Climate sciences, physical science basis

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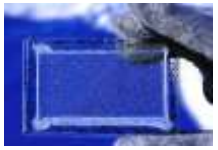
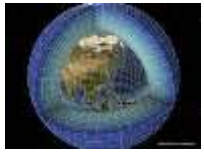
valmasdel

A tremendous scientific endeavour



Fluid physics
Thermodynamics
Radiative transfers

Quantitative paleoclimate
Supercomputers
Satellites



Antiquity

Middle Age

17th Century
Meteorological instruments

19th Century
Networks
Ice ages
Greenhouse effect

Late 20th Century
Key concepts
Climate modelling
Statistical analyses

- A vast scientific community
- Curiosity-driven research
- Societal and policy relevance

Climate models

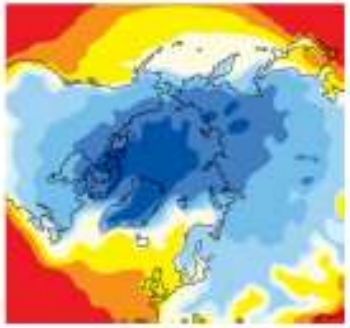
$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$$

$$\frac{\partial(\rho u)}{\partial t} + \frac{\partial(\rho u^2)}{\partial x} + \frac{\partial(\rho uv)}{\partial y} + \frac{\partial(\rho uw)}{\partial z}$$

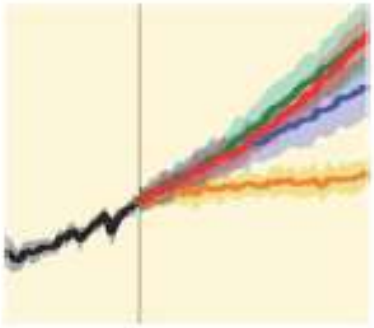
$$\frac{\partial(\rho v)}{\partial t} + \frac{\partial(\rho uv)}{\partial x} + \frac{\partial(\rho v^2)}{\partial y} + \frac{\partial(\rho vw)}{\partial z}$$

$$\frac{\partial(\rho w)}{\partial t} + \frac{\partial(\rho uw)}{\partial x} + \frac{\partial(\rho vw)}{\partial y} + \frac{\partial(\rho w^2)}{\partial z}$$

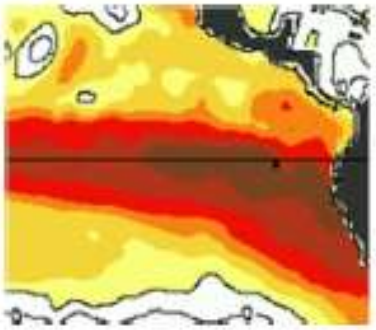
Physical principles



Climate patterns



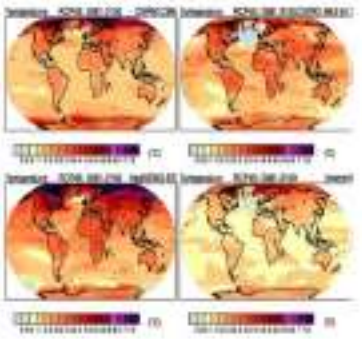
Recent trends



Processes

Weather forecast

Past climates

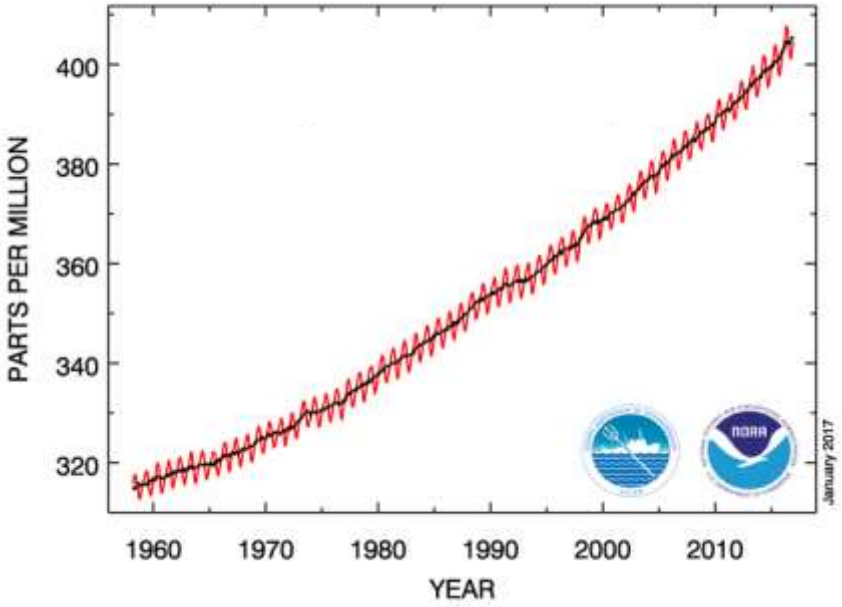


Robustness

R. Knutti, ETH Zürich

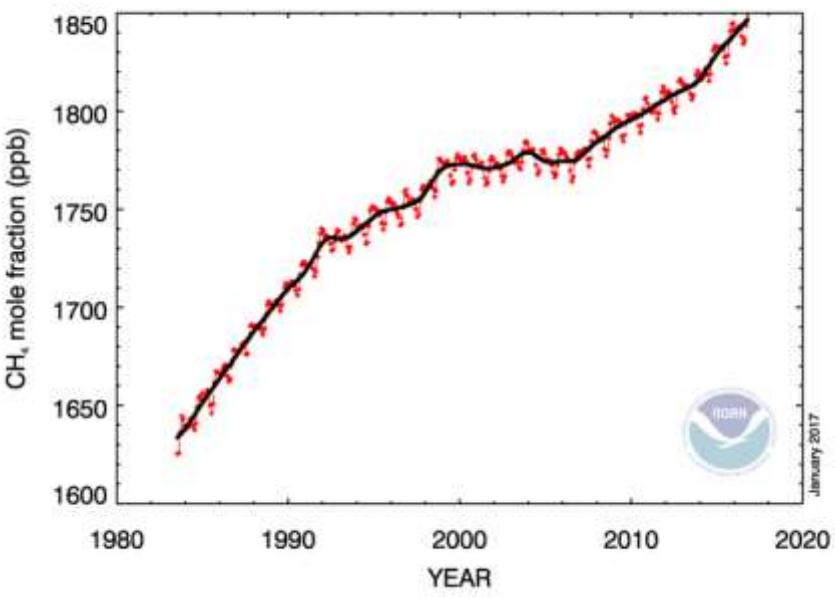
Atmospheric composition is deeply modified by human activities

Dioxyde de carbone (CO_2)



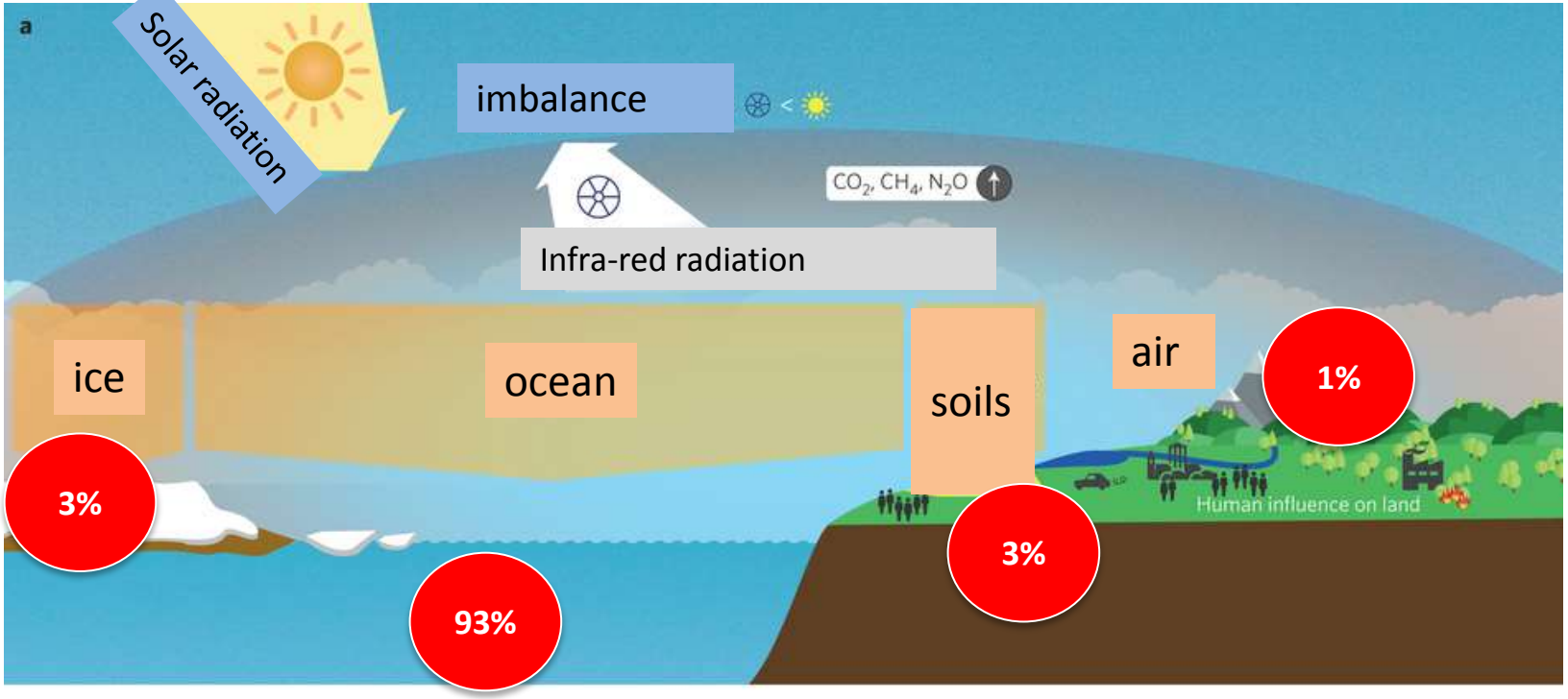
40% above pre industrial levels

Méthane (CH_4)



