Seasonal hydrography at the eastern flank of the Filchner Trough

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Key Points

- New two-year long moored time series at the eastern flank of the Filchner Trough reveals pronounced seasonal signal in hydrography
- The seasonal presence of MWDW and ISW is observed at the eastern flank
- Winter time hydrographic conditions impede a year-long inflow towards the Filchner Ice Shelf

1. Introduction

The **Filchner Ronne Ice Shelf** (FRIS), being one of the largest ice shelves in Antarctica, has long been known to play an important role in the production of dense overflow waters. The ice pump mechanism produces Ice Shelf Water (ISW), which leaves the area via the **Filchner Trough**. Warm Deep Water (WDW), which has circumpolar origin, circulates clockwise in the Weddell basin and is separated from the shelf waters by the Antarctic Slope Front (ASF). WDW enters the continental shelf along the eastern flank of the Filchner Trough in a modified version as **modified WDW** (MWDW) and imposes a potential threat on the Antarctic ice sheet in a warming climate. In 2013 it was observed in the vicinity of the ice front for the first time.

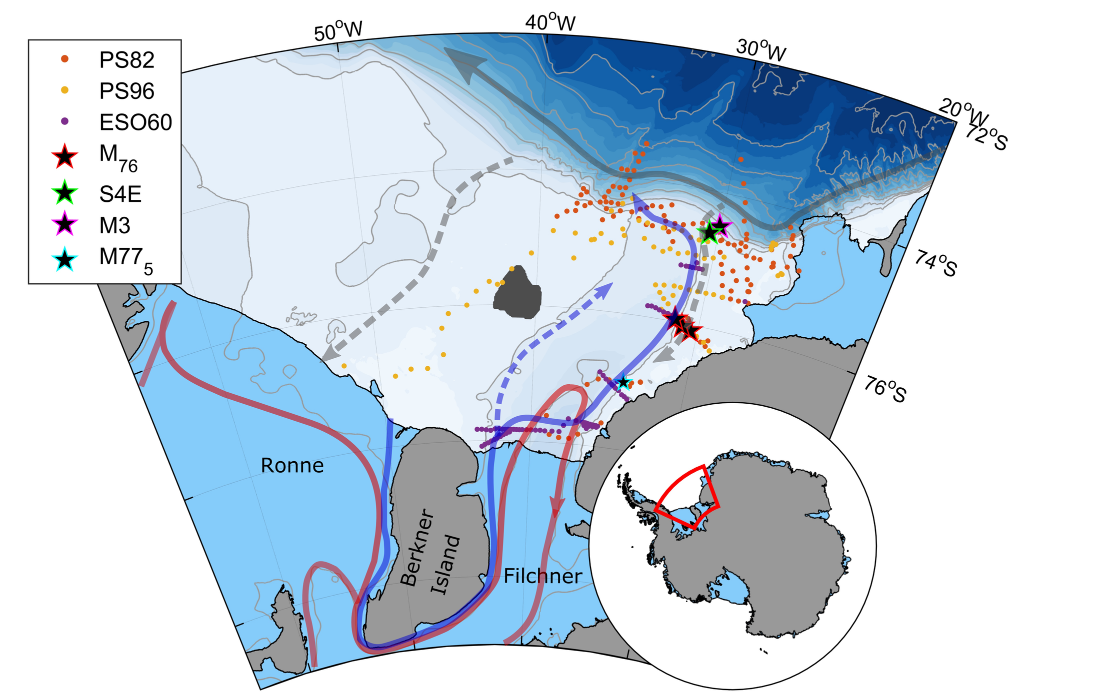

Figure 1: Station map with mooring locations. Arrows indicate the circulation, with red and blue representing the ISW pathways, gray gives the Antarctic Slope Current transporting WDW and dashed gray stands for the MWDW pathways onto the continental shelf. We define the shelf region east of the Filchner Trough as Eastern Shelf.

2. Data

- 3 two-year long **moored time series at 76°S**. At each mooring, temperature, salinity and pressure were recorded at two levels and velocities were measured close to the bottom.
- **hydrographic data** from 2 cruises with *RV Polarstern* in 2013/2014 (PS82) and 2015/2016 (PS96) and 1 cruise with *RSS Ernest Shackleton* (ESO60) in 2013.
- two moorings at the **shelf break** from 2007-2009 (S4E) and 2009 (M3)

