

Validated Maturity Science Review For GCOM-W1 Soil Moisture EDR

Presented by Xiwu Zhan

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- Algorithm Cal/Val Team Members
- Product Requirements
- Evaluation of algorithm performance to specification requirements
 - Evaluation of the effect of required algorithm inputs
 - Quality flag analysis/validation
 - Error Budget
- Identification of Processing Environment
- Users & User Feedback
- Documentations (Science Maturity Check List)
- Conclusion
- Path Forward

Algorithm Cal/Val Team Members

Name	Organization	Major Task
Xiwu Zhan	NESDIS-STAR	Team lead and validation
Jicheng Liu	UMD-CICS	Algorithm and software development
Ralph Ferraro	NESDIS-STAR	NESDIS GCOM-W team deputy lead
Zorana Jelenak	NESDIS-STAR	NESDIS GCOM-W algorithm lead
Tom King	NESDIS-STAR	NESDIS GCOM-W AIT lead
Paul Chang	NESDIS-STAR	NESDIS GCOM-W team lead

Requirements

- Product performance requirements from JPSS L1RD supplement (threshold) versus observed/validated

Attribute	Threshold	Observed/validated
Geographic coverage	Global	Global
Vertical Coverage	Surface to -0.1cm (skin layer)	Surface to -5cm
Vertical Cell Size	NA	Surface only
Horizontal Cell Size	40km	20km
Mapping Uncertainty	5km	1km
Measurement Range	0-50%	0-100%
Measurement Accuracy	6%	5%
Measurement Precision		
Measurement Uncertainty	6% RMSE with VWC<1.5km/m ² or GVF < 0.5 and <2mm/hr rain	5%

Additional Requirements

- Additional requirements from JPSS ESPC Requirements Document (JERD) Volume 2 - Science Requirements
 - List of JERD Vol 2 requirements (shown in previous slide)
 - The primary user of the JPSS/GCOM-W soil moisture product requested that GCOM-W soil moisture EDR is ingested into NESDIS SMOPS so that the NWP models could directly use the gridded data files with the following specific requirements:
 - Spatial resolution: 25km
 - Grid: geographic/lat-lon projection
 - Accuracy: RMSE against in situ measurements: 6-10%
 - Data file format: GRIB2 with NetCDF for archiving daily product
 - Unit: volumetric soil moisture in [m³/m³]
 - QC flags indicating retrieval quality/reliability
 - Latency: shorter than 6 hours

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

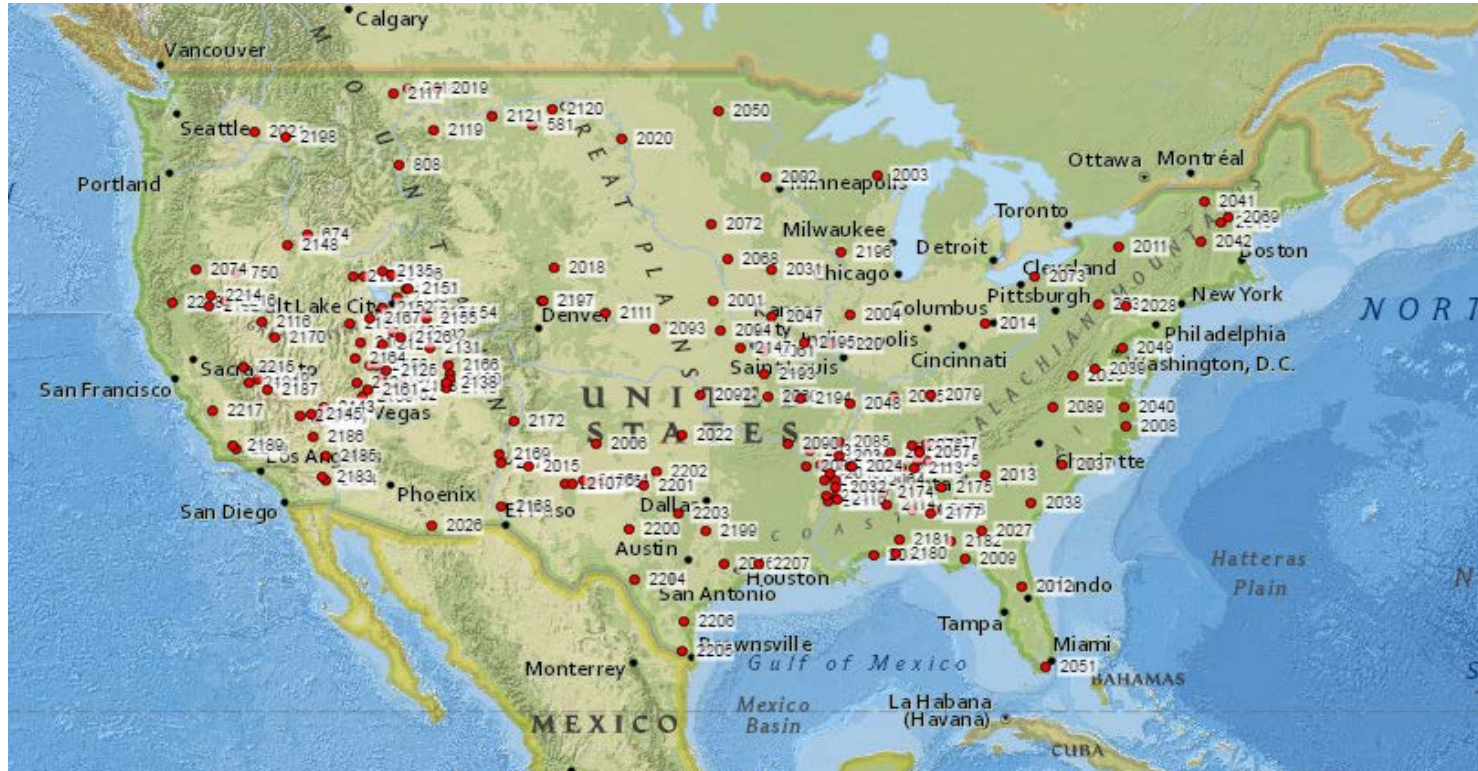
- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

