Observing Tidewater Glacier Variability: Progress and Challenges

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Motivation and Challenges

- Transfer of mass at the **glacier-ocean boundary** plays a significant role in ice sheet dynamics, mass balance and sea level rise.

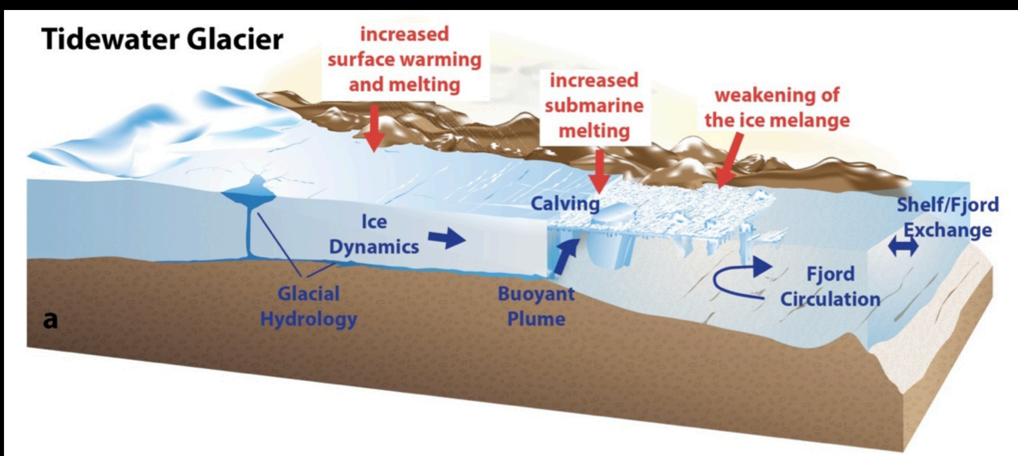
- Processes operating at the ice-ocean boundary operate on a range of **temporal** (seconds to years) and **spatial** (mm to km) scales.

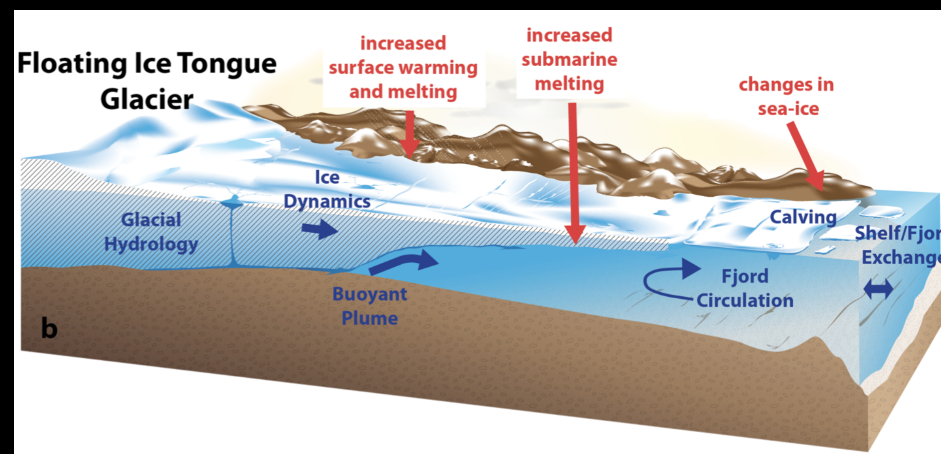
- Some processes are **known** to be important but are **poorly understood**; other important processes might still be **unknown.**

What parameters *(do we think)* are important?

glaciology
- ice flow
- calving
- surface balance
- hydrology

oceanography
- hydrography
- circulation
- mélange





[*GRISO*, 2012]

geometry
- ice thickness
- bathymetry

climate/meteorology
- temperature
- winds

How do we observe these parameters?

glaciology

ice flow - **RS, in situ**

calving - **RS,** *in situ*

surface balance - **RS, in situ**

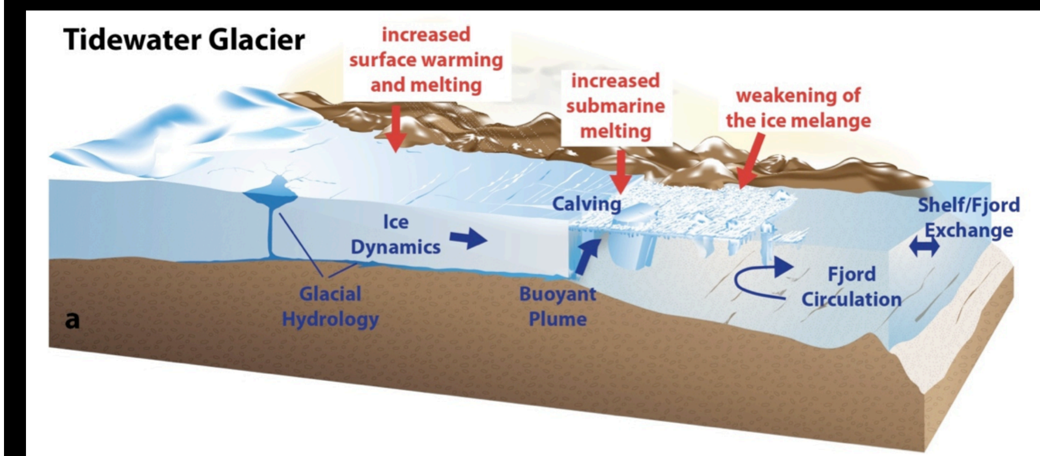
hydrology - *in situ*

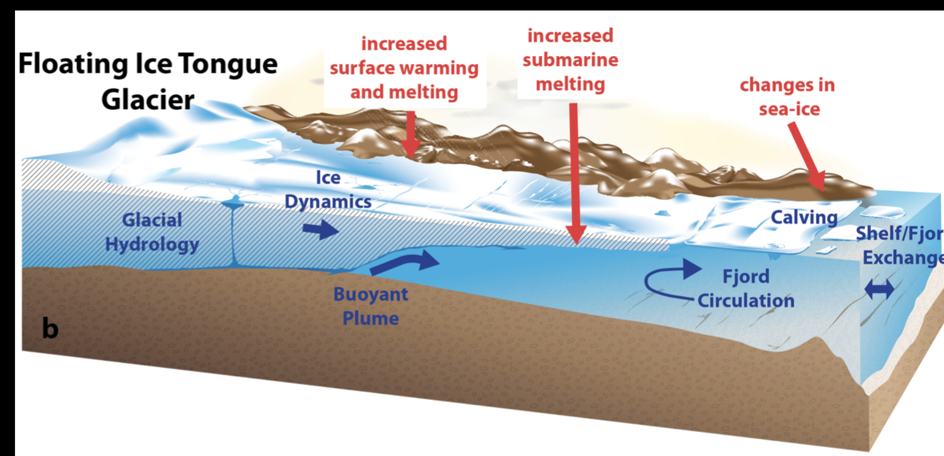
oceanography

hydrography - *RS*, **in situ**

circulation - **in situ**

mélange - *RS, in situ*





[*GRISO*, 2012]

