SOIL MOISTURE FROM SMOPS

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UMD-CICS

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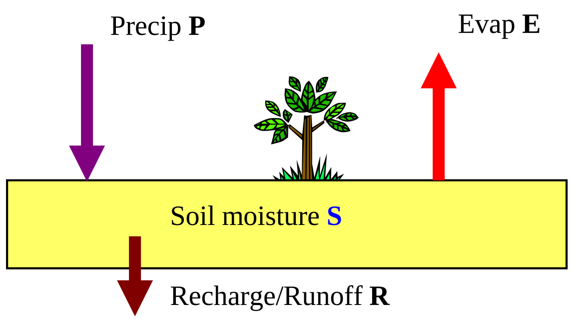
OUTLINE

- 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

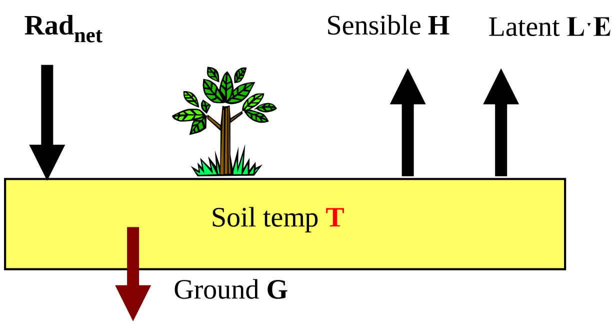
Why Soil Moisture

<u>**Soil moisture**</u> controls land surface **water** and **energy** partitioning through impacting <u>**evapotranspiration**</u> and is a critical component of both water and energy cycles

Mass balance



Energy balance



$$V\frac{d\boldsymbol{S}}{dt} = P - \boldsymbol{E}(\boldsymbol{T}, \boldsymbol{S}) - R(\boldsymbol{S})$$

$$c\frac{d\boldsymbol{T}}{dt} = Rad_{net}(\boldsymbol{T}) - H(\boldsymbol{T}) - L \cdot \boldsymbol{E}(\boldsymbol{T}, \boldsymbol{S})$$

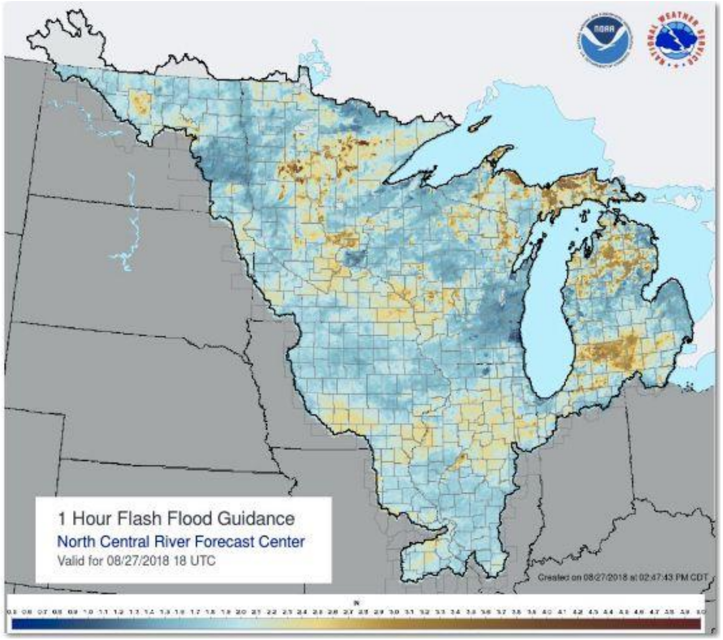
Evaporation & soil moisture **couple mass & energy balances** at land surface

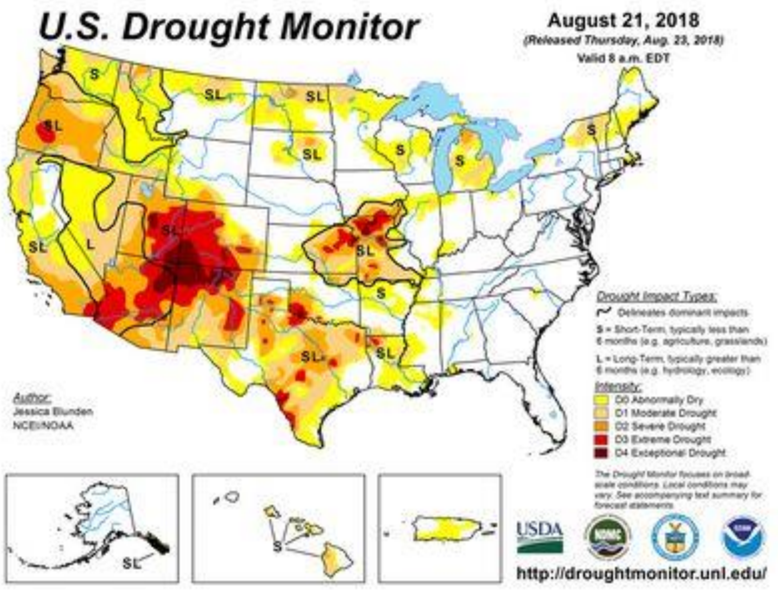
L is the latent heat of vaporization: 2.5×10^{6} [J/kg]

