

## **WS3: Extremes and impacts:**

### **Design your own climate adaptation strategy – a practical application of open-source probabilistic damage modelling**

David Bresch, Swiss Re

[david\\_bresch@swissre.com](mailto:david_bresch@swissre.com), [dbresch@ethz.ch](mailto:dbresch@ethz.ch)

Inspired by/based on (explains the slide layout, too ;-): [“Climate Change Uncertainty and Risk: from Probabilistic Forecasts to Economics of Climate Adaptation”](#), spring term lecture at ETH, by Reto Knutti, IAC ETH and David Bresch, Swiss Re.

All material available at <https://github.com/davidnbresch/climada>

Manual: [https://github.com/davidnbresch/climada/blob/master/docs/climada\\_manual.pdf](https://github.com/davidnbresch/climada/blob/master/docs/climada_manual.pdf)

## Installation

- Create a folder named **climada**
- Download <https://github.com/davidnbresch/climada> into the **climada** folder
- Start MATLAB and browse to your local folder `../climada/climada-master`, then enter<sup>1</sup>:  
`startup`

## Getting started

- MATLAB only (Octave users please proceed to next bullet):  
Enter **climada\_demo** and play with the sliders etc. to get a feel  
(see climada manual, p. 4: "A visual primer" and please consider to inspect/edit the interface file<sup>2</sup>)
- Enter (this also tests whether your installation is OK)  
**climada\_demo\_step\_by\_step**  
Note: If quite familiar with MATLAB, you might also enter  
**edit climada\_demo\_step\_by\_step**  
such that the code opens in the MATLAB editor and play it through using the MATLAB debugger (so you can run it step-by-step, consult the climada manual, p. 13ff: "From tropical cyclone hazard generation to the adaptation cost curve").
- To experiment with the tool, either consider to inspect/edit the interface file<sup>2</sup> or edit parameters etc. directly on the command line, since, once you've run  
**climada\_demo\_step\_by\_step**, all variables are in memory (hence just close MATLAB/Octave, start again and run **climada\_demo\_step\_by\_step** to reset all).  
Please consult the climada manual for a detailed description on the structures as shown below, best is to search e.g. for `entity.assets.Value` in the manual.

```
% change the assets values:
entity.assets.Value=entity.assets.Value*1.1;           % assets 10% more valuable
% change the asset's damage function
entity.damagefunctions.MDD=entity.damagefunctions.MDD*0.9;
% get the name of measure -> elements 4 are thus for building code
entity.measures.damagefunctions_map(4)
entity.measures.cost(4)=entity.measures.cost(4)*0.5; % half the cost
entity.measures.MDD_impact_a(4)=.5                  % e.g. change impact of building code
mi=climada_measures_impact(entity,hazard,'no')        % re-run the whole
modelfigure;climada_adaptation_cost_curve(mi)         % plot it
```

- To continue, make sure the correct entity and hazard event set is in memory, hence:

```
load([pwd filesep 'data' filesep 'entities' filesep 'demo_today.mat'])
load([pwd filesep 'data' filesep 'hazards' filesep 'TCNA_today_small.mat'])
```

and calculate the event damage set (again):

```
EDS=climada_EDS_calc(entity,hazard) % what's happening here? See manual p. 39ff
figure; climada_EDS_DFC(EDS)3
```

<sup>1</sup> all MATLAB climada commands will be set in courier

<sup>2</sup> you find it at `../data/entities/demo_today.xls` (in Octave, very likely `demo_today.xlsx` is used)

<sup>3</sup> The DFC (the [occurrence exceedence] damage frequency curve) is constructed by sorting calculated damages in descending order. The largest damage occurred once in the observation time period, the

Create the climate change impact hazard event set (see `climada_tc_hazard_clim_scen`)

