Reviewer 1 ----------

Response Letter

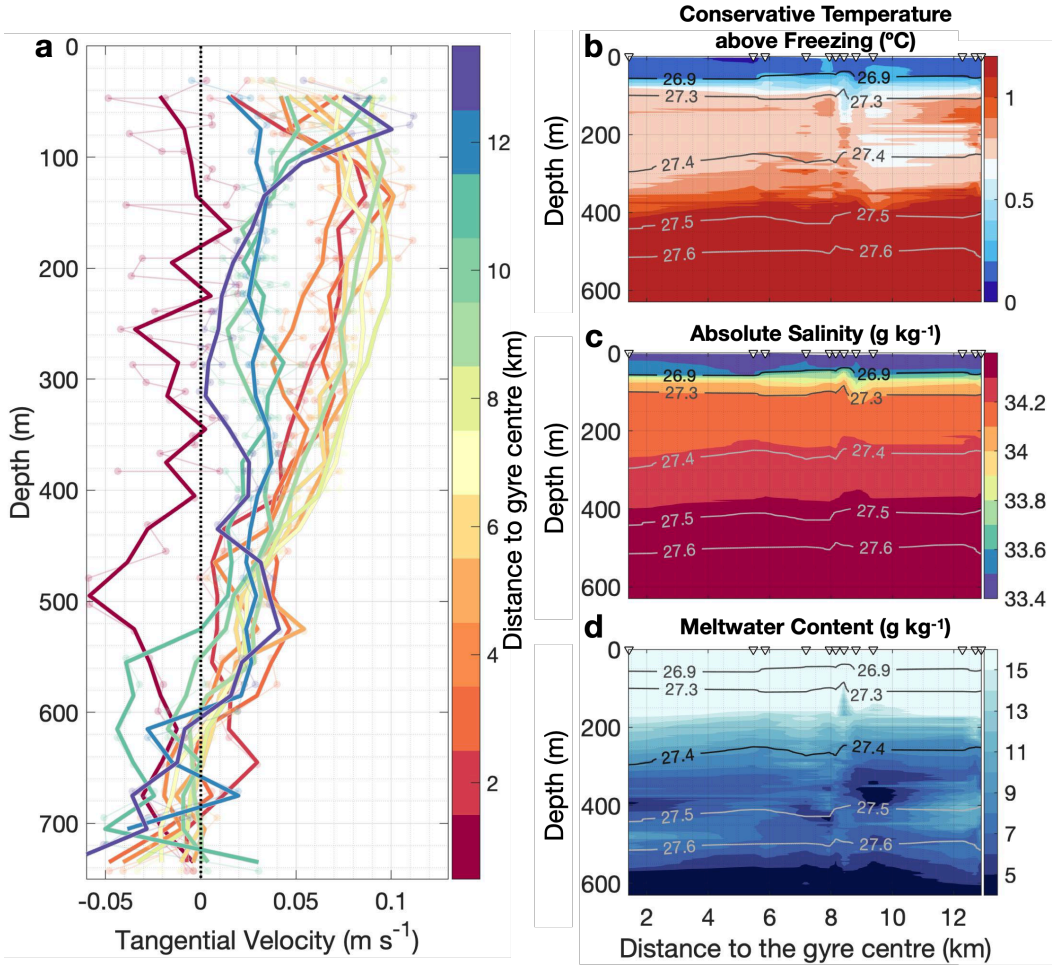
Response to the reviewers is in blue, while the modification to the MS is in green.

The authors claim that they identified Thwaites gyre for the first time. They conducted idealized simulations to investigate how sea ice affects gyre strengths and directions, which possibly impact the amount of warm mCDW intruding into ice shelf cavities. This is a nice paper. I do not have many concerns except for one point (see below).

Thank you very much for the positive comments on the manuscript. We will implement the suggested changes as detailed below.

Major comments

(1) If you would like to state that this paper identifies Thwaites gyre, the authors should provide a bit more detail about the observations and structures of the gyre. For example, vertical sections (T, S, Velocity), the ratio between barotropic and baroclinic components, etc.



Revised Fig. 3. Vertical structure of the Thwaites gyre. **a**. Tangential velocity of the Thwaites gyre with distance to the gyre centre (colours). All velocity profiles are horizontally averaged

into 1-km-radius bins (pale dots and lines) then vertically averaged into 30-m bins (thick lines). **b-d.** Section plots of CTD measurements collected in Thwaites gyre region, with distance to the gyre centre. Potential-density isopycnals (in kg m^{-3}) are denoted by grey contours. Positions of profiles are marked as triangles at the top of the panel. Below 650m, the water column is occupied by modified Circumpolar Deep Water and is relatively stable. Conservative temperature above freezing is presented in **b**. Absolute Salinity is presented in **c**. Meltwater content is presented in **d**.

Thanks for the good suggestion. We will provide vertical sections across the gyre for T, S and meltwater content in the revised version, as shown above.

