WISC in CLIMADA 20180208

Part of https://github.com/davidnbresch/climada_module_storm_europe

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The CLIMADA[1] winter storm module[2] provides a solid basis to test and further develop the WISC[3] storm catalog[4] (4.4 km spatial resolution, time period 1940-2014). The present document does briefly touch upon some first tests and attempts to further develop this catalog within CLIMADA. Most results (and some intermediate files, too) can be found on the polybox[5].

CLIMADA operates on a variable grid, defined by *centroids*. For most calculations, CLIMADA hence uses just the grid the WISC footprints are provided at (4.4km) for all hazard analytics. Please note that for any impact calculations, CLIMADA does automatically assign each exposure point with the closest hazard centroid (i.e. the closest (variable) grid point of the hazard). This way, CLIMADA can handle irregular and dissimilar grids very elegantly.

In order to import all historic wind field footprints into CLIMADA, use `wisc_hazard_set`[6]. To generate the *historic* hazard set, i.e. with all historic WISC footprints, just visit https://wisc.climate.copernicus.eu/wisc/#/help/products, download C3S_WISC_FOOTPRINT_NETCDF_0100.tgz and unzip into a subfolder named WISC of your local climada_data folder, then run:

```
wisc_files=[climada_global.data_dir filesep 'WISC' filesep ...
       'C3S_WISC_FOOTPRINT_NETCDF_0100' filesep 'fp_era*.nc'];
hazard=wisc_hazard_set(wisc_files)
```

Figures 1-3 as shown below are based upon this data in **`hazard`**.

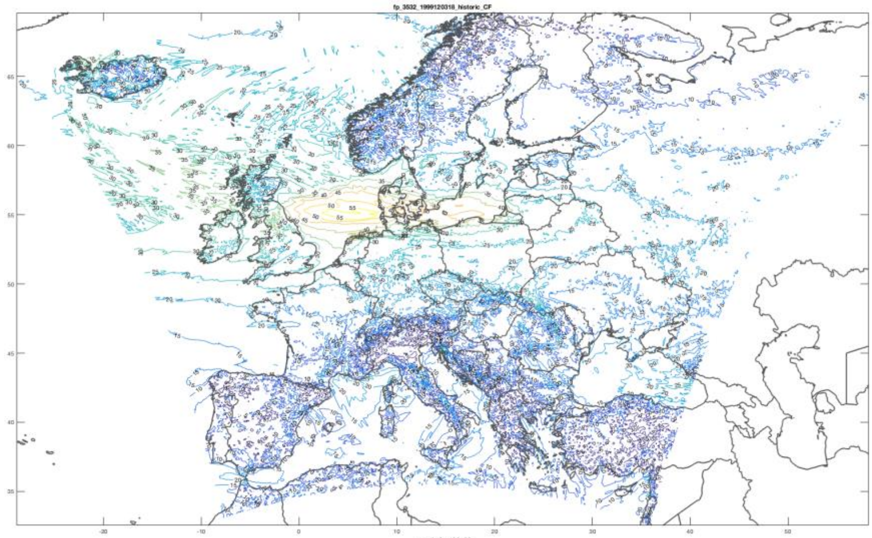

Figure 1: A single WISC storm footprint (1999120318, Anatol) imported by `wisc_hazard_set` and plotted as contours (wind speed in m/s, for details, see WISC documentation).

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[1] https://github.com/davidnbresch/climada

[2] https://github.com/davidnbresch/climada_module_storm_europe

[3] https://wisc.climate.copernicus.eu

[4] https://wisc.climate.copernicus.eu/wisc/#/help/products

[5] https://polybox.ethz.ch/index.php/s/yO1sCMuSFA2qdGR and subfolders of the same structure as in CLIMADA. In order to use these files, just copy them to your local CLIMADA data folder (…/climada_data/hazards … etc.)

[6] CLIMADA commands are formatted as `Courier New` and can usually just be typed into the MATLAB command window once CLIMADA has been started.

