Half a degree matters - climate impacts at 1.5°C and 2°C

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The long-term global temperature goal in the Paris Agreement

Article 2

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

(a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

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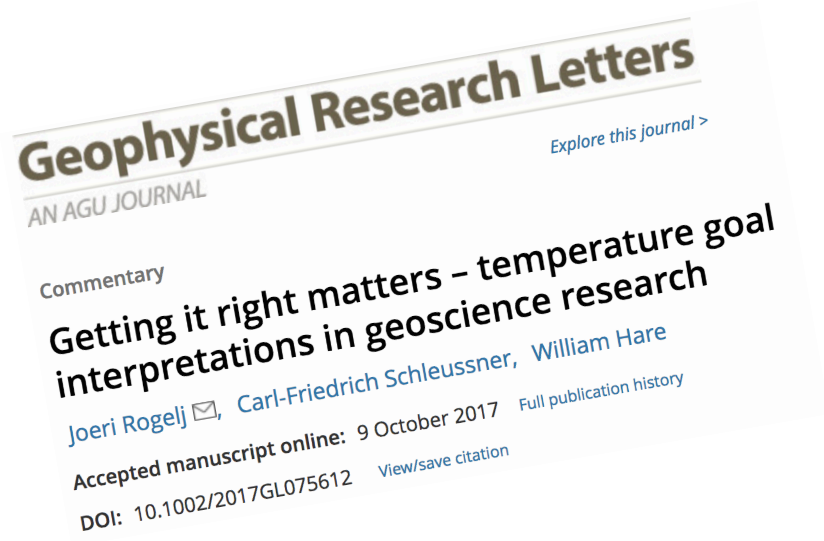
What does the 1.5°C long term temperature limit mean?

- 1.5°C 'hot topic' in the scientific community. A lot of interesting questions surrounding questions of definition and interpretation:
  - For which impacts, global mean temperature is a good indicator? For which it is not?
  - How do impacts at 1.5°C differ between 2030 and 2100, or after an overshoot

- **But:** The Paris Agreement long-term temperature goal refers to **changes in long-term global climatological averages, excluding natural variability**
- Recently, there have been studies discussing 1.5°C on annual periods or at smaller geographical scales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Commentary

Getting it right matters – temperature goal interpretations in geoscience research

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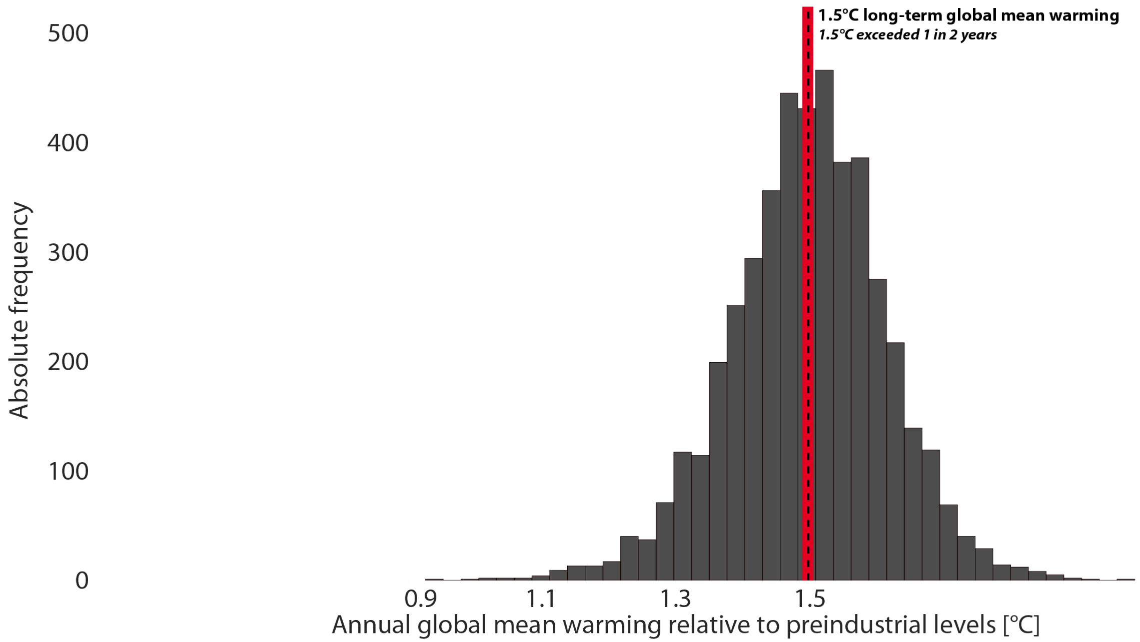
Why does it matter? Temperature limits and carbon budgets



