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Challenges of Distributed Preprocessing, Computation, and Postprocessing in Ice Sheet Simulations

Timm Schultz, Angelika Humbert and the CAPICE team

NFDI4Earth

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The ordinary ice sheet modellers world

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The system

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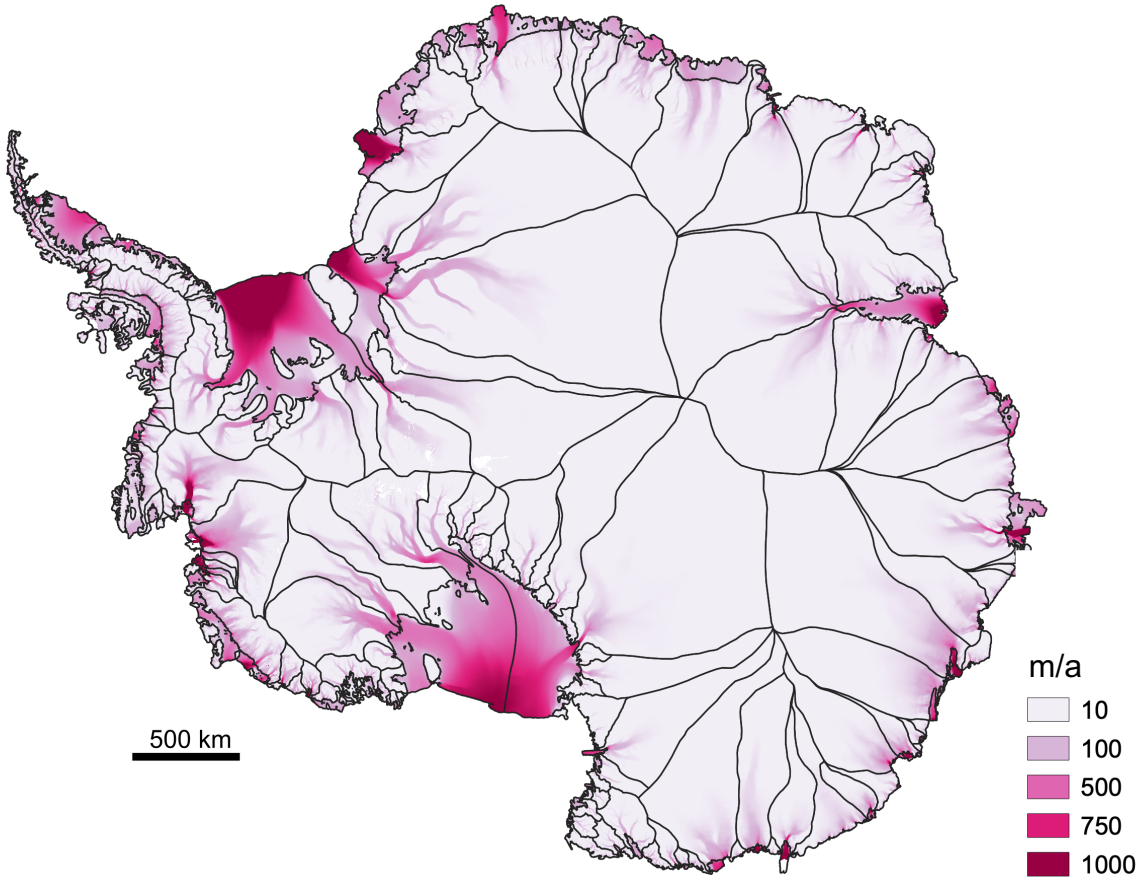
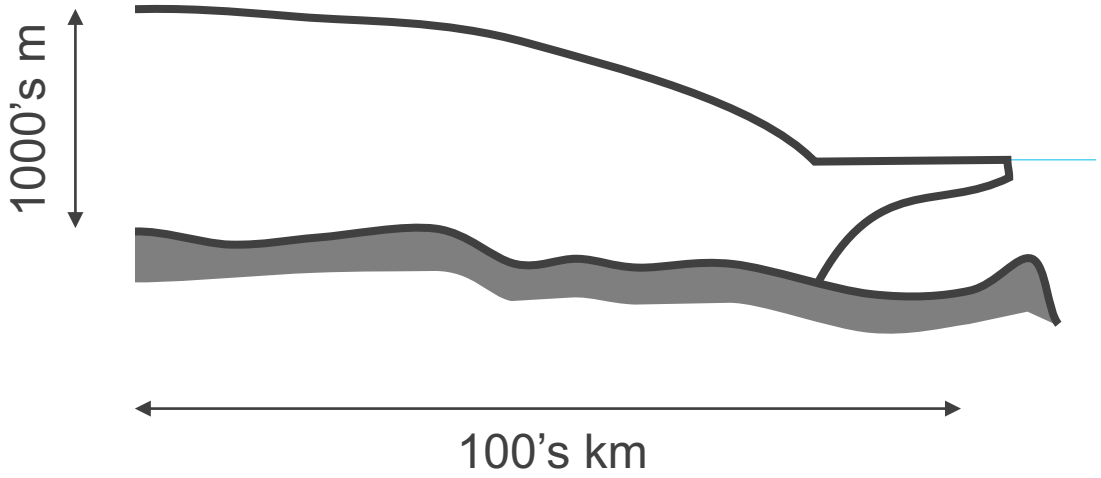
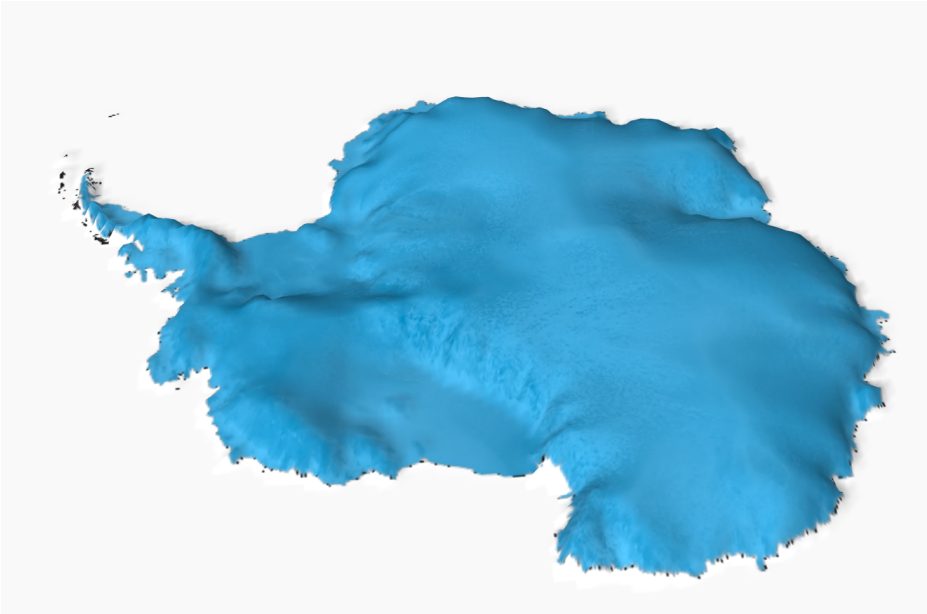


