Outline of the three lessons

- Introduction
- Climate – drivers and processes
- Climate and live
- Observed climate change and impacts

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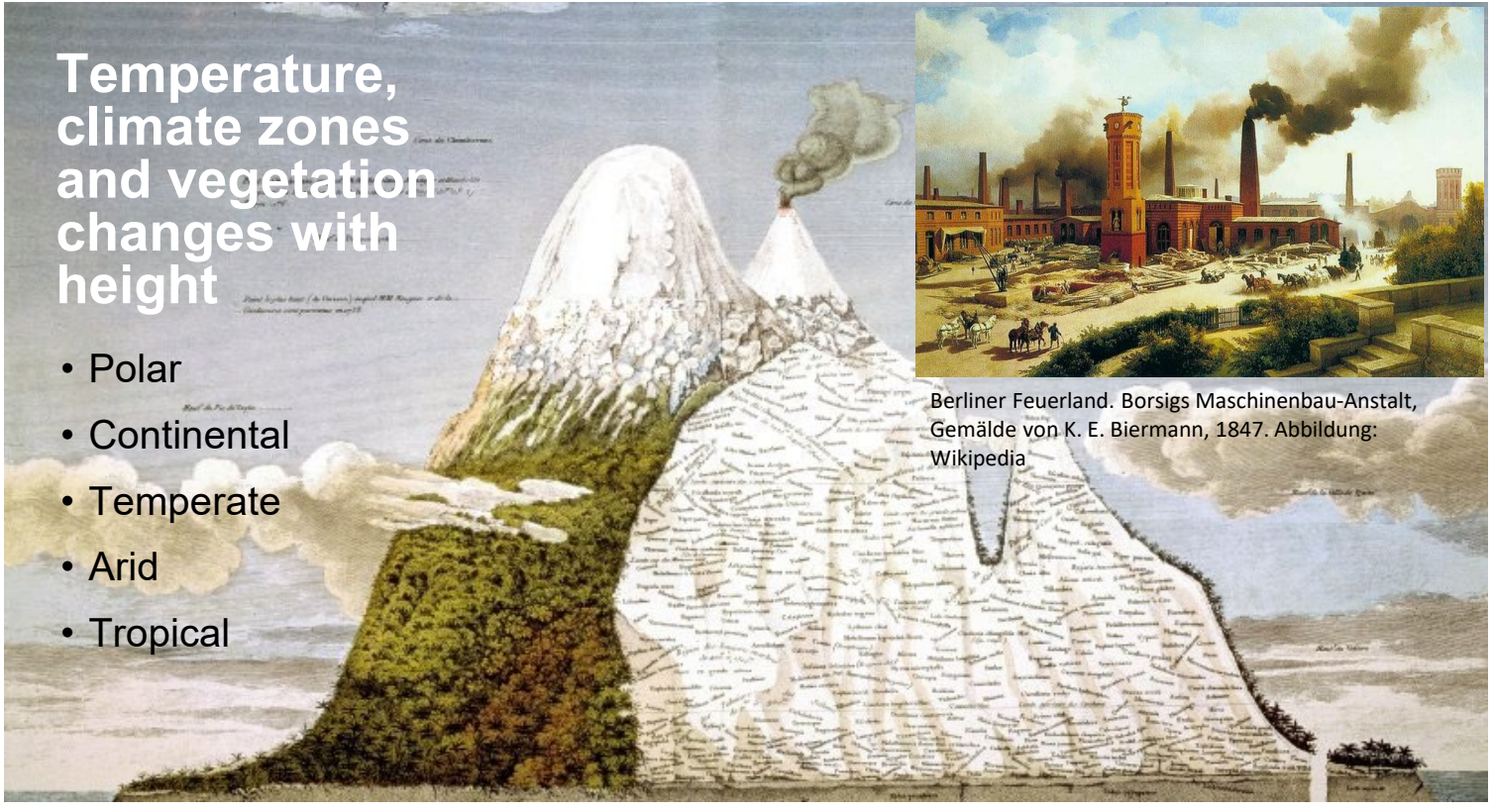
Alexander v. Humboldt and the discovery of climate zones

https://de.wikipedia.org/wiki/Datei:Alexandre_humboldt.jpg

1802:
Volcano
Chimborazo

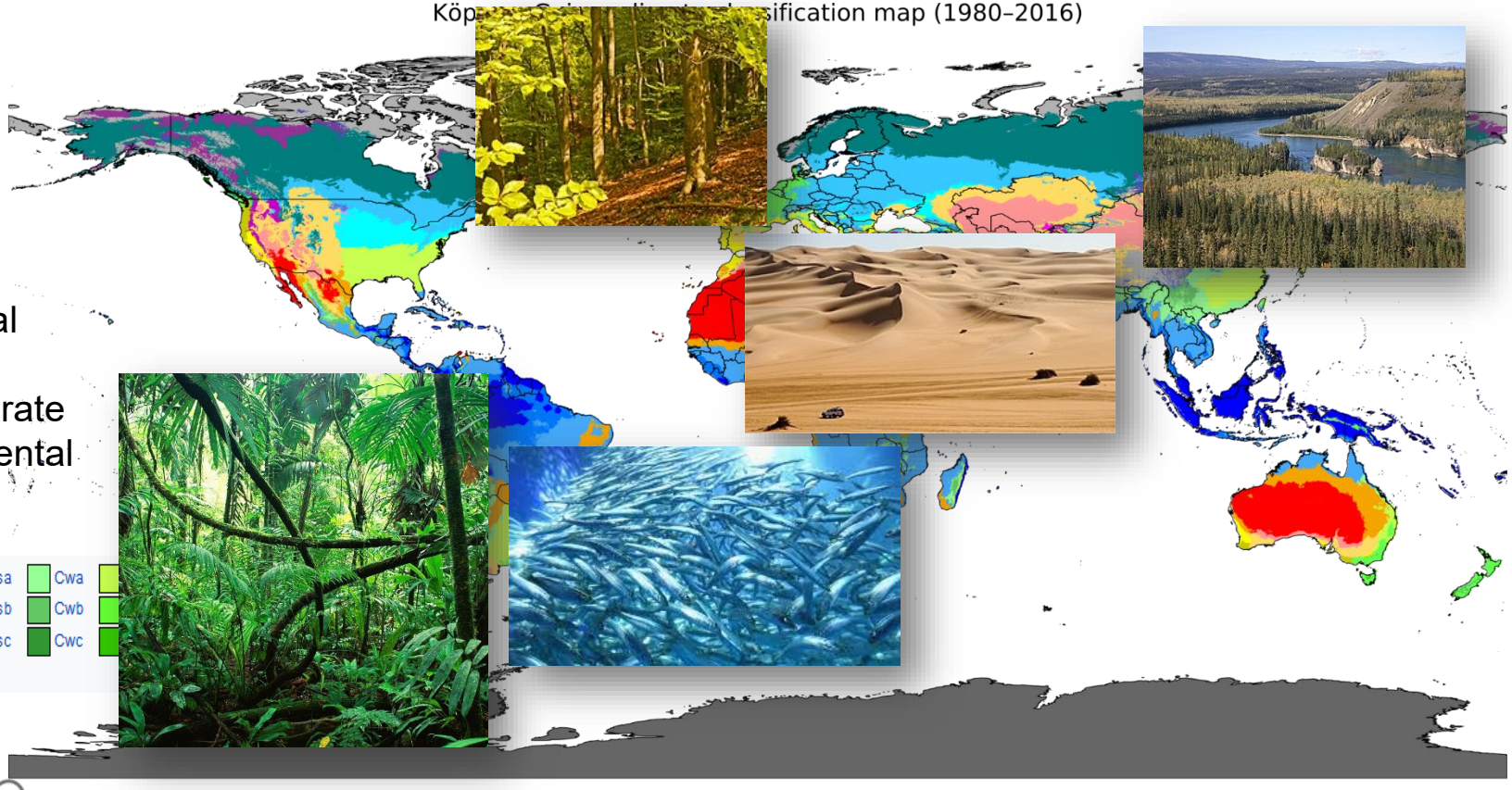
(Ecuador, 6267 m)



Berliner Feuerland. Borsigs Maschinenbau-Anstalt, Gemälde von K. E. Biermann, 1847. Abbildung: Wikipedia

https://www.abendblatt.de/vermischtes/promi-news/article205357999/Humboldt-war-Zeichner-der-ersten-Infografiken.html

Climate zones as habitat of different ecosystems

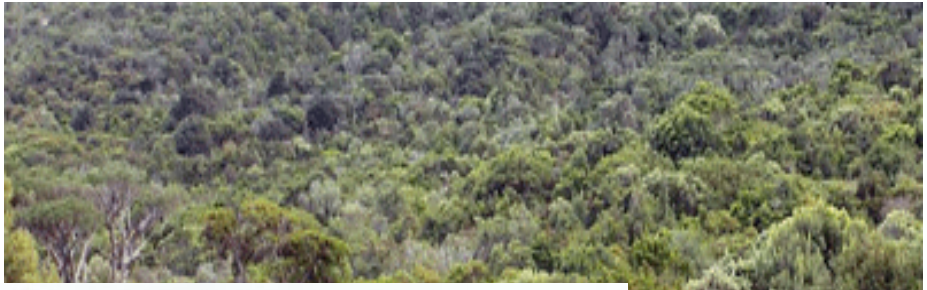


Source: Beck et al.: Present and future Köppen-Geiger climate classification maps at 1-km resolution, Scientific Data 5:180214, doi:10.1038/sdata.2018.214 (2018)

Life adaptes to climate conditions

- **Boreal coniferous forests** (boreal = northern) is the vegetation zone in which trees can still grow despite cold temperatures. The boreal coniferous forest belt stretches practically across the entire northern hemisphere, around the 60th parallel.
- Spruces, pines, firs and larches are generally the dominant coniferous species in boreal climates. Mostly conifers.
- Low precipitation, permafrost, mean temperatures around +5 to -5 °C, with significant upward and downward deviations (-30 °C in the winter months; up to +20 °C in the summer months).

Life adaptes to climate conditions

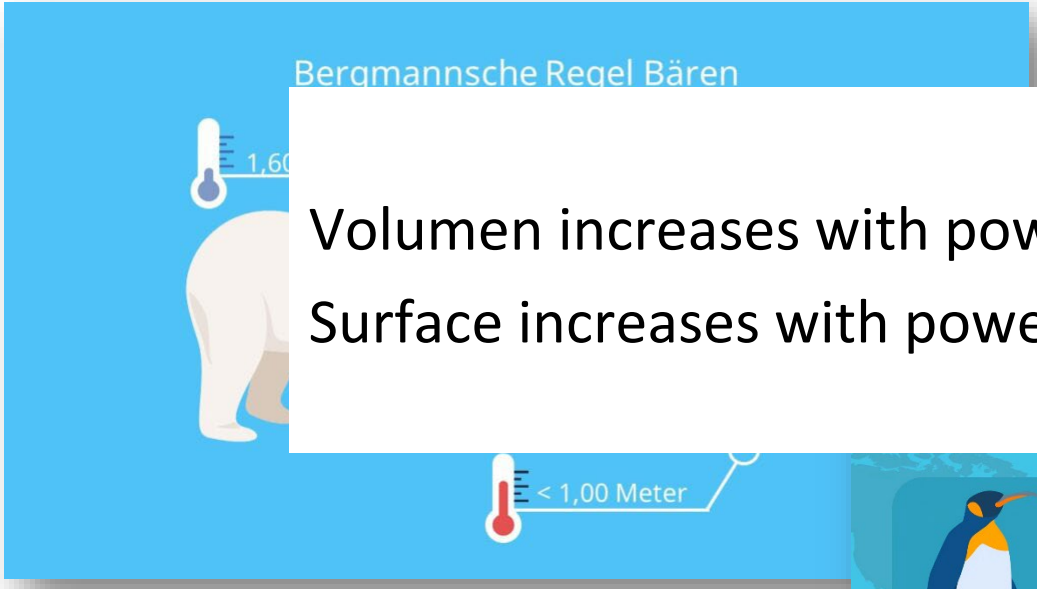


Characteristics of **tropical rainforests**:

1. located near the equator,
2. high temperatures,
3. daily precipitation,
4. evergreen vegetation,
5. high species diversity.

- In the tropical rainforest there are no seasons. A diurnal climate prevails (opposite: seasonal climate).
- Mostly broadleave trees.

