ALEXI/DisALEXI products for ECOSTRESS

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Atmosphere-Land Exchange Inverse

ΔT

ΔT_{RAD} - Geostationary

T_{a} - ABL model

f_{c} - MODIS

Surface temp:

Air temp:

Veg cover:

ET = (R_{NET} - G) - H

Two-Source Model

T_{a}

H = H_{c} + H_{s}

H_{c}

R_{a}

R_{soil}

T_{ac}

T_{c}

R_{x}

T_{s}

T_{RAD(\phi), f_{c}}

Normalization

ALEXI

DisALEXI

4 km

30 m

ET = (R_{NET} - G) - H

Regional scale

Landscape scale

\Delta T_{RAD} - Geostationary

T_{RAD} - Landsat, MODIS, ECO

T_{a} - ABL model

T_{a} - ALEXI

f_{c} - MODIS

f_{c} - Landsat, MODIS

ET = (R_{NET} - G) - H

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DATA FUSION: daily ET at field scale (F. Gao)

Surface Temperature
- Global (25km)
- Continental (10km)
- Regional (5km)
- Basin (1km)
- Watershed (60m)
- Field scale (30m)

Evapotranspiration
- Hourly
- Daily
- ECO - 4 day
- 1 LS - 16 day
- 2 LS - 8 day

Airborne (USU aircraft)
- Temperature (C)
- 1 July 2002 - 10:30AM LST

Polar (MODIS)
- Latent Heat (Wm^2)
- Corn, Soy

Polar (Landsat)
- Temperature (C)

GEO (GOES Imager)

GEO (GOES Sounder)

GEO (ISCCP)
GOES/MODIS/Landsat FUSION

Daily Evapotranspiration – Orlando, FL, 2002

Spatial Temporal Adaptive Reflectance Fusion Model (STARFM) (Gao et al, 2006)
GOES/MODIS/Landsat/ECOSTRESS

Daily Evapotranspiration – Orlando, FL, 2002

DOY 328 329 330 331 332 333 334 335 336

GOES (ALEXI)

MODIS (DisALEXI)

LANDSAT (DisALEXI)

Landsat 5

ECOSTRESS (LST)

Landsat 7
Processing for USDA L3/L4 products

**INPUTS**

- **ECOSTRESS (68 m)**
  - LST
  - Emissivity

- **Landsat (30 m)**
  - SR (Bands 3-7)

- **MODIS (1 km)**
  - LAI (MCD15A3)

- **ALEXI (4 km)**
  - ET (GET-D)

- **MET INPUTS (20 km)**
  - CFSR:
    - Atmospheric pressure
    - Vapor pressure
    - Wind speed
    - Air Temperature
    - Insolation

**PREPROCESSING**

- **ECOSTRESS (68 m)**
  - Resample onto Landsat grid
  - Sharpen LST to 30m

  - Generate MODIS-consistent LAI
  - Generate SW and NIR albedo

- **ALEXI (4 km)**
  - Extract ALEXI ETd over Landsat grids

  - Extract met data over Landsat grids
  - Compute hourly and daily reference ET (RET)

**DisALEXI**

- • Disaggregate ALEXI ETd (4km) to 30 m using ECOSTRESS LST

- ETd at 30 m

- $f_{RET} = \frac{ET}{RET} \text{ at } 30 \text{ m}$

**On ECOSTRESS DAYS**

- L3
- L4

**INPUTS**

- **Landsat**
- **MODIS**
- **ALEXI**
- **Met data**
- **ECOSTRESS**
USDA-ARS LTAR NETWORK
Long-Term Agro-ecosystem Research Sites and Farm Resource Regions

Core sites
Potential tier 2 sites
HIGH RESOLUTION ET DATACUBES

... flux tower comparison
... ET dynamics
... ET/RefET ("ESI")

Retrospective Landsat-based analyses in progress
Satellite ET Drought Indicator

Atmosphere-Land Exchange Inverse Model (ALEXI)

(Anderson et al., 1997, 2007)
Mead, NE

Rainfed corn and soybean in NE

2012 drought

NE1: IRRIGATED

NE2: IRRIGATED

NE3: RAINFED

Percent Error:
20% (daily)
15% (monthly)
8% (seasonal)

(Yang et al., 2017)
Mead, Nebraska (near Lincoln)

GROWING SEASON WATER USE

2010

2011

2012

2013

mm
Aligned on calendar date

Corn fields at Mead site

Irrigated corn
Rainfed corn
Soybean
Riparian

fPET = ET/PET

Calendar day of year
Aligned on calendar date

Irrigated corn
Rainfed corn

Corn fields at Mead site

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Aligned on crop- (or field-) specific emergence date

Irrigated corn
Rainfed corn
Maximum correlation with corn yield

Irrigated corn
Rainfed corn

Days from emergence

Corn yield (Mg ha\(^{-1}\))

Correlation with Yield

fPET anomaly

R = 0.94

Corn fields at Mead site

Irrigated corn
Rainfed corn

fPET = ET/PET

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Yield predictions improve at field scale

GOES
(4km pixels)

Landsat
(30m pixels)

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Water productivity: “Crop per drop”