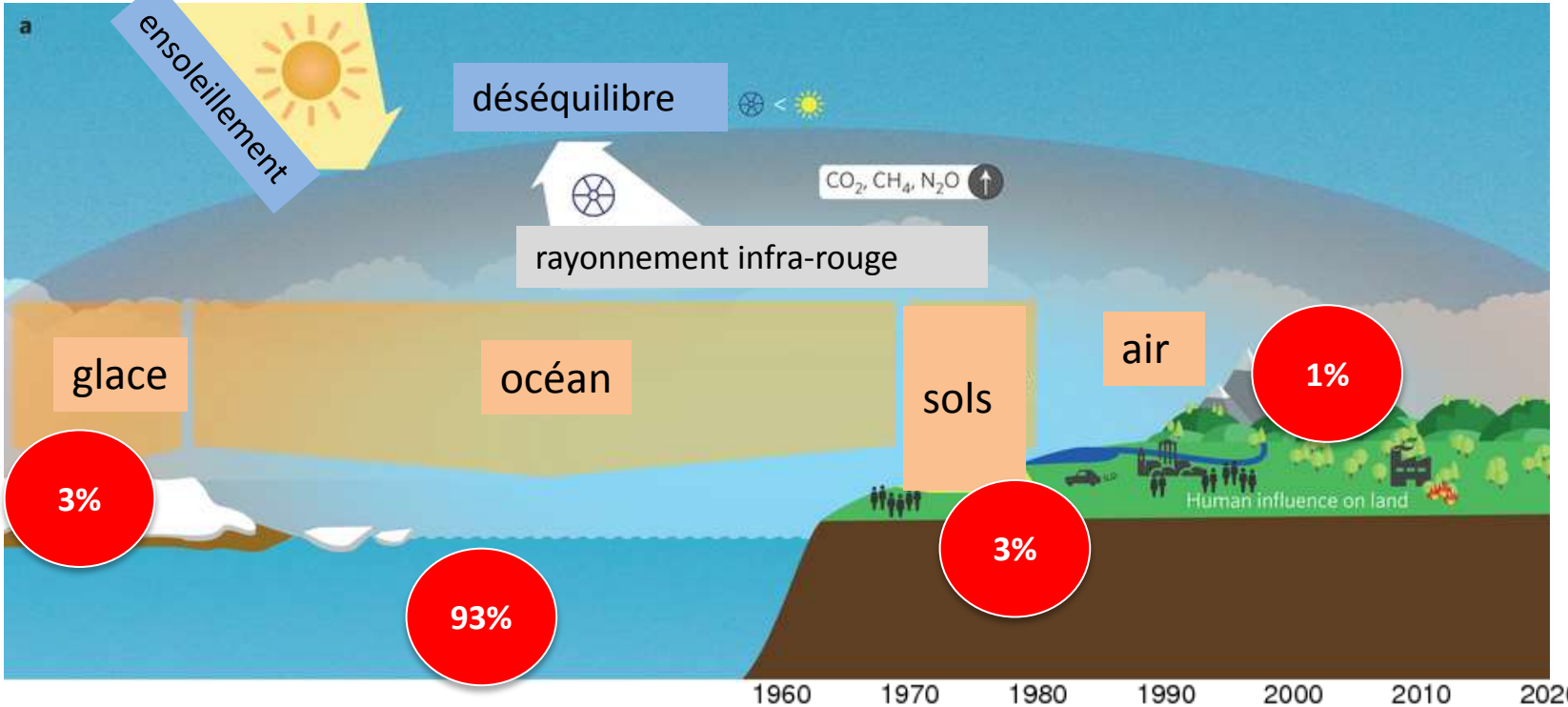
2,3 times pre-industrial levels

Net effect of human activities : an imbalance of the Earth's energy budget
In 2011 + 2,3 W/m²

