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Interactive comment on "An attempt to explain recent trends in European snowfall extremes" *by* Davide Faranda

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Dear Davide Faranda,

as you have seen we have now received two thorough reviews for your manuscript WCD-2019-15 "An attempt to explain recent trends in European snowfall extremes". Thank you for your initial replies to the reviewer comments and thoughts on how to address their major concerns in a revised version.

While I agree that your study and the documentation of snowfall trends is an important topic and in the scope of WCD, I concur with both reviewers, that the dynamical interpretation is not elaborate enough in the current version to explain the observed trend. Having also consulted the editors of the journal this is a major issue which must be

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Discussion paper

addressed prior to publication in WCD.

Therefore a more thorough investigation of the drivers for the observed trends is needed. The reviewers give valuable input in this direction. In particular, the example of how ambiguous trends in Japanese snowfall can be explained by the the JPCZ in Kawase et al. 2016 (Section 4) is an excellent example of a potential dynamical interpretation in their case. Evidence in that direction should be presented; although I see the difficulty in finding common drivers for the various focus regions you investigated compared to them.

We are afraid that your suggestion to investigate convective vs. large-scale snowfall from ERA-5 will not solve the problem. This separation highly depends on the grid spacing in the model and can therefore not be a proper indicator of a physical separation into thermodynamic and dynamic processes. Convective snowfall simply shows the fraction which is processed in the physical schemes vs. dynamical core (or resolved vs. unresolved scales) and therefore not necessarily attributable to actual convection.

It is striking that most of your positive trend locations are along Mediterranean coasts and it is likely that the large-scale circulation is involved. I would therefore suggest that you directly show the synoptic environment during these snowfall events. E.g. parameters indicating stability, flow direction towards the coast and local orography. This would yield a more dynamical interpretation, e.g. that starker sea surface - troposphere temperature contrasts might enhance moisture uptake combined with reduced stability aloft, change ascent, local stability, and local convergence during snowfall events. The body of literature looking at cold-air outbreaks, air-sea interaction, and baroclinicity might give additional guidance here (e.g. Czaja et al. 2019, Papritz and Spengler 2015, 2016). The role of blocking remains obscure although the abstract suggests you would look into this dynamical aspect in more detail (I see that this is ambiguous terminology with "block-maxima" referring to snow depth, but WCD readers might relate this to blocking anticyclones). Apart from this Eulerian investigation a Lagrangian investigation of air mass origin (location and changes of physical properties along trajectories) contrasting events in the early and late decades would also give dynamical insight. Another thought is that these trends might be driven by decadal variability, an aspect that could be discussed more comprehensively (the 2000s were more NAO- compared to the 1990s, e.g. Weisheimer et al. 2017).

Finally I outline a thought that has arisen from the discussion amongst the editors. The thermodynamic argument that a warmer Mediterranean Sea may lead to larger snowfall amounts at some places in Europe requires caution and might be flawed. The reason for this is that snowfall extremes (at least in the midlatitudes) tend to occur at or near the freezing point in both colder and warmer climates (see e.g. O'Gorman et al. 2014). Also the results in the present paper indicate that locally (at the location of the snowfall) the temperature difference between the cold and warm period is small (Fig. 7, although this is a bit hard to see). Now, it is this local temperature that determines the maximum atmospheric moisture content and thus the "thermodynamic“ component of the snowfall amount. If the Mediterranean Sea warms a lot, enhancing evaporation there, but the temperature at the location of the snowfall stays the same, then all the excess moisture precipitates out during the transport to this location, and there is no substantial "thermodynamic“ enhancement of the snowfall. So the question arises if there are more snowfall events rather than more intense events and/or if dynamics enhance the events rather than thermodynamics, again pointing towards variability of the large-scale circulation between the considered periods....

These are some thoughts, but I hope this gives direction on how more dynamical evidence can be given in order to address this critical point.

Kind regards

Christian M. Grams

Czaja, A., C. Frankignoul, S. Minobe, and B. Vannière, 2019: Simulating the Midlatitude Atmospheric Circulation: What Might We Gain From High-Resolution Modeling of Air-Sea Interactions? Curr Clim Change Rep, doi:10.1007/s40641-019-00148-5.

O'Gorman, P. A., 2014: Contrasting responses of mean and extreme snowfall to climate change. Nature, 512, 416–418, doi:10.1038/nature13625.

Papritz, L., and T. Spengler, 2016: A Lagrangian Climatology of Wintertime Cold Air Outbreaks in the Irminger and Nordic Seas and Their Role in Shaping Air–Sea Heat Fluxes. J. Climate, 30, 2717–2737, doi:10.1175/JCLI-D-16-0605.1.

Papritz, L., and T. Spengler, 2015: Analysis of the slope of isentropic surfaces and its tendencies over the North Atlantic. Q.J.R. Meteorol. Soc., 141, 3226–3238, doi:10.1002/qj.2605.

Weisheimer, A., N. Schaller, C. O'Reilly, D. A. MacLeod, and T. Palmer, 2017: Atmospheric seasonal forecasts of the twentieth century: multi-decadal variability in predictive skill of the winter North Atlantic Oscillation (NAO) and their potential value for extreme event attribution. Q.J.R. Meteorol. Soc., 143, 917–926, doi:10.1002/qj.2976.

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