperature
Time of Day

Cont.. Daily ET - Input Data

6. Incoming Solar Radiation
   - GOES-GSIP data
   - SARAH
   - Meteosat (3-km) / will use CFS-4 daily insolation for scaling to daily fluxes as back-up data source monthly-annual time scales



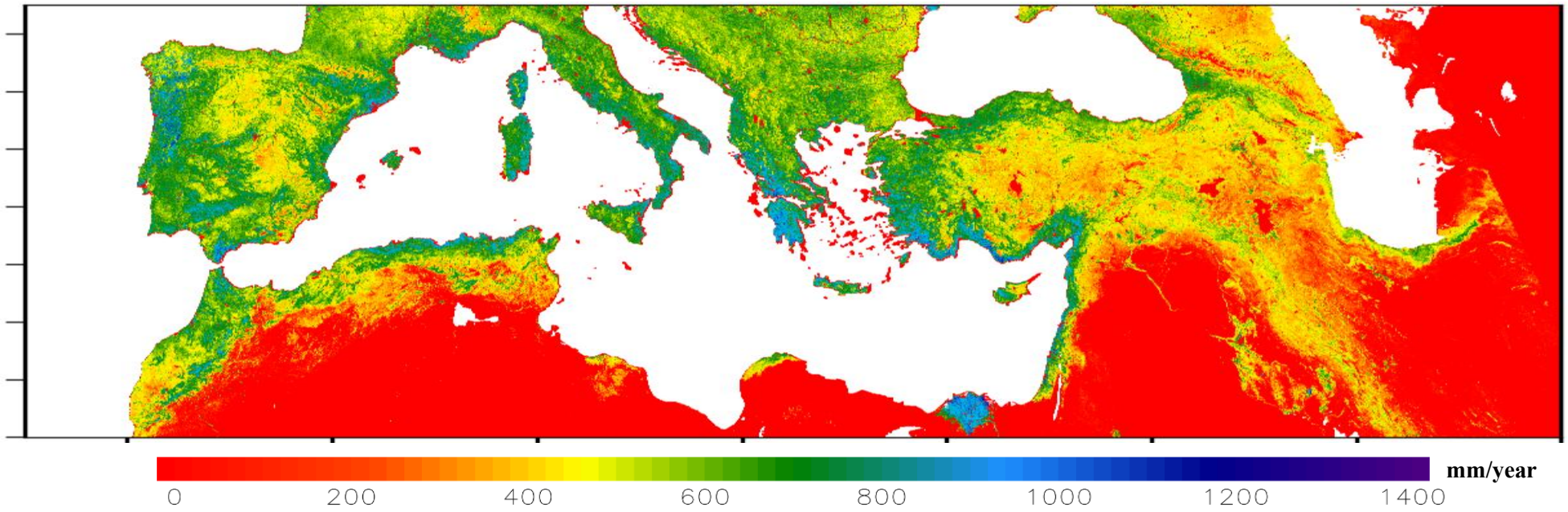
