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Editorial

Introduction to Soil Moisture Experiments 2004 (SMEX04) Special Issue

Soil Moisture Experiments 2004 (SMEX04) addressed two complimentary goals, the development and evaluation of remotely sensed land surface products for Terrestrial Hydrology and the eventual integration of these products in the North American Monsoon Experiment (NAME). Since the goals of NAME established the design parameters of SMEX04, it is important to understand its background.

In much of the interior of the North American continent, summer precipitation is a dominant feature of the annual cycle. Surface boundary conditions play an important role in initiation and maintenance of the North American Monsoon System (NAMS), which controls summer precipitation over much of this region. The most important surface boundary conditions are sea surface temperature and land surface wetness and temperature. The NAMS has important practical as well as scientific implications. As a result of rainfall patterns over the past decade, there have been drastic reductions in agricultural water supply allocations that have resulted in abandonment of agricultural lands in Mexico, international tensions resulting from the inability of Mexico to meet treaty obligations relating to inflows to international reservoirs, and additional pressure on Mexican immigration to the U.S.

One hypothesis of NAME (NAME Science Working Group, 2004) is that one of the land surface antecedent boundary conditions that control the onset and intensity of the NAMS is soil moisture in the southwestern U.S. and northern Mexico. The influence of the land surface is relayed through surface evaporation and associated surface cooling (dependent on soil moisture), terrain, and vegetation cover. Soil moisture and, in particular, the near surface wetness, can change dramatically after heavy rain events. Increased soil moisture after precipitation promotes evapotranspiration between storm events. This may contribute to enhanced convection and further precipitation. Soil moisture can vary both spatially, due to topography, soil, vegetation and precipitation variability, and temporally, due to differences in soil physical characteristics that control drainage and accumulated evapotranspiration.

Over much of the NAME region soil moisture observations are sparse and even precipitation observations that might be used to derive estimates of surface wetness are inadequate. Therefore, it would be difficult to address the hypothesis of NAME without additional soil moisture information. Remote sensing provides an alternative means of observing spatial and temporal variations in surface wetness over the region. Frequent derived estimates of soil moisture over the NAME region are available from the Advanced Microwave Scanning Radiometer (AMSR-E) on Aqua. However, these products have yet to be validated and are known to be of limited value in heavily vegetated regions. SMEX04 provided an excellent opportunity to evaluate AMSR products because much of the region has relatively sparse vegetation.

In addition to NAME, SMEX04 extends previous research. Field experiments in support of remote sensing, hydrology and climate have included catchments throughout North America (Oklahoma: SGP97, SGP99, SMEX03; Alabama and Georgia SMEX03; and Iowa: SMEX02). These experiments have been intensive efforts ranging from one to six weeks in duration. The basic approach used in these experiments has been to collect ground-based samples of soil moisture and surface fluxes in conjunction with aircraft flights at the same time as satellite overpasses.

The NASA Terrestrial Hydrology Program and Aqua Validation Project have been the primary supporters of these efforts and, therefore, each experiment has addressed established research priorities that included the following:

- Development and validation of soil moisture retrieval algorithms using microwave remote sensing in regions with moderate to significant topographic variation;
- Validation of soil moisture products from the Aqua AMSR-E (Advanced Microwave Scanning Radiometer) instrument;
- Establishing long-term in situ soil moisture validation sites for satellite based retrievals;
- Evaluation of new sensor technologies and algorithms for future soil moisture missions including Hydros and SMOS;
- Understanding the feedback mechanisms of surface soil moisture on weather and climate;
- Development of methods to assimilate surface soil moisture observations in models.

SMEX04 builds on the preceding experiments by focusing specifically on topography, vegetation, and strengthening the soil moisture components of the North American Monsoon Experiment (NAME). The timing of SMEX04 and NAME were driven by the NAMS. Rainfall statistics demonstrate quite clearly that the field experiment should be centered on the period of roughly mid-July to mid-August, when the number of rainy days is large and the possibility of having flights prior to and subsequent to heavy rainfall is high.

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The SMEX04 region included a wide range of arid to semi-arid conditions and heterogeneous topography. Between Hermosillo, Mexico and Tombstone, Arizona the topography varies from flat deserts to mountains with elevations of more than 2500 m.

SMEX04 involved in-situ soil moisture networks, tower observations of surface fluxes, vegetation mapping, aircraft mapping of soil moisture, intensive soil moisture sampling concurrent with aircraft overflights, and satellite products. Two regional study sites (~50 km by 75 km) were established in Arizona (AZ) and Sonora, Mexico (SO). A Navy Research Lab P-3 aircraft supported two passive microwave instruments, the Polarimetric Scanning Radiometer (PSR) with X and C band channels and the Two-Dimensional Synthetic Aperture Radiometer (2DSTAR) with L band channels. In addition, satellite data from the Aqua AMSR-E, Terra MODIS and ASTER, Landsat TM, and Envisat ASAR were employed in soil moisture and vegetation studies at local and regional scales.

As part of ongoing efforts to validate soil moisture products from AMSR, several watershed sites in the U.S. have been instrumented to provide continuous long-term observations of surface soil moisture and temperature. One of the sites is the Walnut Gulch Watershed near Tombstone Arizona. For SMEX04, an *in situ* soil moisture network was also established in the Sonora region of Mexico.

The papers in this Special Issue of Remote Sensing of Environment include a number of accomplishments that point to the success of SMEX04. Soil moisture network validation is addressed in Cosh et al. who found that the SMEX04 sensor network was an excellent estimator of the watershed average with an accuracy of approximately 0.01 m^3/m^3. The spatial scaling and temporal variability of surface soil moisture for large footprint validation in mountainous terrain is the subject of a study by Vivoni et al. Gebremichael and Vivoni offered a model to assess the area-averaged performance of a soil moisture network, applicable to other study regions. The scaling of tower fluxes and the effect of remote sensing spatial resolution on land surface models are described in Li et al. Studies by Yilmaz et al. and Cheng et al. used remote sensing to determine the spatial and temporal patterns of vegetation water content, which is a critical parameter in soil moisture retrieval with microwave radiometers.

Aircraft-based passive microwave remote sensing of soil moisture and some aspects of AMSR validation are the subjects of Bindlish et al. Rahman et al. present the results of studies involving radar remote sensing of soil moisture and surface roughness. Thoma et al. offer an image-based approach to determine the appropriate scale for soil moisture retrieval from radar imagery at SMEX03 (Georgia and Oklahoma) and SMEX04 (Arizona) watersheds. The remaining papers address the broader issues of modeling root-zone soil moisture using data assimilation (Mohanty et al.) and characterizing the land surface water cycle within the NAME region with a multi-sensor approach (McCabe et al.).

In addition to the science results presented in this Special Issue, SMEX04 has also resulted in a data archive (http://nsidc.org/data/amsr_validation/soil_moisture/smex04/]) and on-going continuous measurements of soil moisture and associated parameters (http://tucson.ars.ag.gov/dap/). The resulting databases will be of value in the next phase of NAME science investigations and expand our knowledge of the effects of key land surface features and the potential of new technologies for soil moisture mapping.

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