Global Warming Levels as an organizing dimension of future climate projections

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Twenty-year running averages: climate, not weather!

Global average Temperature

CMIP6 models
SSP3-7.0
SSP1-2.6

°C

5
4
3
2
1

2000 2020 2040 2060 2080 2100

Adapted from IPCC AR6 WG1 Ch. 11, box 11.1

Twenty-year running averages: climate, not weather!

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SSP3-7.0
SSP1-2.6

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Global average Temperature °C

Average across models scenarios times

Response at different GWLs (Ensemble average)

Temperature change at 4°C   48
Precipitation change at 4°C   47
4°C

Temperature change at 2°C   137
Precipitation change at 2°C   132
2°C

Temperature change at 1.5°C   153
Precipitation change at 1.5°C   147
1.5°C

°C
-5 -4 -3 -2.5 -2 -1.5 0 1.5 2 2.5 3 4 5

%
-40 -30 -20 -10 0 10 20 30 40

Adapted from IPCC AR6 WG1 Ch. 11, box 11.1

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2°C

1.5°C

No mention of time or scenario

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Straight CMIP models

2°C in SSP3-7.0 ◆
2°C in SSP1-2.6 ◆

Timing of GWLs
Depends on scenarios

Twenty-year running averages: Climate, not weather!
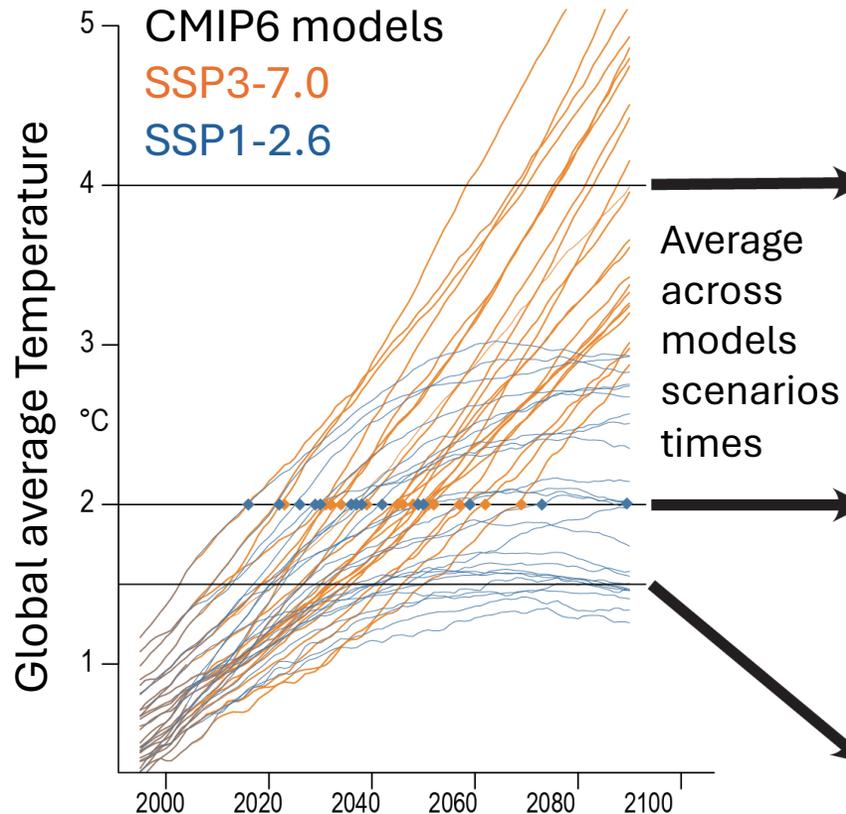
CMIP6 models
SSP3-7.0
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Global average Temperature °C

Average across models scenarios times

Straight CMIP models

2°C in SSP3-7.0
2°C in SSP1-2.6

Timing of GWLs Depends on scenarios

Assessed global temperature projections

2°C in SSP3-7.0
2°C in SSP1-2.6

Response at different GWLs (Ensemble average)