Why Soil Moisture

Applications

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

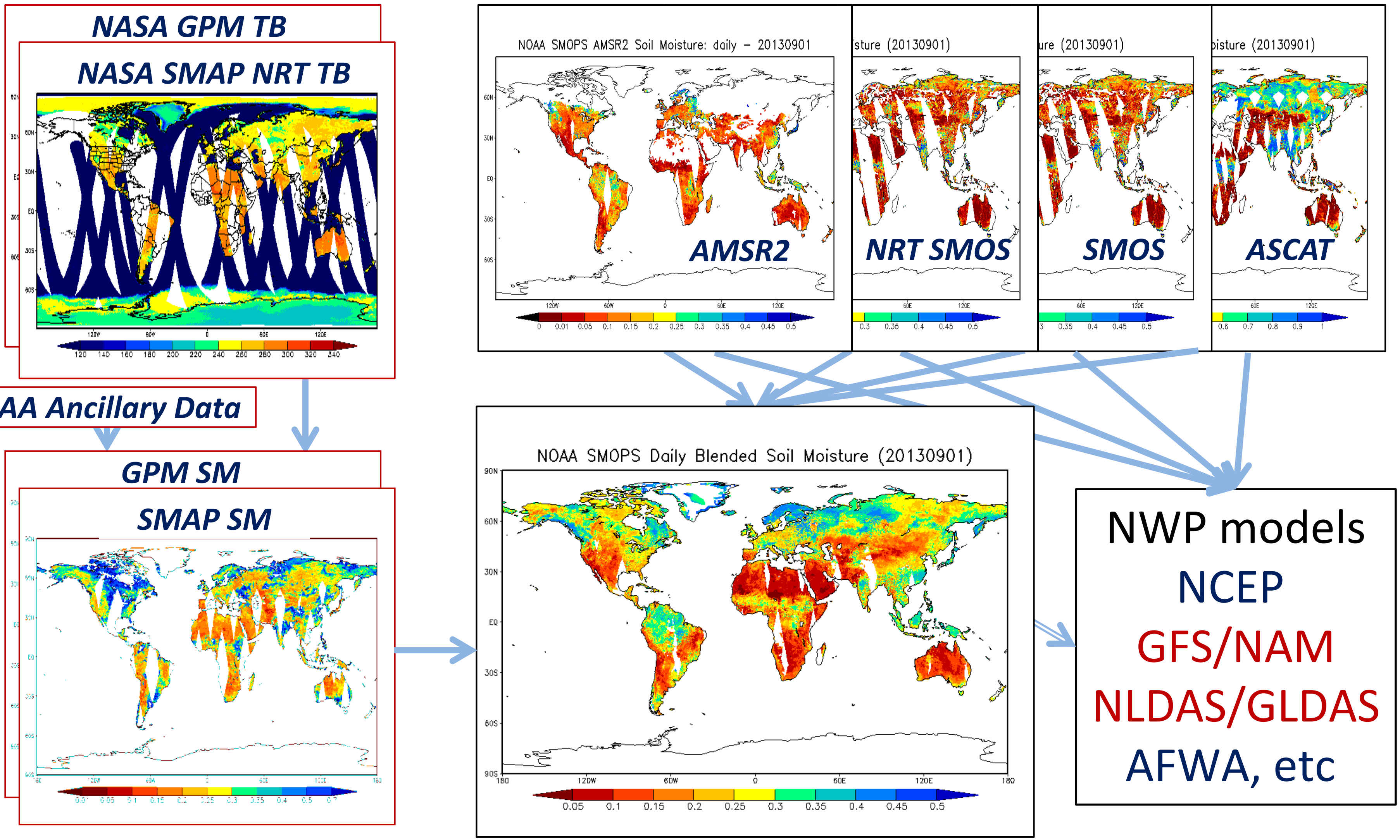




NOAA and National Drought Mitigation Center (NDMC) Operational Drought Indices are also based on *Modeled* Soil Moisture Data.

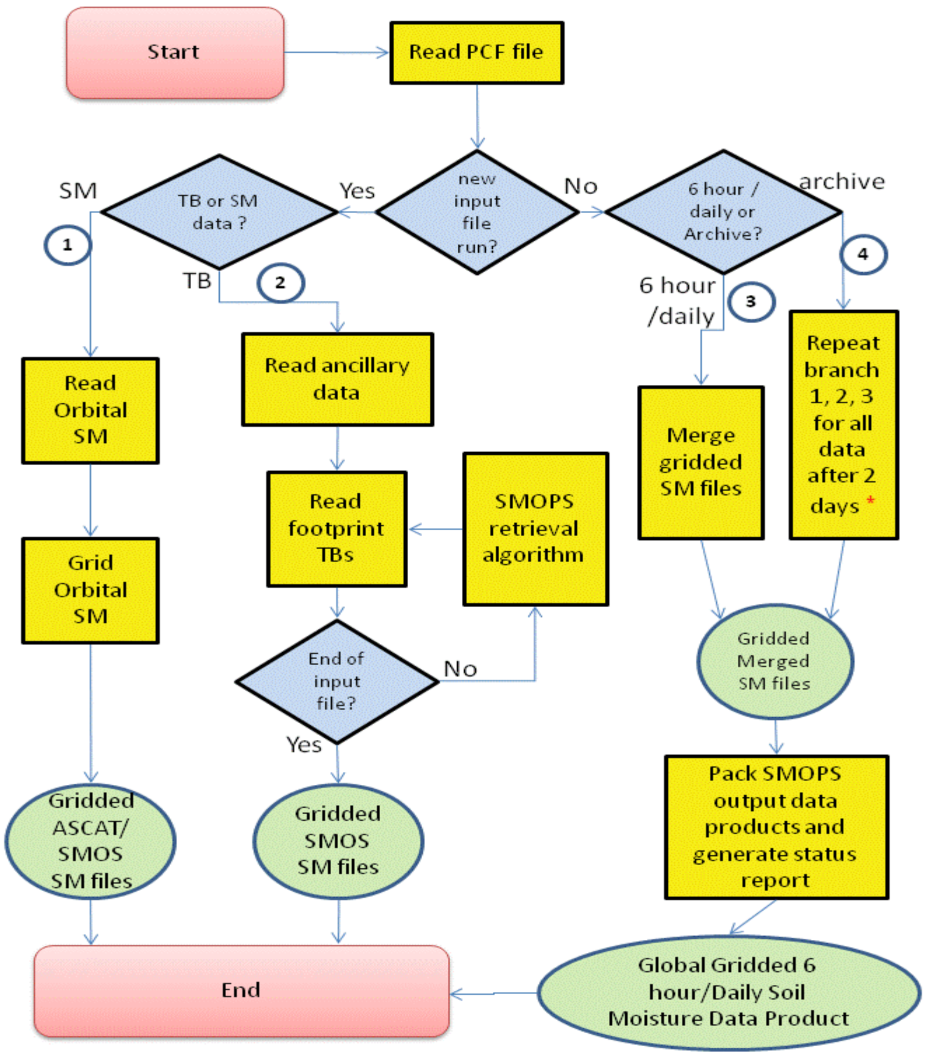
Soil moisture Observational data can replace model data or used to improve model estimates