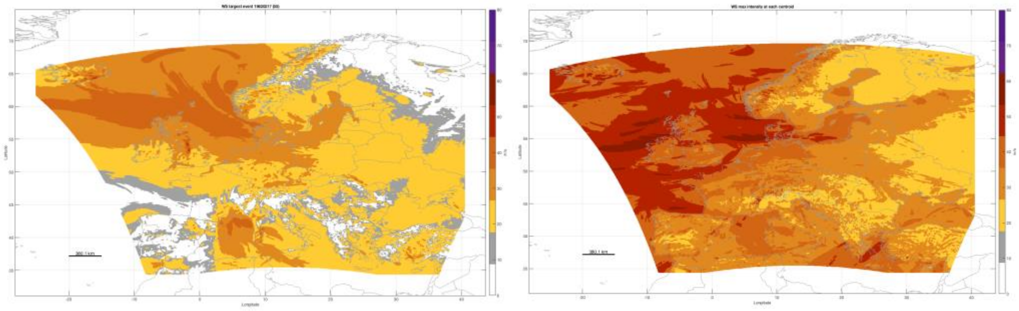


Figure 2: The largest single event (19620217) and the maximum intensity of all historic (era40 and eraint, time period 1940-2014) events at each centroid. Easily produced by the call `climada_hazard_map(hazard,-1)` for the left and `climada_hazard_map(hazard,0)` for the right plot. CLIMADA can obviously render with larger fonts etc. – the plots were just produced to show best on a large screen…

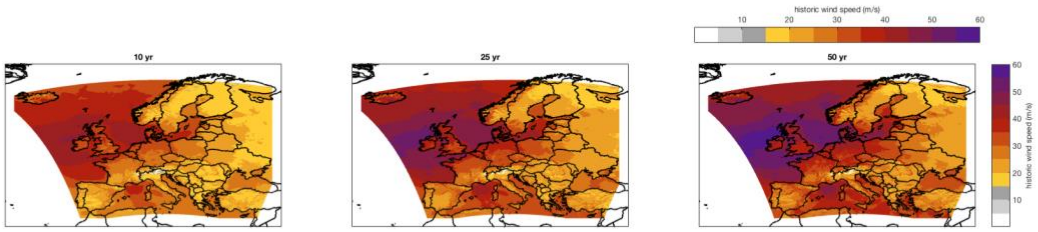


Figure 3a: Wind speed return period maps. Shown are return period maps for 10, 25 and 50 years, wind speed in m/s based on *historic* events. The plot has been automatically produced by the call `climada_hazard_stats(hazard,[10 25 50])`. Note that the color scale shows grey up to wind speeds that hardly lead to any impact (15 m/s) and then aligned with the tick marks up to a max gust of 60 m/s.

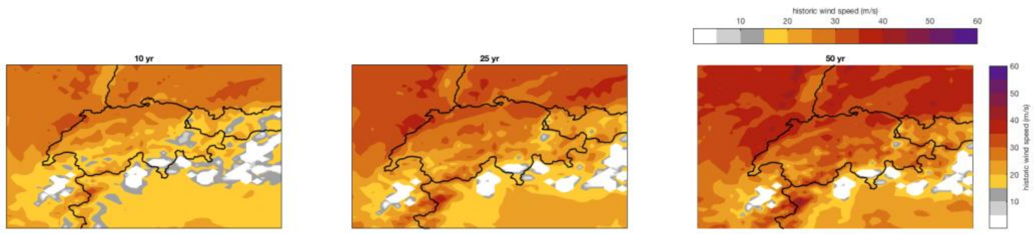


Figure 3b: Same as Fig. 3a, just zoomed in for Switzerland.

CLIMADA does allow for an easy generation of a *probabilistic* hazard event set, i.e. storm catalog based on *historic* events being moved a bit around (see Figure 4) and weakened and intensified. While the moving around allows for an easy way to deal with hazard uncertainty in impact calculations (a single storm might have happened a bit North/South/East/West of the original one), the weakening/intensification does extend the range to include storms which are physically plausible (or possible) but did not happen so far. Obviously, the relative frequencies are adjusted in CLIMADA accordingly.

Please note that the full European WISC grid has 1.6 million points. While calculations for the 148 historic storms can still be performed without RAM swapping and other performance issues, any probabilistic set with more than about ten times the number of original events easily blows the memory. Therefore, we implement all *probabilistic* hazard set generation by country.

As for the historic hazard set, the generation of the *probabilistic* set is another one line of CLIMADA code:

```
wisc_hazard_set_prob('',hazard)
```

with hazard the *historic* hazard, or, to run one single country (here for UK), just

```
wisc_hazard_set_prob('GBR',hazard)
```

Please note that `wisc_hazard_set_prob` does always store single-country hazard sets (for memory and performance reasons). See `wisc_hazard_stats` below for an example how to loop over all countries.