https://glodet.nebraska.edu



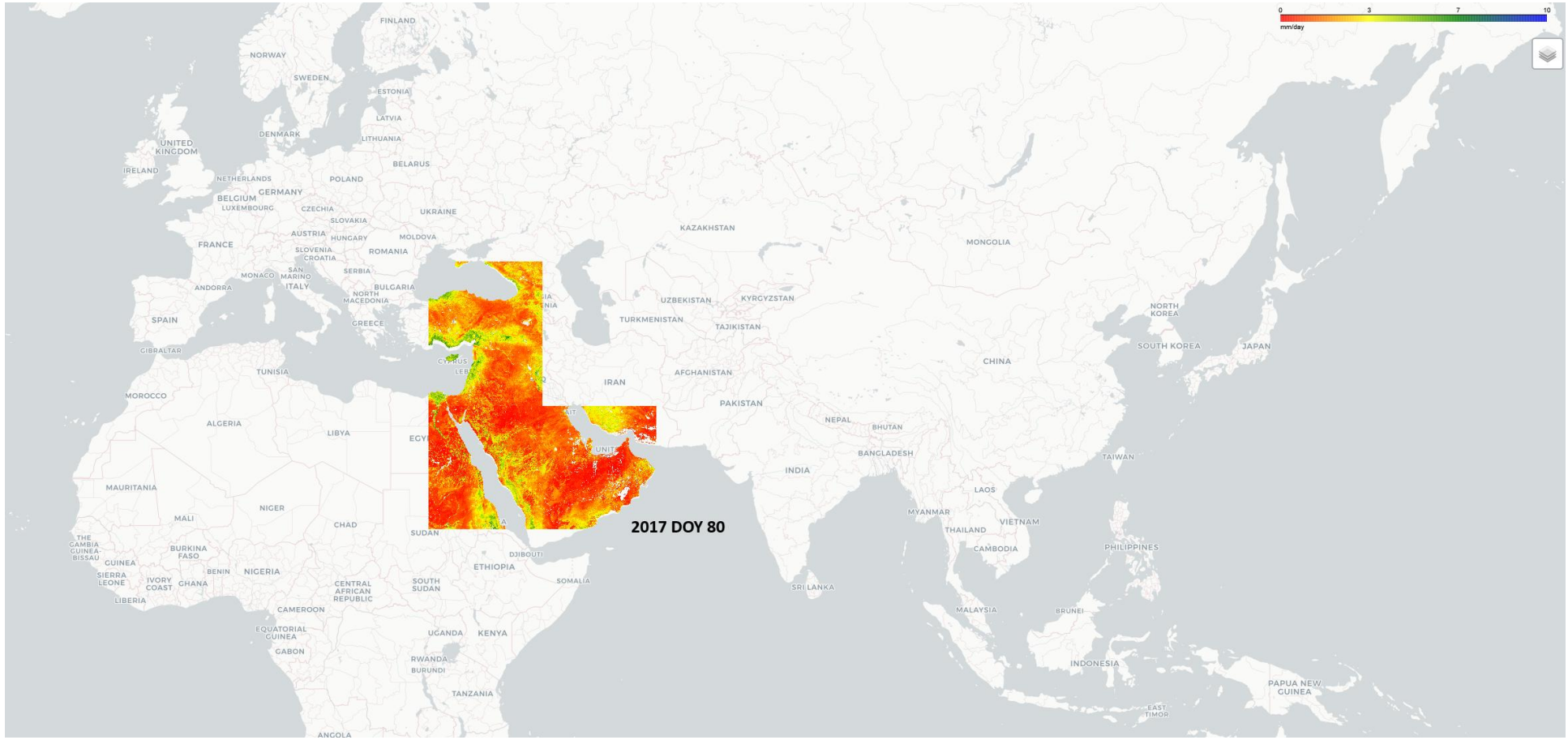
THE DAUGHERTY WATER for FOOD GLOBAL INSTITUTE at the University of Nebraska

Seasonal ET – Example

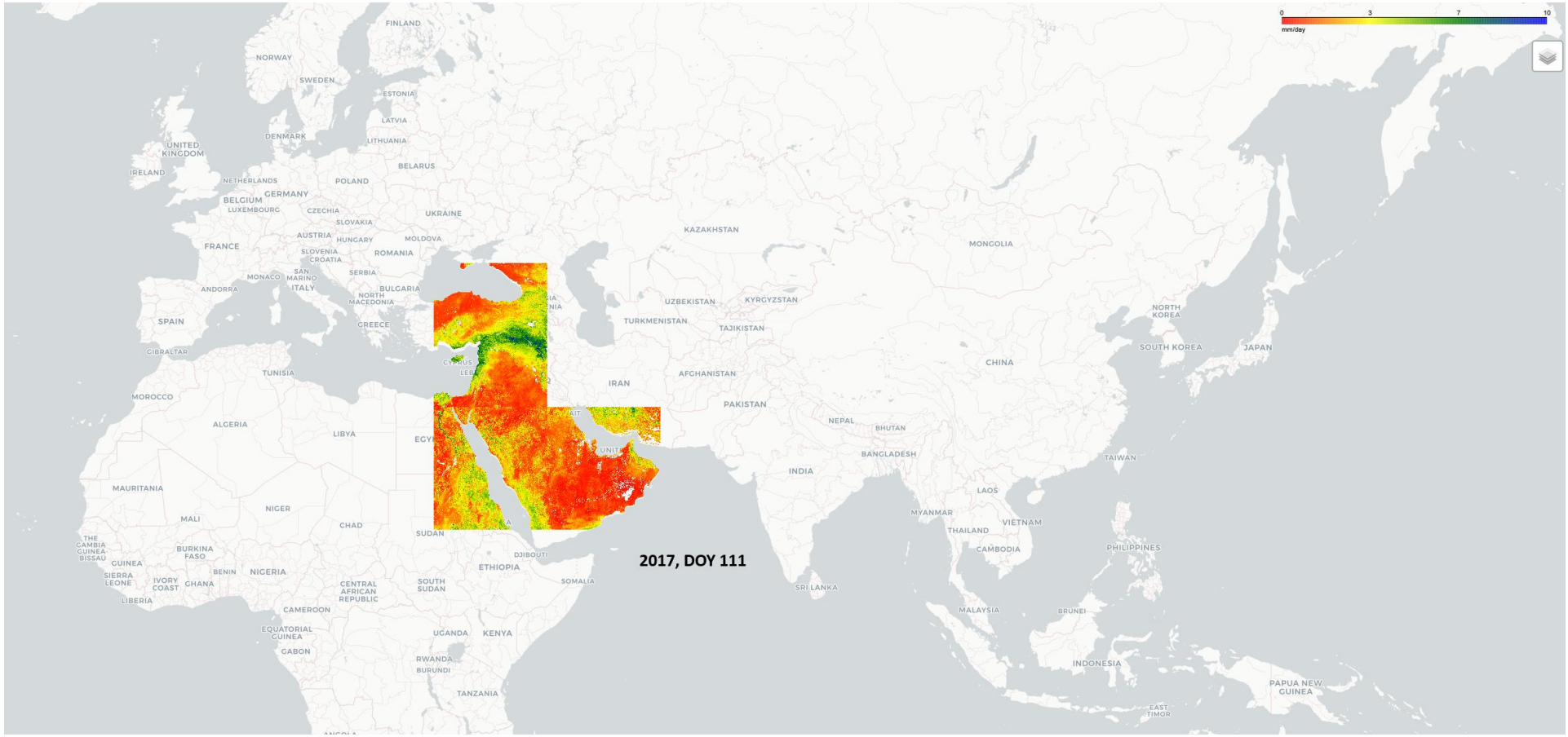
- Annual ET estimated from integrating daily values for 2018