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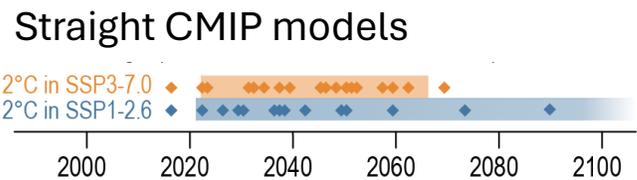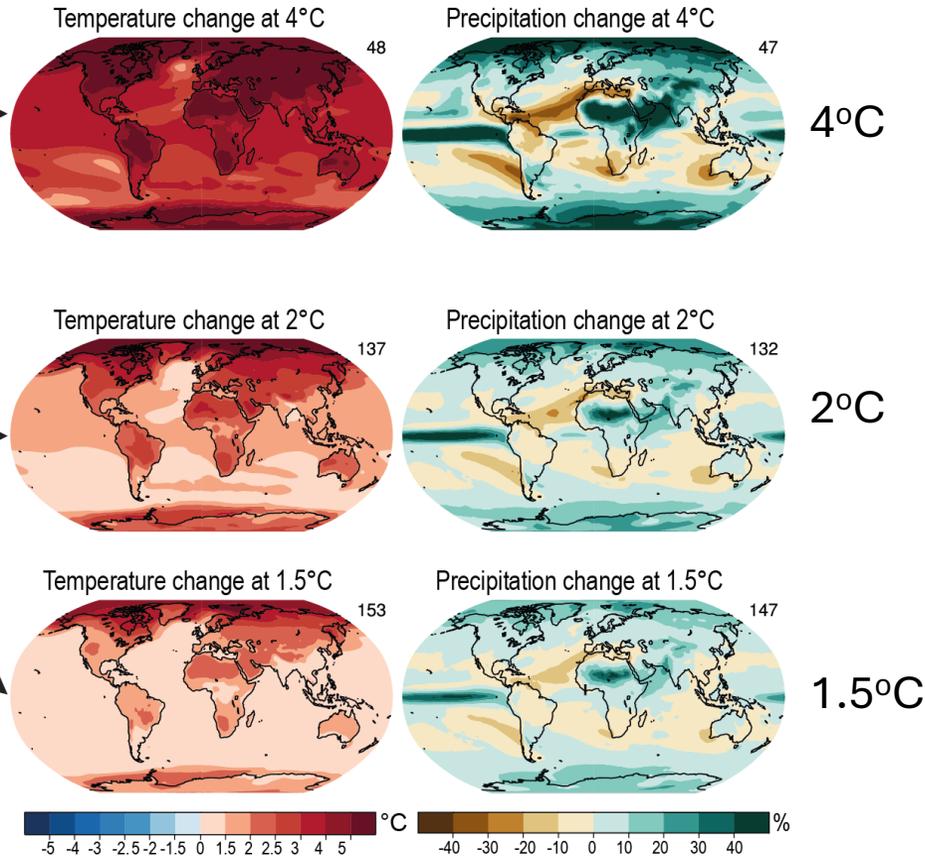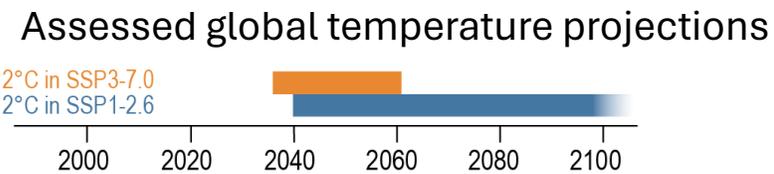
| Timing 2°C	Best estimate	Very likely range
SSP1-1.9	NA	NA
SSP1-2.6	NA	(2031–50 to NA)
SSP2-4.5	2043-62	(2028–47 to 2075–94)
SSP3-7.0	2037–56	(2026–45 to 2053–72)
SSP5-8.5	2032–51	(2023–42 to 2044–63)

Most atmospheric variables relevant to impact modeling behave in sync with global temperature, i.e., are path/scenario independent when conditioned upon the global warming level. This is the case for both mean and extreme metrics.

