Future projections of the climate and surface mass balance of Svalbard with the regional climate model MAR – tcd-9-115-2015
Author answer to the review of anonymous referee #2

Thank you very much for your comments and suggestions that will improve our paper a lot. We have included your comments in the revised version of the manuscript.

Your main concern was that we used only one GCM to force MAR and only one scenario and that we do not stress enough what it implies and that it was an extreme scenario.
In the revised version of the manuscript, we have insisted on why we chose MIROC5 instead of just refer to the companion paper:

- MIROC5 is one of the best CMIP5 GCMs simulating free atmosphere conditions and circulation over Greenland compared to ERA-Interim (Fettweis et al., 2013).
- MIROC5 works also well over Svalbard and the near-surface temperature MIROC5 bias (compared to ERA-Interim) is reduced and becomes insignificant over land in MAR forced by MIROC5 compared to MAR forced by ERA-Interim. As a result, SMB, precipitation and runoff modelled by MAR forced by ERA-Interim and MIROC5 are not significantly different over the current era. As mentioned by Fettweis et al. (2013), as the response of melt is not linearly dependant on temperature, it is very important to have a model that simulates well the present era climate before performing future projections. But it is clear that having a good model over current climate does not necessarily mean that it estimates well future changes. However, MIROC5 projected temperature increase is close to the CMIP5 ensemble mean and this gives us some confidence in our MIROC based future changes.

We have also motivated the choice of an extreme scenario such as RCP8.5. As we decided to use only one scenario (due to high computation time), it is more relevant to show what could happen in an extreme-case scenario to be sure that the climate signal is a lot of higher than the interannual variability .

We chose only one GCM to force MAR and one scenario because running simulations at 10km resolution with MAR takes a huge amount of time. Moreover, our goal was not to do an extensive future projections exercise and estimations over Svalbard but to show what can be expected under a warmer climate.
The CMIP5 GCMs do not project any atmospheric circulation change in the Arctic (Belleflamme et al., 2012) and the future projections made by GCMs mainly correspond to different temperature increases as explained in Fettweis et al. (2013). As shown by Fettweis et al. (2013) over Greenland, for the same temperature increase, the MAR response is the same independently of the GCM used (if there is no temperature bias over current climate) as no atmospheric circulation change is projected. Consequently, what we projected to happen in 2100 may happen earlier or later than what we projected but is still expected to happen some time in the future if we use other GCMs.
Moreover, figure 1 shows that MIROC5 summer temperature is close to the CMIP5 ensemble mean until 2060 and that, after that, it is only a little bit higher than the mean.
In conclusion, the results would of course had been different with another GCM but the general message of our paper would have remained the same. This discussion has been included in the revised version of the manuscript.

Finally, we suggest to change the title of our paper if the editor agrees with it. We could at least add that we made a future projection with MAR forced by MIROC5 under the RCP8.5 scenario.

Belleflamme, A., Fettweis, X., Lang, C., and Erpicum, M.: Current and future atmospheric circulation at 500 hPa over Greenland simulated by the CMIP3 and CMIP5 global models, Clim. Dynam., 4, 2061–2080, doi:10.1007/s00382-012-1538-2, 2012.

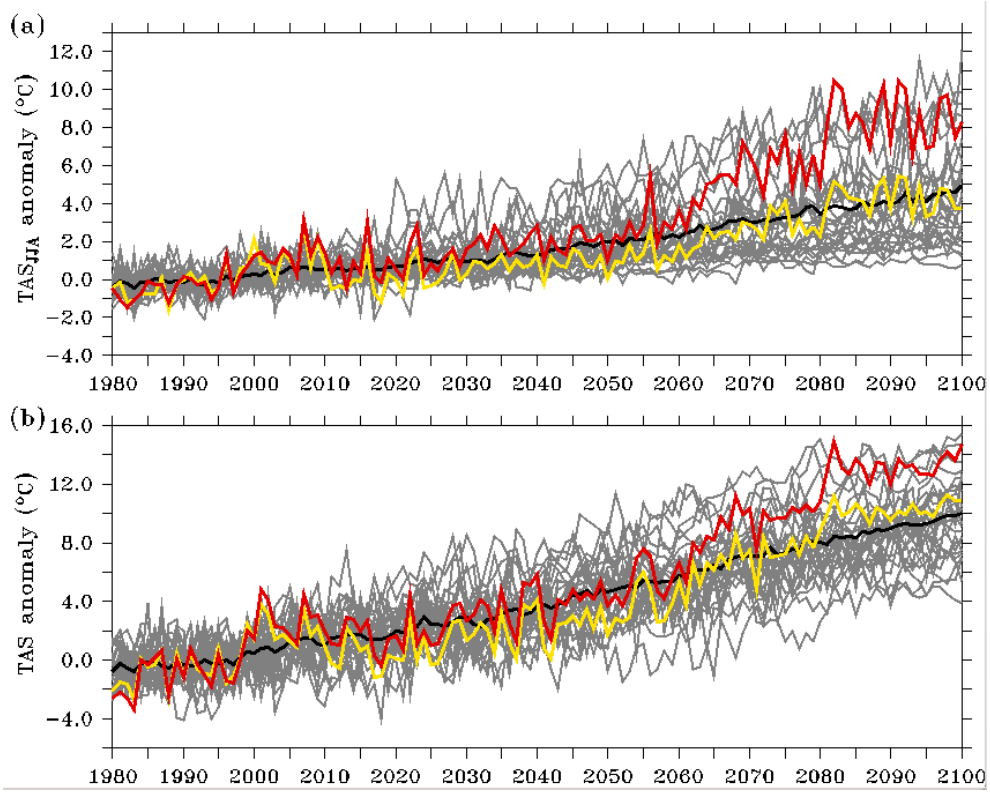

Figure 1: (a) 1980 – 2100 evolution of the anomaly of the JJA near-surface temperature of the CMIP5 GCMs (using RCP8.5 scenario) with respect to the 1980 – 2005 mean. The red curve represents the MIROC5 anomaly, the grey ones the other GCMs, the black one the ensemble mean and the yellow one the MAR anomaly. (b) Same as (a) but for the annual temperature.

