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IMPACT OF RADIO FREQUENCY INTERFERENCE MITIGATION ON ERRORS IN SOIL MOISTURE RETRIEVAL

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Abstract

The Soil Moisture Active/Passive (SMAP) mission is one of the high priority missions identified in the recent NRC Earth Science Decadal Survey. It will produce global maps of soil-moisture estimates from active and passive observations at L-Band. Man-made Radio-Frequency Interference (RFI) signals have been observed in a few airborne campaigns at L-Band (LeVine, 2002; Misra *et al.,* 2007; Misra *et al.,* 2009). If left unmitigated, the resulting corrupted brightness temperature (Tb) values can result in erroneous retrieval of soil-moisture estimates (O'Neill *et al.,* 2006). If, on the other hand, an RFI mitigation algorithm overcompensates and removes too much uncorrupted data while trying to limit the effects of RFI, the remaining Tb values and soil moisture retrievals can become very noisy. We attempt to characterize these competing factors by, first, analyzing the impact of RFI on soil-moisture estimates and, second, assessing the effects of detection algorithm "aggressiveness" on soil-moisture errors.

The SMAP mission plans on implementing a digital kurtosis detector for RFI detection and mitigation purposes. The kurtosis detection algorithm operates by measuring the gaussianity of the incoming signal (Ruf *et al.,* 2006). In the presence of man-made signals, the distribution of the incoming voltage deviates from normality and the resulting sample is flagged as being corrupted by RFI. The University of Michigan's Agile Digital Detector (ADD) was one of three radiometer back ends that were integrated with the JPL Passive/Active L/S Band (PALS) (Wilson *et al.,* 2001) for flights on board a Twin Otter aircraft. Several soil-moisture science flights were performed near Des Moines, Iowa and Choptank, Maryland between 22 September

and 19 October, 2008. ADD is capable of measuring the higher order moments required to calculate the kurtosis.

This paper analyses the impact of RFI detection threshold on the noise-statistics of soil-moisture estimates. Based on studies done by (De Roo *et al.,* 2008), the detection threshold determines the False-Alarm Rate (FAR) and Probability of Detection (PD) of the algorithm based on the type of RFI. If the threshold is too 'strict' then even though most of the RFI corrupted samples are detected and discarded, due to a high FAR, a large percent of clean Tb samples are also discarded which can affect the standard deviation of the retrieved soil-moisture estimates. If the threshold is too 'lenient' then soil-moisture is directly impacted by RFI corrupted samples missed by the detection algorithm. For SMAP algorithm implementation purposes it is necessary to determine the optimum detection threshold to minimize the impact of FAR as well as RFI. The paper attempts to utilize soil-moisture ground-truth measurements made during the SMAPVEX08 campaign to assess the impact of detection threshold.

The paper will also assess the sensitivity of soil-moisture estimates to Tb errors (introduced due to RFI) for various land parameters such as vegetation canopy parameter, vegetation water content, surface roughness etc. This is done by feeding RFI Tb errors obtained during flight campaign into microwave soil-moisture retrieval algorithm as described in (Jackson, 1993; Ulaby *et al.* 1986). Initial results indicate that a soil-moisture error of approximately $0.1cm^3/cm^3$ can result from a RFI Tb signal of as low as 10K. Since the flight-campaign data indicated most of the RFI present around the 0-1K region, most of the soil-moisture error observed is around that region. Soil-moisture error due to RFI is also highly dependent on the soil-parameters involved. Results indicate that soil-moisture error is most sensitive to canopy vegetation water content. RFI can be extremely detrimental to soil-moisture retrievals for high water content canopies, with a few Kelvin of RFI resulting in almost unrealistic soil-moisture retrievals.

A brief overview of the kurtosis algorithm for RFI detection and mitigation, the hardware involved as well as the soil-moisture retrieval algorithm will be presented. A description of the sensitivity analysis of soil-moisture error with respect to RFI detection threshold will be shown based on data obtained during the Fall 2008 Twin Otter campaign. This will be followed by an analysis of the sensitivity of soil-moisture estimates to typical RFI observed during the campaign as a function of various soil-moisture parameters.

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