# Polar ice sheets and sea-level rise: threats and uncertainties

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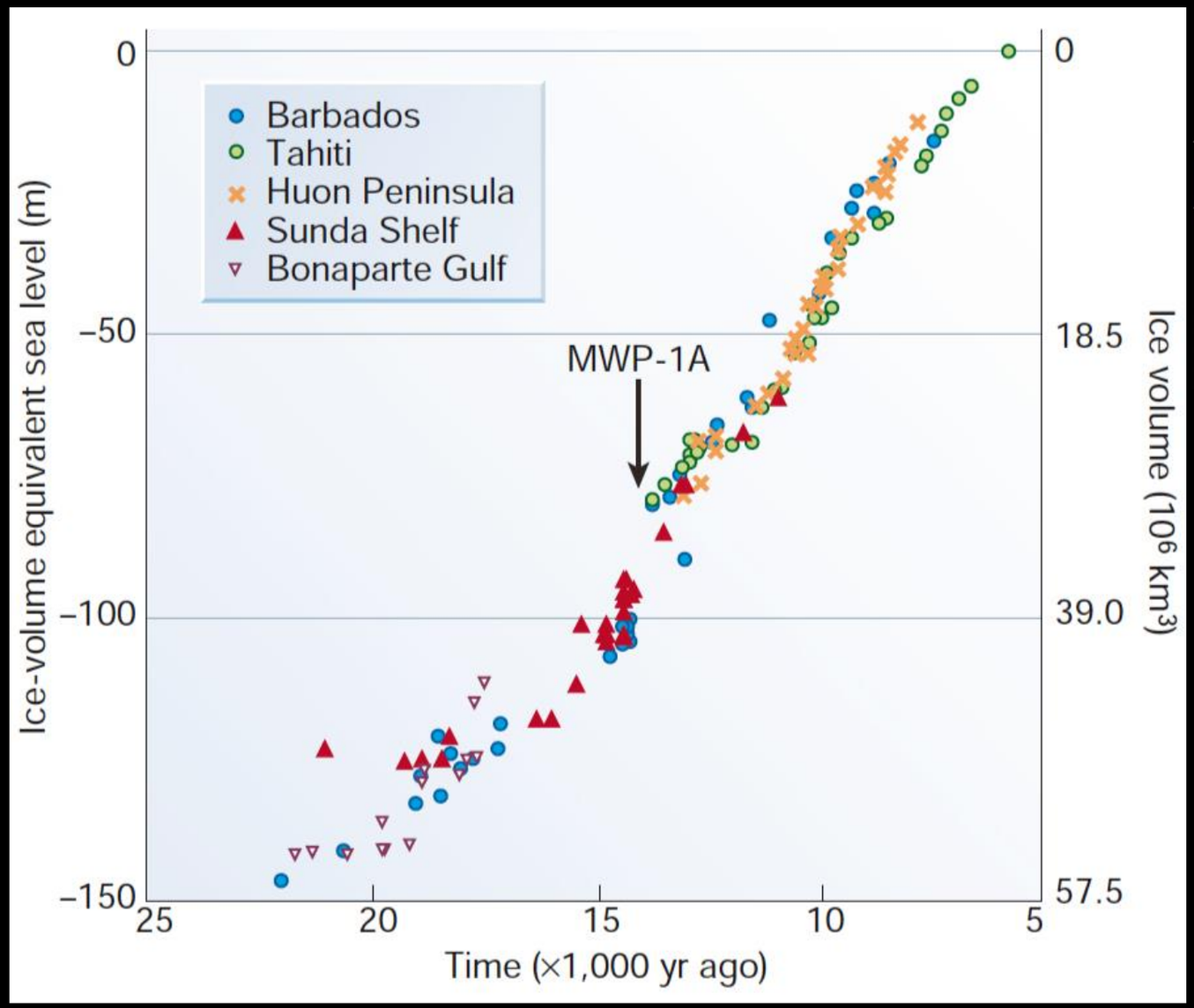
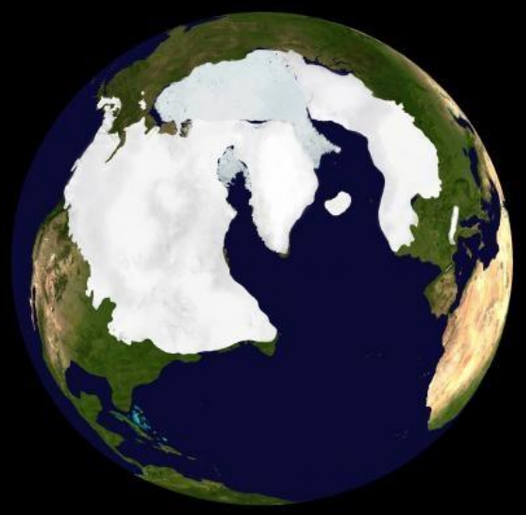
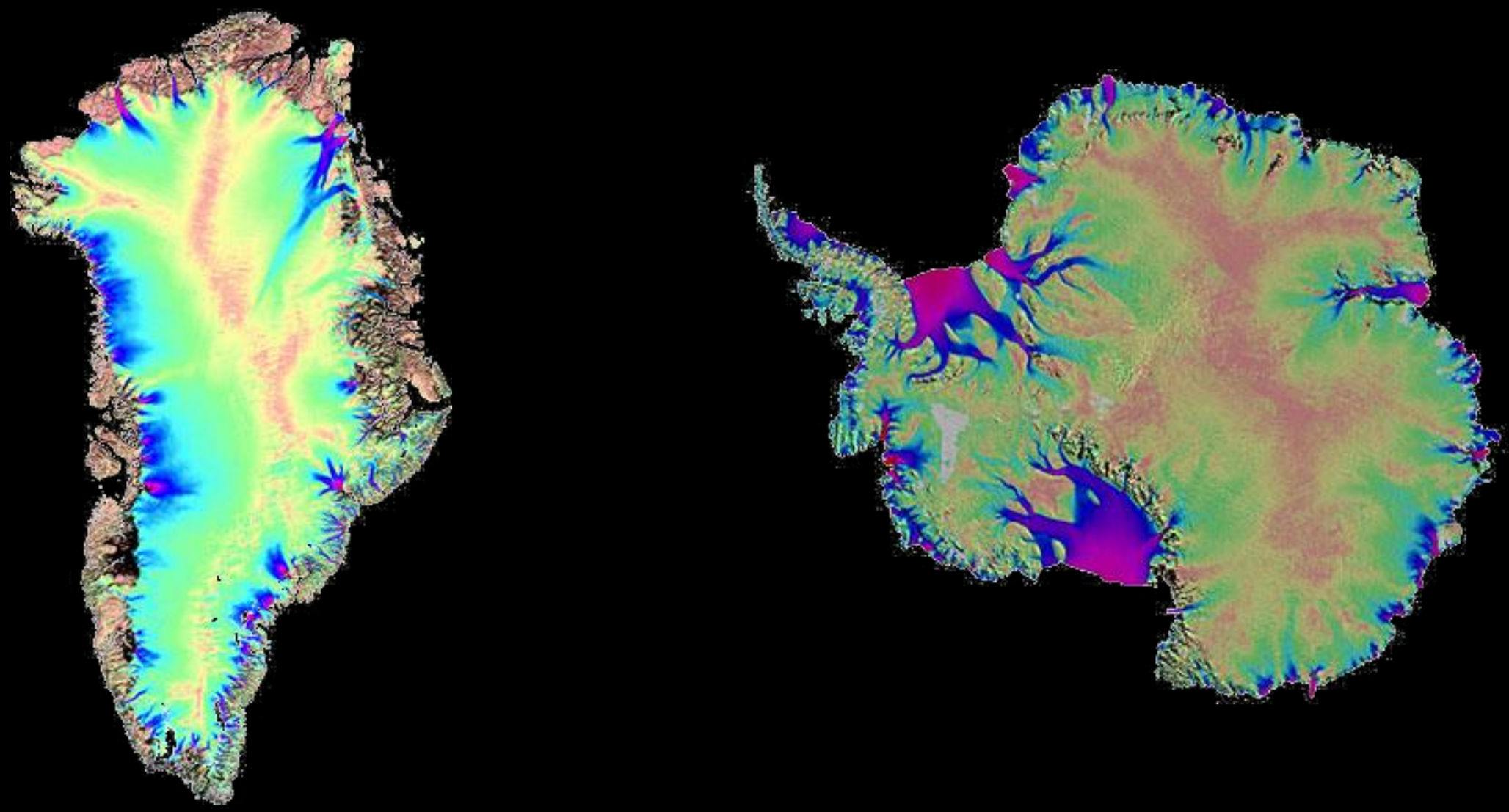
# ice sheets: sea-level pacemaker



