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Modelling the ocean circulation underneath the Filchner-Ronne ice shelf :
What is the role of vertical discretization?

Background

Warm waters intruding underneath the Filchner-Ronne Ice shelf might destabilize the Antatctic ice sheet. This could have long-term implications for the global sea level rise. Feedbacks, that either damp or amplify Antarctica's contribution to the global sea level, can only be investigated in a fully coupled ice sheet–earth system model.

z layers are utilized to reduce the amount of computational resources at sufficient fine spatial resolution without sacrificing the model skill in simulating the sub-ice shelf ocean. Moreover, the shelf break is represented better in ocean geometry.

FESOM

We utilize the global multi-resolution ocean and sea ice model FESOM (Finite Element Sea ice–Ocean Model, Wang et al., 2014).

- CORE2 atmospheric forcing
  (Griffies et al., 2012)
- Initial condition: PHC3 Winter
- Run for 60 years
- Time step 5 min
- 72000 2D surface nodes
- Three mesh setups in the vertical :
  48 and 100 z- levels /
  36 hybrid (23 terrain following)
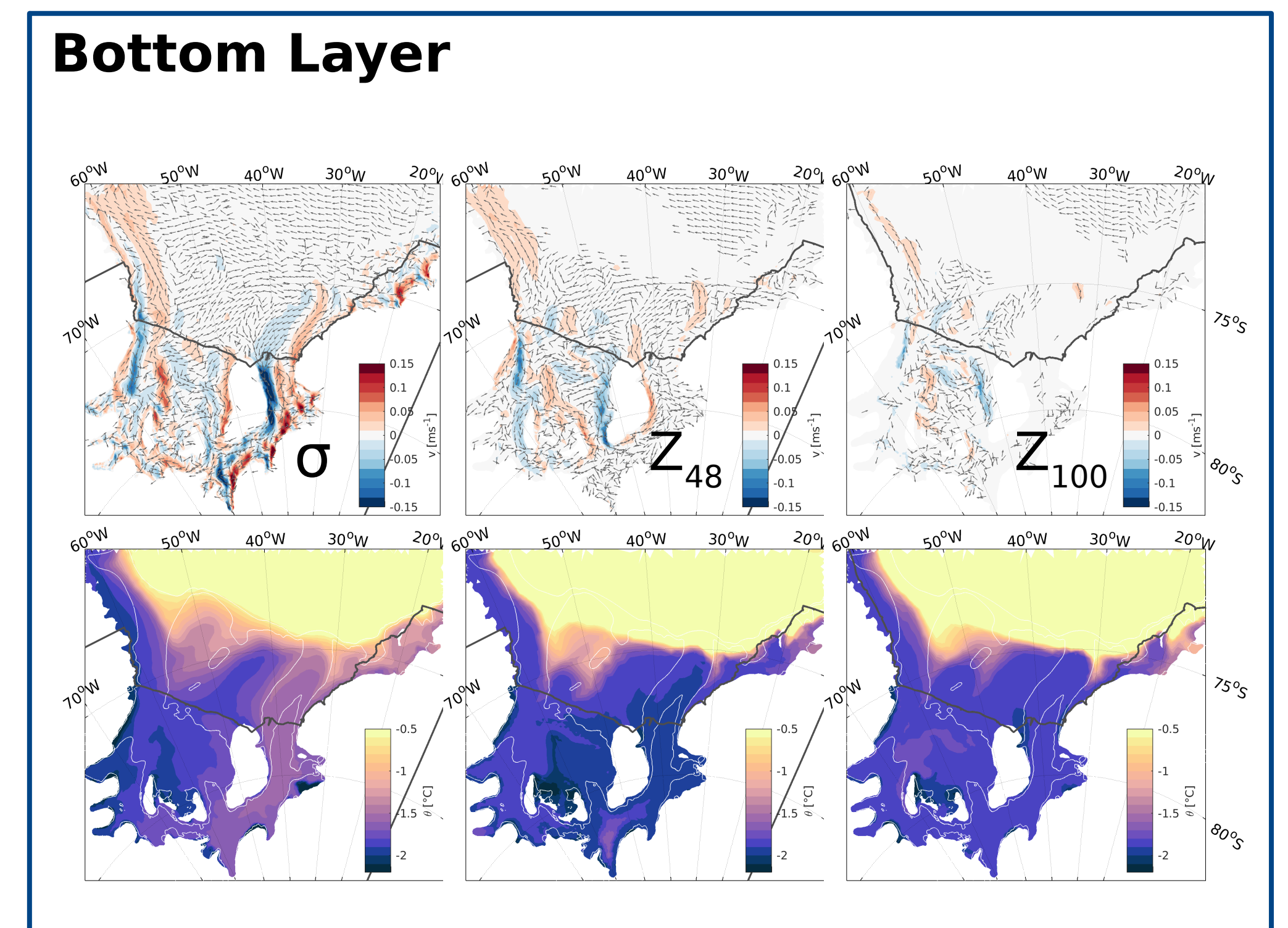
Mankind's two great unanswered questions:

