Review of:
Andres and Tarasov, Towards understanding potential atmospheric contributions to abrupt climate change: Characterizing changes to the North Atlantic eddy-driven jet over the last deglaciation, Climate of the Past Discussion

This work is potentially of interest to the geosciences community.

Summary:
This manuscript describes a set of transient simulations of the last deglaciation (from LGM to present), investigating the evolution of the North Atlantic jet stream characteristics, such as axial tilt and meridional variability. Data from two different circulation models are analyzed: the Planet Simulator (an intermediate complexity model), and the TraCE-21ka simulation that was run with NCAR CCSM3 (a coupled atmosphere-ocean general circulation model).

In agreement with pervious studies, the authors find that the jet was narrow, fairly zonally oriented, and had a low meridional variability at the LGM and in the first part of the deglaciation, followed by an abrupt change in the jet characteristics (widening, increased axial tilt and latitudinal variability) around 14 ka (14,000 years ago). Altered jet characteristics are also identified at around 19 ka and 11 ka; to my knowledge, neither of the latter two have previously been discussed in the literature.

A number of sensitivity experiments are also carried out where the impact of different forcing agents is examined in isolation, e.g. ice sheets (and topography in isolation), greenhouse gas concentrations, and orbital parameters. The main conclusion is that the ice sheet topography has the strongest influence on the jet characteristics, especially over the western ocean basin where it is very latitudinally stable when the ice sheet is present. The eastern side of the jet is proposed to be more influenced by the thermal state of the background climate, which, in turn, is shaped by the ice sheet topography, greenhouse gas concentrations, and orbital parameters.

The paper is well written and presents a coherent and succinct story. I recommend publication, subject to some intermediate revisions. My main concerns are outlined below, followed by more specific line-by-line comments.

Major concerns:

Lack of explanations:
The authors provide an explanation for the suppressed variability of the western side of the jet stream (though I personally think that one key aspect is missing – see comment below). However, the more complicated part of the story, explaining the jet characteristics over the eastern ocean basin, is not discussed at the same level of detail. I think this is a shame and I encourage the authors to do more analysis to improve that part of the story.

Lack of dedicated discussion section:
The authors have decided to jump straight from the results section to the conclusions without having a proper discussion section where your findings are put in perspective with the existing literature. This makes it hard to get a sense for how your results differ from earlier studies and how they contribute to our understanding of the atmospheric circulation during the deglaciation. The discussion section is in my mind the most important part of a paper, so its omission feels instinctively wrong and may give this paper less traction than it deserves.

Line-by-line comments:

Page 1, line 5:
Remove "we performed" and specify that PlaSim is an intermediate complexity model.

Page 2, line 17:
Missing space between sentences

Page 3, line 12:
"Low levels of the atmosphere" is ambiguous. Perhaps better to say "lower troposphere".

Page 3, line 13:
Missing word. The extratropical jet stream is due to "momentum-flux convergence" by synoptic eddies.

Page 4, line 11:
Lofverstrom et al. (2016) showed that stationary waves can influence the jet characteristics in the eastern North Atlantic at the LGM as well.

Page 4, line 23:
Sentence starting with "These changes.." is incorrect. To the best of my knowledge, none of the papers cited here suggest that the subtropical and midlatitude jets entered a merged state over the N Atlantic at the LGM; see, e.g., Fig. 1 in Li and Battisti (2008) where there is a clear separation between the subtropical and eddy driven jets.

Page 4, line 26:
Missing space between sentences.

Page 4, lines 26-28:
None of the papers cited here investigated that explicitly.

Page 4, line 32:
"The timing.." meaning here is not clear.

Page 5, line 5 and section 2.1:
Perhaps nit-pick but this not technically correct. PUMA (the dynamical core of PlaSim) is indeed a dry primitive equation model. However, the extra layer of physics on top of the dynamical core makes PlaSim more than a primitive equation model. More correct to say that it is a simplified general circulation model or, better yet, an Earth-system model of intermediate complexity (EMIC).

Page 5, line 28:
It was recently shown by Lofverstrom and Liakka (2018) that T42 resolution is sufficient to reasonably capture planetary waves in simulations of the LGM climate.

Page 5, line 29:
The description here is not correct. The Gaussian grid is the 128 x 64 cell grid in real space that the data is outputted on ("Gaussian" refers to how the grid is generated). The primitive equation are partially solved in spectral space (wave space) and are thus transformed between grid space (on the Gaussian grid, in this case 128 x 64 grid points in lon x lat) and the spectral representation in wave space, which supports at most 42 harmonics in the zonal and meridional direction, respectively. (Hence the name T42, where the T is short for

"truncation" or more specifically "triangular truncation").

Page 6, line 1:
Not sure if I understand how the LSG models works. Is it a dynamic model that only runs in the mixed layer? If yes, how can a realistic ocean circulation be established if there is no deep ocean? Do you parameterize fluxes between the deep ocean and mixed layer? If yes, how are these fluxes calculated? What is the depth of the mixed layer? Prescribed or dynamic? Studies have shown that the mixed layer depth was substantially greater at the LGM (e.g. Sherriff-Tadano et al., 2018), which can have profound implications for the ocean heat contents and energy exchange between the ocean and atmosphere.

Page 6, line 17:
Please clarify, you update the boundary conditions every simulation year, but with 10x acceleration, meaning that you effectively only run every 10 years from LGM to PI. Is that correct?

