Ice-ocean interactions at Riiser-Larsen Ice Shelf assessed by unveiling of seabed beneath it

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Survey area

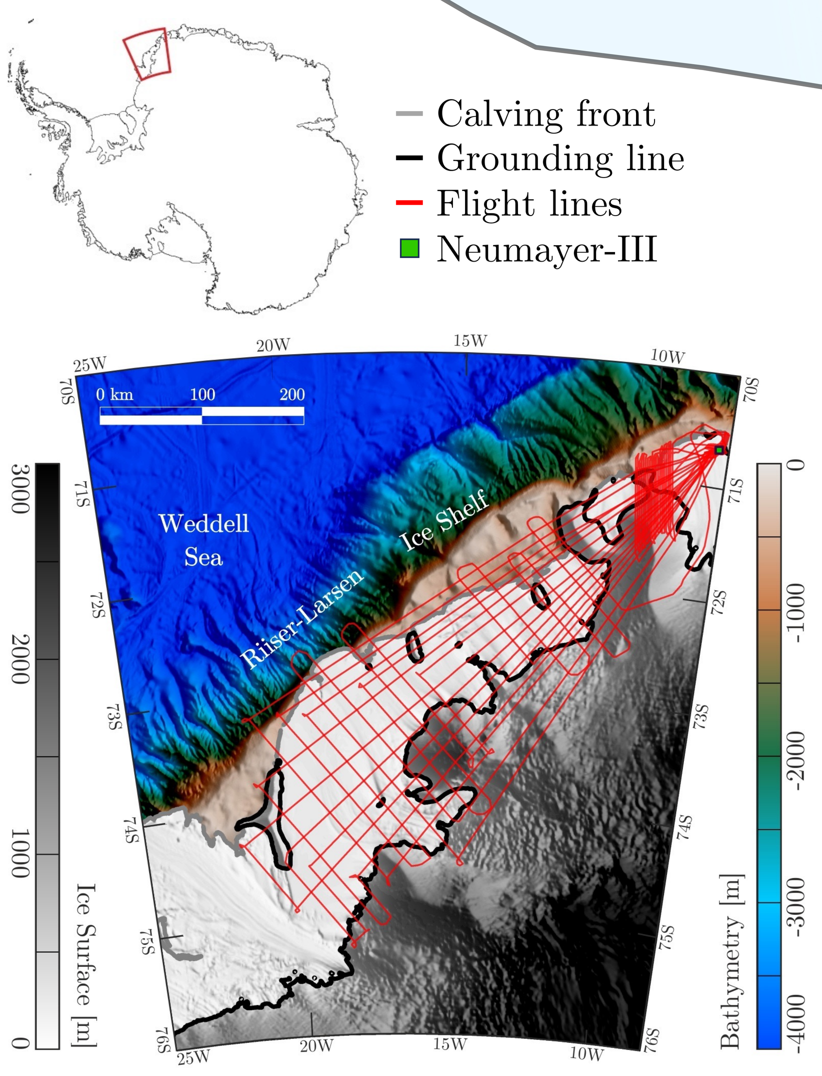


Figure 1. Overview of Antarctica with Riiser-Larsen Ice Shelf in East Antarctica; the fourth largest ice shelf of Antarctica[3] with REMA[4] across the ice-covered regions and IBCSOV2 in the open ocean[5]. Gravity, magnetic, and ice penetrating radar data was acquired in 2022/23 along indicated flight lines.

PROBLEM

Stability of **interconnected ice shelves** and **ice sheets** is challenging to assess.

Shape of **seafloor** beneath ice shelves **controls** water mass and heat **exchange** beneath them[1,2].

Bathymetry beneath Riiser-Larsen Ice Shelf is entirely unknown.

ACTION

Generation of **bathymetric model** based on gravity inversion.

Analysis of available **oceanographical** data along coast.

Analysis of **ice base morphology** based on radar data.

AIM

Assessment of **ice-ocean interactions** and ice shelf stability at the **Riiser-Larsen Ice Shelf**.

