Some Logistics: Class projects

- Please schedule a meeting with me to discuss your project.
- From the syllabus:

  Students will work alone or in groups to answer a glaciological research question that they formulate with the assistance of the Instructor.

  It's recommended that students begin to formulate their research question by visiting office hours throughout the term.

  The final project will consist of

  1) a written report of about the length of a paper in Geophysical Research Letters,
  2) 2) an open repository of any codes developed for the project, and
  3) 3) a 15- minute "AGU" style talk.

- 50% of the class grade consists of the final project.

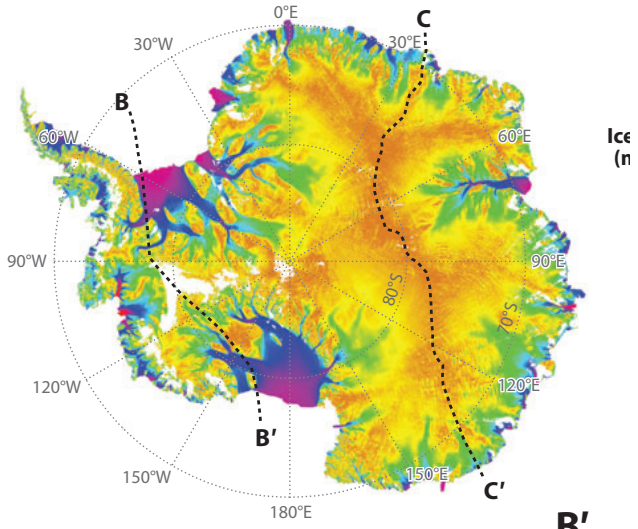
Project Ideas

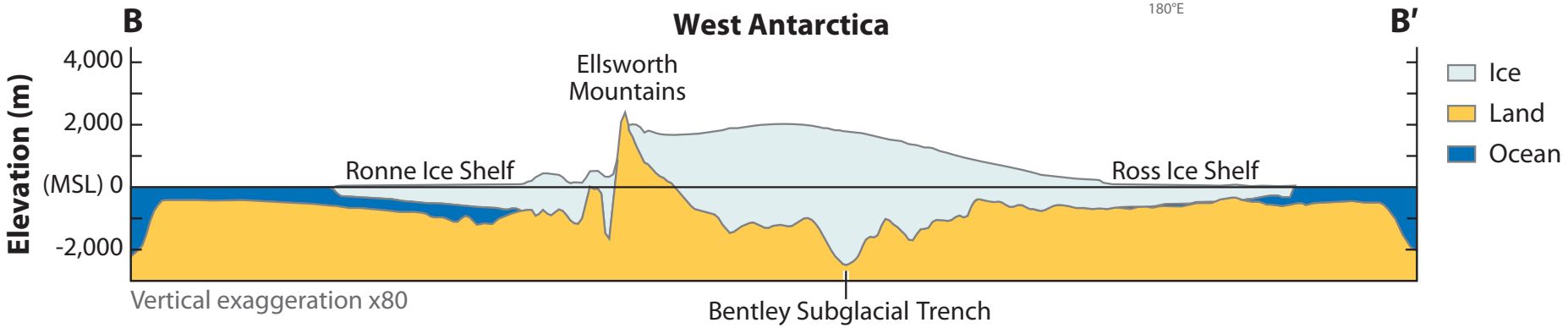
- Climate centered: describe, model, and analyze a climate-related time series that requires glaciological insight. Examples: radar stratigraphy in Antarctica, South Pole weather station data.
- Geophysics centered: describe, model, and analyze a glacier seismic data set that relates to glacier basal seismicity.
- Applied Math: Pursue results in nonlinear stokes flow: time reversibility, representation theorems, flow approximations.
- Large scale computing: run a large scale ice sheet model to investigate the ice dynamics in a particular glacier or region of the ice sheets.
- Laboratory experiments: do actual lab experiments on the physics of ice. Possibilities include high speed friction of ice, ice fracture properties, experiments on floating ice plates, slow ice deformation.
- Or propose your own topic!

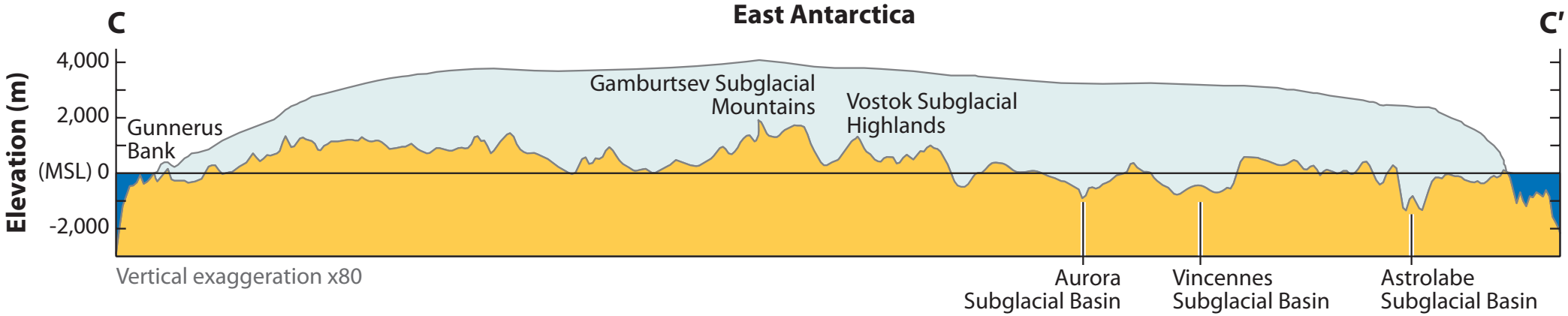
Glaciers as thin flows

Photo: Swiss Glaciers

Glaciers as thin flows







Glaciers as thin flows

Aspect ratio 1 (Icebergs)

Aspect ratio 10 (Width cross section of a valley glacier)

Aspect ratio 100 (Length cross section of a valley glacier)

Aspect ratio 1000 (Length cross section of an entire ice sheet)

