# Monitoring fjord circulation ^ *and ice mélange and shelf circulation using GPS-tracked icebergs*

Fiamma Straneo, Bob Pickart (WHOI)
Gordon Hamilton (UMaine)
Leigh Stearns (UKansas)
Ginny Catania (UTexas)
Jonathan Nash, Emily Shroyer (Oregon State U)
John Mickett (UW/APL)
Aqqalu Rosing-Asvid (GINR)
….and many others

*Dave Sutherland*
*University of Oregon*

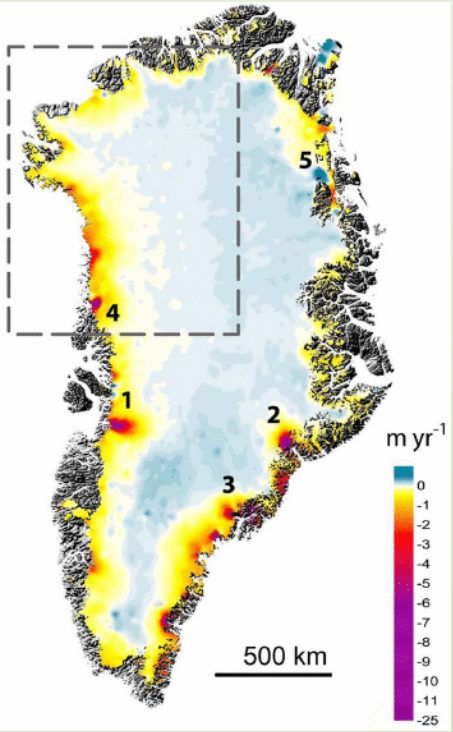
KISS workshop
Caltech, June 2014

UNIVERSITY OF OREGON

*(photo: D. Carroll 2013)*

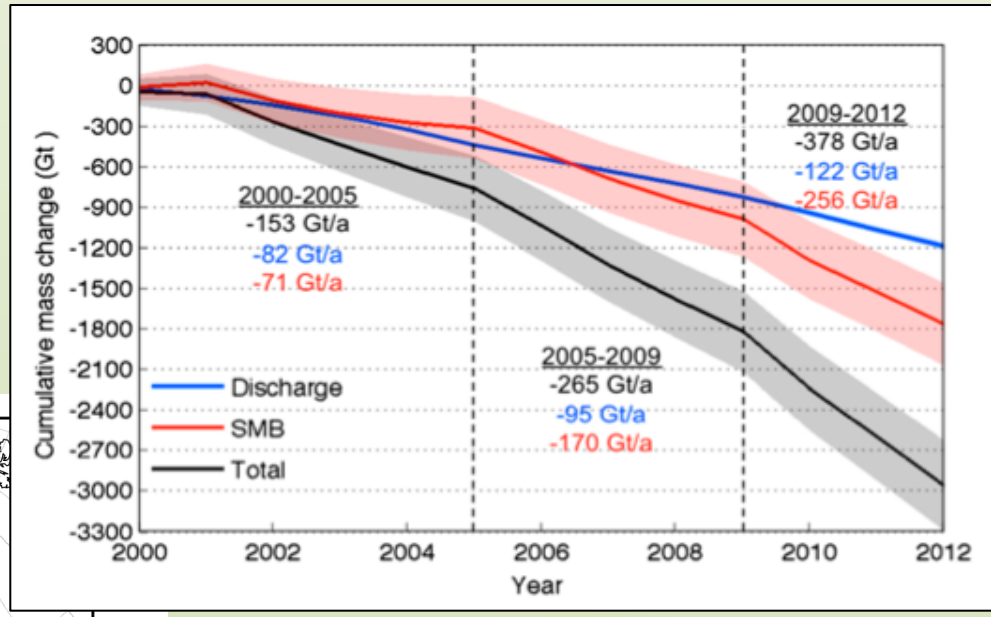
# Greenland Ice Sheet variability

- Accelerating rate of mass loss
- Change is most rapid at edges

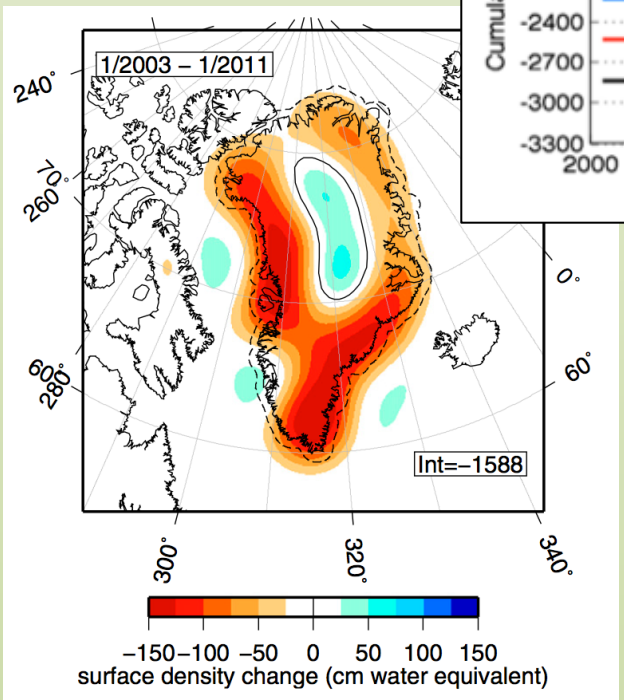



**ICESat**

*(Schenk and Csatho, 2012)*




*Enderlin et al. 2014*




**GRACE**

*(Harig and Simons, 2012)*

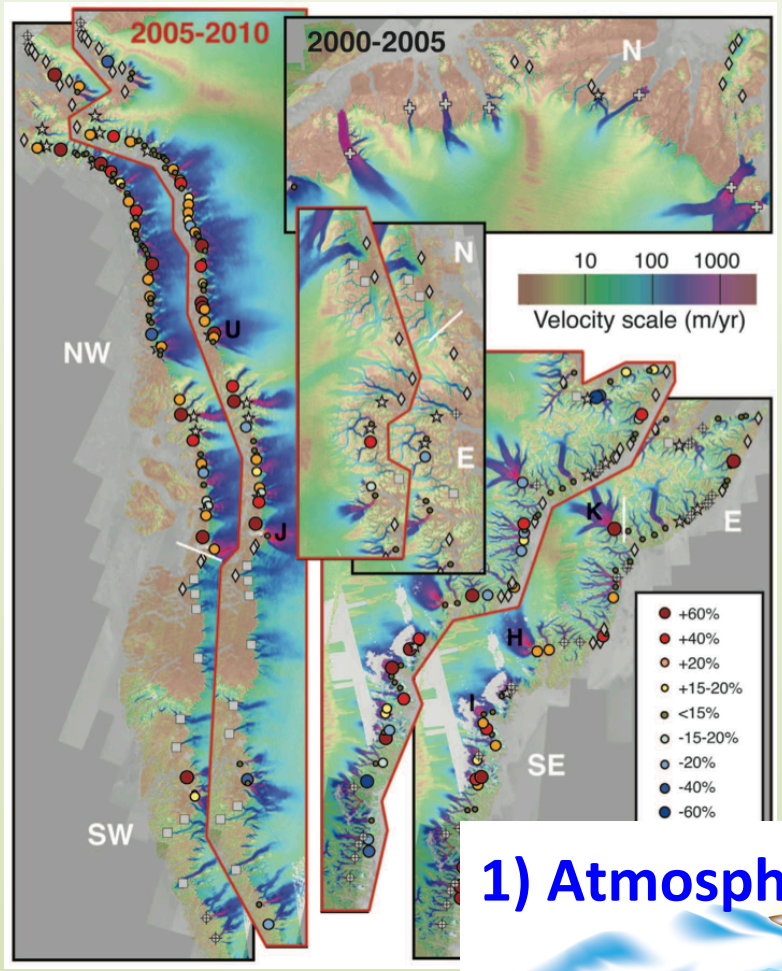
- Icebergs decreasing on Labrador Shelf and Grand Banks

