BLUE WATERS
SUSTAINED PETASCALE COMPUTING

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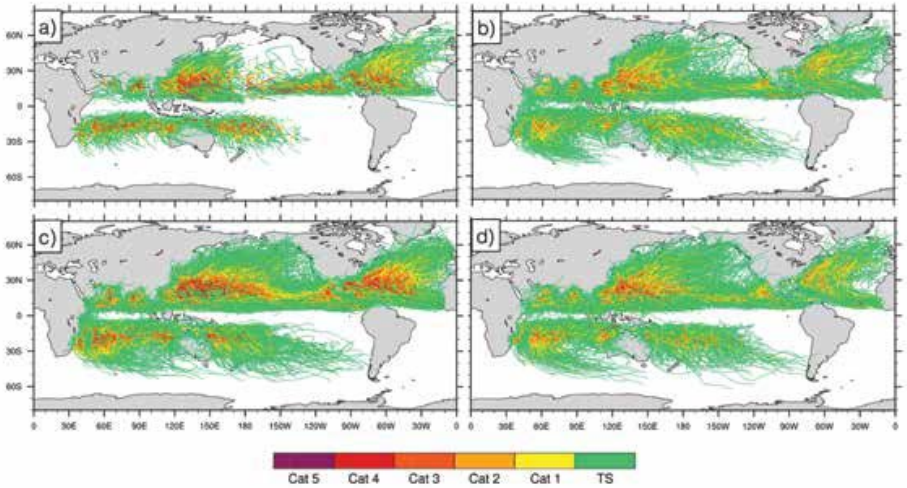
Geoscience

IMPACT OF OCEAN COUPLING ON SIMULATED TROPICAL CYCLONE ACTIVITY IN THE HIGH-RESOLUTION COMMUNITY EARTH SYSTEM MODEL

Research Challenge

Tropical cyclones (TCs) are among the world's deadliest natural hazards. How TC activity will vary with the changing climate is a topic of great interest. Correct representation of air–sea interactions under TCs is important for simulating realistic storm intensities and track durations. Local feedbacks due to ocean mixing and surface fluxes can inhibit storm development and intensification, as well as influence larger-scale ocean and atmospheric circulations.



Global TC tracks accumulated over 30 years in the (a) observational best-track (1985–2014), (b) fully-coupled simulation, (c) atmosphere-only simulation, and (d) partially-coupled simulation.

Methods & Codes

In this project, the team assessed the impact of ocean coupling on simulated TC activity using a high-resolution configuration of the CESM (Community Earth System Model) with a 25-km resolution atmosphere. They performed three 30-year simulations in which the atmosphere model is configured with three different levels of ocean coupling. The models are configured to focus on ocean–atmosphere interactions associated with TCs. Each simulation is run under preindustrial climate conditions with an active carbon–nitrogen cycle.

Results & Impacts

The team found that TC number, geographical distributions, and intensity are sensitive to ocean coupling. Differences in TC characteristics are mainly attributed to model differences in local air–sea flux exchanges and large-scale climate conditions. This research enables fundamental advancement of our understanding about important physical processes related to TC dynamics, ocean mixing, ocean heat storage and transport, and global ocean–atmosphere circulations. It paves the way for more comprehensive coupled climate model experiments capable of linking extreme weather events with large-scale climate.

Why Blue Waters

Given the substantial computational expense of high-resolution Earth system models, it is difficult to apply these models to study tropical cyclones because of the necessary grid resolution (1/4 degree), model run length (multiple decades), and high frequency output (multiple times per model day). Blue Waters provides unique capabilities to handle the computational demand associated with running the model at ultra-high resolutions, including scalability to over 15,000 cores, high-frequency input and output, and post-processing and visualization of model results.