GCOM-W1/AMSR2 SOIL MOISTURE

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Outline

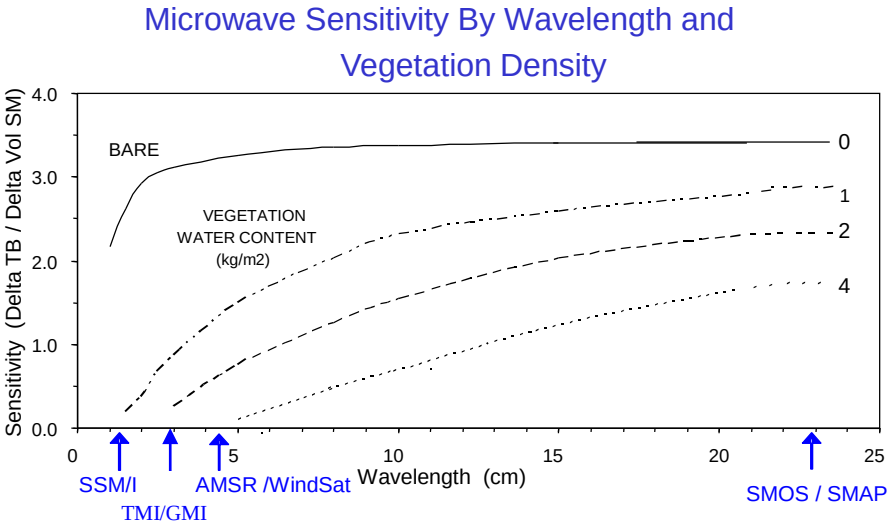
- AMSR2 Soil Moisture EDR Team Members
- Soil Moisture Sensor Overview
- AMSR2 Soil Moisture Algorithm
- AMSR2 Soil Moisture Data Product
- Summary and Path Forward

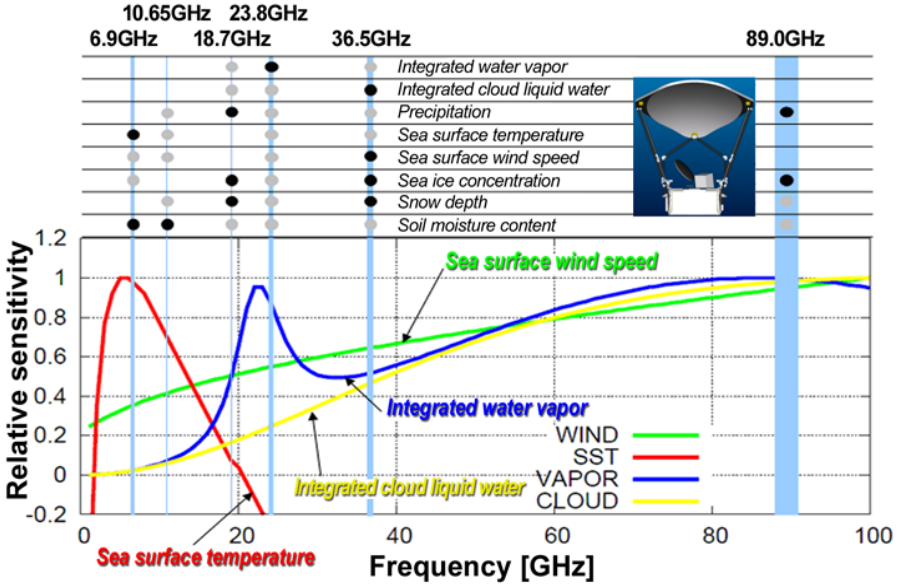
AMSR2 Soil Moisture Team Members

Team Member	Organization	Roles and Responsibilities
Xiwu Zhan	NESDIS-STAR	AMSR2 Soil Moisture Team Lead
Jicheng Liu	UMD-CICS/ NESDIS-STAR	SM Algorithm and Validation Lead
Tom King	IMSG/ NESDIS-STAR	GAASP Development Lead
Zorana Jelenak	UCAR/ NESDIS-STAR	JPSS GCOM-W1 EDR Lead
Ralph Ferraro	NESDIS-STAR	JPSS GCOM-W1 Project Deputy
Paul Chang	NESDIS-STAR	JPSS GCOM-W1 Project Lead

Soil Moisture Sensor Overview

- Soil Moisture remote sensing is based on the sensitivity of L/C/X band microwave emission to soil dielectric constant
- Soil moisture capable passive microwave satellite sensors include: SMMR, SSM/I and SSMIS, AMSR/AMSR-E, WindSat, **SMOS**, **AMSR2**, **GMI** and **SMAP**
- AMSR2 on board of JAXA's GCOM-W1 satellite is currently the **only** **operational passive microwave soil moisture** sensor in NASA-NOAA JPSS program





JPSS Requirements for AMSR-2 Soil Moisture EDR

Table 6.1.10 - GCOM-W Soil Moisture		
EDR Attribute	Threshold	Objective
Applicable conditions	Delivered under “all weather” conditions	Delivered under “all weather” conditions
Sensing depth	Surface to -0.1 cm (skin layer)	Surface to -80 cm
Horizontal cell size	25 km (1)	3 km
Mapping uncertainty, 3 sigma	5 km	1 km
Measurement Uncertainty	6% volumetric RMSE (goal) with VWC < 1.5 kg/m^2 or GVF < 0.5 and < 2 mm/hr precip rate	Surface: 5% 80 cm column: 5%
Measurement range	0 – 50%(2)	0 – 50%
Refresh	At least 90% coverage of the globe about every 20 hours (monthly average)(3)	n/s

Note:
(1) Per AMSR-E legacy and user convenience, 25km can be obtained with resampling AMSR-2 footprints to 25km. 3km could be obtained by interpolation with VIIRS optical observations
(2) Absolute soil moisture unit (m^3/m^3 volume %) is preferred by most users of NWP community
(3) This Refresh requirement is consistent with the AMSR-2 Cross-track Swath Width design of 1450 km for a single orbit plane

Soil Moisture Algorithm Overview

Land Parameter Retrieval Model (LPRM) :

(Owe, de Jeu & Holmes, 2008)

$$\min\{delta = T_{Bh}^{obs} - T_{Bh}^{cmp}\}$$

$T_{Bh}^{cmp} = T_s \{e_{h,r} \exp(-\tau/\cos\theta) + (1 - \omega)[1 - \exp(-\tau/\cos\theta)][1 + (1 - e_{h,r})\exp(-\tau/\cos\theta)]\}$

$\tau = f(MPDI)$, $MPDI = (T_{Bv} - T_{Bh})/(T_{Bv} + T_{Bh})$

$e_h = f(e_s, h, Q)$

$e_s = f(\varepsilon)$ -- Fresnel Equation

$\varepsilon = f(SM)$ -- Mixing model (Wang & Schmugge)

$T_s = f(T_{B37v})$ or T_s^{LSM}

$T_{Bh}^{obs} = T_{B06h}$, T_{B07h} or T_{B10h}

Soil Moisture Algorithm Overview

Single Channel Algorithm (SCA) :

(Jackson, 1993)

$$T_{B10h} = T_s\,[1 - (1-e_r)\exp(-2\tau/\cos\theta)]$$

$$\tau = b * VWC,\ VWC = f(NDVI)$$
$$e_h = f(e_v, h, Q)$$
$$e_s = f(\varepsilon) \quad \text{-- Fresnel Equation}$$
$$\varepsilon = f(SM) \quad \text{-- Mixing model}$$
$$T_s = f(T_{B37v}) \text{ or } T_s^{LSM}$$

AMSR2 Soil Moisture Algorithm

SCA: Inverse tau-omega equation of a TB_h (C/X-band) for *SM* with *tau* from *NDVI* and T_s from TB_{36v}. Used in SMOPS

