

## ***Interactive comment on “Quantifying the variability of the annular modes: Reanalysis uncertainty vs. sampling uncertainty” by Edwin P. Gerber and Patrick Martineau***

**Edwin P. Gerber and Patrick Martineau**

gerber@cims.nyu.edu

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Thank you for these detailed comments our manuscript. We will respond to them below, and in the revision of our manuscript.

*1. Page 3, line 30. There have been many different definitions of the annular mode in addition to the polar cap averaged geopotential height used in this study. Baldwin and Thompson (2009) compared different annular mode definitions. In analogy with Baldwin and Thompson (2009), it would be beneficial to briefly discuss the strengths and weaknesses of the particular annular mode used in this study.*

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A practical issue for this study was handling the volume of all the reanalysis data: this simple definition in part made it possible to compare all the reanalyses with an efficient and reproducible framework. Given that there are a number of definitions of the annular mode that are effectively equivalent, we also wanted to emphasize the simplest one for future researchers.

*2. Figure 3. How is the consistency determined? This does not appear to be clearly defined in either the text or the figure caption. Does the consistency correspond to the average of the six pairwise correlations between the four Reanalysis datasets?*

Yes, by consistency, we meant to refer to the average pair-wise correlations between the four most modern reanalyses. We will clarify the figure caption in the revision.

*3. Page 6, line 19. What is meant by conventional observations? In the abstract, the term conventional appears to correspond to surface observations which doesn't appear to be consistent with the rest of the paragraph. Since on page 3, line 22, where it is indicated that JRA-55C data lacks satellite measurements, it appears that conventional in this paragraph corresponds to the exclusion of satellite measurements.*

Yes, conventional observations refers everything but satellite based measurements. In the revision, we will make this distinction more clear, especially in the abstract and section 2. In particular, we'll use more clear language, distinguishing full-input, conventional-input, and surface-input reanalyses.

*4. Page 7, line 6. It is stated that the NAM is consistently represented prior to the satellite era. However, this appears to be the case only for the troposphere. For the stratosphere, the ERA-20C, as indicated in the text, and the two versions of 20CR are much poorer?*

It was our intent to indicate that the NAM is consistent in the full-input reanalyses; for the surface-input reanalyses, there is only consistency in the troposphere. This will be clarified in the revision.

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5. Page 8, line 8. *The relatively high R2 value between the 20CR and ERA-20C is mentioned for the early half of the 20th century. This is taken to indicate that the NAM may be reasonably accurate during this time period. It is not indicated in this paragraph that this result applies only for 1000 hPa.*

Yes, this refers only the surface level, and it will be clarified in the revision.

6. Page 9, line 11. *It is stated that the strong vortex build up is less abrupt than its decay. I don't see this in Fig. 8.*

We are afraid that the non-linear color bar (and potentially visual differences between the cool and warm colors) in Fig. 8 gave this incorrect impression. For weak vortex events, the index drops by over 3 standard deviations in 10-15 days, the bulk of the drop in the last 5 days. For strong vortex events, the increase in the index is only 1.5 standard deviations over approximately 40 days. We will clarify this in the revision.

7. Page 9, lines 25-31. *I did not follow how the sampling uncertainty is determined. Was the standard deviation determined for all four modern Reanalysis datasets over the lag days? A little more detail would be helpful.*

The sampling uncertainty was determined from JRA-55 alone, and quantified by the standard deviation of the composite mean in Figure 8 a,b: it is the inter-event standard deviation (shown in Fig. 8c,d) divided by the square root of the number of events. The inter-event uncertainty for the other reanalyses is comparable to JRA-55 over the satellite era (as evidenced by the reanalysis uncertainty). As there are fewer events over the satellite period, however, there is greater uncertainty in the composite mean. This will be clarified in the revised text.

8. Page 11, line 12. *To remove the interannual variability, one could simply apply a high pass filter to the data with a cutoff period shorter than one year and longer than the longest e-folding time scale in the raw data.*

The use of decadal means was chosen primarily to enable us to quantify the sampling

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uncertainty. (That is, we assume that each decade was independent, and use the differences between decades as a crude measure of the sampling uncertainty.) This will be clarified in the revision.

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