Gathering basal melt rate time series from Antarctic ice shelves

Keith Nicholls (with David Holland as proxy)
British Antarctic Survey
New York University

The need being addressed

Technical solution

Example datasets

Progress and plans

OASIIS Workshop, AWI, 2017

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

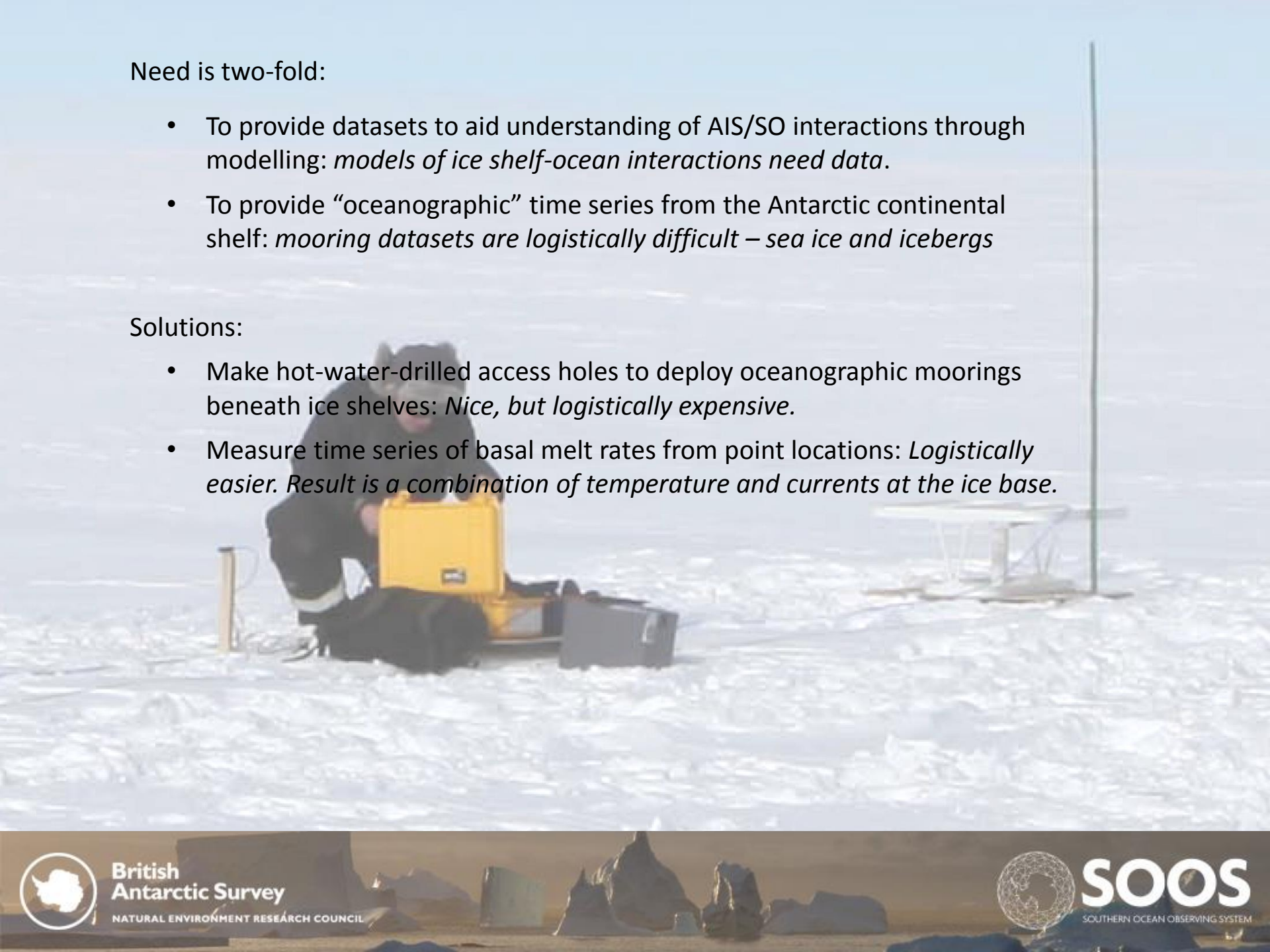
SOOS
SOUTHERN OCEAN OBSERVING SYSTEM

Need is two-fold:

- To provide datasets to aid understanding of AIS/SO interactions through modelling: *models of ice shelf-ocean interactions need data*.
- To provide “oceanographic” time series from the Antarctic continental shelf: *mooring datasets are logistically difficult – sea ice and icebergs*

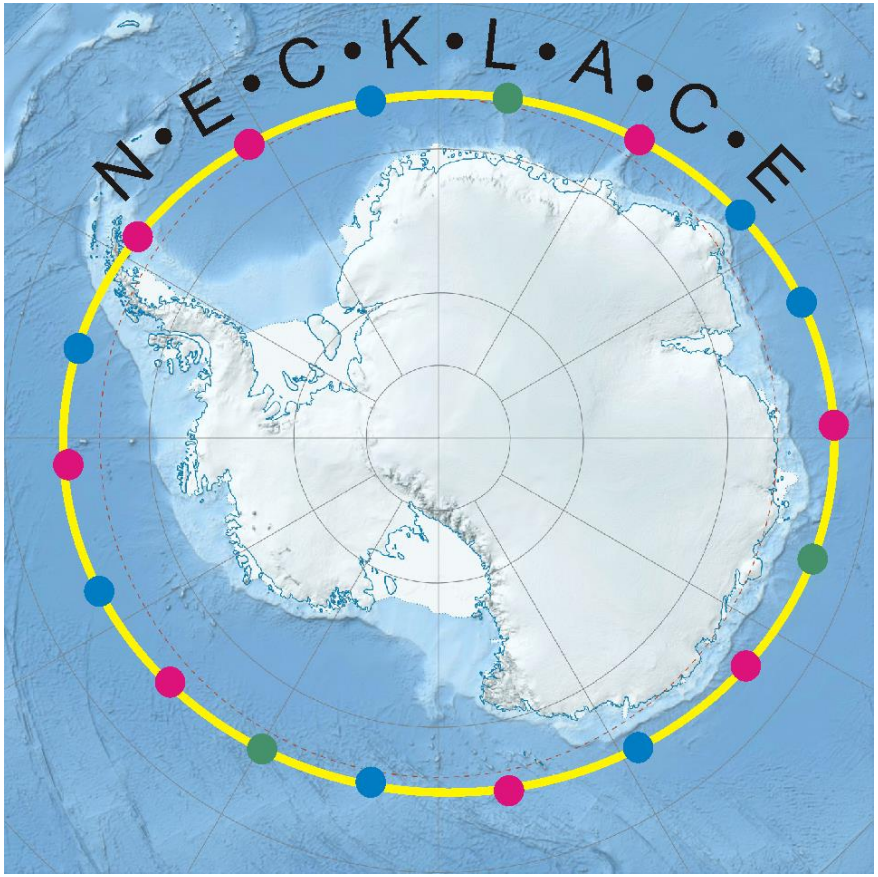
Solutions:

