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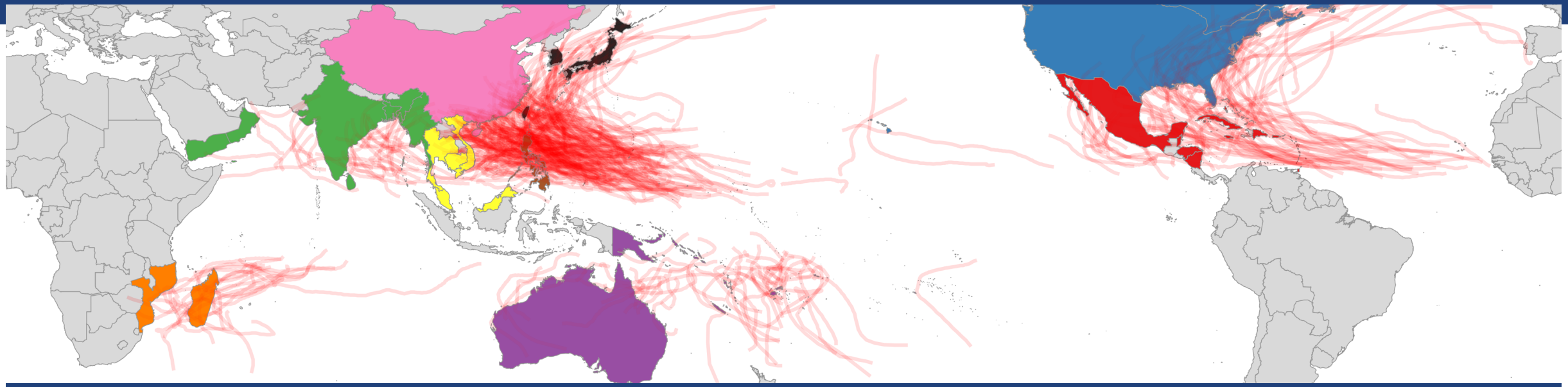

Regionalization of tropical cyclone impact functions

EGU General Assembly 2020

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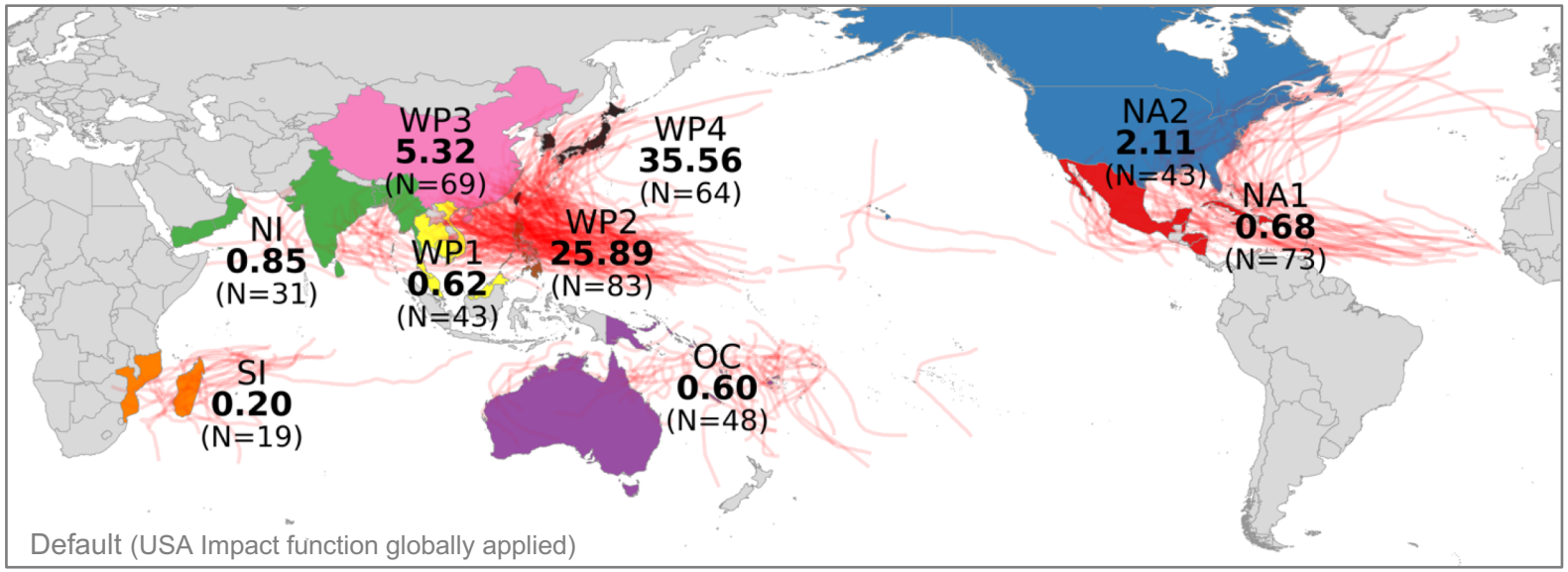
Introduction: Beyond *the* singular global tropical cyclone impact function