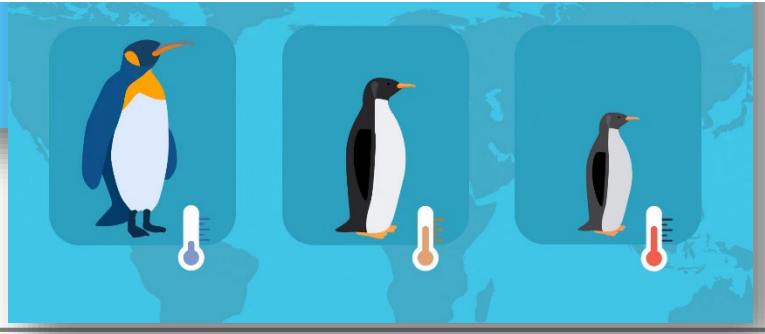
Life adaptes to climate conditions



Bergmann's rule states that animals of the same

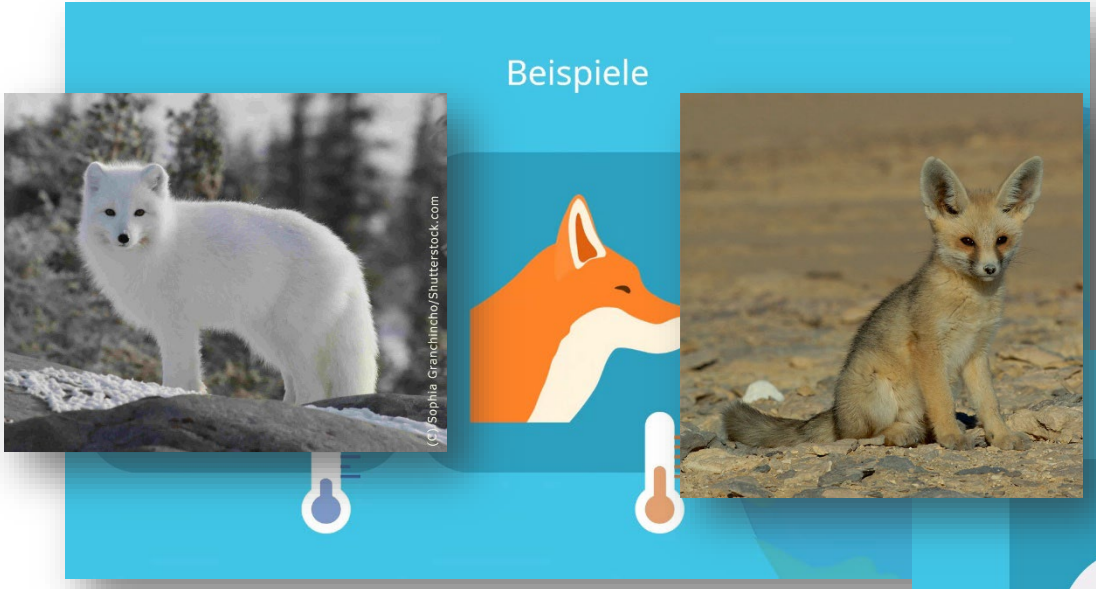
Volumen increases with power 3 (Sphere $= \frac{4}{3}\pi r^3$)

Surface increases with power 2 (Area $= \pi r^2$)

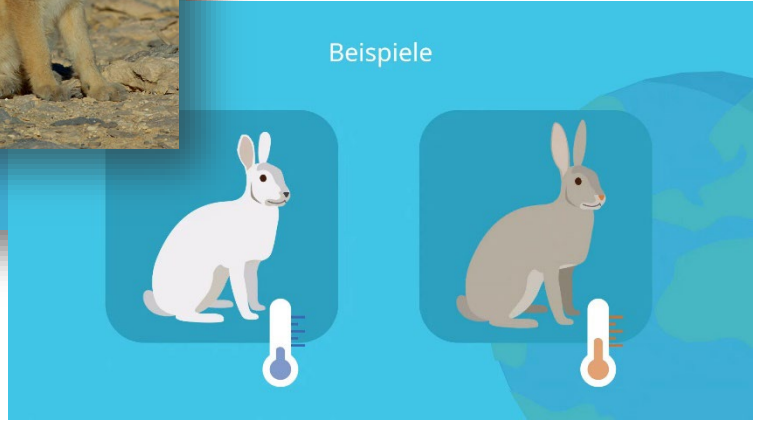


Source: https://studyflix.de/

Life adaptes to climate conditions



Allen's rule states that mammals in colder regions, for example, have smaller limps, ears etc. than their closely related species in warmer regions.



Source: https://studyflix.de/

Outline of the three lessons

- **Introduction**
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- **Climate and live**
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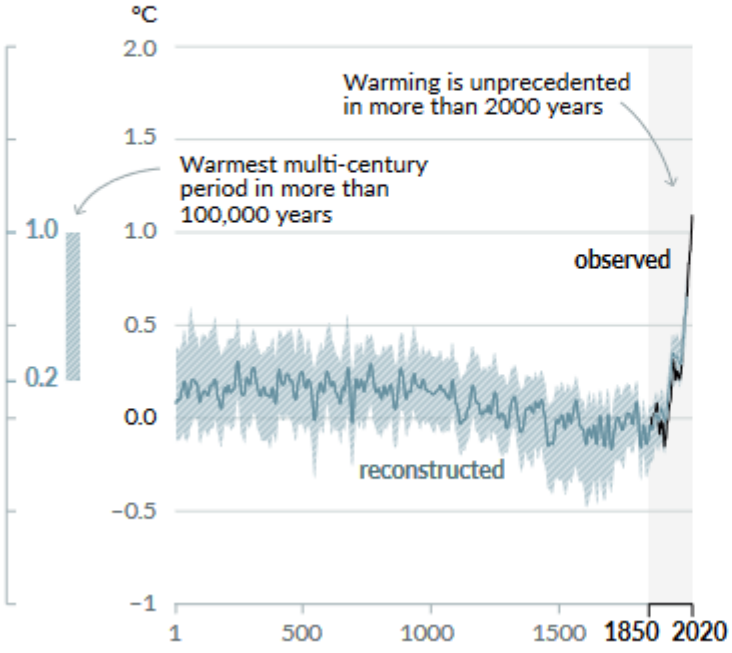
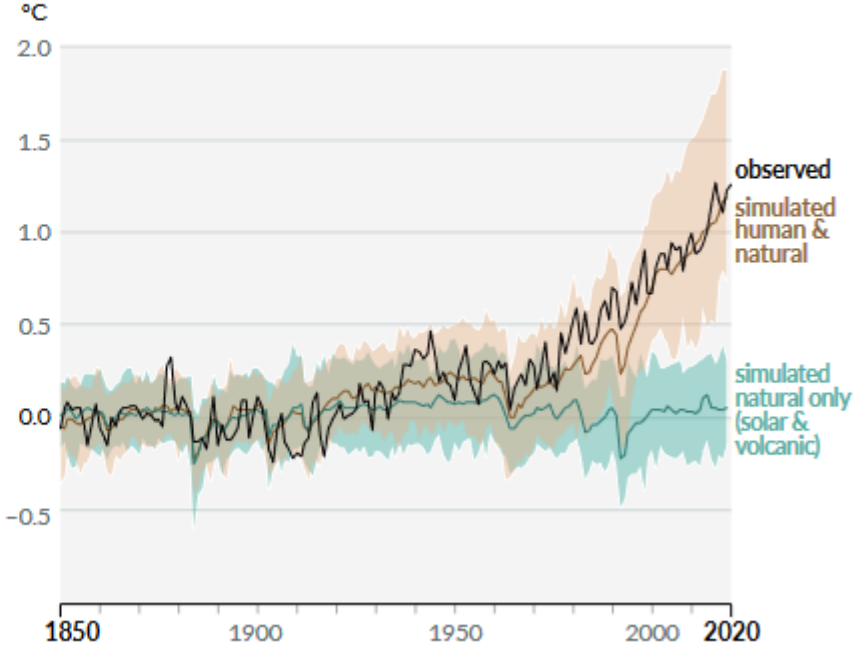
Changes in global surface temperature relative to 1850–1900

(a) Change in global surface temperature (decadal average) as reconstructed (1–2000) and observed (1850–2020)

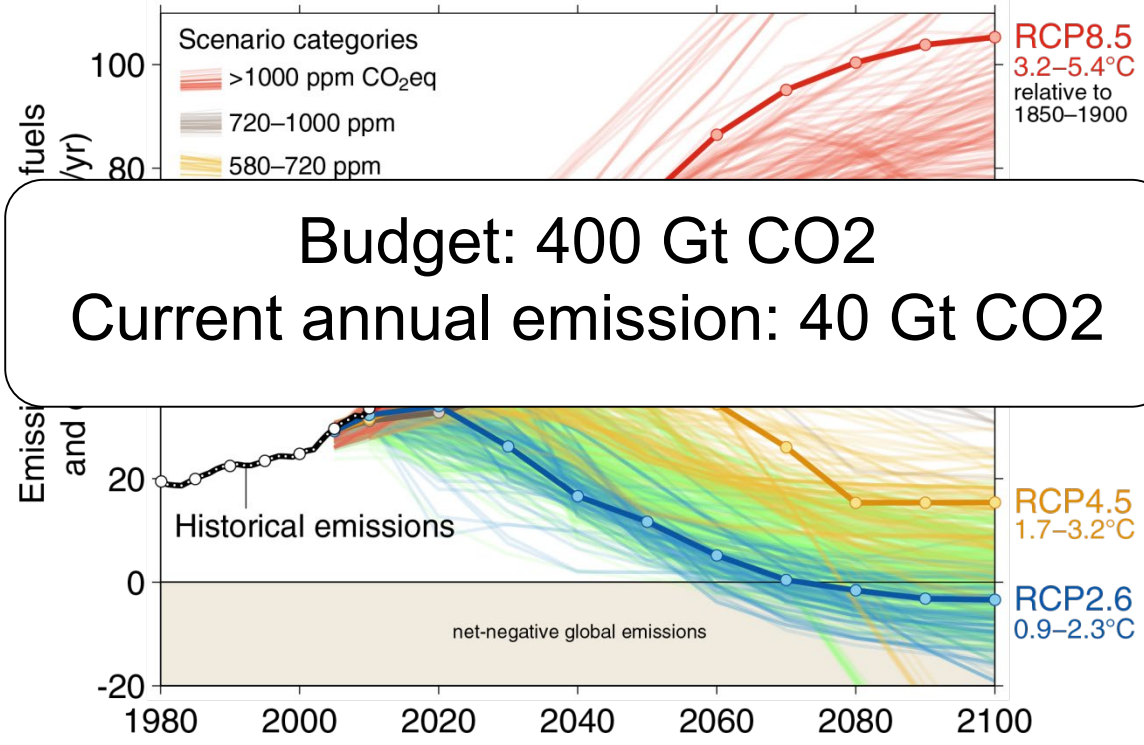


(b) Change in global surface temperature (annual average) as observed and simulated using human & natural and only natural factors (both 1850–2020)



Scenarios: from emissions to temperatures

Business-as-usual in red



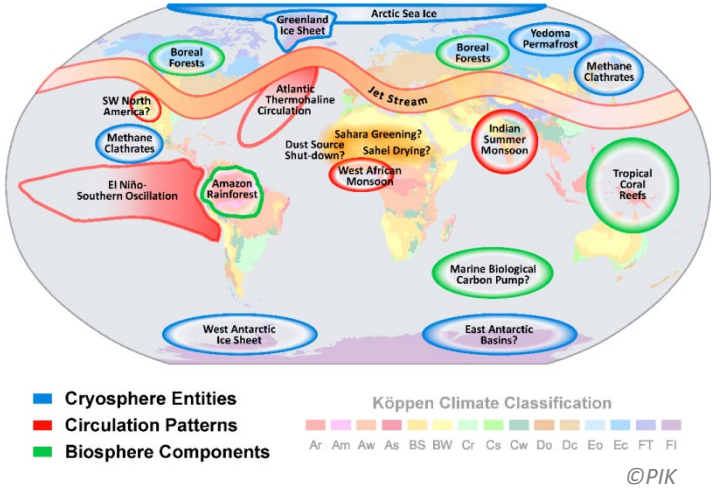
Budget: 400 Gt CO2

Current annual emission: 40 Gt CO2

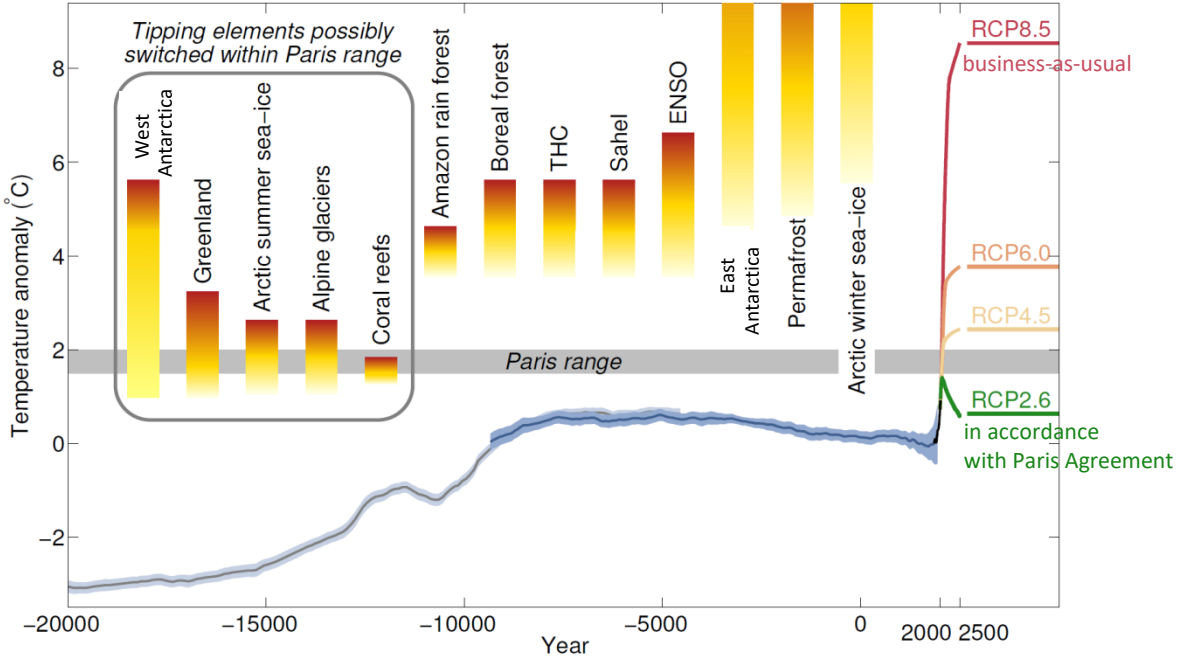
World Meteorological Organization, 2014

Climate tipping points

Risks at the horizon



- Humans are a geological force
- Crucial parts of the climate system are at risk of tipping even within the Paris range of 1.5 – 2 ° C