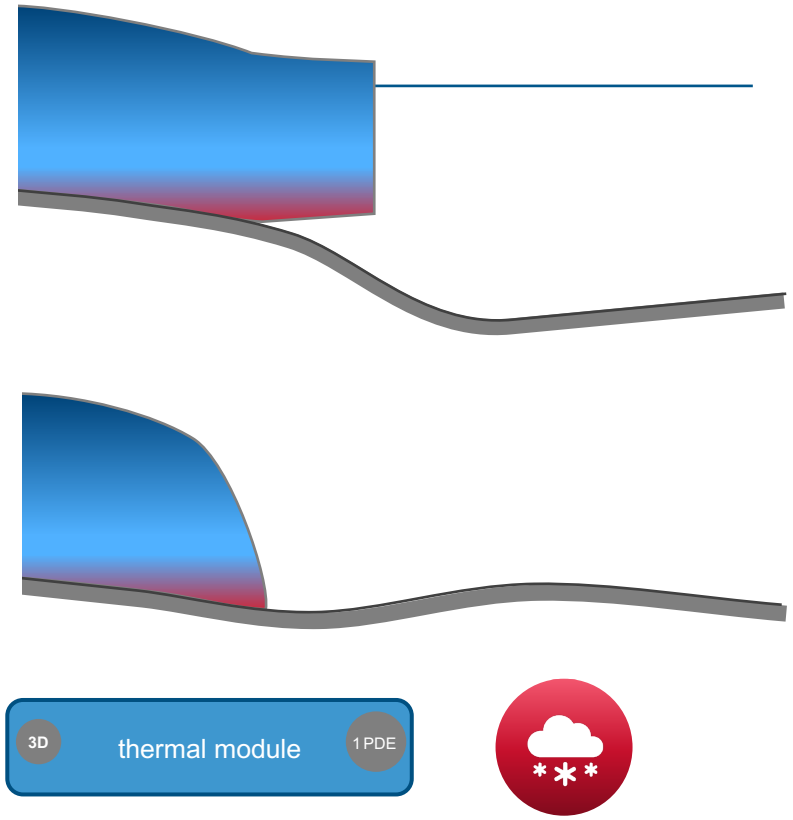
gravity driven lubricated flow



thermo-mechanically coupled problem

Enthalpy field





Surface mass balance

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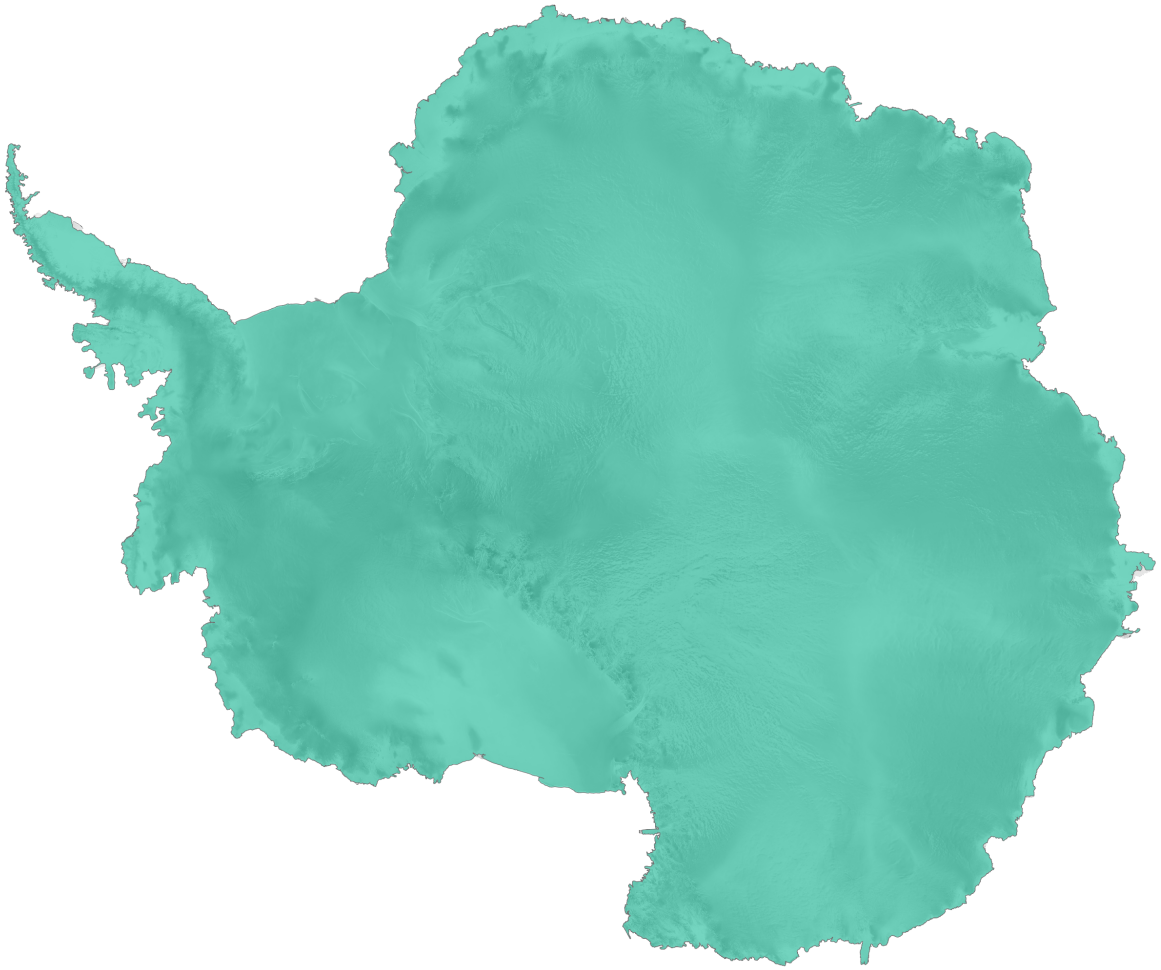

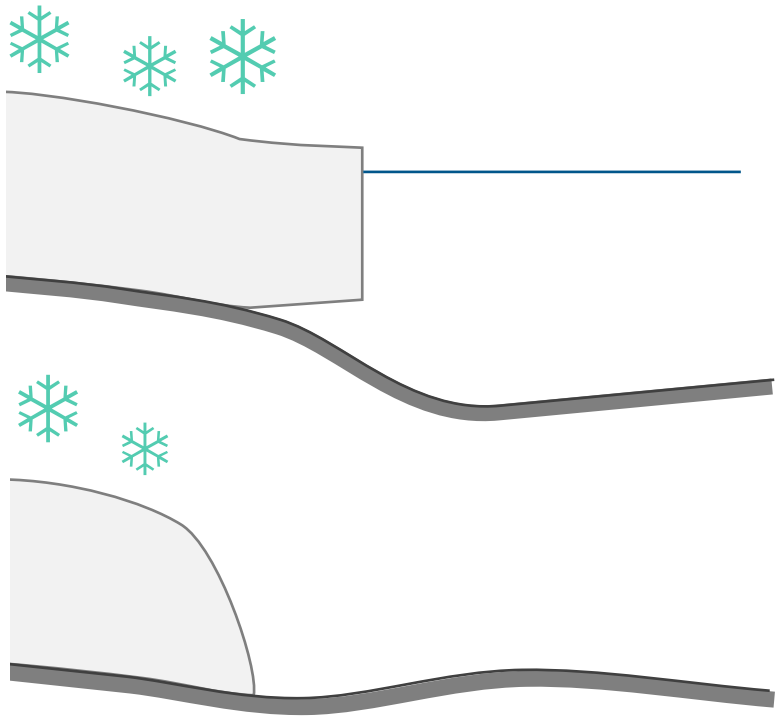

2D SMB module par

Velocity field

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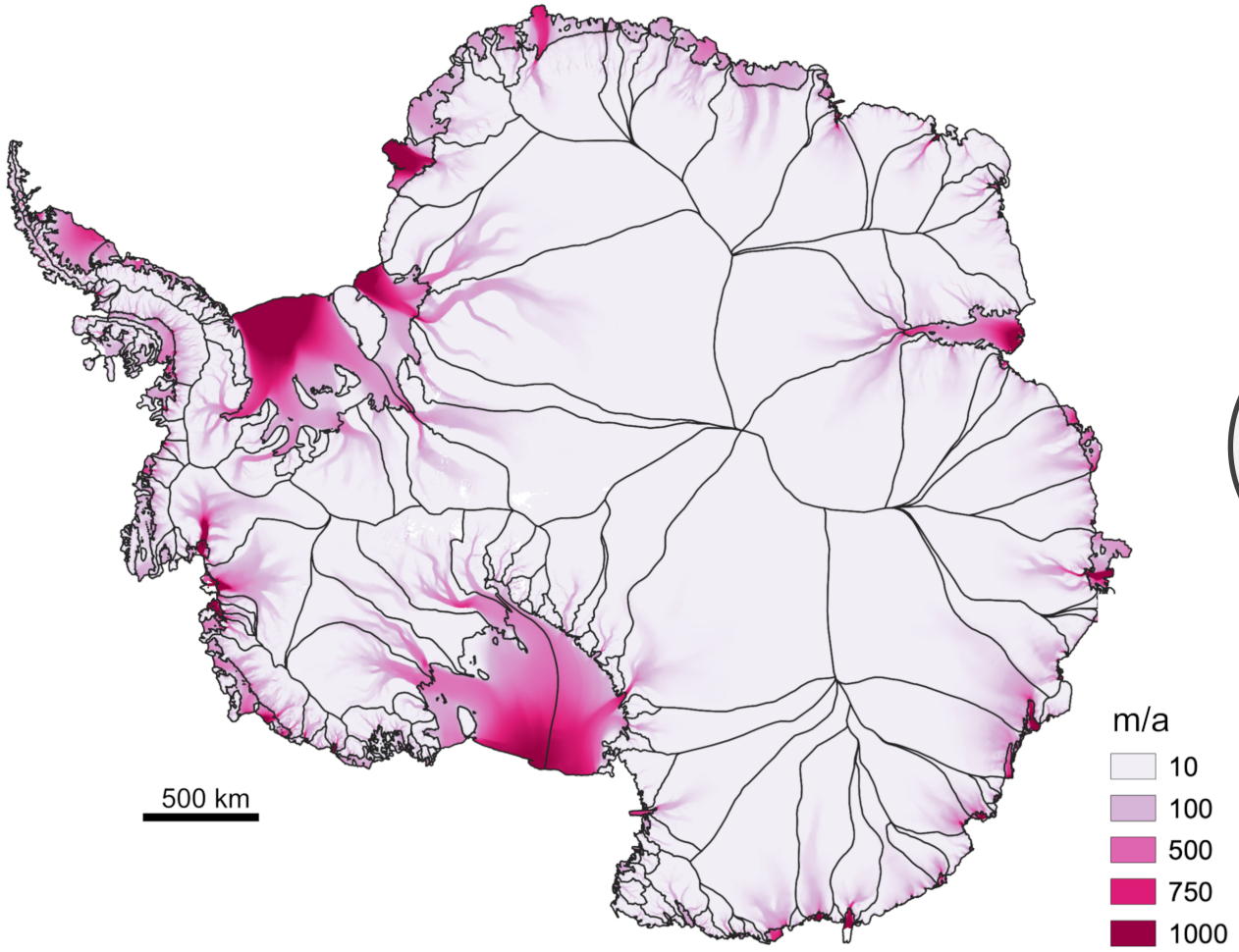

