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Estimation of daily rainfall over Italy by merging multiple microwave-based satellite products

Giulia Panegrossi (1), Daniele Casella (1), Anna Cinzia Marra (1), Paolo Sano (1), Stefano Dietrich (1), Luca Brocca (2), Luca Ciabatta (2), and Christian Massari (2)

(1) Institute of Atmospheric Sciences and Climate, National Research Council, Rome, Italy (g.panegrossi@isac.cnr.it), (2) Research Institute for Geo-Hydrological Protection, National Research Council, Perugia, Italy

Precipitation retrieval from space has seen great advances thanks to the improving quality of PMW measurements, the refinement of precipitation retrieval techniques, and the increasing number of microwave radiometers on board LEO satellites orbiting around the Earth. With the recent advent of the Global Precipitation Measurement (GPM) mission the constellation of cross-track and conically scanning microwave radiometers with precipitation-sensing capabilities currently ensures 1- to 3-hourly coverage at mid/high latitudes. Traditionally passive microwave (PMW) retrieval algorithms are based on the principle that surface precipitation can be estimated from the multichannel brightness temperature (TB) measurements because these are affected (in different ways depending on channel frequency, viewing geometry, spatial resolution, and surface background conditions) by the microphysical properties and 3-D distribution of liquid and frozen hydrometeors within the precipitating cloud, and, therefore, can be related to surface precipitation. These approaches can be categorized as top-down approaches and they provide instantaneous precipitation rate estimate at the surface at the time of the satellite observation. Recently a new perspective for surface precipitation estimate has been proposed, the bottom-up approach, based on the principle that the soil moisture can be considered as a "natural raingauge" and can be employed for "measuring" rainfall. The algorithm, called SM2RAIN, allows estimating rainfall directly from soil moisture retrieved from spaceborne sensors (i.e. ASCAT). Several recent studies have demonstrated that the approach is very effective for precipitation estimation from the daily to 5-daily scale, even though not applicable in regions where soil moisture retrieval is not feasible (i.e. highly vegetated areas, frozen surfaces, oceans).
This study shows that the precipitation estimates obtained by PMW observations using the two approaches (top-down and bottom-up) can be combined to provide accurate estimates of daily rainfall. For the top-down approach two different precipitation retrieval algorithms are used: the Cloud Dynamics Radiation Database algorithm (CDRD), a physically ¬based Bayesian algorithm applied to the conically scanning radiometer SSMIS, and the Passive microwave Neural network Precipitation Retrieval (PNPR) algorithm for cross-track scanning radiometers AMSU/MHS. Four-year (2011-2014) assessment over Italy (complex territory with orography, sea-land interface, vegetation, frozen soils) is carried out for the daily rainfall estimates obtained from SM2RAIN, combined CDRD-PNPR, and merged SM2RAIN-CDRD-PNPR products, all regridded at 0.25°x0.25° spatial resolution. Rainfall measurements from the Italian raingauge network are used as reference. Results show that both SM2RAIN and CDRD-PNPR rainfall products are as accurate as state-of-the-art products, e.g., the TRMM product 3B42RT. The CDRD-PNPR product shows sensitivity to the number and frequency of SSMIS and AMSU/MHS overpasses available, and evidences worse results along the coast, while SM2RAIN shows criticalities mostly related to soil moisture retrieval feasibility. The merged SM2RAIN-CDRD-PNPR product shows better results in terms of correlation (R=0.7), accuracy (RMSE=6.6 mm), and rainfall detection capability (POD=0.75, FAR=0.32, TS=0.5 for 1 mm threshold). The study demonstrates that daily rainfall estimate over a complex territory such as Italy can benefit from the exploitation of multiple PMW radiometers, and from the integration of the top-down and bottom-up approaches.