We would like to thank the reviewer #2 for his constructive comments which will help to improve our manuscript.

1. You perturb both the SST and the SIC, but not necessarily in a consistent way. In my opinion, more material should be given to illustrate a consist perturbation, for example by comparing how the SST bias in the GCM compares to the SIC bias? Another way would be to assume – for example – that meridional SST gradient remains unchanged as the SST increases, which imposes the retreat of the sea-ice edge.

We recognize that our method does not necessarily lead to consistent SIC perturbations associated to the SST perturbations since SIC perturbations depend on the number of neighbouring pixels taken into account. However, the experiments has been designed in order to study the effect of perturbations similar to SST and SIC biases in the GCMs (see Table 1 and p6, L9-11). Our SIC and SST perturbations can also be compared to previous works such as Van Lipzig et al. (2002). They reduced the mean sea ice cover by 50% for a 2°C temperature rise (values also suggested by Thompson and Pollard (1995) in a 2°C warmer climate), which is close to our SIC perturbations (-53% in winter).

Furthermore, the methods used in this study lead to smoothed SST field preventing abrupt SST changes near the sea ice edge, and also enable to modify polynya extents as SIC can vary from 0 to 100% in MAR. This would not have been possible with a method using a retreat of sea-ice edge only based on an unchanged meridional SST gradient. We would also encounter difficulties for determining the sea-ice edge as the MAR ice mask is not a binary mask. Assuming that the meridional SST gradient remained unchanged is also a strong hypothesis that still have to be demonstrated as the meridional SST gradient strongly depends on the presence/absence of the sea ice. In the context of the polar amplification (even less strong in the southern hemisphere), the gradient can be expected to decrease but if some sea ice remains in a warmer climate, it would constrain the SST at the freezing point over the highest latitudes while increasing at lower latitudes. They are thus two opposite effects, probably leading to high uncertainties about the meridional SST gradient (François Massonnet, UCL, personal communication, 2018). Although it is an interesting debate and research, we think that the future of the meridional SST gradient is beyond the scope of this study and we have thus preferred not to rely on the hypothesis of an unchanged meridional gradient.

The aim of using CMIP5 anomalies was also to apply to the ERA-Interim SSC a SIC perturbation related to the SST bias. However, it appears that SIC biases in CMIP5 models are not only related to SST but also to process parameterization such as lateral melting (e.g., Roach et al., 2018) so that SST biases and SIC biases could not be consistently derived from one to another.

For all those advantages compared to disadvantages of each method, we have preferred to follow the methods defined by Noel et al. (2014) for constructing our SSC perturbations. We suggest to clearly report that our sensitivity experiments does not necessarily lead to consistent SIC perturbations associated to SST changes by adding this discussion to P6L6.

P6, L6: *Table 1 compares SSC perturbations to the reference SSC for June-July-August (JJA) and December-January-February (DJF) SST and sea ice area (SIA). The SIA is defined as the sum of the products of the SIC and area of all grid cells with a SIC value of at least 15%. SIA is preferred to sea ice extent because it better accounts for SIC variations (Roach et al., 2018). Sensitivity experiments with altered SST by ±2 °C and SIC with the ±3 neighbour pixels are in the range of CMIP5 anomalies. Other perturbations (SST±4 and SIC±6) represent a 1.5 times larger anomaly in SIA and/or SST for both JJA and DJF mean values than CMIP5 mean anomalies over the current climate. However, it should be remembered that our sensitivity experiments are not based on climatological consistent SIC (resp. SST) perturbations related to SST (resp. SIC) perturbations. For instance, the SIC prescribed in our experiments associated to 2°C warmer SST could be significantly different from the real SIC in a 2°C warmer climate since we do not use SIC projections from a GCM.*

2. I do not really following the reasoning throughout the paper why there is more precipitation inland when SST is lower or SIC is higher. You argue that this is because the dryer air has to rise up higher to reach saturation. Although, this is of course true, it does not imply that precipitation can be brought higher up – it just means the saturation point is at a higher elevation. For saturated air, the amount of moisture transported in the interior is only dependent on temperature and circulation. So additional analyses are needed to shed light on this issue. The best way would be to do a moisture budget over the interior and see whether small circulation changes might be responsible for this. Although you do spectral nudging, circulation close to the surface might deviate which can be relevant for moisture advection. Although this comment is valid for the entire results/discussion section, p11, line 14/15 is particularly misleading.