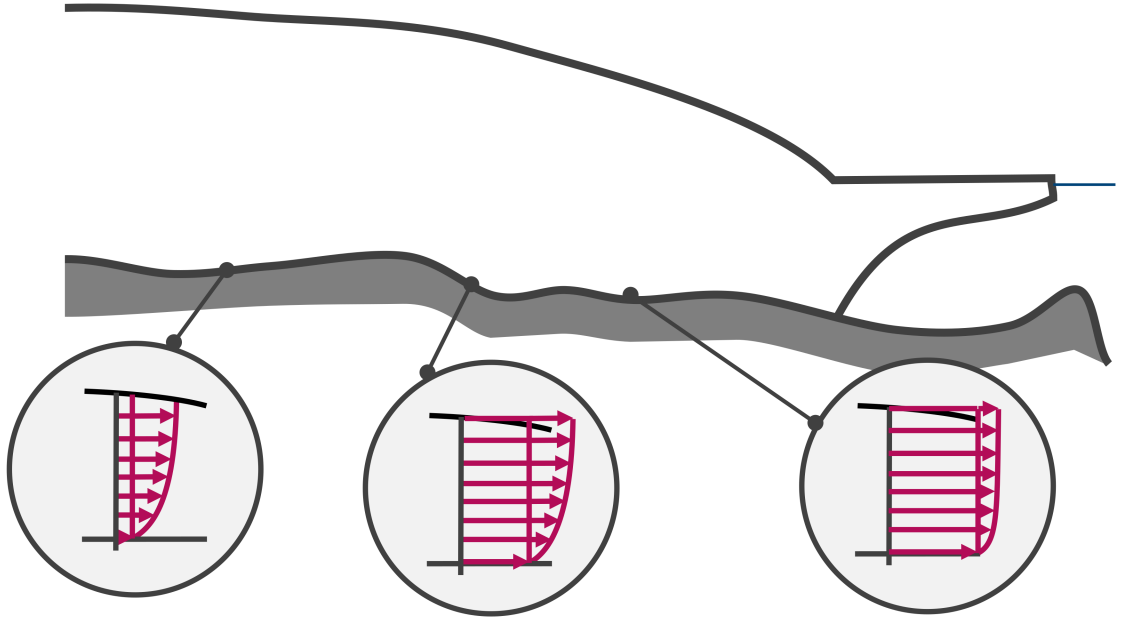

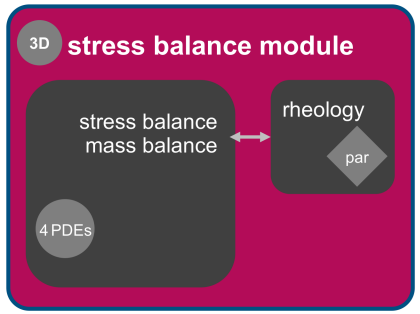

Evolving lateral margins

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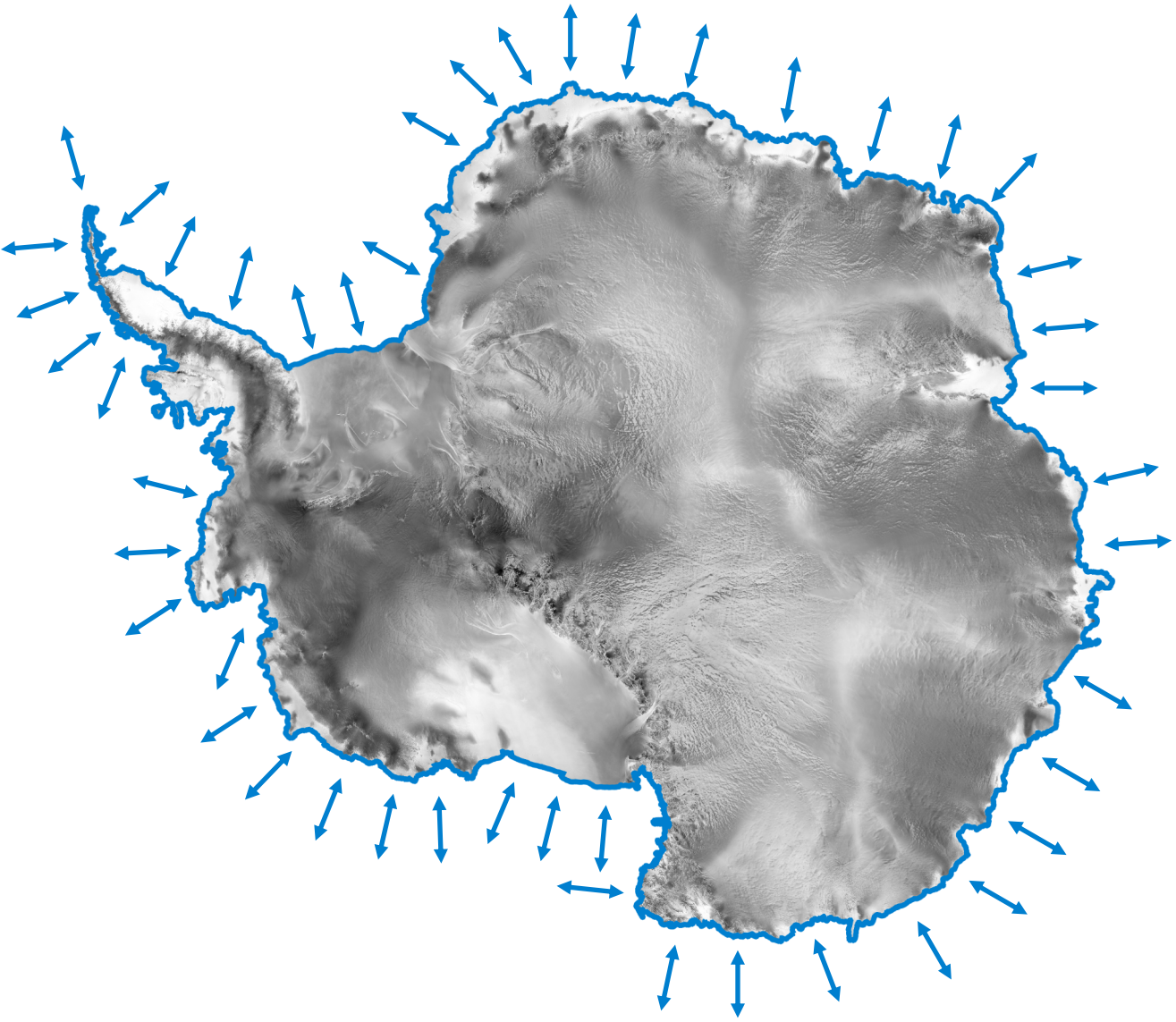
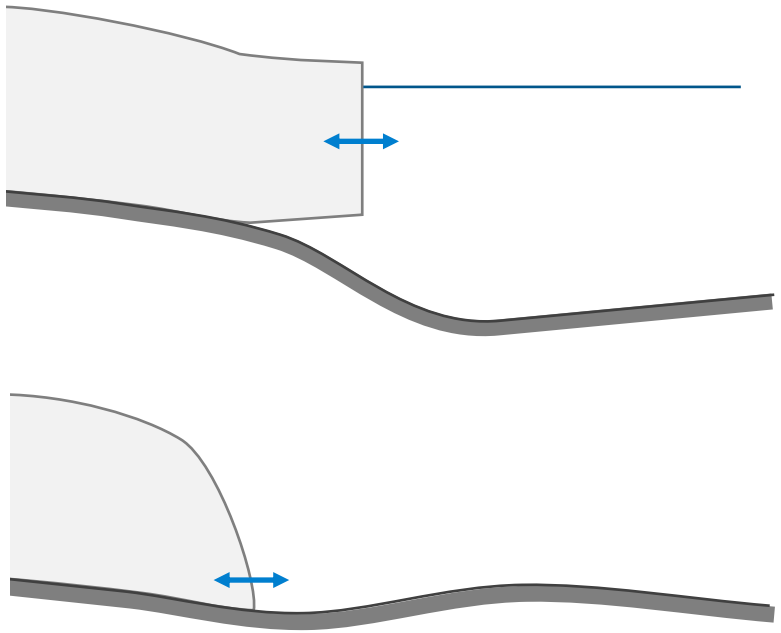
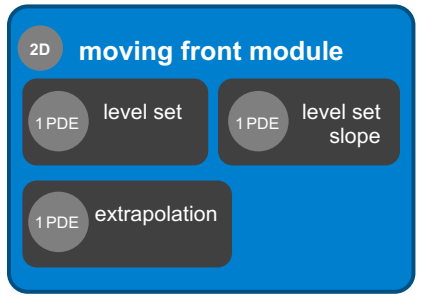


