The Effects of Explicit versus Parameterized Convection on Extratropical Air Sea Interactions: A Case Study of the Gulf Stream System using a High-Resolution Coupled Regional Climate Model

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Evidence is mounting that the atmosphere and ocean are tightly coupled along extratropical oceanic fronts, such as the Gulf Stream and Kuroshio. Unlike the coupling in the tropics that operates on large scales, the intense extratropical ocean-atmosphere interaction occurs at frontal-and meso-scales, which is not explicitly resolved by the current generation of climate models. This raises the question whether the unresolved air-sea interactions may contribute to large model biases over the oceanic frontal zones. To shed light on this issue, we conducted a set of eddy-resolving coupled regional climate model simulations of North Atlantic winter climate, where we systematically increase the resolution of the atmospheric model –the Weather Research & Forecast (WRF) –from 27 km to 9 km and finally to 3 km, while keeping the resolution of the ocean model –Regional Ocean Modeling System (ROMS) –at 9 km. At 3 km resolution, the atmosphere model begins to explicitly resolve convection, allowing us to simulate frontal- and meso-scale air-sea interactions without using parameterized convection in the coupled integrations. Inter-comparison among these numerical experiments provides some insight into how atmospheric model resolution and parameterized convection can have an impact on extratropical air-sea interactions and, consequently, on the simulation of the Gulf Stream system. The preliminary analysis shows that the simulation of the Gulf Stream system is sensitive to both atmospheric model resolution and convective parameterization. At 27 km resolution with parameterized convection, the simulated Gulf Stream shows a tendency to overshoot Cape Hatteras and separate too far north. As a result, the sea-surface temperature north of the Gulf Stream is significantly warmer in the 27 km simulations than in the 9 km simulations. Interestingly, when explicit convection is used at 3 km resolution, surface warming also occurs north of the Gulf Stream. However, this warming does not seem to be associated with the Gulf Stream overshoot, rather caused by changes in surface fluxes produced by explicit vs. parameterized convection.

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