The Shallow Ice Approximation

Vertical Profile of glacier velocities

$$u = u_0 + \frac{1}{2}A(\rho g \sin\alpha)^3 \left(H^4 - (H-z)^4\right)$$

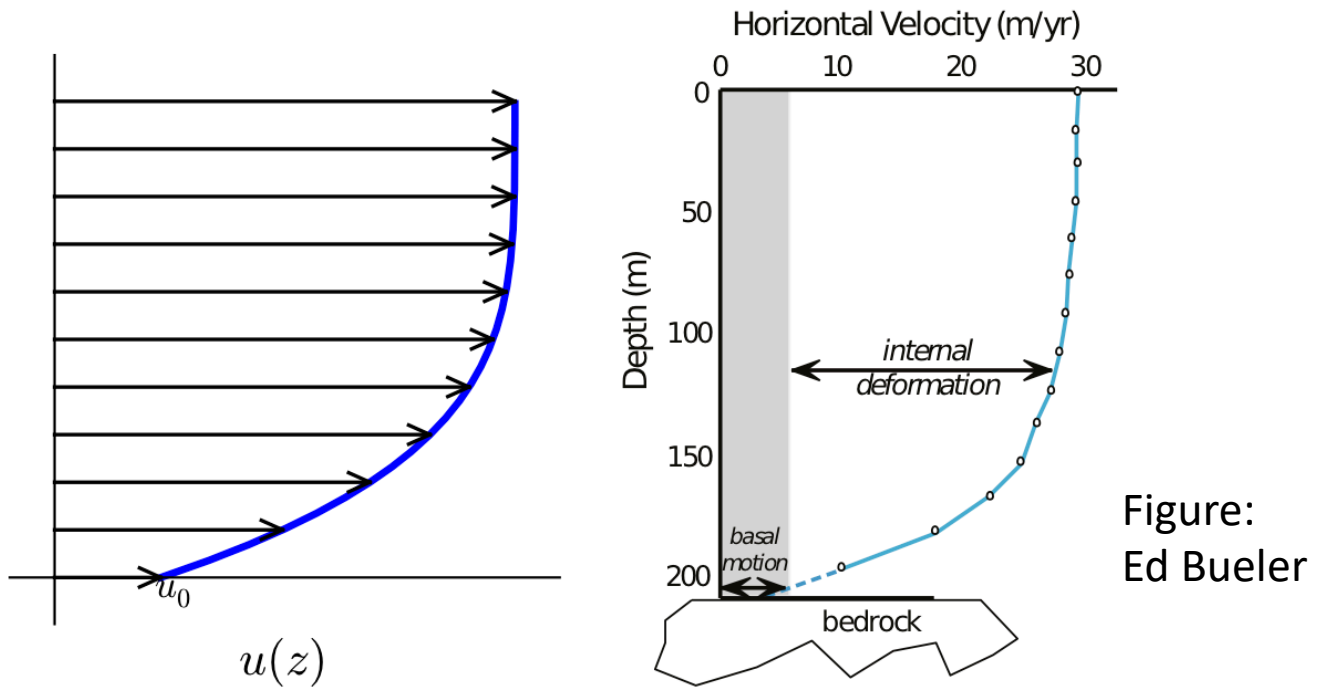


Figure:
Ed Bueler

FIGURE 2. Left: Velocity from slab-on-a-slope formula (14). Right: Inclinometry-measured velocity in a glacier (Athabasca Glacier [55]).

SIA is extremely diffusive

Figure: Ed Bueler

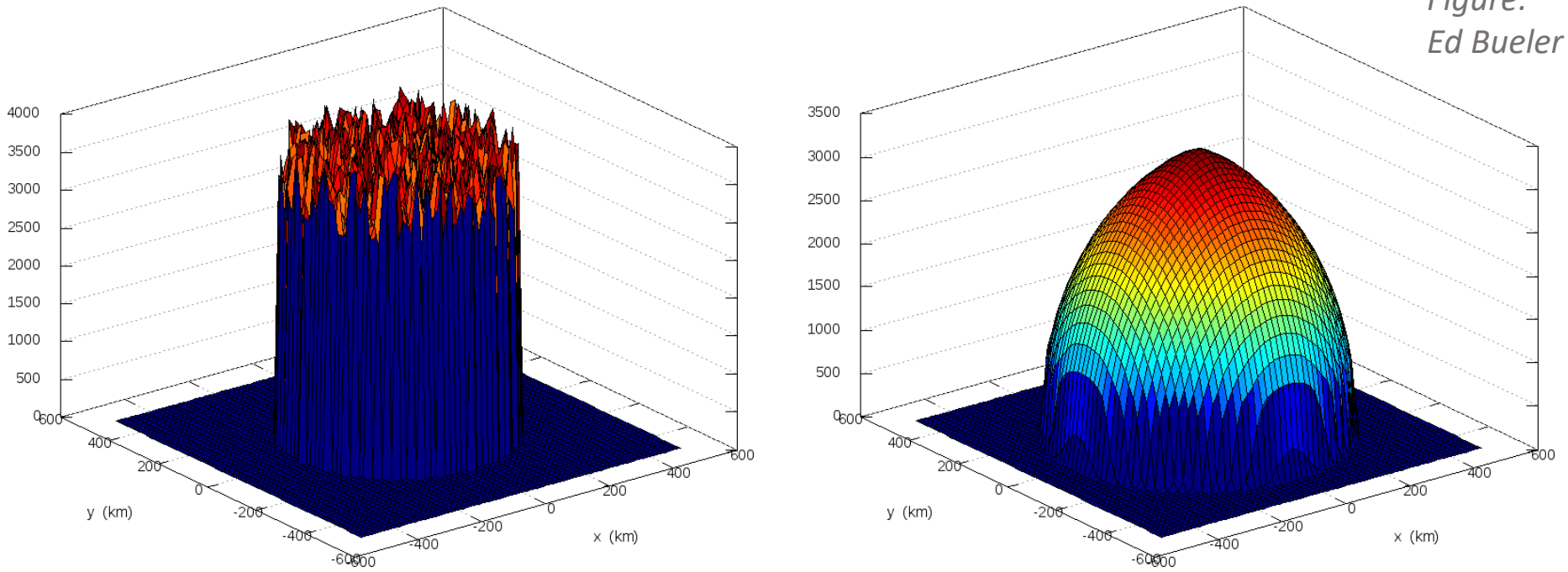
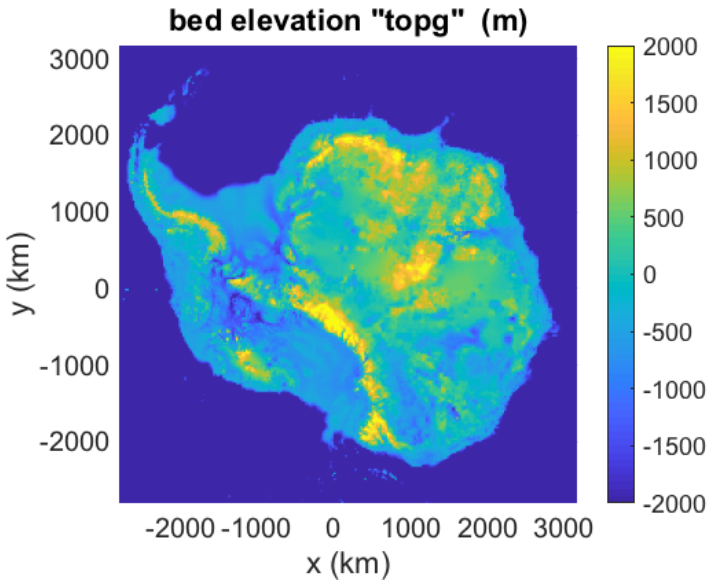
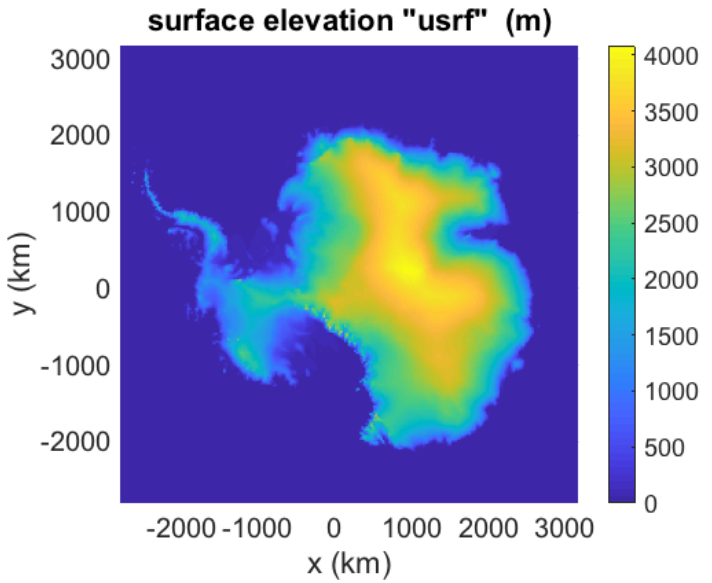