Change in temperature of the hottest day of the year

(a) At 1.5°C global warming 112

(b) At 2.0°C global warming 98
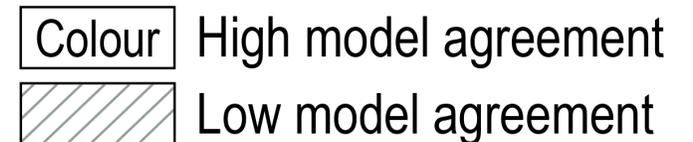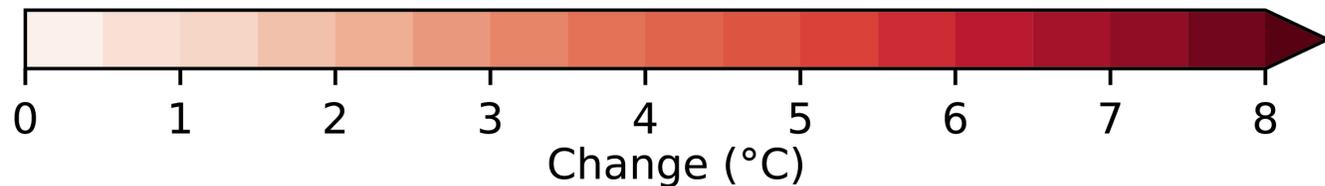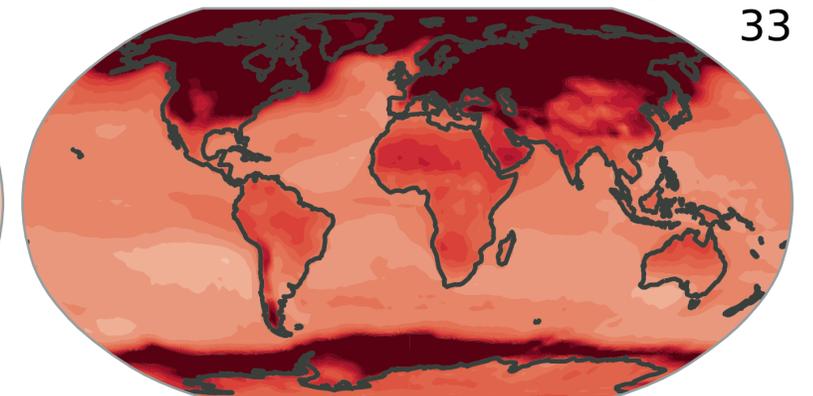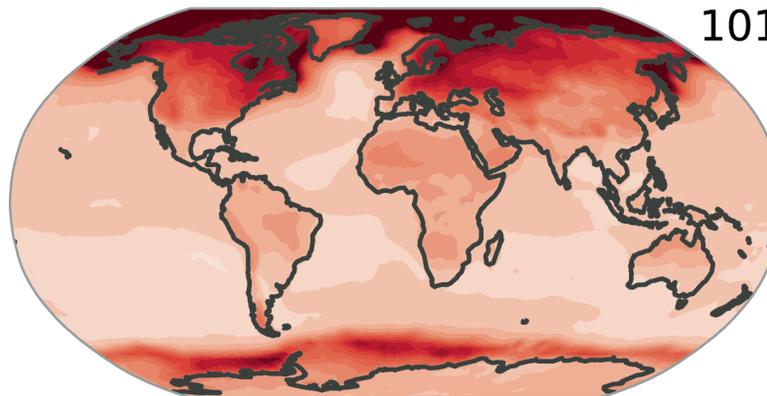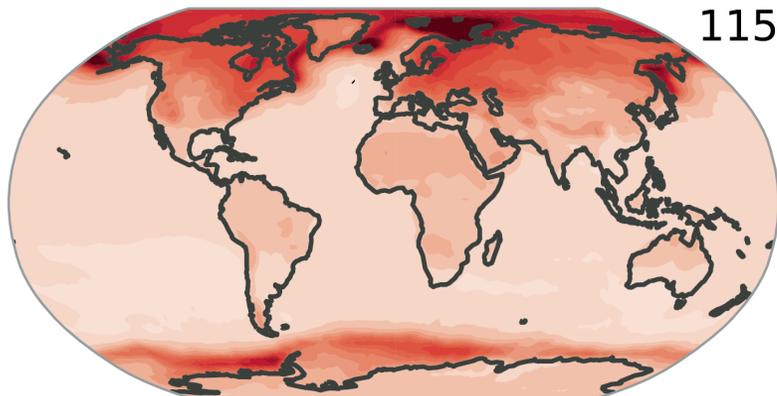
(c) At 4.0°C global warming 32
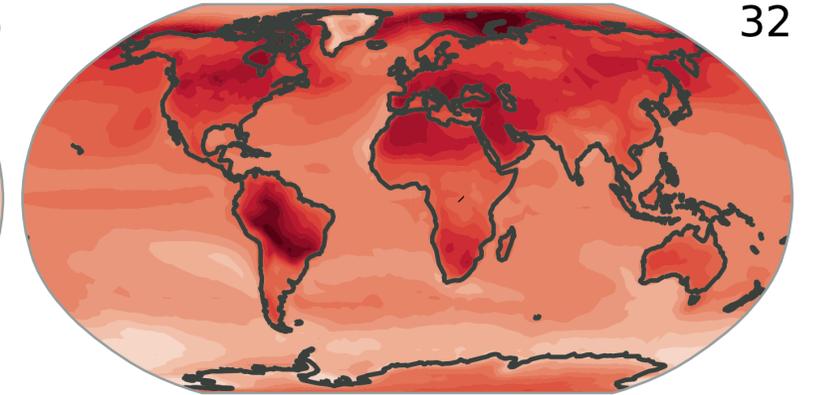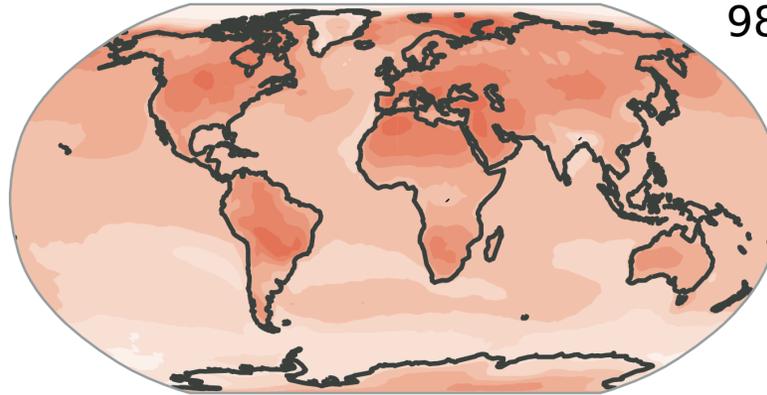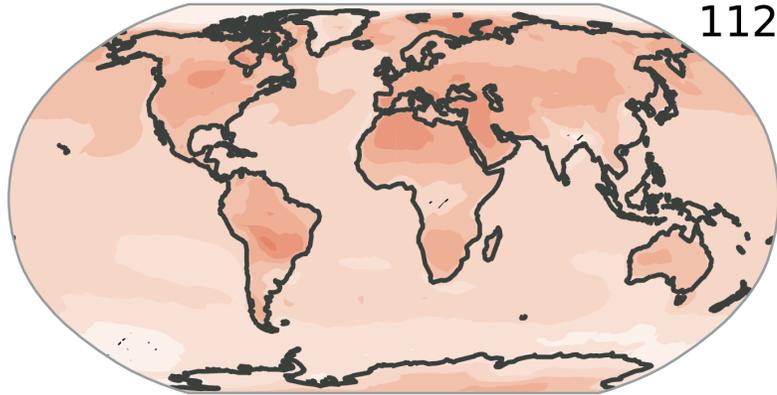
Change in temperature of the coldest day of the year

(d) At 1.5°C global warming 115

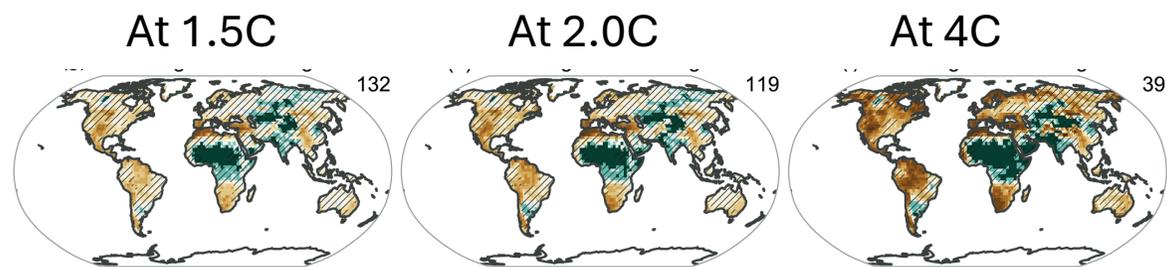**(e)** At 2.0°C global warming 101

(f) At 4.0°C global warming 33

Change (°C)

