ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Hydro-meteorological extremes in a changing climate

OPERANDUM Summer School

Nature-based Solutions for hydro-meteo hazards and climate change adaptation

29 Aug 2022

Dr. Heikki Tuomenvirta
Finnish Meteorological Institute

EU funded project
GA no. 776848

OPERANDUM

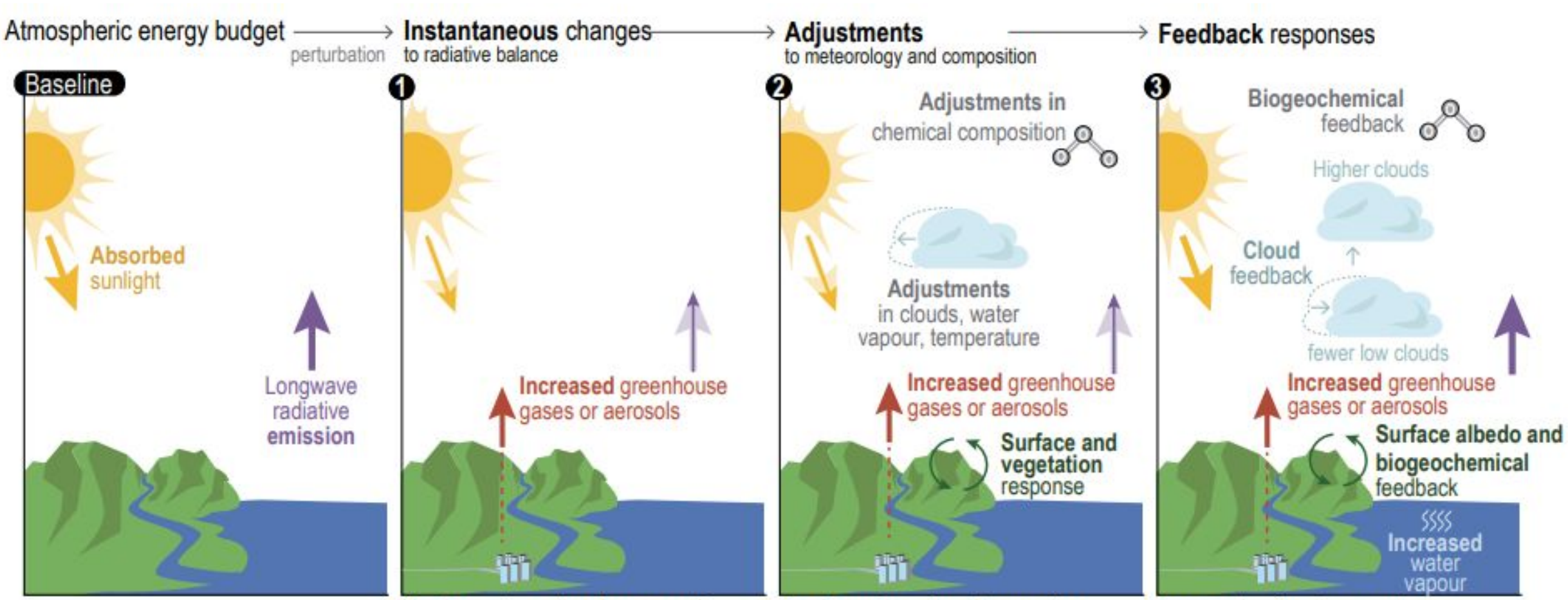
OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

Luke
NATURAL RESOURCES INSTITUTE FINLAND

#NatureIsTheSolution

IPCC AR5: ”human influence on climate system is clear”

AR6: now an established fact”



PRINCIPLES OF IPCC

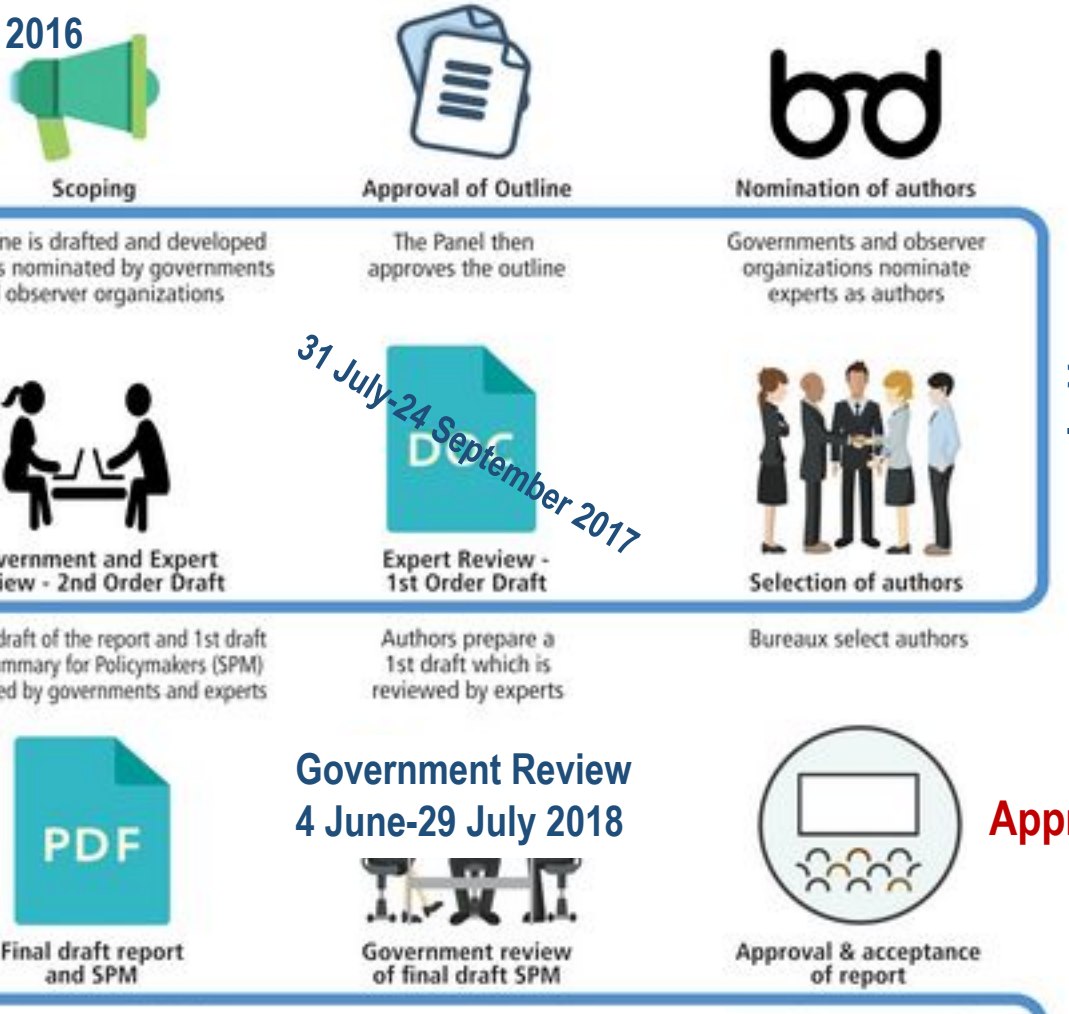
The work of the IPCC must be policy-relevant and policy-neutral, but never policy-prescriptive

- **COMPREHENSIVE** – all the latest relevant scientific, technical and socio-economic literature published woldwide is assessed
- **BALANCED** – differing views are reflected in the reports
- **OPEN** – selection of authors from all countries and relevant discipline, wide review process by experts and governments
- **TRANSPARENT** – strict clear procedures
- **RIGOUR** – scientific accuracy in analysis and interpretation

HOW IPCC RAPORT IS PREPARED?

Global Warming of 1.5°C

Aug 2016



>560 nominations
-> 89 selected

Government and Expert Review 8 Jan-25 Feb 2018

Papers acepted by April 2018

Government Review 4 June-29 July 2018

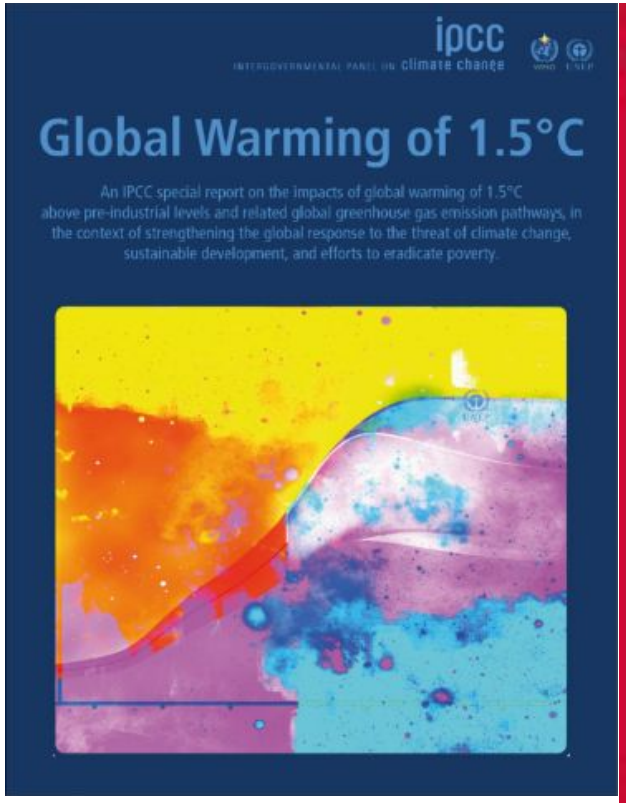
Approval and acceptance 1-7 October 2018

"The review process is essential for the quality of IPCC assessment reports. The first round of review was extremely successful, with nearly 13,000 comments from almost 500 expert reviewers in over 60 countries“

