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Potential of High-resolution Detection and Retrieval of Precipitation Fields from X-band Spaceborne Synthetic Aperture Radar

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X-band Synthetic Aperture Radars (X-SARs), able to image the Earth's surface at metric resolution, may provide a unique opportunity to measure rainfall over land with spatial resolution of about few hundred meters, due to the atmospheric moving-target degradation effects. This capability has become very appealing due to the recent launch of several X-SAR satellites, even though several remote sensing issues are still open. This work is devoted to: i) explore the potential of X-band high-resolution detection and retrieval of rainfall fields from space using X-SAR signal backscattering amplitude and interferometric phase; ii) evaluate the effects of spatial resolution degradation by precipitation and inhomogeneous beam filling when comparing to other satellite-based sensors. Our X-SAR analysis of precipitation effects has been carried out using both a TerraSAR-X (TSX) case study of Hurricane "Gustav" in 2008 over Mississippi (USA) and a COSMO-SkyMed (CSK) X-SAR case study of orographic rainfall over Central Italy in 2009. For the TSX case study the near-surface rain rate has been retrieved from the normalized radar cross section by means of a modified regression empirical algorithm (MREA). A relatively simple method to account for the geometric effect of X-SAR observation on estimated rainfall rate and first-order volumetric effects has been developed and applied. The TSX-retrieved rain fields have been compared to those estimated from the Next Generation Weather Radar (NEXRAD) in Mobile (AL, USA). The rainfall detection capability of X-SAR has been tested on the CSK case study using the repeat-pass coherence response and qualitatively comparing its signature with ground-based Mt. Midia C-band radar in central Italy. A numerical simulator to represent the effect of the spatial resolution and the antenna pattern of TRMM satellite Precipitation Radar (PR) and Microwave Imager (TMI), using high-resolution TSX-retrieved rain images, has been also set up in order to evaluate the rainfall beam filling phenomenon. As expected, the spatial average can modify the statistics of the high-resolution precipitation fields, strongly reducing its dynamics in a way non-linearly dependent on the rain rate local average value.