- We can implement climate change scenarios in the *climada* model by modifying the wind frequency and/or the wind speed (hazard intensity) of a hazard set<sup>4</sup>. For example an increase in frequency (`f_screw`) of 10% and a 3% increase (`i_screw`) in wind speed for all SS3 and stronger storms<sup>5</sup>. To create a hazard set with a climate change scenario based on today's hazard set, enter (set reasonable values for `f_screw` and `i_screw` and enter `atl_prob_clim.mat` when prompted for a filename):

```
hazard_CC=climada_tc_hazard_clim_scen(hazard,[],f_screw,i_screw)
```

- Calculate the damage again the compare, i.e.

```
EDS_CC=climada_EDS_calc(entity,hazard_CC)
figure; climada_EDS_DFC(EDS,EDS_CC) 6
```

Create the economic growth scenario (edit `entity.assets.Value` or tab assets in the Excel)

- In order to account for the total risk in our calculations, we have to consider the economic growth in the assets as well; in addition to the expected climate changes expressed in the climate scenarios. (climada manual p. 53)
- To construct the 2030 asset base to reflect the economic growth (remember: **total climate risk = risk today + risk due to economic growth + risk due to climate change**), we thus need to inflate assets. While this can be done diligently and based on detailed considerations, just inflate with say 3%, i.e. with a factor  $1.6 \approx (1+0.03)^{15}$  until 2030. You can either just execute this in MATLAB or in the Excel<sup>7</sup>:

```
entity_future=entity % make a copy
entity_future.assets.Value=entity_future.assets.Value*1.6; % inflate
entity_future.assets.Cover=entity_future.assets.Value; % technical step
```

- Save your future entity in the `.../climada/climada-master/data/entities` folder, e.g.  
`save([pwd filesep 'data' filesep 'entities' filesep 'demo_future'],'entity_future')`
- Analyse these 2030 assets with both the present-day (`hazard`) and climate change scenario hazard (`hazard_CC`) event sets:

second largest damage has been exceeded twice in the observation period, the third largest damage three times... how this is done? Have a look into the code `climada_EDS_DFC`.

<sup>4</sup> Well, we can do much more (almost no limits), but let's start with these two simple modifications.

<sup>5</sup> Note that the climate change screws contain the new total percentage and not only the changes. For example a 3% increase in wind speed is made by `i_screw = 1.03` (and not only 0.03).

<sup>6</sup> The DFC (the [occurrence exceedence] damage frequency curve) is constructed by sorting calculated damages in descending order. The largest damage occurred once in the observation time period, the second largest damage has been exceeded twice in the observation period, the third largest damage three times... how this is done? Have a look into the code `climada_EDS_DFC`.

<sup>7</sup> In case you'd like to work in the Excel, just inflate the Value column (tab assets) and save under a new name `MYCOUNTRY_future.xls`, then import into climada using `entity_future=climada_entity_read` (will prompt for the file `MYCOUNTRY_future.xls`)

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```
EDS_future=climada_EDS_calc(entity_future,hazard)
EDS_future_CC=climada_EDS_calc(entity_future,hazard_CC)
```

- Plot a "waterfall" graph with the following command:

```
climada_waterfall_graph(EDS,EDS_future,EDS_future_CC,9999) %8
```

#### Edit the adaptation measures

- While this step would require a substantial amount of time, starting with stakeholder workshops to define the raw set of measures etc., careful evaluation of costs and context, let's just edit the cost values for a small set of pre-defined measures to get an initial feel. Have a look into `entity.measures` and consult the climada manual, p. 12 and the comments in the file `.../climada/climada-master/data/entities/entity_template.xls` in tab *measures*.
- At the end, make sure you copy `entity.measures` into `entity_future.measures`, i.e. `entity_future.measures=entity.measures`, as otherwise the comparison of present and future costs and benefits would be inconsistent.

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<sup>8</sup> 9999 to indicate that we want to see the annual expected damage, you can also enter say 100 to see the 100yr damage

Finally, calculate the impact of measures

```
impact_today=climada_measures_impact(entity,hazard,'no')
impact_future=climada_measures_impact(entity_future,hazard_CC,impact_today)
```

And produce the full adaptation cost curve

```
climada_adaptation_cost_curve(impact_future)
```

And you can even compare how the effect of adaptation measures varies over time

