An Evapotranspiration Data Product from NOAA GOES-16 and 17

S. Kalluri[1], L. Fang[1], **M. Schull[1]**, X. Zhan[1], C. Hain[2], M. Anderson[3]

[1] NOAA NESDIS Center for Satellite Applications and Research,
[2] NASA MSFC Earth Science Branch
[3] USDA ARS Hydrology and Remote Sensing Lab

OUTLINE

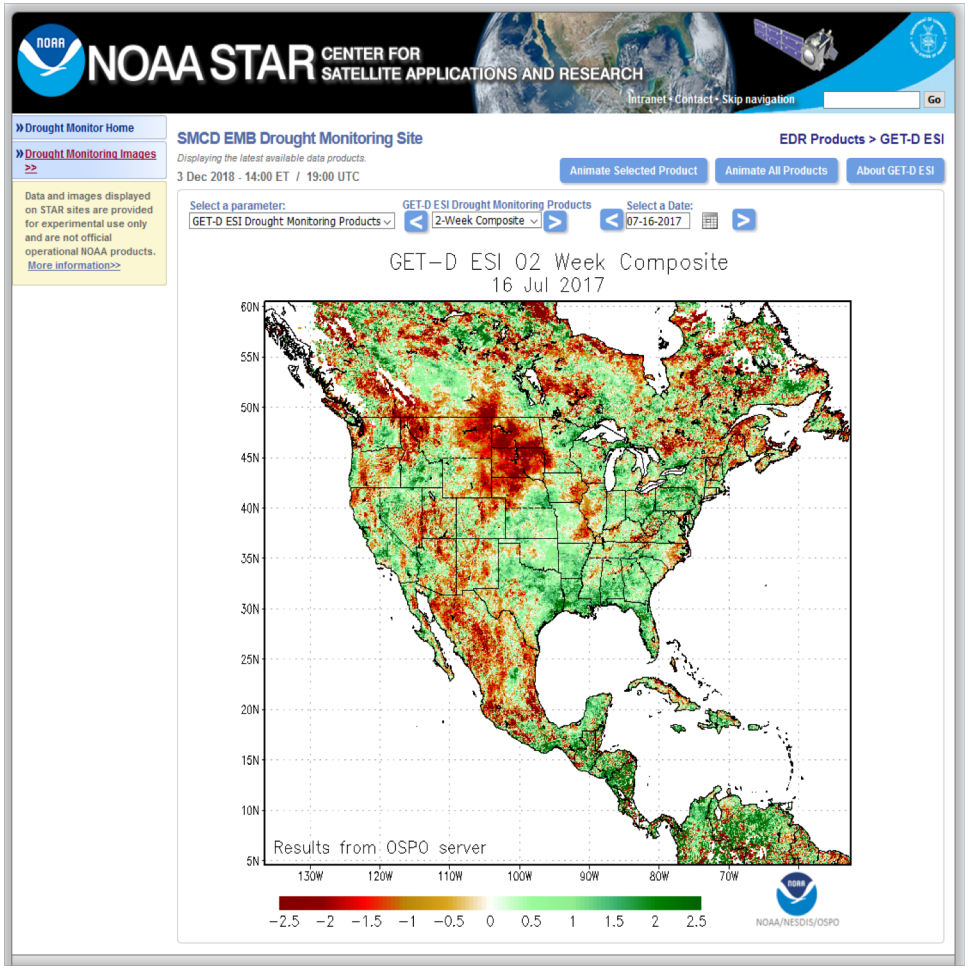
- ABI on GOES-16/17 vs Heritage
- NESDIS GET-D Product System
- ET from GET-D Update with GOES-16/17
- Summary and Next Steps

Advanced Baseline Imager (ABI) on GOES-16/17 vs its Heritage

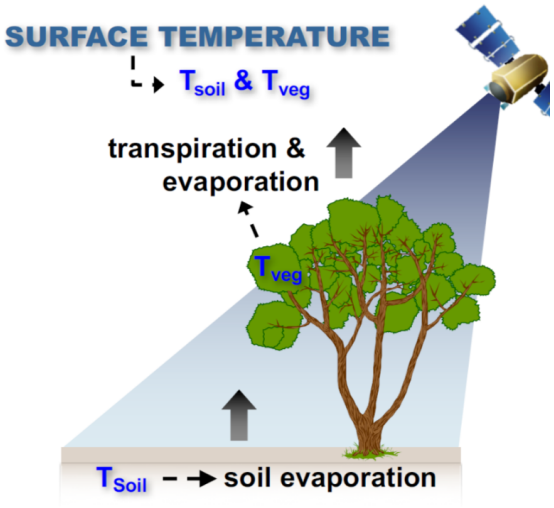
	ABI	IMAGER
Spectral Bands	16	5
Spatial Resolution	0.65 μm visible - 0.5 km Other visible/NIR - 1 km Bands (> 2 μm) – 2 km	~1 km NA ~4 km
Temporal Resolution	Full Disk - 15 min. CONUS – 5 min. Mesoscale – 0.5 min.	Scheduled 3 hrs ~15 min. NA

NESDIS GOES Evapotranspiration and Drought Product System (GET-D)

- Regional daily ET at 8km has been generated from GOES-13 and GOES-15 thermal infrared (TIR) data via GET-D using the Atmosphere-Land Exchange Inversion (ALEXI) model
- Daily ET is converted to Evaporative Stress Index (ESI) that represents soil moisture status
- Negative ESI is used to monitor drought early warning and occurrence



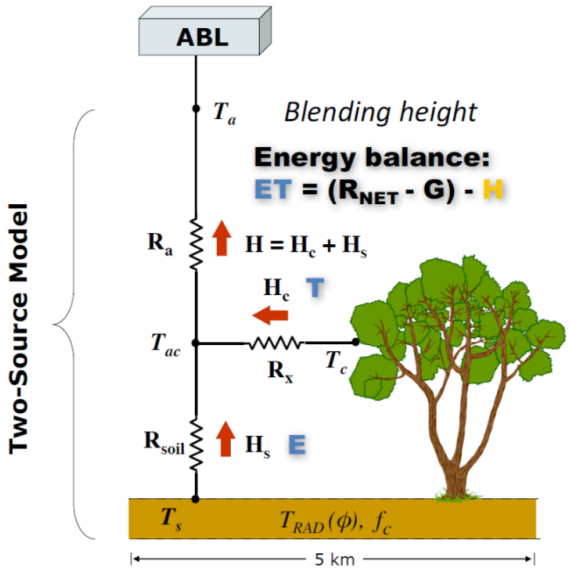
Atmosphere-Land Exchange Inversion model (ALEXI)



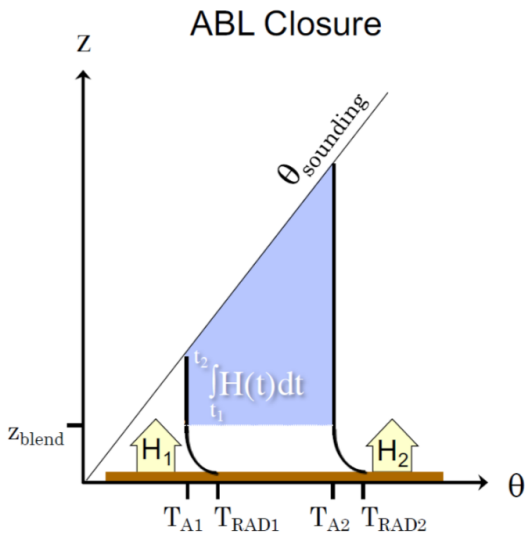
Given known radiative energy inputs, how much water loss is required to keep the soil and vegetation at the observed temperatures?

