Strength in numbers: using climate ensembles to study extreme weather phenomena on long timescales

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Interest in understanding the role of extreme weather events within the global climate system continues to grow, particularly with regard to earth system predictability on seasonal and beyond timescales. Because these features occur on small spatial scales, research targeting the weather-climate nexus has historically leaned on applying large-scale predictors (i.e., wind shear, regional temperature fields, etc.) or statistical/dynamical downscaling (i.e., synthetic vortex seeding, forced timeslices within regional climate models, etc.) since CMIP-class model resolutions (e.g., 1^o) may not adequately capture extreme events. Deterministic runs of high-resolution climate models improve the fidelity of these features, but may lack that statistical power to draw meaningful conclusions about rare events that return on decadal (and longer) timescales (e.g., Category 5 hurricanes, 1-in-100 year atmospheric rivers, etc.).

In this presentation we tackle two weather phenomena – coastal snowstorms and tropical cyclones – where recent work has explored the benefit of using ensemble frameworks to better understand climate extremes. For snowstorms, we highlight the benefit of using the CESM Large Ensemble to capture "tail" phenomena – in this case, impactful snowfall events along the northeastern corridor of the United States. Climate ensembles allow for robust, event-level statistics and for higher confidence with respect to infrequently-occurring events when compared to single runs coupled with statistical techniques. With regard to tropical cyclones, we present a sensitivity analysis to explore structural uncertainty in algorithmic techniques for extracting storm data from gridded weather and climate datasets. While this work is done across an ensemble of reanalyses, the lessons regarding uncertainty and optimization apply to large climate ensembles, particularly those completed at higher resolution. We close by proposing sample 2-D fields that can be saved at high temporal frequency at low "disk space" and input/output cost, enabling frontier science across the weather-climate paradigm with the next generation of climate ensemble projects.