Institute for Atmospheric and Climate Science
ETH Zürich
Universitätsstr. 16
8092 Zürich, Switzerland

Extraordinary Seminar

Professor Michael P. Byrne, University of St Andrews, St Andrews

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Extreme temperatures over a range of climate states

Understanding the sensitivity of extreme temperatures to climate change is a key scientific challenge with important societal implications. Yet basic questions persist regarding extreme temperatures, including why hot days and the average day warm at different rates and the role of local versus large-scale processes in controlling extreme temperatures over land and ocean.

Here we use an idealised GCM to explore extreme temperatures over a wide range of climate states. Climate is varied by scaling the longwave optical thickness. Slab-ocean aquaplanet simulations are performed along with simulations using a meridional-band land configuration and a simple bucket model for hydrology. The behaviours of the daily temperature distributions over this suite of simulations are investigated. The responses of extreme temperatures (i.e. high percentiles of daily near-surface temperature) to climate warming contrast strongly over tropical land and ocean. Over land, warming is amplified for hot days relative to the average day. But over ocean, hot days generally warm less than the average day, implying a tightening of the temperature distribution.

The contrasting responses of tropical extreme temperatures over land and ocean are interpreted using a theory based on convective quasi-equilibrium. In the limit of constant relative humidity, the theory predicts that warming of extremes relative to the average temperature depends on the climatological specific humidity on hot days. Over land, warming is amplified for hot days because they are dry relative to the average day. But over ocean, warming is muted for hot days because they are relatively moist. Changes in relative humidity affect the scaling of extreme temperatures over both land and ocean, particularly in warmer climates. Extensions of the theory to understand the sensitivity of extratropical extreme temperatures to climate change are discussed.