C35A-0866 Helheim Glacier's terminus position controls its seasonal and inter-annual ice flow variability

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Method and Data

Which processes are responsible for the seasonal and inter-annual variability of Helheim Glacier's surface velocity?

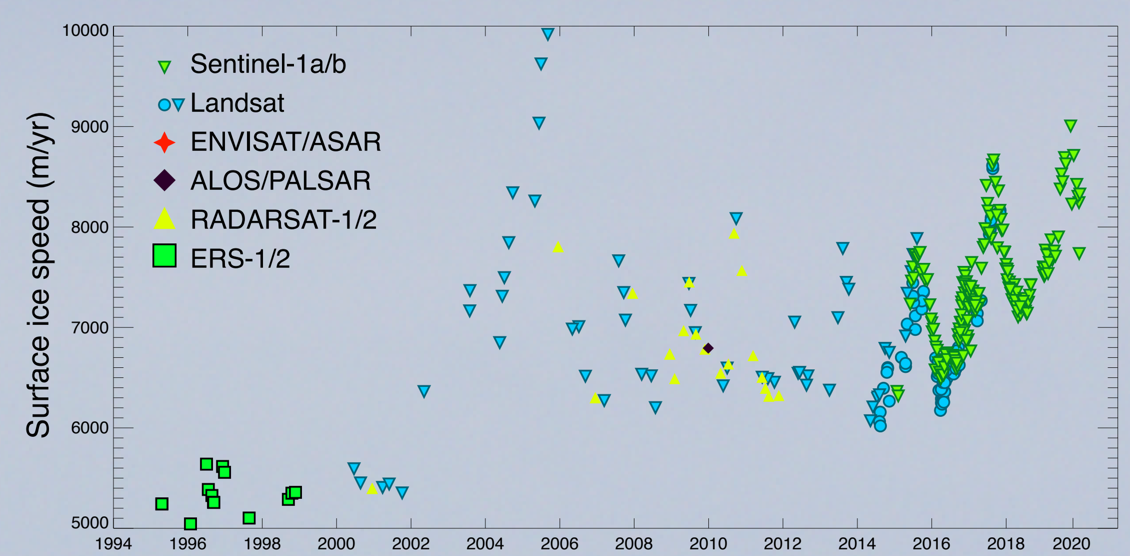

Figure 1: Mean surface velocity of the Helheim Glacier (Mouginot et al., 2017, 2019).

Numerical Model

- Shelfy-Stream Approximation (SSA, MacAyeal, 1989)
- Mesh resolution: between 100 m and 1.5 km (∼28,000 elements)
- Bed from BedMachine v4 (Morlighem et al., 2017)
- Ice-sheet and Sea-level System Model (ISSM, Larour et al., 2012)
- Transient simulation from 2007 to 2020 (time step: 1.8 days)

Observations (2007-2020)

- A time series of surface velocities at 150 m resolution, derived from the data acquired by Landsat-8 or Sentinel-1 (Mouginot et al., 2017, 2019)
- A time series of calving front positions, extracted from satellite images by the Calving Front Machine (CALFIN, Cheng et al., 2021)

Experiments

1. Constrain the calving front position using observations, and run the model with different friction laws and ice temperatures. For comparison, we also show the observed surface velocity and a control run whose ice front is kept fixed during the whole simulation
2. Remove the constraints on the terminus positions and apply smoothed ablation rates using moving average filters with different time span