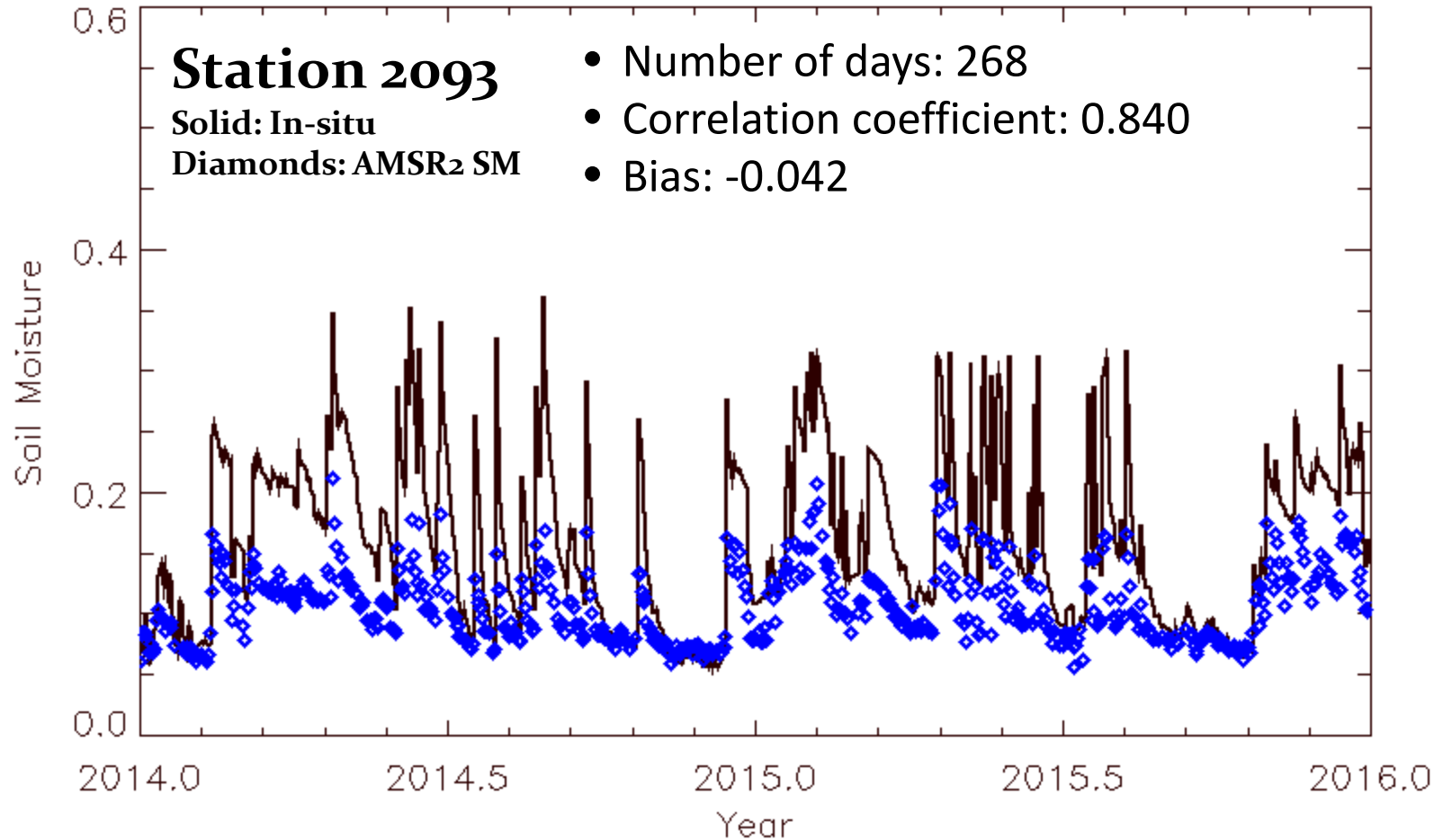
- **Cal/Val Activities for evaluating algorithm performance:**
 - Test / ground truth data sets: *Soil Climate Analysis Network (SCAN) Data*
 - Validation Strategy: Point measurements (Ground) vs Gridded AMSR2 Soil Moisture (0.25 degree lat/long)
 - Validation Metrics: Correlation Coefficient, Bias and RMSE
 - Validation results

