Climate impact attribution using simulations driven with historical natural (HIST-NAT) radiative forcing

An extension to ISIMIP3b

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PROCLIAS Task Groups TG1.6 and TG2.1

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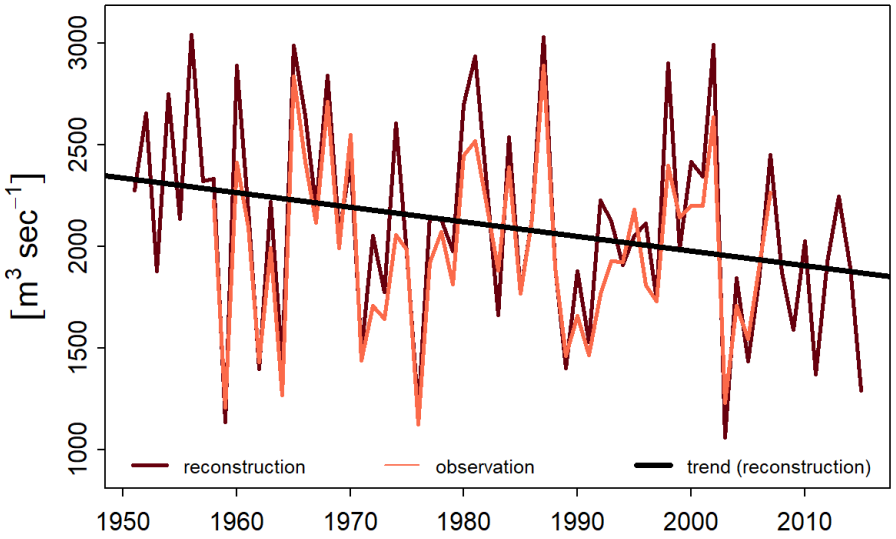
The type of question we are trying to answer

Has human influence on the climate system contributed to or caused impacts?

Trends: Dry season Rhine discharge



Trends: Extreme flood in Germany, 2021

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cost EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

PROCLIAS

ISIMIP Inter-Sectoral Impact Model Intercomparison Project

WEBINAR SERIES

Climate impact attribution

27 Jan. 1pm CET	Classical climate change detection & attribution (G Hegerl)
3 Mar. 1pm CET	Attributing of extreme weather events (F Otto)
28 Apr. 1pm CET	Concepts of climate impact attribution (K Frieler & M Mengel)
9 May. 1pm CET	Machine-learning for climate impact attribution (M Callaghan & Q Lejeune)
23 May. 1pm CET	Attribution of European heavy rainfall event of July 2021 (J Tradowsky)
14 Jun. 1pm CET	Attribution of crop production loss in West Africa (B Sultan)
5 Jul. 1pm CET	Attribution of physical changes in freshwater lake systems (L Grant)

Detection & Attribution of Climate Change

Detection:

*"the process of demonstrating that an **observed change is significantly different … from natural internal climate variability**, … [i.e.] the chaotic variation of the climate system that occurs in the absence of anomalous external natural or anthropogenic forcing…"*

Attribution:

*"Attribution of anthropogenic climate change … require[s] a **demonstration that the detected change***

[1.] ***is consistent with simulated change driven by … anthropogenic changes in the composition of the atmosphere**…,*

[2.] *and **not consistent with alternative explanations of recent climate change**…"*

Hegerl et al., JoC, (2006)

