Dear editor, dear reviewers,

We first would like to thank you for your comments and for taking the time to discuss our manuscript.

We are conscious that the paper in its present state needs to be improved, but we would like to address a few points that have been highlighted and that we think should not be a reason to reject the paper.

First, the paper was written as a continuation of Hanna et al (2018). It was therefore important for us to keep the same methodology and structure as in 2018. This explains the different choices that have been made here and criticized for some of them: indices studied, reference period, rolling average, etc. We would like to point out that most of them (ie., indices, reference period, rolling average) have already been discussed and answered here
(https://www.the-cryosphere-discuss.net/tc-2018-91/tc-2018-91-AC2-supplement.pdf)

Secondly, we understand that the choice of a single reanalysis may be subject to questioning. If we have focused on only one it is because the choice of the reanalysis used for the comparison does not influence our conclusions, as was the case in Hanna et al. (2018) and as shown their fig 1 (and presented hereafter). We acknowledge that we should have presented in the paper that using other reanalyses does not change the results. Adding reanalyses for comparison is therefore part of the easy corrections to the analysis and does not seem to compromise the interest of the study, neither the result accuracy.

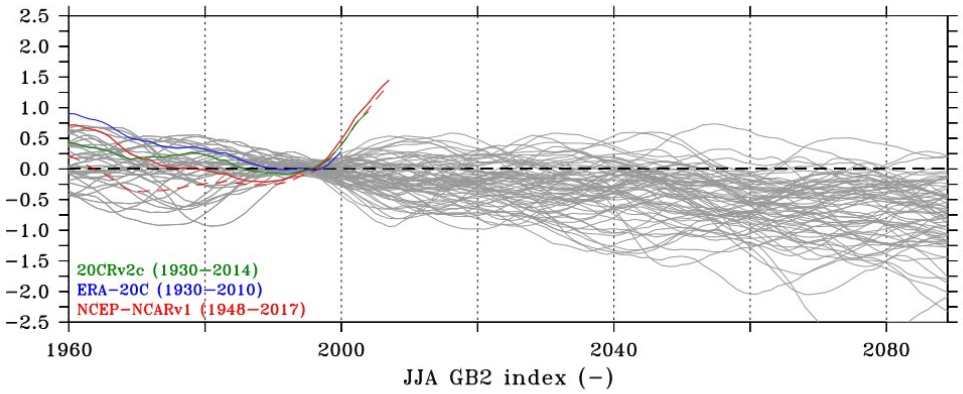

Figure 1. Time series of JJA GB1 (dashed red line) and GB2 (solid red line) indices over 1950–2100 as simulated by NCEP/NCAR Reanalysis 1 (red line), by 20CRv2c reanalysis (green line), and by ERA-20C reanalysis in blue as well as by all the CMIP5 models (grey lines) for which both RCP4.5 and RCP8.5 scenarios are available. For the CMIP5-based time series, the historical scenario is used over 1900–2005 and both RCP4.5 and RCP8.5 afterwards. A 20-year running mean has been applied to smooth the time series, and values have been normalised (average = 0 and standard deviation = 1) using 1986–2005 as the reference period.

Then we agree that it is not the best strategy to focus only on the ESM mean rather than on their individual trends. Indeed, if one or two models have negative trends for the wrong reasons, they pull the trend downwards. We therefore analzyed each model individually and since they mostly do not differ from the mean, we decide to present and mainly discuss the average value of CMIP5 and CMIP6 models. However we highlighted the few models that have normalized GB2 values close to or above 1 (similar to the current observed normalized GB2 values). And when we say that no circulation change is represented in the future, we are not only considering the mean trend, but the fact that no ESM (when considered independently) represents such an increase as the reanalyses currently do.

