

Review of “Wintertime Extreme Warming Events in the High Arctic: Characteristics, Drivers, Trends, and the Role of Atmospheric Rivers” by W. Ma et al.

General comments:

The authors have put a lot of effort into the revisions and have addressed many of my previous concerns. The results are interesting and provide insight into the characteristics of extreme Arctic warm events, defined first per grid point and then as contiguous regions with $T2m > 0^{\circ}\text{C}$ (concurrent warm events). I particularly like the analyses of the concurrent warm events. My major concern is still the same as in the first version of the manuscript, namely the definition of Arctic warm events per grid point (see comment 1 below). Many of my remaining comments concern language and terminology and can be addressed with some rewording.

Specific comments:

- 1) You have explained in detail why you define Arctic warm events at each grid point separately, but I am still struggling with the fact that adjacent grid points with $T2m > 0^{\circ}\text{C}$ at the same time are referred to as many separate “events”. You motivate this with the studies by Moore (2016) and Graham et al. (2017), who used meteorological buoy observations to study the warm event in December 2015. However, even if they looked at different point observations, they did not refer to them as different Arctic warm events – they used the point observations to characterize one single event. I am ok with your method (although I am more convinced by your definition of concurrent warm events, which, however, is not the main focus of the paper), but the problem for me is the word “events” that does not always fit well in the text and can lead to confusion. Maybe you can carefully scan your manuscript and write more often something like “grid points with $T2m > 0^{\circ}\text{C}$ ” instead of “Arctic warm events”. For instance, you write about the onset of the event (or, in the revised version, the start of the event, which for me is actually the same as the onset) and its termination, but I find the suggestion of the second reviewer much more convincing to use something like “time when a grid point’s $T2m$ exceeds / falls below 0°C ”, as the warm temperatures are most likely simply being advected from one grid point to the next. And instead of short-duration and long-duration events, maybe you could use something like “grid points experiencing the warming for a short / long duration”. I understand that this also makes the text more cumbersome, and you can't replace all your mentions of “event” with a formulation like this, but wherever possible this would increase the accuracy of the text and help to minimize confusion for the reader.
- 2) I find your new Fig. S4 very interesting, but I am quite surprised by the large number of days per season with at least one grid point with $T2m > 0^{\circ}\text{C}$. According to this figure, these events are actually not that rare, with most winters having at least one such warm event and many winters even having one in more than 20 out of the 90 days. This is different to the findings of previous studies. For instance, according to Moore 2016, Arctic warm events occur once or twice each decade, and Binder et al. 2017 found 12 out of 36 winters with Arctic warm events. Of course, these studies are based on different methods, different datasets, different study regions, etc., but I am still surprised by the quite different findings. Maybe you could briefly discuss your results and explain why you have a much higher number of events than found in previous studies.
Also, your sentence in line 16 in the abstract (“They occur rarely, with a total absence during some winters over most of the region.”) and the text in Section 3.1 might be revised a bit. And in my opinion, it would be more informative if you could write in how many of the 42 winters there has been at least one Arctic warm event somewhere in the studied region (your new Fig. S4).
- 3) Section 2.1: Even though you rewrote large parts of the section, it remains quite difficult to read and to quickly get the relevant information, as you mix in information that rather belongs to the introduction or even the conclusion, and you write a lot about how others defined the events and how the events could be defined, before actually writing how you define them in a different way. My suggestion would be to write a first subsection with the title “Data”, where you describe the

ERA5 data, then a second subsection “Definition of extreme Arctic warming events”, both in a more streamlined form, and a final subsection “Calculation of anomaly fields”. For instance, when describing ERA5 I would leave away the first sentence “Results based on previous case studies suggest that extreme warming events with near surface air temperature above 0 °C tend to be short-lived, ...”, as you already mentioned this in the introduction and here it rather disturbs the flow. And also the last sentence of the paragraph “The results being presented here thus bear significance to our understanding of ...” does not really fit into the data and method section but is rather part of the motivation or even the conclusion of the study. And in the subsection where you define the events, I would start with writing something like “In this study, we define Arctic warm events in two ways: first, as grid points with $T2M > 0^{\circ}\text{C}$, which is the main focus of the study, and second, as contiguous regions with $T2m > 0^{\circ}\text{C}$...” (and please also add more details about how you define the contiguous events). Afterwards, it is nice if you write about the motivation of defining the events in these ways, and their advantages and disadvantages.

- 4) I am not always convinced by the words “drivers”, “direct drivers” and “directly driving”, which are all used very often in the paper (e.g., abstract line 23, Section 3.2 and Section 3.4). In general, there is not just one driver, but it is the interplay between various processes and weather systems that contributes to an Arctic warm event. For instance, in line 23 in the abstract, you write that “ARs are the direct driver for 100% of these event”, but I would rather use “associated with” or “related to” (and similarly in many other parts of the text). You already changed the words in some parts of the paper in the revised version, but they still appear in many places where I don’t think that they are suitable.
- 5) “Subsequent examination reveals the short-lived nature of this event, with the duration of staying above 0°C for less than an hour locally ...”
This sentence is not so nice – I would write something like “with buoys close to the North Pole recording temperatures above 0°C for less than an hour ...”