Direct Validation of Satellite Based Rainfall Estimates against Ground Based Observations from Rain Gauges

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Abstract

Accurate knowledge of rainfall is essential for near-real time drought monitoring and crop-yield forecasting. This is especially important in Africa where agriculture is mainly rainfed, but ground-based rainfall monitoring stations are most sparse with often discontinuous and incomplete time-series record, and a time-delayed availability – all factors that stumble operational monitoring and forecasting systems such as those used at the Monitoring Agricultural ResourceS (MARS) Unit at the Joint Research Centre of the European Commission. Daily and 10-daily (dekadal) rainfall time series derived from satellite data or model-based approaches may be used to assess drought probability (for crop insurance) or monitor crop growth at larger spatial scale than from gauge observations. TAMSAT rainfall estimates at the 10-daily (dekadal) time step covering 1983 to present are routinely derived from _˜4-km Meteosat thermal infra-red (TIR) imagery captured every 30 minutes (for Meteosat First Generation satellites, until 06/2006) and every 15 minutes (Meteosat Second Generation satellites, 07/2006 to present) through calibration with historical rain gauge observations. Other rainfall products (e.g. NOAA RFE2.0) use near-real time rain gauge data in addition to Meteosat and radar (SSM/I, AMSU) data or are based on outputs from numerical weather prediction (NWP) models (e.g. ECMWF). These dekadal rainfall estimates are currently used for operational African drought monitoring, but from a users and practitioners' perspective, it remains challenging to understand the reliability of rainfall estimates derived from satellite data that are calibrated against gauge records using different methods. TAMSAT has addressed this challenge through a consistent system for routine operational validation of the dekadal satellite based rainfall estimates using independent rain gauge observations from the Global Telecommunications Network (GTN) of the World Meteorological Organization (WMO) covering the time period from 01/2011 to present. This approach for routine validation helps to identify where dekadal rainfall estimates are reliable based on the spatial and temporal coverage of gauges through systematic statistical analysis. The results show that over the time period considered in the validation, the Pearson's correlation between TAMSAT dekadal rainfall estimates and gauge observations ranges from 0.1 to 0.9, the bias – from -18 to 3 mm dekad-1, percentage bias varies between approximately -60% and 15%, root mean square difference (RMSD) ranges from approximately

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-22 to 50 mm dekad-1, and the normalized RMSD (NRMSD) is between 5 and 20%. The analysis of validation results is complicated by the challenges involved in direct validation of satellite estimates and gauge observations of rainfall, namely point-based observations versus area-averaged estimates. The results highlight important implications for assessment of drought occurrence and severity, as well as for modeling and forecasting of crop conditions (e.g. through the Global Water Stress Index).