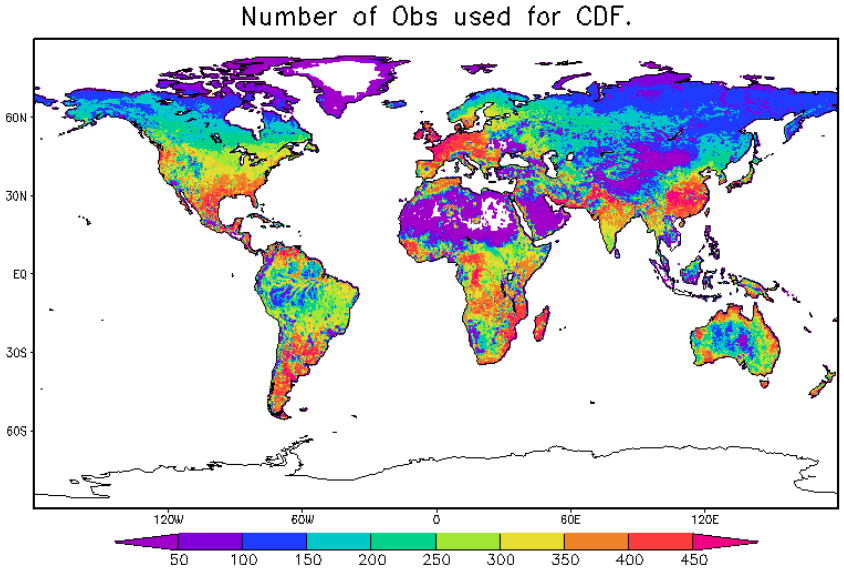
LPRM: Inverse tau-omega equations of TB_h and TB_v (C/X-band) for *tau* and *SM* with T_s from TB_{36v}

Hybrid: Use LPRM inversed *tau* in SCR for AMSR2 soil moisture EDR

AMSR2 Soil Moisture Algorithm Update

1. Fine-tuning of LPRM model parameters for better spatial coverage of valid retrievals.
2. Updating static data base with longer data period.

CDF Version 1.0 (2013-2014)



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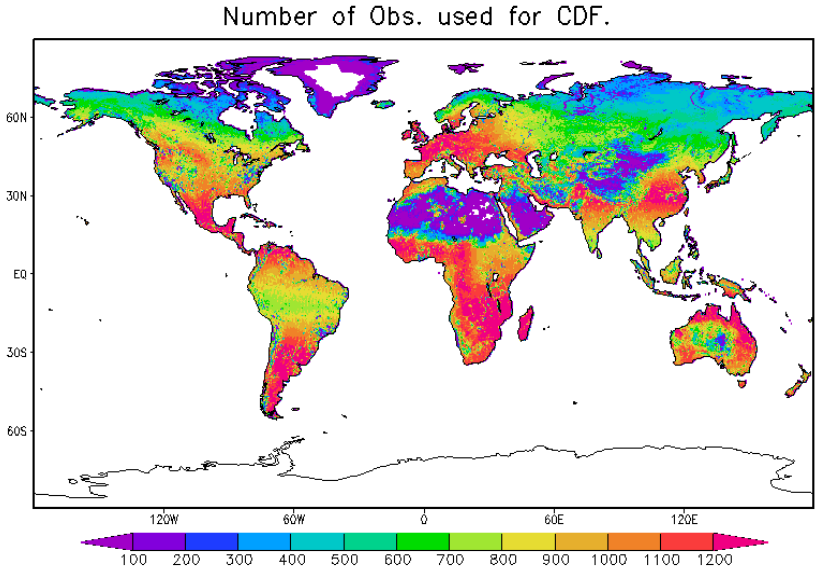
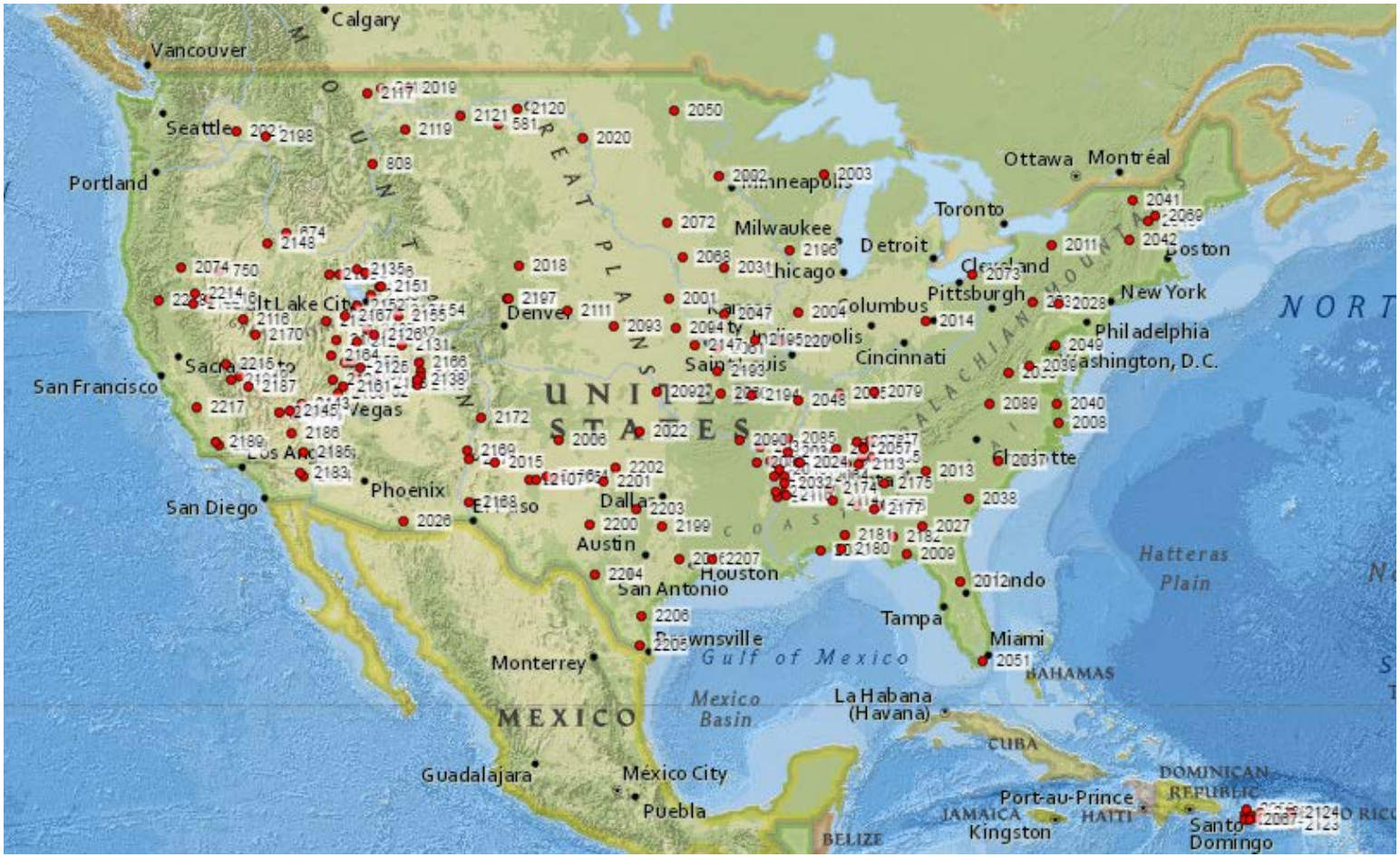


AMSR2 Soil Moisture Products

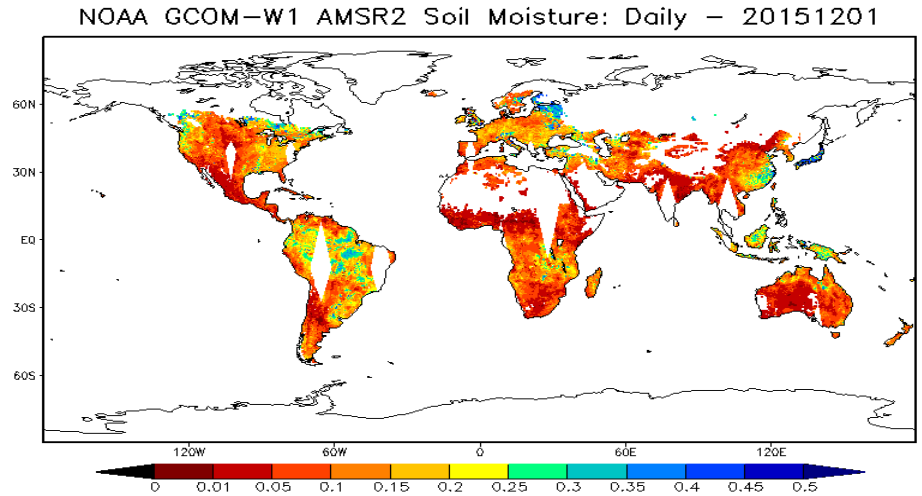
- AMSR2 soil moisture EDR is generated with the hybrid algorithm implemented in NESDIS GCOM-W1 AMSR2 Algorithm Software Processor (GAASP) using AMSR2 6.9/7.3GHz H-pol TB data, available as Level 2 swath product
- Global 0.25 degree (Level 3) gridded AMSR2 soil moisture data product are made available through NESDIS Global Soil Moisture Operational Product System (SMOPS) in 6 hour or daily NetCDF and GRIB2 files
- Algorithm Readiness Review for the Day 2 EDR of GCOM-W1 products was held in May 2016
- SMOPS update for AMSR2 to provide Level 3 global soil moisture product for users has been operational since September 2016

