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# InitMIP-Antarctica experiments with the ice sheet model SICOPOLIS

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# InitMIP-Antarctica:
# Antarctic ice sheet model initialisation experiments

**Early initiative within**

ISMIP6

Ice Sheet Model Intercomparison Project for CMIP6

- Initialise ice sheet to present day with method of choice (init)
- Run three forward experiments (100 a)
  - unforced control run (ctrl)
  - prescribed schematic SMB anomaly (asmb)
  - prescribed sub-ice-shelf melting anomaly (abmb)

(Seroussi et al., in prep.)

# Spin-up with SICOPOLIS

(www.sicopolis.net)

Model time: $t = -135$ ka ... 0 ka (one glacial cycle).

Grid spacing: $\Delta x = 16$ km.

(1) Without ice-stream dynamics / (2) with ice-stream dynamics.

Fixed topography (except first 100 a and last 500 a).

Surface temperature anomaly $\Delta T$ from Vostok δD record.

(Petit et al., 1999)

Precip = precip_today x fct($\Delta T$).

(Precip_today: Arthern et al., 2006; Le Brocq et al., 2010)

Runoff: PDD.

Parameterization of ice-shelf basal melting (next slides).

# Parameterisation of ice-shelf basal melting

Basal melting rate $a_\mathrm{b}$ = function of ocean temperature $T_\mathrm{oc}$:

(modified after
Beckmann and Goosse, 2003)

$$a_\mathrm{b} = \frac{\rho_\mathrm{w} c_\mathrm{w} \gamma_\mathrm{t}}{\rho L}\, \Omega \left(\frac{d}{d_0}\right)^{\alpha} (T_\mathrm{oc} - T_\mathrm{m,b})$$

$$T_\mathrm{m,b} = -\beta_\mathrm{sw}\, d - 1.85^\circ\mathrm{C}$$

$\Omega$: sensitivity parameter for each sector.

$d$: ice-shelf draft (reference value $d_0$ = 200 m).

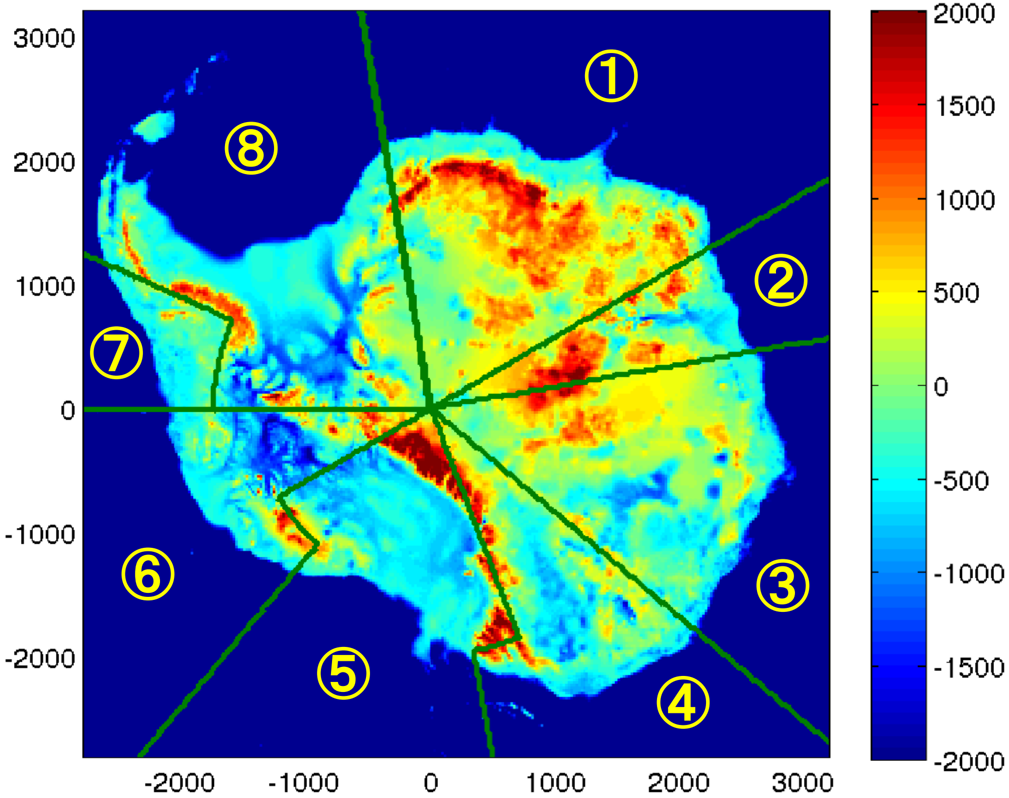
$\alpha$: non-linearity parameter.

$T_\mathrm{m,b}$: melting temperature at ice-shelf base, depends on draft *d.*

# Definition of eight sectors

1. ① Western East Antarctica.
2. ② Amery/Prydz Bay.
3. ③ Sabrina Coast/Aurora subglacial basin.
4. ④ George V Coast/Wilkes subglacial basin.
5. ⑤ Ross Sea.
6. ⑥ Amundsen Sea.
7. ⑦ Bellingshausen Sea
8. ⑧ Weddell Sea

