Investigating the drivers of Helheim Glacier's variability from 2007 to 2020

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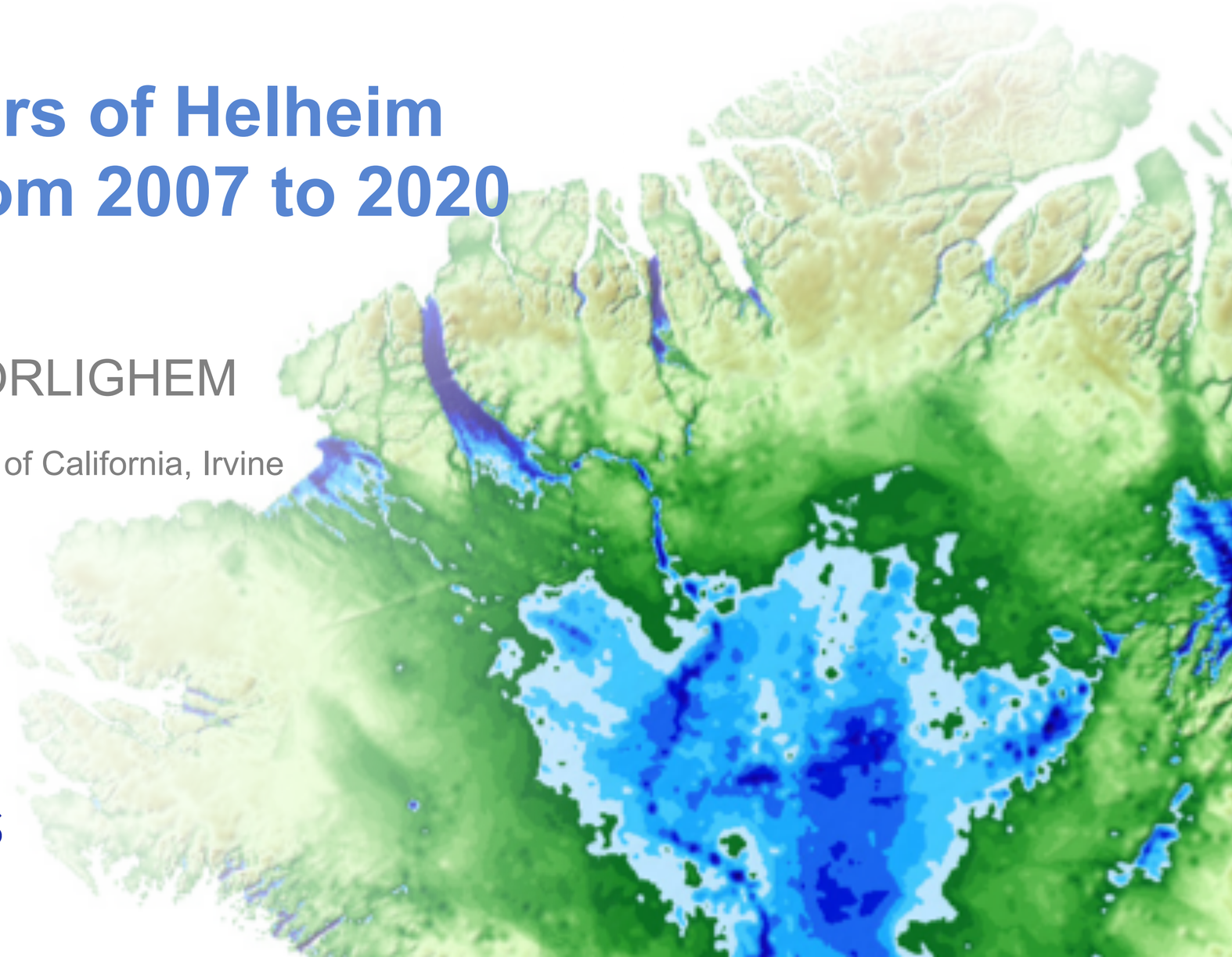
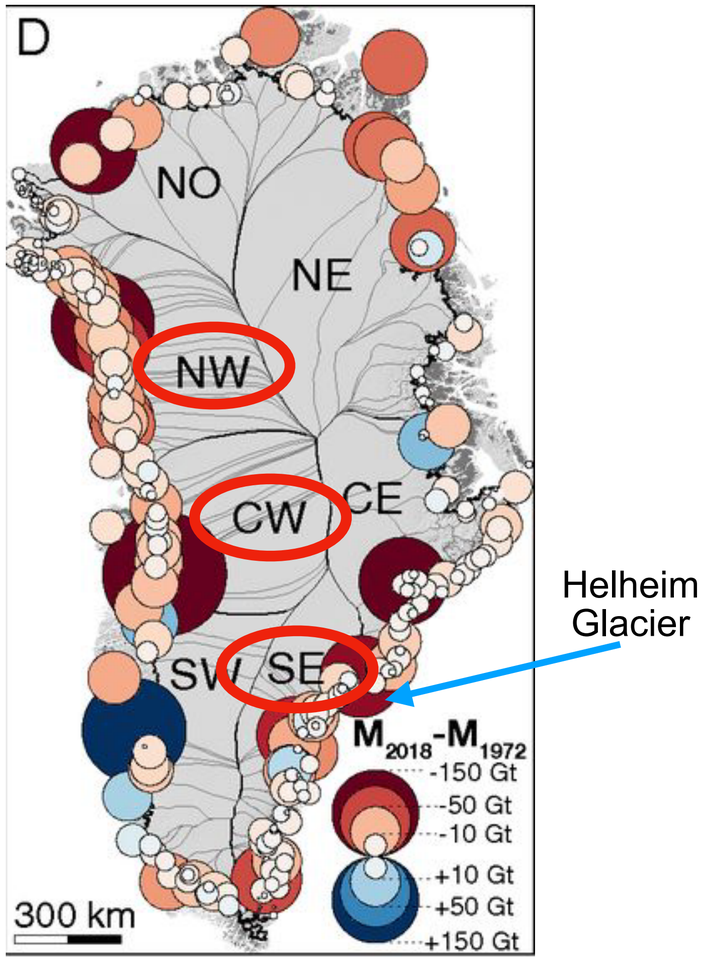


