Ocean interactions with ice-shelves/sheets

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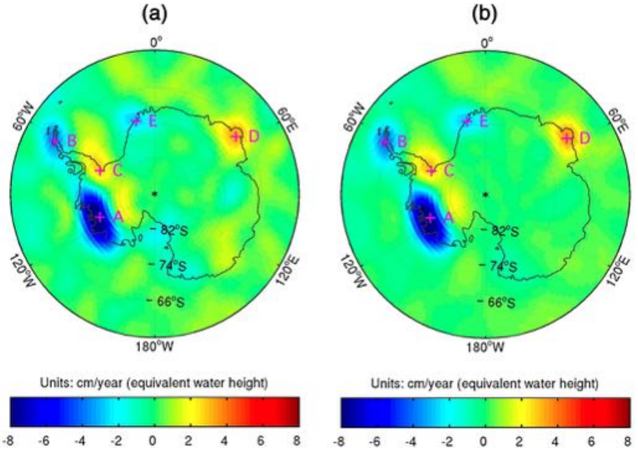
Ice drilling workshop

Outline

- Oceans could be a "blowtorch" at underside of ice shelves.
- Ice shelves provide backstress to grounded ice.
- Grounding lines are where the melt occurs.

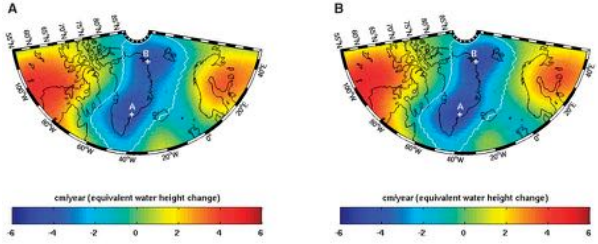
Mass Balance from GRACE

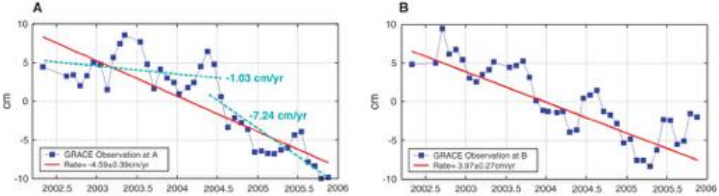


Chen et al., EPSL, 2008

Mass Balance from GRACE

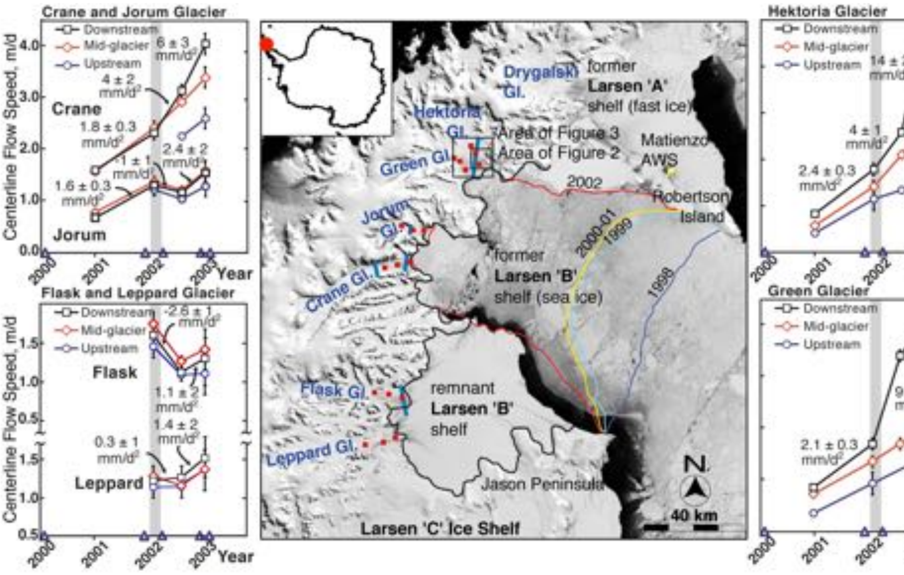
Fig. 2. (**A**) GRACE long-term mass rates over Greenland and surrounding regions during the period April 2002 to November 2005, determined from mass change time series on a 1° grid. (**B**) Simulated long-term mass rates over Greenland and surrounding regions from the experiment as described in SOM text and fig. S1.





Chen et al., Science, 2006

Speedup of Grounded Ice



de Angelis and Skvarca, 2003

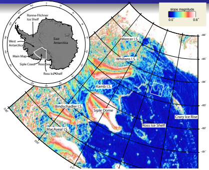
Ice Shelf observations

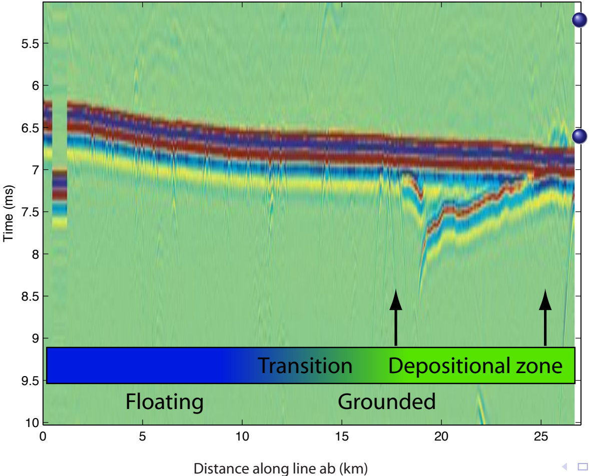
- Physical oceanographic measurements (temperature, salinity, heat flux).
- Basal melt and freeze-on.
- Biota.
- Ice sheet advance/retreat history.

