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The development of regional atmosphere-ocean-wave coupled model for typhoon

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An Atmosphere-Ocean-Wave regional coupled model has been developed by the First Institude of Oceanography (FIO-AOW). The FIO-AOW includes four components: an atmosphere model (WRF), an ocean model (POM), a wave model (MASNUM-Wave) and a coupler (C-Coupler). The sensitivities of typhoon intensity to the physical processes at the air-sea interface are evaluated using FIO-AOW. Three processes are investigated in this paper: sea spray, non-breaking wave-induced vertical mixing and cooling effects of rain. It has been found that sea spray can increase air-sea moisture and heat flux, providing more vapor and thermal energy for typhoon to strengthen its intensity. Therefore, sea spray has a positive effect on typhoon intensity. At the same time, non-breaking wave-induced vertical mixing can enhance upper-ocean vertical mixing rate and result in sea surface temperature (SST) cooling, which in turn prevents typhoon from getting more energy from ocean. The third process we explored concerns the effect of rain. Rain drops evaporate and lose heat when falling from high altitude to sea surface, thus cooler and lighter fresh water will remain on sea surface, resulting in SST cooling, thus decreasing the upward surface heat fluxes from the ocean. Both wave mixing and rain have negative effects on typhoon intensity. For the strong typhoon case Haiyan, the sea spray effect is dominant over the negative effects of wave mixing and rain. The combined effects of the three processes tend to strengthen and improve the typhoon intensity. However, the typhoon dimensions have been exaggerated by all the experiments even in control run. For the weak typhoon case Jebi, the effect of wave mixing is relatively much more significant. The negative contribution of non-breaking wave induced mixing to the total upward heat flux are comparable with the positive contribution of sea spray. Therefore considering wave mixing scheme and the cooling effect by rain prevents Jebi from further deepening. As well as Haiyan, all the experiments tend to exaggerate the dimensions of Jebi. The numerical results of this study indicate that the physical processes at air-sea interface should be one of the critical factors in improving prediction of typhoon intensity.