- Make hot-water-drilled access holes to deploy oceanographic moorings beneath ice shelves: *Nice, but logistically expensive.*
- Measure time series of basal melt rates from point locations: *Logistically easier. Result is a combination of temperature and currents at the ice base.*



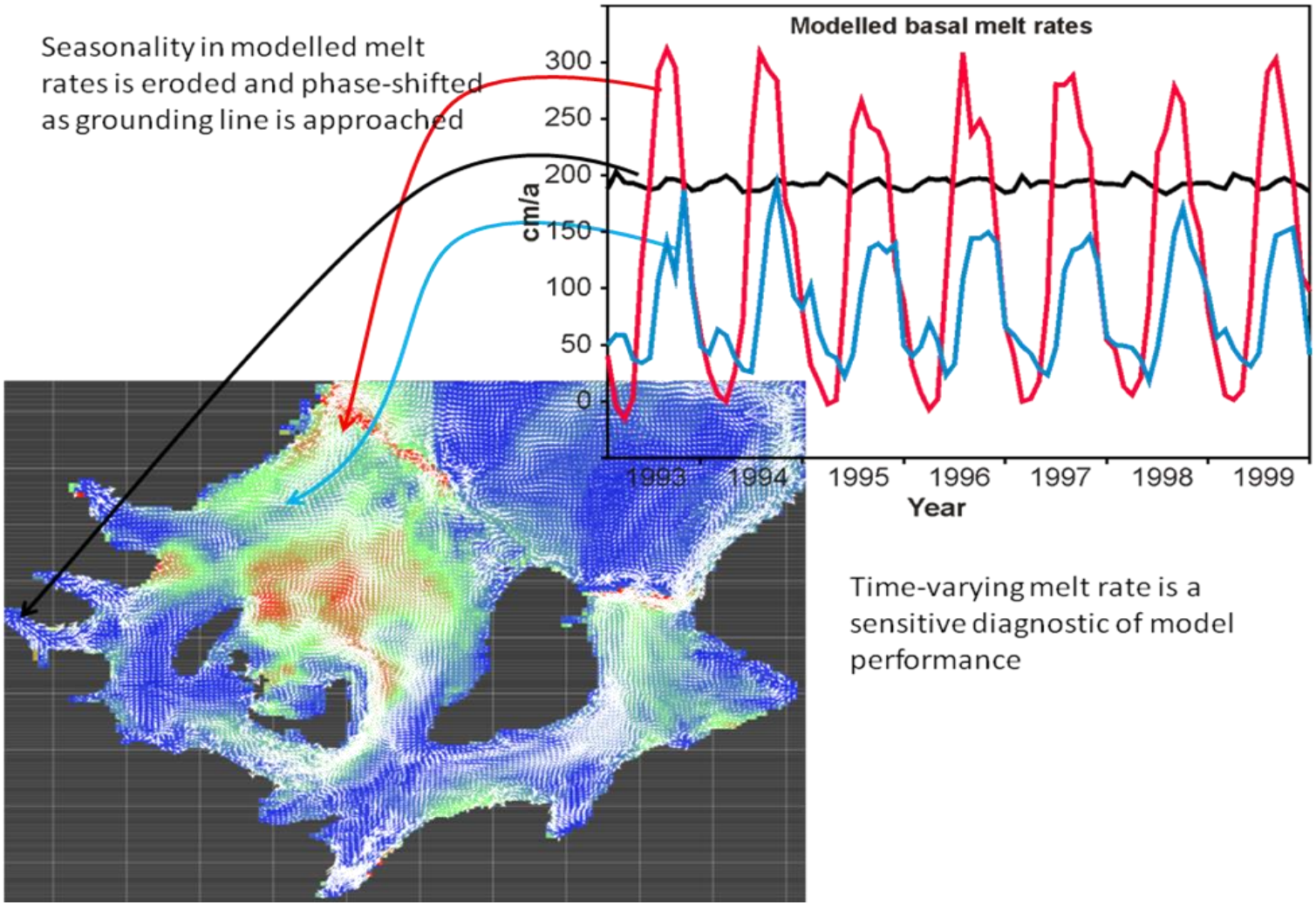
NEtwork for the Collection of Knowledge on meLt of Antarctic iCe shElves

NECKLACE: SOOS-Endorsed project , nominally 2015-2020



Results from a numerical model of interaction between Filchner-Ronne Ice Shelf and the southern Weddell Sea