HEISING-SIMONS FOUNDATION

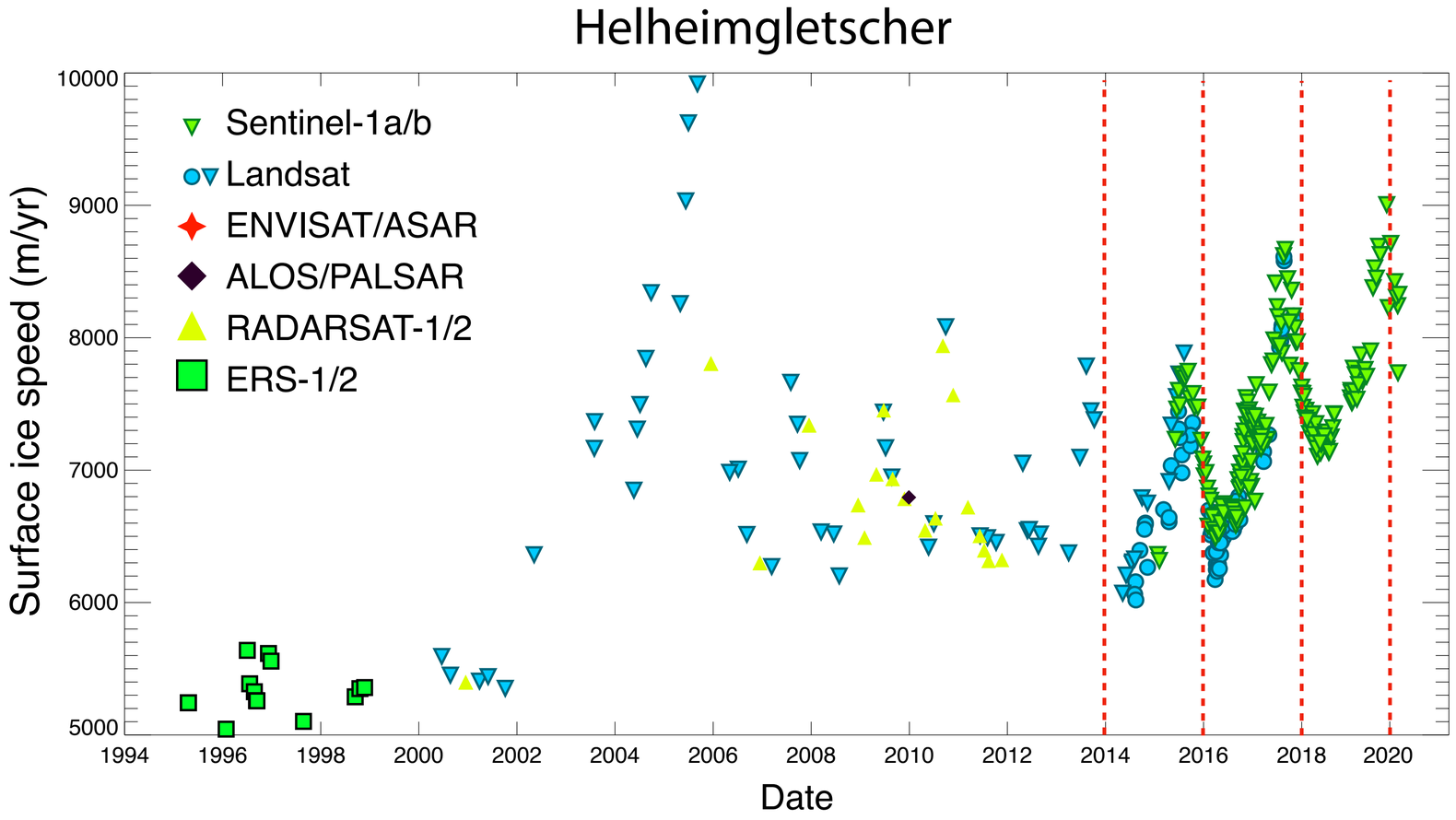
Outline

- Motivations
  - Brief Introduction about the background
  - Evidence of the variability.
- Basal friction
  - Which friction law and friction coefficient?
- Ice rigidity
  - How much does it influence the ice dynamics?
- Frontal ablation rate
  - Non-smoothing vs. smoothing
- Conclusion

Motivations

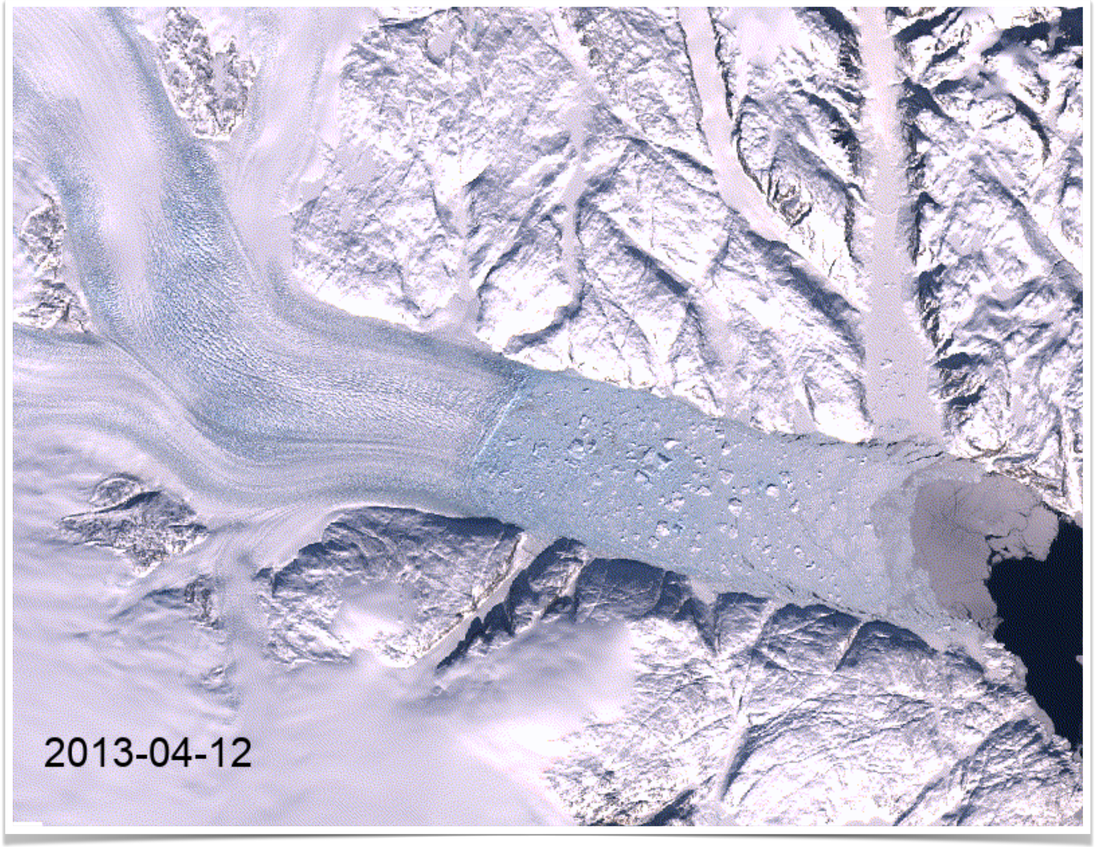


Mass loss, Mouginot et al. (2019)

