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Future changes in the South American Monsoon System and its consequences over south-eastern Peru

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Tropical regions in South America are characterized by rich biodiversity, diverse climatic zones and heterogenous weather. This heterogeneity is caused by the South American Monsoon System (SAMS) and the atmospheric low-level jets (LLJ). Both atmospheric circulation features have a critical role in the distribution of moisture and precipitation. The regions located where the rainforest meets the Andes are highly affected by these LLJs. One example is the department of Madre de Dios, located in south-eastern Peru. Its economy and the well-being of the population are highly dependent on natural resources provided by the ecosystem. Hence, understanding how the SAMS and the associated LLJs will change under global warming is important for water management in the region. To investigate the climate change signals, we employ the Weather Research and Forecasting model (WRF; version 3.8.1) at convection-permitting scales (up to 1 km). Two 30-year periods of a global climate simulation are dynamically downscaled for the present (1981–2010) and the future (2071–2100). Thereby, we consider the mitigation scenario representative concentration pathway (RCP) 2.6 and the high-emission scenario RCP8.5.

The validation of the simulation for the present period indicates that while precipitation amounts fall within the range of observational datasets such as PISCO or CHIRPS, a cold bias is found from April to July compared to ERA5 or CRU. The bias in temperature is potentially caused by biases in the driving global climate simulations and by the difference in land elevation between WRF and observational datasets.

The comparison of present and future simulations shows changes in both temperature and precipitation in Madre de Dios. The climate projections indicate an increase in temperature of 1 and 3 °C under the RCP2.6 and RCP8.5 scenarios, respectively. Precipitation is projected to overall decrease in Madre de Dios. During the rainy season from September to April, the average decrease is 5 and 12 % under the RCP2.6 and RCP8.5 scenarios, respectively. During the dry season from May to August, the rain is reduced by more than 50 % in both scenarios. The general reduction in precipitation seems to be related to the changes in the SAMS under climate change, which include a less intense Bolivian High during the peak months of December and January (particularly in RCP8.5), a less intense Chaco Low in February, and a more intense Atlantic Tropical High that extends much further into the continent in both climate scenarios from April to August.

These changes reduce the occurrence of LLJ events under both climate scenarios, and consequently, affecting precipitation east of the Andes.