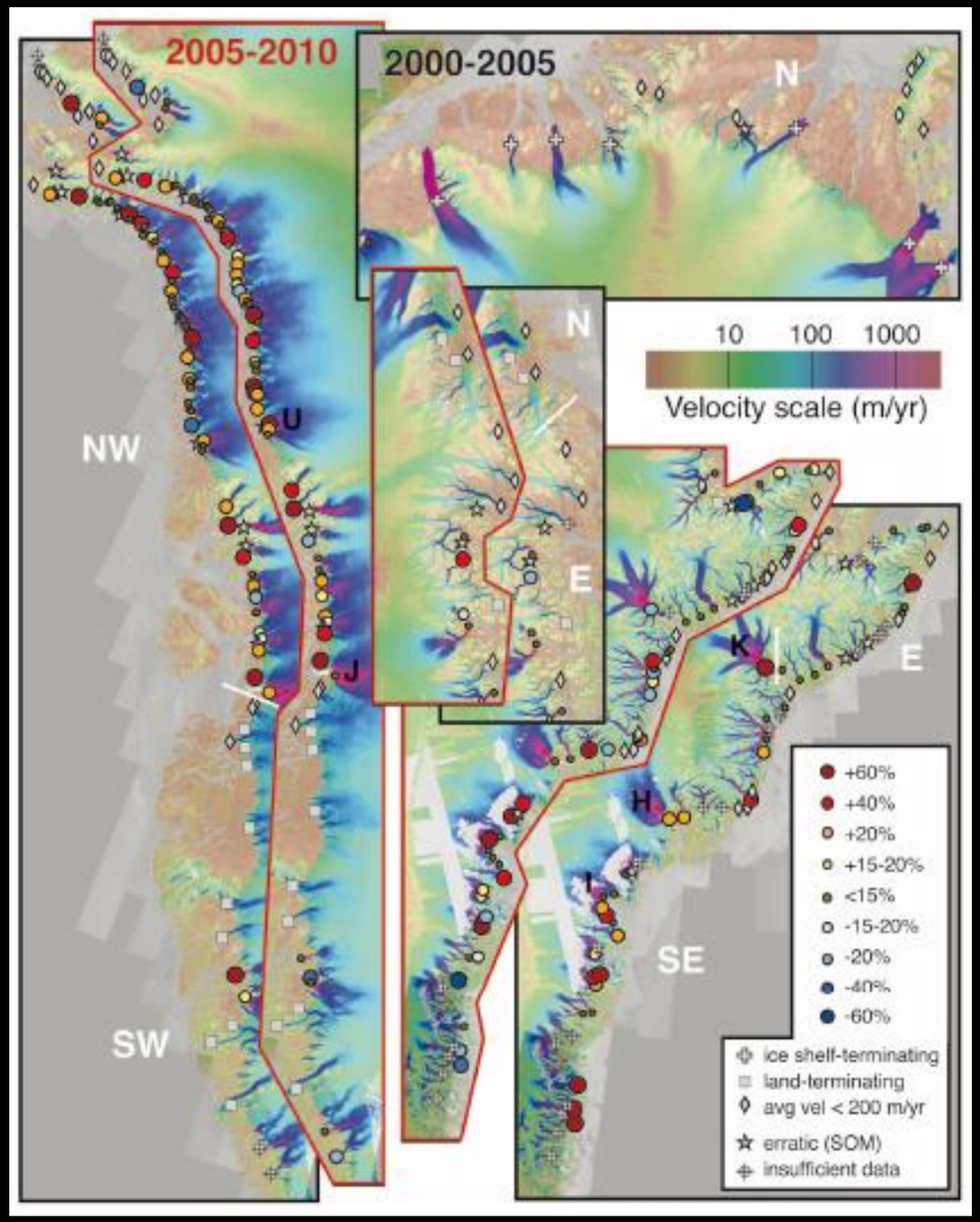



Lambeck et al. 2002

# Ice sheet flow



# Greenland

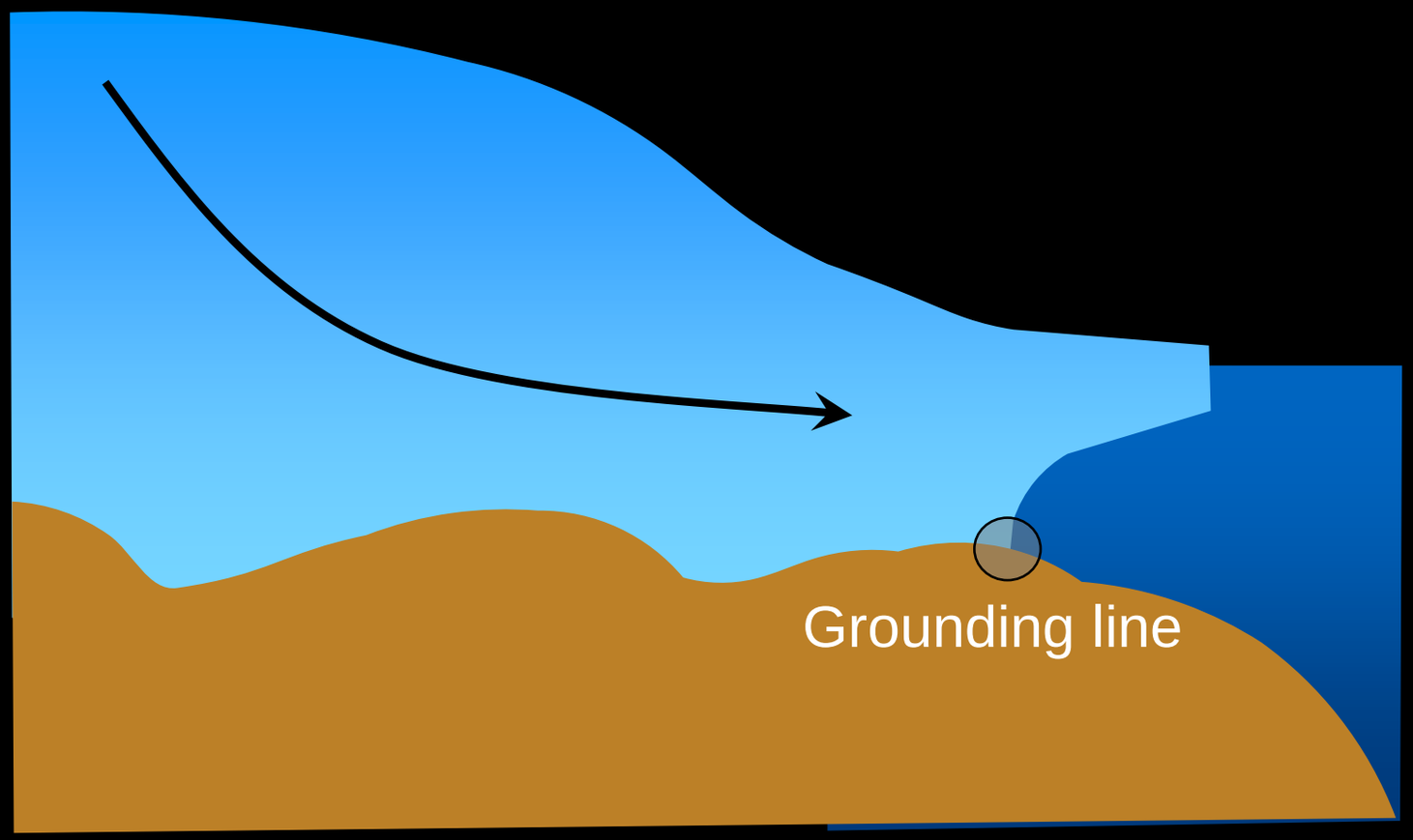



Moon et al. 2012

- General pattern: acceleration N W & E
- Spatial and temporal variability

# Outlet glaciers - Processes

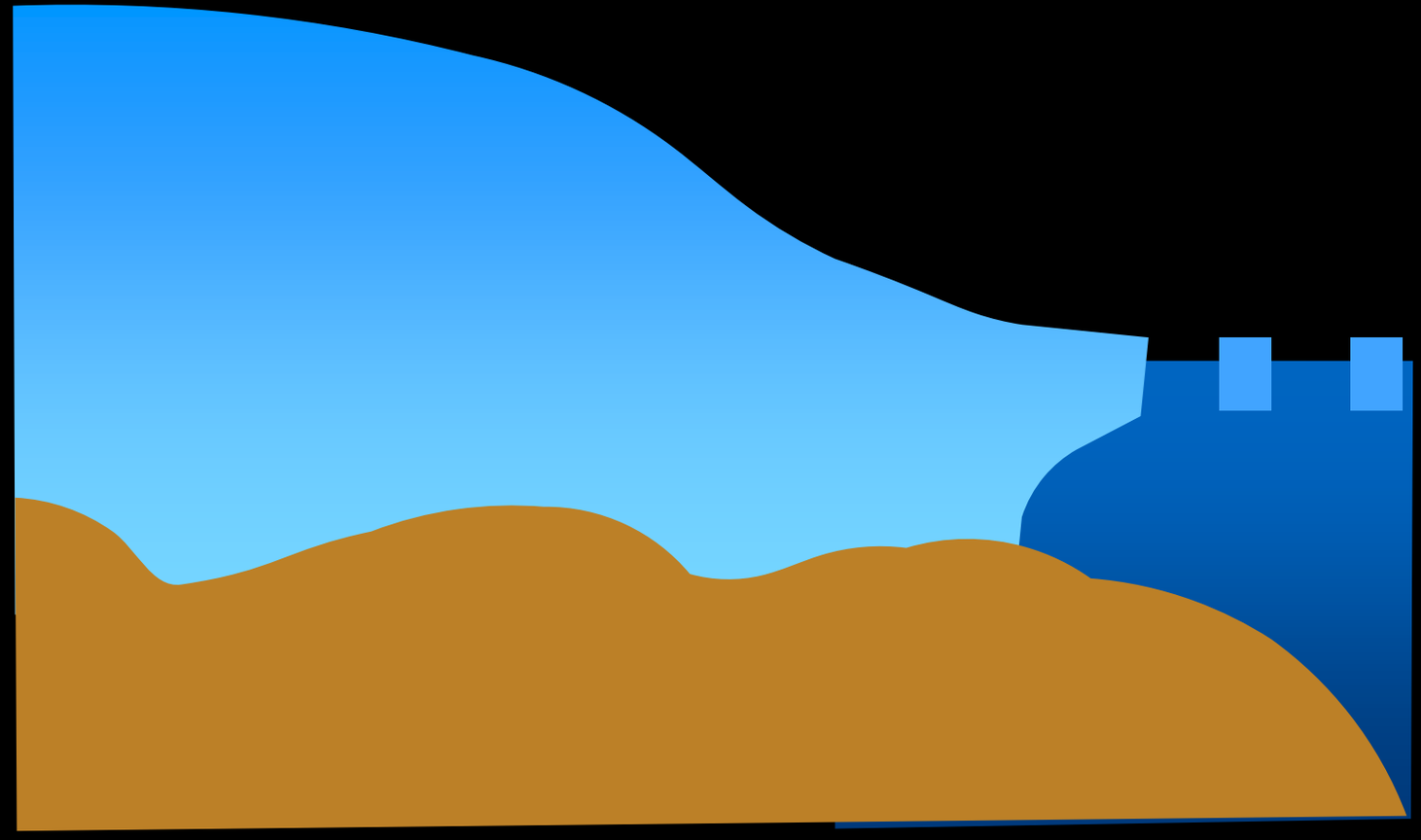





Buttressing

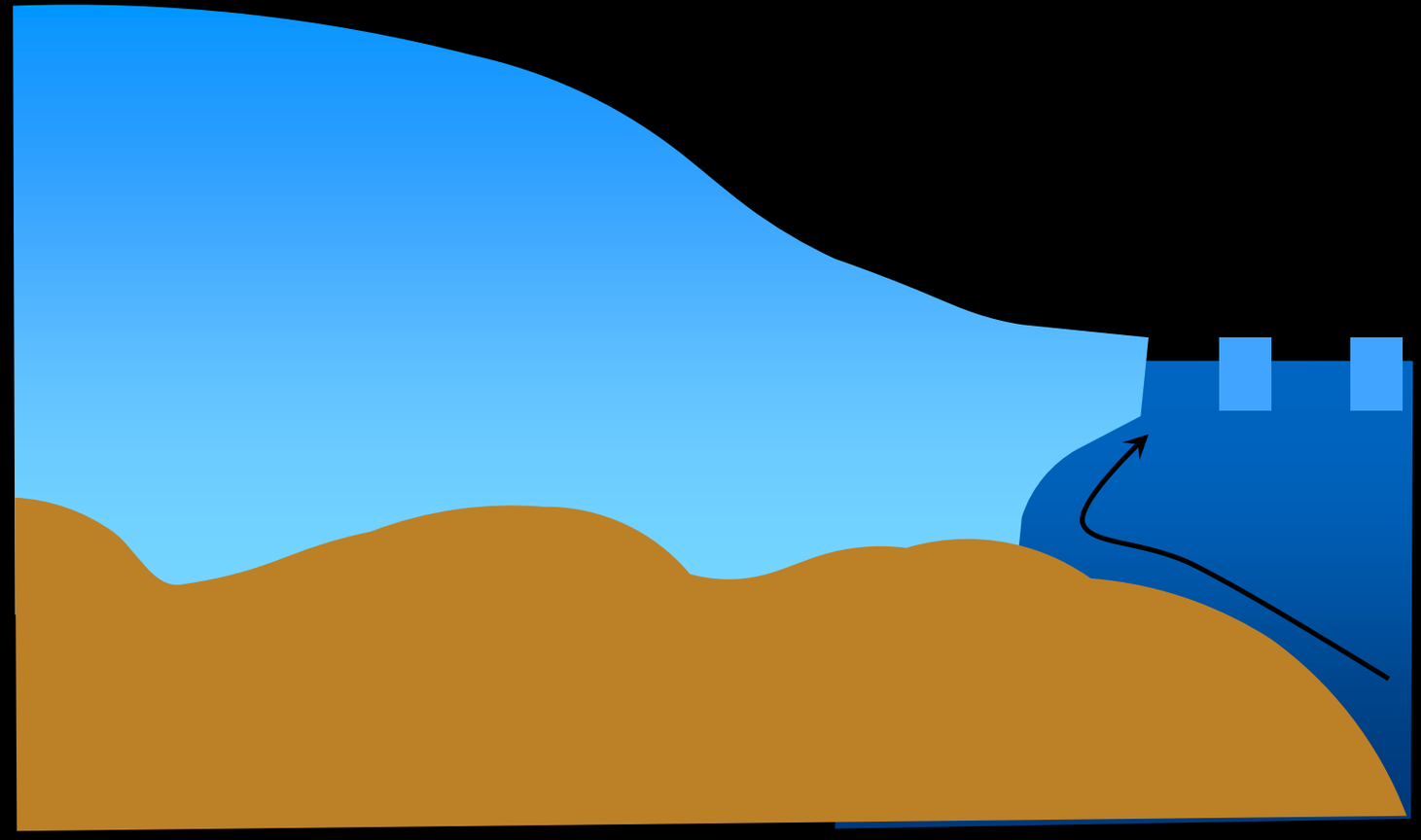
