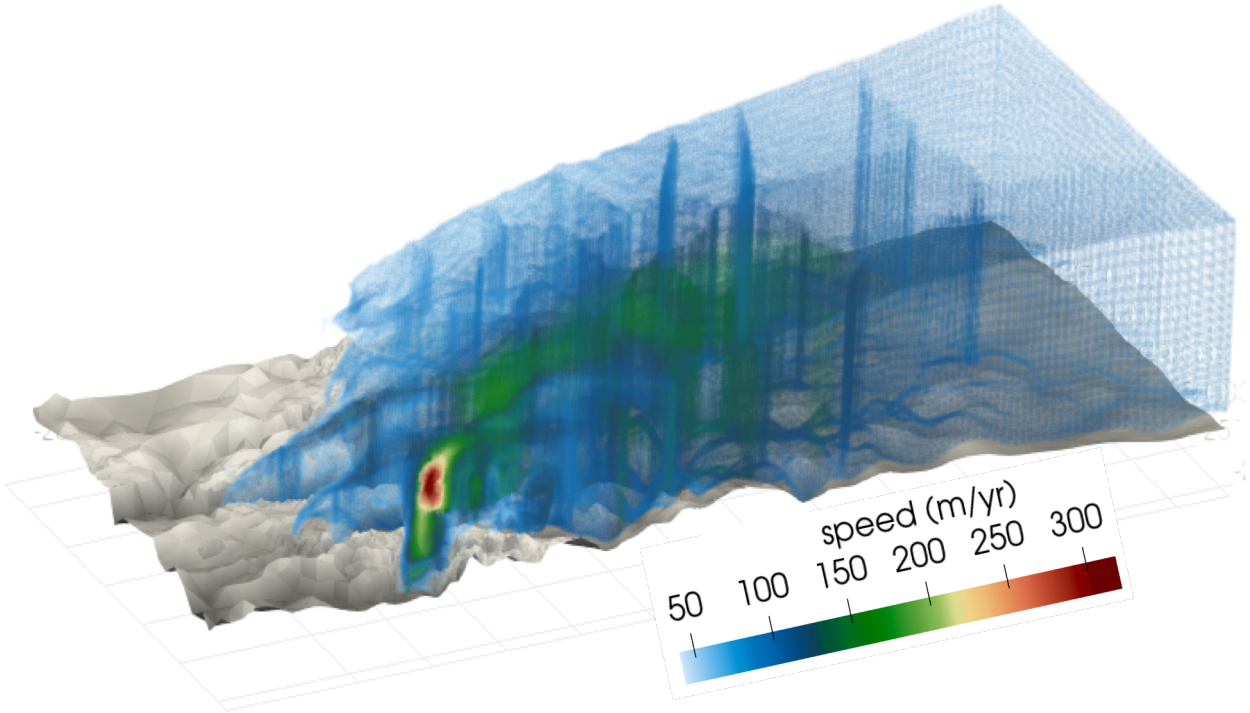
# Modeling of the Russell glacier basal conditions at seasonal time scale using the satellite observations of surface ice speed