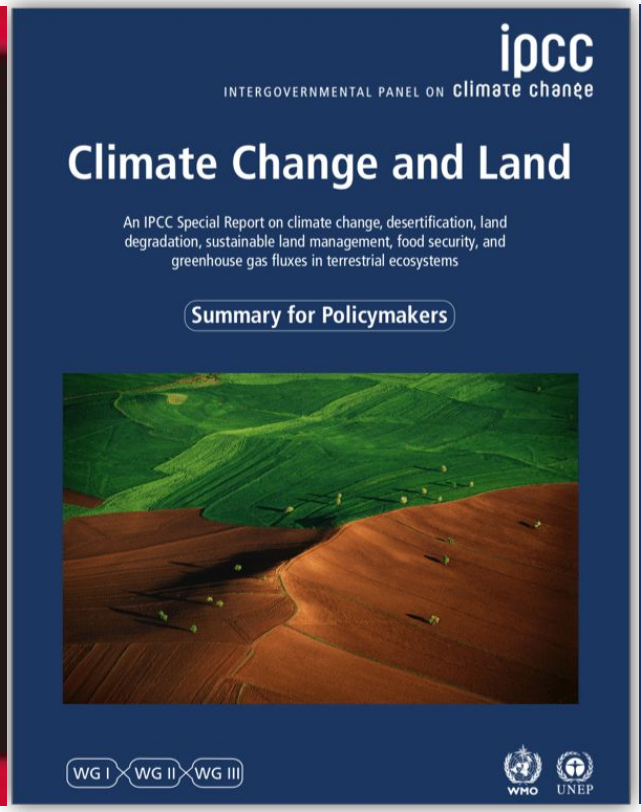
Valérie Masson-Delmotte, WG1 Co-Chair

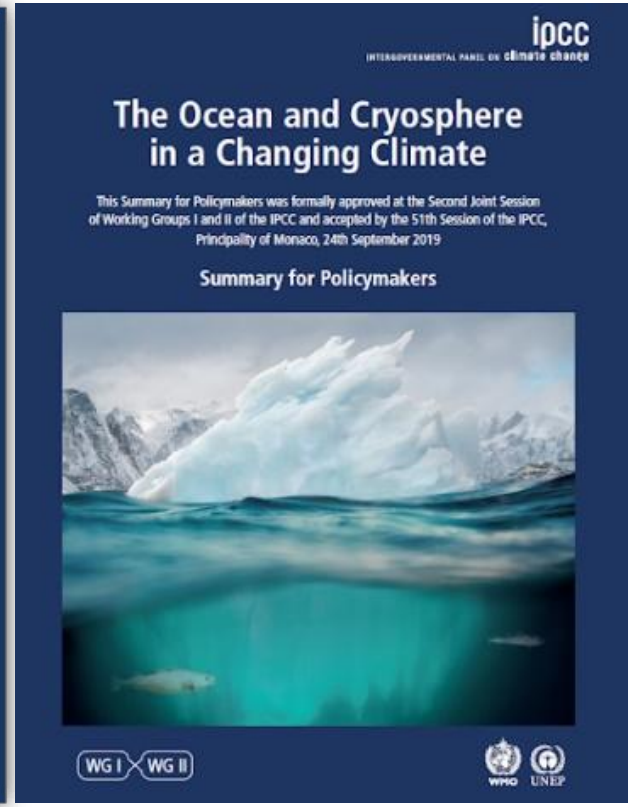
OPERANDUM

ASSESSMENTS ARE IPCC'S MAIN PRODCUTS 1/2



2019 Refinement *to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*

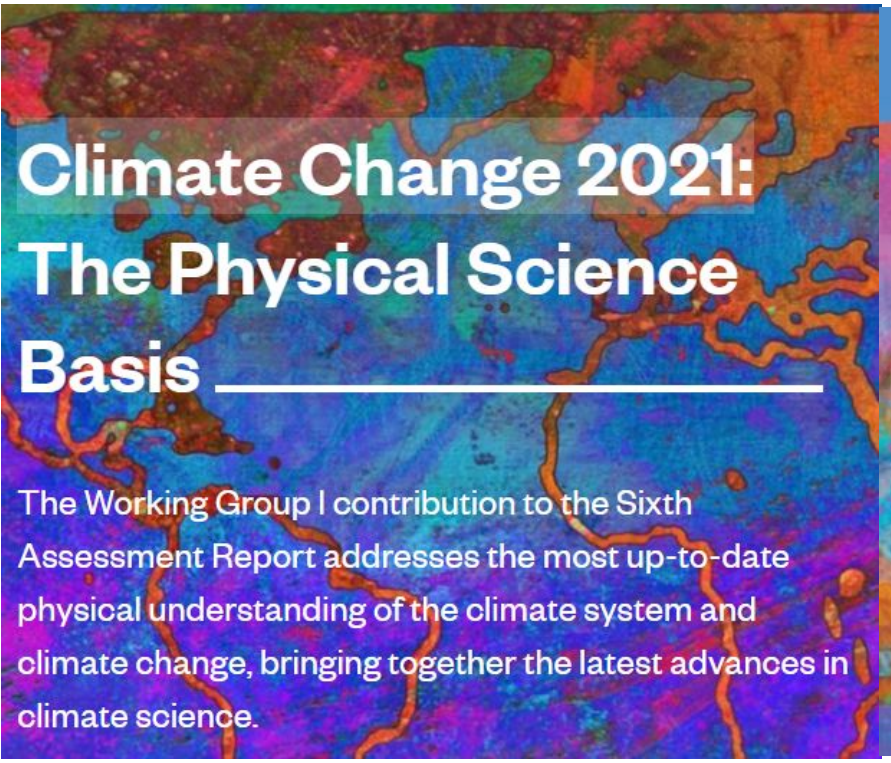




OPERANDUM

ASSESSMENTS ARE IPCC'S MAIN PRODCUTS 2/2

Working Group 1

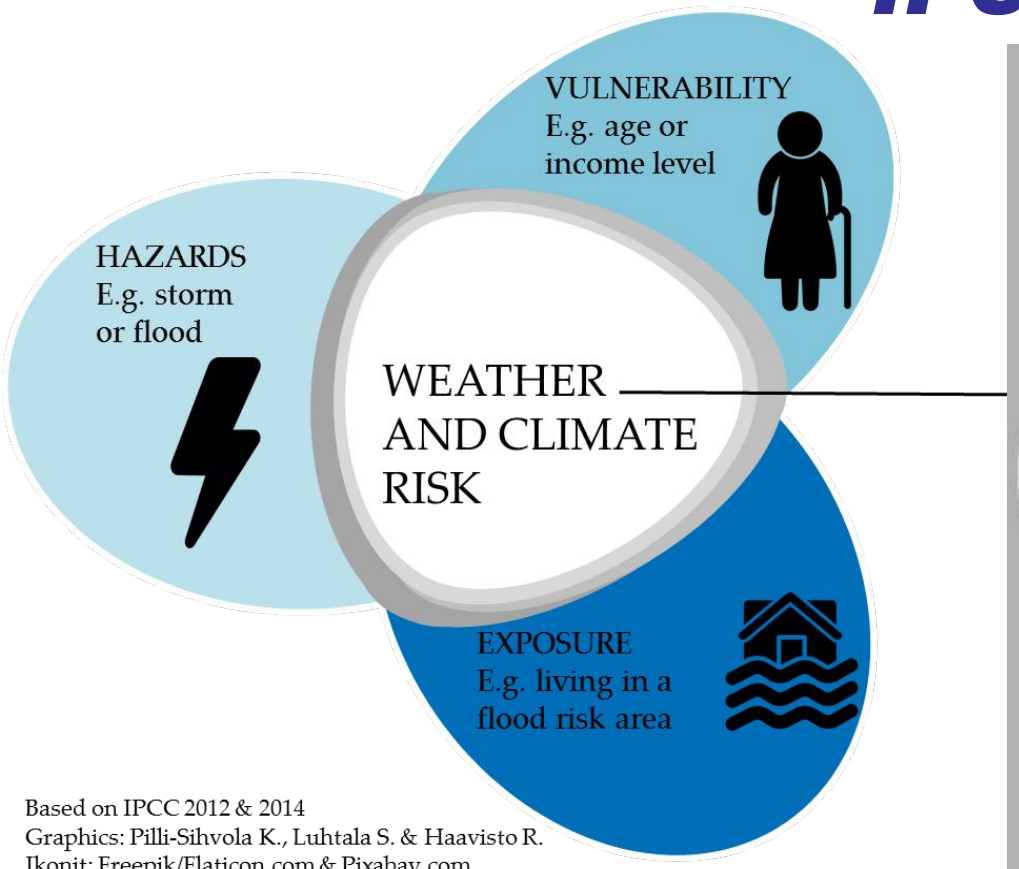


Working Group 2

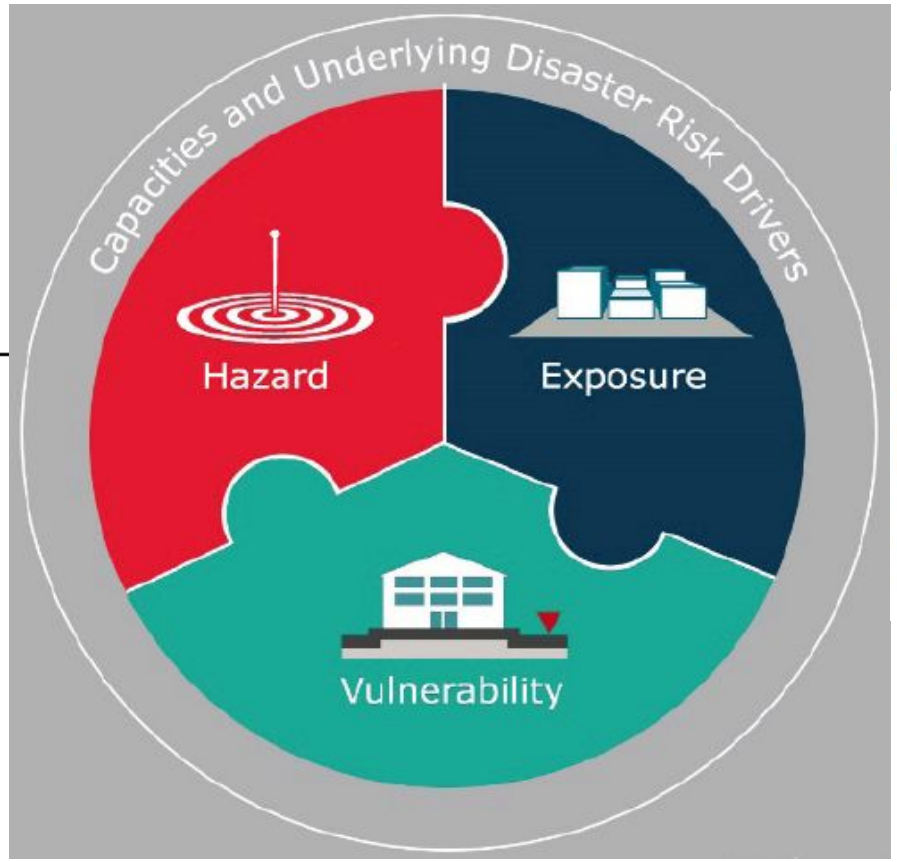
Working Group 3

Hydro-meteo risk framework used in OPERANDUM is compatible for climate change adaptation and disaster risk management

IPCC & UNISDR



Based on IPCC 2012 & 2014
Graphics: Pilli-Sihvola K., Luhtala S. & Haavisto R.
Ikonit: Freepik/Flaticon.com & Pixabay.com.