# Outlet glaciers - Processes

Calving



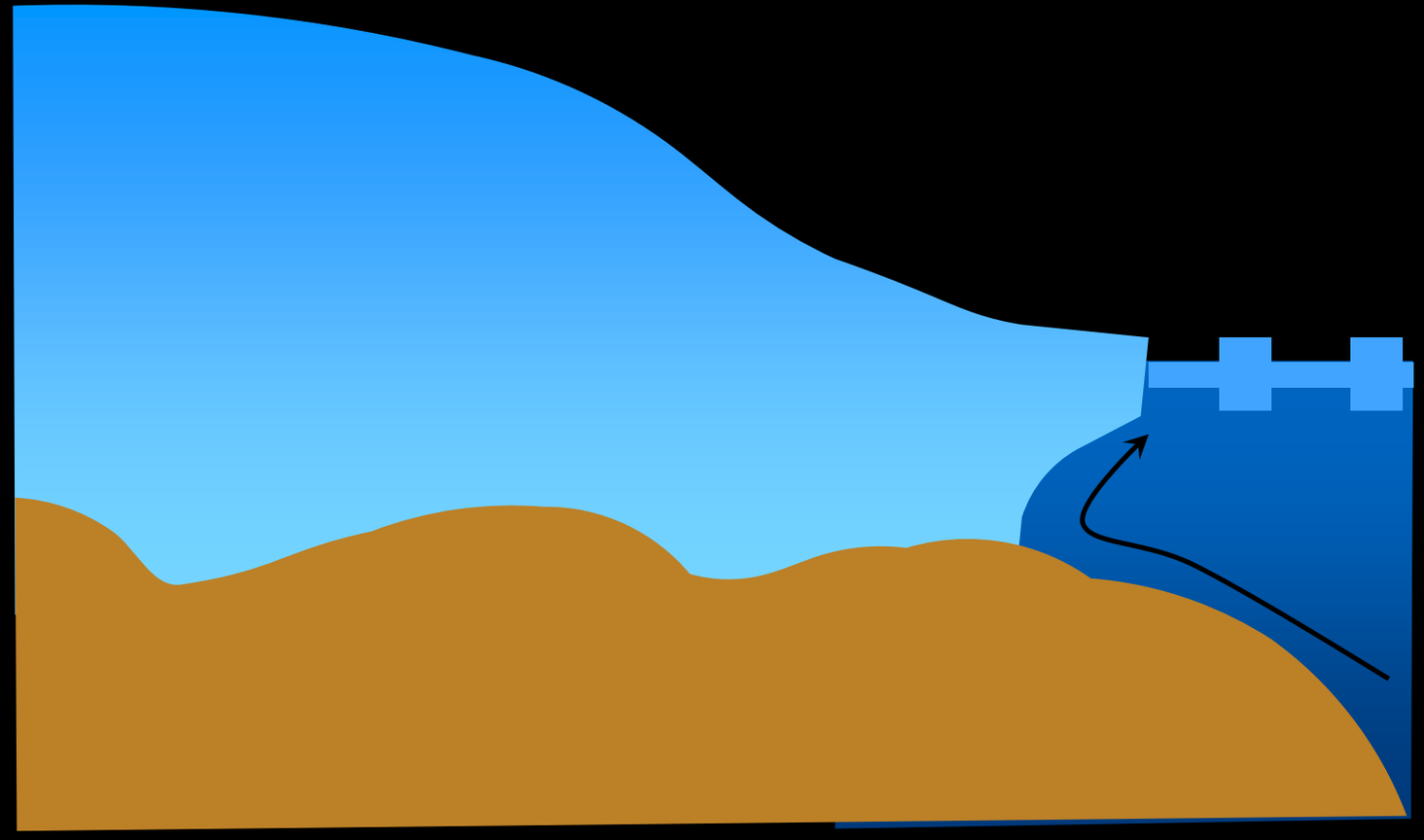
# Outlet glaciers - Processes

Calving
Frontal melting

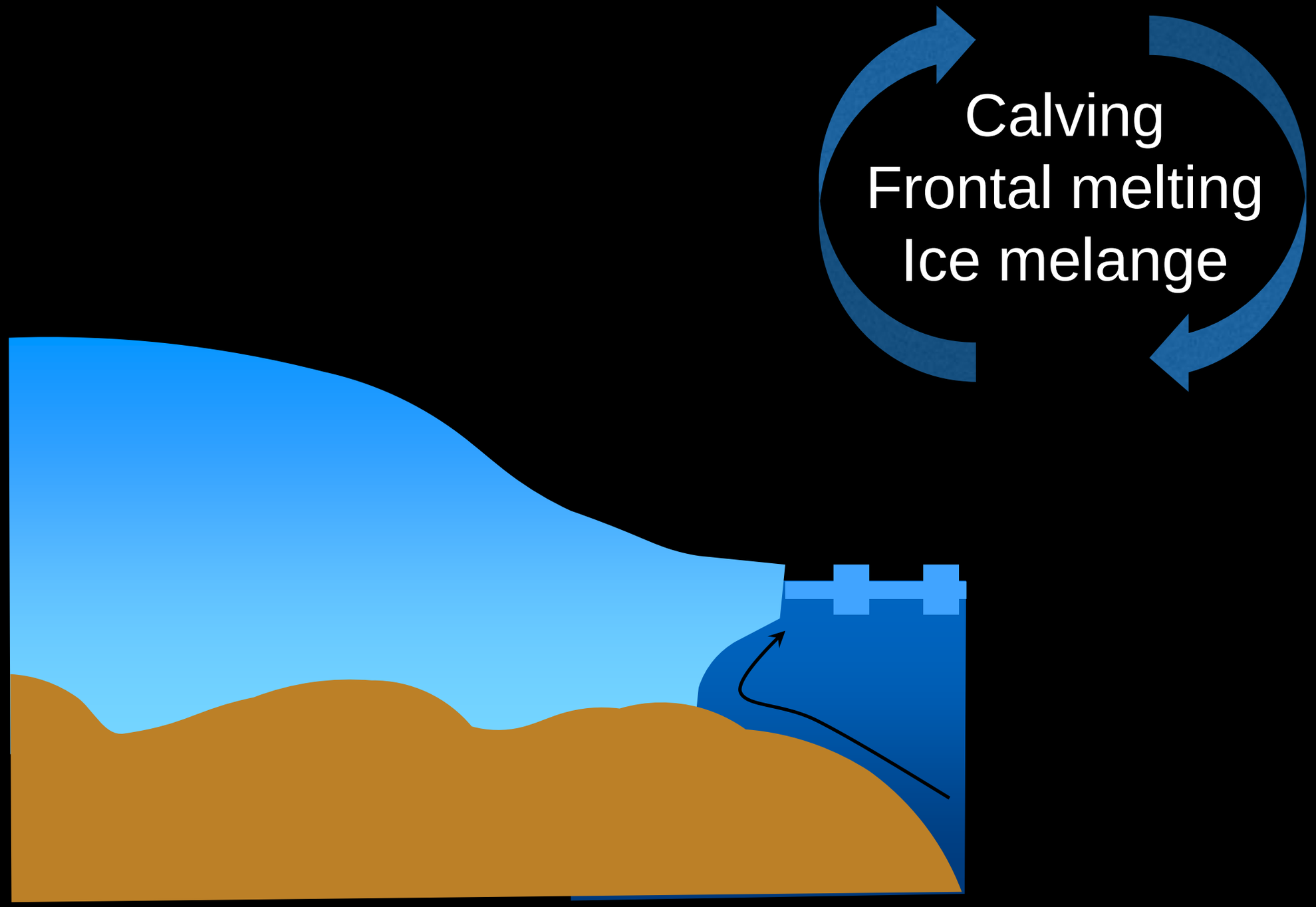


# Outlet glaciers - Processes

Calving
Frontal melting
Ice melange



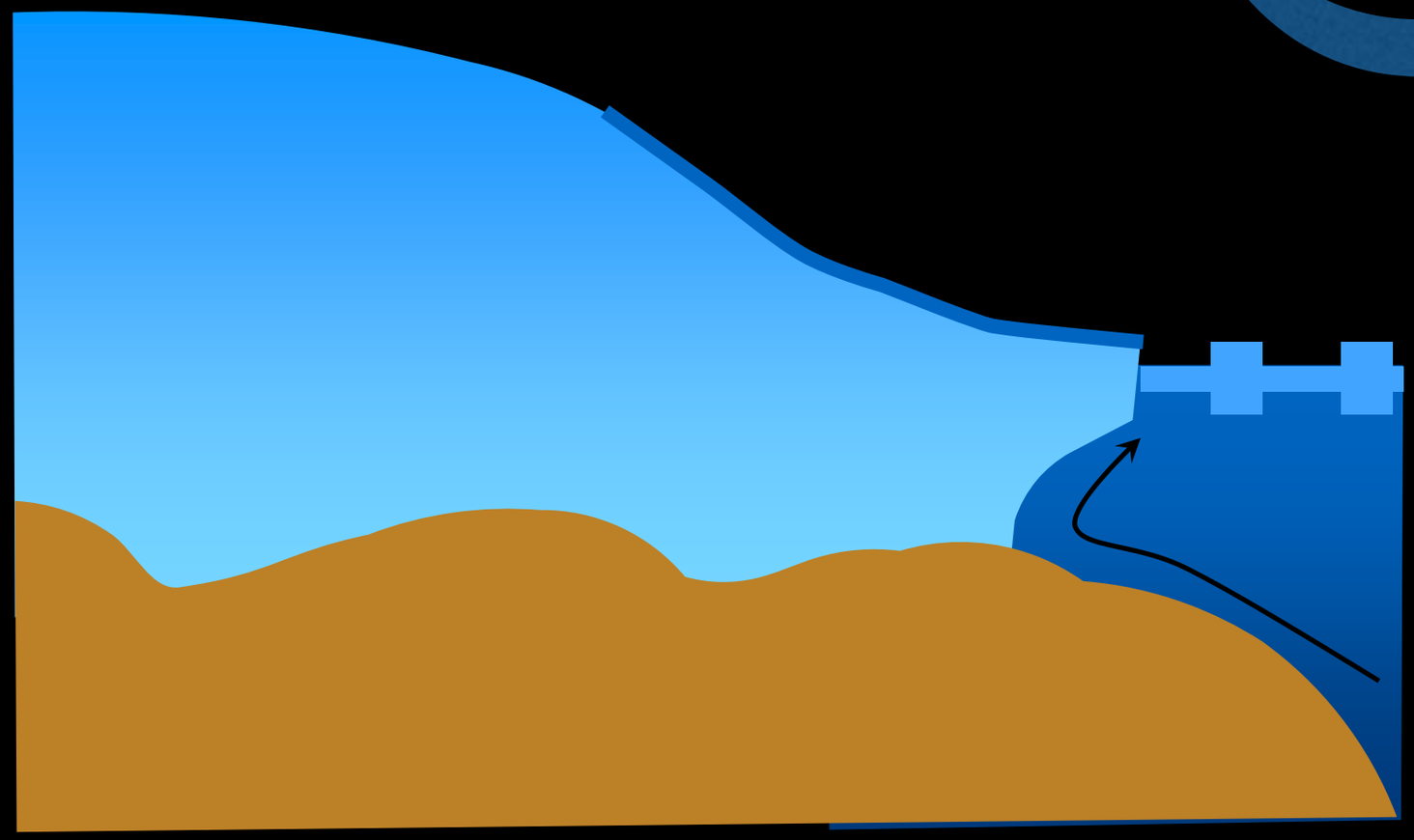
# Outlet glaciers - Processes



# Outlet glaciers - Processes

Surface Mass Balance