Finally, to better illustrate the situation, we would like to add 2D graphs of situations representing 1) Greenland over the last 20 years affected by recurrent summer blocking events, 2) the non representation of this type of situation by the CMIP6, and the non projection of such situations.
To do this, we removed the mean Z500 of the area considered (northern hemisphere, 90-50° N) in order to isolate the « basic » Z500 from the global increase in Z500 due to warming (called ZG2 hereafter). Indeed, if we consider "raw" anomalies of future Z500 with respect to a reference period, we end up with stifled information in the increase in Z500 caused by the respective warming of each ESM since air temperature increase will lead to an increase in geopential height (e.g. Fig 2 for EC-Earth3). By removing the average over the considered area, we mainly remove the signal coming from temperature increase by assuming here that the warming is almost uniform over the considered area. Finally, we compared this average ZG2 over the critical period of the NCEP (2000-2019) with that of the reference period (1970-1999), which was not characterised by summer blocking events (fig 3a). We also applied this analysis to the ERA5, which show a strong similarity to the NCEP reanlaysis (Fig 3b). The same argument was also applied to two CMIP6 ESMs. Fig 4a (5a respectively) therefore compares the NESM3 ZG2 anomalies (resp. MRI-ESM2-0) for the period 2000-2019 with respect to the reference period, and Fig 4c (5b respectively) compares the reference period ZG2 to 2080-2100. These ESMs were already highlighted in the manuscript as they have higher values of GB2.
For NESM3, the GB2 anomaly for the period 2030-2050 was also compared to the reference period (Fig 4b) given the values of normalized GB2 very close to unity in Figure 2 of the paper. The 2D comparison does show a positive ZG2 anomaly over the Baffin Island but not significant relative to the variability of ZG2 during the reference period, which is not the case for ZG2 anomalies derived from reanalysis over Greenland. It is exactly the same case for MRI-ESM2-0 over 2000-2019 over Greenland (Fig 5a), but the anomalies are also not sgnificant.
All of these figures illustrate the fact that the reanalyses represent an increase in blocking situations inferred from an increase in the Z500 located in Greenland, whereas the ESMs show neither a significant increase for the current period nor for the future.

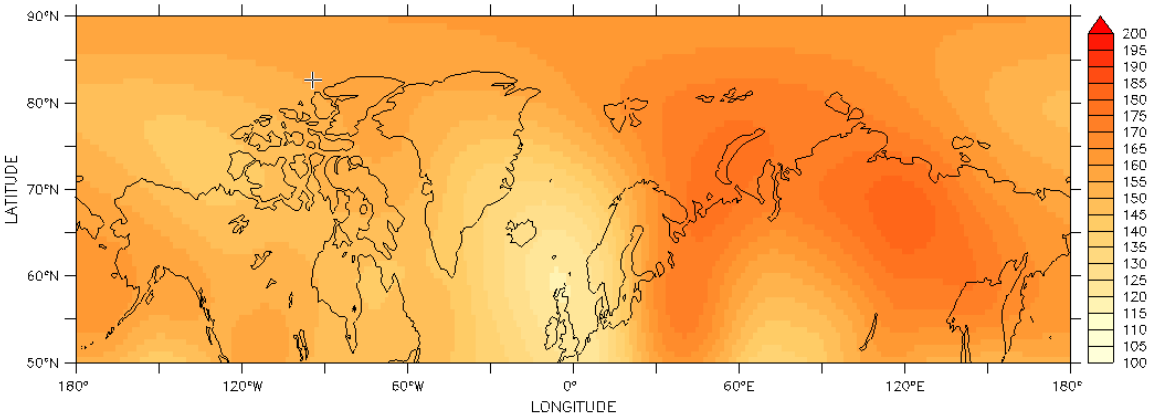

Fig 2. Z500 anomalies (m) over 2080-2100 from EC-Earth3 with respect to reference period (1970-1999).