bold = well-developed

italics = less well-developed

geometry

ice thickness - **surveys**

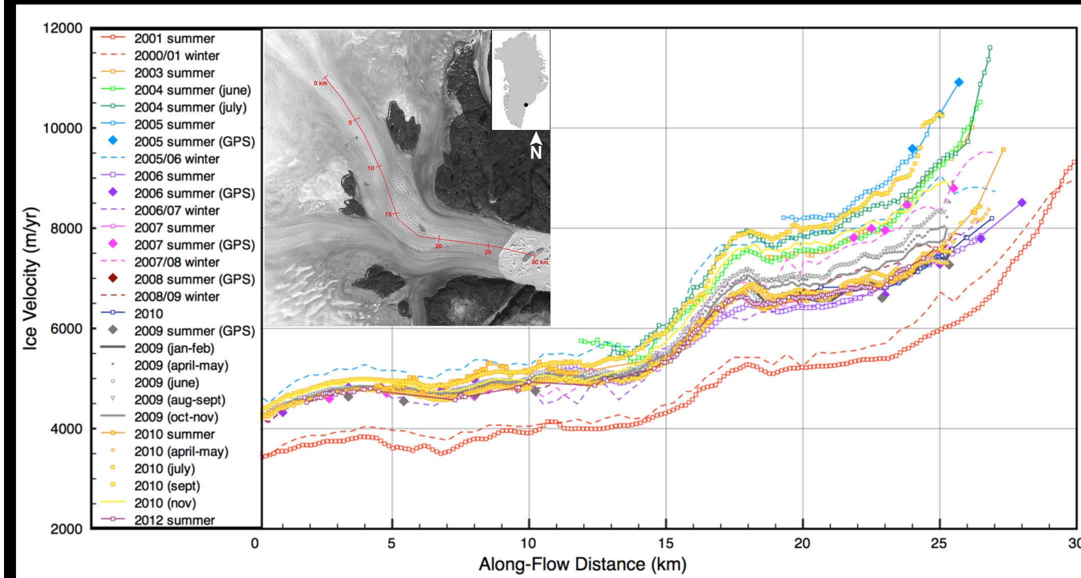
bathymetry - **surveys**

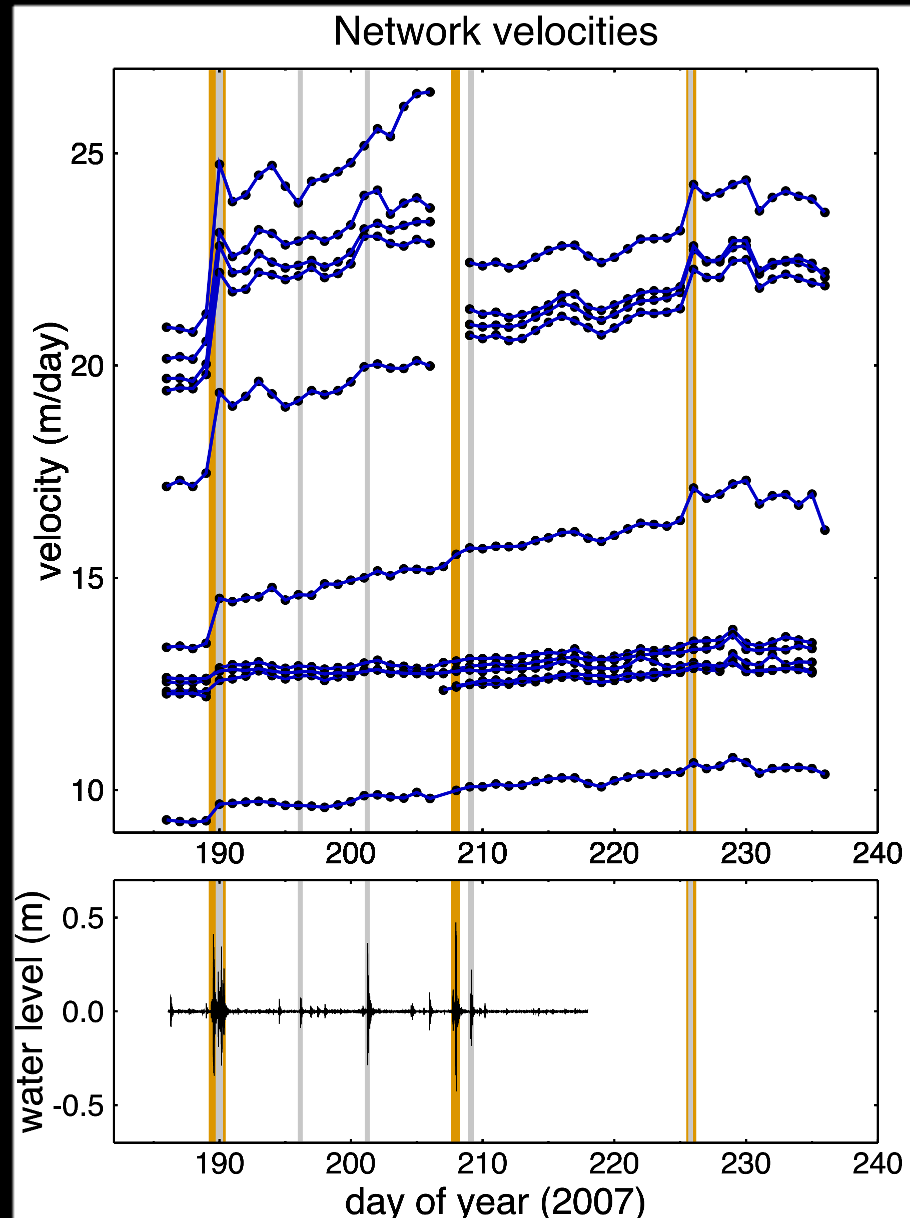
climate/meteorology

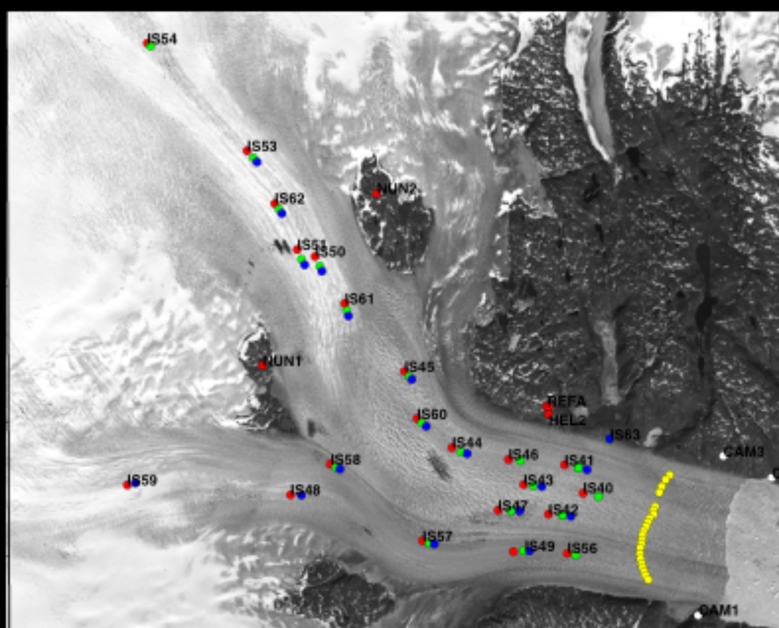
temperature - **in situ**

winds - *RS*, **in situ**

Problem of Scale *(spatial and temporal)*







[*Nettles et al, 2008*]