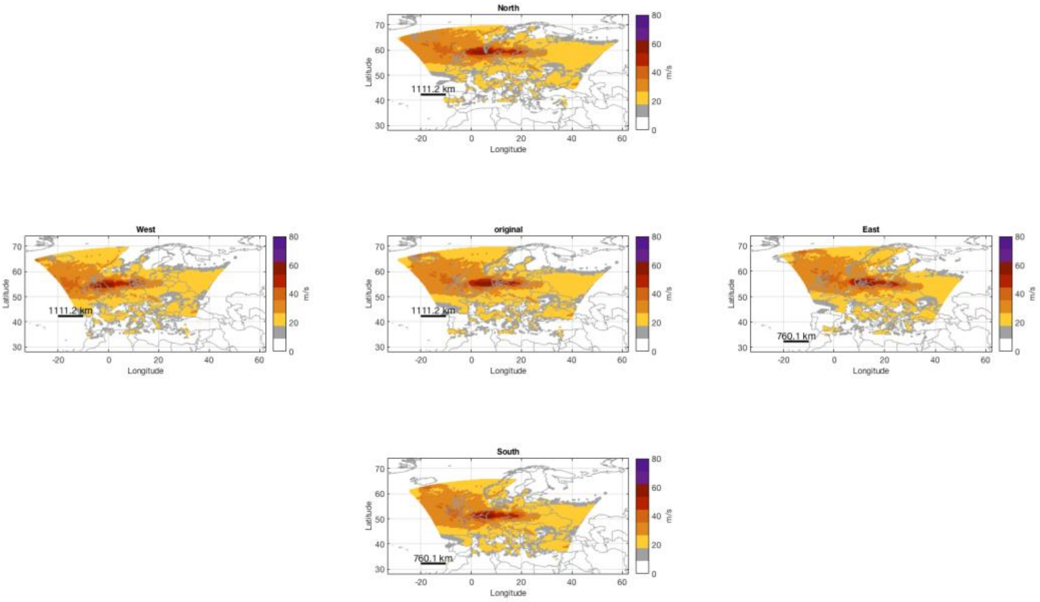


Figure 4: Schematic of the derived spatial ‘siblings’ (in the respective directions) of an original WISC footprint (Anatol, 1999, at the center). The spatial translation is hugely exaggerated (here about 100km) for illustrative purposes only. In the real case, the ‘wiggle’ is by a mere one or two grid points (4.4 or 8.8 km). Generated by `climada_ws_hist2prob` (a low-level function, usually called by `wisc_hazard_set_prob`).

In order to check whether the synthetic catalog does not under- or overestimate event intensities compared to the historic catalog, we employ storm severity index statistics according to Lamb (1990), as shown in Figure 5. Again, these statistics can easily be generated on any WISC hazard set by simply invoking `wisc_hazard_stats`.

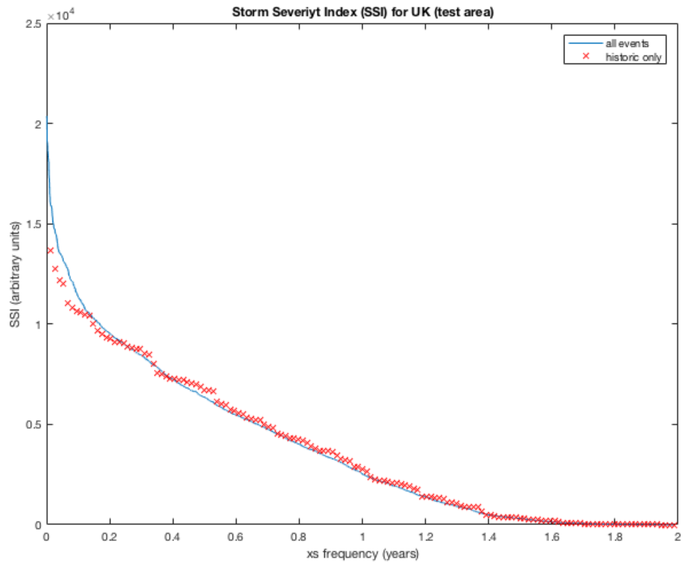


Figure 5: Storm Severity Index (SSI) for both the historic and synthetic set for the United Kingdom. We show the UK results, since the probabilistic severity distribution is a bit heavier than historic for rare events, while it matches even better or very well for most other countries. But before spending too much time on tinkering with the probabilistic event set generation, the full chain of impact shall be completed. See Appendix A2 for single country SSI figures.

Similar to the historic set, return period maps can be drawn, but now obviously for much higher return periods, see Figure 6.