AMSR2 vs SCAN: Overall Statistics

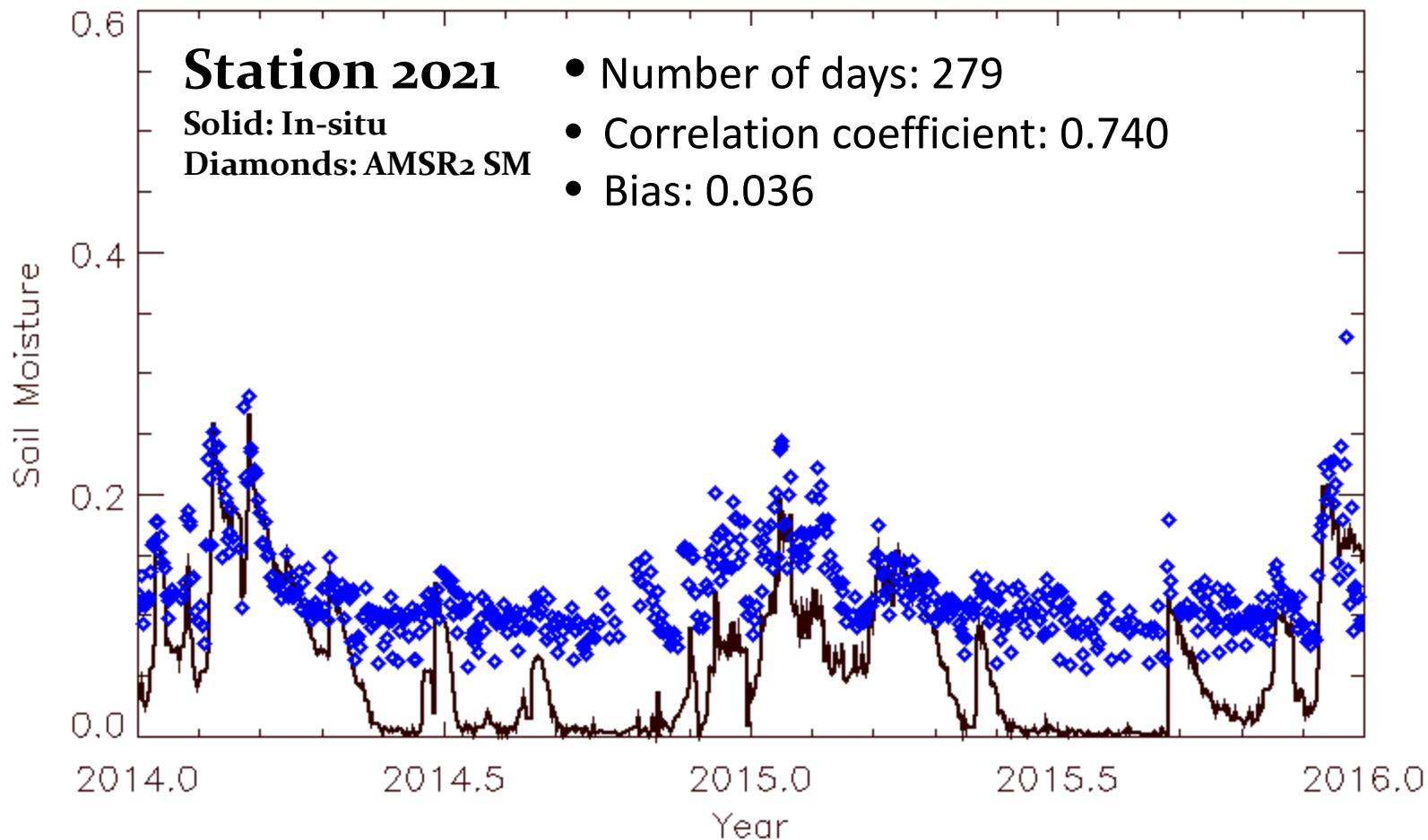


- **Number of Stations: 150**
- **Mean correlation coefficient: 0.545**
- **Mean Bias: 0.021**
- **Mean RMSE: 0.038**

