

Towards AI-Based Extreme Rainfall Prediction Using Multi-Source Precipitable Water Vapor and Meteorological Data

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Abstract

Extreme rainfall events create serious risks to infrastructure, ecosystems, and human life, making accurate short-term rainfall prediction essential for disaster risk management and early warning systems. Precipitable Water Vapor (PWV), representing the total amount of atmospheric water vapor, is considered an important early indicator of precipitation and can improve rainfall forecasting models. This study presents an artificial intelligence-based framework for predicting extreme rainfall using multi-source PWV observations and meteorological data. The proposed approach integrates PWV derived from Global navigation satellite systems (GNSS) observation, GNSS Radio Occultation (GNSS-RO), radiosonde observations, and ERA5 reanalysis datasets together with surface meteorological parameters such as temperature, pressure, and relative humidity. PWV values will be derived from GNSS observations collected between 2015 and 2025 from 57 GNSS stations belonging to the International GNSS Service (IGS) and TUSAGA-Active networks located in the Marmara and Black Sea regions of Türkiye. These heterogeneous atmospheric datasets will be analyzed using a Transformer-based deep learning architecture, particularly the Informer model, to investigate temporal relationships in atmospheric processes. The proposed framework aims to improve short-term extreme rainfall prediction and support operational early warning systems. This study is supported by the Scientific Research Projects Coordination Units of Istanbul Technical University (MGA-2026-47555), Yıldız Technical University (FBA-2026-7468), and Karadeniz Technical University (FTU-2026-16985) within the scope of the Technical Universities Cooperation (TU11) projects.

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