Regarding the ratio between the barotropic and baroclinic components, we could not obtain a full-depth velocity measurement to calculate barotropic velocity since the sADCP velocities did not extend down to the sea bed. The vertical current structure can be seen in Revised Fig. 3, and implies that the gyre is a likely to be a combination of baroclinic and barotropic components. We calculate the averaged vertical shear of the tangential velocities between 3—7 km from the gyre centre to quantify this baroclinicity, defined as the vertical gradient of the tangential velocity between the velocity maximum at 130 m, and 620 m, where the tangential velocities are consistent and small. The gyre velocity decreases with depth at a relatively constant rate between these depths. The calculated averaged vertical shear is 2×10^{-4} s^{-1}, i.e. a change of 0.1 m s^{-1} over 490 m.

Minor comments

Lines 35-40 Authors define PIB gyre. However, I think that Schodlok et al., 2012 do not argue the importance of small gyre circulation in front of PIG. They showed the importance of gyre circulation, which is larger than small gyre circulations discussed in this manuscript, which is confusing to me. A better definition of PIB gyre may be required.

Thank you for pointing it out. We cited Schodlok et al. 2012 because, in its page 160, in the right to the Figure 5b, it says (in orange) "The significant correlation (r= 0.42) between the melt rate and the strength of the Pine Island Bay streamfunction indicates that the **increased basal melt rates of the PIG ice shelf may be due, in part, to local circulation changes**…… On the one hand, there is little change in the **main part of the gyre, which is adjacent to (but does not cross) the shelf break** [*that is the big gyre*], indicating that the flux across the shelf break is not coupled to the continental shelf circulation. On the other hand, **the strength of the smaller gyre, just outside the PIG cavity** [*that is our small PIB gyre*]**, is amplified during the period of high melt rate**, **indicating that circulation on the shelf is more important than the initial provision of CDW across the shelf break**. …… Our study **finds maximum heat transport to the sub-ice-shelf cavity** at the end of summer and beginning of autumn, which is **associated with a maximum in the streamfunction of the small gyre, just outside the PIG cavity** [*that is our small PIB gyre*]" which shows the importance of our small PIB gyre to the melt rate of PIG.

However, we understand why it is confusing as this paper indeed does not emphasise the importance of this small PIB gyre to be their main finding. We will therefore modify this part of text as "Gyres play an important role in local ocean circulation, distributing heat and enhancing water mass exchange in the Amundsen Sea (Zheng et al., 2021; Schodlok et al., 2012). Schodlok et al. (2012) use a high-resolution model to infer that **the strength of this**

small PIB gyre can be the main determinant of heat transport toward the ice shelf and the associated glacial melt rate (Schodlok et al., 2012)."

Lines 35-43 It would be nice to see a paragraph on simulated gyre structures (or at least directions) in observations and the existing simulations. For example, you mention Schodlok et al., 2012 show that the strength of the PIB gyre is the main determinant of heat transport. Can you judge from their papers if they simulate gyres in front of PIG? Do previous models show gyres in the same direction or do some models show opposite circulation? As far as I can find, simulated circulation in Nakayama et al., 2014 (Ocean Modelling) is also reversed. Do you find some other examples? Additionally, do you also find something similar to Thwaites gyre in the existing model simulations? If not why? I understand that the authors added a few sentences on this point in the Discussion (Line 351-360) but it would be nice if you could summarize existing model studies with a focus on the representation of eddies in from of Pine Island, Thwaites, etc in the Introduction. Reviews on existing model studies would be helpful.

Thanks for the good suggestion. We will add a few sentences in the Introduction. Regarding the papers the reviewer mentioned: yes, as mentioned above, Schodlok et al., 2012 simulated gyres in front of PIG, and it is cyclonic in their model. We carefully read the Nakayama et al. (2014, Ocean Modelling) paper but we did not find any content about any gyre, eddies or local recirculation - could the reviewer please specify what circulation is reversed? Or perhaps the reviewer is thinking of a different paper? We would welcome any further references that the reviewer is aware of.

All papers we found (based on both models and observations) about the PIB gyre have been mentioned in our MS. We will add a short sentence about a new study focusing on PIB gyre modulating heat flux toward ice shelf (Yoon et al., 2022) in the Introduction. We did not find any other simulations that produce similar features like the Thwaites Gyre. The reasons for that could be: 1. Thwaites gyre region is habitually ice-covered, and 2. gyres with sizes like the Thwaites gyre in model simulations are often overlooked due to the lack of model validation with in-situ observations. We will emphasise the lack of information from models in the Discussion in the revised paper.

Lines 361-362: See major comment above.

We will provide discussion here of the new figures to provide more details of the observed Thwaites gyre.

Figure 7: Sea ice coverage is indicated by shaded patches. It is a bit confusing as initially, I thought white patches are sea ice. Maybe you could state "No sea ice" or something similar to clarify?

Thanks for pointing it out. We will make changes accordingly in the revised version.