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Detecting and understanding extreme temperature events and heatwaves using machine-learning

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Abstract

Extreme events are rare atmospheric phenomena that cause significant damage to humans and natural systems, but detecting such events in the future within a changing climate can be challenging. Traditionally, temperature distributions were assumed to follow a normal distribution, and specific thresholds were used to define extreme events. However, the mean and variance of temperatures are expected to change in a future climate, potentially limiting the application of traditional methods for detecting extreme events. In our study, we observed that daily maximum surface temperature data can be accurately described using a multimodal distribution. We employed Gaussian Mixture Models (GMM) to fit a multimodal distribution to multi-year daily near-surface maximum air temperature data from simulations in the Coupled Model Intercomparison Project Phase 6 (CMIP6) for 46 Intergovernmental Panel on Climate Change (IPCC) land regions. The use of GMM allowed us to derive parameters from the Gaussian distribution fitted to higher temperatures, which were then employed to define thresholds for the return period of extreme events. In the next step, we aim to understand the characteristics and evolution of heatwaves by exploring the application of Variational Autoencoders (VAE) combined with Gaussian Mixture Models (GMM). This involves leveraging insights gained from multivariate data and latent space to enhance our understanding of the spatiotemporal evolution of heatwaves.