We do not mean that precipitation can be brought higher up, but only that the saturation is likely to occur at a higher elevation. In cases of marine air (i.e., with a high humidity content) intrusion towards the central part of the ice sheet, precipitation is then formed further inland (p11, L13-15).

The indiscriminate nudging applied to the upper atmosphere of the model is designed to prevent any wind deviation from the forcing. Figure 1 presents the mean near-surface (2 m) wind speed in the reference simulation and wind anomalies for both wind speed and direction in SST-4/SIC/6 and SST+4/SIC-6 experiments. It highlights the absence of a wind deviation but shows a strengthening (resp. weakening) of the flow in a warmer (resp. colder) ocean over both the ice sheet and the ocean. However, these changes are mainly significant over areas where sea ice is removed or added similarly to Gallée (1996) and Van Lipzig *et al.*(2002). These changes are due on one hand to the surface roughness strongly modified over the ocean. On the other hand, the higher (resp. lower) temperature contrast between the ocean and the atmosphere reinforces (resp. weakens) the ice-breeze effect as described by Gallé. (1996). Although we show here the mean surface flow and direction over 1979-2015, it is also true for any specific day.

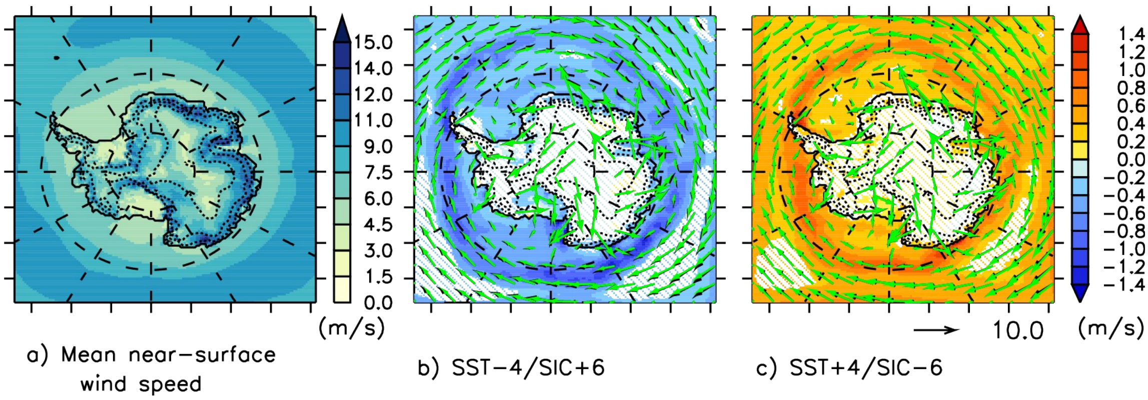

Figure 1. a: Mean near-surface (2m) wind speed modelled by MAR over 1979 – 2015. Difference in mean surface wind speed (m/s) between the reference simulation and (b) SST-4/sSIC+6, (c) SST+4/SIC-6 experiments. Wind speed differences lower than the interannual variability are considered as non-significant and are dashed. The wind direction is also indicated with black (resp. green) vectors for the reference simulation (resp. sensitivity experiments).

The large amount of MAR simulations did not enable us to store the atmospheric variables at each vertical level of the model preventing us to compute a moisture budget over the ice sheet. As an alternative, we propose to analyze the specific humidity (Figs 2 and 3) and temperature (Figs 4 and 5) at 600 hPa (Figs 2a,b,c,d,e and 4a,b,c,d,e) and at 700 hPa (Figs 3a,b,c,d,e and 5a,b,c,d,e). We found a negative anomaly at the ice sheet margins but a higher specific humidity over the central part of the ice sheet in SST-4/SIC+6 (Fig 3b and Fig 4b). On the opposite, the specific humidity is significantly increased in the SST+4/SIC-6 over the margins and decreased over the central region (Fig 3c and Fig 4c). We also compared the snowflakes content between the sensitivity experiments (SST-4/SIC/6; SST+4/SIC-6) and our reference simulation (not shown). These anomalies are very similar to the snowfall anomalies pattern presented in our supplementary materials (Figure 4, p5) with for instance, higher snowflake concentration (up to 30%) over the central ice sheet in the SST-4/SIC+6 experiment and lower snowflake concentration over the same area in SST+4/SIC-6 (up to -30%).