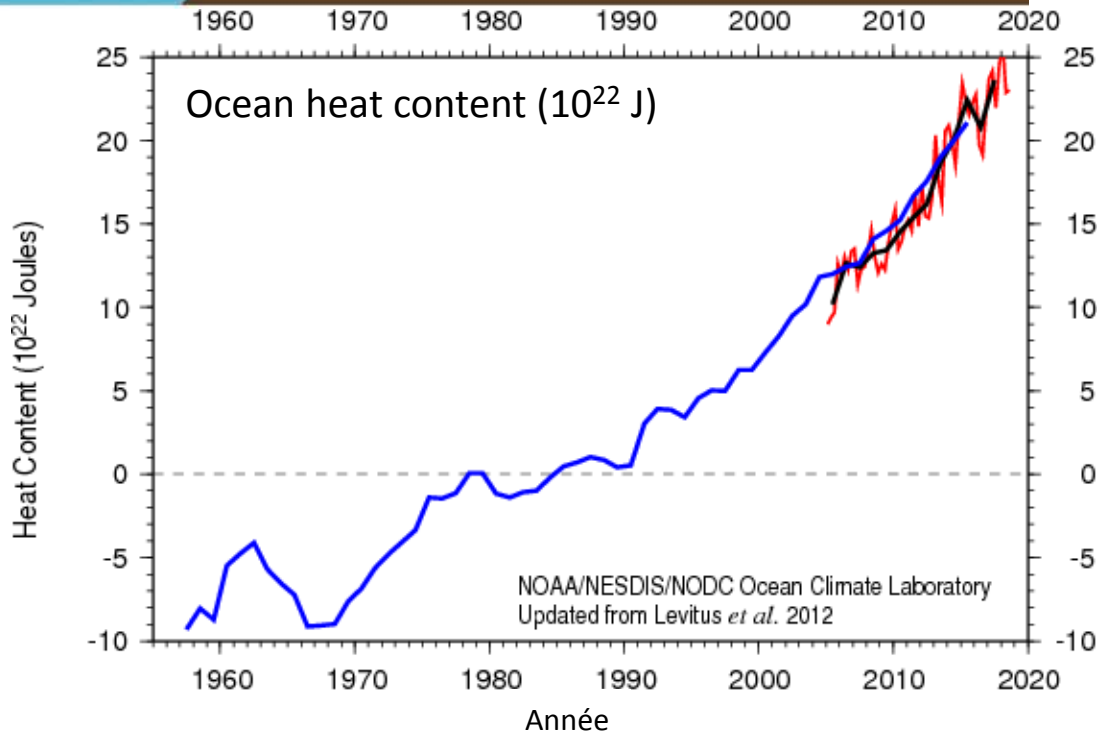


Climate is changing due to the Earth's energy imbalance

WCRP, 2017

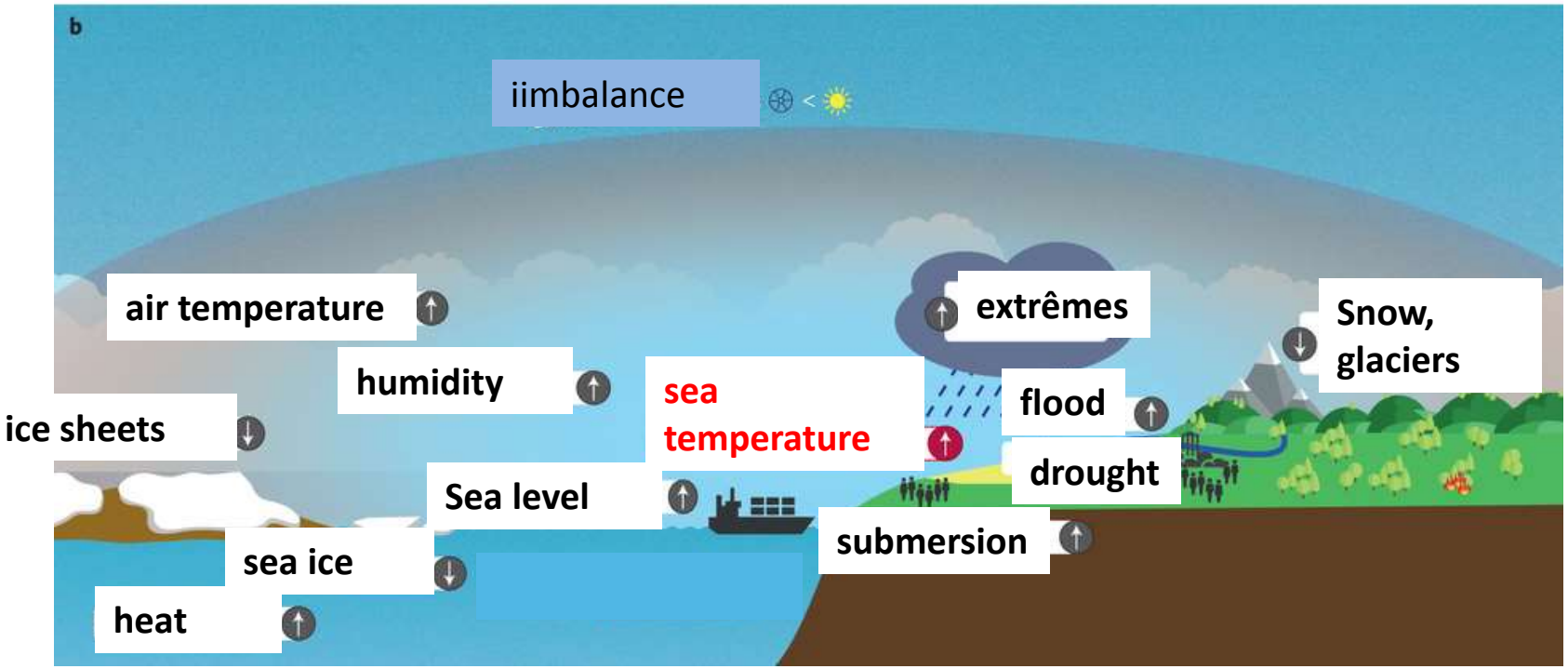


The ocean accumulates most of the extra heat



www.nodc.noaa.gov

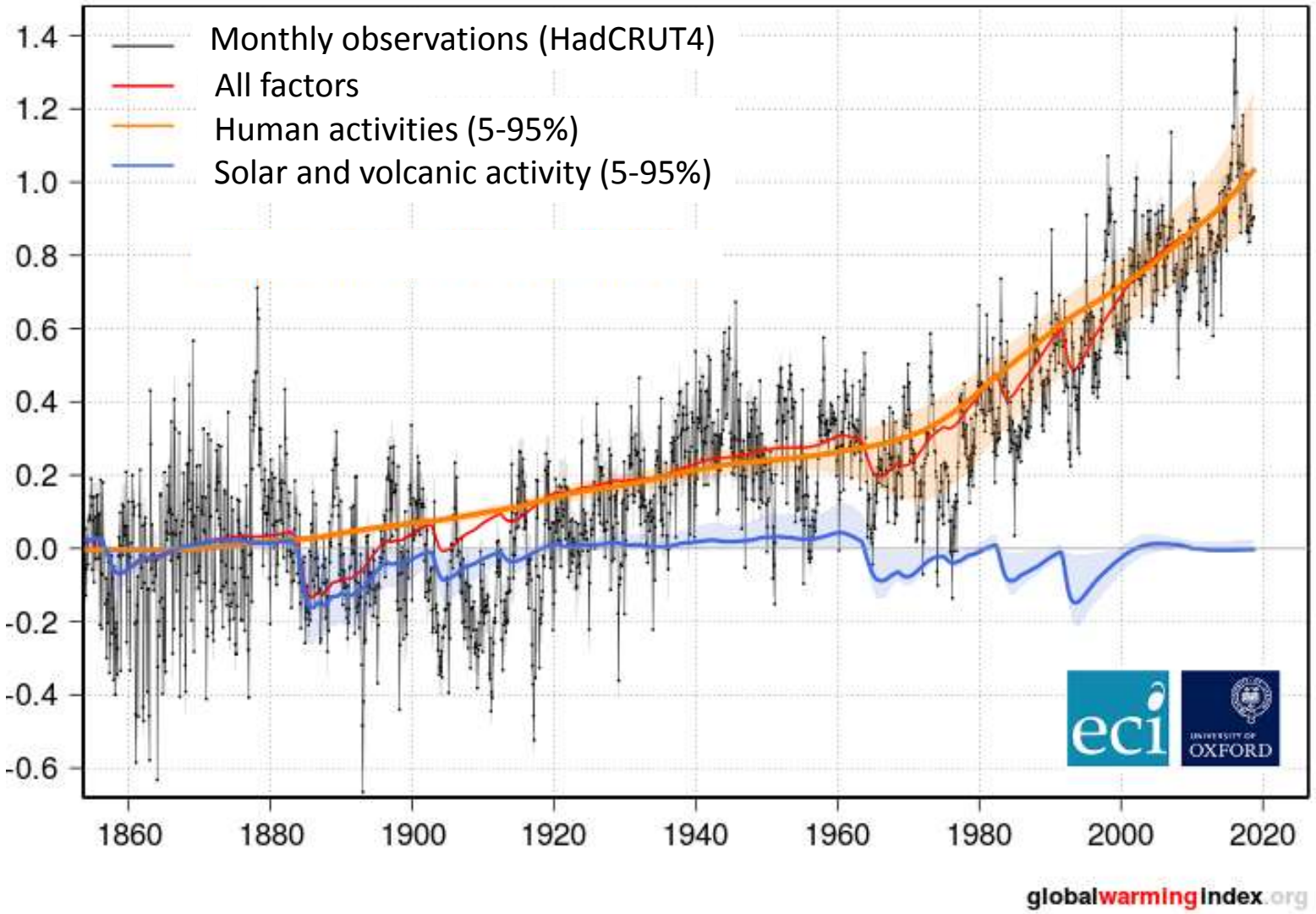
Consequences of the Earth's energy imbalance



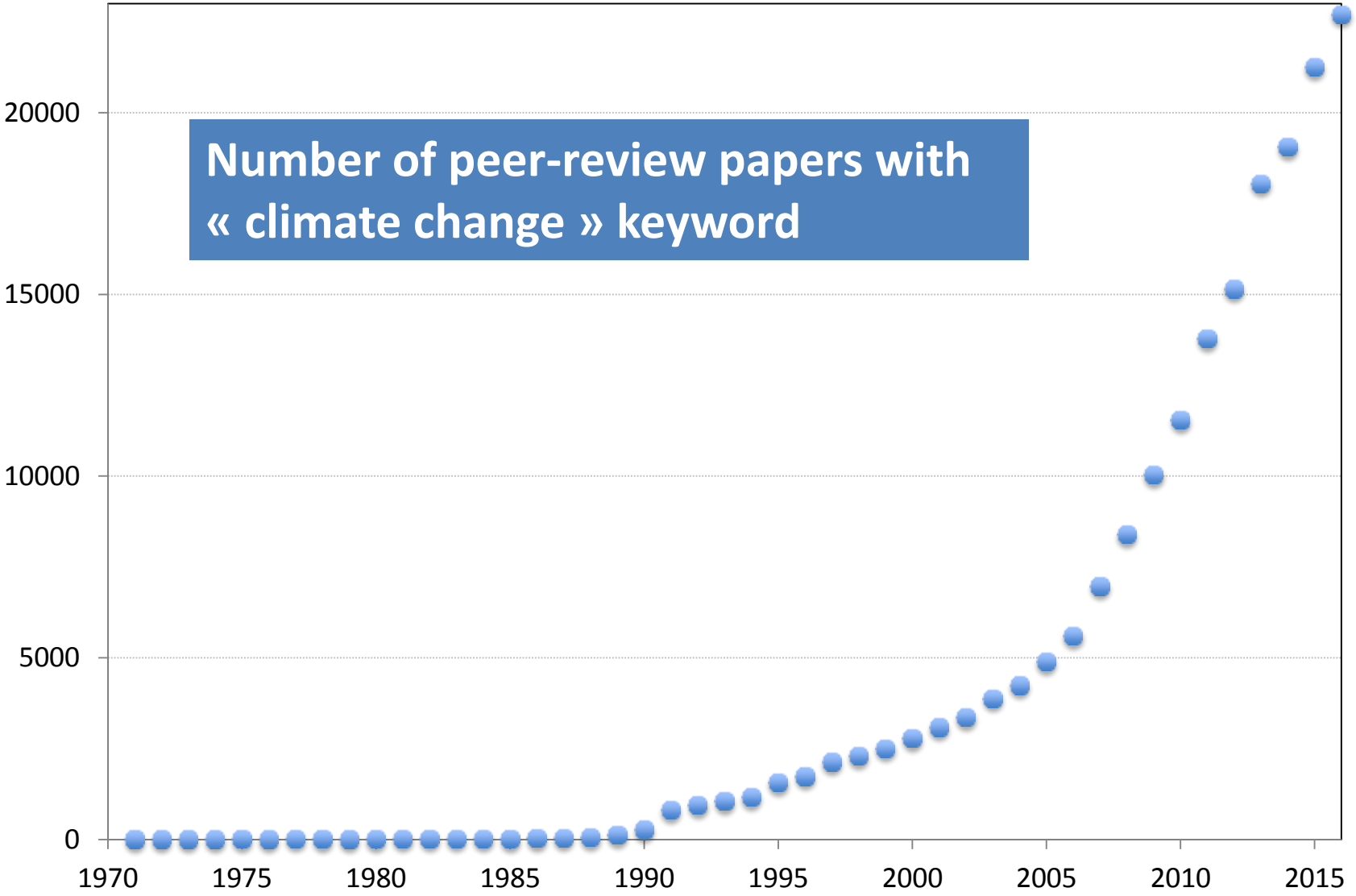
WCRP, 2017

Role of natural and human factors in observed warming

Global warming compared to 1850-1879 (°C)



From knowledge production …



to the assessment of the state of knowledge

- International climate research is coordinated by the World Climate Research Programme (WCRP), related to WMO, UNEP and IOC

- The IPCC is a scientific body under WMO and UNEP

- IPCC assessment reports are key sources of scientific information for the United Nation Framework Convention on Climate Change (UNFCCC)

