climada module **country risk**  13 Feb 2015

<https://github.com/davidnbresch/climada_module_country_risk>

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This module runs all (available) perils for one country or for a list of countries. First, it allows generating the country assets (10 or 1 km resolution, based on night light intensity[[1]](#footnote-1)), second to generate the hazard event sets and second to run all damage calculations.

Currently implemented is the automatic generation of earthquake (EQ), tropical cyclone (TC), torrential rain (TR), storm surge (TS) and European winter storm (WS) hazard event sets. The core function is country\_risk\_calc, which does it all in one go[[2]](#footnote-2). Instead of whole countries, one can also analyze single states/provinces, see country\_admin1\_risk\_calc. The module does contain a series of support functions to calibrate country results – they are named cr\_\*, while the top-level functions of this module are named country\_\* or country\_risk\_\*, see function reference below. The batch code selected\_countries\_all\_in\_one does provide the reference xample about how to use all these functions.

Further, the module calculates the economic loss (i.e. the full range of economic costs in the wake of a natural disaster) associated with the hazard event sets[[3]](#footnote-3).

The whole module introduces the structure country\_risk, the core output of country\_risk\_calc and country\_admin1\_risk\_calc which contains country results in a standardized way and is therefore input to a series of functions of this module. country\_risk(i).res.hazard(j) contains the EDS for country i and hazard j (country\_risk(i).res.hazard(j).EDS), the name of the peril in country\_risk(i).res.hazard(j).peril\_ID, the name of the entity in country\_risk(i).res.hazard(j).entity\_file and the name of the hazard event set in country\_risk(i).res.hazard(j).hazard\_set\_file.

**Function reference** (use help to get a detailed description and input/output specification):

Top level functions

country\_risk\_calc: generate assets and hazard sets for a given country (i.e. admin0, or a list of countries). This function provides a convenient way to get started for any given country.

country\_admin1\_risk\_calc: Once country\_risk\_calc has been run for a country (or a series of), calculate the admin1 (state/province) level results.

country\_risk\_EDS\_combine: combine sub-peril EDSs in country\_risk structure, such as TC and TS – helpful to reduce the complexity of results.

country\_risk\_EDS2YDS: convert event event damage sets to year damage sets

country\_risk\_report: produce a report given output from country\_risk\_calc, country\_admin1\_risk\_calc or cr\_economic\_loss\_calc (see also cr\_loss\_multiplier\_plot).

country\_damagefunctions\_adjust: for many countries, climada has been calibrated (to some extent) and this code does modify the damagefunctions of a given country accordingly.

climada\_nightlight\_entity: Generate the (high-resolution) asset distribution for any country (admin0) and any state/province (admin1) within.

Support-level functions

cr\_economic\_loss\_calc: given (property damage) output from country\_risk\_calc, calculate total economic loss

cr\_EDS\_emdat\_adjust: given an event damage set, adjust such that it matches best the EM-DAT damage history of a given country and hazard (see also emdat\_read)

cr\_EDS\_emdat\_adjust: given an event damage set, adjust such that it matches best the EM-DAT damage history of a given country and hazard (see also emdat\_read)

Also useful (in core climada)

climada\_entity\_value\_GDP\_adjust: given an entity with assets for a country, adjust total asset value to represent country assets (a simple formula based on GDP and country development index)

Basic procedure implemented in country\_risk\_calc is as follows:

1) generate centroids for the country (uses climada\_create\_GDP\_entity[[4]](#footnote-4) or climada\_nightlight\_entity)

2) figure which hazards affect the country

3) create the hazard event sets, using

- climada\_tc\_hazard\_set (tropical cyclone wind[[5]](#footnote-5))

- climada\_tr\_hazard\_set (tropical cyclone rain[[6]](#footnote-6))

- climada\_ts\_hazard\_set (tropical cyclone surge[[7]](#footnote-7))

- eq\_global\_hazard\_set (earthquake[[8]](#footnote-8))

- European winter storm (hazard not generated, just assigned[[9]](#footnote-9))

4) run the risk calculation for all hazards

Next steps are country\_risk\_report, country\_risk\_EDS\_combine and country\_risk\_EDS2YDS plus cr\_plot\_DFC or cr\_plot\_DFC\_aggregate to plot the resulting country damage frequency curves.

