A new method to allocate the responsibility for regional, glacier-related sea level change

Julia Eis
(Speaker: Ben Marzeion)
June 6th,2023

SPP 1889
REGIONAL SEA LEVEL CHANGE AND SOCIETY

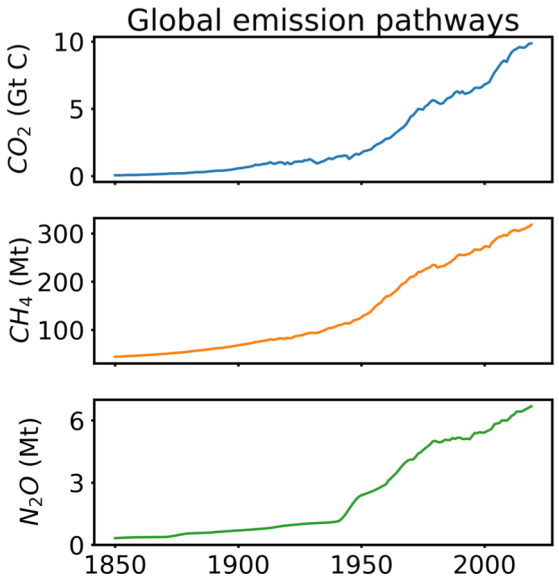
Universität Bremen

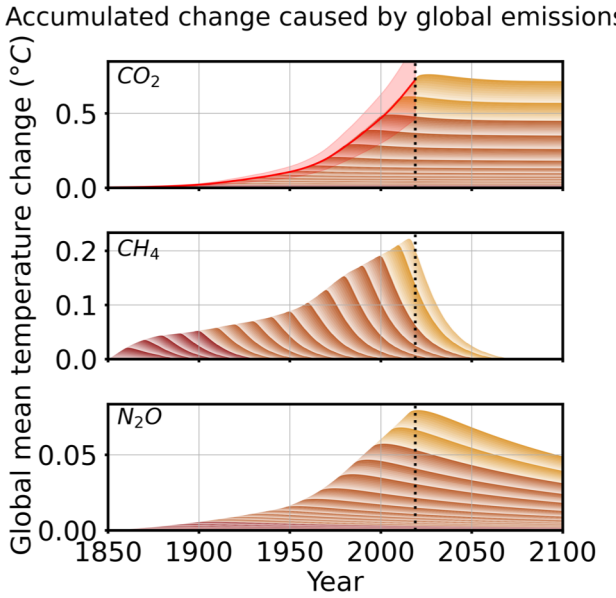
Objective

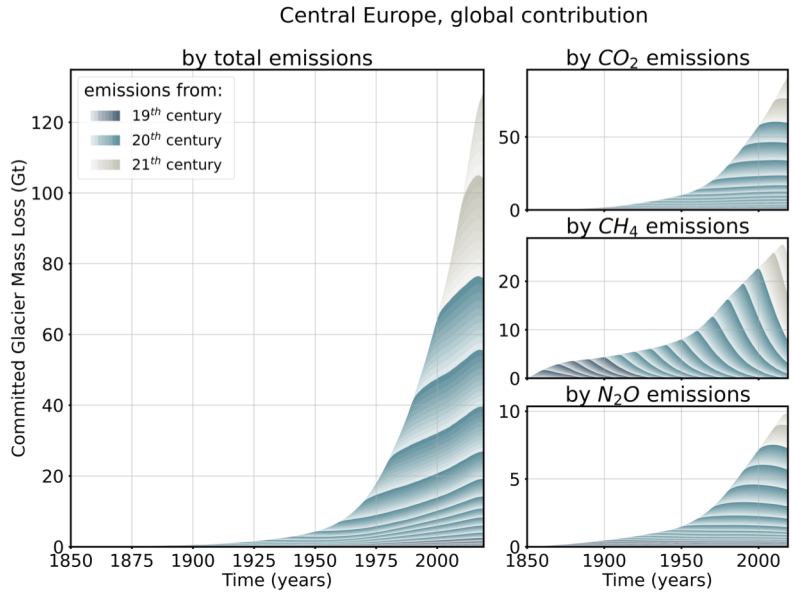
Allocating the responsibility for regional, glacier-related sea level change to specific past emission pathways

- What is the responsibility of, e.g., Germany (given its historic emission pathway) for glacier-related sea-level change?
- How much of that sea-level change has already been realized, and how much will be realized in the future?
- What are the uncertainties in this allocation of responsibility?

Methods - Overview







Emission Pathways CO_2, CH_4, N_2O

FaIR

Simple emission-based climate model

Accumulated change in GMT

OGGM

Open Global Glacier Model

Commited glacier mass loss

- PRIMAP-hist
  - globally
  - country specific or
  - sector specific

- Distinction between contribution from individual years and gases

- due to specific emission pathways

FAIR- Finite Amplitude Impulse Response model

- free, open-source
- written in Python
- simple emissons-based climate model
- designed to emulate the behaviour of more complex climate models

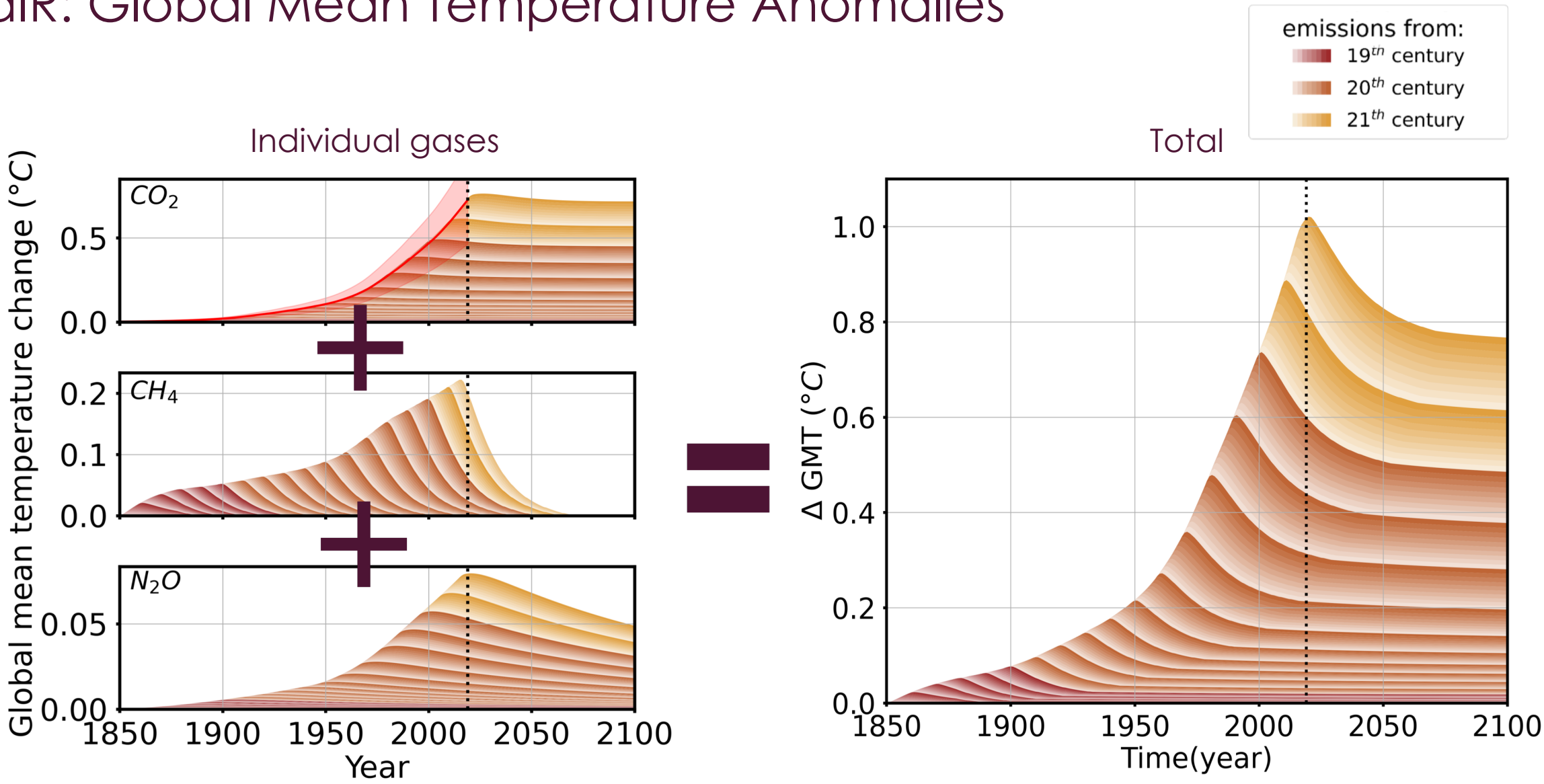
- Input:
  - emissions of greenhouse gases and
  - short lived climate forcings

- Output:
  - global mean atmospheric GHG concentrations
  - radiative forcing and
  - global mean temperauture anomalies

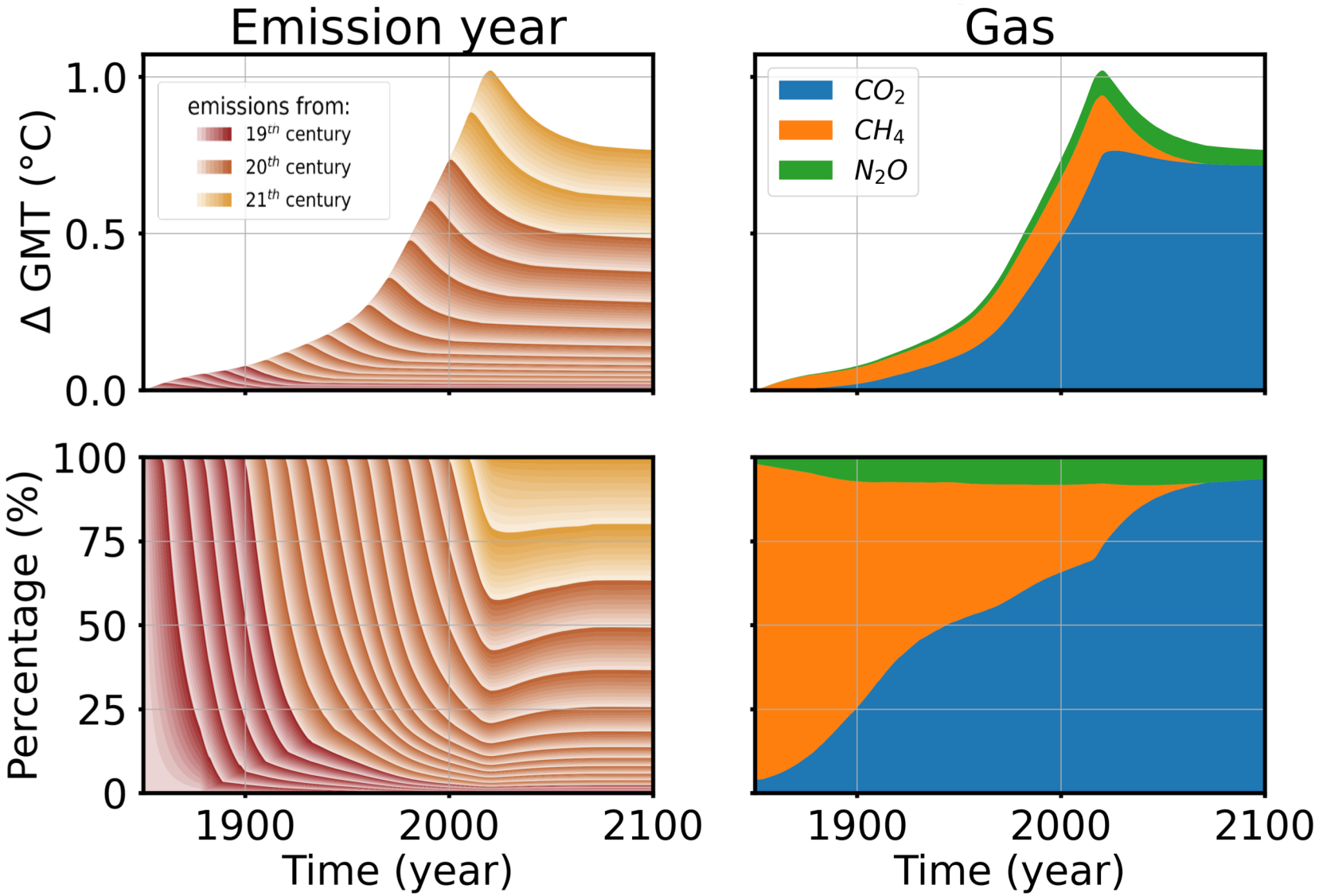
Leach, N. J., Jenkins, S., Nicholls, Z., Smith, C. J., Lynch, J., Cain, M., Walsh, T., Wu, B., Tsutsui, J., and Allen, M. R.: FaIRv2.0.0: a generalized impulse response model for climate uncertainty and future scenario exploration, Geosci. Model Dev., 14, 3007–3036, https://doi.org/10.5194/gmd-14-3007-2021, 2021

Smith, C. J., Forster, P. M., Allen, M., Leach, N., Millar, R. J., Passerello, G. A., and Regayre, L. A.: FAIR v1.3: a simple emissions-based impulse response and carbon cycle model, Geosci. Model Dev., 11, 2273-2297, https://doi.org/10.5194/gmd-11-2273-2018, 2018

FaIR: Global Mean Temperature Anomalies



FaIR: Responsibilities for ΔGMT

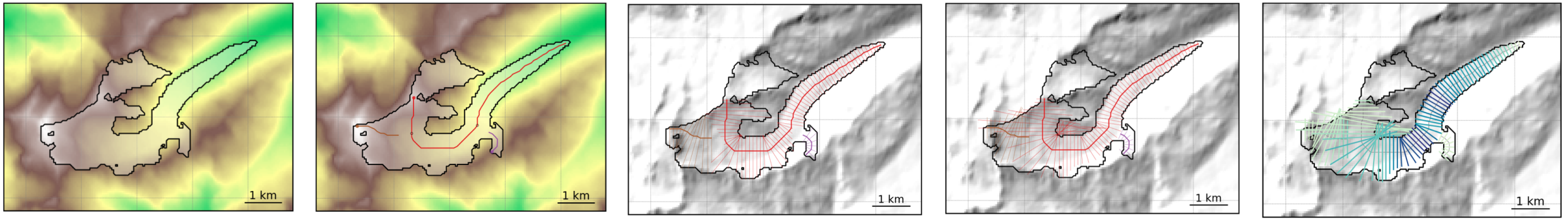


Open Global Glacier Model

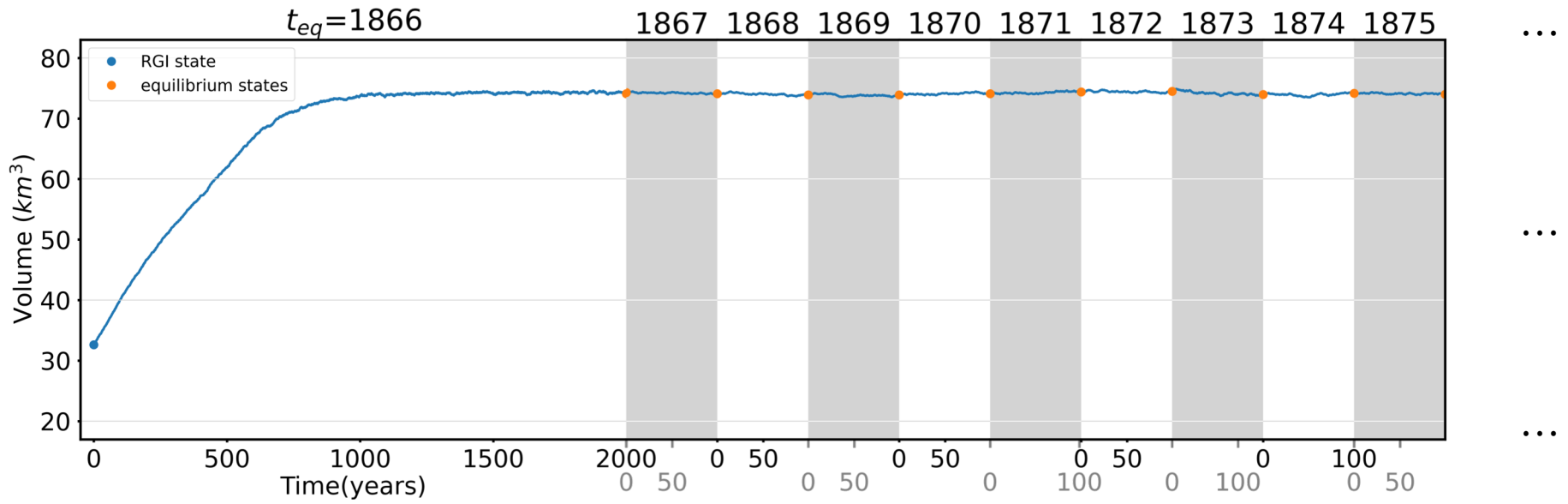
OGGM

Open Global Glacier Model

- open source numerical model framework
- written in Python programming language
- simulates glacier evolution of any glacier in the world individually



OGGM: Calculation of the equilibrium changes



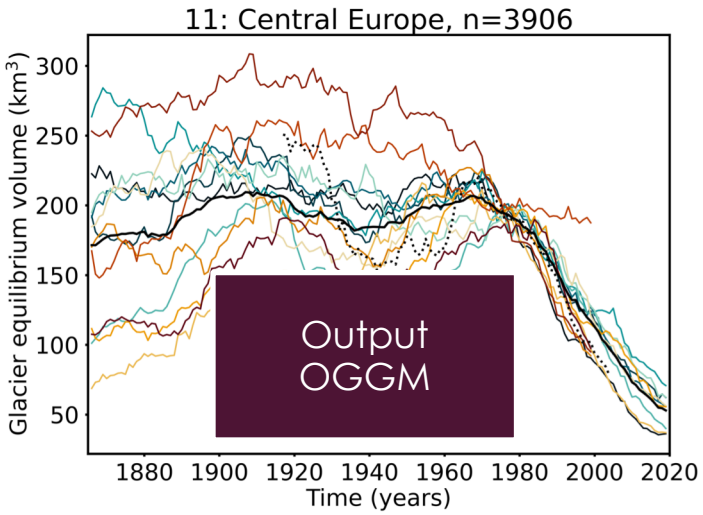
inital year

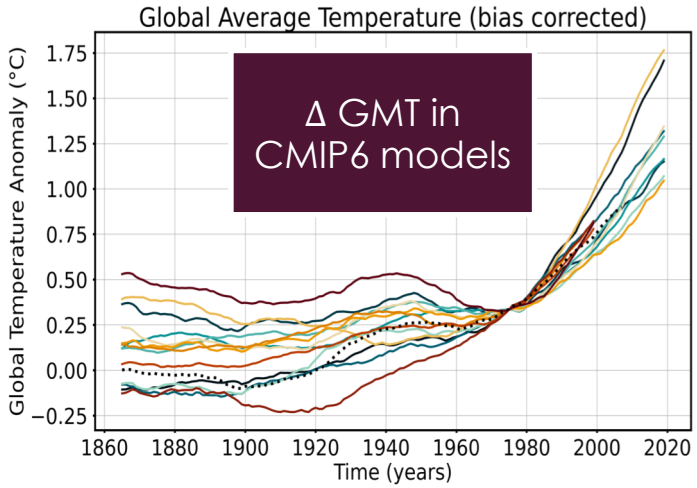
- run_random_climate
- start = RGI state
- y_0 = 1866
- n_{years} = 2000

subsequent years

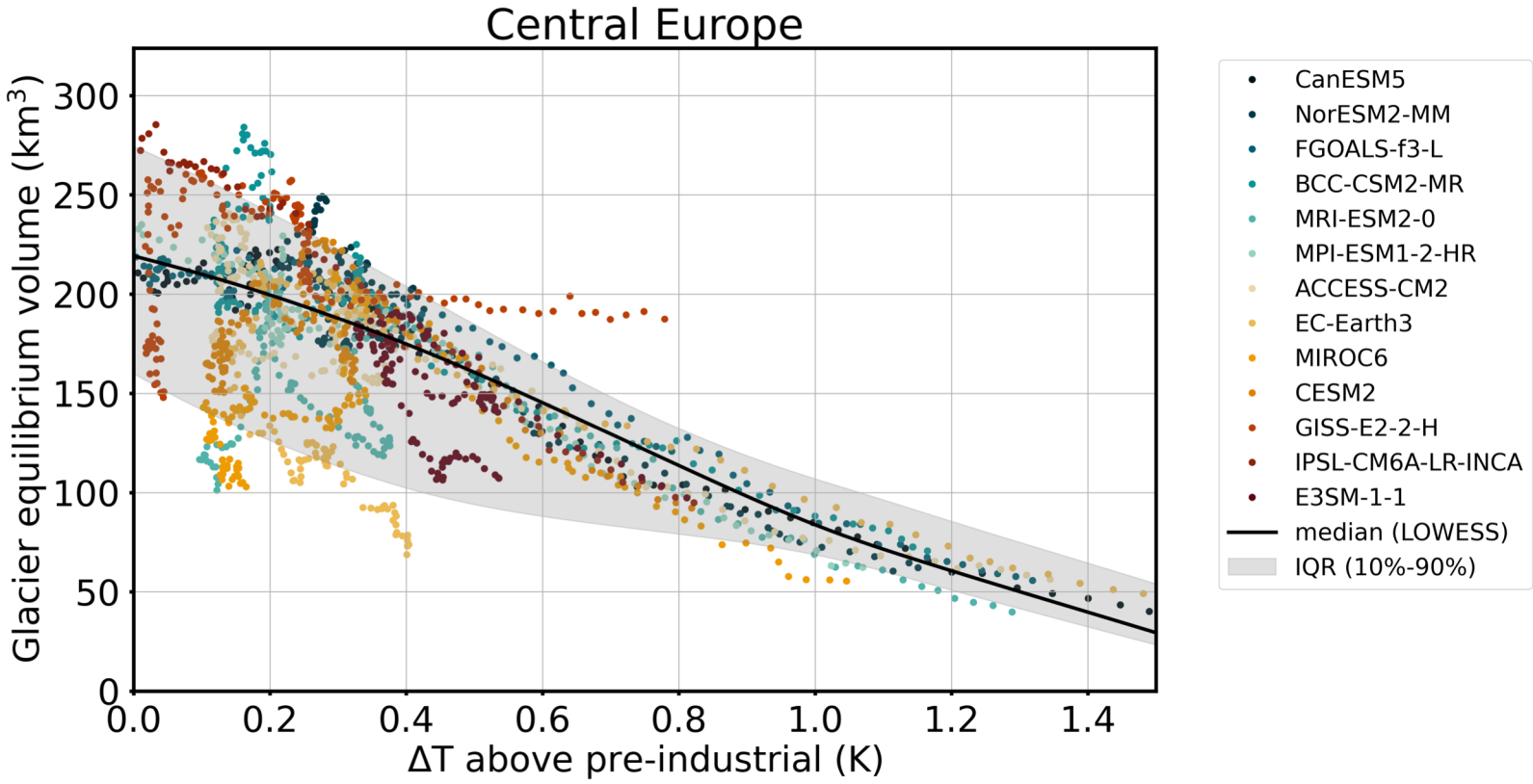
- run_random_climate with stopping criteria
- start state = previous equlibrium state
- y_0 = $t_{eq} \in \{1867, \ldots, 2019\}$