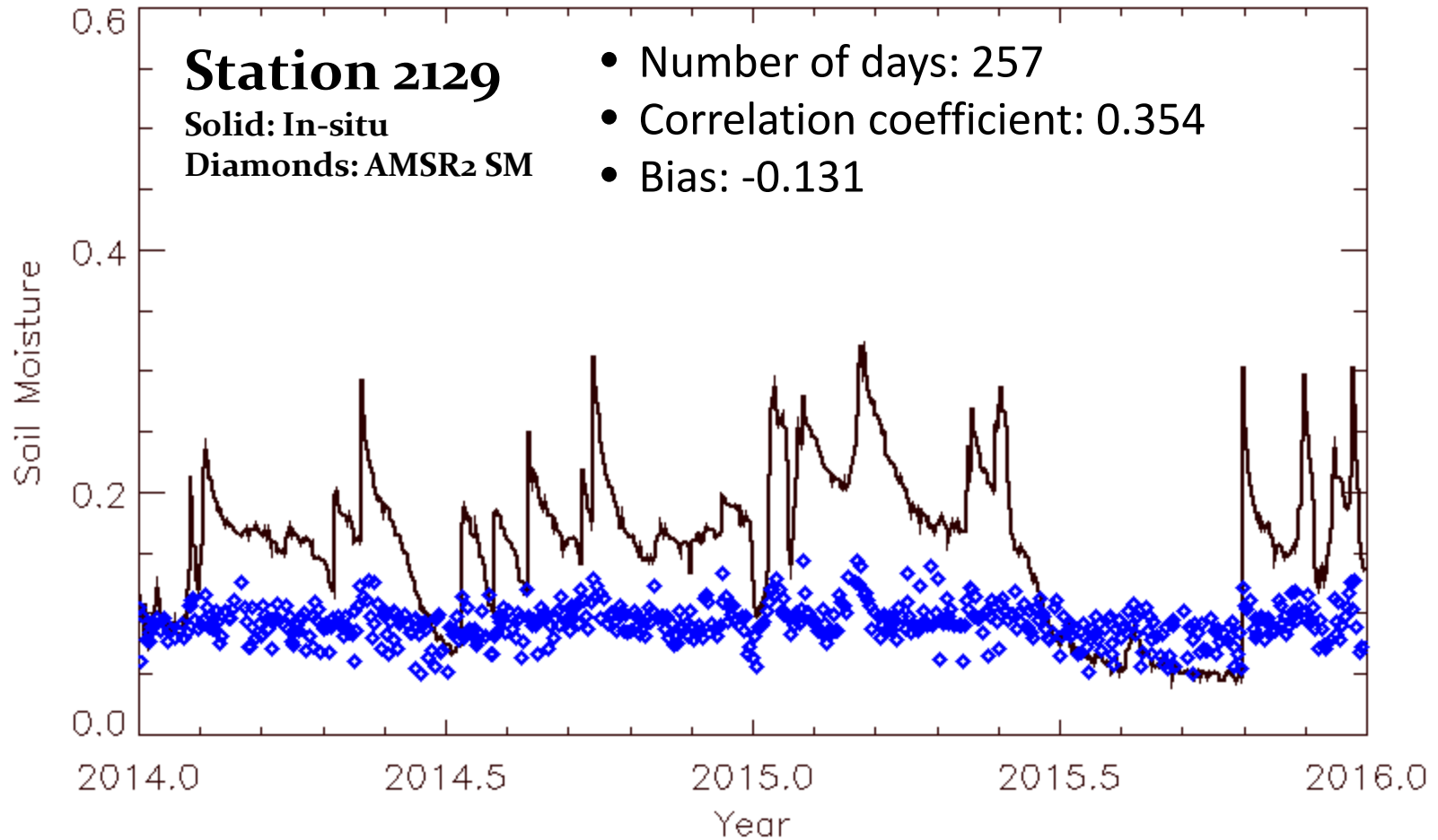
AMSR2 vs SCAN: time series



AMSR2 vs SCAN: time series

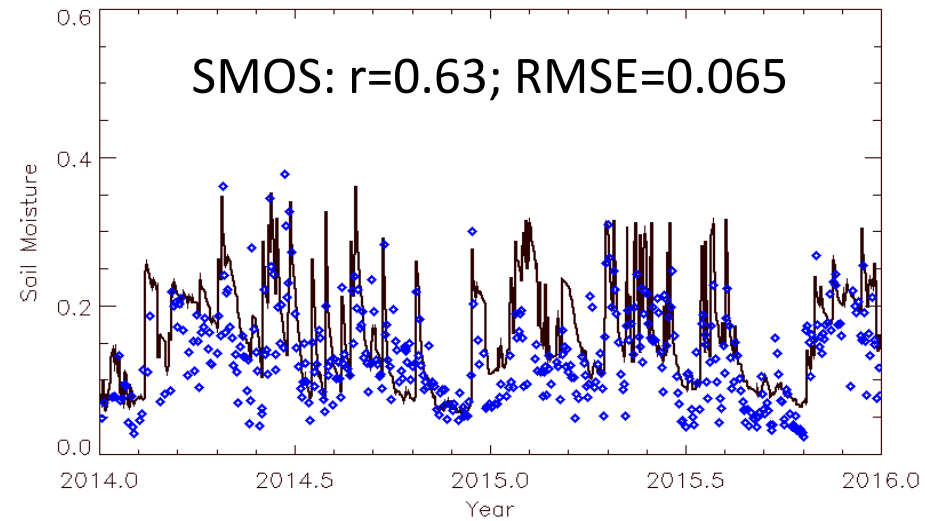