Exceedance of 1.5°C annual mean warming	Equivalent long-term global-mean warming [°C]	Implied reduction in long-term warming [°C]	Reduction in carbon budget [Gt CO_2]
1 in 2 years	1,5	0	0

Annual GMT anomalies from running 21-year average for 24 CMIP5 models and the 1900-2090 period (combined historical and RCP2.6 scenario)

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Rogelj et al. 2017

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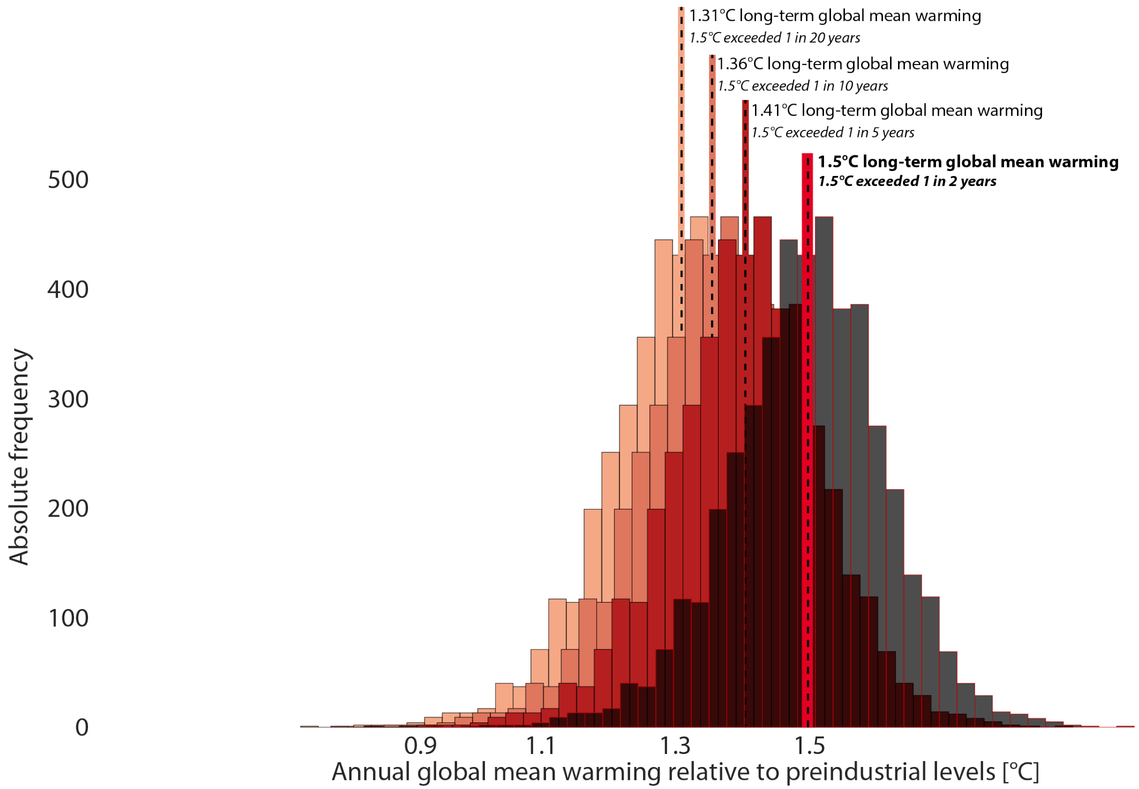