- Can we detect significant differences around/beneath Filchner-Ronne ice shelf (FRIS) in changing the vertical coordinate from sigma to z in *FESOM*?

- Can we get the circulation, hydrography and basal melt rates of the FRIS close to the observations when we increase number of z layers in *FESOM* (Similar to the study of Schodlock et al. 2016)?
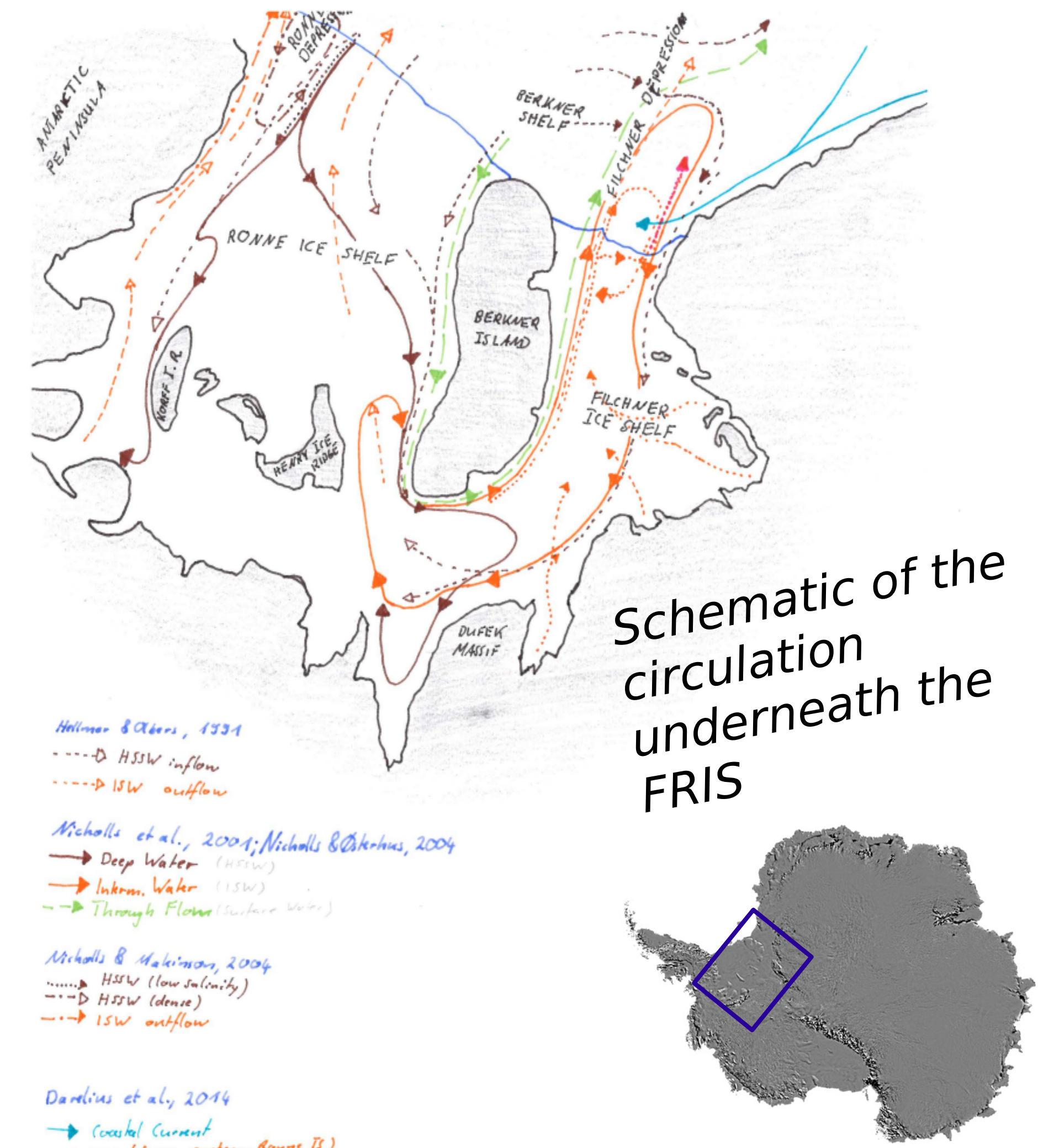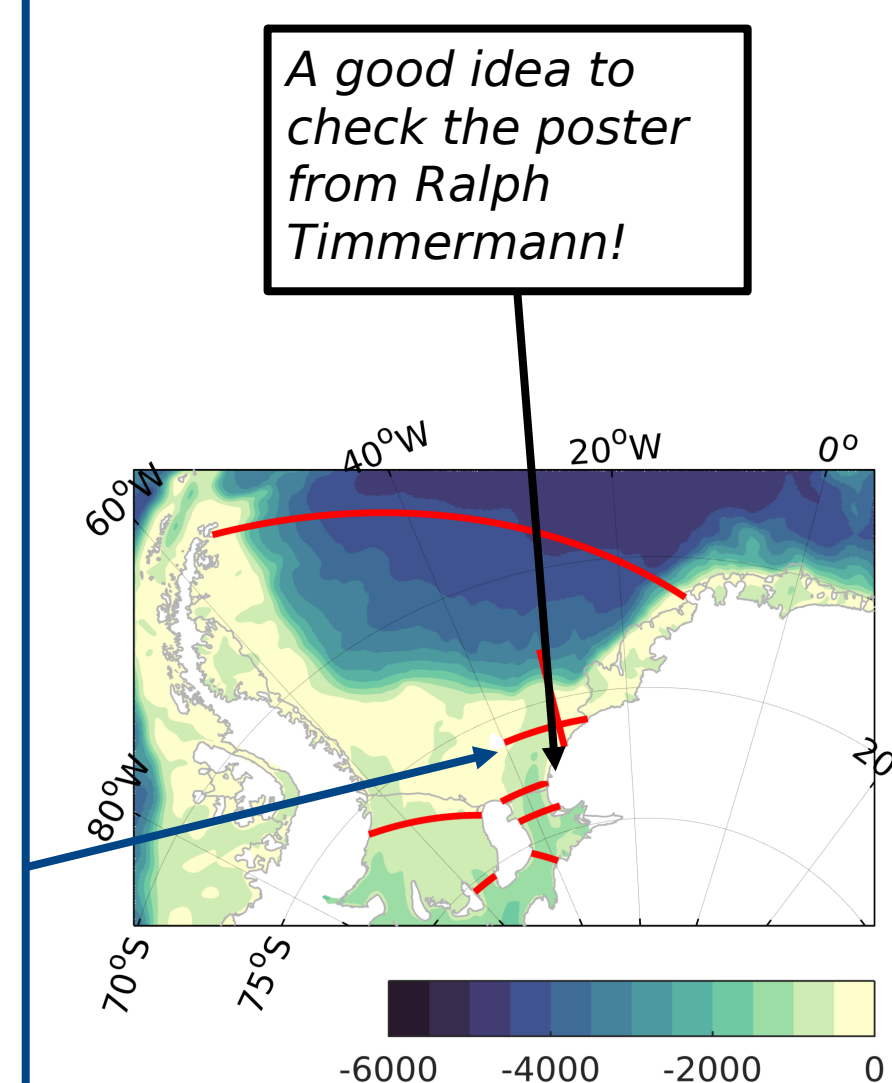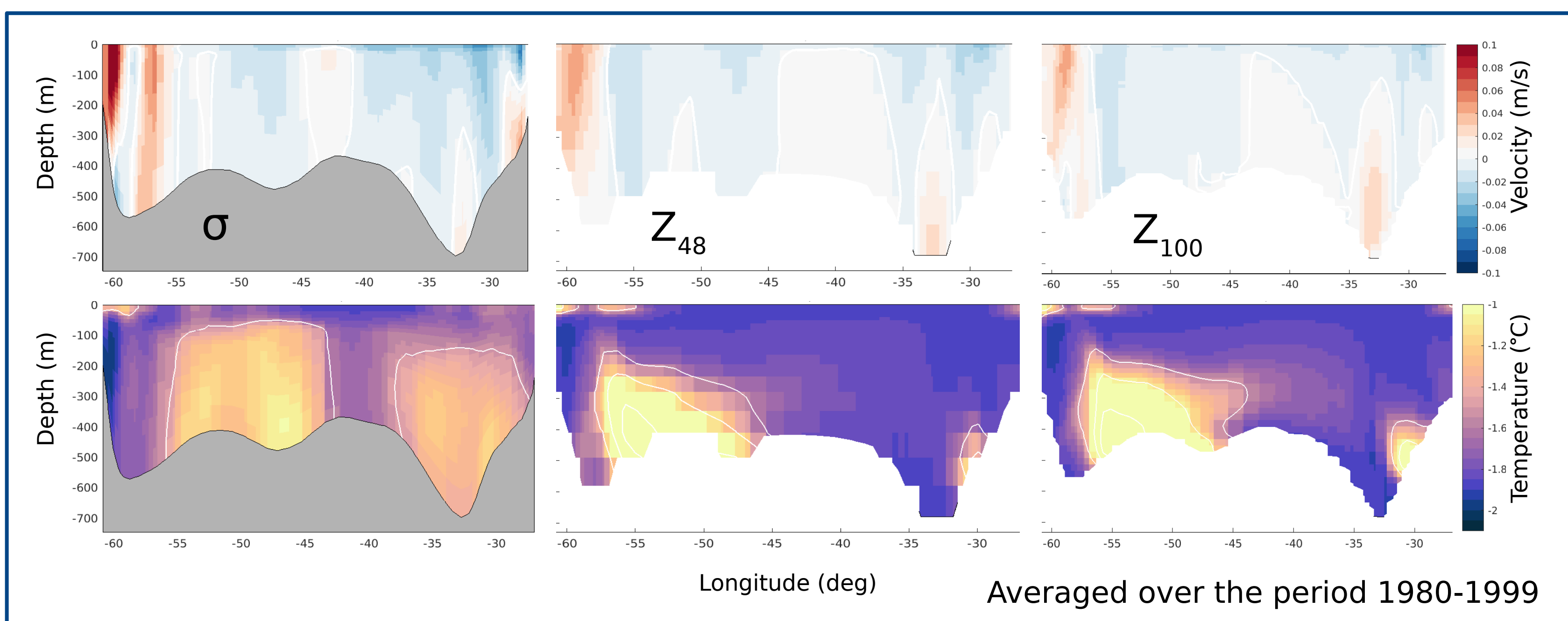
Sub-ice shelf circulation