ENERGY BALANCE APPROACH
(diagnostic modeling)

From Martha Anderson



ALEXI
(Atmosphere-Land Exchange Inverse model)

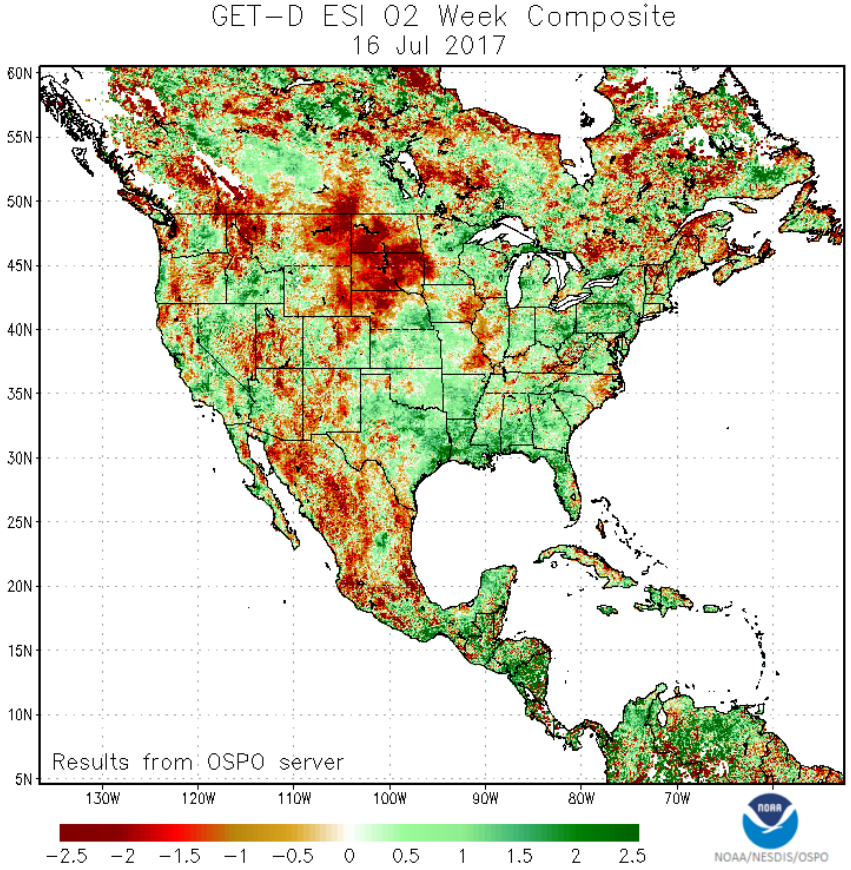


Regional scale

Surface temp: ΔT_{RAD} - Geostationary
Air temp: T_a - ABL model

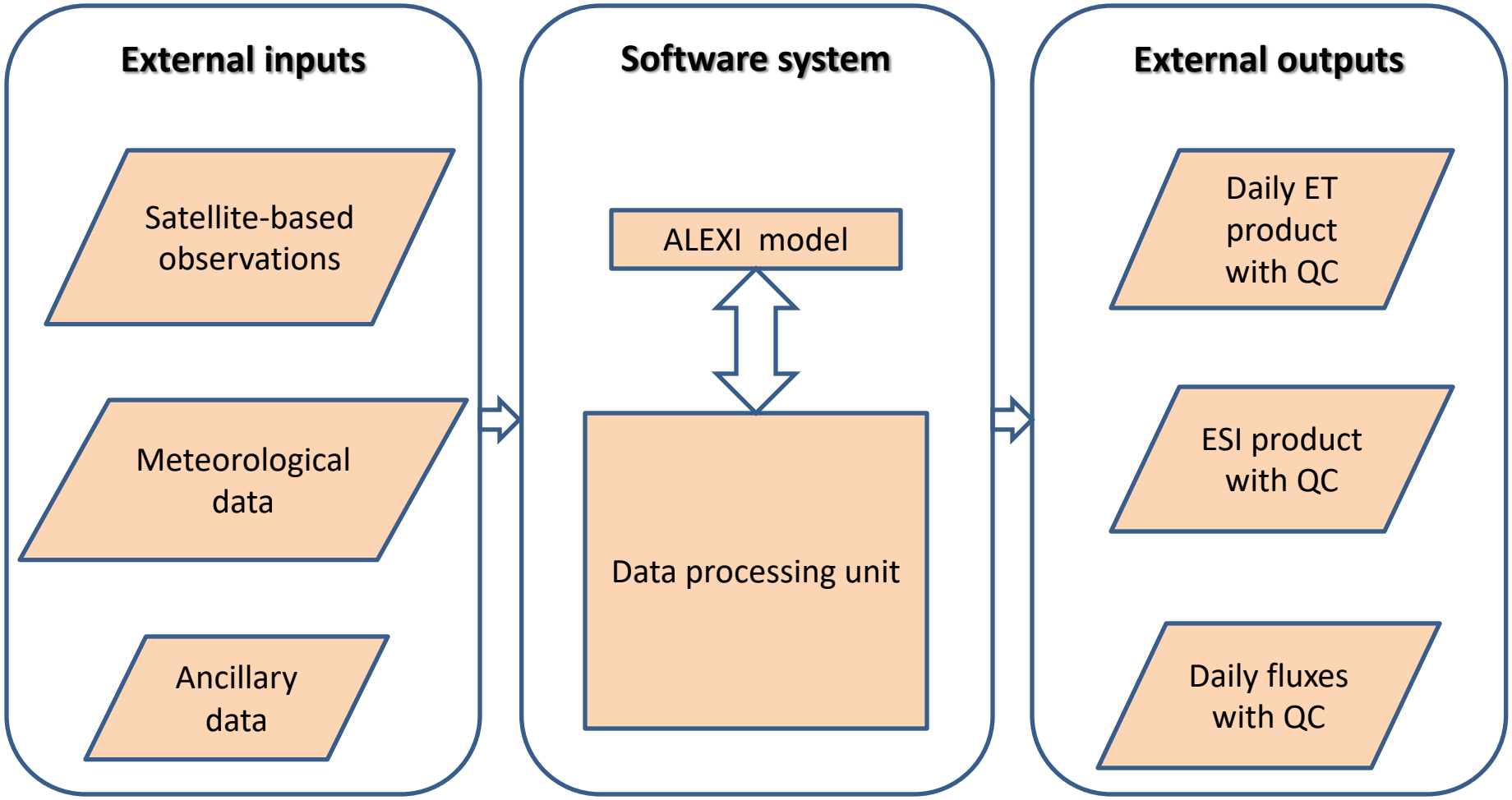
- ALEXI model exploits the mid-morning rise in LST from GOES to deduce the land surface fluxes, including evapotranspiration ET
- A simple evaporative stress index (ESI), the ratio of actual-to-potential ET (f_{PET}), can then be computed from ALEXI ET estimates to represent surface soil moisture status; Negative ESI anomaly may indicate drought occurrence