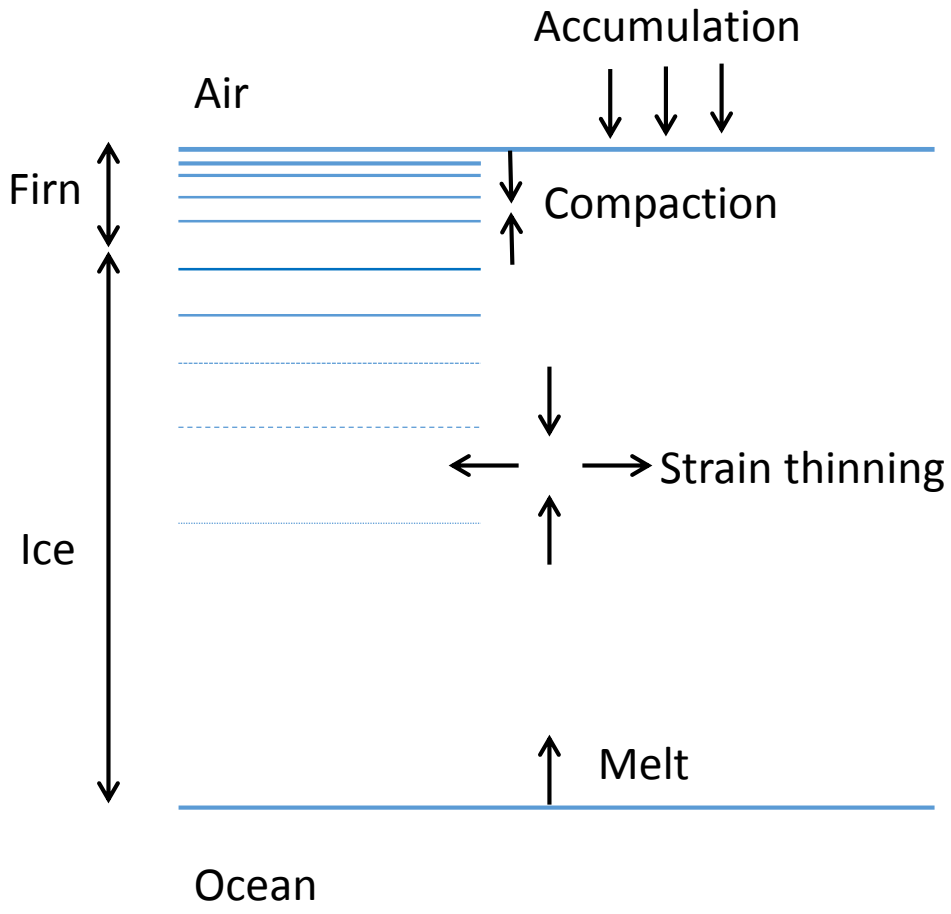
Seasonality in modelled melt rates is eroded and phase-shifted as grounding line is approached



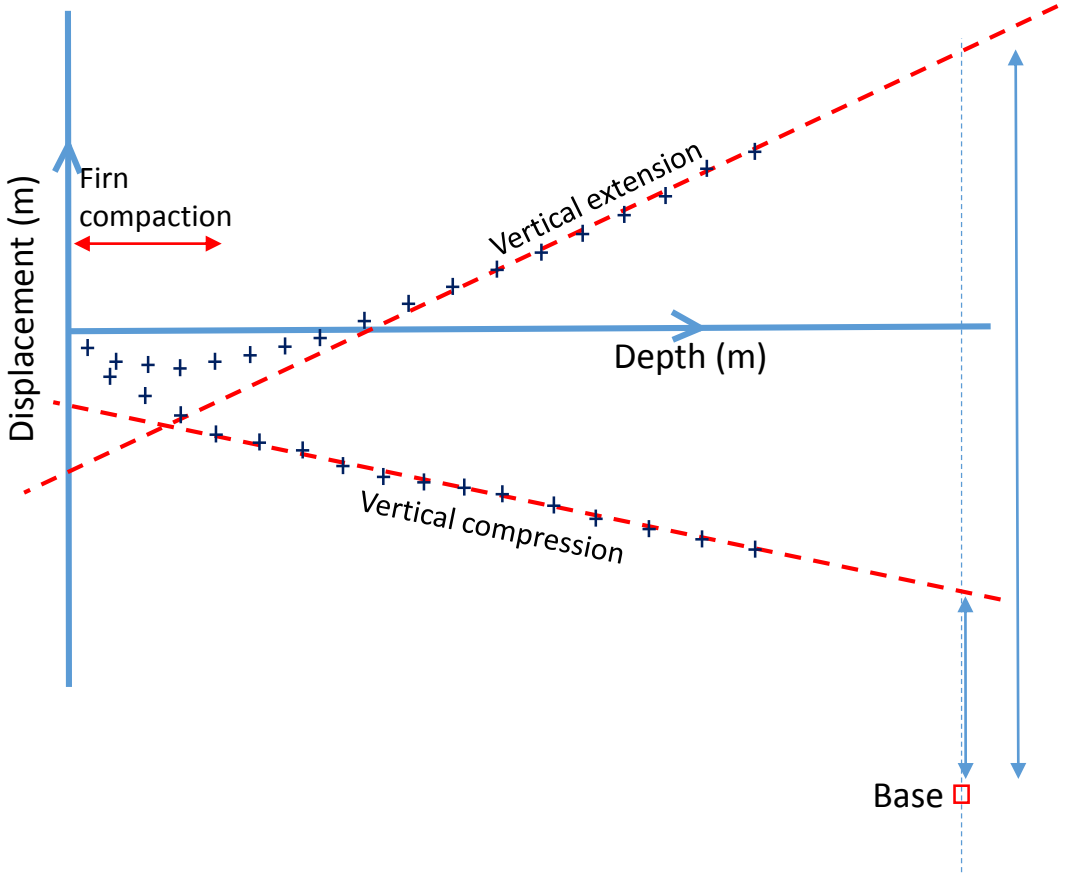
Time-varying melt rate is a sensitive diagnostic of model performance

Monitoring ice-shelf melt rates

1. Monitor change in range between internal reflecting horizons;
2. Determine strain effects of compaction and strain thinning;
3. Calculate melt rate, correcting for strain induced thickness change.