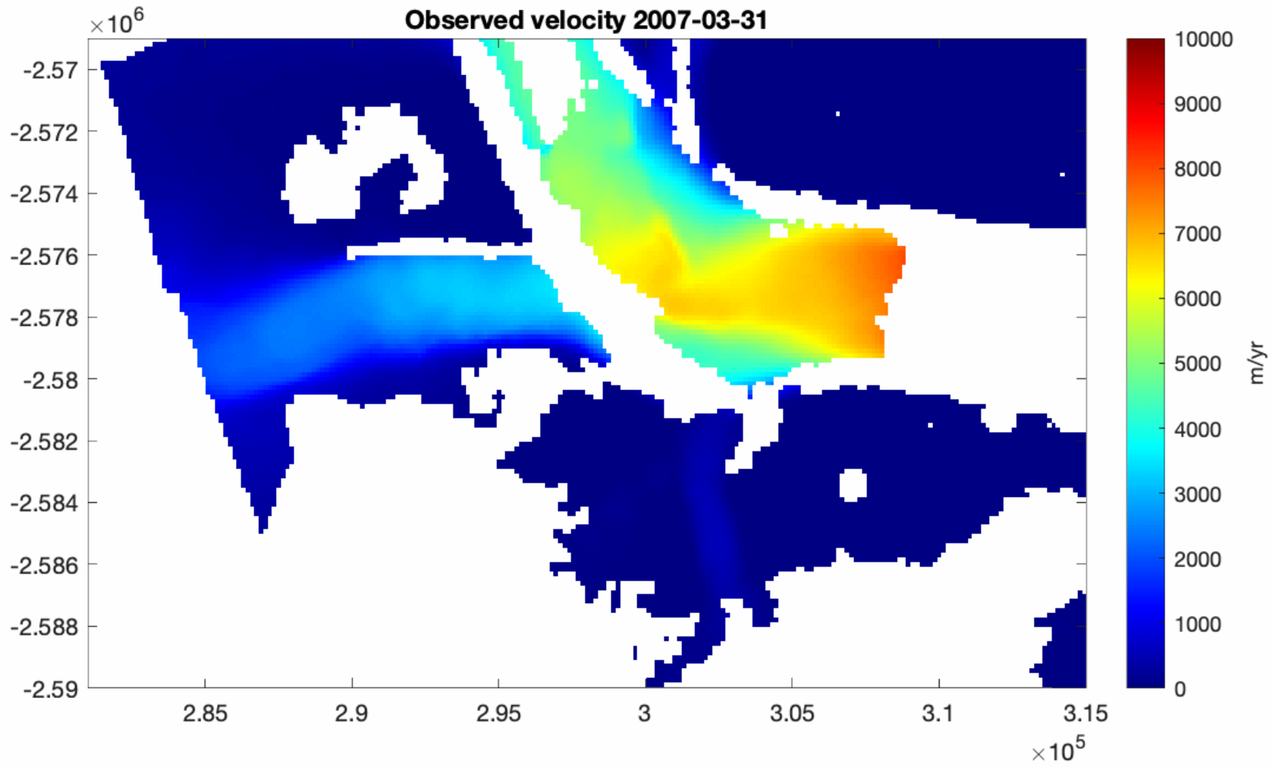


Mean surface velocity of the Helheim Glacier, Mouginot et al. in prep

Seasonal Variability of Helheim Glacier



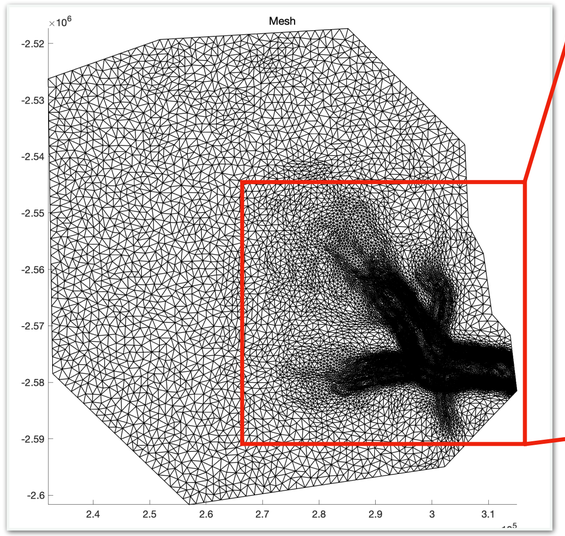
LANDSAT images, Cheng et al. 2020.

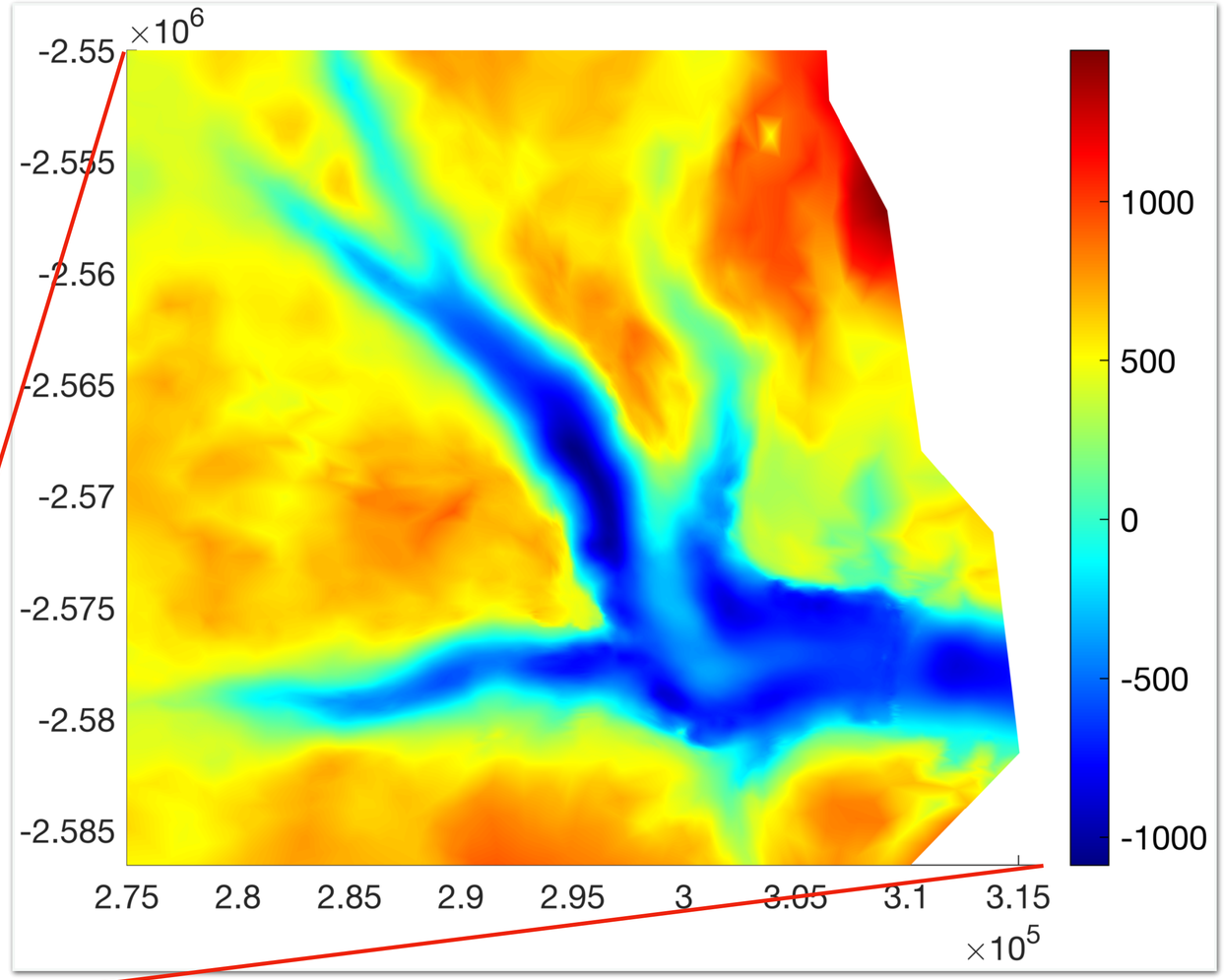


The velocity magnitude at Helheim Glacier, Mouginot et al. in prep.