$\Rightarrow$ in 2018 : 30 years of IPCC assessments

Report preparation steps

1. Plenary decision to prepare a report

Scoping

Outline approval

Nominations of authors

Selection of authors

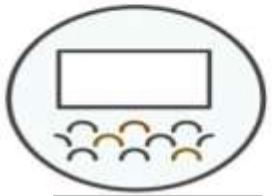
First Order Draft

Expert review

Second Order Draft + draft SPM

Publications cut-off submission date

Expert and government review



Plenary approval

Final SPM draft

Goverment review of SPM

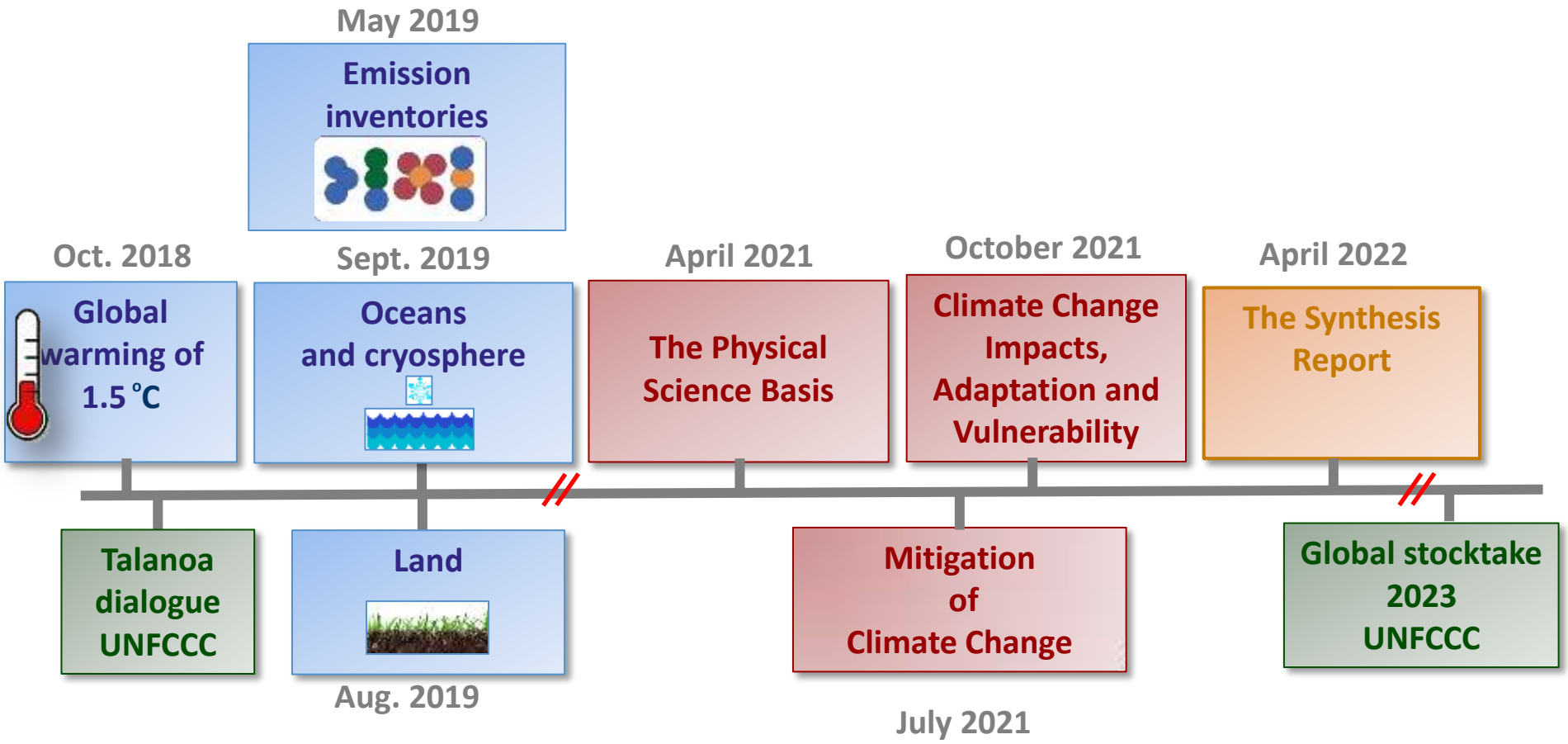
Final chapters & SPM for gov. review

Publications cut-off acceptance date

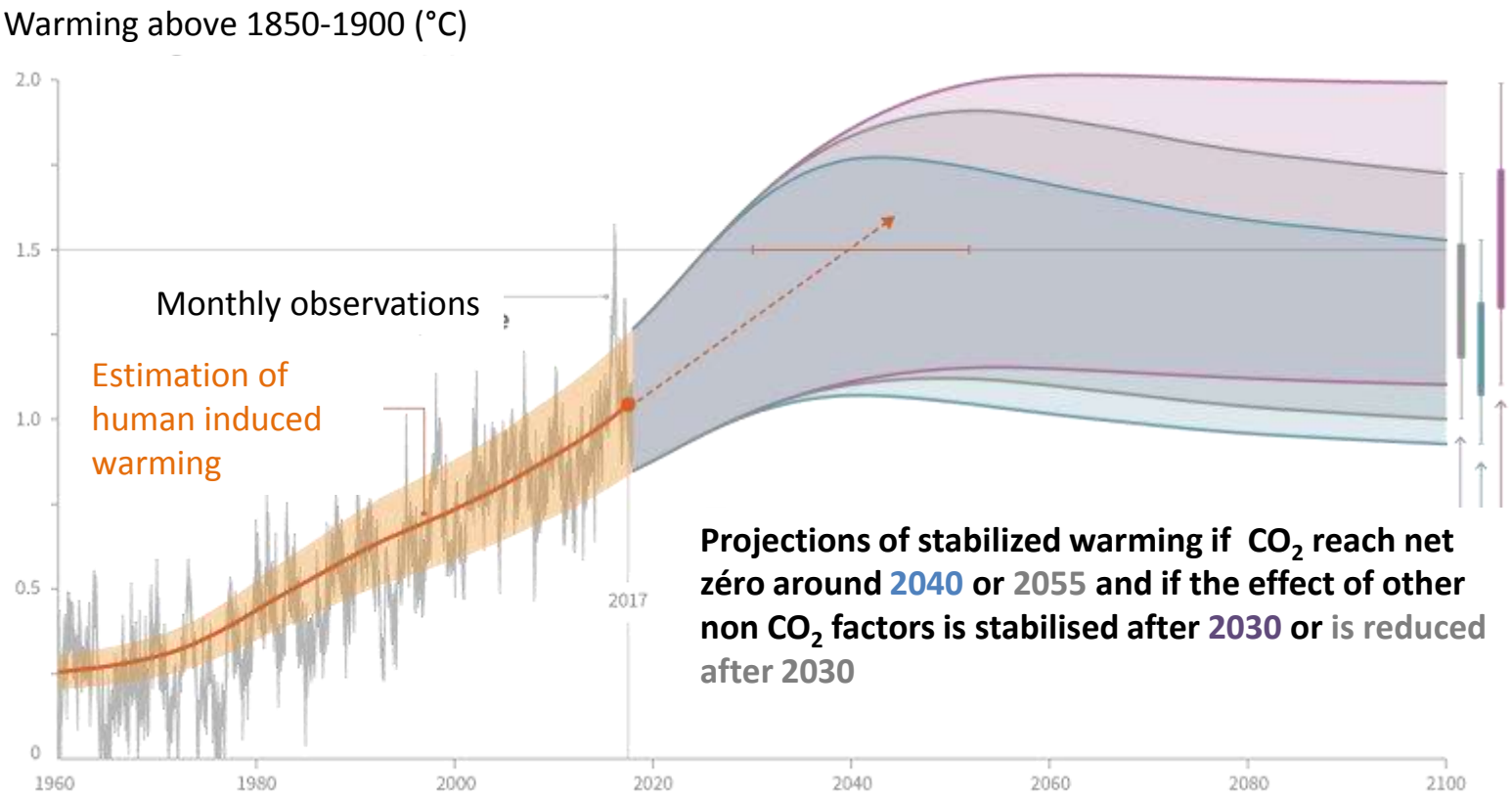
12. Report Publication!

SPM = Summary for Policy Makers

Sixth assessment cycle of the IPCC



Human activities have caused around 1°C of global warming

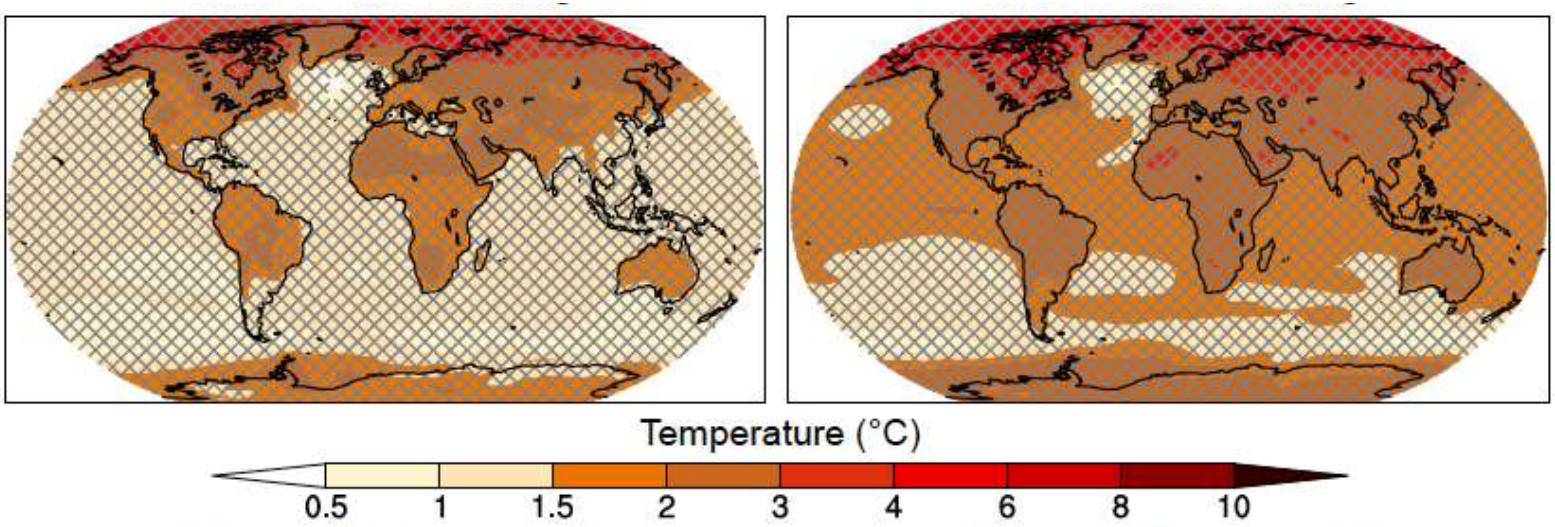


IPCC, 2018 (www.ipcc.ch/report/sr15)