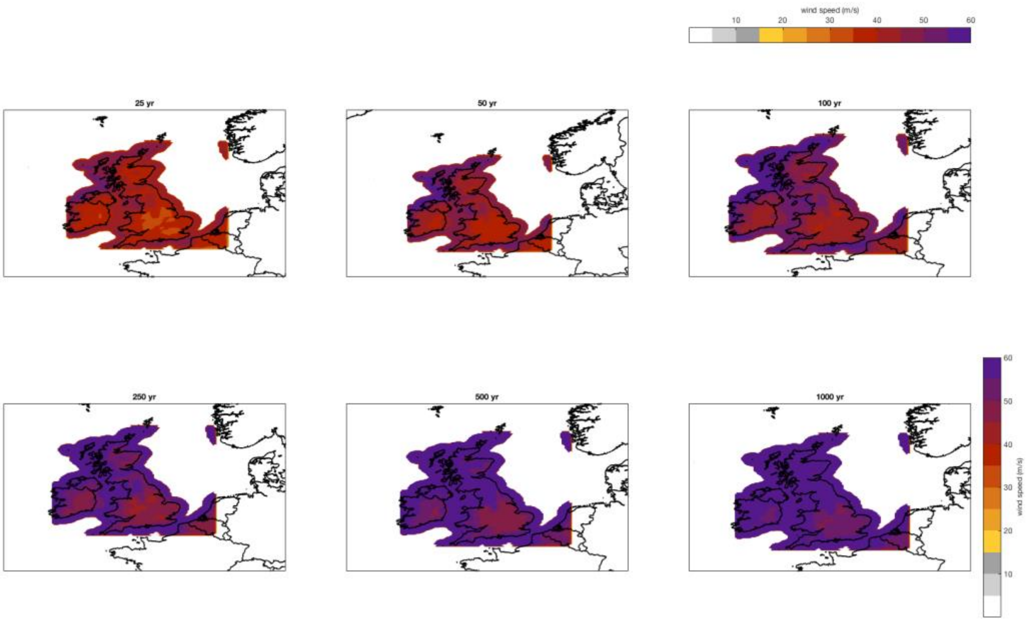


Figure 6: Hazard intensity return period maps for United Kingdom for return periods of 25, 50, 100, 250, 500 and 1000 years. Figure created by `climada_hazard_stats(hazard,[25 50 100 250 500 1000],1)` for `hazard` containing the *probabilistic* set for UK.

Last but not least, CLIMADA allows to quantify winter storm impacts, as shown in Fig. 7a and 7b for UK.