Soil Moisture Operational Product System (SMOPS)



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)



* *All data acquired within the 6 hour or whole day time period arrived in the past 48 hours*

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

SMOPS Output Data layers

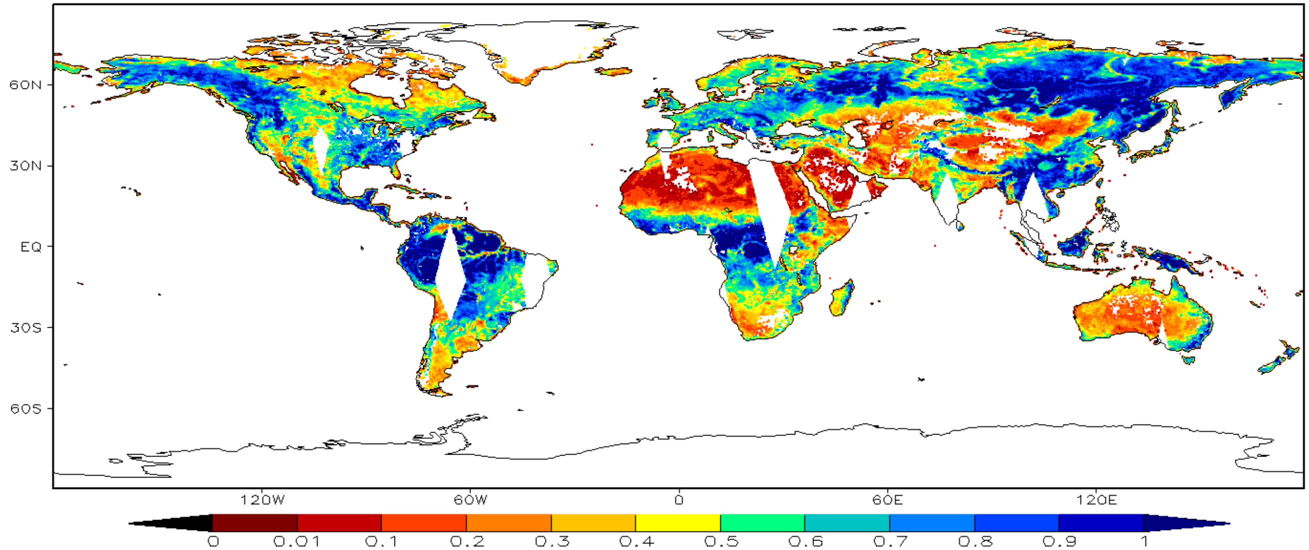
Soil Moisture Product	SMOPS Version 1.3	SMOPS Version 2.0	SMOPS Version 3.0
SMOPS Blended	√ (1)	√ (1)	√ (1)
NOAA AMSR-E	√ (2)	×	×
NOAA NRT SMOS	×	√ (2)	√ (2)
ESA SMOS	√ (3)	√ (3)	√ (3)
EUMETSAT ASCAT-A	√ (4)	√ (4)	√ (4)
EUMETSAT ASCAT-B	√ (5)	√ (5)	√ (5)
NOAA WindSat	√ (6)	×	×
NOAA AMSR2	×	√ (6)	√ (6)
NOAA GMI	×	×	√ (7)
NOAA NRT SMAP	×	×	√ (8)
NASA SMAP	×	×	√ (9)

JPSS GCOM-W1/AMSR2 Soil Moisture

Algorithm and Refinement:

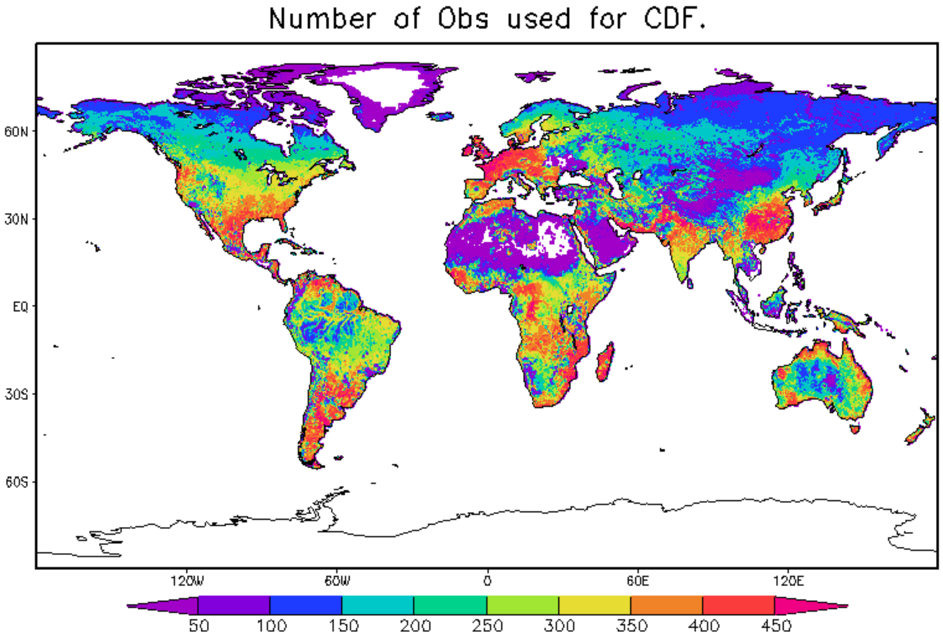
- The LPRM algorithm was used to retrieve Vegetation Optical Depth (VOD) from TBv and TBh
- Derive VOD climatology for Single Channel Algorithm (SCA) of soil moisture retrieval with historical AMSR2 data
- Inverse soil moisture from TBh using the VOD scaled to VOD climatology with CDF matching
- **Improved 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.**

