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Defining the Optimal Spatio-Temporal Sampling Interval for Observing Soil Moisture Dynamics from Space. Case Study: the GeoSTARe Satellite Mission Design

Luca Cenci (1,2), Luca Pulvirenti (2), Giorgio Boni (2,3), Flavio Pignone (2,3), Alessandro Masoero (2), Valerio Basso (2,3), and Nazzareno Pierdicca (1)

(1) DIET, Sapienza University of Rome, Rome, Italy, (2) CIMA Research Foundation, Savona, Italy (luca.cenci@cimafoundation.org), (3) DIBRIS, University of Genoa, Genoa, Italy

The research framework of the presented investigation is the GeoSTARe satellite mission design. GeoSTARe is a GEOsynchronous satellite carrying on-board a Synthetic Aperture Radar (GEO-SAR) sensor, which can provide satellite images with unprecedented temporal resolution, opening the path to novel or more powerful applications of SAR imagery. Thanks to its geosynchronous elliptic orbit, that allows the system to focus a synthetic antenna on the ground with different lengths, images can be generated with different time sampling (from minutes to half a day) associated with different spatial resolutions (<1km). Amongst the numerous possible applications that such system retains for environmental monitoring, those related to hydrology are the objective of the current research. In particular, the objective of this work is to investigate the potentialities that the GEO-SAR system retains for soil moisture (SM) monitoring. In fact, most of the satellite missions currently used for SM mapping exploit scatterometer (ASCAT) and radiometer sensors' acquisitions (AMSR2, SMOS, SMAP). Their observations are characterised by low spatial resolution (25-50 km) and high temporal resolution (1-3 days). Since the launch of the Sentinel 1 constellation, which carries a SAR sensor, the scientific community has begun to investigate the potential of operational SM monitoring at high spatial resolution (0.1–1 km) and moderate temporal resolution (≤6 days). However, SM dynamics are characterised by a high variability, both in space and in time. Therefore, the satellite-derived SM products currently available on the market may not properly represents the SM spatio-temporal variations. Despite the type of sensor, frequency and/or retrieval algorithm exploited for collecting SM data from satellite, it is of great scientific interest the understanding of the optimal spatio-temporal sampling interval for observing SM dynamics from space. Within this context, the objective of this work is to understand the GeoSTARe mission requirements, in term of spatio-temporal resolution, for SM mapping finalized to hydrological applications. Concerning the SAR sensor, C-band is presently envisaged as the designed microwave frequency inasmuch as it is compromise between SM detection capability and system performances. However, this information is not important for the purpose of the presented study, where the focus is only on the optimal spatio-temporal sampling interval of the system. In order to achieve the objective of the presented research, three GeoSTARe-derived SM products, characterized by different spatio-temporal resolutions and matching the expected radiometric performance of the sensor, are simulated. The three products are produced by adopting the following specifications (in terms of spatial resolution/temporal resolution): 1) 800m/1h; 2) 400m/2h; 3) 100m/12h. In order to account for the lower radiometric performance of a GEO-SAR, with respect to SAR sensor carried by a satellite with a sun-synchronous near-polar orbit, a conservative error of 0.07 m3/m3 is applied to the simulated SM observations. Then, these products are used in a synthetic SM - data assimilation experiment where the observations are assimilated within a hydrological model by adopting a Nudging approach. Finally, results are evaluated in term of impact on model discharge predictions to understand which GeoSTARe-derived SM product is more useful for hydrological applications.