ETH zürich

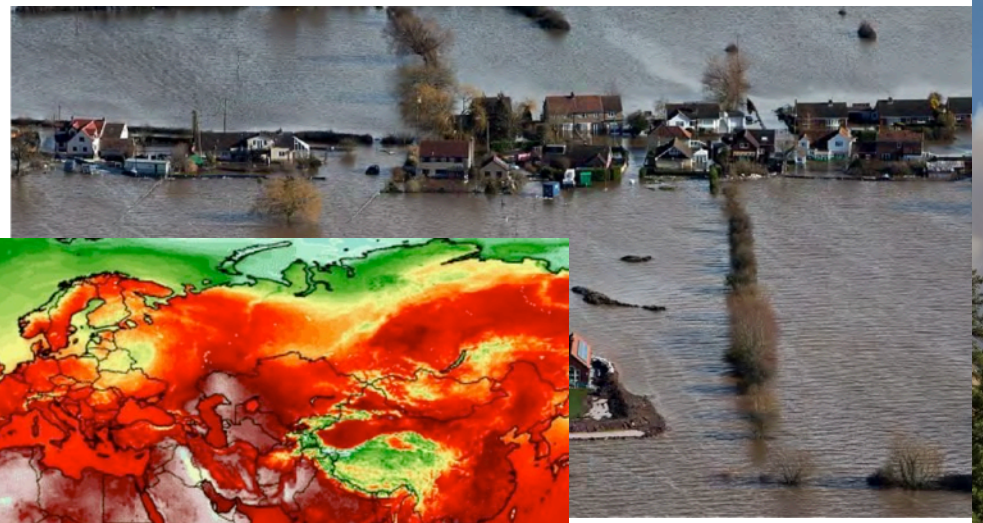
Weather and Climate Risks

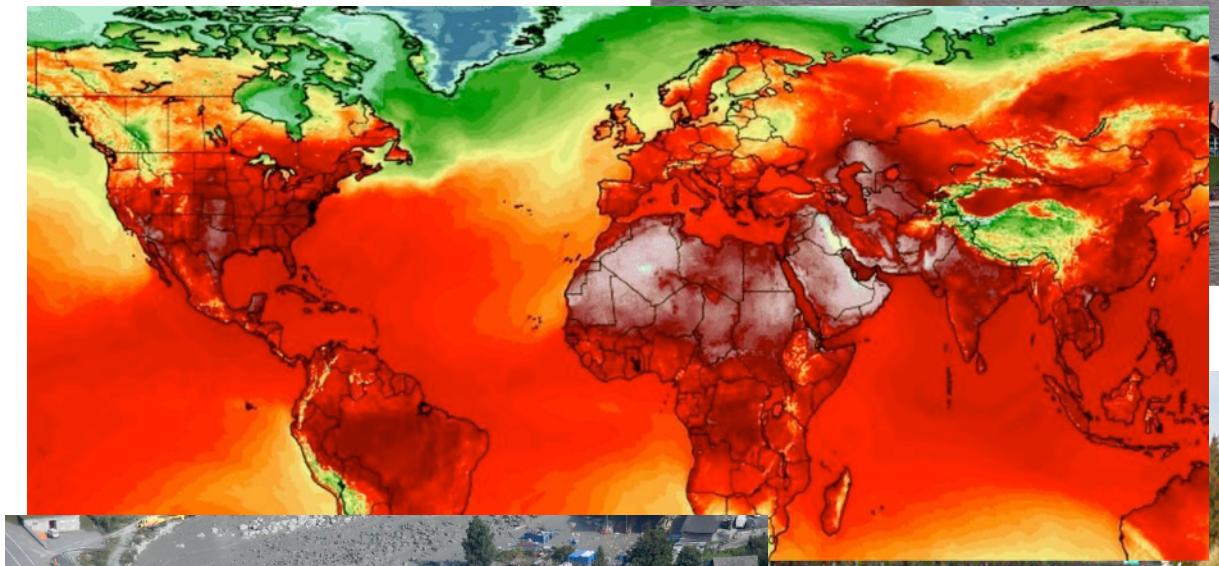
CLIMADA
Economics of Climate Adaptation

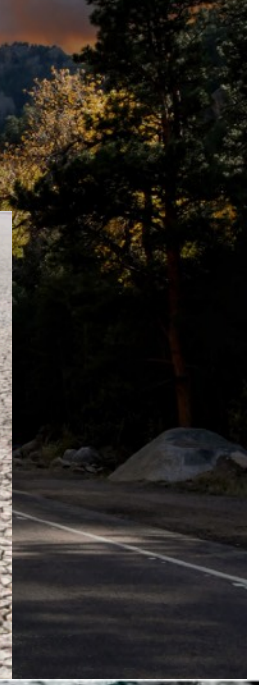
The open-source model CLIMADA

Opening the world of catastrophe models
16.05.2023
Dr. Chahan M. Kropf

Natural hazards





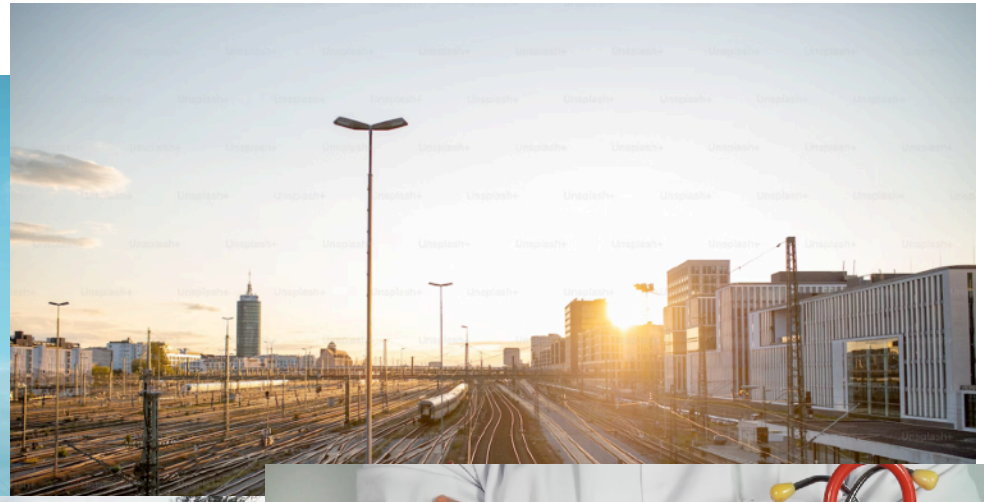


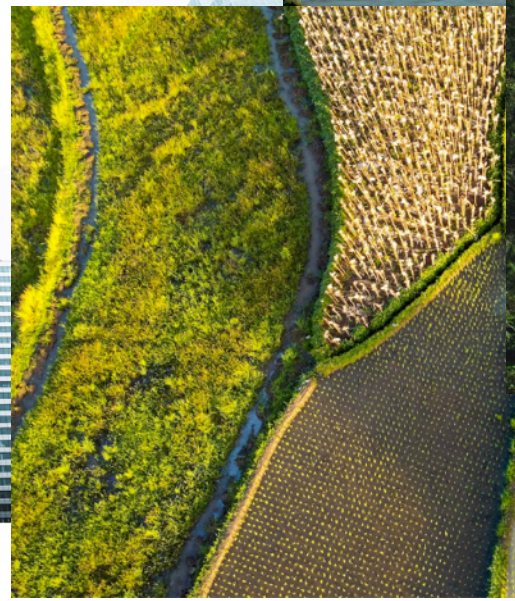
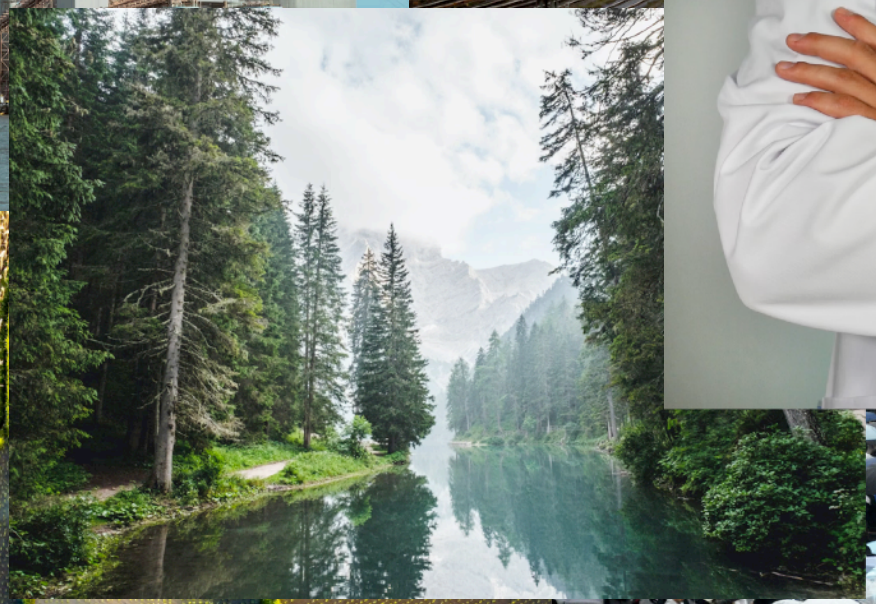
https://unsplash.com/