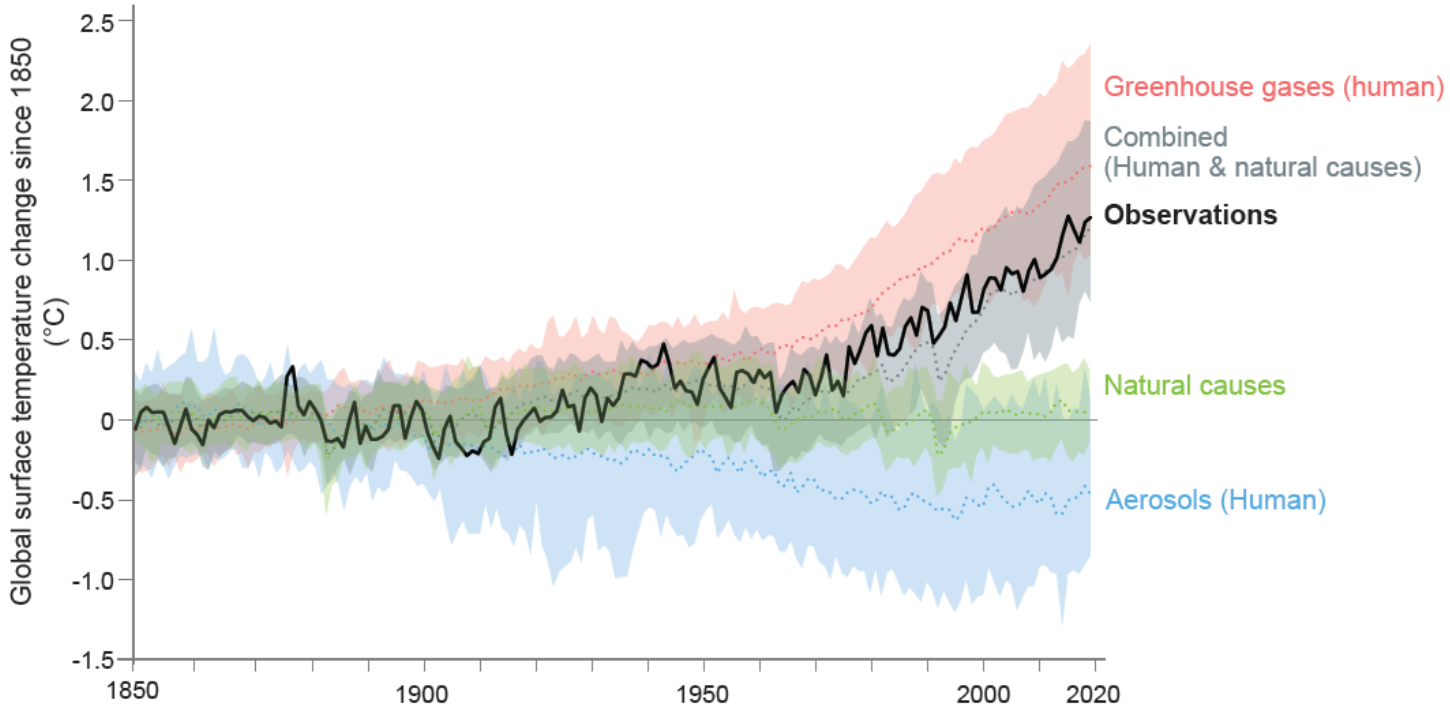
Often considered radiative forcings

- **Pre-industrial radiative forcing (PIC)**
  - Constant radiative forcing equivalent to pre-industrial times
  - No climate change signal expected
  - → Detection
- **Historical natural radiative forcing (HIST-NAT)**
  - Natural factors including e.g. variations in solar radiation and impacts of large volcanic eruptions.
  - Climate change signals possible
  - → Attribution
- **Historical radiative forcing (HIST)**
  - Human emissions to the atmosphere (GHG, aerosols) + natural radiative forcing.
  - Climate change signal possible
  - → Attribution

D&A in practice: Global mean temperature change

FAQ 3.1: **How do we know humans are causing climate change?**

Observed warming (1850-2019) is only reproduced in simulations including human influence.