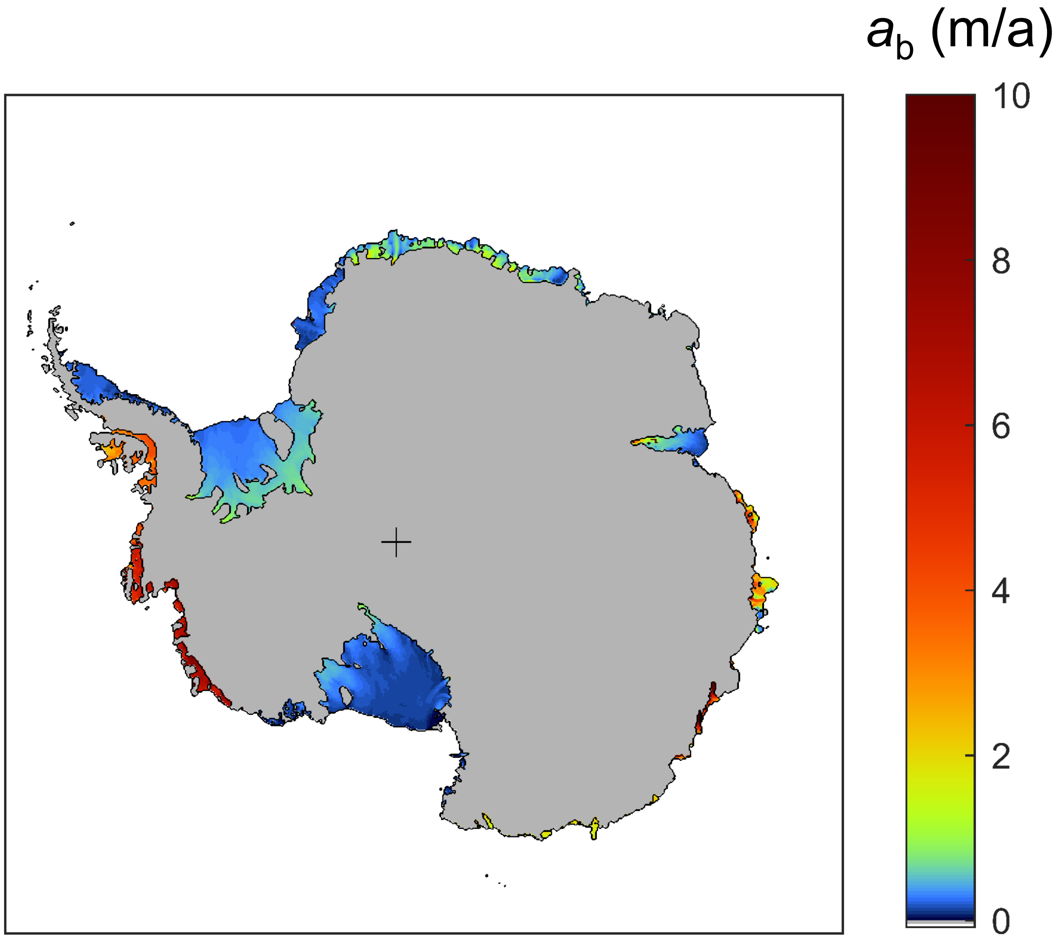
Basal/seafloor topography (m AMSL)




**Tuning by "observed" melting rates…**

# Distribution of basal melting

(on a 10-km grid)




Enhanced melting near deep grounding lines reproduced well.

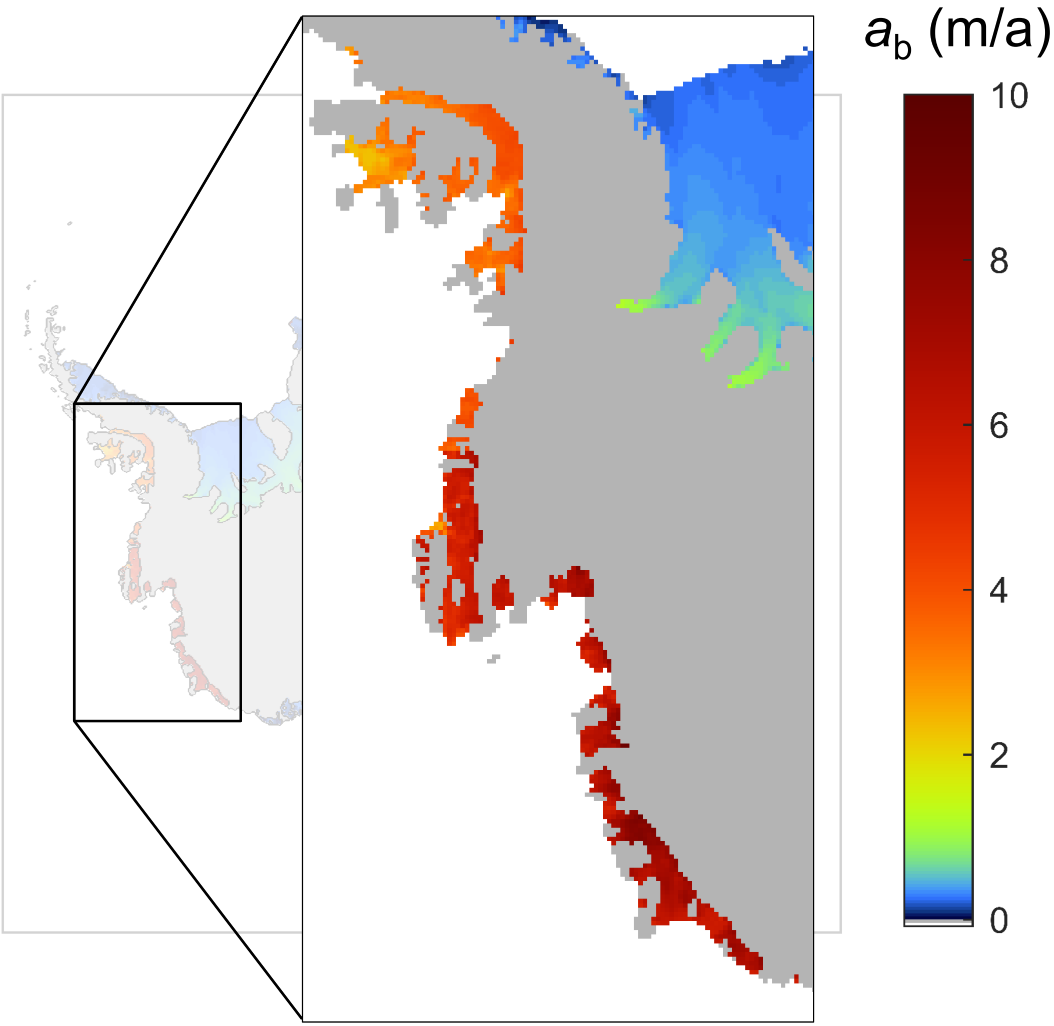
Due to different physics:

No enhanced melting near calving fronts.

No accretion of frazil ice.

# Distribution of basal melting

(on a 10-km grid)