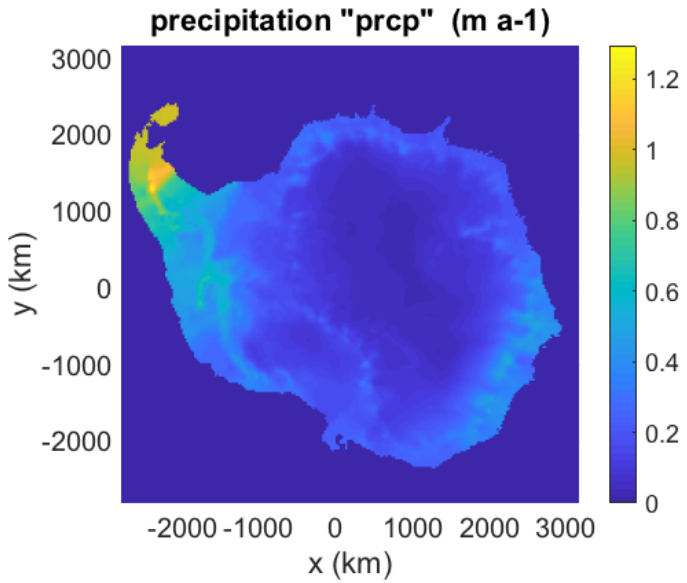
FIGURE 12. The SIA model evolves the huge-driving-stress initial ice sheet at left to the ice cap at right in only 50 model years.

- Wavelengths attenuate as exp (- k^2 t)

