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# Abrupt transitions, wave interactions and precipitation extremes in climate

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There is an urgent need to better understand the how climatic change may cause abrupt transitions and tipping points in the underlying dynamic process (κ ->κ') that can result in more severe extremes. The variability in precipitation based flooding and arid events in the Sahel and SE Asia may be related to alterations to Atlantic (AMOC) and Pacific (ENSO) modes, and how they teleconnect. Extreme value process distributions are widely used for assessing the environment. In this work we apply a spatial Dominant Frequency State Analysis (DFSA) to GPCC reanalysis data to evaluate the extreme properties of precipitation extremes and dry arid events in these regions. The spatial variation we find implies that how the wave interaction properties vary and that wave guide teleconnection is important. The physical wave interaction reasons for why extremes occur and how they vary has not been fully explained to date: that is a statistical mechanics problem. For earth system climate analysis General Circulation Model simulation sizes are too small, 10 to 30 ensemble members (due to computational complexity), to carry out such a large ensemble analysis. However large ensembles are intrinsic to the study of Anderson localization and Random Matrix Theory (RMT) transport study. So we use a theoretical based approach to provide a wave interaction explanation of how differing forms of extreme can occur. This theory work is a generic advance in the study of wave propagation phenomena and extremes in the presence of disorder. To do this we merge the universal wave transport approach used in solids with the geometrical extreme type max stable universal law to evaluate the ensemble based on wave interaction principles. This provides a generic ensemble random Hamiltonian and characteristic polynomial to give a physical proof for encountering extreme value processes. This shows that the Generalized Extreme Value (GEV) shape parameter ξ is a diagnostic tool that accurately distinguishes localized from unlocalized systems and this property should hold for all wave based transport phenomena. This work establishes that ξ(κ) can change when the dynamical system fundamentally changes its physical structure κ ->κ' and that this is a universal result. For our earth system a disorder induced state transition to a heavy tailed process could indicate a wave localization state has occurred in some locations. If this was the case the associated climate phenomena would become dominated by destructive wave interference that can manifest as a catastrophic breakdown, for example as an extreme runaway of temperatures. We discuss this wave interaction theory result in the context of the precipitation extremes and how these could be altering for the Sahel and SE Asia.

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