Geosci. Model Dev. Discuss., referee comment RC2
https://doi.org/10.5194/gmd-2021-384-RC2, 2022

Comment on gmd-2021-384

Anonymous Referee #2

Referee comment on "Cyclone generation Algorithm including a THERmodynamic module for Integrated National damage Assessment (CATHERINA 1.0) compatible with Coupled Model Intercomparison Project (CMIP) climate data" by Théo Le Guenedal et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-384-RC2, 2022

Overview:

The paper presents a novel approach to evaluate damage from tropical cyclones at a national scale, and allowing for the influence of climate change on both TC intensity and economic exposure. The system is composed of TC track and intensity generation model, nationally-applicable damage functions and bias-correction techniques for key climate variables. These components have potential to provide a reliable approach to estimating future economic losses from TCs that incorporates changes to both the physical phenomena driving damage, and the local asset values impacted by TCs. In a topic that is receiving significant attention in the literature (e.g. Jewson 2021, 2022; Steptoe et al. 2022), this approach provides another view on evaluating TC-related risk, further expanding our understanding of epistemic uncertainties.

Detailed comments:

- Table 1: the selection of GCMs used should be justified. This could be through reference to model performance literature for key parameters, a specific evaluation process or perhaps simply availability of required variables for the analysis (though I note the variables used are available for all CMIP5 models).
- Section 2.2: the MSLP from ERA-5 is sampled 500 km from the centre of the cyclone. Is the same done for the other variables? Since the data are sampled from monthly means, it's possible the sampled values may not accurately represent the conditions at the time of TC passage (especially relevant for variables with sharp gradients such as SST).
- Section 3.2: Given the literature of TC track generation methods, comparison with common metrics is encouraged. Specifically, as landfall is critical to reliable performance of a damage model, it would be helpful to present a comparison of the observed and simulated landfall rates (see for example Hall and Jewson, 2007; Lee et

al., 2018; Arthur, 2021). This would strengthen the quality of the track generation results significantly.

- Eq 3 - note that most best track data used wind pressure relations (WPRs) to determine Pc. Typically the work flow involves determining the Dvorak T number, converting this to a sustained wind speed, followed by regionally-specific WPR to determine Pc. The conversion back to wind speed from reported Pc using a single WPR will introduce errors, as an array of WPRs are used to operationally estimate Pc, not only between basins but within basins as well (e.g. Harper, 2002; Courtney and Knaff, 2009; Courtney and Burton, 2018; Courtney et al. 2021).
- Eq 10 describes the dominant control on the maximum intensity of TCs (maximum pressure drop - MDP). This is tied only to SSTs. The model uses maximum potential intensity (MPI) to control the depression dynamics (i.e. intensification rates). The formulation of MPI is directly applicable to the problem of estimating the maximum intensity, accounting for factors beyond SST alone that control maximum intensity. This suggests using SST as the only predictor of the MDP is deficient.
- Further, Chen et al. (2021) suggest rapid intensification is dependent on dynamical (e.g. upper divergence and wind shear) as well as thermodynamical factors. While the difference between Pc and MPI is a factor in predicting rapid intensification, and the dynamical factors are probably accounted for by the random innovation (Eq. 12), these other dynamical factors should be acknowledged.
- Apply CDF-t to model variables, then evaluate MPI - I suggest comparing quantiles of ERA5 MPI against the bias corrected CMIP MPI values to demonstrate the effect of bias correction. Q-Q plots would be an effective way to do this. One risk with this approach is that correcting individual variables may lead to unrealistic combinations when evaluating MPI - e.g. extremely low tropopause temperatures in combination with very high SSTs that lead to unrealistic lapse rates and therefore unrealistically large MPI. Two solutions present themselves: 1) apply the bias correction methods to calculated MPI or (2) consider the joint distributions of variables when evaluating the bias corrections.
- The distributions of SST presented in Figure 16 do not appear representative of SSTs sampled in the vicinity of TCs, and is inconsistent with the distribution shown in Figure 10. SSTs of 26C (299K) are typically considered a lower bound for TC formation (Gray, 1979), but median values from the ERA5 are well below that - for example based on Figure 16 the median SST for the South Pacific basin along synthetic tracks is 290-292K, for the Western Pacific 295K. Only the N Indian basin has a median SST near 300K. This suggests that the synthetic tracks are traversing areas not typically covered by TCs, or occurring at the wrong time of year for the respective basin leading to the unusual SST distribution.
- Completely absent is any discussion on TC rates in the projections. Comprehensive literature reviews and expert elicitations indicate a global decline in TC frequency (albeit with generally low-medium confidence) (Knutson et al. 2020). Changes in TC rates will have a significant impact on the annualised losses. This is an important component that should be addressed.
- In parallel, there is no discussion on changes in track behaviour. Observed trends in TC translation speed (Kossin, 2018) and poleward migration of maximum intensity (Kossin et al., 2014) should be considered in projections of TC activity. This has profound implications for TC-related risk in key marginal areas (e.g. Bruyere et al., 2020) where vulnerabilities are high, but present-day frequency of TCs is low.
- Section 5.2: Consideration of SSPs in determining the effects on damage is novel, but the explanation is very limited. Given growth of exposure is constrained in existing high exposure regions, regional growth may not be in areas exposed to TC impacts.
- The description of the implementation of projections of local physical asset value dynamics is very limited, but probably the most novel part of the connected modelling system. There should be a more substantial discussion on how the SSP definitions are used to modify asset values.

