Predicting glacier mass balance by data assimilation from on-ice cameras

THANKS FOR ATTENDING OUR PICO ☺

Johannes Landmann, Christophe Ogier, Matthias Huss, Daniel Farinotti

A project within „CRAMPON – Cryospheric Monitoring and Prediction Online“

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Swiss Federal Institute for Forest, Snow and Landscape Research WSL
Glacier Monitoring Switzerland GLAMOS

Laboratory of Hydraulics, Hydrology and Glaciology

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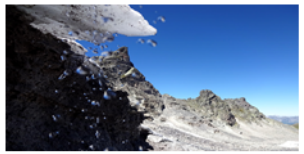
Motivation: No water in the hot summer months?

- Countrywide, daily glacier mass balance estimates could help to better manage water resources in future dry spells
- Frequent observations are essential to support mass balance models in giving frequent estimates, but field work is expensive

Near-Real Time Mass Balance = Model + Data Assimilation



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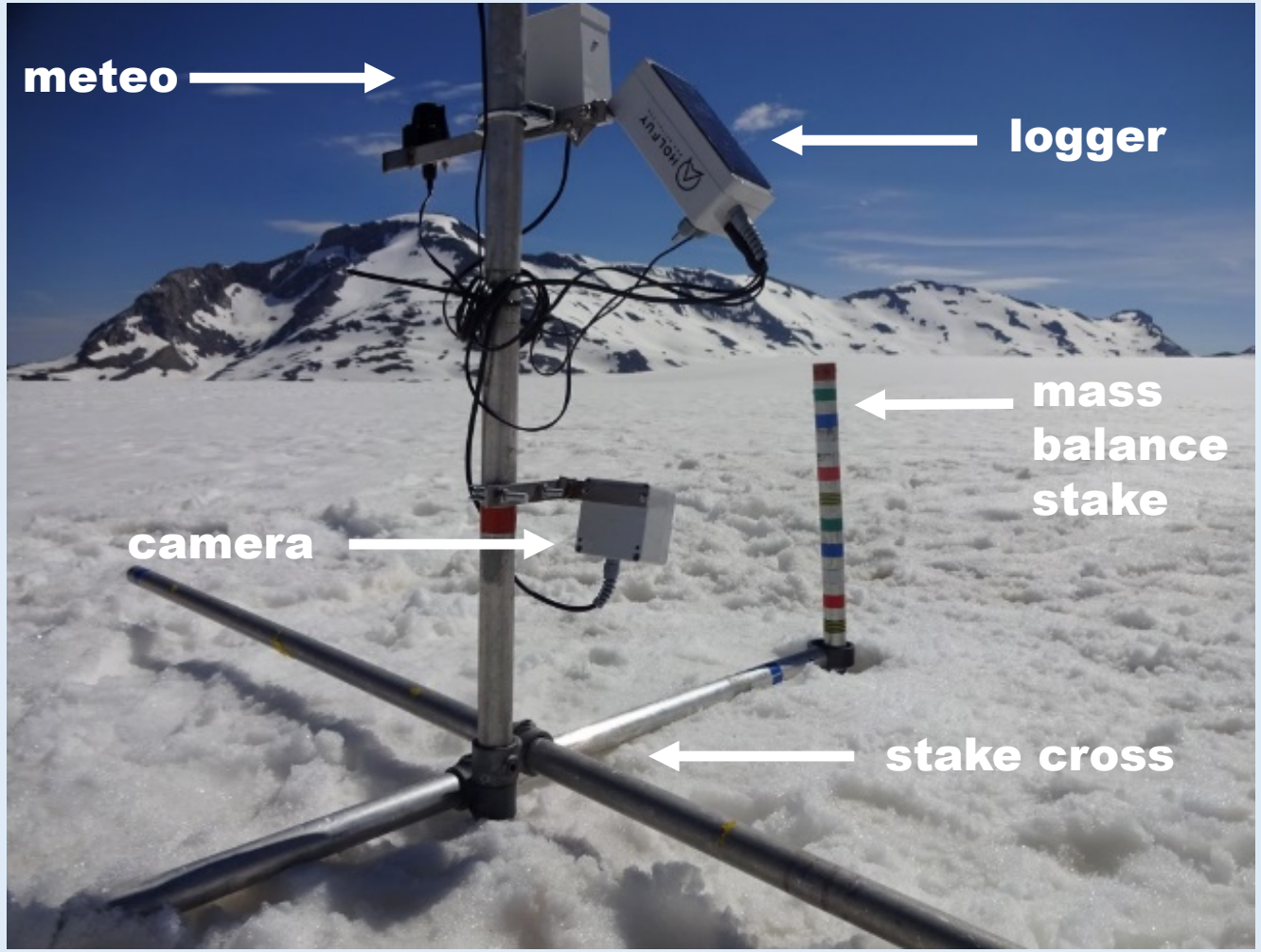
IDEA: Get „best near-real time estimate“ for a few well-observed glaciers and try to extrapolate this estimate into space

Put up cameras to obtain daily observations



- low maintenance
- daily melt estimates
- low cost!