ETH zürich

Exposures

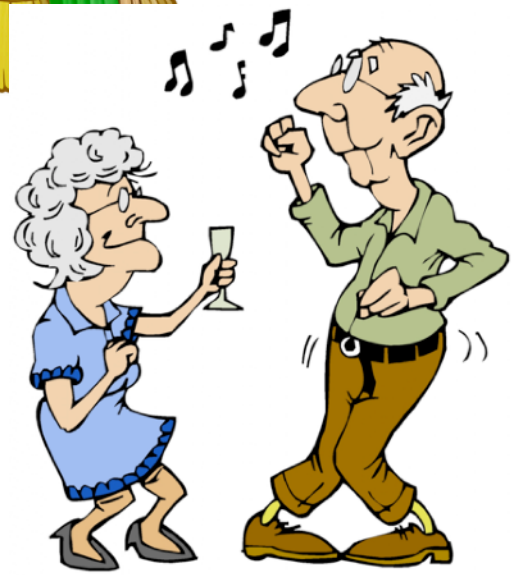




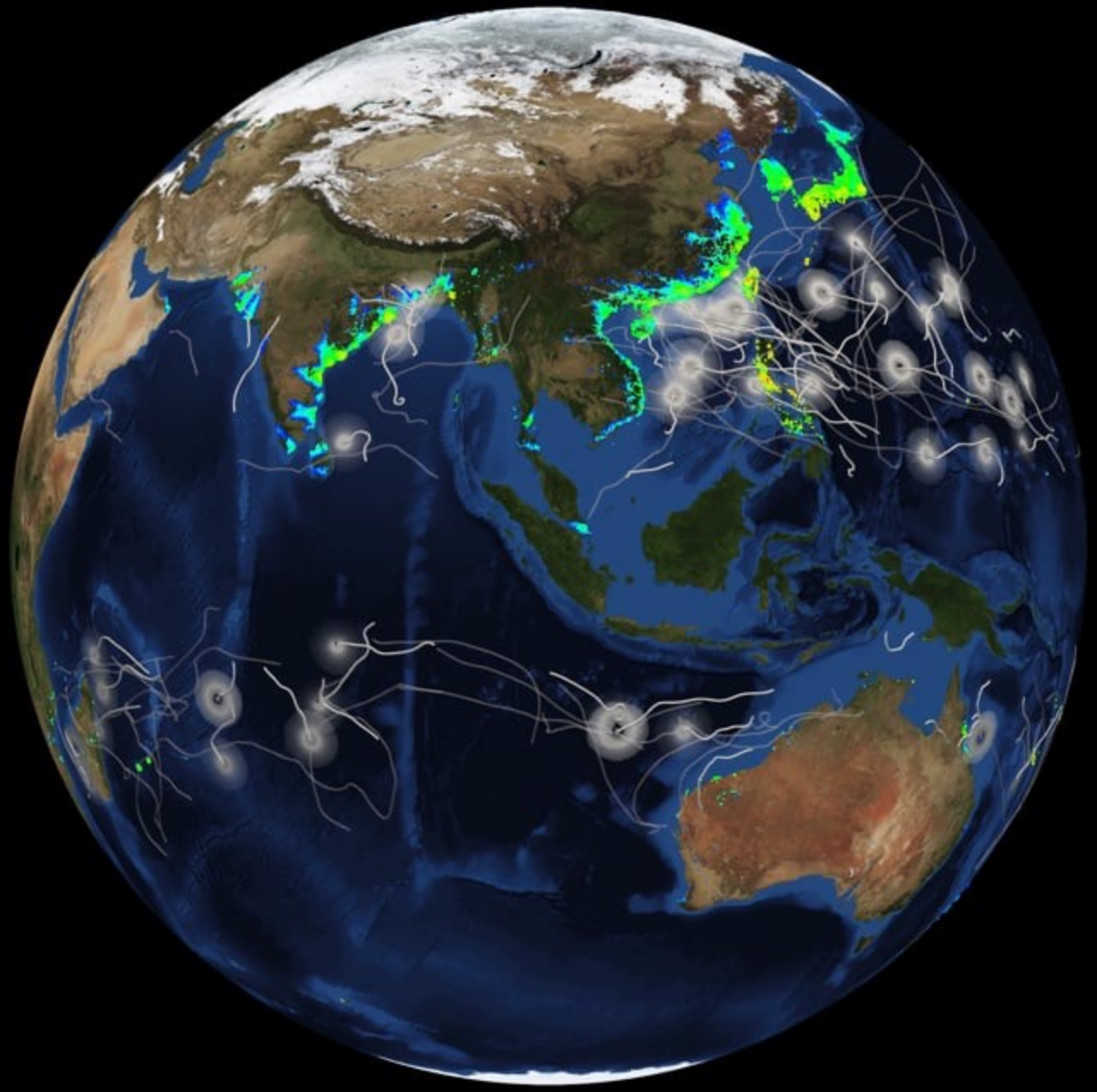





https://unsplash.com/

Vulnerability

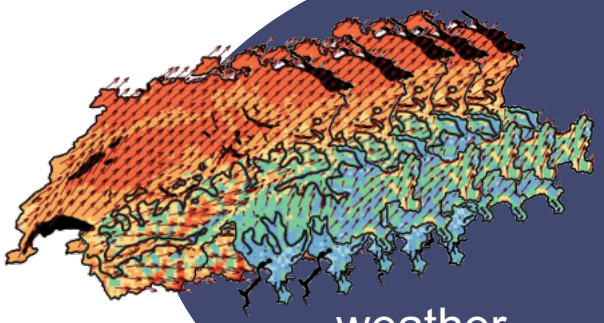


https://unsplash.com/


ETH zürich
2010

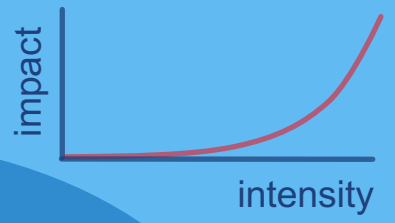
CLIMADA
Economics of Climate Adaptation

resilience measures
(for example:
prevention, spatial planning,
building codes ...)

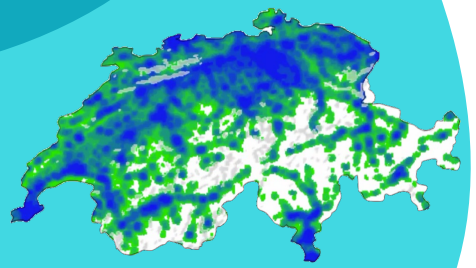


weather
→ hazard

vulnerability



CLIMADA
probabilistic
event-based
simulation
open-source[1]



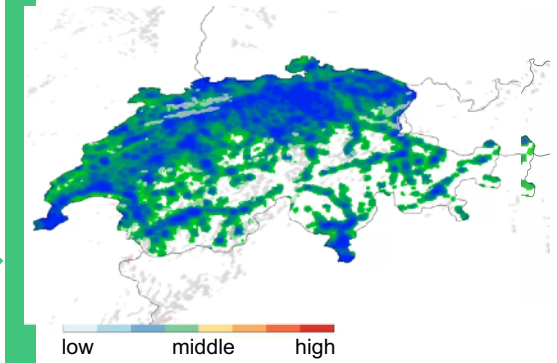
exposure

climate scenarios

development scenarios

outputs:
risk analysis
+ mapping,
+ (early) warning ...