GET-D Product System Characteristics



- ALEXI does not require precipitation data, ***the current surface moisture state is deduced directly from the remotely sensed LST*** , therefore it may be more robust in regions with minimal in-situ precipitation monitoring
- Signatures of vegetation stress are manifested in the LST signal before any deterioration of vegetation cover occurs, as indicated by vegetation indices such as NDVI, so TIR-based indices such as ***ESI can provide an effective early warning signal of impending agricultural drought***

GET-D General Architecture



GET-D Input Data

Name	Category	Source	Description
Brightness temperature	Satellite observation	GOES	GOES East/West Imagery; 11micron/3.9 micron brightness temperature
Insolation	Satellite observation	GSIP	GSIP real time insolation
Vegetation Index	Satellite observation	VIIRS	VIIRS EVI
Snow mask	Satellite observation	NOAA IMS	IMS Daily Northern Hemisphere Snow and Ice Analysis
Air temperature	Meteorological data	CFS	Surface and pressure level profiles
Specific humidity	Meteorological data	CFS	Surface and pressure level profiles
Geopotential height	Meteorological data	CFS	Surface and pressure level profiles
Wind speed	Meteorological data	CFS	Surface
Downwelling longwave radiation	Meteorological data	CFS	Surface
Land Cover	Ancillary data	University of Maryland	Land cover classes in 1km resolution (static)
Albedo	Ancillary data	MODIS	Surface Albedo from MODIS (static)
Clear day insolation	Ancillary data	GSIP	Clear day insolation (static)

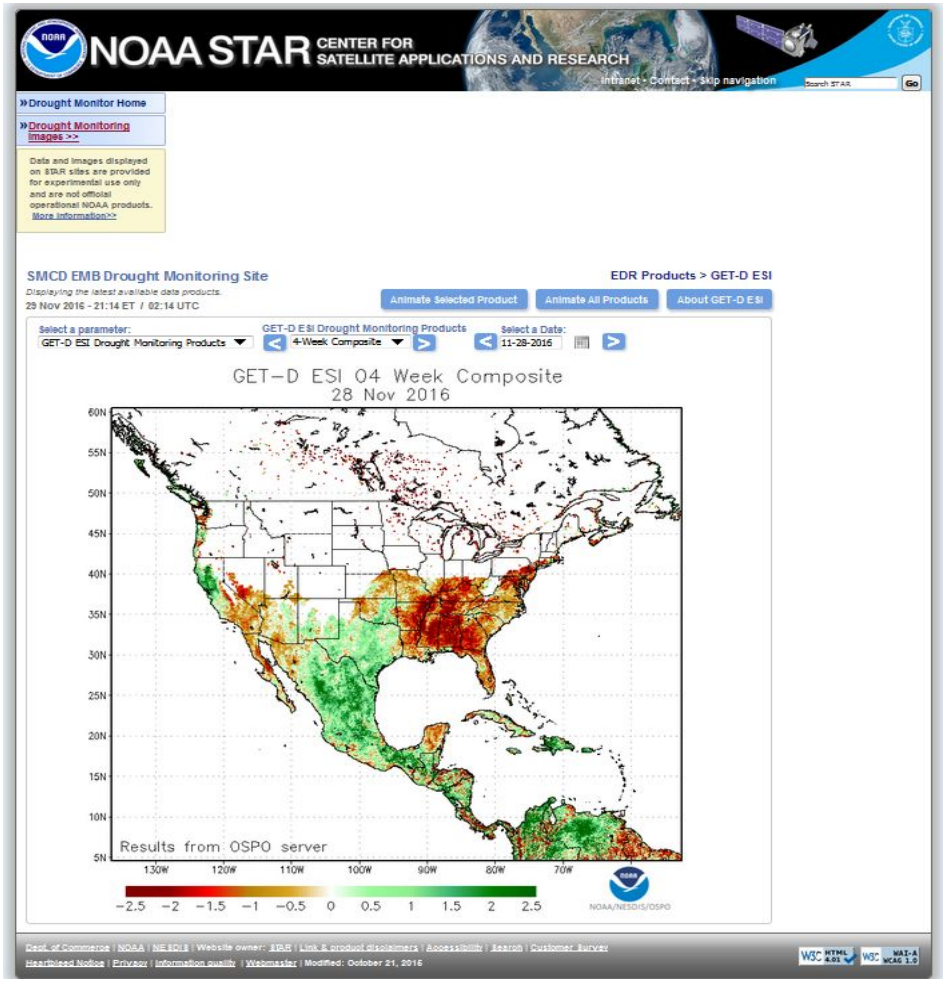
GET-D Output Products

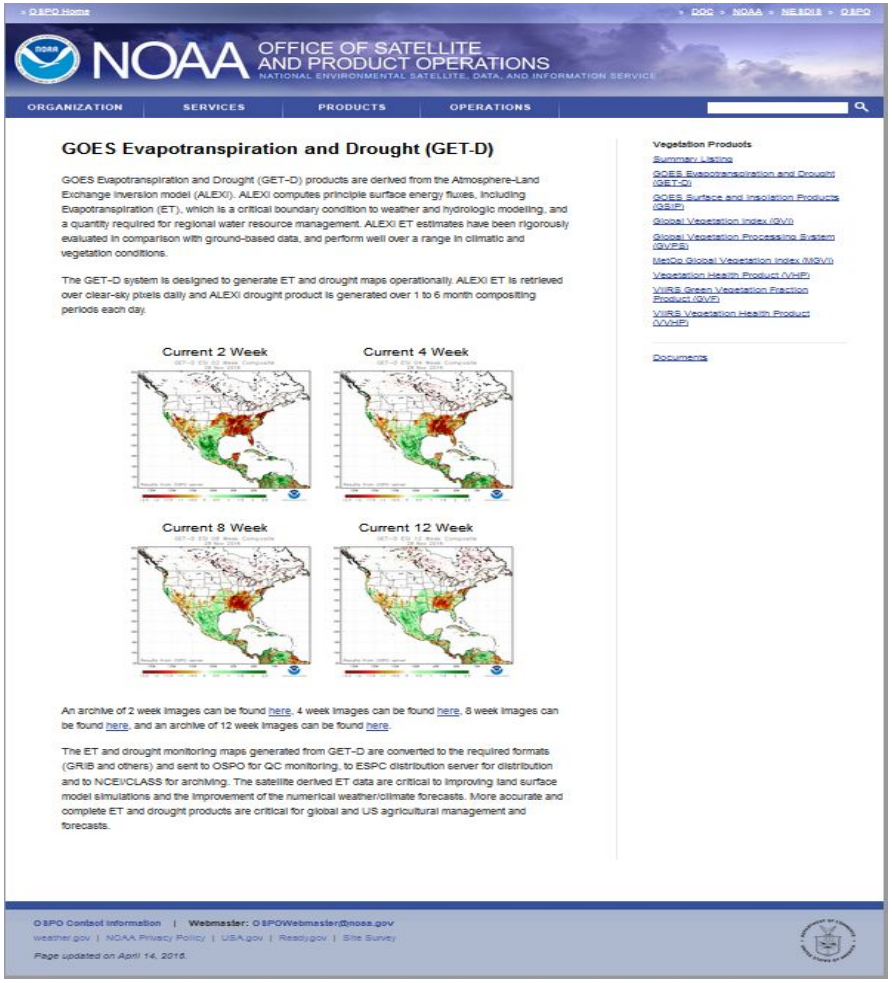
Variables	Description
ET product with QC	Daily ET map
ESI products with QC	2,4,8, 12-week composite drought map
Flux products with QC	Daily sensible heat, soil heat, downward short wave radiation, long wave down/up ward radiation and net radiation
Coverage	North America
Spatial Resolution	8km