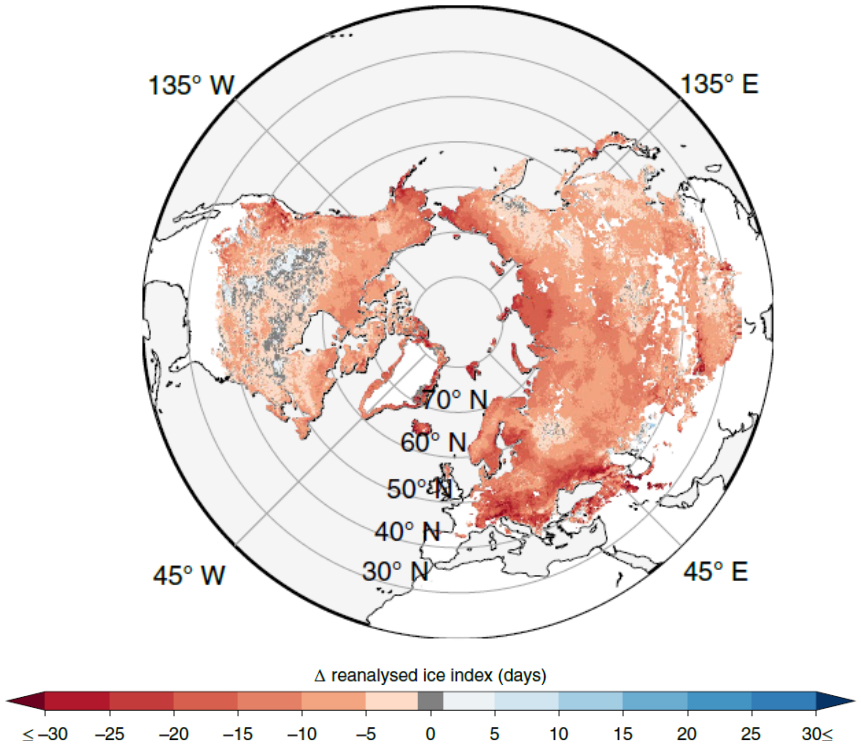


FAQ 3.1, Figure 1 | Observed warming (1850–2019) is only reproduced in simulations including human influence. Global surface temperature changes in observations, compared to climate model simulations of the response to all human and natural forcings (grey band), greenhouse gases only (red band), aerosols and other human drivers only (blue band) and natural forcings only (green band). Solid coloured lines show the multi-model mean, and coloured bands show the 5–95% range of individual simulations.

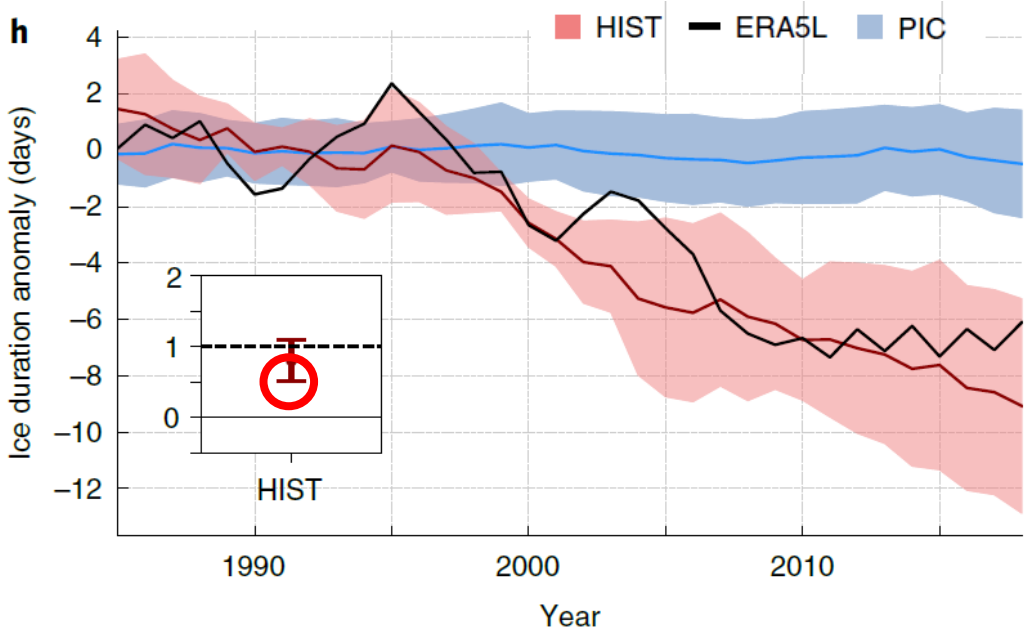
IPCC, AR6, WGI, Chapter 3

Global change in lake ice duration using ISIMIP2a

Reconstructed change in lake ice duration (reanalysis)