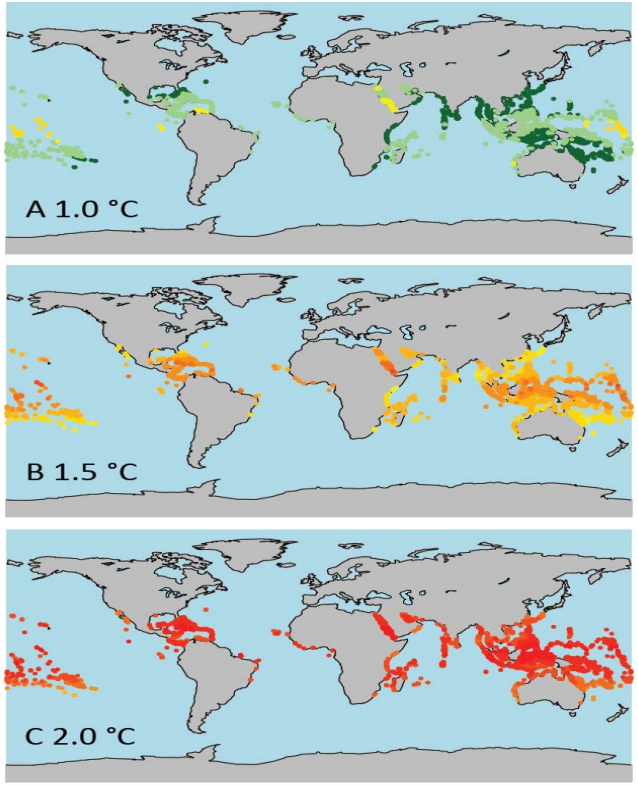


PIK

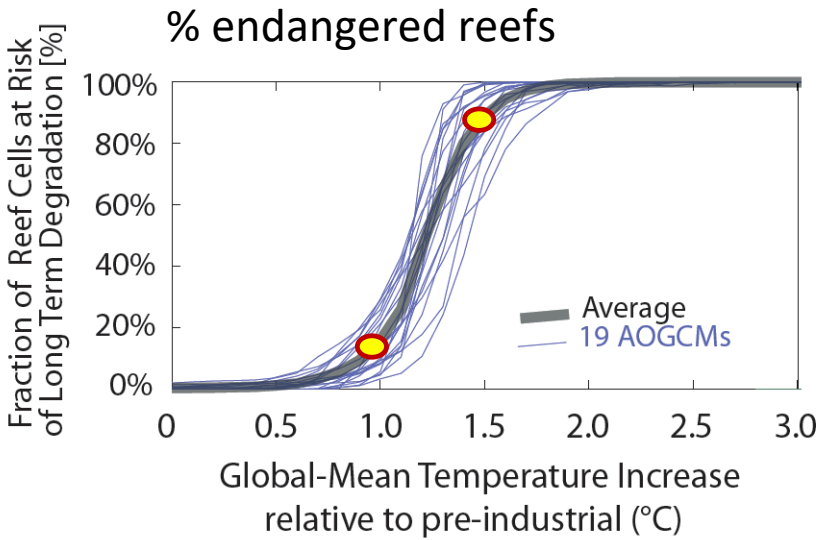
Schellnhuber, Rahmstorf, Winkelmann, Nature Climate Change (2016)

Coral reefs perish

Already 2°C is too much



Number of bleach events

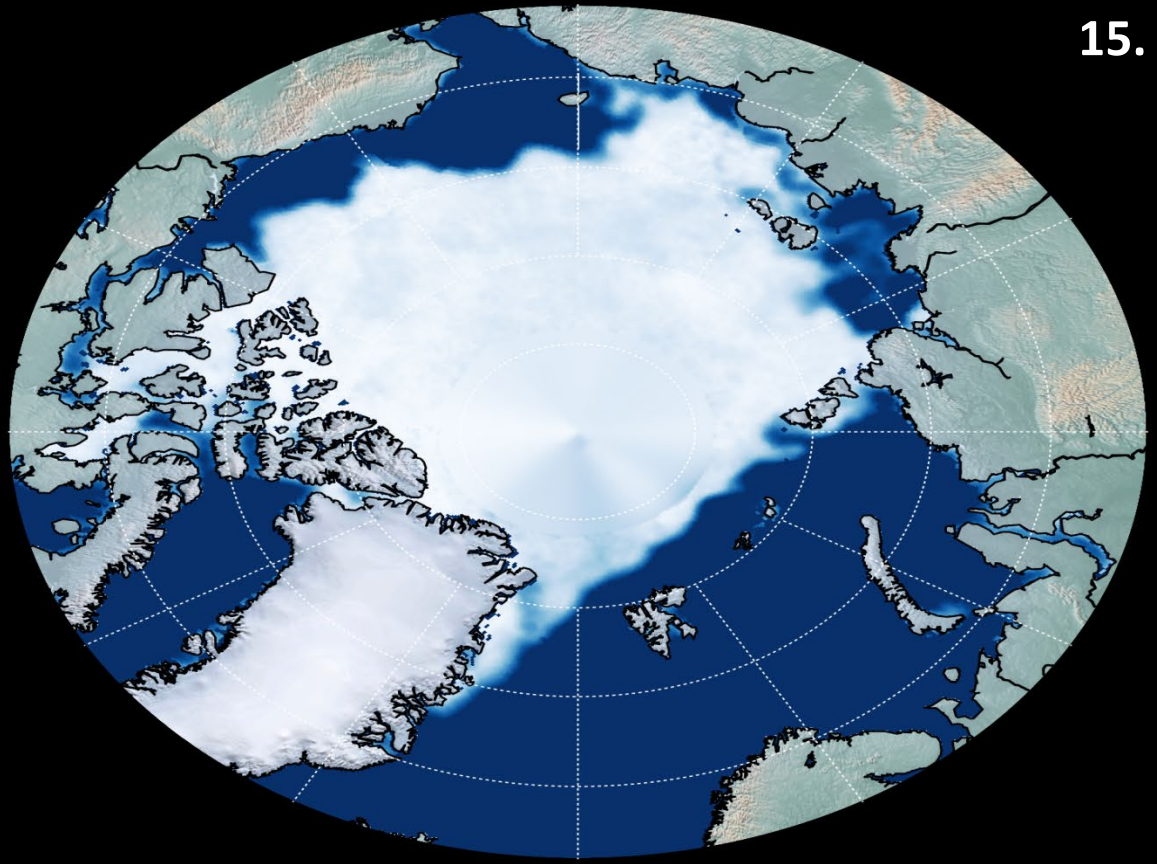


Frieler et al. Nature Clim. Ch. (2012).

Arctic sea ice

1979

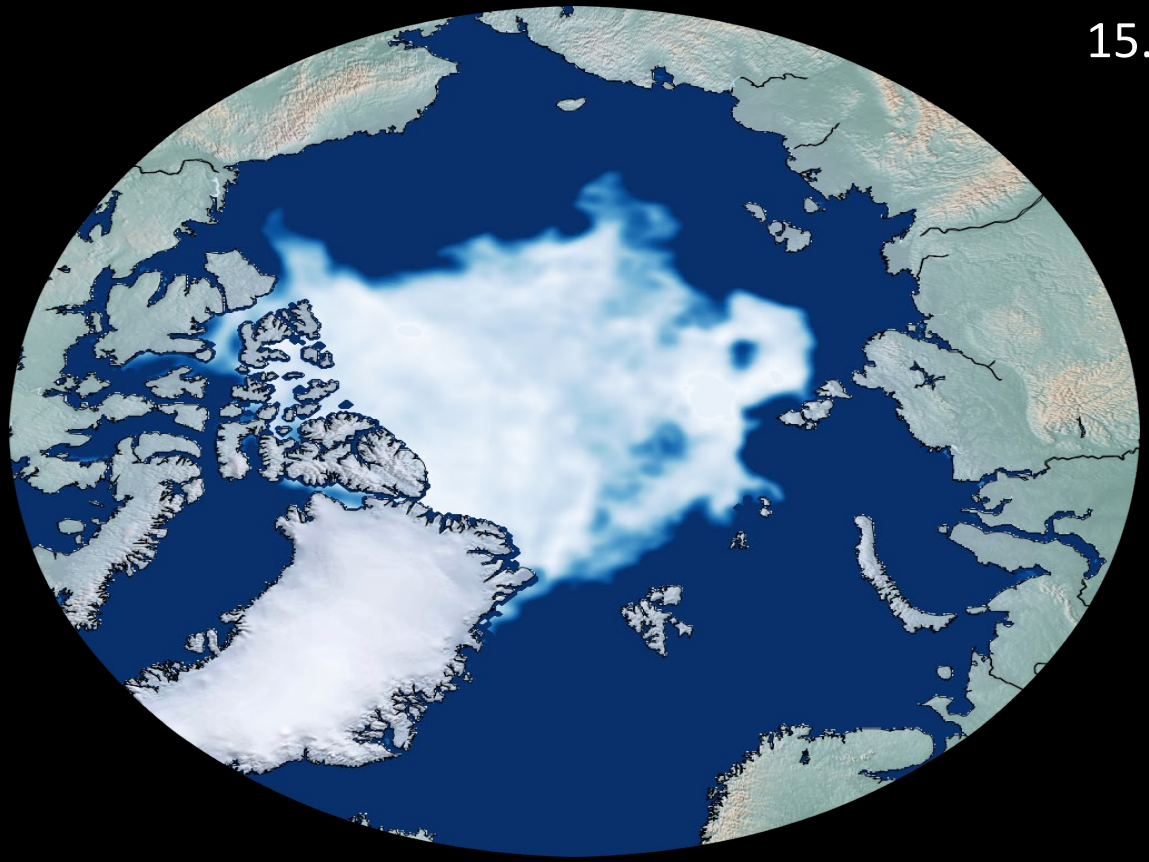
15. September



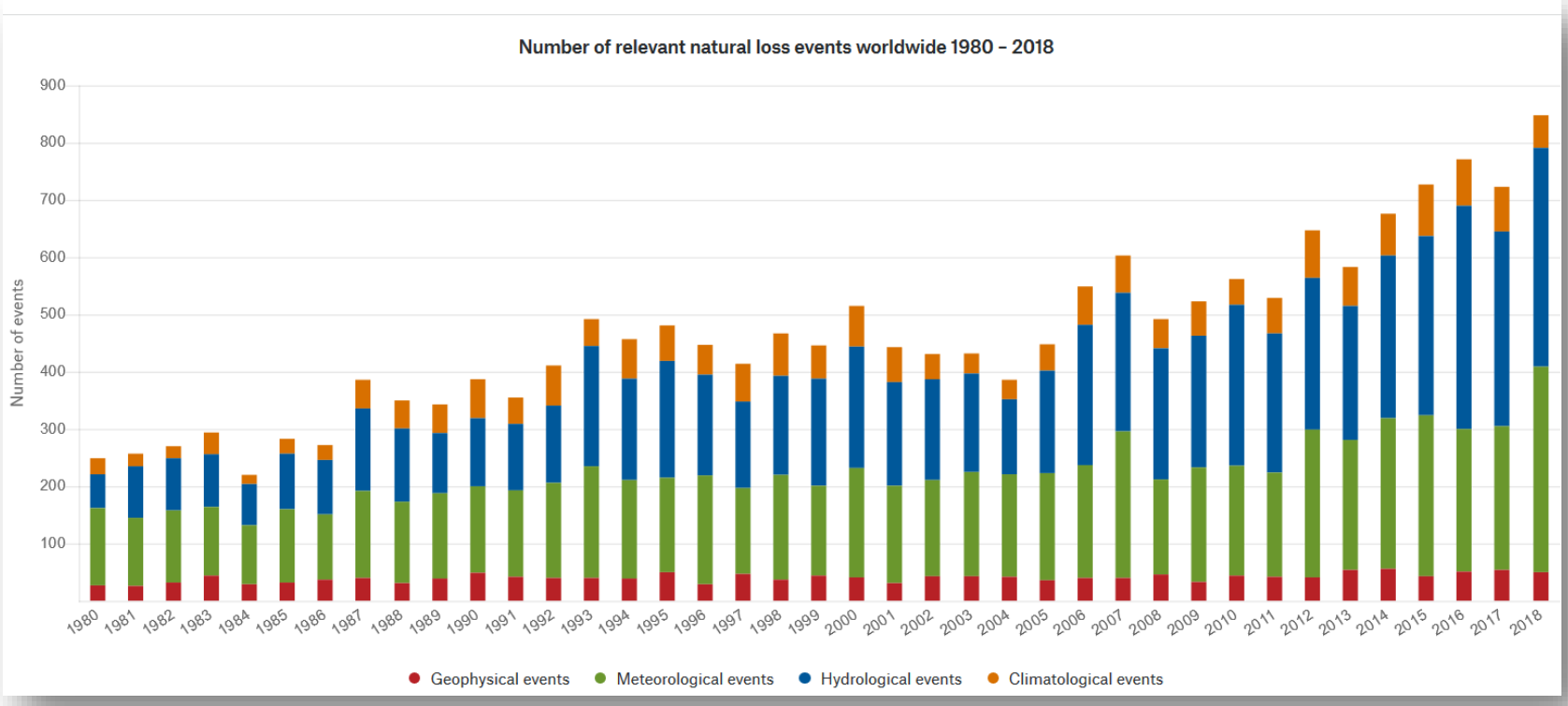
Arctic sea ice

2017

15. September



Number of events worldwide (Munich Re NatCat)