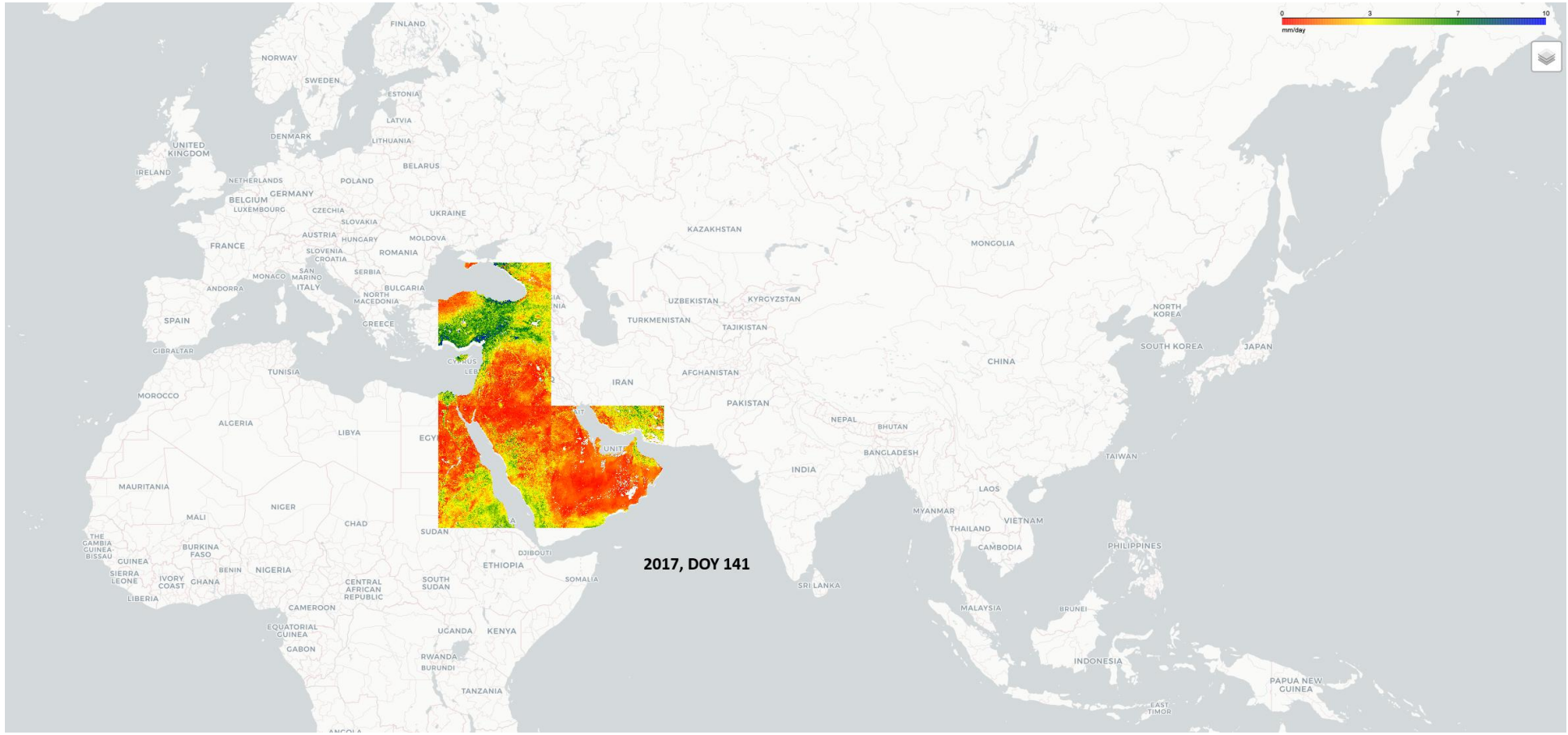
Daily ET – Example



Daily ET – Example

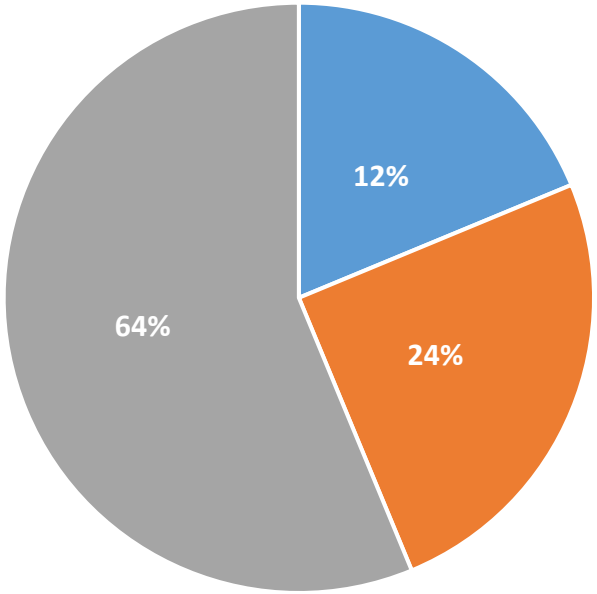


Daily ET – Example

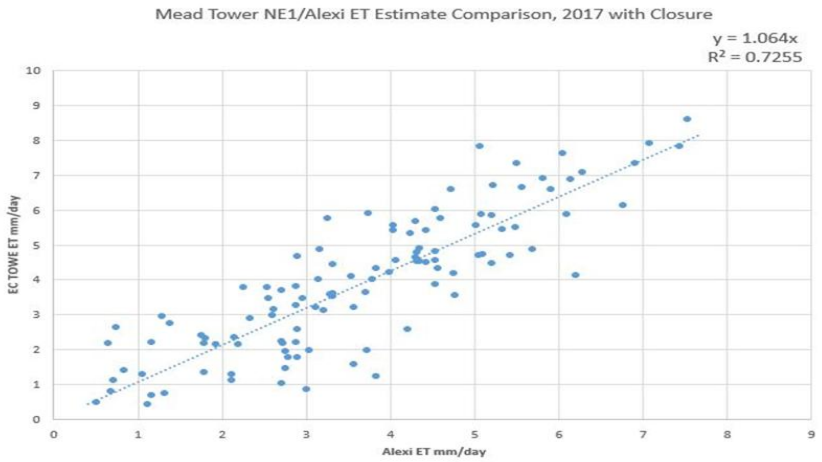


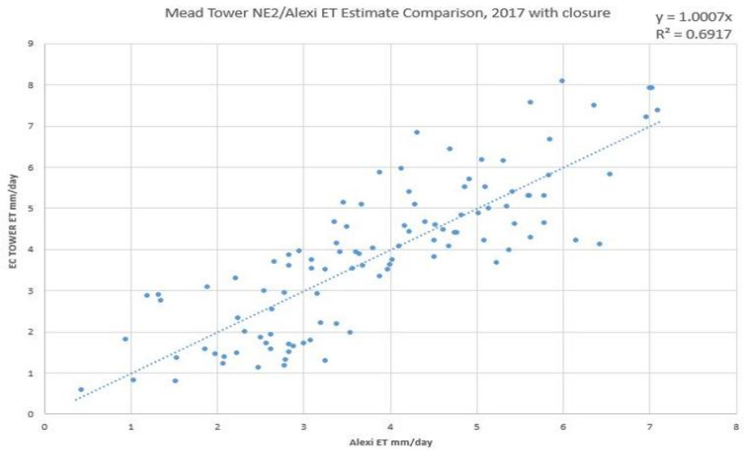
GloDET – Outcomes & Impacts

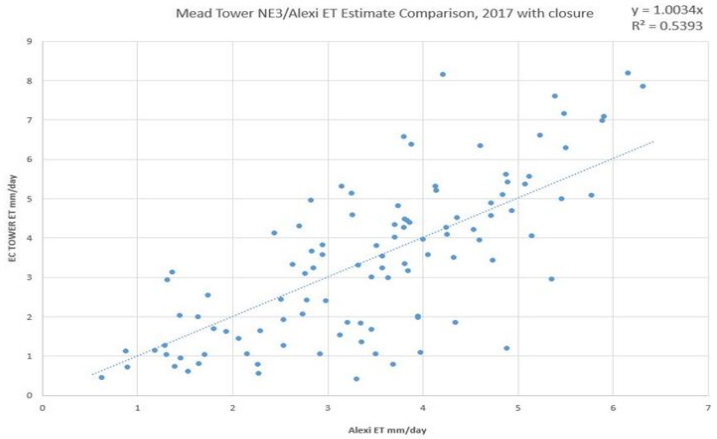
- ET maps published online.
  - From 2013-2018 NENA region.
  - From 2013-2024 Brazil -T129, T130, T153 and T177.
  - From 2014-2024 CONUS- T054.
- More than 300 registered users to date from more than 20 countries.



GloDET – Validation ALEXI VIIRS ET Values @375 m, Tile 54, Carbon Sequestration Ameriflux Site, Mead NE also on Parallel 41 Flux Network