Ice Shelf projects

- LARISSA (Larsen Ice Shelf)
- PIG (Pine Island Glacier)
- WISSARD (Whillans Ice Stream)
- Petermann Glacier
- NE Greenland Ice Stream
- ... Andrill

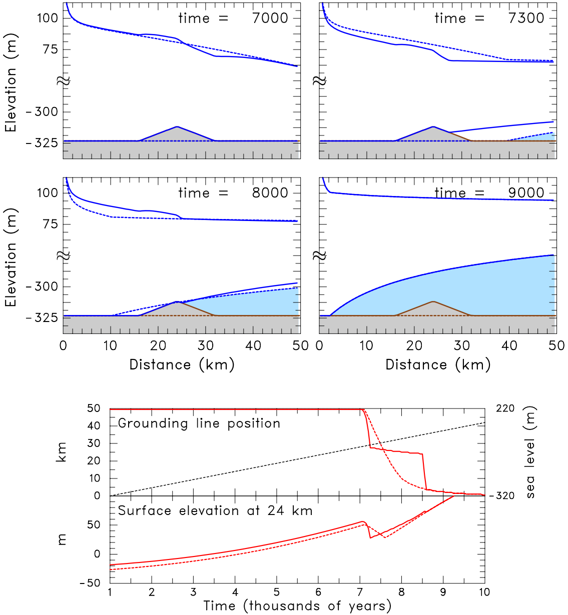
Grounding Line Processes affect Stability





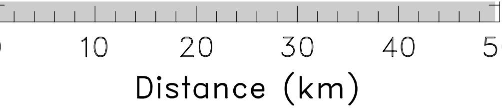
- Colors represent reflection strength.
- Ice thickness $\sim$ 600 m based on $168\, m \cdot \mu s^{-1}$.
- Basal crevasses prominent to left (floating).
- Sub-base reflection: "Till Wedge"

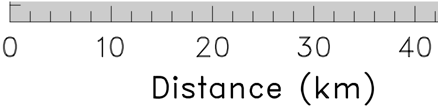
Consequences of Subglacial Till Deposition

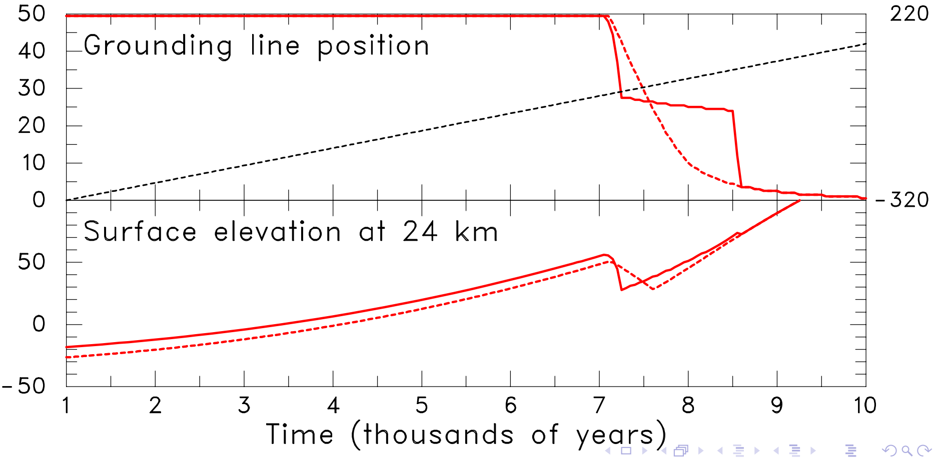


- With a subglacial wedge, grounding line retreat interrupted.
- Grounding line stable for millenium.
- Submarine deposition would not stabilize grounding line.

Consequences of Subglacial Till Deposition







Grounding Line projects

- WISSARD (Whillans Ice Stream)
- Thwaites Glacier (Cresis)
- Byrd Glacier
- PIG, Helheim,
- NE Greenland Ice Stream

Required measurements

- Physical properties (water, sediment, temperature)
- Dynamics of basal environment.
- Microbiology.

Ice Drilling Needs

- Access to underside of ice shelf ($\sim$1000 m thick) for physical oceanography.
  - Commercial instruments are $\sim$25 cm diameter.
  - AUV/ROV (Autonomous, Remotely-operated vechicles are larger (up to 1 m diameter).
  - Hole needs to stay open for deployment (ROV/AUV: ... and retrieval).
  - Ice shelves are crevassed, but safe areas are helo accessible.
- Accesss to grounding zone for sedimentation data.
- Lightweight (twin-otter/helo), rapid (days), hot water drill.
- Data cables remain in frozen hole.

Ice drilling needs for geophysics

- Shallow access holes ($\sim$30–100 m) for shotholes.
- Deep access holes (full ice depth) for basal heat flux.
- Access holes for instrumentation (strain, EM, acoustics, seismics, etc.)