0 1 2 3 4 5 6 7 8

| Colour | High model agreement |
| Low model agreement |

Change in length of longest dry spell of the year

At 1.5C · At 2.0C · At 4C

Colour — High model agreement
Hatching — Low model agreement

Change (days): −35, −25, −15, −5, 5, 15, 25, 35

Change in soil moisture

At 1.5C · At 2.0C · At 4C

Colour — High model agreement
Hatching — Low model agreement

Change: −1.5, −1.0, −0.5, 0.0, 0.5, 1.0, 1.5
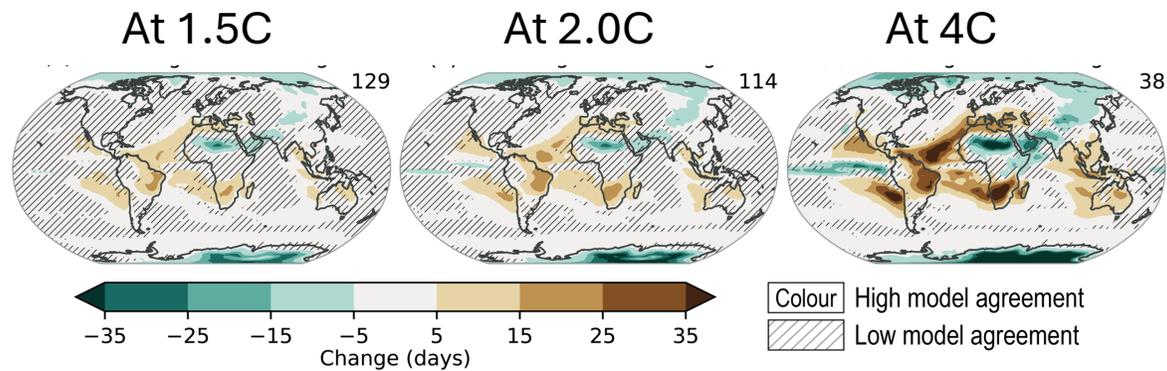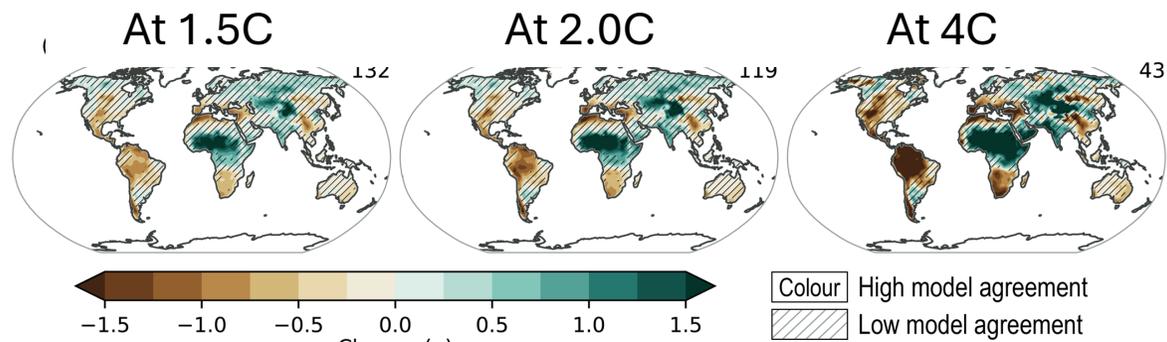
Change in 10-year drought events (JJA)

At 1.5C · At 2.0C · At 4C

Change in 10-year drought events (DJF)