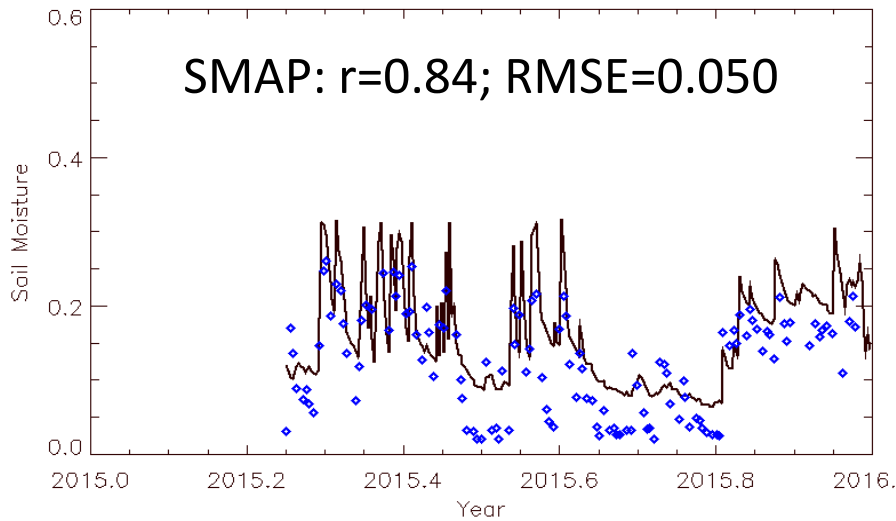
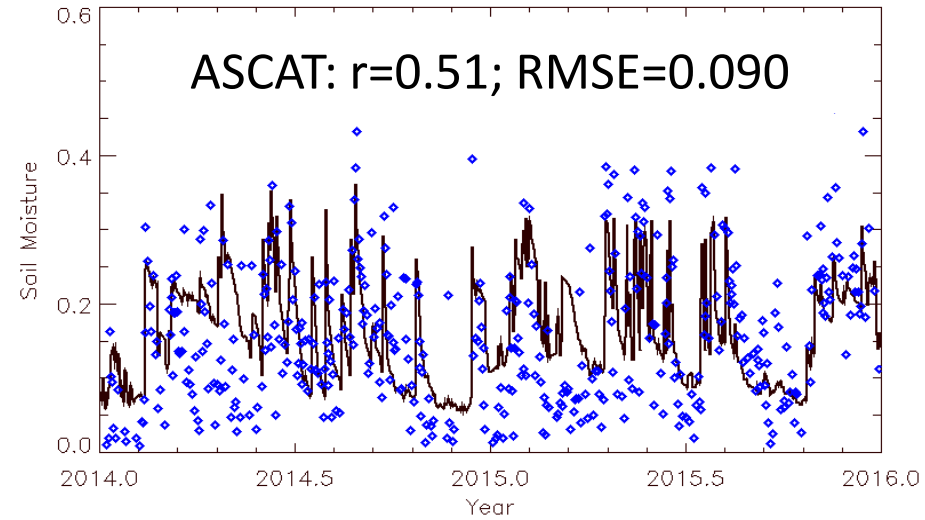
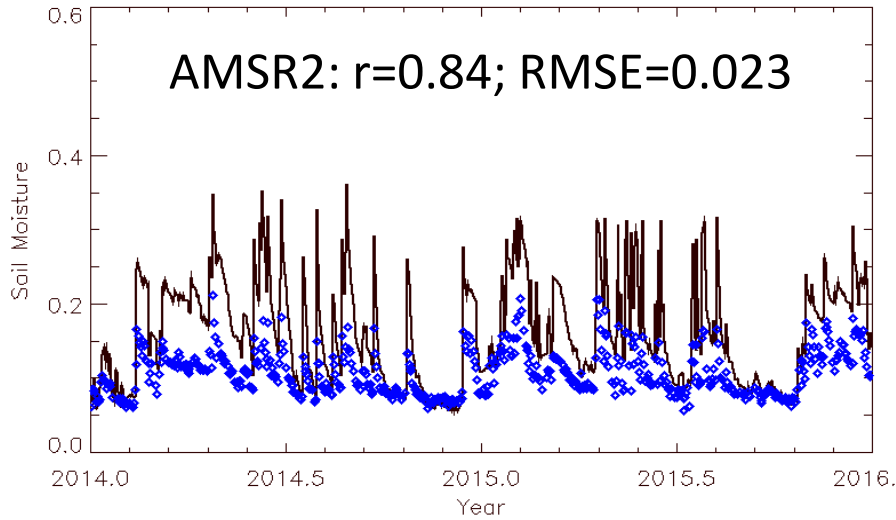