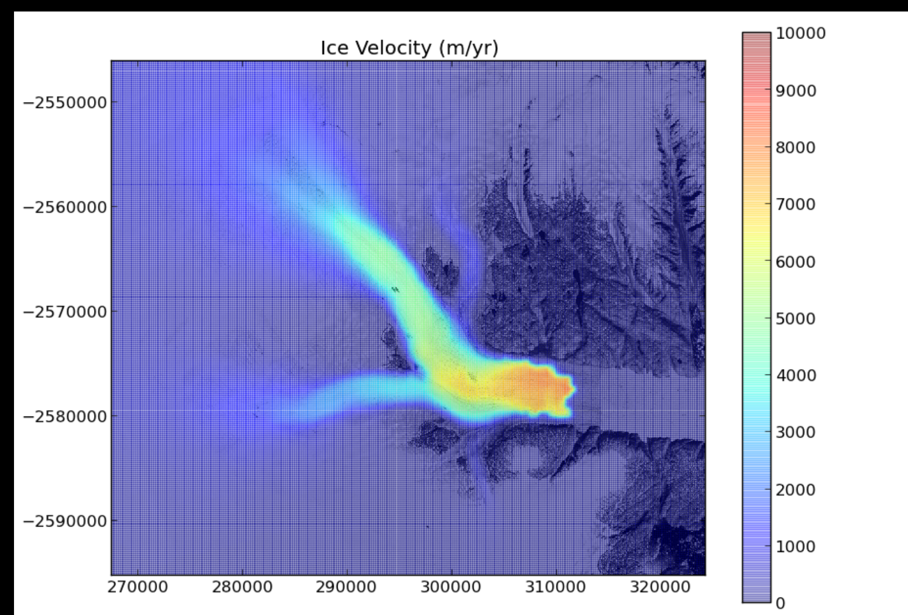
in situ vs. remote sensing observations

in situ:

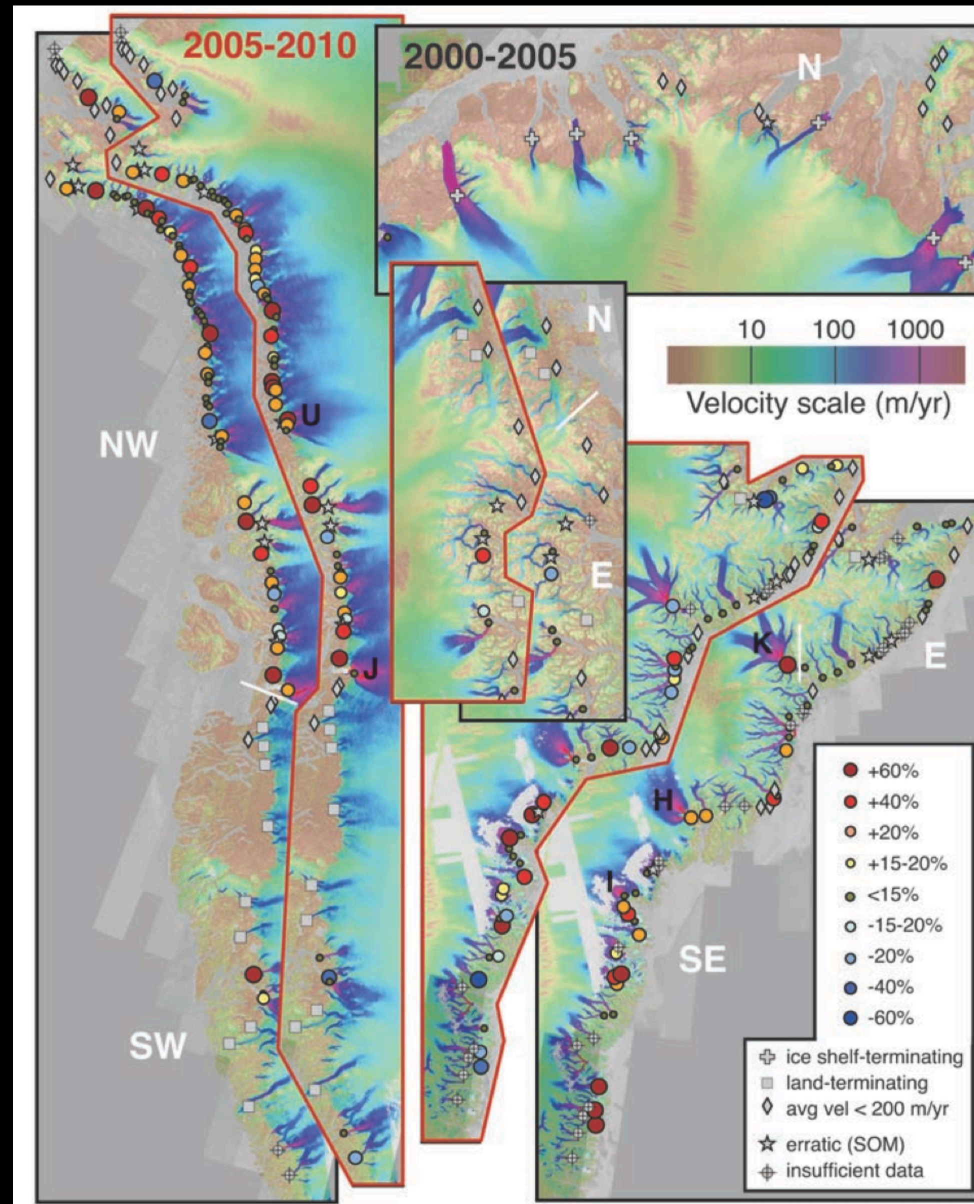
- **continuous sampling**
- *spatially limited*
- *difficult to incorporate into models*
- *expensive, challenging*

remote sensing:

- **spatially extensive**
- **easier to incorporate into models**
- **cheap and ‘easy’**
- *periodic sampling*



