

# On the Modified Warm Deep Water Flow toward the Filchner Ronne Ice Shelf: Observations and Model Results

Svenja Ryan <sup>1</sup>, Michael Schröder <sup>1</sup>, Ralph Timmermann <sup>1</sup>, Tore Hattermann <sup>1,2</sup> and Torsten Kanzow <sup>1</sup>

<sup>1</sup>Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

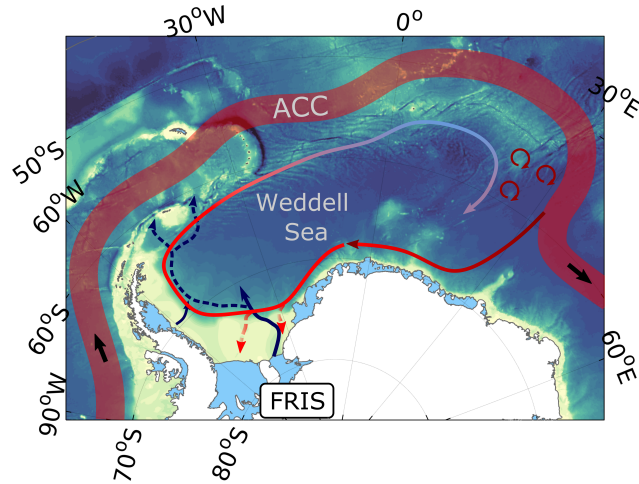
<sup>2</sup>Akvaplan-niva AS, High North Research Centre, Tromsø, Norway



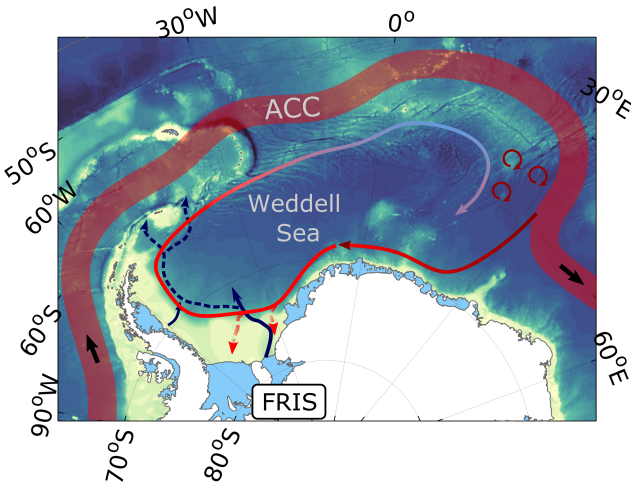
ALFRED-WEGENER-INSTITUT  
HELMHOLTZ-ZENTRUM FÜR POLAR-  
UND MEERESFORSCHUNG



# Why the Filchner Ronne Ice Shelf?



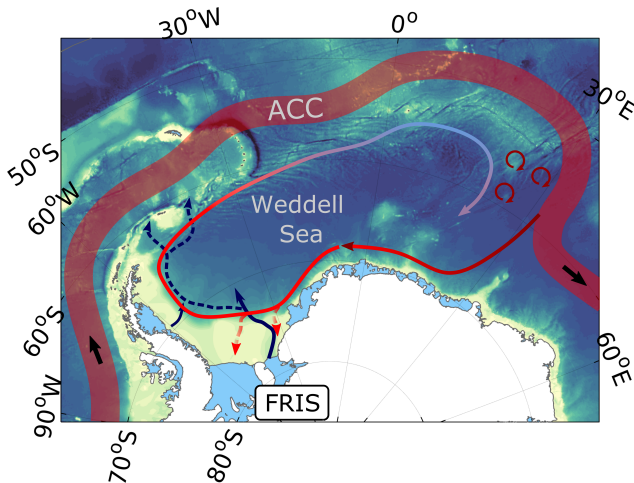
# Why the Filchner Ronne Ice Shelf?