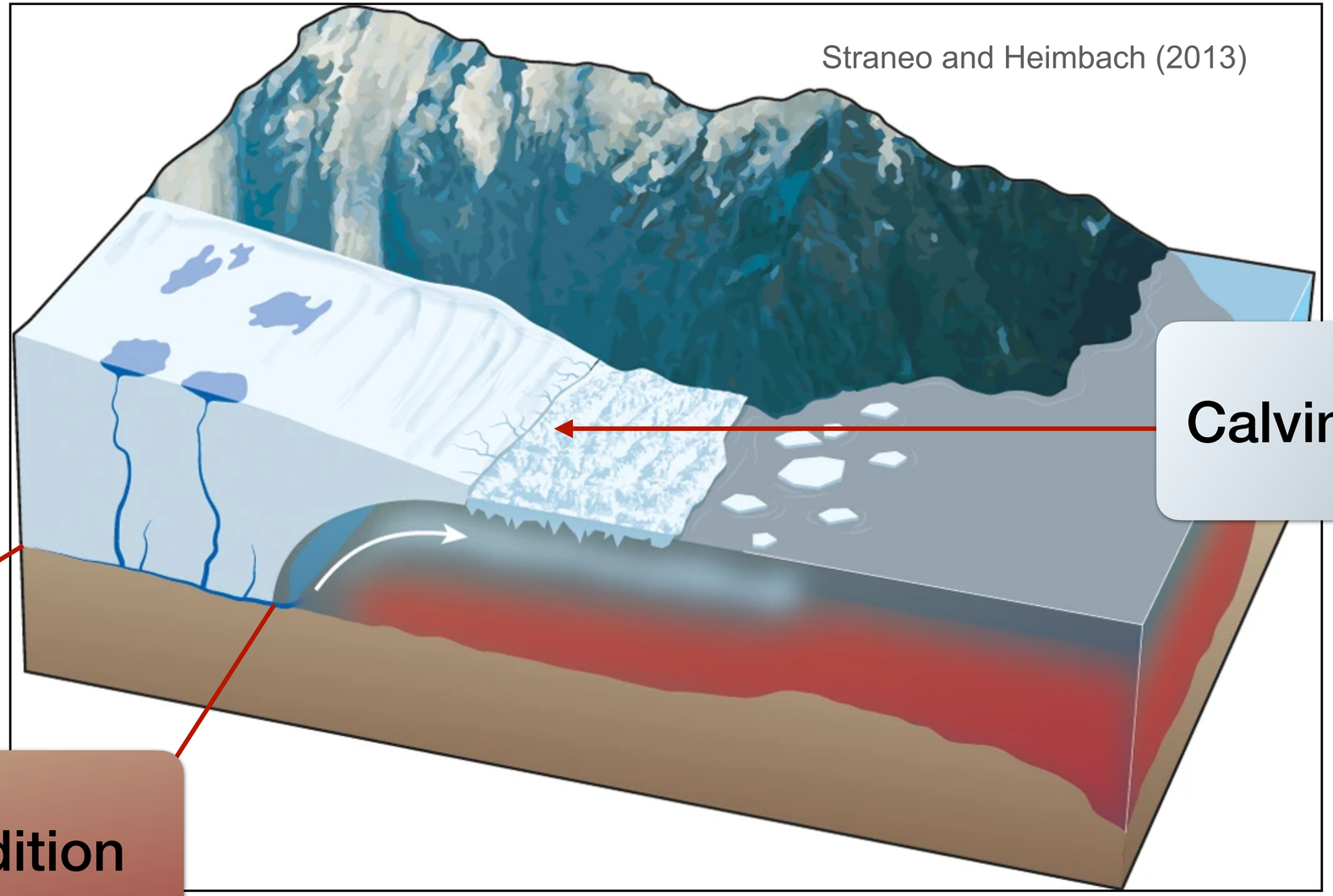
Model setup

- Ice-sheet and Sea-level System Model (ISSM).
- Shelfy Stream Approximation (SSA).
- Finite element method (~28,000 elements).
- Resolution from 100 m to 1.5 km.
- The bed elevation: BedMachine v3.
- Transient simulation from 2007 to 2020.
- Time steps: ~1.8 days.
- SMB forced by MAR.





The possible drivers



Calving dynamics

Basal condition

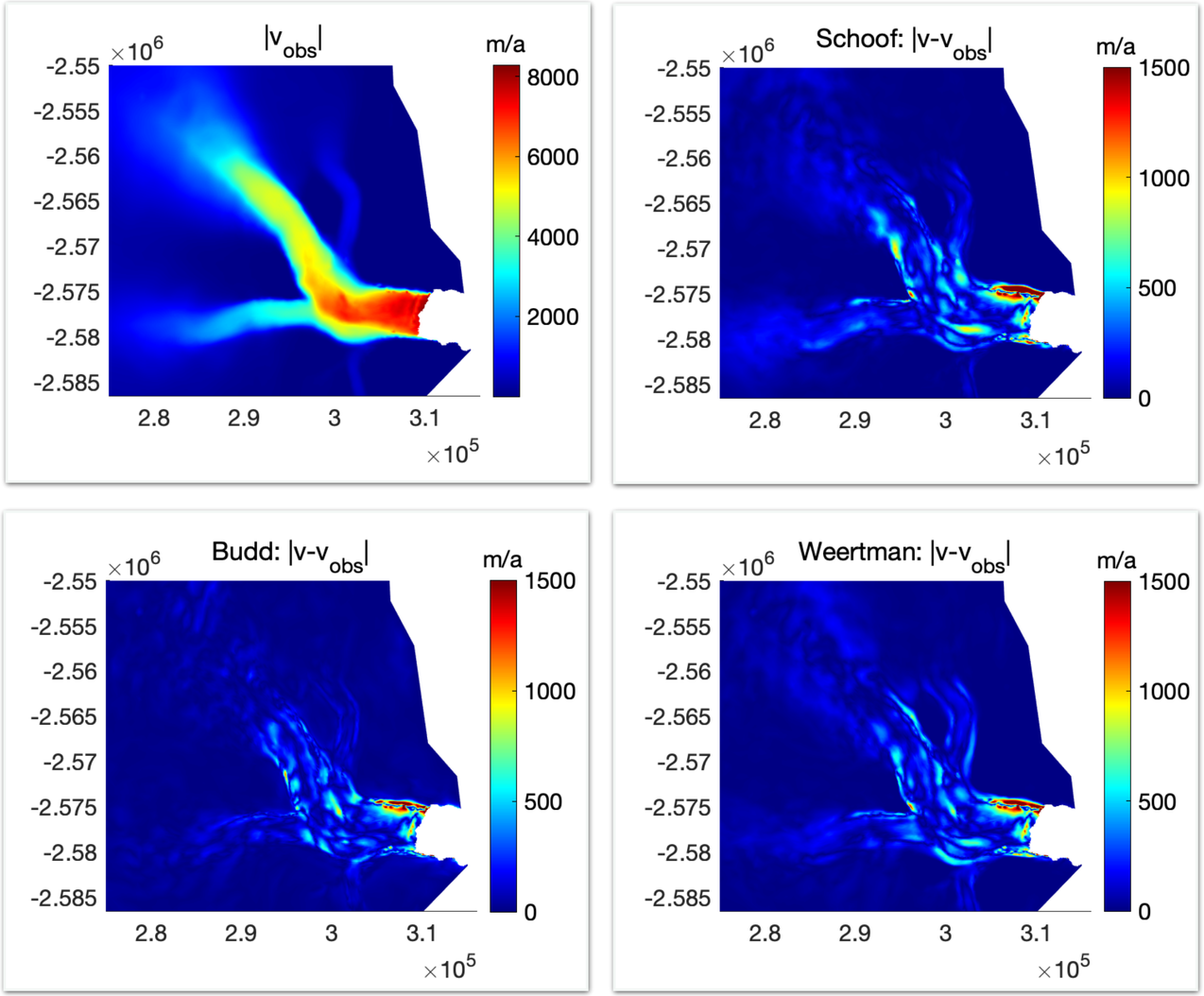
Basal Friction

Schoof's law: $\tau_b = \dfrac{C_S u_b^m}{\left(1 + u_b \left(\dfrac{C_S}{C_{\max} N}\right)^{1/m}\right)^m}$