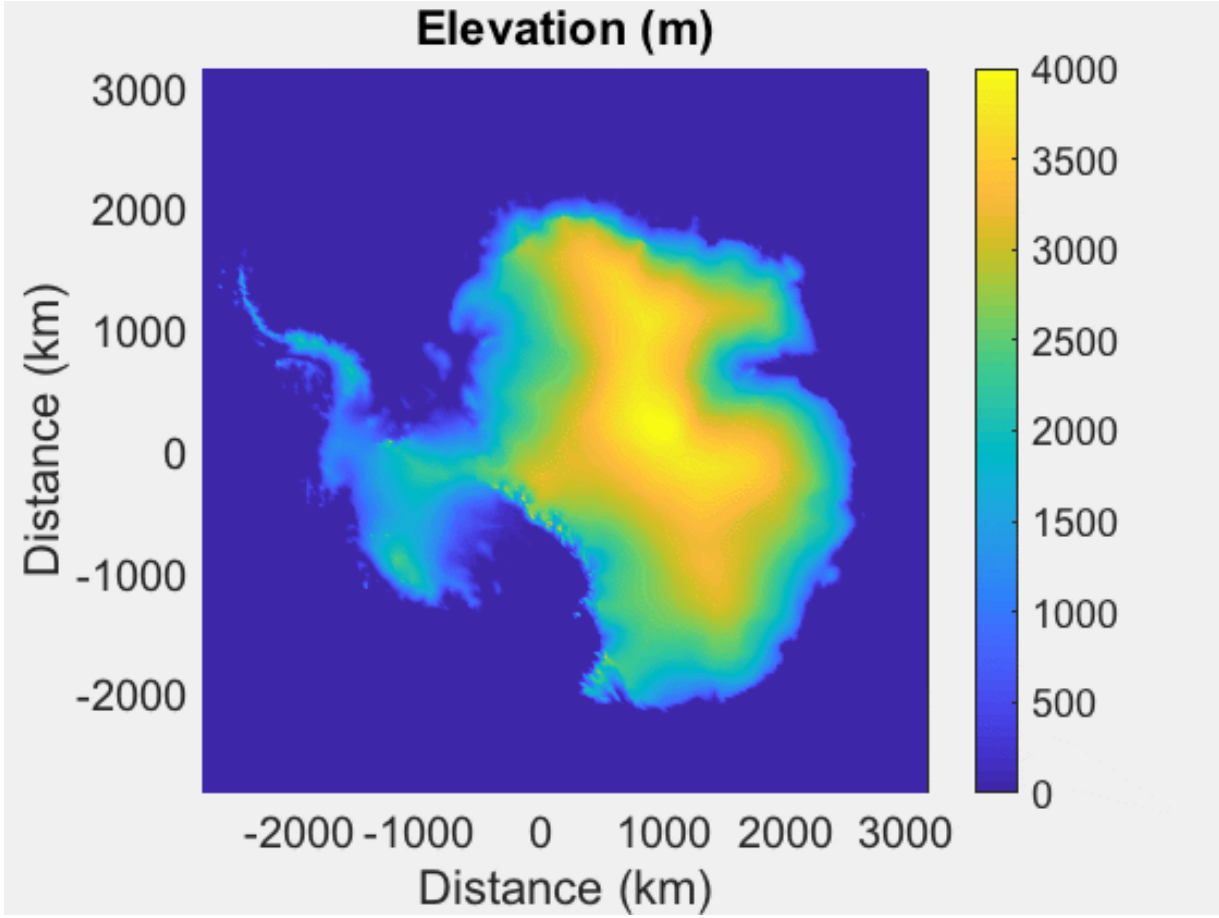
Shallow Ice Approximation: Model Inputs



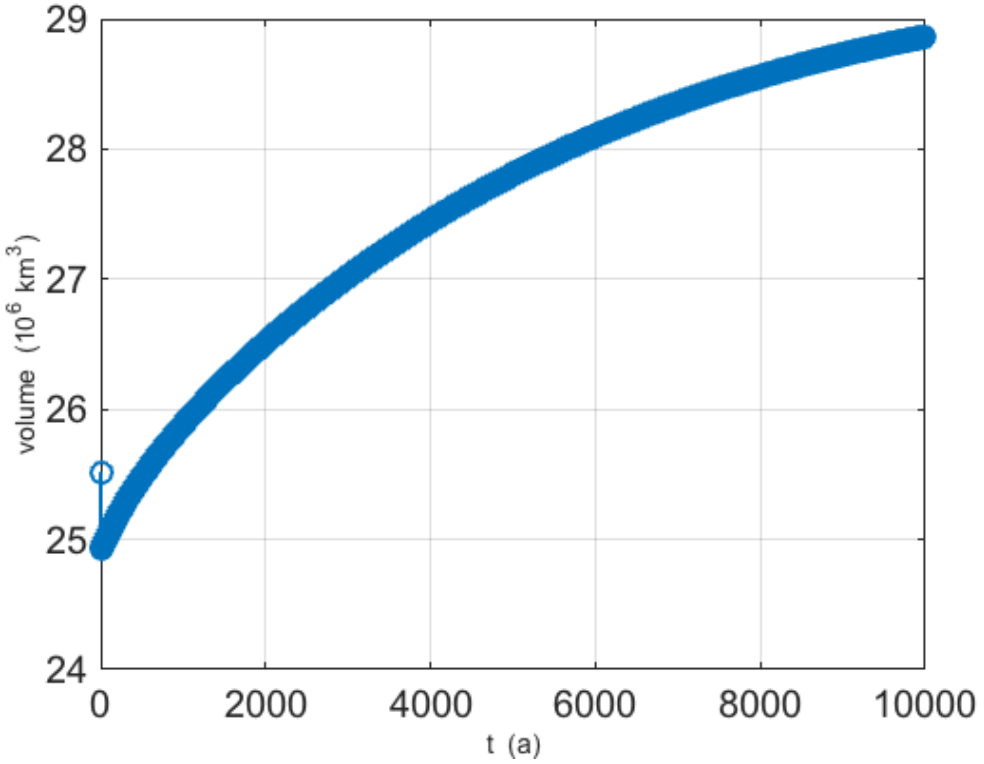


