Effect of Translation Speed of Typhoons on Wind Waves

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INTRODUCTION

Climate change appears to be modifying the characteristics of recent tropical cyclones. It is reported that the translation speed (V_o) of typhoons has slowed down globally in the course of the last 60 years (Kossin, 2018). In fact, some slow-moving typhoons have triggered devastating flood damage, such as Hurricane Harvey in Texas in 2018, Typhoon Jebi in Japan in 2018, and Hurricane Dorian over the Bahamas in 2019. Although the change in V_o would influence the generation of wind waves, up to date little attention has been paid to this phenomenon. Thus, the present study aims to clarify how the change in V_o affects the wind field, and the consequence effects that this can have on the significant wave height (H_s).

METHODOLOGY

A WRF-SWAN coupled model was used for the modelling of wind waves. The forcing to the model was provided by NCEP FNL Operational Global Analysis data. The model was first validated through a comparison with observations of wind and waves by past typhoons, and simulation results were deemed acceptable. The V_o of past typhoon was then changed in SWAN. By skipping or delaying the original input data for SWAN, V_o can be modified while maintaining the storm's shape and course. Additionally, the wind speed was modified to account for the change in gross wind speed which was modelled as the vector summation of wind by pressure gradient and translation. Eight different typhoons in the vicinity of Japanese islands were simulated to investigate the effects that this change in V_o can have on H_s.

RESULTS

The different types of trends were found to exist amongst the 8 simulated typhoons. In typhoons with an original V_o that was relatively fast (more than 60 km/h), and with modest size (storm areas of up to 200 km), the increase in V_o resulted in higher H_s (as shown in Fig. 1-a). In contrast, typhoons which were relatively slow (40 to 50 km/h), large (storm area over 220 km), and with a low central pressure (less than 950 hPa) H_s decreased as V_o increased (Fig. 1-b). The difference between these two trends could be explained by the difference between magnitude of the wind generated by the pressure gradient and that by typhoon translation. In the second type of storms, due to the low central pressure the effects of the pressure gradient are more dominant for wind generation. As a result, wind waves are less sensitive to the change in V_o than in the first type, and continue to generate high waves even if V_o decreases. It should be noted that when V_o decreases to 10% of its original value, the time over which H_s is higher than 4 m is over 70 hours (see Fig. 1-b). Fig. 2 shows the duration over which H_s is over 4 m for the case of Typhoon Trami in 2018 (categorized as the second type of typhoon). The results indicated that the nearshore area would experience high waves for 25 to 30 hours when the typhoon slowed down to 50% of its original speed. Considering these results, it is important to raise awareness of the problems that can be caused by large typhoons staying almost stationary for long periods of time, as with happened with Hurricane Dorian.

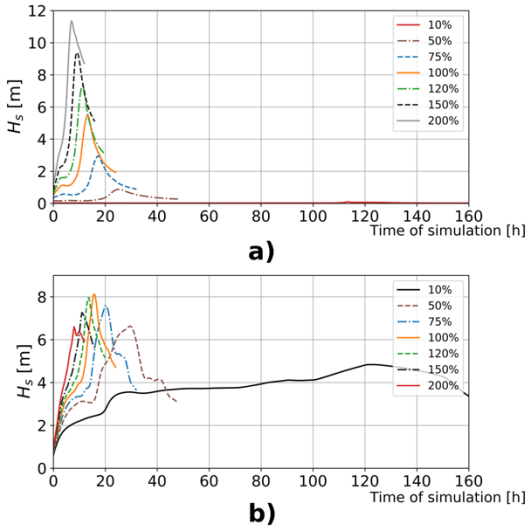

Figure 1. H_s profiles with the variation of V_o at Shiono-misaki, Japan. Percentage shows the ratio to the original case simulated by SWAN. a) Typhoon Nanmadol in 2017. b) Typhoon Vongfong in 2014.

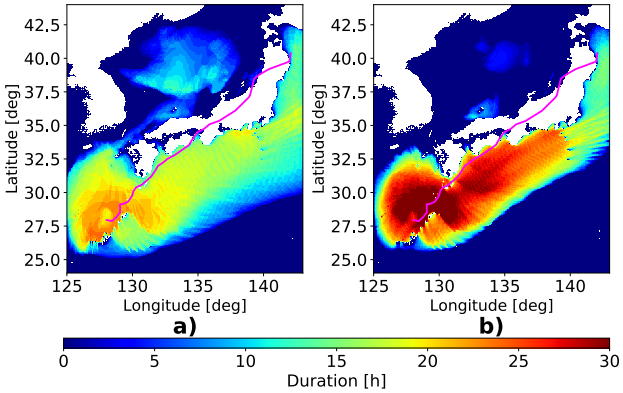

Figure 2. Duration over which H_s is over 4 m for the case of Typhoon Trami in 2018. The line shows the track of the typhoon center. a) original V_o. b) 50% reduction in V_o.

REFERENCE

Kossin JP. (2018). A global slowdown of tropical-cyclone translation speed. *Nature 558*, 104-107.