example: building damage

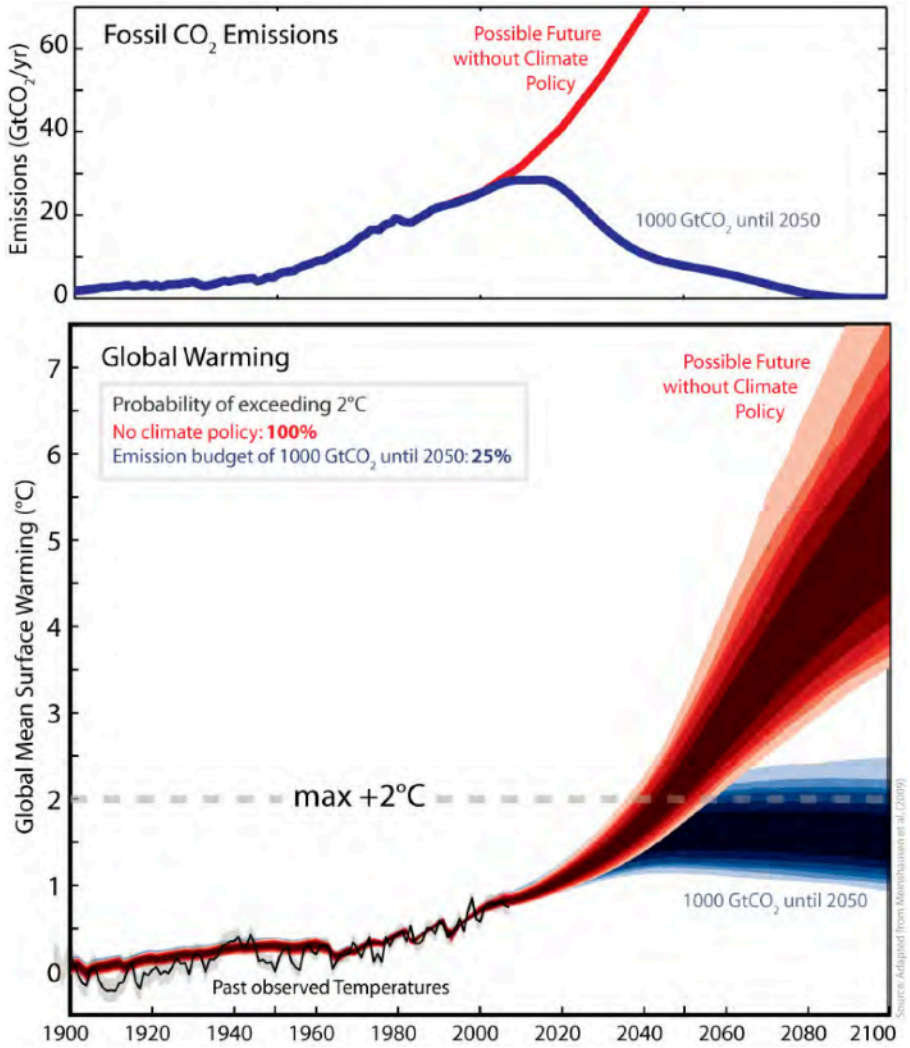


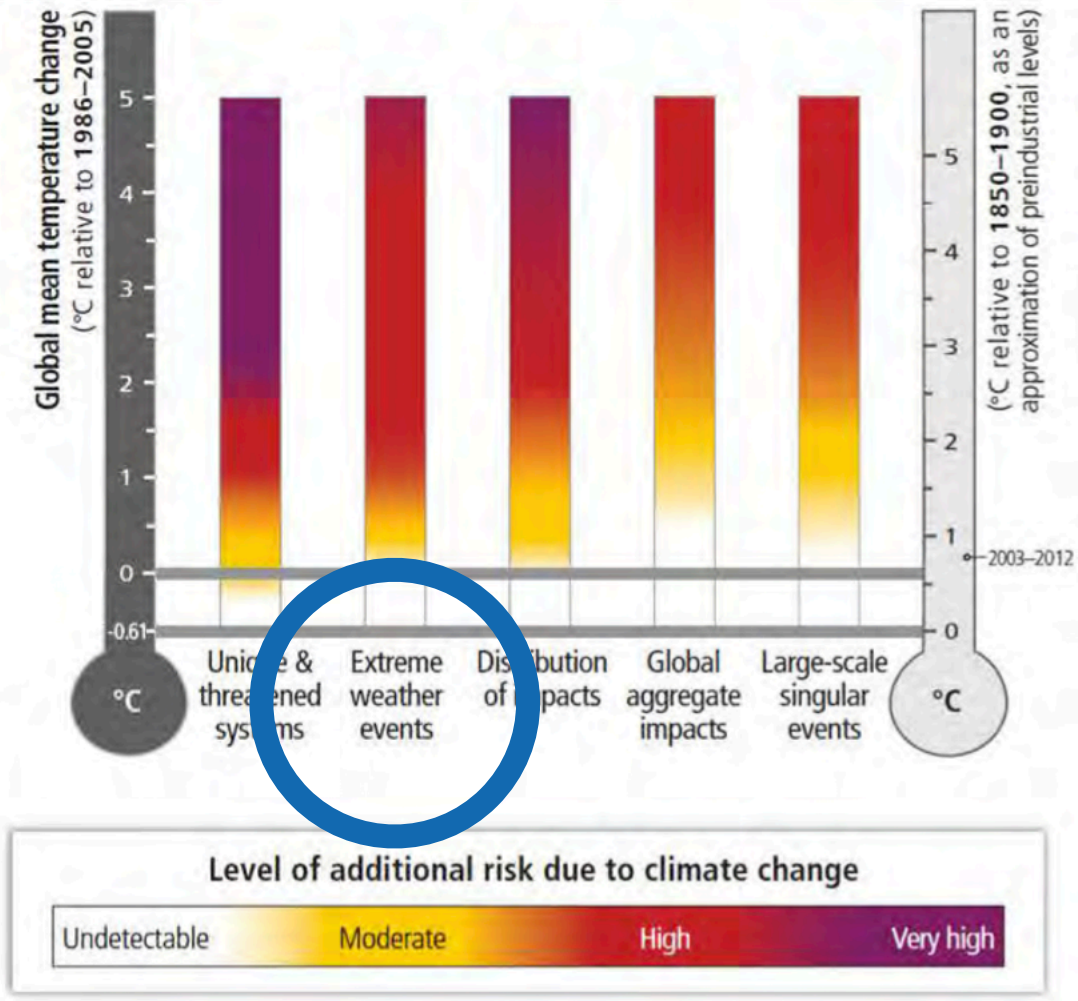
above: Burglind, 3 Jan 2018,see also Lothar,
26 Dec 1999: https://vimeo.com/223292292

+ appraisal of risk management options (effectiveness, cost/benefit)
+ quantification of uncertainty

[1] https://wcr.ethz.ch/research/climada.htm und Aznar-Siguan & Bresch, 2019: CLIMADA ... weather and climate risk assessment ..., https://doi.org/10.5194/gmd-12-3085-2019

Climate Change





(Meinshausen et al. 2009)

