THE HEATWAVE DIAGNOSTICS PACKAGE: A NOVEL HIGH-PERFORMANCE TOOL TO QUANTIFY HEATWAVE METRICS ACROSS LARGE PARAMETER SPACES

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ABSTRACT

Over the past few decades, a plethora of large-scale heatwaves have occurred globally, resulting in significant economic damage and loss of life. Heatwaves are expected to increase in frequency, duration, and intensity with global warming and many studies have already attributed past events to anthropogenic climate change. Future projections produced by earth system models (ESMs) across multiple climate realizations can be used to directly quantify the evolution of heatwave metrics over both space and time. However, existing software used to calculate heatwave metrics from ESM output face many computational barriers, particularly when working with large ensembles at higher resolutions. While scientific literature suggests that using multiple heatwave definitions and thresholds may be necessary to ensure study robustness, existing software tools do not explicitly provide diagnostic frameworks that evaluate metrics across this parameter space. Here, we present the Heatwave Diagnostic Package (HDP), an open-source Python package that features computationally efficient methods and diagnostic plots for computing heatwave metrics from ESM large ensemble data across multiple parameters and variables. Following open-source software principles, the HDP includes annotated source code on GitHub, a modular application program interface (API), automated unit tests, and detailed user documentation available through a ReadTheDocs webpage. To demonstrate the utility of the HDP, we quantify the impact of aerosol forcing uncertainty on patterns of heatwave hazard under a range of thresholds and definitions using model output from the Community Earth System Model 2 (CESM2) provided by the Regional Aerosol Model Inter-comparison Project (RAMIP). By computing the effect of the time-evolving, spatially heterogeneous aerosol forcing on heatwave frequency over a large portion of the heatwave parameter space, we show that aerosols impact certain types of heatwaves more than others, providing additional insight into which heatwave processes are most impacted by aerosol uncertainty.

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