FRIS plays key role  
in bottom water  
formation

By volume, the  
largest ice shelf in  
Antarctica

# Why the Filchner Ronne Ice Shelf?

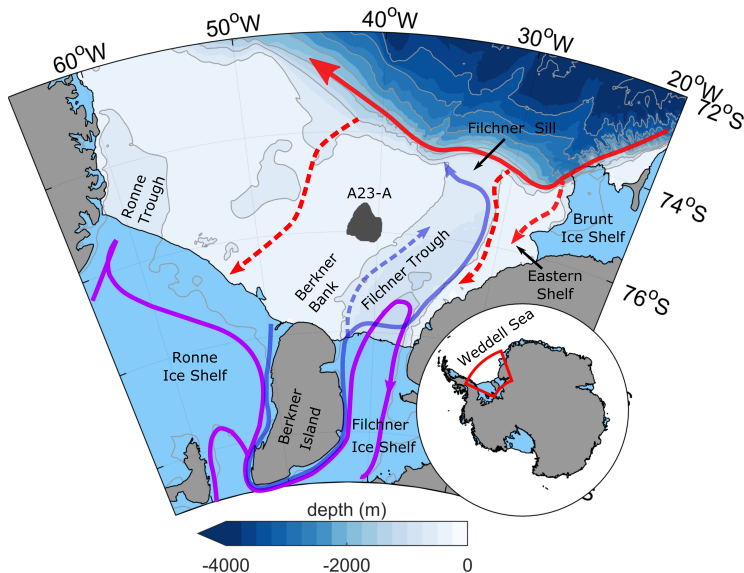


FRIS plays key role  
in bottom water  
formation

By volume, the  
largest ice shelf in  
Antarctica

No warm water  
enters cavity

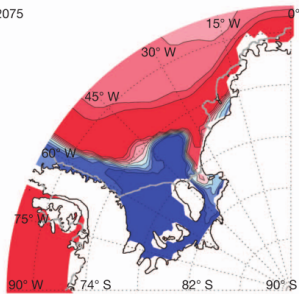
# The Filchner Ronne Ice Shelf



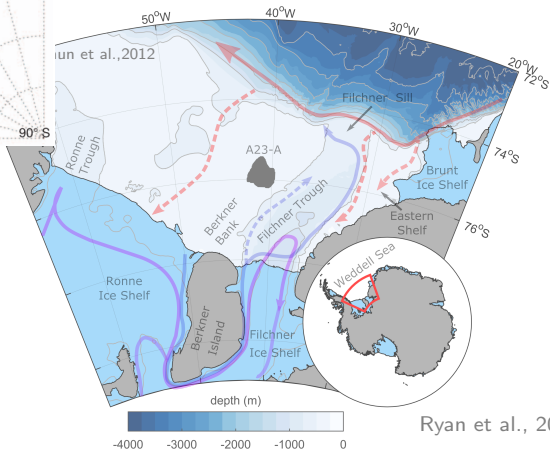
# The Filchner Ronne Ice Shelf



b 2075



Hellmer et al., 2012

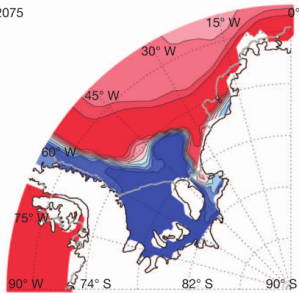


Ryan et al., 2017

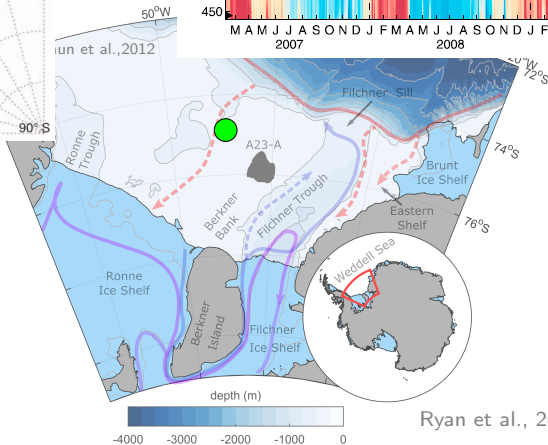
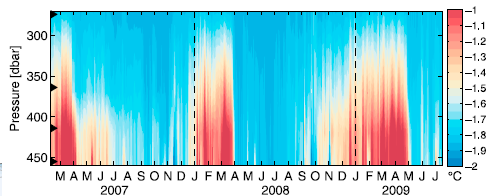
# The Filchner Ronne Ice Shelf



**b** 2075



Hellmer et al., 2012

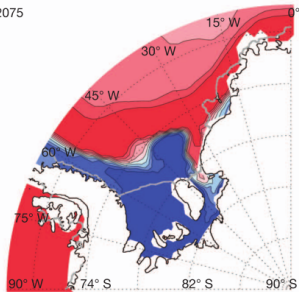


Ryan et al., 2017

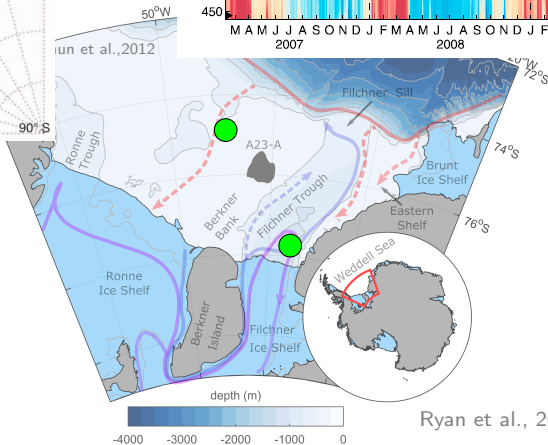
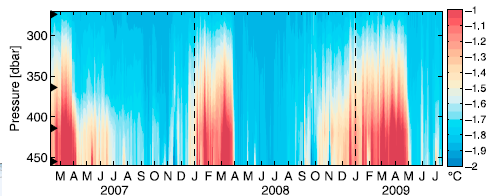
# The Filchner Ronne Ice Shelf