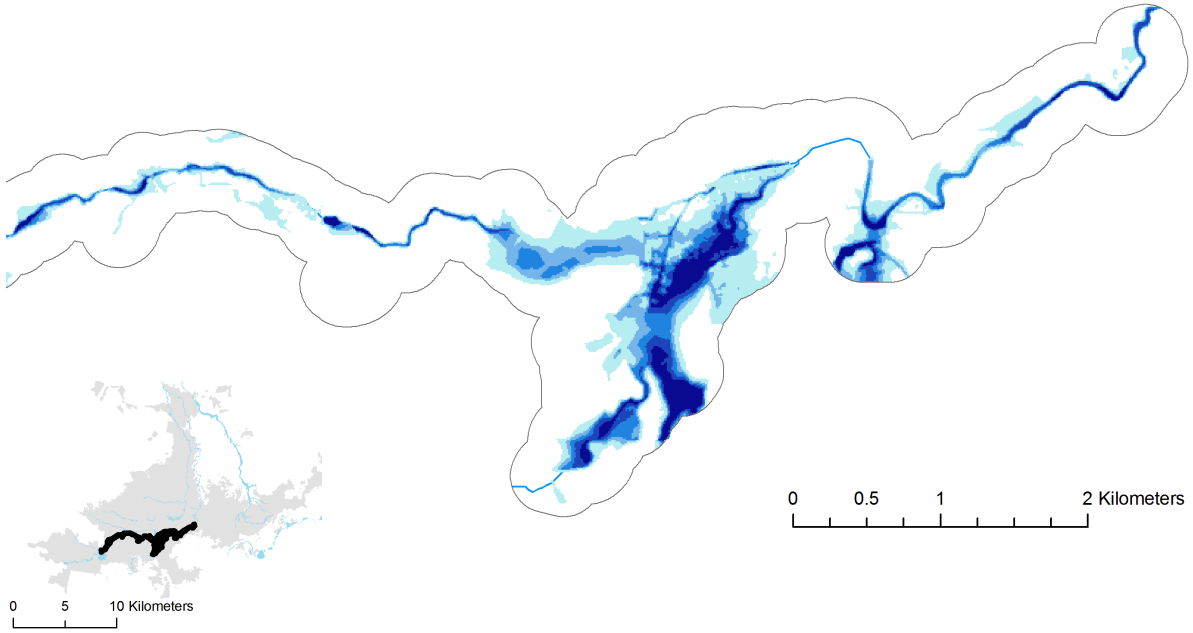
Climate impact matters

1. Impacts from winter storm are projected to increase by up to 40% in the North Sea and Baltic region, and to decrease by 30% in the rest of Europe.
2. Dry snow avalanches lead to ~9millions in average annual damage in central Switzerland, and is projected to increase until 2050 and decrease until 2100.
3. The global risk of Human displacement by river flood is projected to increase by up to 120% until 2050, and 300% until 2100.
4. When large losses occur in mainland Europe, as in 2017 after the earthquake in Central Italy, large payouts due to tropical cyclones could exacerbate that loss and prevent a recovery of the capital for the European Union Solidarity fund (EUSF) in the following years.
5. Global multi-hazard risk of tropical cyclones and river floods is projected to increase by 28% at +2C°.
6. A person born in 1960 experiences 4 heatwaves in her life, a person born in 2020 is projected to experience 30.
7. Annual productivity loss from heatwaves around to ~413Mio. CHF today and is projected to increase by up to 58% until 2050 in Switzerland

1.Severino, L. G. et al. Projections and uncertainties of future winter windstorm damage in Europe. EGUsphere 1–31 (2023) doi:10.5194/egusphere-2023-205.
2.Ortner, G. et al. Large-scale risk assessment on snow avalanche hazard in alpine regions. Natural Hazards and Earth System Sciences Discussions 1–31 (2022) doi:10.5194/nhess-2022-112.
3.Kam, P. M. et al. Global warming and population change both heighten future risk of human displacement due to river floods. Environ. Res. Lett. 16, 044026 (2021).
4.Ciullo, A., Martius, O., Strobl, E. & Bresch, D N. A framework for building climate storylines based on downward counterfactuals: The case of the European Union Solidarity fund. Climate Risk Management 33, 100349 (2021).
6.Thiery, W. et al. Intergenerational inequities in exposure to climate extremes. Science 374, 158–160 (2021).
5.Stalhandske, Z. et al. Projected Impact of Heat on Mortality and Labour Productivity under Climate Change in Switzerland. Natural Hazards and Earth System Sciences Discussions 1–20 (2021) doi:10.5194/nhess-2021-361.
7. .Stalhandske, Z. et al. Global multi-hazard risk assessment in a changing climate. (2023).