- accumulation?
- indirect estimate of melt

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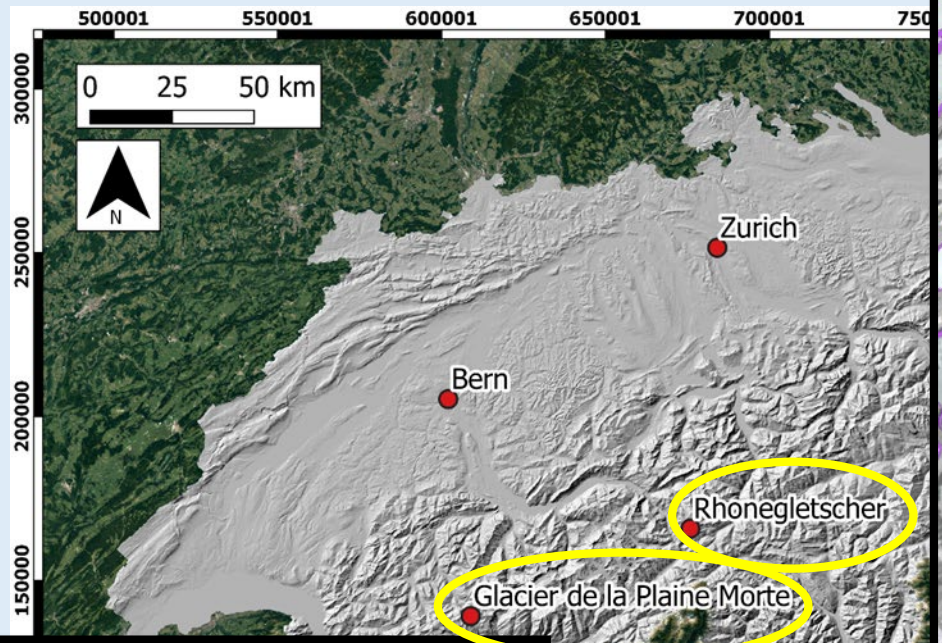
Images:wp-expert.net,pinterest.com, vectorstock.com