**b** 2075



Hellmer et al., 2012



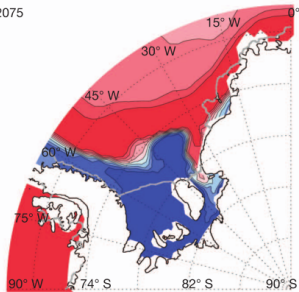
Ryan et al., 2017



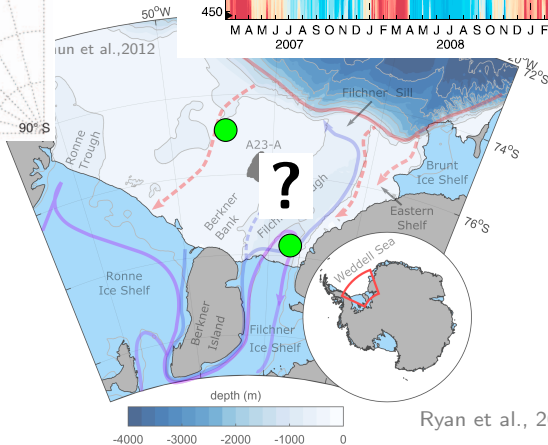
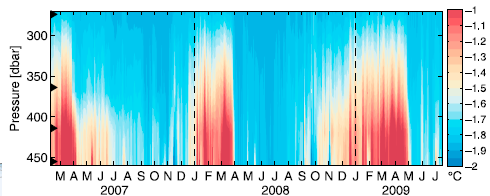
# The Filchner Ronne Ice Shelf



