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An inter-comparison of soil moisture data products from satellite remote sensing and a land surface model

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ABSTRACT

Significant advances have been achieved in generating soil moisture (SM) products from satellite remote sensing and/or land surface modeling with reasonably good accuracy in recent years. However, the discrepancies among the different SM data products can be considerably large, which hampers their usage in various applications. The bias of one SM product from another is well recognized in the literature. Bias estimation and spatial correction methods have been documented for assimilating satellite SM product into land surface and hydrologic models. Nevertheless, understanding the characteristics of each of these SM data products is required for many applications where the most accurate data products are desirable. This study inter-compares five SM data products from three different sources with each other, and evaluates them against in situ SM measurements over 14-year period from 2000 to 2013. Specifically, three microwave (MW) satellite based data sets provided by ESA's Climate Change Initiative (CCI) (CCI-merged, -active and -passive products), one thermal infrared (TIR) satellite based product (ALEXI), and the Noah land surface model (LSM) simulations. The in-situ SM measurements are collected from the North American Soil Moisture Database (NASMD), which involves more than 600 ground sites from a variety of networks. They are used to evaluate the accuracies of these five SM data products. In general, each of the five SM products is capable of capturing the dry/wet patterns over the study period. However, the absolute SM values among the five products vary significantly. SM simulations from Noah LSM are more stable relative to the satellite-based products. All TIR and MW satellite based products are relatively noisier than the Noah LSM simulations. Even though MW satellite based SM retrievals have been predominantly used in the past years, SM retrievals of the ALEXI model based on TIR satellite observations demonstrate skills equivalent to all the MW satellite retrievals and even slightly better over certain regions. Compared to the individual active and passive MW products, the merged CCI product exhibits higher anomaly correlation with both Noah LSM simulations and in-situ SM measurements.
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1. Introduction

The impact of soil moisture (SM) on precipitation forecasts of numerical weather prediction models is well known (Chang and Wetzel 1991; Entin et al., 2000; Frye and Mote, 2010a,b). Availability of SM can exhibit profound effects on meteorological phenomena with the coupling of the surface and atmospheric boundary layer through its influence on land-atmosphere water and energy exchange processes. The demand for consistent SM observations has been steadily growing over the past few years (Wagner et al., 1999; Njoku et al., 2003). SM observations are available from multiple sources including satellite-based remote sensing, land surface modeling and ground-based measurements. Satellite-based SM products have shown a great deal of promise because of their capability to provide spatially continuous observations of SM while accurately capturing the temporal dynamics (Bolten et al., 2010; Hain et al., 2009). In the past decade, a variety of methodologies have been studied to retrieve SM using satellite observations from various microwave (MW) and thermal infrared (TIR) techniques. The most widely used satellite-based SM retrieval products have been based on measurements observed from active and/or passive microwave sensors (Jackson 1982; Njoku and Li, 1999; Owe et al., 2001; Paloscia et al., 2001; Njoku et al., 2003; Wagner et al., 1999). Some of them are routinely available, such

