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ANALYZING EXTREME RAINFALL: A COMPARATIVE STUDY OF GRIDDED DATABASES AND LOCAL STATION DATA FOR ENHANCED IDF CURVE GENERATION FOR THE STATE OF RIO GRANDE DO SUL

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INTRODUCTION

This study aimed to compare patterns of extreme rainfall obtained from two gridded databases: CHIRPS (Funk *et al*., 2015) and Xavier (Xavier *et al*., 2016, 2022). with data from rain gauge stations in the state of Rio Grande do Sul retrieved via the HIDROWEB (BRASIL, 2021). Gridded datasets are valuable for regional hydrological analyses, but their coarse resolution often fails to capture the variability of extreme local events accurately (Sillmann *et al*., 2013; Zhang *et al*., 2016). This work investigated their performance using two methodologies: the Localized Comparison Approach (LCA), comparing data directly at rain gauge station locations, and the Spatial Comparison Approach (SCA), analyzing broader spatial interpolations. Statistical models (GEV, Gumbel, and Gamma) and parameter estimation methods (MOM, MML) were used to generate IDF curves, with RMSE and MAPE metrics applied to evaluate the effectiveness of rainfall interpolation techniques such as Inverse Distance Weighting (IDW) and Ordinary Kriging (OK).

This study underscores the necessity of integrating gridded datasets with local station data to improve IDF curve reliability, particularly for engineering applications and climate risk assessments (Wilby, 2010; Zhang *et al*., 2016). While gridded datasets like XAVIER and CHIRPS provide extensive regional coverage, their limitations in capturing extreme events highlight the importance of validating their results with *in situ* records. The developed web application enhances accessibility to IDF data for policymakers and engineers, ensuring that infrastructure planning in RS can incorporate the most accurate rainfall projections. Future work should focus on refining regionalization techniques, enhancing precipitation datasets' spatial resolution, and addressing uncertainties tied to extreme rainfall (AghaKouchak *et al.*, 2013; Raju & Kumar, 2018).

METHODOLOGY

Two comparative methodologies were employed. The Localized Comparison Approach (LCA) focused on evaluating rainfall intensities derived from each dataset at the exact locations of the rain gauge stations. Meanwhile, the Spatial Comparison Approach (SCA) assessed the broader spatial distribution of rainfall intensities by interpolating station data using Inverse Distance Weighting (IDW) and Ordinary Kriging (OK) and comparing these interpolations with values from the gridded

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datasets. Metrics such as the Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) were used to evaluate the performance of IDW and OK methods.

For IDF curve generation, the rainfall data were subjected to frequency analysis using statistical distributions such as Gumbel, Gamma, and Generalized Extreme Value (GEV). Two parameter estimation techniques, Method of Moments (MOM) and L-Moments (MML), were tested to analyze the uncertainty introduced by statistical methods. The study applied the best-performing combinations of statistical models, parameter estimation techniques, and interpolation methods for IDF curve construction across all 497 municipalities of RS.

RESULTS

The results showed that both CHIRPS and XAVIER underestimated rainfall intensities compared to local HIDRO station data, with errors increasing for longer return periods, particularly for extreme events (e.g., 500-year return periods). XAVIER performed better than CHIRPS due to its finer spatial resolution and regional calibration, but significant uncertainties persisted, especially for rarer rainfall events, where discrepancies exceeded 100% in some cases (Gómez-Navarro *et al*., 2012; Sillmann *et al*., 2013). The choice of statistical models and parameter estimation methods added further variability, with the GEV distribution and MML estimation yielding the most accurate results. Interpolation techniques also performed differently: IDW was better suited for shorter return periods, while OK provided more accurate results for longer return periods by incorporating spatial variability (Giorgi & Mearns, 2002). The statistical analysis demonstrated that the choice of the extreme value distribution model and parameter estimation method significantly influenced IDF outcomes. Among the models tested, GEV paired with MML provided the most consistent and accurate results. However, uncertainties grew with longer return periods, where discrepancies exceeded 100% for 500-year return periods in some locations. These results underscore the importance of regional calibration and validation, particularly in datasets designed for extreme rainfall analysis.

Interpolation methods showed varying performance depending on the data and return periods analyzed. IDW performed better for short return periods, providing localized predictions based on the proximity of stations. On the other hand, Kriging demonstrated superior accuracy for longer return periods, reflecting its ability to capture spatial variability effectively. By employing IDW with fine-tuned parameters for short-term events and Kriging for long-term ones, the study achieved higher accuracy in IDF curve generation for all municipalities in RS. Additionally, a web application was developed to present the study's findings and IDF results for each municipality. This interactive platform is available at https://cassiorampinelli.shinyapps.io/IDFs_RS_EN/.

CONCLUSIONS

This study compared IDF curves from gridded datasets (XAVIER and CHIRPS) with local rain gauge data in Rio Grande do Sul, revealing significant underestimation of rainfall intensities, especially for high return periods, with discrepancies exceeding 100%. The GEV distribution, MML estimation, and IDW/Kriging interpolation methods provided the most reliable results. These findings highlight the necessity of validating gridded data with local observations to improve accuracy.

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