```
climada_adaptation_cost_curve(impact_future,impact_today)
```

**And now over to you: investigate, check for sensitivities**

You might consider to calculate different *impact* structures (results of `climada_measures_impact`) and then use `climada_adaptation_cost_curve` with two inputs to compare visually.

## Appendix: For those who would like to experiment with other countries etc.

- In the folder named **climada** create a sub-folder named **climada\_modules**
- Download [https://github.com/davidnbresch/climada\\_module\\_GDP\\_entity](https://github.com/davidnbresch/climada_module_GDP_entity) into **climada\_modules**
- Exit MATLAB. Start MATLAB again, browse to your local folder `../climada/climada-master`, then enter (this adds the new module to the path): `startup`

Decide about the place you're going to study

- As a preparation, obtain all tropical cyclone (TC) track databases:  
`climada_tc_get_unisys_databases`
- We're going to look into tropical cyclone (TC) risk, please choose any TC-exposed country for your analysis, enter (see manual [climada\\_module\\_GDP\\_entity.pdf](#)<sup>9</sup>)  
`[centroids,entity,entity_future]=climada_create_GDP_entity`  
and select a country (from the drop-down list)
- Save your entity in the `../climada/climada-master/data/entities` folder, e.g.  
`save([pwd filesep 'data' filesep 'entities' filesep 'MYCOUNTRY'],'entity')`
- Save centroids in the `../climada/climada-master/data/system` folder, e.g.  
`save([pwd filesep 'data' filesep 'system' filesep 'MYCOUNTRY'],'centroids')`
- Save the entity also as .xls file (to ease editing) using `climada_entity_save_xls(entity)` or just export Latitude (lat), Longitude (lon) and Value into a raw file:  

```
fid=fopen([pwd filesep 'data' filesep 'temp_assets.csv'],'w');
fprintf(fid,'%f;%f;%f\n',[entity.assets.lat',entity.assets.lon',entity.assets.Value]');
fclose(fid)
```

  
and replace the respective entries in the Excel template (`../climada/climada-master/data/entities/demo_today.xls`, tab `assets`), then save it as another file (e.g. `MYCOUNTRY.xls`)

Now proceed as in the step-by-step example, i.e.:

- Generate the TC hazard event set (read the track data of the Unisys database (<http://weather.unisys.com/hurricane>, please refer to the climada manual for details<sup>10</sup>).  
`tc_track=climada_tc_read_unisys_database`  
`tc_track_prob=climada_tc_random_walk(tc_track)`  
`hazard=climada_tc_hazard_set(tc_track_prob,' ',centroids)`

A note on saving time: Instead of re-creating the hazard in each MATLAB session, you can always load from the .mat file climada saves the hazard event set to. Most climada routines can also be called without arguments, prompting the user to provide them via file dialogs.

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<sup>9</sup> in `../climada/climada_modules/climada_module_GDP_entity-master/docs`

<sup>10</sup> The climada manual describes how to download TC track data for other basins and the like. Please note that `TEST_tracks.atl.txt` contains only 10 years of data in order to speed up experimentation. Please use the full dataset `tracks.atl.txt`, in order to proceed with a hazard event set large enough to provide reasonable statistics. If you now run `climada_hazard_stats(hazard)`, you will obtain windspeed maps for up to 1000yr return periods.

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- Calculate the damage (to check it all works)  
`EDS=climada_EDS_calc(entity,hazard) % what's happening here? See manual p. 39ff  
figure; climada_EDS_DFC(EDS)`
  - One special step to get a reasonable list of measures:  
`entity_tmp=climada_entity_load([pwd filesep 'data' filesep 'entities' filesep 'demo_today.mat'])  
entity.measures=entity_tmp.measures; % replace`
  - Calculate the benefit of adaptation measures, create the (risk today) adaptation cost curve (just to get there, not that all values would necessarily be reasonable)  
`measures_impact=climada_measures_impact(entity,hazard,'no')  
climada_adaptation_cost_curve(measures_impact)`