How Does Dew Affect L–band Backscatter? Analysis of PALS Data at the Iowa Validation Site and Implications for SMAP

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Soil moisture is an important yet unobserved reservoir of the hydrologic cycle linked to the spatial and temporal variability of precipitation [1]. Microwave remote sensing technologies have the potential to produce real–time maps of soil moisture since the microwave radiation emitted and scattered by Earth's surface varies with the water content of the soil [2]. Two microwave remote sensing satellite missions will soon make the first global measurements of soil moisture at the optimal microwave frequency of L–band [3]. On November 1, 2009, the European Space Agency launched the Soil Moisture and Ocean Salinity (SMOS) mission [4]. SMOS will make measurements of the L–band brightness temperature of Earth's surface. In 2015, NASA plans to launch the Soil Moisture Active-Passive (SMAP) mission [5]. SMAP will measure both L–band brightness temperature and L–band backscatter.

Microwaves have relatively long wavelengths, and the wavelength at L–band is larger than the wavelengths monitored by any other current Earth–observing remote sensor. The consequence of this is that vegetation is semi–transparent at microwave wavelengths, and even more so at L–band. As a result, the L–band brightness temperature and backscatter is sensitive to soil moisture in both bare and many vegetated areas. Furthermore, because the vegetation canopy is semi–transparent, the microwave radiation emitted and scattered by vegetated surfaces changes with both soil moisture *as well as the moisture content of the vegetation canopy*. Hence liquid water within the vegetation canopy, such as dew, has an affect on the L–band brightness temperature and backscatter of Earth's surface. Although dew will often be present during the planned SMOS and SMAP overpass at 6 AM [6], the effect of dew at L–band has not yet been fully characterized.

Is dew a concern for SMOS? Perhaps. At IGARSS 2009 we demonstrated that the effect of dew on the L–band brightness temperature can be more than 10 K for a soybean canopy and a moderate dew (Figure 1). Previous studies had indicated that it was probably less than 5 K [7]–[9]. Given the sensitivity of L–band brightness temperature to soil moisture, the potential error in the measurement of soil moisture

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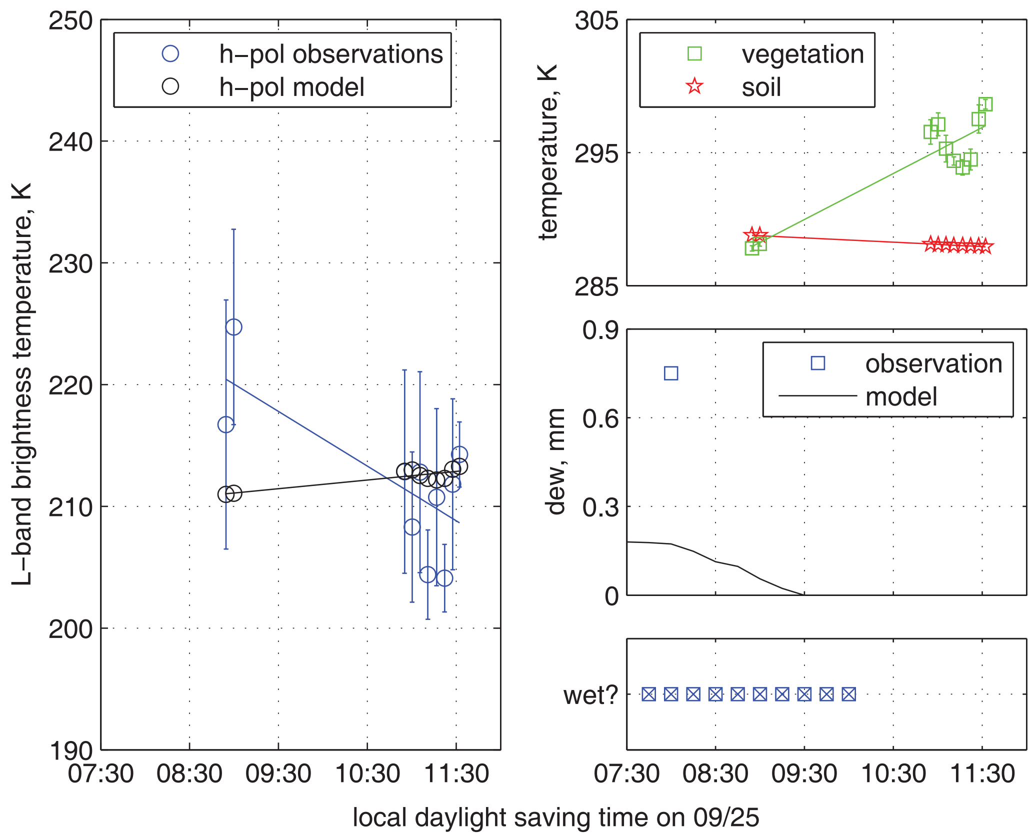

Fig. 1. At left, PALS observations of L–band h–pol brightness temperature of the soybean canopy at the Iowa Validation Site on September 25, 2008. Predictions of L–band brightness temperature made using the τ–ω model are also included. At right, change in observed vegetation and soil temperature, a manual observation of dew, model predictions of dew, and the output of leaf wetness sensors that indicate the presence of dew. Note that the τ–ω model *can not* explain the observations when dew is present. We conclude that dew *increased* the h–pol brightness temperature by 10 K at approximately 9:00.

when dew is present could be more than 5%, which is not an acceptable amount according to the mission specifications. However, SMOS will make measurements of the L–band brightness temperature at multiple incidence angles which will result in more information about the electrical properties of the vegetation canopy (including dew) that can be used to improve the accuracy of soil moisture measurements.