Budd's law: $\tau_b = C_B u_b^m N^q$

Weertman's law: $\tau_b = C_W |u_b|^{m-1} u_b$

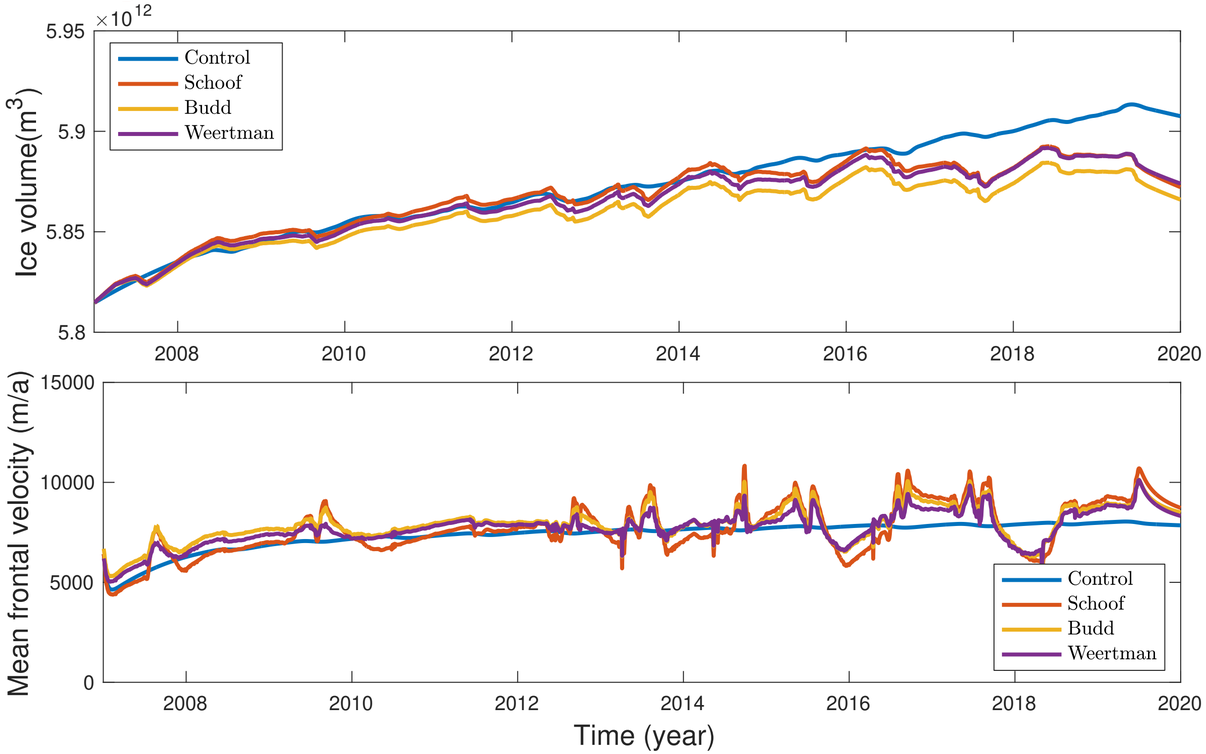
- All the three friction laws match data equally well.



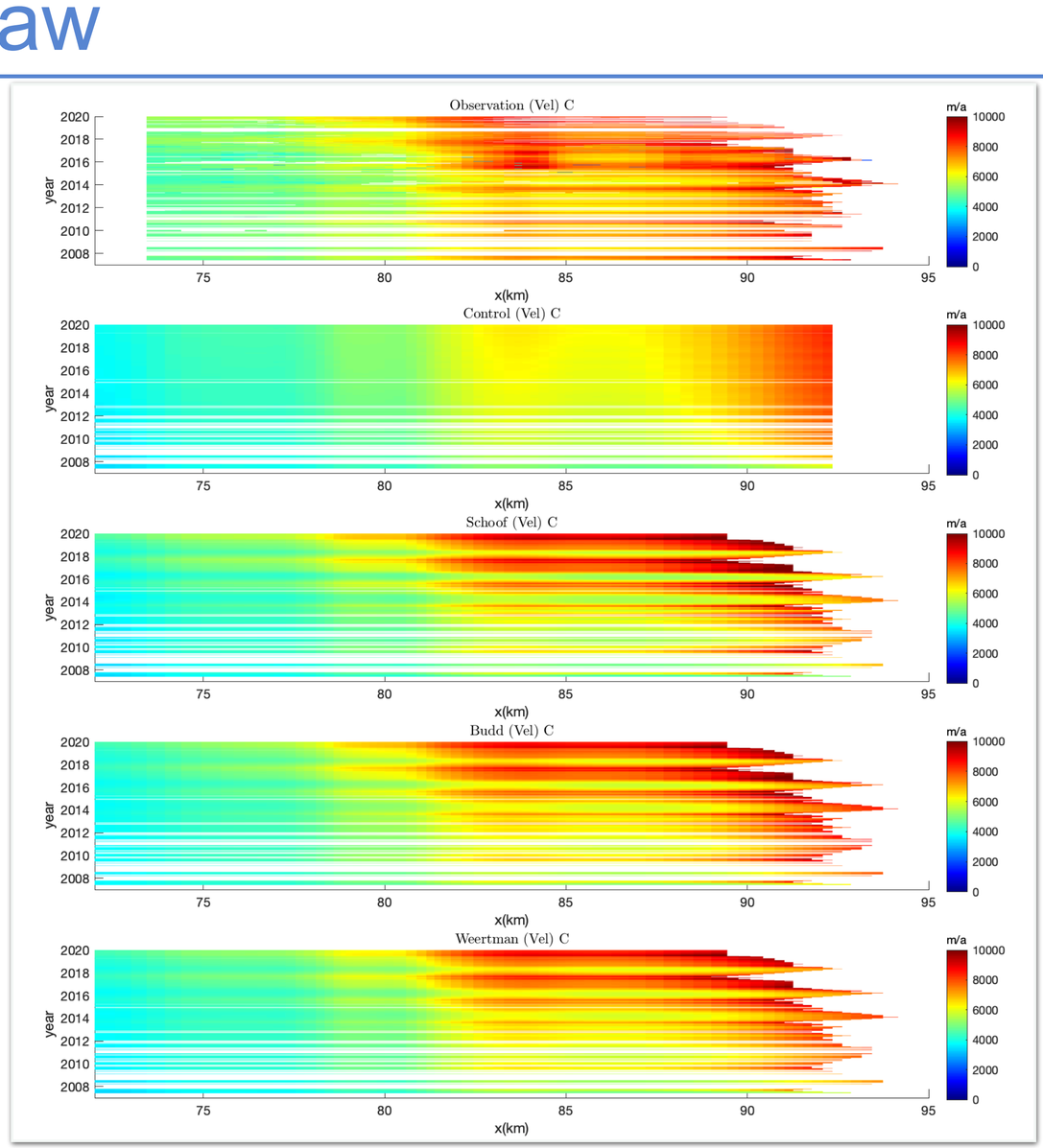
The velocity misfit from different friction laws.