Regional total damage ratio (TDR): ratio between total simulated and reported tropical cyclone (TC) damage for each region. Based on the modeling of wind induced direct economic damage with a default impact function for 473 events, i.e. 376 TCs (red lines) making landfall in 53 countries in nine regions:

NA1: the Caribbean with Central America and Mexico (red);
NA2: the USA and Canada (blue);
NI: North Indian Ocean (green);
OC: Oceania with Australia (purple);
SI: South Indian Ocean (orange);
WP1: South East Asia (yellow);
WP2: the Philippines (brown);
WP3: China mainland (rose);
WP4: East Asia (black).

- Natural hazard risk assessments utilize impact functions to compute economic damage from hazard intensity and asset exposure.
- Regional impact functions are scarce. In the case of tropical cyclones (TCs), curves calibrated for the USA are often applied globally.
- This can lead to a substantial overestimation of regional TC impacts as compared to reported damage (c.f. world map).
- Here, we fit and assess regionalized impact functions in a global TC impact modeling framework.

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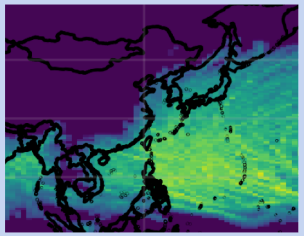
Data and Method: Assessing regionalized TC impact functions

Impact modeling → *Damage comparison* → *Results*

Weather and climate risk modeling platform CLIMADA[1]

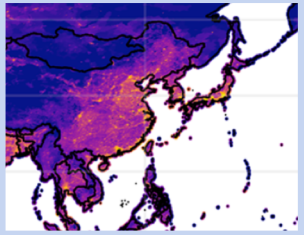
Hazard

Wind fields modelled[1,2,3] from 4098 unique TC tracks[4] (1980-2017)



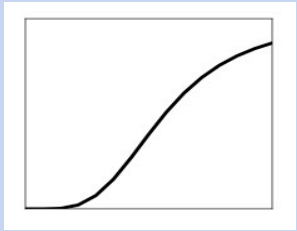
Exposure

Gridded physical asset value[5] (as of 2014)



Vulnerability

Default impact function mapping wind speed to direct damage[6] (calibrated for the USA)



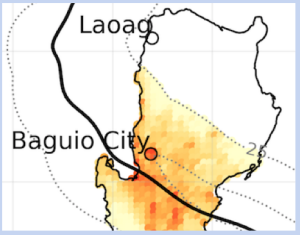
Reported damage

Direct economic damage[7] per TC event and country (992 entries from 1980-2017)

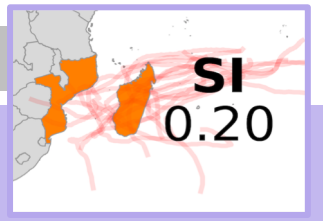
Assigning: *473 matched data points* (damage per TC and country)*

Simulated damage

Direct economic damage per TC event and country



*) The 473 assigned TC events account for ~58% of global simulated TC damage based on all 4098 TC tracks from 1980-2017. Reported damage accounts for 76% of total normalized reported TC damage over the same period of time (91% before normalization).



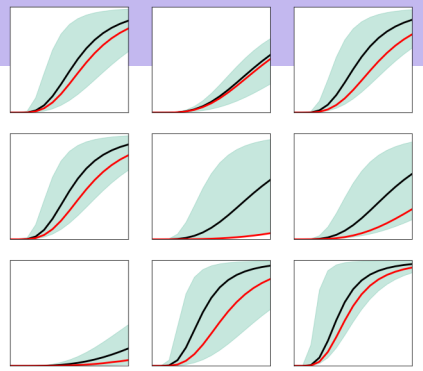
Damage Ratio

- EDR: ratio per event
- TDR: total ratio per region

$$\frac{\textit{Simulated Damage}}{\textit{Normalized Reported Damage}}$$

Regionalized Impact Functions

- Calibration by fitting impact functions per region based on EDR and TDR
- Uncertainty estimation based on spread of EDR