UNISDR
United Nations Office for Disaster Risk Reduction

National Disaster Risk Assessment

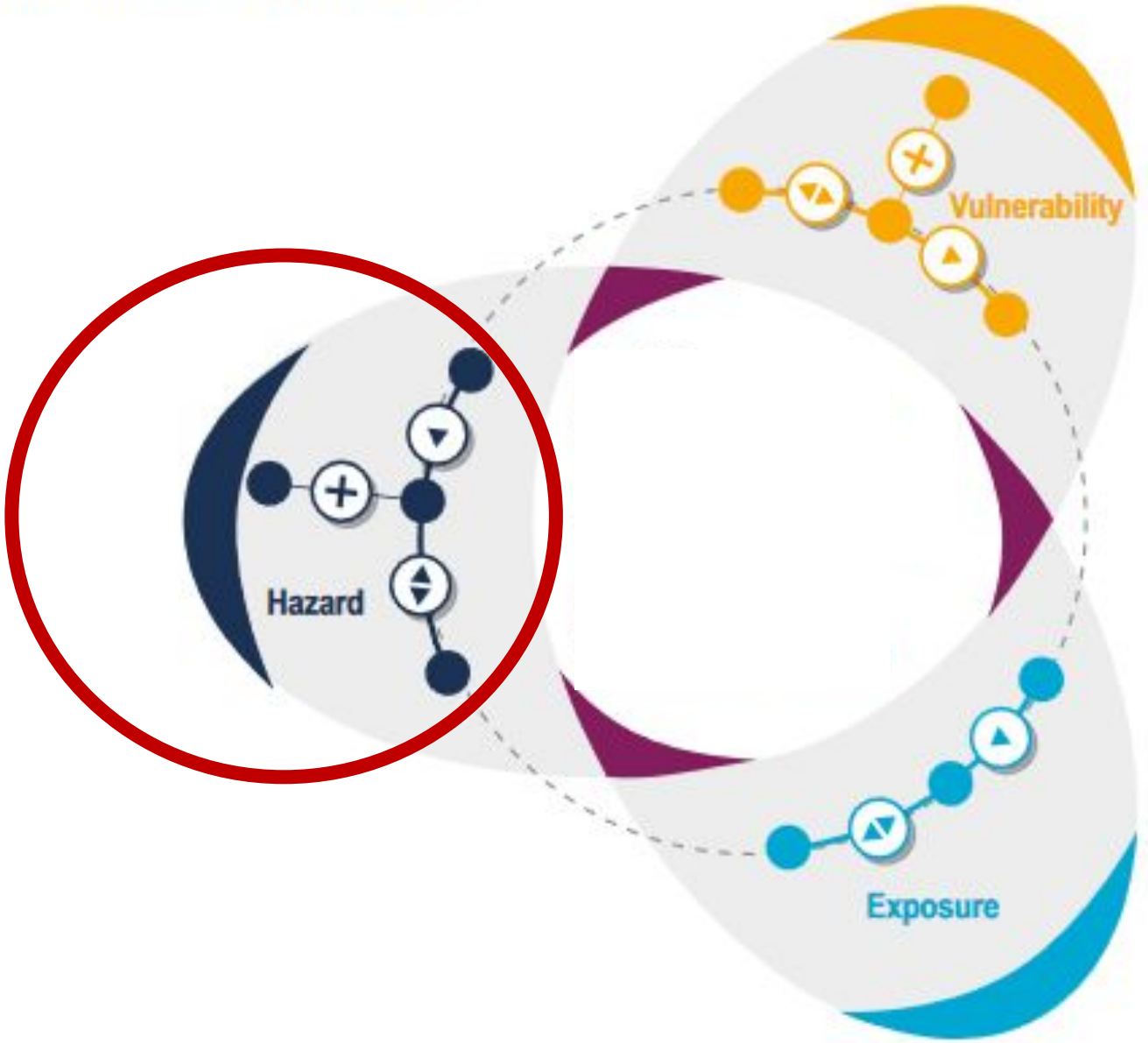
In support of the Sendai Framework for Disaster Risk Reduction 2015 - 2030

OPERANDUM

FOCUS ON HAZARDS – connections between risk factors

(b) AR6 additions: response risk and complexity

”RISK PROPELLER” provides framework for research of risks determinants and design of measures to manage risks.



Differential role of risk determinants for risk related to impacts, adaptation, and vulnerability versus risk related to mitigation becomes an increasingly important feature of climate risk assessment as well as management.

EU funded project
GA no. 776848

IPCC AR6 WG1 Glossary

HAZARD: The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. See also Impacts and Risk.

EXPOSURE: The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

VULNERABILITY: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. See also Exposure, Hazard and Risk.

SCENARIOS

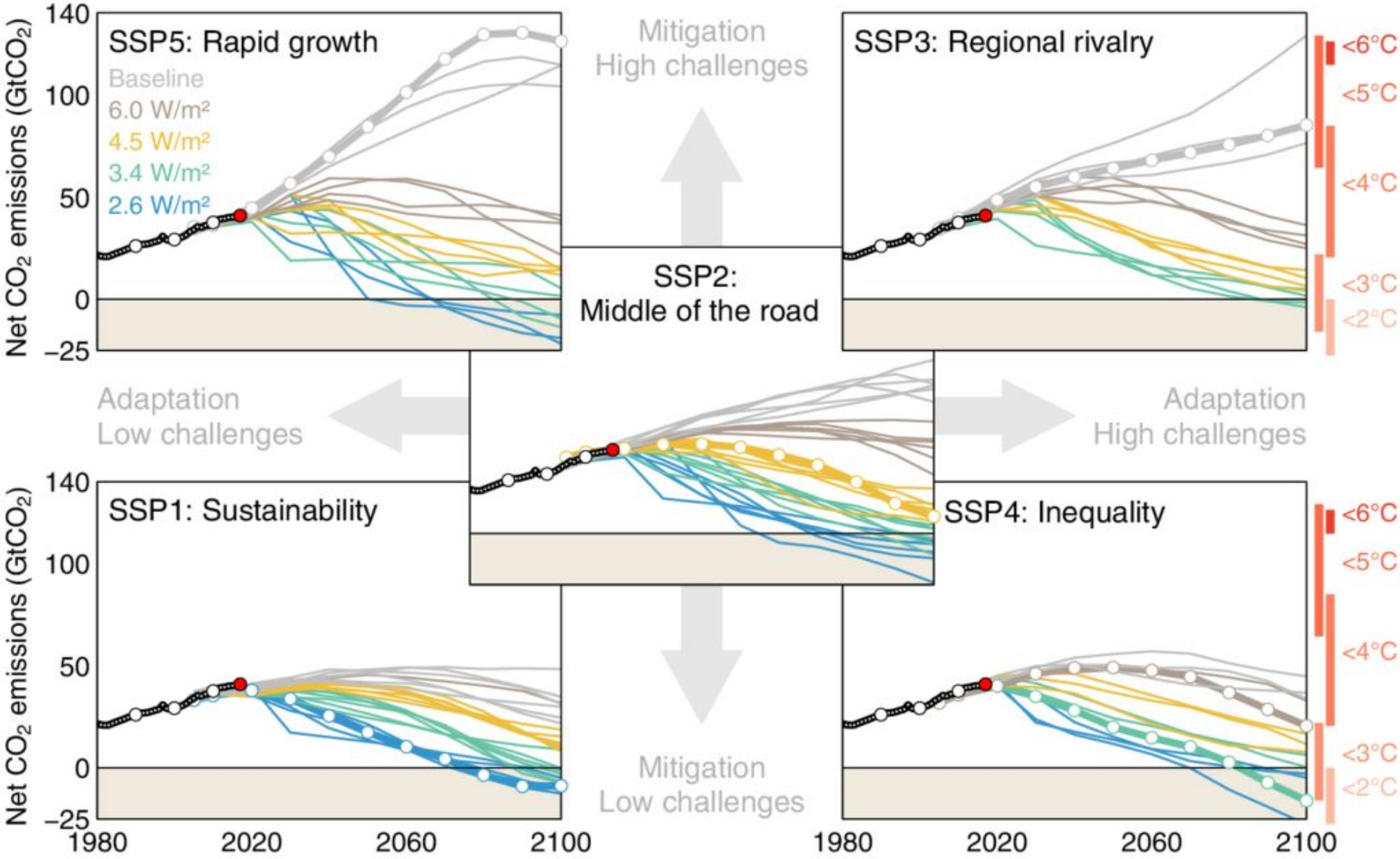
Scenario. A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technological change, prices) and relationships.

Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions in a ‘what-if’ kind of investigation. Term ‘scenarios’ is often used to encompass ‘pathways’.

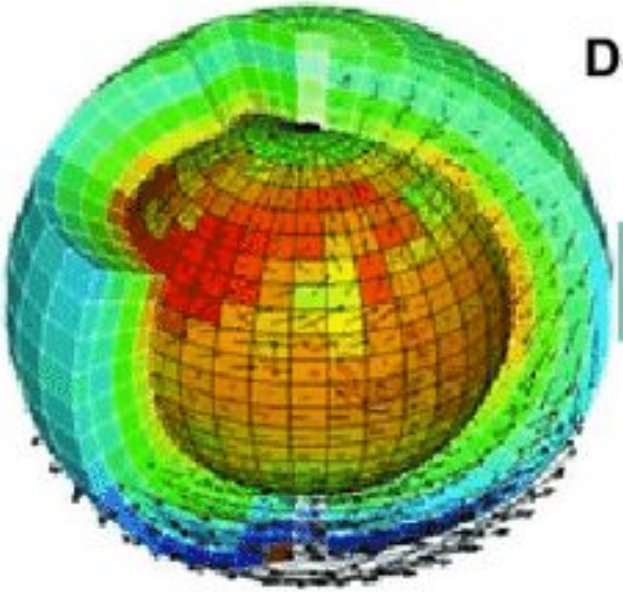
Emission scenario …future development of emissions of substances that are potentially radiatively active (e.g. greenhouse gases, aerosols), plus human-induced land cover changes that can be radiatively active via albedo change..