Ice

Antarctic Surface Water

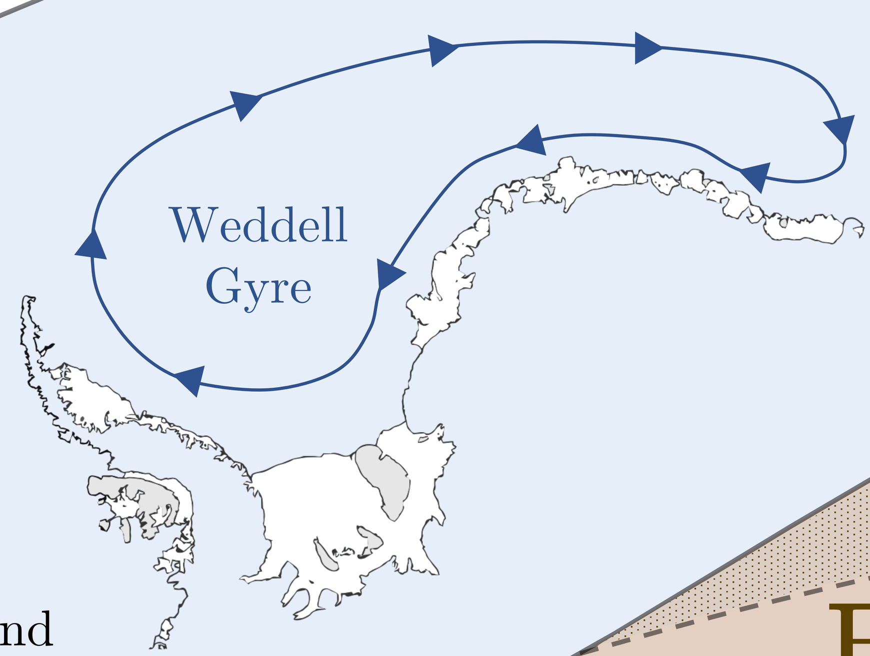
Ocean

Eastern Shelf Water

Warm Deep Water

???

Bathymetry



- The Weddell Gyre shapes water masses along the Riiser-Larsen Ice Shelf[6].
- It transports Antarctic Surface Water, Eastern Shelf Water and Warm Deep Water along the coast[7,8].
- Potential of (seasonal) intrusion of Antarctic Surface Water, Winter Water and/or Warm Deep Water into cavity beneath Riiser-Larsen Ice Shelf.

Preliminary* bathymetric model beneath Riiser-Larsen Ice Shelf

*Inversion is not yet accounting for small- to medium-scale geological variability