Choice of friction law

- **The calving front positions are constrained by the observed terminus.**



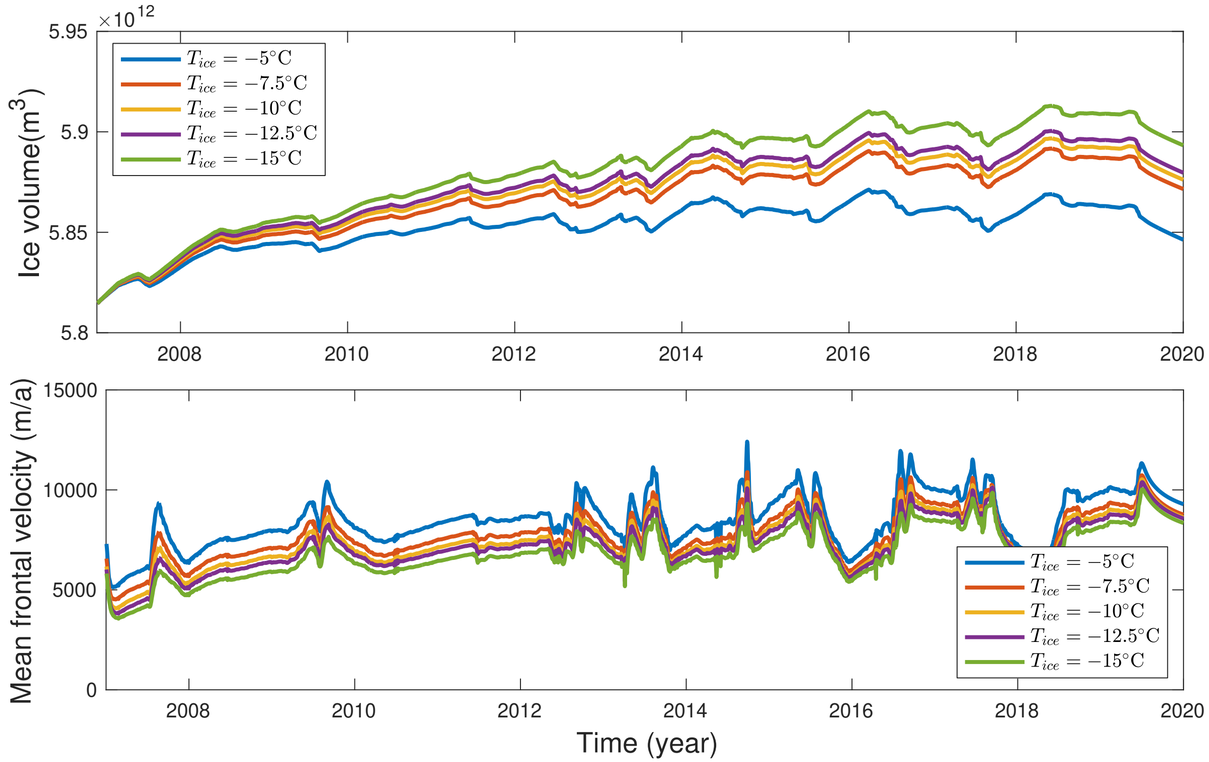
- **The main conclusion**
  - The choice of friction law **DOES NOT** matter in this case.



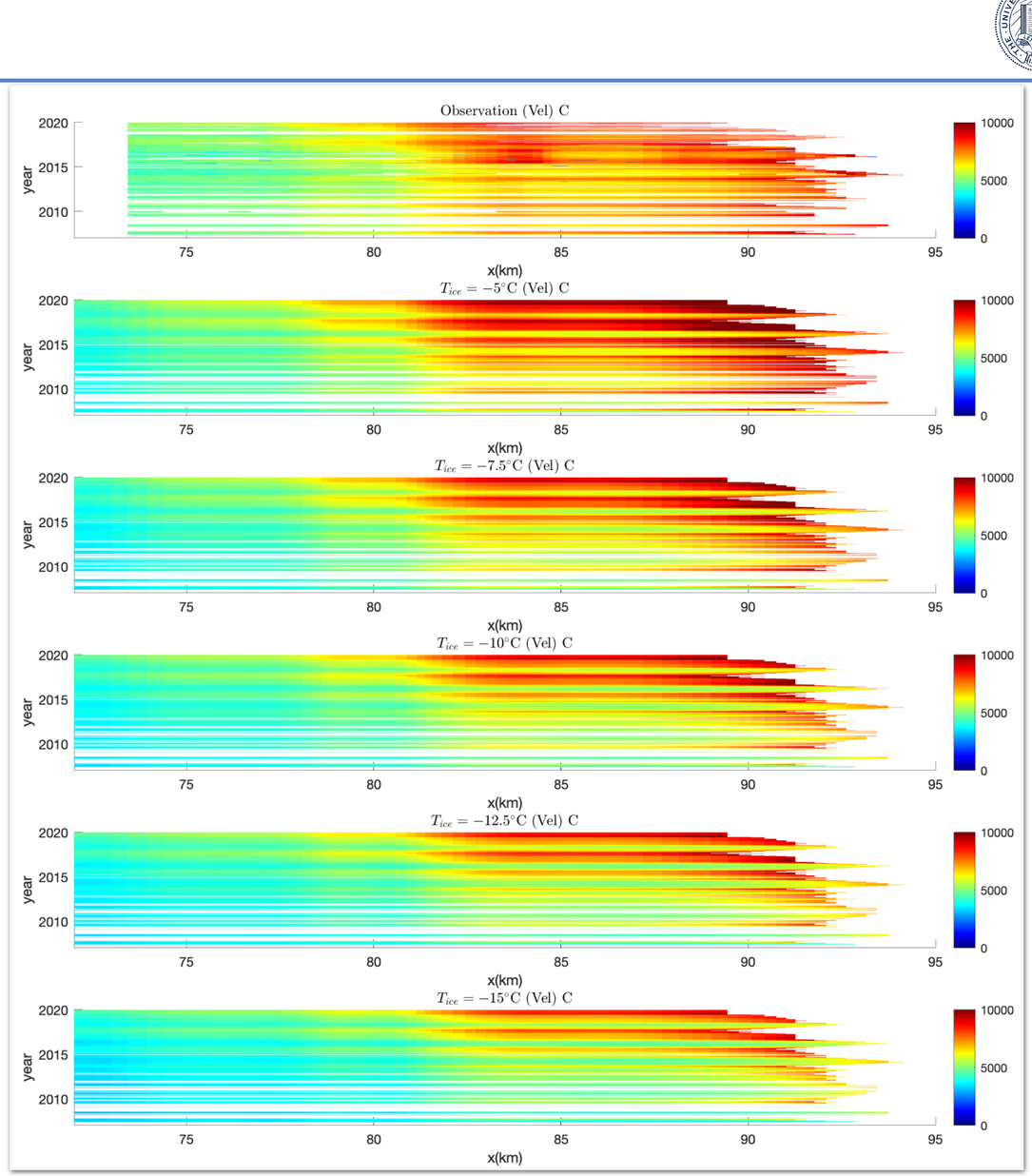
Velocity magnitude along the central flow-line.

Ice rigidity

- **Same calving front as the friction experiments**



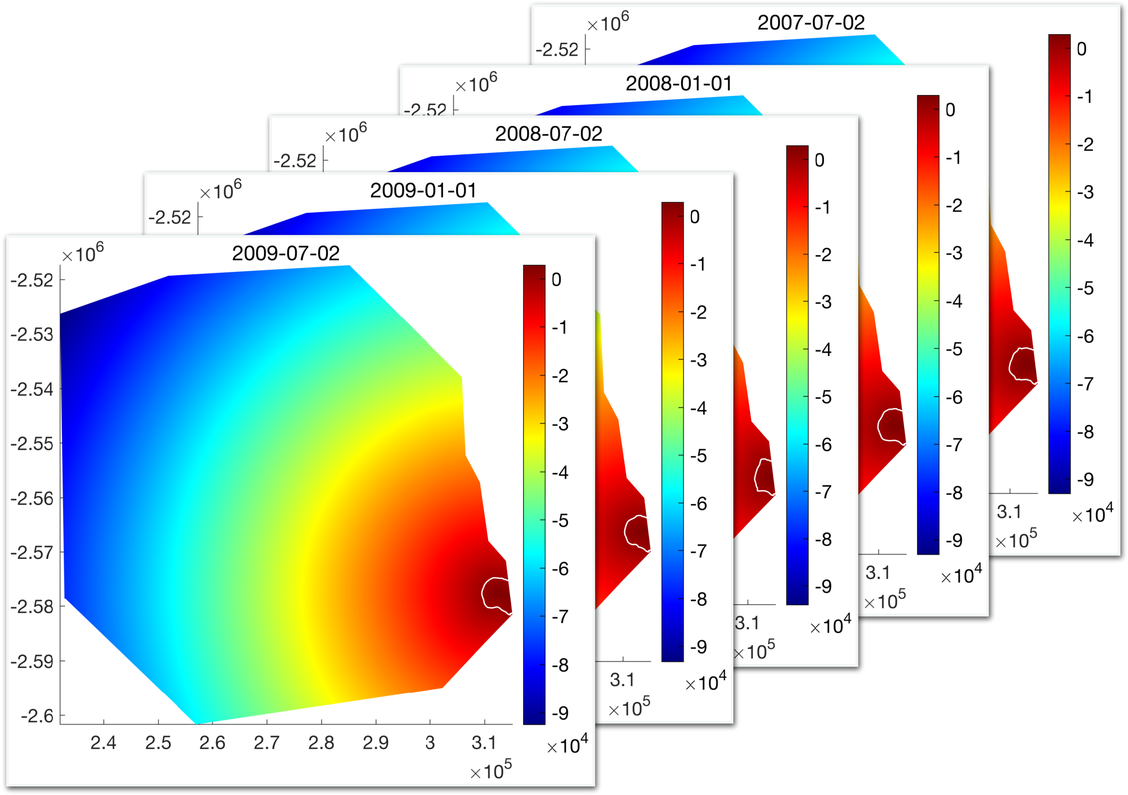
- **The main conclusion**
  - The variability is mainly determined by the calving front position.