These results suggest that precipitation can be formed further inland depending on the properties of air masses. In agreement with Gallée (1996), our hypothesis is that colder and drier air masses in cold ocean experiments are not sufficiently loaded with moisture to enable saturation and then snowfall over the margins. The lack in moisture is likely to overcompensate the lower temperature. This leads to a larger amount of remaining humidity that can be advected further inland (Figure 2b and 3b) before saturation occurs due to lower temperatures. On the opposite, the additional humidity in warm ocean experiments results in air masses that reach saturation faster (humidity still overcompensates the higher temperature) and thus generating precipitation over the ice sheet slopes. MAR also simulates significantly higher air temperatures over the central part of the ice sheet (Figure 4c and 5c) that, combined with the lower remaining humidity, (Figure 2c and 3c) limit snowfall.

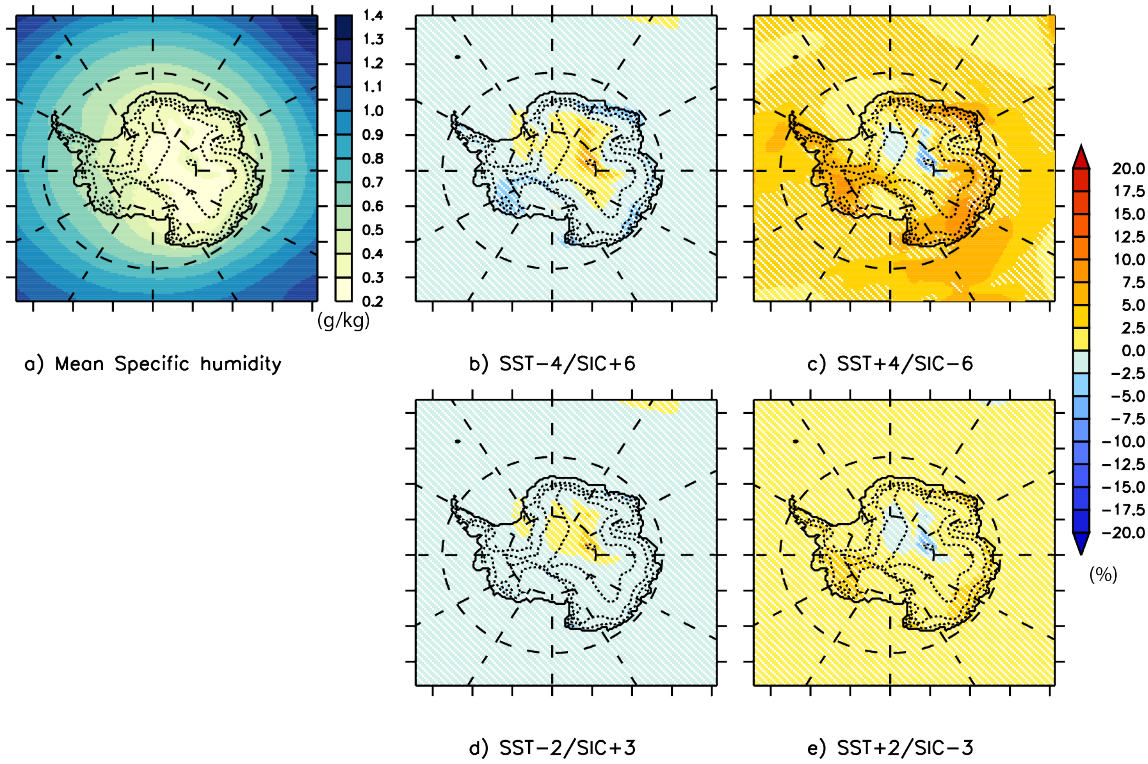

Figure 2. a: Mean specific humidity modelled by MAR over 1979–2015 at 600 hPa (Units: g/kg). Difference in mean specific humidity (%) between the reference simulation and (b) SST-4/SIC+6, (c) SST+4/SIC-6, (d) SST-2/SIC+3, (e) SST+2/SIC-3 experiments. Differences lower than the interannual variability are considered as non-significant and are dashed.

