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Field test of a multi-frequency electromagnetic induction sensor for the study of soil moisture in different land-soil units

Giuseppe Calamita (1), Beniamino Onorati (2), Angela Perrone (1), Salvatore Manfreda (2), and Luca Brocca (3)

(1) Institute of Methodologies for Environmental Analysis, National Research Council, Tito Scalo (Pz), Italy, (2) School of Engineering, University of Basilicata, Potenza, Italy, (3) Research Institute for Geo-Hydrological Protection, National Research Council, Perugia, Italy

The crucial role of the soil moisture (SM) in a number of natural processes that act at different spatial and temporal scales has been largely recognized by the scientific community. Although the most used ground-based techniques for SM measurement (i.e. the Thermo-gravimentric, Time Domain Reflectometry (TDR) probes, Capacitance sensors, Neutron-moisture meters (NMM)) proved to be accurate and permit to acquire data at a high temporal resolution, they still remain invasive and punctual. As the size of the area of interest grows, these methods reveal applicability limitations that have been only partially overcome with the coming of the distributed sensor networks.

During last decade, it has been pointed out that an improved understanding of the processes and factors that control SM patterns at non-punctual scales might result from information collected in larger volume of subsoil or larger study area. Indeed, sensing greater volumes of soil over larger areas would filter less important details that derive from a simple sum of multi-point measurements and would be useful to emphasize the characteristics emerging at larger scales. This implies the collection of measurements on a large number of points distributed over larger scales, although characterized by lower accuracy.

Recently, geophysical methods have received special attention thanks to their ability to collect information that go beyond the local information sensed with traditional sensors. Between potentially useful methods, the Electro-Magnetic Induction (EMI) method has been indicated as one of the most promising for hydrological applications. Ground-based EMI sensors are lightweight, do not require contact with the soil allowing a considerable reduction of the survey costs as long as the spatial extent of the area of interest grows. Moreover, the ability to measure through thicknesses of soil greater than some centimetres and the possibility to collect data in wooded areas make the use of these sensors appealing compared to satellite remote sensing (RS) methods. However, similarly to RS, the interpretation of the EMI measurements is not straightforward due to the simultaneous influence of different soil properties.

So far, the great majority of the studies have used mono-frequency EMI sensors for periods of time shorter than one year. Moreover studies over area with medium to high vegetation density are still quite rare. The focus of this work is to evaluate the usability of the GEM-300 multi-frequency EMI sensor for spatial and temporal SM retrieval at the hillslope scale over a number of diverse land-soil units including some of the less explored types, like highland forested areas. Further, some aspects relating to the inherent stability of the GEM-300 sensor, which were never addressed before in this research area, are also explored.

The test sites are located in the “Fiumarella di Corleto” experimental basin, located in Basilicata region (southern Italy). The experimentation lasted from May 2012 to May 2013. Regular grids (80 x 80 mq) and a transect (60 m) were used as spatial sampling schemes. A TDR mobile probe was used for SM measurements on the 25 points of each grid whereas fixed buried TDR probes were used on the 11 points of transect.

The obtained results allowed us to investigate the spatial and temporal variability and relation between TDR and EMI sensors.