Validation of the SMOS multi-incidence angle soil moisture retrieval over Australia

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Abstract- The Soil Moisture and Ocean Salinity (SMOS) satellite launched by the European Space Agency (ESA) in November 2009 is the first mission dedicated to global mapping of surface soil moisture. After decades of research the concept of passive microwave imaging is recognized as one of the most promising approaches to observe surface soil moisture evolution and has hence been adopted for SMOS. The sensor wavelength of 1400-1427 MHz was specifically chosen in order to operate within a protected part of the electromagnetic spectrum (L-band) that is supposed to be entirely clean of radio frequency interferences. Moreover, the measured brightness temperature response at L-band is highly sensitive to near-surface soil moisture and less affected by contributions induced by the surface roughness conditions and the presence of vegetation. With a desired spatial resolution of better than 50 km, requiring an antenna size around 8 m diameter for this wavelength, an innovative Y-shaped radiometer that unfolded in space was deployed. This antenna uses 2-dimensional interferometric synthetic aperture synthesis on the 69 individual receivers distributed along the arms to produce an image. The novel design of this sensor also enables quasi-simultaneous acquisition of dual-polarized microwave observations at a range of incidence angles ~0-55° for the same location on the earth surface. On the basis of numerous tower experiments and synthetic data, studies have shown that estimates of ancillary model parameters (such as vegetation water content) can be retrieved for the same SMOS footprint in addition to the soil moisture information using angular dependencies of the observed brightness temperature. This significantly enhances the retrieval process capabilities since there is less reliance on input parameters from other sources. Consequently, model issues due to discrepancies in spatial and temporal resolution of different input data should also be reduced. The multi-incidence angle observations are therefore understood to facilitate the overall soil moisture retrieval process and to improve the final SMOS soil moisture product considering a SMOS target accuracy of 0.04 m^3m^{-3}. However, this innovative approach has not been extensively validated using field data across a range of land surface conditions. Consequently, this study compares the SMOS L2 soil moisture products for several different SMOS pixels and at different instances in time with ground and airborne information collected during two recent field campaigns in Australia in 2010. The Australian Airborne Cal/val Experiments for SMOS (AACES) were conducted across a 500x100 km transect within the Murrumbidgee River Catchment, which covers a wide diversity of climatic, topographic and environmental conditions. An area corresponding to 20 independent SMOS pixels was observed at 1 km resolution with an airborne L-

band radiometer using three different incidence angles and two polarizations approximately coincident with the 6 am (local solar time) SMOS overpasses. In addition, ground sampling activities, including near-surface soil moisture, vegetation water content and surface roughness were carried out across representative focus farms of 2x5 km size. The available ground data together with the validated aircraft derived soil moisture estimates are used as ground truth for evaluating the SMOS multi-angle soil moisture and ancillary data retrieval. The research presented here focuses on comparison of the SMOS L2 soil moisture retrieved from multi-incidence angle SMOS L1C brightness temperature data with the ground truth data for a range of typical SMOS pixels. These results are contrasted with soil moisture retrievals from the SMOS L1C data using the core retrieval algorithm of SMOS but with model parameterizations specifically adapted to Australian surface conditions. This inter-comparison of the two SMOS derived soil moisture products is further extended by comparing results with soil moisture retrievals using the multi-angle airborne L-band data. Hence, this study demonstrates the effects of algorithm parameterization and brightness temperature uncertainty on soil moisture retrieval accuracy for a range of surface conditions from dry to wet and bare to densely vegetated.