AMSR2 vs SCAN: time series



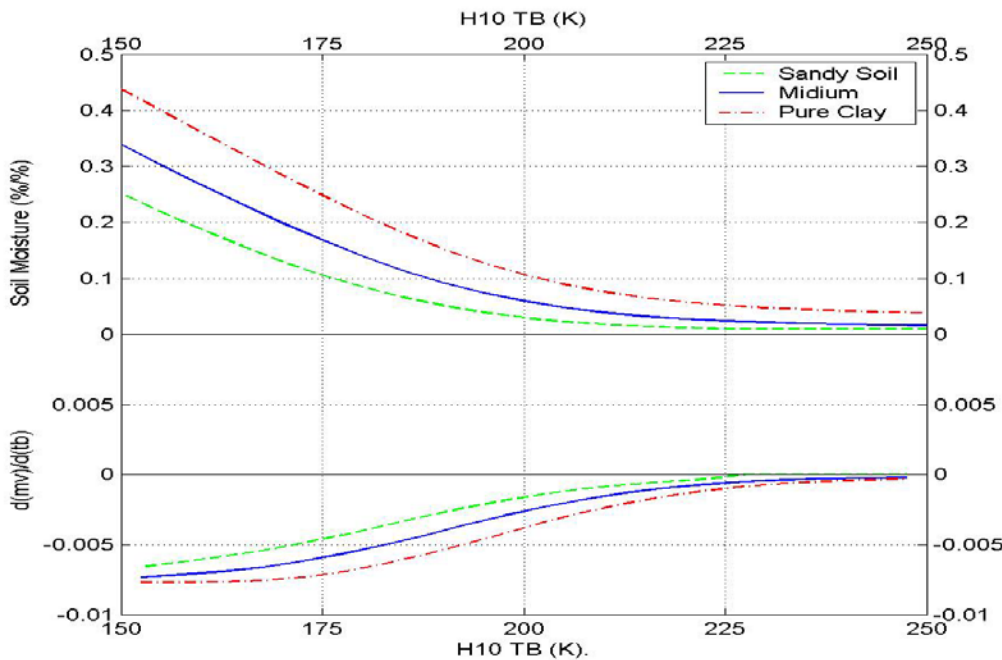
AMSR2 vs In-Situ: SCAN Site 2093

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



- Required Algorithm Inputs

- Primary Sensor Data: L1B Brightness temperature
- Ancillary Data: Land cover map and soil texture maps.
- Cumulative Distribution Function (CDF) data base



The lower part of this figure shows the changing rate of retrieved soil moisture as a function of brightness temperature. In the “sensitive” range (150 – 200 K), the changing rate can go as high as 0.007 (i.e., 0.7%/K). With soil moisture accuracy requirement of 0.10 (10%), this translates to a maximum brightness temperature difference of approximately 14 K.

Quality flag analysis/validation

- Defined Quality Flags: Bit-packed QA

Bit Number	Description
0	0 = overall quality is not good; 1 = overall quality is good
1	1 = retrieval attempted but quality is not good; 0 = otherwise
2	1 = retrieval attempted but unsuccessful due to input brightness temperature data quality; 0 = otherwise
3	1 = retrieval attempted but unsuccessful due to the quality of other input data; 0 = otherwise
4	1 = retrieval not attempted; 0 = retrieval attempted
5	0= not cold desert; 1 = cold desert
6	0= not snow or rain; 1 = snow or rain
7	0= not frozen ground; 1 = frozen ground

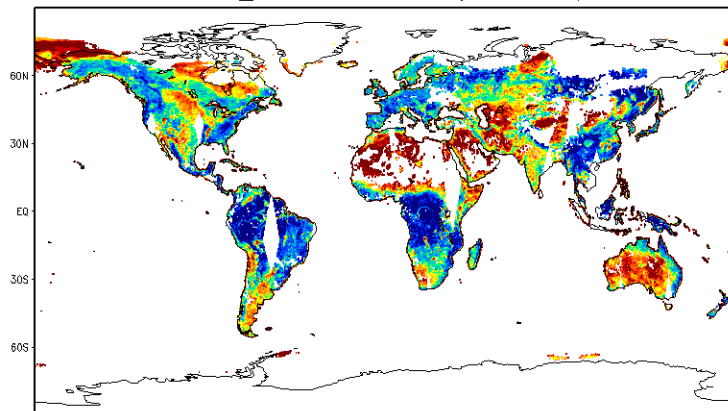
Error Budget

Attribute Analyzed	L1RD Threshold	Analysis/Validation on Result	Error Summary	Support Artifacts
TB	+/- 4 degrees	<0.03 on SM	Requirement meet	

