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Performance analysis of parametric wind models for tropical cyclone vortex simulation

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Parametric wind models are widely used to estimate wind and pressure fields in tropical cyclones (TCs) due to their computational efficiency and ability to capture key storm dynamics. Their flexibility and efficiency allow them to be applied in large-scale climate projections, where computational resources are often limited. In this study, we compare the performance of three key parametric wind models: the Holland model, the empirical vortex model used in the Geophysical Fluid Dynamics Laboratory/University of Rhode Island coupled hurricane-ocean model(GFDL-E), and the Generalized Asymmetric Holland Model (GAHM). The Holland model is known for its simplicity and effectiveness in capturing the general structure of TCs but assumes a symmetric vortex. The GFDL-E improves on this by considering quadrant-specific size differences, introducing asymmetry into the wind field, through it remains symmetric from the center to the radius of maximum winds (RMW). The GAHM model provides a more advanced solution by accounting for asymmetries in all four quadrants, including from the center to RMW. We further modified the GAHM model by converting the grid system to a regular grid to maintain high spatial resolution near the TC core, and adjusted the ambient pressure to a more realistic value using the best-track data. Additionally, we replaced the traditional linear interpolation of track data with spline interpolation to simulate more realistic TC behavior. These models were validated by comparing wind and pressure fields against observations from ocean buoys and land stations, particularly utilizing data observed in Okinawa islands, a key region for TCs heading to Korea.

Key words: tropical cyclone, wind speed, minimum sea level pressure, parametric wind model

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