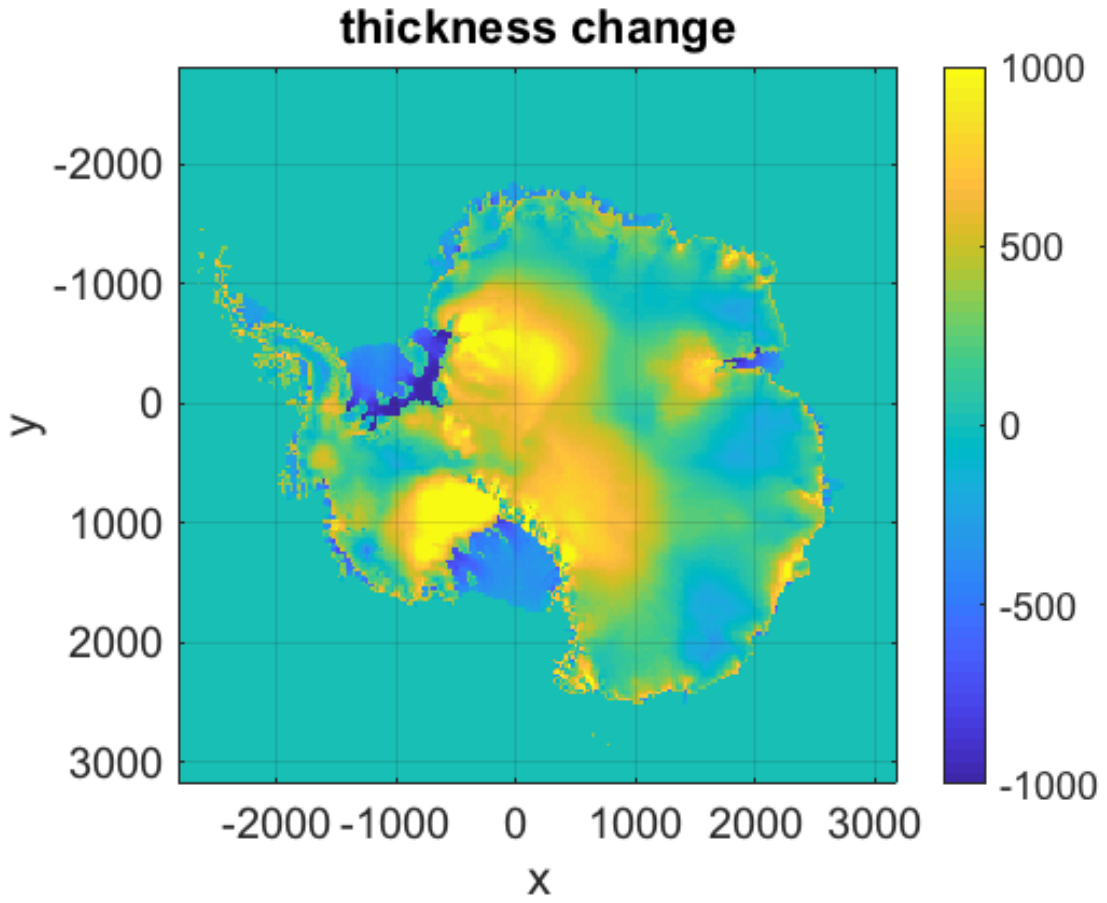


Shallow Ice Approximation: Model results



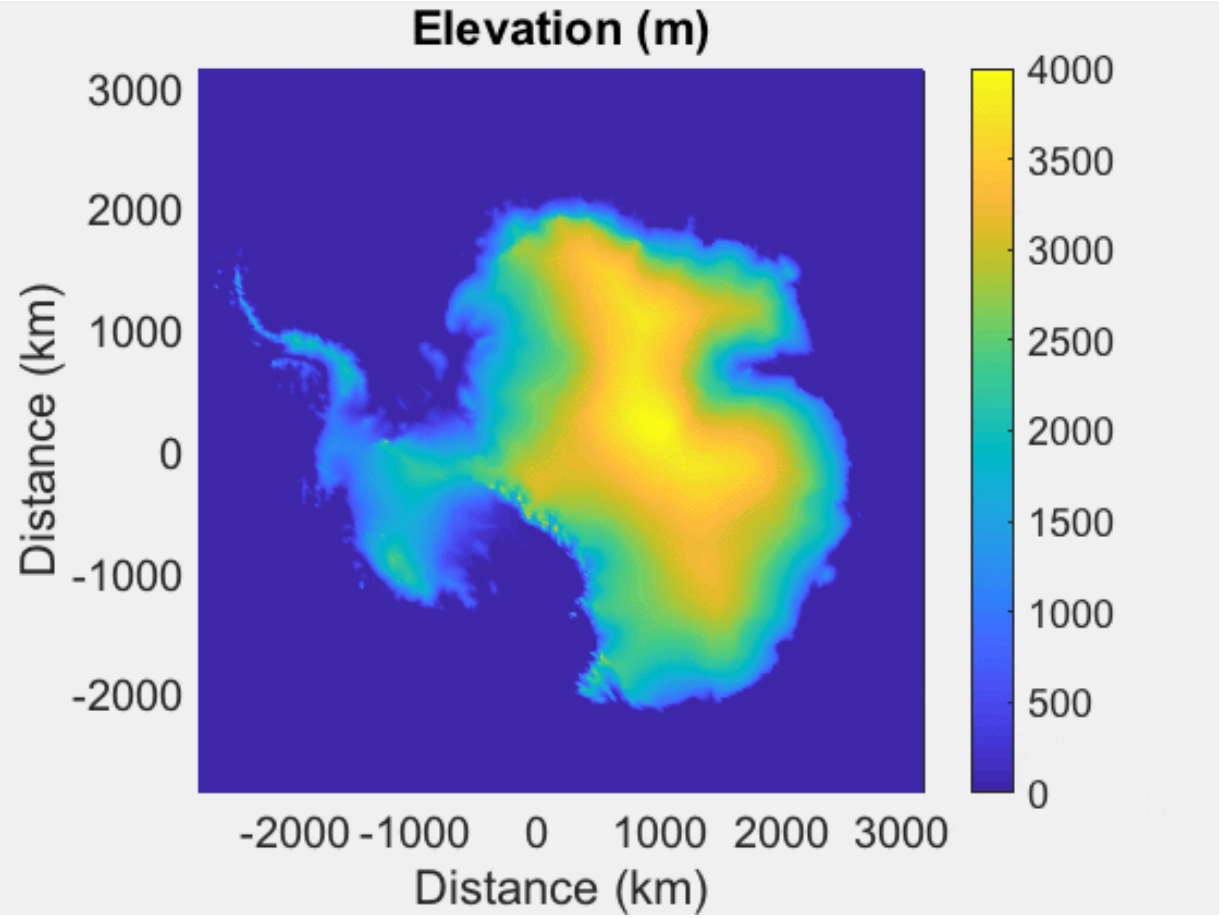
Shallow Ice Approximation: Model results