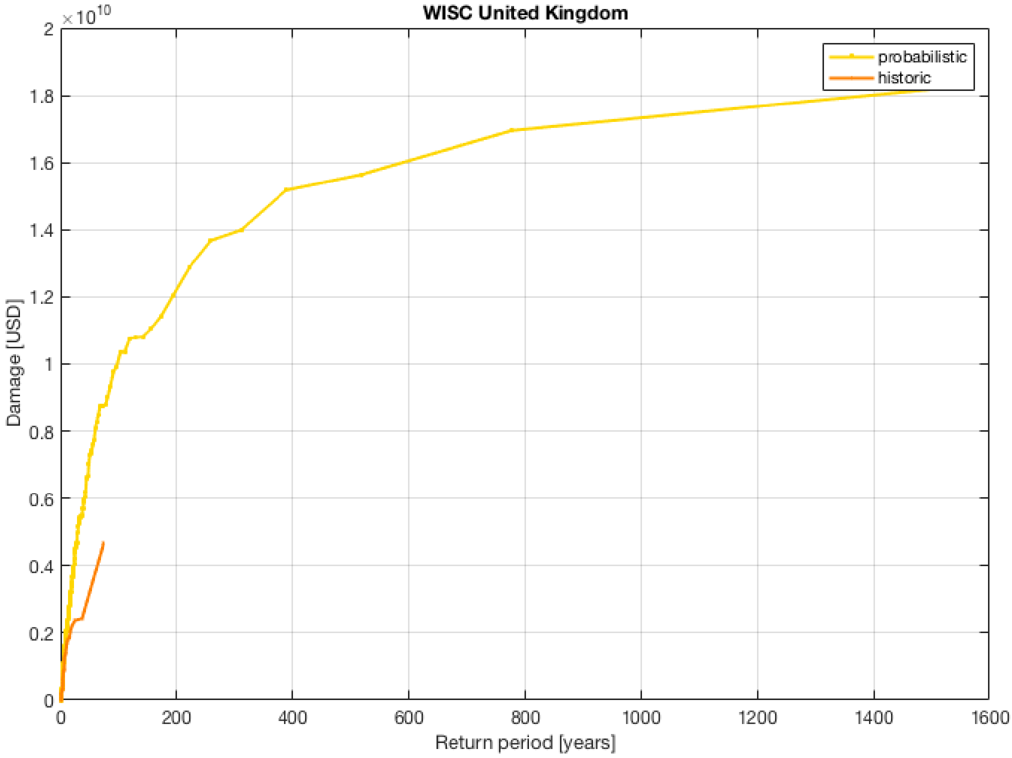


Figure 7a: Impact of winter storms on UK, a quantification of UK winter storm risk. Quantification based on a standard asset portfolio for UK, see CLIMADA for details (see `climada_entity_country('GBR')` for automatic generation of the asset base).

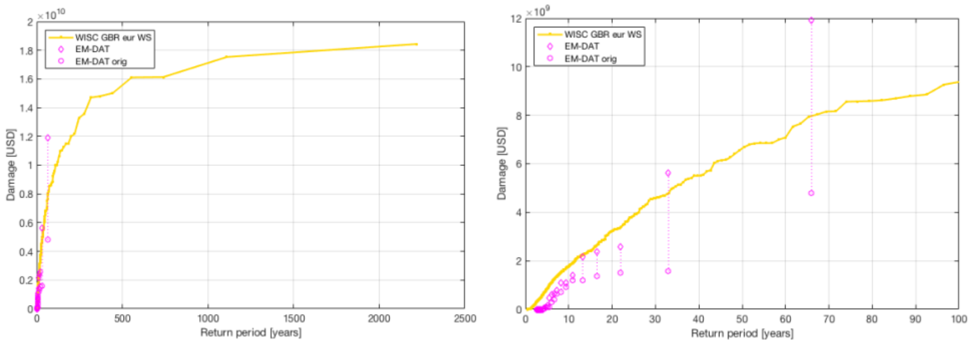


Figure 7b: Impact of winter storms on UK, a quantification of UK winter storm risk and comparison with EM-DAT historic damages (left), with a zoom into return periods up to 100 years (right). EM-DAT are indexed (inflated by GDP) damages and EM-DAT orig refers to the unindexed raw damages as found in the database (i.e. far too low for past events). Quantification based on a standard asset portfolio for UK, see CLIMADA for details (see `climada_entity_country('GBR')` for automatic generation of the asset base).

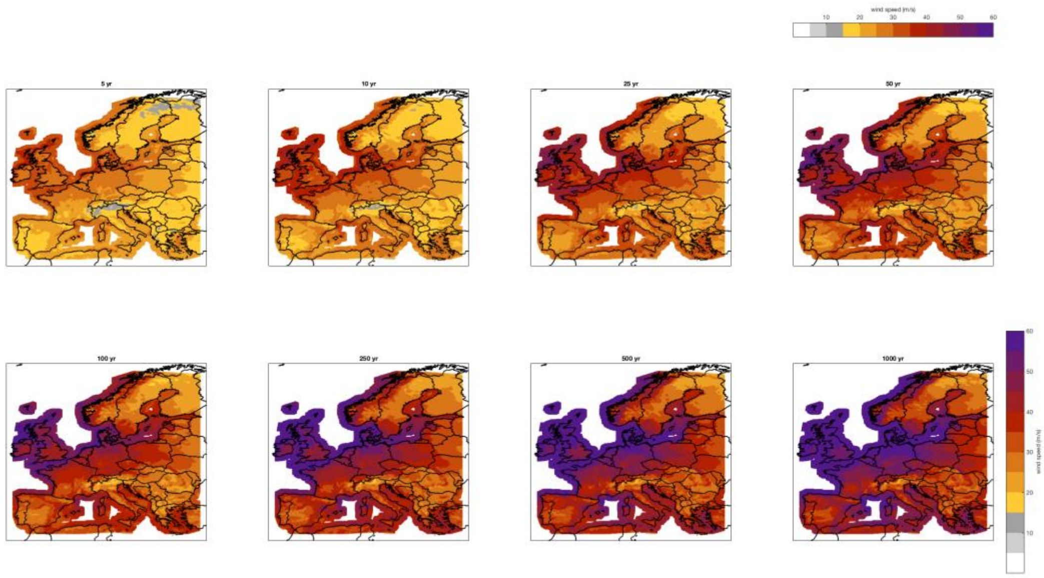


Figure 8: Wind speed return period maps for the synthetic set. Shown are return period maps for 5, 10, 25, 50, 100, 250, 500 and 1'000 years, wind speed in m/s. The plot has been automatically produced by the call[7] `wisc_hazard_stats([5 10 25 50 100 250 500 1000])`. Note that the color scale shows grey up to wind speeds that hardly lead to any impact (15 m/s) and then aligned with the tick marks up to a max gust of 60 m/s. Compare with Figure 3a.