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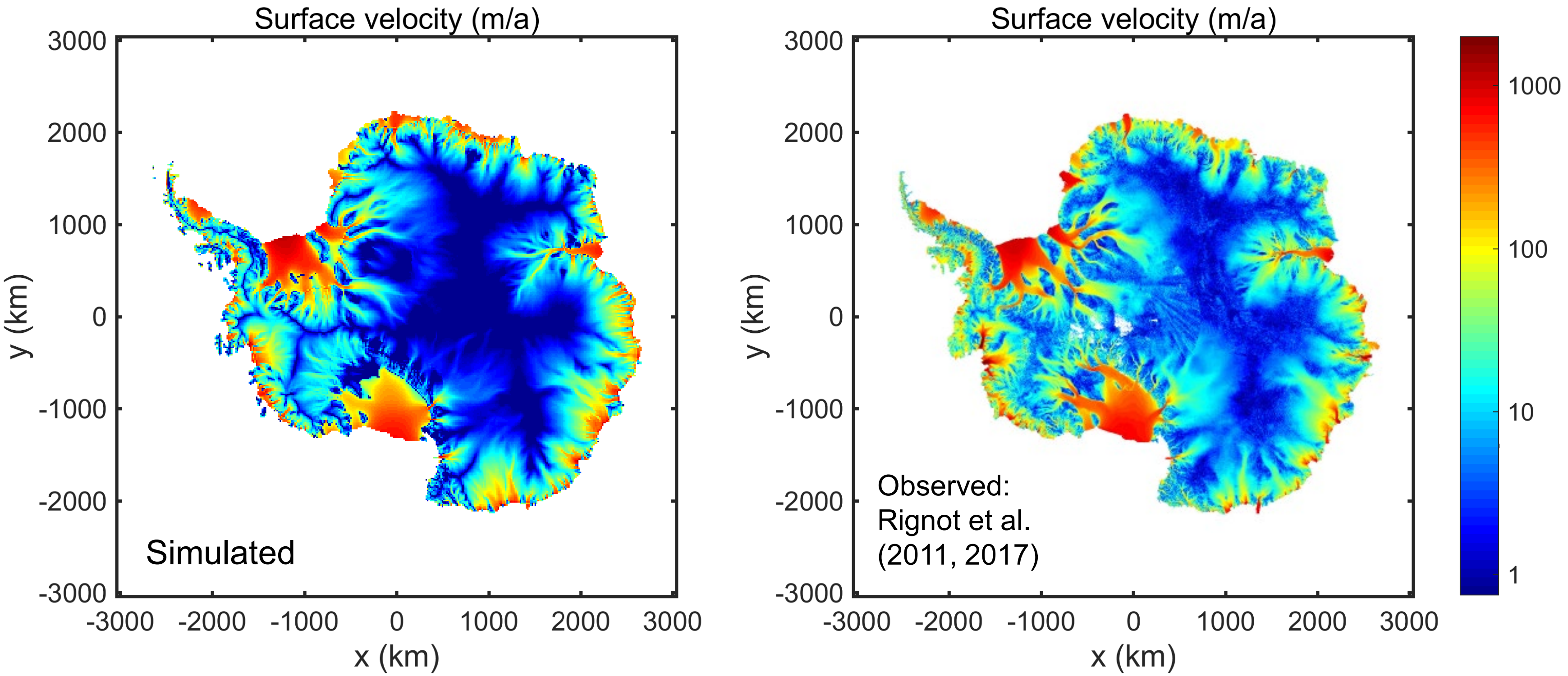
# Spin-up: simulated vs. observed surface velocity

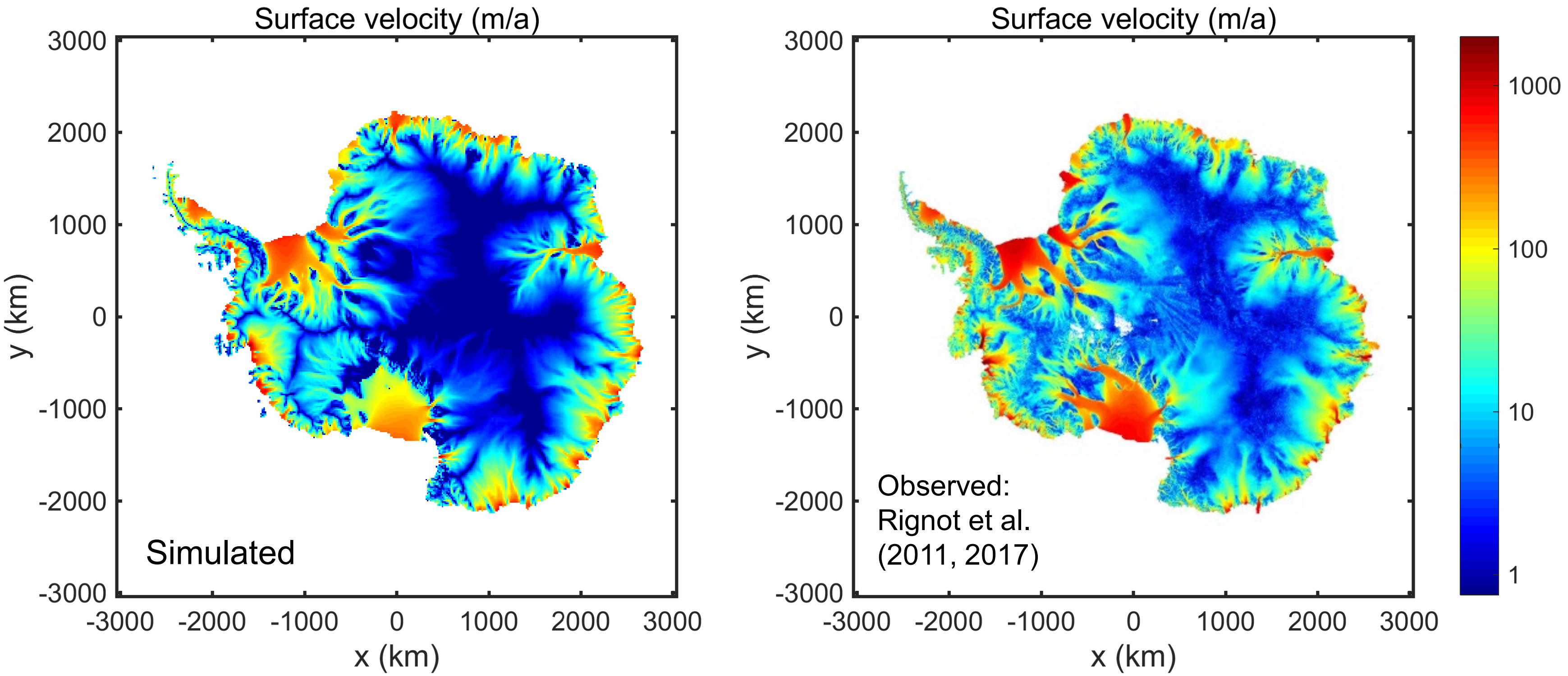
Without ice-stream dynamics:




Very sharp transitions between sheet and shelves.