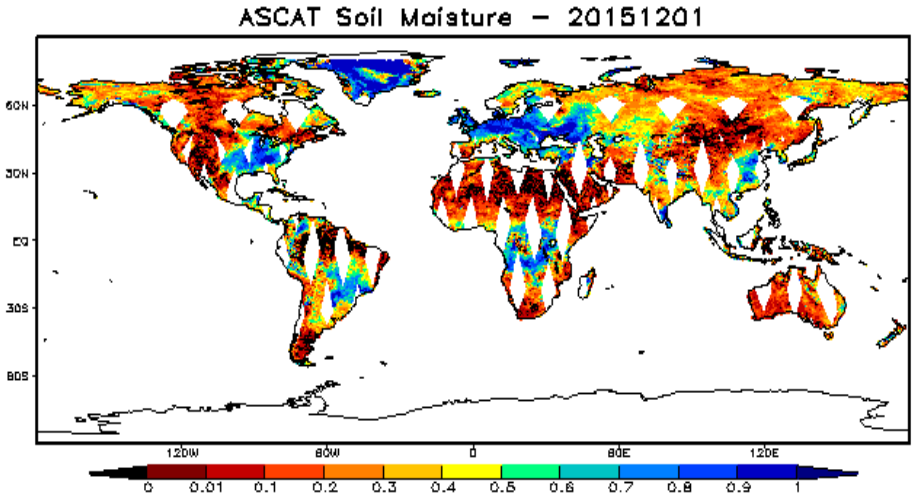
AMSR2 Soil Moisture Performance

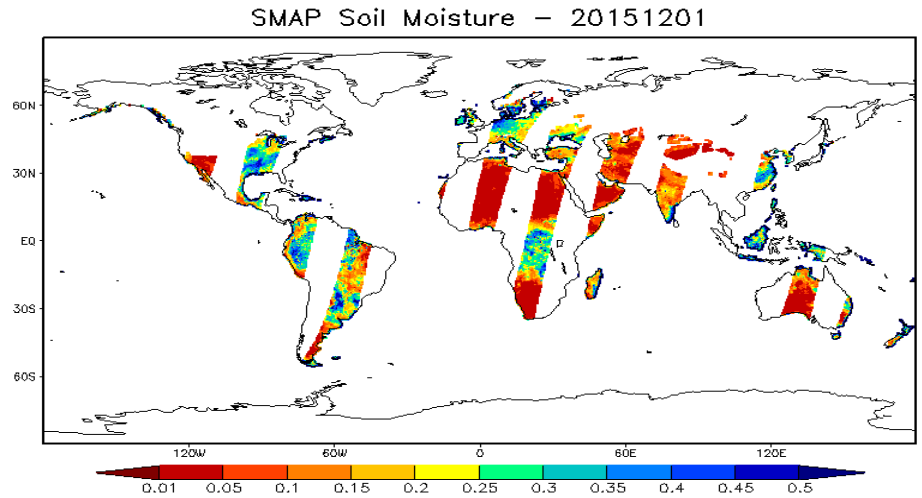
Comparison with in situ Measurements of SCAN Sites

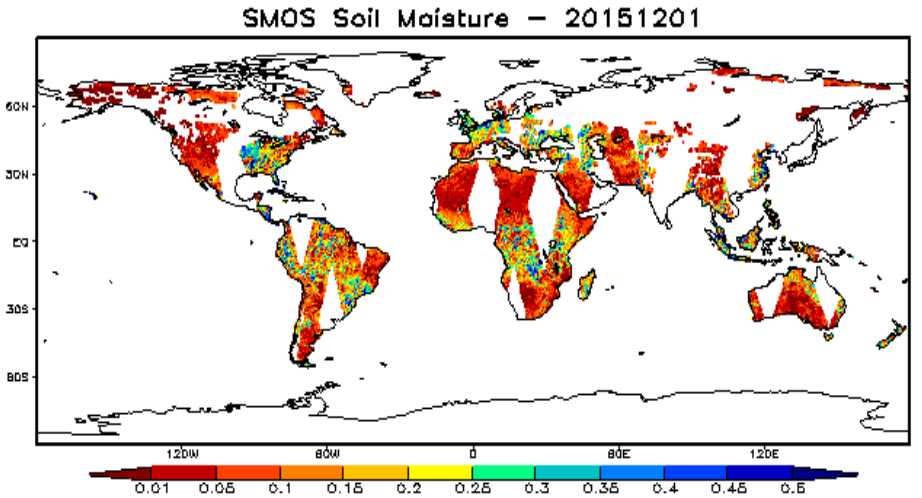


AMSR2 SM vs Other SM Products



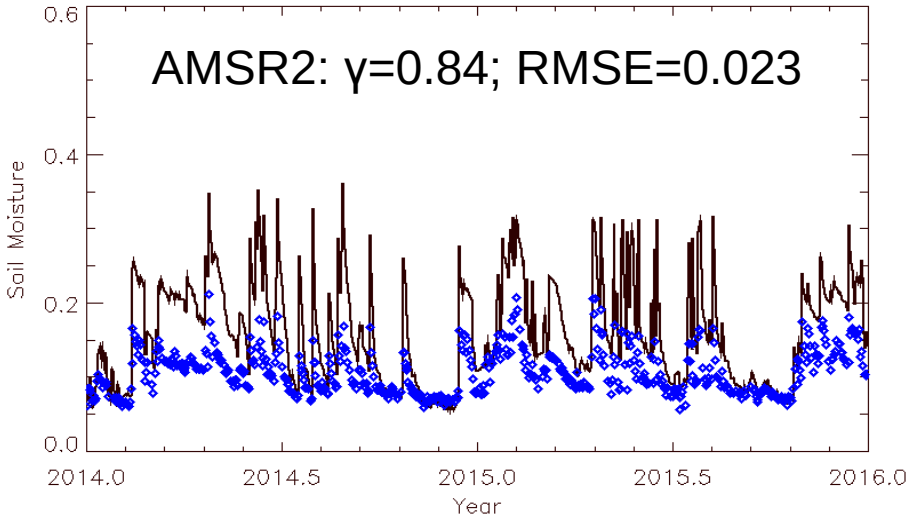


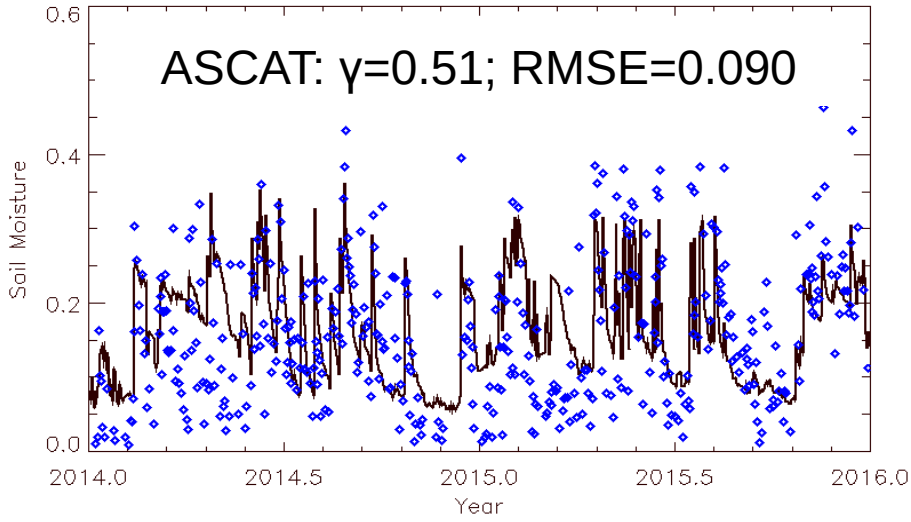


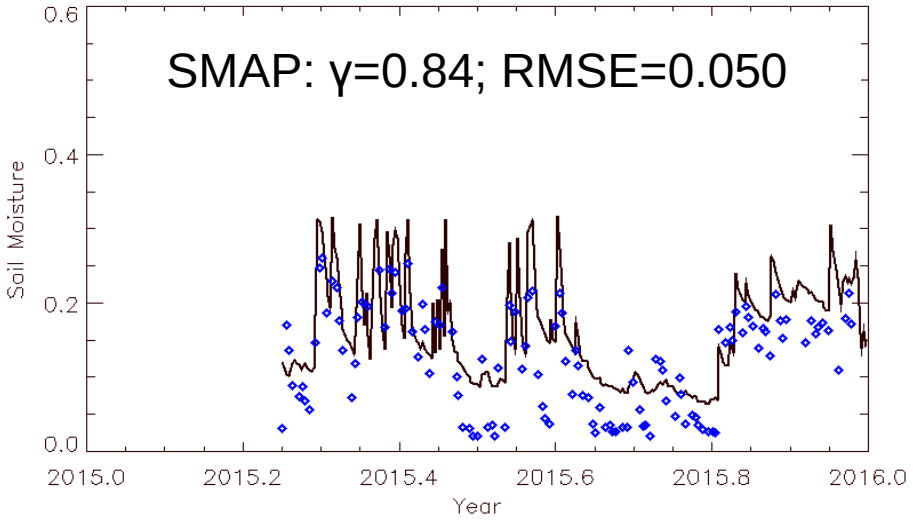


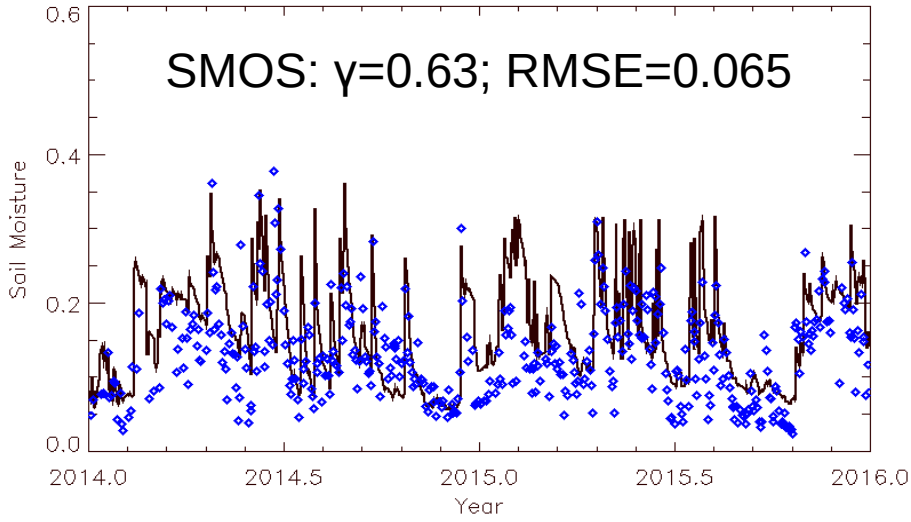
AMSR2 SM vs Other SM Products: Phillipsburg, KS

(γ: correlation coefficient; RMSE: Root Mean Square Error)



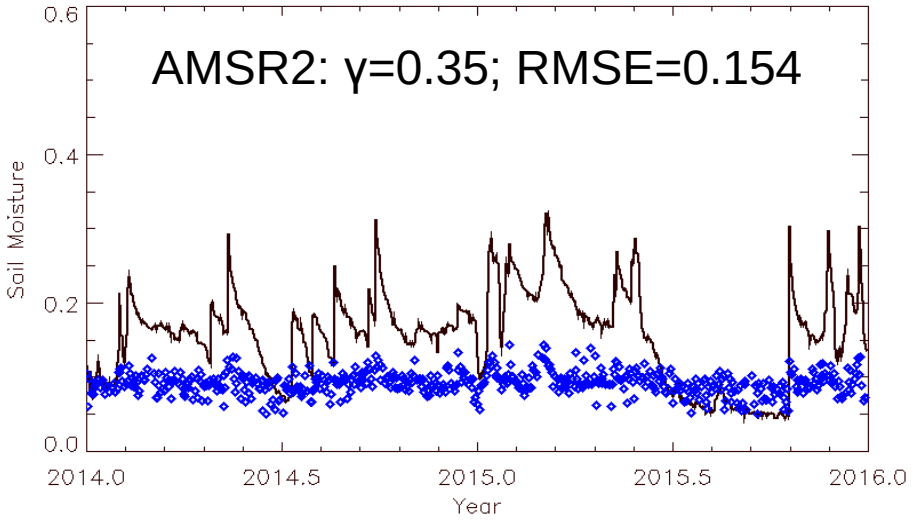


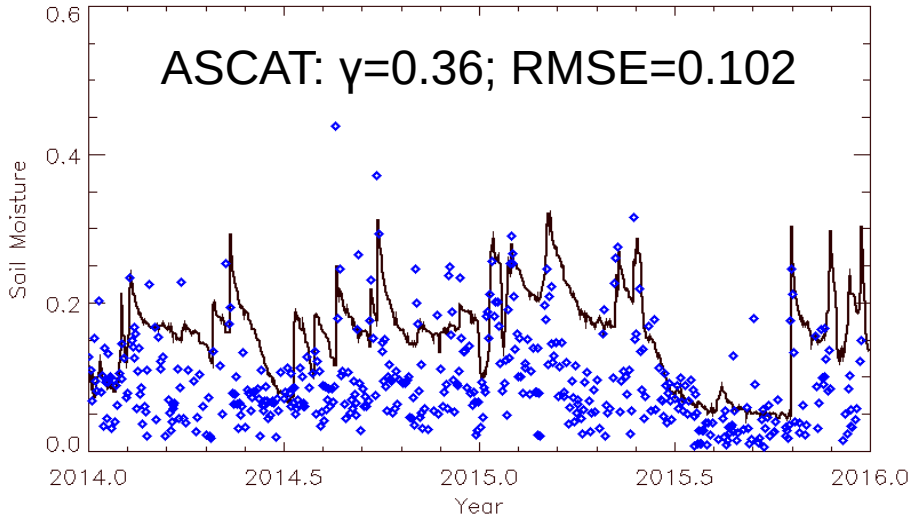


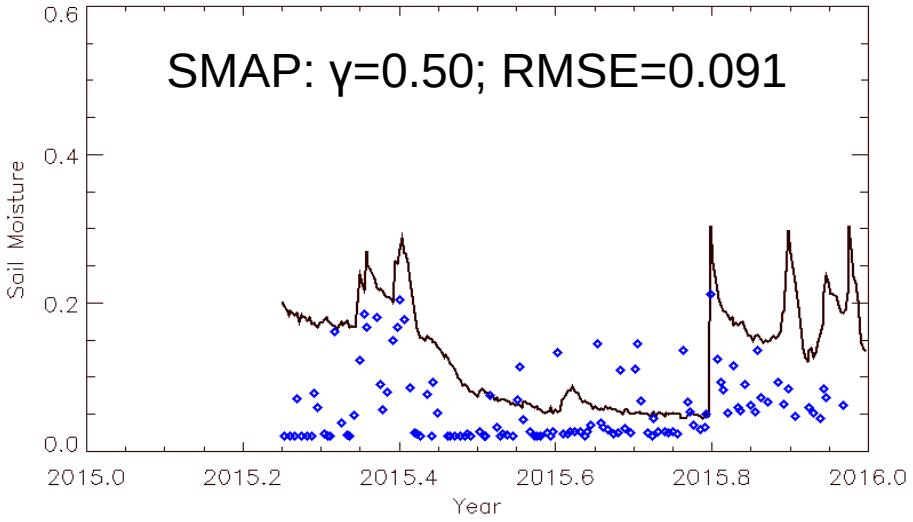


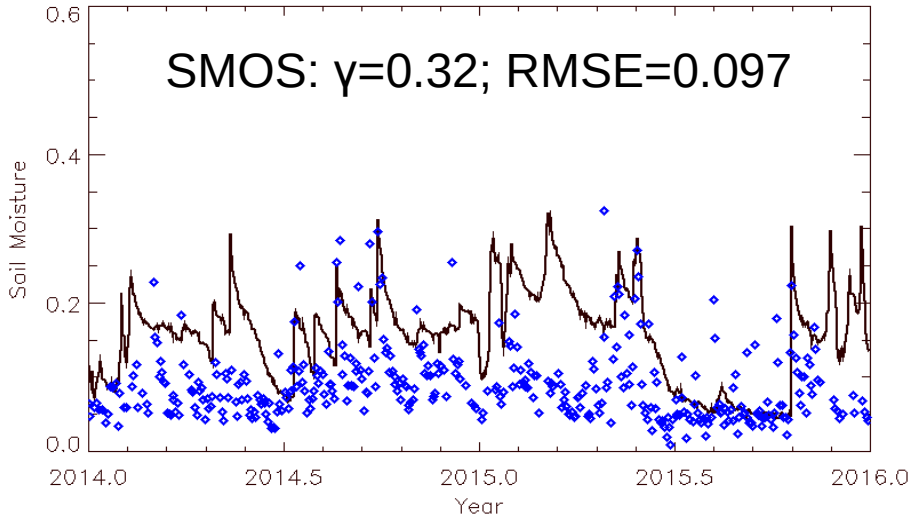
AMSR2 SM vs Other SM Products: Milford, UT

(γ: correlation coefficient; RMSE: Root Mean Square Error)

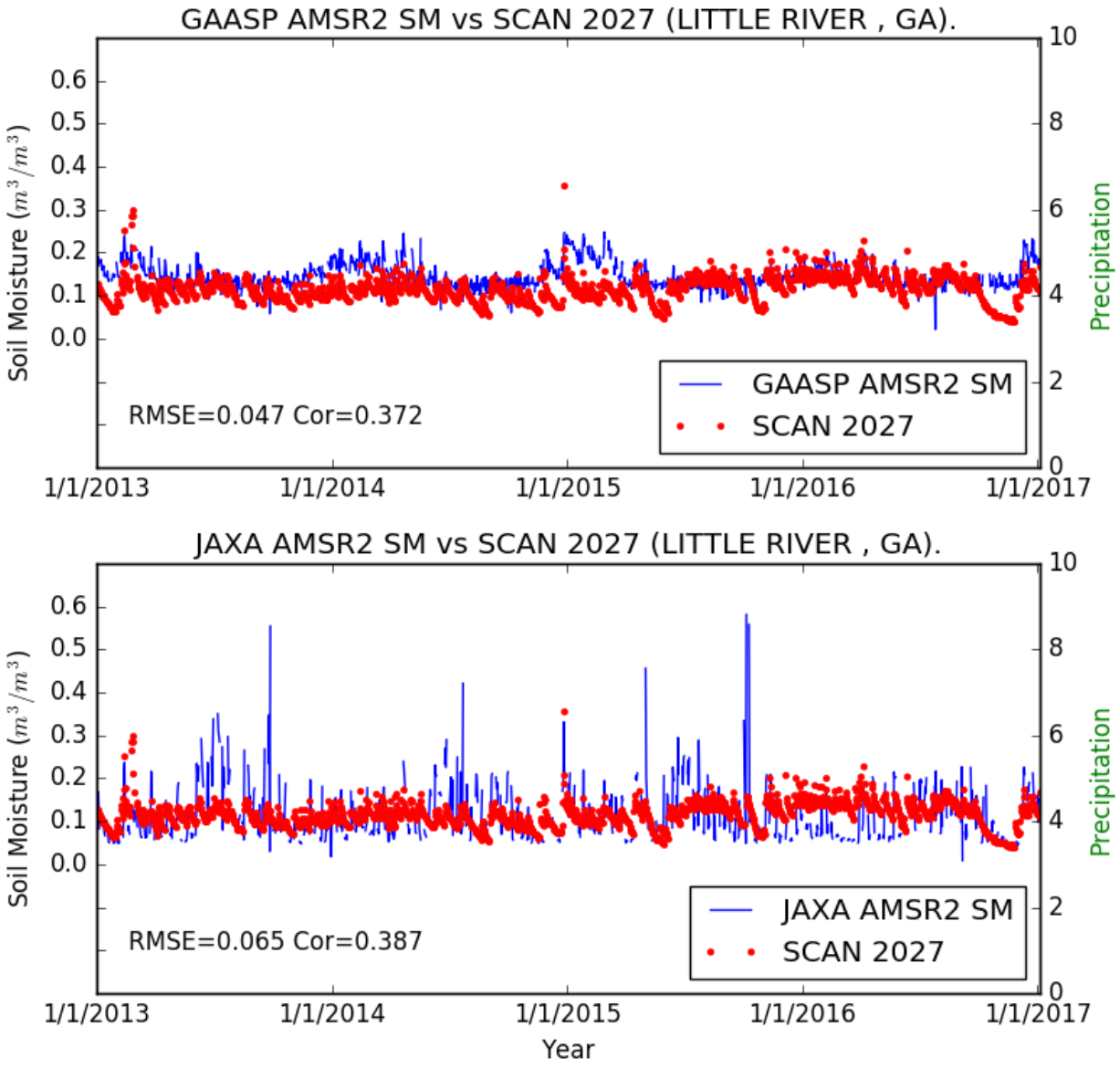








AMSR2 SM Performance: NOAA vs JAXA



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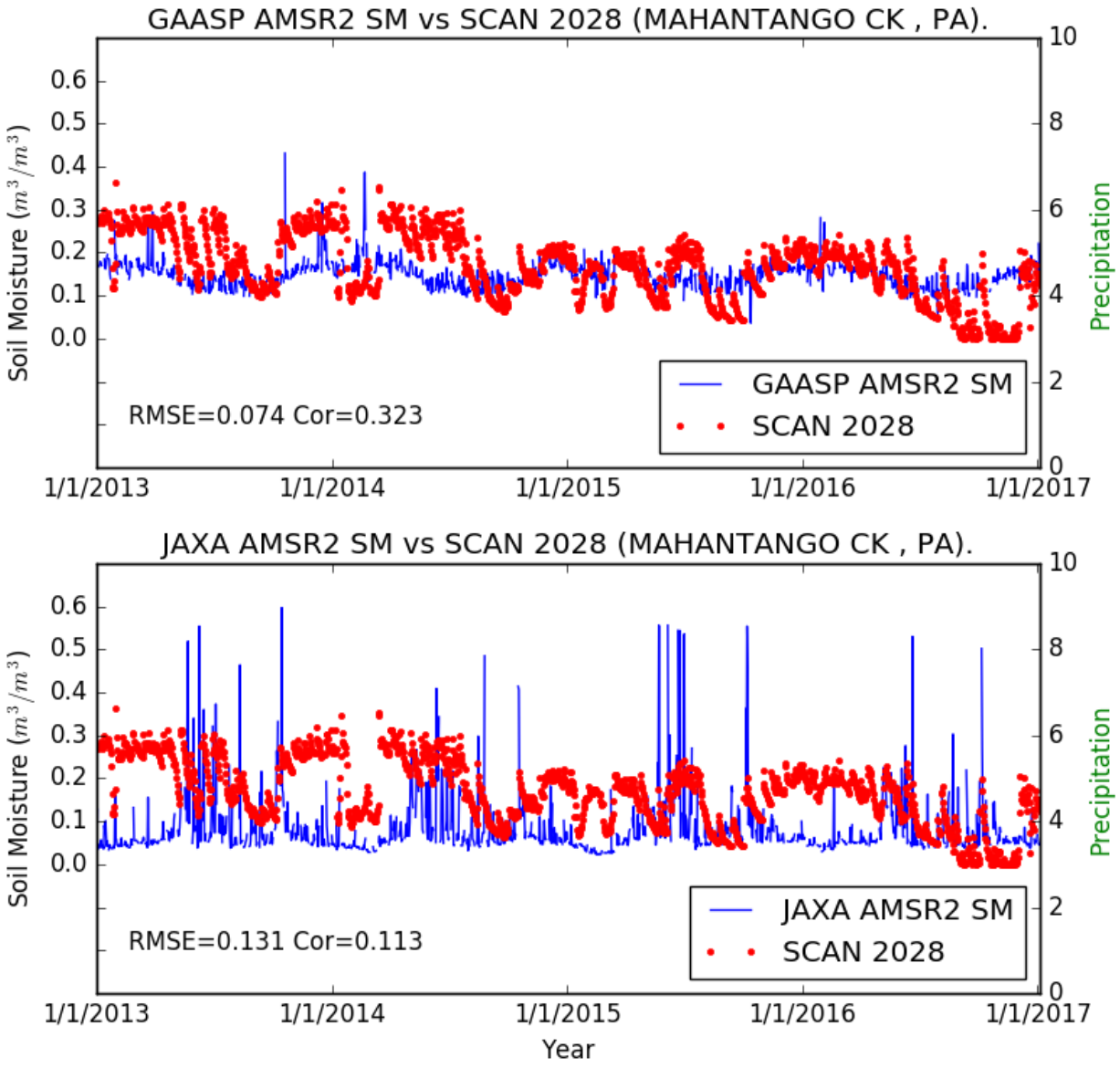