Flooding risk and adaptation option appraisal

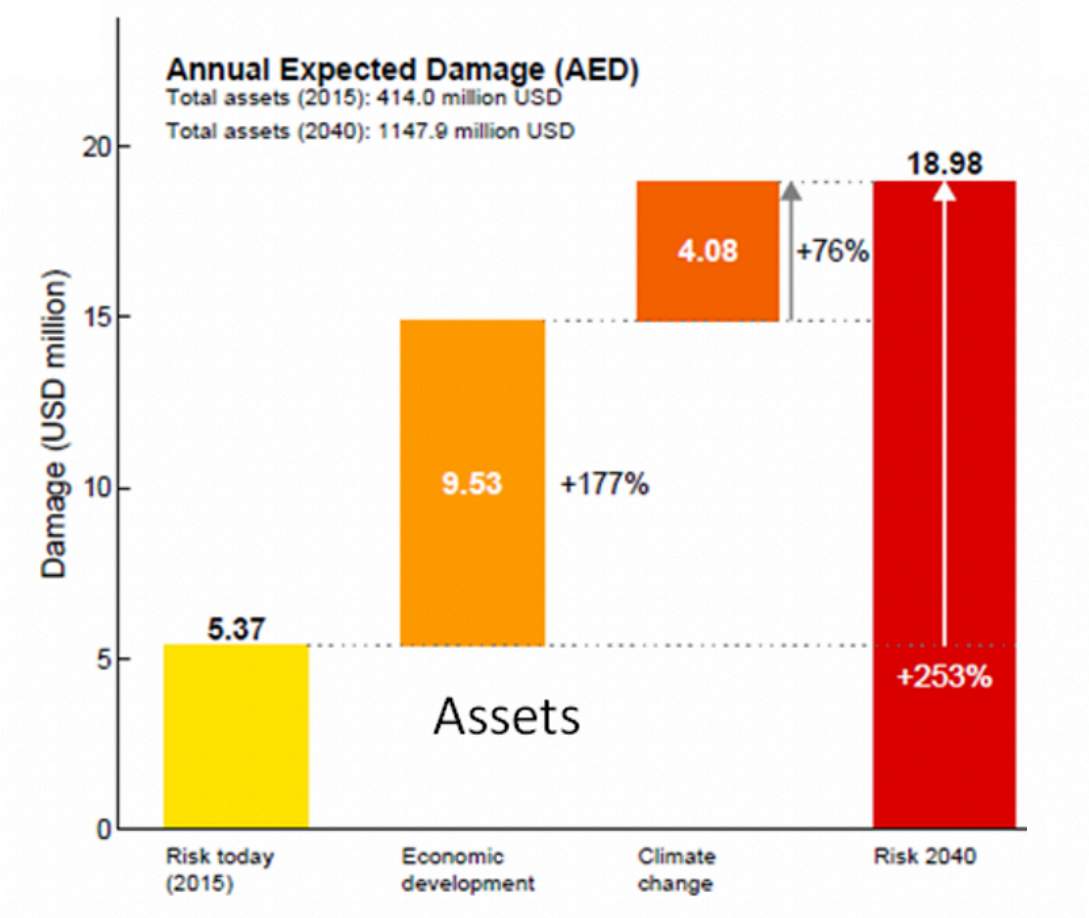
- ECA study: Floods in San Salvador

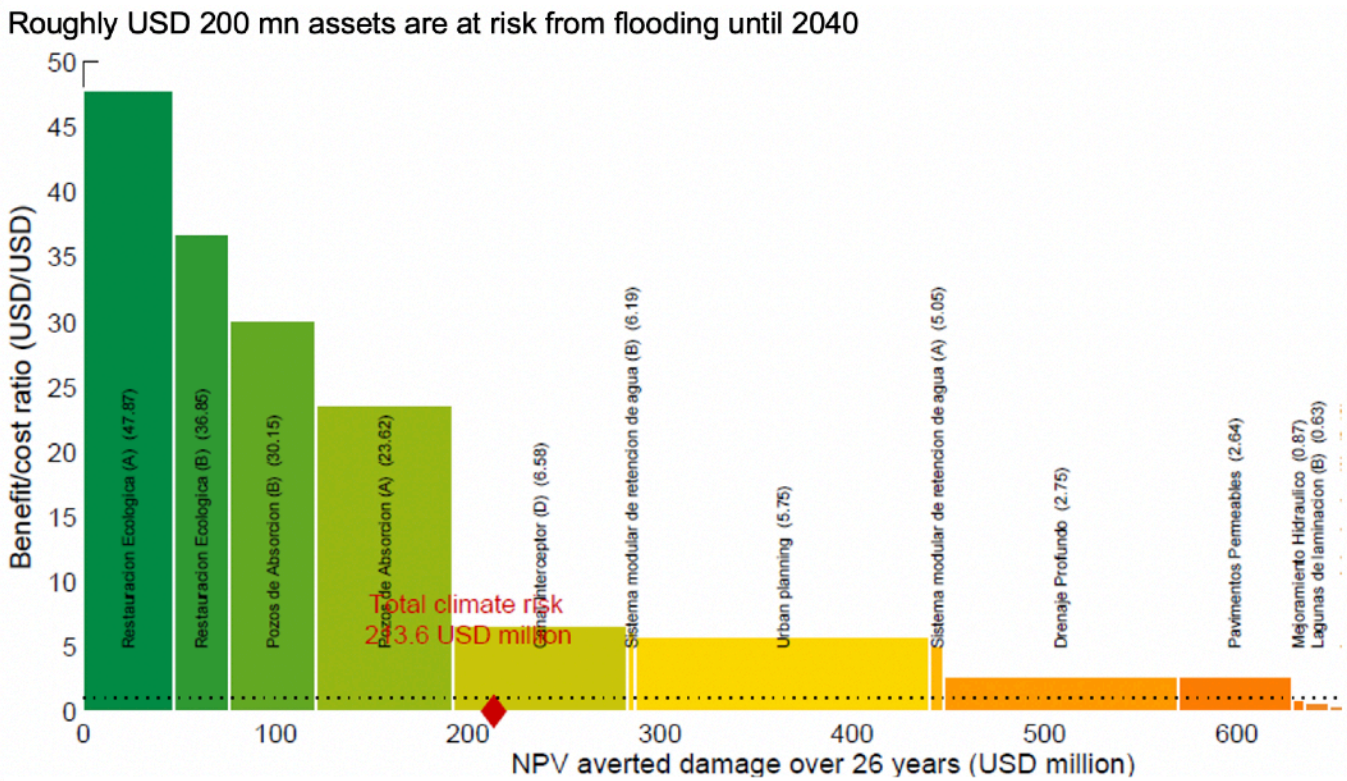


Wieneke & Bresch, 2016: Economics of Adaptation (ECA)

Cooperation: A Climate Risk Assessment Approach Supporting decision making […]. Materials on Development Financing, UNU, KfW. https://www.kfw-entwicklungsbank.de/PDF/Download-Center/Materialien/2016_No5_Economics-of-Adaptation_EN.pdf