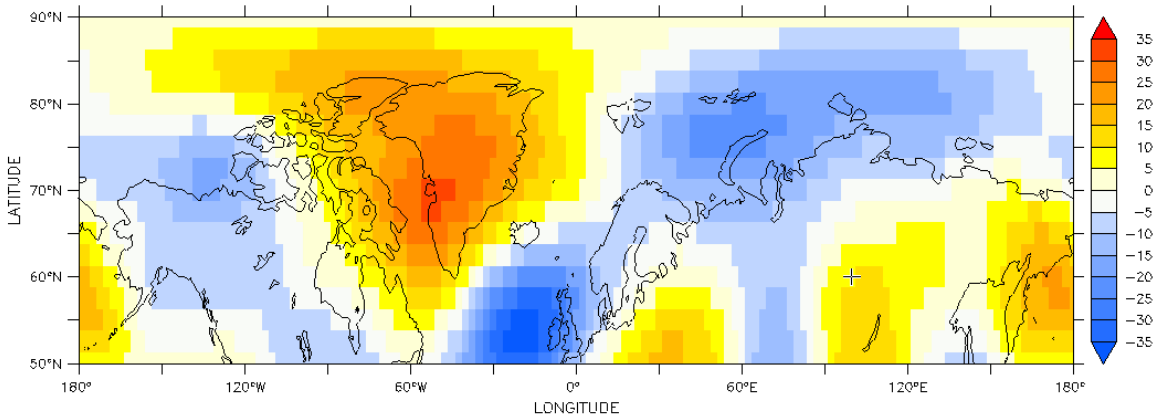

Fig 3a. ZG2 anomalies (m) over 2000-2019 for NCEP reanalysis with respect to the reference period (1970-1999). ZG2 was computed by removing the mean Z500 between 50°N and 90°N to remove the artificial increase in geopotential height due to global warming.

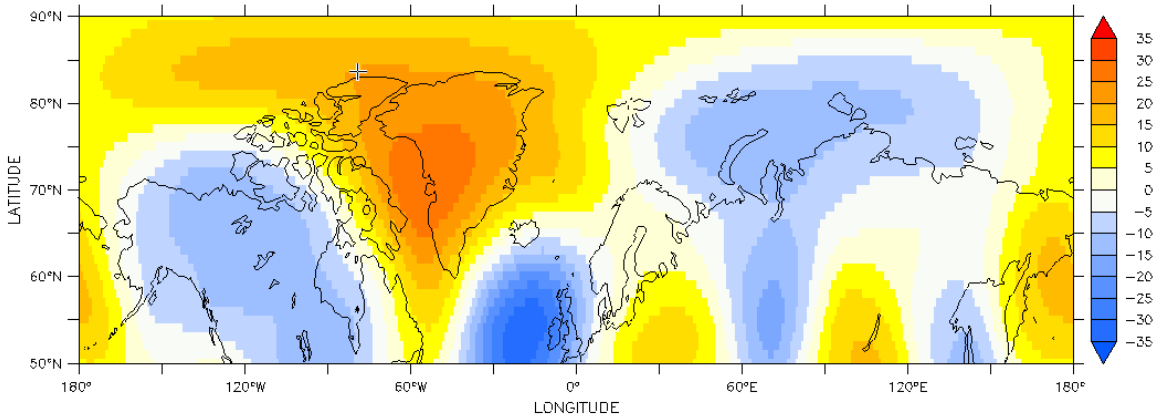

Fig 3b. Similar ton Fig 3a but for ZG2 (m) computed with ERA5 reanalyses.

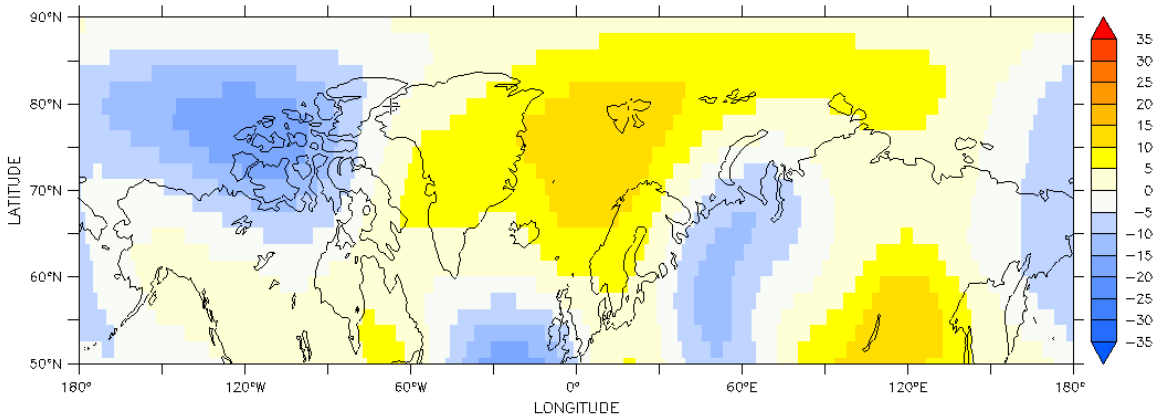

Fig 4a. Similar ton Fig 3a but for ZG2 (m) computed with NESM3 ESM.

