ASSESSMENT OF VERSION 4 OF THE SMAP PASSIVE SOIL MOISTURE STANDARD PRODUCT

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ABSTRACT

NASA's Soil Moisture Active Passive (SMAP) mission launched on January 31, 2015 into a sun-synchronous 6 am/6 pm orbit with an objective to produce global mapping of high-resolution soil moisture and freeze-thaw state every 2–3 days. The SMAP radiometer began acquiring routine science data on March 31, 2015 and continues to operate nominally. SMAP's radiometer-derived standard soil moisture product (L2SMP) provides soil moisture estimates posted on a 36-km fixed Earth grid using brightness temperature observations and ancillary data. A beta quality version of L2SMP was released to the public in October, 2015, Version 3 validated L2SMP soil moisture data were released in May, 2016, and Version 4 L2SMP data were released in December, 2016. Version 4 data are processed using the same soil moisture retrieval algorithms as previous versions, but now include retrieved soil moisture from both the 6 am descending orbits and the 6 pm ascending orbits. Validation of 19 months of the standard L2SMP product was done for both AM and PM retrievals using *in situ* measurements from global core cal/val sites. Accuracy of the soil moisture retrievals averaged over the core sites showed that SMAP accuracy requirements are being met.

Keywords (Index Terms) -- *soil moivement, passive microwave, SMAP, accuracy assessment, cal/val.*

*USDA, NASA, and JPL are equal opportunity employers.

1. INTRODUCTION

Soil moisture plays a critical role in linking together the Earth's water, energy, and carbon cycles, and is important to a large number of applications with societal benefit. NASA's SMAP (Soil Moisture Active Passive) mission launched on January 31, 2015 with a goal of providing global mapping of soil moisture and freeze/thaw state every 2-3 days [1]. The SMAP L-band radiometer (1.4 GHz) began routine science operations on March 31, 2015, and continues to operate nominally today to produce passive-only estimates of soil moisture. The SMAP standard L2SMP product provides soil moisture estimates posted on a 36-km Earth-fixed grid using the radiometer time-ordered brightness temperatures (L1B_TB product) along with a variety of static ancillary data (e.g. water fraction, soil texture, land cover classification, vegetation index climatology) and dynamic ancillary data (e.g. near real-time soil temperature, freeze/thaw state, rainfall intensity) [2]. Previous versions of the L2SMP product retrieved soil moisture from only the 6 AM descending orbits; however, Version 4 of L2SMP now includes soil moisture retrieved from the 6 PM ascending orbits as well.

Table 1. Global Core Cal/Val Sites

CVS Name	Area	IGBP Land Cover
Walnut Gulch	USA (Arizona)	Shrub open
Reynolds Creek	USA (Idaho)	Grasslands
Fort Cobb	USA (Oklahoma)	Grasslands
Little Washita	USA (Oklahoma)	Grasslands
South Fork	USA (Iowa)	Croplands
Little River	USA (Georgia)	Cropland/nat. mosaic
TxSON	USA (Texas)	Grasslands
Kenaston	Canada	Croplands
Carman	Canada	Croplands
Monte Buey	Argentina	Croplands
REMEDHUS	Spain	Croplands
Twente	Netherlands	Cropland/nat. mosaic
HOBE	Denmark	Croplands
MAHASRI	Mongolia	Grasslands
Yanco	Australia	Croplands

2. CALIBRATION / VALIDATION APPROACHES

During SMAP's post-launch calibration/ validation phase, the SMAP L2SMP team is focused on (1) calibrating, verifying, and improving the performance of the science algorithms, and (2) validating the accuracies of the L2SMP soil moisture product, especially in light of mission accuracy requirements. These assessments are based on a number of different approaches, including comparisons with ground-based *in situ* soil moisture measurements from instrumented sites run by SMAP Cal/Val Partners; *in situ* ground measurements from sparse networks; other satellite-based products, especially SMOS soil moisture; model-based products; and results from dedicated SMAP field campaigns. Although the cal/val efforts presented in this paper focus on comparisons with *in situ* data from core cal/val sites, it is expected that cal/val evaluations and monitoring using all approaches will continue throughout the SMAP mission lifetime.