level set method + calving laws where needed





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Evolving lateral margins

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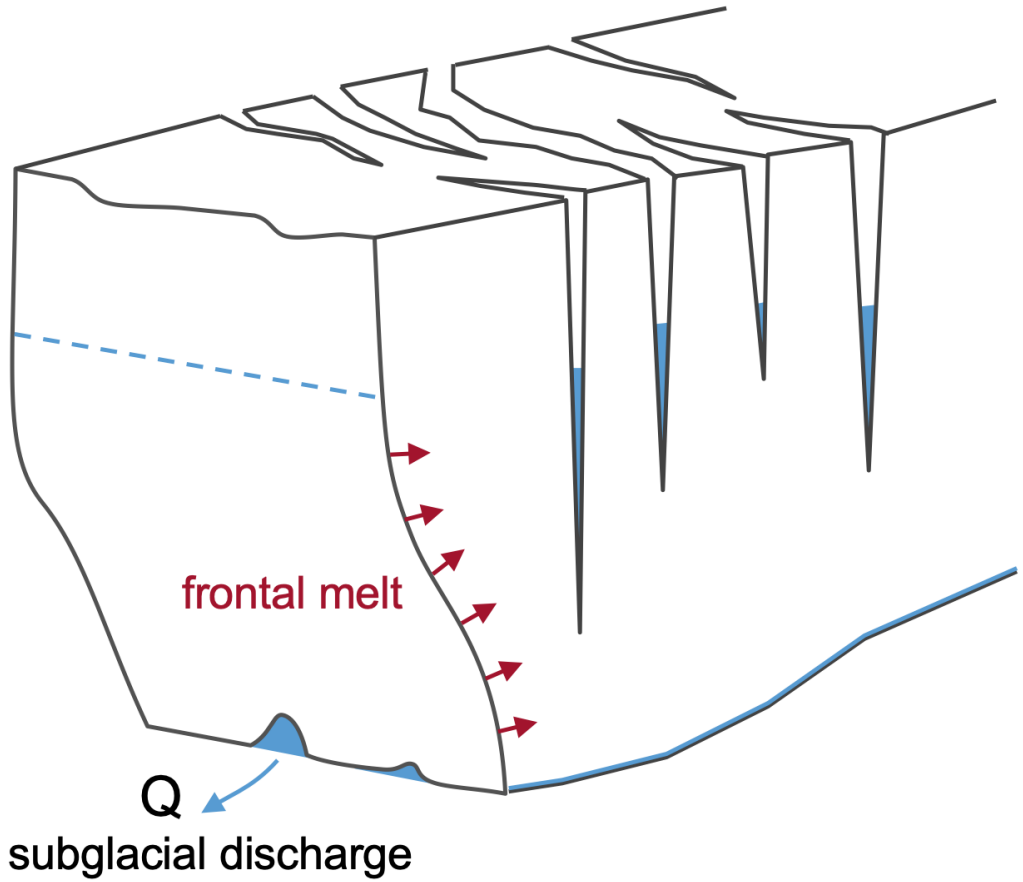
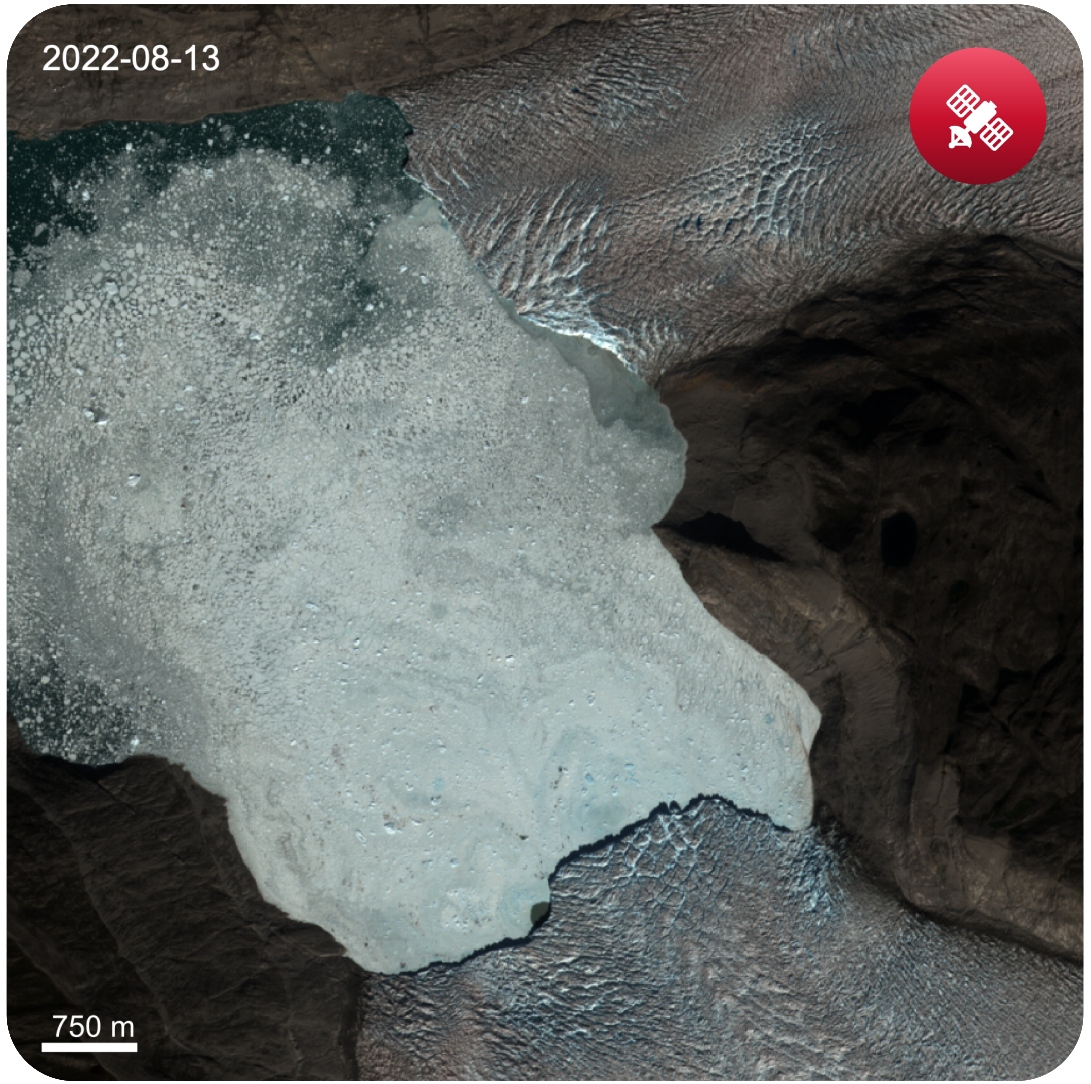