- Compaction
- Vertical strain rate
- Basal melt rate



Changes in instrument properties automatically accounted for.

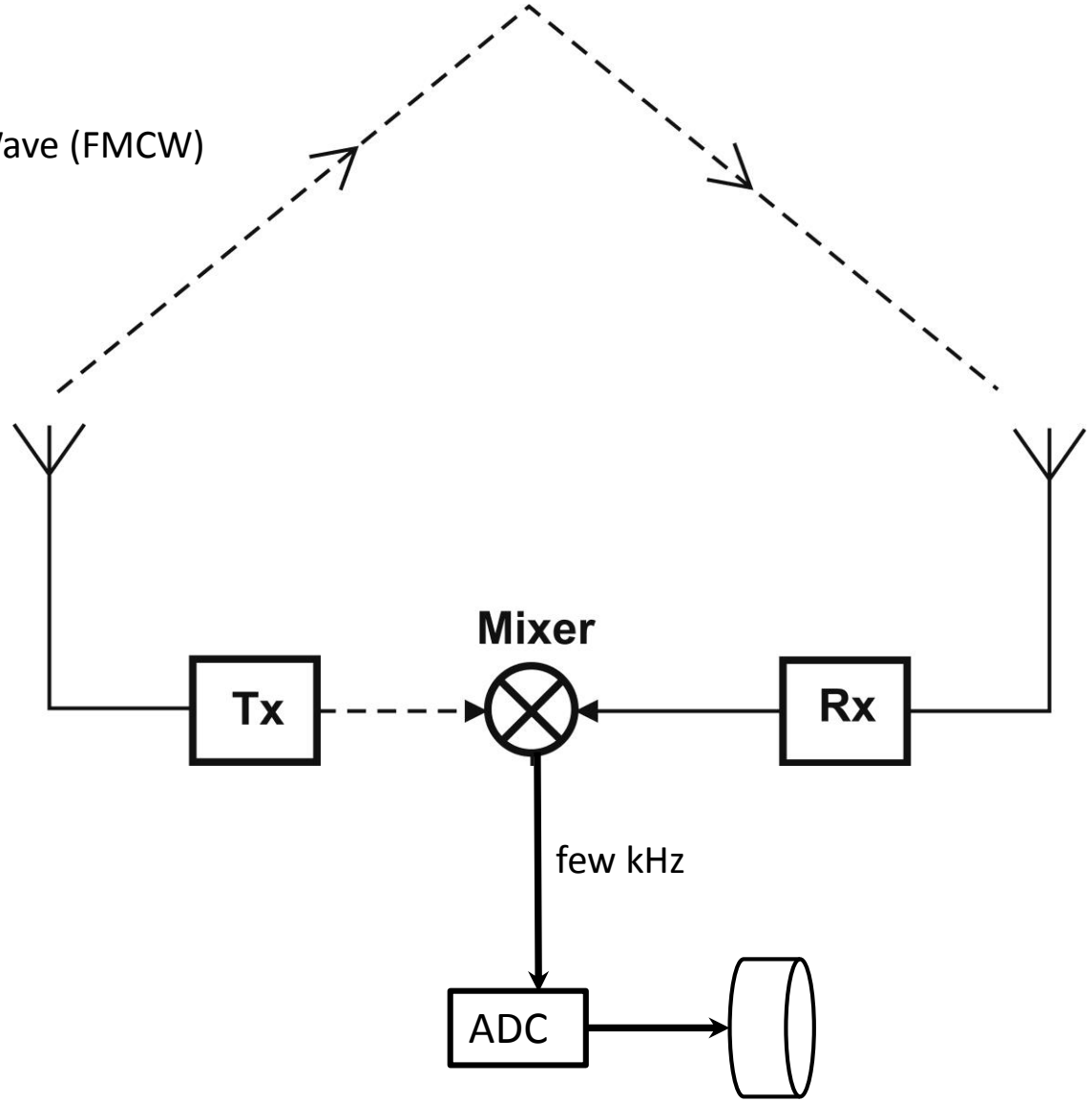
ApRES specifics

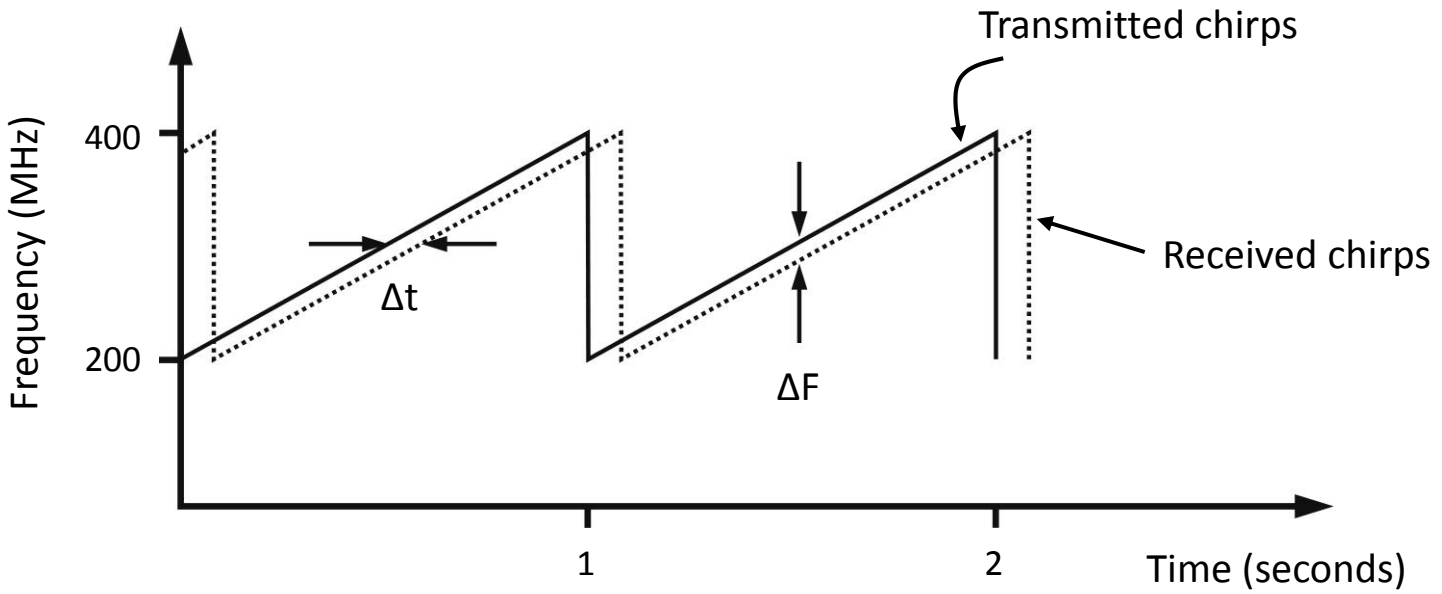
- Low power
- Low temperature
- Light weight
- Easy to use in the field
- Broad band