People at risk because of climate change

Intergovernmental Panel on Climate Change (IPCC):

- at least 3.3 billion people's daily lives are "highly vulnerable" to climate change,
- and people are 15 times more likely to die from extreme weather than in years past, the report said.

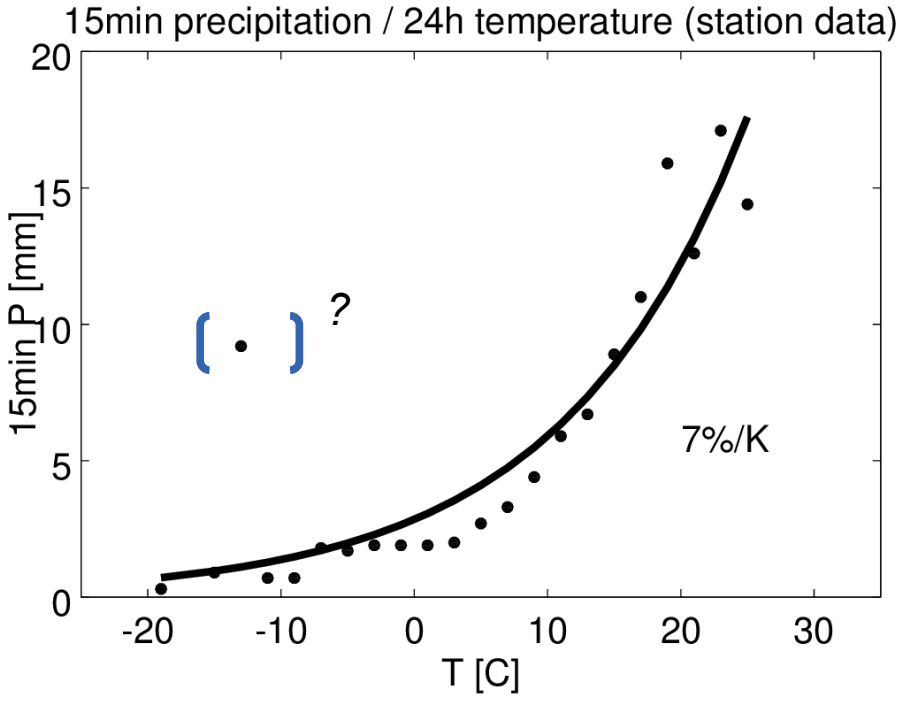
Food production

https://www.ucsusa.org/resources/drought-and-climate-change

Multiple impacts of climate change on food production

Increase of intense precipitation with temperature

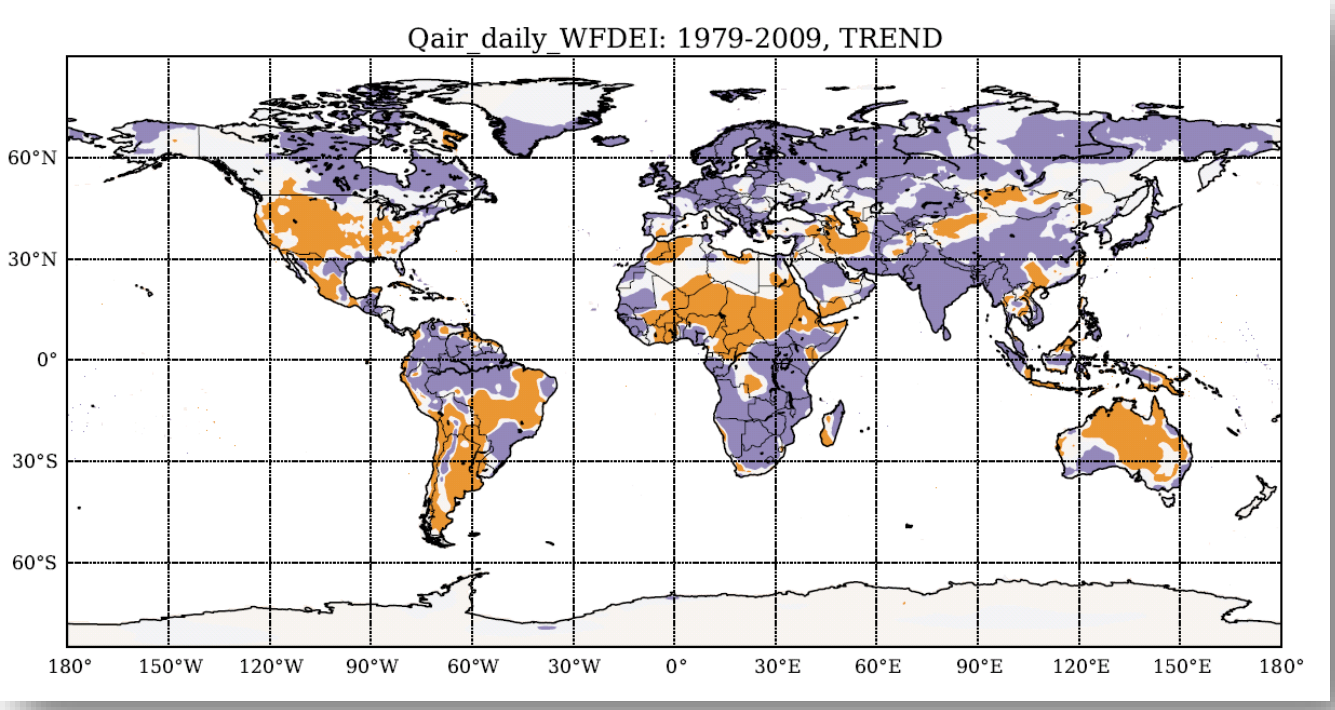
(15min precipitation, 99.9% Quantile, Brixenbachtal, Längental, Ruggbachtal)



Bürger, Uni Potsdam, personal communication

15min

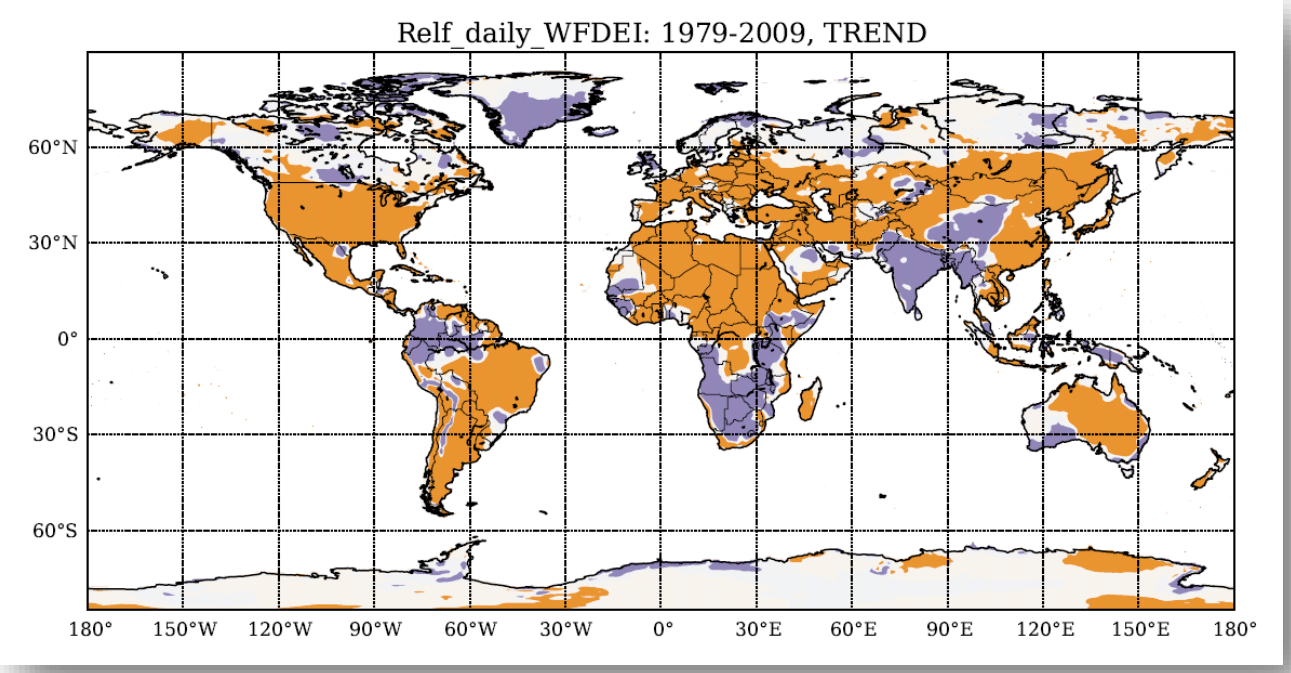
Trend in absolute air humidity



Red: decrease, blue: increase

< -0.2g, 0.0%, >0.2g pro 30y

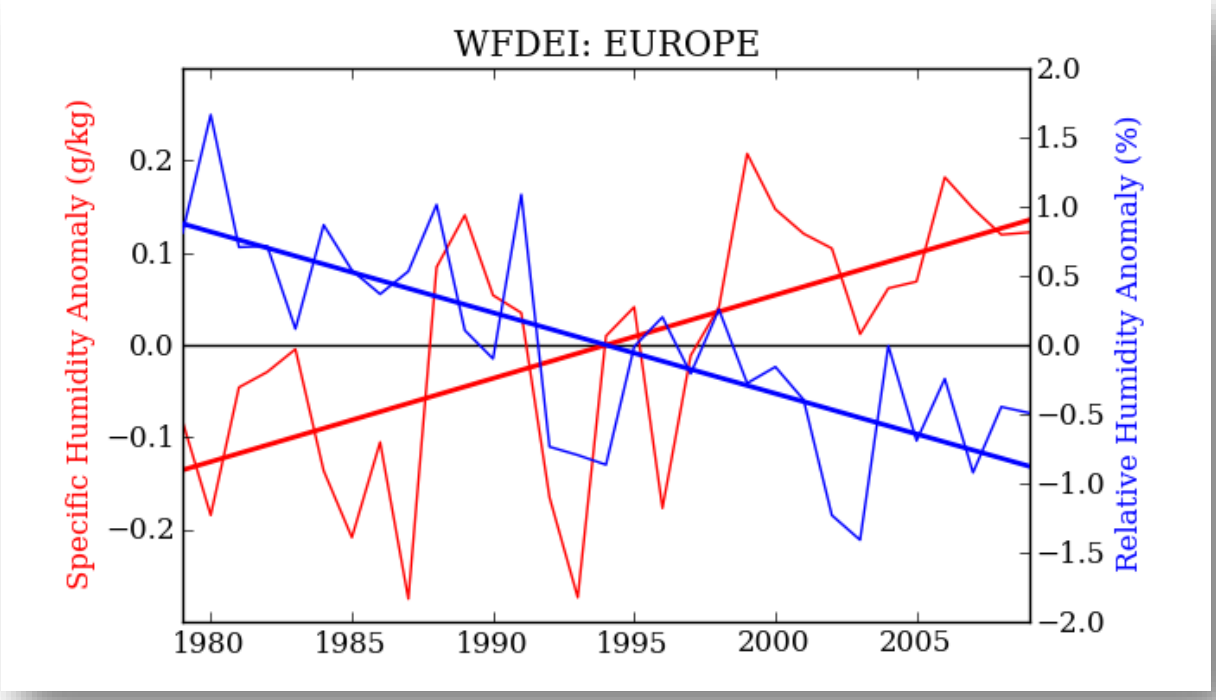
Trend in relative air humidity



Red: decrease, blue: increase

< -0.2g, 0.0%, >0.2g pro 30y

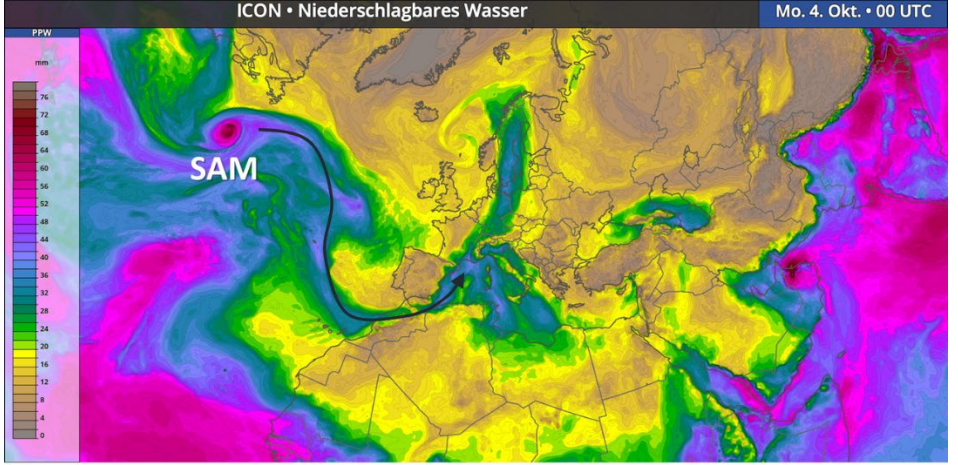
Trends in relative and absolute humidity in Europe