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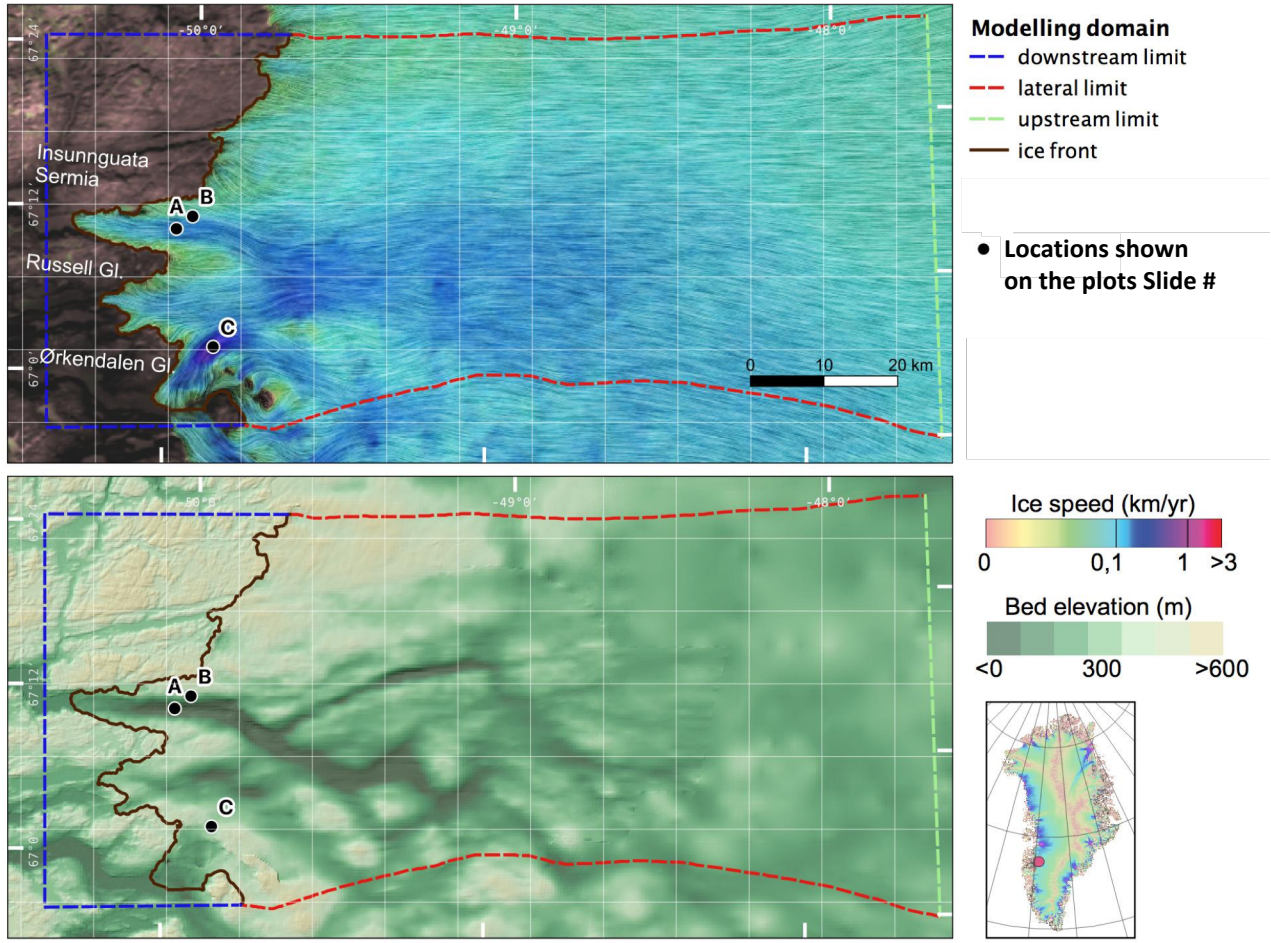
*vEGU2021: Gather Online, 26 April 2021*

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# Modelling domain location

We focus on the land-terminating margin of the Greenland Ice Sheet around the Russell glaciers.

This area is **representative** of the greenlandic margin in term of flow speed, basal conditions and topography. Many in-situ measurements were conducted in this region hence providing calibration and validation to the model.



# Modelling: approach

We use the finite element ice flow model Elmer/Ice to model the ice flow in the Russell catchment.

We invert independently for the basal friction coefficient using 24 maps of the ice velocity time series representing typical seasonal evolution.

We use a pressure-depend friction law of [Gagliardini et al., 2007] to estimate the **water pressure** evolution.