GET-D Websites

NESDIS-STAR:
https://www.star.nesdis.noaa.gov/smcd/emb/droughtMon/products_droughtMon.php

NESDIS-OSPO:
http://www.ospo.noaa.gov/Products/land/getd/

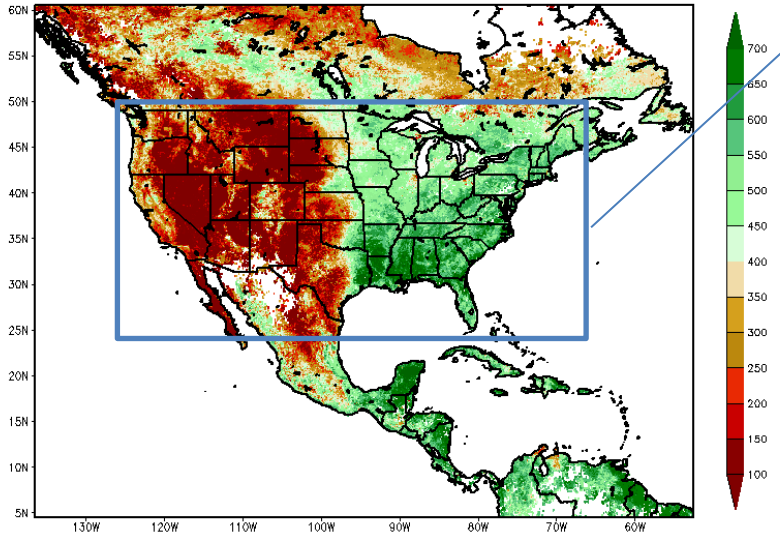




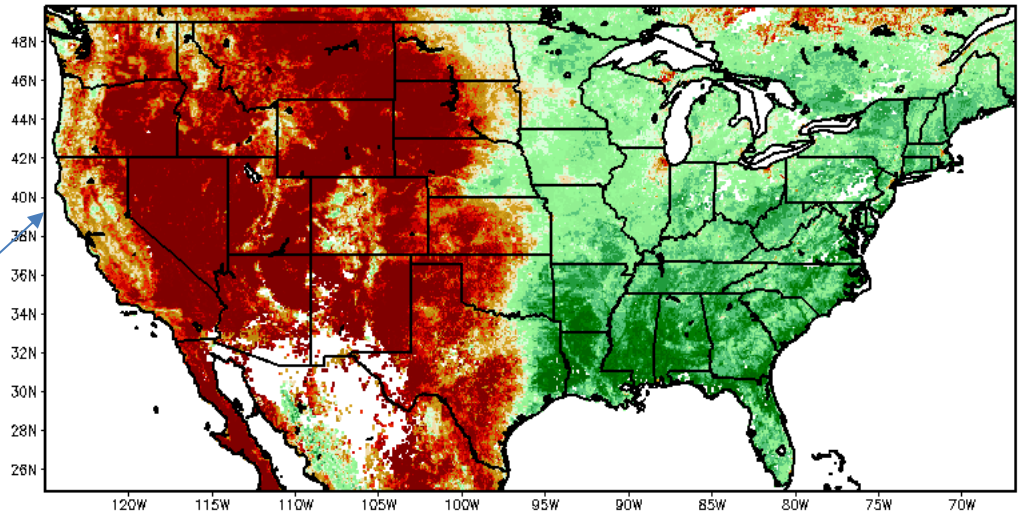
Due to the switch of primary GOES-East from GOES-13 to GOES-16, GET-D stopped operation since Jan 2018.

λET from GET-D using GOES 16 Observations

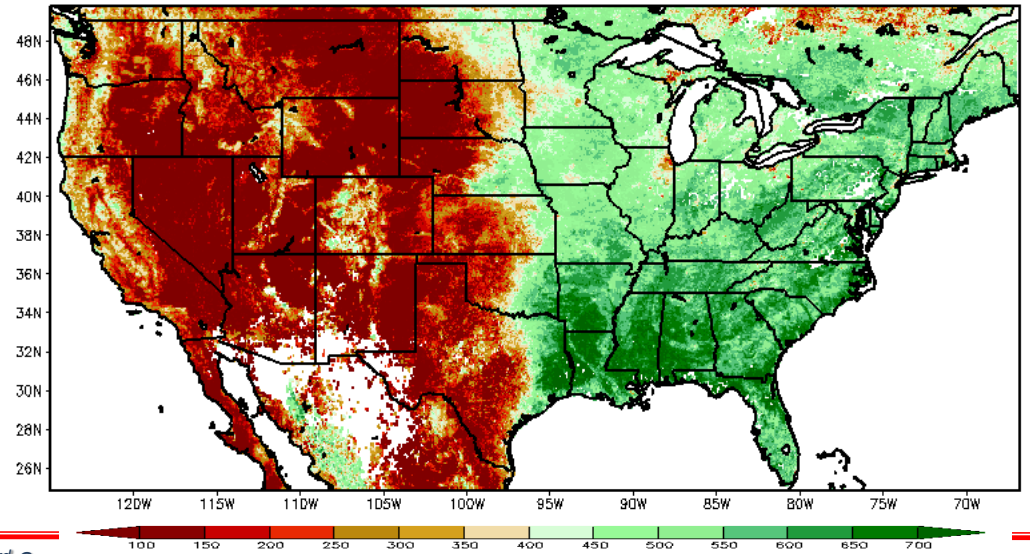
λET over North America at 8km



λET over CONUS at 8km



λET over CONUS at 4km



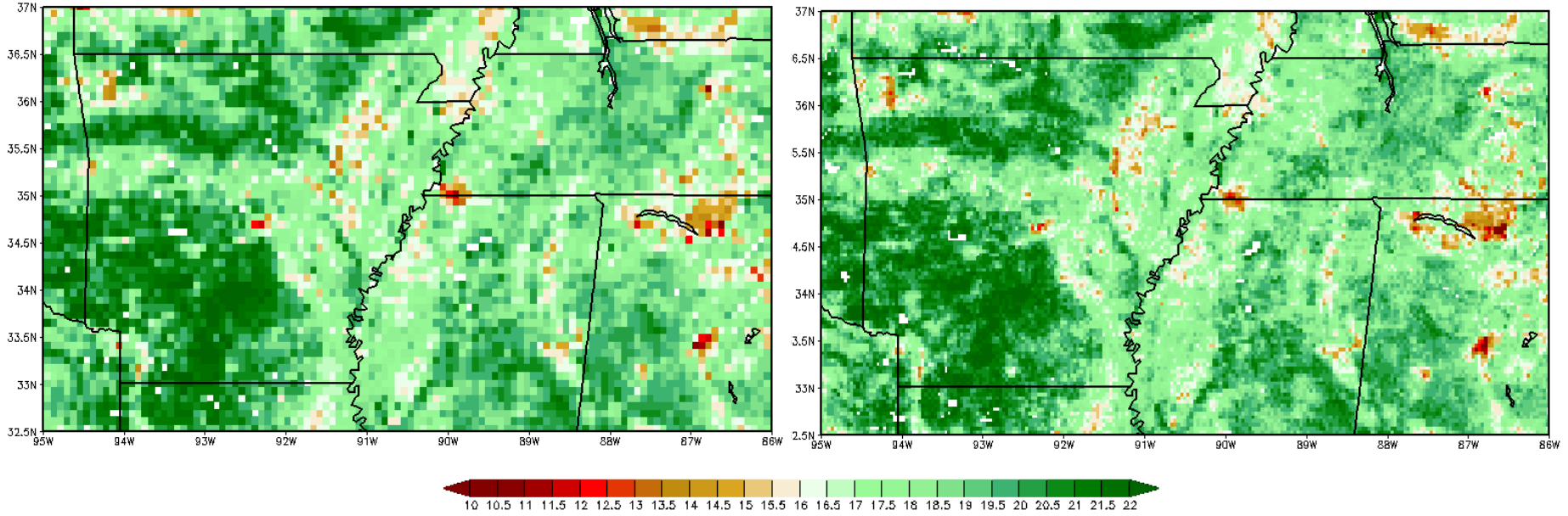
λET (W/m^2) retrieval comparison between operational 8km product and upgraded 4km product; July 10 – 24, 2017