In order to assess the quality of the Version 4 L2SMP data, nineteen months of SMAP soil moisture data from March 31, 2015 through October 31, 2016 were compared against locally scaled aggregations of *in situ* measurements of soil moisture data from fifteen core cal/val sites in the U.S., Canada, Argentina, Europe, Mongolia, and Australia. These sites are listed in Table 1 along with their associated land cover type. For an instrumented ground site to be considered a SMAP core validation site (CVS), it must have achieved a certain level of maturity which would provide confidence that the collection of point data could be used as representative of the spatial area covered by a SMAP satellite footprint [3]. Factors considered include the geographic distribution of the *in situ* stations across the site, the number of stations, the calibration of the *in situ* instruments, and the development of a scaling function to convert the point measurements at the site into an areal average that can be compared to gridded SMAP retrieved soil moisture (default function is a linear average of all stations). The status of other candidate cal/val sites is periodically reviewed to determine if they should be elevated to CVS status. Only the CVS are used in quantitative assessment of SMAP algorithm performance.

3. ADDITIONAL SOIL MOISTURE RETRIEVALS FROM PM ORBITS

The L2SMP product has been expanded in the Version 4 release in December, 2016 to include soil moisture retrievals for the 6 PM (ascending) orbits in addition to the original L2SMP 6 AM (descending) passes. The inclusion of both AM and PM soil moisture data in the standard product now enables faster (~2x) global coverage and diurnal soil moisture monitoring capability. Figure 1a shows SMAP soil moisture retrieved from all the AM orbits on July 3, 2016, while Figure 1b adds in the soil moisture from the PM orbits on July 3, 2016, displaying the increase in global spatial coverage for a single day with both AM and PM orbits. Figure 1c is a 3-day composite of just AM-orbit data which was previously needed to insure complete global coverage with no data gaps. The addition of PM data should cut the time needed for complete global coverage down to ~ 2 days.

4. L2SMP ACCURACY ASSESSMENT

Agreements between the SMAP L2SMP data and the cal/val data sets are reported in unbiased root mean square error (ubRMSE), bias, and time series correlation. The ubRMSE captures time-

