Investigating rain rate estimates from non-conventional satellites to supplement H SAF products at global scale

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Passive microwave (PMW) observations are the backbone of current satellite-based precipitation measurements at the global scale, and they underpin several precipitation products of the EUMETSAT Hydrology Satellite Application Facility (H SAF). Most current MW radiometers used in H SAF (e.g., SSMIS, MHS, ATMS and AMSR2) and upcoming EUMETSAT next-generation instruments (e.g., MWI, ICI and MWS) operate on polar, sun-synchronous Low Earth Orbit (LEO) satellites. This configuration yields non-uniform global sampling in both space and time, with the largest gaps occurring at low latitudes, where revisit times can be up to a few hours. To partially address this limitation, the existing constellation can be complemented with small satellites, which leverage platform standardization and technology miniaturization that have, over the past decade, reduced development time and cost and enabled rapid deployment. In this context, the potential contribution of NASA's TROPICS mission —a PMW atmospheric-sounding constellation based on centimeter-scale CubeSats— has been investigated. During the main operational phase, from June 2023 to February 2025, TROPICS operated three satellites in orbits inclined at ~33°, providing revisit times of roughly 70–90 minutes over the tropics. Each satellite carried the 12-channel TROPICS Millimeter-wave Sounder (TMS) with seven channels near the 118.75 GHz oxygen absorption line, three channels near the 183.31 GHz water vapour absorption line, one imaging channel near 90 GHz, and one channel near 205 GHz sensitive to cloud ice particles. Among the products released by NASA for this mission, the Level-2B Instantaneous Surface Rain Rate (ISRR) has been investigated as a potential supplement to H SAF to increase the temporal sampling and spatial coverage of PMW-based precipitation estimates in the tropics and subtropics. However, its operational implementation requires ISRR estimates to be consistent with existing H SAF precipitation products, ensuring that their combination in downstream applications does not yield markedly different precipitation estimates for comparable scenarios. Downstream products that would benefit from this consistency include, for instance, H SAF's gridded instantaneous precipitation product provided at regular time intervals and the blended products that combine geostationary infrared observations with PMW-based precipitation estimates. Accordingly, this work aims to assess and improve such consistency by developing and implementing a method to compare and adjust TROPICS ISRR relative to an H SAF reference precipitation product. This process should not be considered a calibration against ground truth aimed at removing intrinsic biases, but rather an inter-product alignment, ensuring that the two estimates exhibit comparable distributions and do not show substantial discrepancies. More broadly, this study proposes a methodology for the comparison and adjustment of instantaneous rain rates that can be extended to other satellite missions that provide analogous estimates. Overall, it provides an initial contribution toward leveraging CubeSat observations within H SAF, offering preliminary evidence of the feasibility and potential benefits of developing CubeSat-based precipitation algorithms for integration into H SAF operational products.