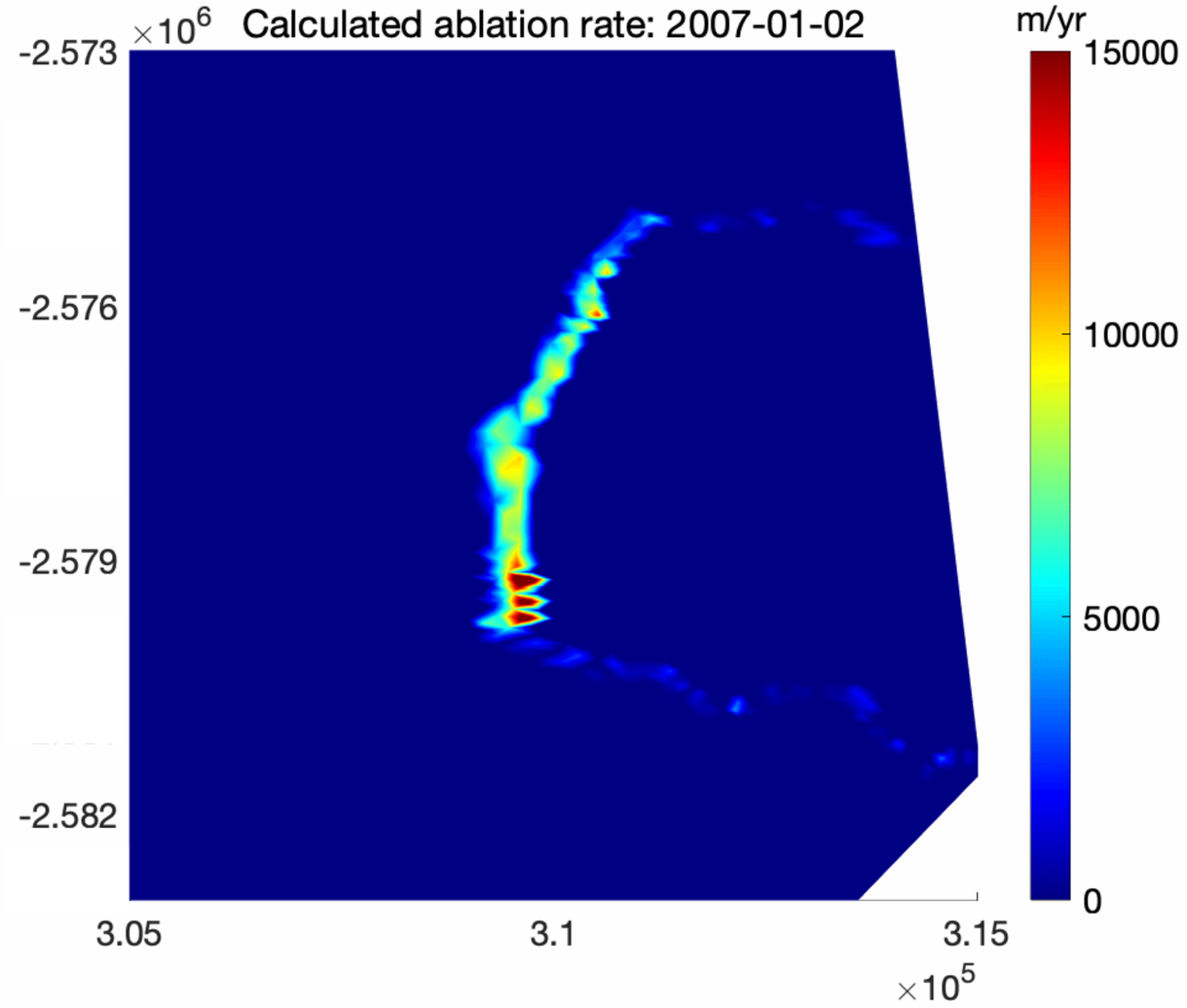


Velocity magnitude along the central flow-line.

Inversion of the ablation rate

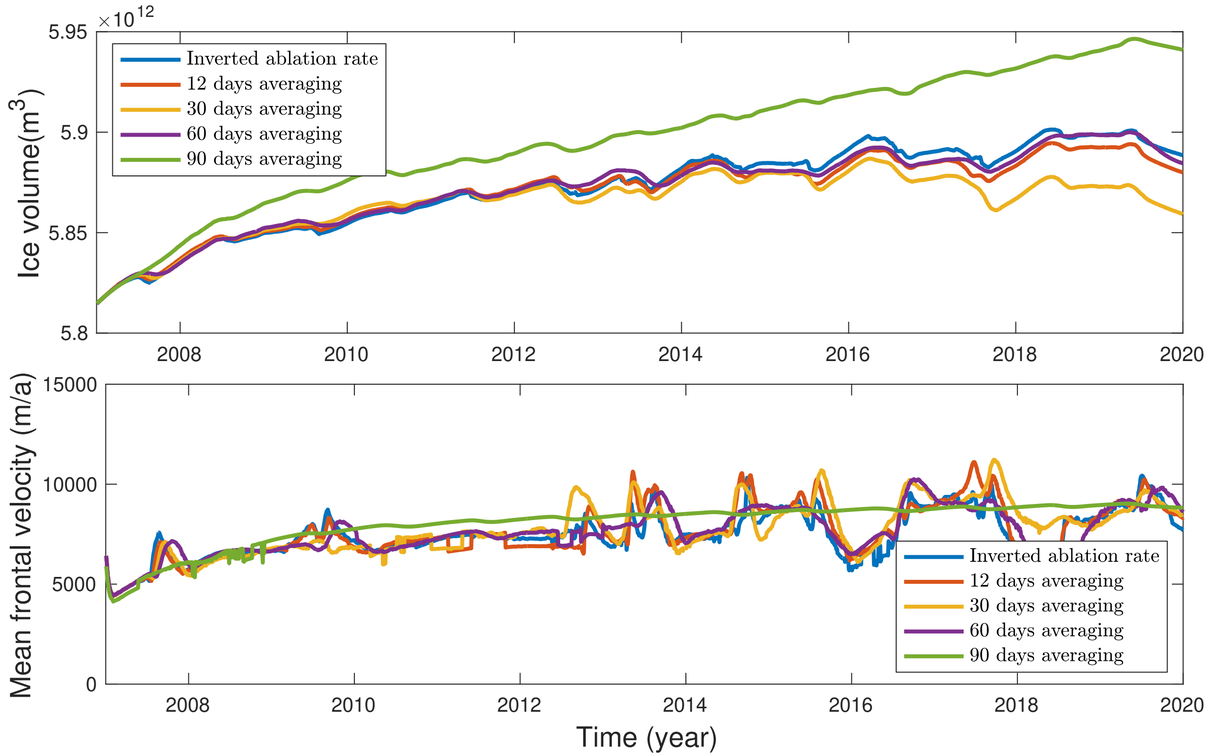
- The ablation rate is inverted directly from the level-set function, which describes the sign distance to the calving front positions.

