Progress Report

February 24, 2003

Extended Validation of AMSR-E Soil Moisture Products

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Project Objectives

The aim of this proposal is to enhance, complement and supplement the activities of the AMSR-E science team to characterize and validate the accuracy of soil moisture derived from the AMSR-E data. We are proposing a broad spectrum of validation activities that will ensure an integrated validation plan. The research objectives of this proposed project are:

a. Validation of AMSR soil moisture retrievals for time periods on the order of days to months to years using in-situ observations within USDA-ARS research watersheds. These watersheds represent a range of physiographic and climatologic conditions in the continental U.S.
b. Analysis and intercomparison of alternative soil moisture retrieval algorithms as a source of validation information and improved products through post processing.
c. Provide an assessment of the AMSR-E brightness temperature over land through comparisons with TMI and MSMR observations over land.
d. Provide the scientific community and public with all data and results of the investigation.

Progress to Date

The original proposal had three elements: insitu validation of soil moisture, algorithm intercomparison, and cal/val of brightness temperature over land using other satellite sensors. This was expanded to include support for large-scale field experiment data collection and processing.

Insitu Validation of the Soil Moisture Products

The sampling and analyses that we are proposing is designed to extend and strengthen the current validation plan. It is also a bridge between the Type-I (intensive field observation) and Type-II (operational networks) validation activities described in the plan.

Existing instrumentation in and surrounding ARS research watersheds located in Oklahoma, Georgia, Arizona, and Idaho has been augmented to include surface soil moisture and temperature observations. The locations are shown in Figure 1. Each watershed was previously instrumented with a USDA NRCS Soil Climate Analysis Network (SCAN) station and its own unique meteorological networks.

Surface soil moisture and temperature sensors (0-5 cm) (Vitel Hydraprobe) were installed at existing instrument locations in the watersheds. This approach takes advantage of the available data logging and transmission equipment and provides important complementary meteorological information needed for a thorough hydrologic analysis. Each watershed location utilizes a slightly different approach to data collection.

Nearly all the instrumentation has been installed at this point. Each location is also considering adding a few additional points outside the watershed to strengthen the spatial domain. Table 1 summarizes the status of each watershed. Planned additions are in parentheses. Investigators from each of the watershed locations have initiated site-specific calibration and validation of the soil moisture networks.