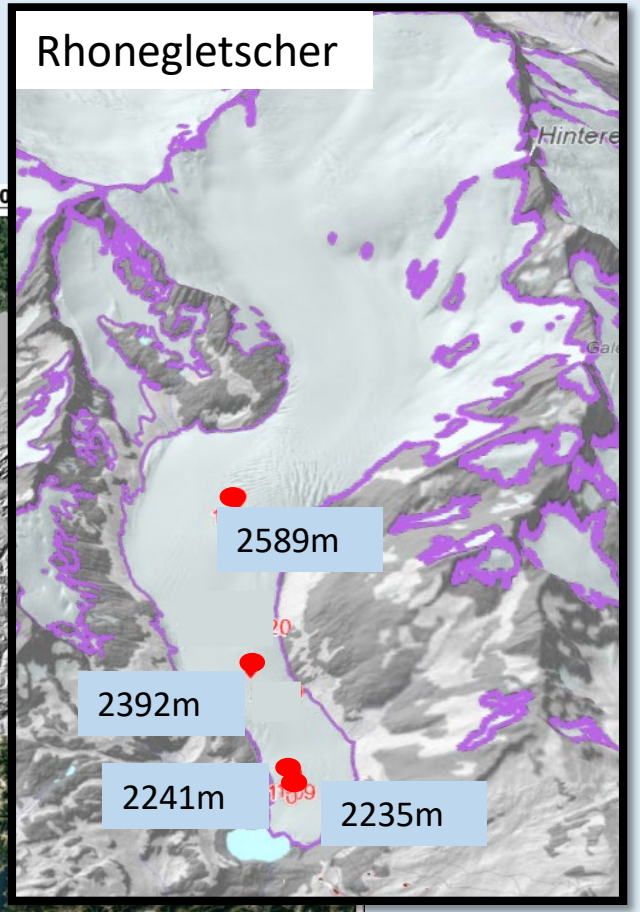
Camera Locations in 2019

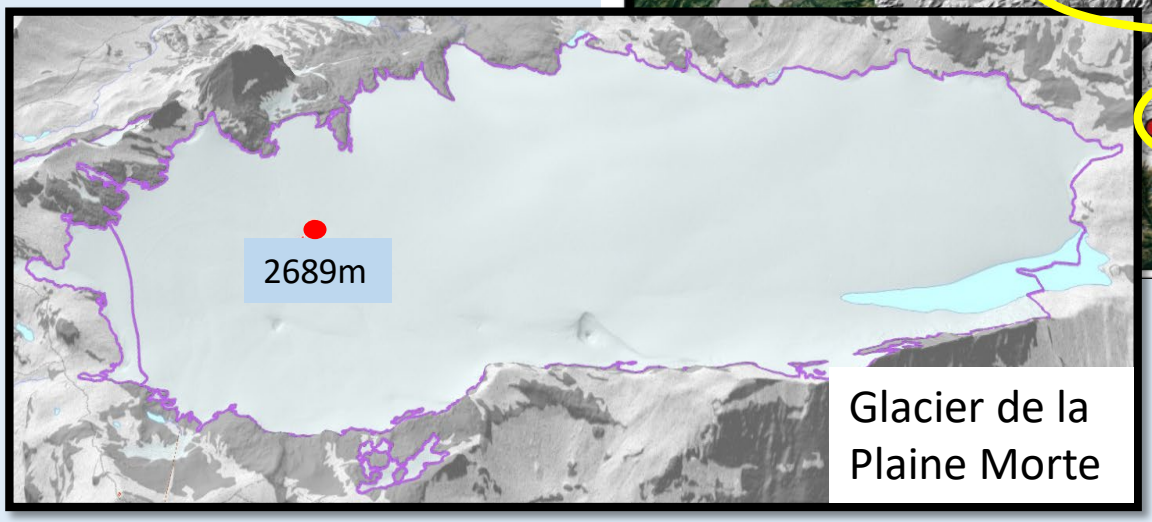
7 cameras

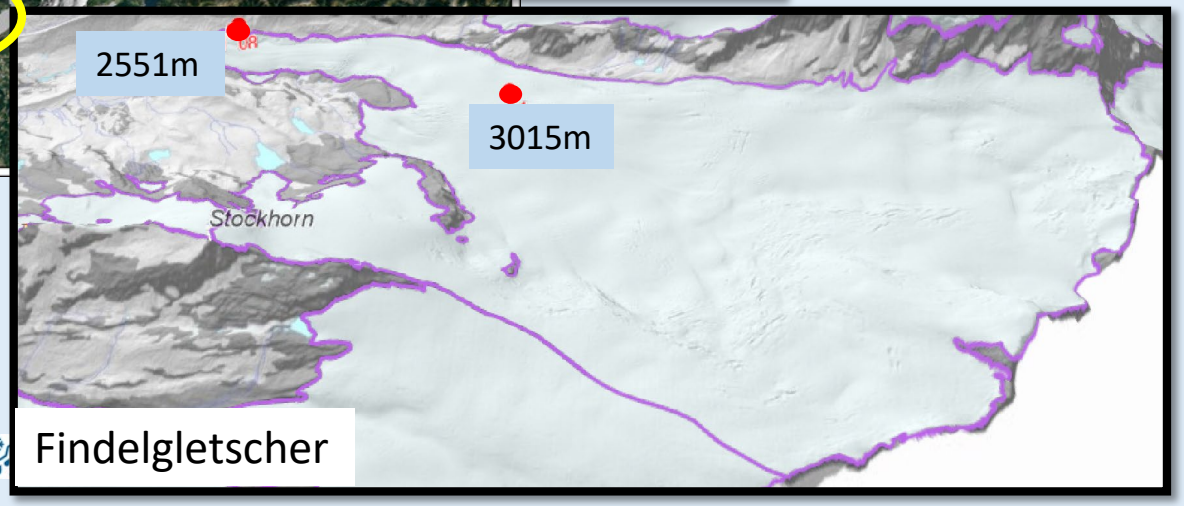
3 glaciers

50m – 80km distance









3D maps provided by swisstopo

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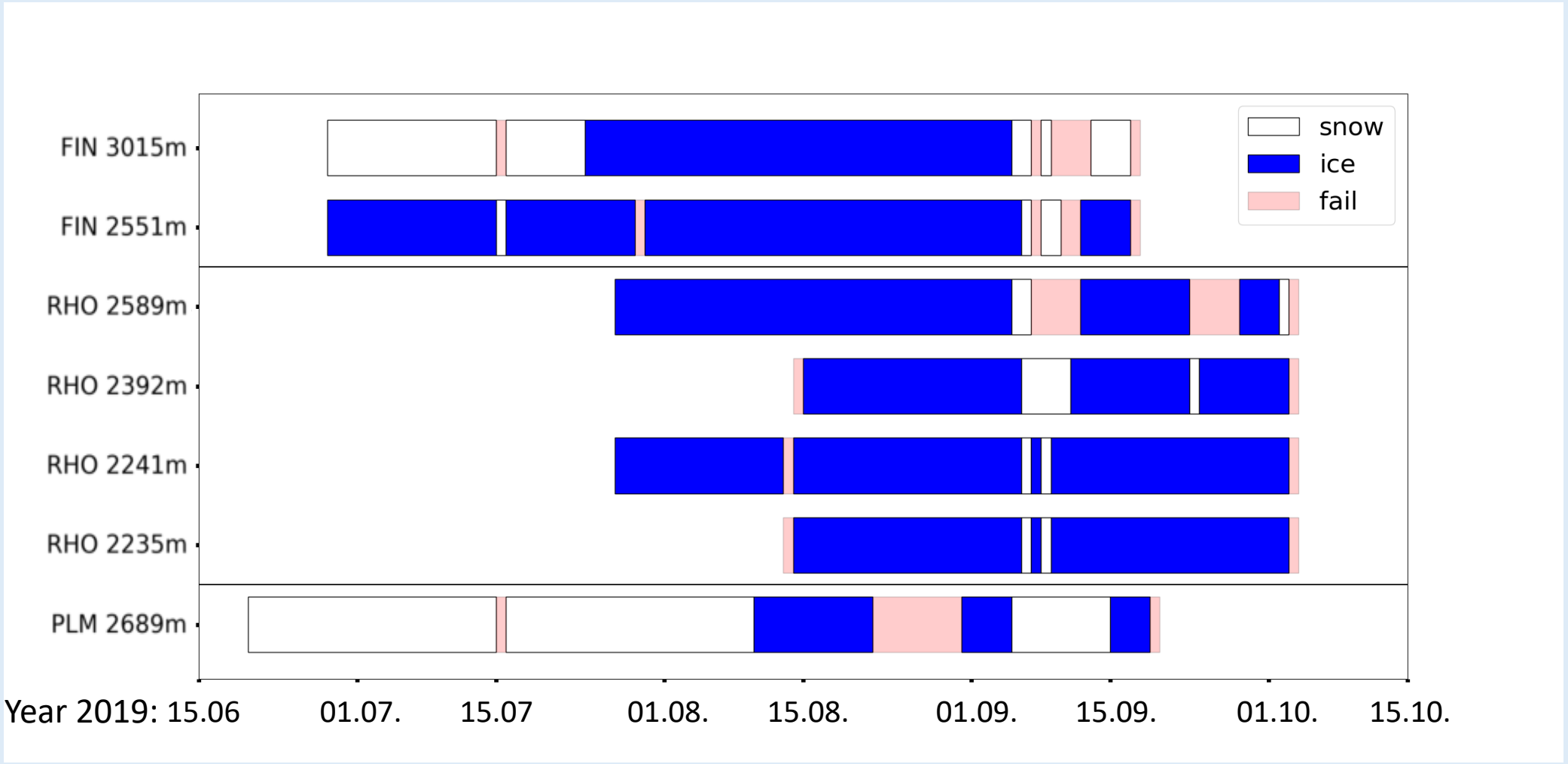
352 Ice point mass balances acquired in year 2019