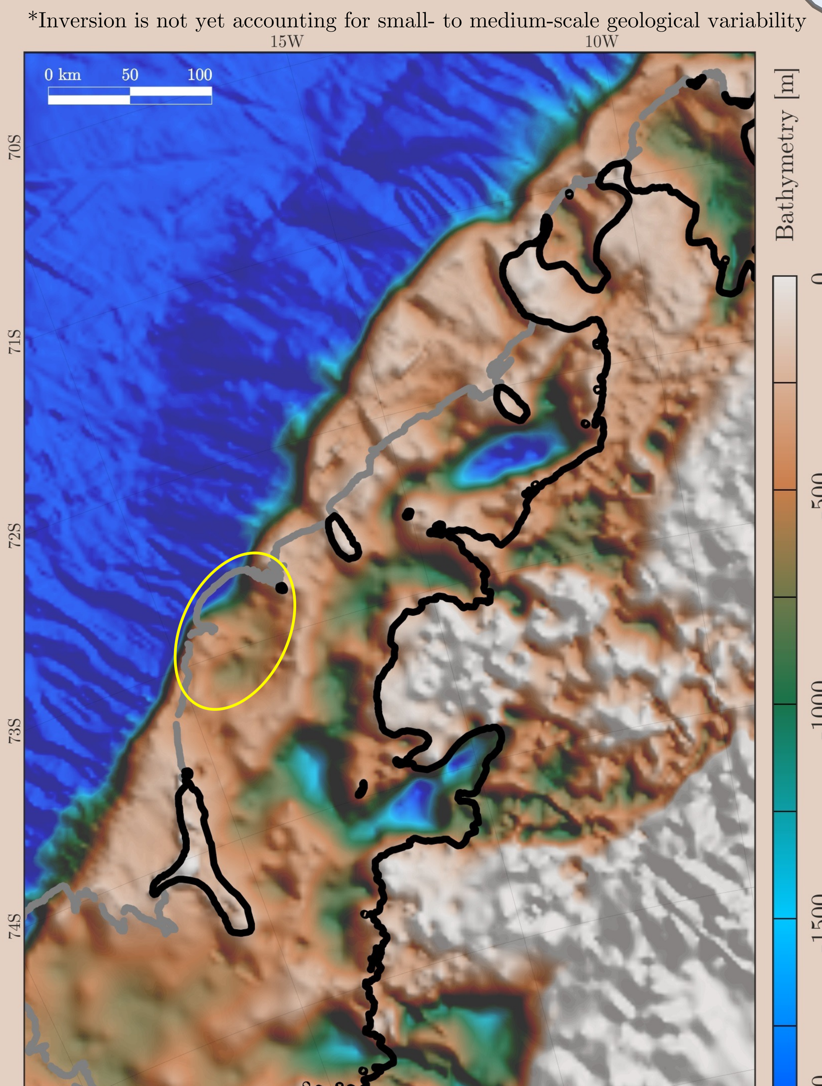


Figure 2. Bathymetric model beneath Riiser-Larsen Ice Shelf based on inversion of airborne gravity data and depth references from Fig. 5.

- **Bathymetric knowledge gap** beneath Riiser-Larsen Ice Shelf **closed** by gravity inversion (Fig. 2).
- **Differences** to current topography compilation[5] **of up to 1200 m.**
- Significant **intrusion of Warm Deep Water is unlikely** due to high thermo-cline depths[9] (Fig. 3); possible exception is a gateway with depths of 500 m beneath the ice shelves central calving front (yellow circle in Fig. 2).
- **Basal melting** likely dominated by intrusion of **Antarctic Surface Water** and **Winter Water** (Fig. 6).

- Basal structures (Fig. 4) show **subglacial channels** in certain areas implying basal melt processes.
- **Central pinning point** is of significance, posing as **onset of** predominant **channels** at ice base.
  - Likely caused by **intrusion** of Warm Deep Water and/or Winter Water

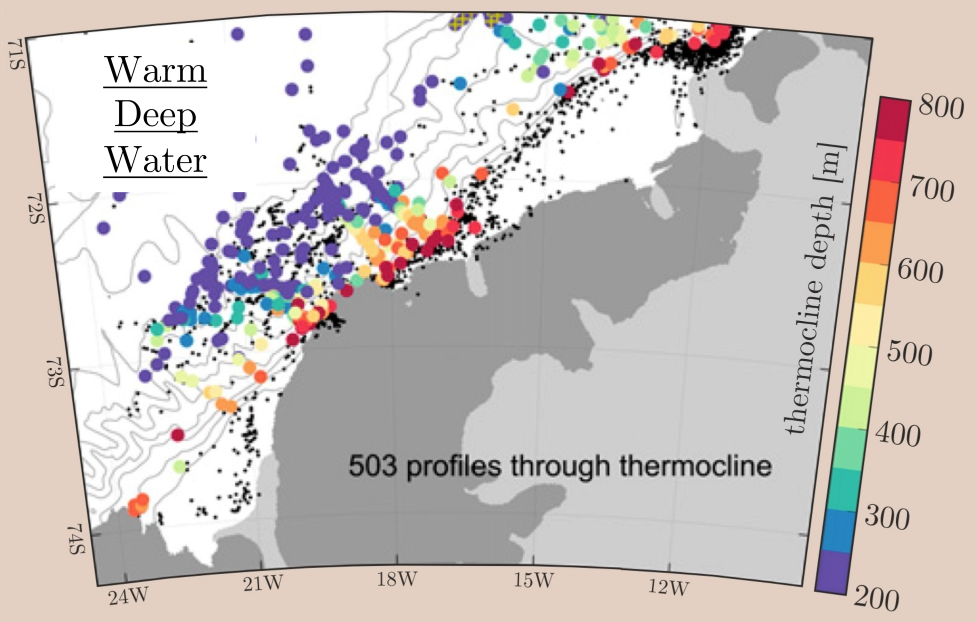


Figure 3. Thermocline depth of Warm Deep Water along the coast of Riiser-Larsen Ice Shelf, modified from Hattermann (2018).