Frequency Modulated Continuous Wave Radar (FMCW)
(Various advantages – options for low power in particular)

How FMCW radar works:

Frequency Modulated Continuous Wave (FMCW)

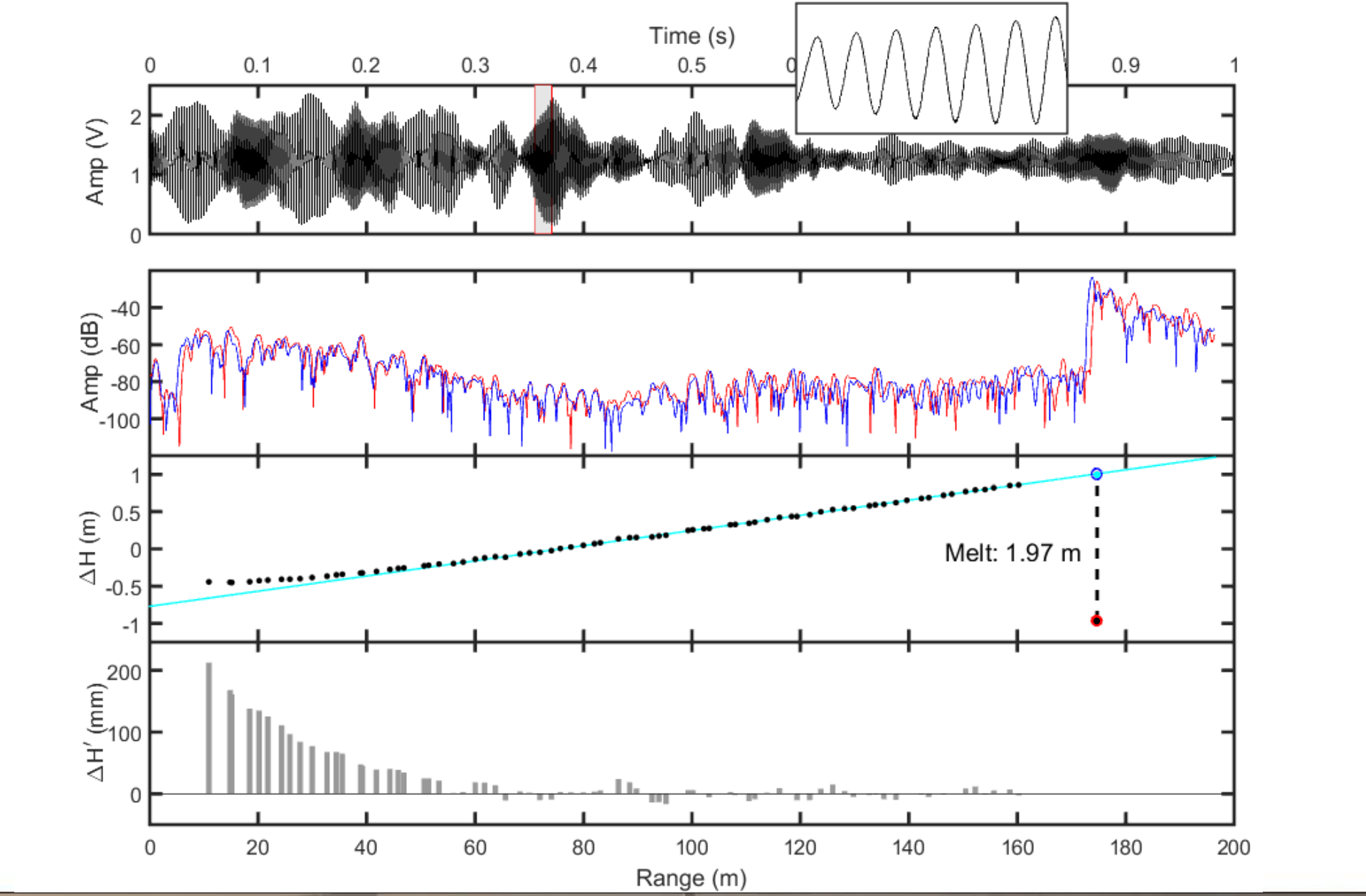


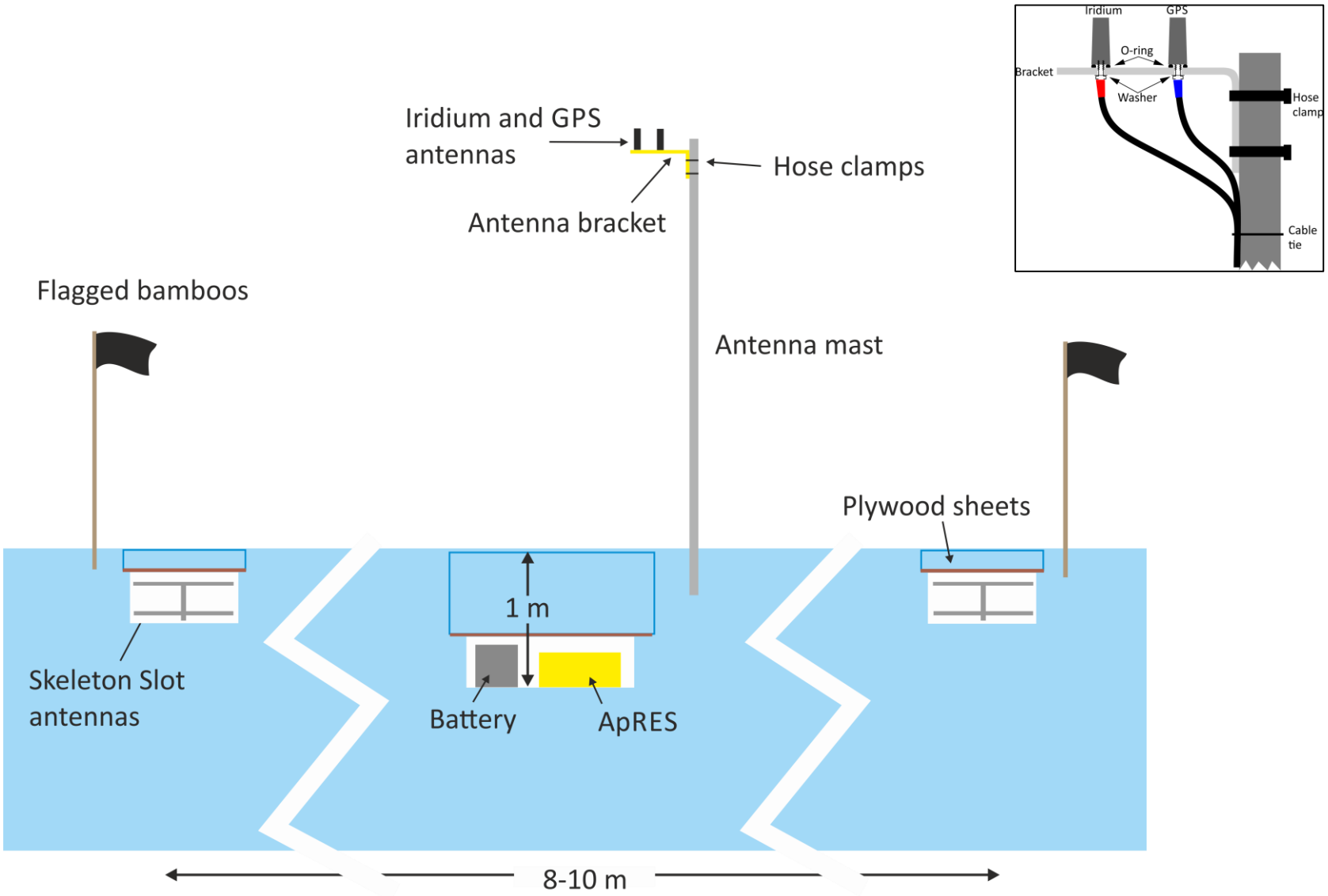