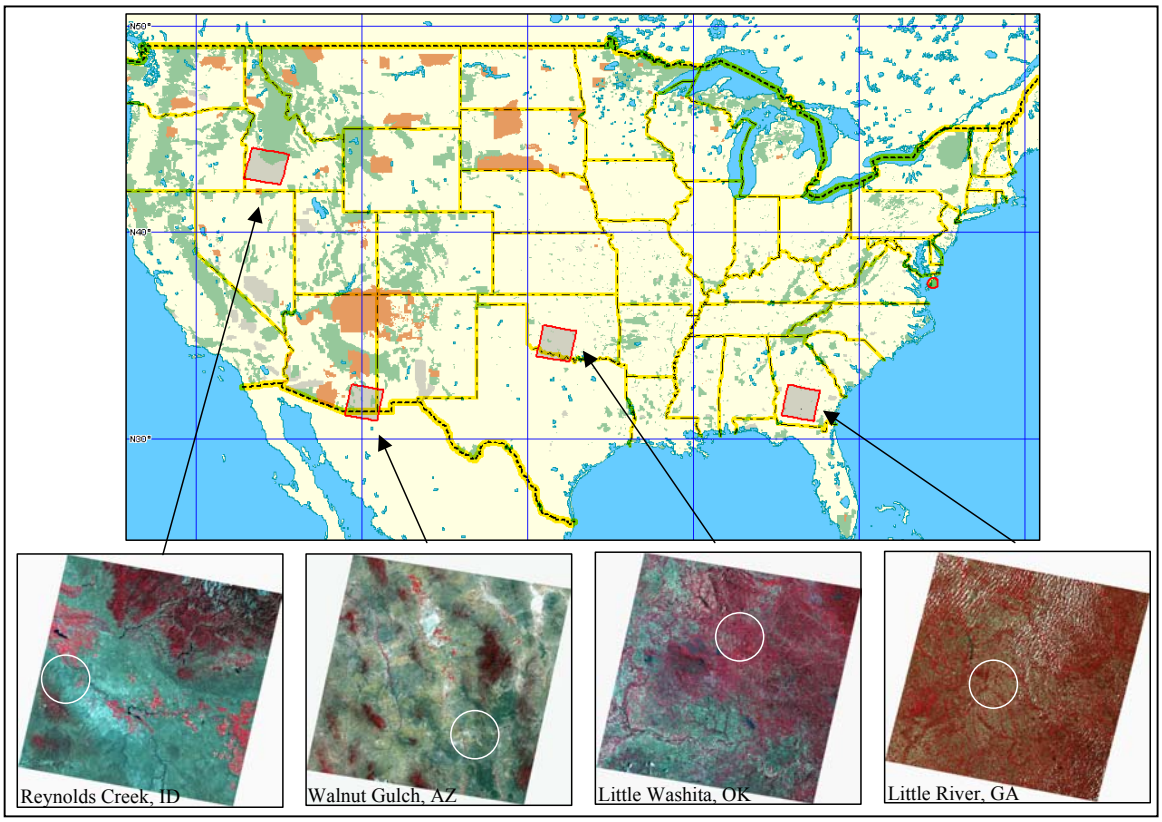

Figure 1. Locations of the ARS watersheds. The watershed locations are shown on the Landsat Thematic Mapper false color composite images as circles.

Table 1. Status of Watershed Soil Moisture Installations	
Watershed Site	Locations Instrumented
Walnut Gulch, AZ	21(1)
Little River, GA	13(7)
Reynolds Creek, ID	19
Little Washita, OK	19(1)

Algorithm Intercomparison

Calibration of the AMSR-E data has been slow and preliminary versions of the data have been poor. Therefore, algorithm intercomparisons have not been initiated with actual data. The RFI at C band will likely impact the algorithms and require modification.

As part of the preparation for this work, we have been comparing the 10.65 GHz data from TMI with the in-situ soil moisture observations at Tifton GA from the SCAN (Soil Climatology Analysis Network) site. The major results from this activity have included field measurements were conducted coincident with the AMSR – Aqua overpass in September, November 2002 and January 2003 with planned visits in March, April and May 2003 before the field campaign June 24-July 2, 2003. These field measurements include samplings in 10 or so locations using the

theta probe (for soil moisture), infrared thermometer for surface temperature and other vegetation sampling to ascertain the land surface state so as to be able to re-create/simulate the AMSR-E observation over Little River Watershed and surrounding areas for the 6.6, 10.6 and 18 GHz channels.

Satellite Brightness Temperature Comparison

As a contribution to Type 3 validation, we intend to compare brightness temperature (T_B) collected by other satellites with passive microwave instruments to AMSR T_B and when feasible to soil moisture products. As noted above, calibration of the AMSR-E data has been slow and preliminary versions of the data have been poor. We have examined several of the preliminary versions of the data, including the most recent Japanese calibration. The early versions were poorly calibrated for land targets. The most recent version looks good.

We are focusing on a data set from Oklahoma in October 2002 that includes a wide range of land surface brightness temperatures and has TMI observations within 15 minutes of the Aqua overpass time on four dates. At this stage the comparisons between the TMI and AMSR for 10, 19 and 37 GHz all indicate similar results. The 6 GHz channel data all have RFI. This was also observed in the analysis of data in July in both Oklahoma and Iowa.

Additional intercomparisons of TMI and Aqua AMSR-E are ongoing for the Little River Watershed in Georgia.

Large Scale Aircraft Experiments

During the past year we planned, implemented and successfully conducted the SMEX02 field campaign. SMEX02 was a large-scale field experiment conducted within a region near Ames, Iowa. The new and unique aspect of SMEX02 was significant agricultural crop biomass (water content).

Intensive soil moisture sampling and aircraft mapping with the Polarimetric Scanning Radiometer (PSR C/X) was conducted between June 25th and July 12th over corn and soybeans. Additional aircraft based mapping was also performed during this period with ESTAR, PALS, and AIRSAR plus several other sensors. Data from theses aircraft instruments is being processed and it is expected that this will be completed by July 2003.

SMEX03 was the FIRST AMSR-E validation experiment. We were able to collect eight coincident ground-aircraft-satellite data sets during the experiment that included a good range of soil moisture conditions. Figure 2 summarizes the data collected and also shows the rainfall at one location to illustrate the general meteorological conditions.