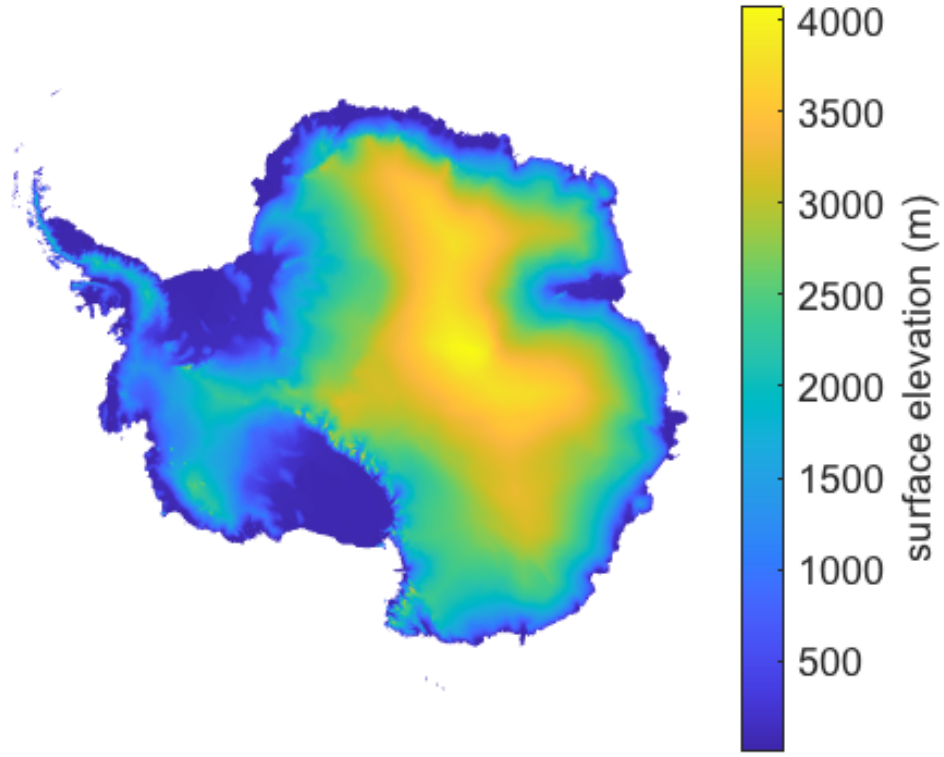




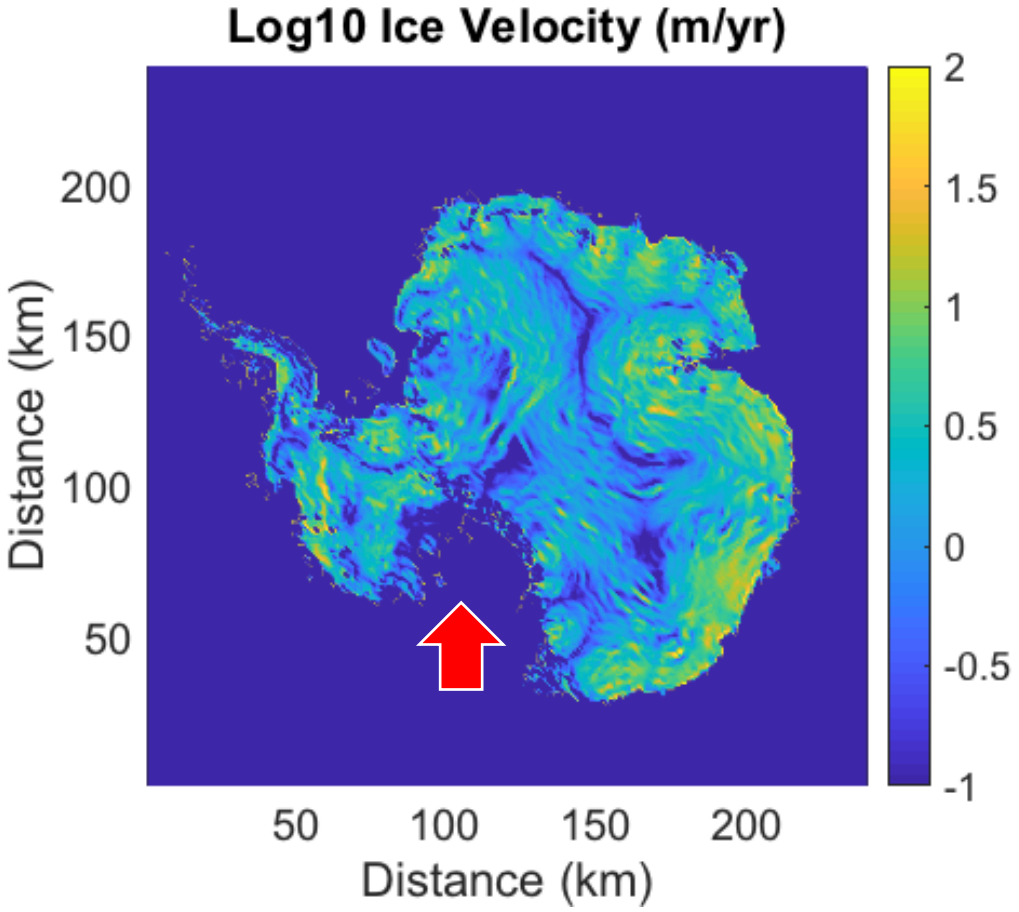
- Model run at 25km resolution takes about 20 minutes to run.

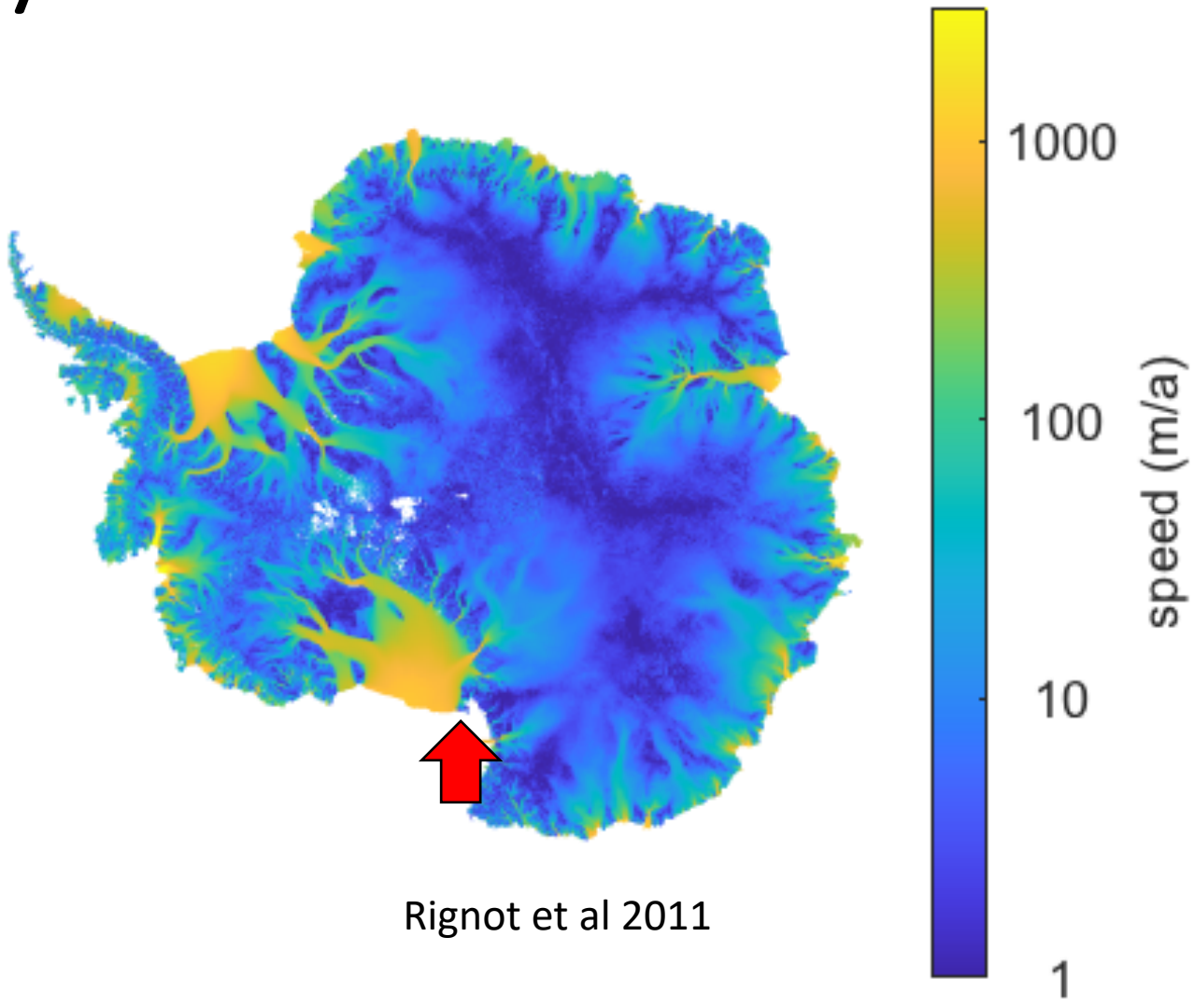
Comparison to **surface elevation** observations