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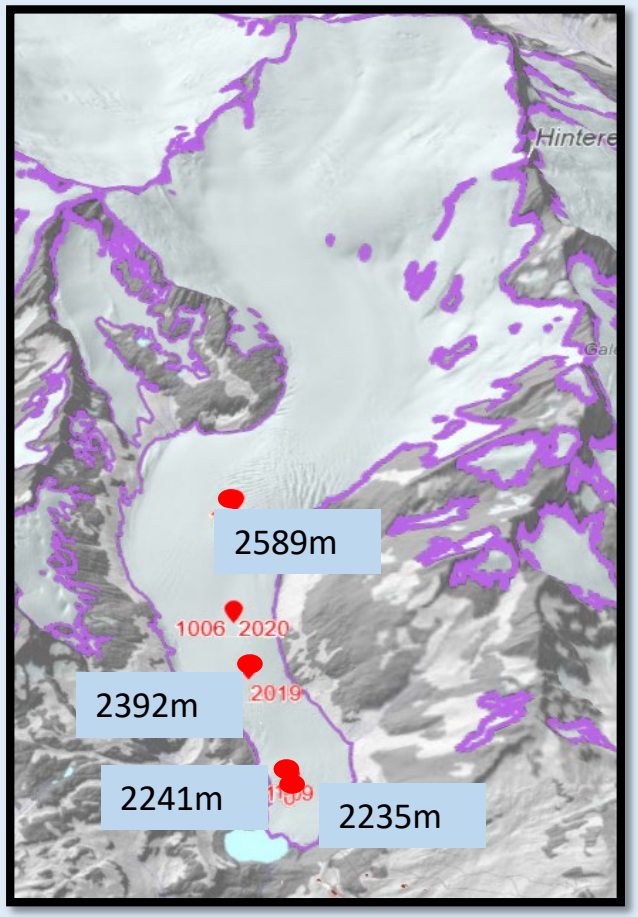
Mass balance estimates on observed glaciers



Recipe:

1) Predict the point mass balance at all camera locations with an ensemble of four temperature index models
2) Update prediction with camera observations using a Particle Filter
3) Use the found parameter distribution to calculate the mass balance for the entire glacier

„Percentile Extrapolation“ technique

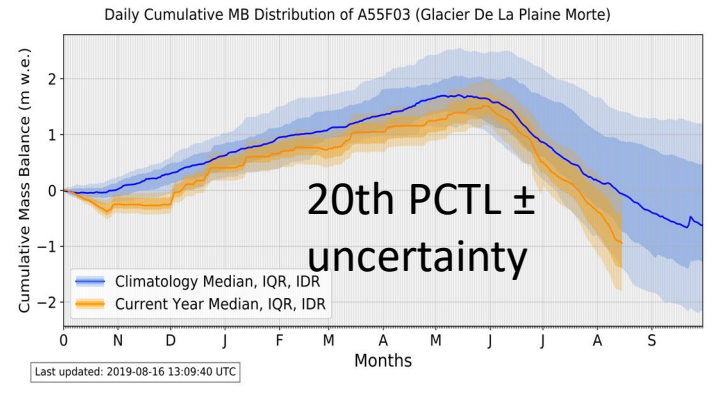
OBSERVED CAMERA GLACIER

CLIMATOLOGY FROM CALIBRATION ON MASS BALANCES FROM THE GLACIOLOGICAL METHOD

Single glacier best estimates (cameras)

