Extreme wave prediction during cyclones along the coast of India: a challenge

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The Indian coast is frequently affected by tropical cyclones, and the frequency of occurrence has increased considerably in the last few years. This indicates the need to have efficient and accurate models, which can predict waves generated by the cyclones for scientific, coastal engineering and societal benefits. The available model versions that we have (WW3, WAM and MIKE21 SW) are unable to predict such extreme waves with the expected accuracy beyond a certain range of significant wave heights, though they do extremely well for fair weather and monsoon conditions (results will be presented). In this context, we have performed a few numerical experiments with WW3 multi-grid system, using NCEP winds for the outer domain and fine resolution WRF winds for the inner domain; results show very good match between measurements and modeling (accuracy has improved substantially). We continued the simulation for four cyclones, and validated the model results with moored buoy data available for the Indian Ocean; also, we compared the results with altimeter data. The results show that when boundary forcing is given to the inner domain, the model yields improved forecast of significant wave heights under extreme conditions. For example, for the Cyclone 01A which formed in the Arabian Sea in May 2001, when only NCEP winds are provided in a single domain, Hs was 6.4m (measured value: 7.8m), and the statistics (bias, RMSE, SI and Cor. coeft) are -0.15m, 2.07m, 0.47 and 0.30, respectively, but with nesting (NCEP/WRF), Hs has become 7.4 m, and the statistics are 0.46m, 0.23m, 0.23 and 0.86, respectively. Similarly, for the Cyclone Mala, which formed in the Bay of Bengal in April 2006, with nesting, the statistical parameters bias, RMSE and SI have reduced from -1.17m to -0.32m, 1.25m to 0.43m and 0.63m to 0.21m, and correlation coefficient increased from 0.89 to 0.95. We do not find much change in wave direction with respect to any wind. The model overestimates the Hs before and after the passage of storm, but slightly underestimates during the passage. This needs to be looked into, probably due to non-inclusion of wave-current interactions and tidal effects in the model.