Using in situ soil moisture observations to evaluate SMOS soil moisture retrievals

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Reviews of Geophysics distills and places in perspective previous scientific work in currently active subject areas of geophysics. Contributions evaluate overall progress in the field and cover all disciplines embraced by AGU.

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Reviews of Geophysics has an impact factor of 8.021 in the 2009 Journal Citation Reports, highest in the geosciences.
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Yann Kerr and colleagues, SMOS

Michael Palecki, Climate Reference Network

Jeff Basara and Brad Illston, Oklahoma Mesonet
How well can SMOS soil moisture retrievals measure soil moisture?

We compared SMOS retrievals to in situ soil moisture observations at 5 cm depth from the following networks:

- Soil Climate Analysis Network (SCAN)
- Atmospheric Radiation Measurement (ARM)
- United States Climate Reference Network (USCRN)
- Oklahoma Mesonet
The Soil Moisture Ocean Salinity (SMOS) satellite was launched in November 2009 on a modified Russian SS-19 ICBM. The satellite retrieves surface (top few cm) soil moisture using a passive L-band (1.4 GHz) interferometer with a 40 km footprint, and we evaluated the level 2 (L2) data stream.
Surface in situ soil moisture observations from:

Soil Climate Analysis Network (SCAN)
http://www.wcc.nrcs.usda.gov/scan/

U.S. Climate Reference Network (USCRN)
http://www.ncdc.noaa.gov/crn/
OK Stillwater 5 WNW, Oklahoma State University (Efaw Farm Site)
36.1°N 97.1°W 909'
March 15, 2002
Surface in situ soil moisture observations from:

ARM Climate Research Facility
http://www.arm.gov_measurements/soilmoist

Oklahoma Mesonet
http://www.mesonet.org/index.php/weather/category/soil_moisture
Volumetric Soil Water Content & Precipitation, Aug–Dec 2010, Hourly
SCAN site 2002 – Crescent Lake, MN (45.42°N, 93.95°W)
SMOS Point (45.45°N, 94.00°W)
SMOS/SCAN Difference (SMOS – 5 cm SCAN)
SCAN site 2002 – Crescent Lake, MN (45.42°N, 93.95°W)
SMOS Point (45.45°N, 94.00°W)
Volumetric Soil Water Content & Precipitation, Aug–Dec 2010, Hourly SCAN site 2068 – Shargbark Hills, IA (42.43°N, 95.77°W) SMOS Point (42.45°N, 95.74°W)
SMOS Difference (SMOS – 5 cm SCAN)
SCAN site 2068 – Shargbark Hills, IA (42.43°N, 95.77°W)
SMOS Point (42.45°N, 95.74°W)

[Graph showing hourly precipitation and difference in m²/m² over time from 16 Aug 2010 to 1 Jan 2011]
Volumetric Soil Water Content & Precipitation, Jul–Dec 2010, Hourly
SCAN site 2001 – Rogers Farm, NE (40.85°N, 96.47°W)
SMOS Point (40.89°N, 96.50°W)
SMOS/SCAN Difference (SMOS – 5 cm SCAN)
SCAN site 2001 – Rogers Farm, NE (40.85°N, 96.47°W)
SMOS Point (40.89°N, 96.50°W)
Volumetric Soil Water Content & Precipitation, Jul-Dec 2010, Hourly
SCAN site 2022 – Fort Reno, OK (35.55°N, 98.02°W)
SMOS Point (35.58°N, 98.09°W)
SMOS/SCAN Difference (SMOS – 5 cm SCAN)
SCAN site 2022 – Fort Reno, OK (35.55°N, 98.02°W)
SMOS Point (35.58°N, 98.09°W)
Volumetric Soil Water Content & Precipitation, Aug–Dec 2010, Hourly SCAN site 2093 – Onward, MS (32.75°N, 90.93°W)  
SMOS Point (39.74°N, 90.98°W)
Comparison between SCAN & USCRN 5 cm soil moisture Data
SCAN site 2001 & USCRN site 94995

Water Content (m³/m³)
- USCRN (40.85°N, 96.57°W)
- SCAN (40.85°N, 96.47°W)
- SMOS (40.89°N, 96.50°W)

Rogers Farm, NE
Comparision between SCAN & ARM 5 cm soil moisture Data
SCAN site 2022 & ARM site E19

Fort Reno, OK

Water Content (m³/m³)
- ARM  (35.56°N, 98.02°W)
- SCAN (35.55°N, 98.02°W)
- SMOS  (35.58°N, 98.09°W)
Volumetric soil moisture ($m^3/m^3$) at 5 cm depth near Fort Reno, OK, SCAN & ARM:hourly, Mesonet:half–hourly

Fort Reno or El Reno, OK
Stillwater, OK

Station Locations

- Garfield
- Noble
- Pawnee
- USCRN–Stillwater 5 WNW
- USCRN–Stillwater 2 W
- Payne
- Logan
- Lincoln
- SMOS center point
- Mesonet–STIL
- Mesonet–PERK
- Mesonet–MARE
- SMOS footprint (20 km radius around center)
Volumetric soil moisture ($m^3/m^3$) at 5 cm depth near Stillwater, OK, USCRN:hourly, Mesonet:half–hourly.
Conclusions

1. SMOS (version 1) has a dry bias, as compared to in situ observations.

2. Because in situ data for the same location have differences as large as the differences between SMOS and the in situ observations, and because in situ data are for a point and SMOS retrievals have a footprint with a 40 km diameter, we cannot expect SMOS to exactly reproduce any individual in situ observation. The error characteristics will require further analysis to determine how useful the SMOS retrievals are.

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