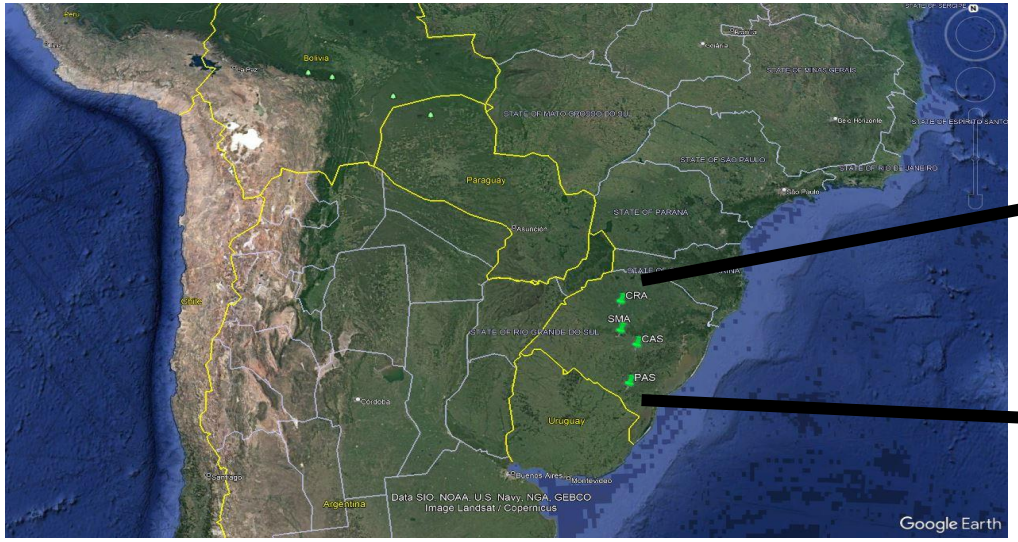


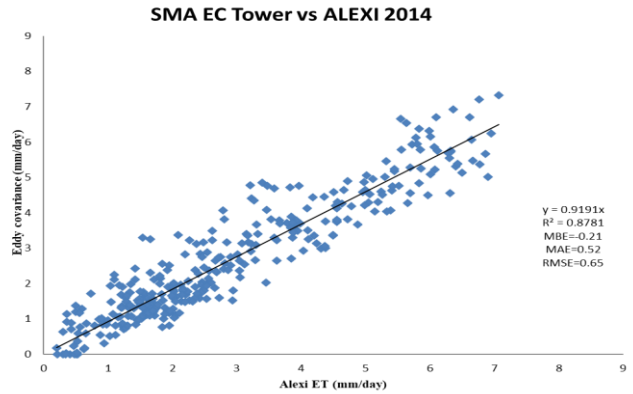


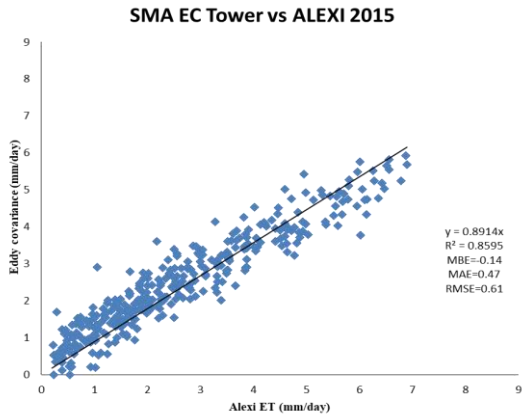


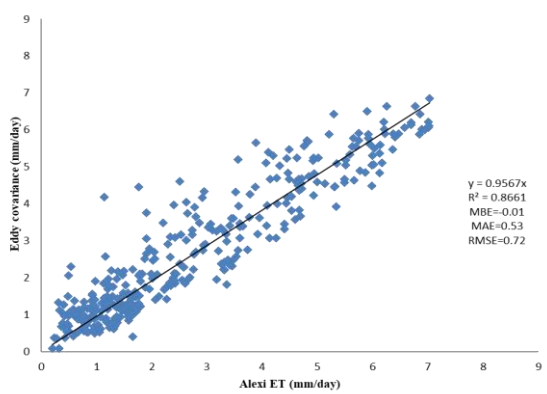
NE1 Continuous maize crop: RMSE= 1.09, MAE=0.87;
NE2 Soybean/Maize rotation with Maize:
RMSE= 1.0, MAE=0.81
NE3 Rainfed Soybean/Maize rotation with Maize:
RMSE= 1.34, MAE=1.03.