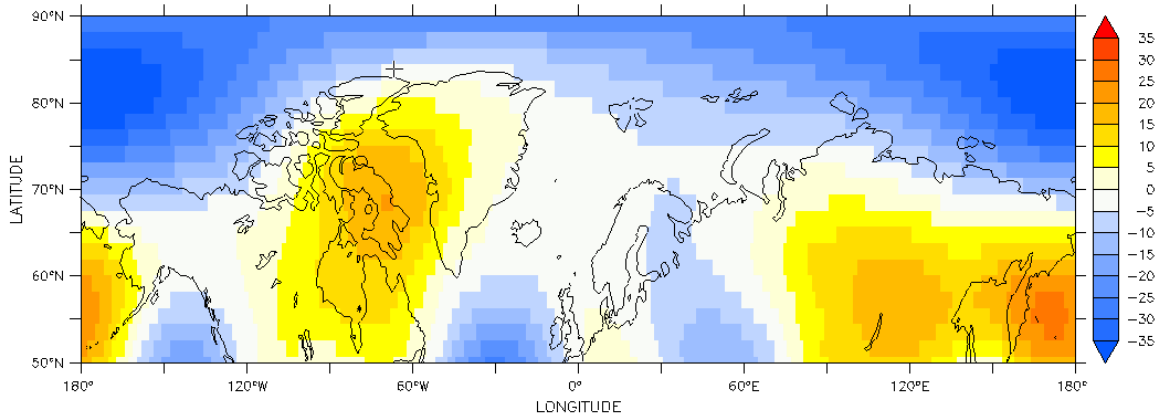

Fig 4b. Similar to Fig 3a but for ZG2 (m) computed with NESM3 ESM over 2030-2050. The period 2030-2050 is displayed as NESM3 has a “high” GBI index during this period but the pattern remains different compared to the observed current blocking pattern over Greenland.

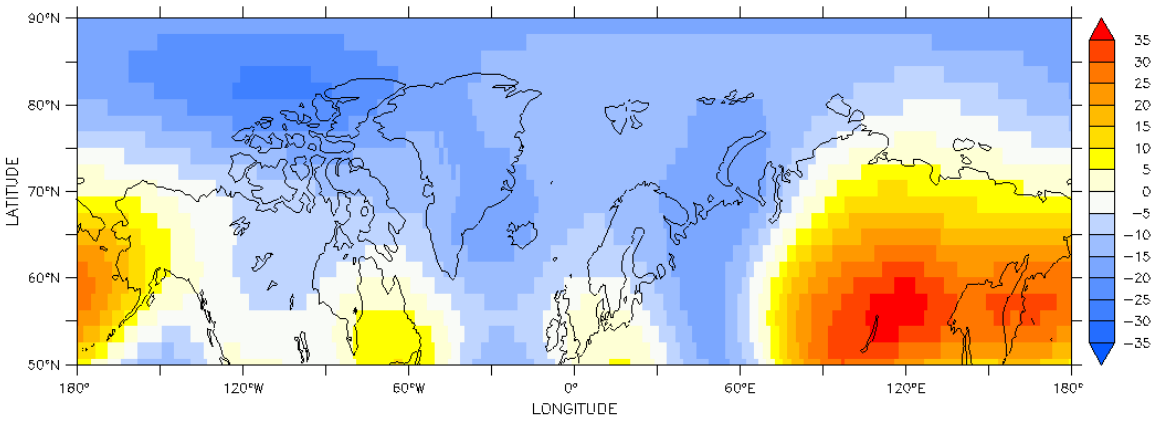

Fig 4c. Similar to Fig 3a but for ZG2 (m) computed with NESM3 ESM over 2080-2100. The figure points out that there is no blocking increase in NESM3 projections for the end of the century.