Calving
Frontal melting
Ice melange



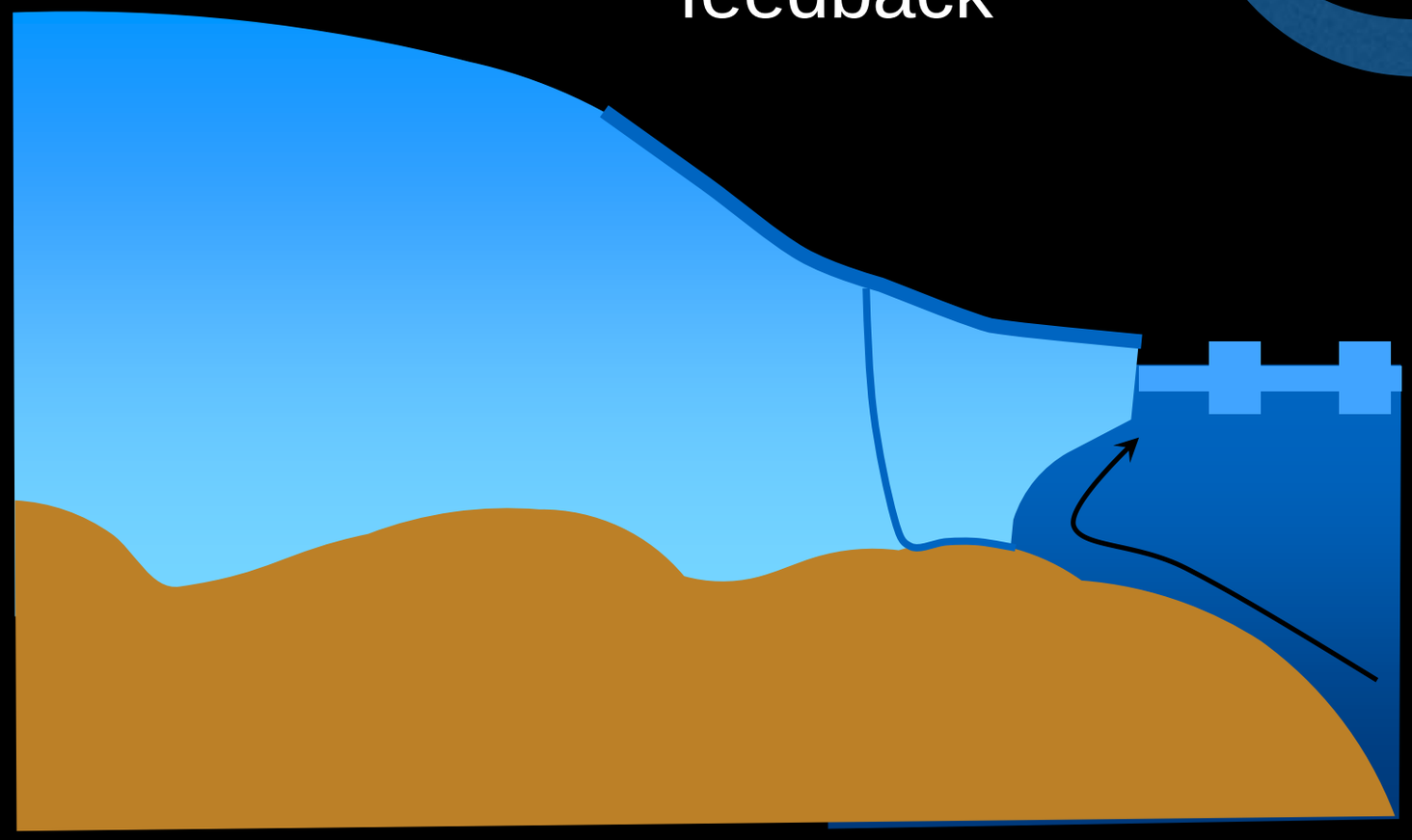
# Outlet glaciers - Processes

Surface Mass Balance

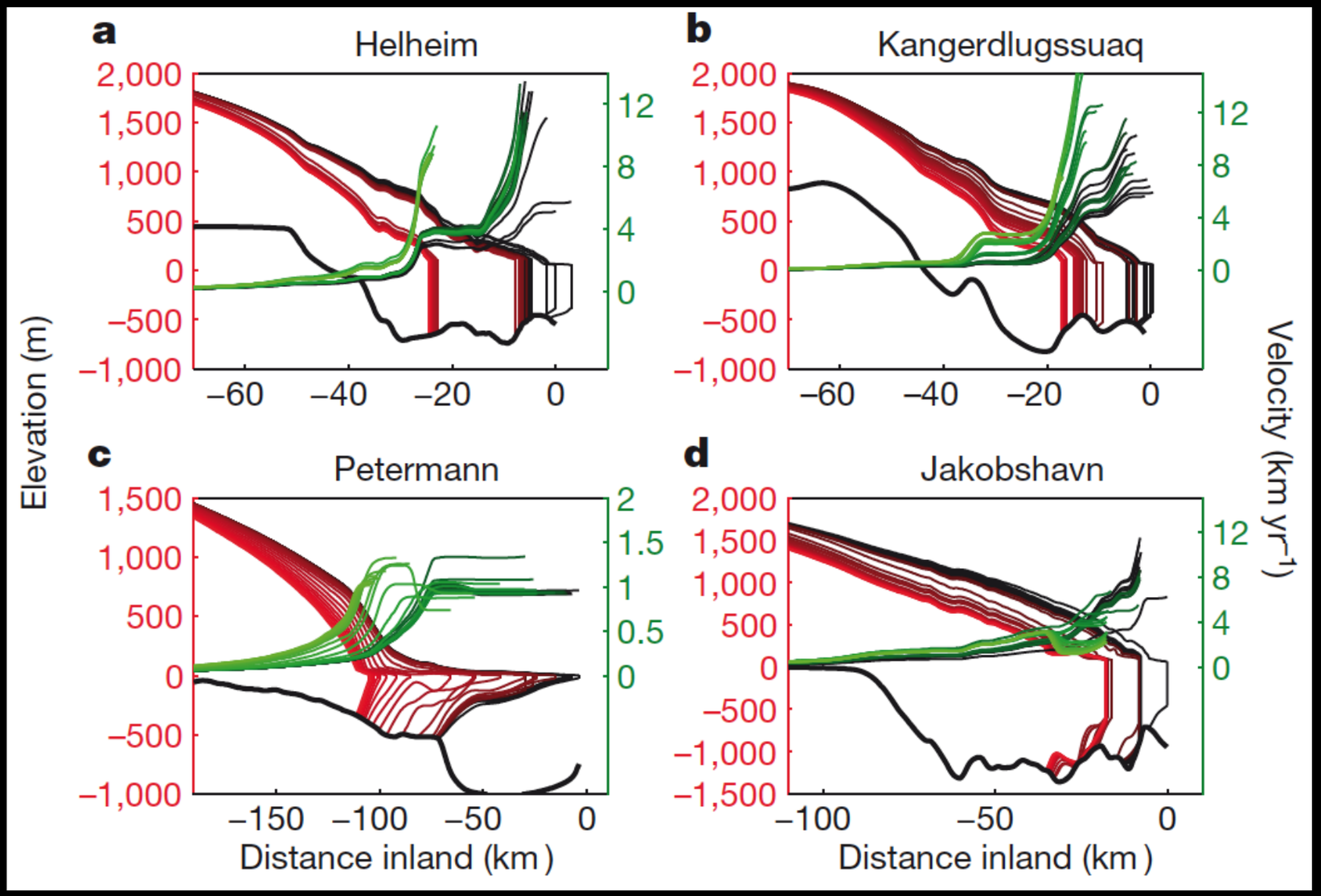
Basal lubrication

Surf-Elevation feedback

Calving
Frontal melting
Ice melange



# Process-based projections



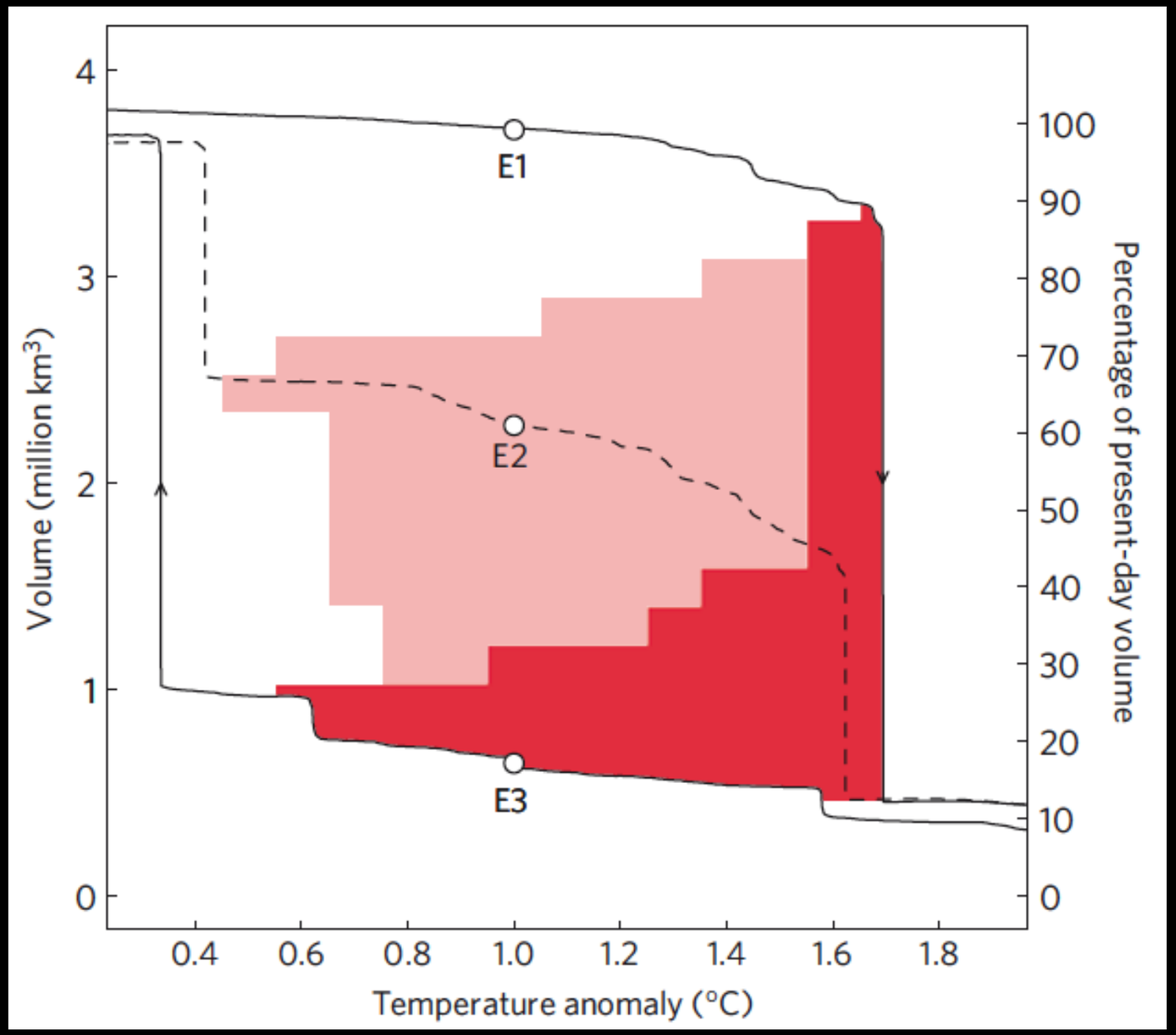

14 – 85 mm