Flooding risk and adaptation option appraisal

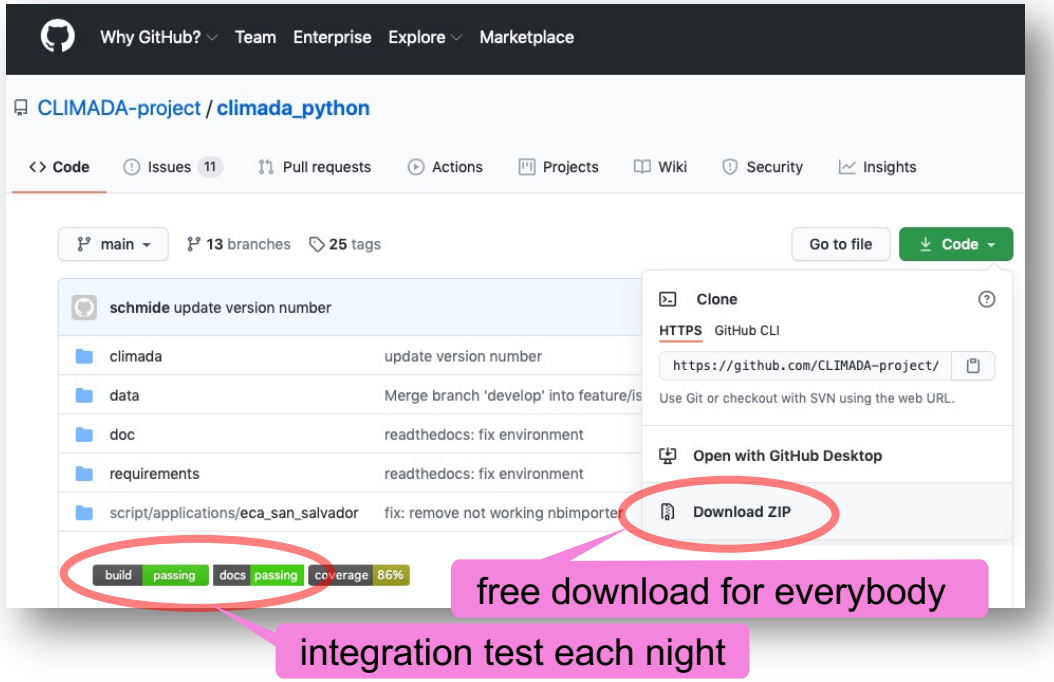




Wieneke & Bresch, 2016: Economics of Adaptation (ECA) in Development Cooperation: A Climate Risk Assessment Approach Supporting decision making […]. Materials on Development Financing, UNU, KfW. https://www.kfw-entwicklungsbank.de/PDF/Download-Center/Materialien/2016_No5_Economics-of-Adaptation_EN.pdf