3. Seasonal Hydrography - 4 Phases

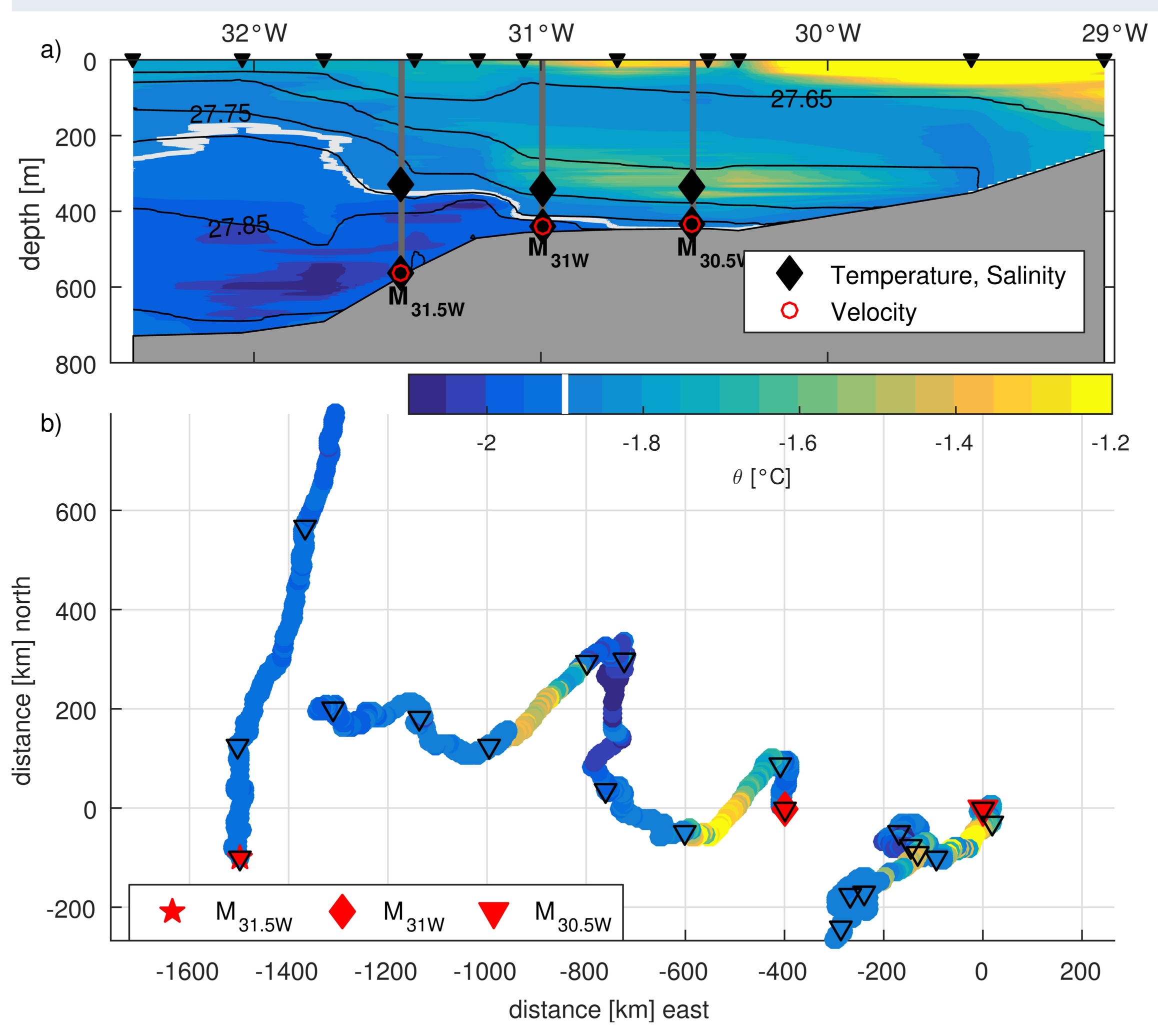

Figure 2: a) Potential temperature (θ) section along 76°S from PS96, with mooring locations and instrumentation. Black isolines denote potential density, referenced to the surface. b) Progressive vector diagram of near-bottom velocities at each mooring with θ in color. The starting points are shifted for better visualisation. Black triangles mark separate phases (defined in the following).

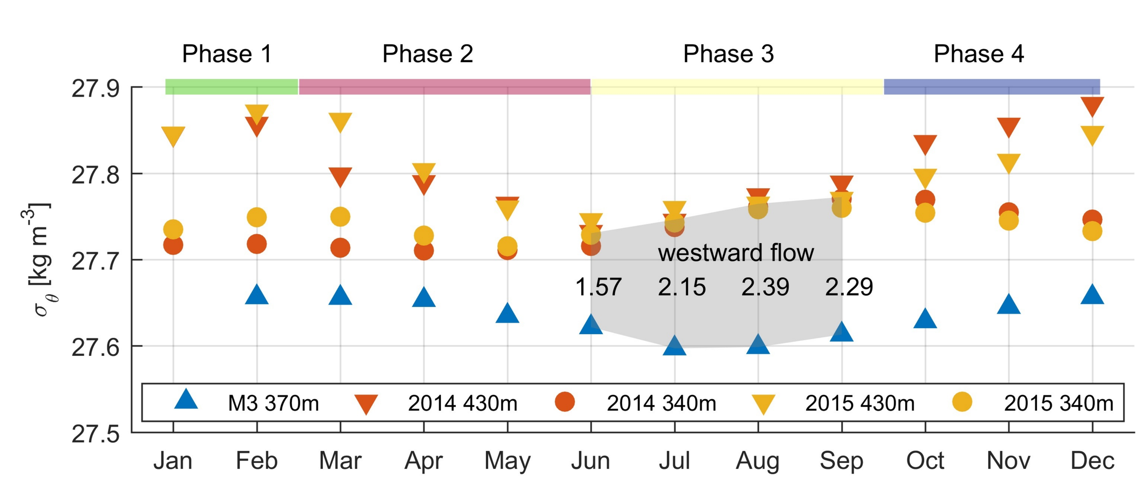

Figure 4: Monthly mean potential density at both instruments at M_{31W} (orange,yellow) compared to M3 at the shelf break (blue). Gray shading denotes months where westward velocities are observed at M_{31W} and the numbers denote estimated geostrophic velocities from the density gradient between both moorings.