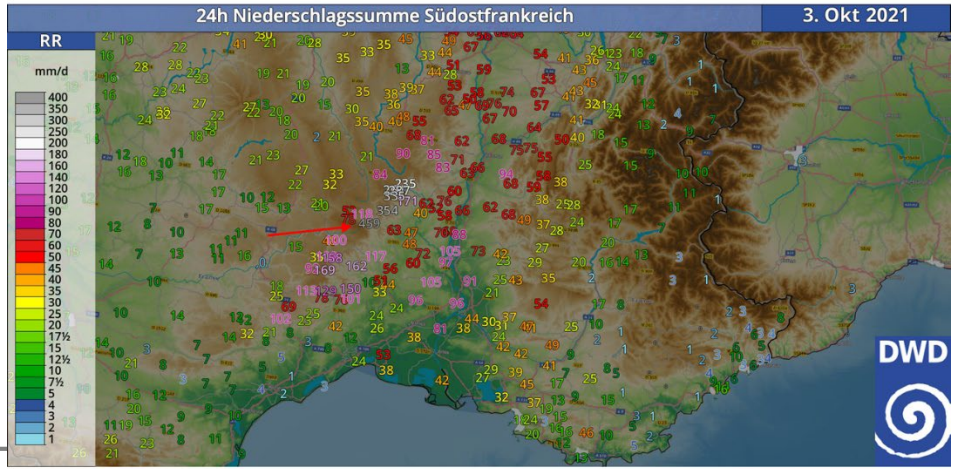
How extreme are extremes?

DWD: “Deluge at the Mediterranean Sea":

- "... Once connected, this low off Norway was able to pump more and more humidity from hurricane "SAM" across the Atlantic, a so-called atmospheric flow. With a newly formed trough on the Atlantic, this flow moved visibly southwards, so that the moisture could reach the Mediterranean. ...“
- E.g. in Villefort: 459 l/m² within 24 hours, of which 251 l/m² within 6 hours.
- The record is probably held by the station in Rossiglione with a breathtaking 848 l/m² in 24 hours - a value beyond any other usual scale. 700 l/m² of this fell within 12 hours.
- Other stations on the eastern edge of the Massif Central recorded precipitation totals of well over 100 l/m² in 24 hours.



Atmosphärisches Feuchteflussband im Modell ICON von Hurrikan „SAM“ Richtung Mittelmeerraum und Zentraleuropa am 3./4.10.2021

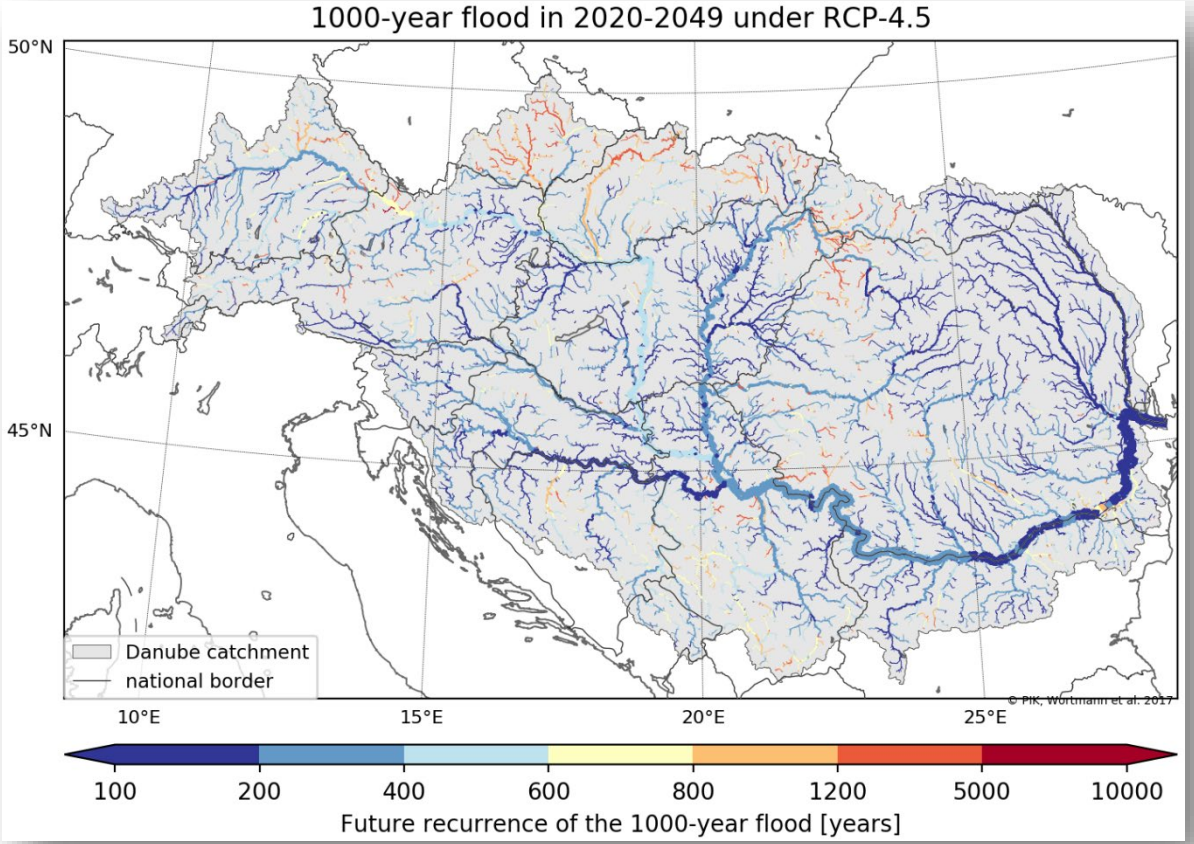


24-stündige Niederschlagssumme vom 3.10.2021 am Zentralmassiv mit 459 l/m² in der Spitze und verbreiteter über 100 l/m².

https://www.dwd.de/DE/wetter/thema_des_tages/2021/10/5.html

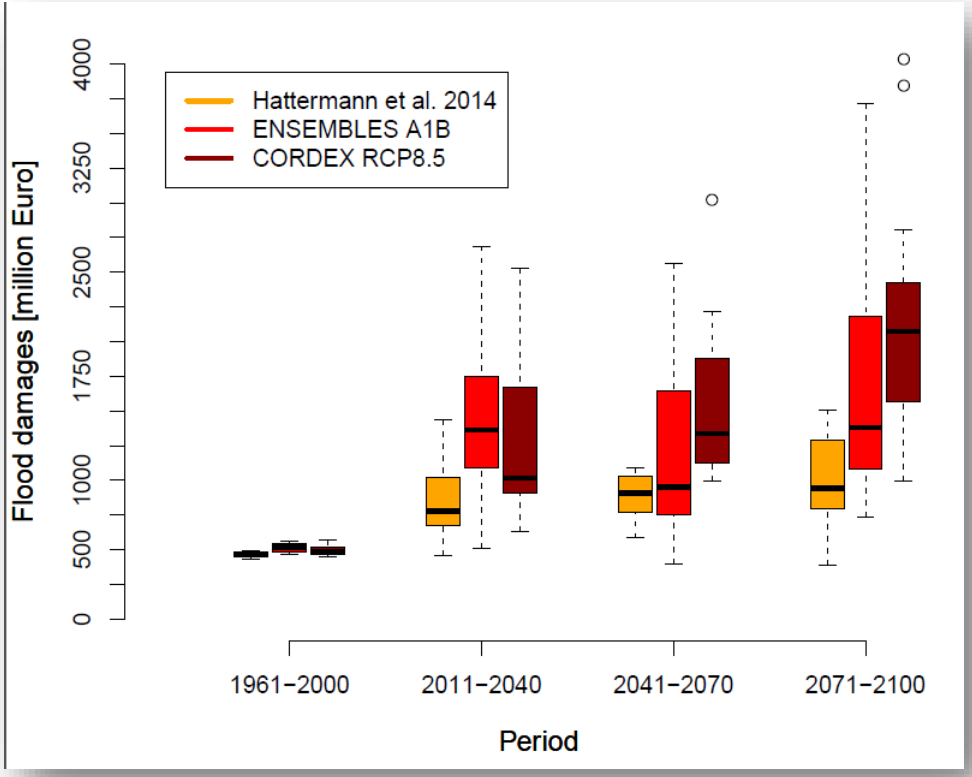
The future reoccurrence of the historical 1000-year flood

RCP4.5, 2020-2049



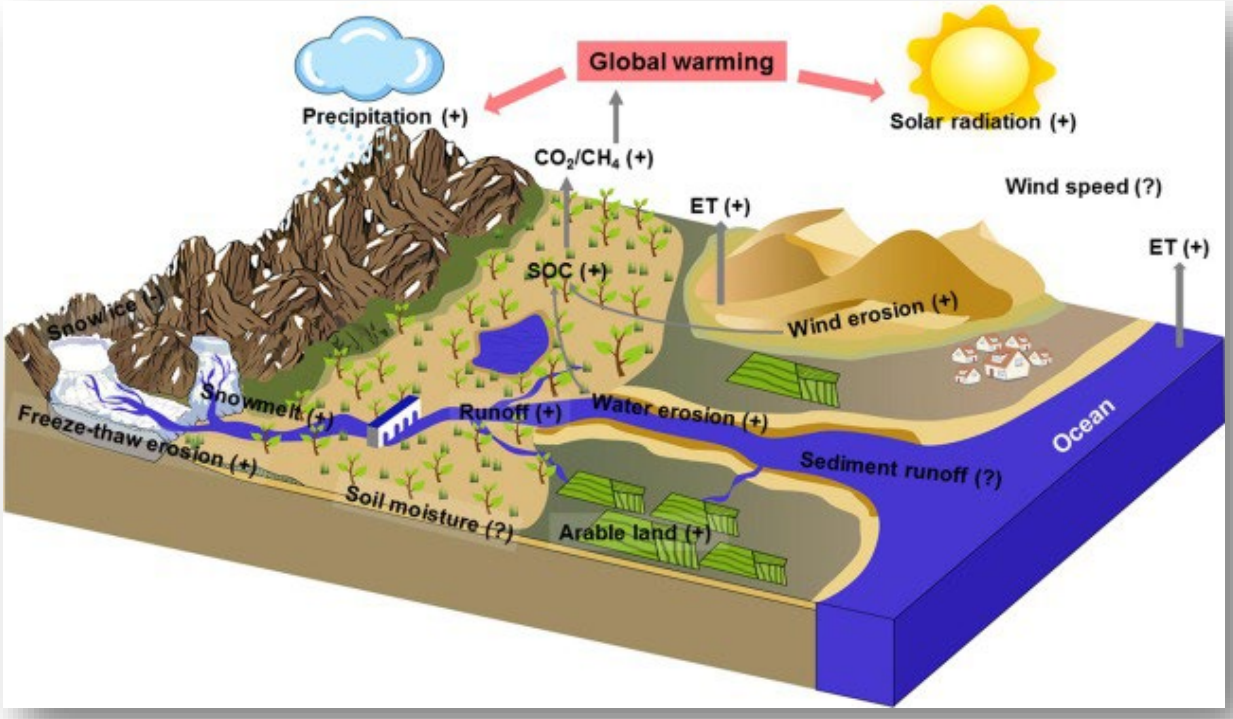
Hattermann et al. 20

Climate change impacts on flood damages



Source of damage functions: German Insurance Association (GDV), modelled at PIK, Hattermann et al. 2017

