



Analysis of satellite precipitation products during the monsoon floods in Pakistan in 2022

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On 24-26 August 2022 Pakistan has suffered one of its most severe floods. The excessive monsoon rainfall throughout the summer, which was worsened by shorter bursts of extremely heavy rain that affected the regions of Sindh and Balochistan, directly contributed to the flooding. According to reports, Pakistan experienced more than three times its typical rainfall in August, making it the wettest month since 1961. The strong monsoon moist currents and thermal lows started from Arabian Sea penetrating into entire area of Balochistan and Sindh, and spread over upper and central parts of the country. The moist currents from the Bay of Bengal penetrating during the entire monsoon season

from mid-June to September resulted in floods and land sliding across Pakistan, causing human casualties as well as widespread destruction of homes and infrastructure. Floods cannot be entirely avoided, but their harmful effects can be significantly managed with careful planning and adequate preparation. The use of operational satellite precipitation products could facilitate prompt and accurate monitoring (and forecasting) as well as the implementation of impact-minimizing strategies, reducing vulnerability to floods.

The European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) application facility on Support to Operational Hydrology and Water Management (H SAF) (<http://h-saf.eumetsat.int/>) provides operational satellite products of important hydrological parameters, including snow cover and water equivalent, soil moisture, surface rain rate and cumulated rainfall. Among these, H SAF generates a near-real time (NRT) product providing instantaneous surface precipitation rate over the Meteosat Second Generation (MSG) Indian Ocean Data Coverage (IODC) every 15 minutes at 3-5 km spatial resolution (H SAF product ID H63). H63 is based on the rapid update blending technique combining passive microwave (PMW) precipitation rate estimates and IR measurements from MSG SEVIRI. On the other hand, since the beginning of March 2014, the NASA Global Precipitation Measurement (GPM) mission (<https://gpm.nasa.gov/missions/GPM>) Integrated Multi-satellite Retrievals for GPM (IMERG) product provides quasi-global (60 N-60 S) precipitation rate estimates every 30 min at 0.1°x0.1° spatial resolution, combining information from the GPM constellation of PMW radiometers available over the majority of the Earth's surface with IR satellite measurements.

This study proposes a comprehensive overview about the performance evaluation of IMERG (Early and Late run) and H63 products using rain gauges data in Pakistan, for the August 2022 Pakistan Flood event. Gauge-based rainfall data from the high-density climate station network of the Metrological Department Pakistan (PMD), are compared with NASA GPM IMERG rainfall products, and with H SAF and H63 rainfall product. Hourly and daily precipitation estimates are derived from the satellite products over specific regions entirely covered by 32 PMD stations. The goal of the study is to evaluate the performance of IMERG and H63 by means of a cross-comparison with rain gauges data (considered as the ground truth) using both statistical and graphical methods and analyze the results considering local environmental conditions. We also illustrate, through selected rainfall event cases and sub-regions, how insufficient coverage by PMW radiometers can lead to larger discrepancies in the IMERG and H63 estimates with respect to the ground measurements.