# Spin-up: simulated vs. observed surface velocity

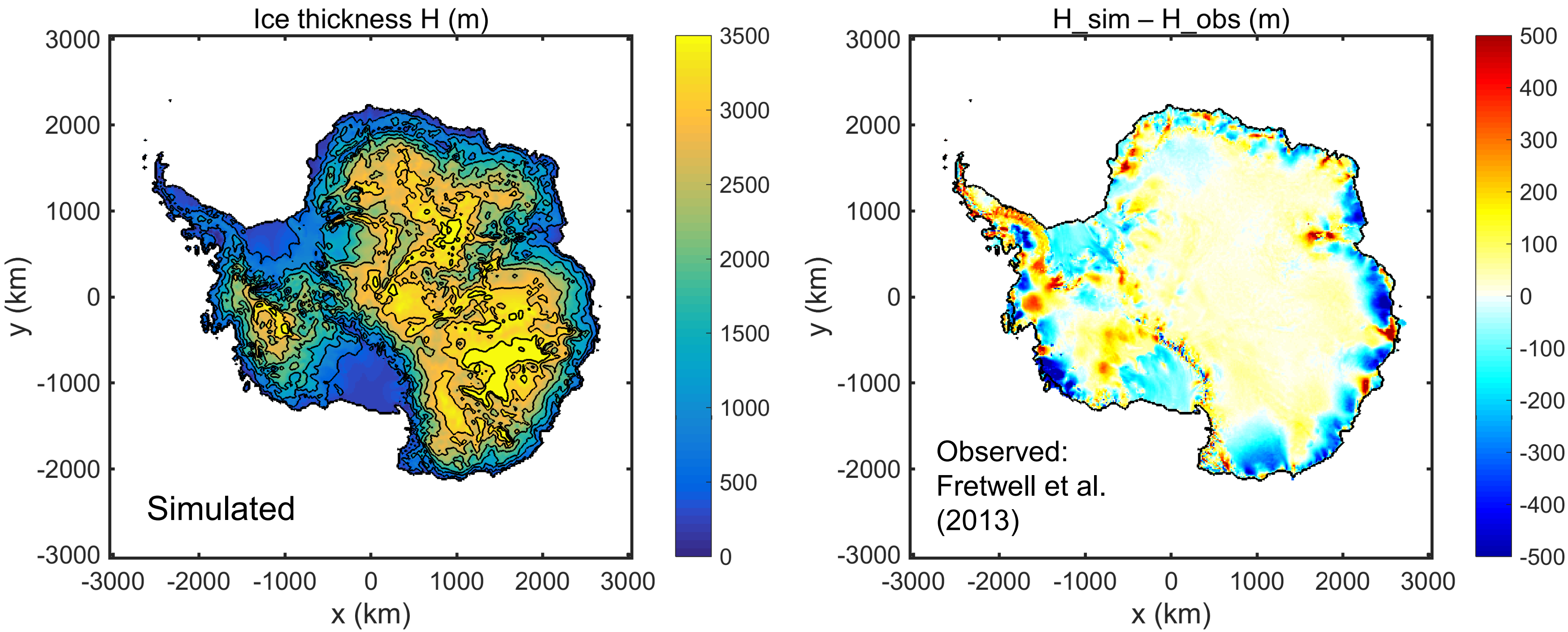
With ice-stream dynamics:




Smoother transitions between sheet and shelves.

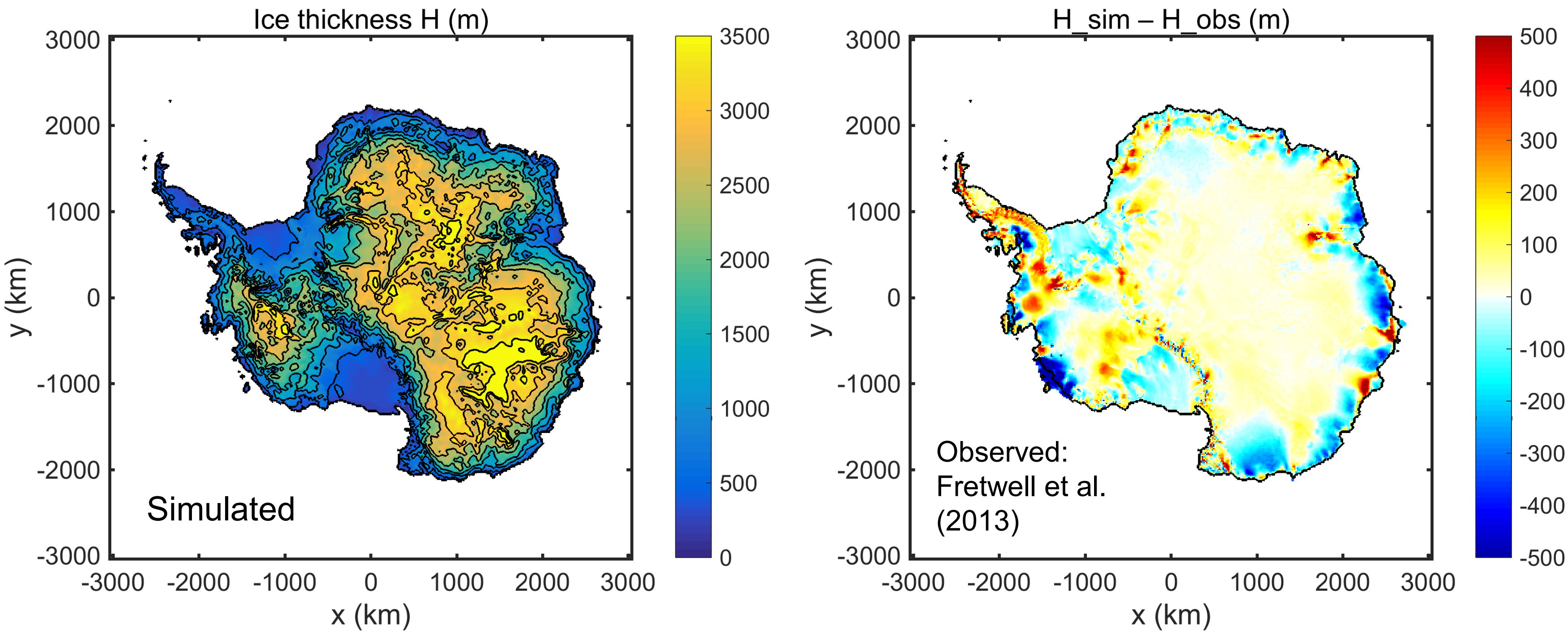
# Spin-up: simulated vs. observed ice thickness

