COMPASS

Dataset of tropical cyclone-affected areas

Deliverable 1.4

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Lead Beneficiary	PIK
Lead Author(s)	Matthias Mengel (PIK)
Contributors	
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Version History

Date	Version	Contributors	Comments
13/12/2024	0.1	Matthias Mengel (PIK)	First version for internal review
18/12/2024	0.2	Natalia Aleksandrova (Deltares), Anaïs Couasnon (Deltares)	Internal review
23/12/2024	1.0	Matthias Mengel (PIK)	Final review and first finished version

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Executive summary

The overarching goal of the COMPASS project is to develop a harmonised methodological framework for climate and impact attribution of various complex extremes that includes compound, sequences and cascading hazard events. This report is a description of deliverable D1.4, a dataset of tropical cyclone-affected areas. It contributes to the COMPASS project's objective of modeling and downscaling of compound extremes in current and future climates and to the Work Package 1 objective resolving the different compound drivers in areas affected by tropical cyclones.

The dataset contains the key impact drivers of tropical cyclones (TCs) from 1950 to 2023 to estimate the affected areas from winds, rainfall, and storm surges. The work lies the basis for the development of the corresponding counterfactual TC footprints (D2.6 from Work Package 2). It will also be used in Work Package 4 for the Use Cases (UCs) focusing on tropical cyclones (UC3 and UC4). More generally, we foresee this dataset to be of use for TC attribution studies.

The dataset (currently v1.0) is available on the COMPASS research repository Zenodo at the following DOI: 10.5281/zenodo.14500820

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1. Dataset of tropical cyclone-affected areas

This dataset contains the key impact drivers of tropical cyclones (TCs) from 1950 to 2023 to estimate the affected areas from winds, rainfall, and storm surges.

It includes maximum winds over the lifetime of the tropical cyclone, maximum 24-hour cumulative rainfall, and maximum flood depths from storm surge. The data is available for all IBTrACS tropical cyclones from 1950 to 2023, with provisional data extending to October 2024. The data is provided at 300 arc-second (~10 km) spatial resolution, in netCDF format.

For the five TCs of the COMPASS phase I use cases, we additionally provide data with hourly temporal resolution for wind speeds and rainfall intensity.

We follow the ISIMIP[1] structure for tropical cyclone data.

1.1. Methodology

The method to produce wind and rain fields is described in Frieler et al. (2024). It uses the track data available from the International Best Track Archive for Climate Stewardship (IBTrACS[2]).

We provide data for winds building on two different wind models, termed here as H08 and ER11. The first is a semiempirical model that estimates the full wind profile from the central pressure variable based on the gradient wind balance assumption (Holland 1980, 2008). The second is a physics-based model and uses (the often less reliable) maximum wind speed variable to derive the wind profile from the boundary layer angular momentum balance (Emanuel and Rotunno, 2011). The code behind this calculation is part of CLIMADA[3].

For rainfall estimates, we use the physics-based model TCR (Zhu et al. 2013, Emanuel 2017). It assumes that the precipitation rate at each centroid is proportional to the vertical vapor flux. The code is part of CLIMADA[4] and follows the description in Lu et al. (2018) including the improvements proposed in Feldmann et al. (2019). The saturation specific humidity is assumed to be constant over the rainfall field and can be estimated from the 600 hPa temperature at the storm center using the Claudius-Clapeyron relation. For more details see the CLIMADA tutorial[5].

TCR needs additional data (wind velocities at 850hPa and the temperature at 600hPa) that are not available from IBTrACS. These data are extracted from the ERA5 reanalysis[6] (Hersbach et al. 2020).

We provide flood depth driven by the tropical cyclone-induced surge based on the GeoClaw adaptive mesh shallow water solver wrapped into CLIMADA[3]. See Vogt et al. (2024) for a short method description.

1.2. Directory: global/hourly/historical

This directory holds data for the five TCs as part of use cases three and four of COMPASS. They cover:

```
TC Idai, South Indian Ocean 2019, IBTrACS sid 2019063S18038

TC Kenneth, South Indian Ocean 2019, IBTrACS sid 2019112S10053

TC Freddy, South Indian Ocean 2023, IBTrACS sid 2023036S12118
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[1] https://www.isimip.org/
[2] https://www.ncei.noaa.gov/products/international-best-track-archive
[3] https://climada-python.readthedocs.io/en/stable/tutorial/climada_hazard_TropCyclone.html
[4] https://github.com/CLIMADA-project/climada_python
[5] https://climada-petals.readthedocs.io/en/latest/tutorial/climada_hazard_TCRain.html
[6] https://cds.climate.copernicus.eu/datasets/reanalysis-era5-single-levels?tab=overview

`TC Iota, Carribean 2020, IBTrACS sid 2020318N16289`

`TC Eta, Carribean 2020, IBTrACS sid 2020306N15288`

We provide the data with hourly temporal resolution for the two different wind field models (H08 and ER11) and the two related resulting rainfields. NetCDF files are provided per model, TC and variable (wind and rain). For now, we do not provide time-resolved TC-induced coastal surge data.

Example filenames:

`h08_obsclim_historical_wind_2019063S18038.nc`

`h08_obsclim_historical_rain_2019063S18038.nc`

1.3. Directory: global/storm/historical

This directory holds data for all tropical cyclones from 1950 to 2023 that are part of IBTrACS. We also include provisional data for the year 2024, with the latest included storm ending on October 21st, 2024. Here we provide fields of maximum 1-minute sustained wind speed over the TC lifetime and the maximum 24-hourly rainfall total during the whole storm duration, given in folders `H08` and `ER11` corresponding to the model that was used to calculate the variables.

Example filenames:

`h08_obsclim_historical_windlifetimemax_1995.nc`

`h08_obsclim_historical_maxrain_1995.nc`

We provide maximum flood depth during the TC-induced coastal surge in the `surge` folder. Surges are calculated based on the older Holland windfield model (Holland, 1980).

Example filename:

`obsclim_historical_maxflooddepth_1995.nc`

2. References

Holland, G.: A Revised Hurricane Pressure–Wind Model, Mon. Weather Rev., 136, 3432–3445, 2008.

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Vogt, T., Treu, S., Mengel, M., Frieler, K., & Otto, C.: Modeling surge dynamics improves coastal flood estimates in a global set of tropical cyclones. Communications Earth & Environment, 5(1), 529, 2024.

Zhu, L., Quiring, S. M., and Emanuel, K. A.: Estimating tropical cyclone precipitation risk in Texas, Geophys. Res. Lett., 40, 6225–6230, 2013.