ET (mm/day) from GET-D using GOES 16 Observations

Middle Mississippi River Basin (weekly: July 10-16, 2018)

8 km

4 km



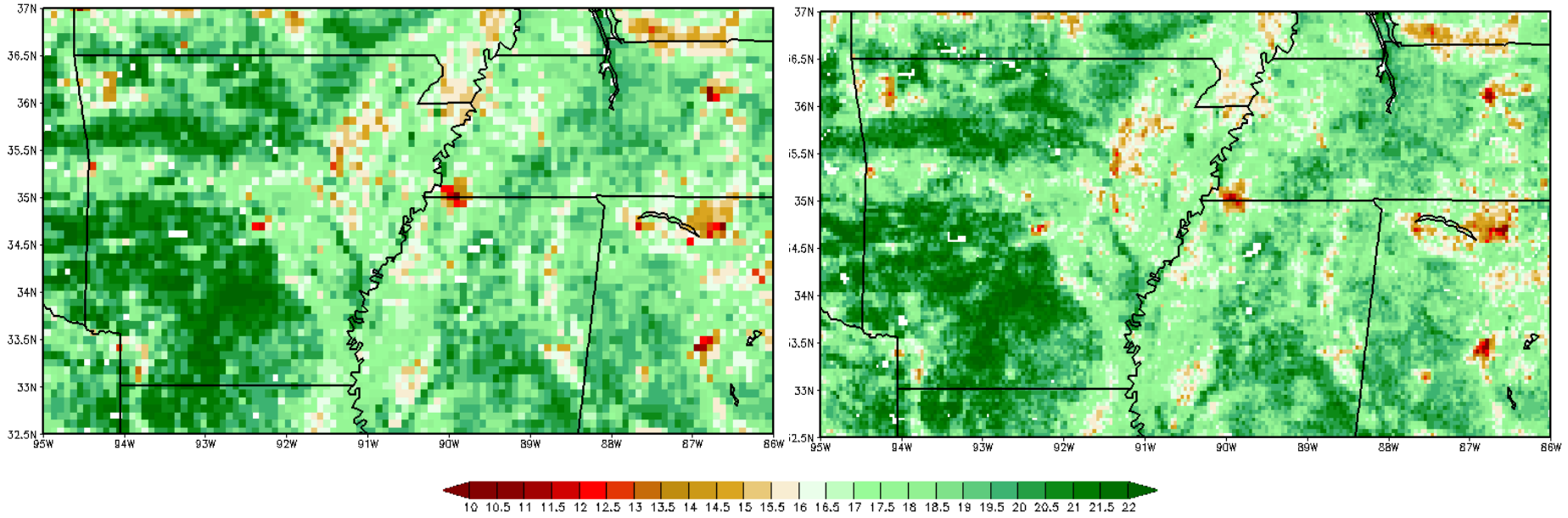
Higher resolution map provides more spatial details
Week 2 may have lower ET

ET (mm/day) from GET-D using GOES 16 Observations

Middle Mississippi River Basin (2 weeks: July 10-24, 2018)

8 km

4 km



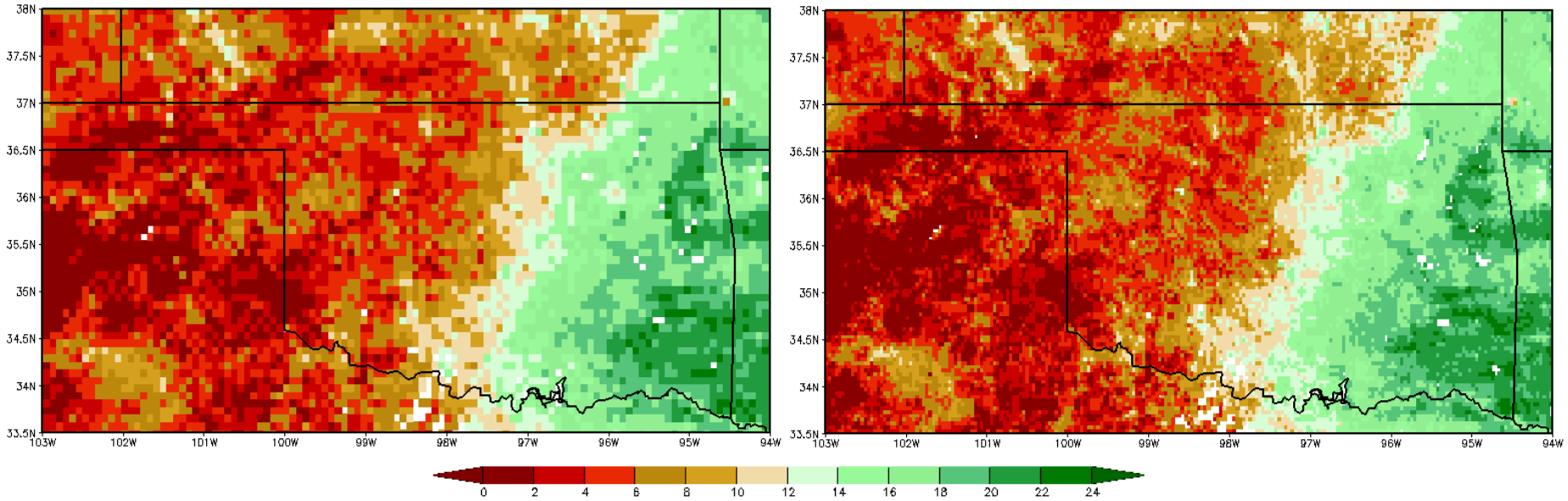
Higher resolution map provides more spatial details

ET (mm/day) from GET-D using GOES 16 Observations

Oklahoma Region (weekly: July 10-16, 2018)