CLIMADA does also provide functionality to assess local wind climatology, i.e. to plot wind gust for return periods etc. (Figure 9).

[7] This call invokes `climada_hazard_stats`, as it loops over all *probabilistic* WISC hazard event sets previously generated by `wisc_hazard_set_prob`.

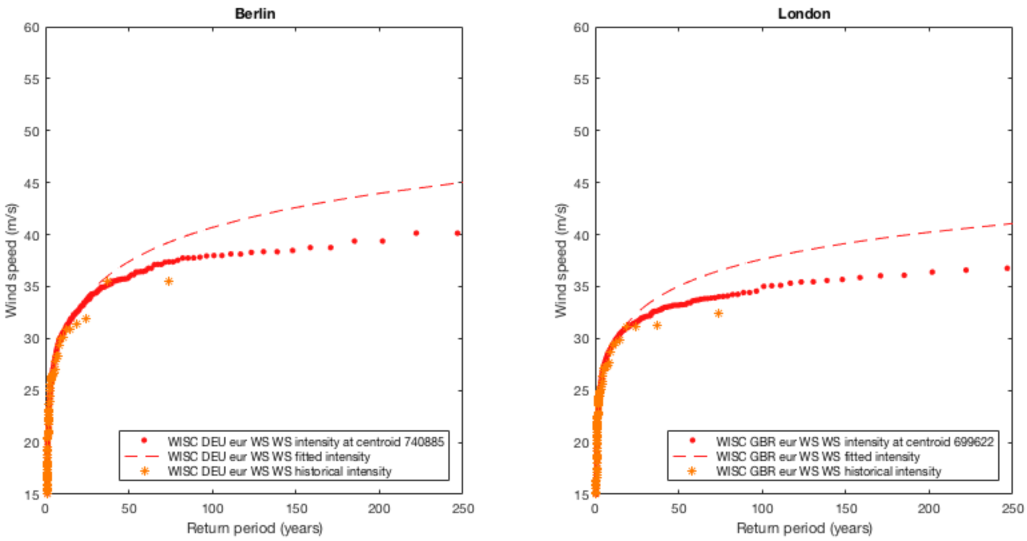
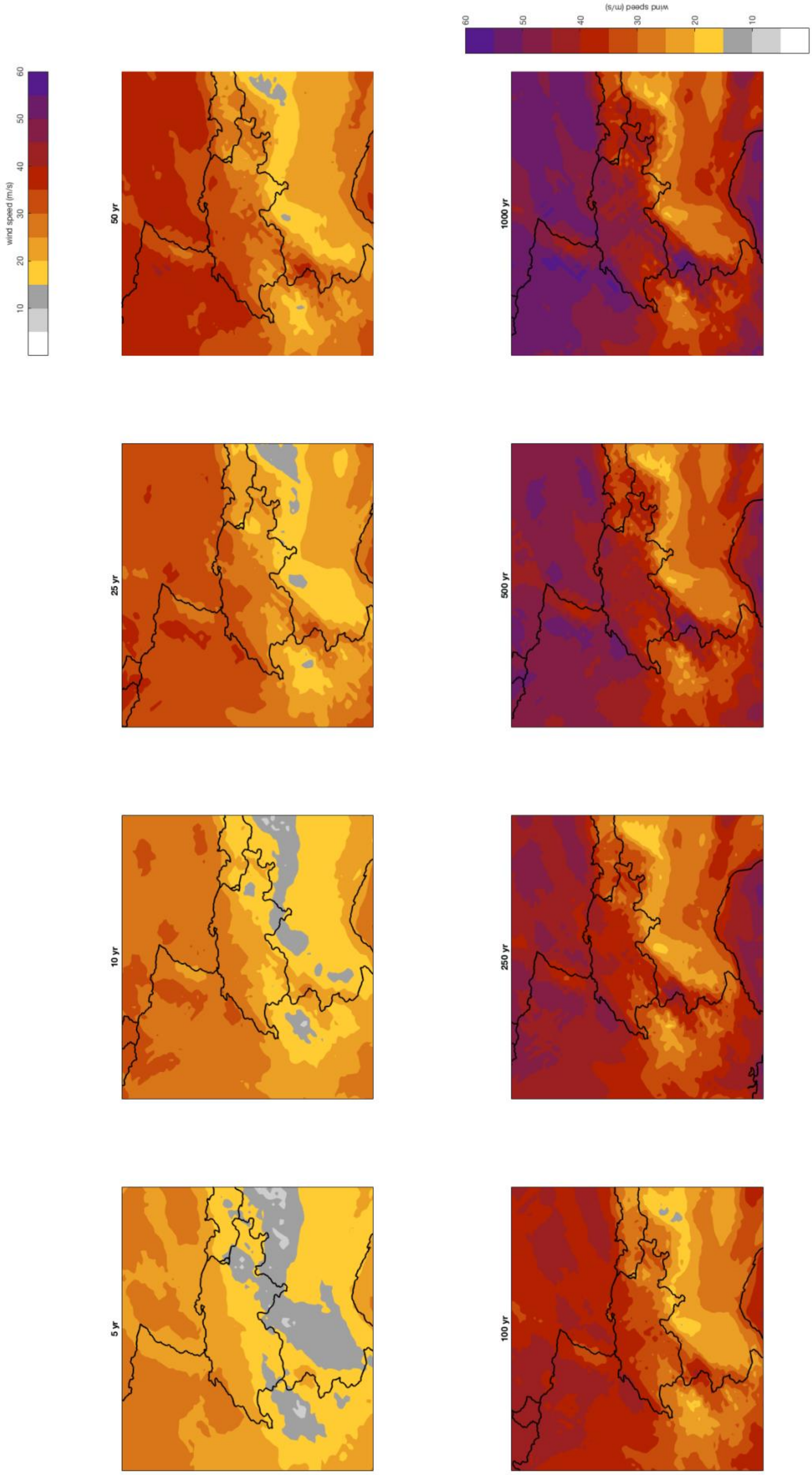