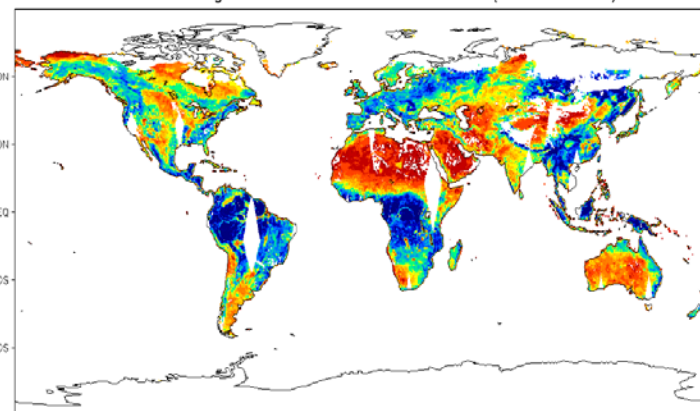
- **Algorithm Improvements**
 - Fine-tuned LPRM model parameters for more valid retrievals
 - Updated Single Channel Retrieval (SCR) algorithm parameters
- **LUT Updates**
 - Updated CDF data base with much longer time period: Only less than 2 years (2013-2014) in first version; 4 years (2013-2016) of data used for the updated version.
 - More reliable climatological matching between LPRM retrieved vegetation optical depth and those from SCR inversion

Vegetation Optical Depth From Version 1.0 From Version 2.0

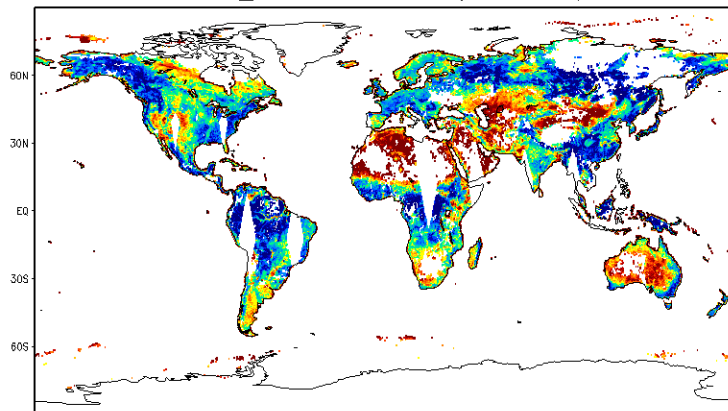
LPRM_TAU from AMSR2 (20140501)



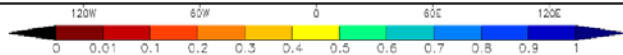
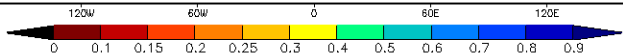
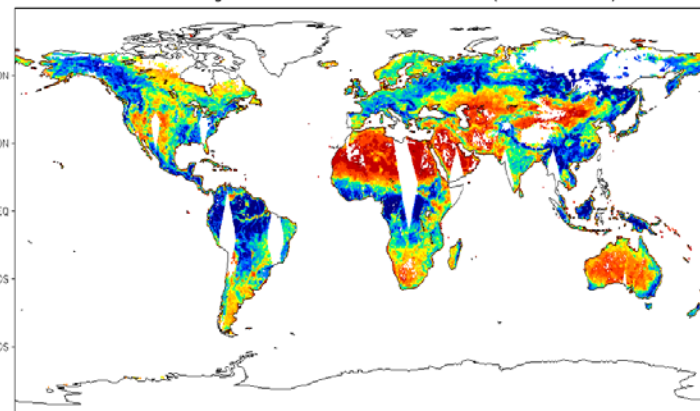
AMSR2 Vegetation OD from LPRM (20140501).



LPRM_TAU from AMSR2 (20140930)



AMSR2 Vegetation OD from LPRM (20140930).

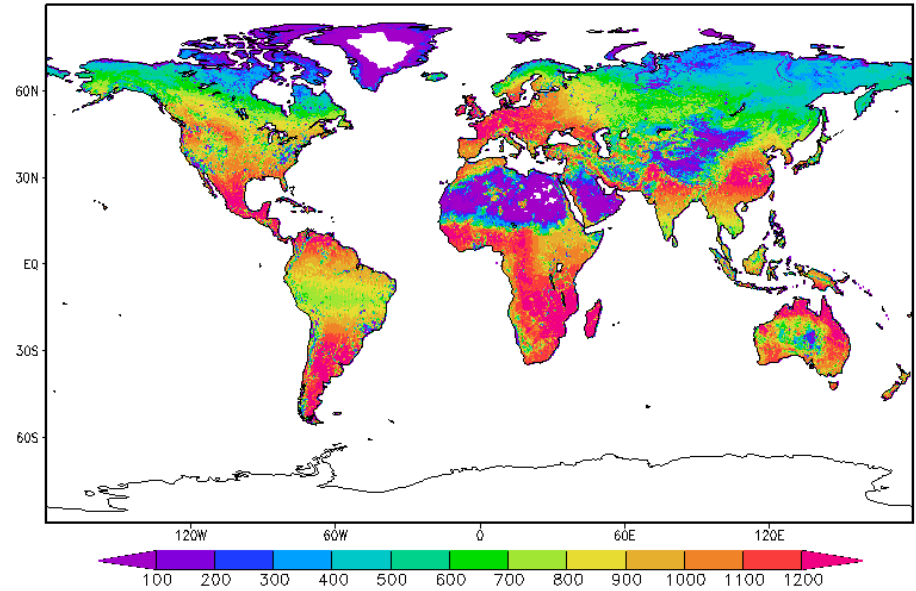
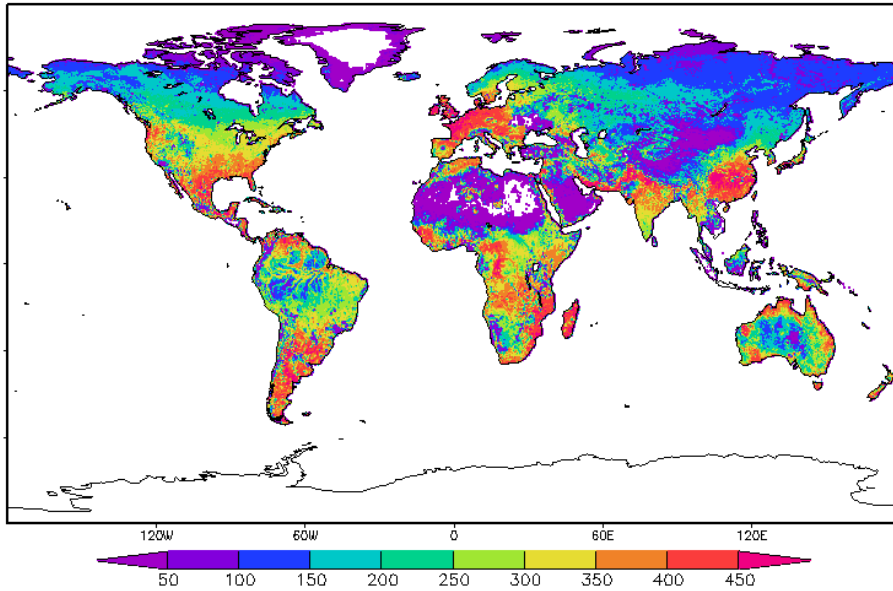


CDF Version 1.0 (2013-2014)

CDF Version 2.0 (2013-2016)

Number of Obs used for CDF.

Number of Obs. used for CDF.



(Different color bar numbers)

- ESPC (e.g., NDE, Okeanos) build (version) number and effective date: Version 1.0, September, 2016
- Algorithm version: 1.0
- Version of LUTs used: 1.0
- Description of environment used to achieve validated maturity stage: Operational environment.

- **User list:**
 - L2 AMSR2 SM: NESDIS/STAR SMOPS
 - L3 AMSR2 SM from SMOPS: NCEP, etc
- **Feedback from users**
 - L2 AMSR2 SM EDR has been ingested into SMOPS since SMOPS Version 2.0, which went operational since September, 2016
 - L3 AMSR2 SM EDR is merged in SMOPS with other satellite retrievals such as SMAP, SMOS, ASCAT, GMI for better spatial coverage and reliability
 - NWS/NCEP has been downloading SMOPS data for land data assimilation in NLDAS and GFS
- **Downstream product list:**
 - SMOPS AMSR2 EDR SM layer and SMOPS Blended SM product

Documentations (Check List)

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	
Algorithm Theoretical Basis Document (ATBD)	X
Algorithm Calibration/Validation Plan	X
(External/Internal) Users Manual	
System Maintenance Manual (for ESPC products)	
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	X

- **Cal/Val results summary:**
 - Team recommends algorithm validated maturity
 - Comparison with in situ soil moisture measurements indicates the L2 AMSR2 soil moisture retrievals meet requirement (6% RMSE)
 - Algorithm code in GAAPS is in operation
 - L2 AMSR2 SM has been ingested in SMOPS which has become operational in last September
 - L3 AMSR2 soil moisture together with SMOPS blended soil moisture data products has been provided to NWS/NCEP for their application testing
 - Operational use by NWS user is planned pending more testing results and management decision

- **Planned further improvements**
 - Algorithm CDF updates/Refine the single-channel-algorithm with better tuned parameters
 - Downscaling coarse scale (25km) retrievals to finer scale (e.g. 5 or 10km for regional NWP models)
- **Planned Cal/Val activities / milestones**
 - To collect more ground measurements and fully evaluate algorithm performance for different land cover types and climatological zones (e.g. In situ data from Australia, China, USDA ARS, NOAA CRN).