

Comments on Nilssen et al. “**Evaluating the Twentieth Century Reanalysis Version 3 with synoptic typing and East Antarctic ice core accumulation**” submitted to *Climate of the Past*

Owing to limited weather records before the satellite era, understanding long-term variability and inter-decadal pattern in synoptic systems over East Antarctica is challenging. This study evaluated the ability of the Twentieth Century Reanalysis project to reproduce the synoptic conditions associated with increased precipitation at Law Dome since 1948, using daily 500 hPa geopotential height anomalies and the annual snowfall accumulation record from the ice core. The results indicate that this Reanalysis can reliably represent the meridional weather conditions of increased precipitation at Law Dome before the satellite era, and thus extends the time span of available materials for analyzing weather conditions for this region.

I appreciate the objective of this paper, and I am interested in the results and conclusions. However, there are still several issues to be clarified in this study. I recommend that this manuscript needs a major revision before published.

Major points:

1. Since the authors used Twentieth Century Reanalysis Version 3 to perform this study, I have a major concern on the reliability of the data. Especially, the data series for this atmospheric reanalysis may have suffered a “jump” at the ice sheet scale at the beginning of the satellite era. The authors should add some works to prove that it is reliable at least on regional scales (or at Law Dome). This is very important for the analyze, as the major results and conclusions are relied on the 20CRv3 data.

2. I suggest that the second part of the manuscript should be changed to “Data and Methods”, and that its content needs to undergo a substantial reorganization to make it more coherent. For instance, the headings of 2.1 and 2.3 stand for “Data” rather than “Methods”, and 2.4 includes too much information that is not relevant to the heading, such as the division of the period, and the title of 2.3 does not emphasize the classification of precipitation events. The authors should try to separate the description of the data and methods, and introduce each section specifically, such as “snowfall accumulation record from the Law Dome DSS; Twentieth Century Reanalysis version 3...”.

3. The authors claim that the ice core record shows high accumulation rates and seasonality at Law Dome (L76-78), so I am concerned about the possibility of extracting seasonal climate signals (synoptic systems and accumulation) from the ice core record. This would not only enable assessing the reliability of the 20CR on a timescale with higher frequency, but also contribute to understanding the seasonal variability of synoptic patterns affecting the Law Dome.

4. Surface ablation rarely occurs over most of the Antarctic ice sheet, so snowfall accumulation is contributed mainly by precipitation. However, Law Dome is located in the Antarctic coastal region. Studies have been done to show that these areas near the coast are threatened by rainfall from extreme events such as atmospheric rivers. I would therefore suggest that you should distinguish the precipitation pattern (rainfall or snowfall, they have almost opposite effects on accumulation) in this study, rather than comparing precipitation directly to the accumulation from ice core record. Or, another approach is to confirm that rainfall-derived melting or snow blowing is not sufficient to have a significant effect on the inter-annual variability of snow accumulation at Law Dome.

5. Section 3.6 “Linear model estimates of ice core annual accumulation

from synoptic typing”: The description in this section is too short and the authors should have described it in more detail.

6. Although this paper investigated synoptic types on a regional scale, the study relied on ice core records from the Law Dome, so it is inappropriate to show “East Antarctic ice core accumulation” in the title, and I suggest changing it to the “Law Dome”. East Antarctica covers a much larger spatial area not studied by this paper, and a single ice core record may not be strongly spatially representative. The authors also mention in the description of L277-279 that the accumulation record will not appear in the Law Dome DSS when the location of the blocking is slightly offset. Therefore, much of this study is not actually representative of East Antarctica.

7. There are some technical corrections in the manuscript, such as the lack of a uniform format for the minus sign “-”. In section 3.1, authors sometimes label  $p < \dots$ , sometimes labeled  $p = \dots$ . The authors need to re-check and re-edit them.

Minor points:

1. Please check the units of potential height in the Figures.
2. L35: please add the references, such as Zhang et al., 2018; Wang et al., 2020 (which has been presented in the references
3. L112: “The 90th and 99th percentile of 20CRv3 daily precipitation at Law Dome was calculated”. How was the base period for defining extreme events chosen? Extreme precipitation calculated based on percentile thresholds will be very dependent on the selection of base period.
4. Figure 2 and Section 3.1: Please plot the linear trend of the two data series in Figure 2, respectively.
5. L177-179: What are the quantitative standards for dividing the weather types? Type 2 also seems to dominate by meridional, despite the blocking

high not landing on the ice sheet.

6. The discussion of the relationship between annual frequency of synoptic types and DSS accumulation is relevant and needs to be reflected in the Conclusions and Abstract.

#### References:

Zhang Y, Wang Y, Huai B, Ding M, Sun W. Skill of the two 20th century reanalyses in representing Antarctic near-surface air temperature. *Int J Climatol*. 2018; 38:4225–4238. <https://doi.org/10.1002/joc.5563>