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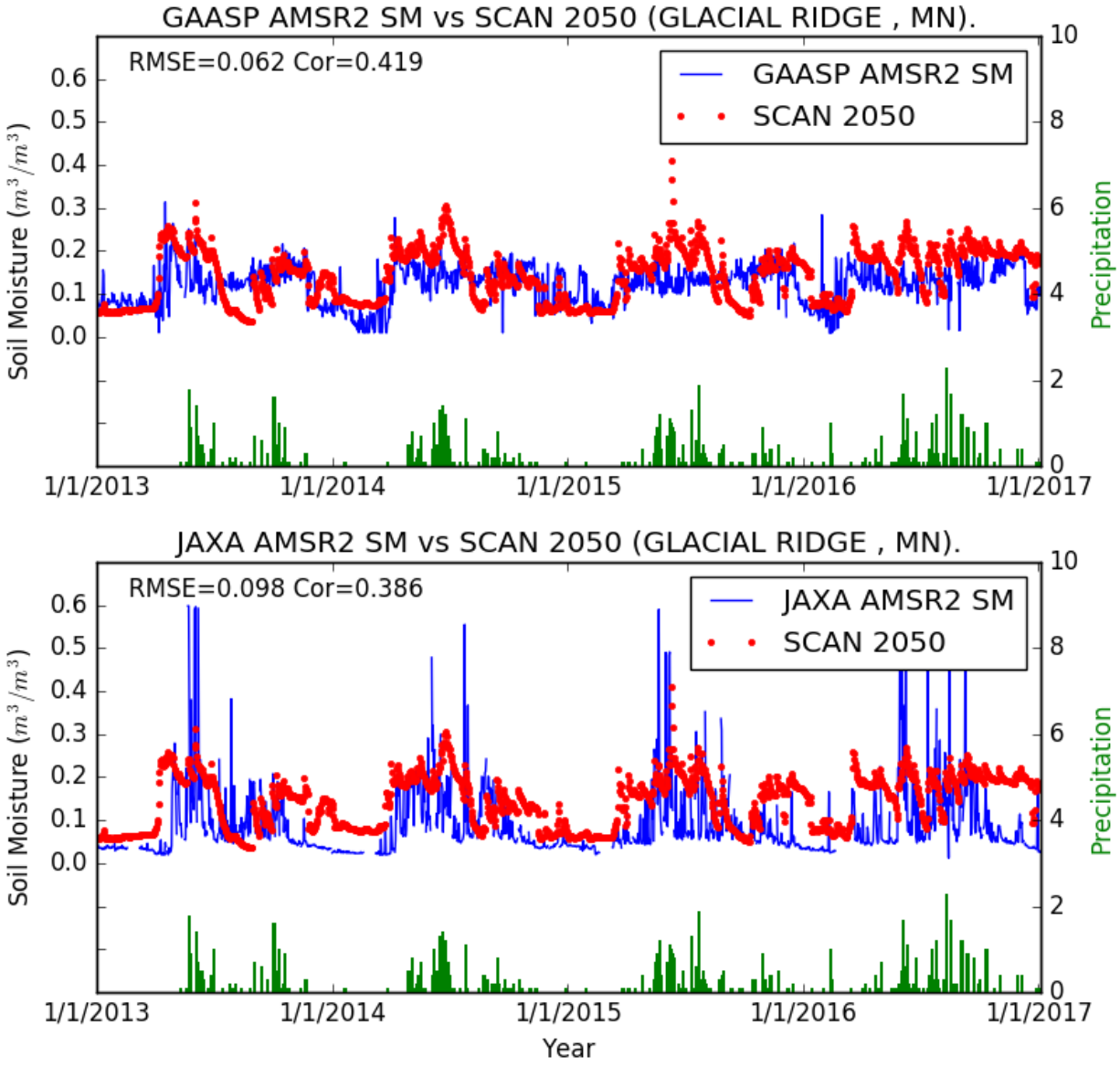

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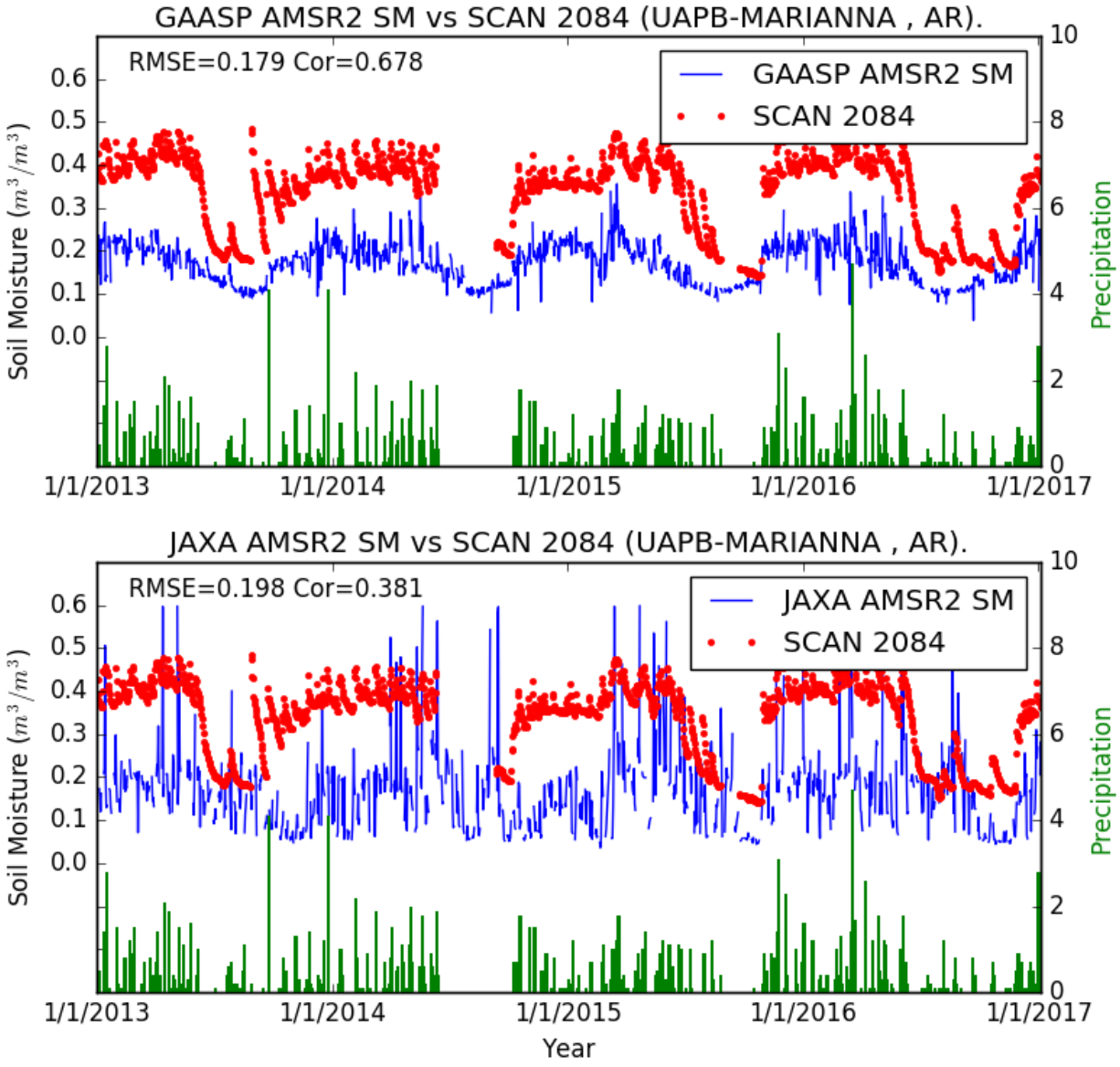