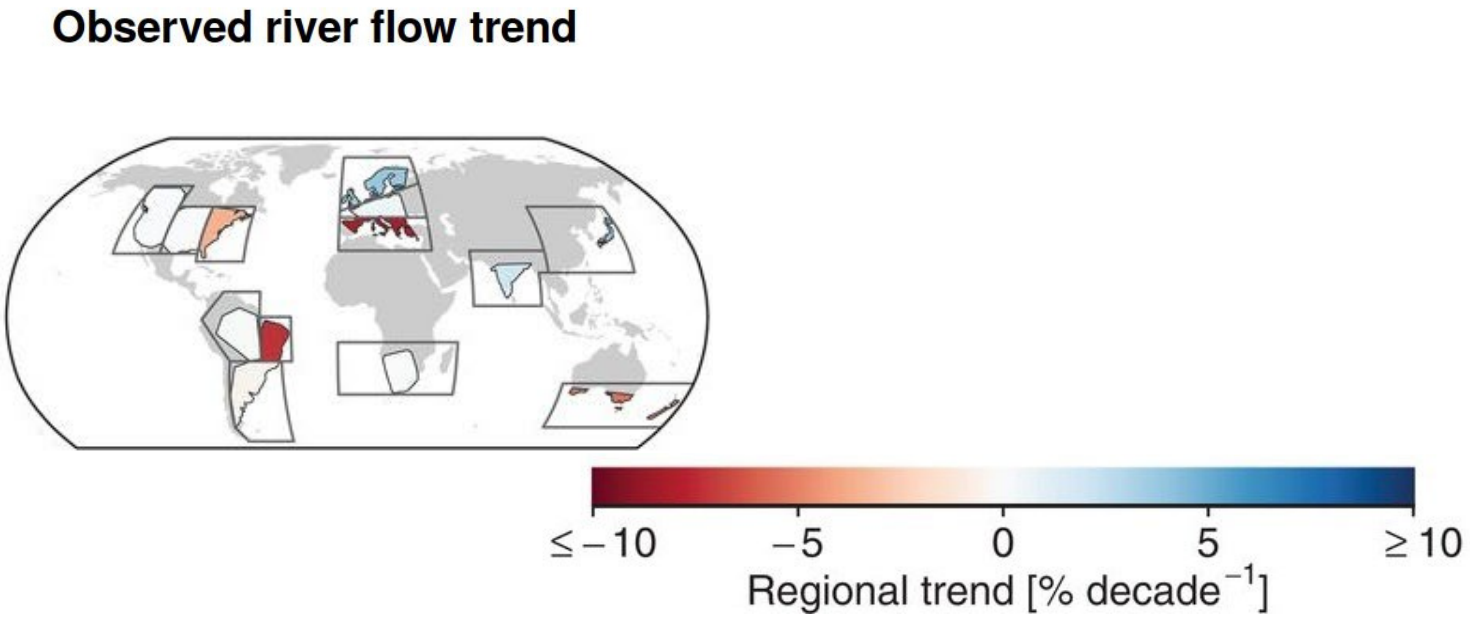


Temporal evolution of observed and simulated ice duration anomalies



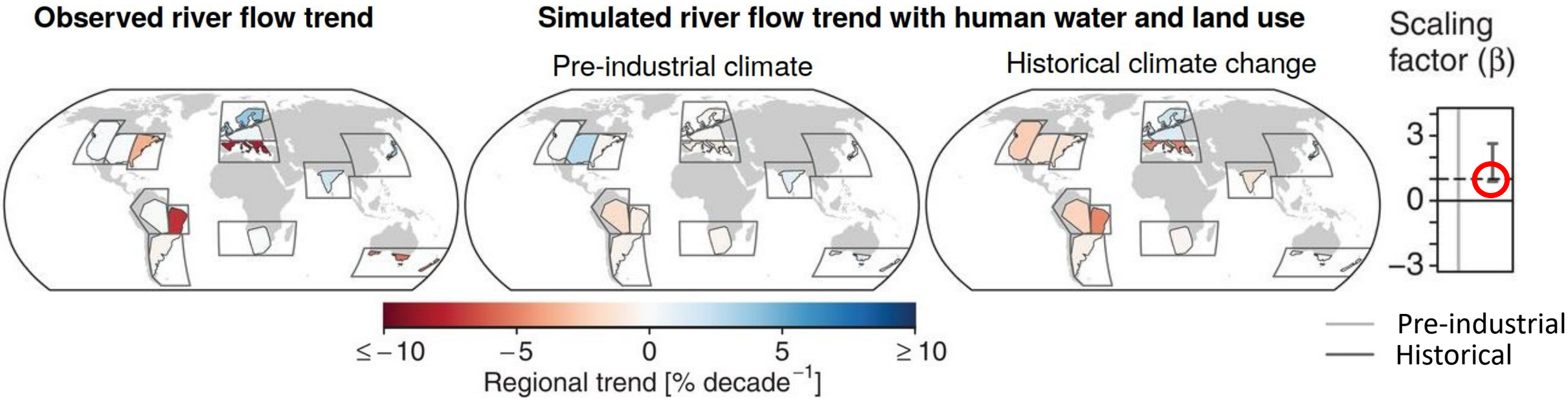
Grant et al., Nature Geoscience, 2021.

Global change in river flow using ISIMIP2a