*(Timco, Canadian Ice Service, 2007)*

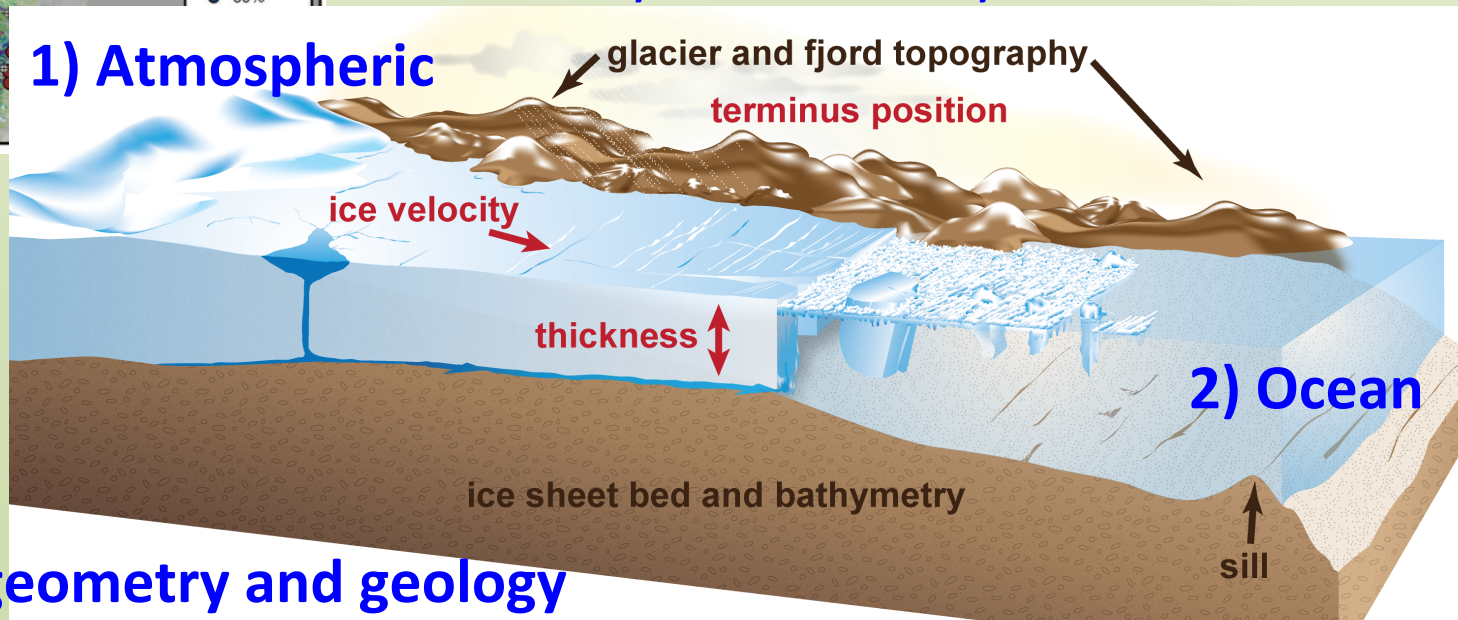
# Outlet glacier variability

- 200+ outlet glaciers: where change is happening
- Surge in interest in ice-ocean processes *(e.g., US CLIVAR working group)*
- **Not just Greenland**: SE Alaska, Patagonia, Antarctic Peninsula

What mechanisms link outlet glacier variability to climate system?



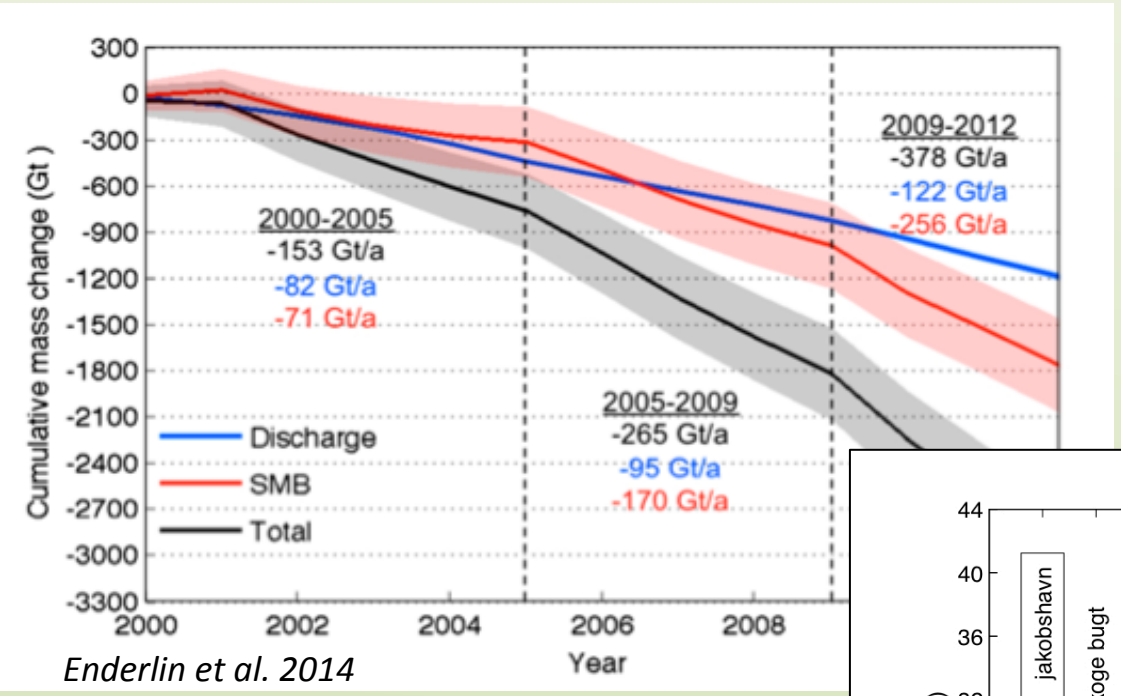

*Moon et al. 2012*



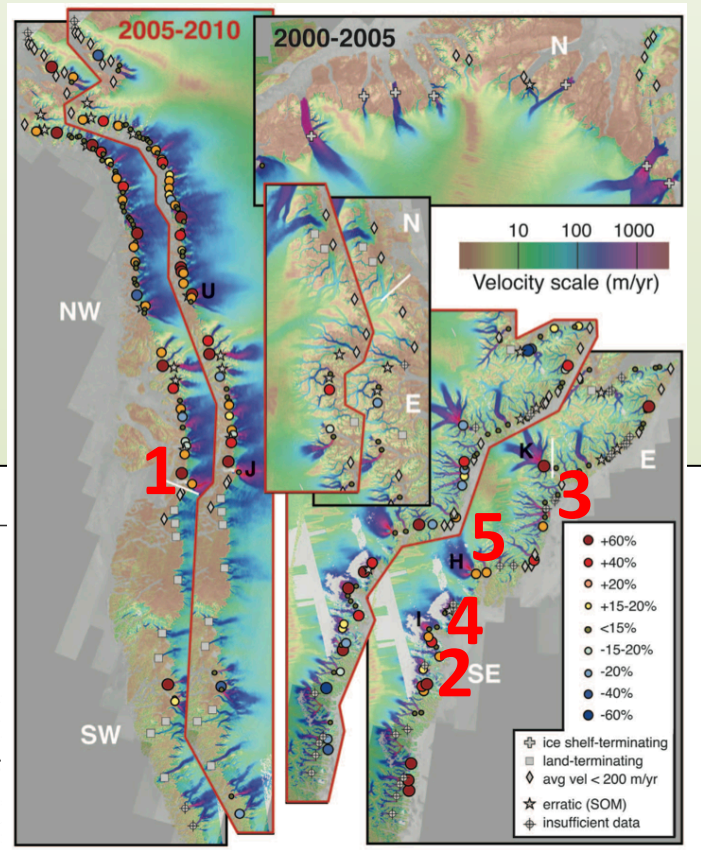

**3) Glacier/fjord geometry and geology**

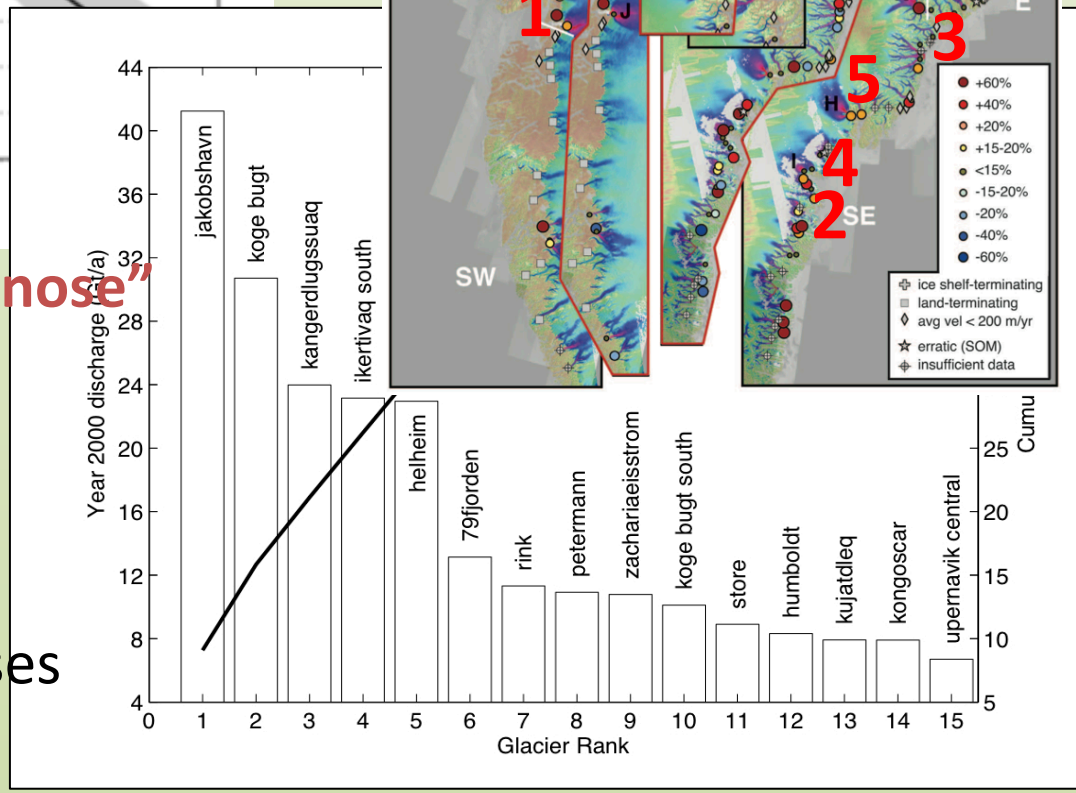
# Icebergs from Greenland

*Moon et al. 2012*




*Enderlin et al. 2014*




**and as a tool to "diagnose"**
**fjord circulation**

Impacts:

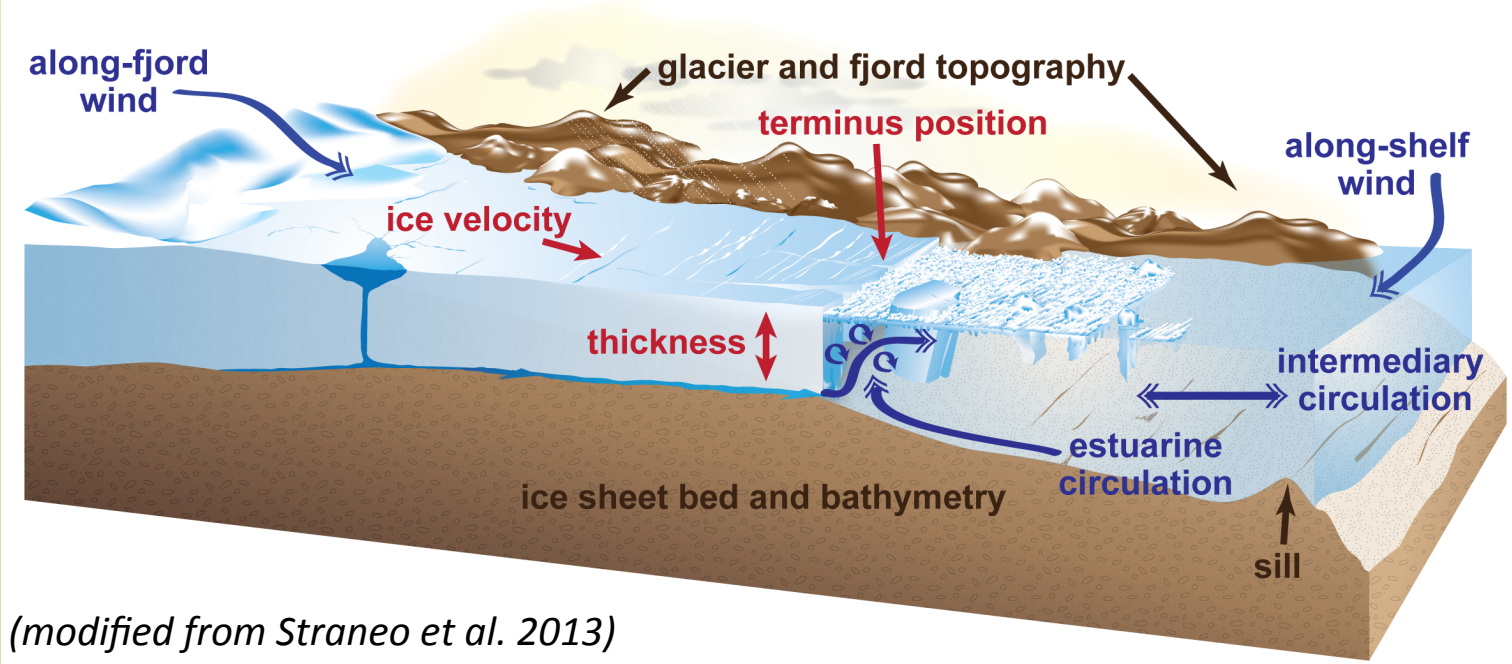
- global sea level rise
- freshwater distribution
- sediment distribution
- catalyst for biological processes
- shipping risks

# Fjord circulation: what do we expect?

Mechanisms: → Linked to 3 triggering mechanisms for glacier variability:

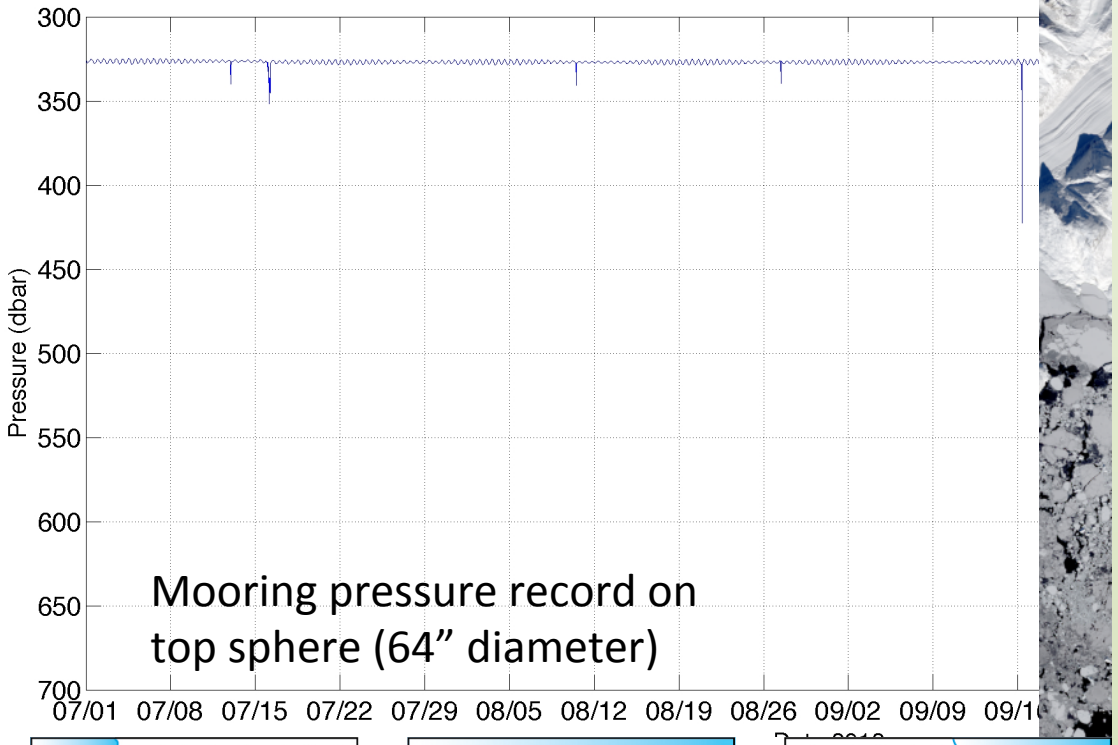
- Estuarine circulation
- Intermediary circulation
- Along-fjord winds
- Tidal processes
- Internal waves
- Hydraulic control

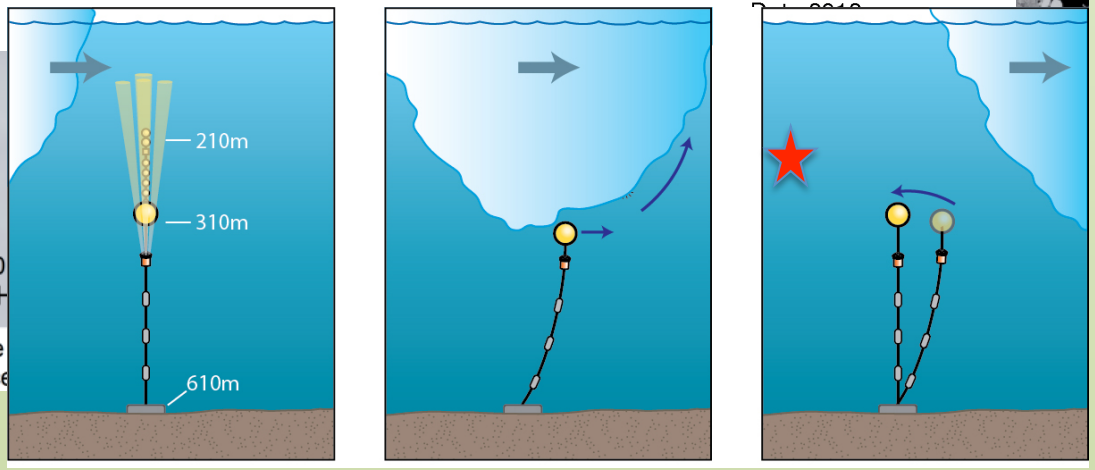
1) increased submarine melting
2) change in ice mélange
3) increased crevassing / surface effects