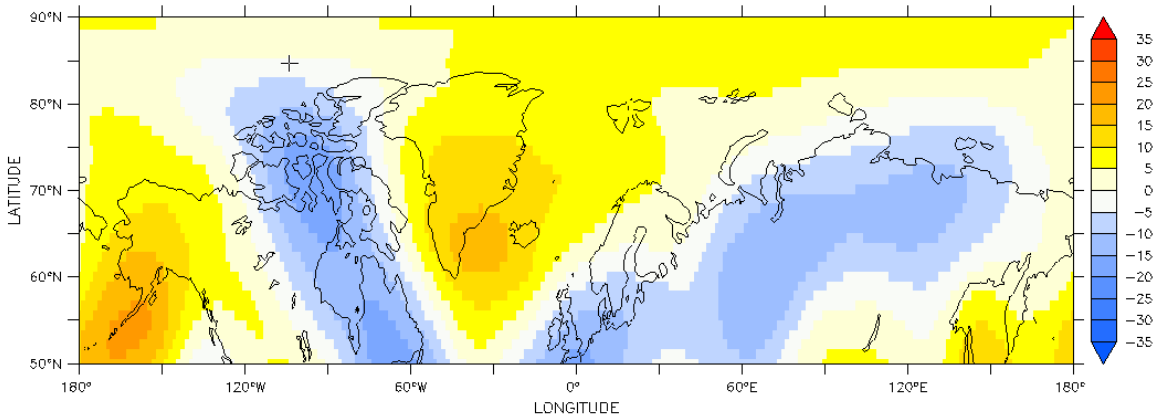

Fig 5a. Similar to Fig 3a but for ZG2 (m) computed with MRI-ESM2-0.

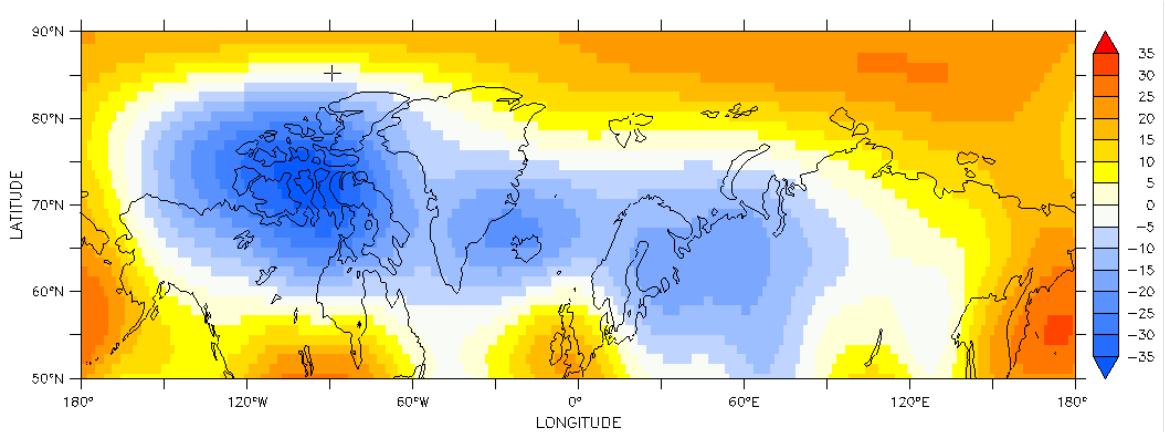

Fig 5b. Similar to Fig 3a but for ZG2 (m) computed with MRI-ESM3-0 ESM over 2080-2100.

We understand the reviewers' comments and yours, but we hope that our answers will make you reconsider your decision and allow us to revise our manuscript. In addition to adding more reanalyses, 2D illustrations of blockings events, we obviously agree to change the title of the paper to something that only discusses anticyclonic blockings such as "CMIP6 does not suggest any increase of blocking event in summer over Greenland by 2100".

Reference : Hanna, E., Fettweis, X., and Hall, R. J.: Recent changes in summer Greenland blocking captured by none of the CMIP5 models, The Cryosphere, pp. 3287–3292, https://doi.org/10.5194/tc-12-3287-2018, 2018.