$$\Delta t = \frac{2 \times \text{Range}}{\text{Speed}}$$

$$\Delta F = \Delta T \text{ (secs)} \times dF/dt$$

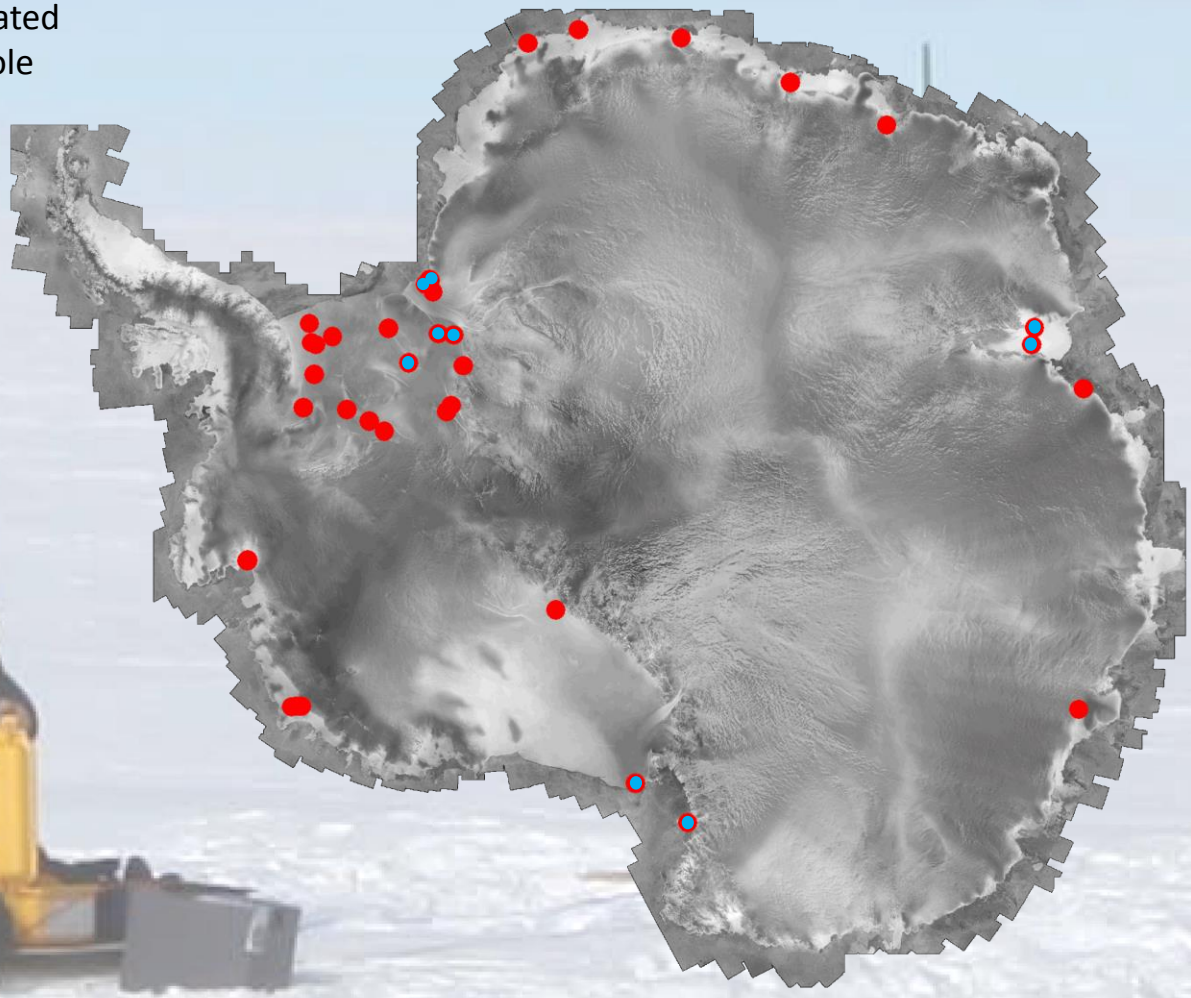
$$\text{Range} = \frac{\Delta F \times \text{Speed}}{2 \times 200}$$