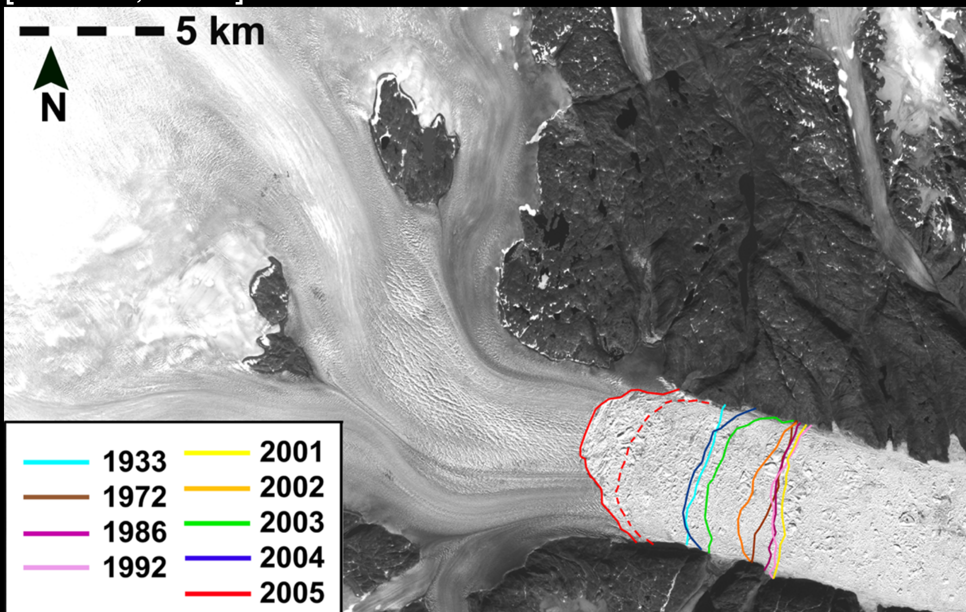
continuous sampling vs. spatial extent



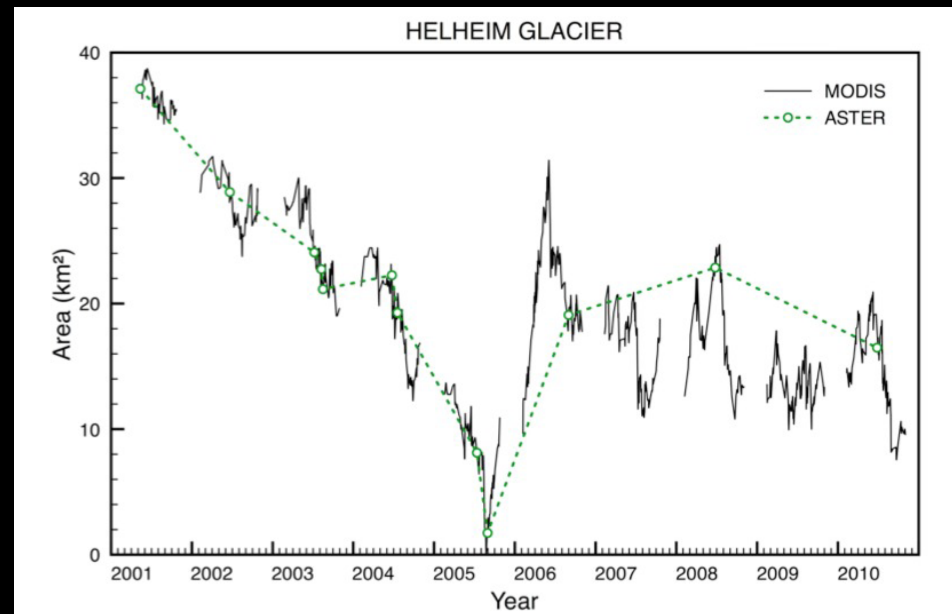
[*Moon et al., 2012*]

How important is temporal resolution?

[*Stearns, 2008*]



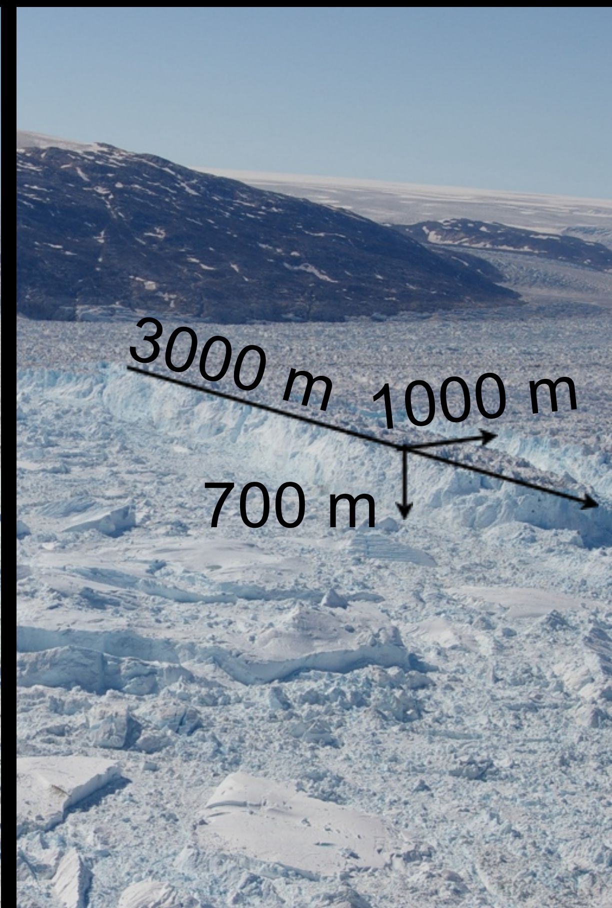
[*Schild,*



minimum position each year

~daily positions

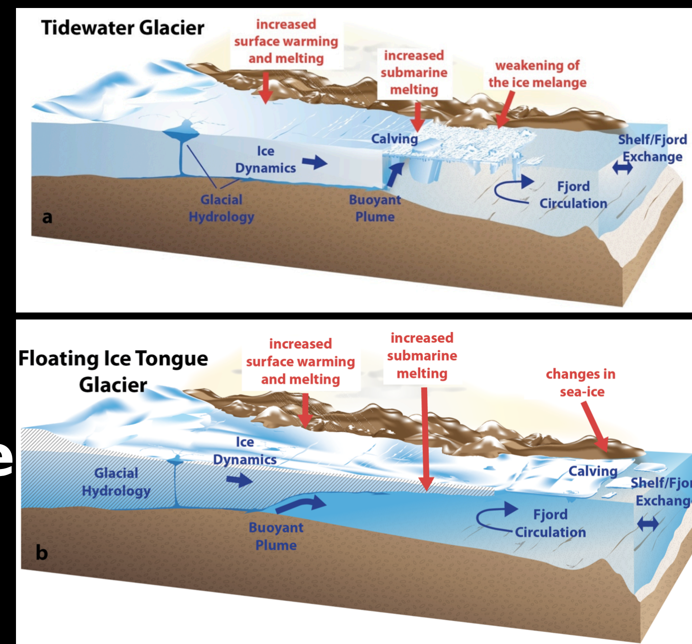
How important is temporal resolution?