Concentration scenario … future development of atmospheric concentrations of substances that are potentially radiatively active…

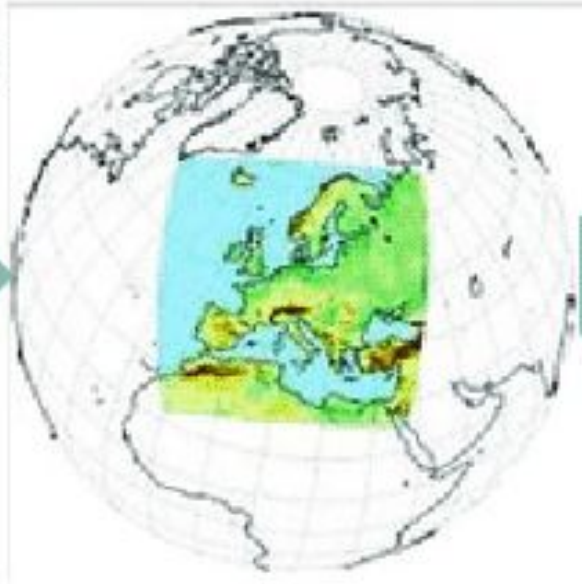
Socio-economic scenario …population, gross domestic product, and other socioeconomic factors ..


SSP5: Rapid growth
Baseline
6.0 W/m²
4.5 W/m²
3.4 W/m²
2.6 W/m²
Mitigation
High challenges
SSP3: Regional rivalry
<6°C
<5°C
<4°C
<3°C
<2°C
SSP2:
Middle of the road
Adaptation
Low challenges
Adaptation
High challenges
SSP1: Sustainability
SSP4: Inequality
Mitigation
Low challenges
Net CO2 emissions (GtCO2)
140
100
50
0
−25
1980
2020
2060
2100

Regional climate projections



Downscaling



Impact modeling

Global climate model (100–300 km)

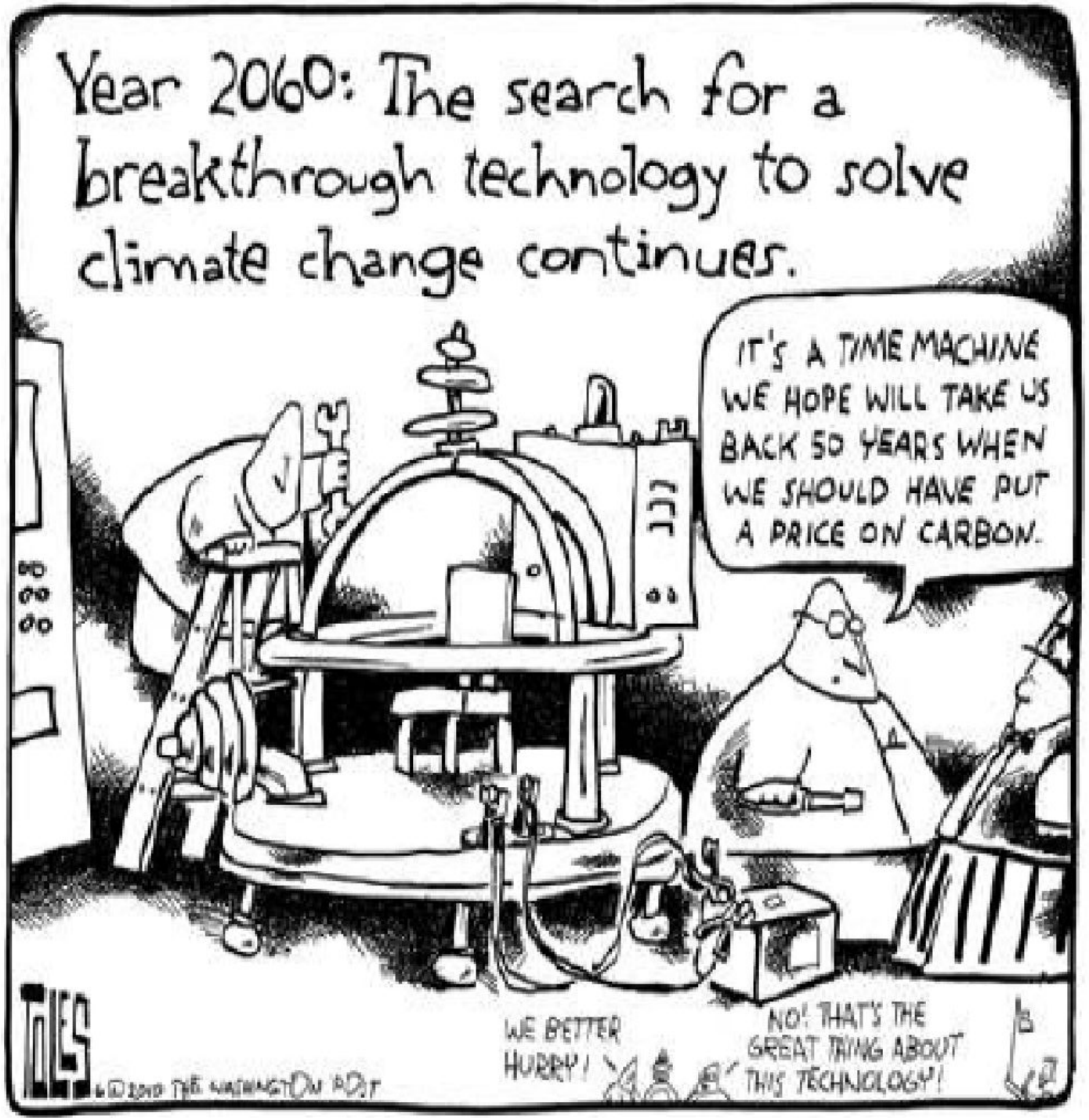
Regional climate model (10–50 km)

Impact model

EMISSION/ CONCENTRATION SCENARIOS

BIAS CORRECTION

Some scenarios are not very likely …



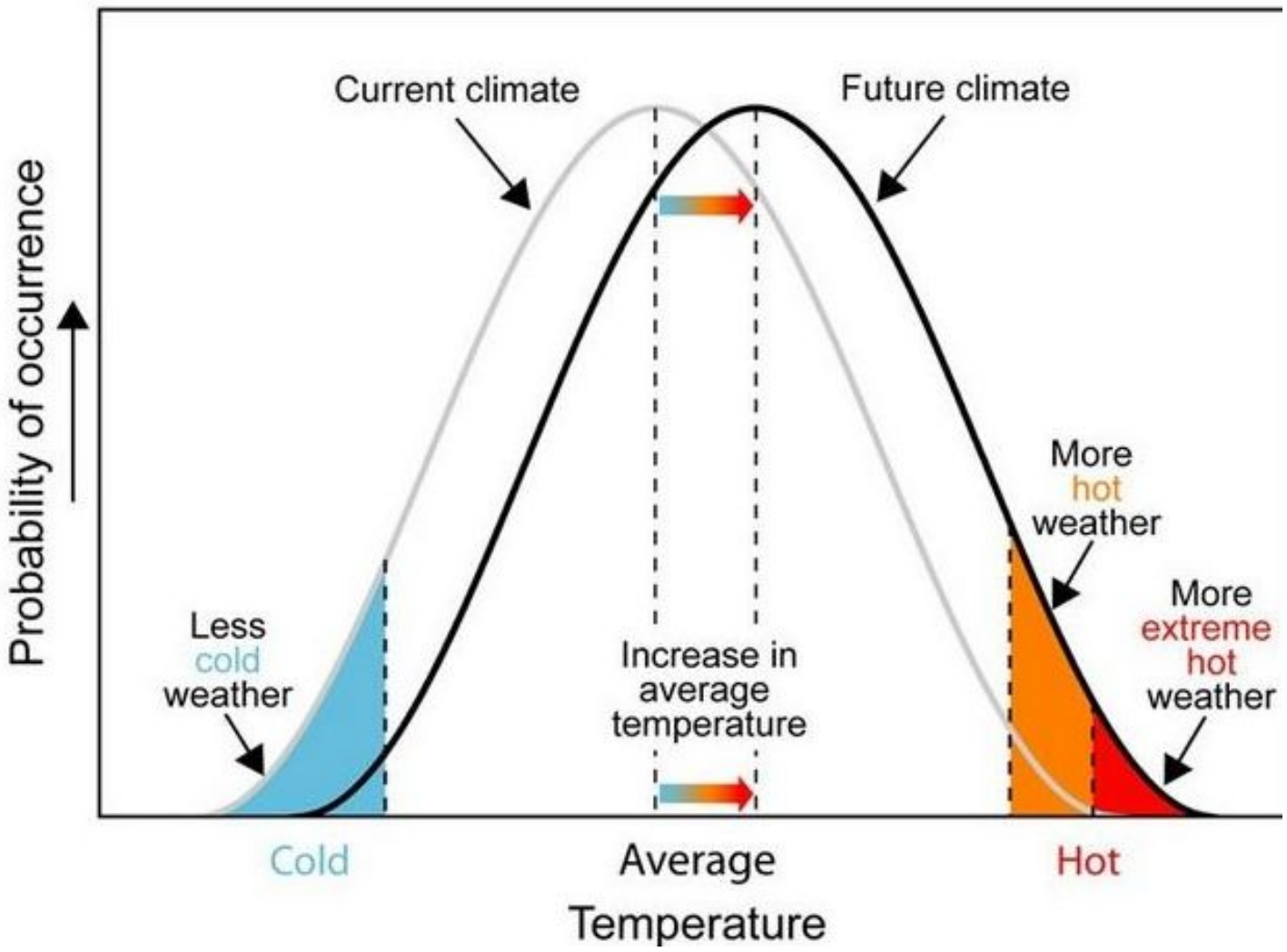
IPCC AR6 WG1 Glossary

Climate extreme (extreme weather or climate event) The occurrence of a value of a weather or climate variable above (or below) a ***threshold value*** near the upper (or lower) ends of the range of observed values of the variable. By definition, the ***characteristics of what is called extreme weather may vary from place to place in an absolute sense***. When a pattern of ***extreme weather persists for some time***, such as a season, it may be classified as an **extreme climate event**, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought, or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as 'climate extremes'.

Extreme weather event. An event that is rare at a particular place and time of year. Definitions of 'rare' vary, but an extreme weather event would normally be as ***rare as or rarer than the 10th or 90th percentile of a probability density function estimated from observations***. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense.

"Man can believe the impossible, but can never believe the improbable" – Oscar Wilde

Climate change impacts to weather extremes



When climate changes, it changes also the statistical distributions of weather variables and their occurrence – this increases natural hazards.

