SOIL MOISTURE FROM SMOPS

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UMD-CICS

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OUTLINE

• Why Soil Moisture
  – Sciences (water and energy cycle studies)
  – Applications (flood and drought monitoring/forecasts)
• Soil Moisture Operational Product System (SMOPS)
  – System Objectives and Architecture
  – Algorithms Updates for JPSS GCOM-W/AMSR2
• Supporting NWC NWM (JPSS PGRR)
• Summary and Path Forward
Why Soil Moisture

Soil moisture controls land surface water and energy partitioning through impacting evapotranspiration and is a critical component of both water and energy cycles.

Mass balance

\[ V \frac{dS}{dt} = P - E(T, S) - R(S) \]

Energy balance

\[ c \frac{dT}{dt} = Rad_{net}(T) - H(T) - L \cdot E(T, S) \]

Evaporation & soil moisture couple mass & energy balances at land surface

*L* is the latent heat of vaporization: \(2.5 \times 10^6\) [J/kg]
Why Soil Moisture

Applications

NWS Operational Flash Flood Guidance (FFG) is Based on Modeled Soil Moisture Deficit

NOAA and National Drought Mitigation Center (NDMC) Operational Drought Indices are also based on Modeled Soil Moisture Data.

Soil moisture Observational data can replace model data or used to improve model estimates
SMOPS ingests all currently available microwave satellite soil moisture observations and blends them into one data layer for NOAA and other users.
Soil Moisture Operational Product System (SMOPS)

1. SM ingesting
2. SM retrieving
3. SM merging
4. Reprocessing for the archive product

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*All data acquired within the 6 hour or whole day time period arrived in the past 48 hours*
## SMOPS Output Data layers

<table>
<thead>
<tr>
<th>Soil Moisture Product</th>
<th>SMOPS Version 1.3</th>
<th>SMOPS Version 2.0</th>
<th>SMOPS Version 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMOPS Blended</td>
<td>√ (1)</td>
<td>√ (1)</td>
<td>√ (1)</td>
</tr>
<tr>
<td>NOAA AMSR-E</td>
<td>√ (2)</td>
<td>×</td>
<td>×</td>
</tr>
<tr>
<td>NOAA NRT SMOS</td>
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<td>√ (2)</td>
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<tr>
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<td>EUMETSAT ASCAT-B</td>
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<tr>
<td>NOAA WindSat</td>
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<td>×</td>
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<tr>
<td>NOAA AMSR2</td>
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<tr>
<td>NOAA GMI</td>
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<td>×</td>
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<tr>
<td>NOAA NRT SMAP</td>
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<tr>
<td>NASA SMAP</td>
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<td>×</td>
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Algorithm and Refinement:

- The LPRM algorithm was used to retrieve Vegetation Optical Depth (VOD) from TBv and TBh.
- Derive VOD climatology for Single Channel Algorithm (SCA) of soil moisture retrieval with historical AMSR2 data.
- Inverse soil moisture from TBh using the VOD scaled to VOD climatology with CDF matching.
- **Improved temporal dynamics and spatial coverage with improved LPRM vegetation Optical Depth retrieval algorithm (below).**
- Improved spatial coverage with longer period of historical data for generating Cumulative Distribution Function (CDF) data base.
- Validation with global in situ measurement data and other products are ongoing.

![AMSR2 Vegetation OD from LPRM (20170901).](image)
More reliable CDF with more historical AMSR2 data
JPSS GCOM-W1/AMSR2 Soil Moisture

Better spatial coverage and the dynamic range of the final product.
1) Comprehensive evaluation of both NWM output and JPSS satellite retrievals of soil moisture with independent data sets (e.g. in situ soil moisture measurement networks in CONUS and ground radar network precipitation data) for certain time periods and locations and for some major hydrological events (e.g. hurricane caused flooding);

2) Identification of NWM needs/requirements for JPSS soil moisture data products in terms of spatial, temporal resolution, operational data formats, and accuracies;

3) Development and validation of JPSS improved soil moisture data products that meet the NWM data needs through data mining approaches to downscale AMSR2 C-band soil moisture retrievals (25km) to 375m scale with VIIRS 375m Vegetation Index, 750m VIIRS land surface temperature, 9km AMSR2 Ka-band brightness temperature, and diurnal ABI observations as well as L-band observations from NASA SMAP and ESA SMOS and ancillary data (e.g. DEM, 30m land cover type);

4) Streamline the production procedure of these products for potential operational applications in NWM.
Ground SM Measurements for Validation

CREST-SMART Network
Millbrook, NY
*M. Temimi, et al., 2011*

Tibetan Plateau
Tibet, China; *K. Yang, et al., 2013*

USDA-ARS SM Networks
*M. H. Cosh, et al. 2008*

OzNet
Australia; *A. B. Smith, et al., 2012*
Ground SM Measurements for Validation

NOAA US Climate Reference Network

USDA Soil Climate Analysis Network (SCAN)
SMOPS SM Comparison with NWM SM

SCAN observations-based RMSE for
(a) SMOPS blended SM,
(b) NWM-based 0-10 cm SM,
(c) their differences.
From top to bottom:
- (Top) $r$ between 8-daily EVI and 8-daily SMOPS blended SM,
- (Middle) 8-daily NWM-based 0-10 cm SM estimations, as well as
- (Bottom) their differences for a lag of SM preceding EVI by 8-day. The grey color shading indicates insignificant correlations ($p>0.05$).

The stronger correlations between SMOPS and EVI are observed over the Great Plains and in the southeastern United States, where moisture-limiting (as opposed to energy limiting) was identified for vegetation growth (Karnieli et al, 2010, JC; Anderson et al., 2011, JC.)
Downscaling for High Resolution for NWM

Figure 1. Comparison of SMAP SM data sets to be validated, over Oklahoma region (100.15W~94.53W, 34.2N~37.06N), on April 30th, 2015, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)

Figure 2. Comparison of SMAP SM data sets to be validated, over Texas region (98W~92.5W, 31N~35N), on April 2nd, 2016, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)
Downscaling for High Resolution for NWM

Validation against OzNet network, Australia. Sept. 2015 – May 2016; Averaged over total 38 in-situ sites (~34.899S, 146.313E)

<table>
<thead>
<tr>
<th></th>
<th>A0-SMAP36</th>
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NESDIS SMOPS has been ingesting global soil moisture data products from available microwave satellite observations including the JPSS/GCOM-W project supported AMSR2

With longer data record, AMSR2 soil moisture data product has larger spatial coverage and is expected to have higher accuracy

JPSS PGRR program supported project on soil moisture for National Water Model has started to comprehensively evaluating both satellite retrievals and model estimates of SM

Leveraging NASA SMAP project, SMOPS soil moisture is being downscaled to high spatial resolution to meet NWM needs

SMOPS team plans to upgrade the software system in order to operationally generate high resolution soil moisture data products for NOAA and other users if supports will be available