Evaluate climate percentile

Single glacier current percentile of climatology

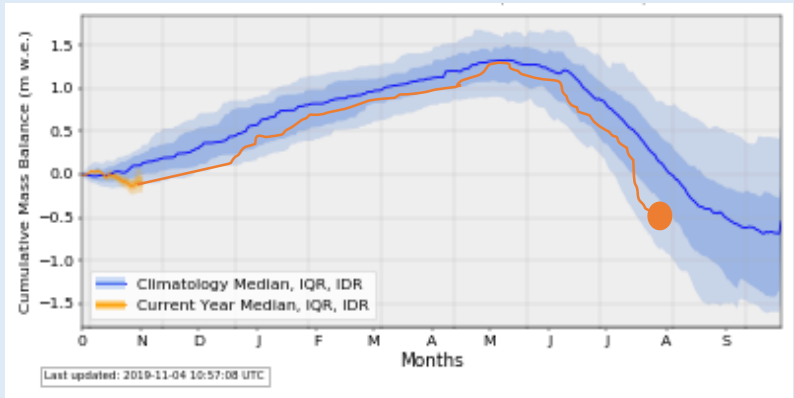


UNOBSERVED GLACIER

CLIMATOLOGY FROM CALIBRATION ON GEODETIC MASS BALANCES

Inverse Distance Weighted Interpolation

Extrapolated PCTL to generate current estimate



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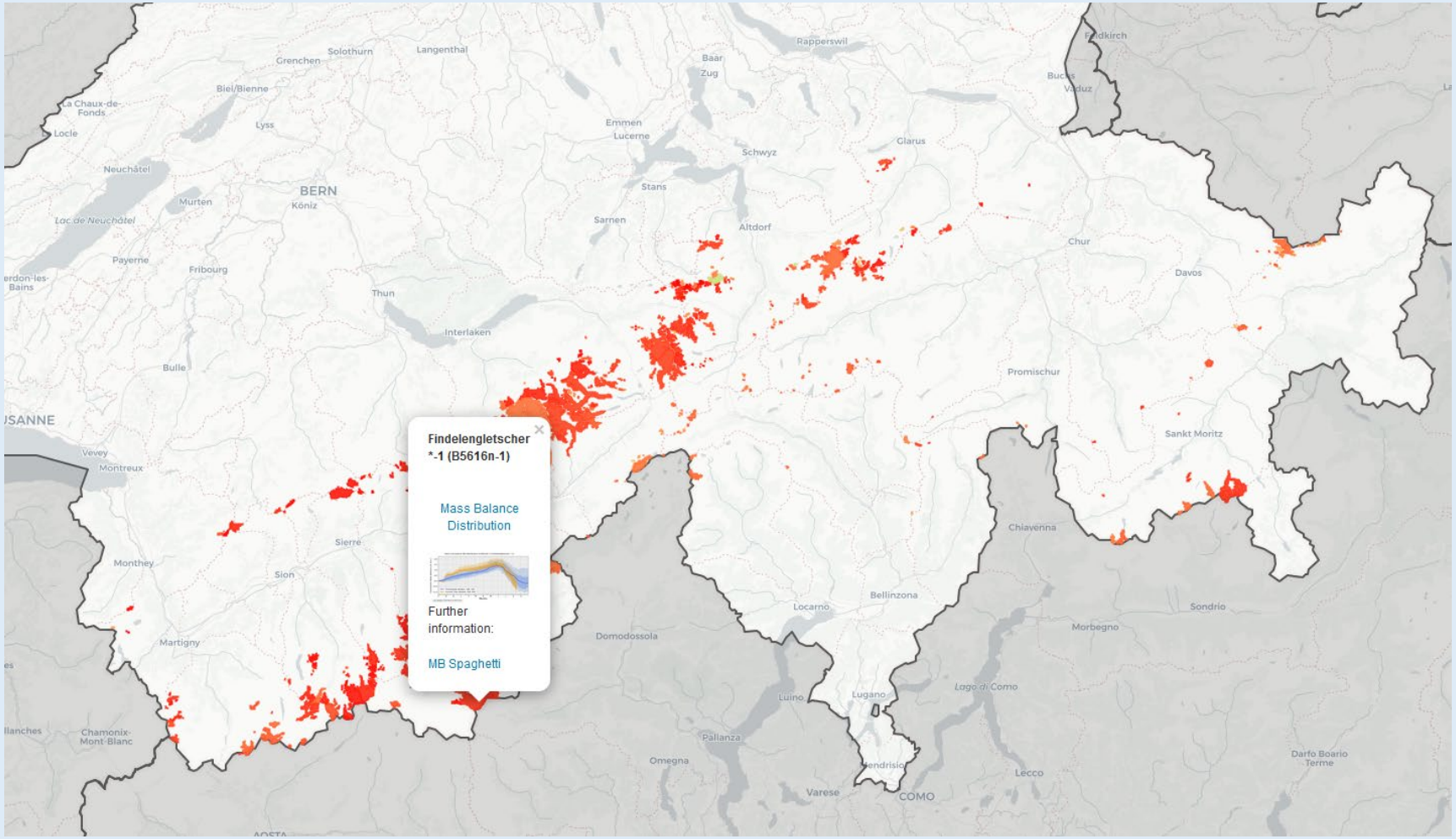
The vision of a clickable map



