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Multiscale interaction in the Western North Pacific: Do tropical cyclones contribute to climate variability?

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The weather and climate in the tropical and subtropical Western North Pacific (WNP) in the boreal summer is characterized by the fluctuations of monsoon trough and anticyclonic ridge, which are affected by the mutual interaction between the perturbations of different time scales ranging from ENSO to intraseasonal oscillation (ISO), and to tropical cyclone (TC). This study reports the downscale modulation effect of lower-frequency circulation on higher-frequency perturbation and the upscale feedback of TCs to the large-scale flow. The presentation will report the following findings. Modulation of lower frequency fluctuation: 1. Regime shift in late 1970s The WNP monsoon became more active in the late 1970s. The stronger monsoon trough resulted in larger interannual and intraseasonal variability in the Western North Pacific. The warmer sea surface temperature is likely the driving mechanism. 2. Modulation of ENSO on monsoon trough, ISO, and TCs During the El Niño, the monsoon trough shifts southeastward. As a result, ISO and TCs are more active in the region to the southeast of its normal location. The reversed situation occurs during the La Nina events: the monsoon trough, ISO and TCs shift northwestward. 3. ISO Modulation effect on TC/sub-monthly wave pattern A sub-monthly (8-30 days) wave pattern is found to propagate northwestward from the tropical Philippine Sea to the East China Sea. The wave pattern is often accompanied by tropical cyclone, which is embedded in its cyclonic circulation. Both the sub-monthly wave and tropical cyclone are found to be more active and better organized during the westerly phase of ISO, when the monsoon trough is strong and extends eastward into the Philippine Sea. On the contrary, both are weak and poorly organized in the easterly phase of ISO, when the monsoon trough is weak and retreats westward to the South China Sea. TC Feedback: 1. Enhancement of climate variability Our recent study reveals that tropical cyclones, while being clustered by the large-scale circulation, in turn enhance intraseasonal and interannual climate variability by more than 50 percents. The existence of TCs also enhance the circulation contrast difference in the WNP between El Niño and La Nina. 2. Enhancement of extratropical wave activity The TC/sub-monthly wave pattern induces wave activity propagating toward North America along the extratropical jet stream, which has a waveguide effect. 3. The embedding TCs in the sub-monthly wave pattern enhance the energy conversion from mean flow to eddy and help sustain the sub-monthly wave pattern. 4. The amplitudes, shape and propagation of eddies in the Western North Pacific were strongly constrained by the configuration of the monsoon trough and the anticyclonic ridge. The findings reveal the nature of active multiscale interaction in the WNP. TCs and large-scale circulation in the Western North Pacific are mutually intertwined through rigorous eddy-mean flow interaction and therefore should be treated as an integrated multiscale system. It is essential to well understand and simulate the multiscale interaction for a skillful prediction and projection of climate variability and change in the Western North Pacific.