Basal features of Riiser-Larsen Ice Shelf

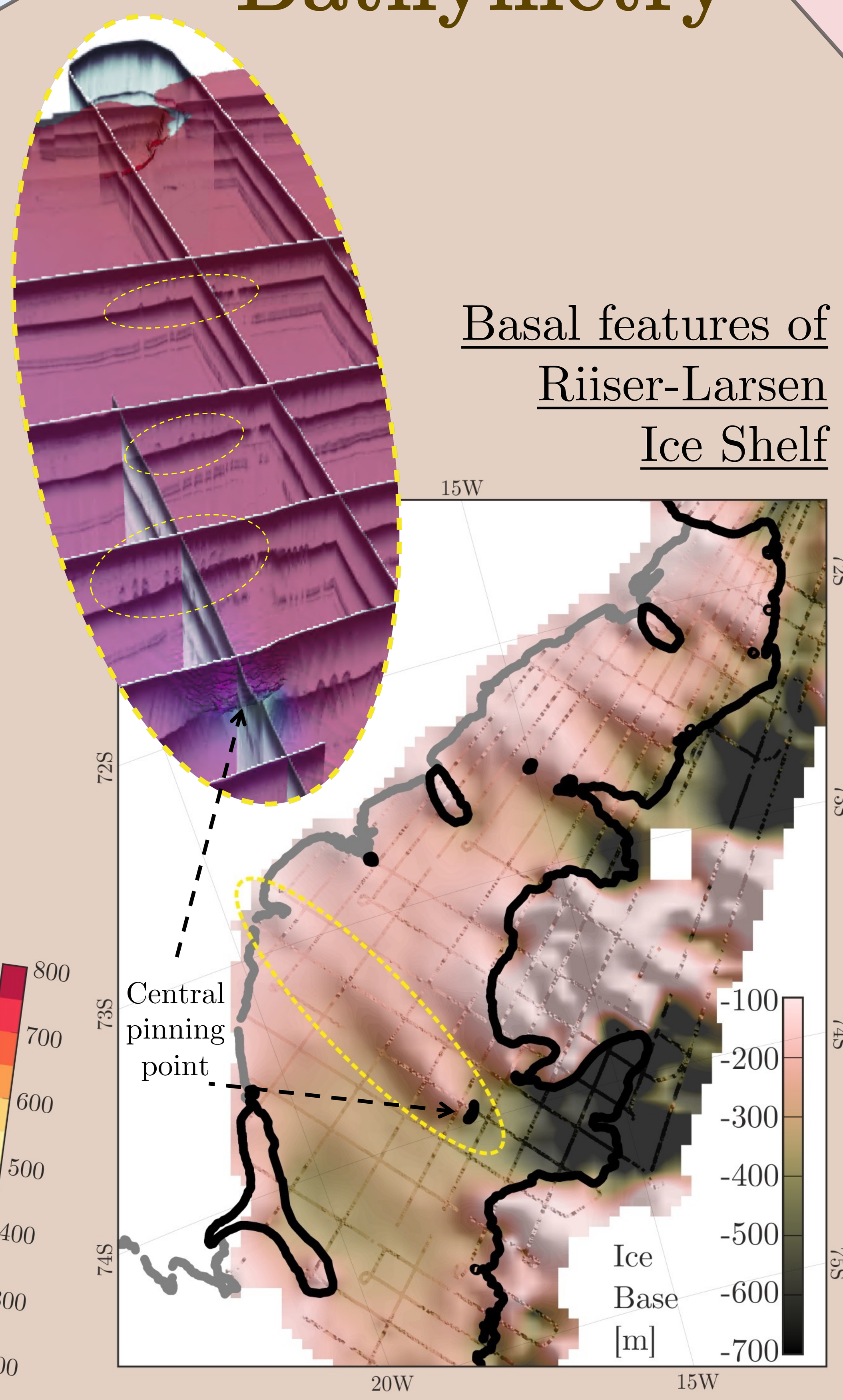