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1 in 5 years	1,41	0,09	200
1 in 10 years	1,36	0,14	311
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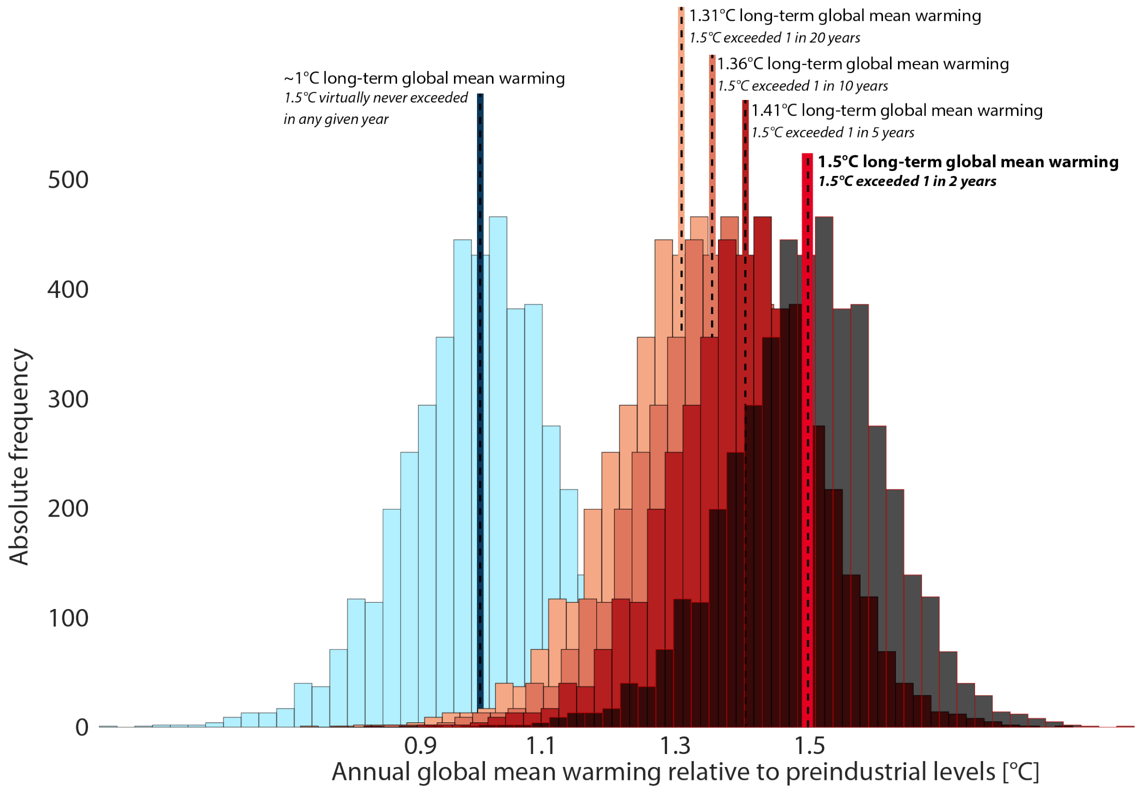

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Never	~1	0,5	1110

For comparison: IPCC AR5 1.5°C cumulative carbon budget since 1860—1880: 2300 Gt CO_2

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Discriminating impacts at 1.5°C vs 2°C

Do we have reason to believe that there will be differences between 1.5°C and 2°C?

Are we able to detect 0.5°C differences given substantial uncertainties in model simulations?

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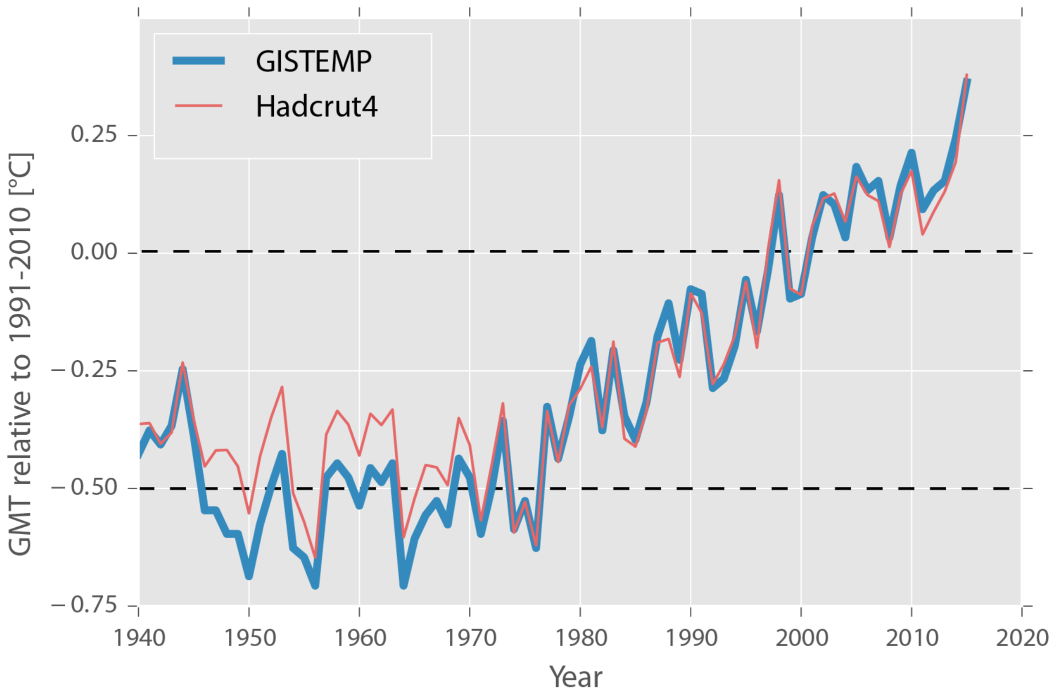
Complementary evidence from the observational record