## Without ice-stream dynamics:

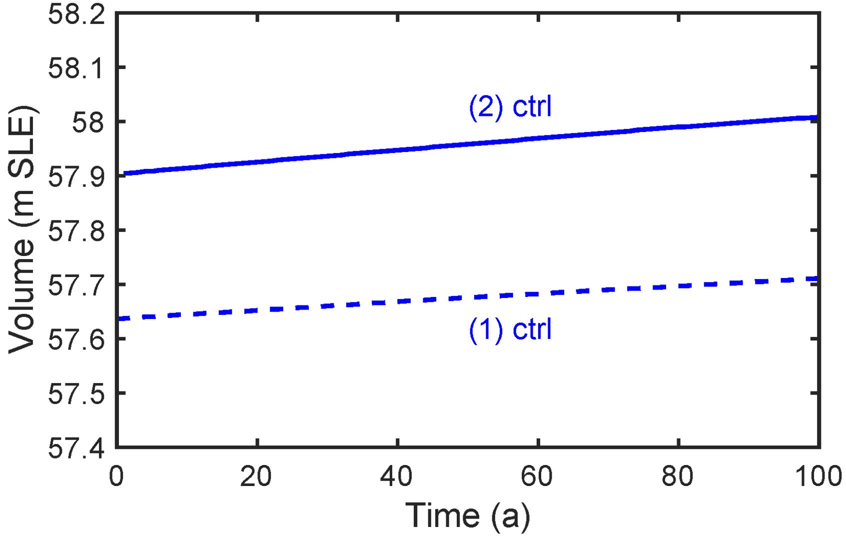


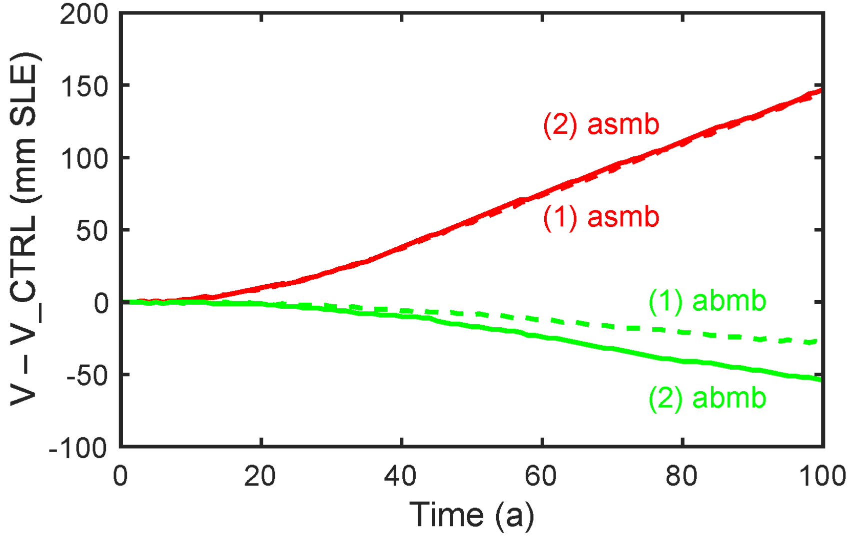
# Spin-up: simulated vs. observed ice thickness

## With ice-stream dynamics:



# Simulated ice volume for future climate runs ctrl, asmb and abmb



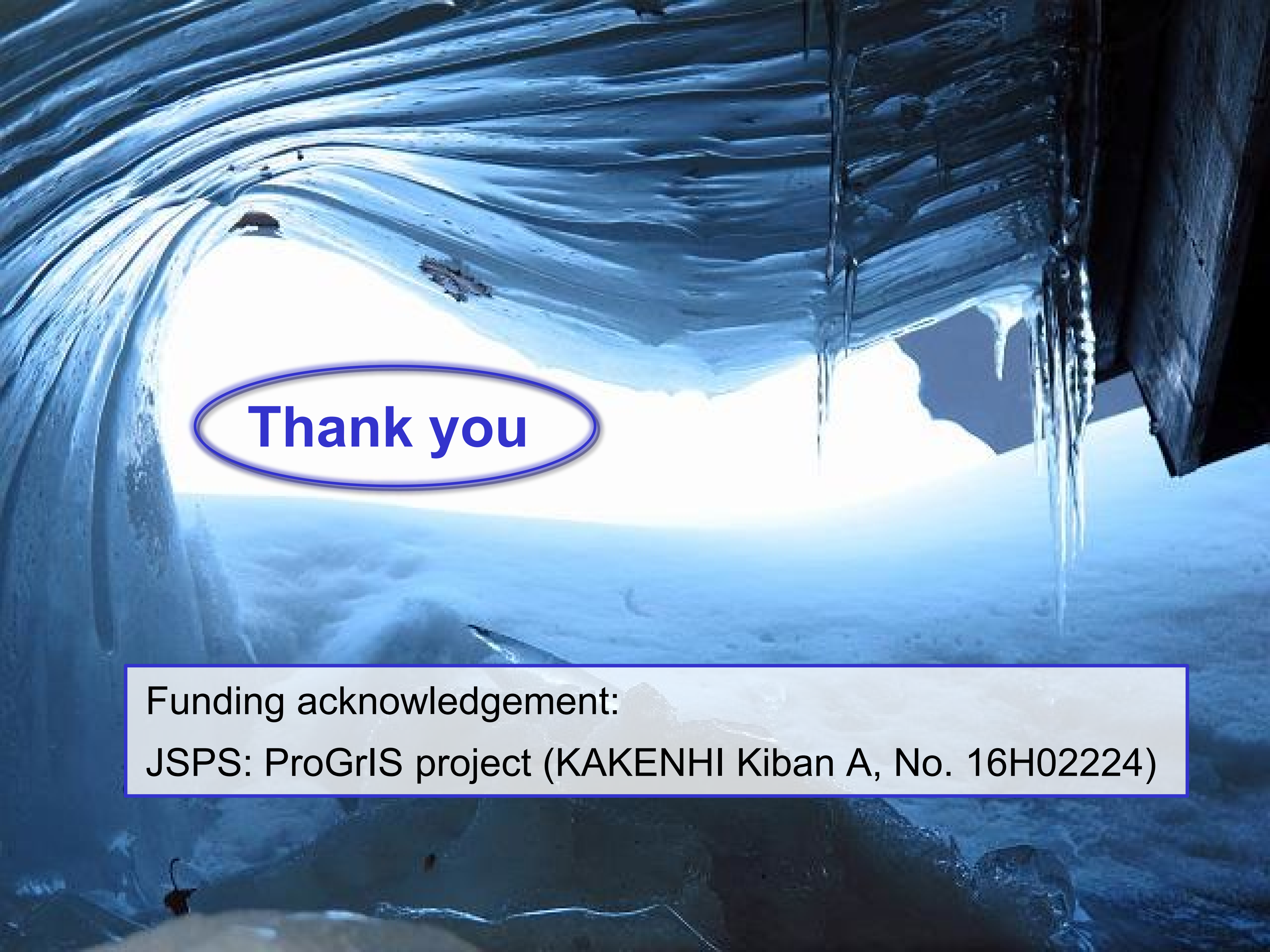

(1) Without ice-stream dynamics.

(2) With ice-stream dynamics.

(1) vs. (2): Sensitivity of abmb notably different.

# Outlook

- Work in progress…
- Grid spacing: 16 km → 8 km.
- Generally too cold & too slow
  → larger geothermal heat flux, tuning of basal sliding?
- InitMIP-Antarctica final submission deadline 31 July 2017
  → ensemble of model results.
- Longer-term goal:
  Realistic climate change scenarios, input for IPCC AR6.