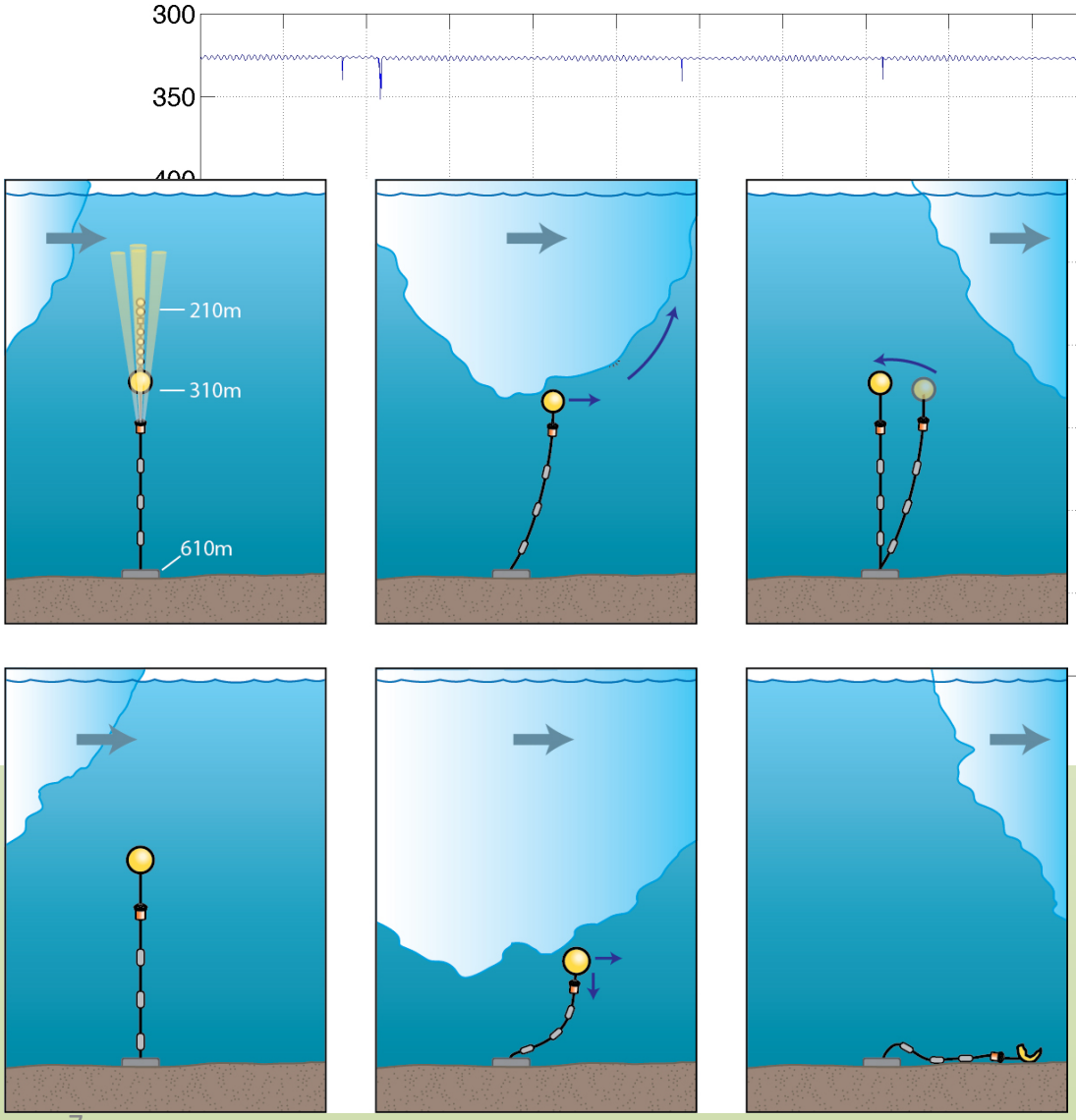

*(modified from Straneo et al. 2013)*

# **Observations in Greenland fjords**: difficult!



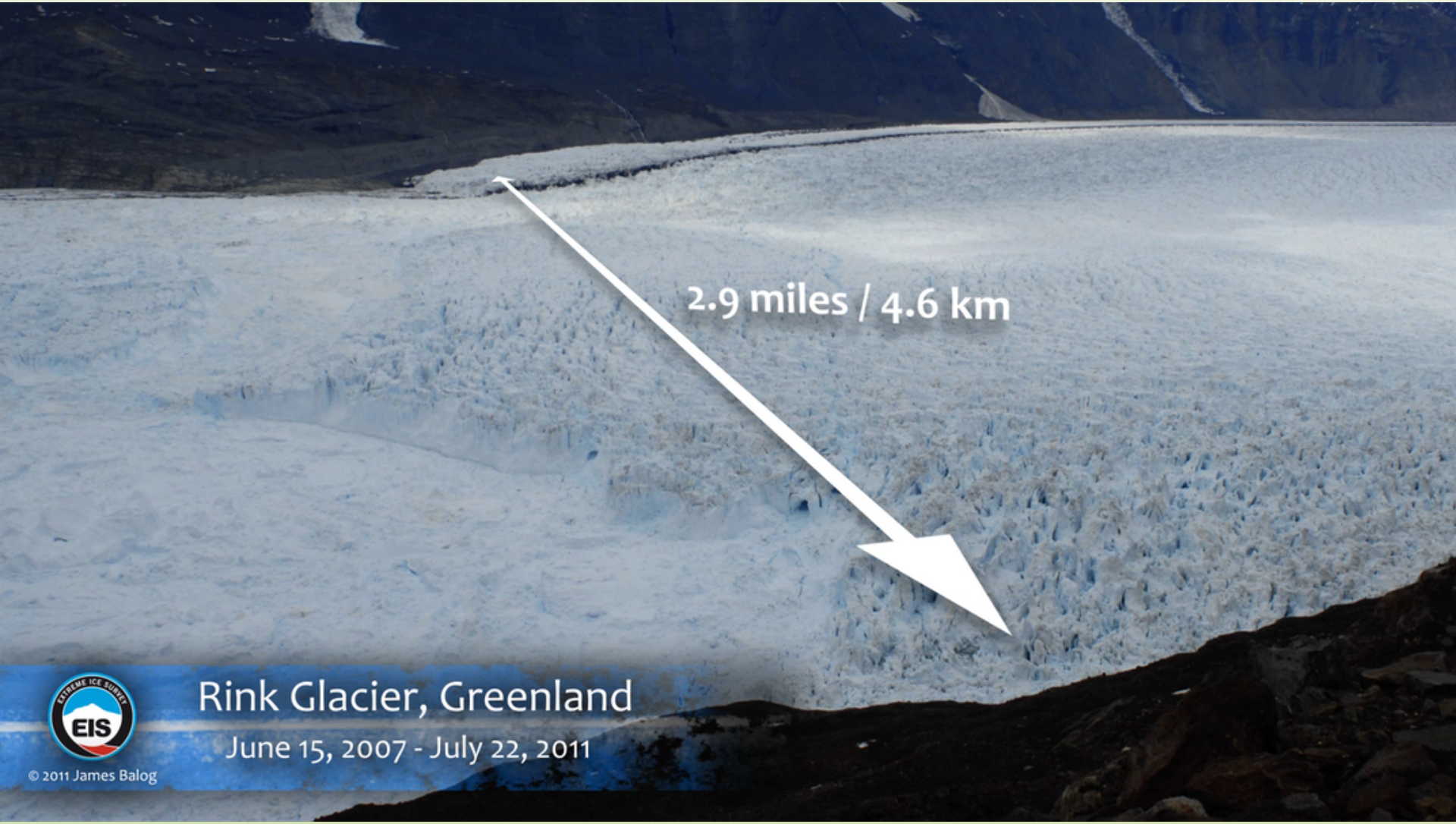



# **Observations in Greenland fjords**: difficult!




09/16

# Icebergs in Greenland




courtesy Ginny Catania; Extreme Ice Survey

# To quantify icebergs' impact, we need:

## 1) Iceberg distributions (size and number)

Helheim Glacier
&
Sermilik Fjord
(SE Greenland)


Sermilik Fjord and 50 m vessel

*MODIS*
*July 30, 2013*

# To quantify icebergs' impact, we need:

1) Iceberg distributions (size and number)

2) Melt rate (dependent on T(z), S(z), velocity, waves, etc.)