8 km

4 km



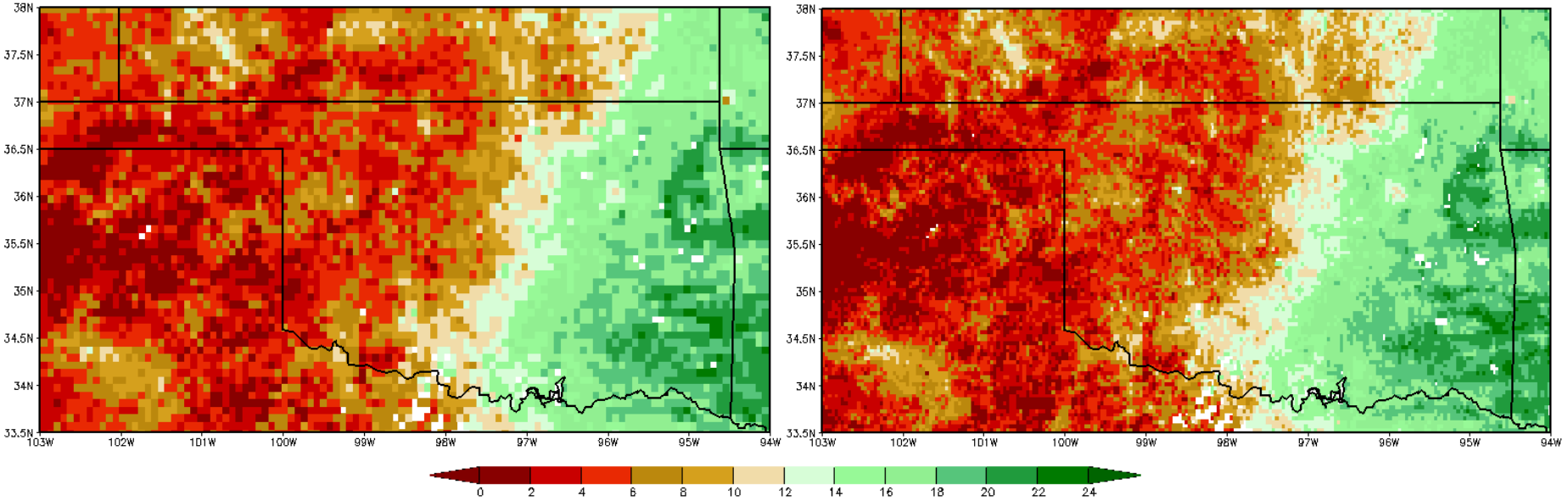
Higher resolution map provides more spatial details

ET (mm/day) from GET-D using GOES 16 Observations

Oklahoma Region (2 weeks: July 10-24, 2018)

8 km

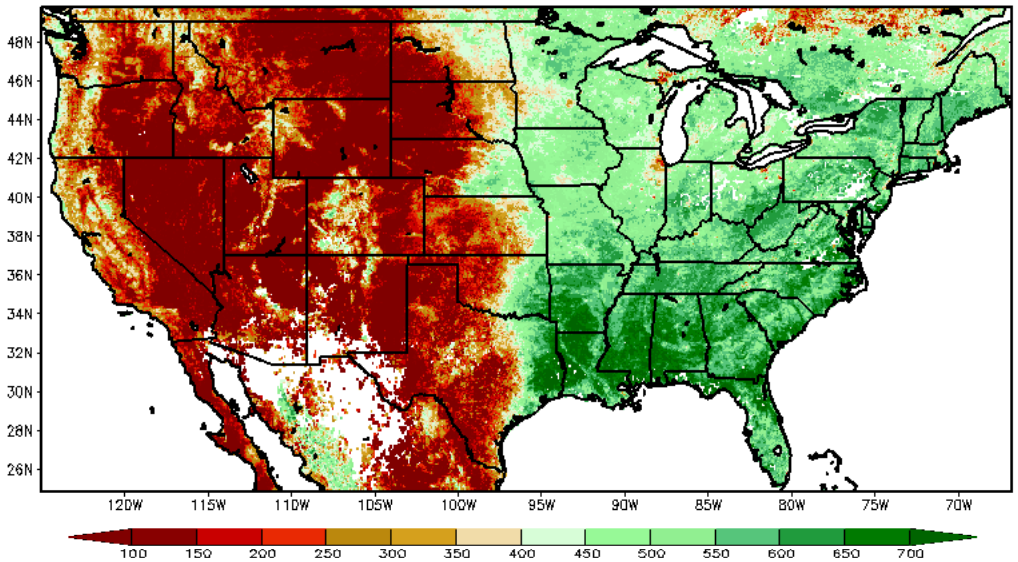
4 km



Higher resolution map provides more spatial details
Week 2 may have slightly higher ET

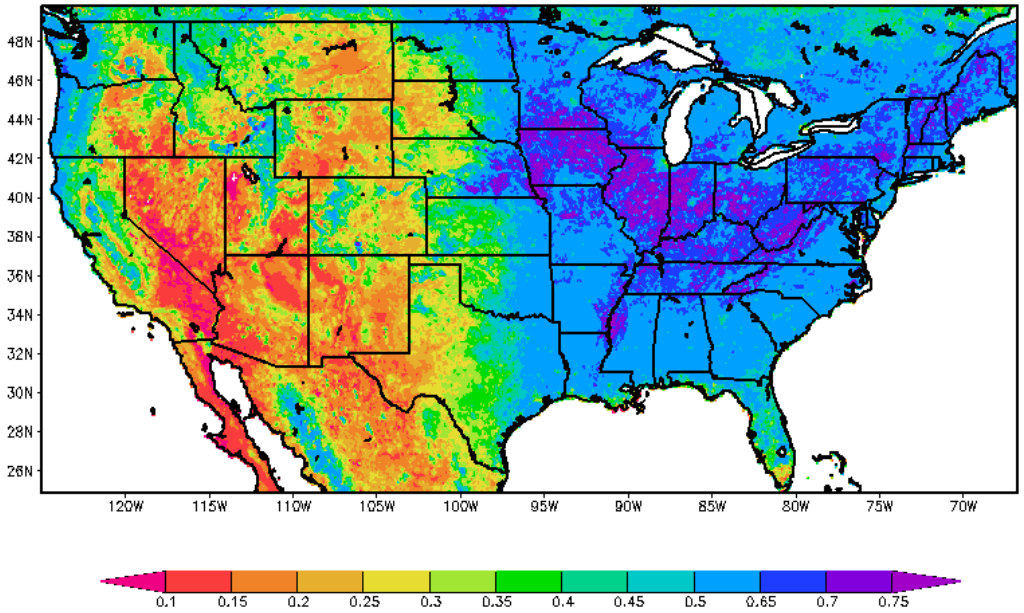
Correlation between λET from GET-D and VIIRS EVI