1-Aug-2008; 1000-1530 UTC; 4 minutes between frames

continuous sampling vs. spatial extent

mechanisms that initiate acceleration and retreat:



1. **increased submarine melting**
   - ice geometry and roughness
   - subglacial discharge of surface melt
   - oceanic properties and circulation
2. **reduction/weakening of ice melange**
   - ice properties/thickness
   - atmospheric and thermodynamic forcing
   - oceanic mechanical or thermodynamic forcing
3. **increased crevassing and reduced ice strength due to surface warming**
   - surface melt

[*GRISO, 2012*]

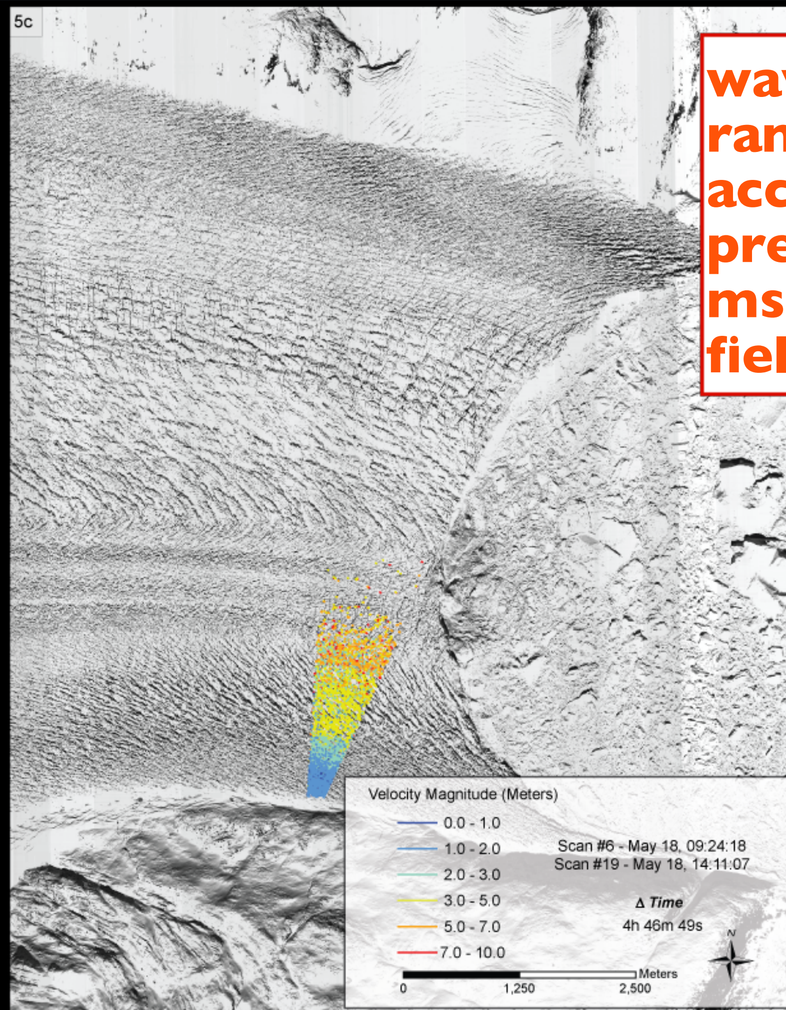
Where do we need innovation and improvement?

in situ methods:

- robust, low-cost GPS receivers
- radio/satellite telemetry
- innovative data processing/analysis methods

Where do we need innovation and improvement?

Riegl LPM-321

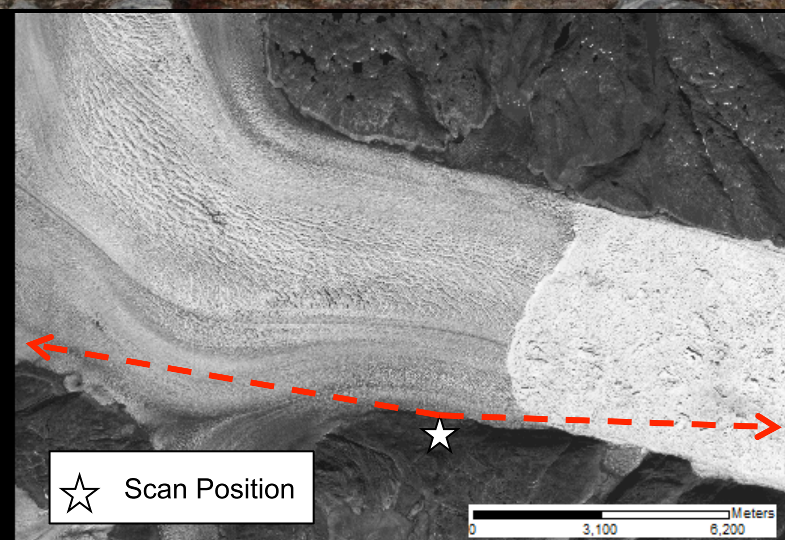


wavelength: 1550 um
range: 1 - 6 km (not ice)
accuracy: 25 mm
precision: 15 mm
msmt. rate: 10 - 1000 Hz
field of view: 360°h x 150°v

near situ methods:

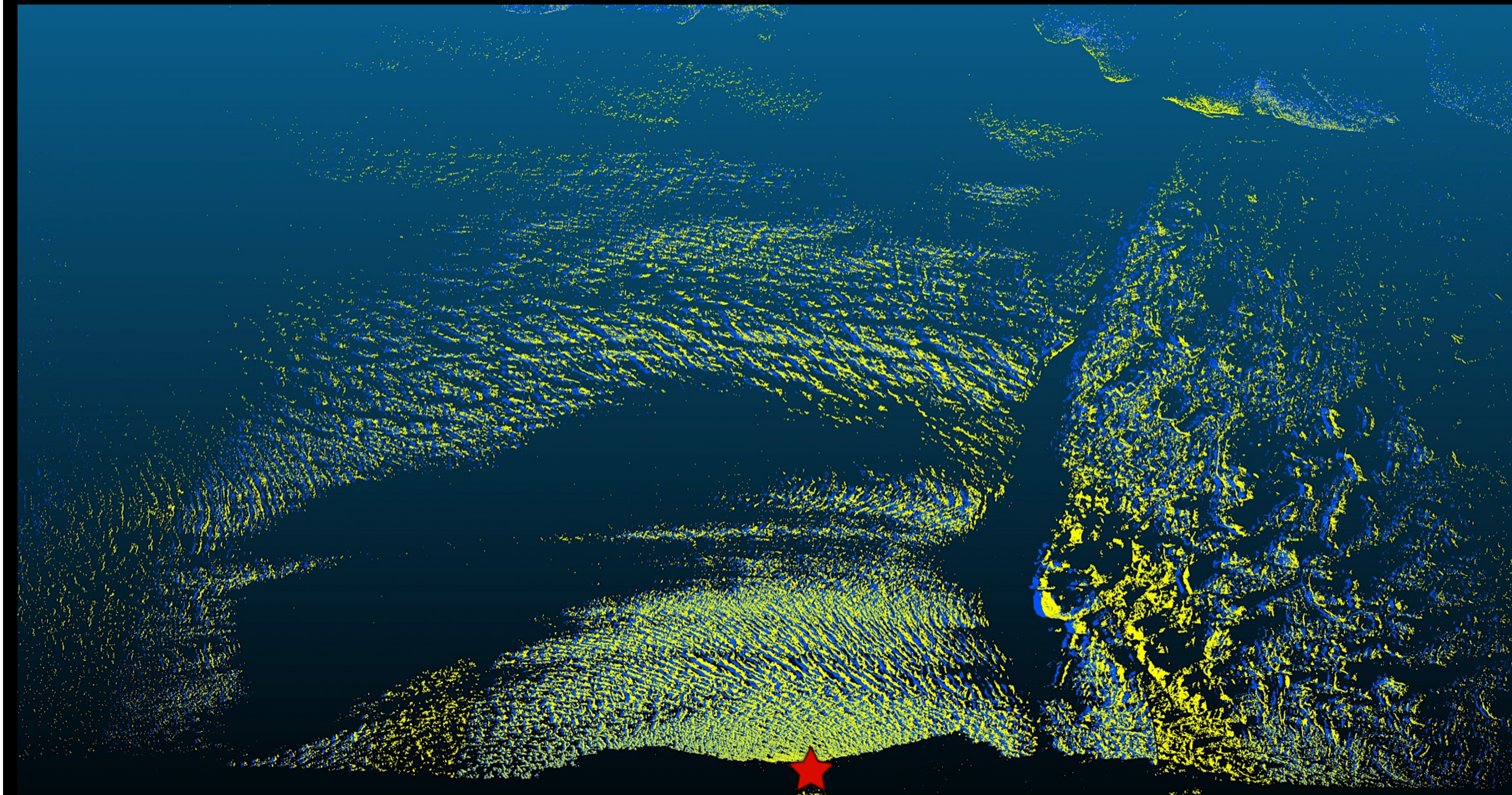
- unattended operation
- high spatial and temporal resolution
- TLS, GBRI, time-lapse cameras