**ET**

**Yield**

**WP = Y/ET**

<table>
<thead>
<tr>
<th>Year</th>
<th>Seasonal evapotranspiration (mm)</th>
<th>Corn yield (Mg/ha)</th>
<th>Crop water productivity (Mg/ha-mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>800</td>
<td>15</td>
<td>0.02</td>
</tr>
<tr>
<td>2011</td>
<td>600</td>
<td>20</td>
<td>0.01</td>
</tr>
<tr>
<td>2012</td>
<td>400</td>
<td>10</td>
<td>0.02</td>
</tr>
<tr>
<td>2013</td>
<td>200</td>
<td>5</td>
<td>0.01</td>
</tr>
<tr>
<td>2014</td>
<td>100</td>
<td>2</td>
<td>0.01</td>
</tr>
</tbody>
</table>

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Data production strategy

At core LTAR sites:

- USDA develops fully fused daily ET cubes with Landsat
- USDA processes ET, ET/RefET on ECOSTRESS days
  - Assess ECOSTRESS ET quality wrt fusion result
  - Assess value added by increased temporal sampling by ECOSTRESS (what is missed by Landsat only?)
- USDA products at core sites serve as benchmark for wider area coverage generated at JPL

hrsl.arsusda.gov/drought

USDA is an equal opportunity provider and employer.
Water quality in the Chesapeake Bay

Liang Sun, Amir Sharifi, 2016
Comparisons with flux tower data

ALEXI ET (4km)
○ Observed ET
△ Landsat retrieval
← Landsat-MODIS fusion
➡ Precipitation

Choptank (2014)

ET (mm/day)

Rainfall (mm/day)

Day of year

Partitioning of E and T

T/E SEPARATION ON CLEAR LANDSAT DATES

Evapotranspiration
Soil evaporation
Canopy transpiration
Calibrating watershed model with ET

Streamflow (SWAT)

Strategy: Iteratively calibrate Soil Water Assessment Tool (SWAT) parameters using PET-ET from remote sensing aggregated to sub-basins. (Sharifi et al., 2017)
Strategy: Iteratively calibrate Soil Water Assessment Tool (SWAT) parameters using PET-ET from remote sensing aggregated to sub-basins. (Sharifi et al., 2017)
2012 FLASH DROUGHT

Figure 1. 2012 State Corn Yields as a Percent of Trend Yield.
Aligned phenology and stress signals

Clear Landsat

NDVI

Date

4/1 5/1 5/31 6/30 7/30 8/29 9/28 10/28

0.0 0.2 0.4 0.6 0.8 1.0
Aligned phenology and stress signals

Clear Landsat

Landsat/ MODIS fusion
Aligned phenology and stress signals

- **Green-up**: Peak in NDVI after dormancy
- **Dormancy**: Reduction in NDVI after green-up

**Remote sensing stages**
- **Clear Landsat**
- **Landsat/MODIS fusion**
- **TIMESAT fit**
- **Remote sensing stages**

**Legend**
- Blue circle: Clear Landsat
- Light blue circle: Landsat/MODIS fusion
- Orange line: TIMESAT fit
- Blue square: Remote sensing stages

**Dates**
- 4/1
- 5/1
- 5/31
- 6/30
- 7/30
- 8/29
- 9/28
- 10/28

**NDVI**
- 0.0
- 0.2
- 0.4
- 0.6
- 0.8
- 1.0

**USDA/GEOGLAM Workshop, May 2016**
Aligned phenology and stress signals

![Graph showing NDVI and stress signals over time.]

**Key Phases:**
- **Green-up**
- **Peak**
- **Dormancy**

**Stages:***
- **planted**
- **emerged**
- **silked**
- **dough**
- **dented**
- **mature**
- **harvested**

**Remote Sensing Stages:**
- Clear Landsat
- Landsat/MODIS fusion

**Phenological Stages:**
- TIMESAT fit
- Remote sensing stages

**Stress (ET/PET):**

**Date:**
- 4/1
- 5/1
- 5/31
- 6/30
- 7/30
- 8/29
- 9/28
- 10/28

**USDA/GEOGLAM Workshop, May 2016**

**Legend:**
- Blue squares: Clear Landsat
- Blue circles: Landsat/MODIS fusion
- Yellow line: TIMESAT fit
- Green line: Phenological stages
- Green arrow: DD linkage
Aligning phenology and stress signals

\[ \text{Yield} = \sum_{i=\text{greenup}}^{\text{dormancy}} [\text{PAR}_i \times f\text{PAR}_i \times LUE_i(\varepsilon_{max}, T, ET)] \times HI \]

**Stress (ET/PET)**

**Green-up**

**Dormancy**

**Date**

4/1 5/1 5/31 6/30 7/30 8/29 9/28 10/28

**NDVI**

0.0 0.2 0.4 0.6 0.8 1.0

**Planted**  **Emerged**  **Silked**  **Dough**  **Dented**  **Mature**  **Harvested**

**Remote sensing stages**

**Remote sensing stages**

**Clear Landsat**

**Landsat/MODIS fusion**

**TIMESAT fit**

**Phenological stages**

**DD linkage**