Basal & surface topography
Ice temperature
Surface speed




Basal sliding speed
Basal friction

$$\tau_b + \nu_b * \frac{\mathrm{CN}|\nu_b|^{1/n-1}}{(|\nu_b| + N^n C^n A_s)^{1/n}} = 0$$

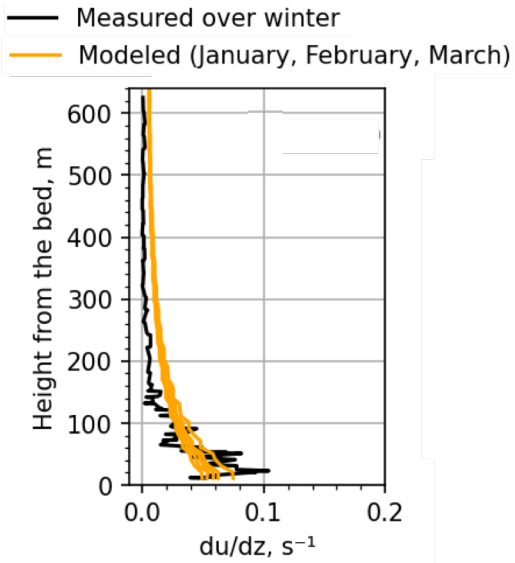
Effective pressure
Water pressure
Flotation fraction

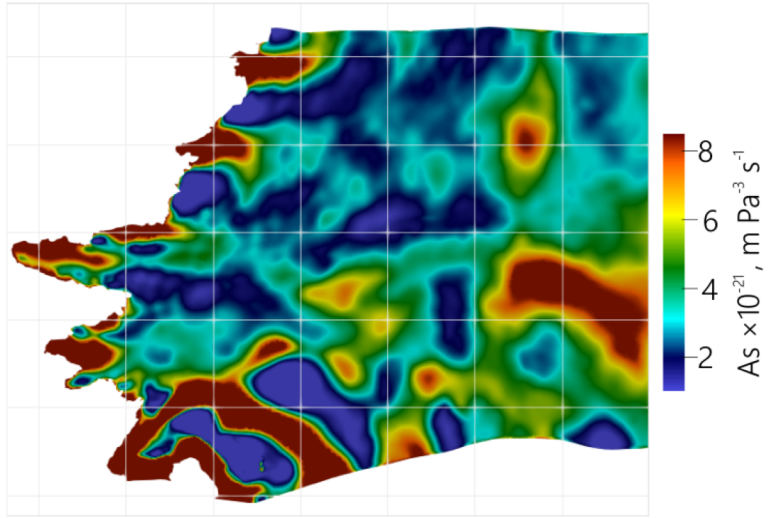
# Modelling: parametrization of the model & friction law

The model and f-law involve some poorly constrained parameters that can significantly affect the results.