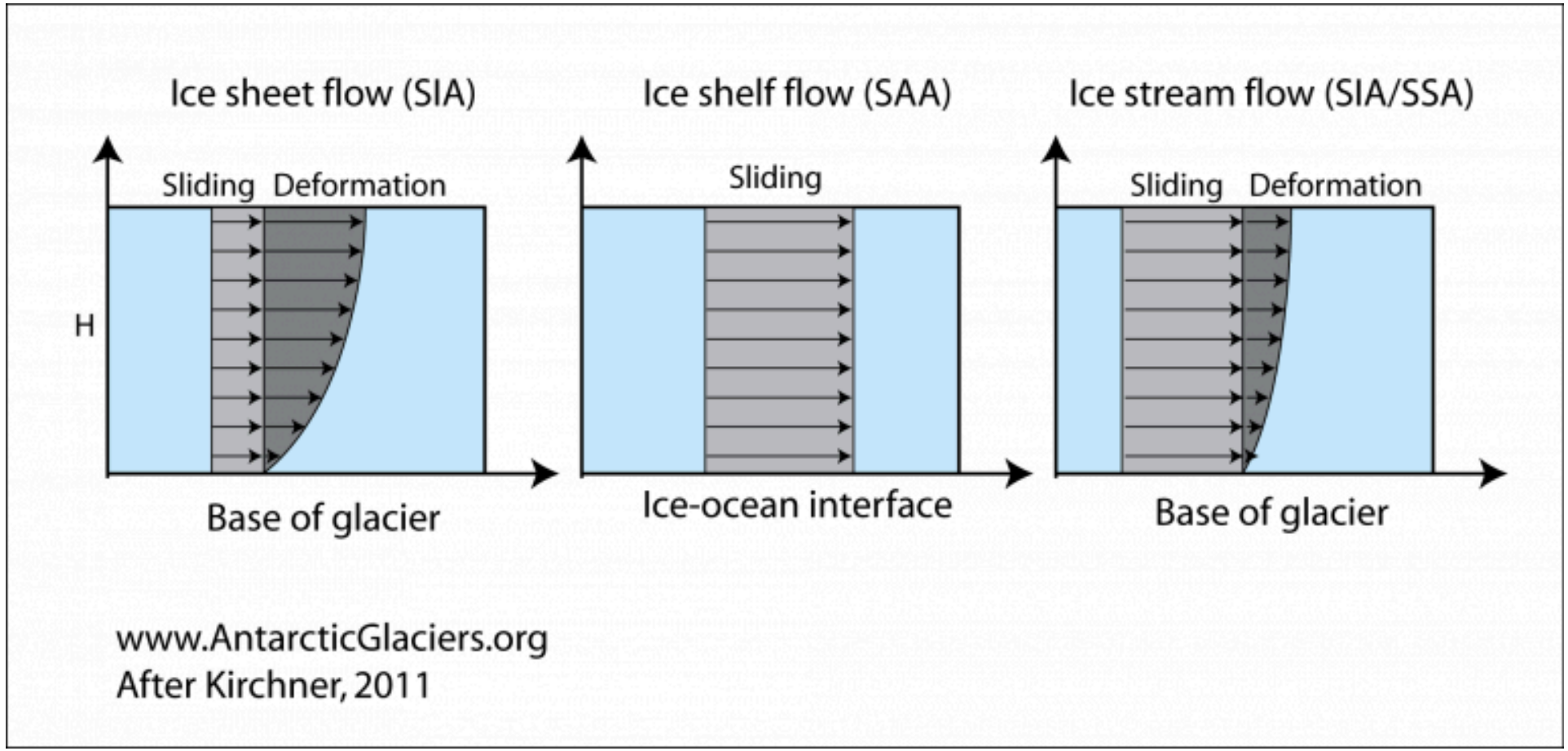


Comparison to **velocity** observations





Rignot et al 2011

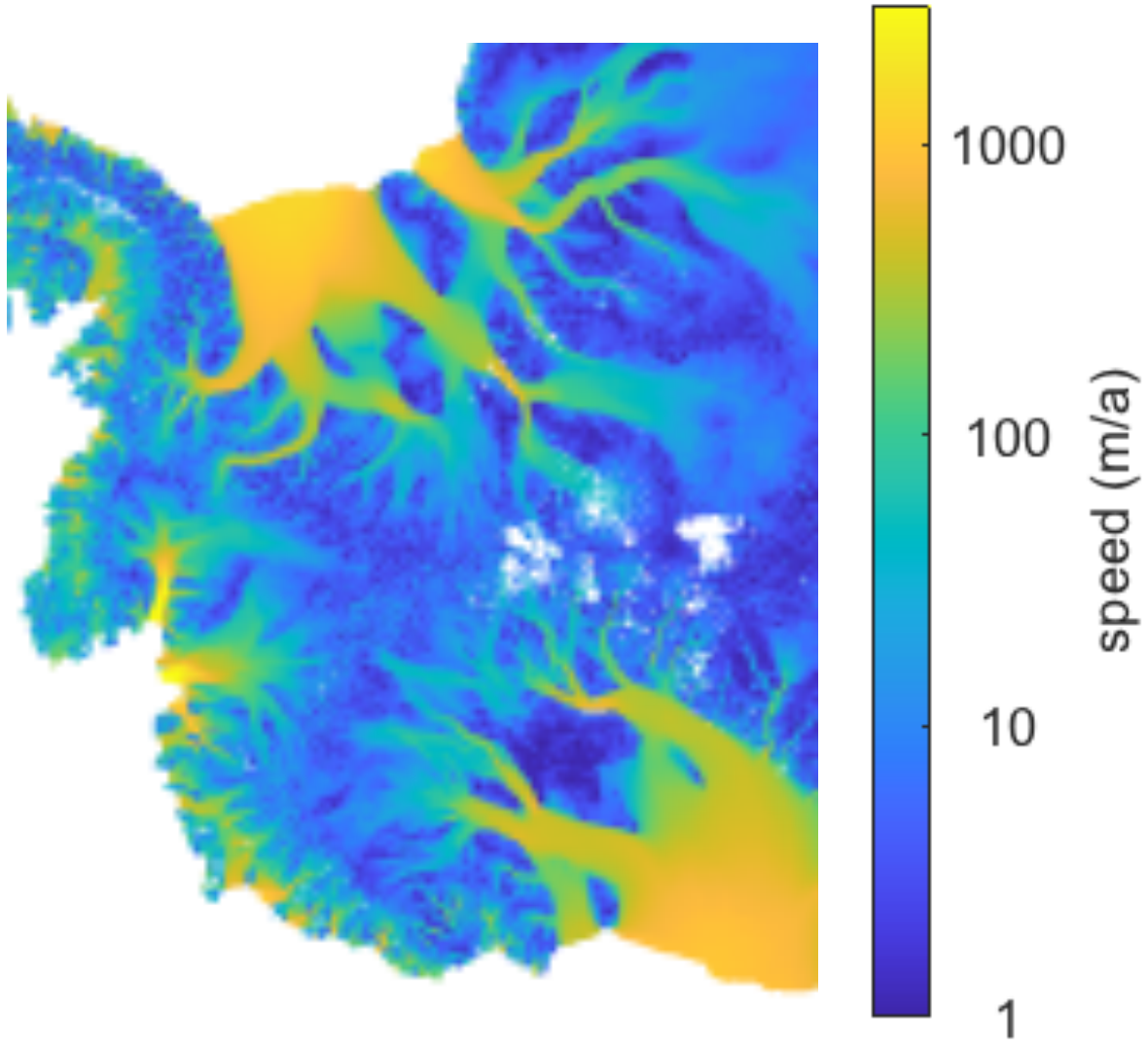

Ice sheet flow (SIA)
Sliding
Deformation
H
Base of glacier
Ice shelf flow (SAA)
Sliding
Ice-ocean interface
Ice stream flow (SIA/SSA)
Sliding
Deformation
Base of glacier
www.AntarcticGlaciers.org
After Kirchner, 2011