Climate change impact on erosion



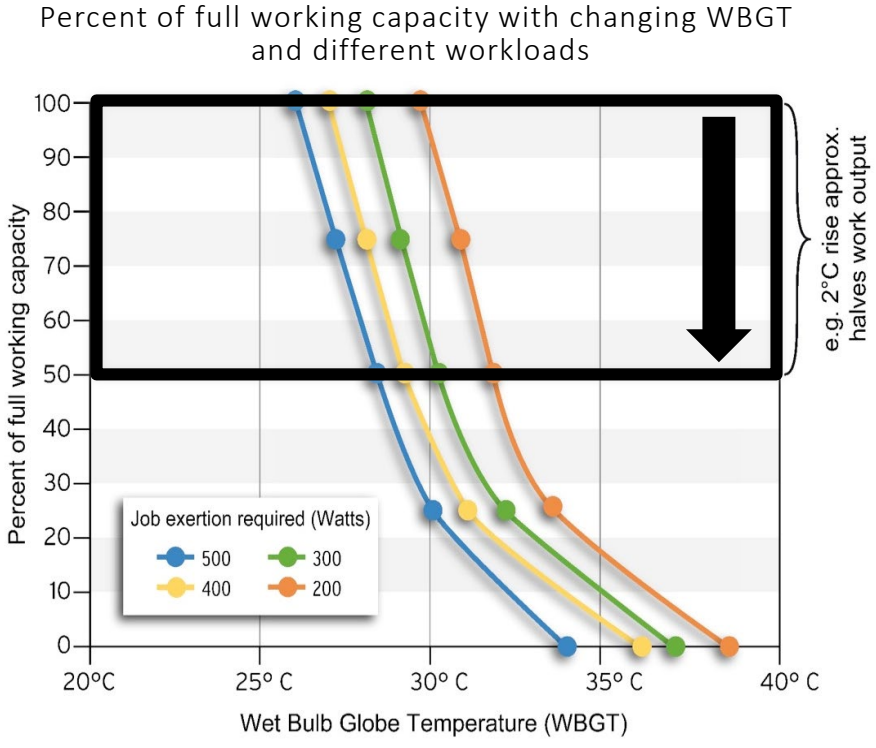
Possibly more erosion because:

- **Heavier precipitation;**
- **Droughts destroy vegetation cover;**
- **More wind erosion;**

Fred Hattermann

Ma et al. 2021, Science

Heat impacts on health and productivity



Glasgow Cop26
Climate Change Summit 2021

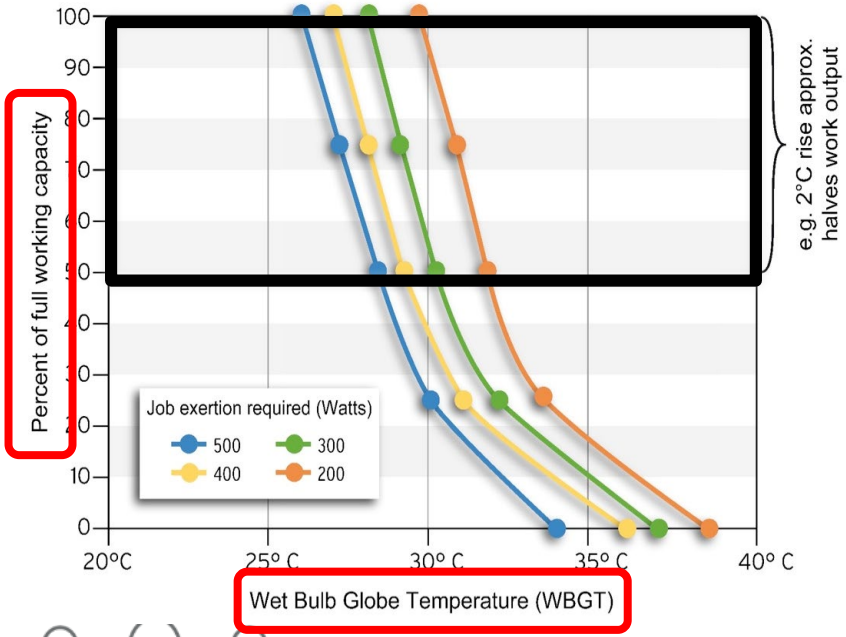
HEAT STRESS – P4

To evaluate the impact of **increased WBGT** on/in:

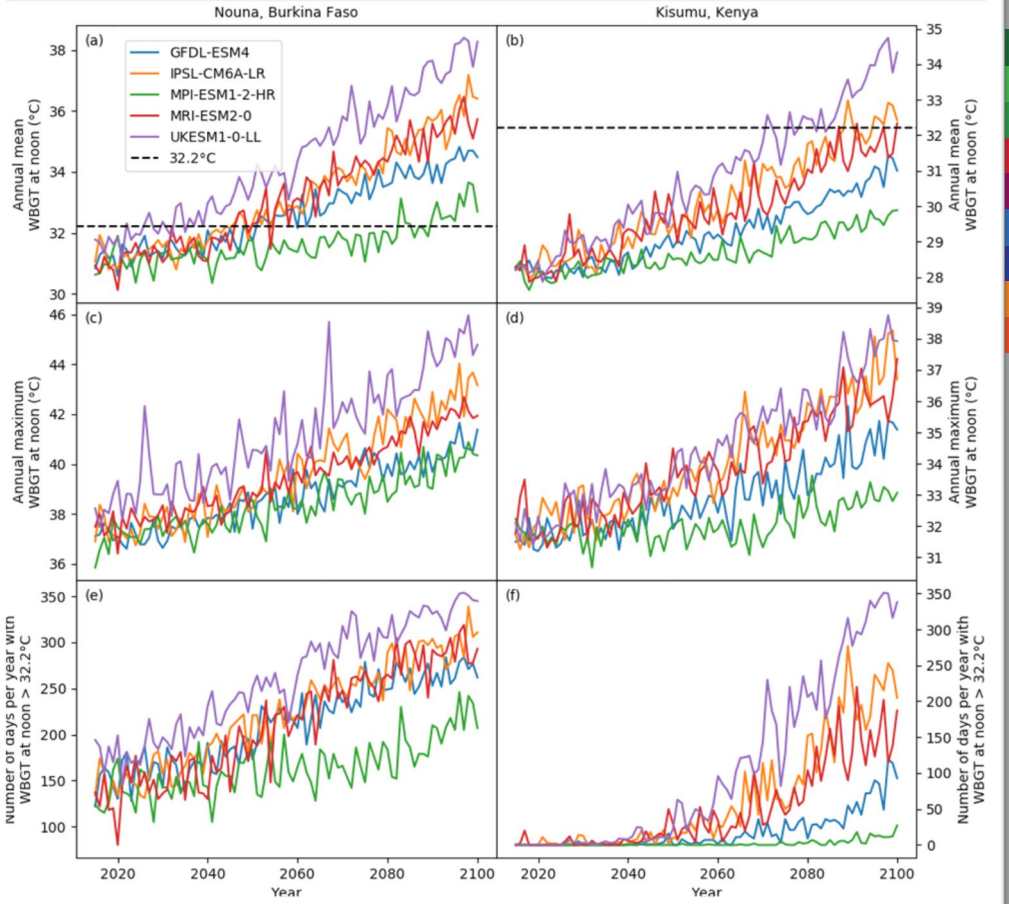
- Activity level –labour capacity **subsistence farmers***
- At low and moderate altitude
- During different seasons
- Working indoor and outdoor
- **Men** and w**omen** (**N* =120; 2x30 Nouna, 2x30 Siaya)

Linking climate impact

Percent of full working capacity with changing WBGT and different workloads



Development of WBGT under climate change



Storms

https://news.uchicago.edu/story/climate-change-will-drive-stronger-smaller-storms-us

Cyclons

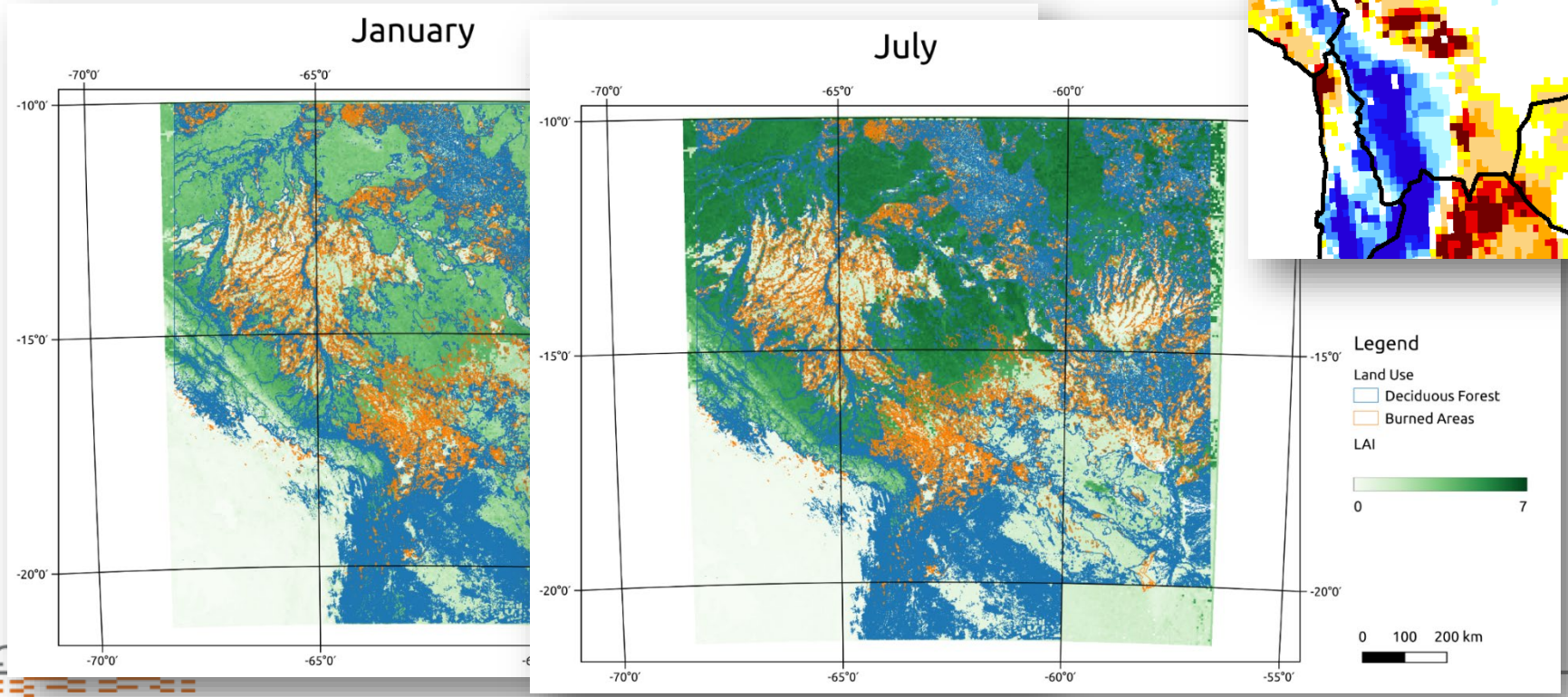
https://www.americanoceans.org/facts/typhoon-vs-hurricane/

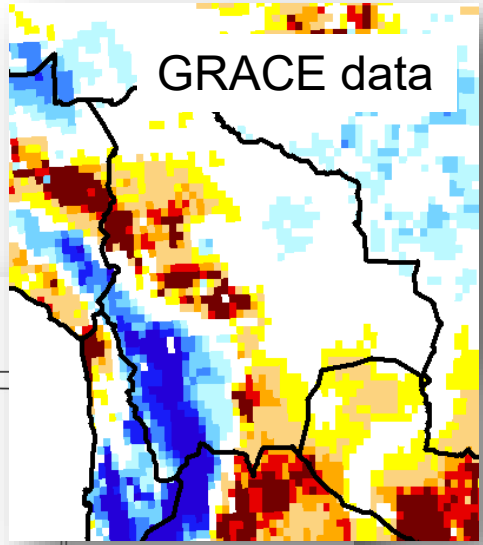
Forest fires

https://www.nhm.ac.uk/discover/does-climate-change-make-wildfires-worse.html

Impacts of forest fires in the Upper Amazon

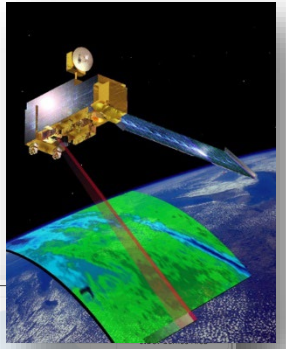
Leaf area index LAI (MODIS satellite data)

