Evaluation of SMOS Level 3 soil moisture products using International Soil Moisture Networks

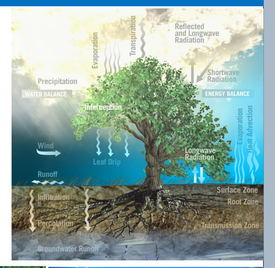
Qiusheng Wu, Ph.D.

Department of Geography, Binghamton University, Binghamton, NY 13902

Introduction

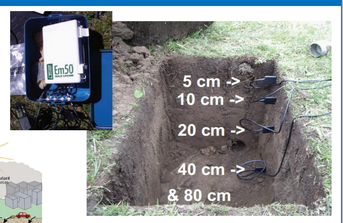
Why Do We Care About Soil Moisture

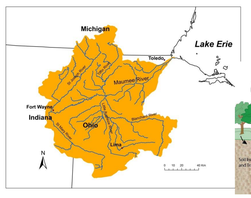
- Hydrology (floods, runoff)
- Numerical weather prediction (drought, precipitation)
- Agriculture & water management
- Climate change

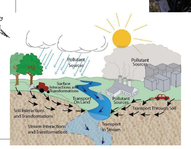


How to Acquire Soil Moisture Data

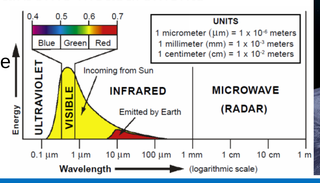
- Ground-based *in situ* measurements
- Physical-based hydrologic models

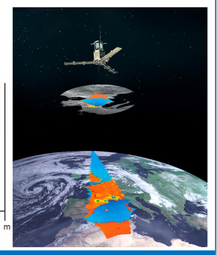






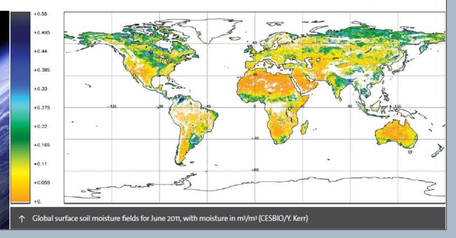
- Satellite-based or airborne measurements
  - Optical
  - Thermal
  - Passive microwave
  - Active microwave





Soil Moisture and Ocean Salinity (SMOS) Mission

- Launched on November 2, 2009 by European Space Agency (ESA)
- First dedicated soil moisture satellite mission
- Global observations of soil moisture over the Earth
- L-band (1.4GHz/21cm) passive microwave
- Mission objective: accuracy of 4% volumetric soil moisture, spatial resolution of 35-50 km and revisit time of 1-3 days
- Crossing times:6AM and 6PM local time for ascending and descending orbits



Methodology

Validate SMOS Level 3 products over continental U.S. by using soil moisture monitoring stations from International Soil Moisture Network (ISMN)

- Direct node-to-site comparison
- Detect combinations of site and satellite nodes with good global statistics and representative dynamics
- Global comparison between different networks

Contributing Networks:

- Atmospheric Radiation Measurement (ARM)
- Automated Weather Data Network (AWDN)
- Cosmic-ray Soil Moisture Observing System (COSMOS)
- Illinois Climate Network (ICN)
- Soil Climate Analysis Network (SCAN)
- SNOwpack TELemetry (SNOTEL)
- US Climate Reference Network(USCRN)

Monitoring Stations:

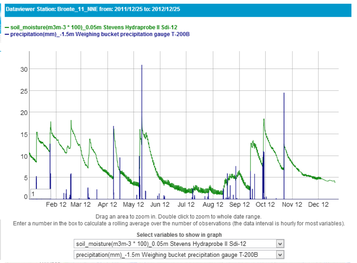
- More than 700 stations across the U.S.
- Near real time (NRT) with hourly sampling data
- Represent a variety of conditions across the U.S.
- Soil moisture at different depth, soil temperature, air temperature, precipitation, etc.

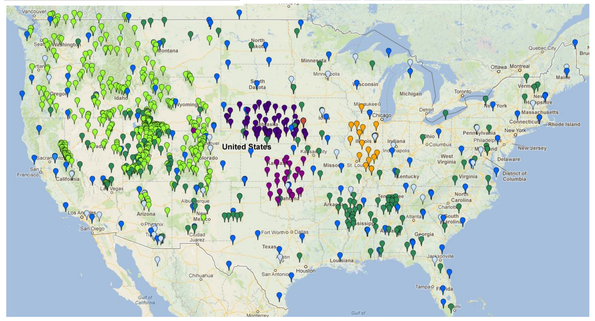
SMOS Soil Moisture Products

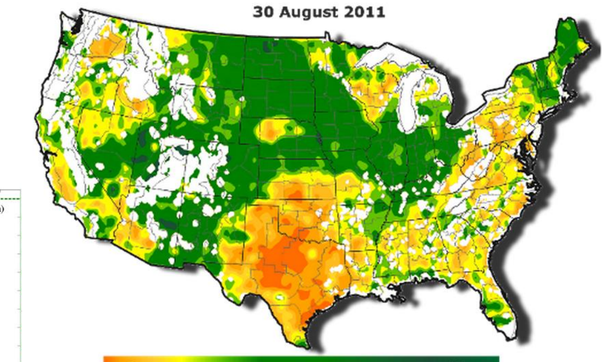
- Level 3 data products: 3-day global product on EASE grid of 25 km resolution
- Time span: 1/1/2010-12/31/2012