Is dew a concern for SMAP? Current plans call for the L–band backscatter measurement to be used to improve the spatial resolution of soil moisture measurements made using the L–band brightness temperature through the use of a change detection technique [10]. In this process, any change in the backscatter measurement is assumed to be caused by a change in soil moisture. The higher–resolution backscatter measurements are then used to disaggregate the lower–resolution brightness temperature measurements. No measurements of the effect of dew on the L–band backscatter have been reported, but considering the effect of dew on the backscatter at slightly shorter microwave wavelengths (X– and C–band) [11] and the the sensitivity of L–band backscatter to soil moisture [12],

> we hypothesize that a change in backscatter caused by dew *could be wrongly interpreted as a change in soil moisture* in this change detection scheme

and there is the potential for an error of more the 5%, which is unacceptable according to the mission

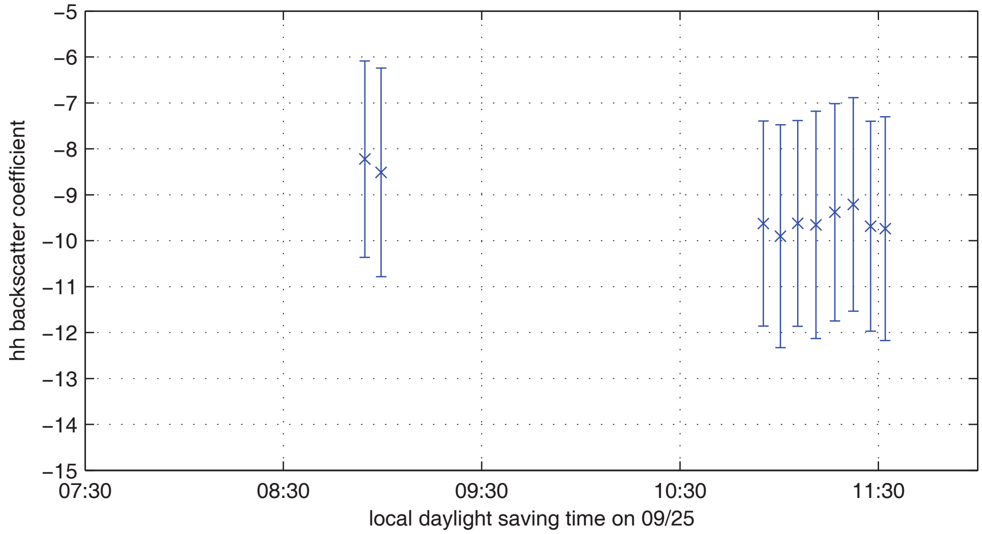

Fig. 2. PALS observed hh backscatter coefficient at the Iowa Validation Site on September 25, 2008.

specifications.

We will present the first case study of the effect of dew on the L–band backscatter at the Iowa Validation Site in the United States Midwest, a region where soil moisture is particularly important [1]. We will use data collected by NASA's Passive and Active L–band System (PALS) over corn and soybean fields at the Iowa Validation Site 23-25 September, 2008. The conditions during this three–day experiment were ideal for deducing the effect of dew on the L–band backscatter. On the first day, cloud cover during the previous night prevented the formation of any significant dew. On the final day, a heavy dew was observed. This dew evaporated as PALS repeatedly collected data over the same flight lines until the vegetation was essentially dry. We will compare the remote sensing data from the first day (no dew) with the data on the third day (heavy dew) and analyze the time–series of data on the third day as the dew dried off in order to deduce the effect of dew on the L–band backscatter. We will use ancillary data such as soil moisture, vegetation biomass, surface temperatures, and surface moisture fluxes to interpret our comparisons and analysis. In particular, we will use four different methods to characterize dew: manual measurements of dew amount; leaf wetness sensor measurements of dew duration; the condensation of water vapor and the evaporation of dew as measured by eddy–correlation sensors (via measurements of latent heat flux); and estimates of dew amount and duration made with a land surface process model called the Atmosphere Land Exchange (ALEX) model [13].

Our initial analysis of the data indicates that the hh L–band backscatter coefficient exhibits some sensitivity to dew. The hh backscatter coefficient as a function of time on September 25 (the day of moderate dew) is shown in Figure 2. Note that there is some change in the backscatter coefficient as dew on the soybean canopy dried over the course of the morning over the same period as the observed change in L–band h–pol brightness temperature as indicated in Figure 1. In our presentation, we will present data for the hh, vv, hv, and vh backscatter coefficients over the course of the entire three-day experiment for both soybean and corn. We will examine the sensitivity of the L–band backscatter to dew as well as a change in soil moisture and intercepted precipitation. We will analyze the data using a backscatter model and construct hypotheses that can explain the response that we observed in terms of the physical scattering mechanisms.

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