As part of SMEX02 we installed a temporary surface soil moisture network over the Walnut Creek Watershed near Ames (12 sites). This network operated from June 23rd until August 19th. We hope to extend our intensive SMEX02 analysis to this two-month period. This network also serves as a means of testing our hypothesis that temporal persistence theory can be used to both design and correctly interpret soil moisture point samples in footprint validation. By applying this concept we will be able to choose the best locations for long term monitoring. Results of this

analysis to date clearly show the potential and also illustrate the pitfalls of single point validation of footprint products.

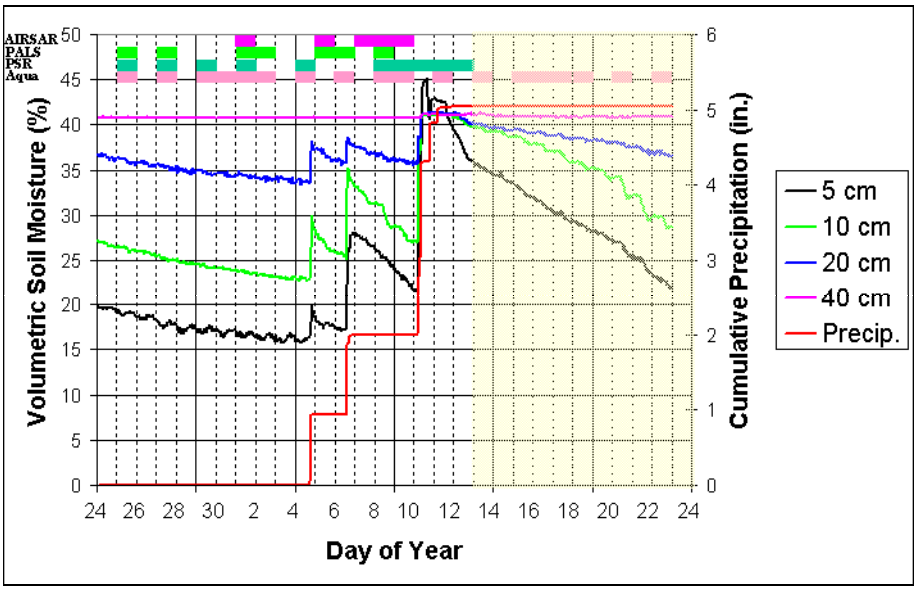

Figure 2. SMEX02 Ames Scan Site Soil Moisture and Microwave Remote Sensing Coverage.

Accomplishments

Publications

- Heathman, G.C., Starks, P.J., and Brown, M.A., Time domain reflectometry field calibration in the Little Washita River Experimental Watershed. Soil Science Society of America Journal 67:52-61. 2003.
- Jackson, T., Hsu, A., O'Neill, P. Surface Soil Moisture Retrieval and Mapping Using High Frequency Microwave Satellite Observation in the Southern Great Plains, Journal of Hydrometeorology, 3;688–699, 2002.
- Jackson, T., Gasiewski, A., Oldak, A., Klein, M., Njoku, E., Yevgrafov, A., Christiani, S., Bindlish, R. Soil Moisture Retrieval Using the C-Band Polarimetric Scanning Radiometer During the Southern Great Plains 1999 Experiment IEEE Tran. Geoscience and Remote Sensing, 40:2151-2161, 2002
- Jackson, T. Soil Moisture Mapping Using Satellite Microwave Remote Sensing: Current and Future Data for Hydrologic Modeling Proceedings Second Federal Interagency Hydrologic Modeling Conference, July 28-August 1, 2002, Las Vegas, NV, CD Publication Section 10D
- Seyfried, M.S. and M.D. Murdock. Effects of soil type and temperature on soil water measurement using a soil dielectric sensor. Proceedings First International Symposium on Soil Water Measurement using Capacitance and Impedance, I.C. Paltineanu, Ed., Beltsville, MD, November 6-8, 2002.