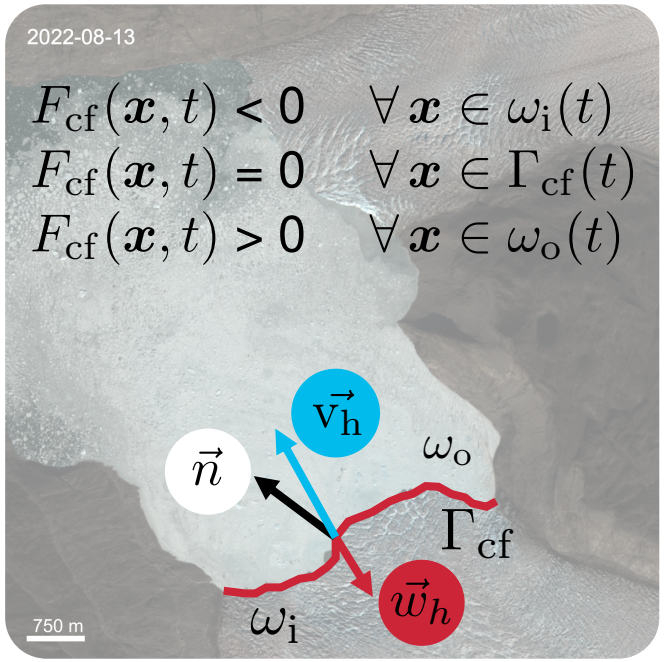
Evolving lateral margins

$$\frac{\partial F_{cf}}{\partial t} + \vec{\mathrm{v}}_h \ \mathrm{grad}\ F_{cf} = -N_{cf} a_{cf}^{\perp} = -N_{cf}(c^{\perp} + m_{cf}^{\perp})$$

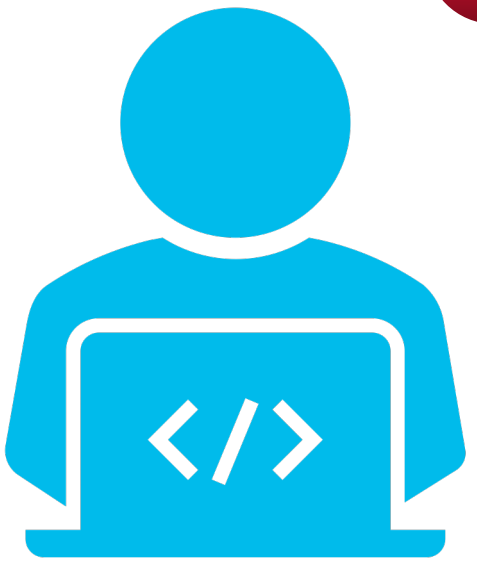
calving rate

frontal melt

level set method



Next step



inverse modelling of calving fronts
parameter optimisation problem

Evolving ice thickness

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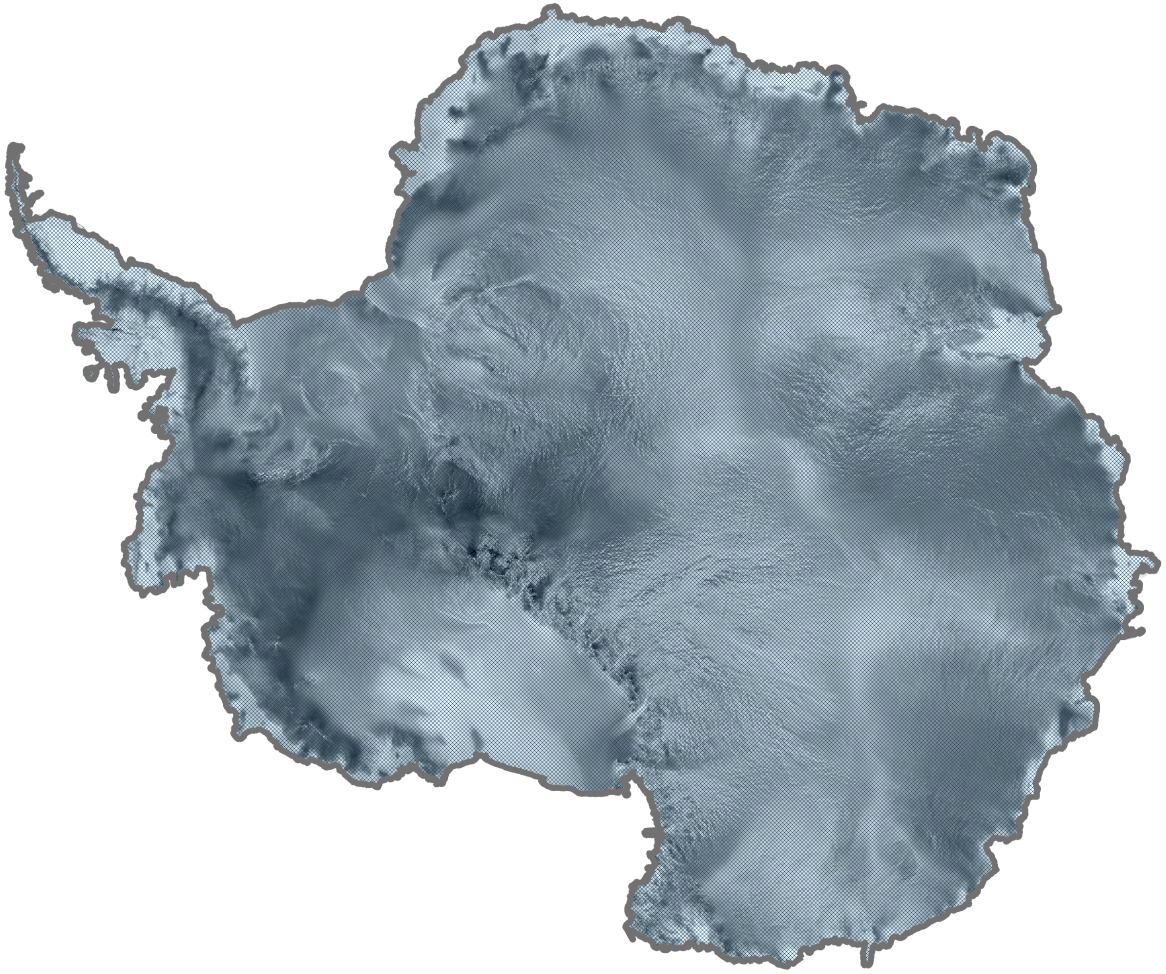
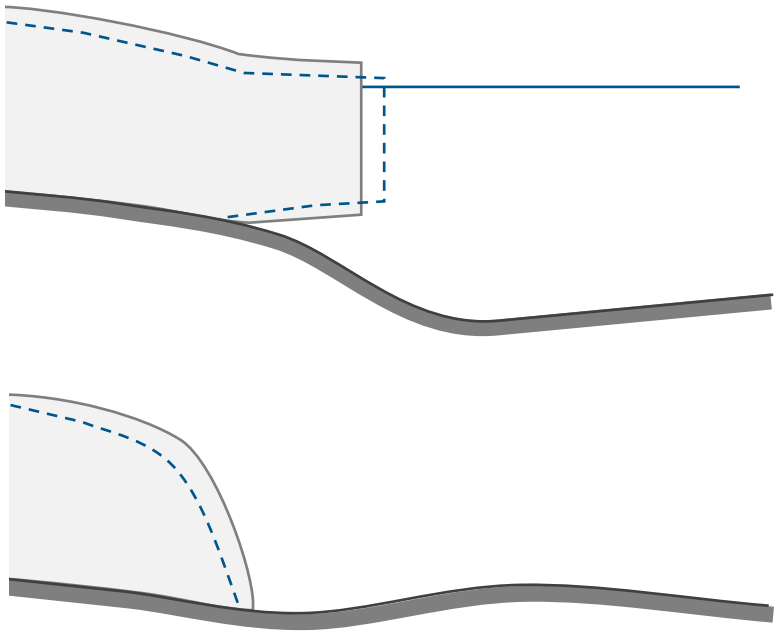