- Most attribution studies refer to 1950s at the earliest → ~ 0.5°C warming
- 1991-2010 vs. the 1960-1979 period → corresponds to 0.5°C GMT difference in GISTEMP



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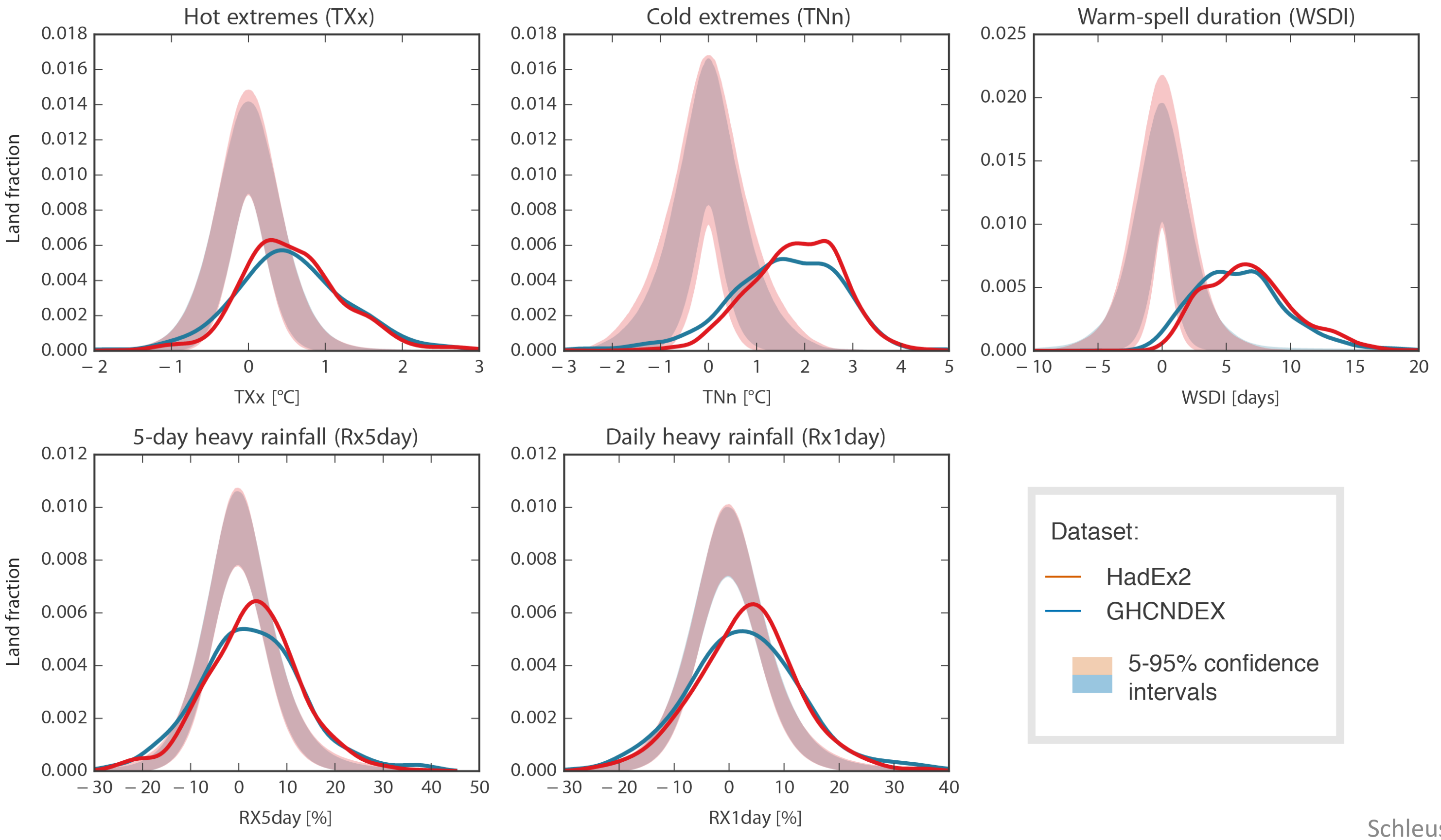
Robust differences for 0.5°C warming over the observational record

- Fraction of global land area that has experienced a certain change in extreme events for 0.5°C between 1960-1979 and 1991-2010
- Internal variability is estimated by statistical resampling of 20yr sets from 1950-2010
- See also Poster P.H14