in 2100

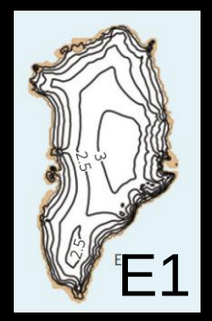
+15% surf-elevation
Feedback

Basal lubrication:
negligible contribution

Nick et al. 2013

# Greenland – multistability



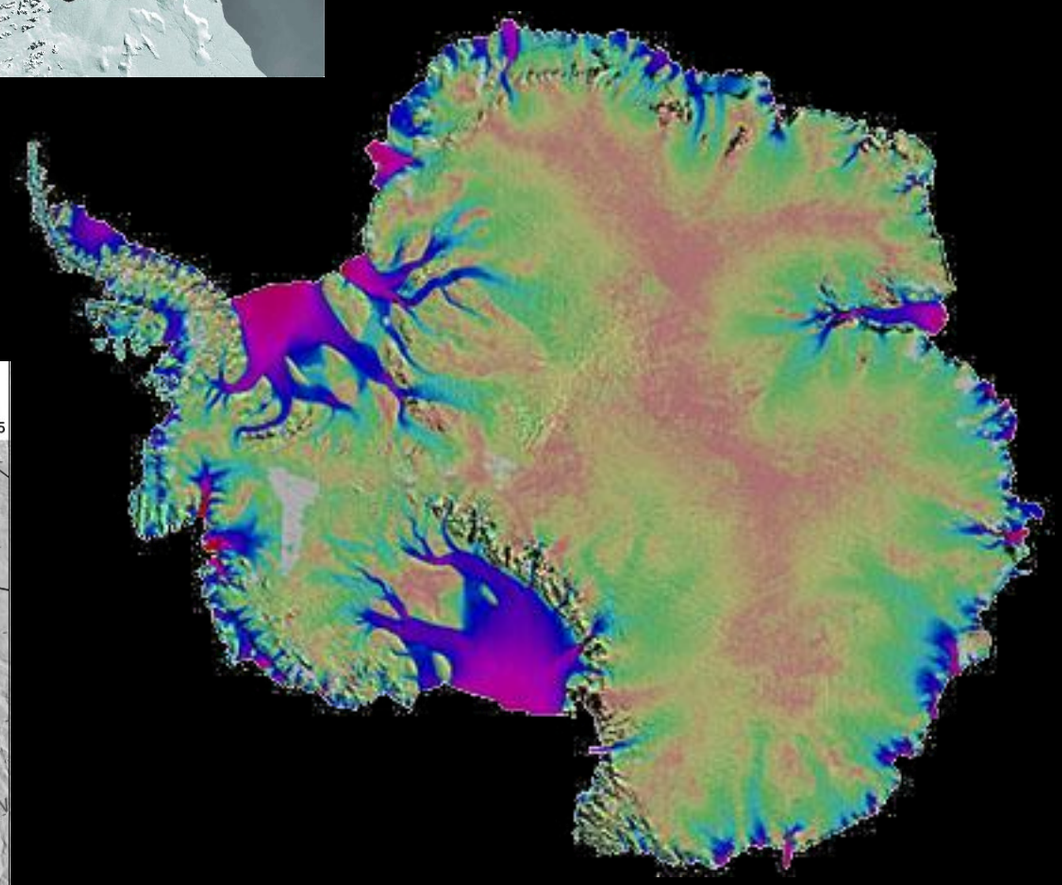






**Timescale depends strongly on magnitude and duration of the temperature overshoot**

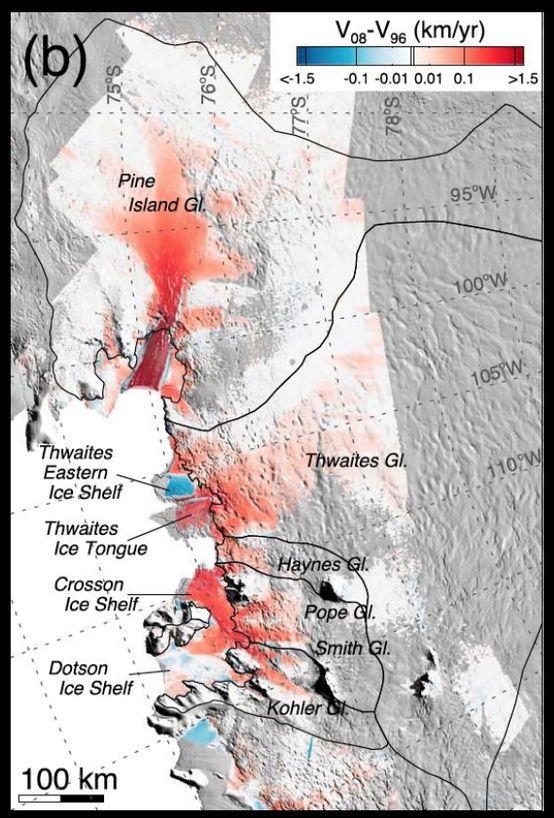
Robinson et al. 2012