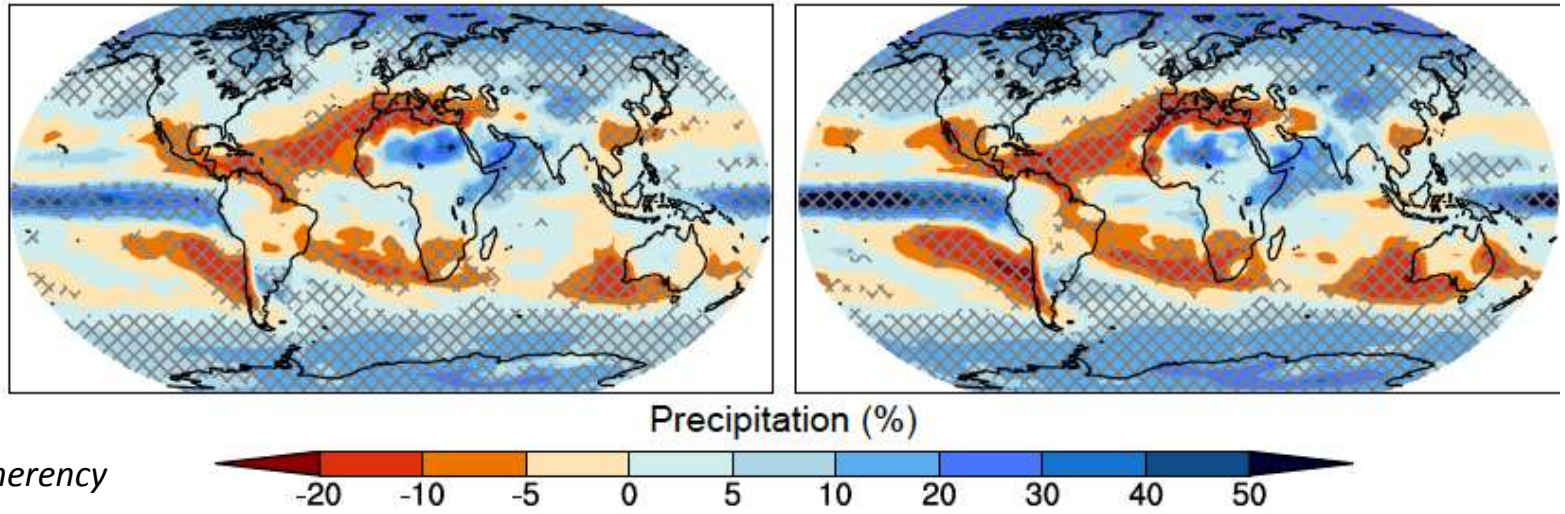
1.5°C warmer world

2°C warmer world

Change in annual mean temperature



Change in annual mean precipitation

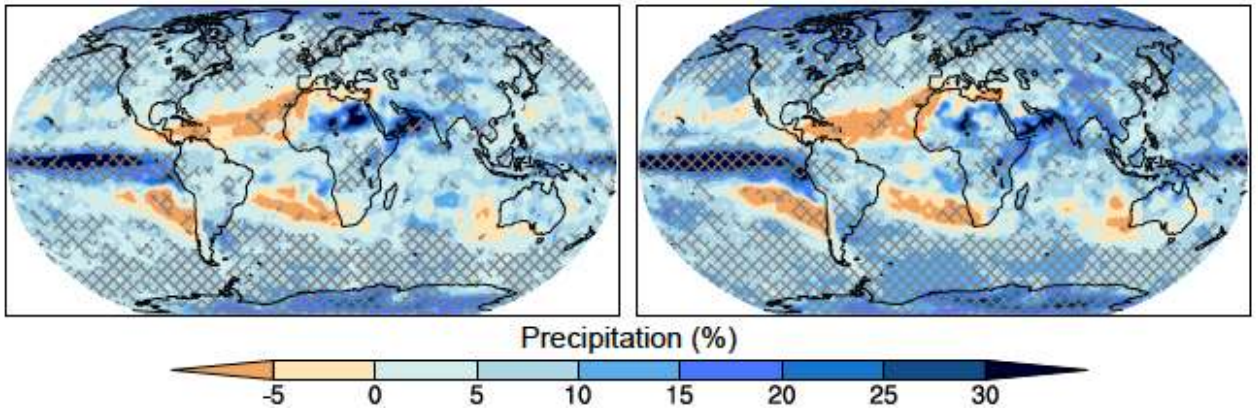


26 CMIP5 models
hatching : 66% coherency

IPCC, 2018 (www.ipcc.ch/report/sr15)

Most intense rainfall

1.5°C warmer world **2°C warmer world**

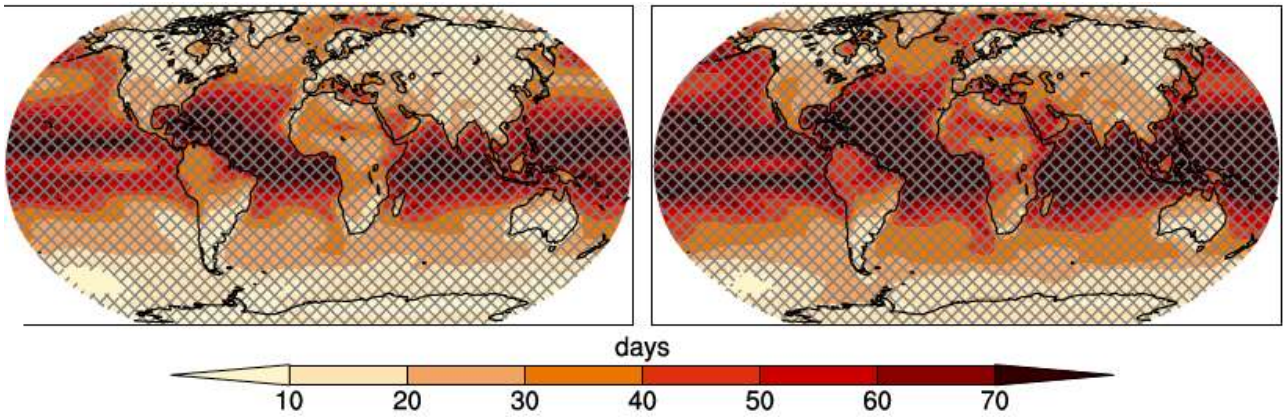


IPCC, 2018 (www.ipcc.ch/report/sr15)

