An Evapotranspiration Data Product from NOAA GOES-16 and 17

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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

<table>
<thead>
<tr>
<th></th>
<th>ABI</th>
<th>IMAGER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spectral Bands</td>
<td>16</td>
<td>5</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>0.65 μm visible - 0.5 km Other visible/NIR - 1 km Bands (&gt; 2 μm) – 2 km</td>
<td>~1 km NA ~4 km</td>
</tr>
<tr>
<td>Temporal Resolution</td>
<td>Full Disk - 15 min. CONUS – 5 min. Mesoscale – 0.5 min.</td>
<td>Scheduled 3 hrs ~15 min. NA</td>
</tr>
</tbody>
</table>
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.
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

**External inputs**
- Satellite-based observations
- Meteorological data
- Ancillary data

**Software system**
- ALEXI model
- Data processing unit

**External outputs**
- Daily ET product with QC
- ESI product with QC
- Daily fluxes with QC
<table>
<thead>
<tr>
<th>Name</th>
<th>Category</th>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brightness temperature</td>
<td>Satellite observation</td>
<td>GOES</td>
<td>GOES East/West Imagery; 11micron/3.9 micron brightness temperature</td>
</tr>
<tr>
<td>Insolation</td>
<td>Satellite observation</td>
<td>GSIP</td>
<td>GSIP real time insolation</td>
</tr>
<tr>
<td>Vegetation Index</td>
<td>Satellite observation</td>
<td>VIIRS</td>
<td>VIIRS EVI</td>
</tr>
<tr>
<td>Snow mask</td>
<td>Satellite observation</td>
<td>NOAA IMS</td>
<td>IMS Daily Northern Hemisphere Snow and Ice Analysis</td>
</tr>
<tr>
<td>Air temperature</td>
<td>Meteorological data</td>
<td>CFS</td>
<td>Surface and pressure level profiles</td>
</tr>
<tr>
<td>Specific humidity</td>
<td>Meteorological data</td>
<td>CFS</td>
<td>Surface and pressure level profiles</td>
</tr>
<tr>
<td>Geopotential height</td>
<td>Meteorological data</td>
<td>CFS</td>
<td>Surface and pressure level profiles</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Meteorological data</td>
<td>CFS</td>
<td>Surface</td>
</tr>
<tr>
<td>Downwelling longwave radiation</td>
<td>Meteorological data</td>
<td>CFS</td>
<td>Surface</td>
</tr>
<tr>
<td>Land Cover</td>
<td>Ancillary data</td>
<td>University of Maryland</td>
<td>Land cover classes in 1km resolution (static)</td>
</tr>
<tr>
<td>Albedo</td>
<td>Ancillary data</td>
<td>MODIS</td>
<td>Surface Albedo from MODIS (static)</td>
</tr>
<tr>
<td>Clear day insolation</td>
<td>Ancillary data</td>
<td>GSIP</td>
<td>Clear day insolation (static)</td>
</tr>
</tbody>
</table>
## GET-D Output Products

<table>
<thead>
<tr>
<th>Variables</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET product with QC</td>
<td>Daily ET map</td>
</tr>
<tr>
<td>ESI products with QC</td>
<td>2,4,8, 12-week composite drought map</td>
</tr>
<tr>
<td>Flux products with QC</td>
<td>Daily sensible heat, soil heat, downward short wave radiation, long wave down/up ward radiation and net radiation</td>
</tr>
<tr>
<td>Coverage</td>
<td>North America</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>8km</td>
</tr>
</tbody>
</table>
Due to the switch of primary GOES-East from GOES-13 to GOES-16, GET-D stopped operation since Jan 2018.

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/
\( \lambda ET \) retrieval comparison between operational 8km product and upgraded 4km product; July 10 – 24, 2017.

\( \lambda ET \) from GET-D using GOES 16 Observations

\( \lambda ET \) over CONUS at 8km

\( \lambda ET \) over CONUS at 4km

\( \lambda ET \) over North America at 8km
ET (mm/day) from GET-D using GOES 16 Observations

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

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)

Higher resolution map provides more spatial details
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)

Higher resolution map provides more spatial details
Week 2 may have slightly higher ET
Correlation between $\lambda ET$ from GET-D and VIIRS EVI

$\lambda ET$ from GET-D

July 10 – 24, 2017

VIIRS EVI

July 10 – 24, 2017
Correlation between ET from GET-D and VIIRS EVI

**CONUS**

\[ r = 0.79 \]

**Oklahoma**

\[ r = 0.895 \]

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.
Sensitivity to irrigation

From Martha Anderson
Sensitivity to shallow water tables

Simulated climatological water table* Temporal variability in ET/PET

From Martha Anderson

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