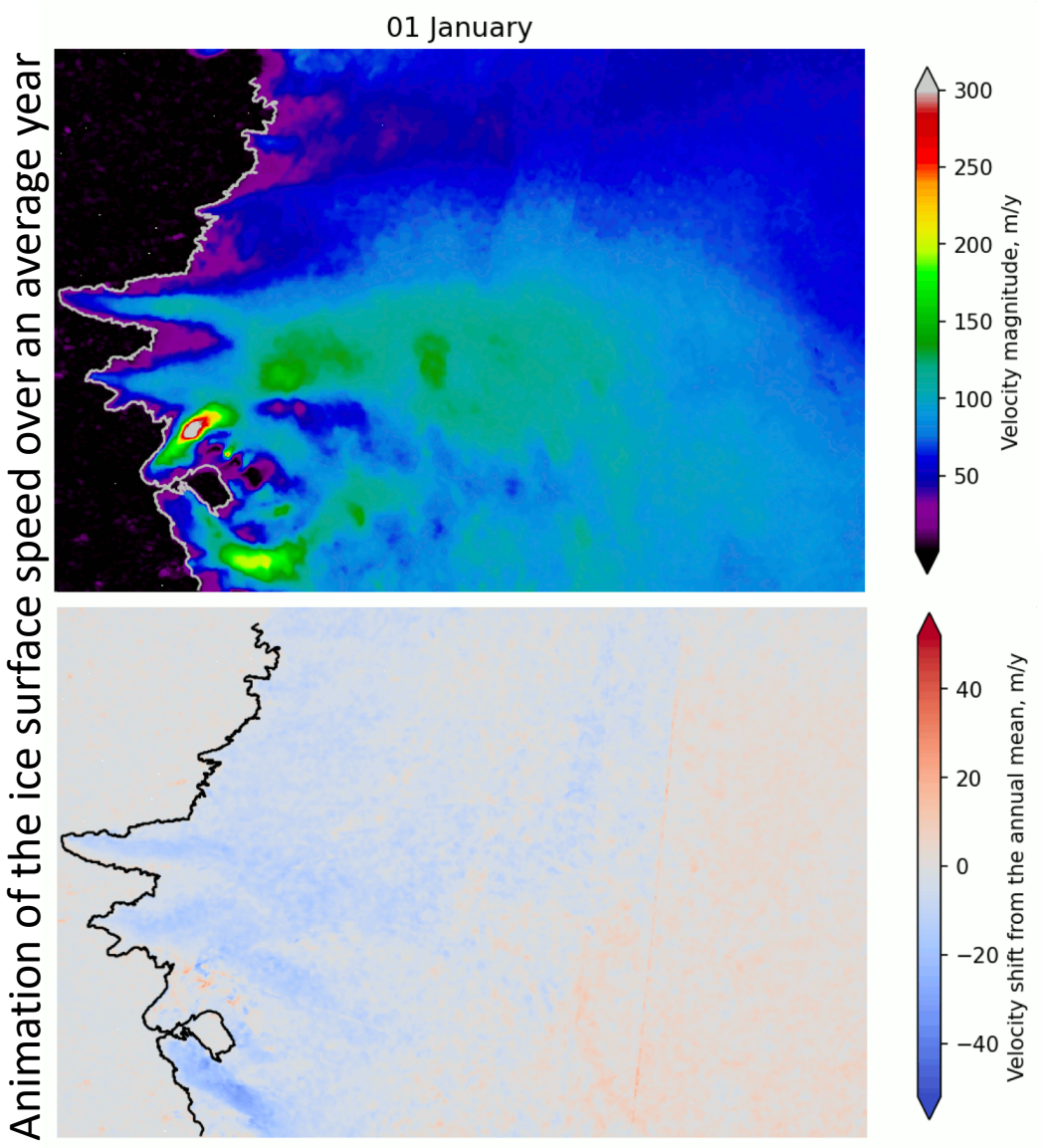
**Ice deformation rate** allows to decompose the surface speed on internal deformation and basal sliding. It depends on the temperature and some ice properties that were explored only in labs. We evaluate the modelled ice deformation rate with the in-situ measurements from [Maier et al., 2019].

**Sliding parameter** $A_s$ is determined by the near-basal ice rheology,.
We derive the $A_s$ with an assumption that the majority of Russell area should be close to the Weertman-type flow in the winter (no or less water at the bed), thus $u_b = A_s * t_b^3$.



# Modelling: surface speed observations




The satellite observations are used to obtain time series of the surface speed.

We combine observations collected from 2015 to 2019 by the radar Sentinel-1 and optical Sentinel-2 and Landsat-8 satellites.

