We are grateful to Drs. Keith Makinson and Hartmut Hellmer for their thorough and thoughtful reviews. This manuscript will be much improved by their input. We have made changes to our document and are including below an overview of these changes.

Referee comments are in **bold**, responses are in *italics*, and corrected grammar indicated by ~~strikethrough.~~

Hartmut Hellmer

Specific comments:

L032 – How can a paper published in 2006 cover the period 2002-2016? Actually, according to Monaghan et al. (2006), which covers the period 1955-2004, small changes in SA only occurred on the EAIS. *Thank you for pointing out this oversight. We have rewritten this text and provided an updated ref. (Wang et al., 2016).*

L055 – With regard to the direct flow of CDW into the ice shelf cavities of ABS Jenkins et al. (2010) is a more appropriate reference. *Corrected (L67). We have also added a cite to Jacobs et al. (2013), since Jenkins et al. (2010) only discusses measurements for Pine Island Glacier ice shelf, while Jacobs et al. (2013) demonstrates CDW flows into Getz (also ABS) as well.*

L081 – More precise: Hellmer et al. (2017) not just reversed the atmospheric conditions to a colder state but to 20th -century conditions. *We have augmented this section to include this clarification.*

L164 - ~~Equation (4) must read wb = QT0/L x rho .~~ And, somewhere it should be mentioned that heat flux through the ice shelf is ignored. *Thank you for catching this typo! We have added a statement regarding the heat flux through the ice to the paragraph preceding Eqn. (1), and stated that we have ignored it for this study (reasonable for thick ice).*

L216 – It comes as a surprise that open ocean wct = h has a maximum value of 1914m, though the model domain (Fig. 1) only covers the southern Weddell Sea continental shelf. *Thanks. The value is now corrected, to 1211 m in Filchner Trough.*

L283 – It is not clear whether the 'bulk dye' was added to the whole water column or just to the surface-sigma layer. The confusion starts when looking at Fig. 8a, which looks more like a 'bottom dye' distribution. *The dye is added uniformly to all levels. We have amended the text to state "The bulk dye was initialized at a concentration of 100%* ***<u>over the entire water column</u>*** *but was not replenished after these simulations began.". We have included a couple of figures here to demonstrate the vertical structure of the bulk dye initialization (*Figure 1*) as well as the dye distribution in the surface and bottom layers.*

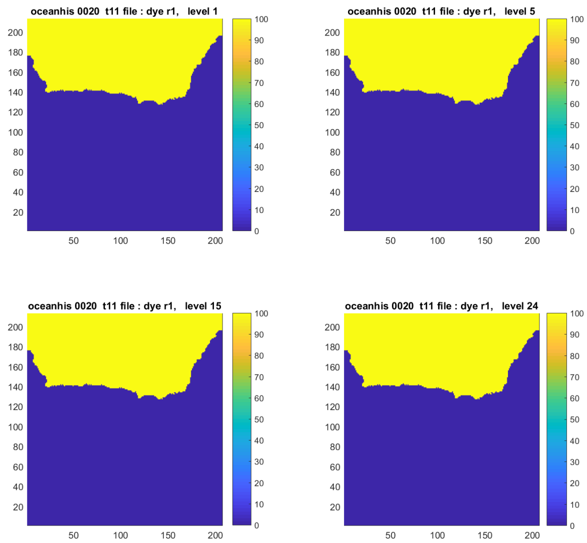

Figure 1 Dye concentration from 0-100% in sigma levels 1 (bottom), 5, 15, and 24 (surface)

(a) (b)

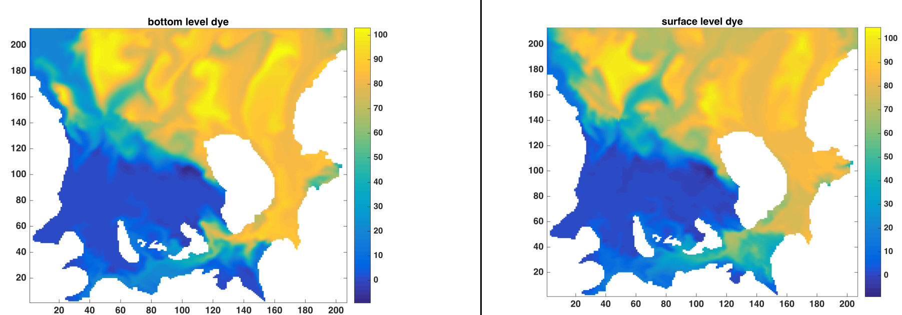

Figure 2 Surface and bottom level dye distribution for the standard cold case, with (b) corresponding to Fig 8a and the upper left panel of Fig. 9.

