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Impact of parametric uncertainty on simulated climate extremes and attribution studies

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The attribution of extreme weather events, such as heavy rainfall, to anthropogenic influence typically involves the analysis of their probability in simulations of climate, such as those conducted in the C20C+ Detection and Attribution Project. The climate models used however, such as the Community Atmosphere Model (CAM), employ approximate physics that gives rise to “parameter uncertainty”—uncertainty about the most accurate or optimal values of numerical parameters within the model. Parameterisations for convective processes, for example, are well known to be influential in the simulation of precipitation extremes.

In the context of extreme event attribution, we investigate the importance of components of parameterisations—through their associated tuning parameters—relating to deep and shallow convection, and cloud and aerosol microphysics in CAM. We present results from the analysis of a large perturbed physics ensemble experiment (~12,000 years of simulation, ~1 degree horizontal resolution) designed to explore extremes in both the observed world and pre-industrial conditions. Using surrogate models based upon Gaussian processes fitted marginally to both regional and grid cell output, we have computed sensitivity measures associated with the physics parameters, for precipitation and temperature extremes and their respective “risk ratios”.

Our results reveal the high geospatial variability in averages and extremes of output variables arising from physics perturbations, and how this contrasts with low variability in estimates of risk ratios based upon the same variables. We conclude that for CAM, variability induced by perturbed physics is typically consistent across warming scenarios, and unlikely to be a significant source of uncertainty in extreme event attribution studies. However, we caution that this may not be the case in regions where relevant parameterisations are strongly active.