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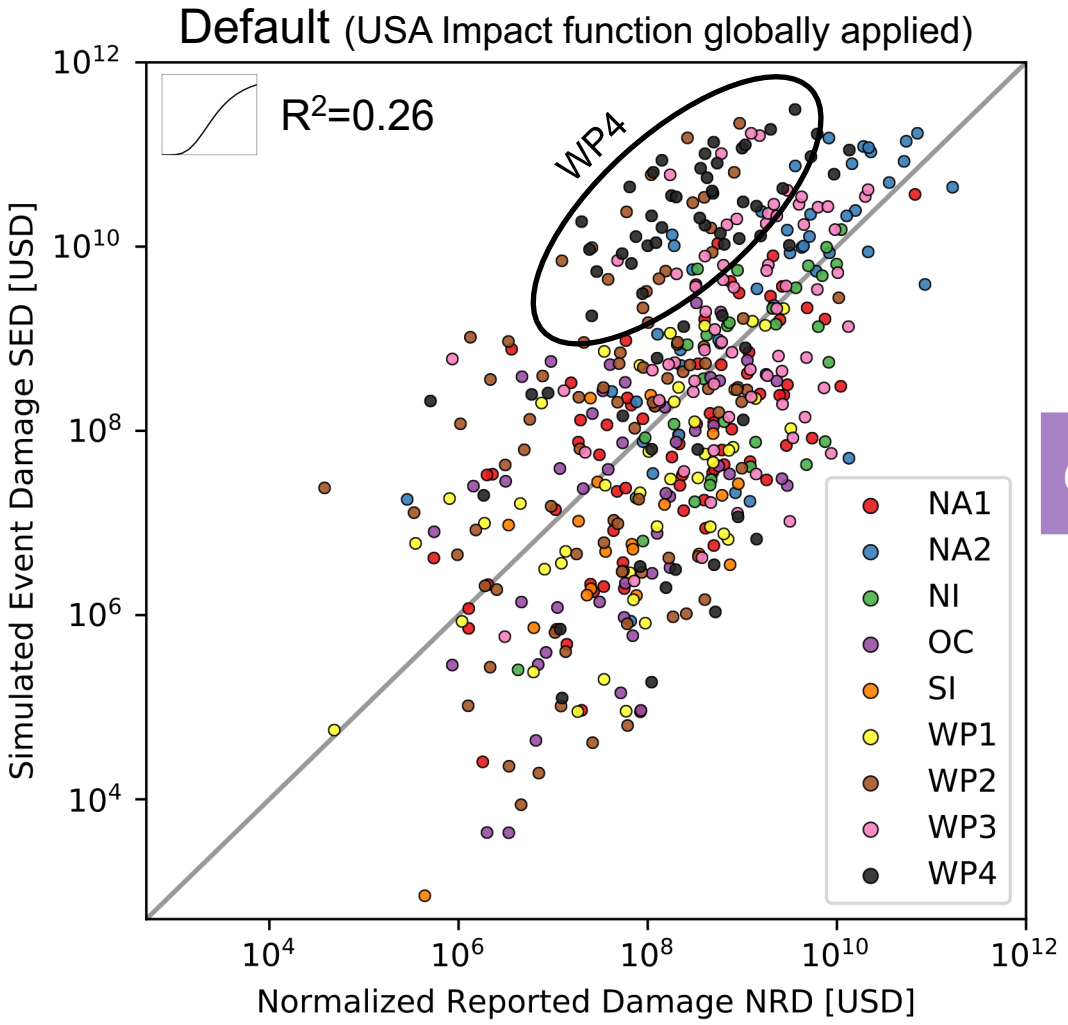
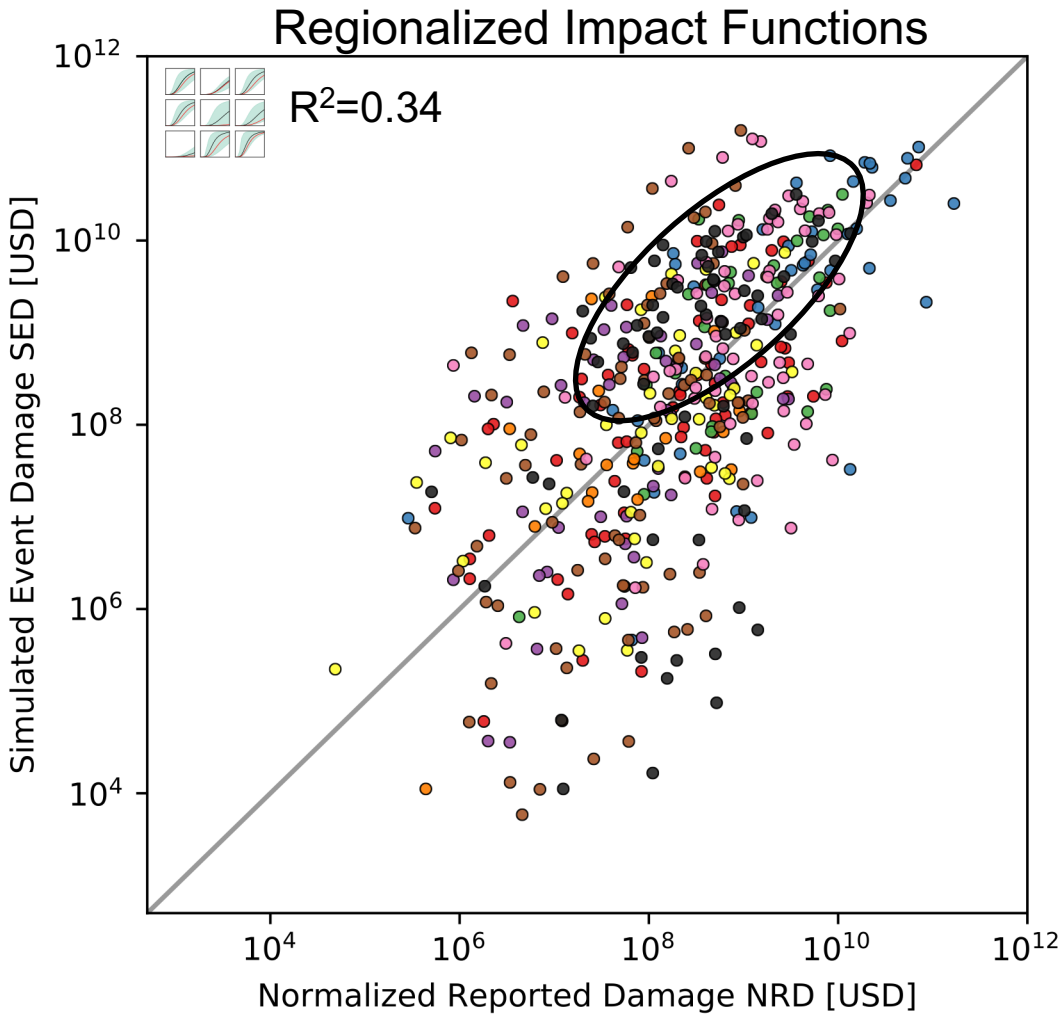
Results: Damage comparison for 473 TC events