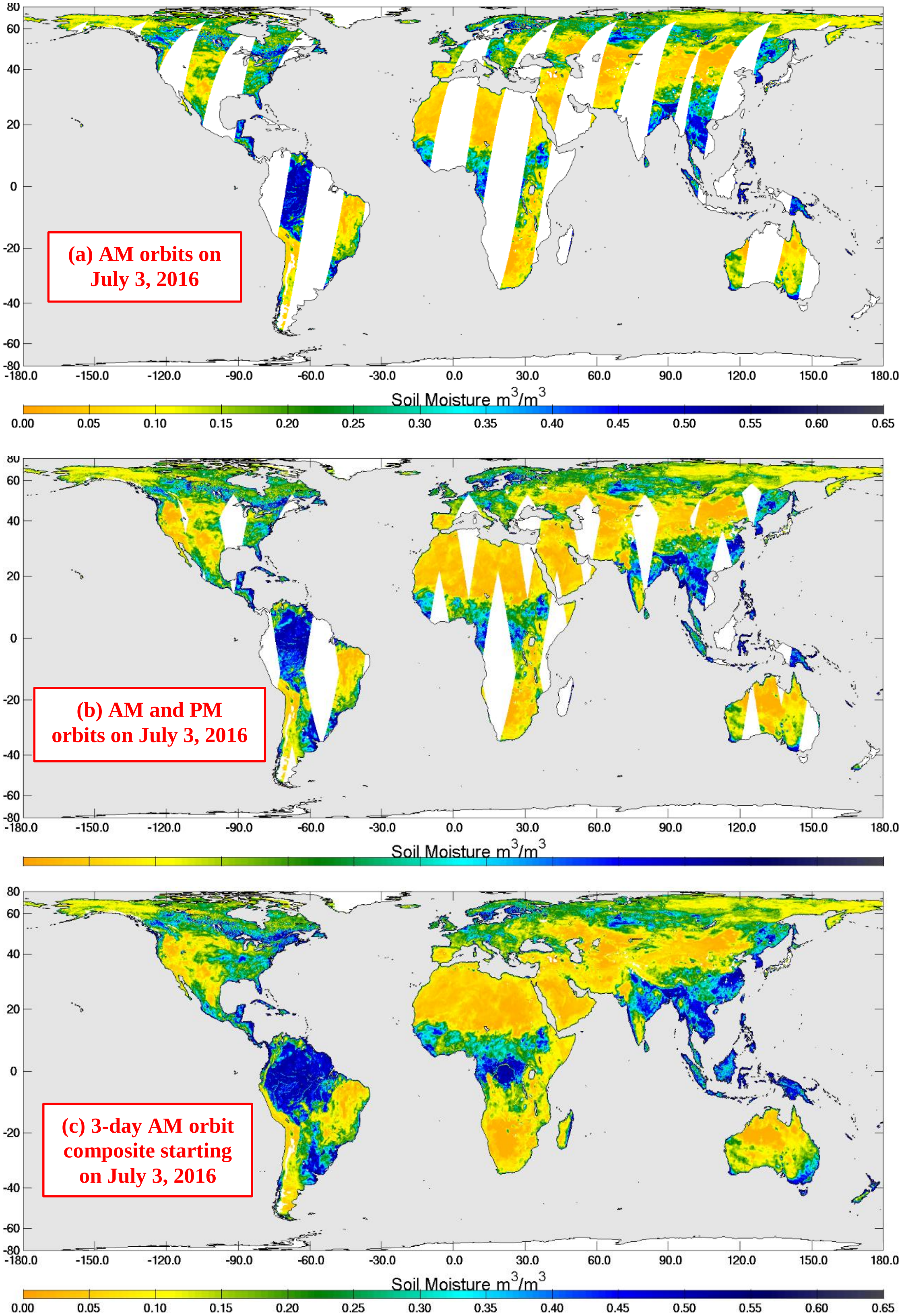

Figure 1 is an example of SMAP L2SMP soil moisture data. (a) includes soil moisture retrieved from one day of 6 am descending orbits on July 3, 2016; (b) adds the 6 pm orbit data for July 3, 2016; (c) is a 3-day composite of just AM orbits showing complete global coverage.

SMAP CVS Accuracy Metrics for March 31, 2015 – October 31, 2016	ubRMSE (m^3/m^3)			Bias (m^3/m^3)			Correlation		
	SCAH	**SCAV**	DCA	SCAH	**SCAV**	DCA	SCAH	**SCAV**	DCA
L2SMP AM data (36-km posting)	**0.044**	**0.037**	**0.043**	**-0.033**	**-0.014**	**0.010**	**0.796**	**0.822**	**0.738**
L2SMP PM data (36-km posting)	**0.046**	**0.039**	**0.047**	**-0.037**	**-0.028**	**-0.015**	**0.772**	**0.795**	**0.700**

Figure 2. Comparisons of 19 months of SMAP L2SMP AM and PM soil moisture with *in situ* soil moisture measurements from SMAP Cal/Val Partner core sites [4].

random errors, bias captures the mean differences or offsets, and correlation captures phase compatibility between data series.

At the present time, the SMAP Project is still evaluating a number of different soil moisture retrieval algorithms, all based on the *tau-omega* model, including the Single Channel Algorithm-Horizontal polarization (SCA-H), Single Channel Algorithm-Vertical polarization (SCA-V), and Dual Channel Algorithm (DCA). A description of these algorithms can be found in the *SMAP L2/3_SM_P ATBD* [2].

As shown in Figure 2, results for nineteen months of SMAP soil moisture examined for the Version 4 data release indicate that the SCA-V currently delivers the best performance of the retrieval algorithms examined. The accuracy of the soil moisture retrievals averaged over the core validation sites was an ubRMSE of 0.037 m^3/m^3 for the 6 AM data and 0.039 m^3/m^3 for the 6 PM data, which meets the SMAP mission accuracy requirements of an ubRMSE < 0.040 m^3/m^3. The slight degradation in the accuracy performance metrics for the 6 PM data compared to the 6 AM data might be expected given that algorithm assumptions that hold true for the AM retrievals might be less valid for the PM data (more Faraday rotation, less hydraulic/thermal uniformity, soil temperature normalization issues, etc.).

6. REFERENCES

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