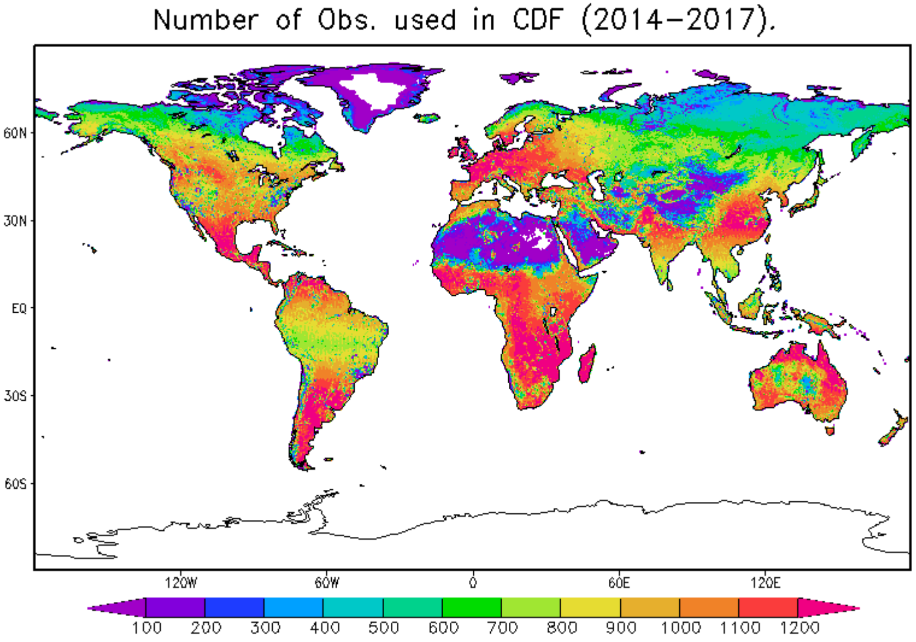
AMSR2 Vegetation OD from LPRM (20170901).



JPSS GCOM-W1/AMSR2 Soil Moisture

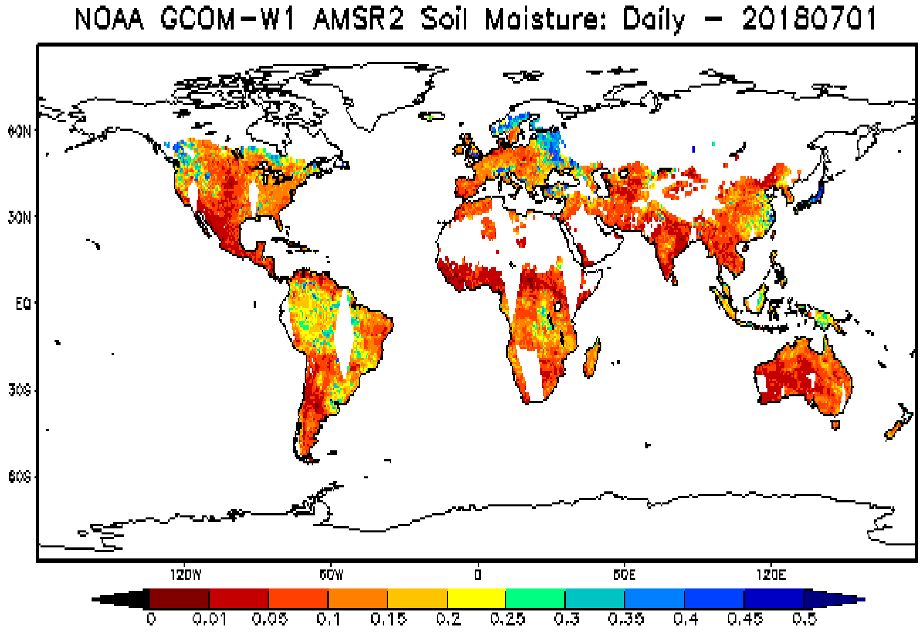
More reliable CDF with more historical AMSR2 data

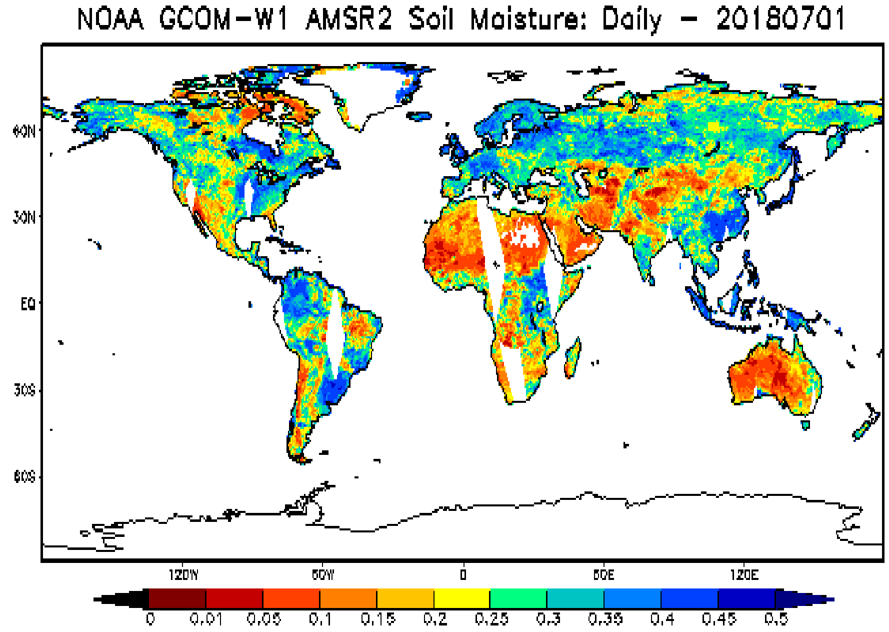




JPSS GCOM-W1/AMSR2 Soil Moisture

Better spatial coverage and the dynamic range of the final product.