Time (s)
Amp (V)
Amp (dB)
ΔH (m)
Melt: 1.97 m
ΔH′ (mm)
Range (m)


Iridium and GPS antennas
Hose clamps
Antenna bracket
Flagged bamboos
Antenna mast
Plywood sheets
1 m
Skeleton Slot antennas
Battery
ApRES
8-10 m
Iridium
GPS
O-ring
Bracket
Washer
Hose clamp
Cable tie

Co-located borehole

Filchner-Ronne
Nivl
Fimbul
Ekstrom
Shirase
Roi-Boudoin
Amery
Totten
Sorsdal
Ross
Dygalski
Nansen
Getz
Pine Island



Sweden
Japan

Australia
Norway

U.K.
New Zealand

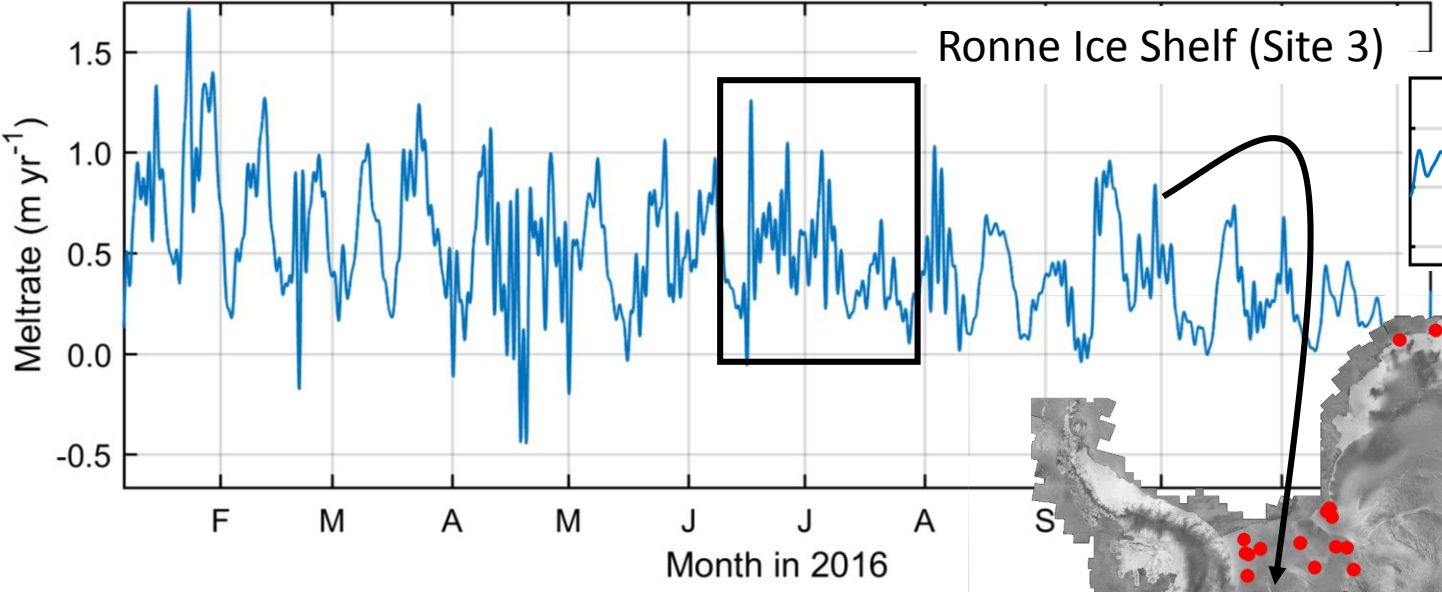
Korea
Belgium

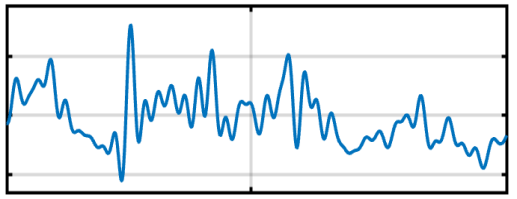
Germany
USA

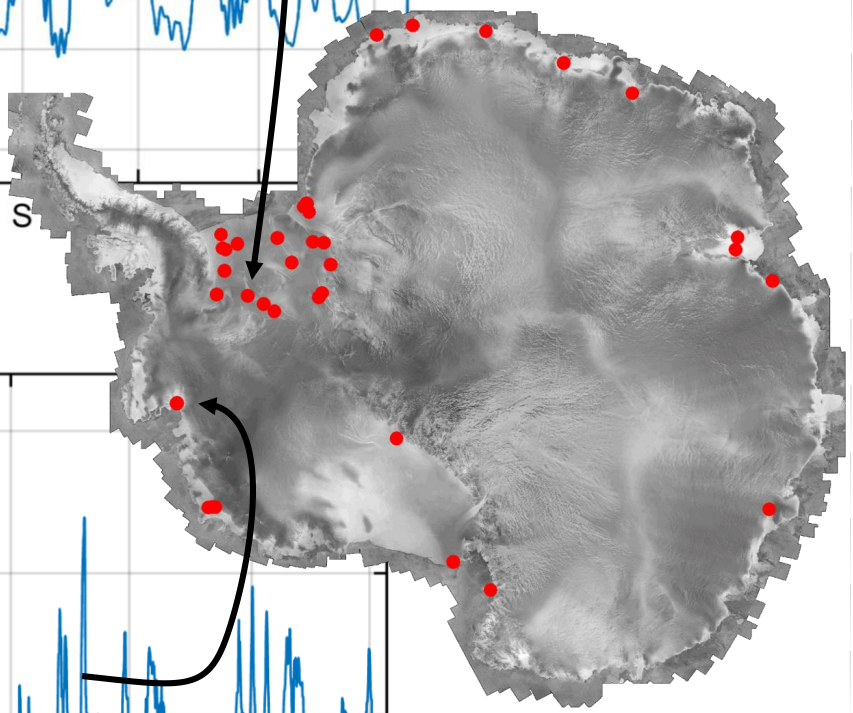
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

SOOS
SOUTHERN OCEAN OBSERVING SYSTEM

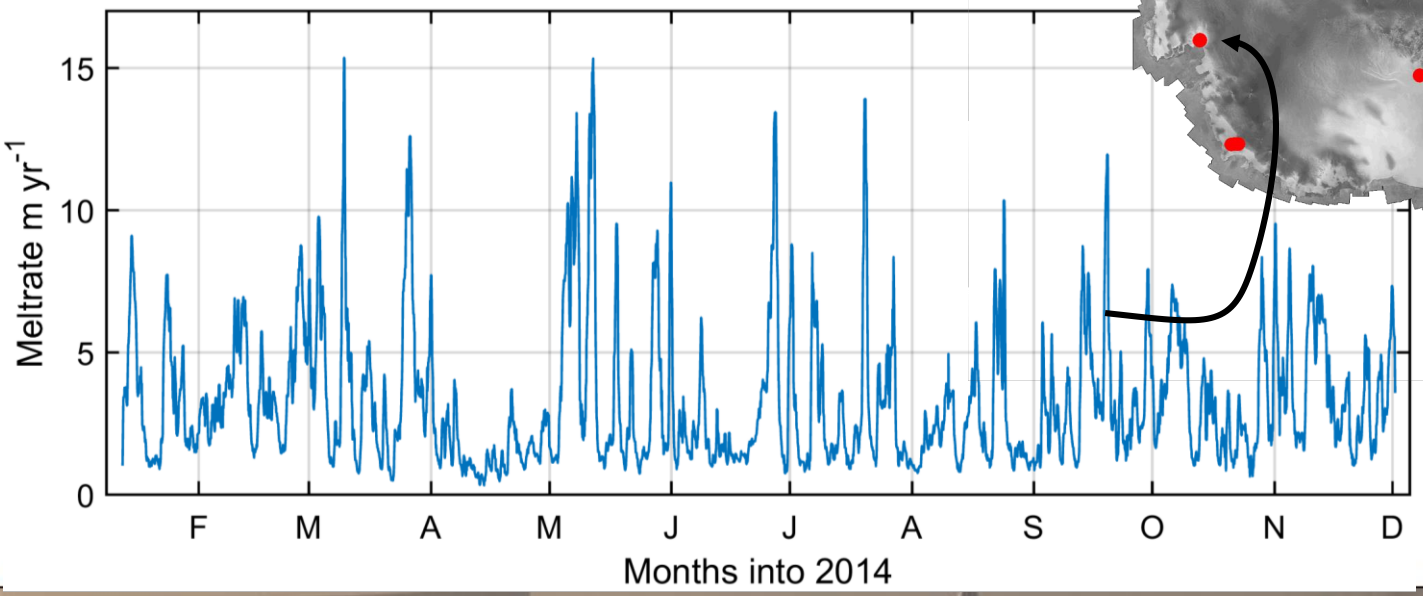
Ronne Ice Shelf (Site 3)







Pine Island Glacier



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

SOOS
SOUTHERN OCEAN OBSERVING SYSTEM

Some results from the 2016 NECKLACE workshop

Website (pages within Southern Ocean Knowledge and Information wiki (SOKI))

Repository for:

1. Instrument manuals
2. Guidance notes for instrument deployment
3. Scripts to process datasets
4. Forum for discussion of problems/solutions

These are presently plans, and are awaiting availability of staff time

Data distribution

- Present plan is for monthly mean melt rates to be made available
- Data format to be confirmed
- Data access to be arranged


British
Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
SOOS
SOUTHERN OCEAN OBSERVING SYSTEM

Abstract

The NECKLACE initiative is a SOOS-endorsed project to gather time series of basal melt rates from Antarctic ice shelves as contemporaneously as possible. Here we discuss the motivation for the project and the field-deployable solution that has been developed. We review the range of sites instrumented to date, and show some example datasets from Filchner-Ronne Ice Shelf that demonstrate variability from tidal, through mesoscale, to seasonal.