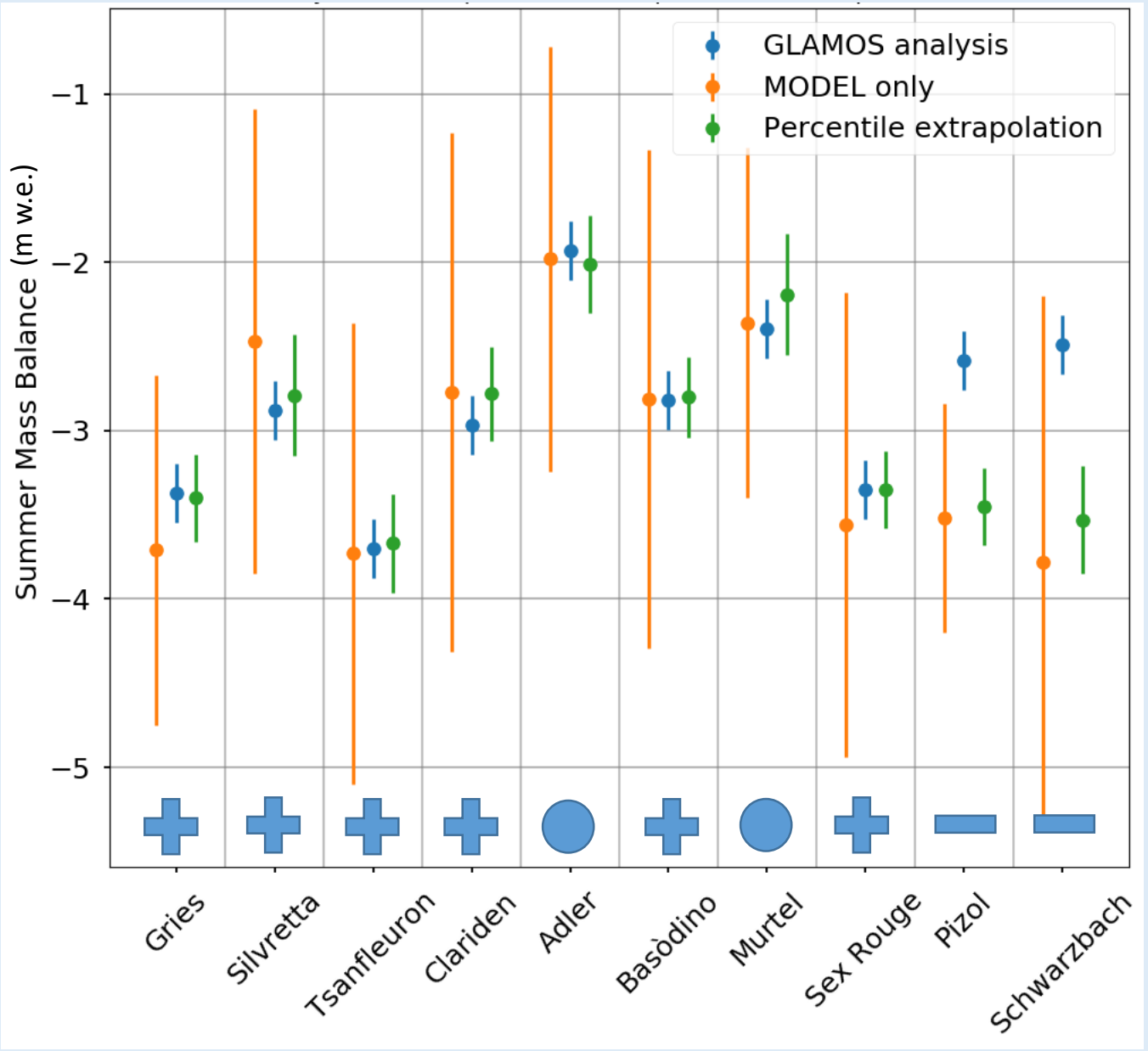
Click on a glacier and see its current mass balance with respect to the mass balance climatology

* This map contains a selection of 600 Swiss glaciers

Validation

Based on climatologies produced with GLAMOS data

The method works well in most of the cases



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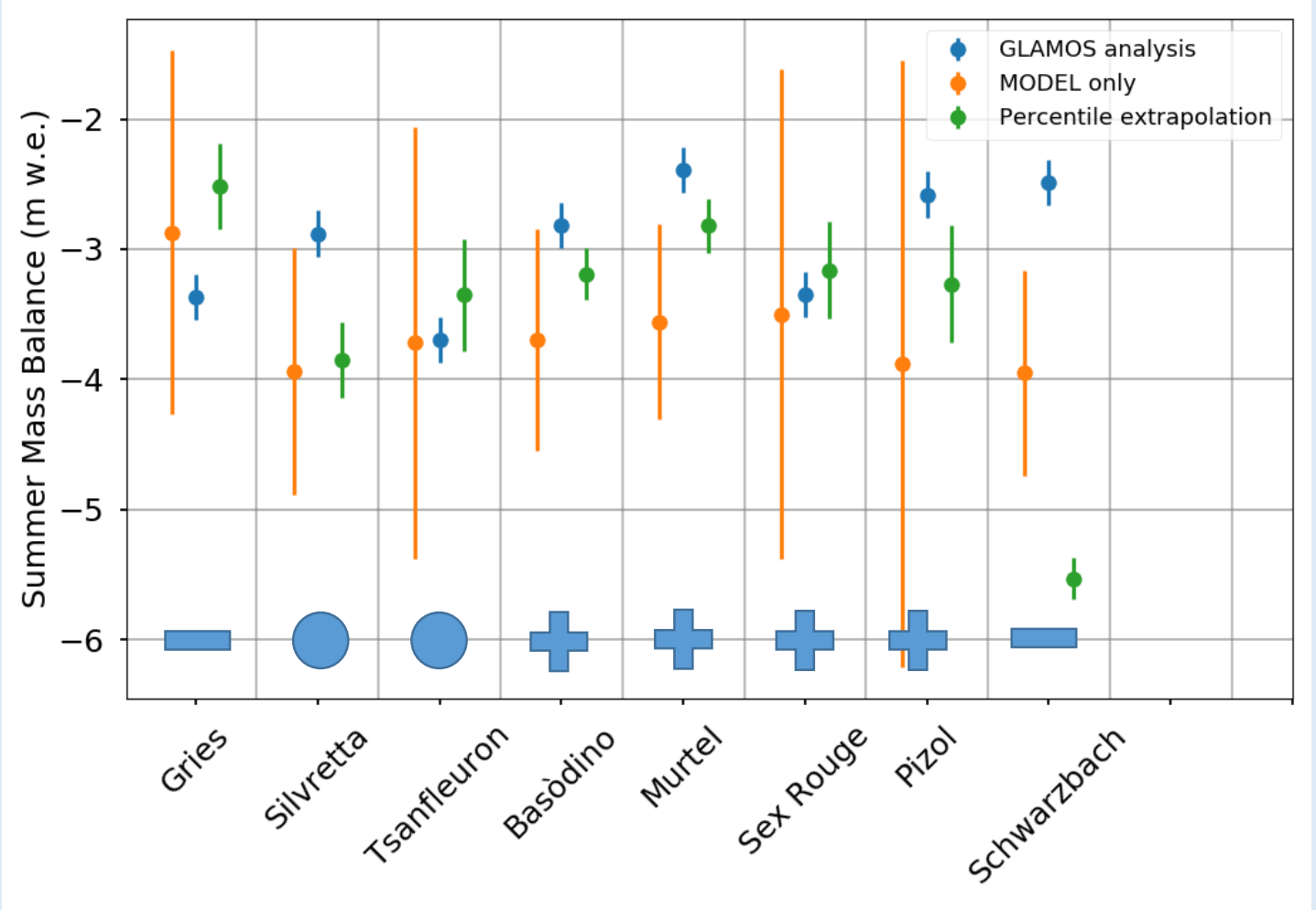
Validation – the devil is in the….calibration on geodetic mass balances?!