In essence, you define the country and the code runs the generation of centroids, default assets (from nightlight intensity, see climada module GDP\_entity) and the EQ, TC, TR and TS hazard event sets plus checks for WS Europe exposure. It even figures whether the country is exposed to more than one ocean basin and in such a case generates a suite of TC/TS/TR hazard event sets for each ocean basin. The code is ready for upgrade with additional hazards (usually a new hazard is a new climada module). That’s why the code notifies the user if the specific hazard module is missing (even indicates the github location where to get it from).

**Simply call e.g. country\_risk\_calc(‘El Salvador’)**

If called without any argument, a list dialog to select the country pops up. See code header for details, i.e. **help country\_risk\_calc**

Behind the scenes, the code centroids\_generate\_hazard\_sets does the heavy lifting, i.e. steps 2) and 3) from above. This way one can generate all relevant hazard sets with one call to centroids\_generate\_hazard\_sets for any set of centroids (e.g. only a part of a country, a region, a city…[[10]](#footnote-10)):

centroids\_hazard\_info=...

centroids\_generate\_hazard\_sets(centroids,force\_recalc,check\_plots)

The resulting structure centroids\_hazard\_info contains the names of the generated hazard sets (or the ones generated earlier if just called to check for step 2) in centroids\_hazard\_info.res.hazard(i).hazard\_set\_file (the somewhat complicated nested structure is due to the flexibility required by country\_risk\_calc).



Figure: Step 1 (generate centroids, assets distribution, color scale indicates value per centroid) and step 2 (hazard selection). The green box shows the selection area around the country, the blue dots are all the TC track nodes (historic) and the red dots the epicenters (historic). This figure is generated if check\_plot=1 in the call, e.g. country\_risk\_calc(‘El Salvador’,0,0,1).



Figure: The most intense single event for all hazard generated for El Salvador (Step 3). Note that El Salvador is both exposed to tropical cyclones from the East and West, that’s why there are two hazard events sets for TC/TS/TR, one for the Atlantic side (atl for Atlantic), one for the Pacific side (epa for East Pacific Ocean). The earthquake model is global. Note further the nice feature of hazard (or peril) – dependent color scales; and the coarser resolution of centroids (blue) around the country (with red dots at high-density centroids) to support plotting hazard intensities around the country, too. This figure is generated if check\_plot=1 in the call, e.g. country\_risk\_calc(‘El Salvador’,0,0,1)

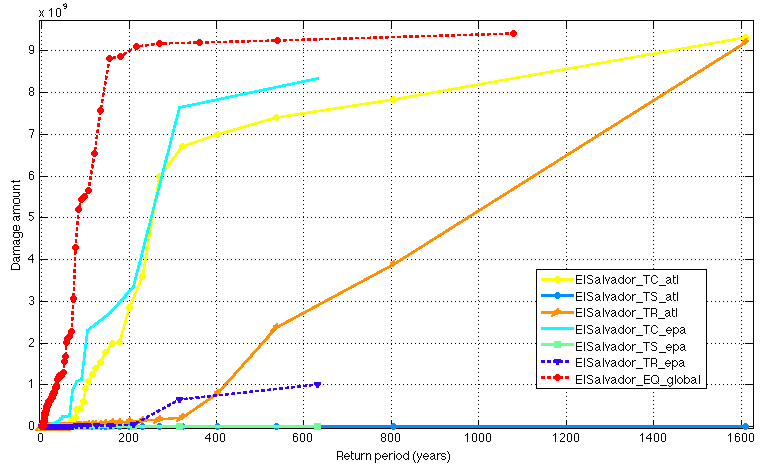


Figure: The resulting damage frequency curves (DFC) for all seven (!) hazards affecting El Salvador (values just for illustration, based on dummy damage functions). This figure is generated with check\_plot=1 in the call, e.g. country\_risk\_report(country\_risk\_calc(‘El Salvador’,1,1),0,1)

**cr\_economic\_loss\_calc:** Major natural disasters can and do have severe negative short-run economic impacts, the severity of which depends on the affected country's resilience, or ability to recover. cr\_economic\_loss\_calc calculates the economic damages resulting from the simple property damages in the hazard event set, taking into account socio-economic data on the country's financial strength, supply chain risk profile, resilience and preparedness for natural disasters (see appendix for details).