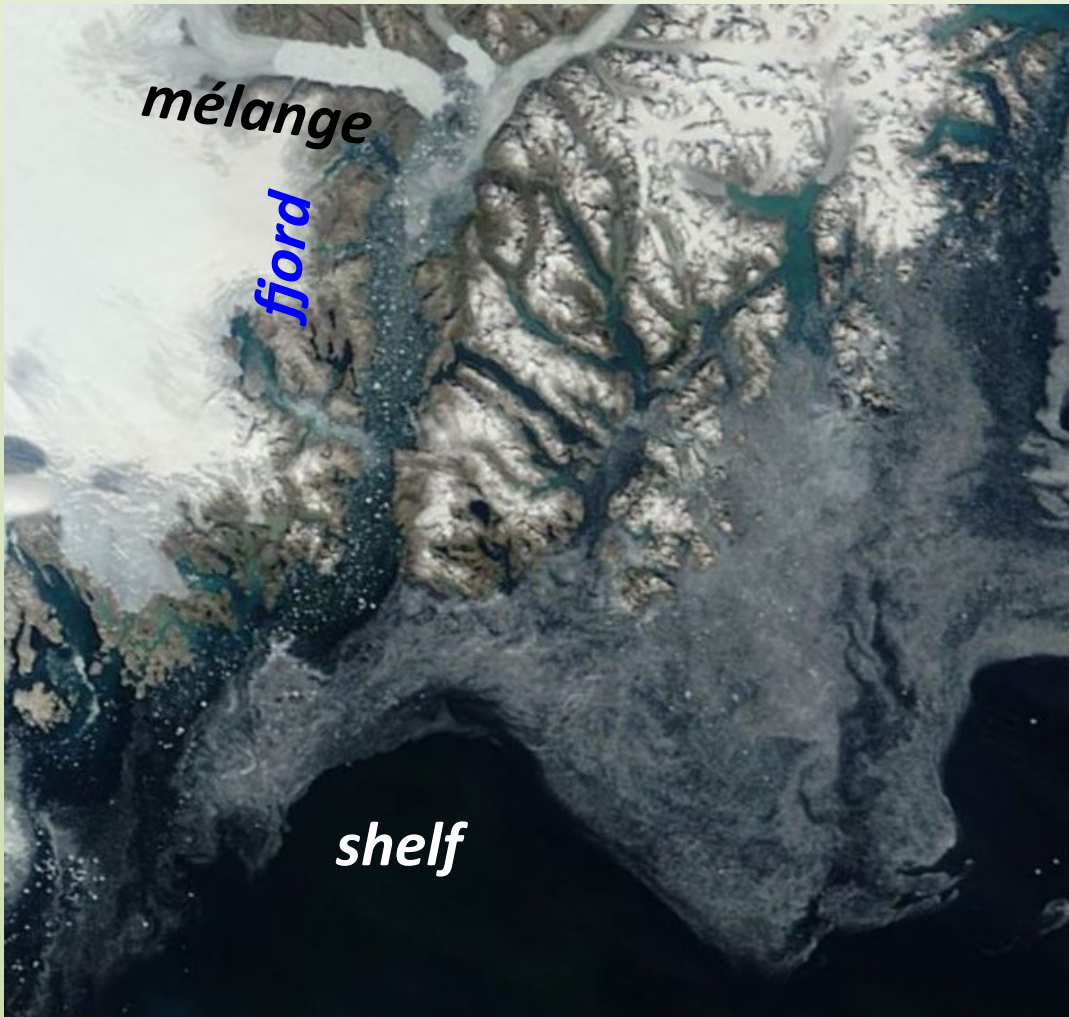
*photos: F. Straneo*

**To quantify icebergs' impact, we need:**

**1) Iceberg distributions (size and number)**

**2) Melt rate (dependent on T(z), S(z), velocity, waves, etc.)**

**3) Residence time of icebergs in specific regions (e.g., fjord, shelf, mélange)**



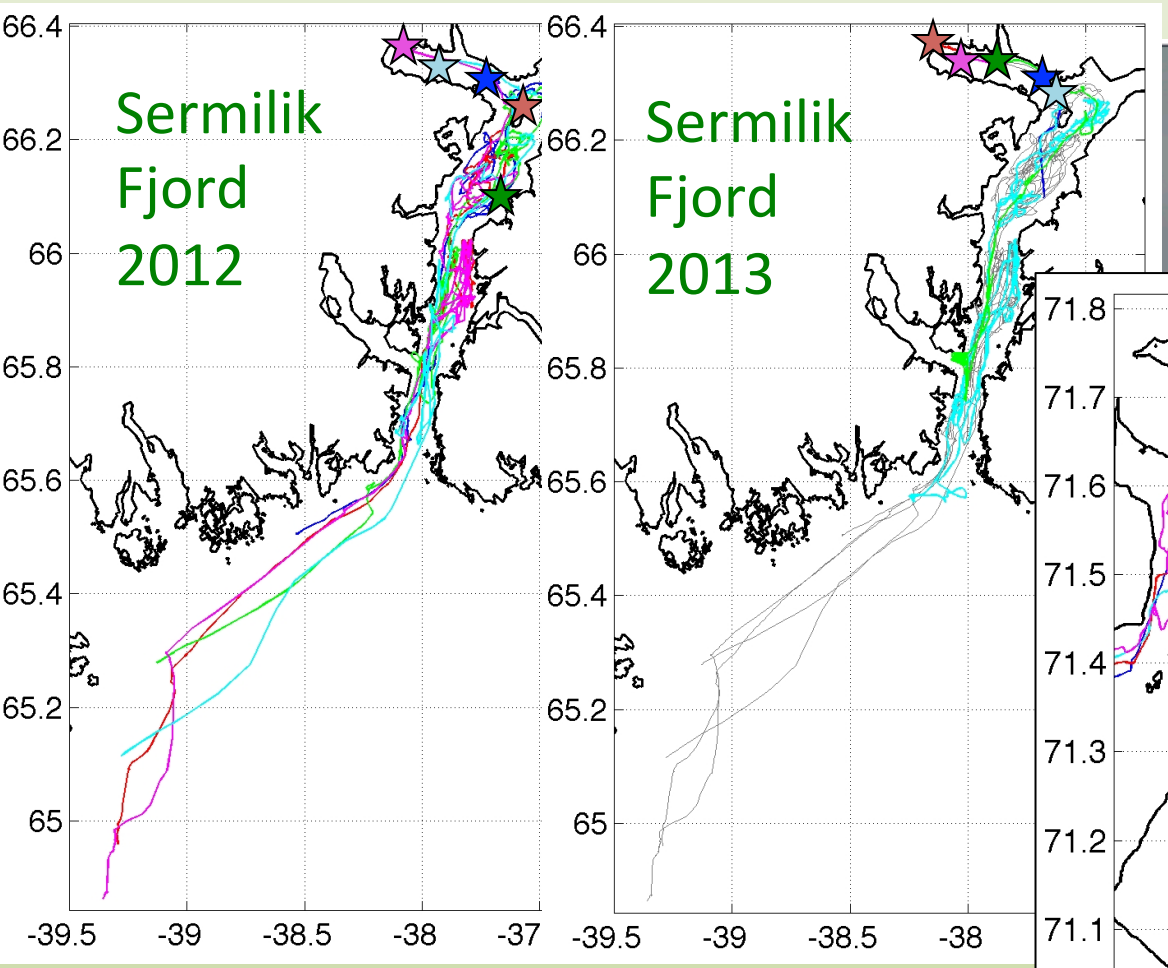

Helheim Glacier
&
Sermilik Fjord
(SE Greenland)

*MODIS*
*July 30, 2013*

# Iceberg trackers

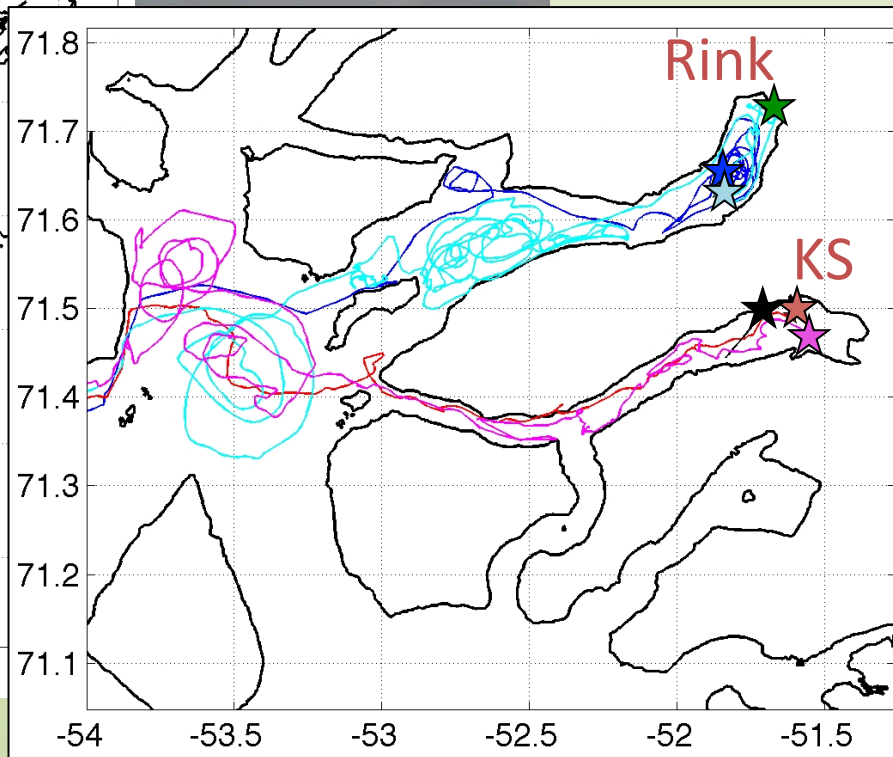
**Sermilik Fjord**:
5 trackers deployed Sept. 2012
5 trackers deployed Aug. 2013