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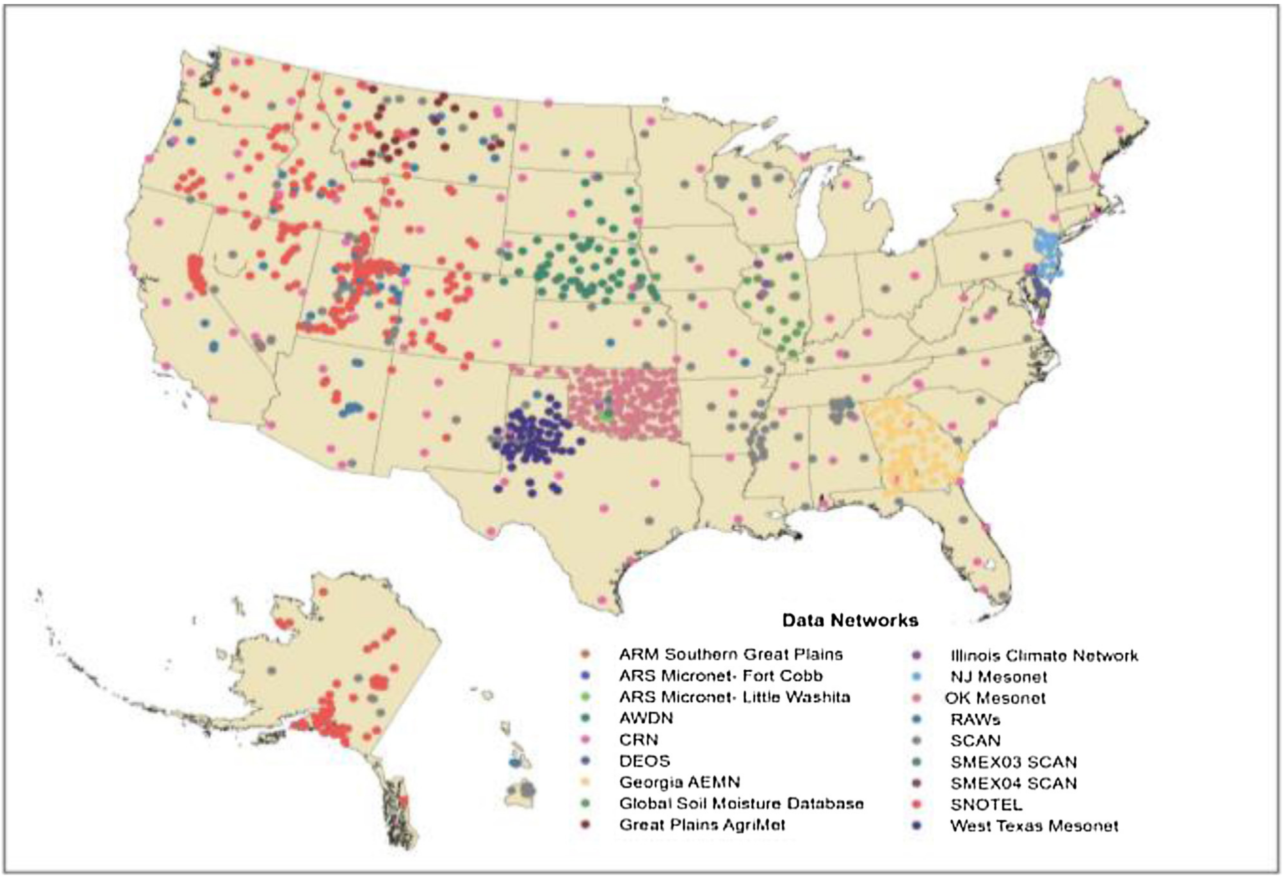

Fig. 1. Distribution of NASMD validation sites.

(Taken from http://soilmoisturemaps.tamu.edu).

as the Soil Moisture and Ocean Salinity (SMOS) from the European Space Agency (ESA), the Advanced Scatterometer (ASCAT) on EUMETSAT's MetOp-A and -B satellites, and the Advanced Microwave Scanning Radiometer 2 (AMSR2) on the GCOM-W1 satellite (Liu et al., 2011b; Ford et al., 2013; Kim et al., 2015), while others are research products that were created for a certain time period only. There has also been an attempt to provide blended MW SM products which aim to make full advantage of active and passive MW signals, such as the Climate Change Initiative (CCI) (Liu et al., 2012; Wagner et al., 2012) and the NOAA-NESDIS Soil Moisture Operational Products System (SMOPS) (Zhan et al., 2011). An additional SM retrieval methodology exploits TIR information through observations of land surface temperature. A number of studies have made progress with TIR SM methodologies (Bosilovich et al., 2007; Carlson, 1986; Carlson et al., 1994; Gillies and Carlson, 1995; Hain et al., 2011; McNider et al., 1994; Price, 1983; Taconet et al., 1986; Reichle et al., 2010). Anderson et al., (2007; 2011) and Hain et al. (2009; 2011) proposed and evaluated a unique methodology to

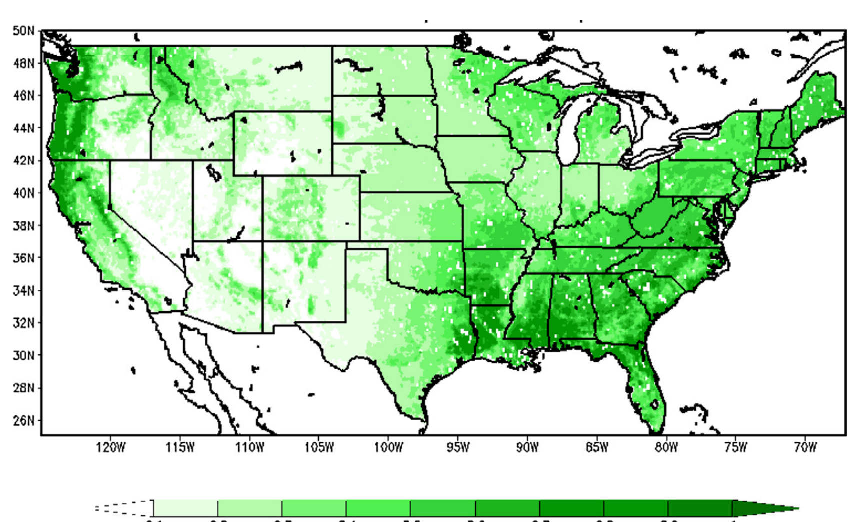

Fig. 2. Average GVF cover throughout the warm season over the period of 2000 to 2013.

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