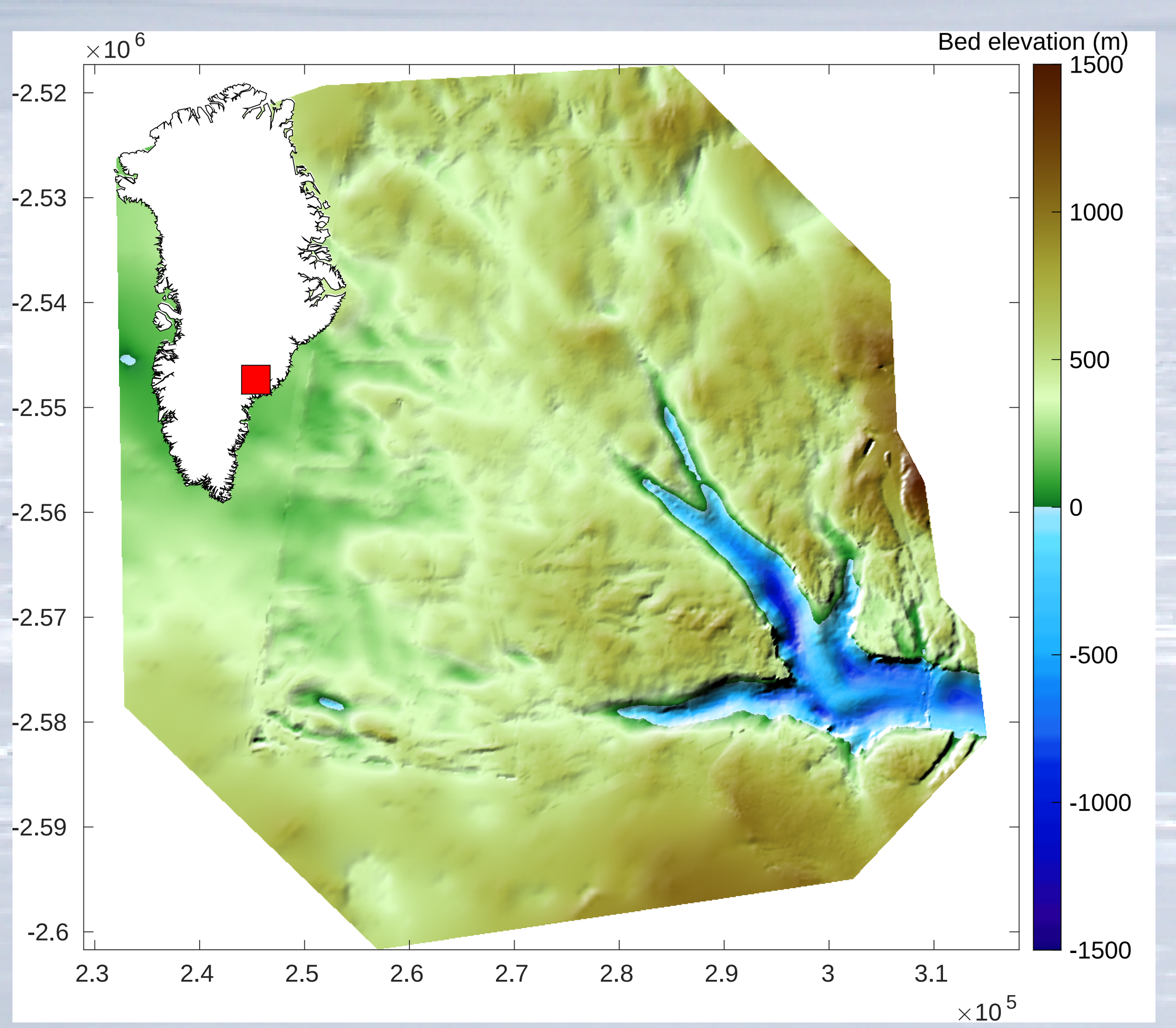

Figure 2: Bed topography (Morlighem et al., 2017) of the model domain.

