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Change on flood discharge frequency in South America in the next decades: assessment of the CMIP6 climate projections

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INTRODUCTION

Floods are the most common and destructive of the natural disasters and their frequency and severity arise from the interplay between precipitation variations and multiple processes within the watershed. Increase in the global temperature will lead to the intensification of multiple and concurrent hazards, creating compound and cascading risks that are more complex and difficult to manage. The aim of this study was to assess climate change impact on flood discharge in South America by detecting the pattern (increase or decrease) of frequency of the maximum annual flows of the continent's main river reaches.

METHODS

The impacts of climate change on flood discharge were investigated through streamflow simulations of the South American MGB hydrological-hydrodynamic model application (SIQUEIRA et al., 2018; PONTES et al., 2015), using an ensemble of 28 global and regional climate model projections from NEX-GDDP-CMIP6 (THRASHER et al., 2022). Daily relative humidity, precipitation, temperature, wind speed, and incident short wave radiation data from two key periods, 1950-2014 (historical) and 2015-2099 (future), were incorporated. The historical period is bias corrected from comparisons with observed data frequency distributions. The future period considers different socioeconomic and CO2 emission scenarios for its simulations and assumes an increase in average global temperature of 2,7°C for the period 2081-2100. We selected the maximum flood discharge of each year of historic and future simulations for each river reach in MGB-SA, excluding the two first years of both simulation periods for model warm up. For the return periods of 2, 5, 20 and 30 years we calculated the reference streamflow from the historical period (1952–2014) adjusting the data to the Generalized Extreme Value (GEV) distribution. Then, for the future period (2017-2099), we calculated the return period of each of the four-reference streamflow algo with GEV distribution. If the return period of a reference streamflow is smaller for the future period, it means that the frequency of that reference streamflow is projected to increase. We repeated this procedure for the 28 climate models. We considered that the models agree in a decrease (increase) flood discharge trend if at least 20 models present the same pattern (~71%).

RESULTS

Figure 1 illustrates the spatial pattern maps for each target return period. The river reaches projected by the MGB-SA model to experience an increase in flood discharge frequency are highlighted in blue, while those predicted to decrease are shown in red. For a return period of two years, a strong reduction in flood discharge frequency in the Amazon River, its tributaries, the São Francisco River, and the Paraná River is evident. Interestingly, the upper Amazon in the Andes, influenced by snow and orographic precipitations, exhibits an increasing flood frequency trend. Conversely, in the greater return periods (20 and 30 years), we see a strong inclination towards higher

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flood streamflow frequency in Southern and Northeast Brazil, regions known for their significant El Niño influence. These observations are consistent with Do et al. (2020) who found evidence of increased peak flows in parts of South and Southeast Brazil, and reductions in others, including Northeast, Midwest, and parts of Southeast Brazil. Brêda et al (2023) attributed such trends to reduced antecedent soil moisture, which is expected to decline across most of the continent, excluding Southeastern South America.

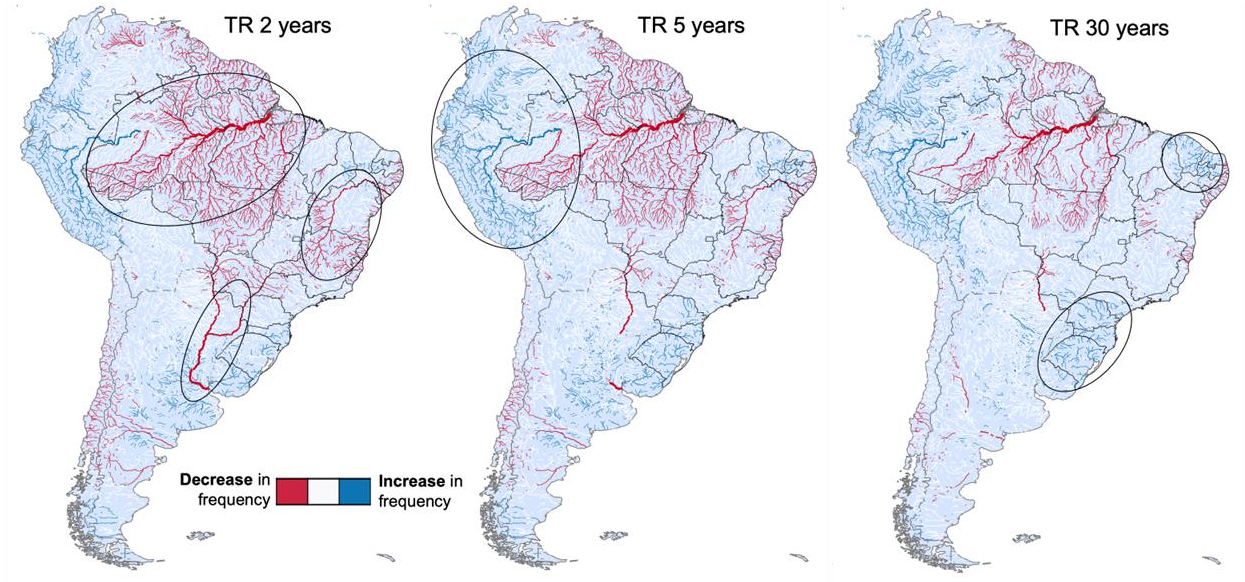

Figure 1 - In blue, 70% of the models indicate increase in frequency of flood streamflow; in red 70 % of the models indicate decrease in the frequency of flood streamflow

CONCLUSIONS

This study offers a preliminary analysis of future shifts in South America's flood discharge frequency. Our findings indicate a probable increase in flood frequency in Southern and Northeast Brazil, with the strongest signs in the higher return periods. Conversely, a decrease is predicted in the Amazon, Central, and Southeast Brazil, primarily within the shorter return period (2 years).

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