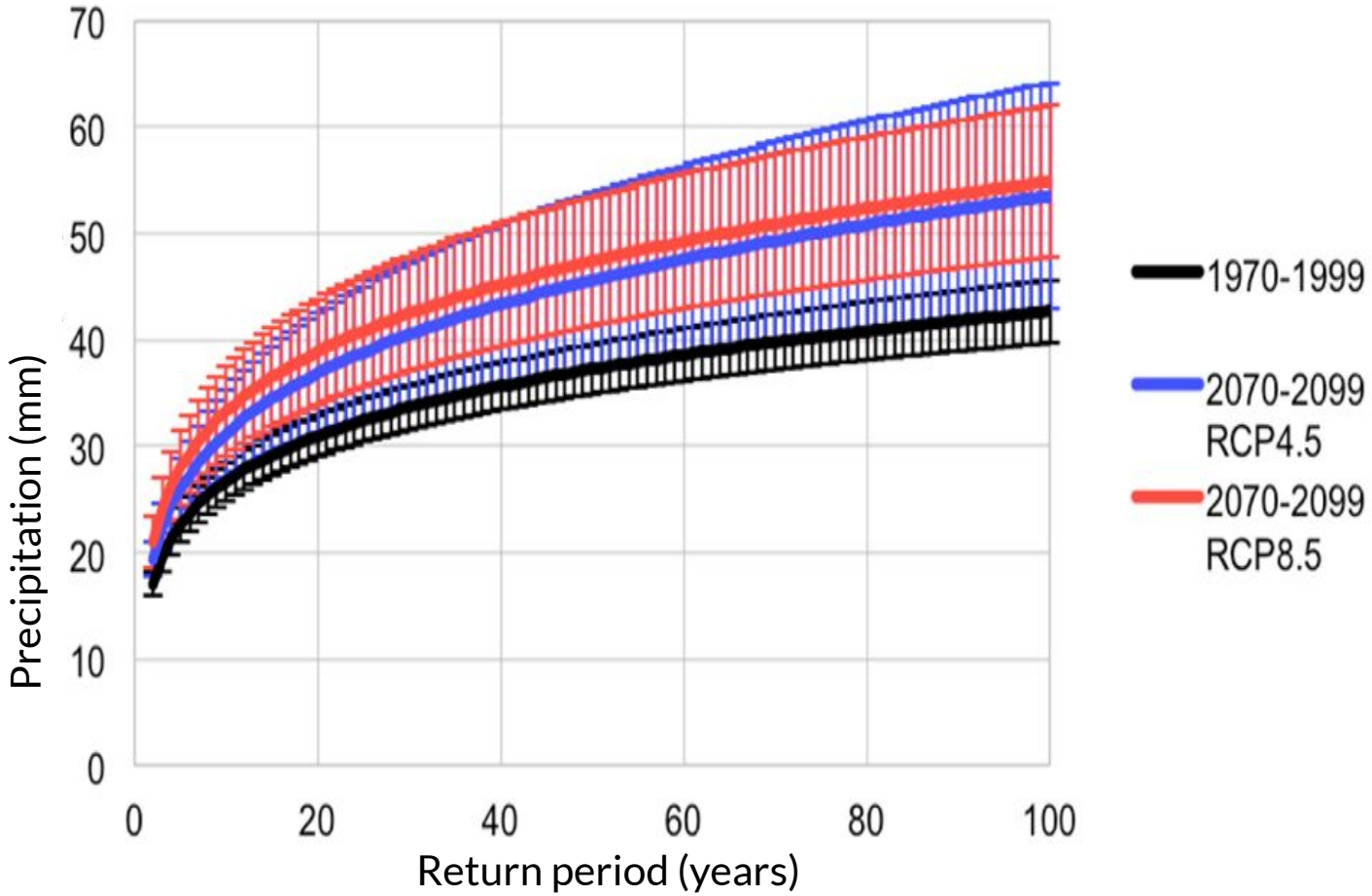
Example: Temperature

- In warmer climate the distribution "moves" to the right
- Less probable for occurrences of "extreme cold"
- More probable occurrences of "extreme hot"

EU funded project
GA no. 776848

Climate change impacts to weather extremes

Return periods of 3-hour max. precipitation, South-Finland



Example: Precipitation

- The distribution is not normally distributed
- e.g., in Finland, the occurrence of heavy precipitation events are estimated to change as follows:
  - Present climate: 1 in 20 years future: 1 in 10 years
  - Present climate: 1 in 100 years future: 1 in 30 years

EU funded project
GA no. 776848

OPERANDUM
OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

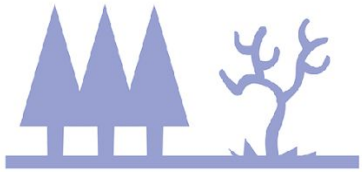
Changes in climate and extremes - observations (1/2)

Climate change is already visible on land, in the oceans and in the atmosphere.

Changes that have already occurred will continue, and some of them will be irreversible for centuries to millennia.

ON LAND

- climate zones shift poleward
- heavy precipitation is increasingly frequent in many places
- droughts have increased



IN THE OCEANS

- oceans warm up
- global mean sea level rises
  IRREVERSIBLE
- acidification occurs and oxygen levels fall in oceans
  IRREVERSIBLE

IN THE ATMOSPHERE

- greenhouse gas concentrations increase
- lowest part of atmosphere warms up
- moisture content increases

IN SNOW AND ICE COVER

- ice cover on seas and lakes decreases
- snow cover decreases
- glaciers shrink
  IRREVERSIBLE

DANGEROUS AND HARMFUL WEATHER EVENTS HAVE BECOME MORE COMMON

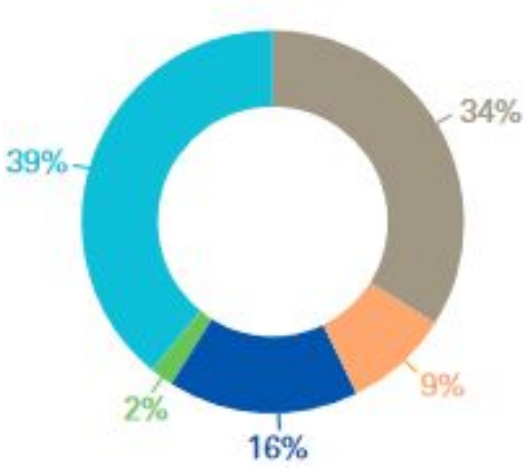
Heatwaves, droughts, heavy precipitation and major tropical cyclones become increasingly frequent.

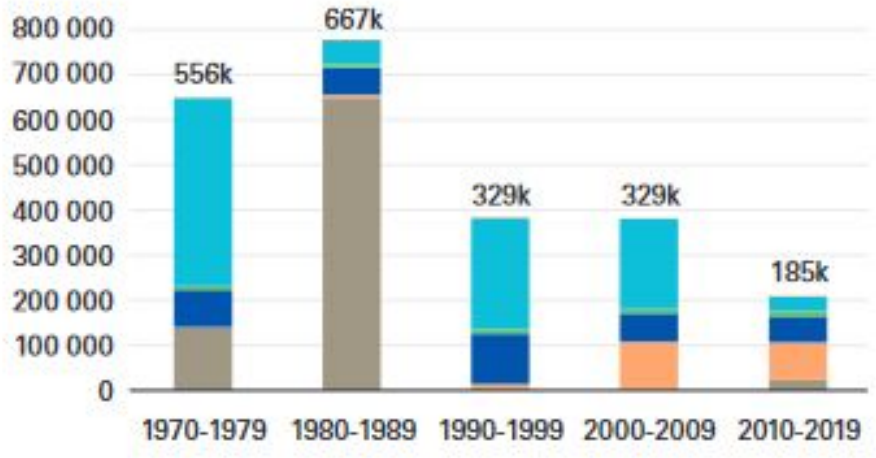
Based on IPCC's Sixth Assessment Report, Working Group I. © FMI and Ministry of the Environment, 2021. Climateguide.fi

EU funded project
GA no. 776848

DEATHS

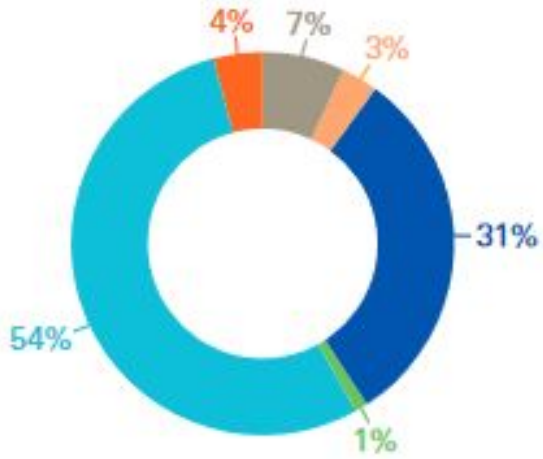
(b) Number of reported deaths
Total = 2 064 929 deaths