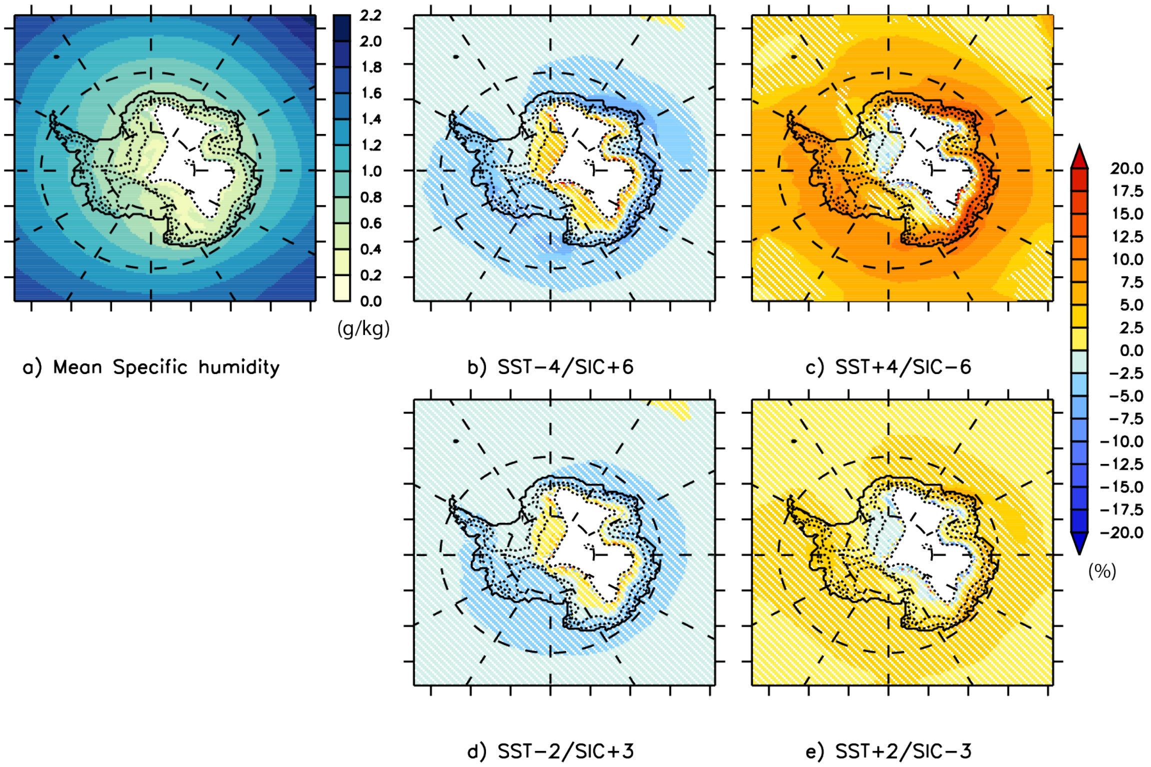

Figure 3. Idem as Figure 2 but at 700 hPa.