PDE



2D mass transport module 1 PDE

Tracking the grounding line

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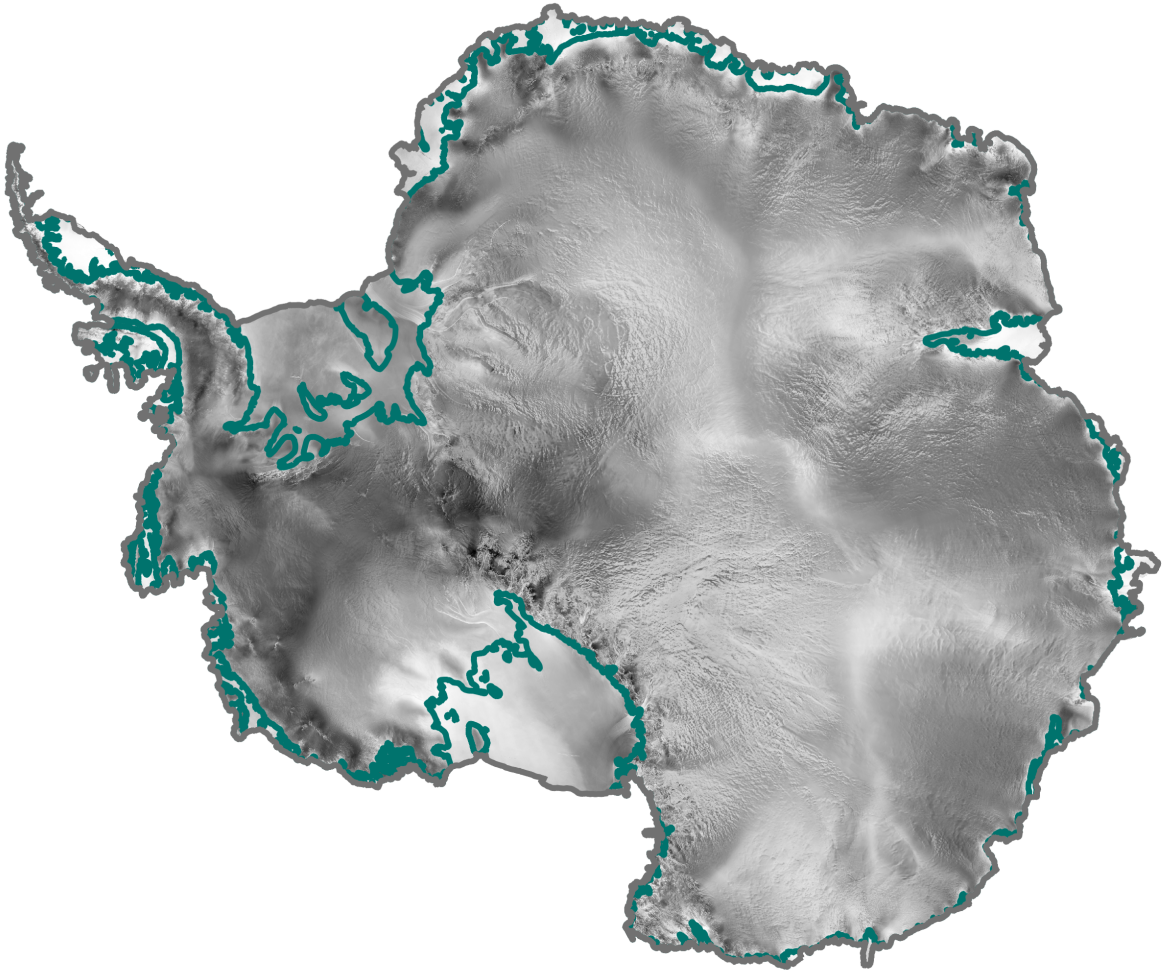
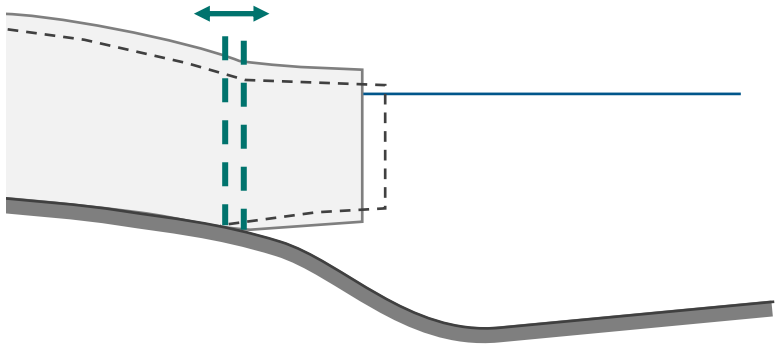


evaluation



2D grounding line module par

Architecture of ice sheet models

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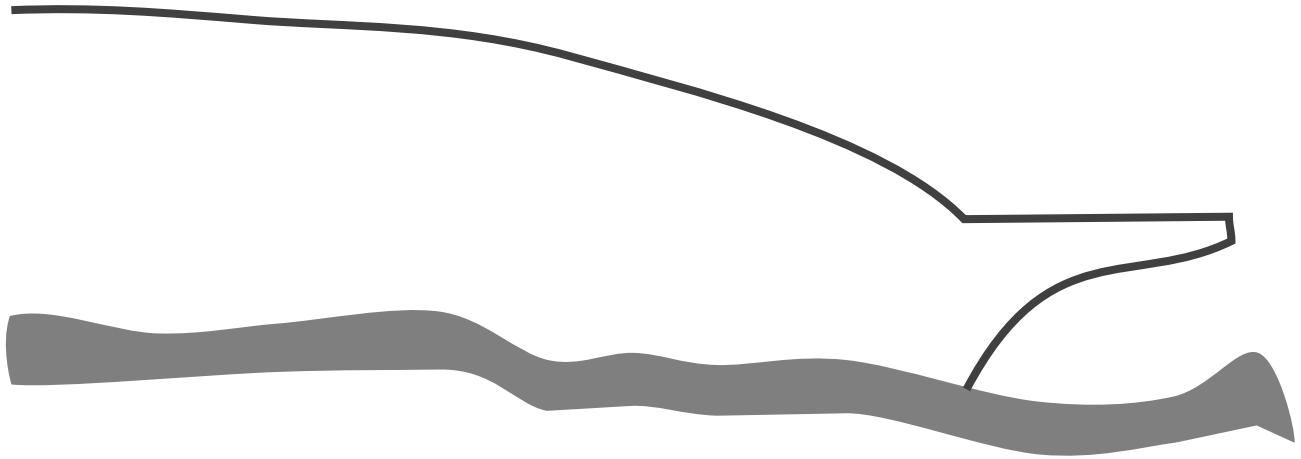
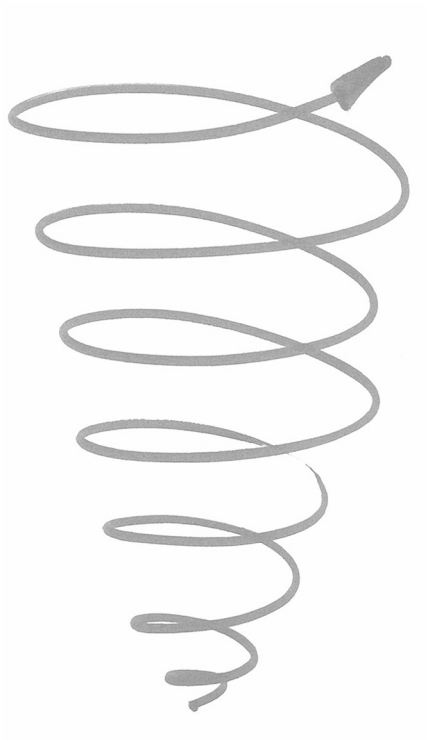
Initial state

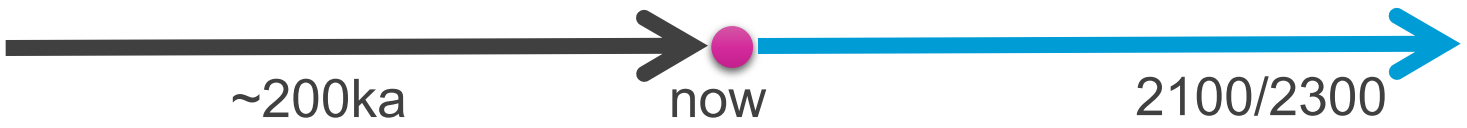
How to obtain a proper initial state for projections?

geometry, velocity, temperature @ initial state ?