**country\_risk\_report**: Comes in handy if one runs some select countries, e.g:

country\_risk=country\_risk\_calc(‘Barbados’)

country\_risk(2)=country\_risk\_calc(‘El Salvador’)

country\_risk(3)=country\_risk\_calc(‘Costa Rica’)

And then country\_risk\_report(country\_risk,0) results in the following output (to stdout, also an Excel or .csv file is written[[11]](#footnote-11)):

Barbados (1)

TR EL=36572051.496470 (8.481508%o) Barbados\_TR\_atl

TC EL=23083330.494007 (5.353308%o) Barbados\_TC\_atl

TS EL=7531.966739 (0.001747%o) Barbados\_TS\_atl

EQ EL=0.000000 (0.000000%o) Barbados\_EQ\_global

ElSalvador (2)

EQ EL=415631535.361110 (17.943889%o) ElSalvador\_EQ\_global

TR EL=141613002.072040 (6.113800%o) ElSalvador\_TR\_epa

TC EL=59386249.565168 (2.563858%o) ElSalvador\_TC\_atl

TC EL=16152772.894979 (0.697357%o) ElSalvador\_TC\_epa

TR EL=621784.438763 (0.026844%o) ElSalvador\_TR\_atl

TS EL=0.000000 (0.000000%o) ElSalvador\_TS\_epa

TS EL=0.000000 (0.000000%o) ElSalvador\_TS\_atl

Costa Rica (3)

EQ EL=523833928.441207 (12.396559%o) Costa Rica\_EQ\_global

TR EL=1530537.767294 (0.036220%o) Costa Rica\_TR\_epa

TC EL=73978.520263 (0.001751%o) Costa Rica\_TC\_epa

TR EL=5765.009179 (0.000136%o) Costa Rica\_TR\_atl

TS EL=1689.347413 (0.000040%o) Costa Rica\_TS\_atl

TC EL=60.830655 (0.000001%o) Costa Rica\_TC\_atl

TS EL=0.000000 (0.000000%o) Costa Rica\_TS\_epa



Figure: The local damage for a given peril (here EQ) for one country (here Costa Rica) in spatial resolution (e.g. at each centroid). Produced by the call (following from above resulting structure country\_risk):

country\_i=3; hazard\_i=7[[12]](#footnote-12);

climada\_circle\_plot(...

country\_risk(country\_i).res.hazard(hazard\_i).EDS.ED\_at\_centroid,...

country\_risk(country\_i).res.hazard(hazard\_i).EDS.assets.Longitude,...

country\_risk(country\_i).res.hazard(hazard\_i).EDS.assets.Latitude)

**country\_admin1\_risk\_calc**: Same as country\_risk\_calc, but for a state or province (admin1 level) of any given country. Run the all (available) perils for one country's admin1 level. Obtain the admin1 boundaries (from [www.naturalearthdata.com](http://www.naturalearthdata.com), shape files already part of the data that comes with the country risk module) and carve out the respective centroids (set Value at all others to zero). Run the risk calculation for each admin1 for all hazards. In case one would like to skip hazards, just (temporarily) remove the respective {country\_name}\_\*.mat hazard event sets. ONLY makes sense if country\_risk\_calc has been run for the respective country (we keep it like this, as automatic mode might trigger lots of un-wanted calculations). If not, the code terminates with the respective messages (no entity found, no hazard set(s) found...). But one can run country\_admin1\_risk\_calc for more than one country, if the respective countries have been run as country\_risk\_calc. NOTE: Before using this code, make yourself familiar with country\_risk\_calc and country\_risk\_report (same format as country\_risk\_calc).