CLIMADA – GitHub open-source und -access[1]

- Implemented in Python
- Ready-to-use impact model, currently about 10 groups internationally using it
- Bi-weekly developer meeting and solid dev/test/deploy in place (Jenkins)



CLIMADA
Economics of Climate Adaptation

CLIMADA data API

open-access to globally consistent hazard and exposure datasets

https://climada.ethz.ch/data-types

https://wcr.ethz.ch/research/climada.html
and https://eca-network.org
(the international community page)

[1] GNU GPL 3, https://github.com/CLIMADA-project/climada_python/blob/main/LICENSE

Inter-operability

- Risk assessment tools
  - OASIS Loss Modelling Framework (LMF) [1]
  - Risk Changes [2]
  - …
- Data sources
  - Global Monitoring for Environment and Security (COPERNICUS) data services [3]
  - OASIS hub [4]
  - …
- Projects
  - Integration with other tools for Disaster Risk Management with EU-Horizon innovation project DIRECTED [5]
  - Network for Greening the Financial System (NGFS) climate scenarios [6]
  - …

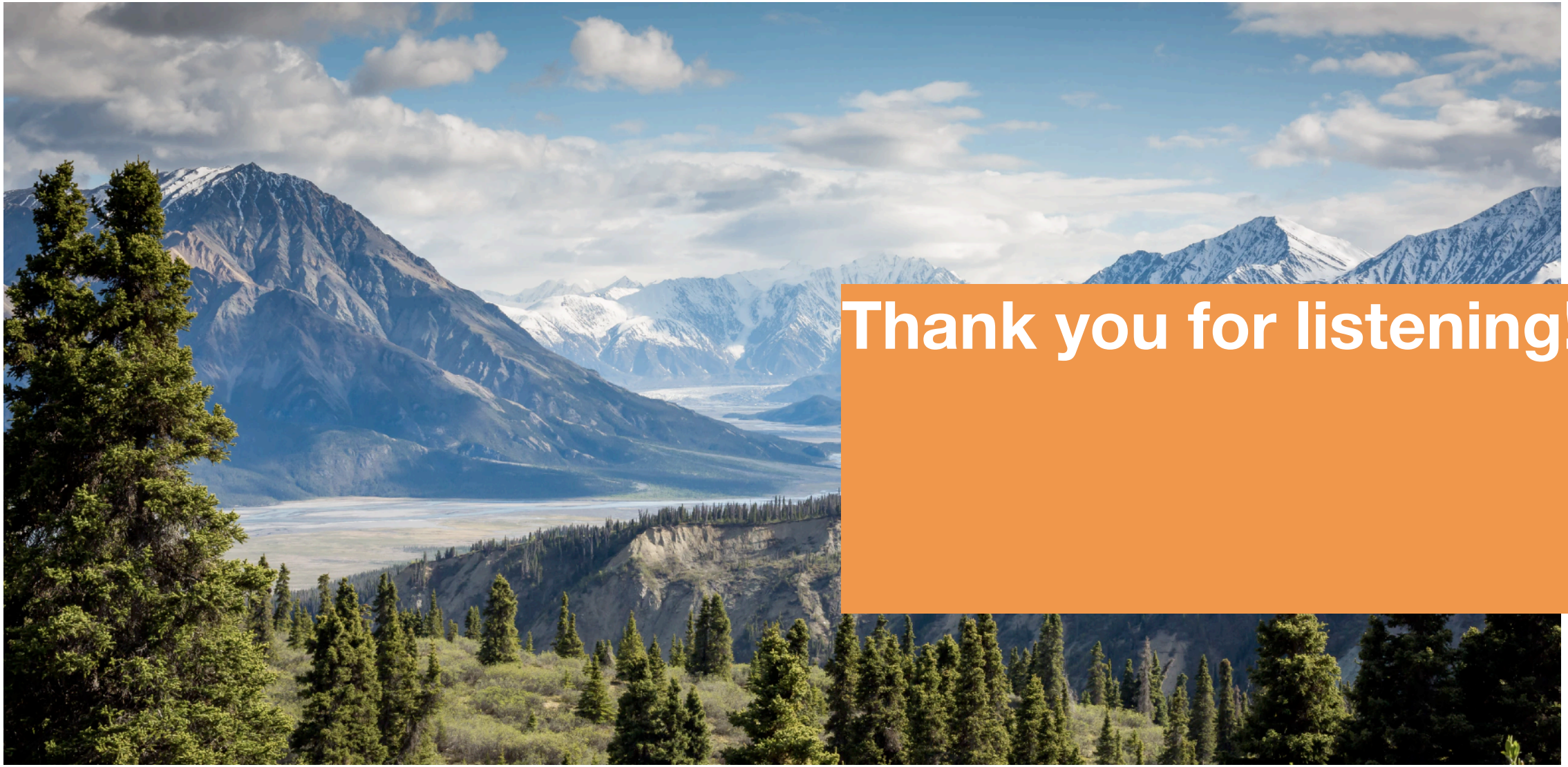
1. https://oasislmf.org/
2. https://riskchanges.org/
3. https://www.copernicus.eu/
4. https://oasishub.co/
5. https://www.ngfs.net/
6. https://directedproject.eu/

CLIMADA summary

- CLIMADA is a **framework** NOT a model.
- **Scale** all: Worldwide, Country, Region, City
- Extreme events (**probabilistic** or single events)
- Now or Near-future casting (e.g., risk warnings), **Current and future risk** (e.g. Socio-economic development + Climate change), Adaptation option
- **Exposures**: People, Ecosystems, Assets, Economic supply chains, Critical infrastructure, …
- **Hazards**: Tropical cyclones, Winter storms, Wildfires, Flood, Drought, Heatwaves,…
- **API**: data as a starting point for analysis - Worldwide consistent at 4x4km
- **Open-source** and open-access Python platform **maintained** and improved by a community of 20+ developers/researchers
- **Uncertainty**: full quantification of uncertainty and sensitivity analysis
- Various **output metrics** (e.g. return period curves, risk transfer, average impact, …)
- **Applications**: Risk assessment, adaptation option appraisal, storylines, forecasting, …

ETH zürich

CLIMADA
Economics of Climate Adaptation



Thank you for listening!