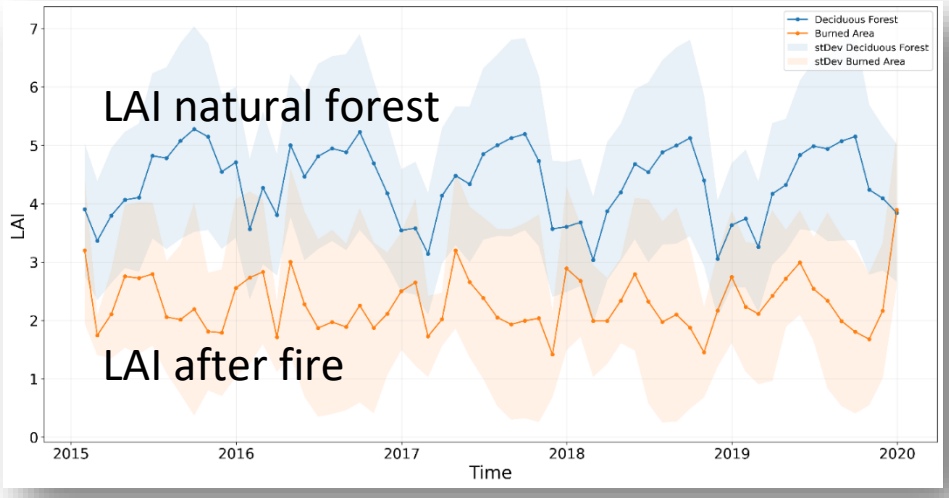


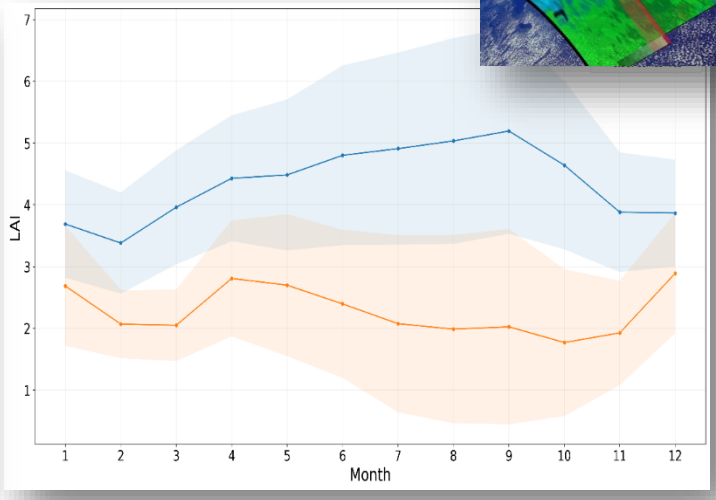


Natural an burned forest areas:

Leaf area index LAI (MODIS satellite data)







- Strong and permanent decrease of vegetation cover
- Highly variable annual course of vegetation cover
- Agriculture?

Consequences of wildfire on the local water balance –

Parametrization of SWIM

- **Leaf area index:** Aus MODIS Satellitendaten.
- **Verbrannte Fläche:** Aus Satellitendaten
- **Geänderte Bodeneigenschaften:** Aus Konstantinos 2018 (rechts).

Estimation of runoff parametrization following forest fires By Konstantinos X. Soulis, DOI: 10.1080/02626667.2018.1501482

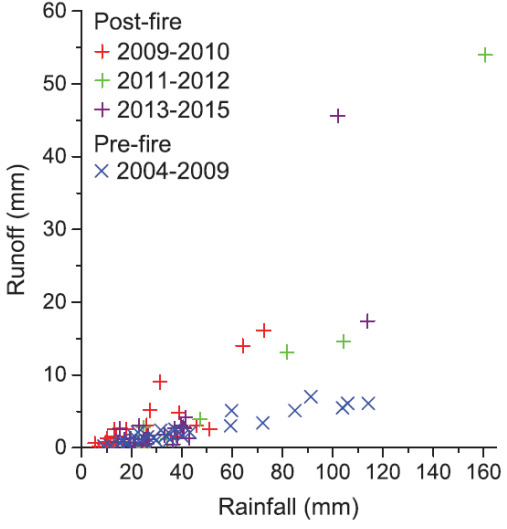


Figure 3. Produced total direct runoff depth *vs* total rainfall depth for the 29 pre-fire and 60 post-fire storm events used in this study. The post-fire events are divided into three chronological sub-groups.

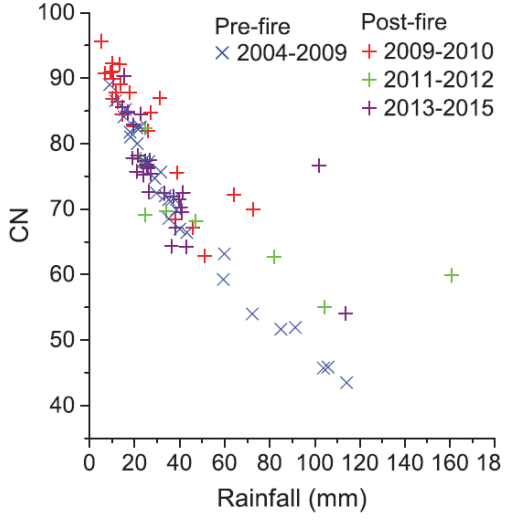
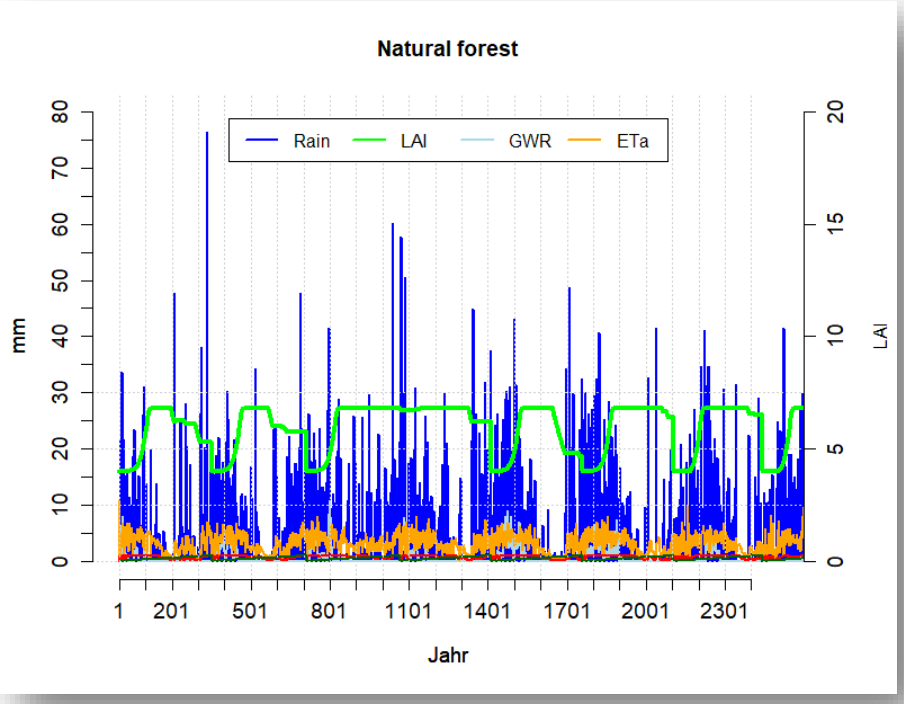
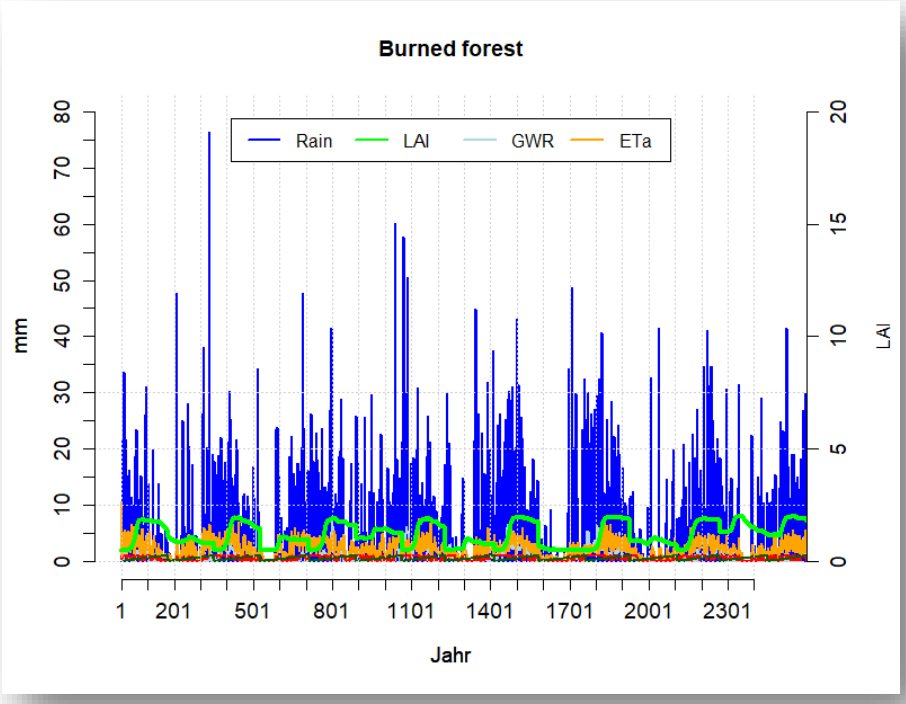


Figure 4. Calculated CN values using Equation (3) for the standard case of $\lambda = 0.2$ plotted against the total rainfall depth for the pre-fire and post-fire periods. The post-fire events are divided into three chronological sub-groups.

