A Study of Soil Moisture Estimation from Multi-Temporal L-band Radar Observations of Vegetated Surfaces

Jeffrey D. Ouellette*(1), Joel T. Johnson(2), Anna Balenzano(2),
Francesco Mattia(2), Giuseppe Satalino(2), Seungbum Kim(3), Jeff Walker(4),
Rocco Panciera(5)

(1) The Ohio State University, Columbus, Ohio, USA
(2) Consiglio Nazionale delle Ricerche (CNR) – Istituto di Studi sui Sistemi Intelligenti per l'Automazione (ISSIA), Bari, Italy
(3) The Jet Propulsion Laboratory (JPL), Pasadena, CA, USA
(4) Monash University, Melbourne, NSW, Australia
(5) University of Melbourne, Melbourne, NSW, Australia

L-band radar remote sensing of soil moisture has been the subject of research for several decades and has seen increasing attention in recent years. Soil moisture inversion from radar backscatter measurements in the presence of vegetation is a complex and difficult task. Several methods for deriving soil moisture estimates from such measurements have been explored, but these methods typically require the availability of a robust forward model and/or the use of ancillary data such as a vegetation estimator. This study presents a retrieval algorithm which requires neither an advanced forward scattering model nor ancillary vegetation data.

The algorithm presented here (originally developed by Balenzano, Mattia, and Satalino) relies on the assumption that the surface roughness and vegetation biomass of the observed scene do not significantly change over the course of a time-series of radar measurements. This retrieval method therefore works particularly well for airborne radar imagery since the latency between such acquisitions does not usually exceed 2-3 days. The method could potentially apply for satellite imagery if revisit times were sufficiently frequent. The method also invokes an assumption that vegetation contributions to observed radar cross sections are a multiplicative correction, so that vegetation effects are canceled in ratios of radar cross sections at successive times. A matrix equation involving these ratios can then be constructed from the time-series of radar backscatter observations. Surface permittivity (and thus surface soil moisture) estimates can then be acquired for each backscatter measurement by assuming that only surface contributions remain.

Results from the retrieval algorithm will be presented for simulated data and for airborne SAR acquisitions paired with in-situ ground sampling. The algorithm has been applied to several recent field campaign data sets, and has been shown to perform particularly well for certain types of agricultural crops such as wheat, canola and corn over a range of moisture and vegetation biomass conditions. Performance degrades in other land-cover types, presumably due to increased additive (as opposed to multiplicative) vegetation corrections. Implications of these results for future soil moisture remote sensing missions will also be discussed.