PrecSat: An Open, Modular, and Scalable Platform for Satellite Precipitation Monitoring, Validation, Tracking, and Nowcasting

Authors: Alan James Peixoto Calheiros, Lourenço Jose Cavalcante Neto, Adriano P Almeida, Helvécio Bezzera Leal Neto

e-mail: alan.calheiros@inpe.br

Accurate satellite-based precipitation estimation and short-term forecasting remain particularly challenging over Latin America due to intense convective variability, complex topography, and heterogeneous surface observation coverage. Although multiple global and regional precipitation products are available, their uncertainties and biases vary substantially across climatic regimes and must be quantified in near real time to support reliable decision-making. Motivated by this operational and scientific gap, and by the need for a regional testbed aligned with the WMO AI Nowcasting Pilot Project (AINPP), we present PrecSat, an open-source, scalable, and modular web platform designed to integrate precipitation monitoring, validation, tracking, and nowcasting within a unified and reproducible framework. PrecSat is built on a container-based architecture following an “in-the-box” concept, in which datasets, processing pipelines, diagnostic tools, and forecasting components are encapsulated in modular units that can be progressively extended. This design allows the platform to evolve as new satellite products, retrieval methodologies, and forecasting models become available. The system integrates satellite-derived quantitative precipitation estimates, including GPM-era products such as IMERG and GSMaP, as well as regional blended datasets such as CPTEC/INPE MERGE. Whenever available, rain gauge and weather radar observations can be incorporated as reference datasets. In the monitoring module, PrecSat performs systematic spatial–temporal collocation between satellite estimates and reference data, enabling consistent pixel-based evaluation of detection skill and intensity errors. Complementary monitoring strategies include precipitation system tracking using pyForTraCC, providing dynamic visualization and analysis of storm evolution. The nowcasting module supports both conventional extrapolation techniques and AI-based forecasting models, with forecast outputs

evaluated independently across multiple lead times to assess skill degradation, intensity bias, and short-term predictive performance. By harmonizing estimation and forecasting diagnostics while preserving dedicated validation workflows, PrecSat enables comprehensive assessment of both retrieval accuracy and forecast reliability. Case studies over Brazil demonstrate how the platform reveals distinct regional error structures, such as large-scale underestimation contrasted with localized overestimation, and how interactive regional selection exposes context-dependent performance that would otherwise be masked by domain-averaged metrics. Initial applications within AINPP-related activities highlight the role of PrecSat as an experimental environment for precipitation tracking and nowcasting evaluation, supporting transferability analyses of forecasting approaches in tropical convective regimes. Currently under active development as a collaborative open-science initiative, PrecSat aims to consolidate a regional benchmark and validation ecosystem that strengthens precipitation product development, accelerates reproducible intercomparison, and supports scalable monitoring and nowcasting capabilities across diverse environments.

Key-words: Satellite Precipitation; Web Platform; Nowcasting; Evaluation