**b** 2075

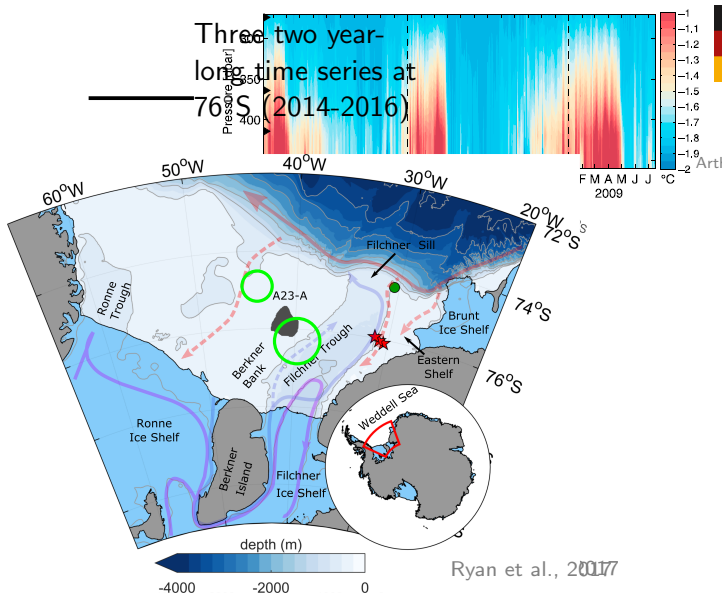


Hellmer et al., 2012

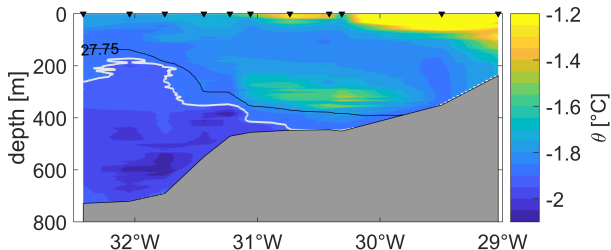


Ryan et al., 2017

# The Filchner Ronne Ice Shelf

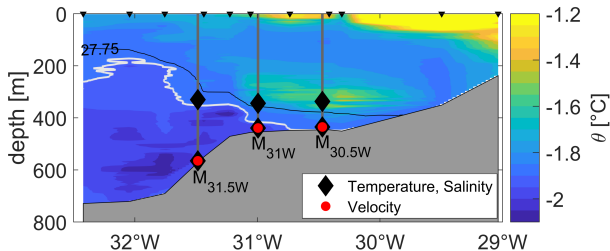


# Seasonal Hydrography Filchner Trough



- thick ISW layer filling the trough
- MWDW enters over the eastern shelf

# Seasonal Hydrography Filchner Trough

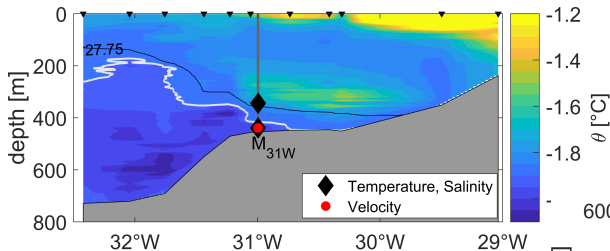


- thick ISW layer filling the trough
- MWDW enters over the eastern shelf

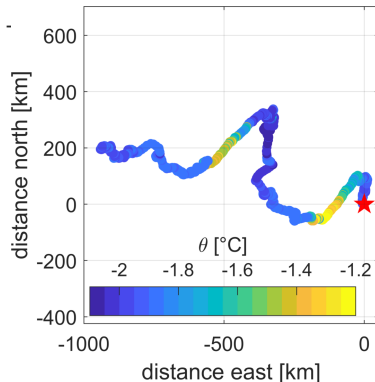
# Seasonal Hydrography Filchner Trough



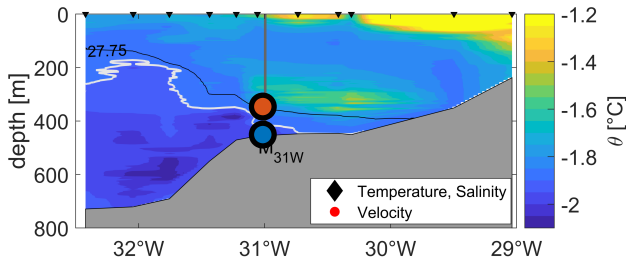
Ryan et al., 2017



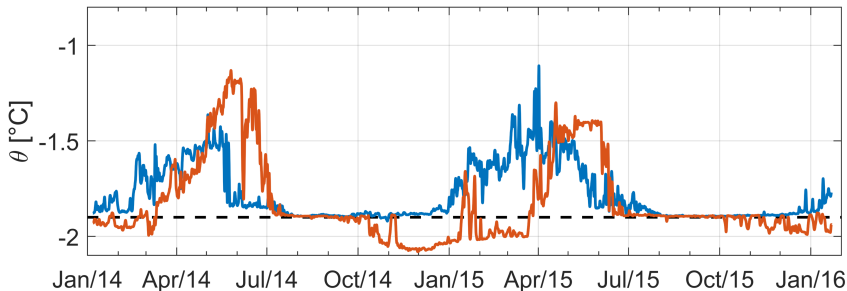
- thick ISW layer filling the trough
- MWDW enters over the eastern shelf
- persistent inflow of MWDW in summer
- strong seasonal shift in circulation



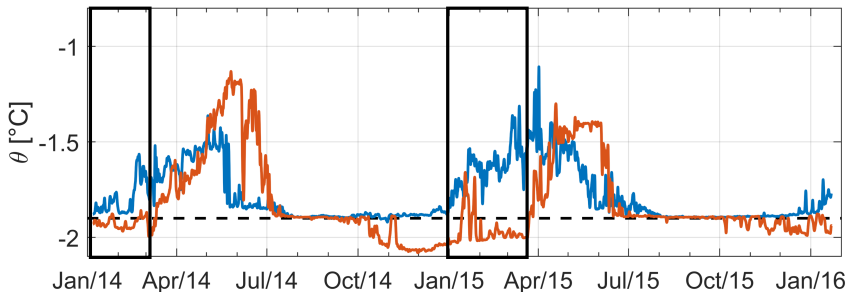
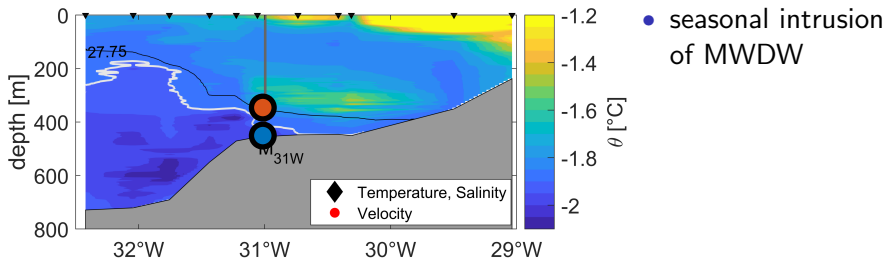
# Seasonal Hydrography Filchner Trough