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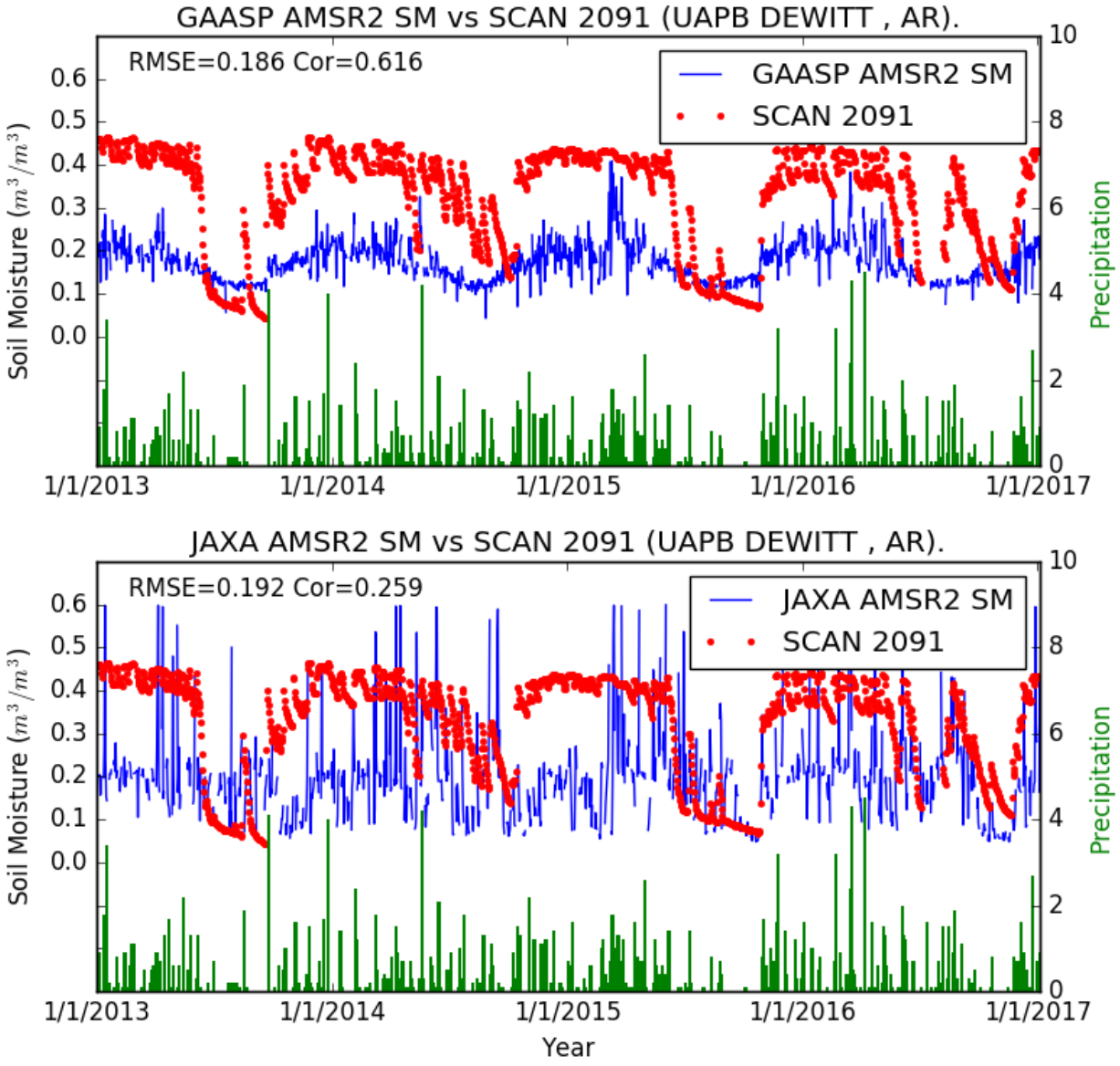

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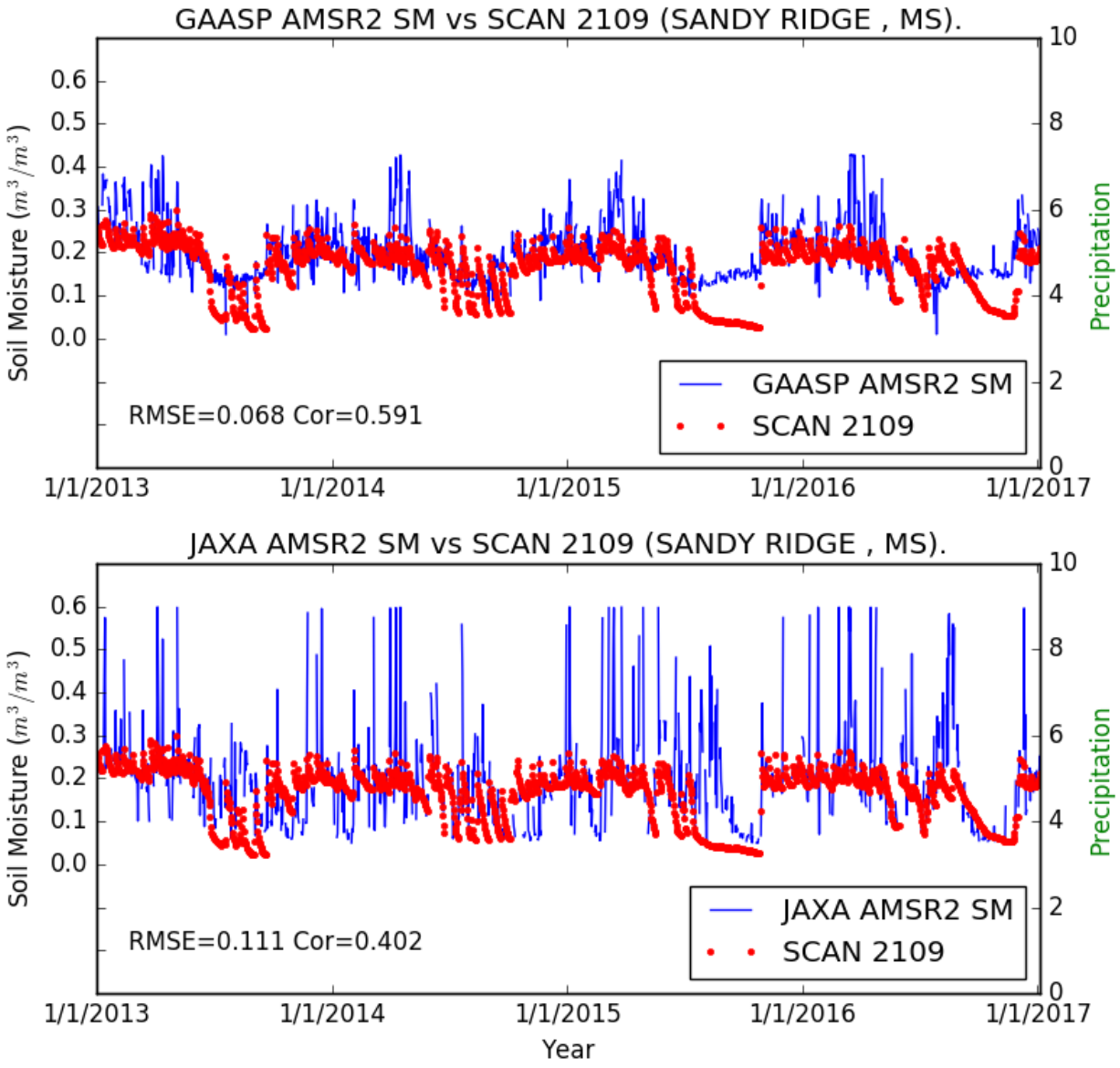
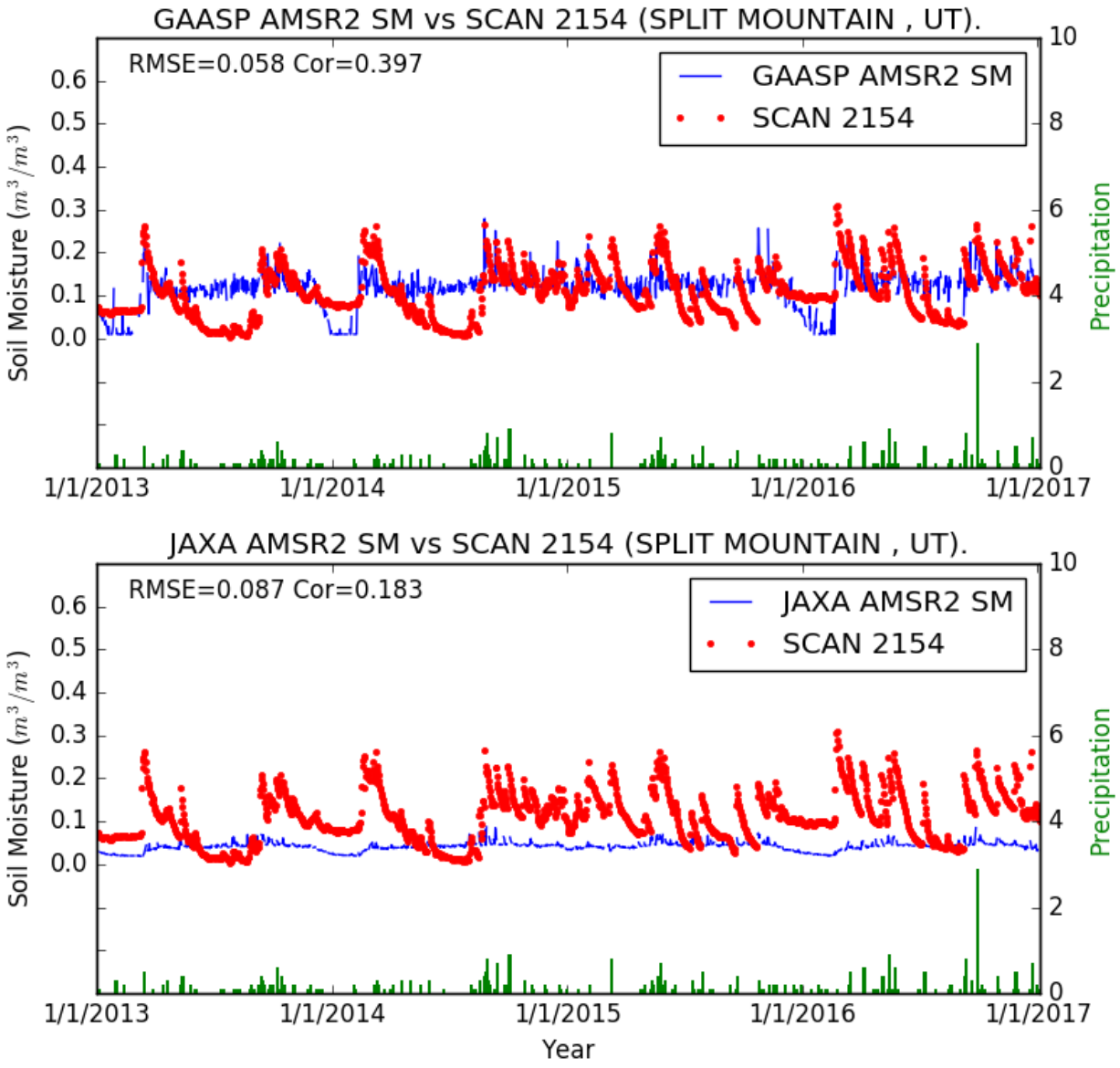