Where do we need innovation and improvement?



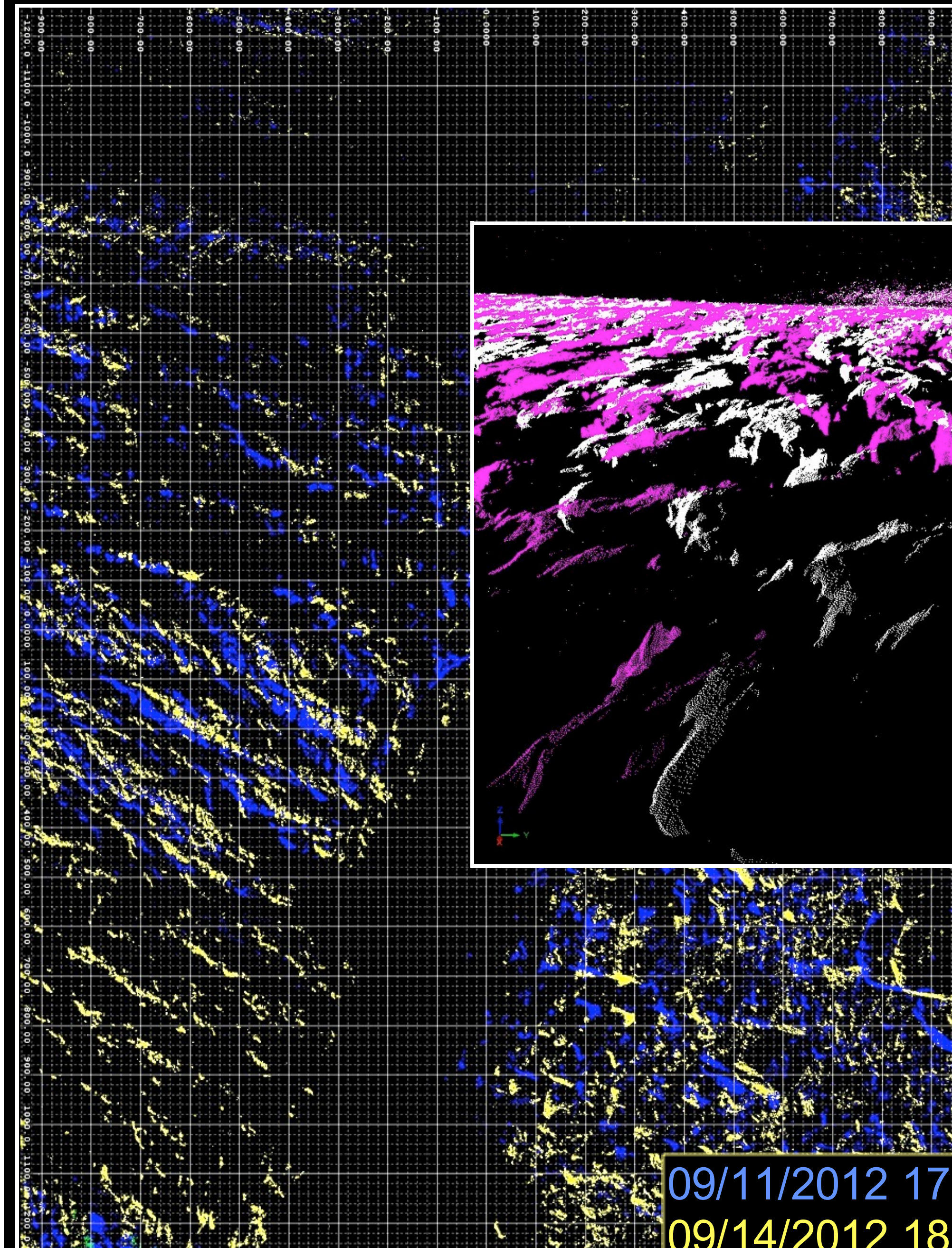
wavelength: 1064 um
range: 6 - 10 km
accuracy: 15 mm
precision: 10 mm
msmt. rate: 222 kHz
field of view: 360°h x 60°v

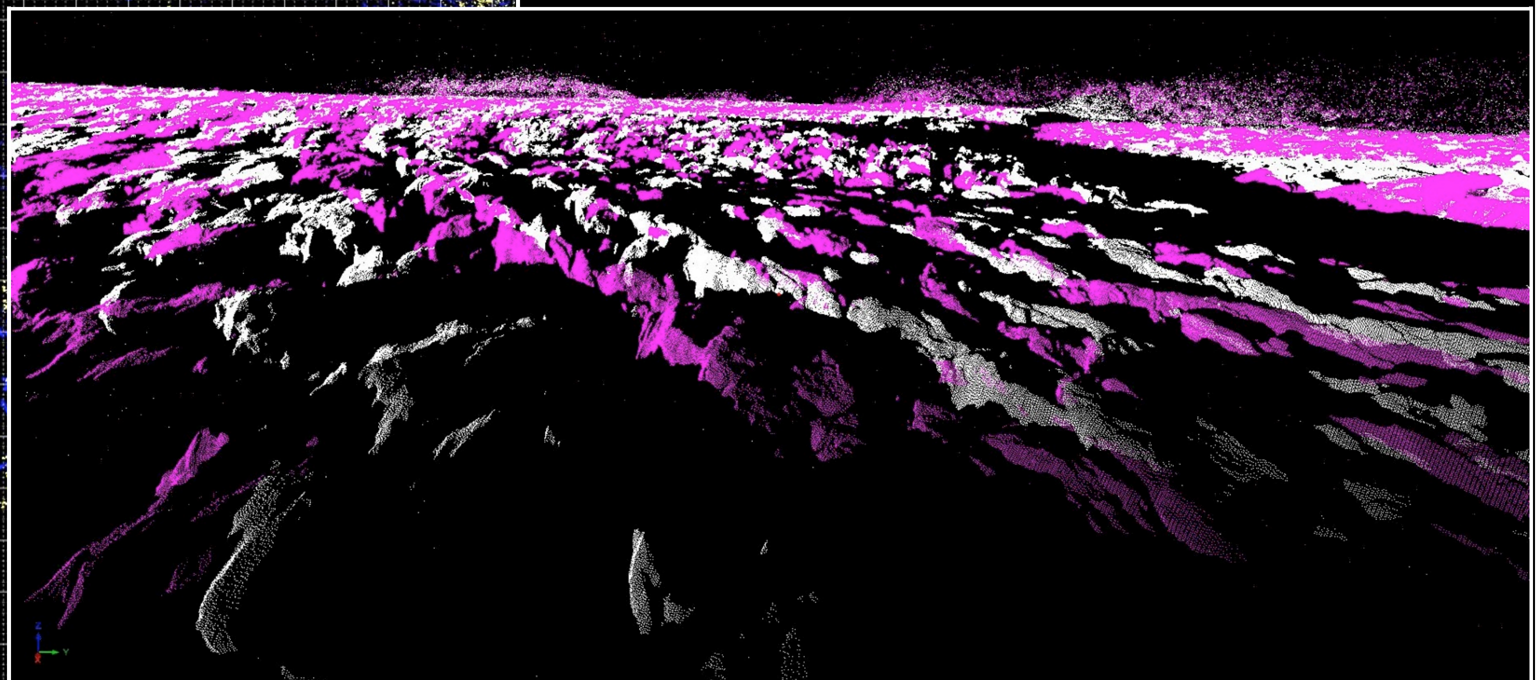
Where do we need innovation and improvement?