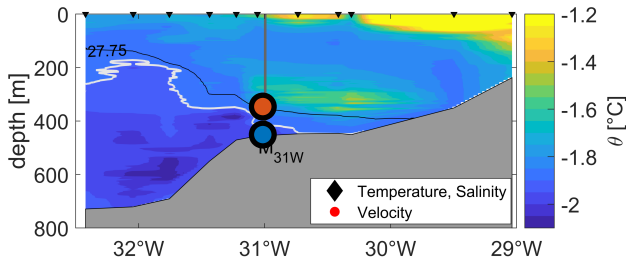
- seasonal intrusion of MWDW



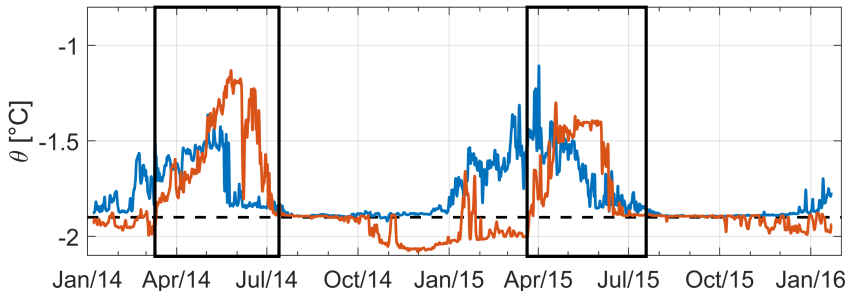
# Seasonal Hydrography Filchner Trough



# Seasonal Hydrography Filchner Trough

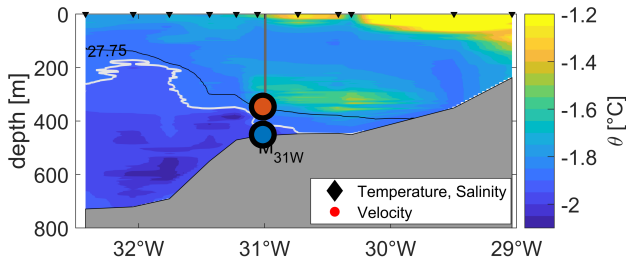


- seasonal intrusion of MWDW

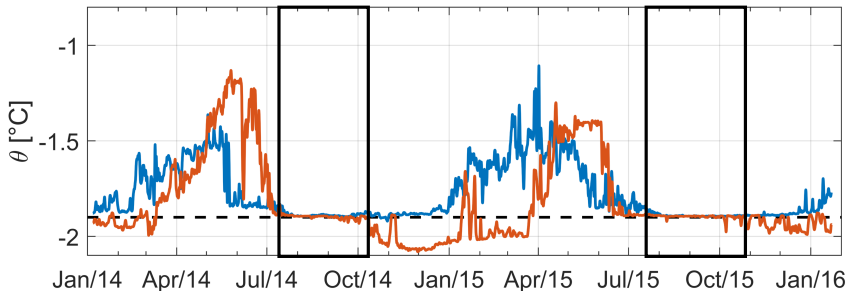




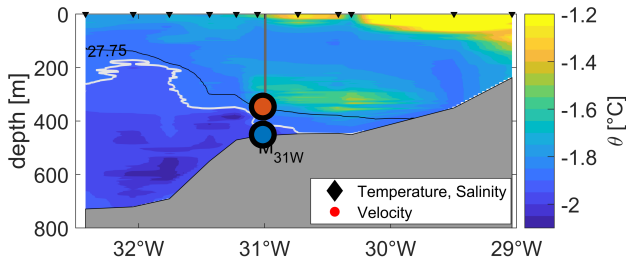
# Seasonal Hydrography Filchner Trough



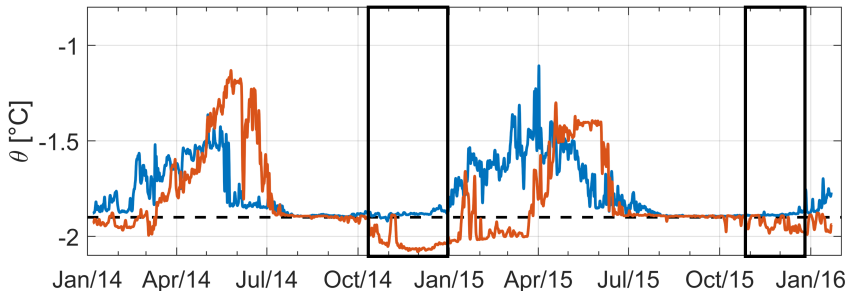
- seasonal intrusion of MWDW
- shelf convection in winter



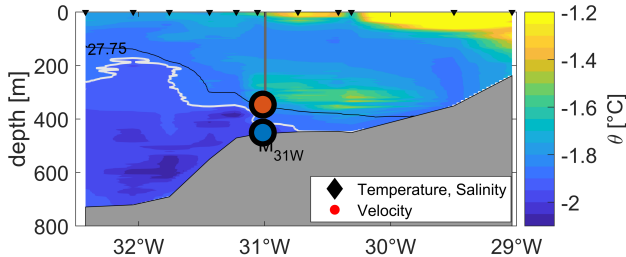
# Seasonal Hydrography Filchner Trough



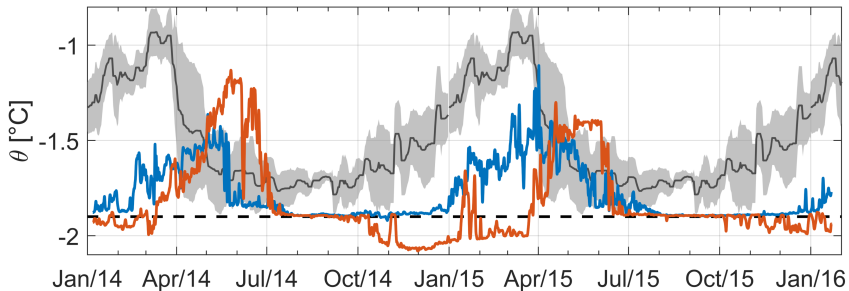
- seasonal intrusion of MWDW
- shelf convection in winter
- connection to slope front position



# Seasonal Hydrography Filchner Trough

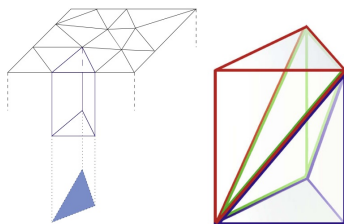


- seasonal intrusion of MWDW
- shelf convection in winter
- connection to slope front position



