IAC Colloquium, 9 October 2023, ETH Zürich

Quantifying the physical processes leading to atmospheric temperature extremes

Matthias Röthlisberger, IAC ETH Zürich

Abstract: Heat and cold waves are among the most impactful climate hazards, and play a prominent role in the public perception of climate change. Yet the relative importance of the physical processes causing their temperature anomalies—advection of air from climatologically warmer regions, adiabatic warming in subsiding air and diabatic heating—is still a matter of debate. In this talk, a novel Lagrangian temperature anomaly decomposition will be introduced, which allows quantifying the contributions of these three physical processes to temperature extremes. First, we will focus on the infamous June 2021 Pacific Northwest heat wave and discuss the temporally and vertically varying contributions of the three processes to this event. Then, a decomposition of near-surface temperature anomalies during heat extremes at each grid point in ERA5 will reveal causes of heat extremes that strongly vary across the globe. Moreover, quantifying the temporal and spatial scales over which these temperature anomalies form reveals that in some tropical regions heat extremes form quasi-locally, while air contributing to heat extremes in the extra-tropics typically accumulates temperature anomalies over multiple days and more than 1000 km. Finally, applying the Lagrangian temperature anomaly decomposition to cold extremes unravels that globally over oceans, their near-surface temperature anomalies are exclusively due to advection, while over land there is a gradual transition from advectively to diabatically dominated cold extremes when moving towards the climatologically coldest regions on Earth.