JPSS PGRR Project: Sat SM for NWM

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

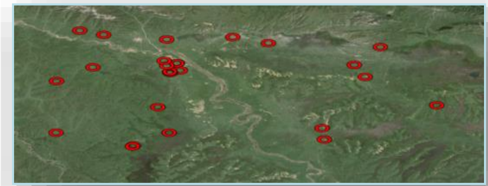
CREST-SMART Network

Millbrook, NY

M. Temimi, et al., 2011

Tibetan Plateau

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



USDA-ARS SM Networks

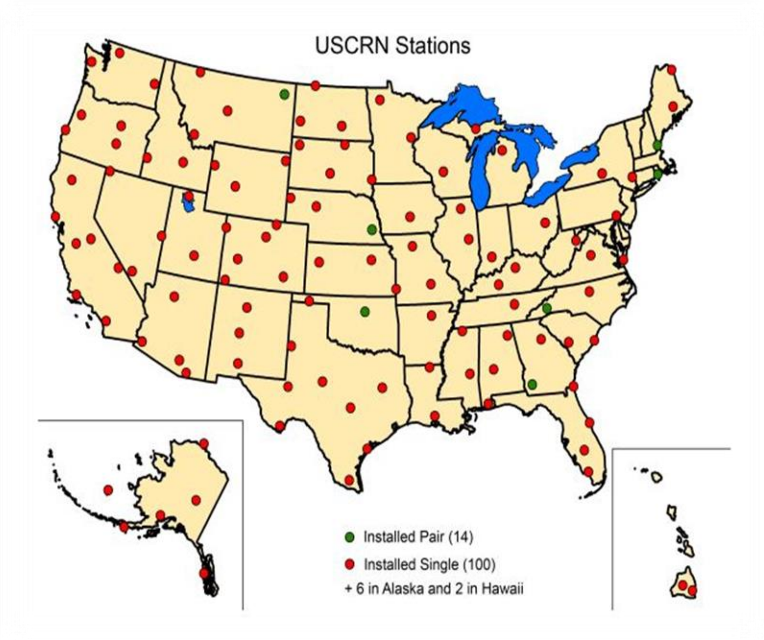
M. H. Cosh, et al. 2008