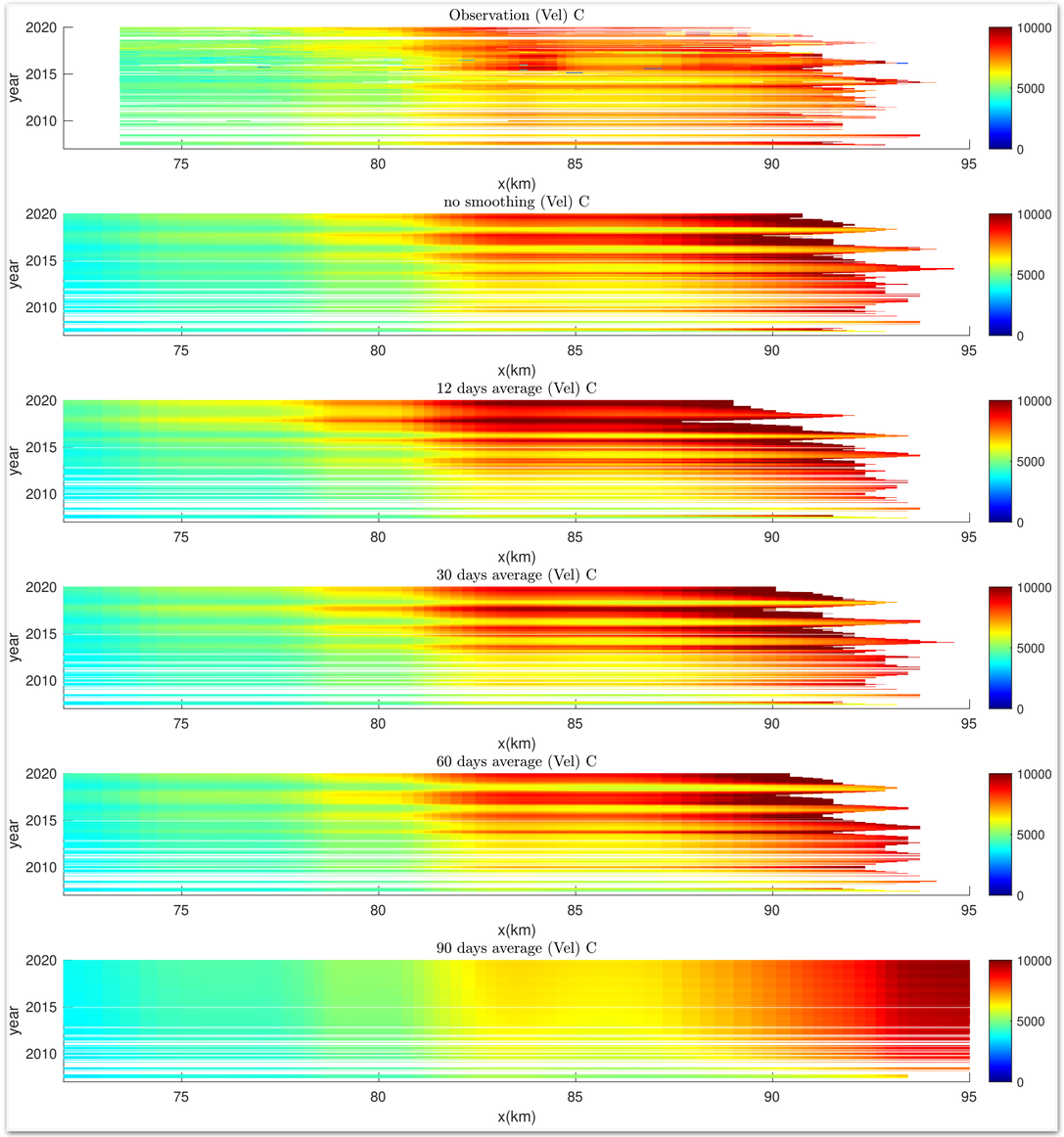




The inverted ablation rate at the calving front element from 2007 to 2020.

Smoothing the inverted ablation rate



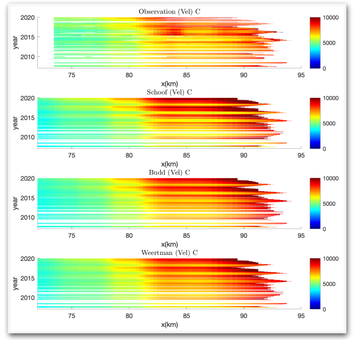


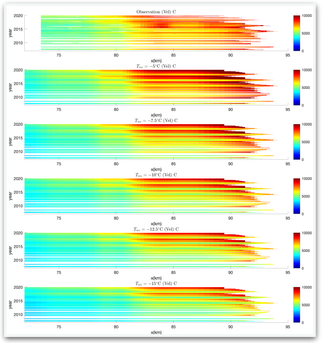
The main conclusion

- Averaging the ablation rate over 60 days does not change the glacier behavior significantly.

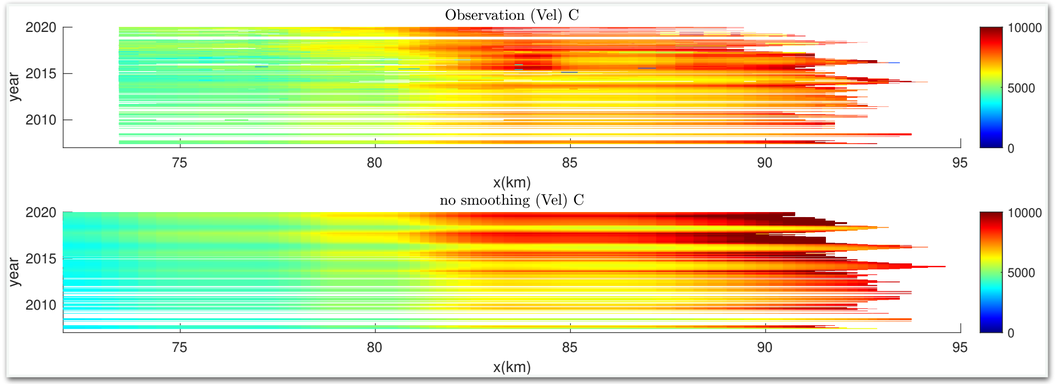
Summary

- Basal conditions and ice temperature does not matter for Helheim's variability.

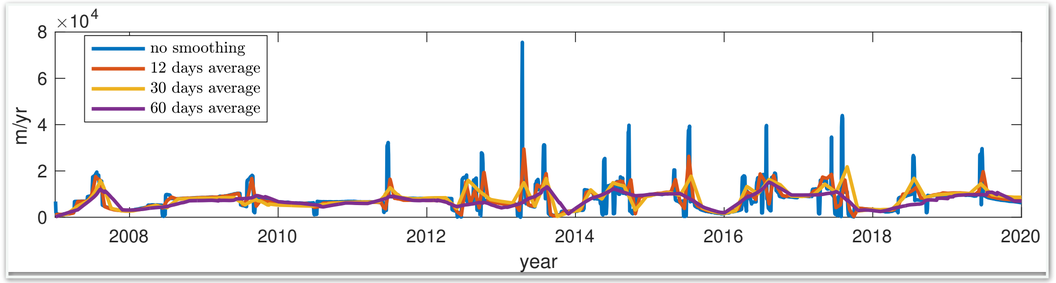




- The terminus position is of most important.



- To capture the variability, there is no need to resolve all the individual calving events.



Thank you!

- References

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