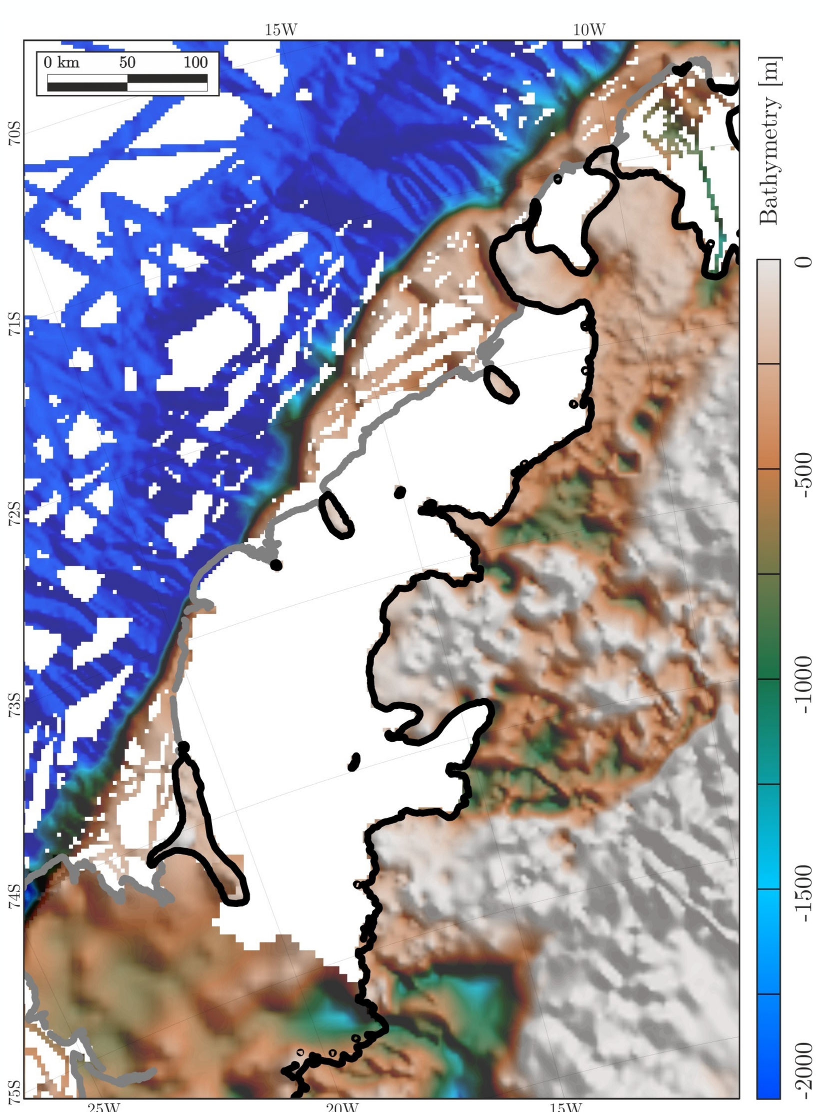


