Soil Moisture Retrieval Using ALOS PALSAR

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Abstract
Radar remote sensing provides very high spatial resolution data that can be used to estimate soil moisture and agricultural parameters. The radar signals depend upon many factors. Limitations of operational satellites have been the wavelength and the number of independent radar parameters. ALOS PALSAR incorporates a low frequency and multi-polarizations that may lead to improved soil moisture retrievals. As part of this project, ground based soil moisture observations from existing soil moisture networks and field experiments will be used to develop and evaluate retrieval algorithms. The networks include four watersheds in different climate regimes and others as they become available. Another component of the project involves field experiments that are part of ongoing research programs. Preliminary results from June-July 2007 over Oklahoma are discussed. Further research and analysis is planned, however, the availability of coverage is proving to be a limitation.

Keywords: Soil moisture, remote sensing, hydrology

1. INTRODUCTION

Radar remote sensing provides very high spatial resolution data that can be used to estimate soil moisture and agricultural parameters. The radar signals depend upon many factors. Limitations of available satellites systems have been the wavelength and the number of independent radar parameters. ALOS PALSAR includes a low frequency and multi-polarizations that may lead to improved soil moisture retrievals. This project will evaluate this new data.

Ground based soil moisture observations from existing soil moisture networks and field experiments will be used to develop and evaluate retrieval algorithms. The networks include four research watersheds maintained by ARS in different climate regimes. Additional sites may be included as they become available. This approach does not provide intensive sampling but it supports long term analyses.

Field experiments on the other hand are typically more intensive but shorter in duration. Our efforts include planned activities that are part of ongoing research programs.

A brief description of the sites and recent activities will be presented. Factors that are limiting success will be discussed.

2. WATERSHED NETWORKS

In order to provide a close approximation of soil moisture within the area and depth measured by low frequency passive microwave sensors we had implemented four watershed soil moisture networks throughout the U.S. (Jackson et al. 2007). We used existing dense meteorological networks as the backbone of the soil moisture networks. The resources we chose were part of the ARS Watershed Research Program. These were watersheds that had been previously selected to represent typical conditions in specific climate regions of the U.S., thus providing diverse conditions. The selected watersheds are listed in Table 1 and illustrated in Figure 1.

Table 1. USDA ARS watershed characteristics

Watershed	Size (km^2)	Soil Moisture Sites	Climate	Annual Rainfall (mm)	Topography	Land Use
Little Washita, OK	610	16	Sub humid	750	Rolling	Range/ wheat
Little River, GA	334	29	Humid	1200	Flat	Row crop /forest
Walnut Gulch, AZ	148	21	Semiarid	320	Rolling	Range
Reynolds Creek, ID	238	19	Semiarid	500	Mountainous	Range

To implement this network, additional surface soil moisture and temperature sensors (0-5 cm depth) were installed at and around existing instrument locations. The same soil moisture/temperature instrument was used at all sites and watersheds, which is the same as that used in another the continental scale Soil Climate Analysis Network, SCAN (Schaffer et al. 2007). Each watershed also has a SCAN site and additional meteorological and hydrological information.

Data collection began in May of 2002. Since then a number of investigations have been conducted to verify and calibrate the network sensors and to characterize the scaling behavior and how well the network represents the spatial average. As a result we have a high degree of confidence that the watershed average soil moisture data being produced by the networks is a reliable representation of the average near surface condition.

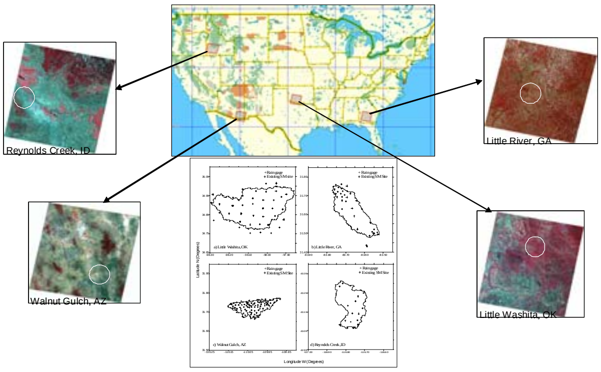

Figure 1. Locations of the ARS watershed soil moisture networks. The images are Landsat false color composites. Red is indicative of vegetation and blue indicates bare soil.

3. FIELD EXPERIMENTS

As noted, field experiments can provide more intensive ground observations but typically last a short period of time (<1 month). It should also be noted that these are supported by other programs and projects and, therefore, may not satisfy ALOS PALSAR goals. Over the past year we have attempted to incorporate the satellite radar data into three campaigns that are described in the following sections.

3.1. NAFE

The National Airborne Field Experiment (NAFE) was conducted in New South Wales, Australia during the month of November, 2006. Very intensive ground sampling of soil moisture was integrated with permanent in-situ long term stations. In addition, a large number of high resolution L band radiometer observations were made using an aircraft platform. Ground conditions included a range of irrigated agricultural conditions and grazing land.