P119 line 17: Based on Fig. 2a of the supplement, I also notice an acceleration of the temperature increase after 2050. So part of the acceleration of melt since 2050 can be ascribed to acceleration of air temperature. Please reformulate.

Yes, the acceleration of runoff/melt increase after 2050 can be partly explained by the acceleration of the temperature increase but the larger acceleration in the south can not and is explained by the evolution of the net shortwave radiation. We have rephrased this in the revised version of the manuscript.

P119 line 25-26: The ocean around Svalbard is already under present climate conditions ice-free in summer, so higher cloud cover in summer is unlikely related to a reduction of sea-ice. Please reconsider.

First, we meant that the larger cloud cover was partly due to a more humid atmosphere caused by higher temperatures and partly due to the higher evaporation caused by the reduced sea-ice cover in the south and west compared to the north. We did not mean that everything was caused by the regional SIC differences.
Then, MIROC5 overestimates the sea-ice extent in summer over the present and the ocean is not ice-free around East Spitsbergen and the ice caps (see the comparison with ERA-Interim in fig. 2). The SIC therefore still has a small role in the cloud cover difference.
However, it is true that the SIC role will be less important as time passes since the summer SIC will rapidly decrease even in MIROC5. As most of our discussion concerns the rapid changes around

2060 rather than the evolution over the entire century, we have removed this statement from the revised version of our manuscript to avoid confusion, since SIC has obviously no influence anymore in summer around 2060.

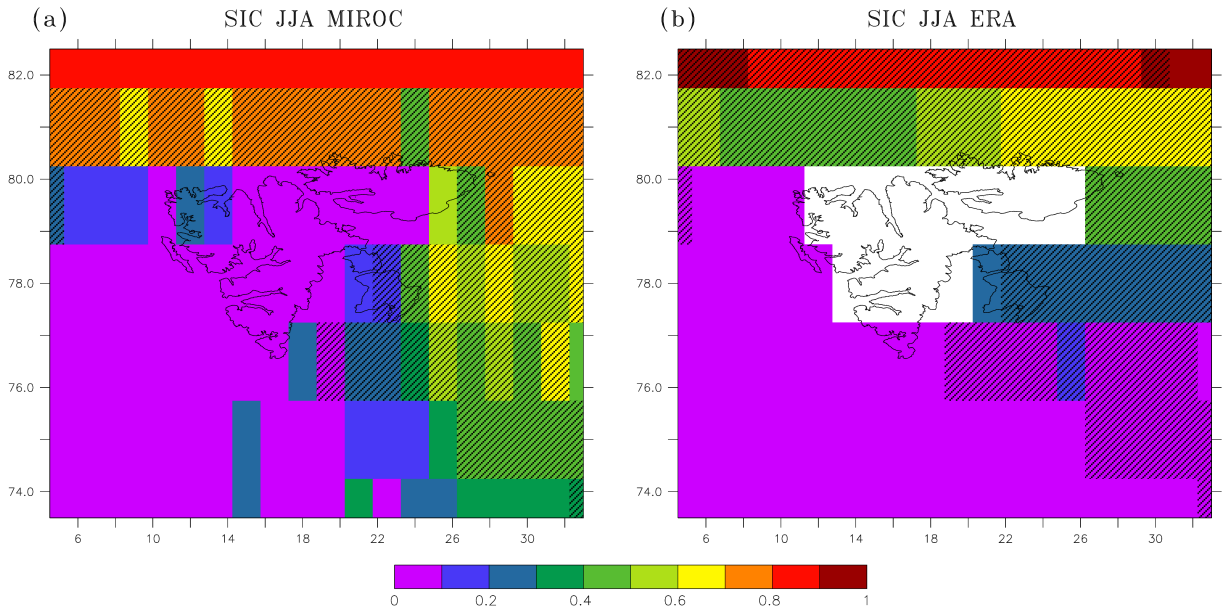

Fig. 2: Mean 1980-2005 summer SIC in MIROC5 (left) and ERA-Interim (right).

P121 line 9: It can be mentioned here that mass loss by calving will lead to even more glacier mass loss of ice mass in addition to surface mass loss.

Our 7.2 mm of SLR corresponds to the additional SLR coming from the SMB changes compared to the present era. As we are looking at anomalies, the contribution of calving will decrease with time as glaciers retreat and therefore contribute negatively to the additional SLR.

P123 line 10-11: Please add “albedo” to “positive feedback”.

It is not an albedo feedback we are talking about but a temperature feedback: the atmospheric temperature increases and causes the SIC to retreat. Without SIC, the sea surface temperature is higher and warms the atmosphere. This additional warming of the atmosphere causes the SIC to decrease furthermore, etc.

Here, the albedo feedback does not have any role since the impact of the SIC retreat mainly concerns winter, when there is no sunlight in Svalbard.

P125 line 1: Please clarify “impermeable snow pack” here, or remove if appropriate.

When the density of snow reaches 830 km/m³, the meltwater can not percolate through the snowpack and refreeze anymore and all the meltwater runs off.