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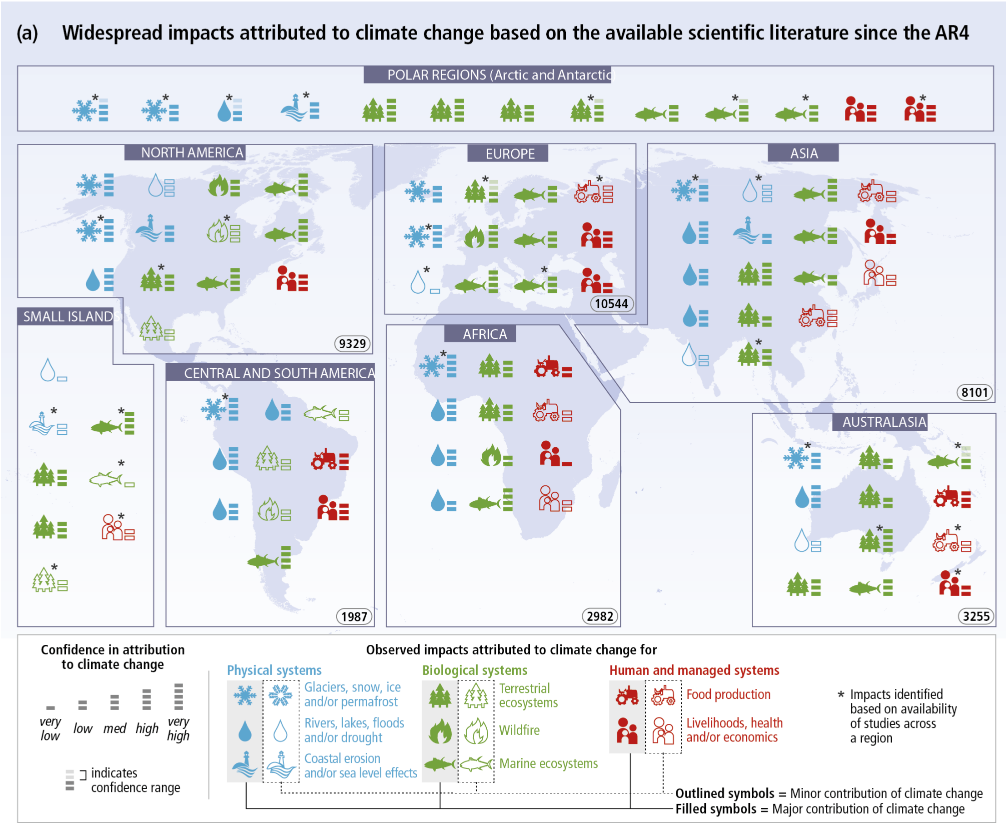
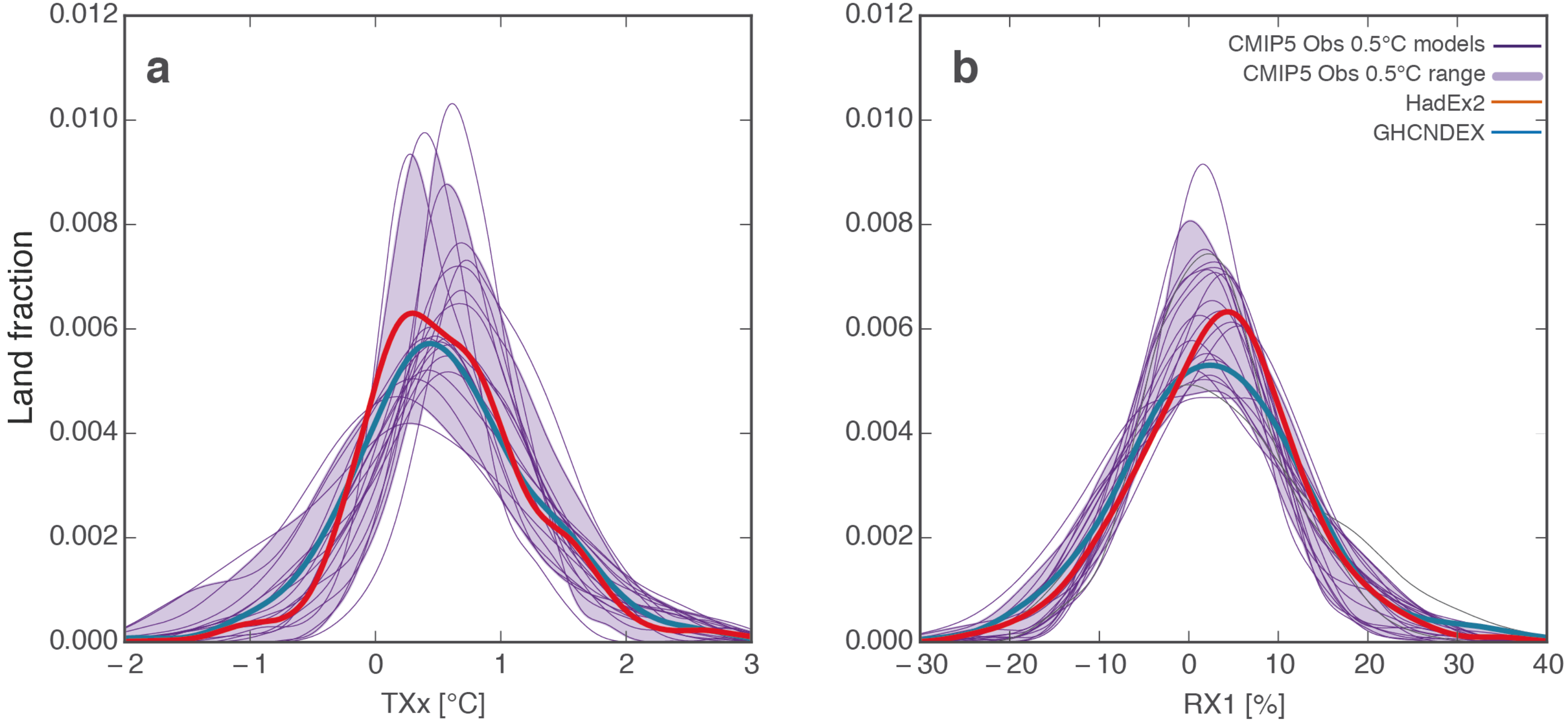
Detection and attribution of observed impacts