ALOS PALSAR coverage of the domain was extremely sparse, only a few scenes may be relevant. We have experienced difficulties and long delays in locating data. We have been waiting on requests for ten months due to difficulties in transferring data between different download centers.

3.2. CLASIC

The Cloud Land Atmosphere Surface Interaction Campaign (CLASIC) took place in the Southern Great Plains, Oklahoma during June 2007. Intensive ground sampling and aircraft L band active microwave observations were obtained on many days during the month. This region includes one of our watershed networks, Little Washita (Figure 2).

Land cover conditions include a range of dryland and irrigated agricultural conditions and grazing land. Record precipitation was observed over Oklahoma during June 2007 that resulted in extremely wet conditions.

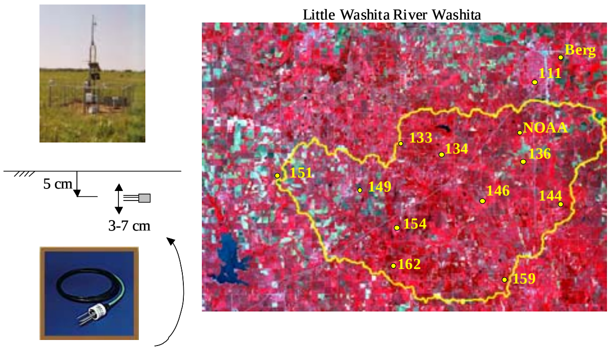

Figure 2. The Little Washita, OK watershed soil moisture network. This is a Landsat false color composite. Red is indicative of vegetation and blue indicates bare soil.

A unique aspect of this field experiment was the availability of the Passive Active L-band System (PALS). PALS was installed on an aircraft and flown on multiple dates over flightlines representing diverse conditions. PALS has a fully polarimetric radar along with a dual polarization radiometer operating at an incidence angle of 40^o. The center operating frequency of PALS radar is 1.26 GHz. During the one-month long field campaign, PALSAR data was available for 2 days for two different sampling regions (June 9 – Forest site; July 1- Little Washita watershed). We collected PALS and ground truth data on both days.

Field average PALSAR observations were compared with field average PALS observations. Each sampling site is about 800 m x 800 m in size. This results in multiple PALSAR and PALS footprints within the sampling field that can be averaged or filtered (PALS resolution is ~300 m). A total of 15 fields were sampled during the experiment (6 – pasture, 9 – winter wheat). The prevailing wet conditions delayed the winter wheat harvest resulting in unharvested (senescent) winter wheat fields. A preliminary comparison of data collected over test sites within the Little Washita on July 1, 2007 is plotted in Figure 3. Although it covers a limited range, the results are encouraging and indicate comparative calibration and possibly linear scaling.

Further research will focus on developing soil moisture retrieval algorithms and comparison with ground observations. Efforts will also be made to develop integrated radar-radiometer soil moisture algorithms using PALS radiometer and PALSAR radar observations.

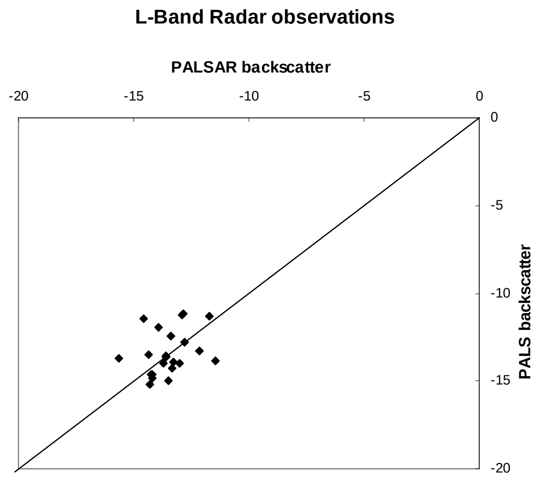

Figure 3. Comparison of PALSAR and PALS HH polarization radar backscatter for intensive soil moisture sampling sites in the Little Washita watershed on July 1, 2007. Each field is 800 m x 800 m.

3.3. Active Passive Tower Experiment (APEX)

A ground based tower with L-band active and passive sensors is being deployed at tests sites in Maryland. The primary objective is soil moisture retrieval under tree canopies throughout the annual leaf cycle using integrated active and passive observations.

We have requested PALSAR coverage of these sites. The limited seasonal coverage of this particular region will limit the amount of leaf-on observations.

4. SUMMARY

Soil moisture radar retrieval algorithms can be advanced by robust validation data sets. Two approaches are being used to achieve this; long term in-situ watershed networks and short term field experiments. The amount of coverage that is being obtained by the ALOS program makes it very difficult to establish a robust data set for algorithm investigations. The limited repeat and limited seasons that are observed impact the range of soil moisture observed but introduce highly variable vegetation conditions.

Acknowledgement

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References

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