Calibration



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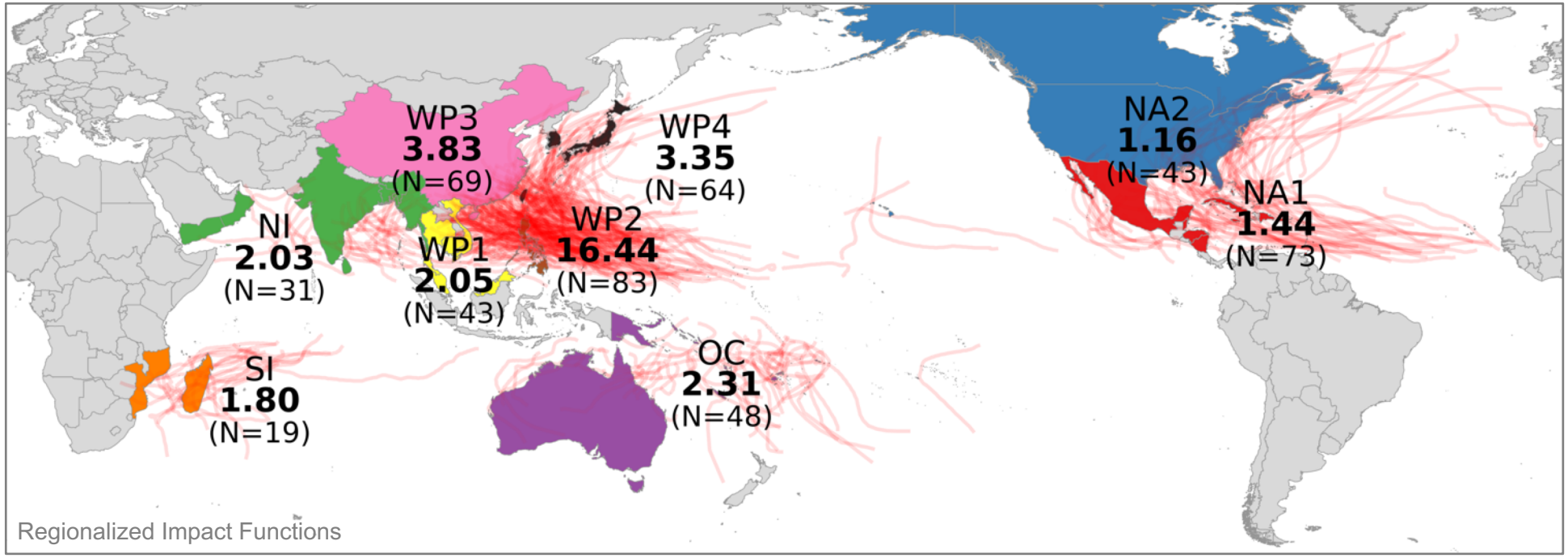
Results: Total damage ratio per region with regionalized impact functions