Gudmundsson et al., Science, 2021.

Global change in river flow using ISIMIP2a



Simulations only consistent with observations if historical climate change is considered

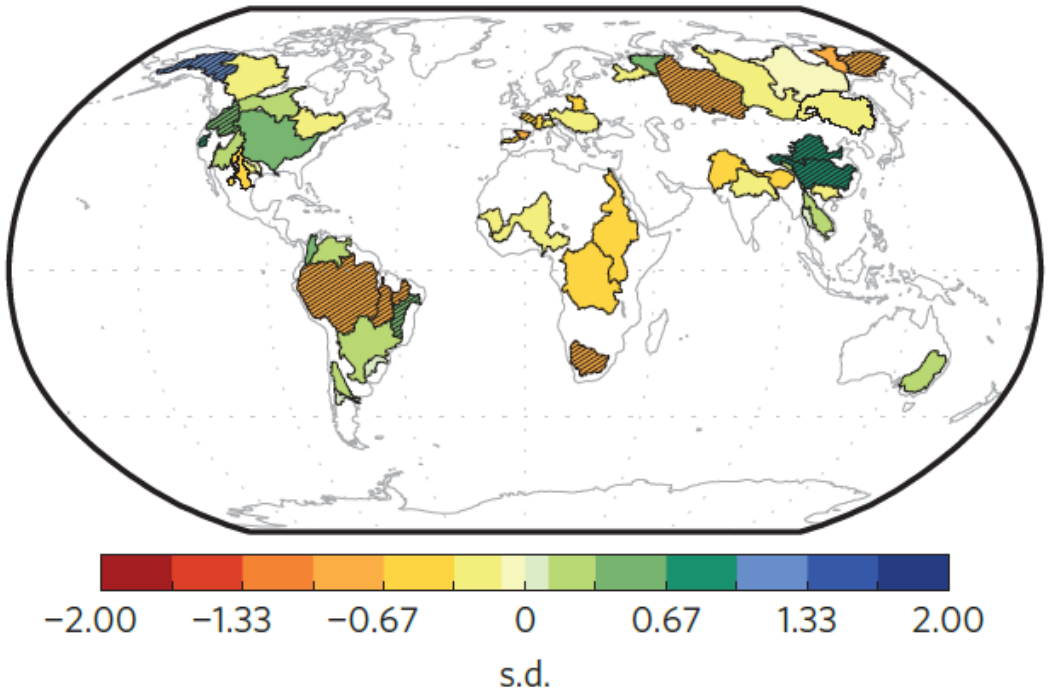
Gudmundsson et al., Science, 2021.