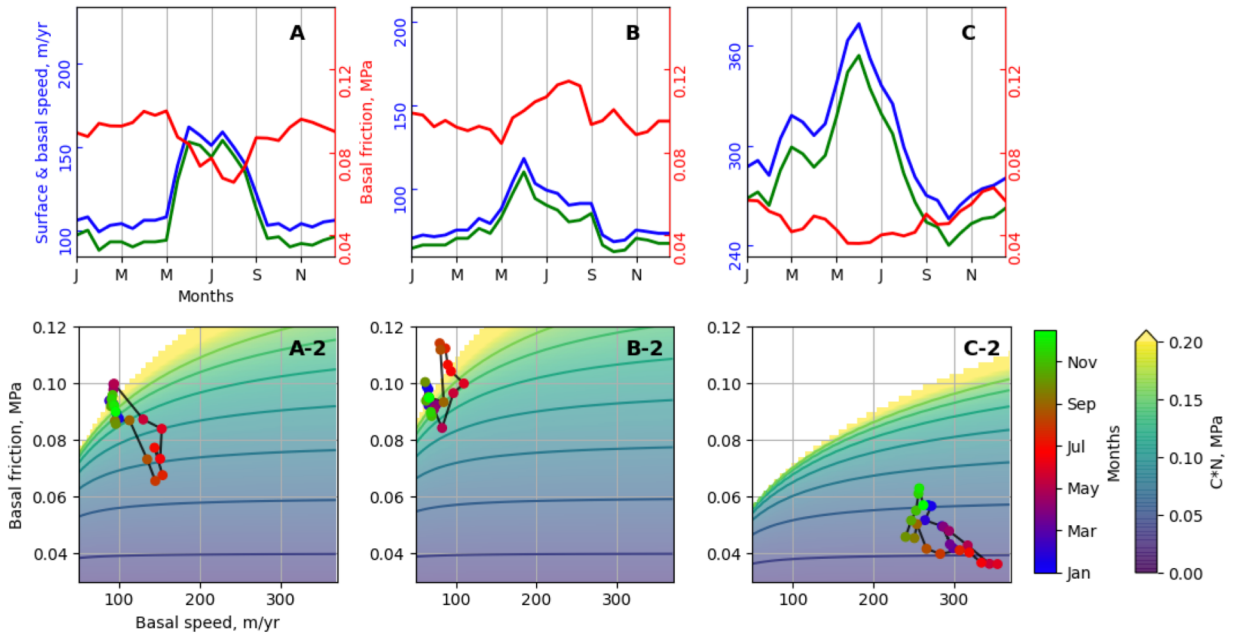
That allows to construct a dataset that represents an **average year** with **bi-weekly** temporal resolution.

Derkacheva, A., Mouginot, J., Millan, R., Maier, N. and Gillet-Chaulet, F.: Data reduction using statistical and regression approaches for ice velocity derived by Landsat-8, Sentinel-1 and Sentinel-2, Remote Sens., 12(12), 1–21, doi:10.3390/rs12121935, 2020.

# Results: basal conditions dynamics over a year

The theories suggest different relationships between the change of sliding speed and friction. The actual processes will depend on the local bed type (hard or soft) and the current water presence, and thus can evolve over the year.

(A) The speed rises and the friction drops if the water pressure increases, as this facilitates the sliding. That is what typically happens with summer melt onset.
(B) In absence of water (Weertman-type sliding), the friction rise with the increasing speed.
(C) Friction and speed can became almost independent (Coulomb-type sliding), with the friction leaded only by the water pressure change.



