

Interactive comment on “The Nonequilibrium Thermodynamics of Atmospheric Blocking” by Andrew Jensen

Anonymous Referee #1

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This manuscript discusses a diagnostic calculation of the entropy balance of two atmospheric blocking events. Some attempts are made to interpret the differences in the computed balance between the events. Unfortunately, in my opinion the paper does not meet several basic requirements of a scientific study: The method of calculation is unclear, the results are not presented in an adequate way, and the physical mechanisms linking blocking and entropy production are totally obscure, as detailed in the comments below. I therefore cannot recommend the publication of this manuscript in ACP.

Major comments:

- The methods used to calculate the entropy balance are not made sufficiently clear. Instead of repeating the derivation of the balance equation from Li et al., 2014 (section

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2 is nothing more than a shortened paraphrase of a similar passage from this study, also using the same notation), the author should provide more details on how each of the individual terms of equations 6-8 is computed from the MERRA reanalysis. For instance, how are frictional heating rates and convective fluxes derived? Are these really output variables of the reanalysis?

- It is really not enough to present only a few summarizing numbers from the calculation in the form of tables. Spatial fields of the different budget terms should be shown. Otherwise, it is impossible for the reader to get a basic idea of (and also build some trust in) the presented analysis.

- The potential physical relationship between entropy production and atmospheric blocking is totally unclear. If I got this right, the author obviously thinks that blocking is a somehow disordered structure that can be supported by the production of entropy (in contrast to cyclones, which are argued to be maintained by negative entropy fluxes). I don't think that this is the case. An atmospheric blocking is characterized by a large-scale, persistent and well-structured anti-cyclonic flow anomaly. As such, it has (at least) the same degree of 'orderliness' as a cyclonic flow anomaly. Also if the flow may have (in certain cases) a somewhat more dissipative character at the boundary of the blocking anomaly, it has to be shown how this dissipation could contribute to the maintenance of the blocking anticyclone.

- Following from the previous comment: Taking the author's result of increased entropy production (in particular at the surface) during the blocking events as a given, this does still not provide evidence of a causal effect of this entropy supply on the maintenance of the block. On the contrary, I would rather think it is the other way around: An anticyclonic flow anomaly over the northwestern US coast in winter is associated with increased occurrence of cold air outbreaks (transport of cold air from the continent over the ocean with an anomalous easterly flow), which in turn induce an increase in surface fluxes (due to the large temperature and humidity difference between the cold air and the surface). In the author's diagnostic, this should show up as increased

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surface entropy supply, which could explain the diagnosed anomaly. In summary, it is well possible that the blocking anomaly causes the increased entropy supply, and not the other way around.

- When speculating about a potential effect of surface entropy supply on the blocking, potential physical mechanisms linking the surface input to the upper-tropospheric flow anomaly should be analyzed and discussed. A vertically integrated budget alone does not provide enough information on this linkage.

- I think the analysis is superficial with regard to the spatial and temporal details. Probably the blocking index used by the author provides information on the exact onset and decay of as well as on the region affected by the blocking. Why is everything averaged over the whole months of January and February, and not the specific blocking periods (both with regard to the diagnostic and the fields shown in the figures)? Why is the entropy budget averaged over such a large region, and not only over the blocking area?

Less major comments:

- Comparing the diagnosed entropy anomalies with annual data does not make much sense given that some of the input fields (in particular the surface fluxes) have a very strong seasonal cycle.

- Page 6, first row: A Bowen ratio of 7.46 is very unrealistic for a mainly oceanic region (I don't know exactly what 'rough calculation' means, but in this case this may be too rough).

- Tables: Provide units. What does 'total' mean (aren't these temporal averages? Then summing them up does not make much sense)?

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