ETH zürich

CLIMADA
Economics of Climate Adaptation

Supplementary information

CLIMADA is the open-source and -access global platform for probabilistic multi-hazard risk modelling and options appraisal **https://wcr.ethz.ch/research/climada.html** (CLIMADA infograph at the bottom of that webpage, narrated here)

Using state-of-the-art probabilistic modelling CLIMADA allows to estimate multi-hazard socio-economic impacts as a measure of risk today, the incremental increase from economic development and the further incremental increase due to climate change. The Economics of Climate Adaptation (ECA) methodology as implemented in CLIMADA provides decision makers with a fact base to understand the impact of weather and climate on their economies, including cost/benefit and multi-criteria perspectives on specific risk reduction and resiliency measures as well as risk transfer solutions. The model is well suited to operate on diverse spatio-temporal scales, e.g. from **impact-based warning** applications (regional to local, timescale of days) to providing an **open and independent global** (yet still high-resolution) **view on physical risk** (including tail risk quantification), in line with e.g. the TCFD (Task Force for Climate-related Financial Disclosure). Key references: Aznar-Siguan, G., and Bresch, D. N., 2019: CLIMADA v1: a global weather and climate risk assessment platform, Geosci. Model Dev., 12, 3085–3097. https://doi.org/10.5194/gmd-12-3085-2019 and Bresch, D. N. and Aznar-Siguan, G., 2021: CLIMADA v1.4.1: towards a globally consistent adaptation options appraisal tool, Geosci. Model Dev., 14, 351–363, https://doi.org/10.5194/gmd-14-351-2021

As of today, **CLIMADA** provides global coverage of major climate- related extreme- weather hazards at high resolution, namely (i) **tropical cyclones**, (ii) **river flood**, (iii) **agro drought,** (iv) **European winter storms**, and (v) **wildfire**, all at 4km spatial resolution globally - landslides to be added soon. For all hazards, historic and probabilistic event sets exist, for some also under select climate forcing scenarios (RCPs) at distinct time horizons (e.g. 2040). All are directly available via the **CLIMADA** data API (CC BY 4.0): https://climada.ethz.ch/rest/docs#/, for an intro, see https://github.com/CLIMADA-project/climada_python/blob/main/doc/tutorial/climada_util_api_client.ipynb

There is no specific **CLIMADA training** offered, there is a very short (5 min: https://vimeo.com/677754997), short (6 min, https://vimeo.com/678230951) and a bit longer (12 min: https://vimeo.com/584851312) CLIMADA introduction plus an Economics of Climate Adaptation (ECA) introduction (18 minutes, https://vimeo.com/584849541). With basic Python knowledge, one can get quickly up to speed by installing (guide: https://climada-python.readthedocs.io/en/latest/guide/install.html) and working through the tutorials (https://github.com/CLIMADA-project/climada_python/tree/main/doc/tutorial. The online documentation is also always up to date: https://climada-python.readthedocs.io/en/latest/. General literature can be found on https://www.zotero.org/groups/2502787/climada_open/library

For technical question on the framework itself, please open an issue on the github page. For operational coding question please do not hesitate to post on StackOverflow.

CLIMADA ressources

- Github repository:
  - https://github.com/CLIMADA-project/climada_python
- Documentation:
  - https://climada-python.readthedocs.io/en/stable/
- Example of case studies:
  - https://github.com/CLIMADA-project/climada_papers
- Literature:
  - All: https://www.zotero.org/groups/2502787/climada_open/library
  - Impact assessment: https://www.geosci-model-dev.net/12/3085/2019/
  - Adaptation option appraisal: https://gmd.copernicus.org/articles/14/351/2021/
  - LitPop exposures: https://doi.org/10.5194/essd-12-817-2020
  - Uncertainty analysis: https://doir.org/10.5194/gmd-2021-437

CLIMADA coverage – “as is”

Peril	Coverage	Resolution	*Ready in API by*[6]
▪ Tropical cyclones	global	4 x 4 and 1 x 1 km	now
▪ European winter storms	all Europe[1]	4 x 4 km	now
▪ River flood	global[2]	4 x 4 km	now
▪ Wildfire	global[3]	4 x 4 km	now
▪ Heat	global	50 x 50 km	summer 2023
▪ Agro drought	global[4]	50 x 50 km	now
▪ Landslide	global, *in development*	4 x 4 km	summer 2024
▪ Earthquake and Volcano	global, *in MATLAB still*[5]	10 x 10 km	now (EQ only)
Asset base and population	global	4 x 4 and 1 x 1 km	now

Climate change implemented by altering probabilistic hazard event sets (e.g. SREX) or based on isimip.org

[1] based on Copernicus WISC, see also https://github.com/CLIMADA-project/climada_python/blob/main/doc/tutorial/climada_hazard_StormEurope.ipynb
[2] isimip global flood, 30 years x 46 models at 4 km, for higher resolution, interface to 3rd party hazard models exists (e.g. tested with Witteveen&Boos)
[3] wildfire spreading and probabilistic engine works, ready to be used, but land characteristics not taken care of properly yet. Will be updated together with delta climate hazard set(s)
[4] using isimip 2a/b data, check metadata
[5] earthquake ported to CLIMADA, Volcano hazard sets can readily be used in Python for impact calculations, but their generation still happens in MATLAB
[6] CLIMADA data API, fully open under CC BY 4.0, see https://climada.ethz.ch/rest/docs#/ release dates indicative

https://wcr.ethz.ch/research/climada.html