SWIM: Water cycle before and after fire



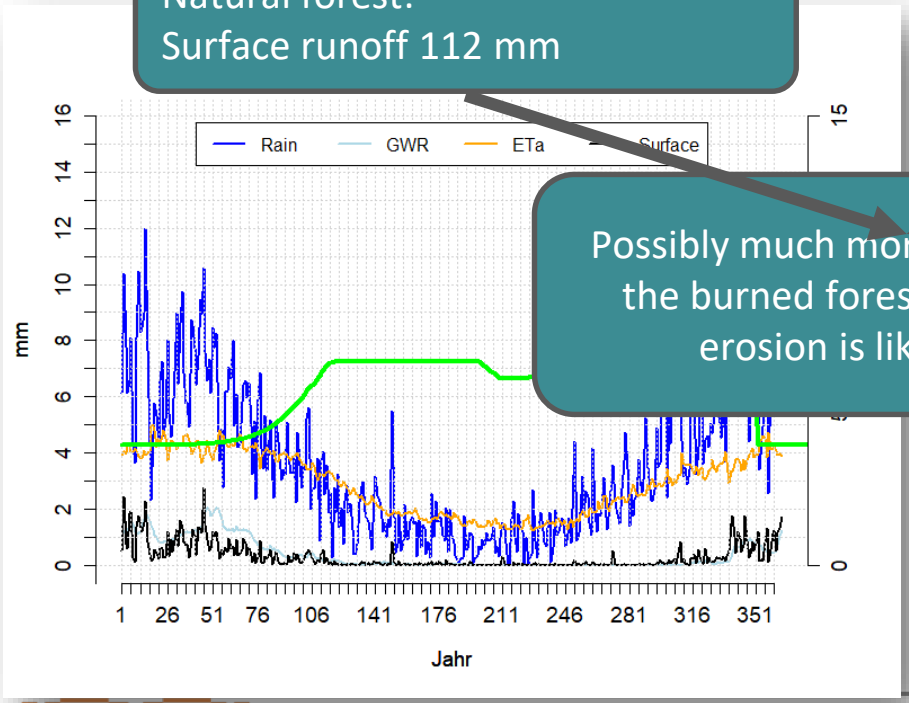


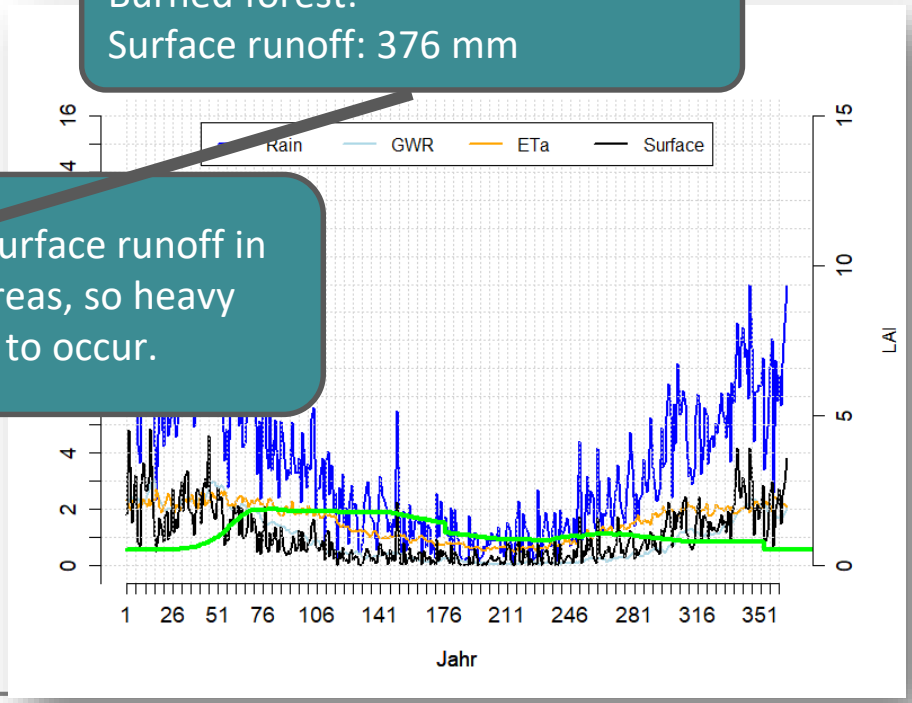
SWIM: Water cycle before and after fire

Natural forest:
Surface runoff 112 mm

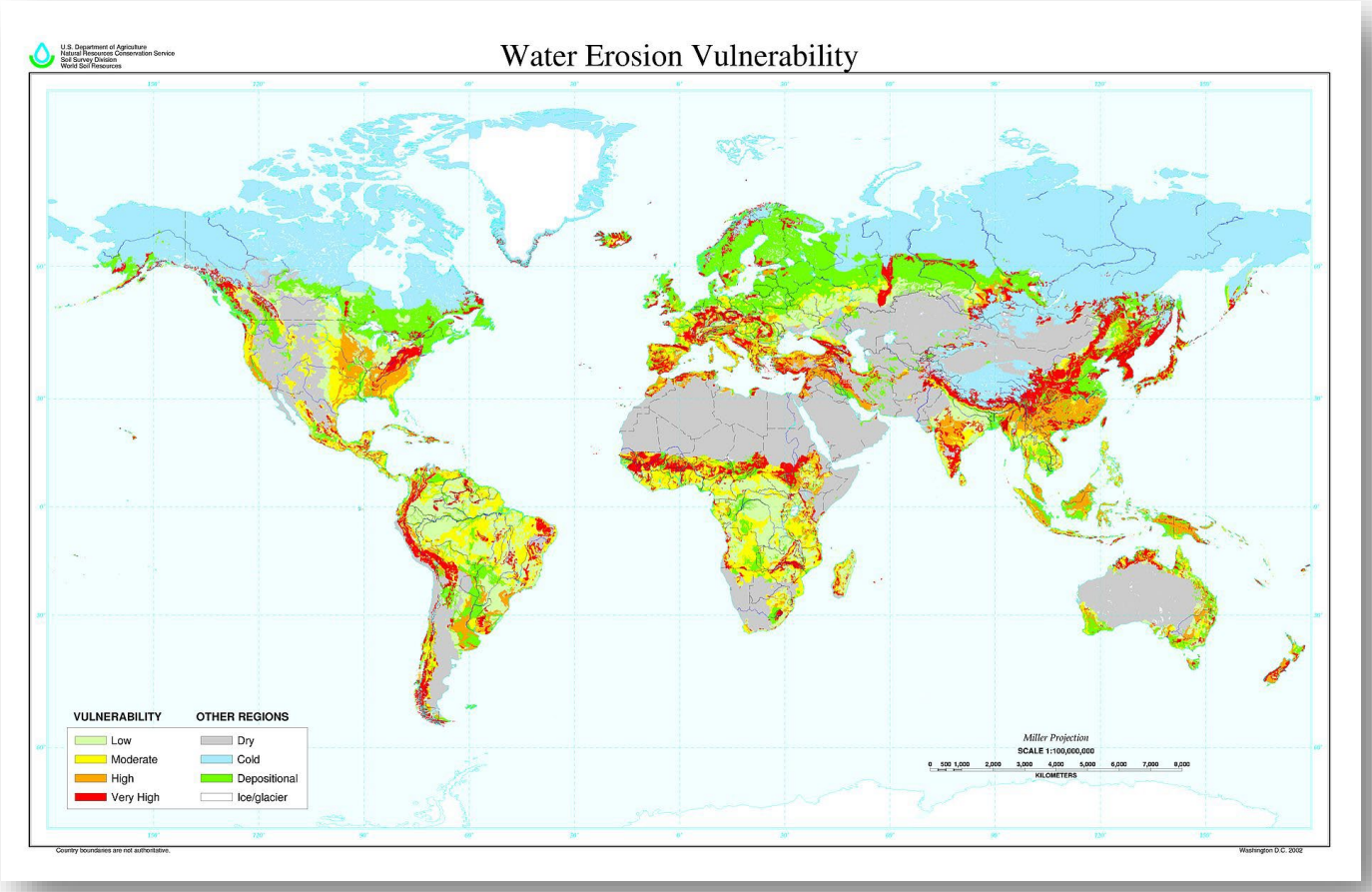
Burned forest:
Surface runoff: 376 mm

Possibly much more surface runoff in the burned forest areas, so heavy erosion is likely to occur.





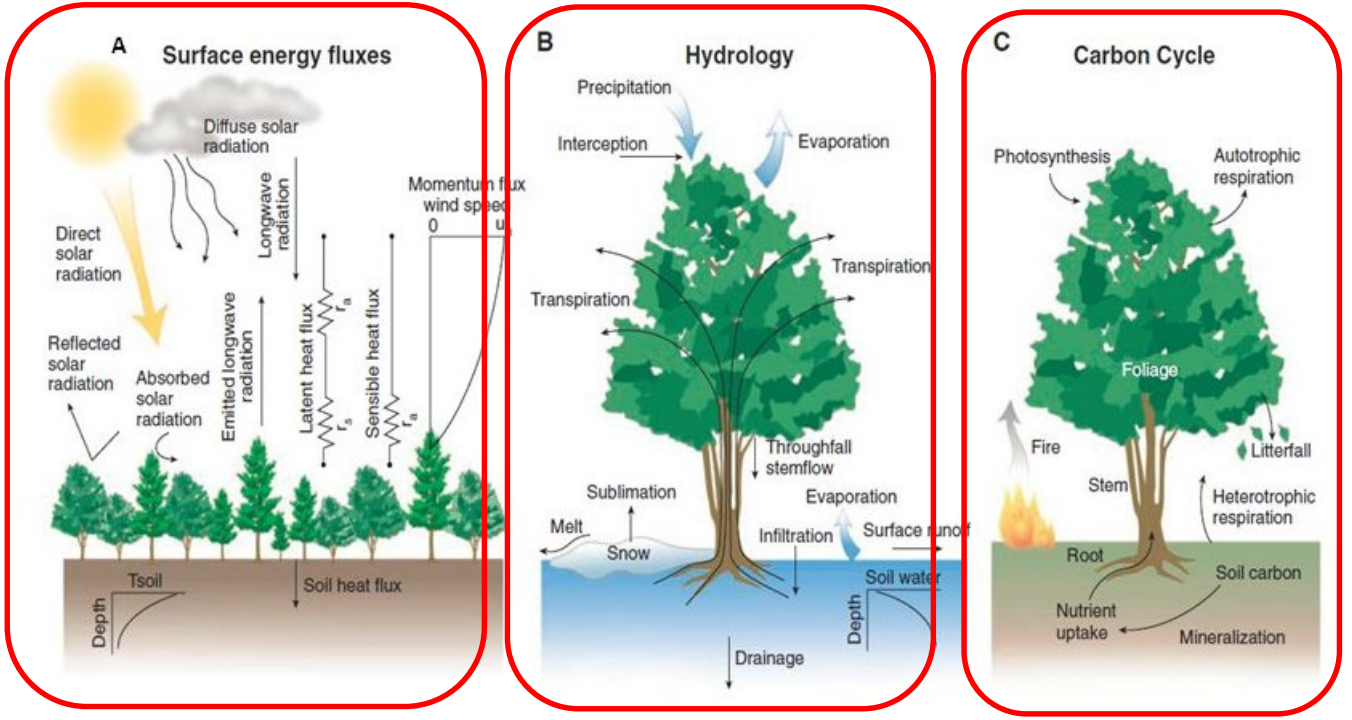
Vulnerable regions



How should a landscape look like / be composed to be climate resilient and still providing basic ecosystem services such as water, food and protection?

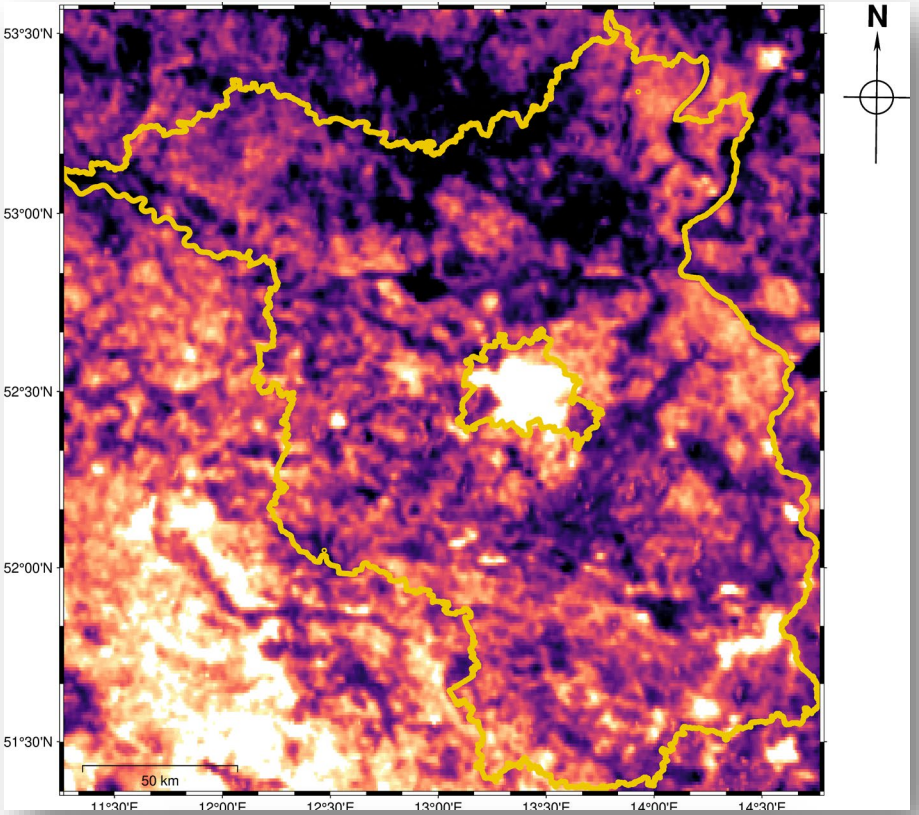
-> **climate landscapes?**

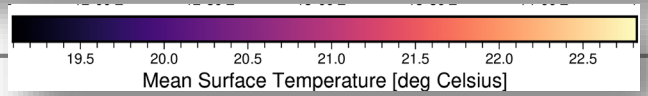
Energy – Water – Carbon

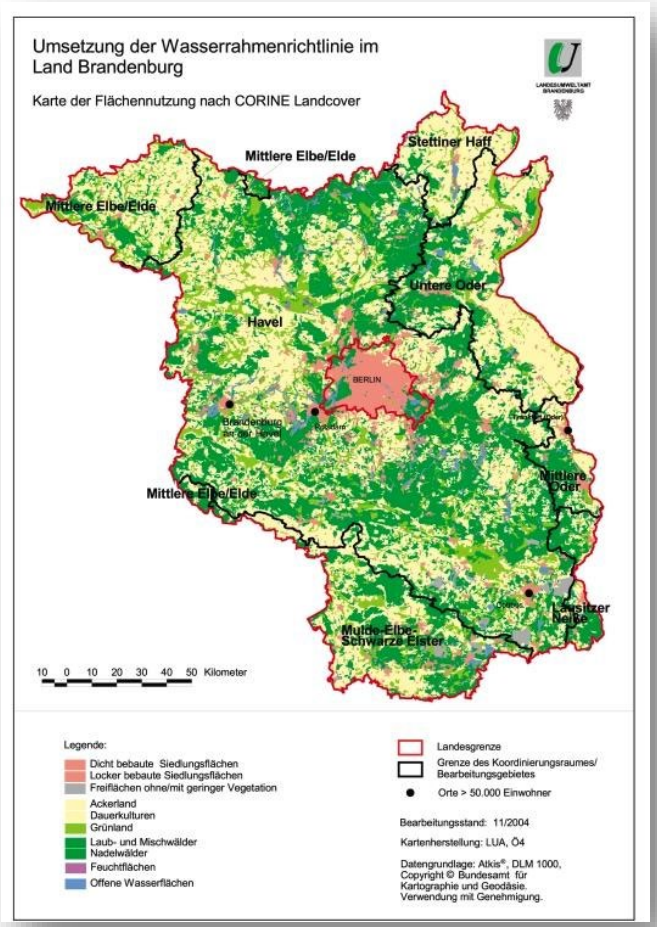


Source. Bonan et al. 2008

Thermal photo (Landsat, August)







UN sustainable development goals