# Thank you

Funding acknowledgement:
JSPS: ProGrIS project (KAKENHI Kiban A, No. 16H02224)

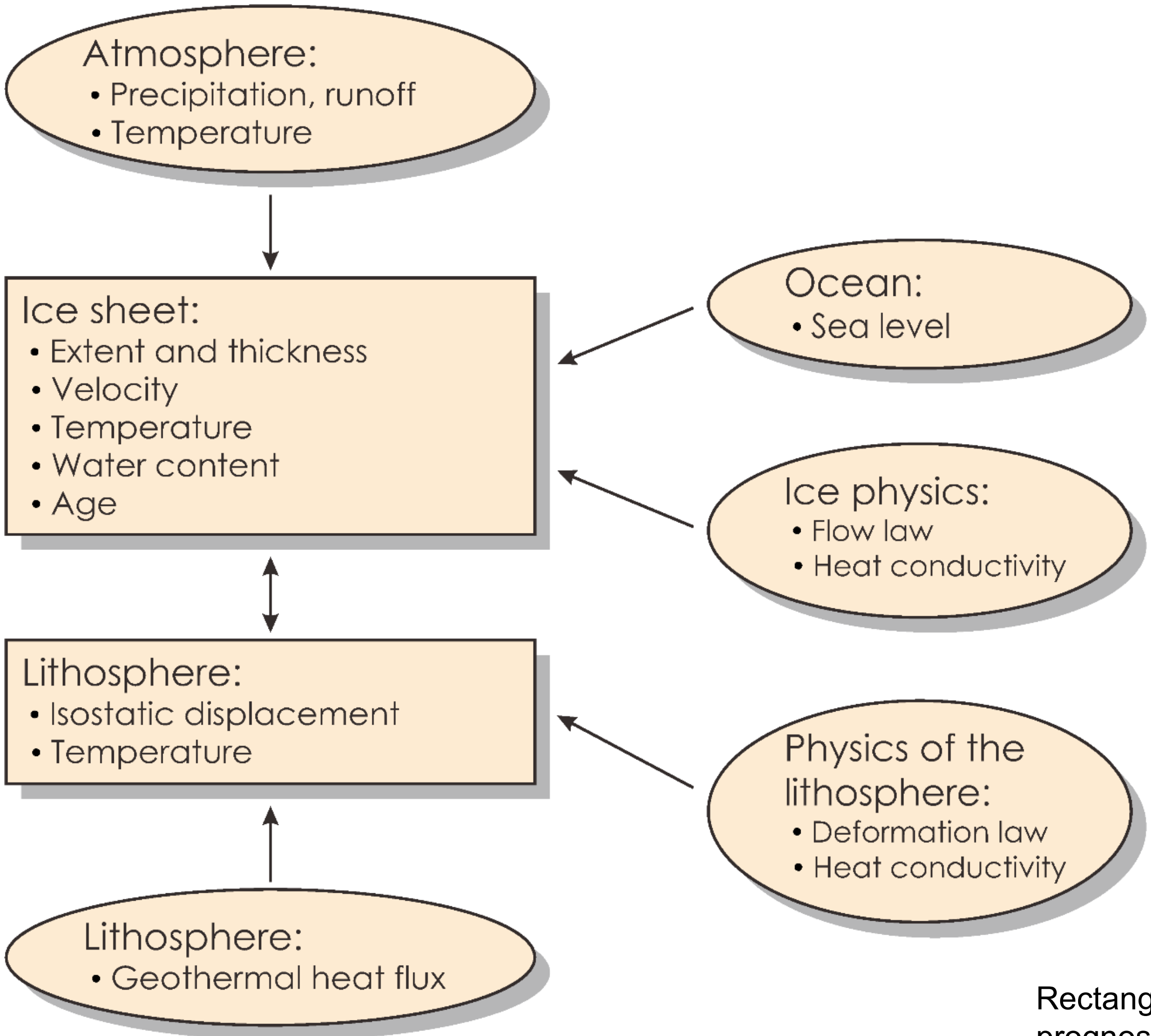
# Appendix A: SICOPOLIS

# Ice sheet model SICOPOLIS


“SImulation
COde
for
POLythermal
Ice
Sheets”

- Open-source model, mainly delevoped at ILTS (www.sicopolis.net).
- Coded in Fortran.
- Shallow ice + shallow shelf approximations.
- Finite difference method.