Drivers of Helheim's variability

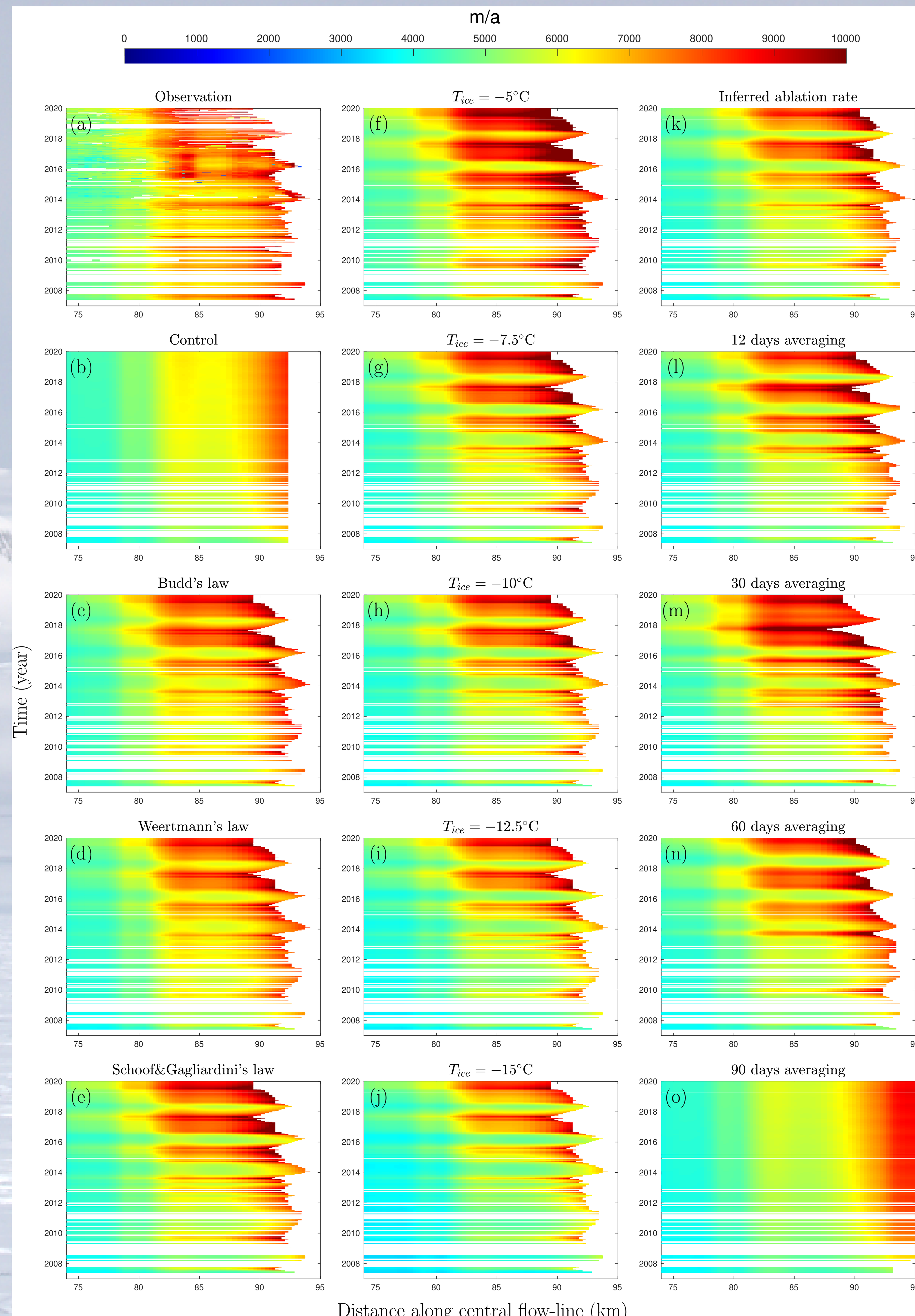

Figure 3: Hovmöller diagram of ice velocity along the central flowline of the (a) observation, (b) control run with fixed calving front position, (c)-(e) different friction laws, (f)-(j) different ice temperatures, (k)-(o) use inferred ablation rate. The x-axis indicates the distance along the flowline and the y-axis is time.