Technical comments

- Page 4, footnote 2: Please use the full reference for the Copernicus Climate data store (Hersbach et al., 2020)
- Figures need to be larger to be legible.
- Figure 3: Recommend plotting each track with the same vertical scale (on the pressure and wind axes respectively) - i.e. use a scale of 0-75 m/s for wind speed and 880 - 1025 hPa for pressure on all panels. This will aid intercomparison of the time histories
- Line 135: Please include an equation label
- Page 7 - footnote: References to World Bank (2019b) and Credit Suisse Research Institute (2017) in the footnote of page 7 are not included in the bibliography.
- Page 11: Footnote 13 should be in the body of the manuscript, as this is a key difference between James and Mason (2005) and the implementation in the current study. Following on from this, Tables A2, A4 and A6 reflect basin-wide fits, while the tracking method uses 5-by-5 degree grid. It may be more appropriate to provide maps of the relevant coefficients on the grids in the Appendix rather than the tables.
- Page 17, line 289: Does "This study" refer to the current manuscript, or to the previously referenced Unawa et al. (2000). Please clarify.
- Page 20, line 333: Change "non-EOCD" to "non-OECD"
- Page 24, line 376: suggest changing "unbiased" to "bias-corrected"
- Figure A8: Add units to the horizontal axes of the plot, or indicate what the values are in the caption. Ideally, each of the sub-plots should also use the same horizontal scale to aid comparison

References:

- Arthur, W. C., 2021: A statistical–parametric model of tropical cyclones for hazard assessment. Nat. Hazards Earth Syst. Sci., 21, 893–916, https://doi.org/10.5194/nhess-21-893-2021.
- Bruyère, C., and Coauthors, 2020: Severe Weather in a Changing Climate. Insurance Australia Group, https://www.iag.com.au/sites/default/files/Documents/Climate%20action/Severe-weather-in-a-changing-climate-2nd-Edition.pdf
- Chen, Y., S. Gao, X. Li, and X. Shen, 2021: Key Environmental Factors for Rapid Intensification of the South China Sea Tropical Cyclones. Frontiers in Earth Science, 8.
- Courtney, J. B., and A. D. Burton, 2018: Joint Industry Project for Objective Tropical Cyclone Reanalysis: Final Report. Bureau of Meteorology, Australia.
- ——, G. R. Foley, J. L. van Burgel, B. Trewin, A. D. Burton, J. Callaghan, and N. E. Davidson, 2021: Revisions to the Australian tropical cyclone best track database. Journal of Southern Hemisphere Earth Systems Science, 71, 25, https://doi.org/10.1071/ES21011.
- Courtney, J., and J. A. Knaff, 2009: Adapting the Knaff and Zehr wind-pressure relationship for operational use in Tropical Cyclone Warning Centres. Australian Meteorological and Oceanographic Journal, 58, 167.
- Gray, W. M., 1979: Hurricanes: Their formation, structure, and likely role in the tropical circulation. Meteorology over the tropical oceans, D.B. Shaw, Ed., Royal Meteorological Society, 155–218.
- Hall, T. M., and S. Jewson, 2007: Statistical modelling of North Atlantic tropical cyclone tracks. Tellus A, 59, 486–498.

- Harper, B. A., 2002: Tropical Cyclone Parameter Estimation in the Australian Region: Wind Pressure Relationships and Related Issues for Engineering Planning and Design. Systems Engineering Australia, Pty. Ltd.
- Hersbach, H., and Coauthors, 2020: The ERA5 global reanalysis. Quarterly Journal of the Royal Meteorological Society, 146, 1999–2049, https://doi.org/10.1002/qj.3803.
- James, M. K., and L. B. Mason, 2005: Synthetic Tropical Cyclone Database. Journal of Waterway, Port, Coastal, and Ocean Engineering, 131, 181–192, https://doi.org/10.1061/(ASCE)0733-950X(2005)131:4(181).
- Jewson, S., 2021: Conversion of the Knutson et al. Tropical Cyclone Climate Change Projections to Risk Model Baselines. Journal of Applied Meteorology and Climatology, 60, 1517–1530, https://doi.org/10.1175/JAMC-D-21-0102.1.
- ——, 2022: Application of uncertain hurricane climate change projections to catastrophe risk models. Stoch Environ Res Risk Assess, https://doi.org/10.1007/s00477-022-02198-y.
- Knutson, T. R., and Coauthors, 2020: Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming. Bulletin of American Meteorological Society, 101, E303–E322, https://doi.org/10.1175/bams-d-18-0194.1.
- Kossin, J. P., 2018: A global slowdown of tropical-cyclone translation speed. Nature, 558, 104–107.
- Kossin, J. P., K. A. Emanuel, and G. A. Vecchi, 2014: The poleward migration of the location of tropical cyclone maximum intensity. Nature, 509, 349–352.
- Lee, C.-Y., M. K. Tippett, A. H. Sobel, and S. J. Camargo, 2016: Rapid intensification and the bimodal distribution of tropical cyclone intensity. Nature Communications, 7, 10625, https://doi.org/10.1038/ncomms10625.
- Steptoe, H., C. Souch, and J. Slingo, 2022: Advances in numerical weather prediction, data science, and open-source software herald a paradigm shift in catastrophe risk modeling and insurance underwriting. Risk Management and Insurance Review, n/a, https://doi.org/10.1111/rmir.12199