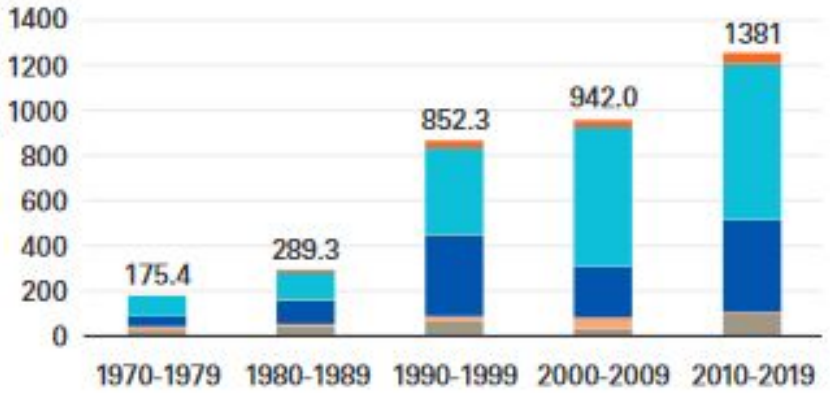




ECONOMIC LOSSES

(c) Reported economic losses in US$ billion
Total = US$ 3.6 trillion





Drought | Extreme temperature | Flood | Landslide | Storm | Wildfire

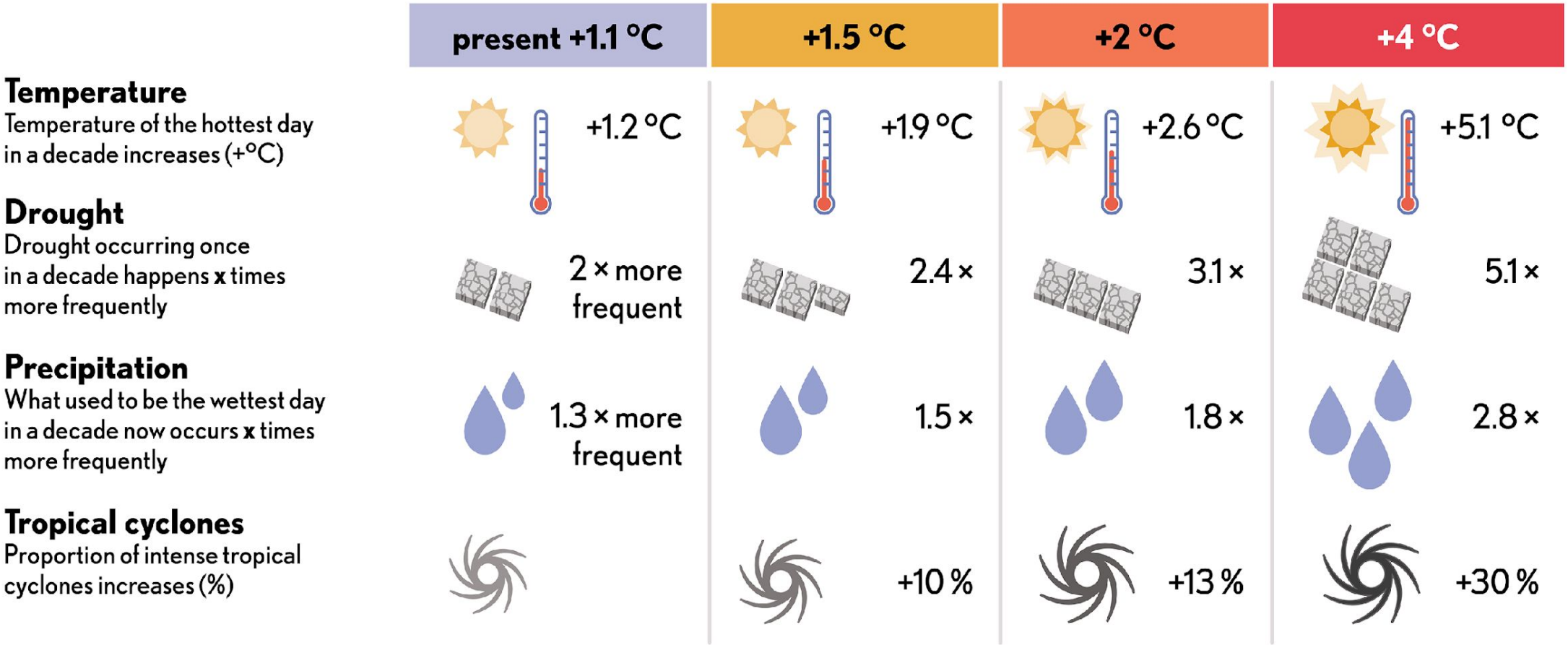
Source:
The Atlas of Mortality and Economic Losses from Weather, Climate and Water Extremes (1970–2019), WMO (2021)

OPERANDUM
OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

Changes in climate and extremes – projections (2/2)

Risks and impacts of global warming are the higher the more the climate warms up.

Change in extreme weather events that cause damage from pre-industrial times 1850–1900



Based on IPCC's Sixth Assessment Report, Working Group I. © FMI and Ministry of the Environment, 2021. Climateguide.fi

Change in Indicator	Observed (since 1950)	Attributed (since 1950)	Projected at GWL (°C)		
			+1.5	+2	+4
Warm/hot extremes: Frequency or intensity	↑	✓ Main driver	↑	↑	↑
Cold extremes: Frequency or intensity	↓	✓ Main driver	↓	↓	↓
Heavy precipitation events: Frequency, intensity and/or amount	↑ Over majority of land regions with good observational coverage	✓ Main driver of the observed intensification of heavy precipitation in land regions	↑ ↑ in most land regions		↑ in most land regions
Agricultural and ecological droughts: Intensity and/or frequency	↑ in some regions	✓ in some regions	↑ in more regions compared to observed changes	↑ in more regions compared to 1.5°C of global warming	↑ in more regions compared to 2°C of global warming
Precipitation associated with tropical cyclones	↑	✓	↑ Rate +11%	↑ Rate +14%	↑ Rate +28%
Tropical cyclones: Proportion of intense cyclones	↑	✓	↑ +10%	↑ +13%	↑ +20%
Compound events: Co-occurrent heatwaves and droughts	↑ (Frequency)	✓ (Frequency)	↑ (Frequency and intensity increases with warming)		
Marine heatwaves: Intensity & frequency	↑ (since 1900)	✓ (since 2006)	↑ Strongest in tropical and Arctic Ocean		
Extreme sea levels: Frequency	↑ (since 1960)	✓	↑ (Scenario-based assessment for 21st century)		

medium confidence

likely/high confidence

very likely

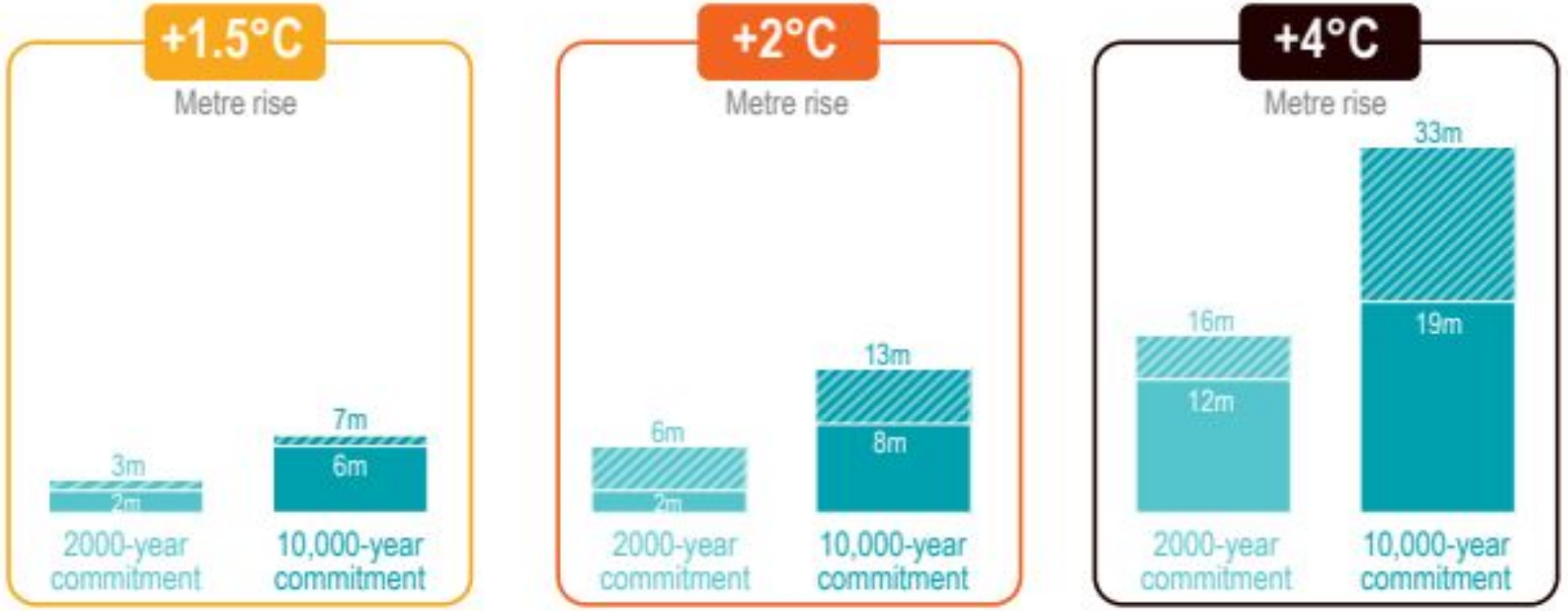
extremely likely

virtually certain

Long-term consequences: Sea level rise

Today, sea level has already increased by 20 cm and will increase an additional 30 cm to 1 m or more by 2100, depending on future emissions.

Sea level reacts very slowly to global warming so, once started, the rise continues for thousands of years.

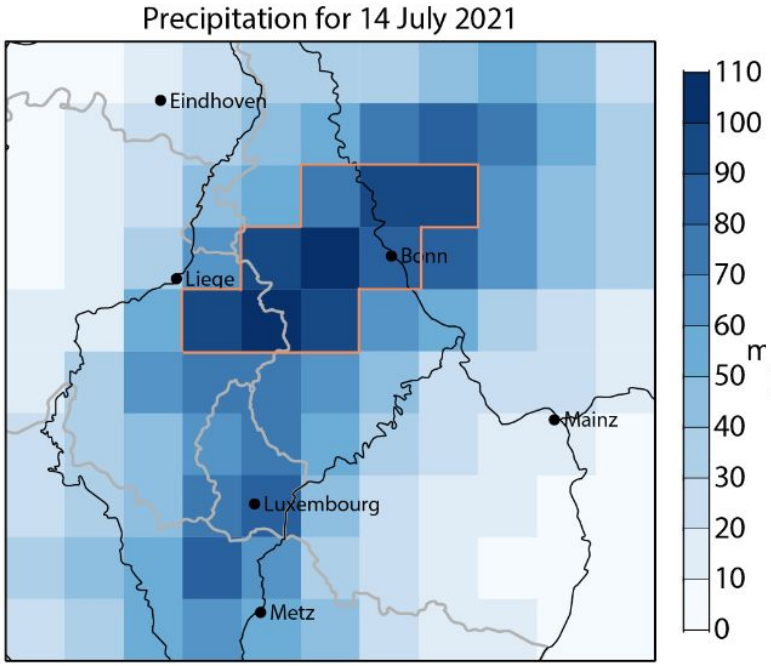


Global mean sea level rise will cause the frequency of extreme sea level events at most locations to increase. Local sea levels that historically occurred once per century (historical centennial events) are projected to occur at least annually at most locations by 2100 under all RCP scenarios (*high confidence*). Many low-lying megacities and small islands (including SIDS) are projected to experience historical centennial events at least annually by 2050 under RCP2.6, RCP4.5 and RCP8.5. The year when the historical centennial event becomes an annual event in the mid-latitudes occurs soonest in RCP8.5, next in RCP4.5 and latest in RCP2.6. The increasing frequency of high-water levels can have severe impacts in many locations depending on the level of exposure (*high confidence*).
Source: IPCC SROCC SPM

