Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

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Tropical cyclones (TCs) decrease sea surface temperature (SST), and the decreased SST weakens TC intensity. This SST decrease is asymmetric with respect to the TC track, known as “rightward bias”. Preceding numerical studies suggested that this asymmetry may influence on the course of the TC. The interaction between TC and the upper ocean is one of key ingredients for precisely predicting TC's development, and the upper ocean response to TC should also be clarified.
The SST decrease during TC passage is mainly caused by two processes; vertical turbulent mixing and advection (Ekman suction). The rightward bias is associated with the mixing which is more intense on the right side of the TC track due to resonant inertial currents with winds. Magnitude and distribution of SST decrease induced by the mixing should vary with parameters characterizing TC; transition speed U_T, radius of maximum wind R_{max}, the friction velocity U_*, and the Coriolis coefficient f. However, detailed physical processes of the mixing and its dependence on these parameters have not been well quantified, because of lack of in-situ data and complicated processes involved in the mixing.

The present study focuses on the vertical turbulent mixing effects on asymmetric SST response. To this aim, vertically one-dimensional model was used in which the vertical turbulent mixing was parameterized with the Nakanishi-Niino-Mellor-Yamada scheme modified by Kitamura (2010). We considered TC-like wind stress of magnitude U_*^2 at radius R_{max} from the TC center moving with transition speed U_T and investigated the mixing on both sides of TC track at distance *r*. Experiments with several friction velocities U_*, maximum wind radii R_{max}, transition speeds U_T and distances *r* were performed. No surface heat flux was considered for simplicity.
The results showed that the rightward bias of the SST response depended on these parameters. The location of the largest SST decrease moved away from the axis as U_T increased, but it depended less on U_*. The SST decreased more with larger U_* and smaller U_T. These results can be explained by energy flux at the surface. In our model configuration, the energy flux depends on two non-dimensional parameters, U_T/fR_{max} and U_*/U_T, and the energy flux had maximum and turbulent kinetic energy penetrated deeper at larger U_*/U_T and at U_T/fR_{max}~1, suggesting the resonance between wind and the inertial current. The SST decrease corresponded with the energy flux, but it depended largely on U_*/U_T, implying importance of wind forcing duration.
Thus, the asymmetric SST response due to the vertical turbulent mixing can be characterized with U_T/fR_{max} and U_*/U_T. Additional advection effects on the SST response will be discussed at the conference using three-dimensional simulation in which the advection as well as the mixing are fully included.

Keywords: Tropical cyclone, Vertical turbulent mixing, Ekman suction, Rightward bias