Figure 9: Wind speed return period plot for Berlin. Automatically produced as follows:

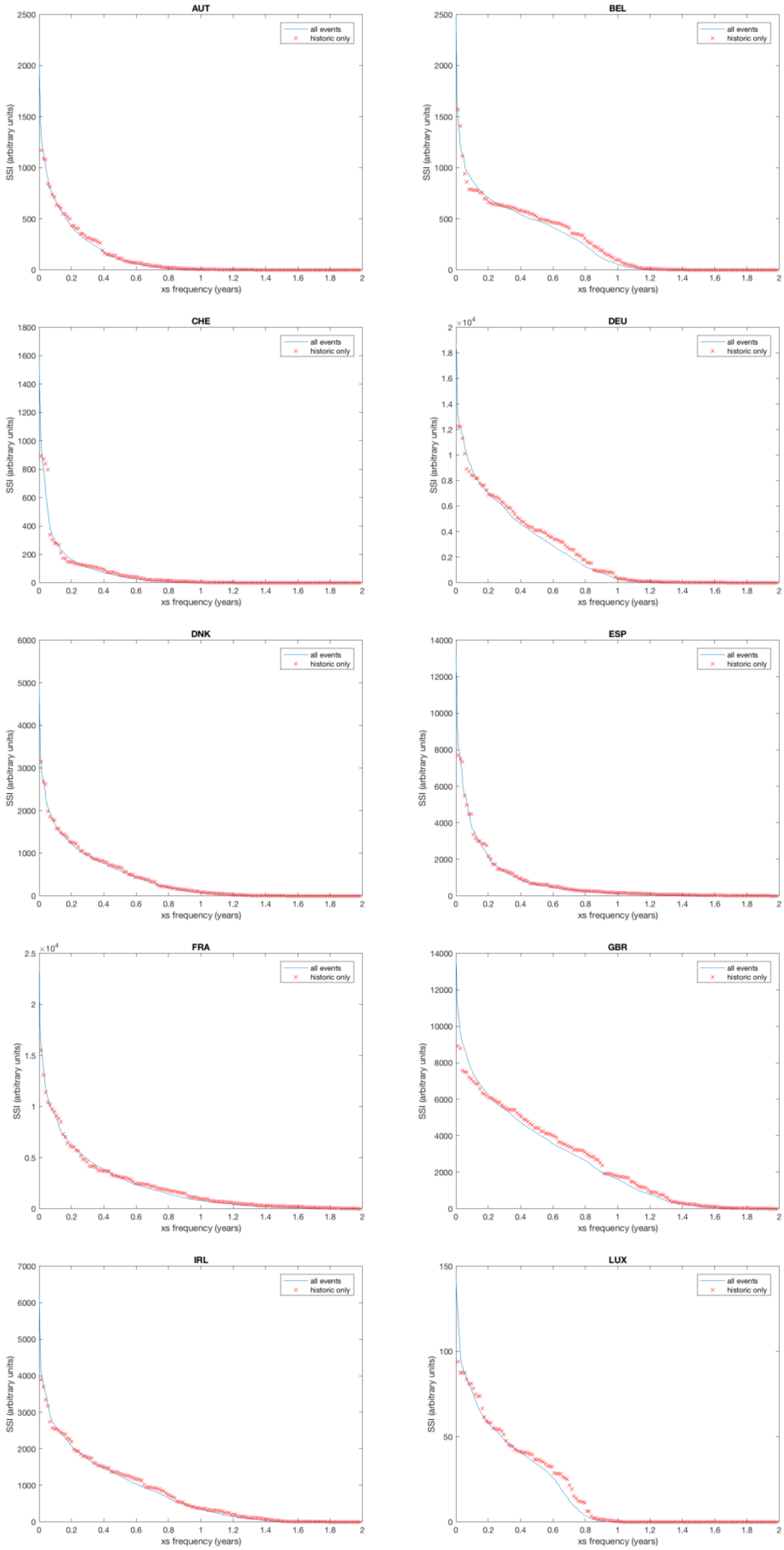
```
hazard_DEU=climada_hazard_load('WISC_DEU_eur_WS'); % load hazard set
hazard_GBR=climada_hazard_load('WISC_GBR_eur_WS'); % load hazard set
Berlin.lat=52+31/60;Berlin.lon=13+24/60; % define coordinate
London.lat=51+31/60;London.lon= 0-07/60; % define coordinate
figure;subplot(1,2,1);climada_IFC_plot(climada_hazard2IFC(hazard_DEU,Berlin));
xlim([0 250]);ylim([15 60]);title('Berlin');
       subplot(1,2,2);climada_IFC_plot(climada_hazard2IFC(hazard_GBR,London));
xlim([0 250]);ylim([15 60]);title('London');
```

