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COMMENT

Comment on 'Roles of interbasin frequency changes in the poleward shifts of the maximum intensity location of tropical cyclones'

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The article by Moon *et al* (2015) [1] (henceforth MKKC) considers interbasin tropical cyclone frequency variability and its effect on the poleward migration of the mean latitude of tropical cyclone lifetime-maximum intensity (LMI) shown in Kossin *et al* (2014) [2] (henceforth KEV). We read MKKC with great interest, but given the key focus and the title of the article, we were somewhat surprised that MKKC in no way acknowledges that KEV included an analysis that explicitly explored the role of interbasin frequency changes in the poleward shift of LMI. KEV states:

> 'The global trends in the annual mean latitude of lifetime-maximum intensity (LMI) are a result of both intrabasin and interbasin changes. The climatological mean latitude of LMI varies by basin (see, for example, extended data figure 1) such that, in addition to meridional shifts within each basin, changes in the relative annual frequency of storms from each basin can also contribute to the global trends in the latitude of LMI. To quantify this contribution, the LMI latitude of every storm was normalized by the respective basin-mean LMI latitude, and the analysis of figure 1(c) was repeated. When this was performed, the trend in the best-track data decreased from 115 ± 70 to 78 ± 66 km per decade and the trend in the ADT-HURSAT data decreased from 118 ± 70 to 92 ± 65 km per decade. Thus, both factors contribute, but the intrabasin poleward migration of LMI dominates the trends'.

It should be clear from the above that the authors of KEV were very much aware of the main issue that MKKC focuses on. We welcome the more in-depth exploration of this question in MKKC, but feel that introducing it as something new is misrepresentative.

Ultimately, the main finding of MKKC is that when the global historical best-track data are segregated into hemispheres, and interbasin frequency variability is accounted for, and an ad hoc intensity threshold is applied to the data, the migration rate in the northern hemisphere is no longer statistically significant. MKKC then claims that this result obviates the results of KEV, but this assertion does not follow from the results of MKKC. Firstly, it is an elementary aspect of statistics that the subsetting of a larger data sample into subsamples will often reduce the signal-to-noise ratio, sometimes to a point of statistical insignificance, so the lack of a significant poleward migration rate in the northern hemisphere does not obviate the existence of a significant global migration. Secondly, there are large and statistically significant poleward migration rates in the western North Pacific, South Pacific, and Southern Indian ocean basins, none of which can be attributed in any way to the interbasin variability that MKKC focuses on. Tropical cyclone activity in these three basins comprise the vast majority of global activity, so the statement that the northern hemispheric trend is dominated by interbasin frequency variability misses the larger and more relevant question of what has driven the poleward migration in these basins (which contribute substantially to the global migration). Toward this question, MKKC offers little advancement.

As a final note, KEV analyzed a documented homogenized reanalysis dataset [3] in addition to the historical best-track data. When the latitude of LMI from the homogenized reanalysis data is normalized to remove the effects of interbasin frequency changes, the poleward migration rate in the northern hemisphere does in fact remain highly significant, decreasing from 83 ± 50 km per decade (with interbasin variability included) to 58 ± 42 km per decade (after accounting for interbasin variability). The analysis of MKKC was limited to the best-track data and did not discuss the robustness of the migration rates in the homogenized data, although these data are available.

The large and significant poleward migration rates in three of the largest and most active tropical cyclone regions, which as stated above cannot be attributed in any way to interbasin variability, the maintenance of significant global trends after removing interbasin variability, as shown in KEV, and the robust trend in the northern hemisphere homogenized reanalysis data (that were not included in MKKC), all point clearly toward a very real physical phenomenon that warrants further study.

References

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[3] Kossin J P, Olander T L and Knapp K R 2013 Trend analysis with a new global record of tropical cyclone intensity *J. Clim.* **26** 9960–76