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Investigating the sensitivity of hurricane intensity and trajectory to sea surface temperatures using the regional model WRF

Cevahir Kilic (1,2) and Christoph C. Raible (1,2,3)

(1) Climate and Environmental Physics, Physics Institute, University of Bern, Switzerland, (2) Center for Space and Habitability, University of Bern, Switzerland, (3) Oeschger Centre of Excellence for Climate Research, University of Bern, Switzerland

It is well known that the sea surface temperature (SST) has an influence on the development and intensification of tropical cyclones (TCs). This influence has become even more important during the past decades, as TCs show an intensification, which goes along with an increase in SSTs.

The influence of sea surface temperature (SST) anomalies on the hurricane characteristics are investigated in a set of sensitivity experiments employing the Weather Research and Forecasting (WRF) model. The idealised experiments are performed for the case of Hurricane Katrina in 2005. (Kilic and Raible, 2013)

The first set of sensitivity experiments with basin-wide changes of the SST magnitude shows that the intensity goes along with changes in the SST, i.e., an increase in SST leads to an intensification of Katrina. Additionally, the trajectory is shifted to the west (east), with increasing (decreasing) SSTs. The main reason is a strengthening of the background flow. To gain further insights in the dynamics, the potential vorticity (PV) and its tendency (PVT) are analysed. A positive PVT is located to the moving direction relative to the TC centre. Splitting the PVT in the horizontal advection, vertical advection, and diabatic heating terms, we find that mainly the horizontal advection term contributes to this PVT maximum, due to a steering by strong environmental flow. The impact of the diabatic heating is of minor importance and, hence, the TC motion is dominated by horizontal advection. The amount of the horizontal advection as well as the amount of the diabatic heating rise with increasing SST due to the enhanced Carnot cycle.

The second set of experiments investigates the influence of Loop Current eddies idealised by localised SST anomalies. The intensity of Hurricane Katrina is enhanced with increasing SSTs close to the core of a TC. Negative nearby SST anomalies reduce the intensity. The trajectory only changes if positive SST anomalies are located west or north of the hurricane centre. In this case the hurricane is attracted by the SST anomaly which causes an additional moisture source and increased vertical winds. This study confirm the linear relation between SST and TC intensity. However, in case of localised SST anomalies, the relative location to the TC core determes the gradient of the linear relation. The gradient decreases with increasing distance between SST anomaly and initialisation point. The anomalies located west and north of the initialisation point have a stronger impact than the ones located south and east, as they lie in the moving direction of the TC. Further, in terms of magnitude and pattern, the horizontal advection term of PVT does not strongly differ from the reference simulation. However, the pattern of diabatic heating term differs: A maximum of diabatic heating is still located in moving direction, but additionally the diabatic heating is found in the spiral rain bands. Thus, the vortex is drifted to the SST anomaly due to the asymmetry in the TC circulation induced by the diabatic heating term of the PVT.

References

Kilic, C., and C. C. Raible, Investigating the sensitivity of hurricane intensity and trajectory to sea surface temperatures using the regional model WRF, METEOROLOGISCHE ZEITSCHRIFT, 22(6), 685–698, 2013.