At 1.5C · At 2.0C · At 4C

Colour — High model agreement
Hatching — Low model agreement

Change (times as frequent): 0.125, 0.25, 0.5, 1, 2, 4, 8
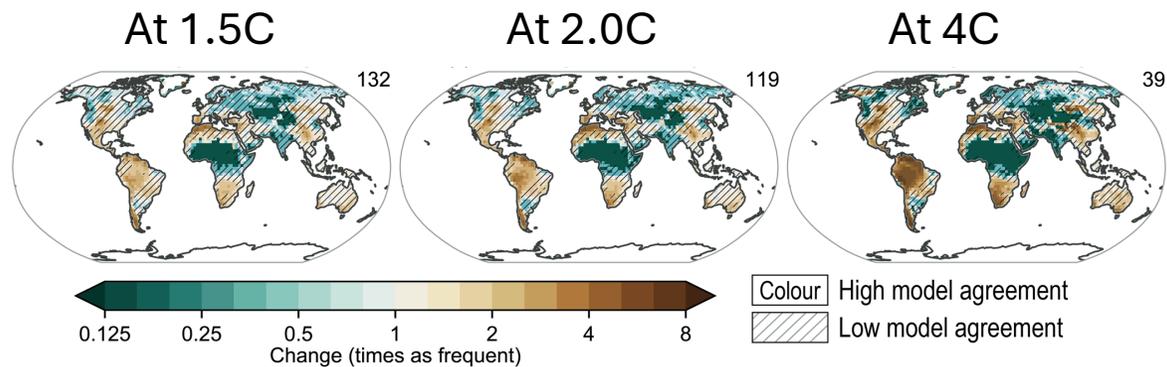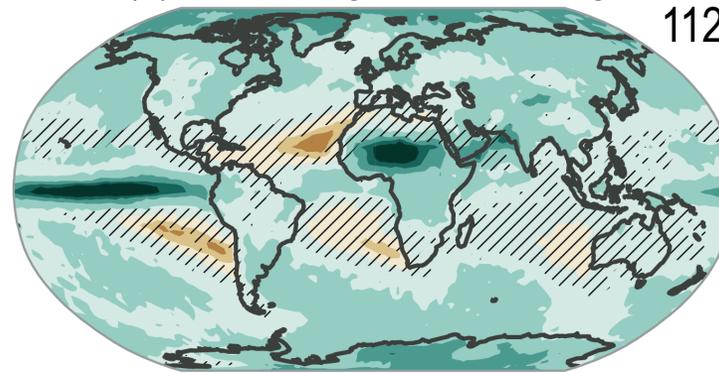
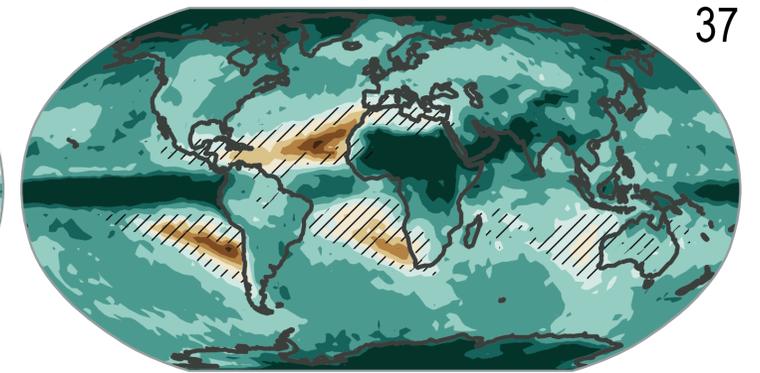# Change in precipitation amount during the wettest day of the year
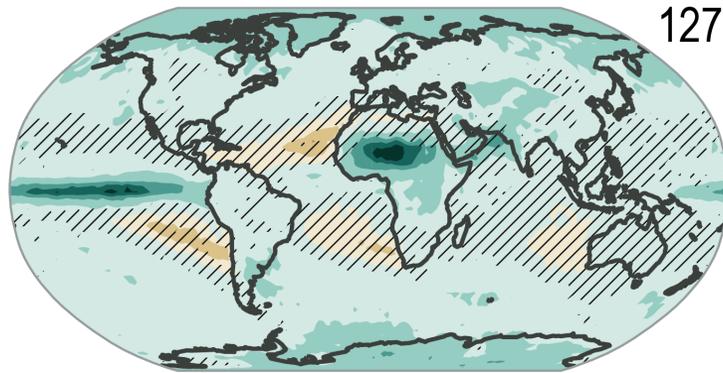
(a) At 1.5°C global warming 127

(b) At 2.0°C global warming 112

(c) At 4.0°C global warming 37

Colour | High model agreement

Low model agreement

-40 -30 -20 -10 0 1 2 3 4

Change (%)
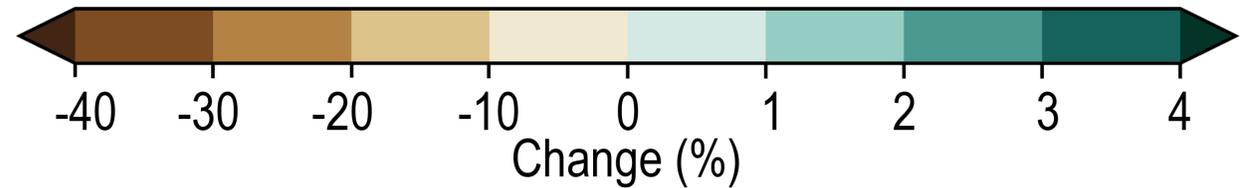
==Quantities with long memory== do not depend only on the global temperature level reached, but on how the system got there, for how long it has been there -> Sea Level Rise

==Non-reversible impacts== may look very different on one side or the other of the temperature trajectory peak -> Ice Sheets, Desertification

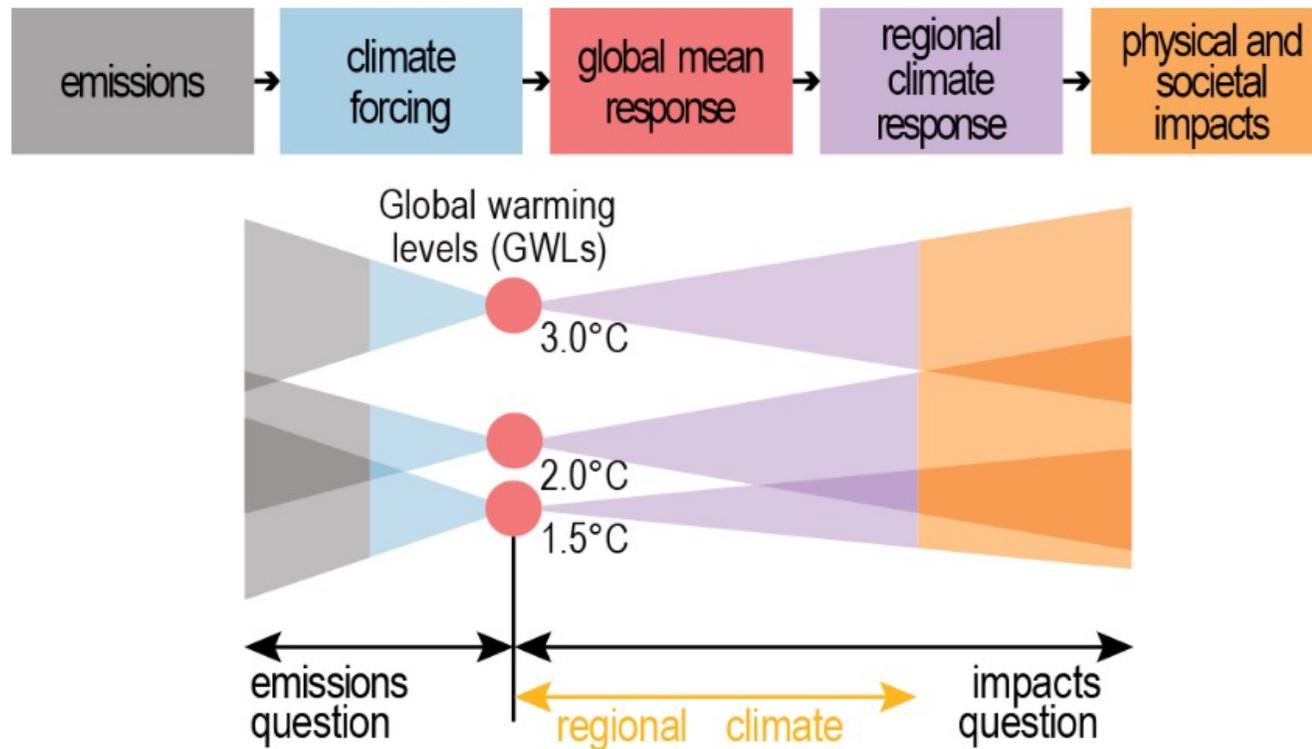Impacts may depend on the ==rate of change== besides the level of warming.

