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The link between extremes of temporal and spatial averages in a simplified atmospheric circulation model

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In geophysical applications temporal scales are related to spatial scales, a persistent event in time has usually a significant spatial extent. Especially in case of extreme events persistent phenomena are highly relevant, having mostly larger impacts than single non-persistent extremes. Extremes of temporal and spatial averages of geophysical quantities often represent persistent phenomena. By understanding the link between temporal and spatial averages, we could translate the problem of temporally persistent extremes into spatially extended extremes and vice-versa. We perform simulations of 10000 years with the simplified atmospheric general circulation model PUMA (Portable University Model of the Atmosphere), using an aqua-planet setup with a constant forcing level in time. We apply large deviations theory (LDT) to study the change of surface temperature probabilities as an effect of increasing temporal and spatial averaging windows. This asymptotic law provides a way to overcome the difficulty of a decreasing data amount with an increasing averaging window. Our main goal is to find a link between spatial and temporal averaging. To verify our results, we compare return levels obtained from LDT with empirical ones and return levels based on the Generalized Pareto distribution.