→

M_{31W} reveals the most pronounced seasonal signal, with a distinct warm inflow followed by a shift in circulation. We take a closer look at the temperature and salinity time series at M_{31W}. $M_{30.5W}$ shows the same fundamental features.

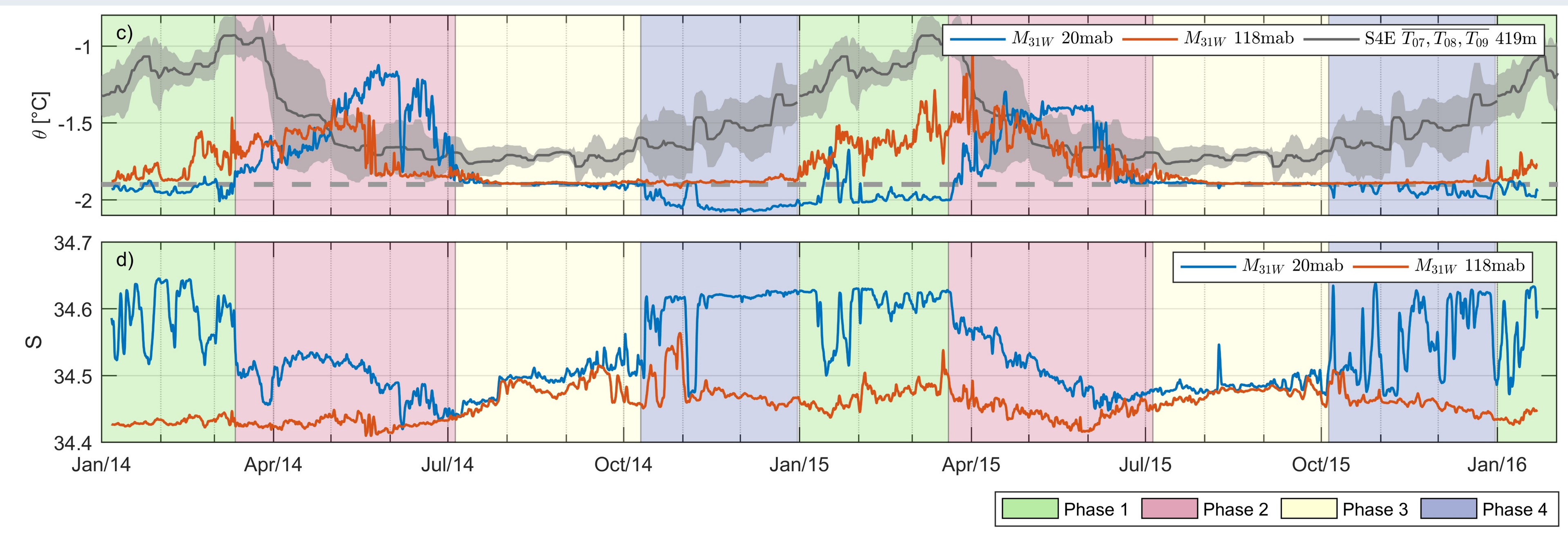

Figure 3: c) Low-pass filtered (24h) potential temperature (top) and salinity (bottom) at 338 m and 436 m depth at M_{31W}. A mean seasonal time series (2007-2009) at 419 m depth from S4E at the shelf break was constructed (gray line) with its standard deviation (gray shading). The background colors indicate the defined phases representing the seasonal cycle.

↓ Define 4 phases representing the seasonal cycle (see shading in Figure 3.)

Phase 1

- ISW at bottom → northward flow
- MWDW at intermediate depth
- relaxed ASF → weak wind stress curl & fresh surface layer
- sea ice minimum

Phase 2

- ISW disappears from Eastern Shelf → decreasing ISW layer thickness in trough
- MWDW inflow at bottom → travel time from shelf break to M_{31W} is 1-2 month.
- inflow ends with abrupt drop of temperatures to the surface freezing point → strong interannual variability of timing

Phase 3

- deep winter convection (~ 500 m) → weak stratification on Eastern Shelf
- salinification of water column
- MWDW absent from continental shelf → suppressed Antarctic Slope front
- shift of circulation to westward flow → N-S density gradient (see Figure 4)

Phase 4

- ISW at bottom → northward flow
- MWDW absent on the Eastern Shelf
- freshening of shelf water
- ASF starts to relax → warming at shelf break

Drivers

The observed seasonal cycle on the Eastern Shelf stems from the interplay of different processes, such as the **seasonal heaving of the Antarctic Slope Front**, the **seasonal change of the ISW layer thickness** within the Filchner Trough and the atmospheric conditions, causing **deep winter mixed layers**.

References

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