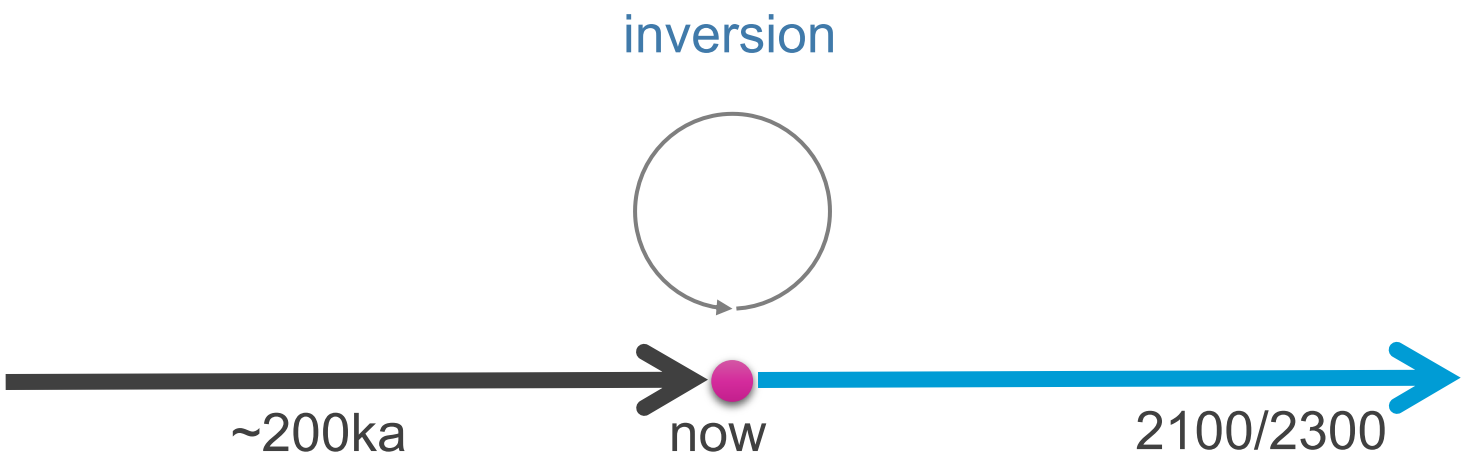


Initial state

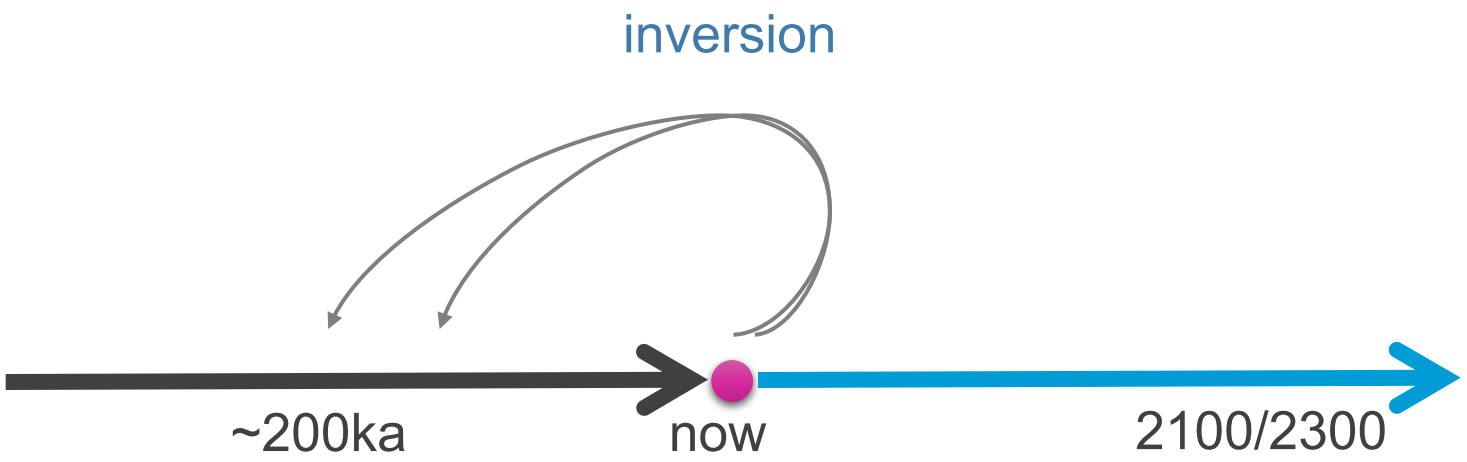




Initial state



Initial state



Inversion + thermal spin-up

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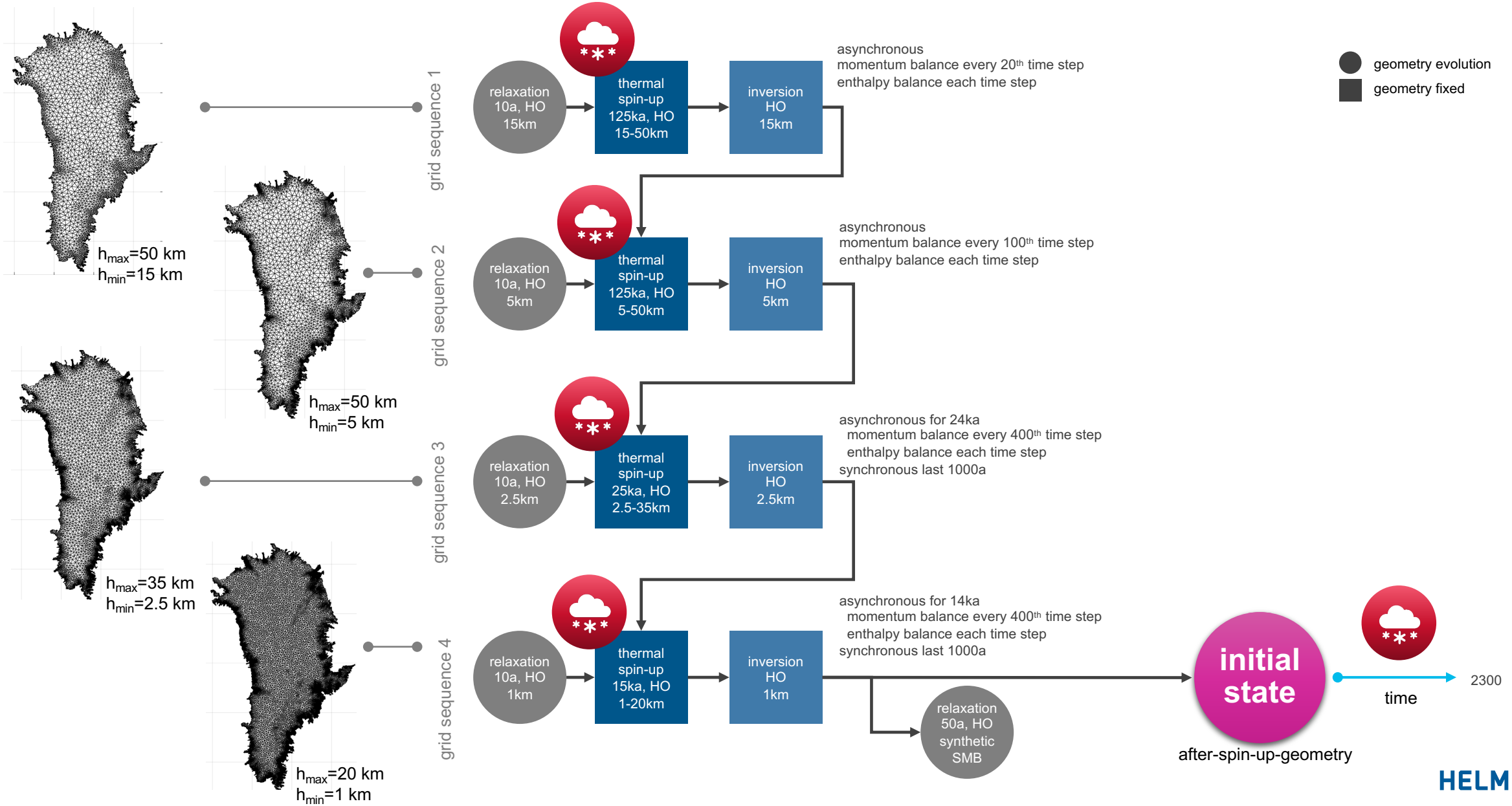