OGGM: Results

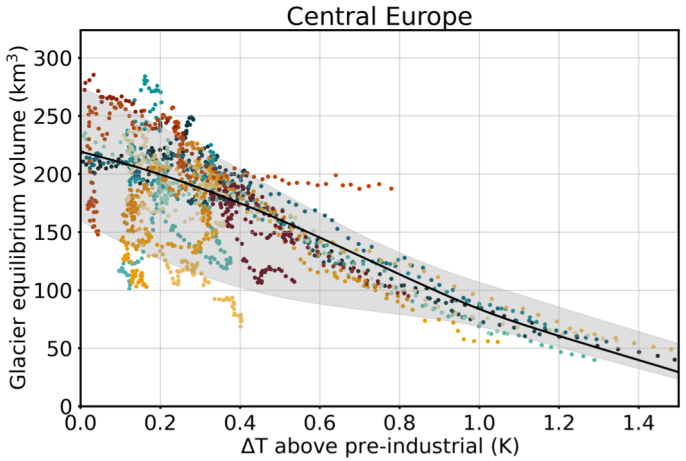


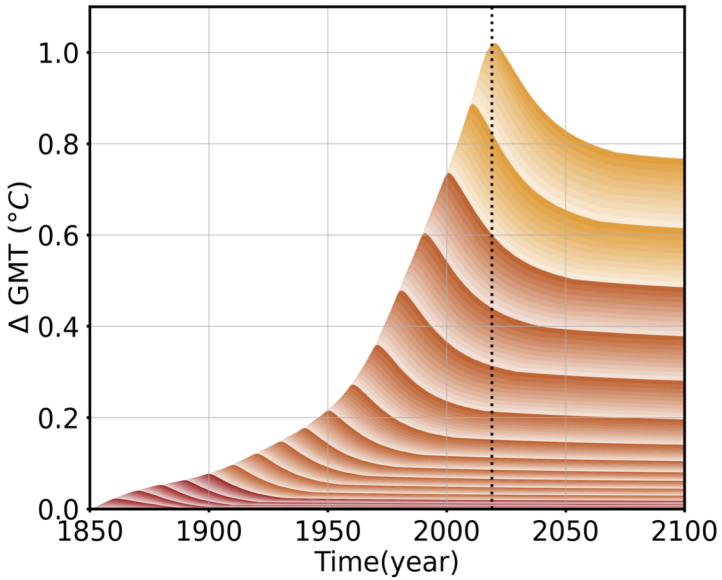


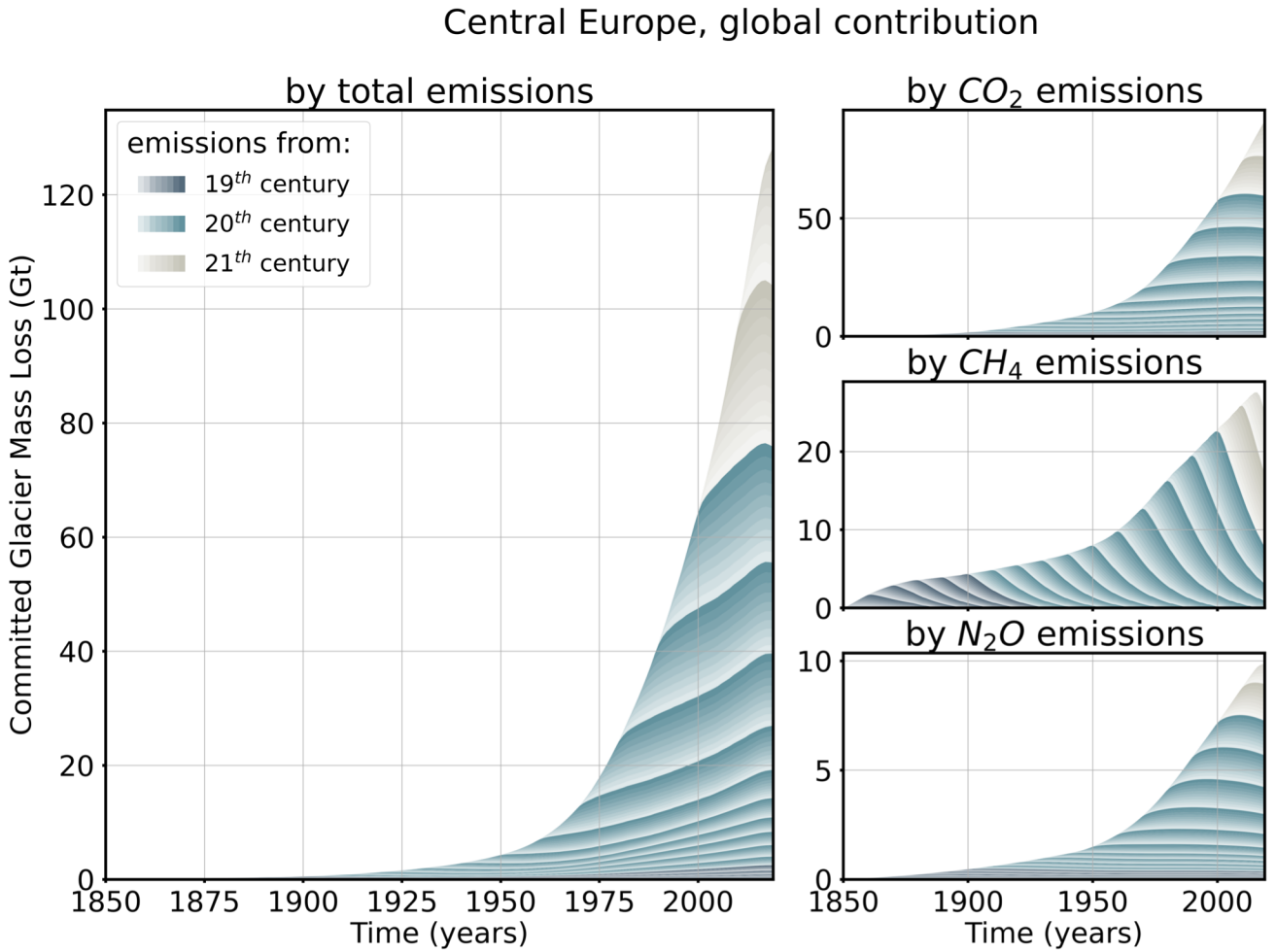
Equilibrium changes over Δ GMT



Combining FaIR and OGGM results







Preliminary results – global application

- ~40% of global glacier volume is missing
- Problem: past tidewater glaciers
- Techniques to detect past tidewater glaciers and an adjustment of OGGM will be necessary !