# Antarctica

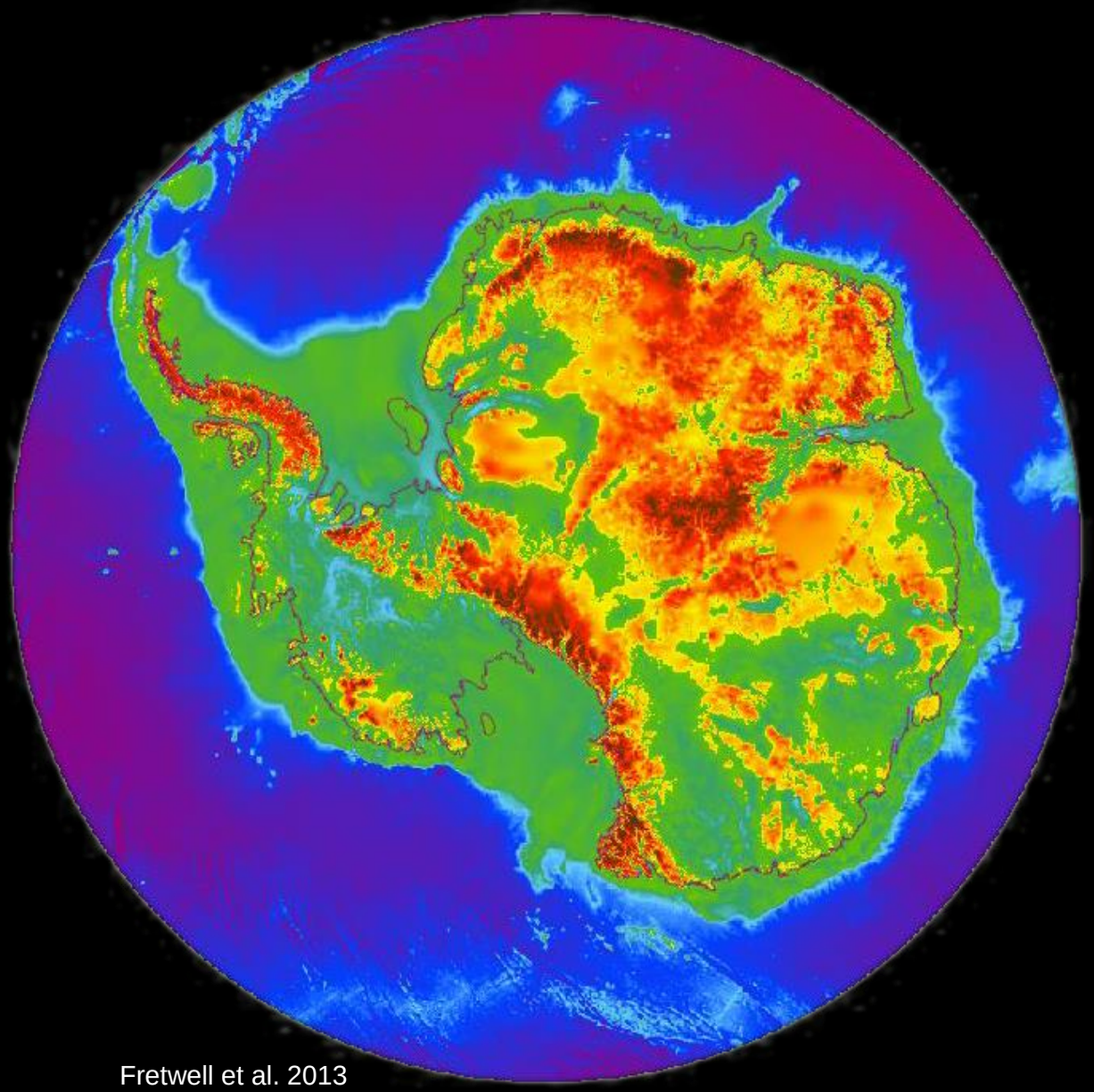
Successive ice-shelves collapses in Peninsula

Amundsen Sea : acceleration and grounding line retreat



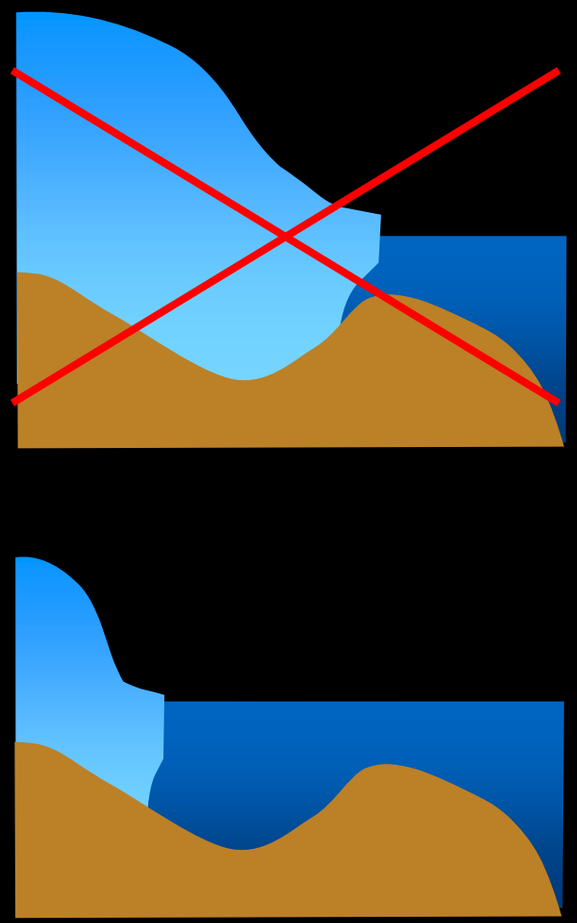

Mouginot et al. 2014

# Antarctica

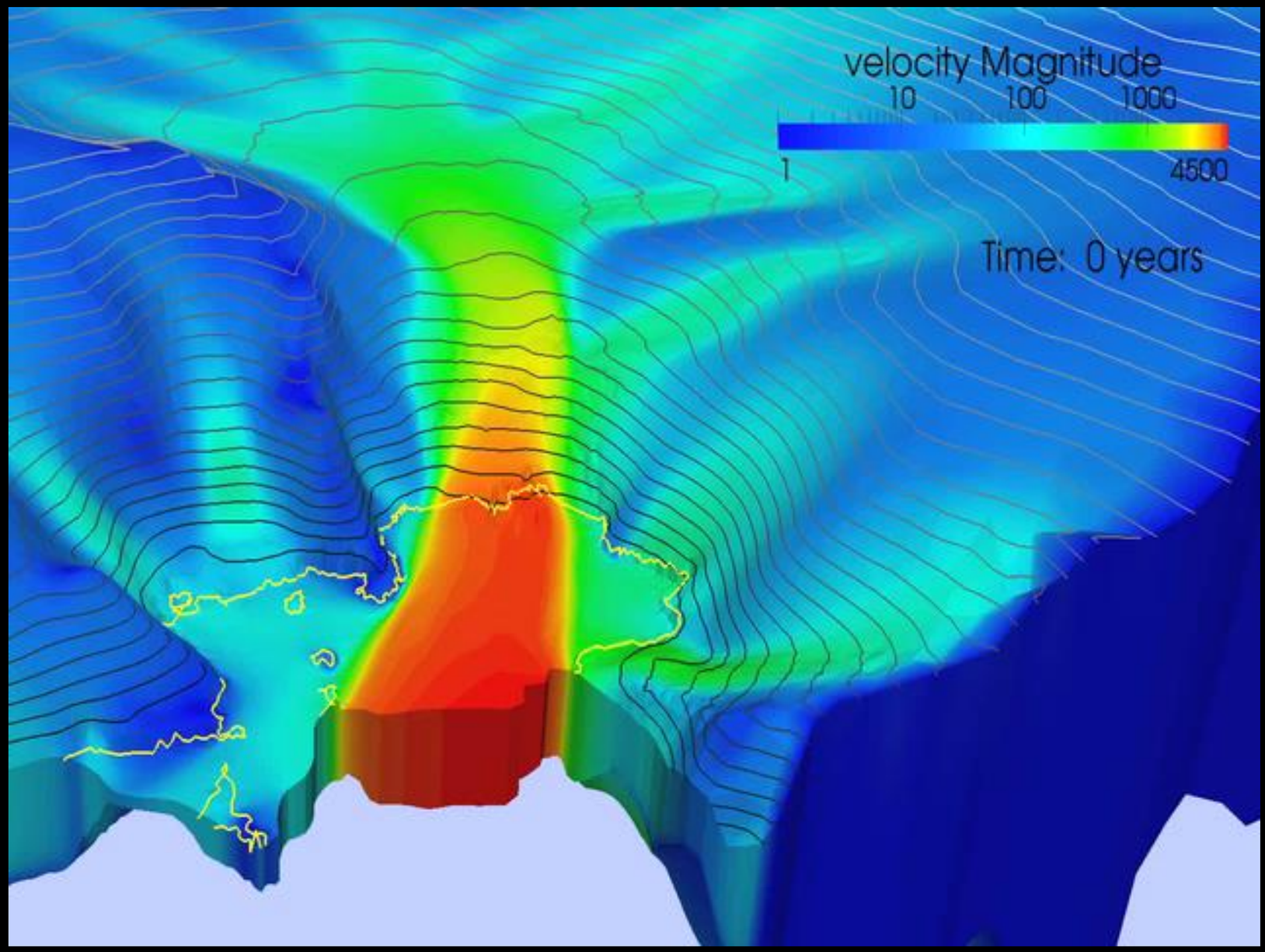


Fretwell et al. 2013

Marine based ice-sheet:
Potential instability (MISI)

