

Review of “Exploring the sensitivity of the large-scale atmosphere circulation to changes in surface temperature gradients using a Statistical-Dynamical Atmosphere Model ”

Sonja Totz, Stefan Petri , Jascha Lehmann, Erik Peukert, Dim Coumou

Reviewer #1

The paper aims to disentangle the role of global mean, meridional and azonal temperature changes on large scale atmospheric circulation (specifically focusing on jet stream, storm track, planetary wave and Hadley Cell) in the Northern Hemisphere. In order to separate the effect due to each other, the authors carried on simulations with a statistical-dynamical atmosphere model (SDAM) Aeolus 1.0. The authors found that the strength of the Hadley cell, storm tracks and jet streams depends almost linearly on both the global mean temperature and the meridional temperature gradient whereas the zonal temperature gradient has little or no influence. The width of the Hadley cell behaves nonlinearly with respect to all three temperature components.

After the first round of review authors improved substantially the manuscript. I found however some sources of ambiguities and some unclear statements. I think that the paper can be accepted after a minor revision. I have listed below my suggestions.

Specific Comments:

Title: Consider re-title the paper as “Exploring the sensitivity of Northern Hemisphere atmospheric circulation to different surface temperature forcing using a Statistical Dynamical Atmospheric Model” as authors stated in conclusions (P.13 Ln 20-21 and P.14 Ln 1).

Abstract: Ln 14:...including the strength of the Hadley cell”. Please include “...the strength and the width of the Hadley cell” since you are investigating both and both have changed in last decades.

Page 2, Ln 17-18: You can be more precise, and state why the HC is related to jet-streams, storm track and planetary wave activity. Please refer to the wide literature about it.

Page 3, Ln 3-4: “These waves strongly interact with storm track activity in the mid-latitudes”. Need reference here. Since you are investigating change in the atmospheric dynamics, you must further expand here the relationship between planetary waves and storm tracks. Few sentences would be enough.

Page 5, Ln 6: Large scale atmospheric circulation is surely related to large scale temperature difference but don't forget to mention that also angular momentum is a key ingredient. You can refer to this nice review:

<https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2006RG000213>

Egger, J., Weickmann, K., & Hoinka, K. P. (2007). Angular momentum in the global atmospheric circulation. *Reviews of Geophysics*, 45(4).

Page 4 Data and Methods: Maybe I missed it but I did not find any specification about the time-step of data you used to prescribe the SDAM. Are they monthly-seasonal mean or the seasonal mean are computed by daily means? I was just wondering if prescribing monthly mean data you can get a sufficient statistical representation of transient eddies and synoptic activity. I got from page 4 Ln 2 -3 that "Aeolus is based on time-averaged (over short time scales) equations..." but what are these short time scales? Furthermore, what is the temporal resolution of your model output? Please include these information.

Page 6, typo at Ln 24 (after 700 mb).

Page 6, Ln 25 - 26: The strength and the width of the Hadley Cell are computed usually differently. The strength is the max or min inside each individual NH or SH cell described by the meridional mass streamfunction. The width is the zero-crossing latitude of the streamfunction averaged between 200 - 700 mb. Then there is an ambiguity in the definition of the strength and edges of the HC relative what you state in the response to reviewer. Please clarify.

Page 7, Ln 21 - 24. So: small difference of the meridional temperature gradient, narrower HC... Please refer to Levine and Schneider, 2015 (page 2755 - Discussion).

Please refer in the discussion to this paper.

<http://climate-dynamics.org/wp-content/uploads/2015/08/Levine-Schneider-2015.pdf>

Levine, X. J., & Schneider, T. (2015). Baroclinic eddies and the extent of the Hadley circulation: An idealized GCM study. *Journal of the Atmospheric Sciences*, 72(7), 2744-2761.

Page 7, Ln 26 - 27: there is a blank space or a discontinuity in the line. Remove.

Page 8, Ln 7: "... are visible" ... rephrase as "... are detectable".

Page 8, Ln 14 - 16: You can expand here the description of the figures.

Page 9: Strength of the planetary waves. It is not really clear to me what you mean for "strength" here. Are you referring in change in the phase speed? Are you referring to meridional amplitude of Rossby waves? Can you be more precise please?

Page 9, Ln 25 - 26: I don't understand this statement. Why then in a warming climate the HC is robustly weakens while in the LGM it robustly strengthens?

Refer to Hill et al., 2015 also. Hill, S. A., Ming, Y., & Held, I. M. (2015). Mechanisms of forced tropical meridional energy flux change. *Journal of Climate*, 28(5), 1725-1742.

Consider to rephrase.

Page 10, Ln 3 - 6: I don't understand this statement. Can you clarify?

Page 10, Ln 10: typo "present-day climate"

Page 12, "Strength of planetary waves" see comment above.

Page 13, Ln 26 - 27. Refer to Levine and Schneider paper.

Page 13, Lb 28 - 30: I don't understand this sentence. Please clarify.

Figures.

Fig. 5 and 7 : y-labels. It is pressure (mb), not altitude (km). Correct please.