**climada\_nightlight\_entity**: Construct an entity file based on high-res (1km!) night light data[[13]](#footnote-13). Reads an image file with nightlight density[[14]](#footnote-14) and matches it to the local geography. Prompts for country (admin0) and state/province (admin1), constrains the active centroids (with values>0) to the selected country or admin1 and saves the entity. Since we're dealing with admin1, no automatic scaling or allocation of GDP to centroids is performed (for this, see climada\_create\_GDP\_entity[[15]](#footnote-15)).

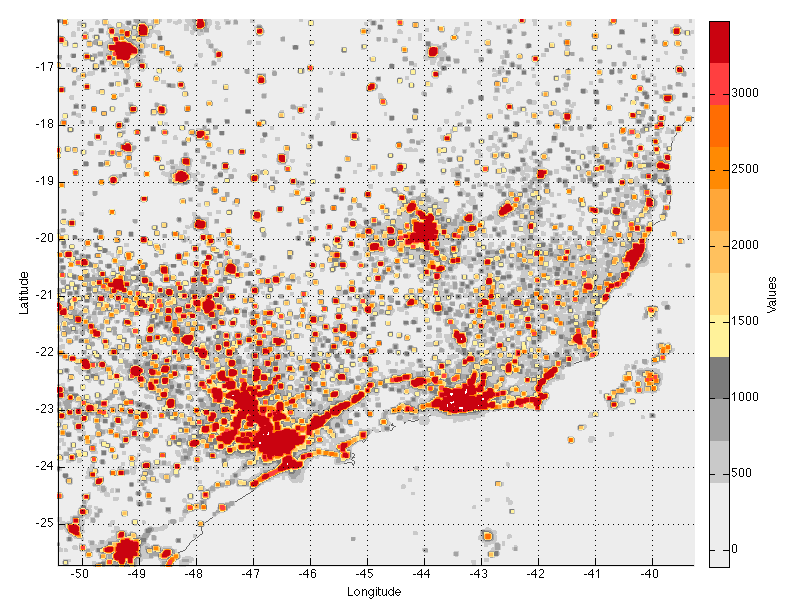
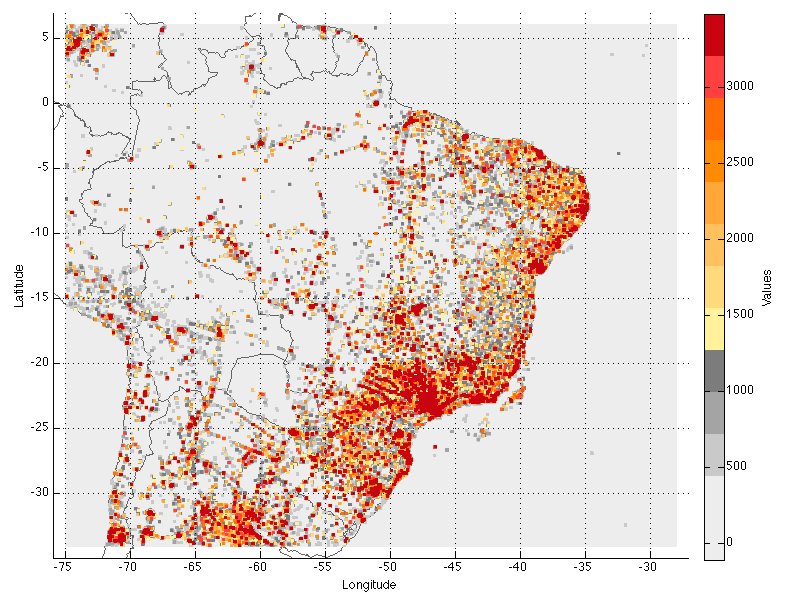


Figure: Brazil value distribution on 1km (!) resolution (left, zoomed in right) as generated by climada\_nightlight\_entity(‘Brazil’,’’,2)

**Appendix**

**A. Calculation of economic damage in cr\_economic\_loss\_calc**

Starting point for the economic loss calculation is damage(event\_i), i.e. the property damage calculated by climada\_EDS\_calc. The economic loss then also includes secondary losses to an economy including e.g. lost ouput, retail sales, wages, costs to business form rerouting goods and services around the affected area, reduced taxable receipts, etc.