**Rink and KS Fjords**:
6 trackers deployed Jul. 2013





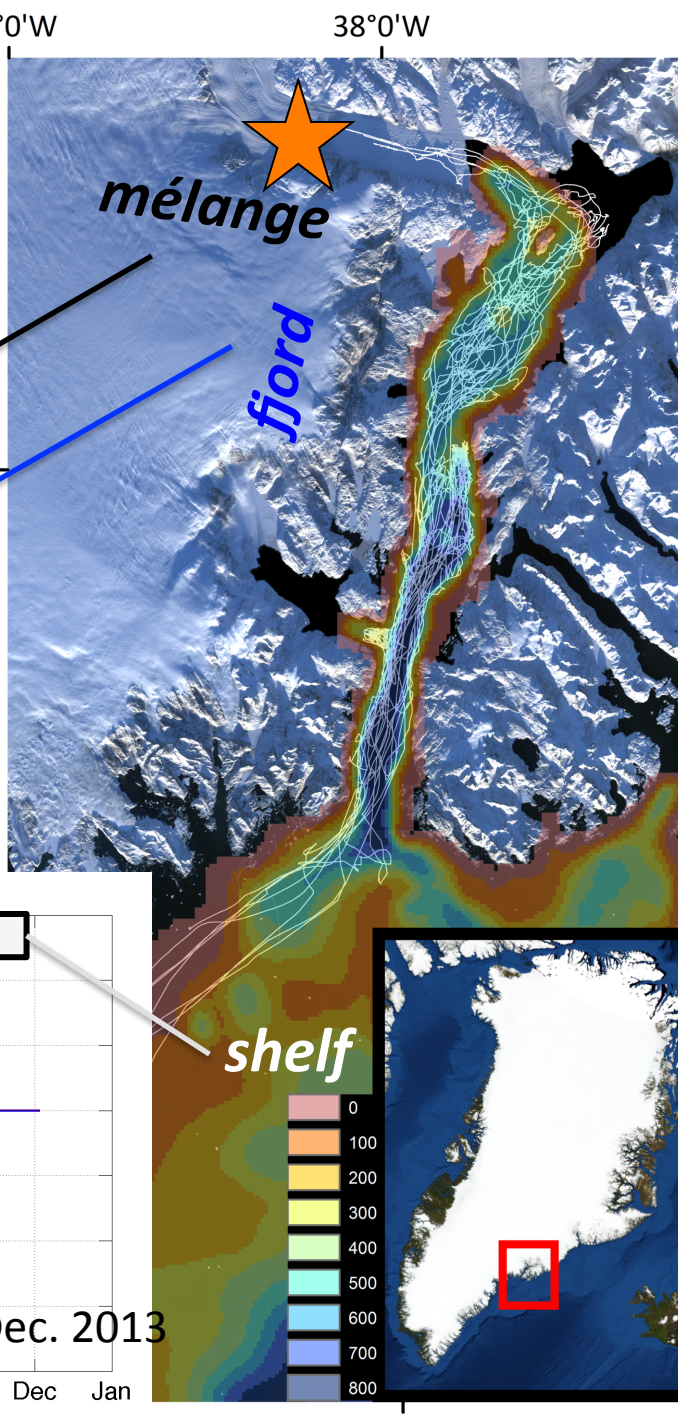


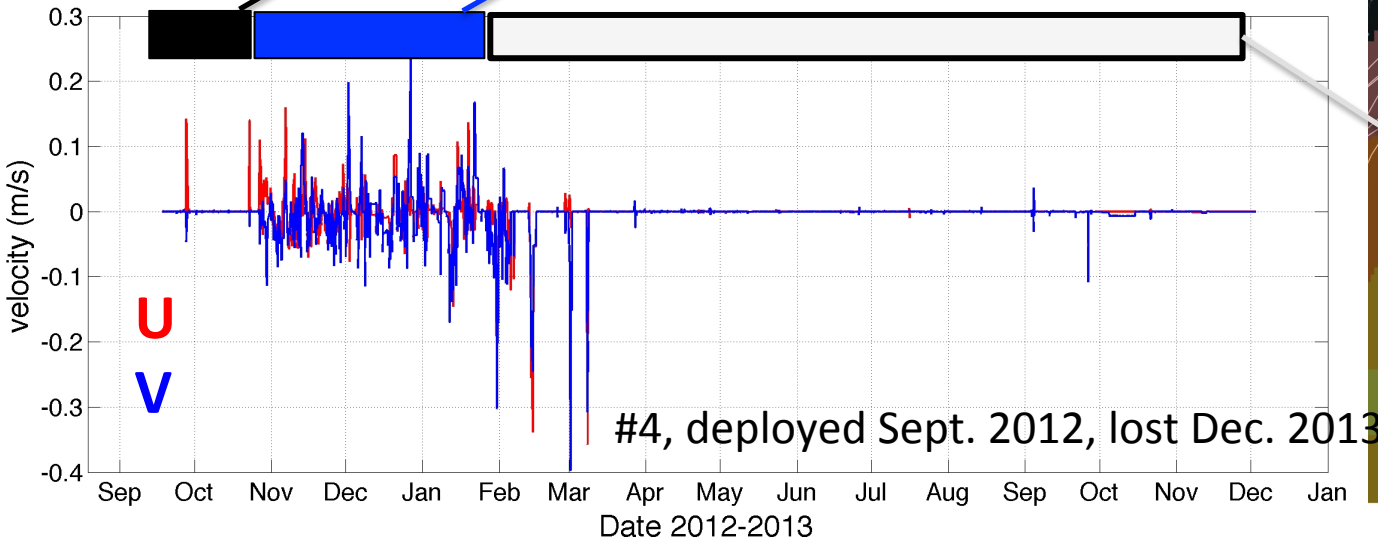


# Iceberg trackers

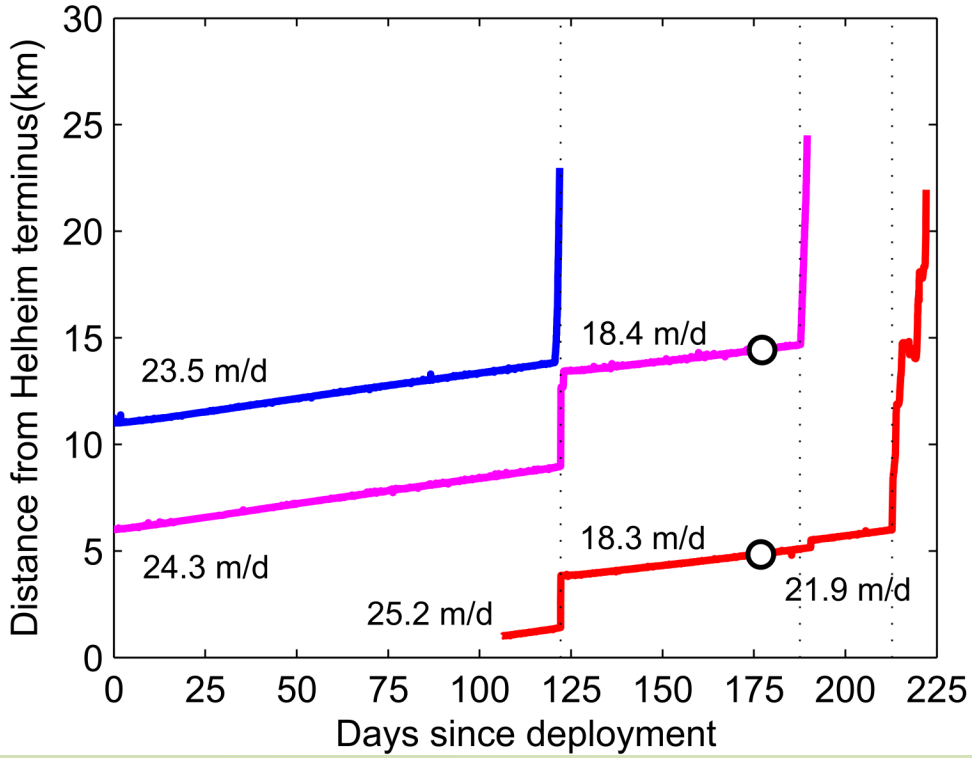
## BENEFITS

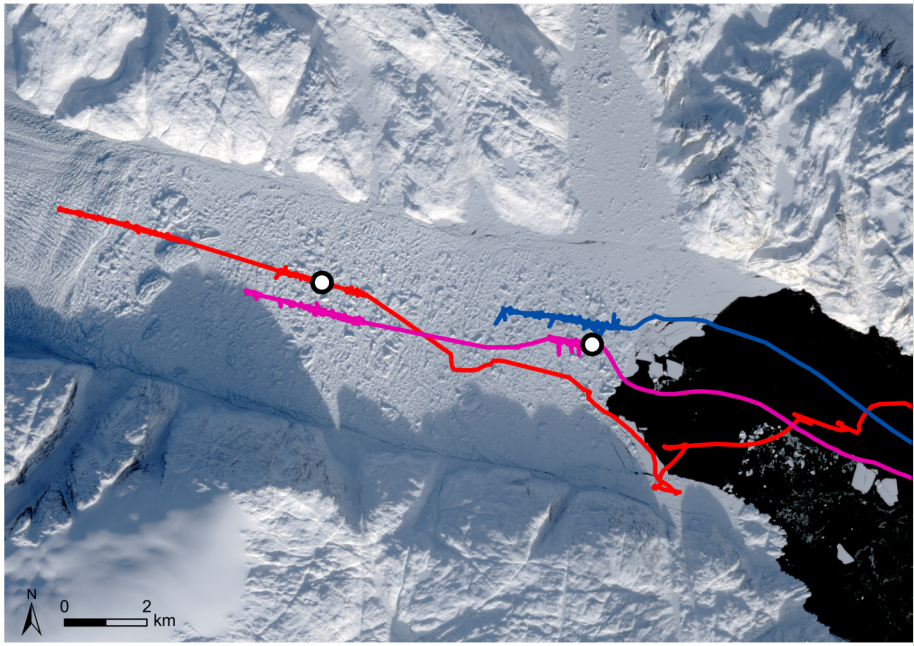
- Expendable and very cheap
- Hourly velocities, lifetimes > 1 year
- Can be used for more than fjord circulation:
  - ice mélange movement
  - coastal currents
  - iceberg melt