Presentations

- Jackson, T. J. Soil Moisture Experiments in 2002 and 2003. AGU Spring Meeting, Washington, DC, May 2002.
- Jackson, T. J. Soil Moisture Experiments. NASA Investigators Working Group Meeting, Ellicott City, MD on Nov. 18-19, 2002.
- Cosh, M.H., Jackson, T.J., Bindlish, R., Prueger, J.H., Estimation of Watershed Scale Soil Moisture from Point Measurements in SMEX02. AGU Fall Meeting, San Francisco, December 2002.
- Jackson, T. J. Soil Moisture Experiments 2003 (SMEX03). AGU Fall Meeting, San Francisco, December 2002.
- Famiglietti, J., Berg, A., Ryu, D., Holl, S., Bindlish, R., Cosh, M., Jackson, T.J., Ground-Based Soil Moisture Observations Within Satellite Footprints During SMEX02. AGU Fall Meeting, San Francisco, December 2002.
- Lakshmi V., J. Bolten and E. Njoku, Active passive remote sensing of soil moisture, American Meteorological Society 82nd Annual Meeting, 16th conference on hydrology, Orlando, FL, January 13-17, 2002
- Bolten, J., V. Lakshmi, E. Njoku, T. Jackson, Comparisons of Soil Moisture Retrievals Using the C-Band Polarimetric Scanning Radiometer and Passive/Active L/S Band Sensor During the Southern Great Plains 1999 Experiment, American Geophysical Society, Spring Meeting, Washington DC, May 28-31, 2002
- Bolten, J., V. Lakshmi, A. Gasiewski, T. Jackson, E. Njoku, An Evaluation of Soil Moisture and Vegetation Estimation Using Passive/Active Microwave and Optical Remote Sensing, American Geophysical Union Fall Meeting, December 6-10, 2002

NASA Workshops and Meetings

- NASA Aqua Science Team Meeting, Buellton, CA, May 4, 2002.
- Joint U.S. and Japan AMSR Science Team Meeting, Santa Maria, CA, May 5, 2002.
- Joint U.S. and Japan AMSR Science Team Meeting, Santa Rosa, CA, August 2002.
- NASA IWG, Ellicott City, MD, November 2002.
- SMEX02 Science Team Meeting, Columbia MD, January 14-15, 2003

Plans

Our tasks for this project are listed below. Two important items for the coming year are the planning and implementation of the SMEX03 experiment and initiating the flow of data from the watershed networks to an accessible archive. Both of these are challenging tasks.

Insitu Validation

1. Calibration of existing real-time observation stations within ARS watersheds
2. Supplemental monitoring and calibration of the surface soil moisture at existing meteorological stations distributed over the watersheds
3. Examination of the averaging and variability and temporal persistence for soil moisture in each watershed
4. Analysis of four climate regions of the United States

5. Provide real time observations at a point and average values within 30 days as well as ancillary meteorological observations
6. Assess AMSR soil moisture product on a continuous basis for the duration of the mission using insitu observations

Algorithm Intercomparison

7. For the U.S., and selected locations, implement alternative soil moisture retrieval algorithms under consideration by NASDA for AMSR
8. Establish a database of insitu observations for all sites
9. Provide quantitative intercomparisons of all satellite soil moisture retrieval algorithms versus insitu data comparisons
10. Provide these products as an alternative validation for AMSR-E soil moisture provided operational long-term networks, problems with data distribution and public access
11. Make available via the internet all AMSR-E and watershed data for research studies by the community

Satellite Data Comparison

12. Implement a model to quantify the effects of the various incidence angles of the satellites on brightness temperature
13. Extract seasonal data sets for the watershed sites as well as water and other targets
14. Establish comparison datasets with minimal time offsets
15. Compare the 19 GHz and 37 GHz channels of all satellites – AMSR, TMI, SSM/I
16. Compare 10 GHz for TMI, MSMR, and AMSR-E
17. Compare AMSR-E and AMSR when available
18. Analysis of the 6.6 GHz data (through satellite data comparison) for Radio Frequency Interference (RFI) over populated areas.

Large Scale Aircraft Experiments

19. Provide processed 6.9 GHz and 10 GHz aircraft data to the AMSR science team from the SMEX02 and SMEX03 experiments.
20. Provide regional ground validation for validation of soil moisture from aircraft microwave observation in SMEX02 and SMEX03.

Data Management

There are two separate data management activities under this project, each involving numerous contributors. The first component involves the soil moisture network data. Data quality and preprocessing are performed at the location level. These data will then be assembled for all locations at the NSIDC DAAC. Our goal is to eventually update these records on a monthly basis.

The second component involves the SMEX data sets. These are large and diverse data sets that originate from a wide variety of sources and contributors. We are following the model that we successfully used in SGP97 and SGP99. This involves working closely with both our contributors and the DAAC. We promote timeliness by holding workshops and telecons to keep people aware and focused. We anticipate that 50% of the data sets will be delivered to the DAAC by the end of March 2003 and 90% by July 2003.