09/11/2012 17:24:59 - blue
09/14/2012 18:38:10 - yellow

Where do we need innovation and improvement?





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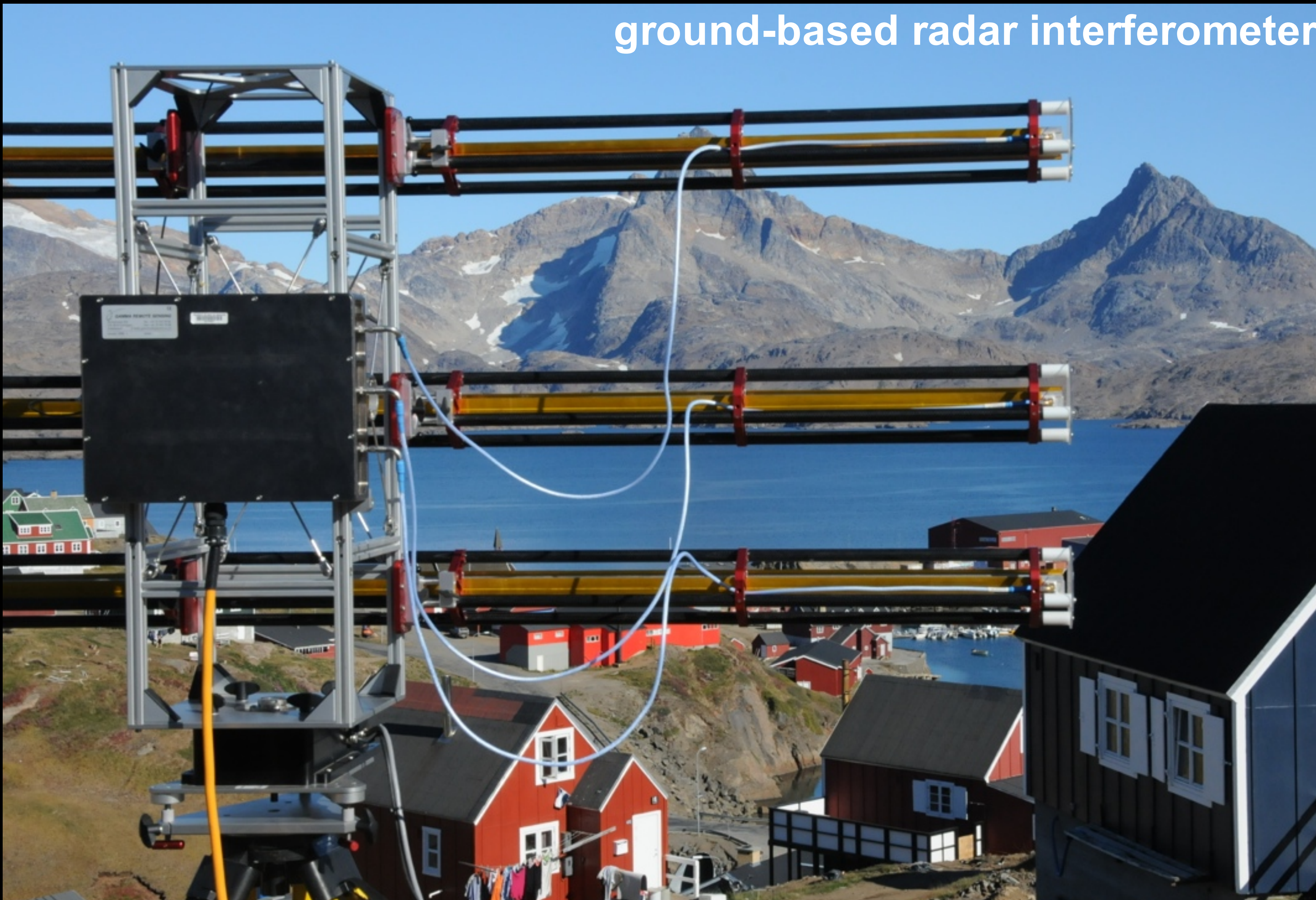
Where do we need innovation and improvement?



