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Evaluating historic atmospheric river associated extreme rainfall and its flooding potentials based on a high-resolution climate model

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Atmospheric Rivers (ARs) transport vast amounts of water vapor from the tropics to mid-latitudes, resulting in sustained, heavy precipitation that explains about 50 % of mid-latitude annual mean rainfall. AR events over the Western US have shown particularly high societal impact, where orographic and soil conditions make communities vulnerable to floods and mudslides. Climate modelling approaches for capturing extreme precipitation and water runoff on land are both strongly constrained by the horizontal resolution that is currently deployed, typically on the order of 100 km. Such grid spacing neither allows for explicitly resolving key processes associated with extreme precipitation like atmospheric convection, nor complex terrain that controls water runoff. However, recent advances in computational capabilities and model development at the Geophysical Fluid Dynamics Laboratory (GFDL) at a finer horizontal resolution of 50 and 25 km have shown promising perspectives for simulating important characteristics of ARs and their associated mean and extreme precipitation. In addition, advances in GFDL land model hydrology now allow for investigating climate model capabilities in predicting precipitation induced flood hazard precursors like excessive runoff and streamflow in a physically coupled, orography-aware atmosphere-land framework.

Here, we make use of the high resolution GFDL coupled atmosphere-land model by running hindcast experiments for a handful of high impact AR events over the Western US. We evaluate the model's predictive skill in AR associated precipitation by running ensemble forecasts on weather time scales, which we evaluate against observations and reanalysis. We attribute the found biases in terms of dynamical and thermodynamic drivers, revealing current model constraints. Accounting for the biases found in precipitation, we turn to the land hydrology and evaluate catchment associated hydrological characteristics, which we compare to satellite derived and in-situ observations.