First Layer

σ   Z$_{48}$ Z$_{100}$

Schematic of the circulation underneath the FRIS
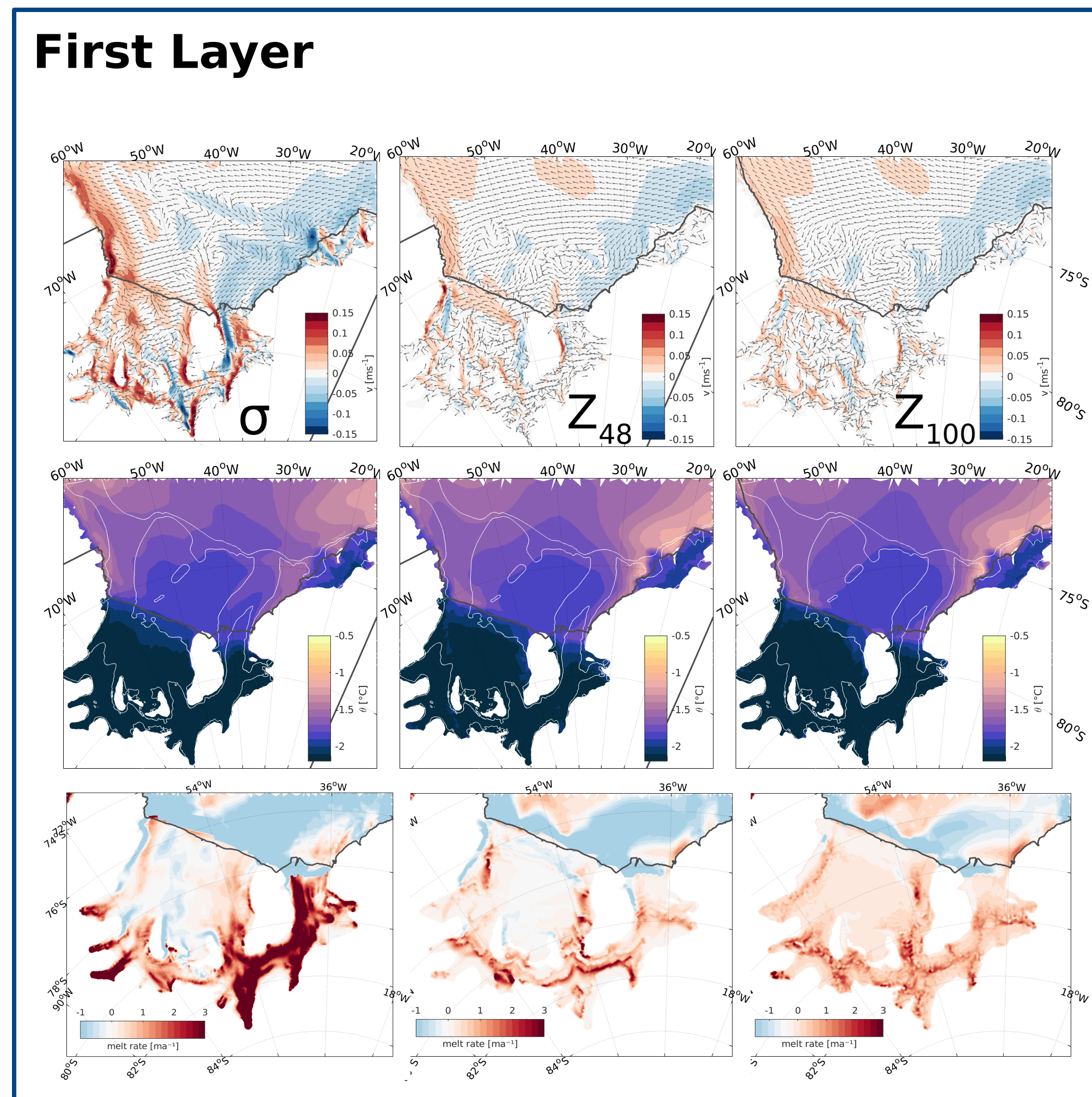
Mean velocity, temperature and basal melting rate for the time period 1980-1999

Bottom Layer

σ   Z$_{48}$ Z$_{100}$

Filchner section at 76 S

σ   Z$_{48}$ Z$_{100}$

Longitude (deg)   Averaged over the period 1980-1999

A good idea to check the poster from Ralph Timmermann!