1.5°C warmer world

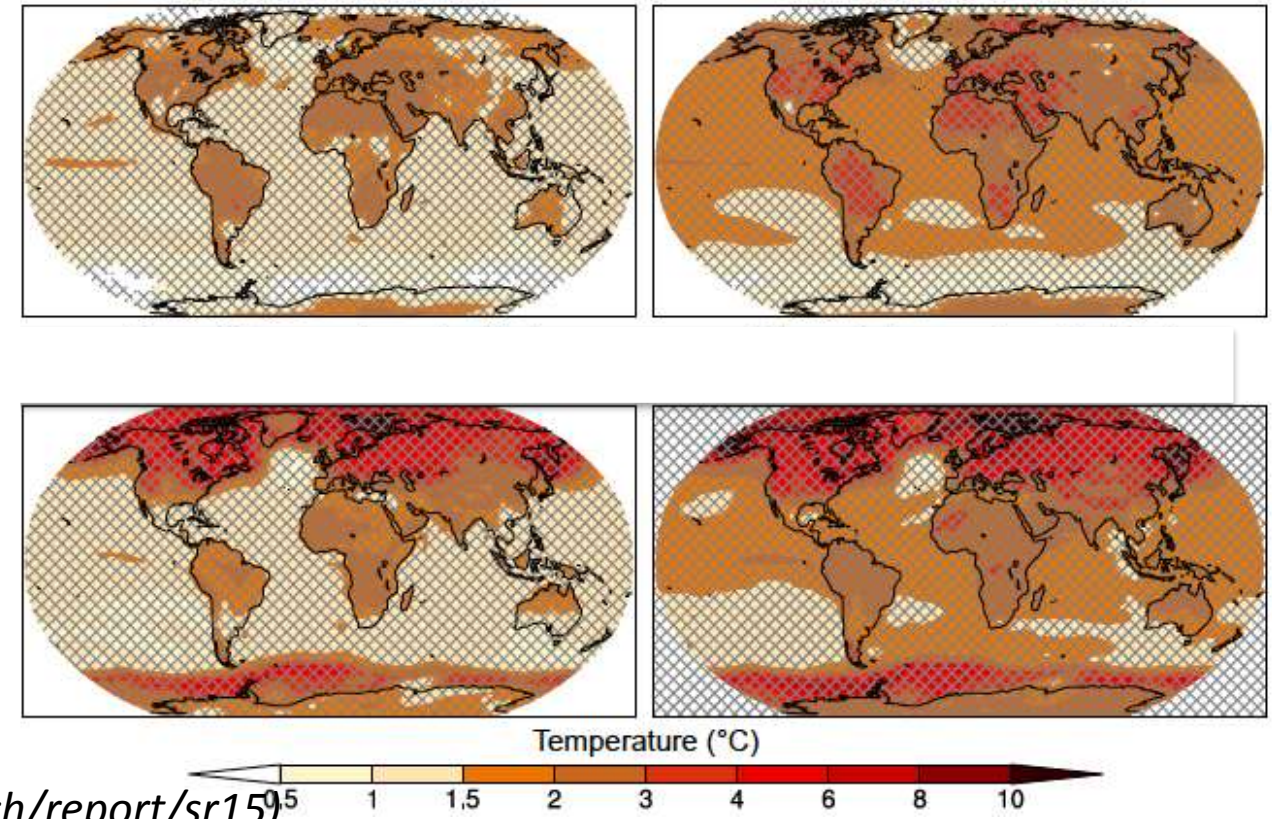
2°C warmer world

Number of very hot days



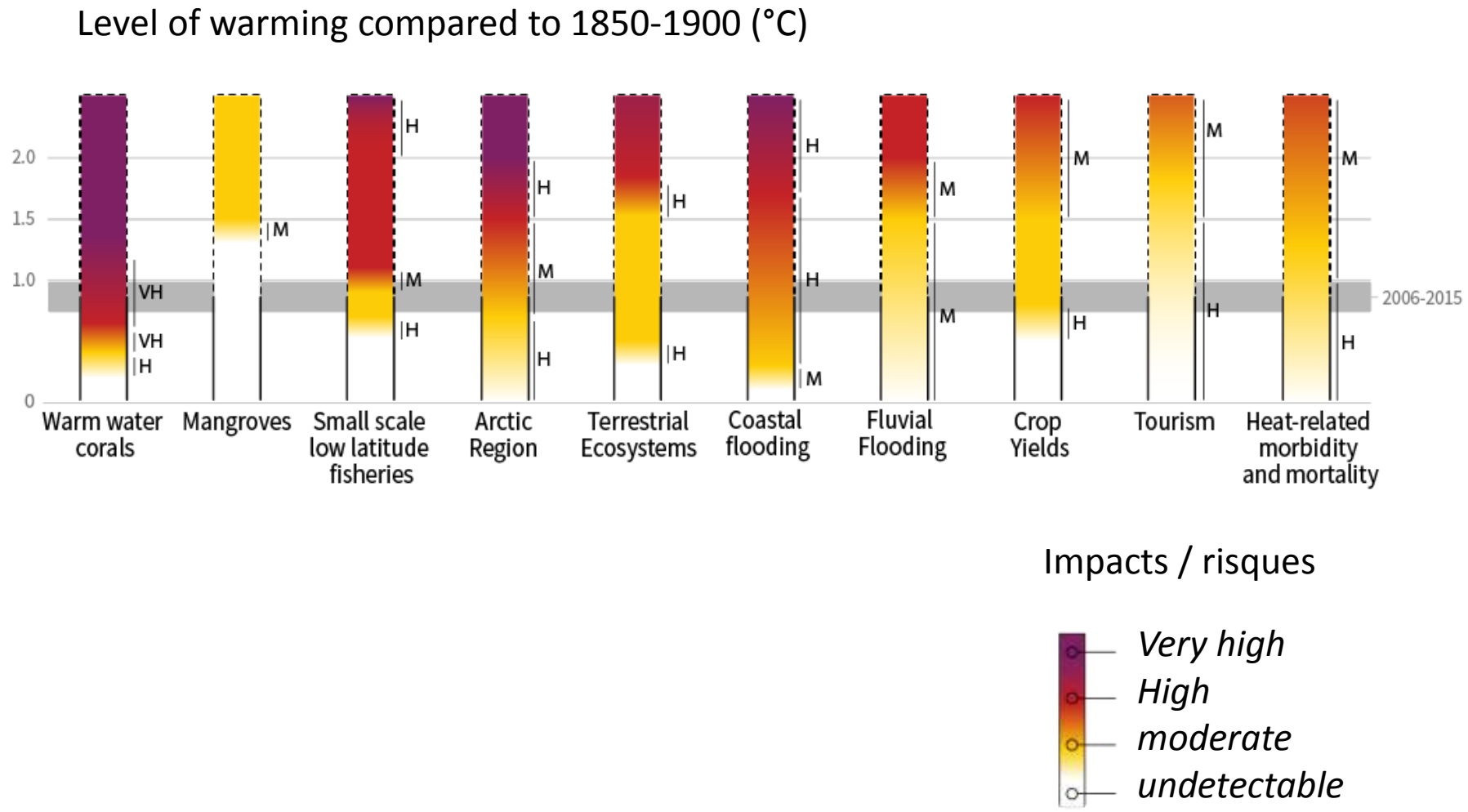
Temperature of hottest days

Temperature of coldest nights



IPCC, 2018 (www.ipcc.ch/report/sr15)

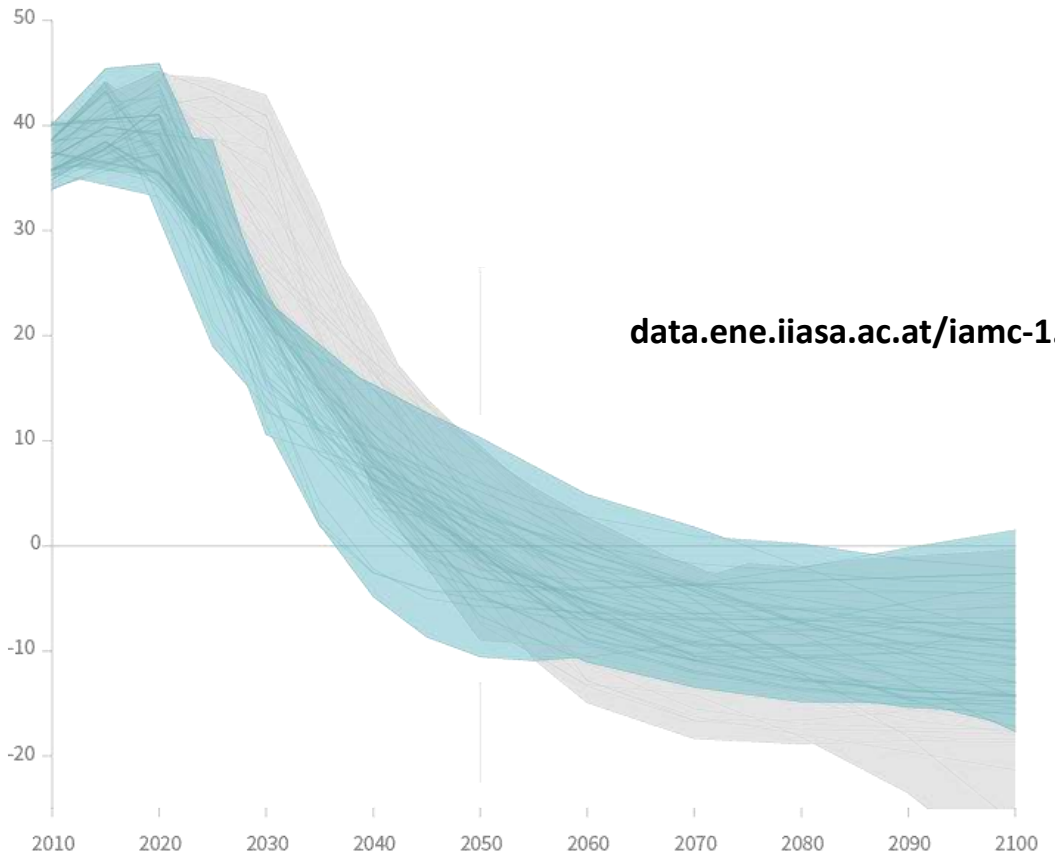
Impacts and risks for different natural, managed and human systems



IPCC, 2018 (www.ipcc.ch/report/sr15)

Trajectories of CO_2 emissions which could stabilie global warming at 1,5°C with and without overshoot

Annual emissions (billon tons CO_2)



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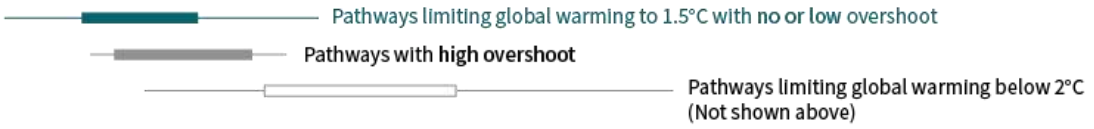
net zero:

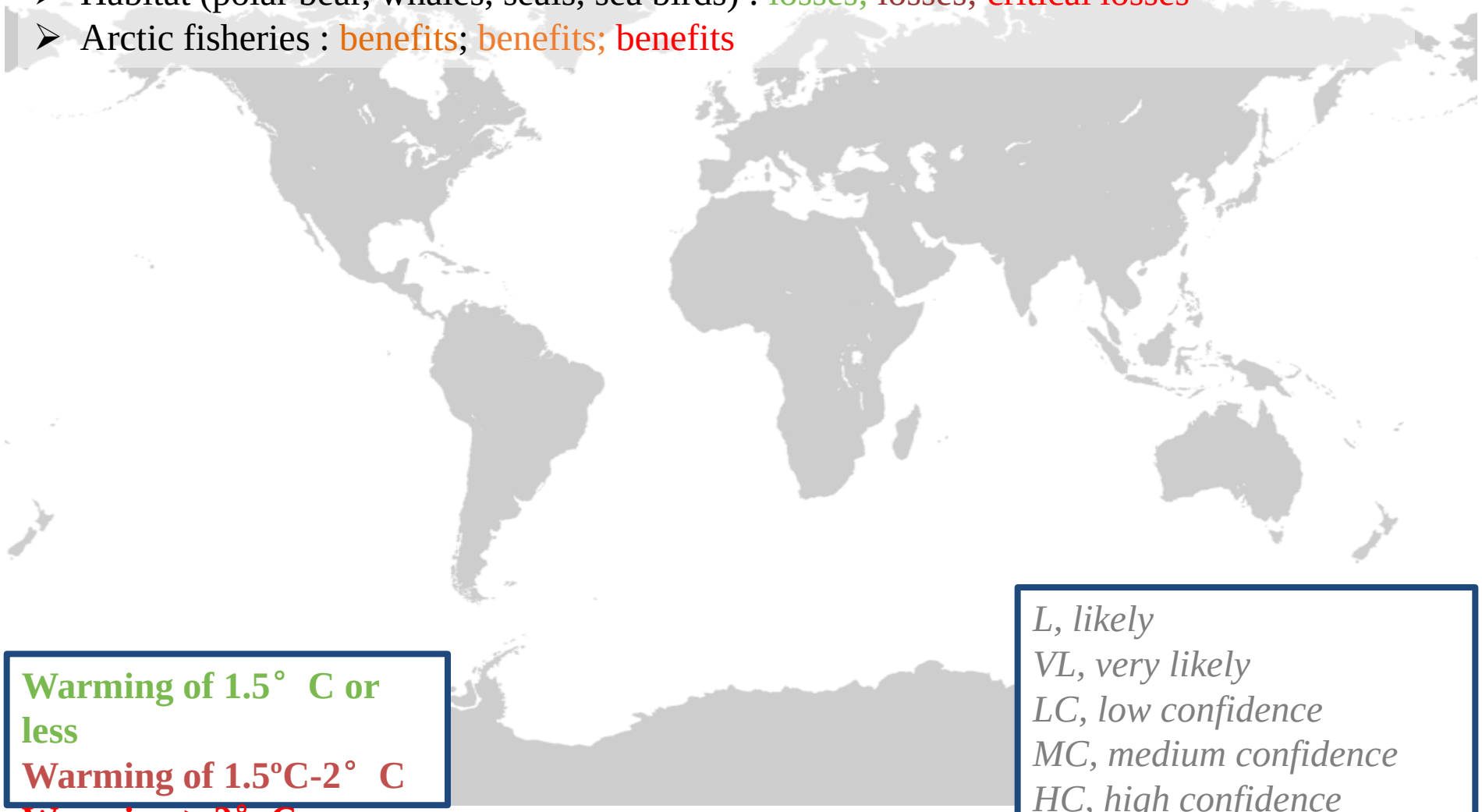


IPCC, 2018 (www.ipcc.ch/report/sr15)

Emergence and intensity of regional climate change hot spots

Arctic summer sea-ice

- *L* maintained; 50% or higher risk to be ice free; *VL* to be ice free
- Habitat (polar bear, whales, seals, sea birds) : losses; losses; critical losses
- Arctic fisheries : benefits; benefits; benefits



Warming of 1.5° C or less
Warming of 1.5ºC-2° C
Warming > 2° C

L, likely
VL, very likely
LC, low confidence
MC, medium confidence
HC, high confidence

Emergence and intensity of regional climate change hot spots

Arctic land regions

- Cold extreme: warm up to 4.5° C *(HC)*; warm up to 8° C *(HC)*; *VL* drastic warming
- Tundra : *L* biome shifts; *L* more shifts; drastic biome shift possible *(LC)*
- Permafrost : *L* 17-44% reduction; *L* larger (28-53%); potential for collapse *(LC)*
- Boreal forest : increased mortality at S. boundary *(MC)*; further *(MC)*; potential dieback *(LC)*

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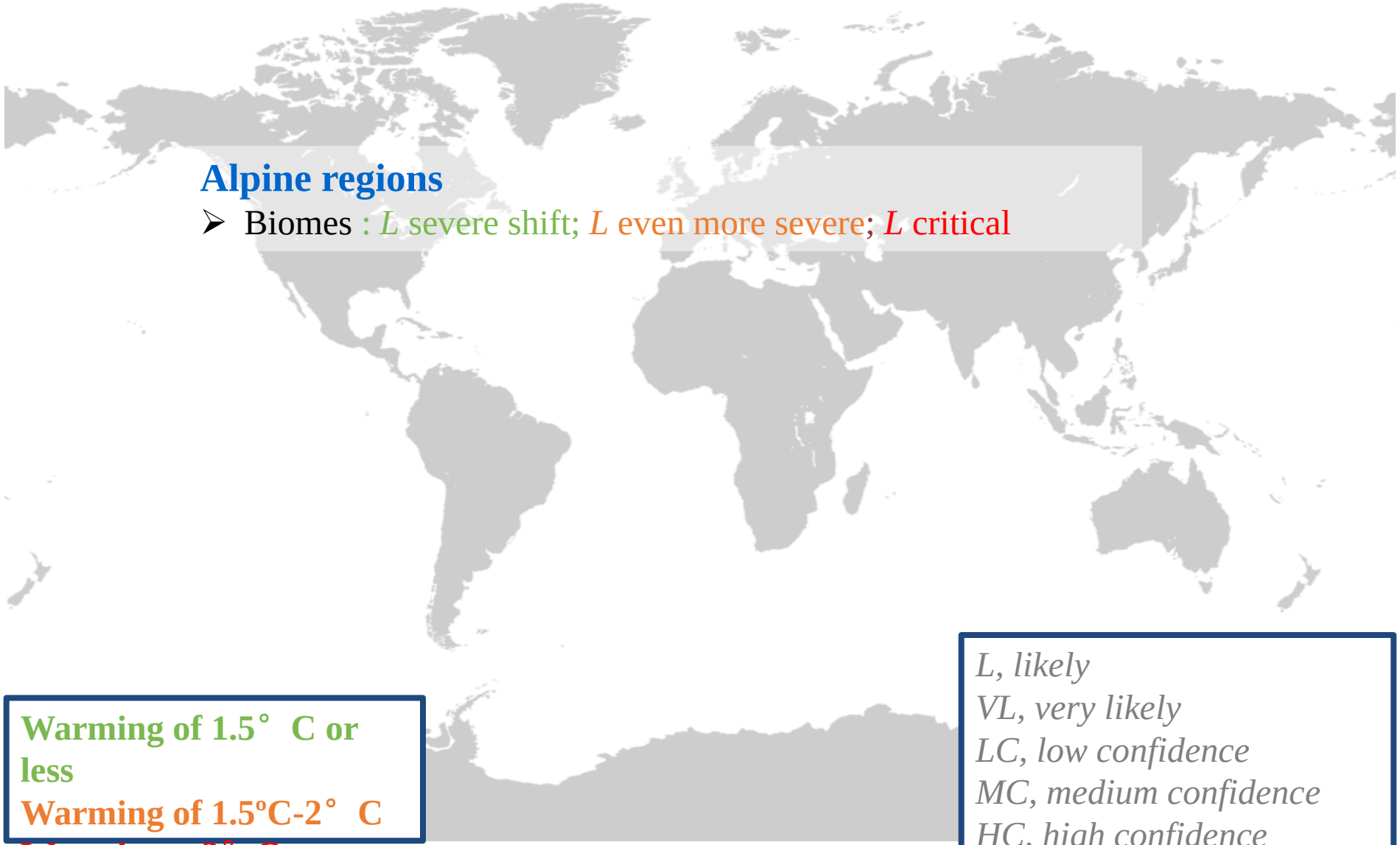
Emergence and intensity of regional climate change hot spots