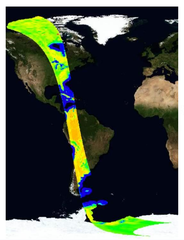
Data extraction

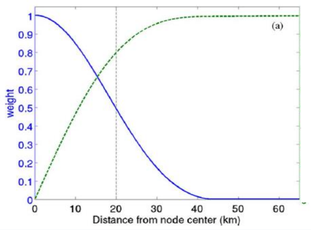
- Nearest nodes located less than 25 km from the monitoring sites
- Ascending and descending orbits were processed separately





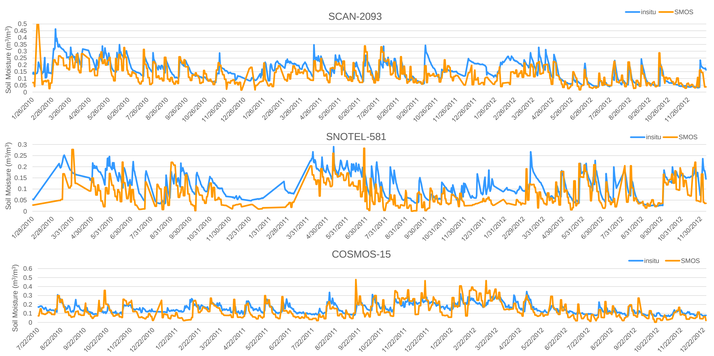






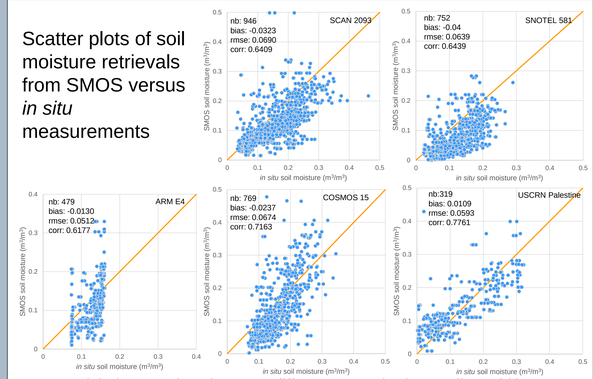
Results

Time series plots of soil moisture retrievals from SMOS versus *in situ* measurements



Results

Scatter plots of soil moisture retrievals from SMOS versus *in situ* measurements



Global comparison between different networks (Ascending orbit)

Network	Stations	Bias	RMSE	Correlation	Nb. of records
ARM	12	-0.1483	0.1686	0.5190	648
COSMOS	50	-0.1077	0.1550	0.3583	358
SCAN	147	-0.0611	0.1248	0.3620	668
SNOTEL	271	-0.0951	0.1420	0.2735	426
USCRN	101	-0.0429	0.1175	0.4319	254
ALL	581	-0.0796	0.1350	0.3358	456

Global comparison between different networks (Descending orbit)

Network	Stations	Bias	RMSE	Correlation	Nb. of records
ARM	12	-0.1442	0.1654	0.5424	642
COSMOS	50	-0.0932	0.1487	0.3273	344
SCAN	147	-0.0557	0.1229	0.3603	637
SNOTEL	271	-0.0770	0.1375	0.2833	381
USCRN	101	-0.0415	0.1124	0.4255	237
ALL	581	-0.0682	0.1310	0.3366	423

Conclusions

- Statistics show an underestimation of the soil moisture from SMOS Level 3 products compared to *in situ* measurements
- SMOS meet the mission requirement of 0.04 m3/m3 over bare soil and/or low vegetation areas
- Differences are observed over many sites and need to be addressed
- Overall, SCAN and USCRN networks perform better than ARM, COSMOS and SNOTEL
- Statistics show similar results for both ascending and descending orbits.

References

- Al Bitar, A., Leroux, D., Kerr, Y.H., Merlin, O., Richaume, P., Sahoo, A., & Wood, E.F. (2012). Evaluation of SMOS soil moisture products over continental U.S. Using the SCAN/SNOTEL network. IEEE Transactions on Geoscience and Remote Sensing, 50, 1572-1586
- Dorigo, W.A., Wagner, W., Hohensinn, R., Hahn, S., Paulik, C., Xaver, A., Gruber, A., Drusch, M., Mecklenburg, S., Van Oevelen, P., Robock, A., & Jackson, T. (2011). The International Soil Moisture Network: A data hosting facility for global in situ soil moisture measurements. Hydrology and Earth System Sciences, 15, 1675-1698
- Jackson, T.J., Bindlish, R., Cosh, M.H., Zhao, T., Starks, P.J., Bosch, D.D., Seyfried, M., Moran, M.S., Goodrich, D.C., Kerr, Y.H., & Leroux, D. (2012). Validation of soil moisture and Ocean Salinity (SMOS) soil moisture over watershed networks in the U.S. IEEE Transactions on Geoscience and Remote Sensing, 50, 1530-1543
- Kerr, Y.H., Waldteufel, P., Wigneron, J.P., Delwart, S., Cabot, F., Boutin, J., Escorihuela, M.J., Font, J., Reul, N., & Gruhier, C. (2010). The SMOS Mission: New Tool for Monitoring Key Elements ofthe Global Water Cycle. Proceedings of the IEEE, 98, 666-687