GloDET – Validation







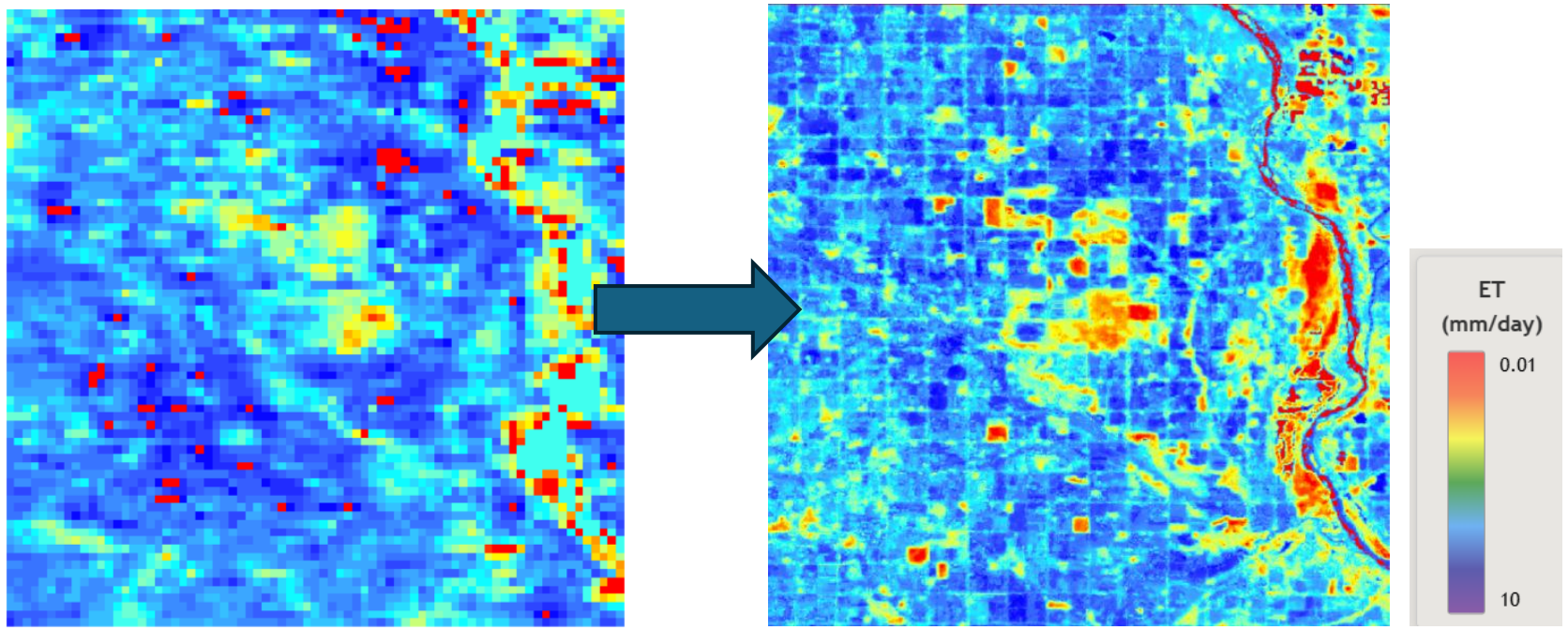


Natural Grass

Daily ET - PyDisALEXI

375-m Res

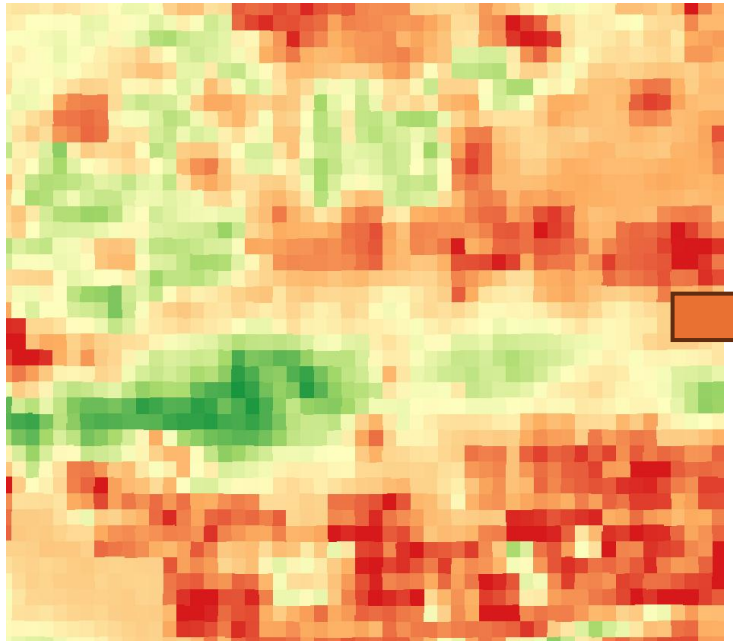
30-m Res



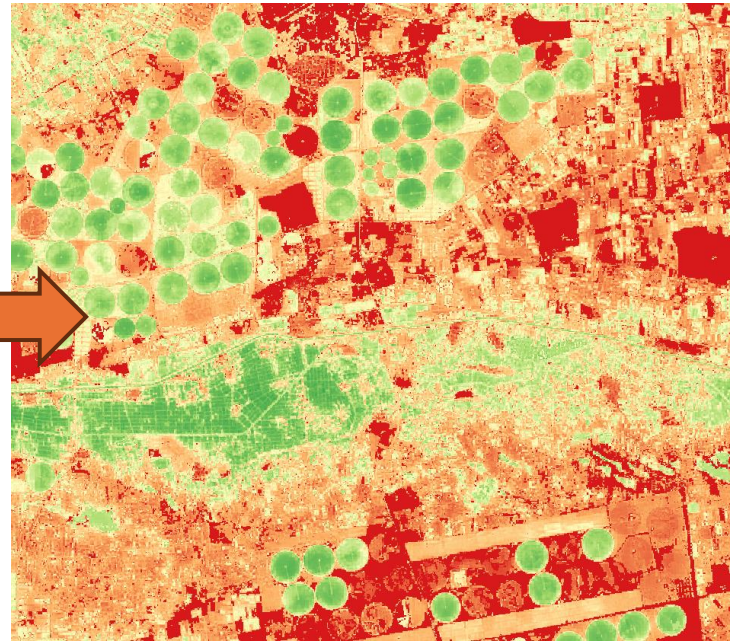
Downscaled Daily ET (mm/day) - Mead area using PyDisALEXI and Landsat 8, July 27, 2021.

ET - PyDisALEXI

- In Nile Delta
  - VIIRS daily ET (mm/day)



Daily ET calculated at VIIRS 375 m using the ALEXI model.