λET from GET-D



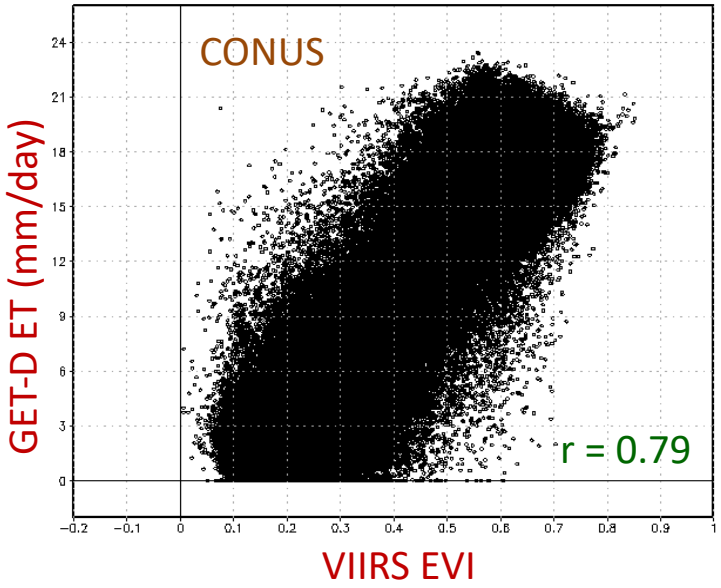
July 10 – 24, 2017

VIIRS EVI

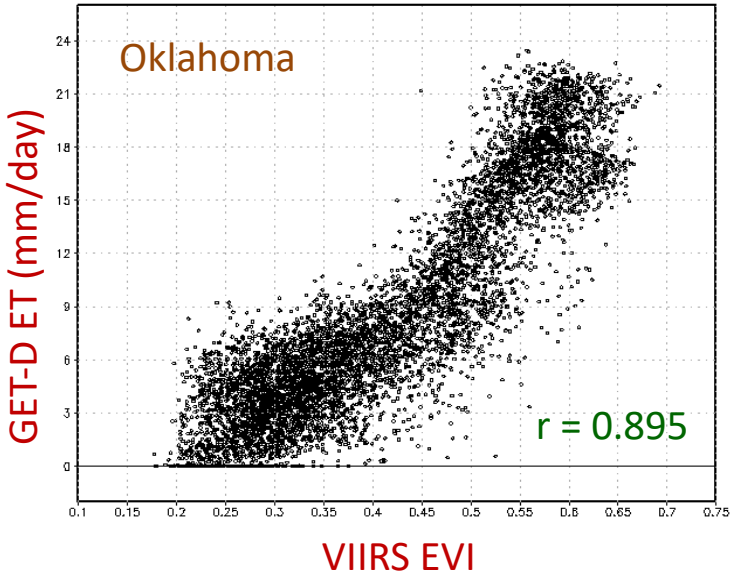


July 17 – 24, 2017

Correlation between ET from GET-D and VIIRS EVI



July 10 – 24, 2017



Summary and Next Steps

- NESDIS GET-D has been generating **ET** and ESI data products at **8km** resolution for NCEP NWP model validation and Drought Monitoring since 2016
- GET-D is updated successfully to generate **ET** at **4km** spatial resolution using **GOES-16** observations
- Validation against independent data sets (e.g. AmeriFlux sites) is on-going
- GET-D is being upgraded to **1km** spatial resolution using the high spatial resolution observations from both **GOES-16/17**

Back up Slides

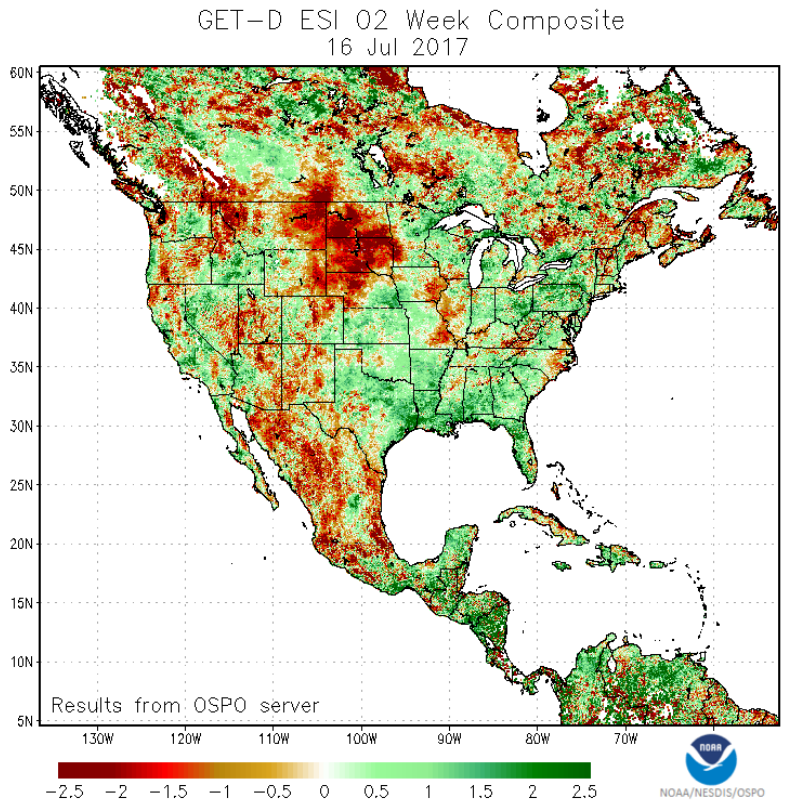
GET-D Product System Characteristics

System major inputs

- Satellite-based observations
  - GOES East and West
  - GSIP insolation
  - VIIRS EVI
  - IMS snow
- Meteorological forcing
  - NCEP Climate Forecast System (CFS)
- Ancillary data
  - Land cover
  - GOES view angle
  - Soil reflectance and surface parameters

System outputs

- Daily ET and other energy fluxes
- drought maps (2, 4, 8, 12 weekly composite)



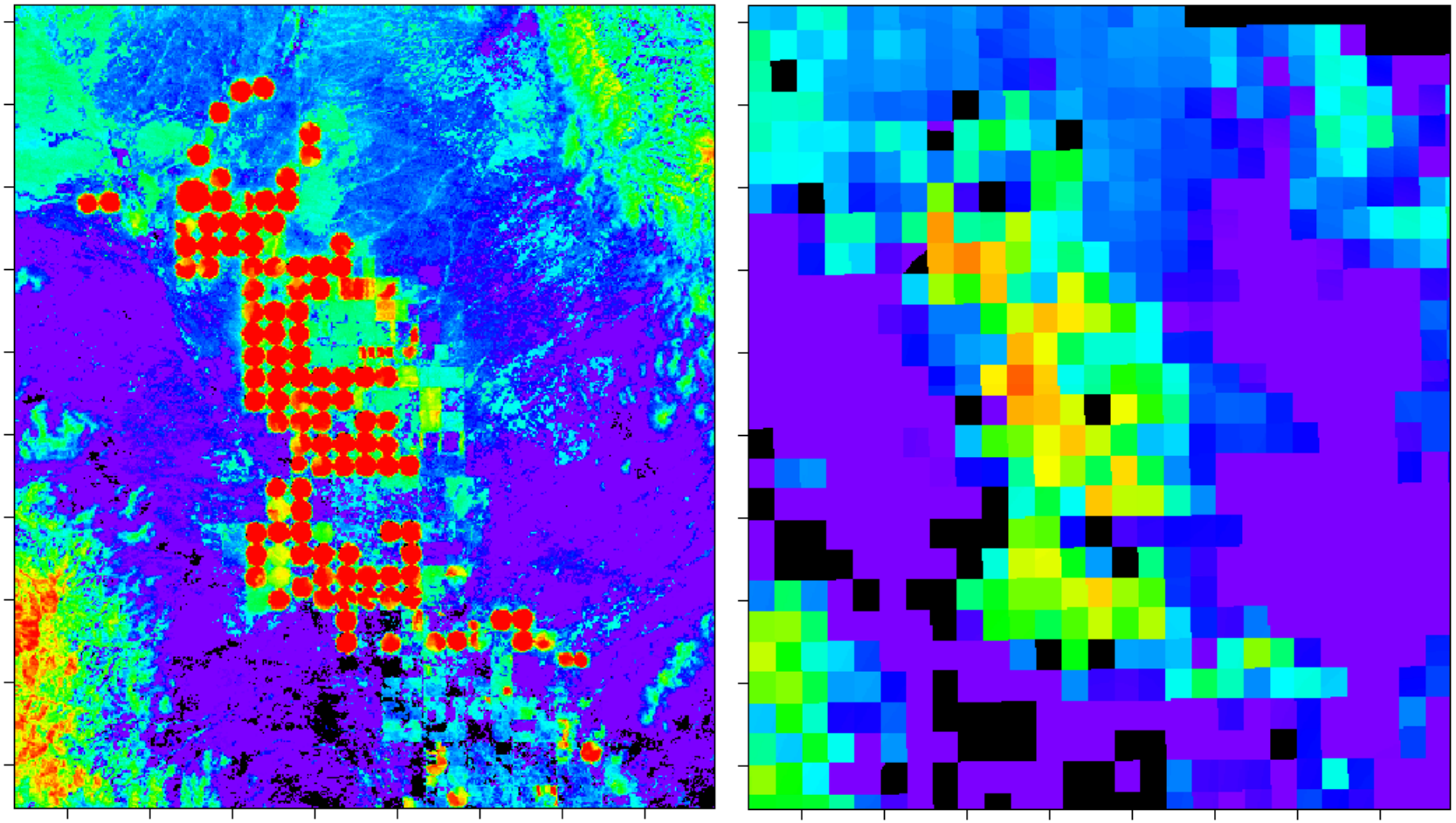
- ALEXI does not require precipitation data, ***the current surface moisture state is deduced directly from the remotely sensed LST*** , therefore it may be more robust in regions with minimal in-situ precipitation monitoring
- Signatures of vegetation stress are manifested in the LST signal before any deterioration of vegetation cover occurs, for as example as indicated in NDVI, so TIR-based indices such as ***ESI can provide an effective early warning signal of impending agricultural drought***