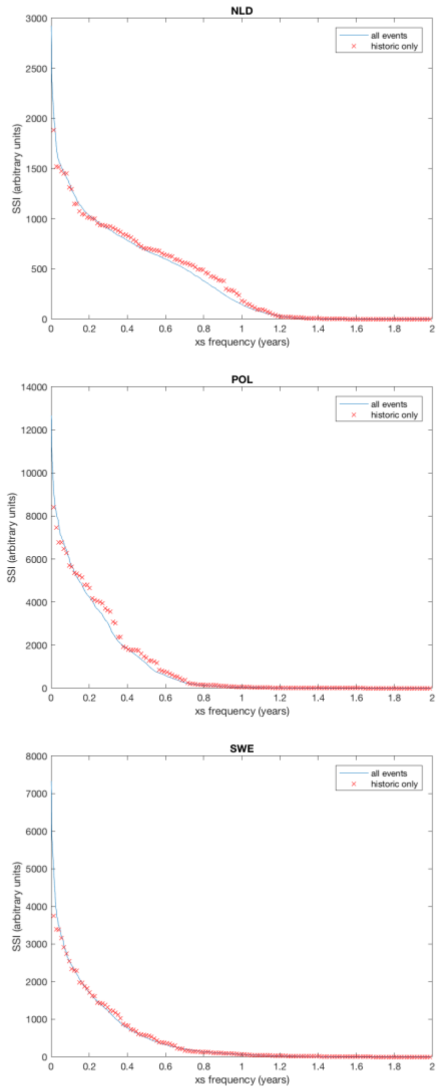
Appendix

Figure A1 (next page): Wind speed return period maps for the *probabilistic* set for Switzerland. Shown are return period maps for 5, 10, 25, 50, 100, 250, 500 and 1'000 years, wind speed in m/s. The plot has been automatically produced by the call `wisc_hazard_stats(hazard,[ 5 10 25 50 100 250 500 1000])`. Note that the color scale shows grey up to wind speeds that hardly lead to any impact (15 m/s) and then aligned with the tick marks up to a max gust of 60 m/s. Compare with Figure 3a.


wind speed (m/s)
10
20
30
40
50
60
5 yr
10 yr
25 yr
50 yr
100 yr
250 yr
500 yr
1000 yr
wind speed (m/s)
10
20
30
40
50
60

Figures A2 (below): Storm severity index plots for all European countries, generated by the call `[~,combined_ssi,country]=wisc_hazard_stats([],1,2).`





and the combined SSI curve: