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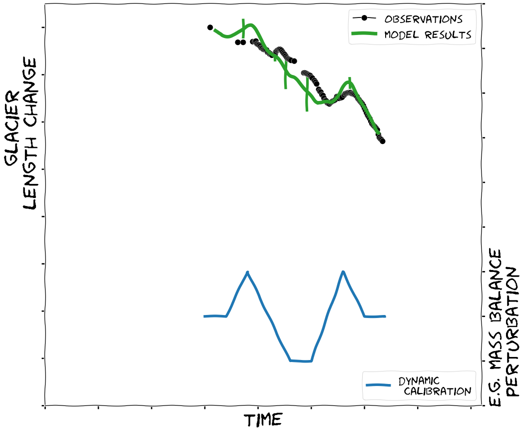
Calibrating a regional glacier model using post-LIA glacier length changes in the Alps

Matthias Dusch, Fabien Maussion, Kurt Nicolussi

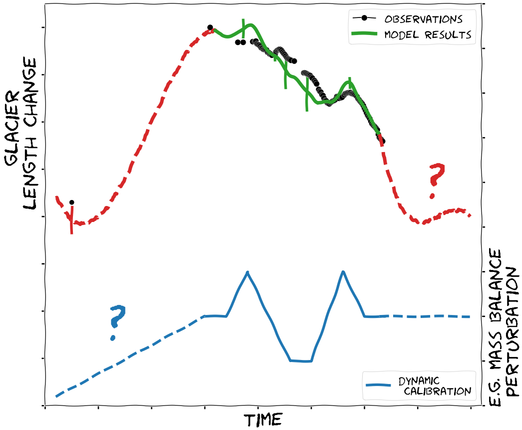
2 minute pitch

Motivation



- *Dynamic calibration* can be used to match model simulations with observations

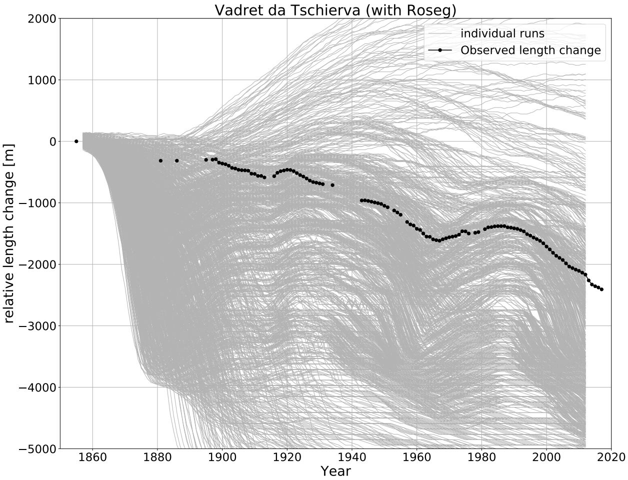
Motivation



- *Dynamic calibration* can be used to match model simulations with observations
- But calibration is no validation
- No information for unknown periods

Goal: time invariant calibration with uncertainty assessment

- Open Global Glacier Model
- 3 varying parameters for:
  - input climate
  - model dynamics
  - mass balance
- 1365 unique combinations
- 30 Alpine glaciers



Goal: time invariant calibration with uncertainty assessment

- Open Global Glacier Model
- 3 varying parameters for:
  - input climate
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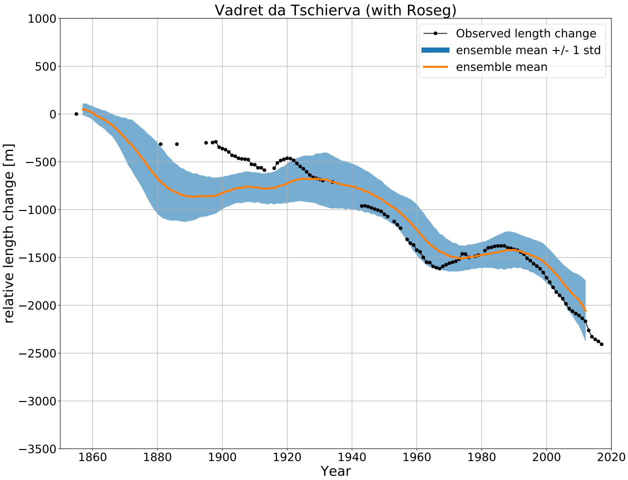
- 1365 unique combinations
- 30 Alpine glaciers

- Select ensemble of runs
- Cross-validate results

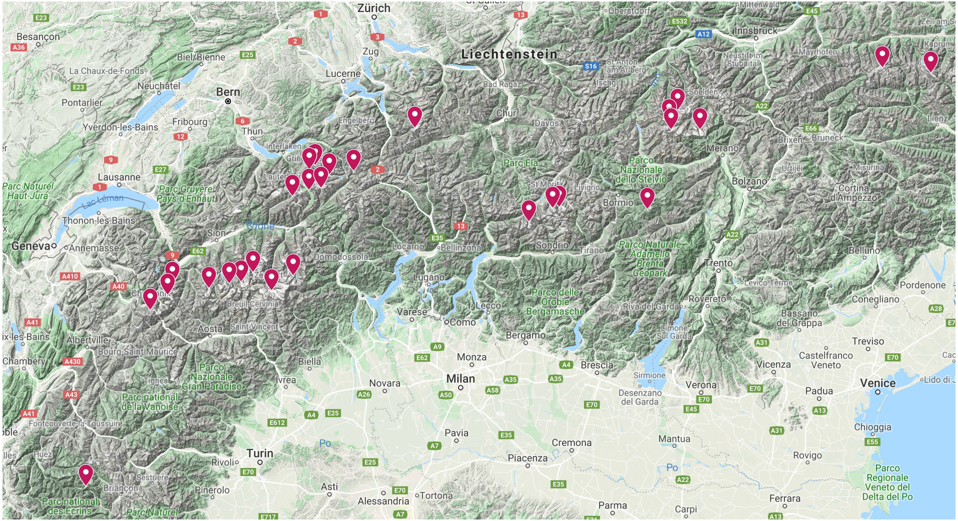


⇒ For details see uploaded display and join the break-out room

additional material

30 selected glaciers -> 25% of today’s glaciated area

- Pasterze
- Obersulzbachkees
- Taschachferner
- Gepatschferner
- Gurgler Ferner
- Hintereisferner
- Rhonegletscher
- Oberer Grindelwaldgletscher
- U. Grindelwaldgletscher
- Unteraargletscher
- Aletschgletscher
- Fieschergletscher
- Langgletscher
- Morteratschgletscher
- Forni
- Tschiervagletscher
- Mont-Miné-Gletscher
- Fornogletscher
- Zinalgletscher
- Allalingletscher
- Trientgletscher
- Tsijiore-Nouve-Gletscher
- Corbassièregletscher
- Gornergletscher
- Hüfigletscher
- Glacier d'Argentière
- Glacier des Bossons
- Glacier Blanc



Model and data

- Open Global Glacier Model (OGGM) [1]
- Applicable to all glaciers
- Excels at large scales

- HISTALP [2] climate data
- RGI [3] glacier outlines
- GLAMOS [4] length change observations for Swiss glaciers
- WGMS [5] length change observations for the rest

Chosen calibration parameters

- **precipitation scaling factor**
- Glen A - Ice flow creep parameter
- mass balance bias

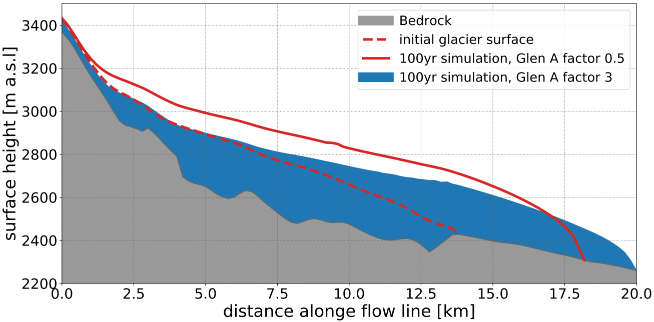
$$m = p_{sf} P_{solid} - \mu^* T_{>melt} + \epsilon$$

m	mass balance
$p_s f$	**precipitation scaling factor**
P_{solid}	solid precipitation
$T_{>melt}$	temperature available for melt
ϵ	residual
μ^*	**temperature sensitivity**

$\rightarrow$ calibrated against measurements

Chosen calibration parameters

- precipitation scaling factor
- **Glen A - Ice flow creep parameter**
- mass balance bias



- Also: Elevation feedback $\rightarrow$ Volume difference

Chosen calibration parameters

- precipitation scaling factor
- Glen A - Ice flow creep parameter
- **mass balance bias**

glacier mass balance [m w. e. a^{-1}]

$$m_{meas} = m_{model} - \Delta m$$

- **bias** Δm derived from measurements
- subtracted in the model
  $\rightarrow$ negative values **add mass**

Chosen calibration parameters

- precipitation scaling factor
- Glen A - Ice flow creep parameter
- mass balance bias

- $\in$ [1.0, 4.0], 0.25 steps (OGGM default: 1.75)
- $\in$ [1.0, 4.0], 0.5 steps (OGGM default: 1.0)
- $\in$ [-1.4, 1.0], 0.2 steps (OGGM default: ± 0)

- **1365 individual parameter combinations**

Influence of the different parameters

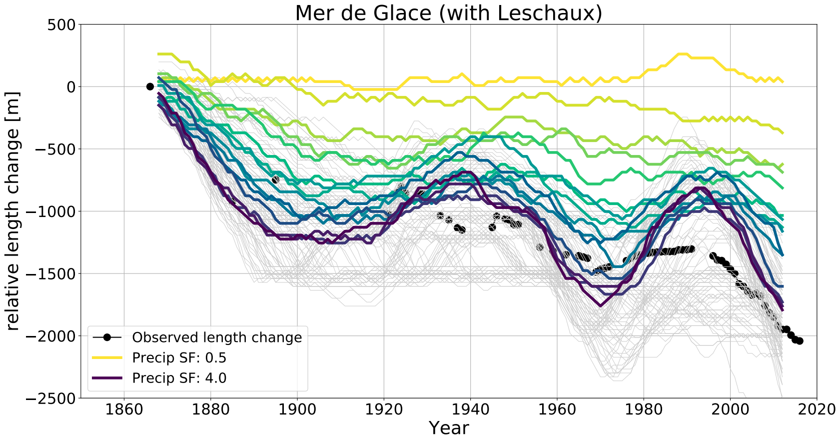
- Fixed:

  Glen A = 1.0

  MB bias = -200

- Variable:

  p_{sf}



Influence of the different parameters

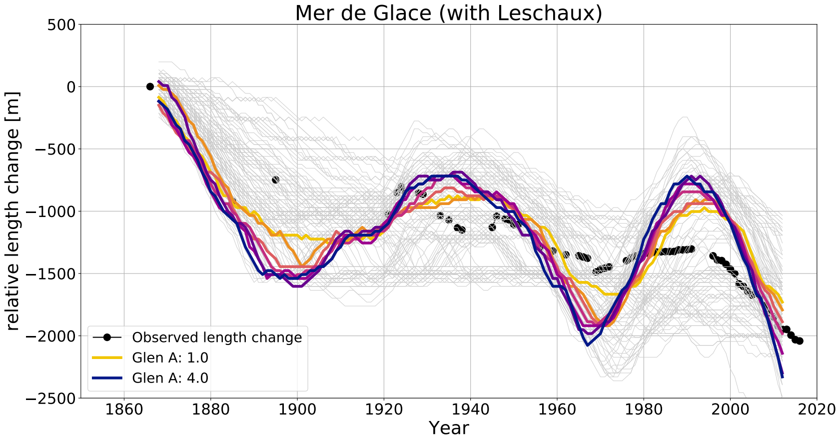
- Fixed:

  MB bias = -200

  p_{sf} = 3.5

- Variable:

  Glen A



Influence of the different parameters

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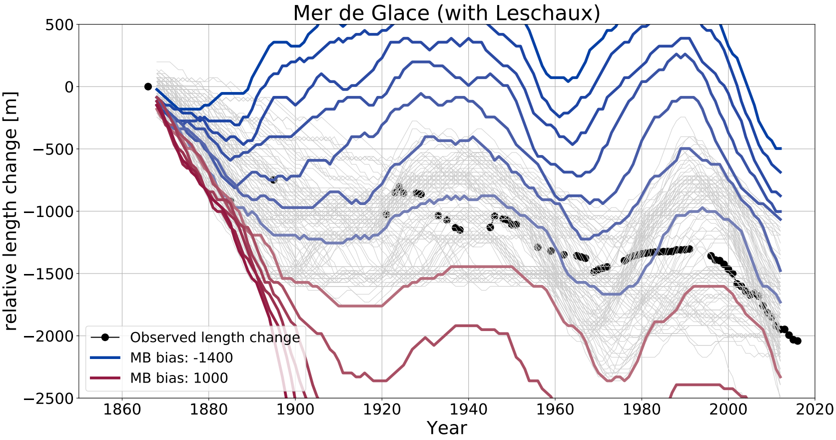


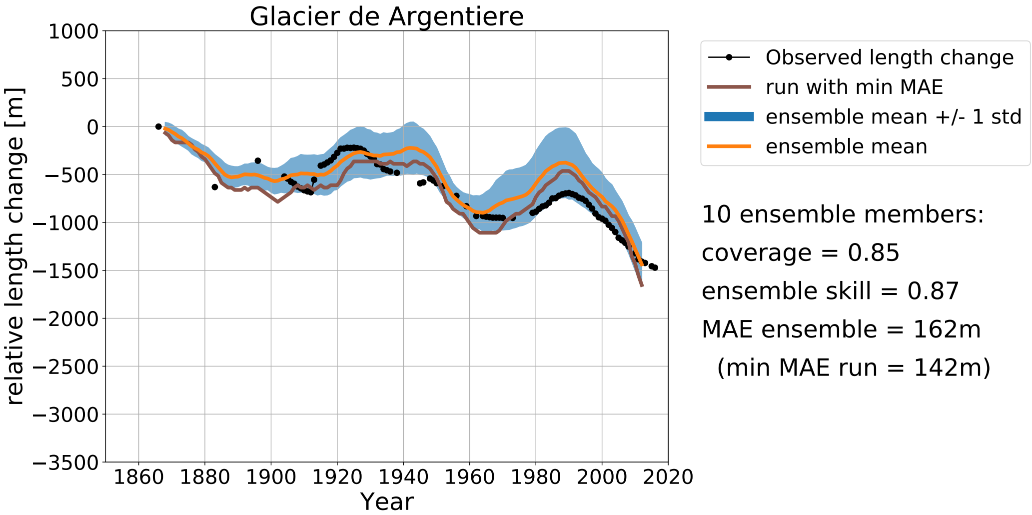
Select run ensemble

- reduce from all runs to 20%
  - 10% smallest mean error > 0
  - 10% smallest mean error < 0

- randomly select (Monte Carlo) 10–20 ensemble members

- choose best ensemble based on:
  - coverage: percentage of observations within $\pm$ 1 standard deviation
  - MAE: mean absolute error of the ensemble mean
  - ensemble skill: $\frac{RMSE}{SPREAD}$ $(SPREAD = \sqrt{VAR})$

Some results



10 ensemble members:

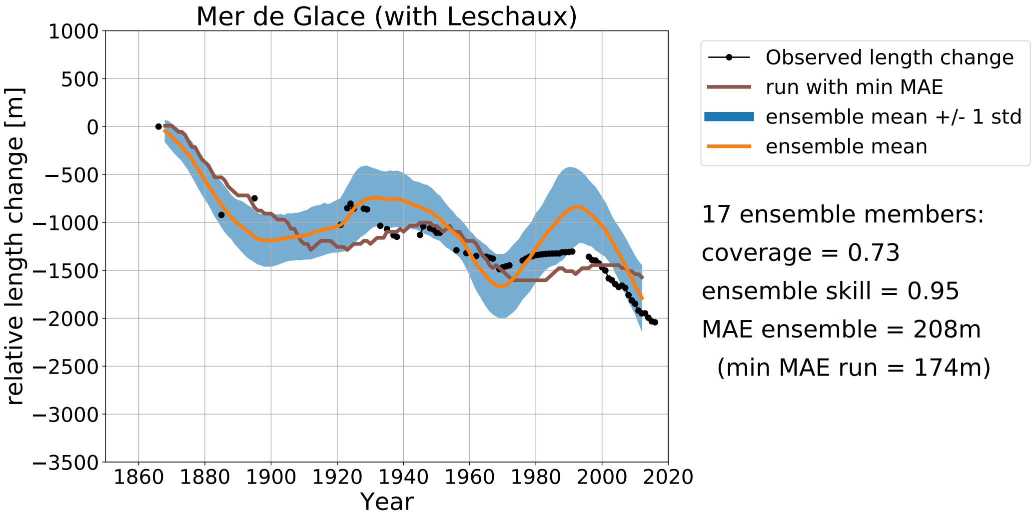
coverage = 0.85

ensemble skill = 0.87

MAE ensemble = 162m

(min MAE run = 142m)

Some results



17 ensemble members:

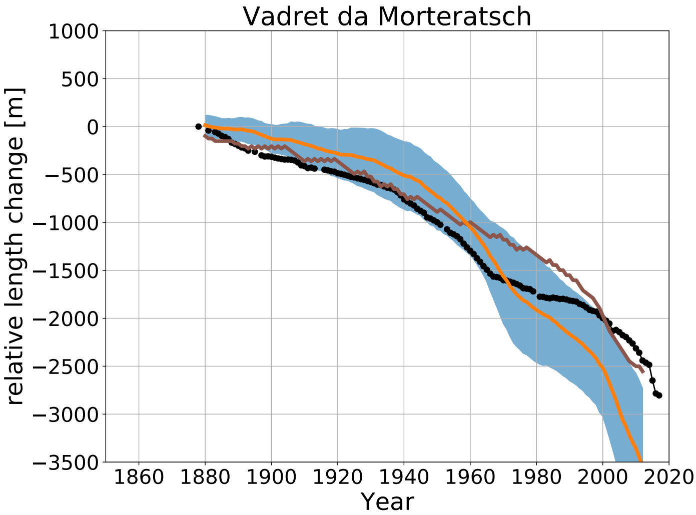
coverage = 0.73

ensemble skill = 0.95

MAE ensemble = 208m

(min MAE run = 174m)

Some results



12 ensemble members:

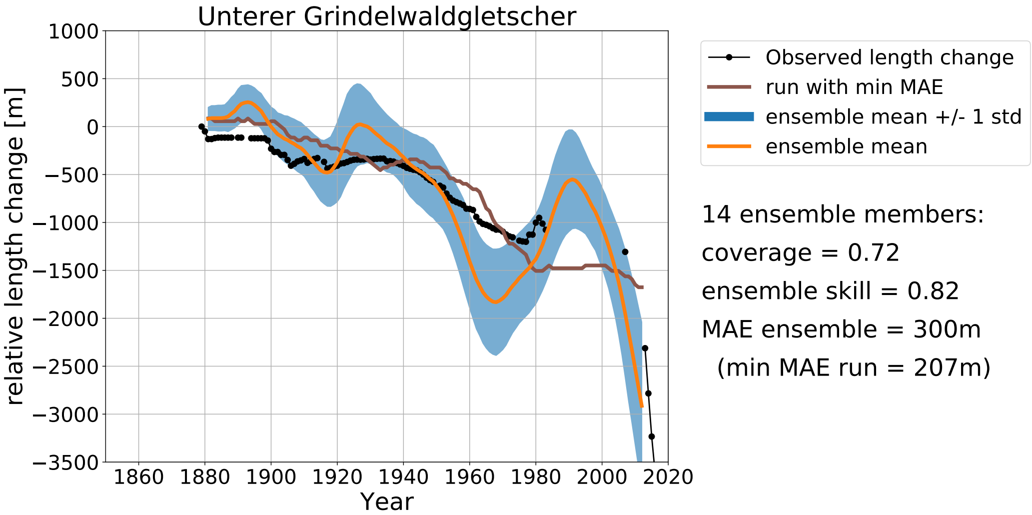
coverage = 0.72

ensemble skill = 0.96

MAE ensemble = 292m

(min MAE run = 167m)

Some results



14 ensemble members:

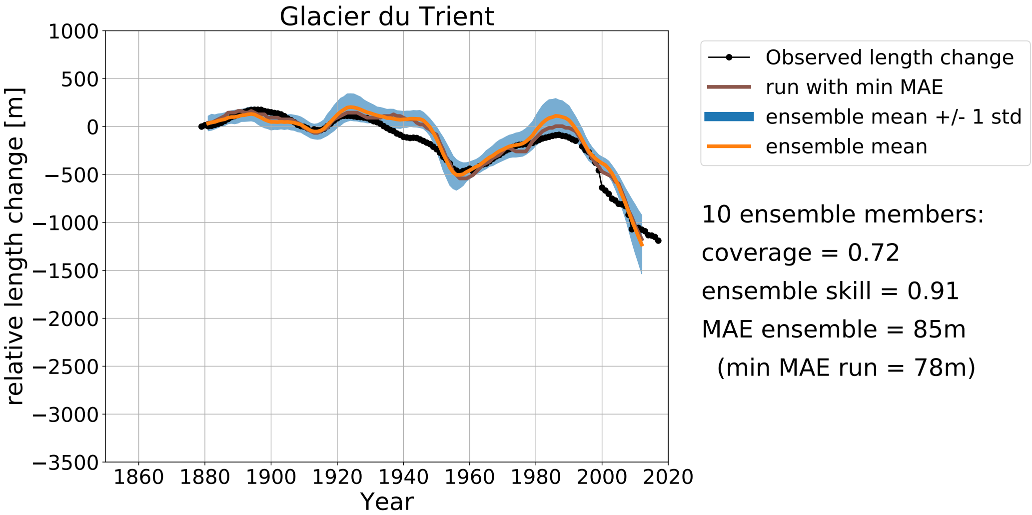
coverage = 0.72

ensemble skill = 0.82

MAE ensemble = 300m

(min MAE run = 207m)

Some results



10 ensemble members:

coverage = 0.72

ensemble skill = 0.91

MAE ensemble = 85m

(min MAE run = 78m)

Thank you for your attention!

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References

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