

## **Wide-Area Soil Moisture Estimation Using the Propagation of Low-Frequency Electromagnetic Signals**

**Bill Scheftic**, Kenneth L. Cummins and E. Philip Krider  
*University of Arizona*  
*Tucson, Arizona*

David Goodrich, Susan Moran, and Russell Scott  
*USDA Southwest Watershed Research Center*  
*Tucson, Arizona*

To date, there is no in-situ method for obtaining continuous, wide-area, near-surface (5-30 cm) soil moisture measurements. Land surface moisture measurements are central to our understanding of the earth's water system. They are necessary for basic resource management such as land use change, and are needed to produce accurate model-based weather predictions and analyses of climate change. Also, since the rainfall rates in individual convective storms vary significantly over distances of a few kilometers, soil moisture estimates derived from point measurements may not accurately reflect broader regional conditions. This problem is particularly severe in southern Arizona, where roughly 60% of our rainfall is produced by local convection during the Southwest Monsoon.

Recent studies have shown that regional differences in surface electrical conductivity are reflected in the average rise-times of radiation field waveforms produced by cloud-to-ground lightning. This lightning-related effect is strongest in the low- and medium-frequency range (100 kHz to 1 MHz). Since surface conductivity depends on soil moisture content, time-variations in the average lightning rise-time during the Southwest monsoon have been examined in order to see the effects of integrated rainfall. Preliminary results show a clear positive correlation between a simple model of the average daily surface moisture derived from rainfall estimates, and changes in the conductivity based on lightning rise-time measurements.

Given these lightning-related findings, we are currently evaluating the use of anthropogenic narrow-band radio emissions (non-directional beacons and AM radio signals), in the same frequency range, as a practical means to provide continuous estimates of near-surface soil moisture integrated over the central San Pedro Basin. Our long-term objective is to provide continuous estimates of soil moisture throughout North America, with a spatial resolution of a few tens of kilometers.

This presentation will include an overview of both techniques and related validation studies. Findings using the lightning-based approach for the 2005 monsoon season near Tucson will be compared to rainfall-based soil-moisture estimates. If available, we will also present preliminary findings from radio-based measurements that are currently underway in the San Pedro Basin. The primary reference dataset for these measurements is provided by USDA-ARS rain gauge and soil moisture instrumentation in the San Pedro Basin. This includes land surface moisture measurements being made in 1 m deep profiles at three sites along the San Pedro River and at two sites in Walnut Gulch in addition to over 20 sites where rainfall and near-surface soil moisture is measured (5 cm).

***HYDROMETEOROLOGY INTEGRATION***