Alpine regions

- Biomes : *L* severe shift; *L* even more severe; *L* critical

Warming of 1.5˚ C or less
Warming of 1.5ºC-2˚ C
Warming > 2˚ C

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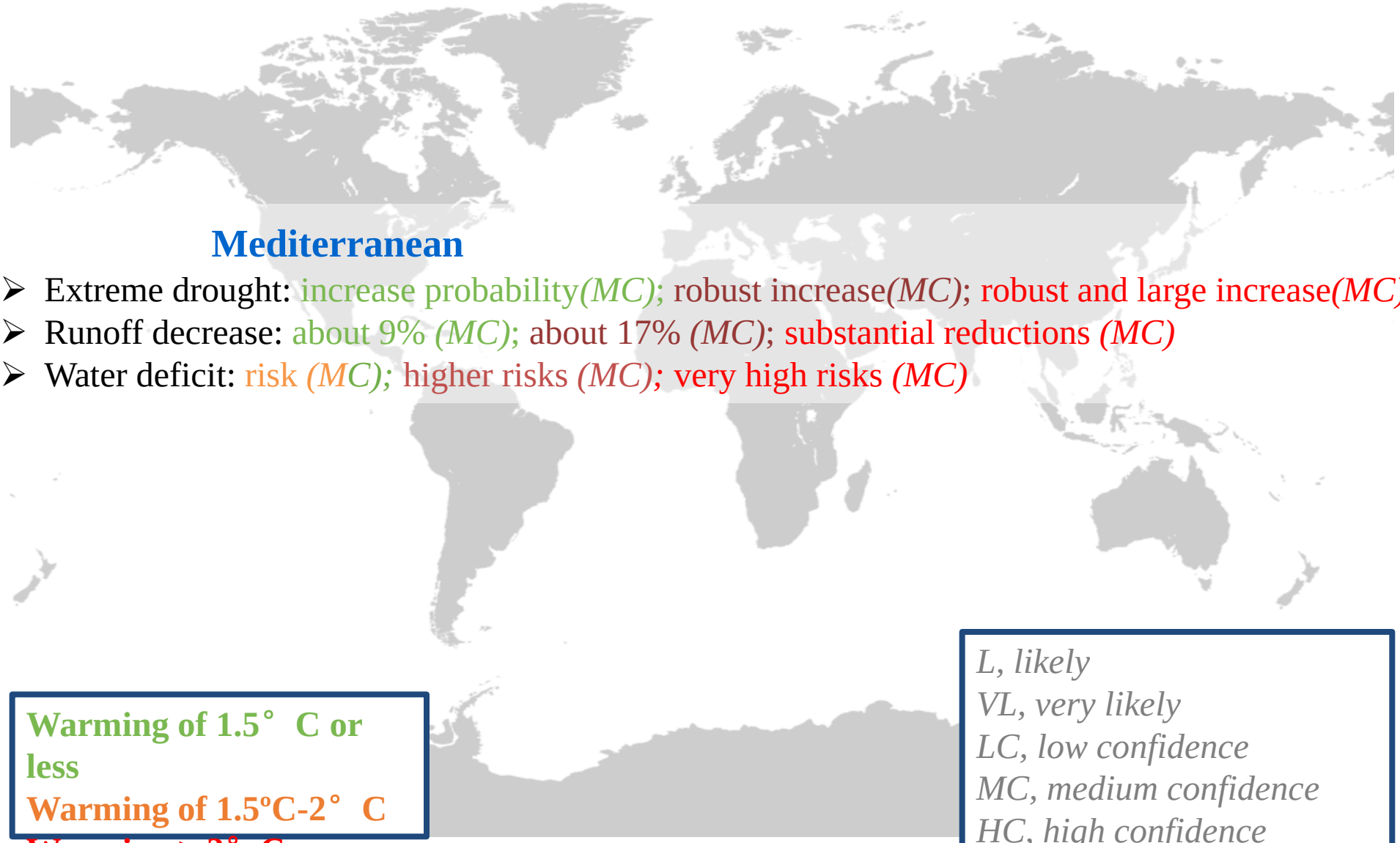
Emergence and intensity of regional climate change hot spots



Mediterranean

- Extreme drought: increase probability*(MC)*; robust increase*(MC)*; robust and large increase*(MC)*
- Runoff decrease: about 9% *(MC)*; about 17% *(MC)*; substantial reductions *(MC)*
- Water deficit: risk *(MC)*; higher risks *(MC)*; very high risks *(MC)*

Warming of 1.5˚ C or less
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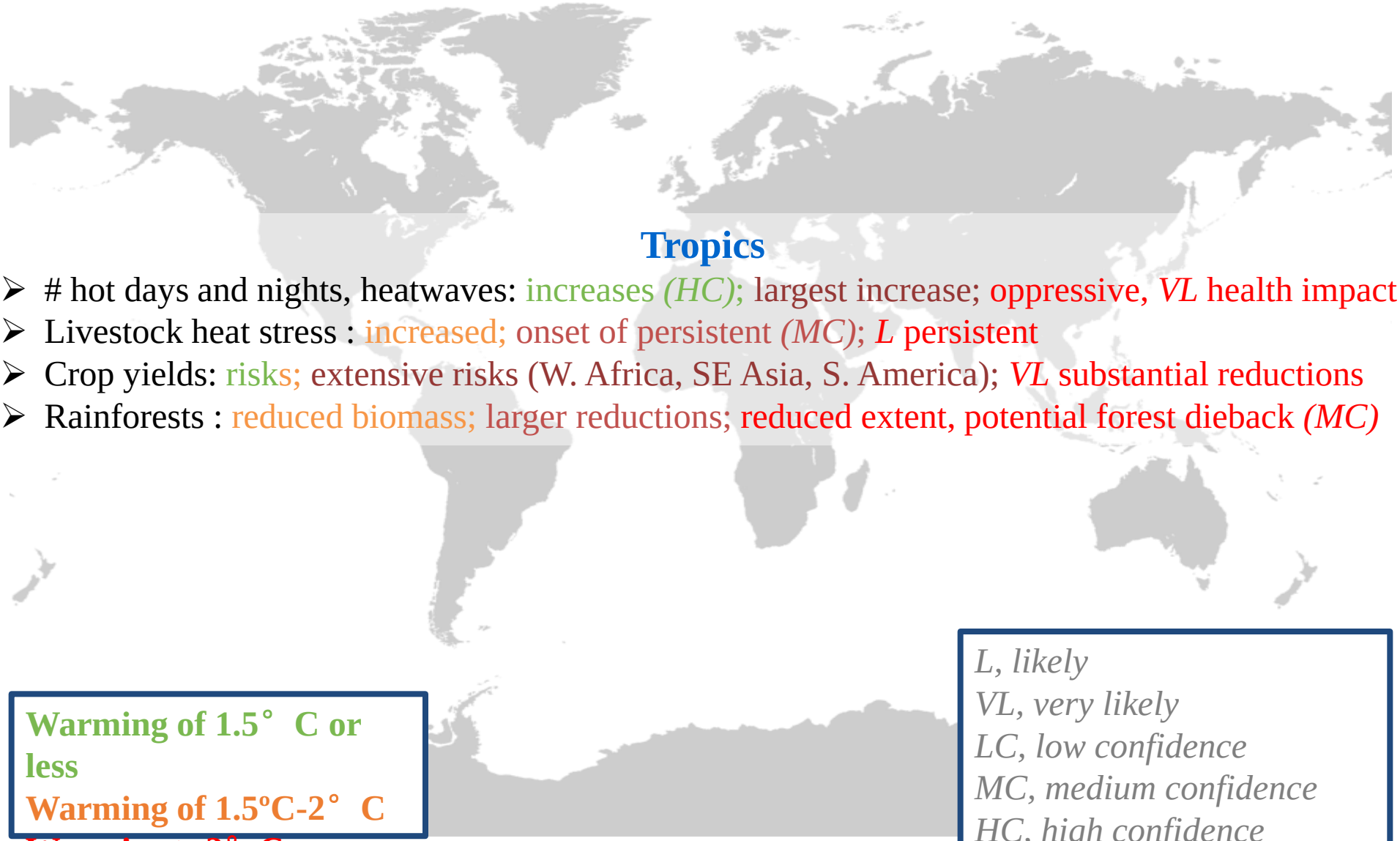
Emergence and intensity of regional climate change hot spots



Tropics

- # hot days and nights, heatwaves: increases *(HC)*; largest increase; oppressive, *VL* health impact
- Livestock heat stress : increased; onset of persistent *(MC)*; *L* persistent
- Crop yields: risks; extensive risks (W. Africa, SE Asia, S. America); *VL* substantial reductions
- Rainforests : reduced biomass; larger reductions; reduced extent, potential forest dieback *(MC)*

Warming of 1.5˚ C or less
Warming of 1.5ºC-2˚ C
Warming > 2˚ C

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Emergence and intensity of regional climate change hot spots

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Southeast Asia

- ↗ flooding related to sea-level rise: risks; higher risks *(MC)*; substantial increases in risk
- Asian monsoon : *LC; LC; L* increase in precipitation intensity
- Heavy precipitation: increase; stronger increase *(MC)*; substantial increase
- Crop yield reductions: -; one third decline in per capita *(MC)*; substantial reduction

Emergence and intensity of regional climate change hot spots

Warming of 1.5° C or less
Warming of 1.5°C-2° C
Warming > 2° C

L, likely
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West African and the Sahel

- Monsoon : uncertain ; uncertain ; strengthening *(LC)*
- Hot nights, longer, more frequent heat waves: *L* ↗; *L* further ↗; *VL* substantial ↗
- ↘ in maize and sorghum production: *L*, about 40% ↘ suitable area; *L* larger ↘; major regional food insecurities *(MC)*
- Undernutrition risks : increased; higher; high

Emergence and intensity of regional climate change hot spots

Warming of 1.5° C or less
Warming of 1.5°C-2° C
Warming > 2° C

L, likely
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HC, high confidence

Southern Africa

- Water availability: reductions *(MC)*; larger reductions *(MC)*; large reductions *(MC)*
- # of hot nights and ↗ heat waves : increases *(HC)*; further increase *(HC)*; drastic increase *(HC)*
- Increased mortality from heat-waves: high risks; higher risks *(HC)*; sustantial impact on health and mortality *(HC)*
- Undernutrition / dryland agriculture and livestock: high risk; higher risk *(HC)*; very high risks

Emergence and intensity of regional climate change hot spots

Warming of 1.5° C or less
Warming of 1.5°C-2° C
Warming > 2° C

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Small islands:

- Inundation risk : land exposed; tens of thousands displaced ; substantial, widespread impacts
- Coastal flooding: risks; high risks ; substantial and widespread impacts
- Fresh water stress : increased; projected aridity; substantial and widespread impacts
- # of warm days : increase; further increase (70 warm days/year), persistent heat stress in cattle ; persistent heat stress
- Loss of coral reefs: 70-90%; most coral reefs ; loss of most coral reefs *(VL)*