Regional total damage ratio (TDR): ratio between total simulated and reported tropical cyclone (TC) damage for each region. Based on the modeling of wind induced direct economic damage with regionalized impact functions for 473 events, i.e. 376 TCs (red lines) making landfall in 53 countries.

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Discussion

- **There is not *the* singular global TC impact function.**

  While the default impact function works well for the North Atlantic, fitting a regional impact function improves results for other world regions, especially in East Asia and Africa.

  The regionalized impact functions will soon be published and made available within the open-source CLIMADA[1] framework.

- **The modeling of direct economic impacts from TCs based on wind speed as the only hazard type comes with regionally large uncertainties.**

  In this study, TC hazard intensity is represented by wind speed alone. Whereas the impact model set-up returns robust results for the North Atlantic regions, we found an extensive spread both in EDR and calibrated impact functions for other regions. The largest uncertainties were found for the Philippines (region WP2) and China mainland (WP3).

- **Sources of uncertainty are the hazard, exposure, and vulnerability components of the impact model; as well as the reported damage data[8].**

  A case study for the Philippines reveals limitations of the TC impact modeling set-up and the impact function calibration. Uncertainties can be related to:
  (1) the lack of an explicit representation of associated sub-perils such as storm surge, torrential rainfall, and landslides;
  (2) differences in exposure and vulnerability between urban and rural areas.
  (3) Furthermore, inaccuracy and potential biases in the reported damages are likely to be yet another relevant source of uncertainty[8].

References

1) Aznar-Siguan, G. and Bresch, D. N.: CLIMADA v1: a global weather and climate risk assessment platform, Geosci. Model Dev., 12(7), 3085–3097, doi:0.5194/gmd-12-3085-2019, 2019. Code available from: https://github.com/CLIMADA-project/climada_python

2) Holland, G.: A Revised Hurricane Pressure–Wind Model, Mon. Weather Rev., 136(9), 3432–3445, doi:10.1175/2008MWR2395.1, 2008.

3) Geiger, T., Frieler, K. and Bresch, D. N.: A global historical data set of tropical cyclone exposure (TCE-DAT), Earth Syst. Sci. Data Discuss., 1–15, doi:10.5194/essd-10-185-2018, 2018.

4) Knapp, K. R., Kruk, M. C., Levinson, D. H., Diamond, H. J. and Neumann, C. J.: The International Best Track Archive for Climate Stewardship (IBTrACS), Bull. Am. Meteorol. Soc., 91(3), 363–376, doi:10.1175/2009BAMS2755.1, 2010.

5) Eberenz, S., Stocker, D., Röösli, T. and Bresch, D. N.: Asset exposure data for global physical risk assessment, Earth Syst. Sci. Data, 12(2), 817–833, doi:10.5194/essd-12-817-2020, 2020.

6) Emanuel, K.: Global Warming Effects on U.S. Hurricane Damage, Weather Clim. Soc., 3(4), 261–268, doi:10.1175/WCAS-D-11-00007.1, 2011.

7) Guha-Sapir, D.: EM-DAT – The International Disaster Database, CRED / UCLouvain, Brussels, Belgium, [online] Available from: www.emdat.be, 2018.

8) Guha-Sapir, D. and Below, R.: The quality and accuracy of disaster data: A comparative analyse of 3 global data sets, Disaster Management Facil. World Bank., 2002.