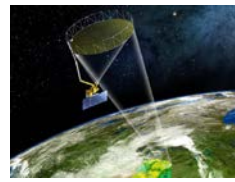


An Evaluation of SMAP Soil Moisture Products over Cold and Arid Regions Using Distributed Observation Network Data

Chunfeng Ma, Shuguo Wang, Rui Jin, Xn Li

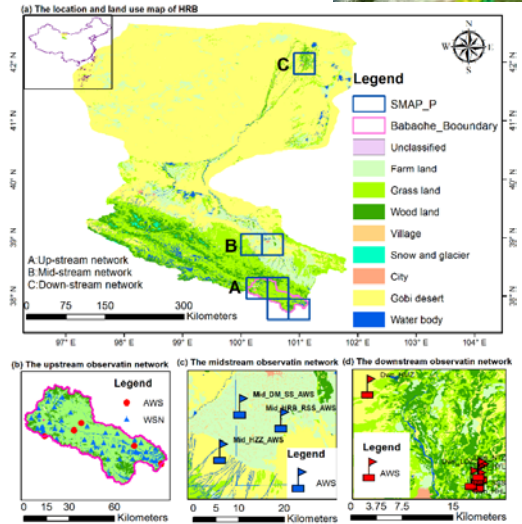


□ We are going to:

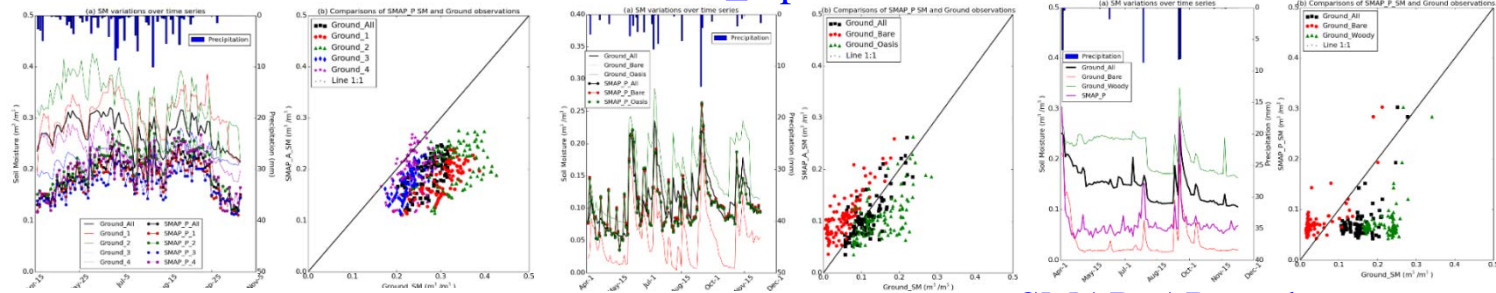
- To validate the **multi-scale SMAP SM products** (active, passive, combined) using distributed ground observation network data over Heihe River Basin (HRB)
- To test SMAP SM products **over typical climatic regions** (cold & arid) **and surface types** (alpine meadow, oasis, desert, etc.)

□ We find:

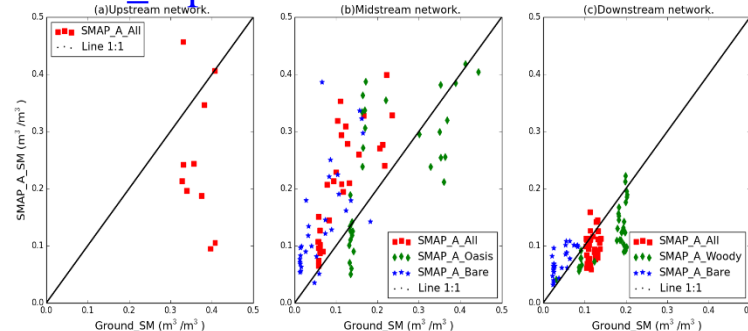
- That the SMAP SM products over the most parts of HRB present relative satisfactory spatial-temporal variation, especially they can capture the typical precipitation events.
- Relatively, the performance of the passive SM products is the best and the active SM products is worse than the two others.
- All SMAP SM product present a little better over the midstream area than those over the cold (upstream) and extreme arid (downstream) of HRB. Better performance of all SMAP SM products can be observed over bare soils than the vegetated soils.
- The unsatisfied performance of SMAP SM products over cold region may be caused by freezing and thawing cycle.



