The Effect of Ocean Waves on an Explosive Cyclone Development: Investigation with a Coupled Model

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Violent ocean waves are generated by the explosive cyclone. Since ocean waves affect the development of tropical cyclones, the impacts of ocean waves on the development of explosive cyclones are expected. Ocean waves have several impacts on the atmospheric surface layer: surface friction, sea spray, and momentum flux. We implemented sensitivity experiments to clarify how much ocean waves affect the development of an explosive cyclone with an atmosphere-ocean-wave coupled model, especially focusing on surface friction affected by ocean waves. The test case is the explosive cyclone emerged in early January 2018 over the Northwestern Atlantic. The atmospheric model is Weather Research and Forecasting Model (WRF), the ocean model is Coastal and Regional Ocean COmmunity model (CROCO), and the ocean wave model is WAVEWATCH III (WW3). We compared the numerical simulation results between the WRF-CROCO model and the WRF-CROCO-WW3 model. In the WRF-CROCO-WW3 coupled model considering ocean wave impacts just on surface friction, it is found that the deepening of the explosive cyclone was intensified by about 2hPa in the central sea level pressure, and the center track slightly shifted. In the fully coupled model, the surface roughness reduced and the wind speed was intensified by and large. Compared with observation data above the ocean, the fully coupled model had more accurate wind speed and sea level pressure than the atmosphere-ocean coupled model. It is also revealed that the boundary surface layer scheme in the atmospheric model is critical for accurate reproduction of surface atmospheric process and ocean waves. To reproduce accurate wind speed and wave height, the YSU (Yonsei University) scheme had a better performance than the MYNN (Mellor-Yamada-Nakanishi-Niino) 3rd scheme. As the next step, it is necessary that a coupled model takes into account the turbulent momentum flux produced by ocean waves to reproduce complete accurate air-sea interactions.

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