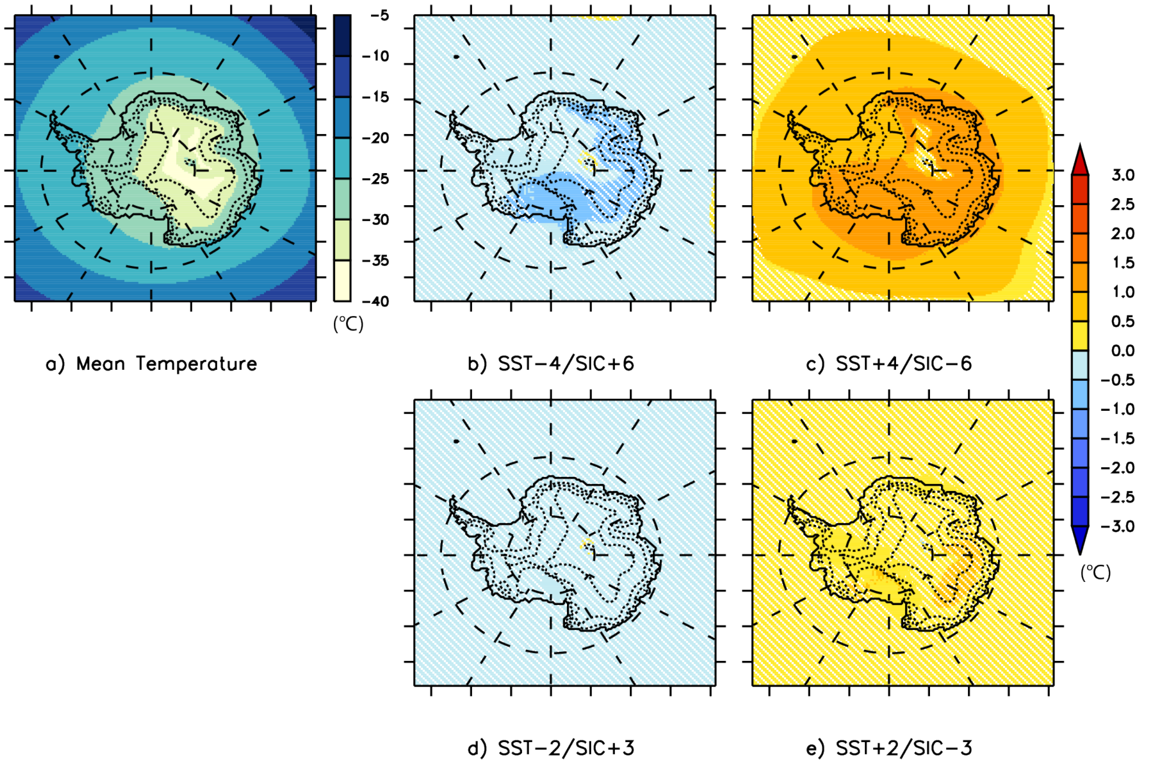

Figure 4. Idem as Figure 2 but for the mean temperature (℃) at 600 hPa.

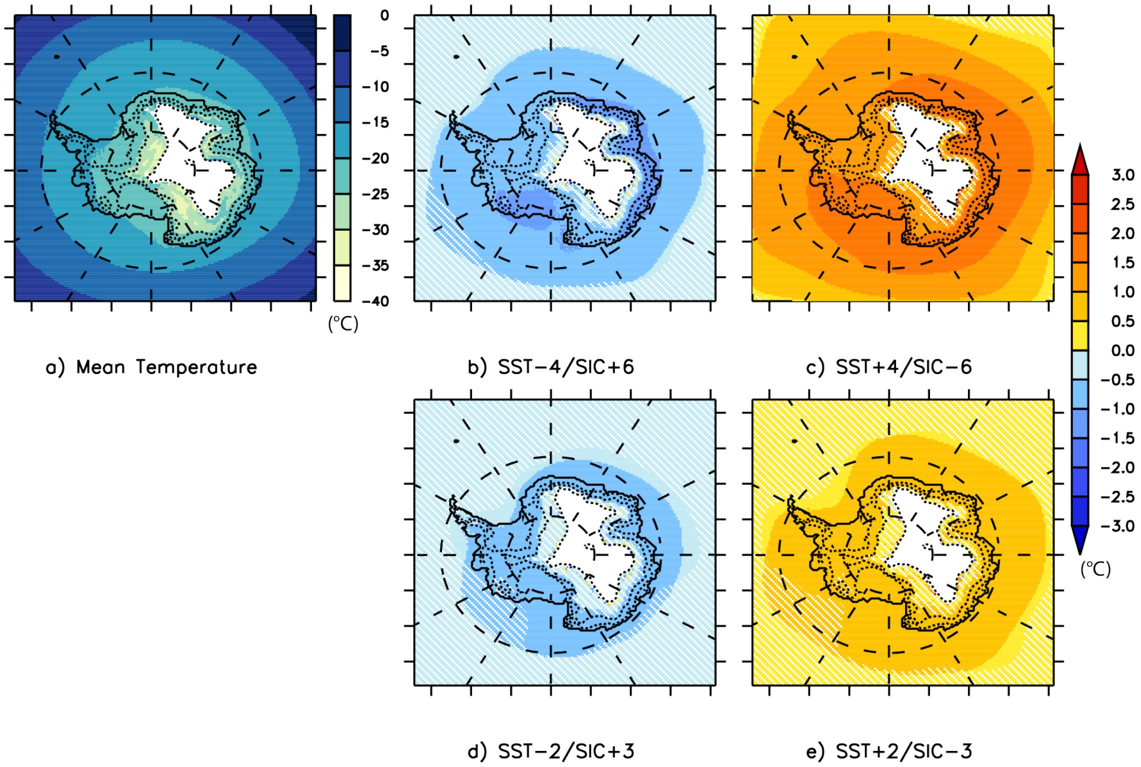

Figure 5. Idem as Figure 2 but for the mean temperature (°C) at 700 hPa.