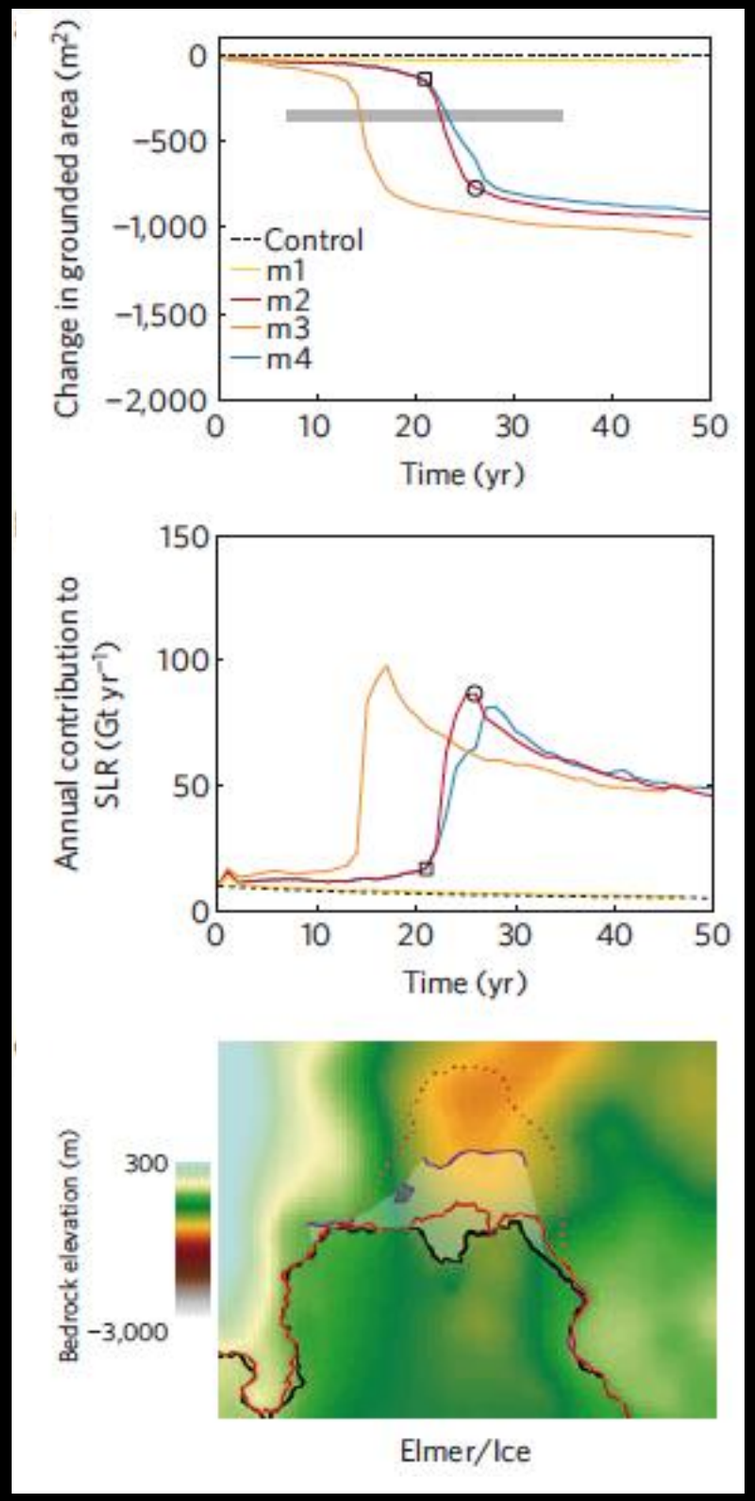


# Pine Island Glacier

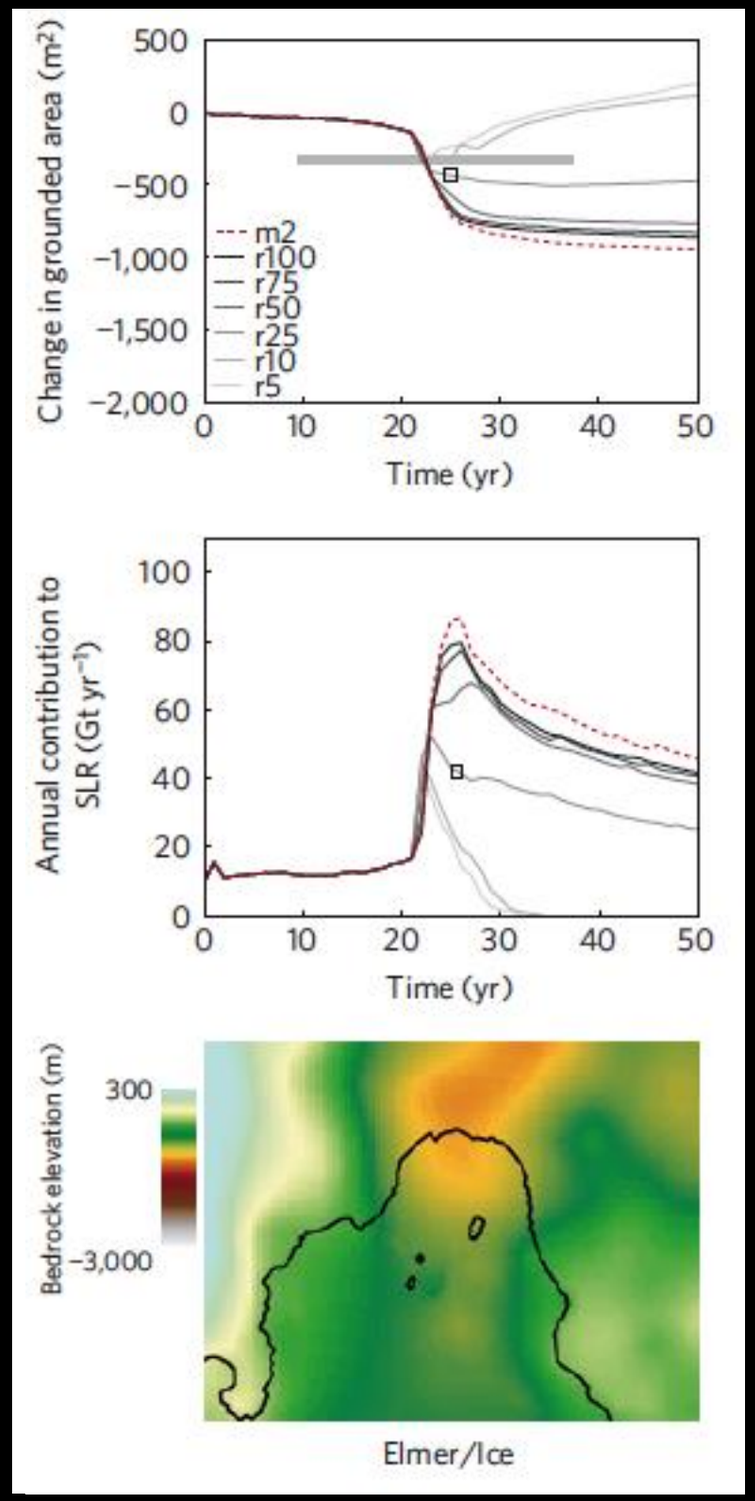



Favier et al. 2014

# Pine Island Glacier




Melt Perturbation



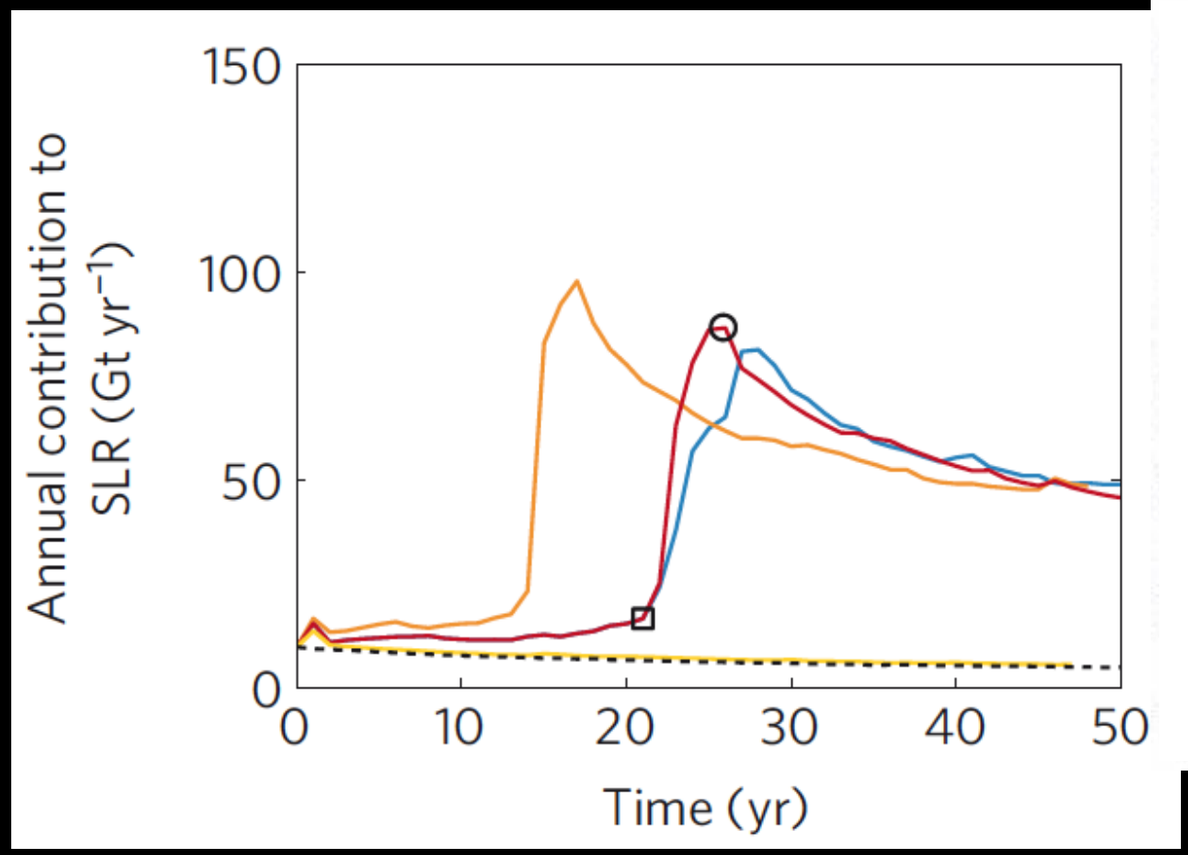

Reversibility

Engaged in a MISI

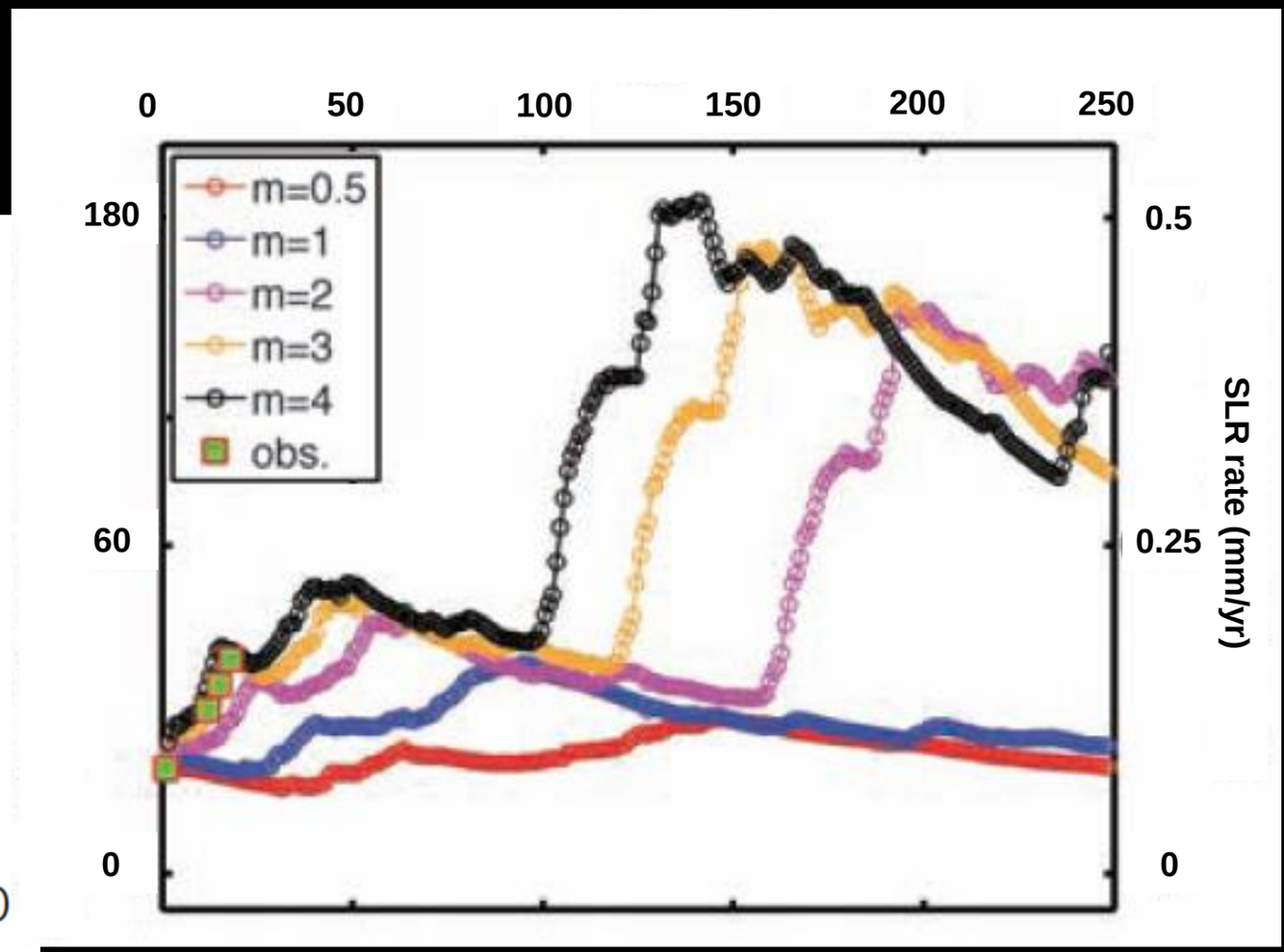
Outflow roughly independent of perturbation

Favier et al. 2014

# Thwaites Glacier



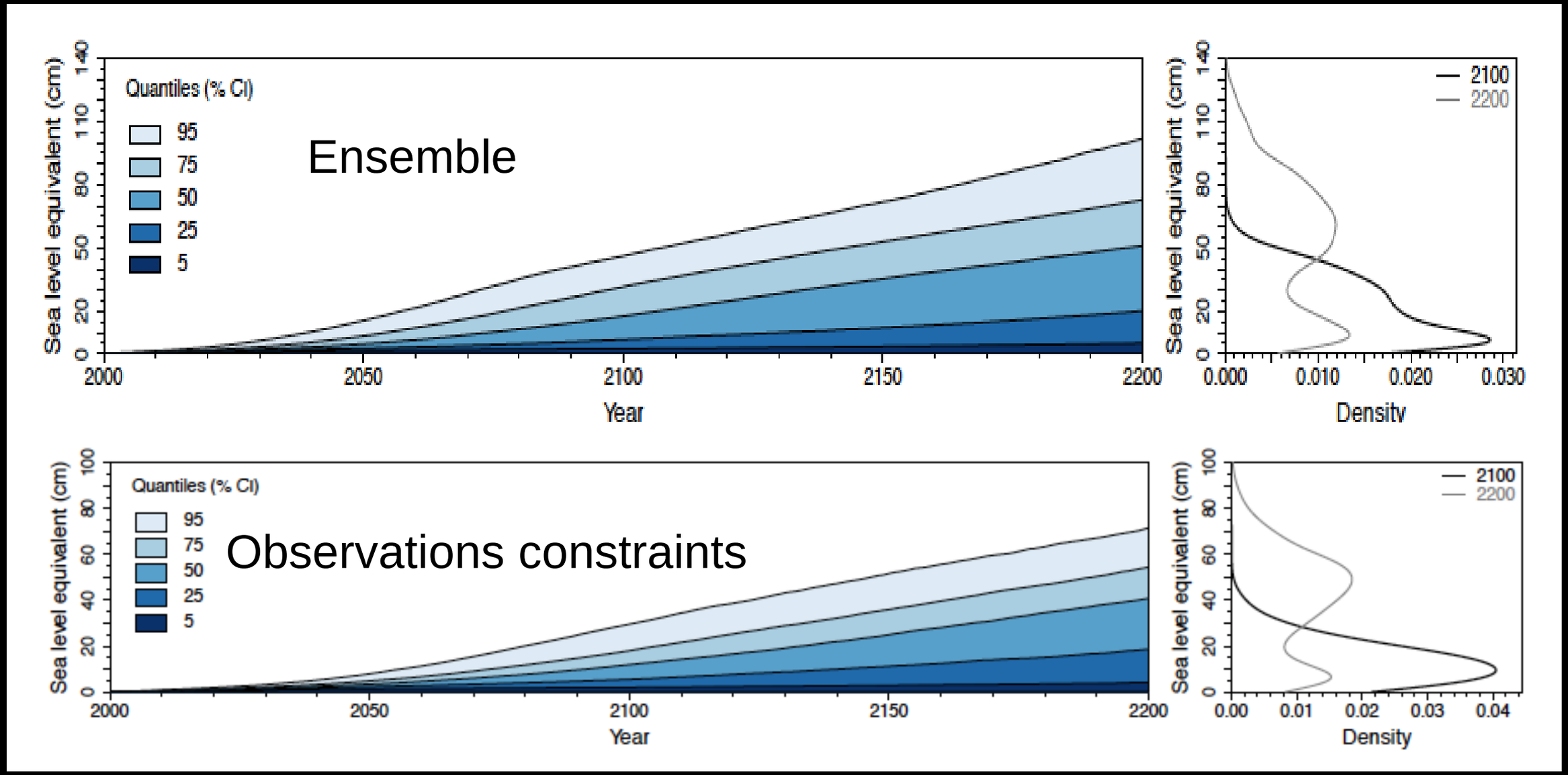

Favier et al. 2014




Joughin et al. 2014

Early-stage collapse may have began