Spin-up's and projections

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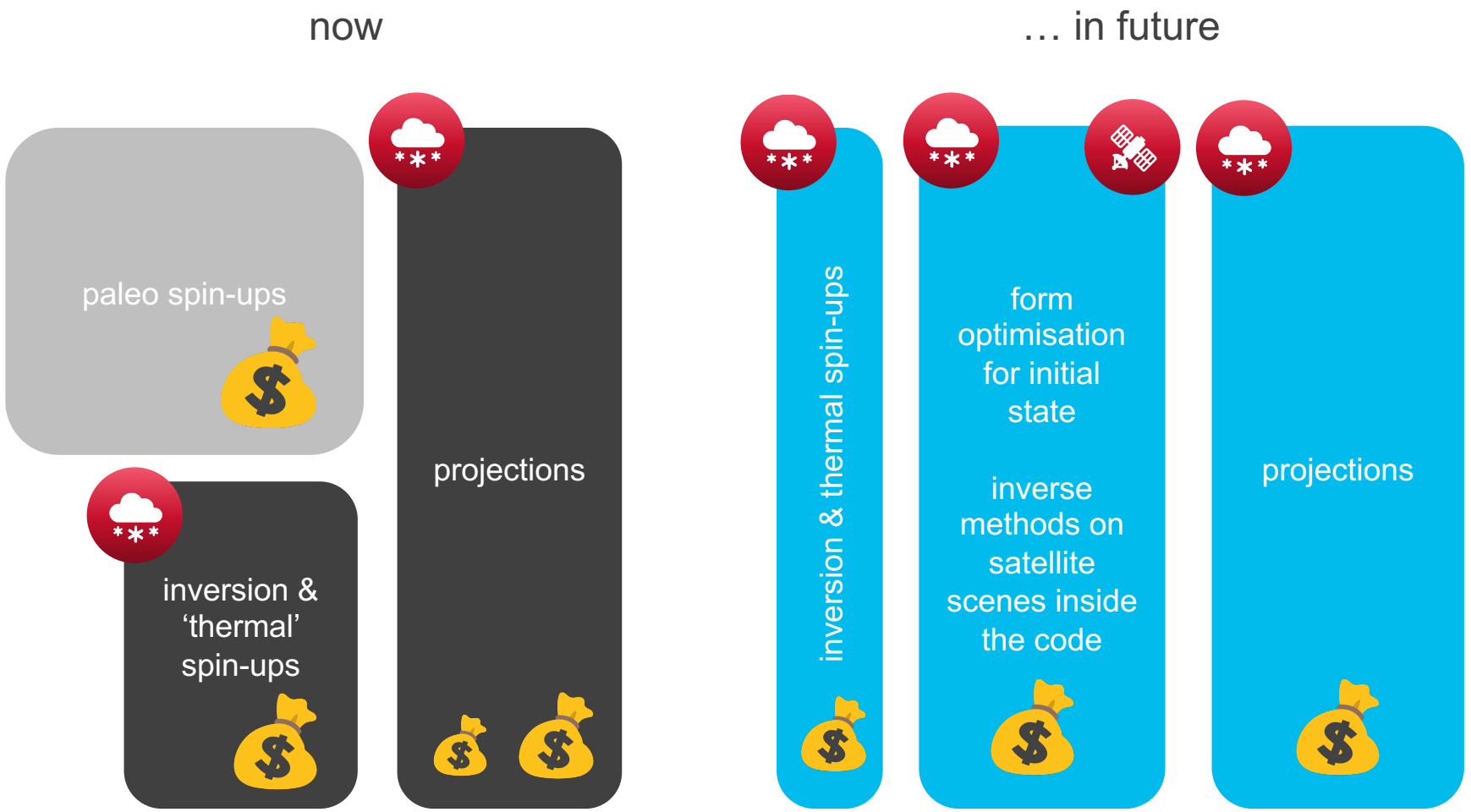


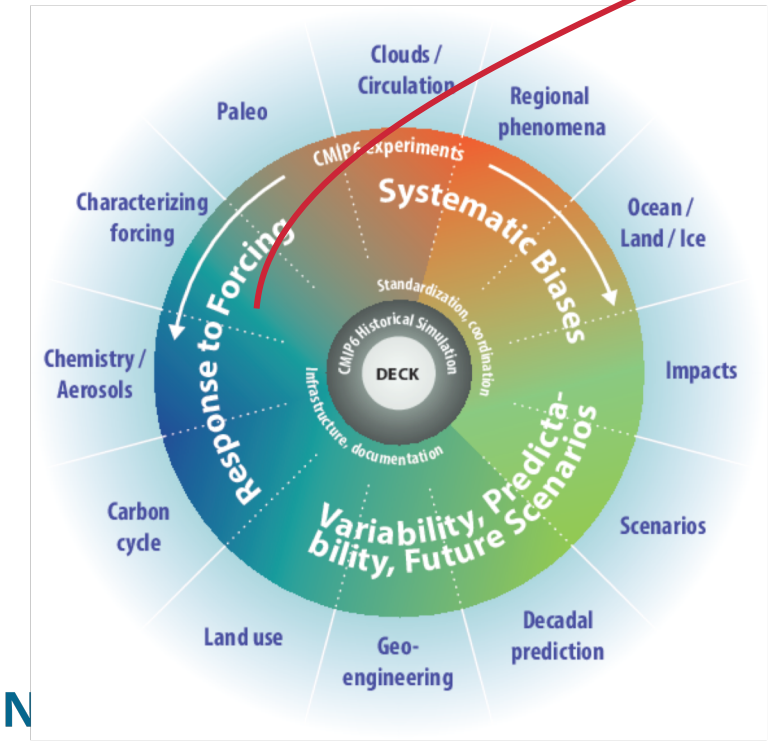
IPCC

AR4 — AR5 — AR6 — AR7

Paris Agreement

SR1.5

SROCC



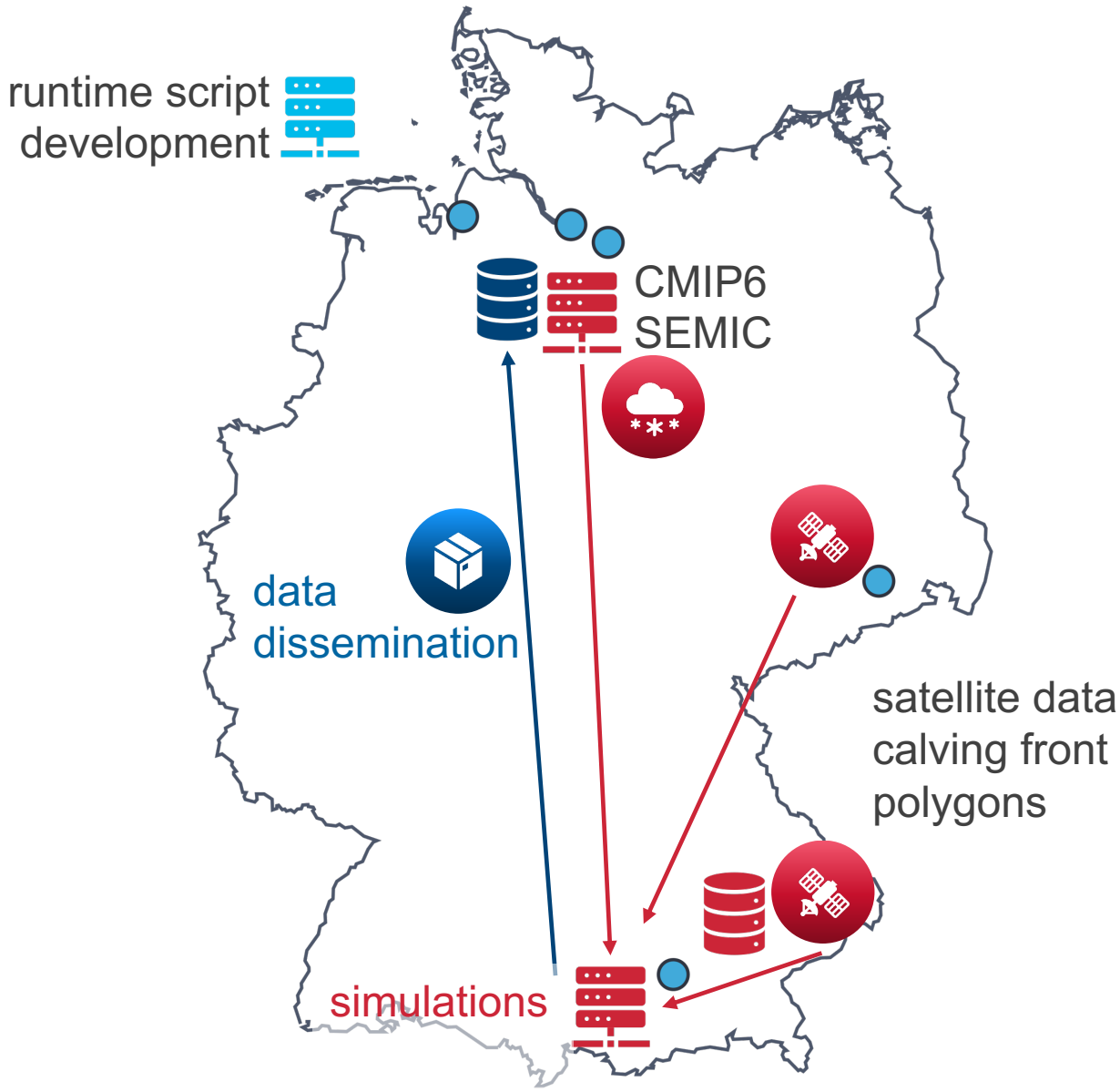
ISMIP6 — Ice Sheet Model Intercomparison Project for CMIP6

initMIP Antarctica
initMIP Greenland

ISMIP6 Antarctica
ISMIP6 Greenland

standardized simulation data

Distributed computing – the plan



DASF

GFZ Helmholtz-Zentrum Potsdam

Eggert, D., Sips, M., Sommer, P. S. and Dransch, D. (2022). *DASF: A data analytics software framework for distributed environments. V. 0.3.0.* GFZ Data Services. https://doi.org/10.5880/GFZ.1.4.2021.008

- central message broker (based on Apache Pulsar)
- remote procedure calls (RPC)
- messaging protocol language bindings for python and typescript
- example: Digital Earth Flood Event Explorer

PULSAR

python™

TypeScript

Outlook

Sounds simple, but ...

.... not trivial for infrastructure providers