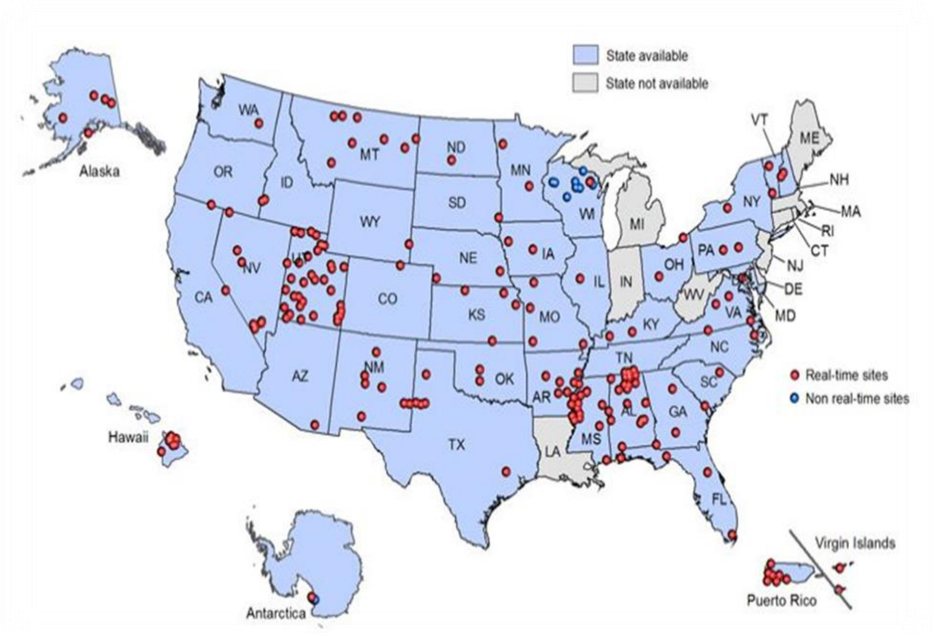
OzNet

Australia; *A. B. Smith, et al., 2012*

Ground SM Measurements for Validation

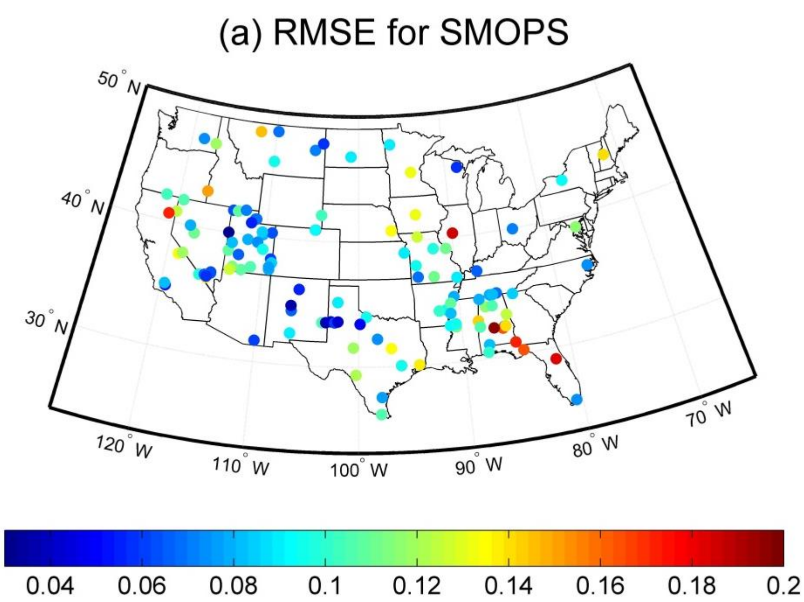
NOAA US Climate Reference Network

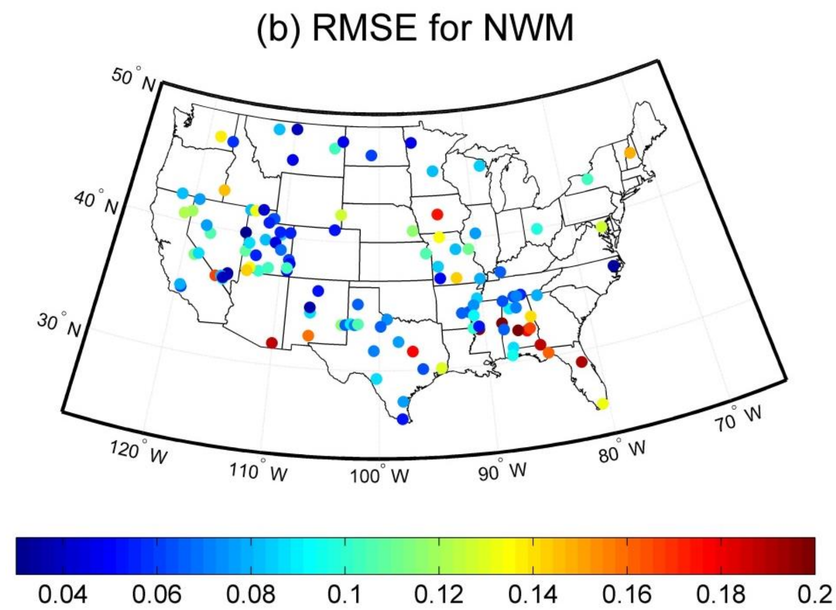


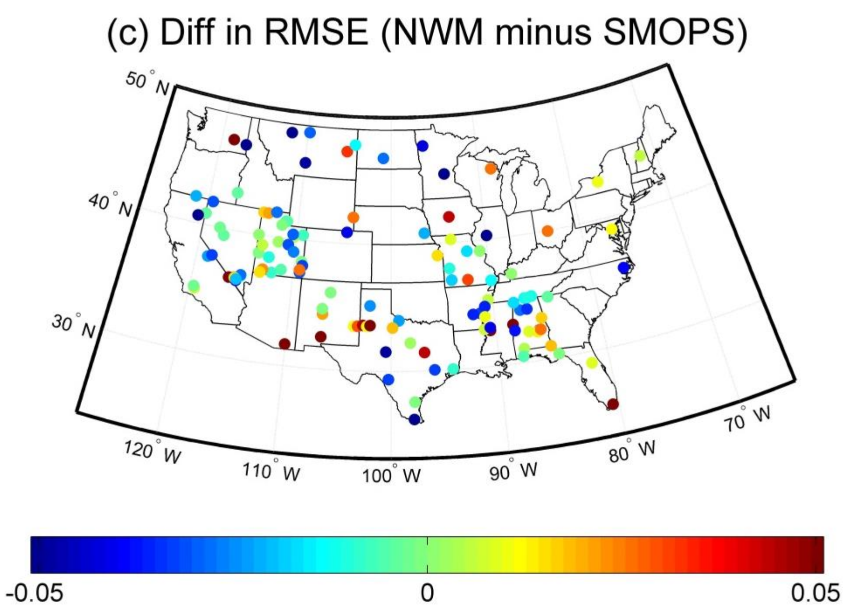


USDA Soil Climate Analysis Network (SCAN)