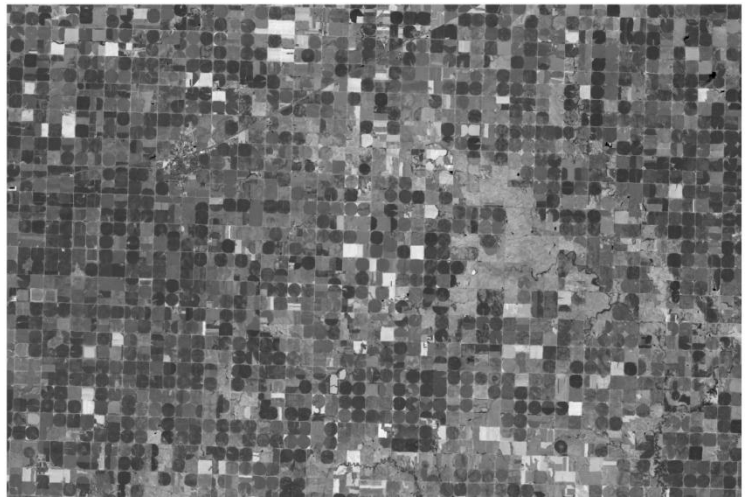


Daily ET downscaled from ALEXI using the **PyDisALEXI** model and Landsat Imagery.

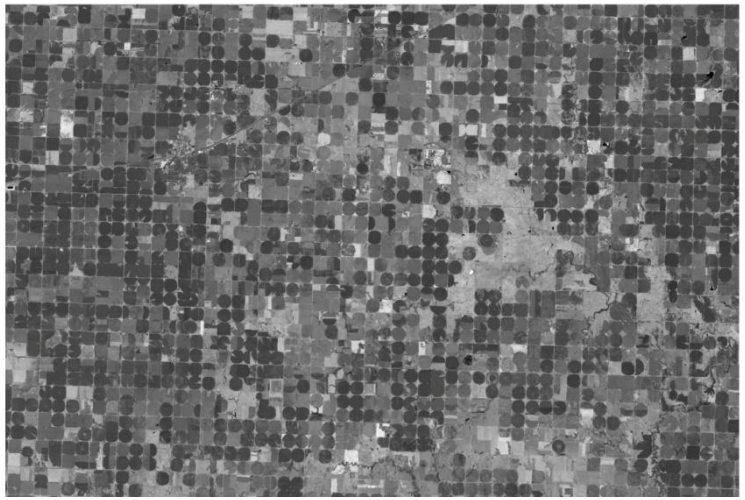
STARFM

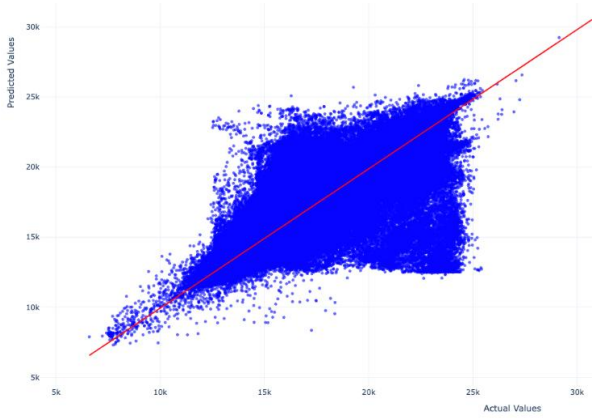
- Spatial and Temporal Adaptive Reflectance Fusion Model

Actual image



STARFM predicted image





Date: 09/18/2023, Band: B6 (SWIR1)
$y = 0.994 * x$
$r^2 = 0.7$
Peak signal to Noise Ratio (PSNR)= 30.9 dB

GloDET Applications

- Agricultural Water Management
- Water Resources Management
- Climate and Drought Monitoring
- Ecosystem and Land Surface Studies
- Disaster Risk and Wildfire Assessment
- Human Health related studies
- Satellite Mission Support and Validation

Conclusions

- The ALEXI-VIIRS model demonstrates strong performance across multiple sites in Brazil and the CONUS at its native resolution.
- Significant progress has been made toward spatial and temporal downscaling using PyDisALEXI and STARFM.
- Daily Global ET maps for MENA, CONUS and Brazil are being published @ https://glodet.nebraska.edu

Under the High Patronage of His Majesty King Mohammed VI

XIX WORLD WATER CONGRESS
International Water Resources Association (IWRA)
Marrakech, Morocco | 1-5 December 2025

Thank you!

Email: sakasheh@nebraska.edu
https://glodet.nebraska.edu/

www.worldwatercongress.com

International Water Resources Association
IWRA

WWCongress | wwcongress | worldwatercongress

Kingdom of Morocco
Ministry of Equipment and Water