What controls amount of basal sliding?

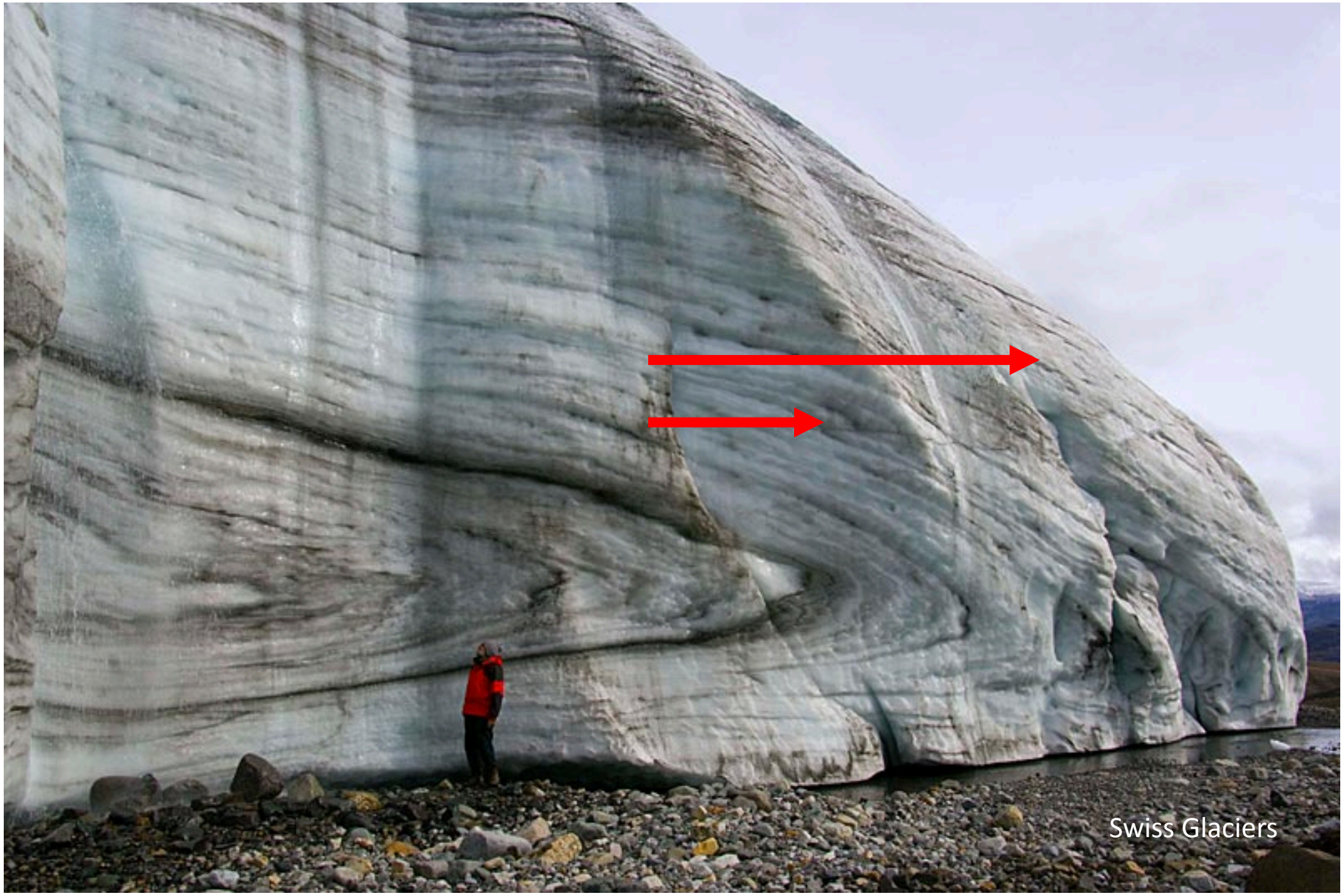
In the next lecture, we'll explore two endmember types of sliding behavior:

1) When water pressure is very high, the ice quickly and easily slides over the bed.

2) At lower water pressures, the ice deforms around bedrock obstacles by shear thinning flow and regelation.




Swiss Glaciers


Swiss Glaciers