Results

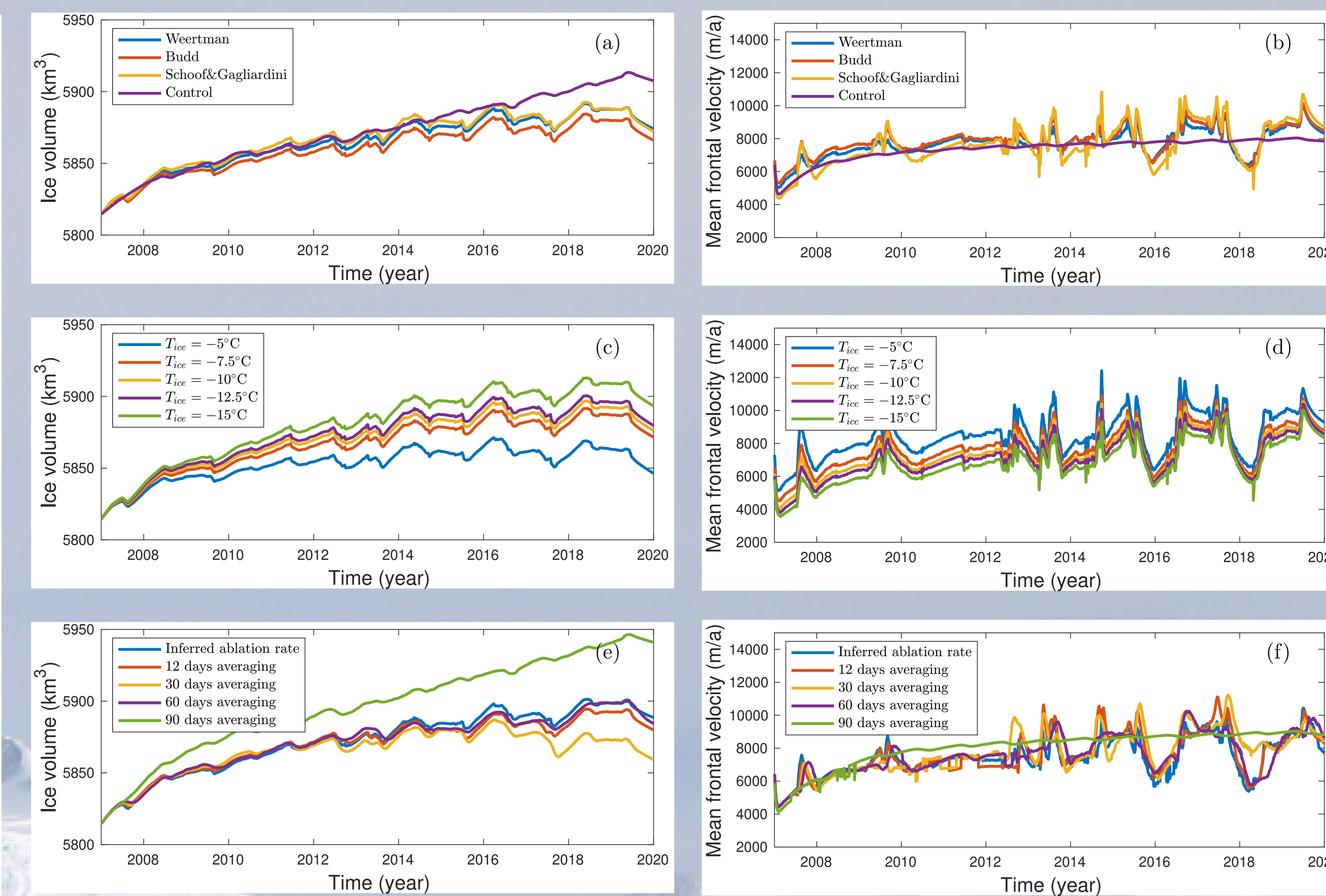

Figure 4: Total ice volume and mean frontal velocity at the calving front. (a)-(b) Friction law experiments. (c)-(d) Ice rheology experiments. (e)-(f) Inferred ablation rate experiments.

Discussion

- Weertman, Budd, and Schoof&Gagliardini's laws work equally well
- Higher ice temperature makes the ice softer and flows faster, but has no influence on the variability
- We are able to reproduce the ice speed variability with an ablation rate smoothed over 60 days (i.e., without the need to capture individual calving event)

Conclusion

- Calving dynamics controls Helheim's variability, irrespective of basal friction or ice rigidity
- Averaging the ablation rate over 60 days does not change the glacier behavior significantly
- Constraining a more realistic calving law is critical to model the future of Helheim Glacier

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