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Study of extreme heatwave seasons in South Asia using rare event simulations

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Extreme climate events have major impacts on human societies and ecosystems. The most detrimental events are often extremely rare, with return time of centuries or even millennia. Studying these events in the context of climate change is crucial to help adaptation efforts globally. Yet the study of these extremely rare events is extremely challenging due to the lack of data. Indeed, such events have likely not been observed in the instrumental period. An alternative is to use a global climate model to simulate these extremely rare events. However, this comes at a huge computational cost : gathering good statistics on centennial events would require to run a few thousand years of simulation.

Rare event algorithms have recently been introduced in the field of climate science to tackle this difficulty [1]. By concentrating the computational effort on the trajectories most susceptible to lead to the extreme event of interest, they allow for the sampling of extremely rare events at a much lower computational cost than standard simulations.

In this study, we run a rare event algorithm to sample extreme heatwave seasons in a heatwave hotspot of South Asia, using the intermediate complexity model Plasim. We compare the outcome of the algorithm against an extremely long – 8000 years – control run. This comparison allows us to demonstrate that the algorithm not only estimates return times with high precision (as shown in previous work), but also exhibits high precision in the estimation of composite statistics: composite maps conditioned on centennial heatwave seasons estimated from the algorithm, are in very good agreement with the ones from the 8000-year long control simulation. Our results suggest that extreme heatwave seasons in the studied region are associated with a quasi-stationary atmospheric wave-pattern stretching from the North Atlantic towards South Asia.

We also show that the algorithm correctly estimates the intensity-duration-frequency statistics of subseasonal heatwaves occuring within centennial heatwave seasons. Thus rare event algorithms could, for instance, be combined with seasonal forecasts to provide information regarding expected number of heatwave days and the distribution of the duration and intensity in an extreme heatwave season, which could be useful for adaptation planning.

References

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