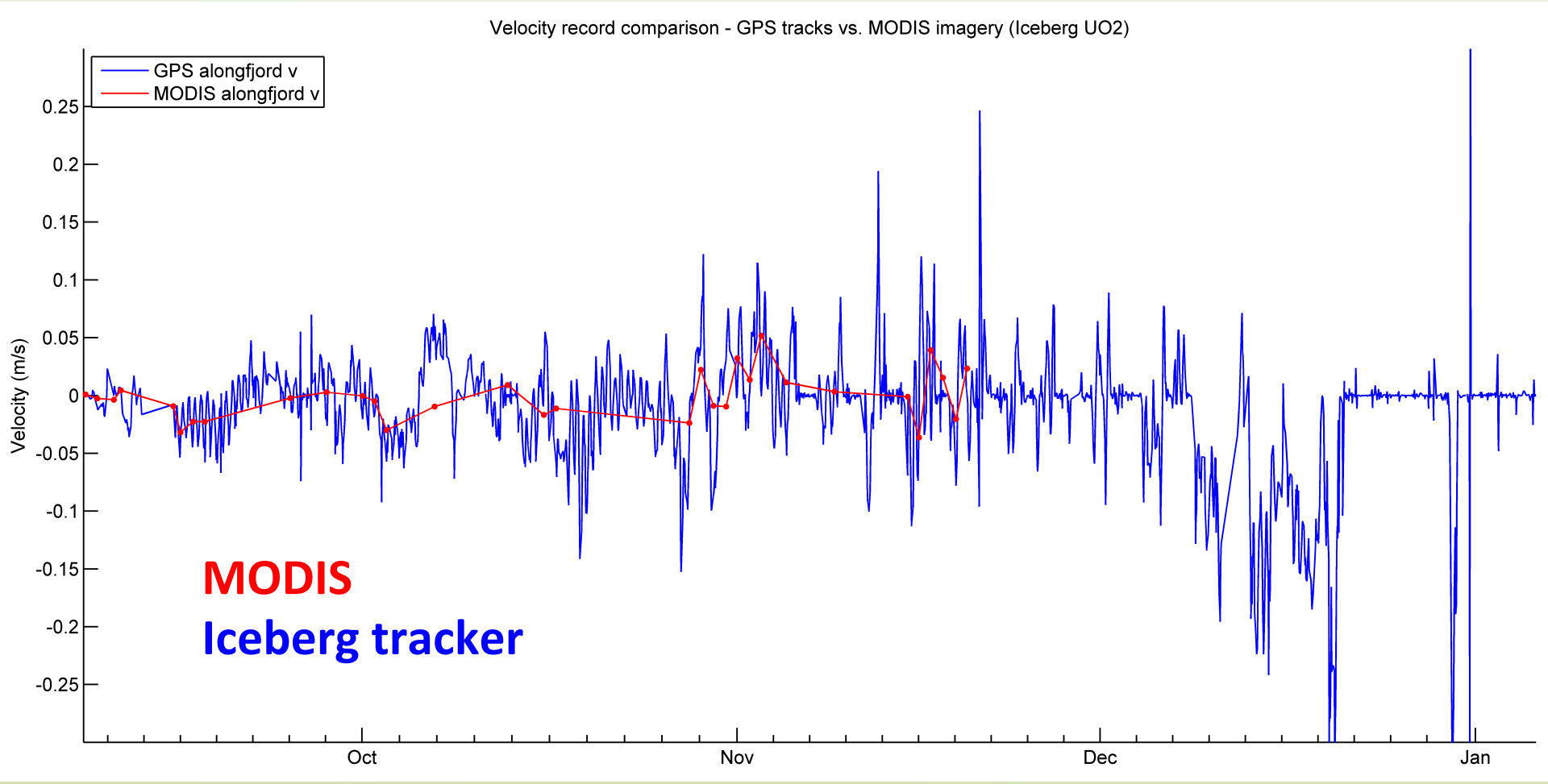



# Ice mélange motion in Sermilik Fjord



# What you get from MODIS imagery




Example of along-fjord velocity, 2012-2013

# Higher temporal resolution needed near terminus

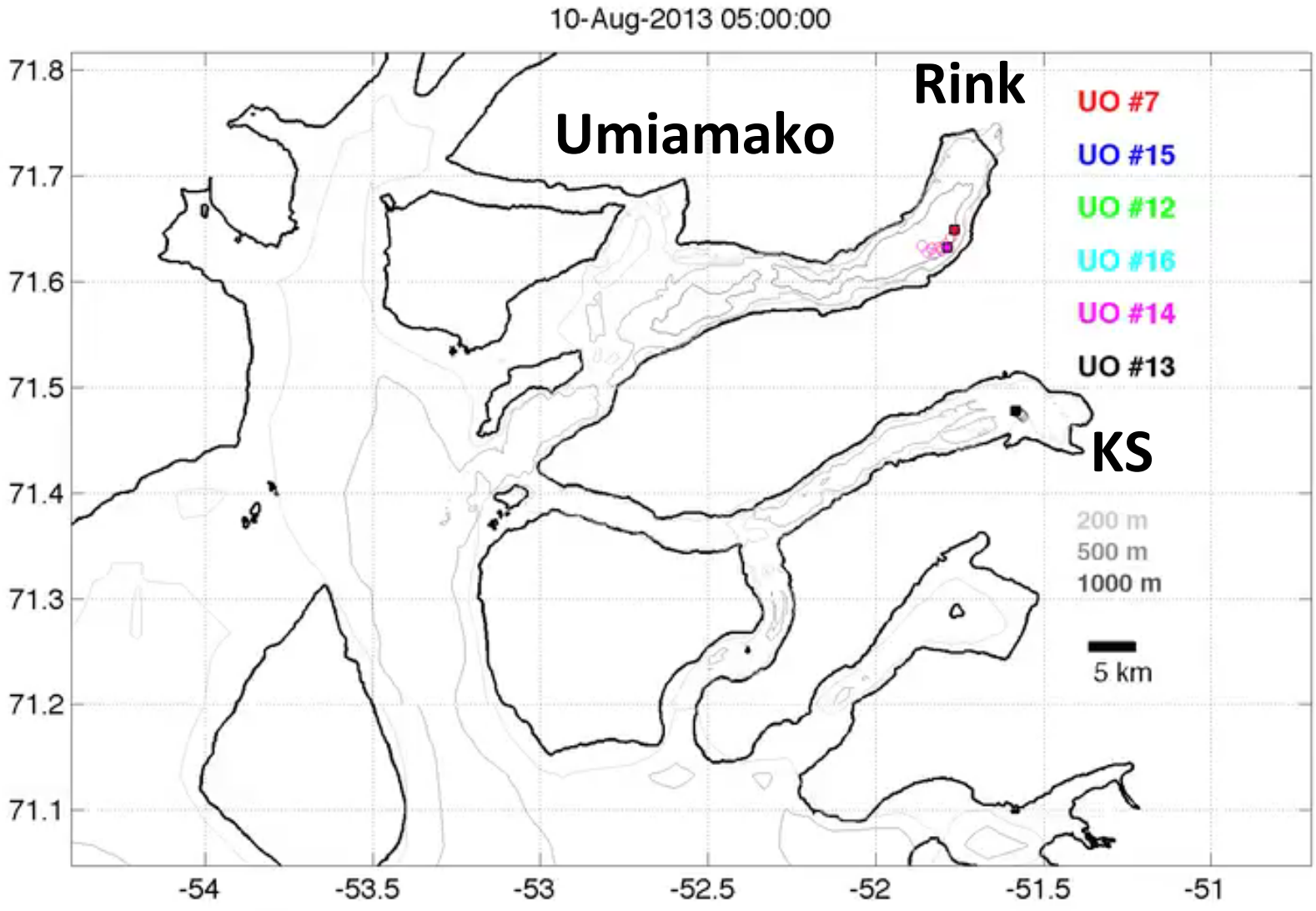
Three case studies:

1) Uummannaq Fjord region, central west Greenland

1) LeConte Glacier, SE Alaska

2) Jorge Montt, Patagonia, Chile

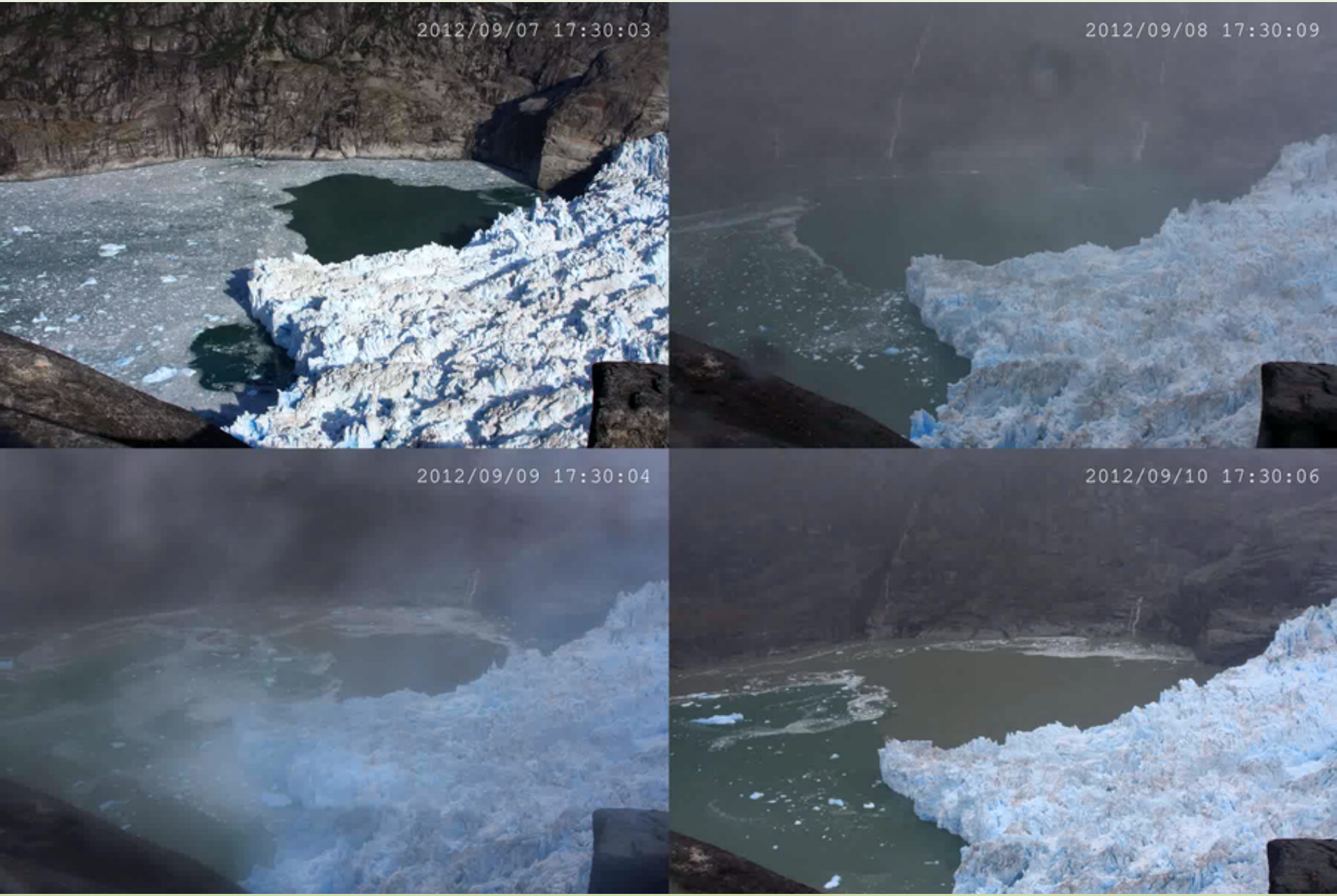
# 1) Uummannaq Fjord region, central west Greenland




*NASA project: Sutherland, Catania, Stearns, et al.*

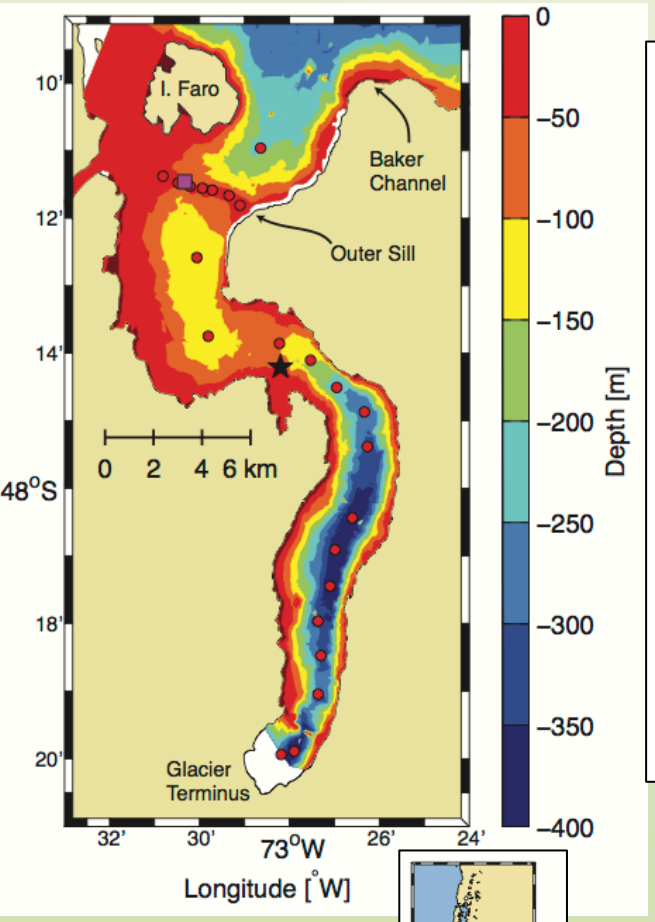
# 2) LeConte Glacier, SE Alaska

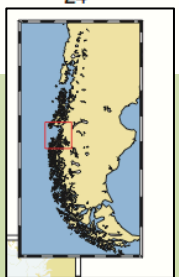
*courtesy of J. Amundson and R. Motyka*

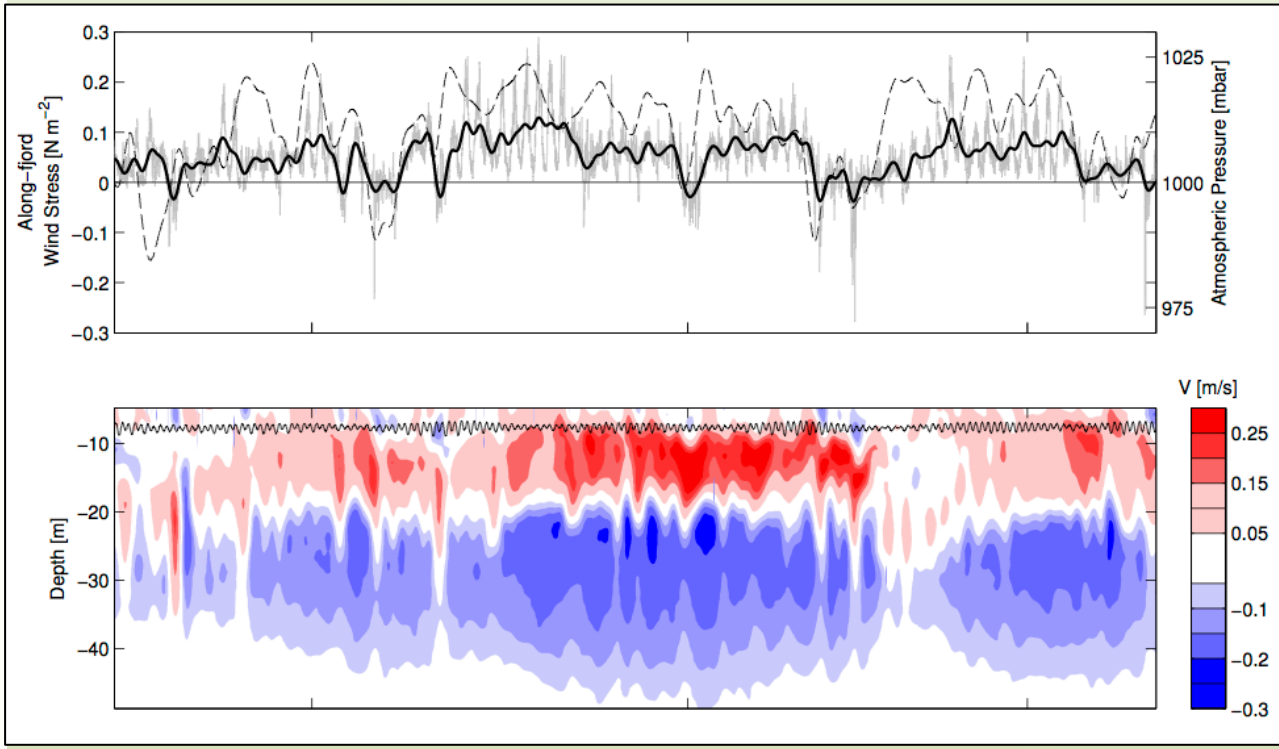


# 3) Jorge Montt Glacier/Fjord, Chilean Patagonia

circulation primarily driven by along-fjord winds






*C. Moffat, 2014*

# Summary so far…

Icebergs are effective drifters (cost- and science-wise) giving unprecedented spatial and temporal information on scales of fjord circulation

Expand network of iceberg trackers—explore rigidity of mélange, get vertical motion, and quantify FW impact

Needs:
1) higher temporal and spatial resolution
2) 3-D reconstructions of above water ice surface

*photo: L. Stearns*

# **Iceberg trackers**: a follow up on the destroyed float