The underlying rationale of the calculation is that a property damage resulting from a natural disaster does not have a major impact on a country's economy as long as the damage is small compared to the country's GDP, and as long as adequate financing and national resources exist. However, if a damage is big, it will be exacerbated depending on how well a country is "in shape" to deal with major shocks.

cr\_economic\_loss\_calc intends to estimate the economic damage as it manifests itself about 3-6 months after a disaster occurred. This first-round effect of natural disasters is usually that income and output (GDP) fall. What happens in the next round then depends on the way the country or region responds to the crisis. For example, Japan is a strong economy and has the resources to start rebuilding quickly, while smaller and badly managed countries such as Haiti can suffer severe long-term effects. It should be noted that cr\_economic\_loss\_calc only calculates the temporary dip following the first months after a disaster (see Figure).

After that initial dip, different scenarios can lead to no, positive or negative follow-on effects over the long run. In particular, a natural disaster can even positively affect total factor productivity, e.g. when it leads to the replacement of damaged, outdated production facilities and physical infrastructure with state-of-the-art facilities and infrastructure. However, as noted above, cr\_economic\_loss\_calc only deals with the calculation of the initial impact, not with the long-term scenarios.

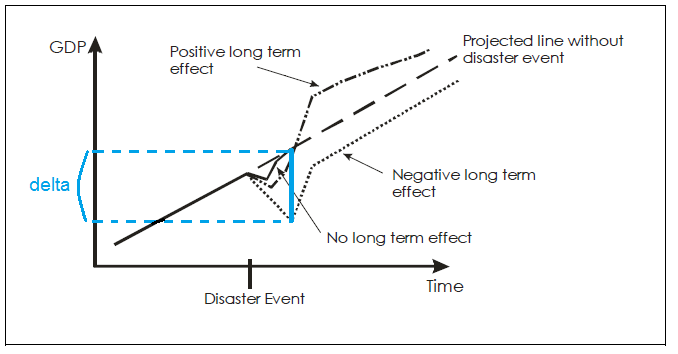


Figure: Possible trajectories of GDP after a disaster[[16]](#footnote-16). The delta is the initial temporary dip cr\_economic\_loss\_calc provides an estimate for.

In cr\_economic\_loss\_calc, the economic loss caused by the natural disaster is calculated according to:

**economic\_loss(event\_i) = damage(event\_i) \* loss\_multiplier**

where loss\_multiplier is defined by:

**loss\_multiplier =**   
**1 + cr\_get\_damage\_weight(damage(event\_i)/GDP) \* country\_damage\_factor**

with:

cr\_get\_damage\_weight: function that determines how much weight a damage should be given based on its ratio to GDP

country\_damage\_factor = 1/financial\_strength ...  
 + BI\_and\_supply\_chain\_risk ...

+ natural\_hazard\_economic\_exposure ...

– disaster\_resilience

Hence, country\_damage\_factor consists of four terms:

* financial\_strength measures a country's economic health and ability to finance the recovery.

financial\_strength = total\_reserves/GDP ...

+ insurance\_penetration ...

+ income\_group ...

- central\_government\_debt

* BI\_and\_supply\_chain\_risk measures a country's risk of disaster-related business and supply chain interruption

BI\_and\_supply\_chain\_risk = GDP\_industry ...

+ FM\_resilience\_index\_supply\_chain/100

* natural\_hazard\_economic\_exposure assesses which countries have a concentration of their total economic output exposed to natural hazards

natural\_hazard\_economic\_exposure = ...