# Ice sheet model SICOPOLIS

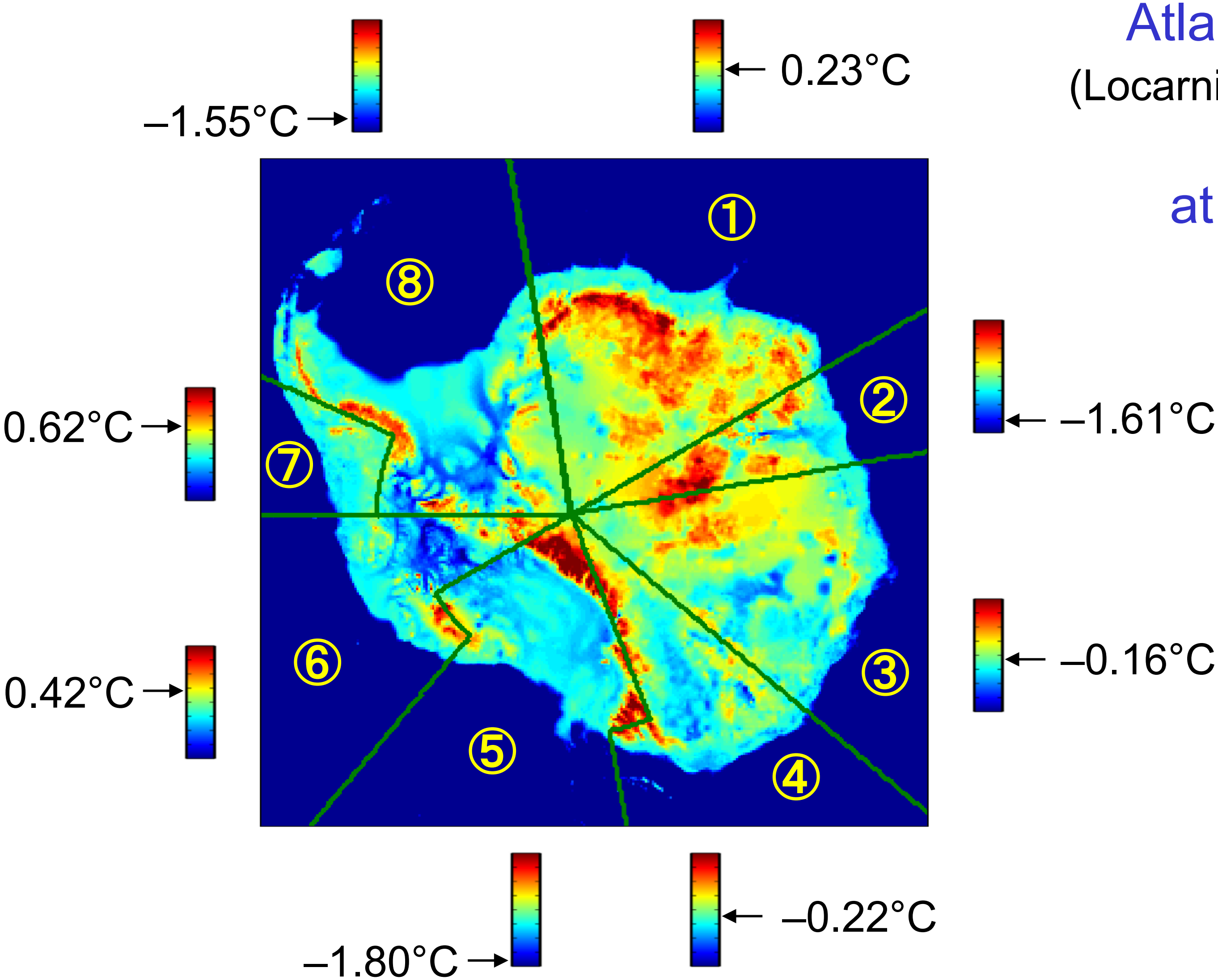



Rectangular boxes:
prognostic model components.
Ovals: model input.

# Appendix B: Ice-shelf basal melting

# Sector-averaged ocean temperature

[World Ocean Atlas 2009 (Locarnini et al., 2010) at 500 m depth]



# Tuning strategy (for each sector)

(1) Target basal melting rate:
"observed", from $a_\mathrm{b} = -\mathrm{div}\,(H\mathbf{v}) + a_\mathrm{s}$ .

(2) Assume α (non-linearity parameter).

(3) Compute point-wise Ω (sensitivity parameter) with nearest-neighbor $T_\mathrm{oc}$ (ocean temperature).

(4) Set up the parameterisation for $a_\mathrm{b}$ with sector-averaged Ω and $T_\mathrm{oc}$.

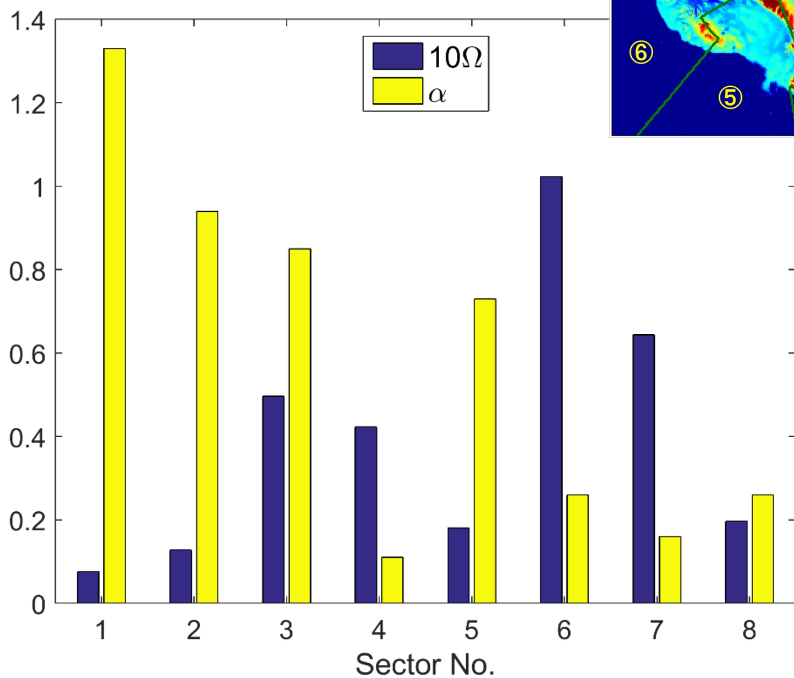
(5) Compute misfit to "observed" $a_\mathrm{b}$.

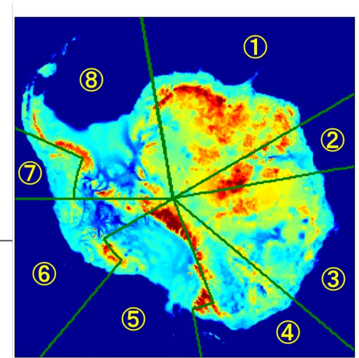
(6) Repeat with different α's → minimize misfit.

(7) Scale Ω's → sectorial and total melt by Rignot et al. (2013)