# Finite Element Sea Ice-Ocean Model (FESOM)

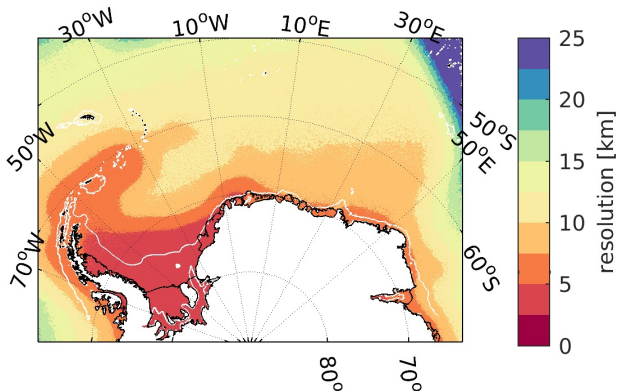
- unstructured mesh
- primitive-equation, hydrostatic global ocean model
- dynamic-thermodynamic sea-ice and ice-shelf component
- hybrid vertical coordinate with 22 sigma-layers and 36 z-layers, transition at 2500 m
- forced with NCEP-CFSR reanalysis (1979-2010)
- initialised with World Ocean Data Atlas 2013



# New high resolution configuration



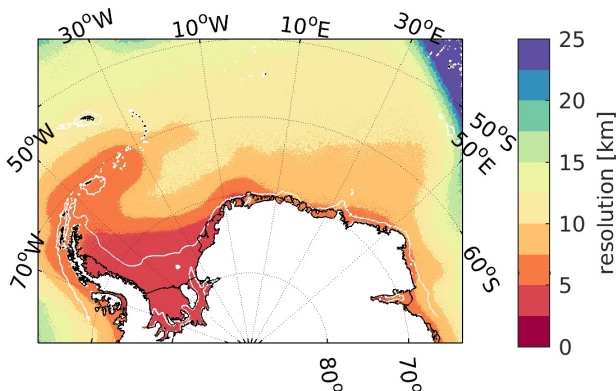
Runtime: 1979-2010, spin-up: 1979-1999, analysis: 2000-2010



# New high resolution configuration



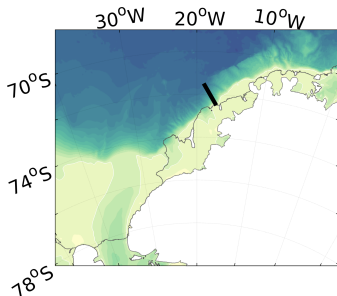
Runtime: 1979-2010, spin-up: 1979-1999, analysis: 2000-2010



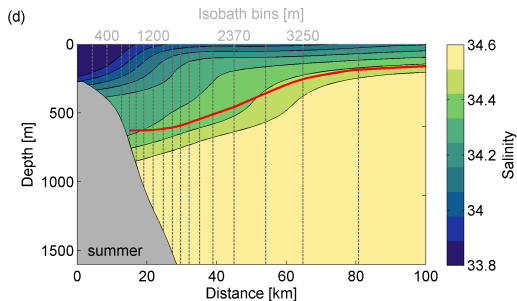
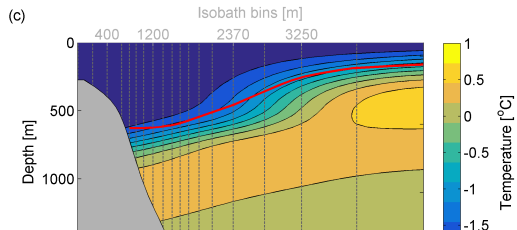
Configuration leads to significantly improved:

- general Weddell Gyre circulation
- slope front properties

# Sensitivity test: Slope front restoring

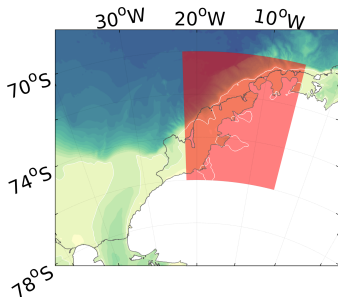


- Implement data into World Ocean Data Atlas (2013)
- restore model upstream of the study area (3 hourly)

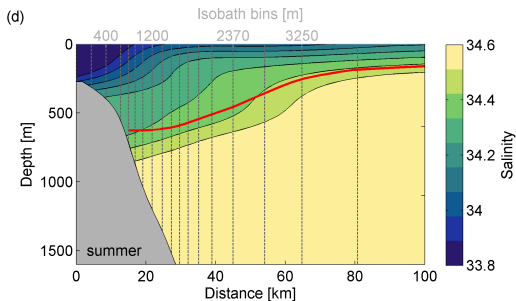
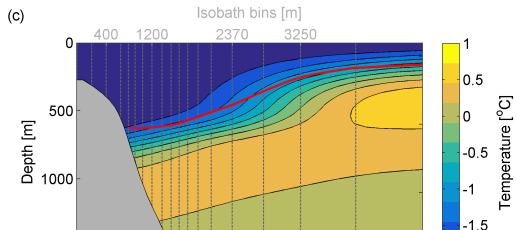


Hattermann, in prep.

