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Satellite Remote Sensing of Soil Moisture at Different Spatial Scales: SAR, Scaterometer and Microwave Radiometer

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To achieve frequent measurements and global coverage of soil moisture (SM), satellite microwave remote sensing has been progressively exploited, representing the perfect complement to in situ measurements. A direct sensitivity to SM exists at microwave bands, where it drives the soil electrical permittivity. Sensors operating in the low-frequency portion of the microwave spectrum (P- to L-band) are able to measure SM within a suitable depth, without being too much affected by sparse vegetation.
Both microwave (passive) radiometers and Synthetic Aperture Radar (SAR) can be used, with different swath width, as well as spatial and temporal resolution. Examples are ERS' scatterometer and SAR, Metop ASCAT, ENVISAT-ASAR, ALOS-Palsar, AMSR-E, and recently SMOS. SAR satellite systems can provide information at very high spatial resolution, in the order of hundreds of meters, although the revisit time is not suitable for many operational applications. Scatterometers and microwave radiometers, on their turn, provide frequent observations of soil moisture, but in this case the spatial resolution is much lower (tens of kilometres). A combination of active (radar) and passive (radiometer) observations are provided at L-band by the SAC-D aboard of Aquarius mission, and in the next future by the SMAP mission, the latter being specifically designed for soil moisture applications. A very promising system for good resolution (less than 1 km) soil moisture mapping with an interesting revisit time (6 days or less) is represented by the upcoming Sentinel 1 satellite carrying on board a C band SAR. The capability to produce reliable maps can be enhanced by exploiting the short revisit time, that is by applying multitemporal inversion techniques which assume a short time variability of soil moisture as opposed to a rather stable or continuous changing of soil roughness and vegetation.

In this work a comparison study has been performed including data from the ESA SMOS radiometer, ERS radar and Metop ASCAT Scatterometer (available through the Eumetsat H-SAF project). This is in view of future possible strategies to combine products generated by different retrieval approaches, exhibiting different spatial and temporal resolutions, thus taking profit from the relevant characteristics of each sensor. The data from the International Soil Moisture Network have been also collected, when available, as an additional source of information.
The potential of the good revisit of the Sentinel 1 mission to produce high resolution maps is demonstrated by testing a multitemporal algorithm on the radar images collected by the ERS satellite when the orbit cycle was set to 3 days. Then, an intercomparison has been carried between the different instruments by looking in particular at the observed spatial structures, which have been characterized throughout the semivariogram statistical tool. In addition, by performing a colocation in space and time of the collected data the respective measurement errors has been characterized by means of the triple collocation statistical technique. Finally, it will be attempted to single out the spatial smoothing associated to the instrument resolution as compared to the relevant spatial scale of the target parameter, that is the soil moisture field.