L305 – It is not clear what is meant with 'outer/interior grounding line' – please explain. *The labeling has been corrected using geographical referencing ("eastern", "southeastern", etc). We hope this helps to clarify the intended meaning.*

L335 – Here, a serious deficit of the model becomes obvious, since the refreezing along the eastern coast of Berkner Island (e.g., Rignot et al. (2013)) is missing, certainly because the model exaggerates the flow into the Filchner cavity. *We have clarified in the text how our lack of density gradient along the continental shelf yields a circulation bias with clockwise flow around Berkner Is., rather than the observed counterclockwise flow that is represented by models that include horizontal density gradients across the front.*

L396 – A reduction of area-averaged melt rates due to adding tides also happens for Support Force. *Support Force is now included in this statement.*

L426 – The comparison with Hellmer et al. (2012) is risky because this kind of circulation only happens for the 'warm phase', while here the same circulation pattern exists for the 'standard cold case'. Such comparison might provoke a critical reader to question ROMS' performance in general. *The intention of this phrasing was to highlight that in both these results and in the Hellmer et al. (2012) results the circulation within the FRIS cavity is clockwise, such that the primary ocean inflow is through FIS; but(!),we have decided to take a different approach in describing this circulation. The Discussion section now includes an overview of how our standard cold results are to be interpreted in the context of known present-day circulation. This addition also aims to address a comment by Keith Makinson.*

> Our results show that tide forcing is important to FRIS ice-ocean interactions over a range of initial temperatures and with large variations in regional impacts. The aim of these simulations was to apply, uniformly, temperatures and salinities that approximate (1) present-day, inflow conditions and (2) a representative temperature of future, inflow conditions, reflecting a modest increase in temperature; however, the circulation within this particular ice shelf cavity is strongly affected by sea-ice formation on top of a general circulation that establish an east to west density gradient across the continental shelf (e.g. Foldvik et al., 1985; Nicholls et al., 2009). As such, our "present-day" scenario is a hypothetical one that forms the basis of this sensitivity study but that should not be interpreted to reflect the known circulation within the cavity. The known circulation within the cavity, setup by the east to west density gradient on the continental shelf, has inflow in the Ronne Depression and a counter clockwise circulation around Berkner Is. (Foldvik et al. 2001). Our simulations for both the present-day and melt-adjusted cases predict inflow through the FIS and a clockwise circulation around Berkner Is. This pattern of circulation reflects the future warming scenario presented in Hellmer et al. (2012). This sensitivity study, therefore, does not include changes that would occur from a shift in cavity circulation from a scenario that has the east to west density gradient along the continental shelf to one where that density gradient is relaxed to the degree that the sub-ice-shelf cavity circulation would change. Although these simplifications restrict the predictive capacity of this study, they do not much affect the results of our sensitivity analysis on ice-ocean interactions within FRIS and in particular the feedbacks found between tides and changing geometry and implications for further research.

L714 – By summarizing important results I miss (5): The increase of refreezing in central RIS in the 'standard cold case', representing today's conditions. This is an important finding because refreezing in this area certainly changes the dynamics of the ice shelf by increasing the buttressing around Henry and Korff. *This result has already been reported in Makinson et al. (2011) for present-day ocean conditions; we therefore added the contribution of our work, with appropriate attribution to Keith Makinson for his, We clarified our results in the context of previous work by introducing a new Discussion section that focuses on basal freezing beneath FRIS (**Sect. 4.5**)*

4.5 Implications of regional freeze conditions on ice sheet mass balance

As described in **Sect. 3.2.1** and **Sect. 3.2.2**, refreezing occurs in our simulations throughout a large region of the central RIS. Refreezing in this region is qualitatively consistent with estimates of basal mass balance from satellite-based remote sensing (e.g., Joughin and Padman, 2003; Rignot et al., 2013; Moholdt et al., 2014). Persistent refreezing along ice flowlines can create a marine ice layer up to hundreds of meters thick, as observed in ice cores (Engelhardt and Determann, 1987; Oerter et al, 1992), and in radio-echo sounding and seismic measurements (Joughin and Vaughan, 2004; Lambrecht et al., 2007). These observations are important in the context of other studies which show that marine ice accretion supports ice shelf stability (Kulessa et al., 2014; McGrath et al., 2014; Li et al. (submitted)). Our standard cold tide-forced case produces local maxima in marine ice growth rates in the northwestern RIS, the region northeast and east of Korff Ice Rise, and the region to the north and west of Henry Ice Rise (**Fig. 5d**). The spatial pattern of these freeze conditions differs from observed patterns (Joughin and Padman, 2003; Rignot et al., 2013; Moholdt et al., 2014). We attribute this difference to the consequences of omitting the east to west density gradient along the continental shelf.