We suggest to clarify our explanation and add the Figure 2 in our manuscript, Figures (3-5) in supplementary materials and modify P11 L7-15 by

> *These results suggest that precipitation can be formed further inland depending on the properties of air masses. In agreement with Gallée (1996), our hypothesis is that colder and drier air masses in cold ocean experiments are not sufficiently loaded with moisture to enable saturation and then snowfall over the margins. The decrease in moisture is likely to be larger than the decrease in the maximal moisture content in the atmosphere associated to lower temperatures. This leads to a larger amount of remaining humidity that can be advected further inland (Fig. 4b,d and S10b,d) where saturation occurs because of the lower temperatures. On the opposite, the additional humidity in warm ocean experiments results in air masses that reach saturation faster (the increase in humidity overcompensates the increase in the maximal moisture content) and thus generating precipitation over the ice sheet slopes. MAR also simulates significantly higher upper air temperature over the central part of the ice sheet (Fig. S11c,e and Fig S12c,e) that, combined with the lower remaining humidity, (Fig. 4C,e and S10c,e) limit snowfall.*

3.On p 11 line 19 you state that 'Katabatic winds prevent significant impacts of SSC on the Antarctic SMB'. Although this might be true, I do not see proof for this in the manuscript. Even if there would be no katabatics, the fact that air has to rise over the topographic barrier and additional moisture is constrained to the boundary layer, might be enough to prevent significant effect.

Similarly to Gallée (1996) and Noel et al. (2014), we found a strengthening of the near-surface katabatic flow associated to lower SIC and higher SST (Figure 6c). Increased katabatic winds bring more cold air masses from the central ice sheet and cool the ice sheet margins. Furthermore, they also export humidity away from the continent (Van Lipzig *et al.*, 2002). However, this effect is limited to the katabatic layer.

Our deepest analysis about the humidity and temperature suggests that a significant part of the additional moisture is not constrained to the boundary layer and reaches upper atmospheric layers (600 hPa or ~4km height) for the experiments with the strongest SSC perturbations (Fig 2b,c and 3b,c). This contrasts with the results presented in Van Lipzig *et al.* (2002) where the surface anomalies were restricted below the lowest 1-2km. The blocking effect due to the topographic barrier is likely to be reduced as these large anomalies reach higher atmospheric levels, contrary to experiments with slightly perturbed SSC (SST+-2/SIC-+3) where anomalies remain confined in the low levels.

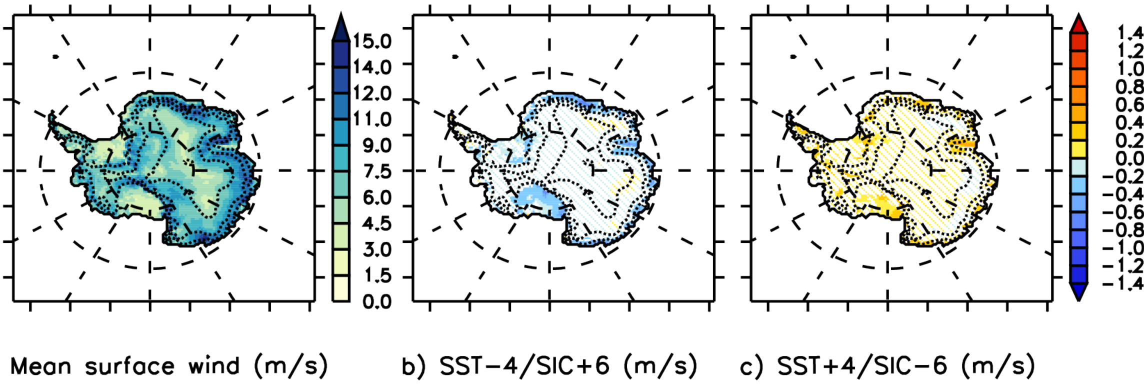

Figure 6. Idem as Figure 1 but without wind vectors and only on the ice sheet.

