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Tracking tropical cyclones in reanalysis and simulations: guidelines from an intercomparison of four algorithms

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The direct detection — or tracking — of tropical cyclones (TC) in gridded datasets outputs from reanalyses or model simulations is required to assess TC statistics. This issue has been tackled independently by many modeling centers or research groups; hence there is little homogeneity in the existing methods. The trackers – i.e., the algorithms used to perform that tracking -- generally fall into one of two categories: physics-based or dynamics-based. Physics-based trackers use sea-level pressure as their primary tracking variable, with additional warm-core and intensity criteria, whereas dynamics-based trackers use kinematic variables such as vorticity.

We compared four trackers taken from both categories and that we deem very different from one another in terms of their formulation: UZ (sometimes called TempestExtremes, Ullrich et al. 2021), OWZ (Tory et al. 2013), TRACK (Hodges et al. 2017) and CNRM (Chauvin et al. 2016). We assessed their performances by tracking TCs in ERA5 and comparing the outcome to the IBTrACS database – a collection of TC observations from several meteorological centers worldwide.

We find typical detection rates ranging from 70 to 80% and False Alarm (FA) rates ranging from 20 to 50% depending on the trackers. Based on the finding that a large proportion of these FAs are extra-tropical cyclones, we adapted an existing filtering method that relies on the relative positions of the detected tracks and the upper troposphere subtropical jet. When applied identically to the four trackers, it reduces FA rates to figures ranging from 9 to 30% while leaving detection rates unchanged.

Even though we were able to find most of the observed TCs in ERA5, we find, in agreement with several results in the recent literature, that their intensity is largely underestimated. However, and perhaps counterintuitively, there is no simple attenuation relationship between observed and reanalyzed TCs: for example, the strongest observed TCs are found in ERA5 with intensities covering almost the entire TC intensity scale.

We conclude by providing guidelines applicable when faced with the question of which tracker(s) to use depending on the research question. In particular, we show that using several trackers is not necessarily relevant for optimizing detection skills but combining them can be helpful to gain insight into different aspects of TCs in the same dataset.

Finally, we used the expertise gained above to track TCs in a set of HighResMIP simulations performed with the IPSL-CM7A model at different resolutions. In agreement with recent results, we find that the ability to simulate TCs improves significantly with resolution. Even though the intensity of simulated TCs remains too weak on average, the global statistics approach observations for simulations at a few tens of kilometers of horizontal resolution.