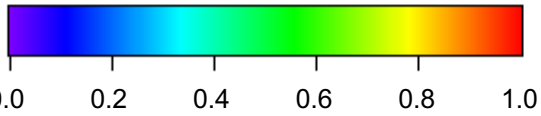
From Martha Anderson

Sensitivity to irrigation

Landsat 7 – 60m

MODIS – 1km



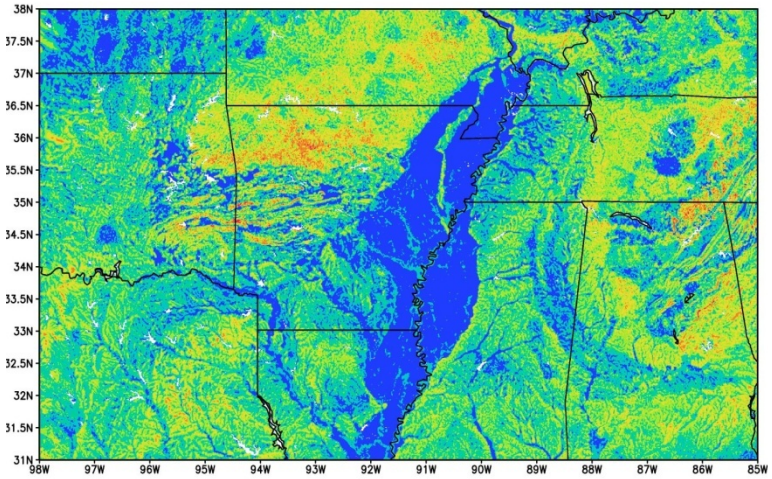


$$\frac{ET}{PET}$$

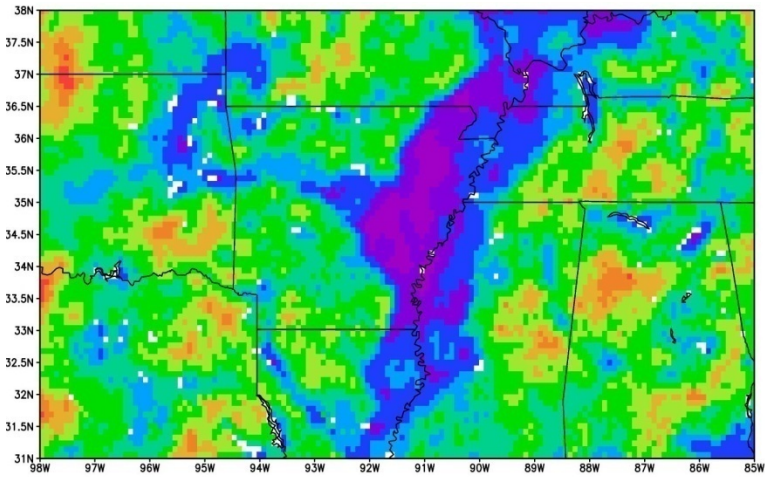
From Martha Anderson

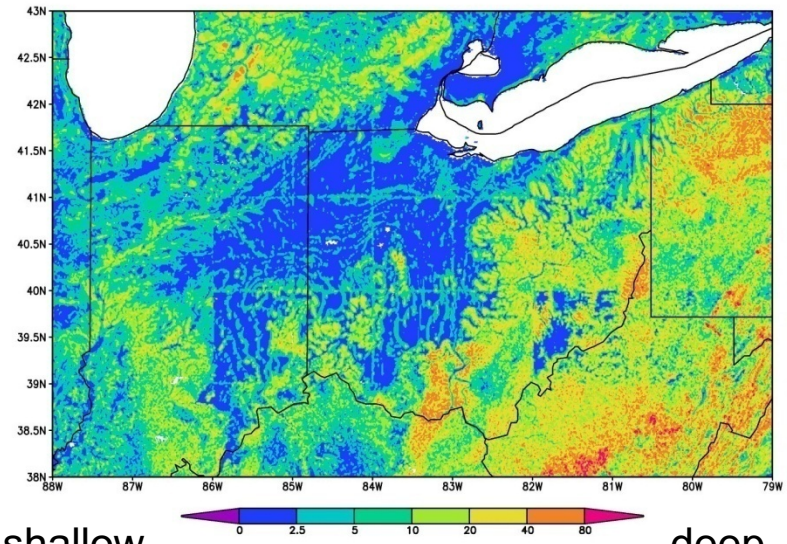
Sensitivity to shallow water tables

Simulated climatological water table*

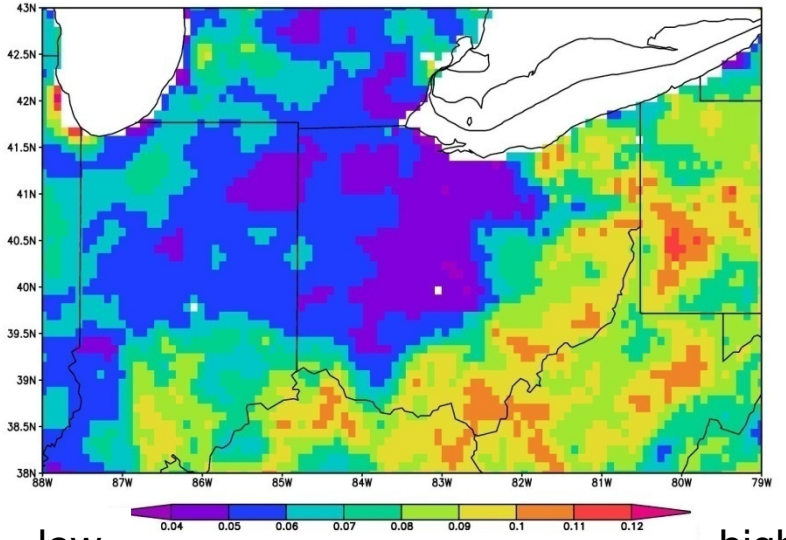


Temporal variability in ET/PET





shallow deep



low high

* Miquez-Macho et al, BAMS, 89, 663-672