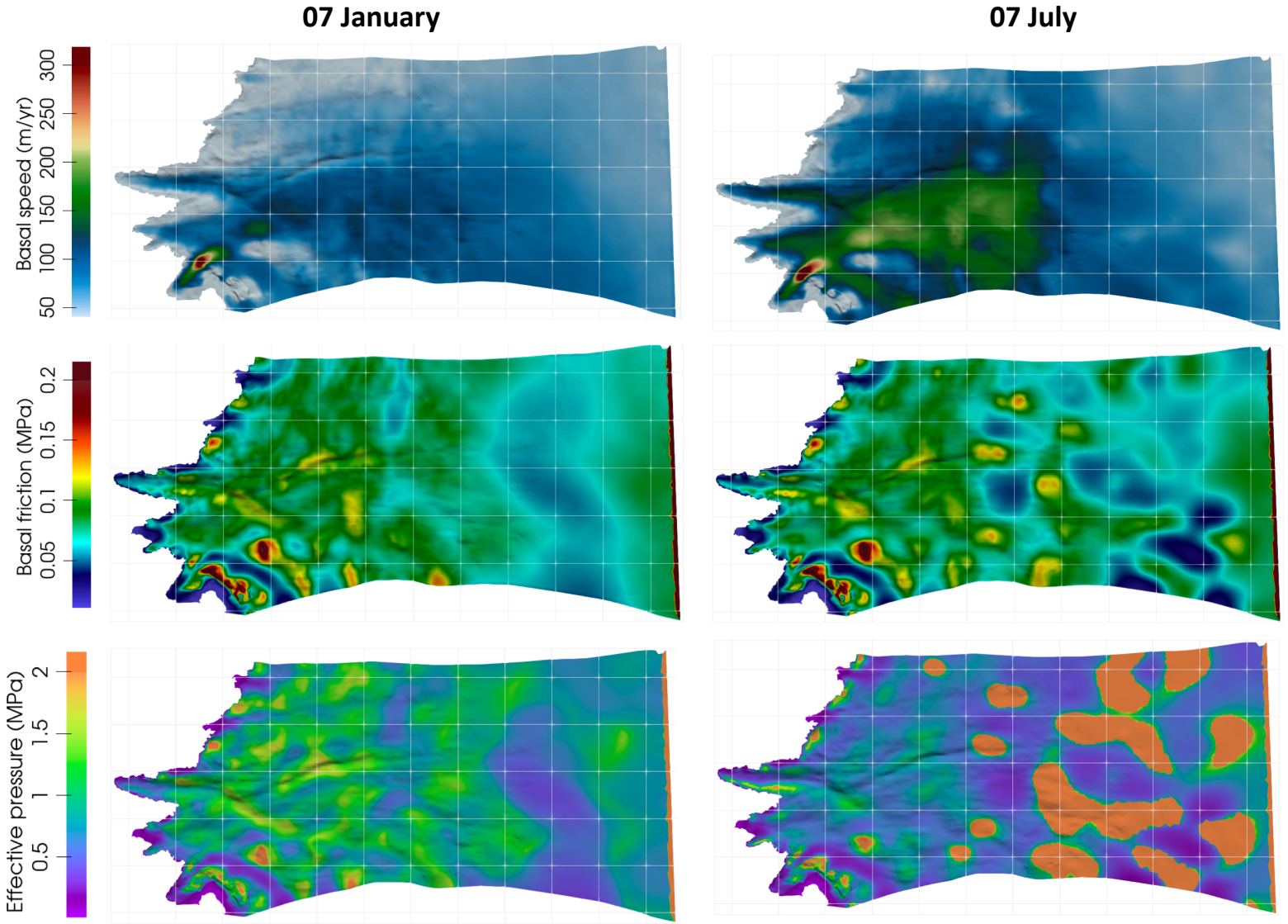

Effective pressure $N=p_{ice}-p_{water}$ scaled to basal friction

# Results: basal conditions dynamics over a year

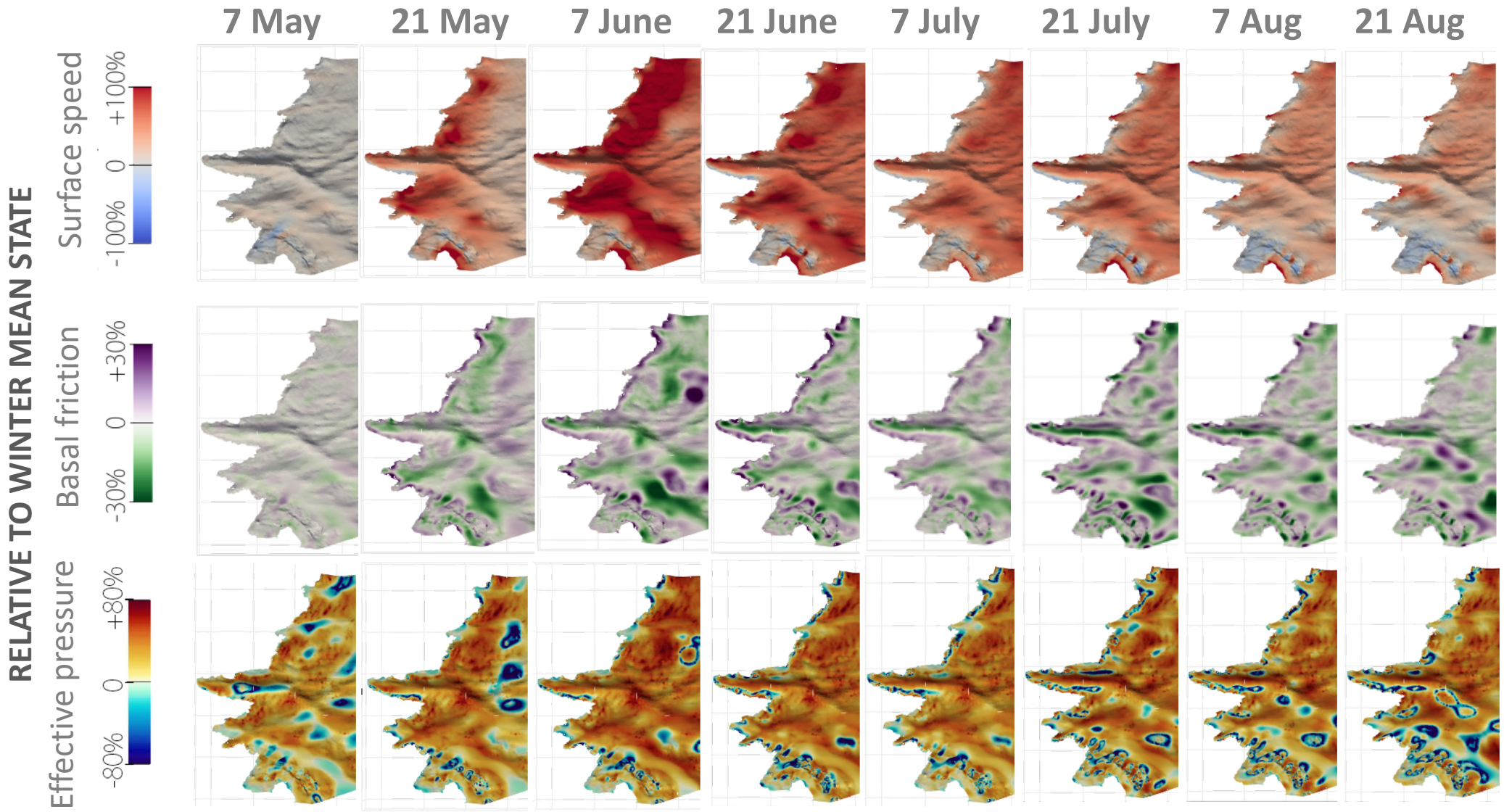
For majority of the area, 90-95% of the surface speed is basal sliding. That is a case in summer as well in winter.

Sliding accelerates everywhere in warm season, commonly accompanied by decrease of the friction and rise of water pressure.

The quality of the basal topography data are critical for the model. *BedMachine* is much less detailed inland thus the results in the upper part have artefacts.



# Results: basal conditions dynamics over a year



# Results: basal conditions dynamics over a year

The comparison of general trends of derived pressure behaviour against the independent runoff data (output of MAR climate model) shows a good agreement.

The spatio-temporal propagation of the effective pressure increase corresponds well to the runoff onset and thus water infiltration to the bed. Ones the melt season and runoff production end, the pressure start to relax up to the winter state.