Figure 4. Base of ice across Riiser-Larsen Ice Shelf from newly acquired ice penetrating radar data with three-dimensional close-up marked in yellow.

Materials and Methods

- Survey design:

During the austral summer of 2022/23 aerogeophysical data was acquired within the *RIISERBATHY* campaign along depicted flight lines (Fig. 1) with the main objective of determining the subglacial topography. Gravity data were acquired simultaneously with a GT-2A and an iMAR strapdown gravity meter. Additionally, ice penetrating radar data (with a centre frequency of 150 MHz[10]) and magnetic data were gathered.

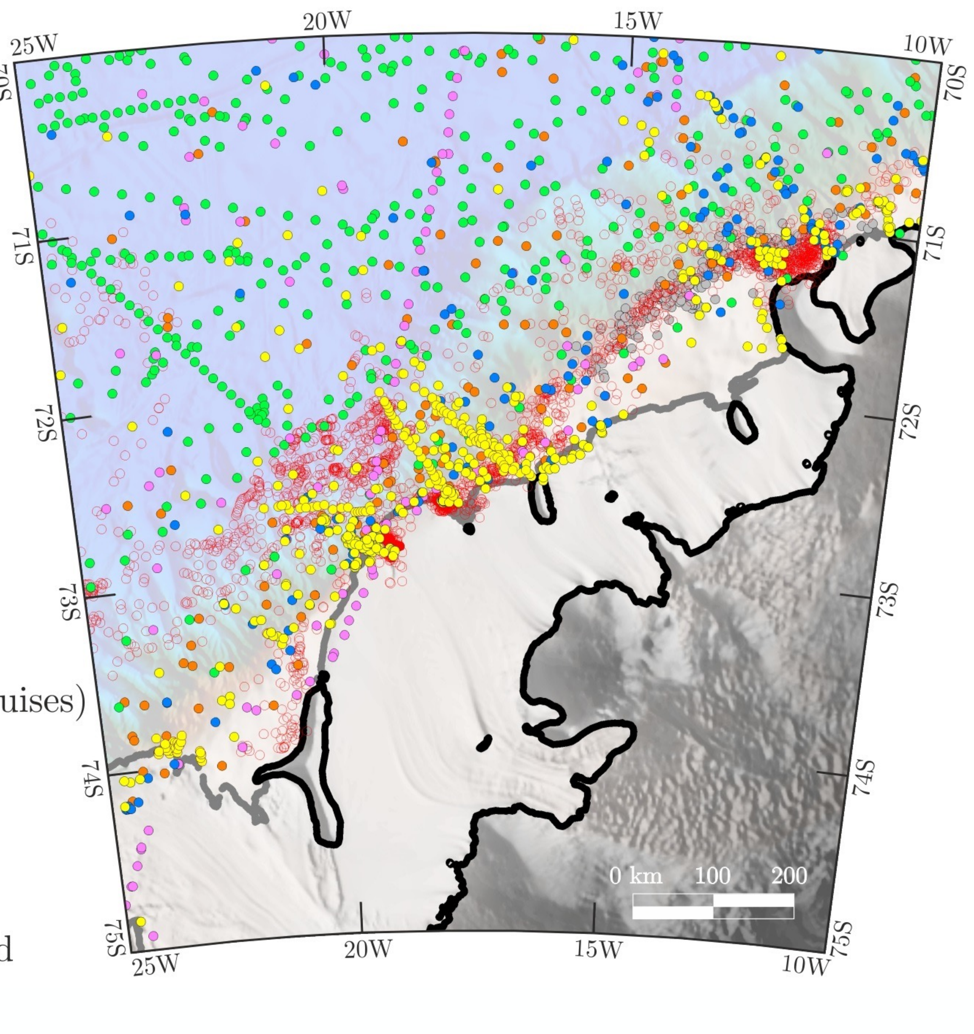


- Bathymetric modelling:

Acquired gravity data are inverted for bathymetry with the module *GM SYS 3D* of *Geosoft Oasis montaj*. Known topography from shipborne hydroacoustic data along the coast and ice penetrating radar data in regions of grounded ice (Fig. 3) are used to support model development. Model resolution and accuracy is in the range of 100 to about 250 m.

Figure 5. Available depth references at the Riiser-Larsen Ice Shelf. These contain newly acquired ice penetrating radar data (Fig. 1) and BedMachine Antarctica[11] in grounded regions, shipborne hydroacoustic data from IBCSO V2[5] in the open ocean, seismic data across Ekströmisen[12], and a bathymetry model across Brunt Ice Shelf[13].

Figure 6. Oceanographic data available offshore the Riiser-Larsen Ice Shelf; available from various sources listed below.



- Oceanography

Oceanographical data in the area was compiled from the World Ocean Database[14], animal-borne measurements[15], and individual casts[9]. The compilation includes over 3000 stations of quality-controlled measurements throughout several decades and all seasons. It is used in combination with the bathymetric model (Fig. 2) and base ice morphology (Fig. 4) to make assumptions about ice-ocean interactions beneath the Riiser-Larsen Ice Shelf. Thermocline depth of Warm Deep Water with a similar dataset has been analysed by Hattermann (2018) in Fig. 3.

References:
Grounding lines and calving fronts in all figures from Mouginot, J. et al. (2017a). *MEaSUREs Antarctic Boundaries for IPY 2007-2009 from Satellite Radar, V2. Boulder, Colorado USA.*
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