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A Causality-guided Approach for Predicting Future Changes in Extreme Rainfall over China Using Known Large-scale Modes

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Over the past few decades, while several advancements in improving the performance of global climate models (GCMs), such as predicting mean climate, have been made, predicting extreme rainfall events related to Mei-yu fronts (MYFs) and tropical cyclones (TCs) remains an open challenge. This is partially due the coarse spatial resolution of the GCMs that restricts their ability to represent extreme events and the associated processes on relevant spatial scales. This poses a problem for stakeholders as a failure to take appropriate precautionary action before the occurrence of extreme events can have disastrous consequences. Although the spatial resolutions of typical GCMs are too coarse to simulate extreme precipitation accurately, they are more likely to be able to simulate large-scale climate modes (LSCMs) better. Given that the activities of MYFs and TCs are linked to LSCMs, we can make use of these causal connections between LSCMs and extreme rainfall associated with MYFs/TCs to construct useful prediction models. This can then be applied to the outputs of climate GCM simulations to increase our capability in predicting extreme rainfall in the future.

In this presentation, we demonstrate a novel technique based on causality-guided statistical models (CGSMs) to assess the projected future changes of extreme rainfall associated with MYFs and TCs over China using the CMIP6 historical and SSP585 scenario simulations for four selected models. First, we show that CGSMs, which are constructed using historical observations and reanalysis, have good performance in modelling historical observations. Then we compare extreme rainfall related to MYFs/TCs from the CMIP6 historical direct output of the selected models with the CGSMs predictions. Our results show that the climatological patterns of CMIP6 direct historical outputs are different to the observed climatological patterns. Yet, CGSMs driven by CMIP6 LSCMs can produce similar patterns as the observed climatology. For the projected change under the SSP585 scenario, projections based on CGSMs provide a more coherent picture than CMIP6 direct model outputs. This shows the potential of causality-guided approach in coarse resolution climate model outputs. The implication and potential use of this approach is also discussed.