Based on climatologies produced from calibration on geodetic mass balances

Parameters are not identifiable, which causes a part of the background climatologies to be bad



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Improvements and the way forward

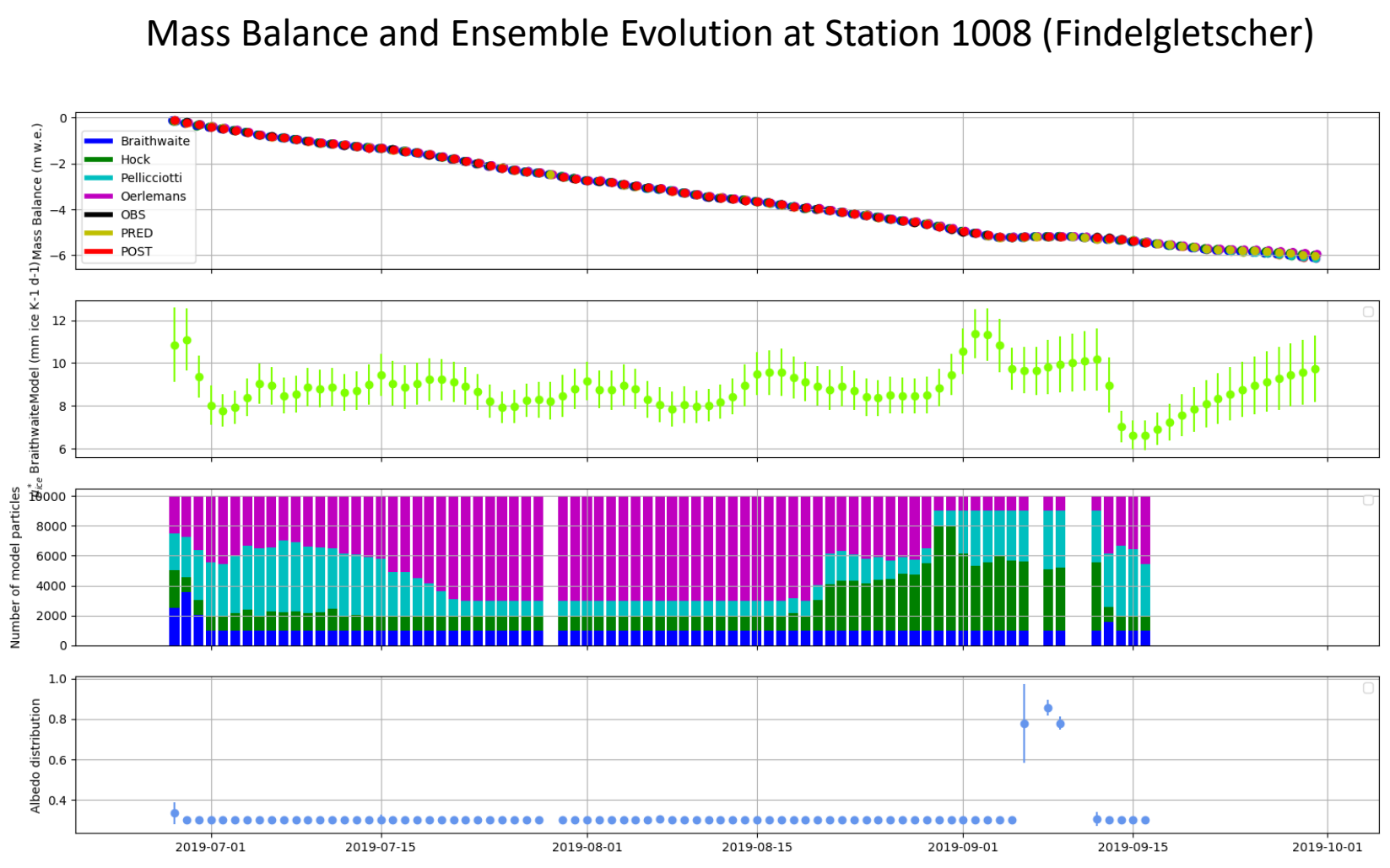
- Current improvement: a stable Particle Filter to make mass balance on camera glaciers operationally available, including various uncertainties (see Appendix)
- In prep.: satellite data to get better spatial information (albedo, snow line) for unobserved glaciers
- In prep.: multiple DEMs to better constrain the calibration on geodetic mass balances for unobserved glaciers
- First camera for 2020 is up on Rhonegletscher: https://holfuy.com/en/camera/1007