We thus propose to clarify of our statement P11 L19-21 about the effect of katabatic winds as well as our refutation about the topographic barrier and the additional moisture. We also suggest to add Figure 6 in supplementary material

Similarly to Van Lipzig et al.(2002), moisture and temperature anomalies remain confined below 700 hPa in the experiments with slightly perturbed SSC (SST+-2/SIC-+3) (Fig S10d,e and Fig S12d,e). *On the* opposite, in the experiments with the largest SSC perturbations (SST+-4/SIC-+6), a significant part of the additional moisture is not constrained to the boundary layer and reaches upper atmospheric layers (600 hPa*) (Fig 4b,c). The blocking effect due to the topographic barrier is likely to be reduced suggesting that these large anomalies can have a deeper influence inland.*

Furthermore, katabatic winds are enhanced when the SIC is decreased and the SST increased (Fig S13c) as already shown in Gallée, 1996; Van Lipzig et al., 2002. Due to their offshore direction, they prevent the influence of warm ocean anomalies by precluding their propagation at the surface of the ice sheet and by advecting cold air from inland regions towards the margins.

Minor comments:

1. Abstract: last sentence: a number for a sensitivity in % is meaningless when the magnitude of the perturbation is not specified. Please clarify in the abstract

We think that giving a magnitude of the perturbation is meaningless as the SSC in these experiments are computed with the CMIP5 biases that significantly differ spatially. We therefore propose to specify that the SSC perturbations are based on the CMIP5 biases in the sentence of *P1 L13*

Sensitivity experiments with warmer SSC based on the CMIP5 biases reveal integrated SMB anomalies (+5% – +13%) over the present climate (1979 – 2015) in the lower range of the SMB increase projected for the end of the 21st century

2. P1, line 22: I am not sure if I follow the definition of the Sea Ice Extent given there. Can you give a reference for this definition or clarify?

This definition can be notably found in Parkinson and Cavalieri (2012), Cavalieri and Parkinson (2012), Roach *et al.* (2018) (all cited in our manuscript) as well as in Vaughan *et al.* (2013).

We propose to slightly modify the definition to use the exact same definition:

P1l22: generally defined as the area of all grid cells of satellite or model products with a SIC of at least 15%

3. P 2, l11: reference is van Lipzig et al., (2002) not van Lipzig and van Meijgaard (see below). Van Lipzig, N.P.M., E. van Meijgaard and J. Oerlemans, 2002. Temperature sensitivity of the Antarctic surface mass balance in a regional atmospheric climate model. J. Clim., 15(19), 2758-2774. doi:10.1175/1520-0442(2002)0152.0.CO;2.

Thank you for the correction of the reference. We have also identified a second reference mistake P2,L2. Turner *et al.* (2013) was right but the interesting paper for our study is:

Turner, J., Bracegirdle, T. J., Phillips, T., Marshall, G. J., & Scott Hosking, J. An initial assessment of Antarctic sea ice extent in the CMIP5 models. *Journal of Climate*, 26(5), 1473–1484. https://doi.org/10.1175/JCLI-D-12-00068.1, 2013

Both references will be corrected in the revised version of our manuscript.

4. P9: l12: Air does not have 'a capacity' to hold water vapour. The water vapour is one of the components of air. Please reformulate.

Ok, we suggest to modify *P9 L12* by:

The higher evaporation and inherent increase in air moisture content [..]

References

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Parkinson, C. L. and Cavalieri, D. J.: Antarctic sea ice variability and trends, 1979-2010, The Cryosphere, 6, 871–880, doi:10.5194/tc-6-871- 2012, 2012.

Roach, L. A., Dean, S. M., and Renwick, J. A.: Consistent biases in Antarctic sea ice concentration simulated by climate models, The Cryosphere, 12, 365–383, doi:10.5194/tc-12-365-2018, 2018.

Thompson, S. L., and D. Pollard, 1995: A global climate model (GENESIS) with a land-surface transfer scheme (LSX). Part II: CO2 sensitivity. J. Climate, 8, 1104–1120.

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