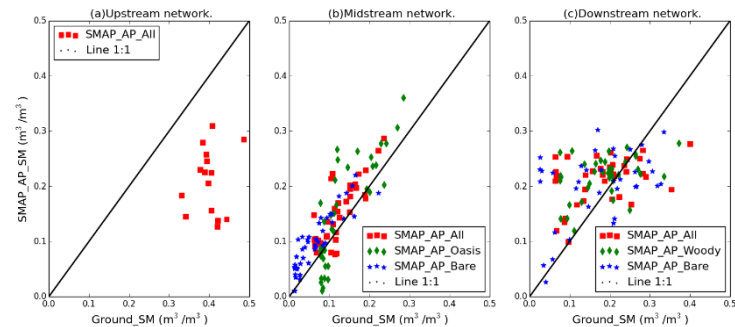
SMAP_P product



SMAP_A product



SMAP_AP product



Thanks for your attention

machf@lzb.ac.cn

Northwest Institute of Eco-Environment and Resources, CAS



Article

Multi-Scale Validation of SMAP Soil Moisture Products over Cold and Arid Regions in Northwestern China Using Distributed Ground Observation Data

Chunfeng Ma ^{1,2}, Xin Li ^{1,2,3,*}, Long Wei ^{1,2} and Weizhen Wang ¹

- 1 Key Laboratory of Remote Sensing of Gansu Province, Northwest Institute of Eco-Environment and Resources, Heihe Remote Sensing Experimental Research Station, Chinese Academy of Sciences, Lanzhou 730000, China; machf@lzn.ac.cn (C.M.); weilong@lzb.ac.cn (L.W.); weizhen@lzbac.cn (W.W.)
- 2 University of Chinese Academy of Sciences, Beijing 100049, China
- 3 CAS Center for Excellence in Tibetan Plateau Earth Sciences, Beijing 100101, China
- * Correspondence: lixin@lzb.ac.cn; Tel.: +86-931-496-7249

Academic Editors: Gabriel Senay, Nicolas Baghdadi and Prasad S. Thenkabail
Received: 13 February 2017; Accepted: 27 March 2017; Published: 30 March 2017

Abstract: The Soil Moisture Active Passive (SMAP) mission was designed to provide global mapping of soil moisture (SM) on nested 3, 9, and 36 km earth grids measured by L-band passive and active microwave sensors. The validation of SMAP SM products is crucial for the application of the products and improvement of the retrieval algorithm. Since the SMAP SM products were released, much effort has been invested in the evaluation of the SMAP radiometer SM product (SMAP_P). However, there has been little validation of SMAP radar (SMAP_A) and active/passive combined (SMAP_AP) SM products. This paper presents an evaluation of SMAP_P, SMAP_A and SMAP_AP SM products by using distributed ground observations networks in different landscapes in the Heihe River Basin of northwestern China. The standard error metrics of SMAP products and relative error are applied to measure the products' performances. The results show that the SMAP SM products exhibit consistent spatial-temporal variation with the ground measurements and typical precipitation events. Three products show various types of performance capability (e.g., active, passive and combined), surface coverage (e.g., bare, vegetated) and climatic region (e.g., cold, arid). Relatively, the SMAP_P shows

Chunfeng Ma¹, Shuguo Wang^{2,1}, Rui Jin¹, Xin Li¹
machf@lzb.ac.cn, swang@lzn.ac.cn, jirui@lzb.ac.cn, lixin@lzb.ac.cn
 1 Key Laboratory of Remote Sensing of Gansu Province, Northwest Institute of Eco-Environment and Resources, CAS, Lanzhou, 730000, China
 2 Jiangsu Normal University, No. 101 Shanghai Road, Xuzhou, China

1. INTRODUCTION

The Soil Moisture Active Passive (SMAP) satellite, launched in January 2015, is the first of the earth observation satellite developed by National Aeronautics and Space Administration (NASA) to provide high resolution global mapping of SM and Evapotranspiration every 2–3 days measured by a host of passive and active microwave sensors. The SMAP satellite incorporates an L-band (GHz) radar and an L-band radiometer (1.41 GHz) to provide 3 km spatial resolution brightness temperature observation and 36 km resolution brightness temperature observation, respectively. The main objective of the present study is to contribute to the evaluation of the available SMAP SM products, including the active product (SMAP_A), passive product (SMAP_P) and active-passive combined (SMAP_AP) product, over the cold and arid regions in the northwestern China.

2. MATERIALS AND METHODS

2.1. Study area

The Heihe River Basin (HRB) (N 37.5–43, E 97–102), located in the northwestern China (Fig. 1a), is used as the study area in this study. The basin is the second largest inland river basin in China, which covers various landscapes. The upstream area (Fig. 1b) is located in the mountain cryospheric region of northeastern Tibet Plateau. The midstream area (Fig. 1c) is located in the center of Hexi corridor which is characterized by arid climate. The downstream area (Fig. 1d) is located in Inner Mongolia where the climate is rather arid with the annual precipitation less than 50 mm.

2.2. Ground observation networks and datasets

Three SM observation networks are respectively established in the up-, middle- and down-stream areas during IIRB/HRE experiments. The networks consist of multi-scale observations, including automatic weather stations (AWS, Fig. 2a) and wireless sensor network (WSN, Fig. 2b).