1 - Natural\_Hazards\_Economic\_Exposure/10

* disaster\_resilience measures the quality of a country's natural hazard risk management, i.e., the country's "preparedness" to deal with the consequences of a disaster

disaster\_resilience = FM\_resilience\_index\_risk\_quality/100 ...

+ (global\_competitiveness\_index-1)/6

See economic\_indicators\_mastertable.xls (in the data folder of the country\_risk module[[17]](#footnote-17)) for more information on the four components of country\_damage\_factor (and their respective subcomponents).

1. I.e. the module allows the generate centroids and entities for each country on these (high) spatial resolution. [↑](#footnote-ref-1)
2. The routine climada\_country\_risk allows for processing a list or even all countries. As always, use e.g. help climada\_country\_risk to get a detailed description on the options. [↑](#footnote-ref-2)
3. See appendix for details on the calculation of economic loss based on the damages in the hazard event set. [↑](#footnote-ref-3)
4. See <https://github.com/davidnbresch/climada_module_GDP_entity> and further below for climada\_nightlight\_entity which allows to generate a high-resolution entity for any country and state/province. [↑](#footnote-ref-4)
5. Core climada contains the basic tropical cyclone hazard, but please add the module <https://github.com/davidnbresch/climada_module_tc_hazard_advanced> to generate useful probabilistic hazard event sets (see parameter probabilistic in country\_risk\_calc). Please consider to run climada\_tc\_get\_unisys\_databases (climada core) in order to download the latest tropical cyclone databases for all ocean basins (core climate comes with TC Atlantic to start with). [↑](#footnote-ref-5)
6. See climada module <https://github.com/davidnbresch/climada_module_tc_rain> [↑](#footnote-ref-6)
7. See climada module <https://github.com/davidnbresch/climada_module_tc_surge> which also requires the module <https://github.com/davidnbresch/climada_module_etopo> [↑](#footnote-ref-7)
8. See climada module <https://github.com/davidnbresch/climada_module_eq_global> [↑](#footnote-ref-8)
9. See climada module for European winter storm, which contains the hazard sets <https://github.com/davidnbresch/climada_module_ws_europe> [↑](#footnote-ref-9)
10. See e.g. the code climada\_cut\_out\_GDP\_entity from <https://github.com/davidnbresch/climada_module_GDP_entity> and also country\_admin1\_risk\_calc and climada\_nightlight\_entity further below (part of module country risk) [↑](#footnote-ref-10)
11. The report does contain the annual expected damage (ED) as well as defined return periods (such as 100 and 250 years). In case writing an Excel file fails, a .csv file is written. [↑](#footnote-ref-11)
12. Note that the number seven here corresponds to the 7th hazard analyzed (EQ). The report to stdout shows EQ as the first result, since country\_risk\_report sorts by descending damage, unless it is called with the second parameter (print\_unsorted) set to 1. [↑](#footnote-ref-12)
13. One can also run it at moderate (10x10km) resolution, see parameter selections, i.e. type help climada\_highres\_entity [↑](#footnote-ref-13)
14. The climada module country\_risk comes with the .mat file F182012.v4c\_web.stable\_lights.avg\_vis.mat (24MB), since the .tif image is about 700MB. See <http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html#AVSLCFC3> to obtain the file <http://ngdc.noaa.gov/eog/data/web_data/v4composites/F182012.v4.tar> and unzip the file F182012.v4c\_web.stable\_lights.avg\_vis.tif in there to the /data folder of country\_risk module. As the .tif is so much larger, the climada module country\_risk comes with the .mat file, but does not contain the original (.tif). Should the .mat file not exist, climada\_nightlight\_entity creates it on first call. Please note that the GDP\_entity could also deal with such a high-res dataset (see respective documentation). [↑](#footnote-ref-14)
15. See footnote 8 above [↑](#footnote-ref-15)
16. Source: Hochrainer, 2006

    https://openknowledge.worldbank.org/bitstream/handle/10986/4162/WPS4968.pdf?sequence=1 [↑](#footnote-ref-16)
17. Download: <https://github.com/davidnbresch/climada_module_country_risk> [↑](#footnote-ref-17)