The regions of freezing are broadly consistent in all our model runs (**Fig. 5**) and the net mass increase in refreezing regions are increased when tide forcing is added (**Fig. 6**). Our standard cold tide-forced case has a ~4-fold mass gain compared to the standard cold no-tides case; this result is consistent with Makinson et al. (2011). In both warm cases, standard and modified geometry, adding tides increases net marine ice formation by a factor of two. That is, tides will continue to be important for marine ice accretion beneath FRIS if ocean temperatures rise as predicted by Hellmer et al. (2012, 2017) and will, therefore, continue to play a role in FRIS ice shelf stability.

We also included the following statement as (3) in our list of conclusions:

(3) Adding tide forcing increases the overall freezing conditions for all three cases including the two warm cases. Since freeze conditions lead to marine ice accretion, and marine ice strengthens the ice shelf, the tidal contribution to ice-shelf dynamics is expected to continue through future ocean warming, increasing grounding and associated contact stresses in the region near the Henry and Korff ice rises and Doake Ice Rumples

L1044 – Please explain the difference between 'region' and 'inlet', used in Fig. 8. *We have corrected the use of "inlet" as shorthand for "inlet region" by changing "inlet" to "region", while also changing the parenthetical statement* "(see Fig. 4 for dye release regions)" *in order to make this phrasing consistent.*

L1061 – Please explain why Foundation shows a high dye concentration at the bottom. The signal cannot be advected from Support Force because there it does not exist, and highest

melting beneath Foundation should stabilize the water column such that most, if not all, of the dye should concentrate at the base. *We puzzled over this for a while. Based on the following figure (Fig. 3, below), and other analyses of T(z), S(z), and FIS dye profiles, we conclude that FIS dye is present at depth in the S. Channel due to the combined influence of mixing within the Möller inlet region as well as a shoaling of bathymetry in both Möller and South Channel. FIS dye appears to circulate first into the Möller inlet region where additional freshwater is added to the "upper" branch of FIS-doped water and where mixing processes transport dye to depths that correspond to bottom level depths within the South Channel. Within South Channel, all water contains meltwater from different sources, including locally. The density stratification depends on the sum of freshwater from all sources, whereas a specific dye (e.g., FIS), depends only on meltwater from that region.*

In order to clarify this influence, we have augmented section 4.3, to include the following statement:

> The presence of Foundation dye in the bottom level of the S. Channel transect reflects a shoaling of bathymetry (**Fig. 2c**) and mixing with the Möller region that allows the dye to be distributed to the bottom level within the Möller inlet region and then advected, at depth, through South Channel.

The evidence for this statement can be seen in Figure 3, below. Foundation dye is shown in the bottom, mid-depth and surface levels of the standard cold case. We attribute the circulation at this depth to be driven by changes in bathymetry, as shown in Fig. 2 of the main manuscript and here by w.c.t.

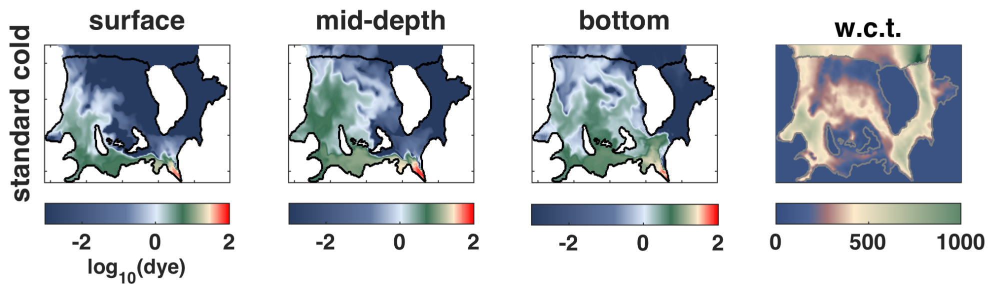

Figure 3: Maps of Foundation dye taken at the bottom level (N=1), a mid-depth level (N=15) and the surface level (N = 24) for the standard cold cases with water column thickness on right (as a duplicate of Fig. 2c, in main manuscript).

Technical corrections:

~~**L031 – The dominant terms in the Antarctic ICE SHEET (AIS) mass budget....**~~

~~**L060 – We focus here ON . . .**~~

~~**L267 - . . . over the LAST 30 days?**~~

~~**L298 - . . . ice shelf frontal zone (ISFZ) of the RIS (here, front is redundant)**~~

~~**L337 - ...northWESTERN RIS.**~~

~~**L466 - . . . from all upstream sourceS.**~~

~~**L510 – Fig. 10e**~~

~~**L 833 – HelLmer, H. H.**~~

~~**L1000 - .. the extent of thE ice shelf…**~~

L1017 – Locations of the six meltwater dye RELEASES. *We have included this change together with an emphasis on "model dye", which isn't really "released" per se, though we agree with this choice in verb.*