



# Reliability Assessment and Applicability Analysis of Geostationary Satellite-Based Precipitation Observations for Climate Change Response

SuYeon Park<sup>1</sup> and Seokhyeon Kim<sup>2</sup>

<sup>1</sup>KyungHee, Civil Engineering, Seoul, Korea, Republic of (zaqmpl02@khu.ac.kr)

<sup>2</sup>KyungHee, Civil Engineering, Seoul, Korea, Republic of (shynkim@khu.ac.kr)

As climate change intensifies the frequency and magnitude of extreme precipitation, the demand for observation systems capable of accurately capturing short-duration, high-intensity events is increasing, while the limitations of existing frameworks are becoming more apparent. Geostationary (GEO) satellites play a pivotal role in precipitation monitoring due to their high temporal continuity, with the Korean Geo-Kompsat-2A (GK-2A), launched in 2018, providing continuous observations via its Advanced Meteorological Imager (AMI). However, most GEO-based precipitation products rely primarily on infrared (IR) observations, which estimate surface rainfall indirectly from cloud-top radiative properties. Because GEO-based IR precipitation retrievals infer rainfall indirectly from cloud-top signals, a structural limitation arises when cloud-top properties become decoupled from near-surface precipitation processes. This motivates a systematic evaluation of the performance and applicability of GEO IR-based precipitation products under diverse environmental conditions.

In this study, the performance characteristics of the GK-2A precipitation product were evaluated using five years of data (2020–2024) over South Korea, compared against observations from 98 Automated Surface Observing System (ASOS) stations. Quantitative evaluation was conducted for hourly and daily accumulated precipitation using the correlation coefficient ( $R$ ), Kling–Gupta efficiency (KGE), and unbiased RMSE (ubRMSE), while categorical detection performance was assessed using Accuracy, probability of detection (POD), and false alarm ratio (FAR). Analyses were performed separately for rainy and non-rainy seasons and further stratified by environmental conditions, including air temperature, humidity, cloud fraction, coastal proximity, and terrain ruggedness index (TRI). The microwave-based GPM IMERG product was used as a reference to contextualize the behavior of the IR-based GK-2A estimates.

Results indicate that GK-2A generally exhibits lower correlation and higher error than GPM IMERG, with performance differences becoming more pronounced under specific environmental conditions. Notably, under low temperature and humidity conditions and in coastal regions, GK-2A shows statistically significant performance degradation ( $p < 0.01$ ), characterized by reduced correlation and increased estimation error. In contrast, GPM IMERG maintains relatively stable performance across the same environmental regimes, suggesting that the observed degradation

in GK-2A is closely linked to conditions under which cloud-top radiative signals inadequately represent surface precipitation.

By identifying environmental regimes associated with systematic performance degradation, this study clarifies the limitations of GEO IR-based precipitation estimation. The GK-2A case study provides insights applicable to other GEO IR precipitation products and highlights the need for algorithm refinement and multi-sensor integration strategies, particularly incorporating microwave observations, to improve the robustness of high-frequency satellite-based precipitation monitoring under changing climate conditions.

**Key Words : Climate change; rainfall intensity; extreme precipitation; ground-based observation; ASOS; GEO-KOMPSAT-2A (GK-2A) satellite**

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