SMOPS SM Comparison with NWM SM







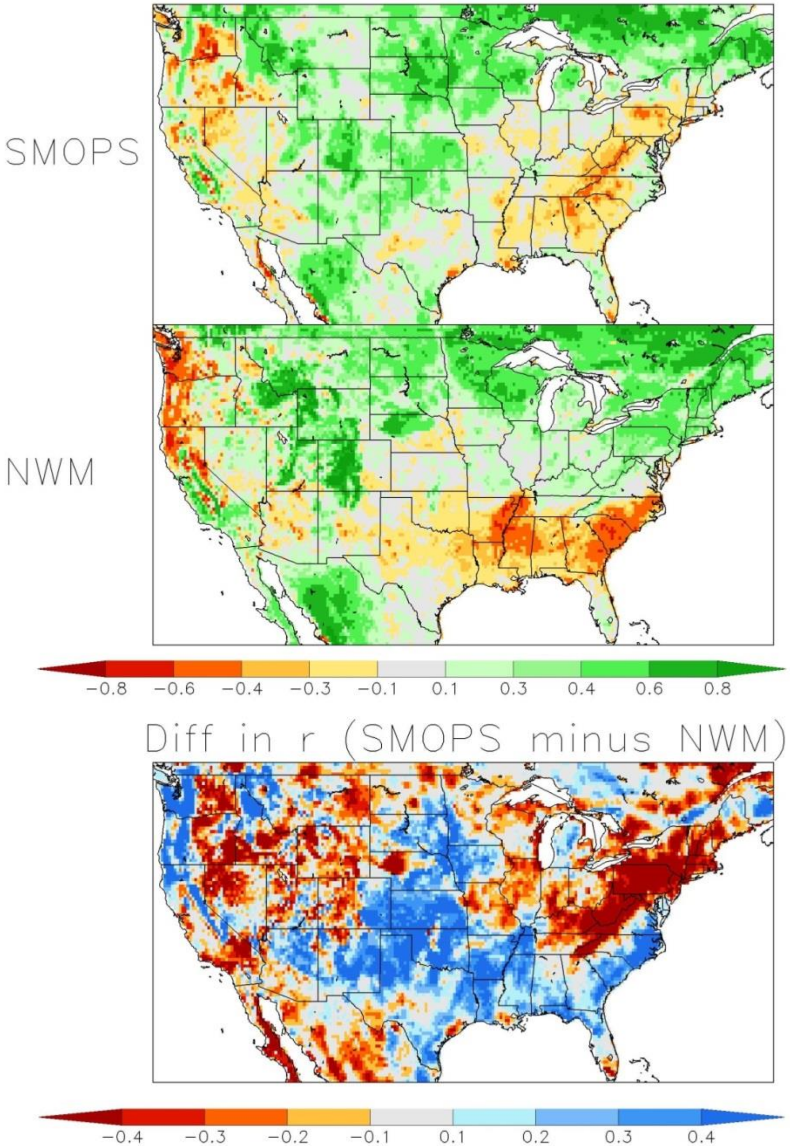
SCAN observations-based RMSE for

(a) SMOPS blended SM,

(b) NWM-based 0-10 cm SM,

(c) their differences.

SMOPS SM Comparison with NWM SM



From top to bottom:
r between 8-daily EVI and
(**Top**) 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

SMAP 36km (L3_SM_P) | **Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E)** | **Downscaled SMAP SM at 9km based on Thermal Inertial Linear Regression Algorithm using ESI** | **Downscaled SMAP SM at 1km based on Regression Tree Algorithm, using MODIS LST and LAI (1km)**

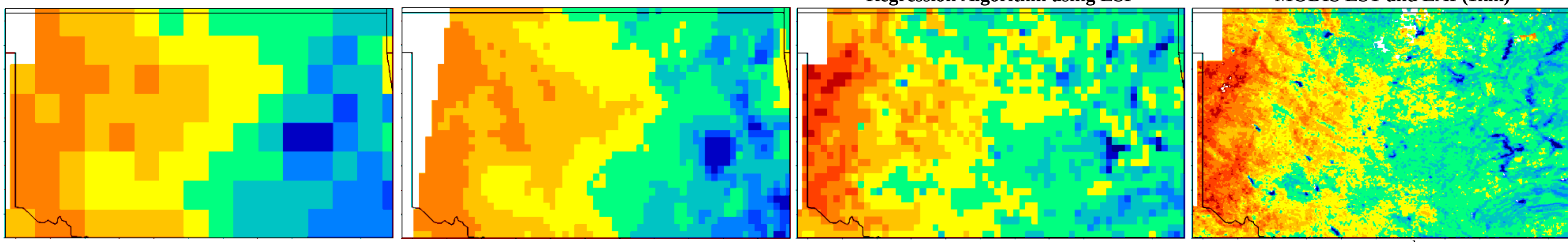


Figure 1. Comparison of SMAP SM data sets to be validated, over Oklahoma region (100.15W~ 94.53W, 34.2N~37.06N), on April 30th, 2015, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP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