- Observed attributable impacts in physical, biological and human systems
- Most assessment are based on about or less 0.5°C warming
- Observed impacts of 0.5°C warming likely a lower bound for future impacts

Robust comparison of 0.5°C warming differences between CMIP5 and observed datasets



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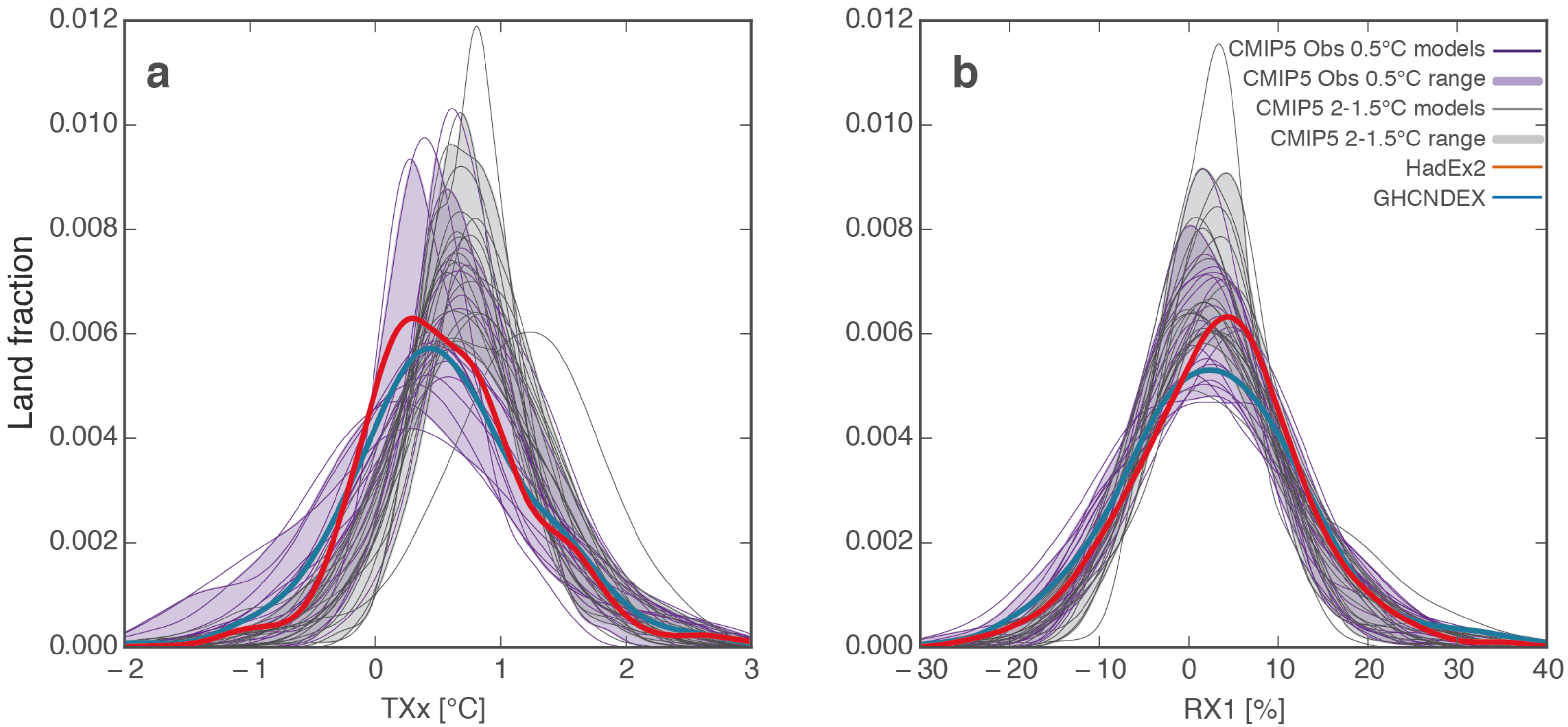
Good agreement between observed 0.5°C warming and 2°C-1.5°C for extreme temperature and precipitation