AMSR2 SM Performance: NOAA vs JAXA



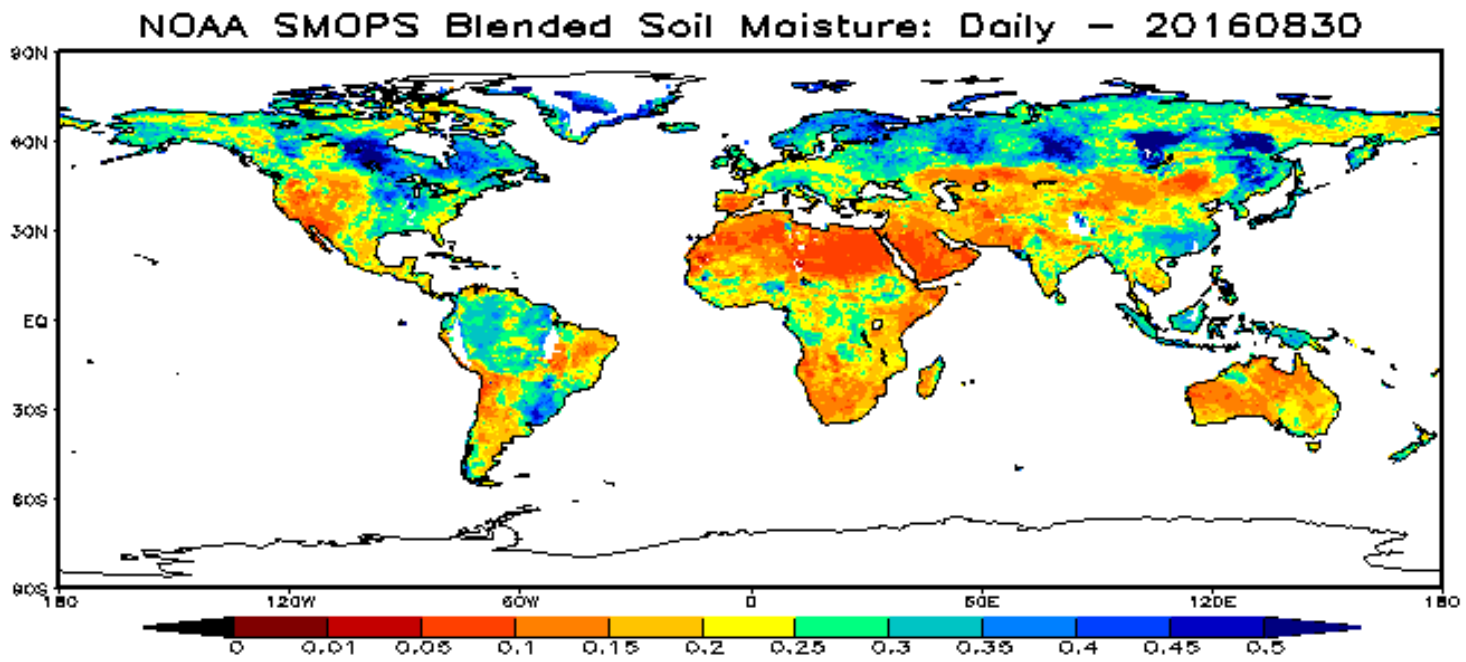
AMSR2 EDR integrated SMOPS

NOAA Soil Moisture Operational Product System (SMOPS) data layers

Soil Moisture Product	SMOPS Version 1.3	SMOPS Version 2.0 (current operational version)	SMOPS Version 3.0
SMOPS Blended	√ (1)	√ (1)	√ (1)
NOAA AMSR-E	√ (2)	×	×
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)
GMI	×	×	√ (7)
NRT SMAP	×	×	√ (8)
NASA SMAP	×	×	√ (9)

AMSR2 EDR integrated SMOPS

AMSR2 SM Contributes to SMOPS Blended Product



Product	NRT SMOS	ASCAT-A	ASCAT-B	AMSR2	GMI	NRT SMAP
Percentage in Blended Product	43	26	26	**30**	39	42

AMSR2 Soil Moisture EDR Overview

- Validated Maturity Review (Oct 2016) Panel Suggestions:
  - ✓ Improvement over dense vegetation areas: Using VIIRS VI
  - ✓ Development of combined product: Blended into SMOPS
- Performance generally meets requirements
- Reprocessing Plan/Status: in development
- Long Term Monitoring/Website Links:
  - SMOPS website at STAR is in development
    - https://www.star.nesdis.noaa.gov/smcd/emb/soilmoisture/SMOPSMaps.php
  - SMOPS update for AMSR2 at OSPO is ready for review later this month
    - http://www.ospo.noaa.gov/Products/land/smops/smops_loops.html?Imap=6H
- Enterprise Algorithm Status: SMOPS
- Users Feedback:
  - NCEP use of SMOPS and AMSR2 data are in research mode
  - SMOPS products are used in DoD AFWA and USDA FAS operationally
  - SMOPS products are tested for Blended Drought Index

Readiness for Follow-on Satellites

- Significant algorithm change may be implemented for follow-on satellite, GAAPS update, and/or AMSR2 reprocessing
- Accomplishments and Highlights Moving forward
  - A NASA funded project may leverage an effort of downscaling AMSR2/3 soil moisture data product for high resolution data need
- Major Risks/Issues/Challenges/ and Mitigation
  - No GCOM-W1 follow-on satellite is approved yet
- Collaboration with Stake Holders/User Agencies
  - Interaction with user community has been frequent, including NCEP, DoD 557, USDA, etc.

Summary

- Validated maturity review for GCOM-W1/AMSR2 soil moisture EDR (NESDIS GAASP as Day 2 product) has been passed in Oct 2016
- AMSR2 soil moisture EDR quality is compatible with other available satellite products and meets JPSS accuracy requirements generally
- NESDIS SMOPS has been operationally ingesting GAAPS SM EDR since September 2016
- Algorithm enhancement and reprocessing are planned for FY18 if support will be available

Thanks!