Are Glaciologists all Oceanographers now?
or...
Are Glaciologists coming to their senses?
Are Oceanographers losing their touch?

Pierre Dutrieux¹ and many, many others
(who should be only credited for the correct statements I may make today...)

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Photo © Maria Stenzel
Adapted from Straneo et al., 2013

Increased precipitation

Increased surface warming and melting

Increased submarine melting

Changes in sea-ice

Floating Ice Tongue Glacier

Glacial Hydrology

Ice Dynamics

Buoyant Plume

Ocean Circulation

Shelf Ocean Exchange

Adapted from Straneo et al., 2013
Research cruises
- CTD, DO, Tr
- Upward ADCP
- Downward ADCP

Airborne radar

Satellites

Observations

Ice Shelf

Ground radar

Research cruises

Autosub 3
- Forward looking altimeter
- Multibeam echo-sounder
- Microrider
- Sub-bottom profiler

(2009)

(2014)
18 years ice shelf thickness change
[Paolo et al, 2015]

Near seabed water temperature
[Schmittdko et al, 2014]
1. Mean Amundsen Sea circulation and properties?

2. Variability of near calving front heat content?

3. Importance for ice discharge?

4. Spatial distribution of melt?

5. Importance for ice discharge?

6. A selection of remaining questions?
Research cruises
- CTD, DO, Tr
- Upward ADCP
- Downward ADCP

Airborne radar

Satellites

Observations

Ground radar

Autosub 3
- Forward looking altimeter
- Multibeam echo-sounder

Numerical models

- CTD, DO, Tr
- Upward ADCP
- Downward ADCP
The Amundsen Sea

Max potential temperature below 150m

Max potential density above 2500m

Max potential temperature below 150m
Max potential temperature below 150m
Max potential density above 2500m
Ice shelf-Ocean interactions features, a simple 2D view;
Baroclinic circulation

Zonal velocity above isopycnal 27.47

Vgeos above isopycnal 27.47

Zonal velocity below isopycnal 27.47

Vgeos below isopycnal 27.47
Continental shelf edge

for now...
Cause(s) of the variability?
Cause(s) of the 2012 anomaly?

2011 anomalous sea surface
Wind stress curl and velocity

Maximum potential temperature below 150 m

[C] Zonal wind, continental shelf edge
Nino 3.4 index

[Dutrieux et al., 2014]
Tropical origin?

Geopotential height anomaly 500hPa

Zonal wind, continental shelf edge
Nino 3.4 index

[Dutrieux et al., 2014]
Impact on the glacier?

Geometrical constraints on dynamics
Impact of the ridge

[Dutrieux et al, 2014]
[Dutrieux et al., 2014]
[Dutrieux et al., 2014]
Net melt volume loss rates from the main trunk:

1994: \(-51\pm7\) km\(^3\)/yr
2009: \(-80\pm10\) km\(^3\)/yr
2010: \(-75\pm10\) km\(^3\)/yr
2012: \(-37\pm5\) km\(^3\)/yr
2014: \(-65\pm5\) km\(^3\)/yr
Impact on the ice?
A detailed pattern of melt

Surface elevation, SPIRIT 2008

Surface elevation, BAS airborne 2011

basal elevation

Surface ice velocity divergence

[Dutrieux et al., 2013]
A detailed pattern of melt

Surface elevation, SPIRIT 2008

Surface elevation, BAS airborne 2011

basal elevation

Surface ice velocity divergence

[Dutrieux et al., 2013]

[Shean et al., in prep]
How about even finer scale?

Shear margin crevasses
How about even finer scale?

Transverse channels
How about even finer scale?
Longitudinal channels
Impact on the ice?

(a) Undeformed ice shelf

(b) Flexing response

(c) Zones of possible failure

from Vaughan et al, JGR 2012
[Shean et al., in prep]
How about even finer scale?

Terraces
Conclusions

• Ocean heat content in the Amundsen Sea varies, driven by a combination of local and remote atmospheric/sea ice forcing;
• Oceanic melting under Amundsen Sea ice shelves is:
  – highly variable in time (x2 or more over interannual timescales),
  – critically distributed at kilometre scales,
  – also largely modulated by finer scale terraces!
• Fundamental coupling between ocean and ice dynamics.

5 questions:

→ What actually controls the ocean heat content in the Amundsen Sea?
→ Role of atmospheric forcing at seasonal/interannual/decadal timescales? Role of tropical teleconnections?
→ Importance of spatial distribution of melt at kilometre scales?
→ How are the terraces created and how important are they for the bigger picture?
→ Coupled dynamics?