2.3. SMAP SM products

Three L3 level SMAP SM products, including radar SM product (L3_SM_A), radiometer SM product (L3_SM_P) and active/passive combined SM product (L3_SM_AP), are chosen for the evaluation in this research. The L3_SM_A and L3_SM_AP products cover April 13–July 7 and the L3_SM_P covers April 2–December 31, 2015. All the L3 SMAP SM products are the daily composite of the level 2 granules and the three resolution grids are well nested as shown in Fig. 3.



Fig. 1. Location and land use map of the study area and the ground SM observation networks.

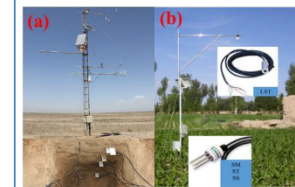


Fig. 2. Photos of AWS and WSN.

Fig. 3. Schematic diagram of multi-scale nested SMAP SM products.

2.4. Evaluation Metrics

$$RMSE = \sqrt{E[(\theta_{sat} - \theta_{ref})^2]}$$

$$RMSE = \sqrt{E[(\theta_{sat} - \theta_{ref})^2]}$$

$$WRMSE = \sqrt{E[(\theta_{sat} - \theta_{ref}) - (\theta_{sat} - \theta_{ref})^2]}$$

$$R = E[(\theta_{sat} - \theta_{ref}) / (\theta_{sat} - \theta_{ref})] / (over - over)$$

$$RE = E \left[\frac{|\theta_{sat} - \theta_{ref}|}{\theta_{ref}} \right] + 100\%$$

3. RESULTS

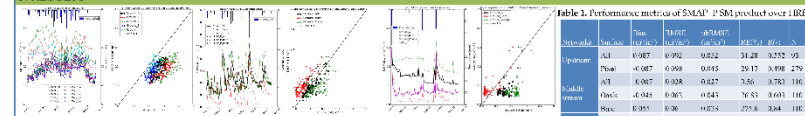


Fig. 4. The evaluation results of SMAP_P SM product over the upstream area network of HRB with (a) the temporal evolution and (b) the scatterplot of ground and SMAP product. Fig. 5. The evaluation results of SMAP_A SM product over the midstream area network of HRB with (a) the temporal evolution and (b) the scatterplot of ground and SMAP product. Fig. 6. The evaluation results of SMAP_AP SM product over the downstream area network of HRB with (a) the temporal evolution and (b) the scatterplot of ground and SMAP product.

Table 2. Performance metrics of SMAP_P SM product over HRB. Table 3. Performance metrics of SMAP_A SM product over HRB. Table 4. Performance metrics of SMAP_AP SM product over HRB.

Network	Surface	Bias (mm)				RMSE (mm)				WRMSE (mm)				R				N		
		All	U	M	D	All	U	M	D	All	U	M	D	All	U	M	D			
Upstream	All	0.987	0.992	0.922	31.28	5.752	95													
	U	0.987	0.998	0.945	29.17	8.799	27													
	M	0.987	0.928	0.827	3.56	3.783	116													
	D	0.944	0.965	0.843	7.63	3.693	116													
Midstream	All	0.993	0.996	0.975	27.54	3.94	116													
	U	0.975	0.99	0.924	9.08	3.776	116													
	M	0.993	0.997	0.989	1.82	3.833	37													
	D	0.993	0.997	0.989	1.82	3.833	37													
Downstream	All	0.929	0.908	0.875	18.83	4.008	38													
	U	0.929	0.908	0.875	18.83	4.008	38													
	M	0.929	0.908	0.875	18.83	4.008	38													
	D	0.929	0.908	0.875	18.83	4.008	38													

Fig. 7. The evaluation results of SMAP_P SM product over the three networks of HRB with (a) the upstream area, (b) the midstream and (c) the downstream areas.

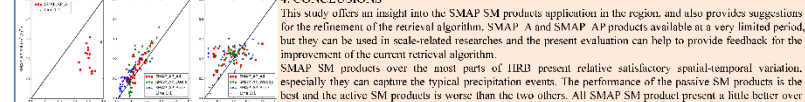


Fig. 8. The evaluation results of SMAP_AP SM product over the three networks of HRB with (a) the upstream area, (b) the midstream and (c) the downstream areas.

4. CONCLUSIONS

This study offers an insight into the SMAP SM products application in the region, and also provides suggestions for the refinement of the retrieval algorithm. SMAP_A and SMAP_AP products available at a very limited period, but they can be used in scale-related researches and the present evaluation can help to provide feedback for the improvement of the current retrieval algorithm. SMAP SM products over the most parts of IIRB present relative satisfactory spatial-temporal variation, especially they can capture the typical precipitation events. The performance of the passive SM products is the best and the active SM products is worse than the two others. All SMAP SM product present a little better over the midstream area than those over the cold (upstream) and extreme arid (downstream) of IIRB. Better performance can be observed over bare soils than the vegetated soils. The unsatisfied performance of SMAP SM products over cold region may be caused by freezing and thawing cycle.