- Regional extreme weather indices scale rather linear with global mean temperature (Seneviratne et al. 2016)

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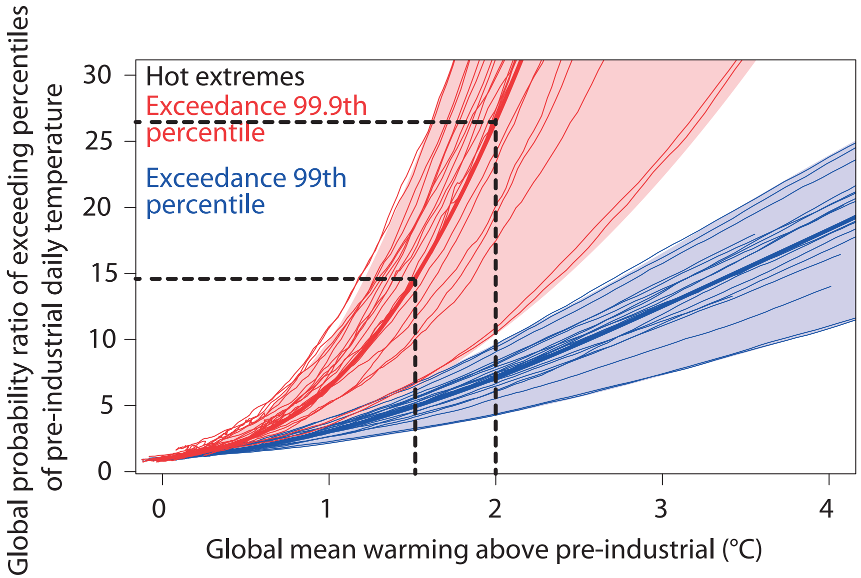
Schleussner et al., 2017

Non-linear increase in threshold exceeding extremes:

- Threshold exceeding hot extremes will increase substantially between 1.5°C and 2°C
- Relative to natural variability, increases are particularly pronounced in tropical regions where unusual heat waves would become the new normal at 2°C (Russo et al. 2016)



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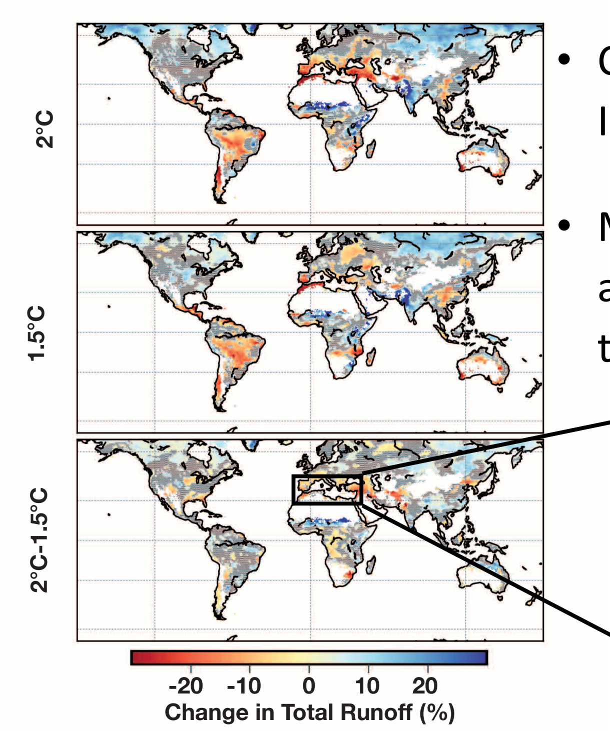
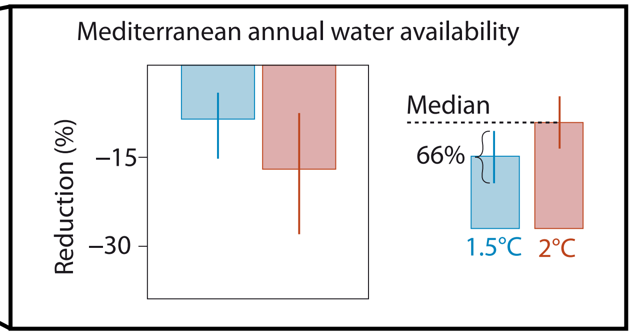
Adapted from Fischer & Knutti (2015)

