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Earth System Dynamics
Discussions

Interactive comment on "Enhanced warming of seasonal cold extremes relative to the mean in the Northern Hemisphere extratropics" *by* Mia H. Gross et al.

Anonymous Referee #2

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Review of manuscript # ESD-2019-36 entitled "Enhanced warming of seasonal cold extremes relative to the mean in the Northern Hemisphere extratropics".

Gross et al. evaluate historical and projected changes in cold extremes across the Northern Hemisphere extratropics in a subset of CMIP5 models. The authors find that cold extremes are expected to warm substantially more than the seasonal mean. They attribute this difference to changes in advection during winter, and reductions in snow cover during fall and spring. The manuscript is fairly well written, but there are some instances where the text is repetitive or confusing. It features interesting analysis that is relevant to ESD and could be a useful contribution after some issues are addressed.

Major Comments:

(1) Section 3.1: Given the weak pattern correlations I recommend changing the way in which these results are discussed. The authors should lead by describing the observed pattern and quantifying the mean across some given regions (e.g. hemispheric or continental). Second, they can discuss how well the models capture this on average (again quantifying results, perhaps with an ensemble mean value), then it makes sense to comment on the regional differences and the pattern correlations. For example, how much more have cold extremes warmed than the mean in observations and models across either the NH extratropics or EU vs NA (using regions in Fig. S1)?

(2) Baseline used for calculating future changes: Wouldn't it make more sense to compare 1982-2014 with 2070-2099 to evaluate future changes rather than using 1950-1981? The current definition used to calculate "future changes" combines both historical and 21st century changes in one. I recommend changing the baseline to the later historical period.

(3) Presentation of results: There are a number of figures which can be improved or combined to better convey the authors main points. Figures 1-3 could be combined into one plot that shows the excess changes from HadGHCND and the CMIP5 mean for each season (as columns). A polar stereographic projection might be useful for this purpose. Individual model results could then be shown in the supplemental material or similarly as figure 2 if there are models of particular interest. If the authors agree that the CMIP5 mean is useful, I would also add it to Figs 4-6. Figs 7,10: Using the CMIP5 mean (or similar) would also be more informative than assessing the changes in an individual randomly selected model (CanESM2).

Specific Comments:

L14: Remove "The consequences of".

L19: Remove "months".

L45-46: Remove second use of “in these regions”.

L54: Change “depending on the region and season” to “both regionally and seasonally”.

L63: Remove “which are warming faster than the warm days” – this has already been established above.

L74-76: Surface albedo feedback stemming from snow cover is strongest in spring not winter (see Fig 1c from Qu and Hall 2014). Furthermore, the timing does not only depend on large snow cover extent, but also insolation (which is very low in high snow cover months like December and January).

L85: Reword the first part of this sentence.

L86: Change “capture” to “represent”.

L87-88: This is a very broad statement. Either remove or be more specific about what is meant and explain how so. It is also unclear what is being “influenced”.

L143: This is repetitive - remove “daily data for”.

L169-170: Remove “one by showing” and “the other by showing”.

L172: Remove “due to the number of figures”.

L176: Change “that have” to “with”.

L177: Define the regions with the latitude/longitude here.

L186: Confusing wording. Change “Excess changes between recent decades” to “Historical excess changes”.

L197: “Springtime show” – reword.

L210: Remove “between future and past decades”. This should be implied by the use of projected.

Figures 4-6, 10: all have colorbars with an unnecessary level of label precision. Increase the tick mark stride.

L214-215: Awkward wording. Change to something like this: “Cold extremes are projected to warm significantly more than mean temperatures across much of the NH extratropics.”

L215: Quantify these results in some way.

L243: Define what is meant by the “actual” change. I assume this is just the change in that variable, but the current wording is awkward and difficult to interpret.

L271: Change “high snow fall” to “seasonal snow cover”.

Figure 8: Fix cut-off MAM label, increase resolution of figure. The caption says this is the change in snow cover on the day of the extreme versus the mean annual snow cover, but in the methods, it says that the excess change is in reference to the change in the seasonal mean of a variable. Which is correct?

L300-301: Might be useful to state that the lack of snow cover changes in the coldest climates (e.g. Siberia) is due to the trade-off between increasing temperatures shortening the snow season and increased moisture holding capacity leading to greater snowfall. (e.g., Krasting et al. 2013 JCLIM, Mankin and Diffenbaugh 2015 Clim Dyn).

L311: Remove “which is calculated using shortwave radiation fluxes” as this is already stated elsewhere.

L3334: But it is the DJF cold extremes that are of the greatest importance, right? Why not include this as well to be consistent with the rest of the paper?

L334-345: This point is slightly counterintuitive so I recommend adding more information to help the reader. Plot the historical DOY when cold extremes occur to add context to Fig 10. It might also be worth promoting some of the discussion material on this matter to help support this conclusion. Also, I am surprised that this timing would

not be somewhat sensitive to internal variability.

L365-375: A new paper by Blackport et al. in highly relevant to this discussion (https://www.nature.com/articles/s41558-019-0551-4).

L408-409: Fix this comment on surface albedo feedback as recommended above.

L411-413: Reword this, removing “as simply the ratio between absorbed and reflected shortwave radiation”.

L418: Promote this material to the paragraph above.

L467: A number of studies have looked at changes in observed versus simulated snow cover (see Brutel-Vuilmet et al., 2013; Mudryk et al 2017).

References listed in this review:

Brutel-Vuilmet, C., M. Ménégoz, and G. Krinner, 2013: An analysis of present and future seasonal Northern Hemisphere land snow cover simulated by CMIP5 coupled climate models. Cryosph., 7, 67–80, doi:10.5194/tc-7-67-2013. http://www.the-cryosphere.net/7/67/2013/.

Krasting, J. P., A. J. Broccoli, K. W. Dixon, and J. R. Lanzante, 2013: Future changes in northern hemisphere snowfall. J. Clim., 26, 7813–7828, doi:10.1175/JCLI-D-12-00832.1.

Mankin, J. S., and N. S. Diffenbaugh, 2015: Influence of temperature and precipitation variability on near-term snow trends. Clim. Dyn., 45, 1099–1116, doi:10.1007/s00382-014-2357-4.

Mudryk, L. R., P. J. Kushner, C. Derksen, and C. Thackeray, 2017: Snow cover response to temperature in observational and climate model ensembles. Geophys. Res. Lett., 44, doi:10.1002/2016GL071789.

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