Comments/Discussion

- Do you have experience in spatial correlations of mass balance/mass balance model parameters that you can share?
- What could be improved in the extrapolation technique?
- What is your approach to solve the parameter identifiability issue in calibration on geodetic mass balances?

Give us feedback on Google Docs or talk to us in the breakout room!

Preview: a stable, augmented multi-model particle filter



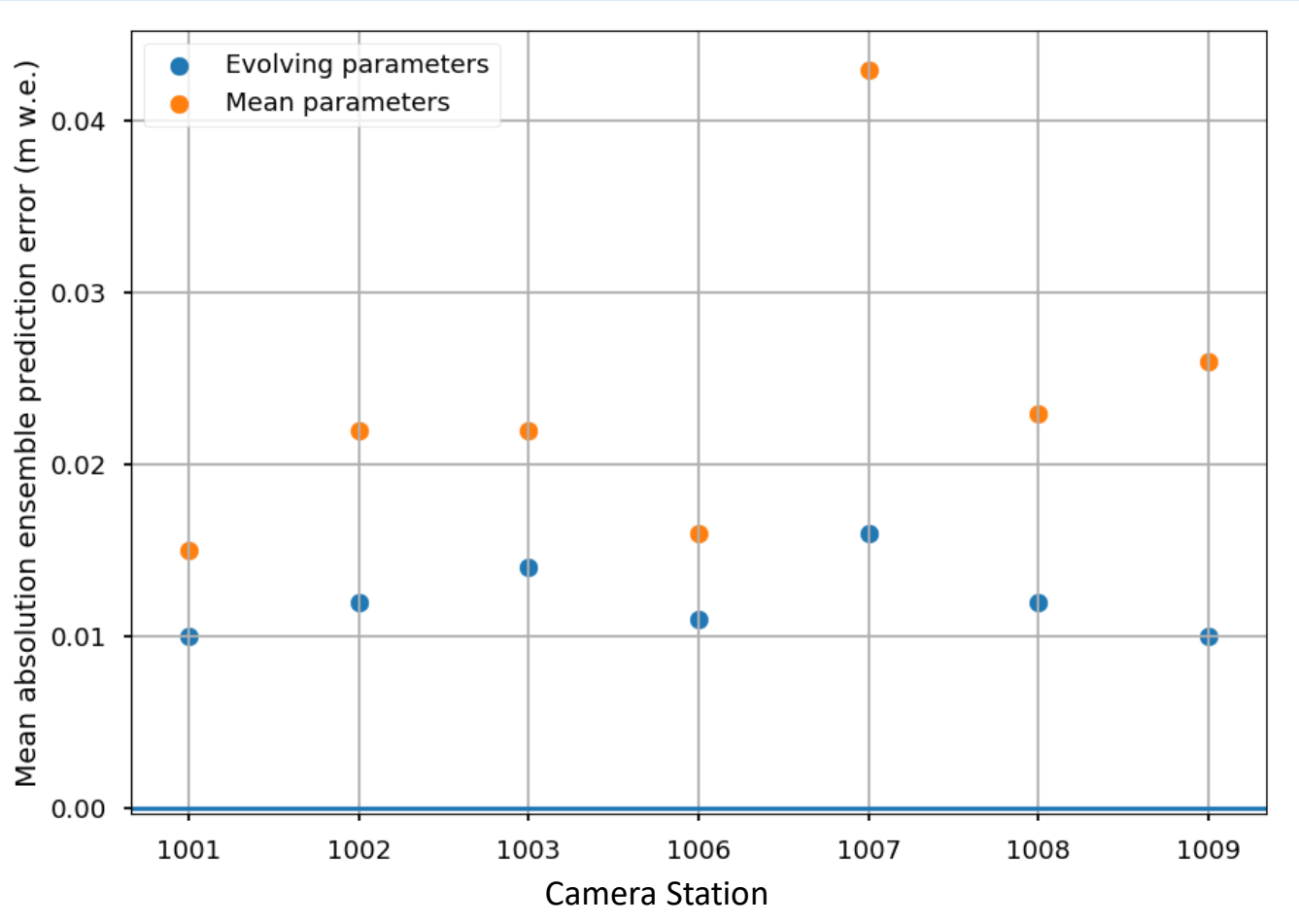
Prediction always within less than one standard deviation of the observation

Temporally adapted parameters

Flexible ensemble ready for operational use

Ready for assimilation of other parameters, such as albedo

Preview: comparison of particle filter ensemble prediction errors vs. prediction with mean parameters



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