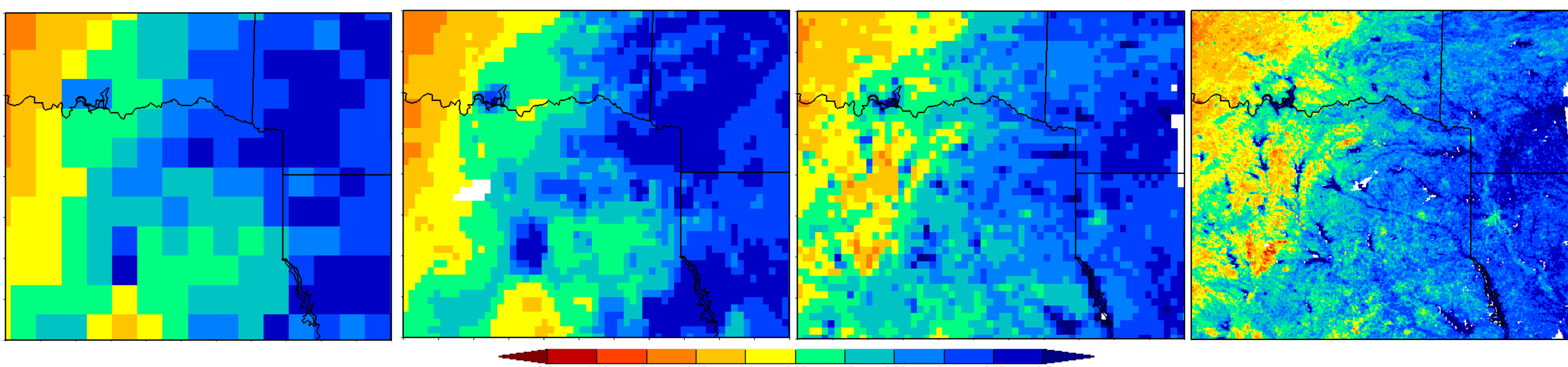
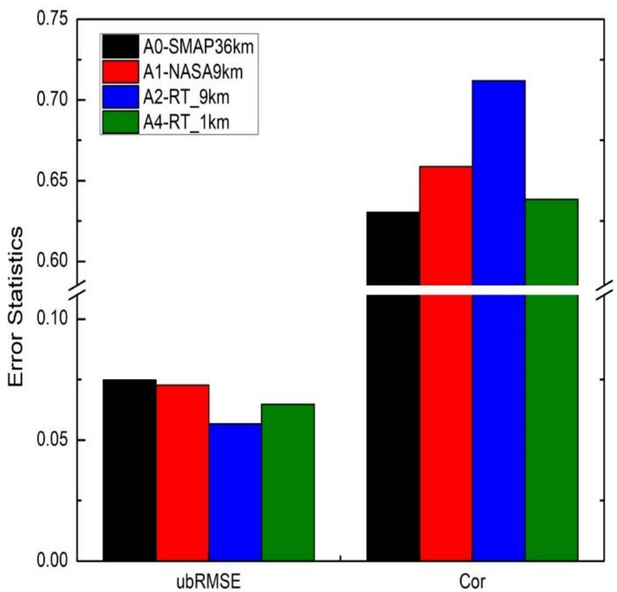
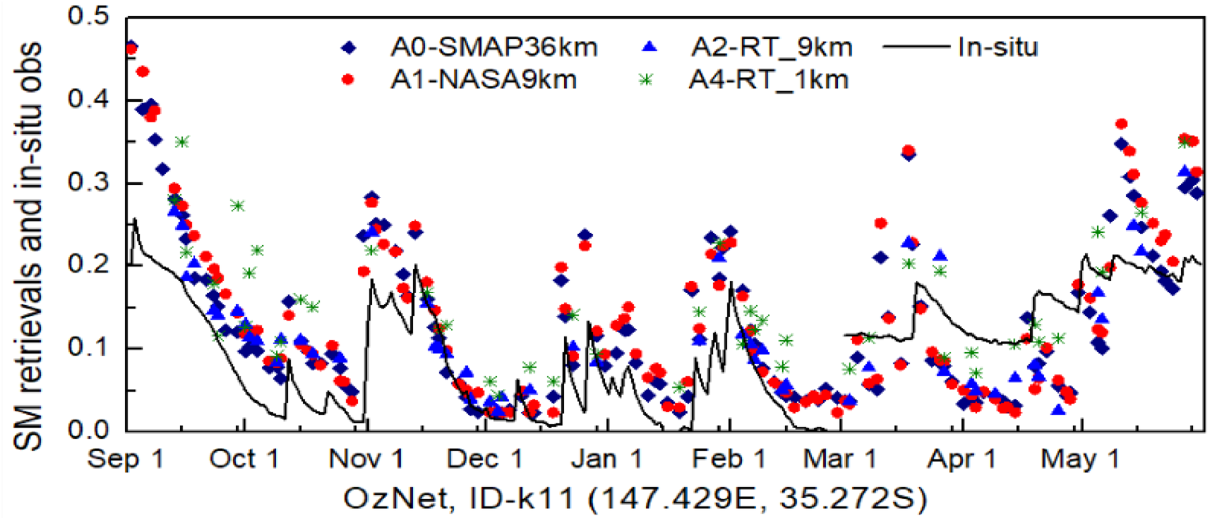


Figure 2. Comparison of SMAP SM data sets to be validated, over Texas region (98W~ 92.5W, 31N~35N), on April 2nd, 2016, including 1) SMAP SM product at 36km (L3_SM_P); 2) Enhanced SMAP radiometer-based SM at 9km (L3_SM_P_E); 3) Downscaled SMAP SM at 9km based on ESI; 4) Downscaled SMAP SM at 1km based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

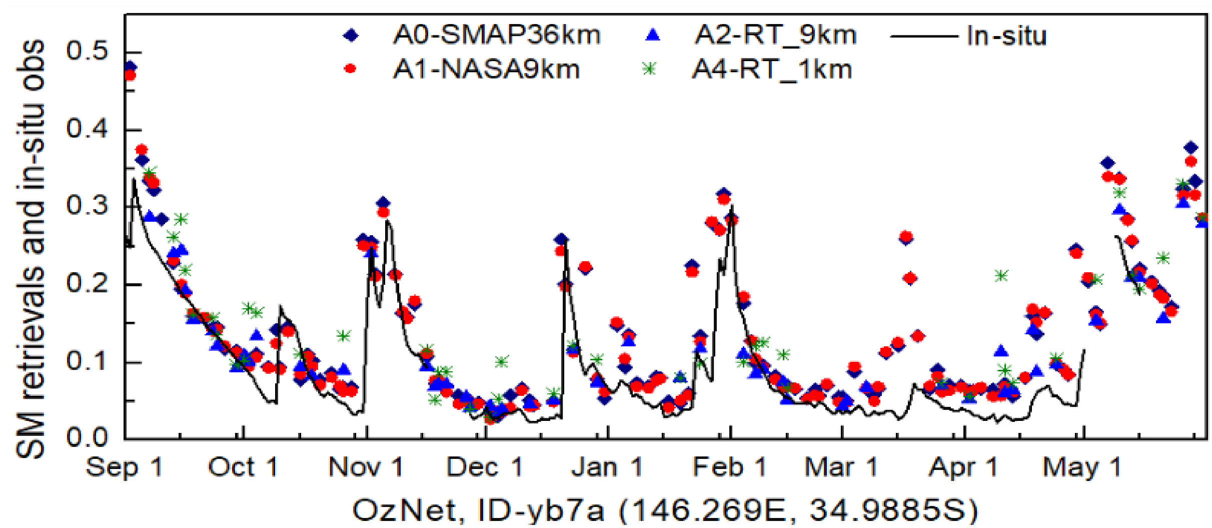
Downscaling for High Resolution for NWM



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



ubRMSE	A0-SMAP36	A1-NASA9	A2-RT_9km	A4-RT_1km
k11	0.0723	0.0748	0.0529	0.0621
yb7a	0.0556	0.0554	0.0434	0.0352



Summary and Path Forward

- *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*