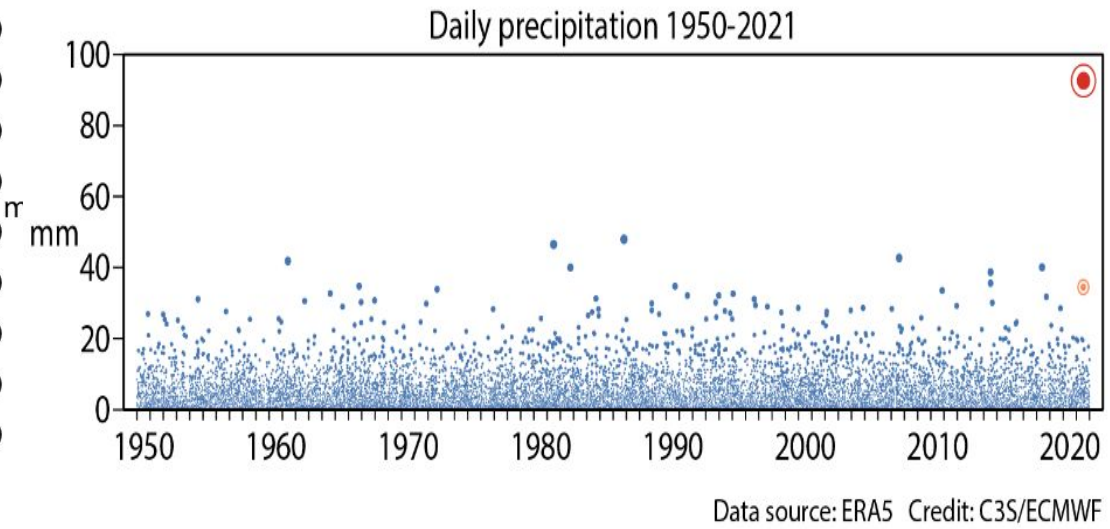
FLOODING

13-14 July 2021
Germany

Was this extreme / rare / high-impact event? *YES / YES / YES*
Was new maximum reached? *YES, several*



Costs: €4.5 to €5.5 billion for Germany



Precipitation across Belgium, Germany and surrounding countries on 14 July 2021. The area bounded by the orange line is that referenced in the panel. Precipitation averaged for the orange-bounded region spanning the border of Belgium and Germany, for each day from 1 January 1950 to 31 December 2021. The size of the dots directly represents the amount of precipitation each day; the circled orange dot is for 13 July 2021 and the circled red dot is for 14 July 2021.

OPERANDUM
OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

Additional remarks on ”extremes”

- Not all new hydro-meteorological records have high impacts, e.g. good visibility, high atmospheric pressure
- “Common values of weather parameters” and especially combinations of them may create extreme events, e.g. minor amount of precipitation followed by below 0°C temperature -> dangerously low friction on roads and pavements
- Weather forecasts use threshold values in warnings which are linked to damages and loss of life but they may vary from country to country

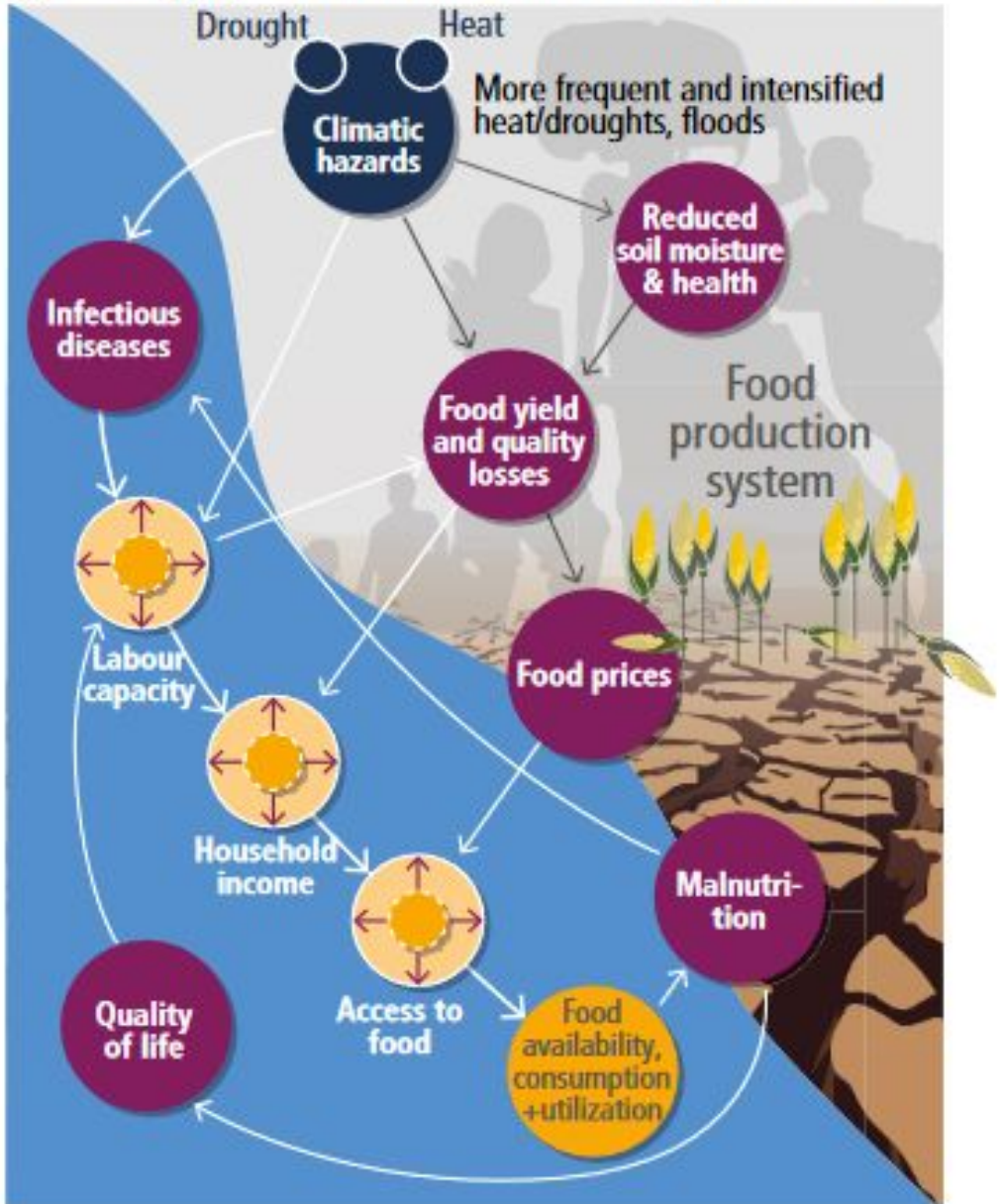
-> There are different definitions for “extreme weather/climate events”

Munich RE: One or more of the following happened:
- **Interregional or international assistance is necessary**
- **>1000 are killed**
- **>100000 are made homeless**
- **Substantial overall losses**
- **Considerable insured losses**

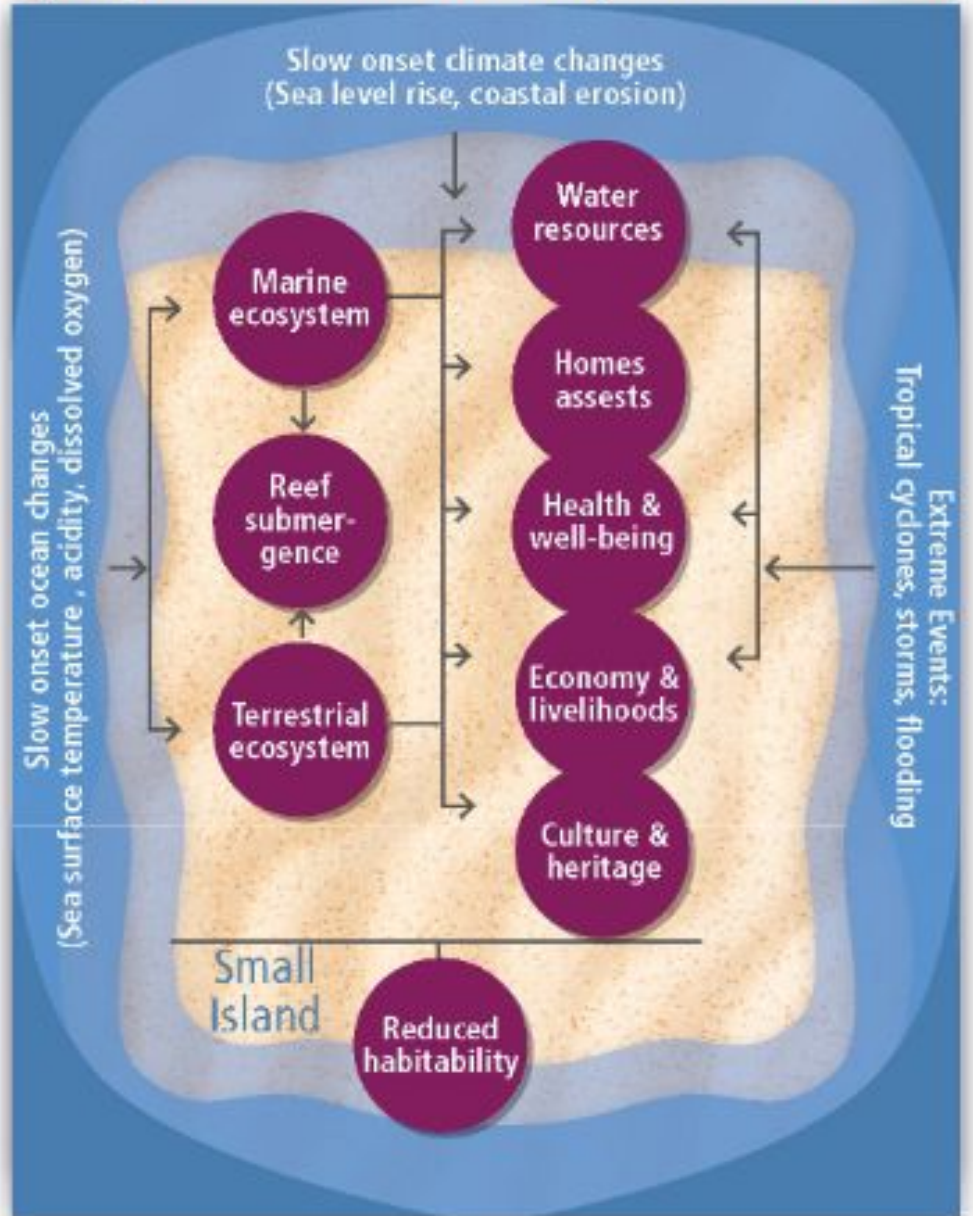
OPERANDUM

Cascading events and Compound hazards/risks

(c) Cascading impacts of climate hazards on food and nutrition



(d) Compound risks in coastal and island systems reduce habitability



Climate change is already affecting every inhabited region across the globe, with human influence contributing to many observed changes in weather and climate extremes