Outlook

Sigma vs. z-layer

- Reversed boundary current around Berkner Island
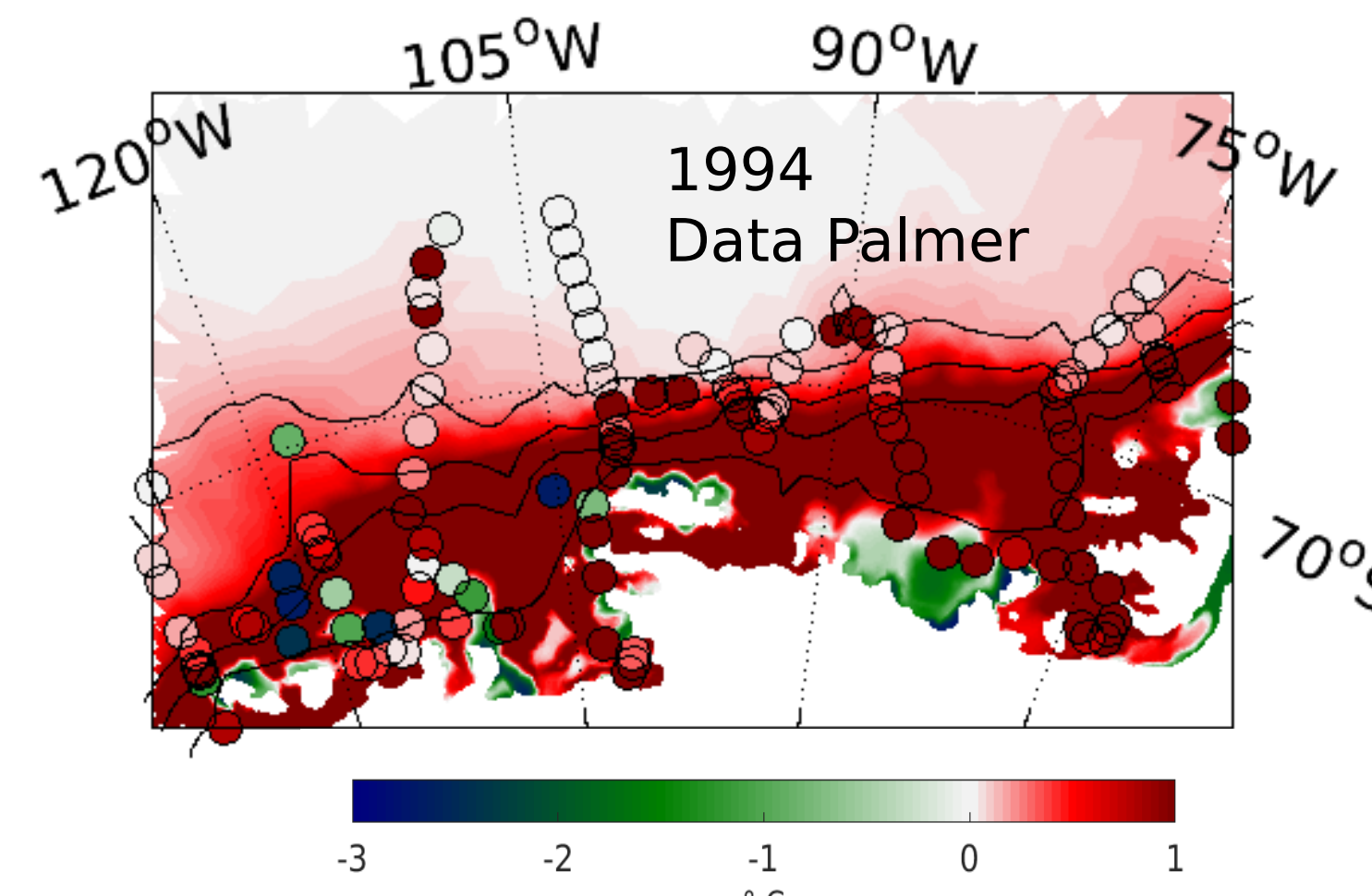- Reduced meridional velocities
- Colder Filchner ice shelf water

