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Quantitative estimation of precipitation on X-Band Synthetic Aperture Radar Imagery

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Spaceborne synthetic aperture radars (SARs) have become an important, in same extent fundamental, instrument for Earth observation and analysis. In particular, platforms operating at L-band and above have found a wide diffusion e.g. for flood areas detection and monitoring, earthquakes analysis, digital elevation model production, land use monitoring and classification, while other application are under research, such as analysis of volcanic ashes. One of most interesting characteristic of these instruments is the ground spatial resolution (that can reach meters dimension). On the contrary, one of their traditional limitations is given by the reduced duty cycle and coverage: in this respect, recent space SAR missions, operational or near to completing deployment, have greatly reduced this limit. Other characteristic, traditionally allocated to SAR system, is the “all-weather” nature, which is insensitivity to meteorological phenomenon. Experience with simulated and observed data has indicated that this affirmation requires some refinements. Precipitations can significantly affect the signal backscattered from the ground surface (e.g. Ferrazzoli and Schiavon, 1997). Moreover meteorological phenomenon can directly alter the SAR received signal, both in amplitude and phase, as assessed by several authors in the last years (e.g. Marzano et al., 2010, Baldini et al., 2014) analyzing X-Band SAR data by COSMO-SkyMed (CSK) and TerraSAR-X (TSX) missions. Indeed the probability of matching a significant event is low (Danklmayer et al., 2009). If this sensitivity usually represents a problem to be addressed by SAR users, it could represent an interesting opportunity to detect and measure precipitations in wild areas. Moreover they offer the unique opportunity to ingest within flood forecasting model precipitation data at the catchment scale.

In this work, we propose a processing framework aiming at producing precipitation maps and cloud masks by X-SARs data. Cloud masks are useful to SAR ground applications user to detect areas compromised by precipitations; in this work, they are used also to improve the SAR precipitation product, using ancillary data. Precipitation maps, obtained at a very high ground resolution, as allowed in microwaves only by SAR systems, offer interesting opportunity not only in itself but also developing synergic uses with ground weather radar (WR), e.g. for WR calibration, development of improved WR precipitation retrieval algorithms or to improve cloud volume characterization, using the different operating frequency and observing geometry. In this respect, even if work has been done in the last years, several issues still need to be fully addressed.

The developed procedure allows distinguishing flooded areas, precipitating clouds together with permanent water bodies, all appearing dark in the SAR image; this allows reducing the possibility of misinterpretations of the SAR data, which obviously have consequences on the precipitation map produced. Moreover, it allows estimating a cloud-free SAR image in order to retrieve the cloud attenuation. The following precipitation map procedure is based on the retrieval algorithm developed by Marzano et al. (2011), applied only to pixels where rain is known to be present. The developed procedure uses image segmentation techniques and fuzzy logic to perform the dark areas detection and recognition, while used ancillary data include local incident angle map and land cover (e.g. Pulvirenti et al. 2014 and Mori et al. 2012).

The proposed methodology have been applied to 16 case study, acquired within TSX and CSK missions over Italy and United States, in order to analyzing both hurricane-like intense events and continental mid-latitude ones. Moreover this choice offer the possibility to establish the comparison with operational ground weather radar products, for both verify and validate the proposed methodology and to exploit the synergic use SAR-WR. We will discuss the results obtained until now in terms of improved rain cell localization and precipitation quantification. Produced precipitations map will be available online within the portal of the FP7 project EartH2Observe “Global Earth Observation for Integrated Water Resource Assessment” (http://www.earth2observe.eu)