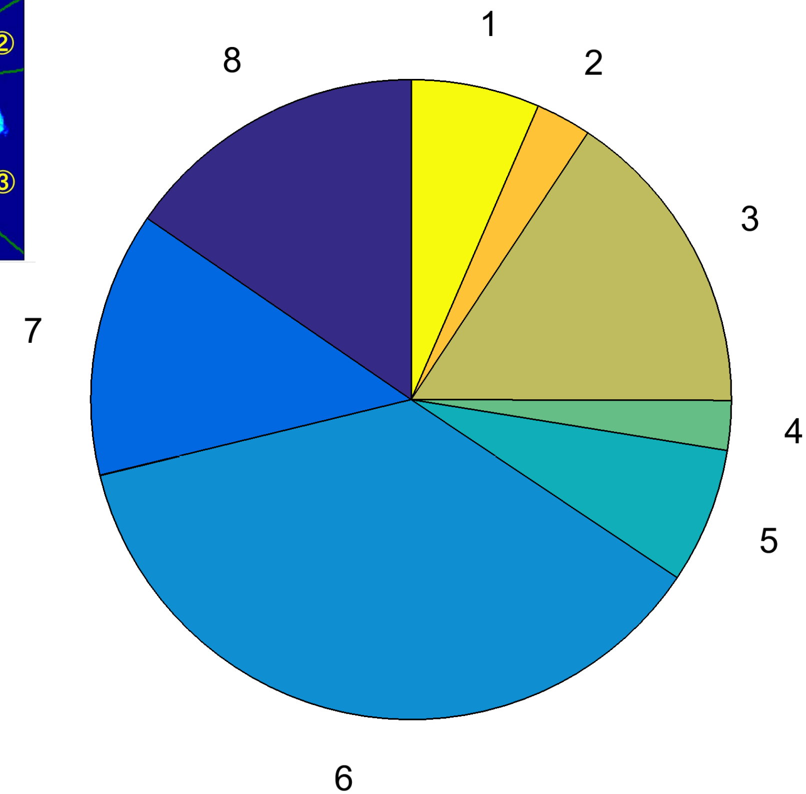
# Ω's, α's and melt rates

Ω's, α's



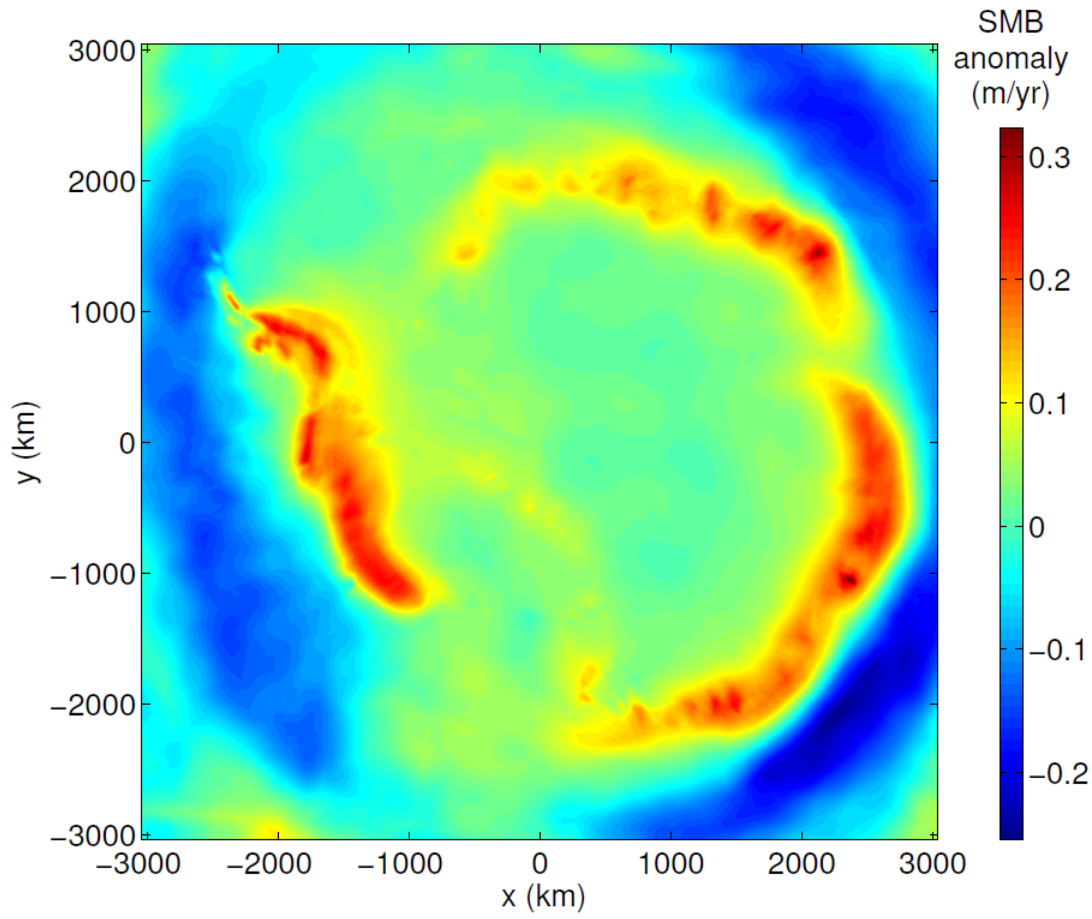

Sectorial melt rates




$Q_{tot}$ = 1323.9 Gt/a

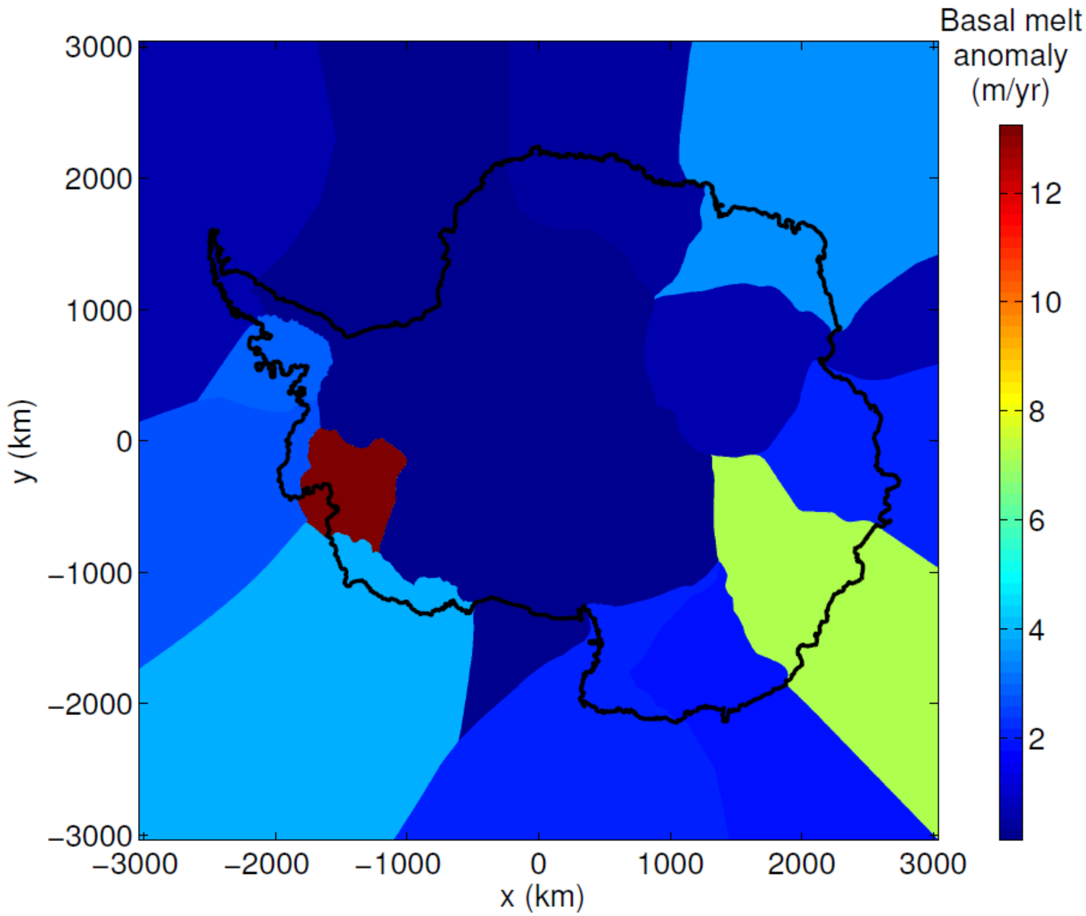
# Appendix C: InitMIP anomalies

# Schematic SMB anomaly (asmb)




(Seroussi et al., in prep.)

# Schematic basal melt anomaly (abmb)




(Seroussi et al., in prep.)

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