Modeling post-LIA glacier length change in the Alps

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Motivation

Our aim in this project is to simulate glacier evolution over hundreds to thousands of years to understand past and future climate change. In order to trust our model results, we need to make sure that the modeled glacier dynamics and evolution are realistic. For periods longer than a few decades, length observations [1, 2] are the only information available to validate our results. In this pilot study, we target 25 glaciers for which we have length observations reaching further than 100 years back.

Because of uncertainties in many aspects of the system (climate, glacier bedrock, ice dynamics, model parameters), glacier models need to be calibrated.

Our objective is **to find an optimal time-invariant set of parameters for each glacier independently**, that would allow us to **quantify the uncertainties associated with each configuration** when applied to longer simulations.

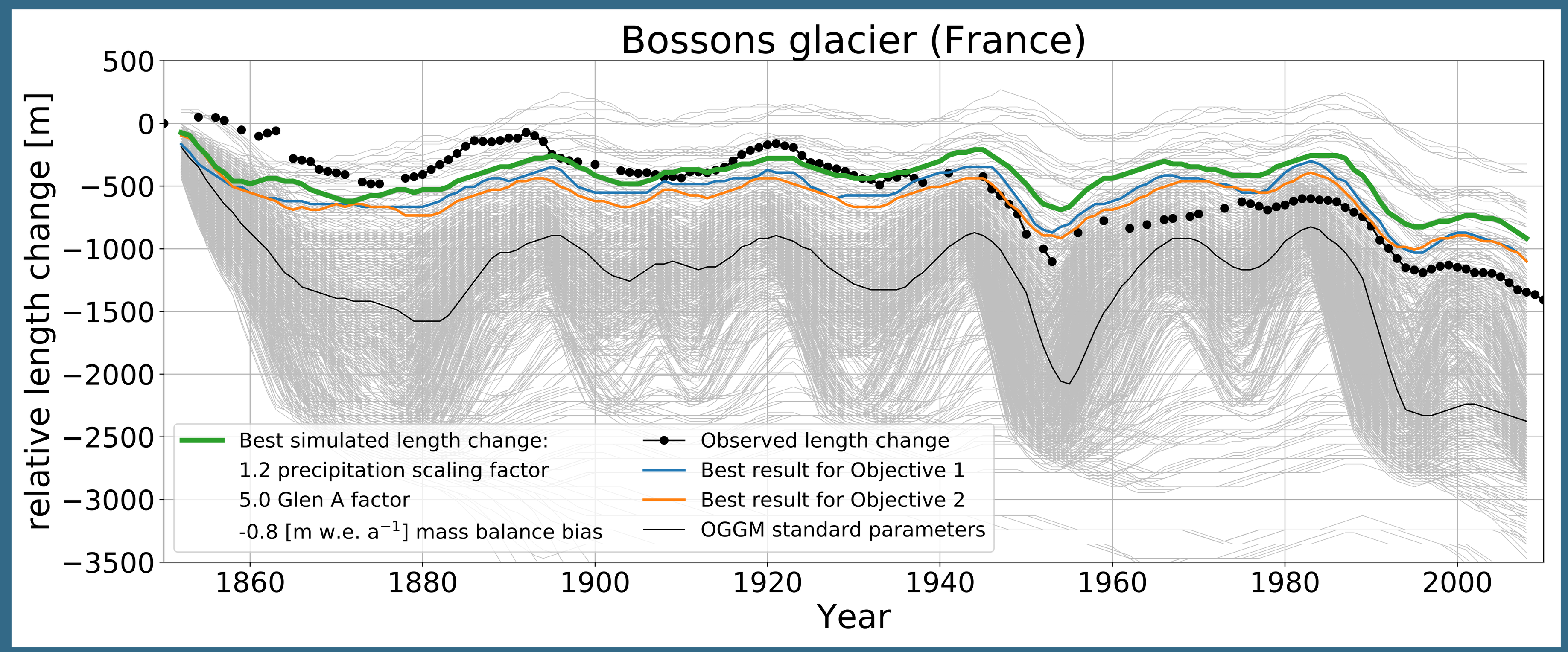
The Open Global Glacier Model

OGGM [3] is an open source glacier model capable of simulating past and future glacier evolution on a global and centennial time scale. The model calculates the glaciers mass balance from gridded climate data, i.e. the HISTALP data set [4] from 1850 onwards, and explicitly solves ice dynamics on glacier flowlines.

Here we systematically vary three model parameters:

- **Precipitation scaling factor**: Is applied to the gridded precipitation data and ranges from 0.6 to 4.
- **Glen A factor**: Scales the default Glen A creep parameter of $2.4 \times 10^{-24}\,\mathrm{s^{-1}\,Pa^{-3}}$ up to 5 times.
- **Mass balance bias**: An additional mass balance bias between -0.8 and $0.5\,\mathrm{m\,w.e.\,a^{-1}}$.

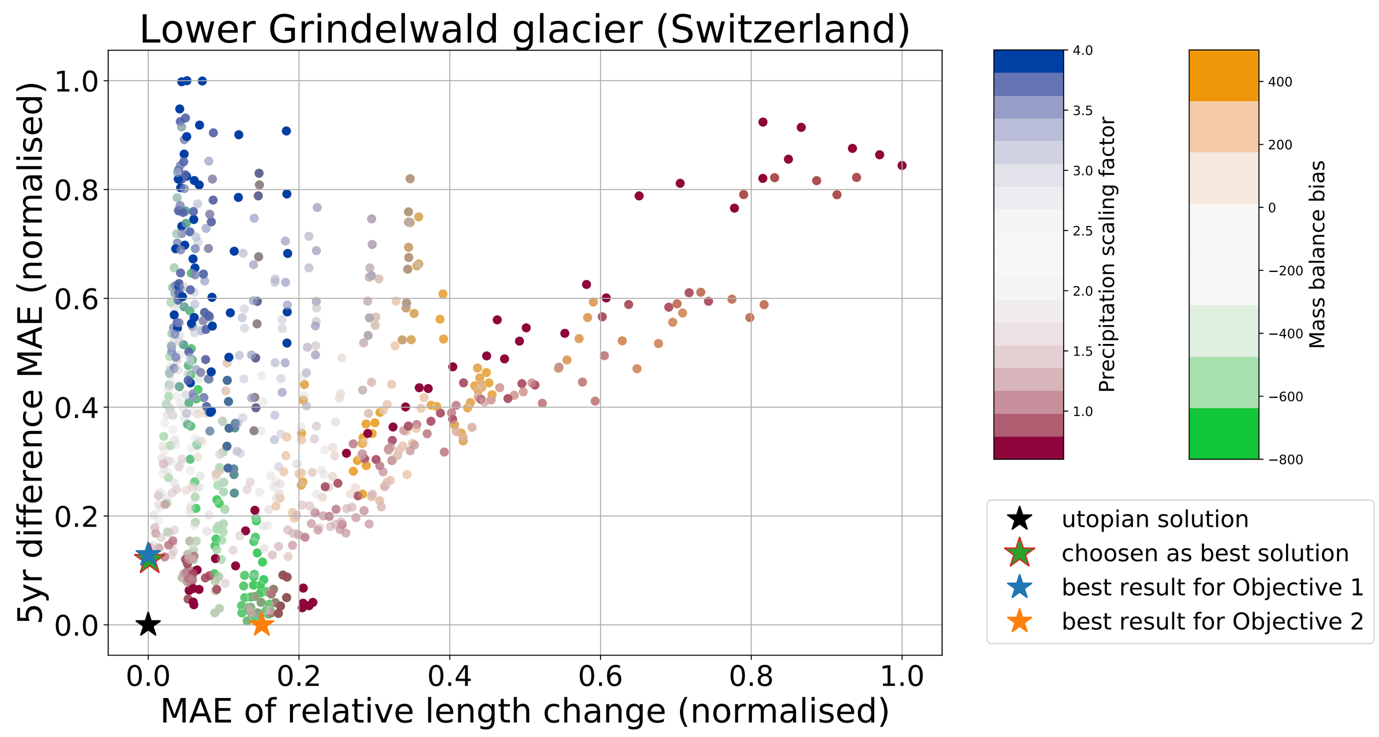
We use observed length change to calibrate a **time-invariant set of model parameters** for selected Alpine glaciers.



This is necessary to **estimate model errors** if periods without observations are simulated.

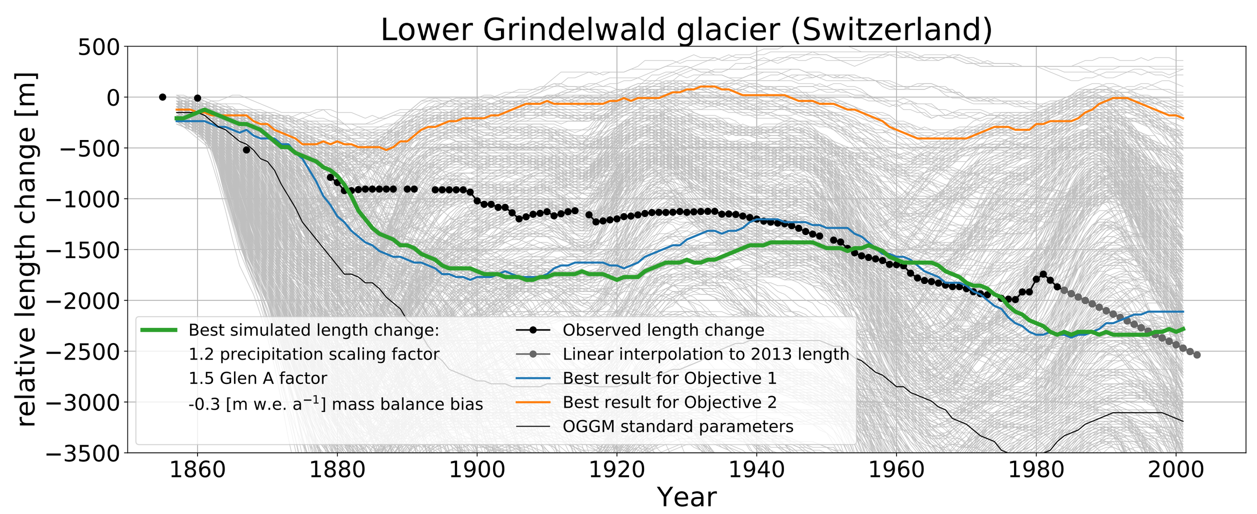
Multi-objective optimization

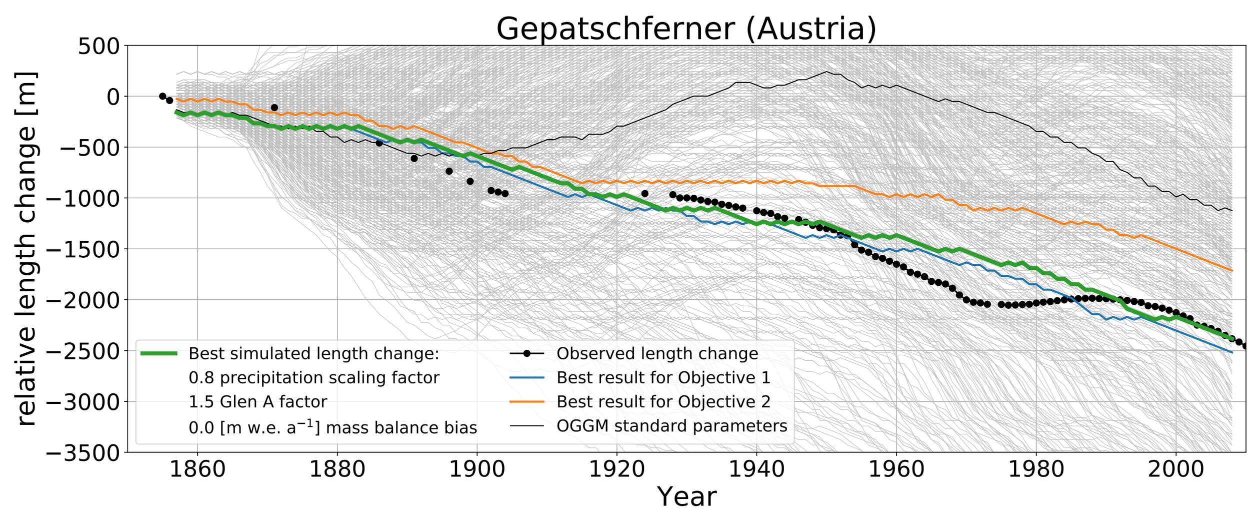
- Objective 1: Mean absolute error (MAE) of the relative length change as measure of the overall error.
- Objective 2: The 5 year difference MAE to represent shorter trends and punish opposing ones.
- Outcome: The combination of both objectives gives one time-invariant parameter set for each glacier.
- We weigh Objective 1 against 2 with a 5:1 ratio.
- The amount and kind of objectives is a subjective choice.



Results

The sensibility to the three tested model parameters is different for every glacier. While default model parameters are a good choice for regional or global simulations, individual calibration is important if single glaciers are studied.





References

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OGGM