Page 7, line 12:
"...temporal resolution of 100 years". This seems to conflict with the synchronous update of boundary conditions described above.

Page 7, line 5:
Please clarify how this process works. You can't fit an even number of 0.5° grid cells in a T42 cell (which is around 2.8°), so there must be some partial overlapping cells. Also, what does "effective higher-resolution grid cell length" mean?

Page 8, line 18:
Ivanovic et al. (2016) is double cited.

Page 8, line 22:
Century should probably be millennium here (you discuss 21 ka - 20 ka and 1 ka to 1950), right?

Page 9, line 10:
Sentence can be simplified; e.g.: "Also, the path of the NPac jet" -> "Also, the NPac jet"

Page 9, line 14:
I agree with this assessment and a similar conclusion was reached by Lofverstrom et al. (2016); see their discussion about sensitivity simulations with extensive sea ice in the eastern N Atlantic (their Fig. 6).

Page 16, line 6:
Write out explicitly that you are referring to Fig. 11 here.

Page 16, line 5:
Typo? ...range or its tilt -> ...range of its tilt (?)

Page 16, line 15:
What standard metrics?

Page 16, line 17:
Replace "instead" with "as well", and remove "For those interested".

Page 17, line 5:
Meaning here is not clear. Do you mean flat ice sheets (i.e., only accounting for the albedo effect)? Also, the ice sheet height is not the only thing influencing the circulation. As you say elsewhere, the spatial extent is also important.

Page 18, line 1:
How did you arrived at this specific number (725 m)?

Page 18, line 9:
Typo? "jet does not always move the the latitude of the jet."

Page 19, lines 3-10:
This explanation is a bit too simplistic. I agree that the presence of the ice sheet constrains the jet latitude in the west, presumable in part because of obstruction of the flow by the topography. However, the thermal gradient at the southern ice margin can influence the flow in a similar fashion (this is not mentioned here as far as I can see) – both the change in albedo at the ice sheet margin, and the adiabatic cooling of the flow by the implied elevation difference. The modern (PI) jet is also less variable in the western ocean basin because of the strong thermal gradient at the sea-ice edge. This is clearly a different mechanism than the presence of a big ice sheet, but the effect is similar.

Page 21, line 25:
Meaning here is not clear — this seems to be the definition of a shift in the jet latitude.

Page 22, line 16:
What figure is discussed here?

Page 22, line 25:
I would encourage you to think a little bit more about this and try to give a mechanistic explanation for this phenomena. Doesn't have to be a full explanation, but at least something that adds a little bit more to the story.

Figure 1:
What ice sheet remained in North America through the Holocene and is 1.5 km thick?

Figure 4:
Panels showing LGM and past1000 are mixed up (LGM is shown in middle panels).

Figure 4:
The top of the LGM ice sheets (and indeed some modern topography) is higher than the 700 hPa isobar. I would advice against extrapolating the wind field in these regions and instead treat it as missing data, as extrapolation can cause some weird effects when doing statistical analysis (e.g. when determining the latitude of the strongest winds in the western N Atlantic).

Figure 6 – 8:
Use the same range on the spines on the right hand side for easier comparison (e.g., in Fig. 6: 0–80 % in top panels and 0–35 % in lower panels).

Figure 9:
10 successive years is a bit ambiguous because it can be done in at least two different

ways: (1) a sliding mean where the input and output arrays have the same length; (2) form decadal averages where the input array is 10x longer than the output array. These methods will yield slightly different results. I doubt that the difference will be of sufficient magnitude to challenge your conclusions, but this type of information is important for reproducibility.

Figure 9 – 11 and 13:
Write out lat and lon bounds and pressure level(s) used in statistics.

Figure 11:
Caption appears to be wrong as you show latitude here, not difference in latitude across the N Atlantic.

Figure 12:
Use same latitude range on vertical axis for easier comparison.

References

Ivanovic, R., Gregoire, L., Kageyama, M., Roche, D., Valdes, P., Burke, A., Drummond, R., Peltier, W. R., and Tarasov, L.: Transient climate simulations of the deglaciation 21-9 thousand years before present (version 1)-PMIP4 Core experiment design and boundary conditions, Geoscientific Model Development, 9, 2563–2587, 2016.

Li, C. and Battisti, D.: Reduced Atlantic Storminess during Last Glacial Maximum: Evidence from a Coupled Climate Model, J. Climate, 21, 3561–3579, 2008.

Lofverstrom, M. and Liakka, J.: The influence of atmospheric model resolution in a climate model-forced ice sheet simulation, The Cryosphere, 12, 1499–1510, doi: https://doi.org/10.5194/tc-12-1499-2018, 2018.

Lofverstrom, M., Caballero, R., Nilsson, J., and Messori, G.: Stationary wave reflection as a mechanism for zonalising the Atlantic winter jet at the LGM, Journal of the Atmospheric Sciences, 73, 3329–3342, doi:10.1175/JAS-D-15-0295.1, 2016.

Sherriff-Tadano, S., Abe-Ouchi, A., Yoshimori, M., Oka, A., and Chan, W.-L.: Influence of glacial ice sheets on the Atlantic meridional overturning circulation through surface wind change, Climate Dynamics, 50, 2881–2903, 2018.