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Performance Evaluation of the SRM and GRxJ—CemaNeige Models for Daily Streamflow Simulation in Two Catchments with Snow and Rain Dominated Hydrological Regimes

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Abstract

This study evaluated the Snowmelt-Runoff Model (SRM) and the Génie Rural à X Paramètres Journalier (GRxJ) model family, analyzing the latter both independently and in combination with the CemaNeige snow module. SRM and GRxJ represent snowmelt-runoff and rainfall-runoff hydrological models, respectively. Accurate streamflow estimation in snow- and rain-dominated basins is crucial for water resource management, especially in the Andes where climate variability and glacier retreat threaten long-term water availability. The analysis was conducted in two Chilean watershed basins with contrasting regimes: the snow-dominated Aconcagua and the mixed rain–snow Duqueco basins. Daily data (2012–2020) of precipitation, temperature, evapotranspiration, snow cover (MODIS), and streamflow were used. Models were calibrated and validated with optimization algorithms and evaluated using NSE, $RMSE$, R^2, $PBIAS$, KGE, MAE, $\log NSE$ and $APFB$. The results show that SRM effectively reproduces variability and, in the case of the rain–snow regime basin, extreme events, with NSE ranging from 0.70 to 0.78 (Aconcagua) and 0.93 to 0.94 (Duqueco). Model selection should take into account the dominant hydrological processes. In this study, SRM showed the best performance in both analyzed catchments, although with limitations in reproducing extreme streamflow events. In contrast, the GRxJ models did not adequately capture the hydrological dynamics of the snow-dominated Aconcagua catchment. However, their performance improved considerably when applied to the mixed regime of the Duqueco River. These findings highlight the importance of adapting modeling strategies to local hydrological conditions and limited data availability, offering practical guidance for water management and climate change adaptation in Andean catchments.

Keywords: snowmelt-runoff model (SRM); GRxJ; rainfall-runoff model; CemaNeige; snow hydrology; streamflow simulation; Andes

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1. Introduction

Accurate estimation of streamflow in river basins is essential for effective water resource management, supporting applications such as irrigation planning, hydropower generation, and reliable water supply for domestic and industrial users [1–5]. Achieving