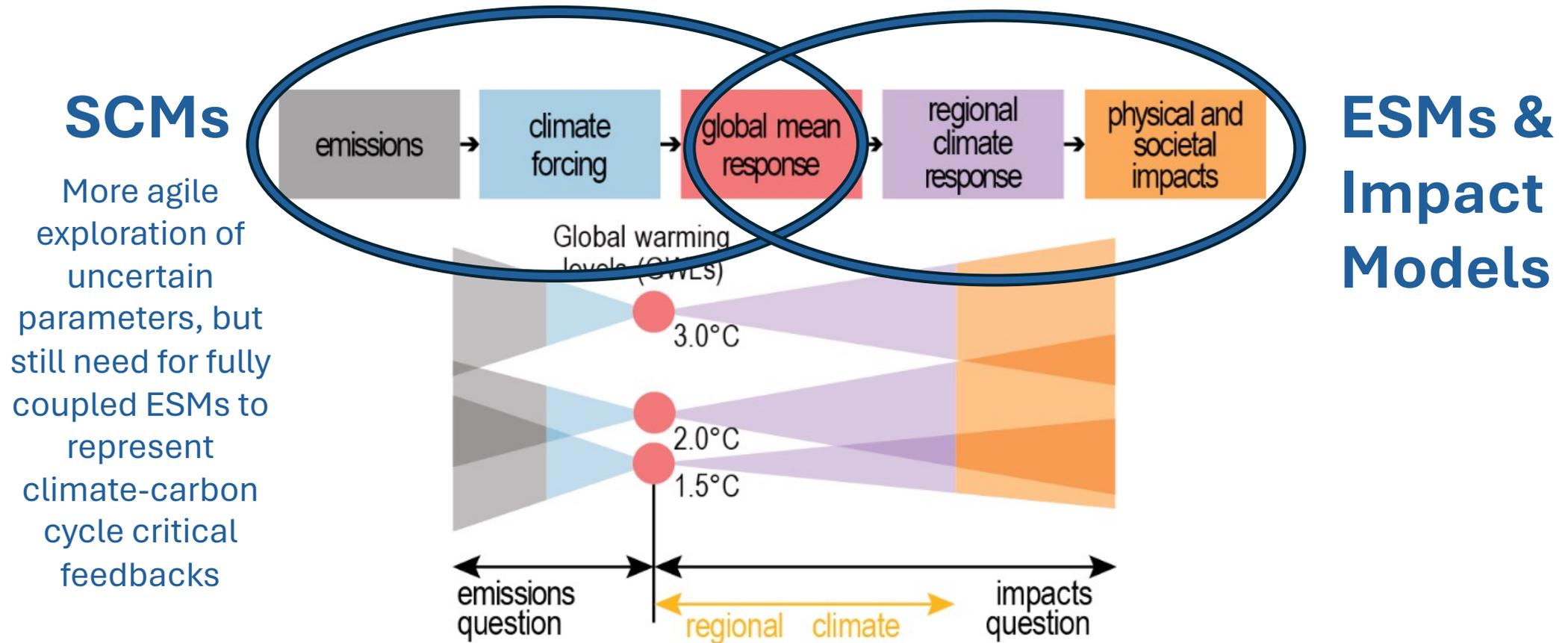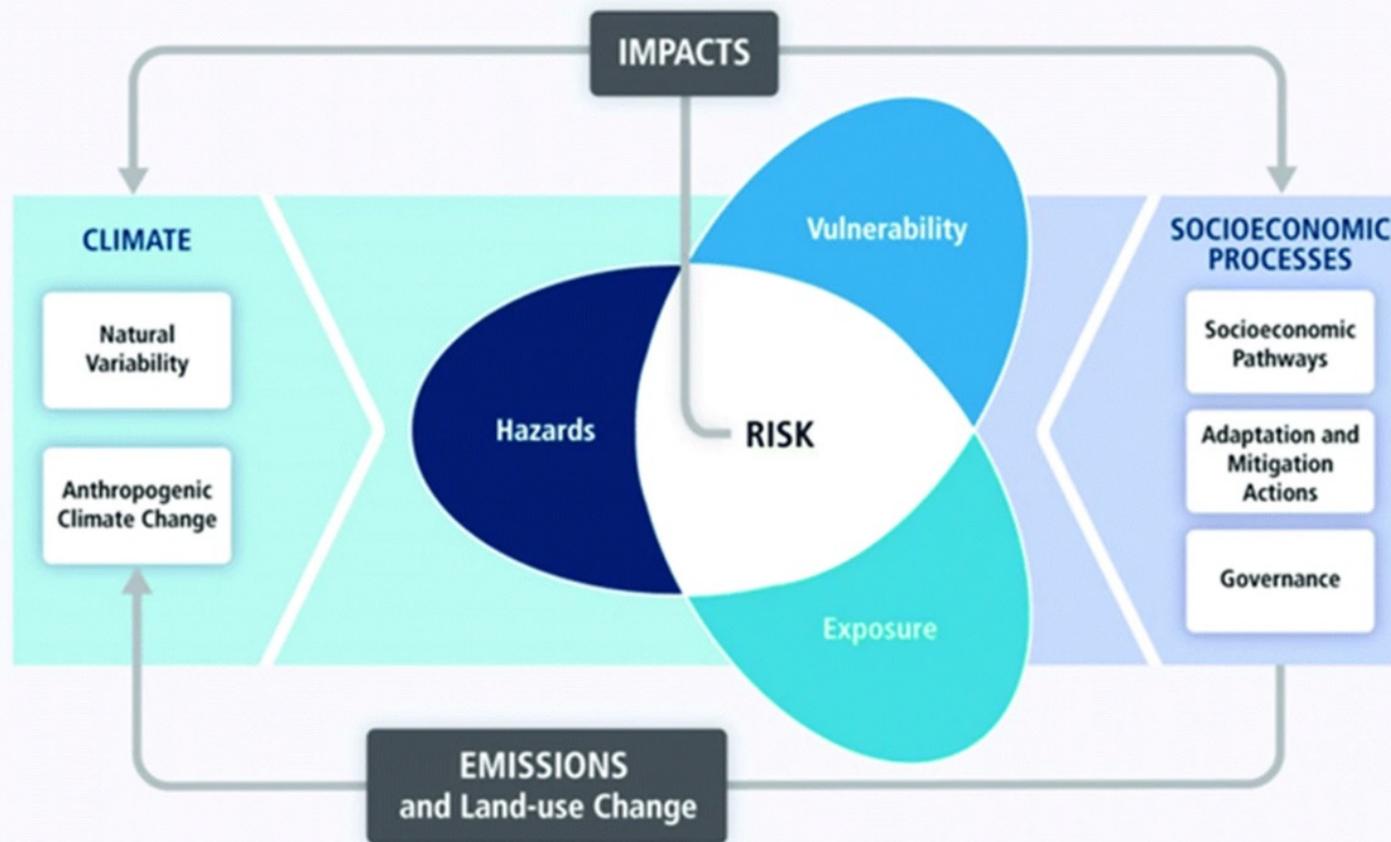# At which GWL <mark>by 2100</mark> will today's 100-yr event become an annual event?
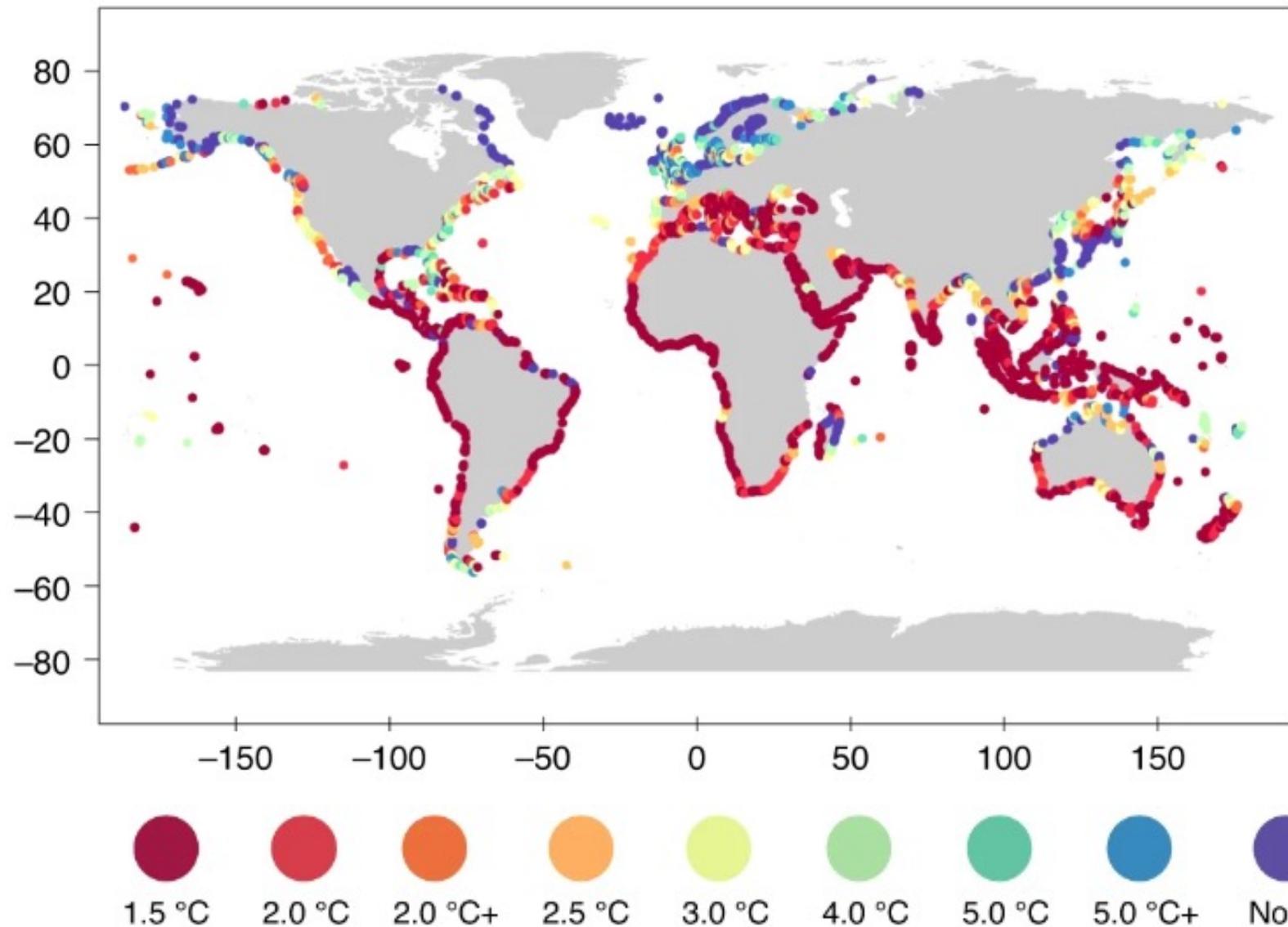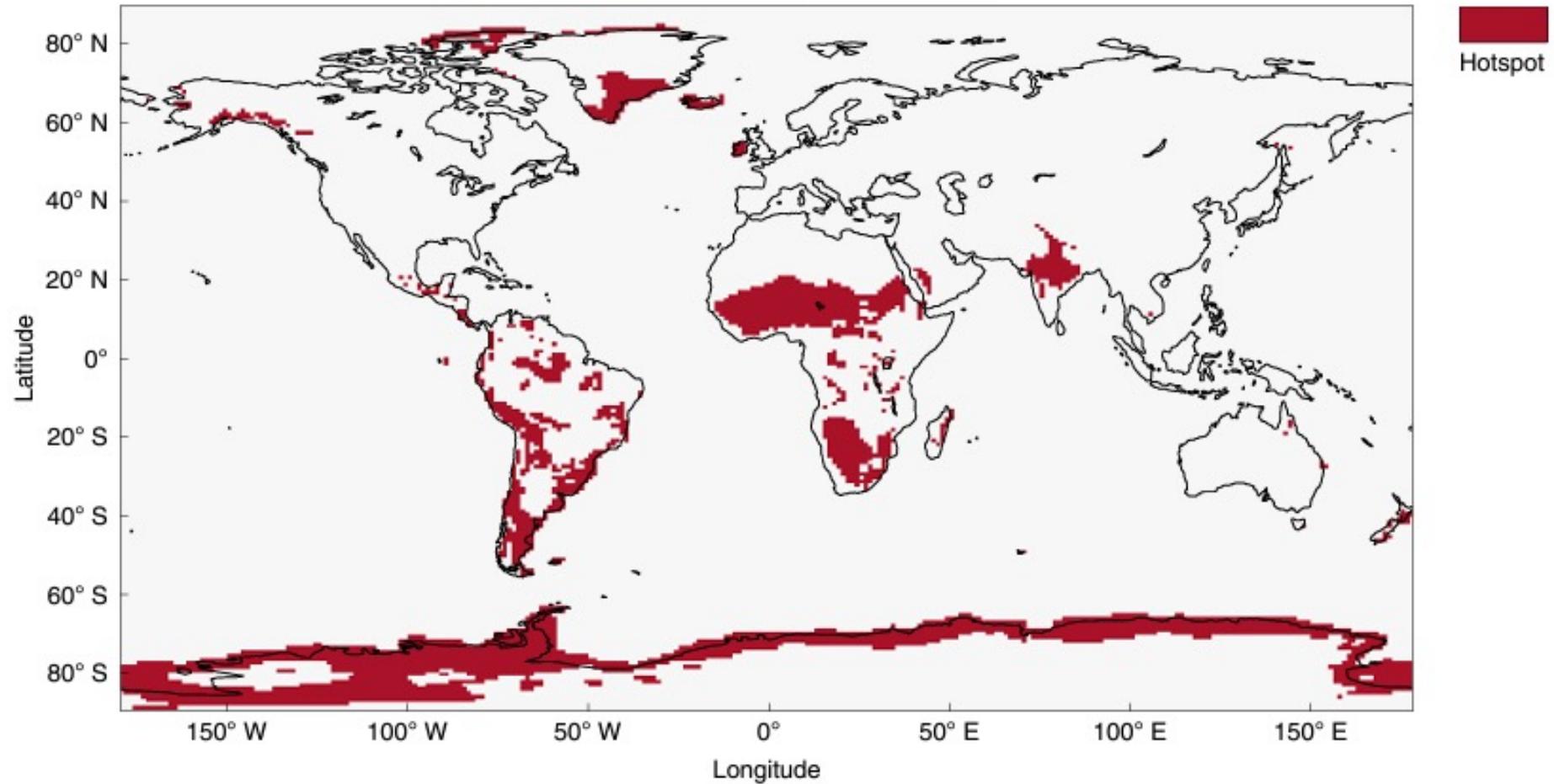
Land areas where temperature and precipitation show irreversible changes

GWLs and uncertainty: where we 'clasp' does not change the sources and relevance, but may change the tools we use to address the various modeling steps.

GWLs and uncertainty: Clasping it does not change the sources and relevance, but may change the tools we use to characterize the various steps.

SCMs

More agile exploration of uncertain parameters, but still need for fully coupled ESMs to represent climate-carbon cycle critical feedbacks

ESMs & Impact Models

emissions → climate forcing → global mean response → regional climate response → physical and societal impacts

Global warming levels (GWLs)

3.0°C

2.0°C

1.5°C

emissions question

regional climate

impacts question

From IPCC AR6 WG1 Ch.11

We still need ==scenarios== of future emissions to tell a coherent story of future developments and action/choices, and to add a consistent representation of the human component to the evaluation of impacts.

==Getting to 2C by 2050== will have very different impacts than getting to it ==by 2090==; In fact getting to 2C ==by 2090 but along different socio-economic pathways== will have very different impacts. Exposure, vulnerability/adaptation are critical determinants and depend on the ==scenario, down to its sub-global assumptions.==

Thank you