# Ensemble & observational constraints

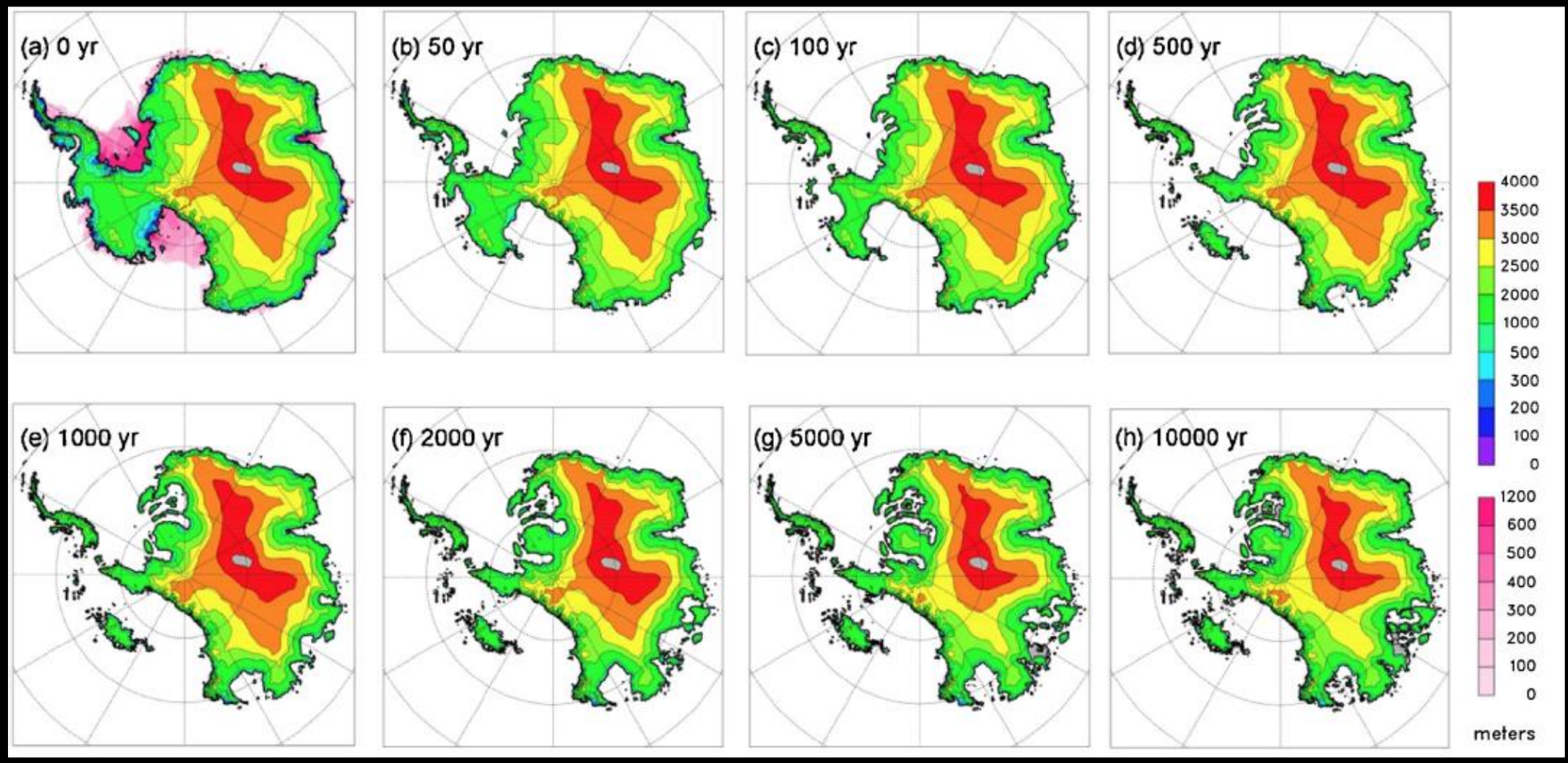



Ritz et al. 2015

Current understanding + Obs -> below 30 cm SLR in 2100

# Forgotten processes?

## Hydrofracturing and ice cliff failure




Pollard et al. 2015

Few m/century

17 m in 5000 years

# Take home message

- ✓ **Greenland + Antarctic SLR contribution likely limited to 50 cm sleq  in 2100**
- ✓ **Greenland and Antarctica close to tipping points**
- ✓ **To improve projections:**
  - **- atmosphere – ocean – ice sheet coupling**
  - **- ice sheet processes (calving, basal friction…)**