Water Availability



- Changes in annual water availability at 1.5°C assessed based on the ISIMIP modelling intercomparison framework
- Mediterranean 'hot-spot' of change: near doubling in annual water availability reduction relative to 1986-2005 from about 9% under 1.5°C to 17% under 2°C

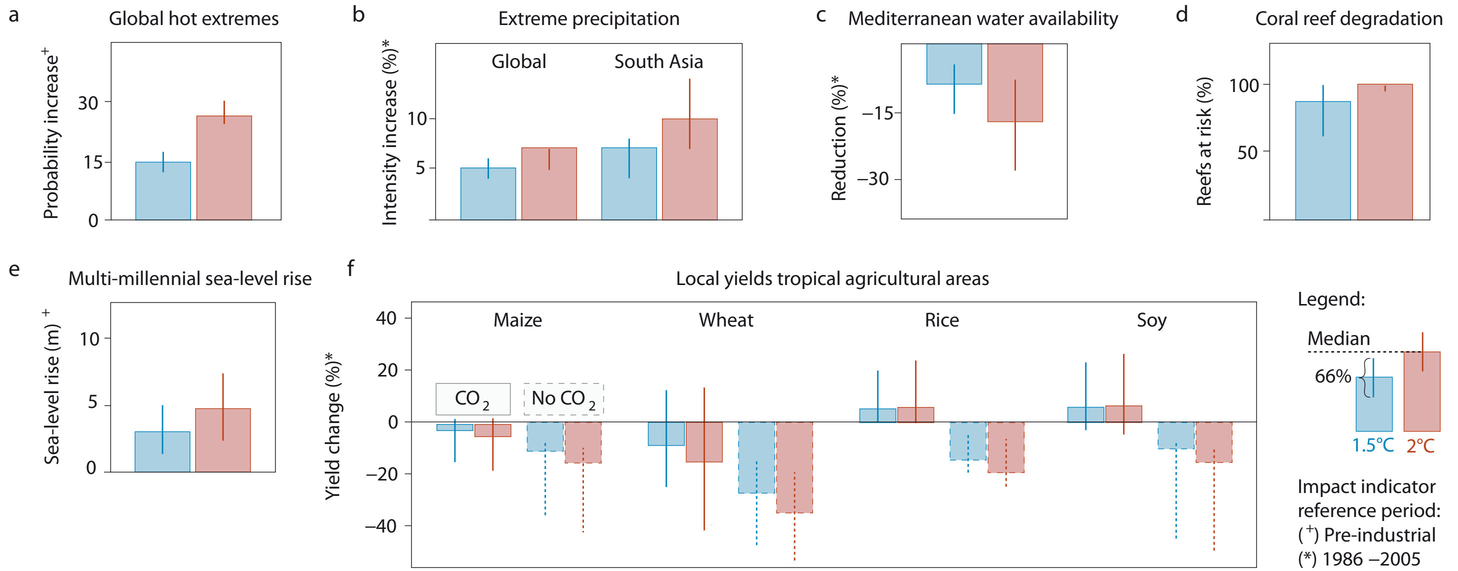


Guiot & Cramer (2016): Exceeding 1.5°C will push ecosystems dynamics out of the Holocene variability

Relative changes in total runoff relative to 1986-2005
Grey: less than 66 % of all ISIMIP GCM-GHM pairs agree with the median sign of change
White: annual mean runoff of less than 0.05 mm/day

Schleussner et al. (2016 a,b)

Difference between 1.5ºC and 2ºC – A reason for concern



- There are discernible differences between climate impacts at 1.5°C and 2°C with tropical regions bearing the brunt of the additional impacts.

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Schleussner et al. (2016)

Improving our understanding of a 1.5°C world

- Regional and impact specific **hot-spots of change** call for targeted studies (e.g. Guiot & Cramer 2016, Notz et al. 2016)

- **Specific modeling protocols** for example with large ensembles to improve signal-to-noise and extreme event assessments (e.g. HAPPI intercomparison project, Mitchell et al. 2017): Results for the water and agriculture sector **Poster P.S16 and P.S31**

- Investigate **abrupt shifts and tipping points** at and around 1.5°C (e.g. Drijfhout et al. 2015, Schellnhuber et al. 2016)

- Investigate **pathway dependencies and (ir)reversibility** of climate impacts

Thank you for your attention!

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