What about natural factors influencing the climate

- Both studies cannot formally exclude that natural factors did contribute to the change.

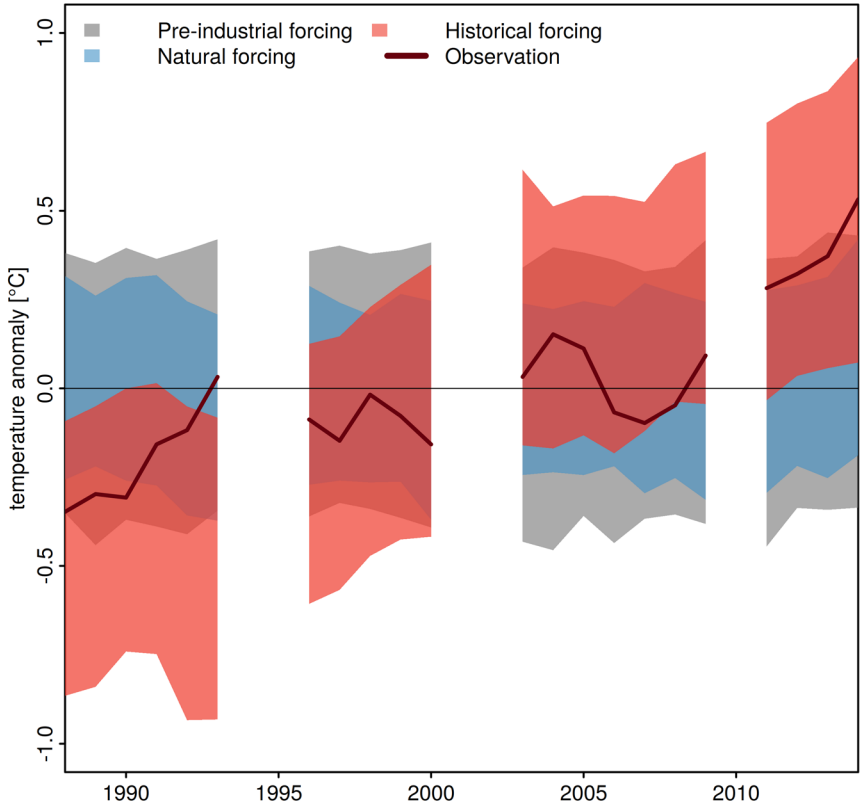
- This can be resolved using simulations that consider HIST-NAT forcing

Observed river flow response to large volcanic eruptions



Iles and Hegerl, Nature Geoscience, 2015.

Permafrost temperature @ Murtèl-Corvatsch (CH)



Caveat: Based on CMIP6; possibly non ideal soil models.

Gudmundsson et al., in review.

Invitation to contribute by running HIST-NAT

- **Extension to ISIMIP 3b, but will be heavily used**

- **All forcing data is available**
  - Bias-adjusted forcing from 3 Tier 1 + 3 Tier 2 GCMs
  - CanESM5, CNRM-CM6-1, GFDL-ESM4, IPSL-CM6A-LR, MIROC6, MRI-ESM2-0
  - https://data.isimip.org/search/climate_scenario/hist-nat/
  - /work/bb0820/ISIMIP/ISIMIP3b/SecondaryInputData/climate/atmosphere/bias-adjusted/global/daily/hist-nat/

- **Several sectors endorse the hist-nat extension**
  - water_global, lakes, health, more?

- **Several models have (committed to) run the simulations**
  - WaterGap, CLM, SWAT+, air2water

- **Several proposals under review building on these simulations**
  - SNF, ERC, BELSPO, FWO

Breakout session on "Open exchange on methods for climate impact attribution"

(House H, VR1)