

RESPONSE TO SECOND REVIEW

wcd-2022-32 Reconciling conflicting evidence for the cause of the observed early 21st century Eurasian cooling (Outten et al.)

We'd like to thank Reviewer 3 for their time and comments once again. Below are their comments in black with our responses in blue.

Response to Reviewer 3 - Second Review

The authors have made improvements to many aspects of the manuscript. Overall, the review and the interpretation of the literature in sections 1-4 is excellent and will be very important given the conflicting conclusions across individual studies. However, I still think the authors may be over-interpreting the results discussed in section 5.

The authors are assuming that the changes in standard deviation seen over 15 year periods in the observed time series (and the odds of a cooling trend) are real, inherent changes (whether forced by sea ice or something else). They never explicitly state this, but it is heavily implied by the analysis and with statements like "with some periods being more susceptible to strong cooling than others" (L12-13 in abstract). However, the standard deviation will vary over short periods across the time series simply by chance without any changes in the real, inherent variability. For example, if you created synthetic data with an AR1 model with a fixed standard deviation, there will be (by chance) 15 year periods with a higher and lower standard deviations because of the small sample size. This, of course, does not mean that the trends were inherently more or less likely during these periods. Similarly, you can't claim that any differences in the observed standard deviations over 15 year periods (and corresponding chances of cooling trend) reflect real changes in the inherent variability, without additional evidence.

Related to the above issues, I may not have been clear in my original comment about the possibility of the trend causing a larger standard deviation. I was not referring to the AR1 model where the standard deviation is fixed. I was referring to the observed time series where the causality can go in both directions. Even if there is no change in the inherent variability, a trend (whether caused by random chance or as part of a forced response) will cause a larger standard deviation.

The authors need to support their claims that the changes in variability are real with additional evidence, or they need to tone down these statements and add caveats/discussion about these issues.

Thanks to the reviewer for these additional comments, and we accept the points raised by the reviewer. From the beginning, the analysis in section 5 was only ever meant to demonstrate some concepts that could be useful in thinking about Eurasian cooling and should not to be viewed as evidence of some mechanism. We felt we had communicated this better in the last revision, but upon re-reading the section, we see how the reviewer could be concerned about possible misunderstandings. In light of this, we have made additional edits throughout the section and to the abstract, and hope that they clarify our intent.

As the reviewer suspects, there is substantial uncertainty in the standard deviations estimated from 15-year periods. The difference between the “extreme” values from the reanalysis data is significant just below the 90% confidence level (the 90% confidence interval for the minimum value of 1.171 K is [0.9, 1.7] K and for the maximum value of 2.145 K is [1.65, 3.13] K, so they overlap slightly). The same conclusion can be drawn from the AR1 model, though the bounds are slightly different. We need to be cautious about deriving statistical properties from 15-year periods, echoing the point regarding temperature trends made early on in the manuscript. These points are now included more explicitly in section 5.