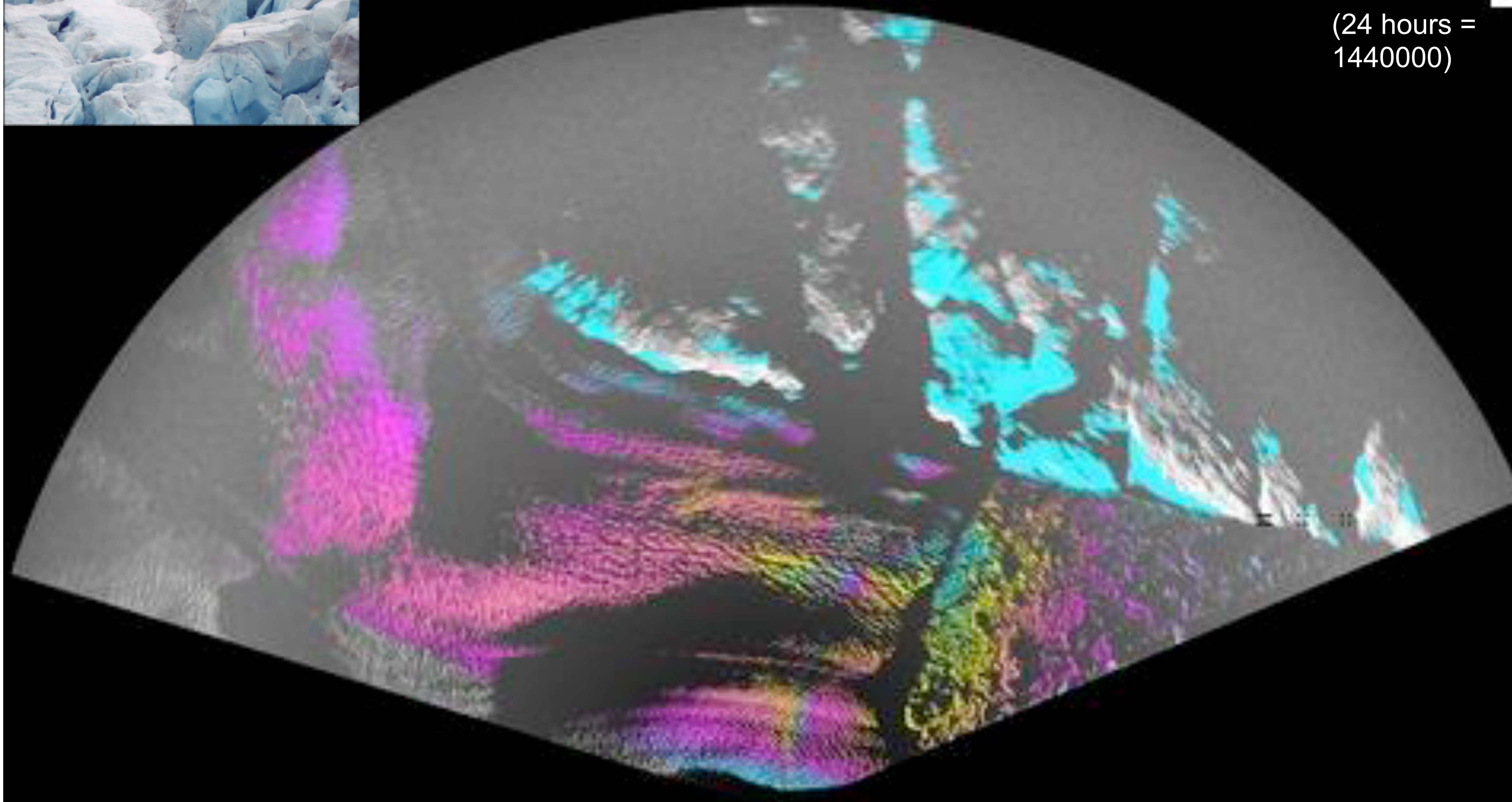
Where do we need innovation and improvement?

wavelength: Ku-band and C-band
range resolution: 75 cm
azimuthal resolution:

- **1 km:** 7m (Ku-band); 24 m (C-band)
- **10 km:** 70 m (Ku-band); 240 m (C-band)

scan rate: 1 min/scan

ve need innovation and improvement?



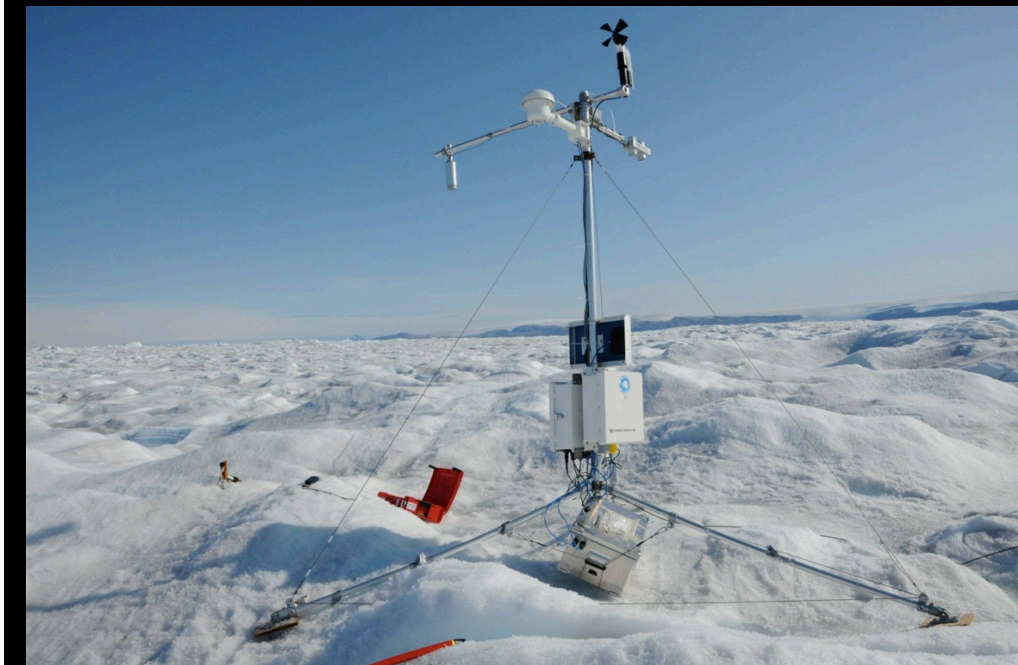
1-minute interferograms from September 10-13, 2012.
Ku-band radar (~16 mm wavelength)

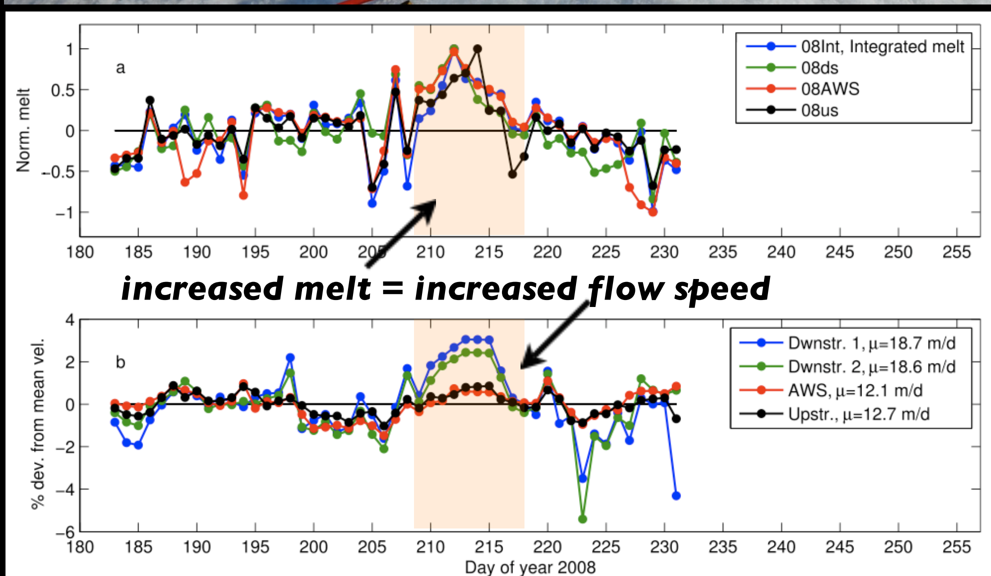
Conclusion

Our ideal ice-ocean observing platform should combine *in situ*, *near situ* and satellite remote sensing measurements.

In some cases, improved remote sensing techniques and platforms reduce the need for extensive networks of *in situ* instruments (e.g. ice flow, calving).

Problem of Scale *(spatial and temporal)*





[*Andersen et al., 2010*]