Figure SPM.3

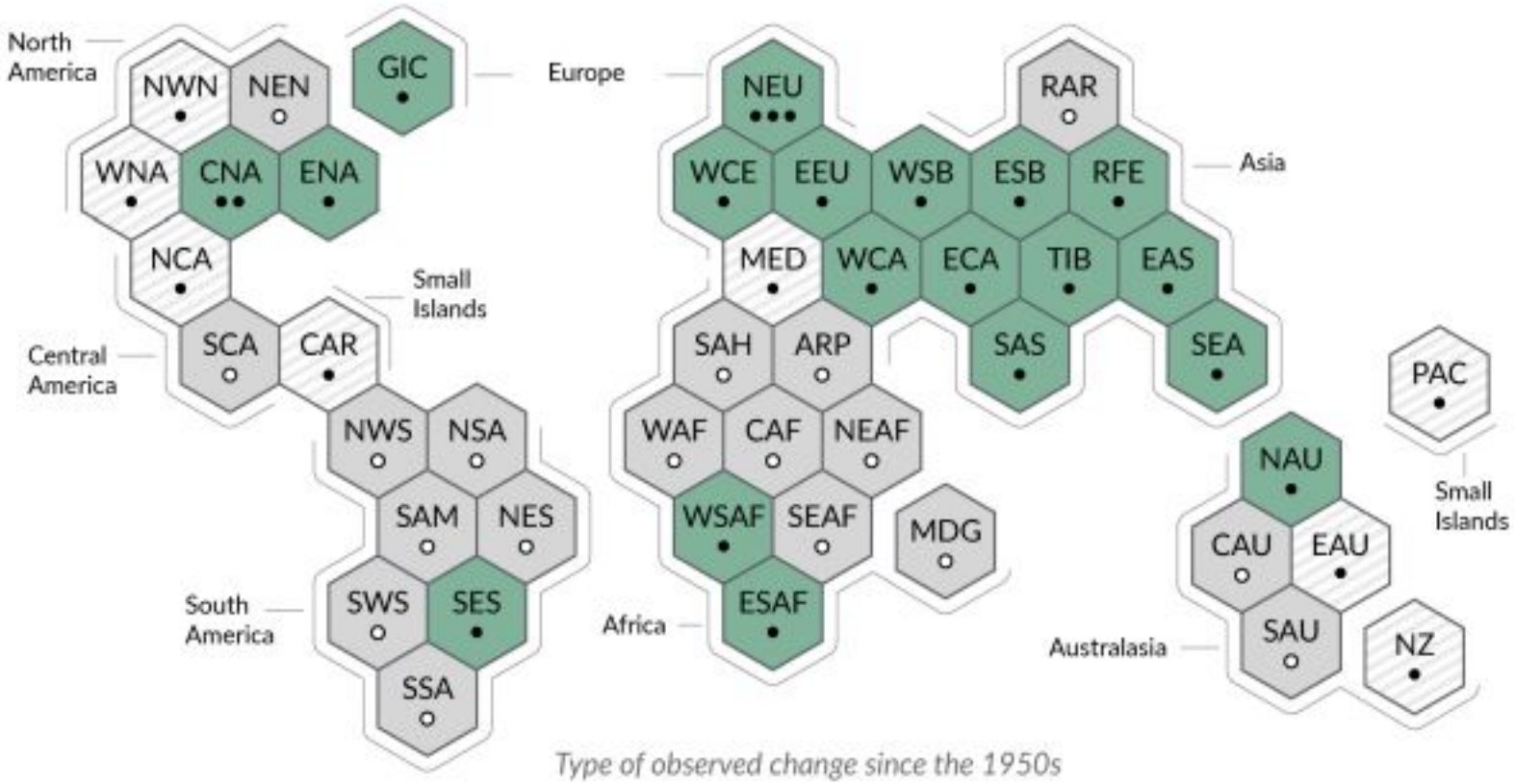
b) Synthesis of assessment of observed change in **heavy precipitation** and confidence in human contribution to the observed changes in the world's regions

Type of observed change
in heavy precipitation

- Increase (19)
- Decrease (0)
- Low agreement in the type of change (8)
- Limited data and/or literature (18)

Confidence in human contribution
to the observed change

- ●●● High
- ●● Medium
- ● Low due to limited agreement
- ○ Low due to limited evidence



Type of observed change since the 1950s

Climatic impact-drivers


Heat & cold


Rain & drought


Snow & ice


Wind

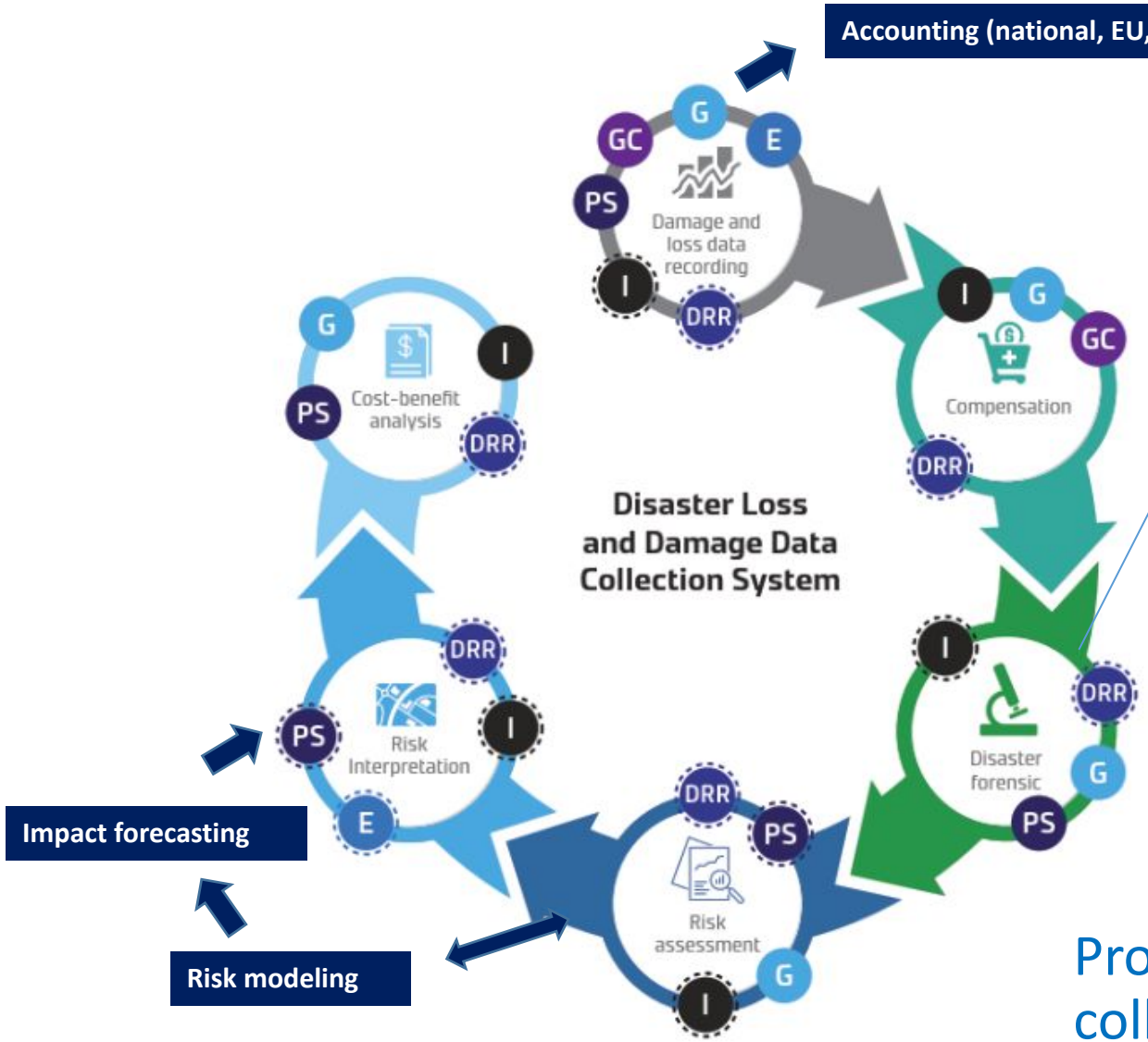

Coastal & oceanic


Other


Open ocean

A **climatic impact-driver** could go over **thresholds** known to lead to **severe consequences** for people, agriculture, or wildlife

Disaster loss and damage data have wide use in societies



Attribution need not to focus to establish responsibility, but also to investigate drivers of change.

Legend

Read/Write data access	Read data access	
G	G	Government
E	E	Experts
DRR	DRR	DRR Researchers
PS	PS	Private Sector
GC	GC	General citizenship/ volunteers
I	I	Insurance agents

Proposed disaster loss and damage data collection system (Fakhruddin, 2017, modified from De Groeve, 2015)

FINAL REMARKS

- Climate change is already affecting every inhabited region of the world and human influence is contributing to many observed changes in weather and climate extremes. This change will continue…
- Climate change need to be taken into account in planning of NBS

- Not all weather events are increasing in intensity, duration, spatial scale, or seasonality, but NBS can anyhow be an economically efficient, acceptable risk management solution
- There is information to estimate frequency, intensity of current and future extreme events as well as trends in climate conditions

-> Consider also possible role of new kind of extremes, compound events, and cascading events

OPERANDUM

SIXTH ASSESSMENT REPORT
Working Group I – The Physical Science Basis

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WMO UNEP

Thank you.

More Information:

IPCC: www.ipcc.ch

IPCC Secretariat: ipcc-sec@wmo.int

IPCC Press Office: ipcc-media@wmo.int

Follow Us:

@IPCC

@IPCC_CH

linkedin.com/company/ipcc

#ClimateReport #IPCC

OPERANDUM

OPEn-air laboRAtories for Nature baseD solUtions to Manage hydro-meteo risks

Thank you!

E-mail: info@operandum-project.eu
Website: https://www.operandum-project.eu/
Twitter: https://twitter.com/OPERANDUM_EU
Facebook: https://www.facebook.com/OPERANDUMproject/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776848.
The publication reflects only the authors' views and the European Union is not liable for any use that may be made of the information contained therein.