# Sensitivity test: Slope front restoring



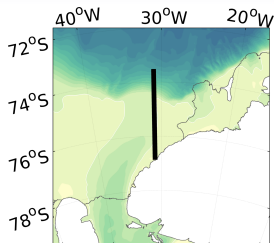
- Implement data into World Ocean Data Atlas (2013)
- restore model upstream of the study area (3 hourly)



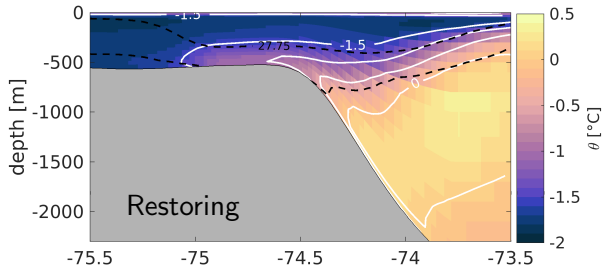
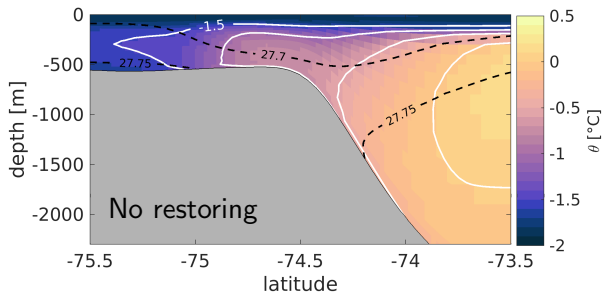
Hattermann, in prep.



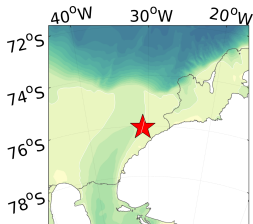
## Shelf break properties



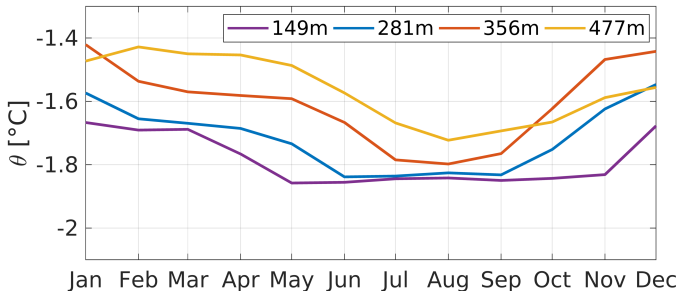
- Hydrographic shelf break properties cannot be reproduced in high resolution run
- Restoring upstream leads to a realistic representation



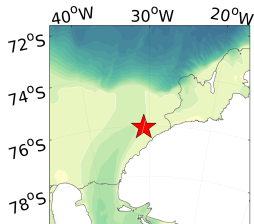
# Modelled inflow eastern shelf



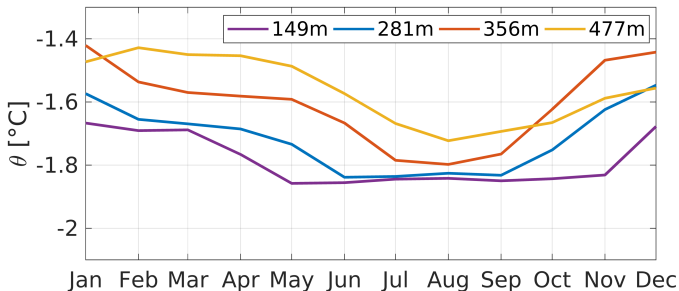
Model reproduces seasonal southward flow of MWDW and deep convection in winter over eastern shelf



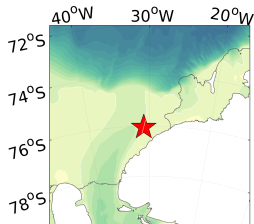
## Modelled inflow eastern shelf



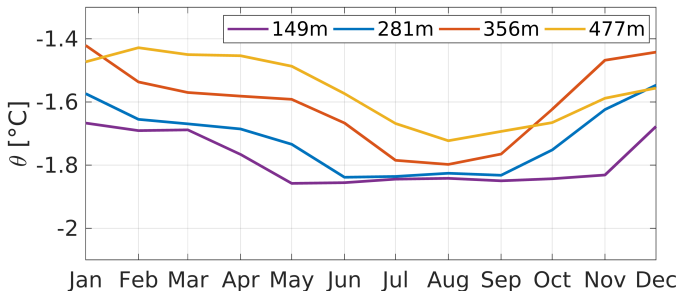
Model reproduces seasonal southward flow of MWDW and deep convection in winter over eastern shelf



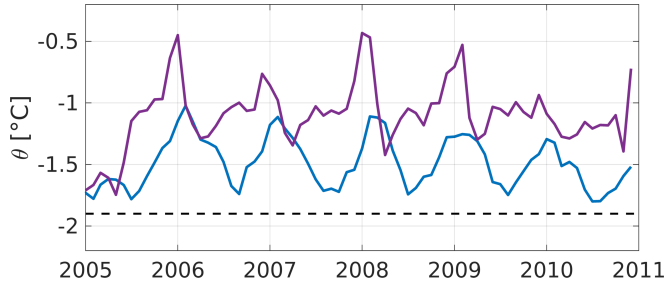
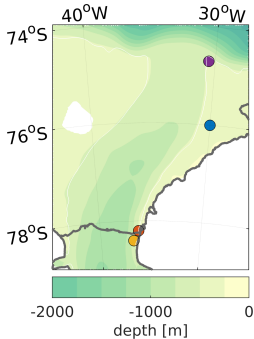
## Modelled inflow eastern shelf