Increase in number of z-layers

- Circulation pattern does not show much sensitivity beneath FRIS
- Warmer rim current
- Significant changes in Circumpolar Deep Water intrusion onto the Amundsen and Bellinshausen Sea continental shelves

Amundsen-Bellinghausen Seas

- σ   Z$_{48}$ Z$_{100}$
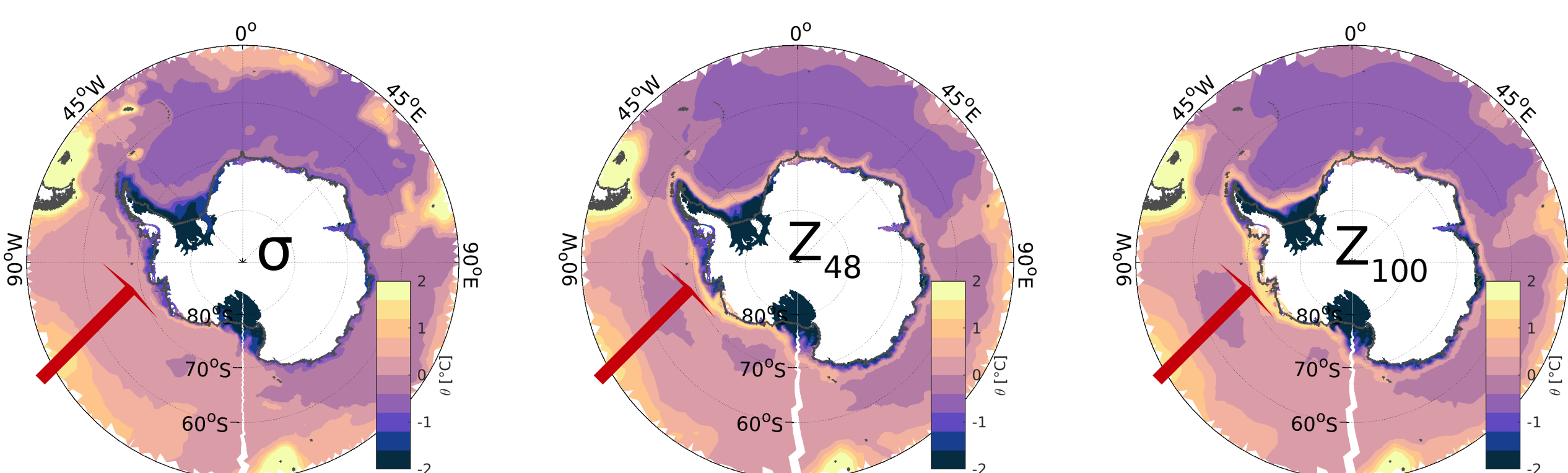
Bottom temperature around Antarctica (mean 1980-1999)

1994 Data Palmer

Bottom temperature in 1994 in simulation Z$_{100}$, compared to data from Palmer et al.

References

- Griffies, S. M., Winton, M., Samuels, B., Danabasoglu, G., Yeager, S., Marsland, S., Drange., H., and Bentsen, M., 2012: Datasets and protocol for the CLIVAR WGOMD Coordinated Ocean-sea ice Reference Experiments (COREs), WCRP Report No. 21/2012, pp. 21
- Wang, Q., Danilov, S., Sidorenko, D., Timmermann, R., Wekerle, C., Wang, X., Jung, T., and Schröter, J.: The Finite Element Sea Ice-Ocean Model (FESOM) v.1.4: formulation of an ocean general circulation model, Geosci. Model Dev., 7, 663-693, https://doi.org/10.5194/gmd-7-663-2014, 2014.