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Interpreting extreme climate impacts from large ensemble simulations — are they unseen or unrealistic?

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Large ensemble simulations may be exploited to appreciate plausible extreme climate impacts that we may not yet have seen. Such information can be vital for decision makers to anticipate otherwise unforeseen impacts. Large ensemble simulations can generate larger data samples than the observed record but biases are likely to exist, which may occasionally produce unrealistic extreme events. Interpreting simulated 'unseen' events that are more extreme than those seen in historical records is therefore crucial, but adequate evaluation is complicated by observational uncertainties and natural variability. In this talk, we introduce a three-step procedure to assess the realism of simulated extreme events based on the model properties (step 1), statistical features (step 2), and physical credibility of the extreme events (step 3). We use the global climate model EC-Earth and global hydrological model PCR-GLOBWB to demonstrate these steps for a 2000 year Amazon monthly flood ensemble. The spatial model resolution of 1x1° and daily temporal resolution is coarse, but no reason to dismiss monthly flood simulations over the Amazon a priori. We find that the simulations are statistically inconsistent with the observations, but we cannot determine whether simulations outside observed variability are inconsistent for the right physical reasons. For example, there could be legitimate discrepancies between simulations and observations resulting from infrequent temporal compounding of multiple flood peaks, rarely seen in observations. Physical credibility checks are crucial to assessing their realism and show that the unseen Amazon monthly floods were generated by an unrealistic bias correction of precipitation. Based on this case study, we discuss the takeaway challenges when evaluating extreme climate impacts from large ensemble simulations. Understanding the drivers of simulations outside observed variability helps to gain trust in unseen simulations. Uncovering the characteristics of events in the models may reveal the most important model deficiencies or improve our scientific understanding of unseen events.