Model reproduces seasonal southward flow of MWDW and deep convection in winter over eastern shelf

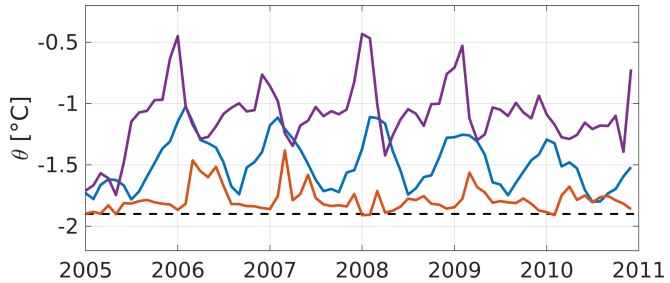
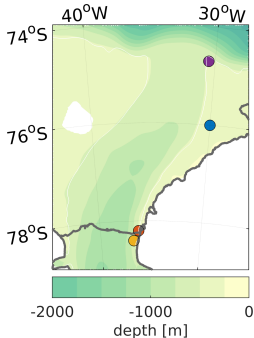


# Does MWDW reach and enter the cavity?



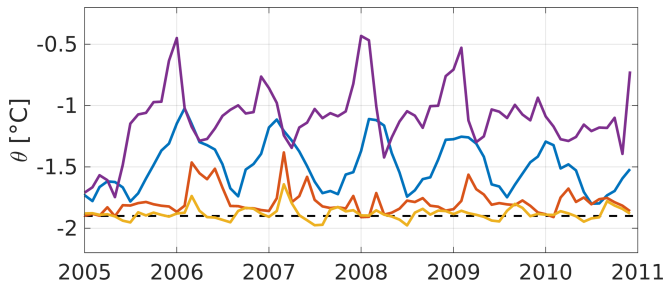
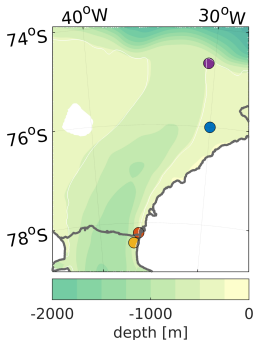
- significant modification of MWDW on the shelf

# Does MWDW reach and enter the cavity?



- significant modification of MWDW on the shelf
- traces of warm water reach the ice front every year...

# Does MWDW reach and enter the cavity?



- significant modification of MWDW on the shelf
- traces of warm water reach the ice front every year...
- ... and can enter the cavity

# Summary

- Strong seasonal cycle over shelf east of the Filchner Trough driven by winter convection and seasonal uplift of Antarctic Slope Front
- deep convection in winter erodes MWDW on shelf, limiting a year long southward heat transport
- the correct representation of the shelf break hydrography in the model is crucial to achieve a realistic hydrography and inflow on the continental shelf



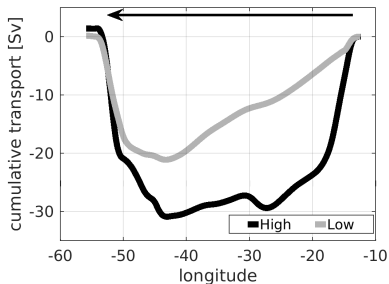
# Summary

- Strong seasonal cycle over shelf east of the Filchner Trough driven by winter convection and seasonal uplift of Antarctic Slope Front
- deep convection in winter erodes MWDW on shelf, limiting a year long southward heat transport
- the correct representation of the shelf break hydrography in the model is crucial to achieve a realistic hydrography and inflow on the continental shelf

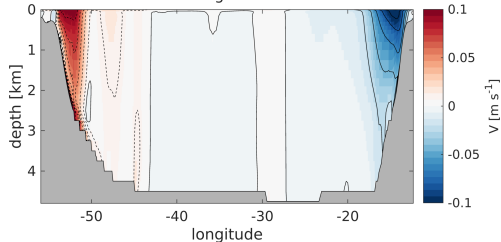
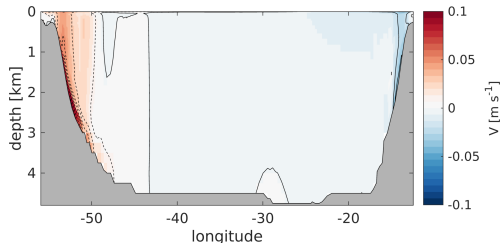
# Improved Slope Front Current



Only oceanic heat supply for Weddell Gyre via the eastern inflow of Circumpolar Deep Water → has to be captured by model



→ New configuration leads to realistic gyre structure and transports



# Erosion of dense layer by MWDW

