

Extending and understanding the South West Western Australian rainfall record using a snowfall reconstruction from Law Dome, East Antarctica

by Yaowen Zheng, Lenneke M. Jong, Steven J. Phipps, Jason L. Roberts, Andrew D. Moy, Mark A. J. Curran, and Tas D. van Ommen,

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We thank the Editor and the Reviewers for the time they have spent reading and reviewing it. They have improved this manuscript. We respond to each of the suggestions for revision below. The Editor/ Reviewers' suggestions are shown in **bold text**, replies are shown in normal text, text from the original manuscript is shown in **blue** and proposed changes to the manuscript are shown in **purple**.

Editor's comment:

10 **Dear authors**

Thank you for the revisions you have made to your paper. As you will see on most issues the two reviewers are happy with the new version and believe it should be published. However I concur with rev 1's concern about the stationarity of the relationship between LD accumulation and precipitation in SWWA (as shown in Fig S6). In the supplement you dismiss this as hardly relevant, but it is precisely the relationship you assume in extending your reconstruction, and it

15 **deserves a fair comment in both the main text and the supplement.**

Specifically rev 1 and I both understand that the instrumental data you have showed a good relationship over the last century between LD accumulation and precipitation in SWWA. In extending the reconstruction you assume that this remains the case, and maybe it does. However your climate model output in Fig S6 quote clearly shows that, at least in the model, the relationship can disappear or even show an opposite sign for century long periods. I appreciate that this

20 **doesn't affect your broader discussion about influences on SWWA rainfall, and that it could be an artefact in the model. But Fig S6 cannot just be dismissed: I am quite sure if the result had been the opposite that you would have made a big deal out of it.**

I am therefore minded to accept the next version of your paper subject to:

a) you deal with the minor points raised by both reviewers and

25 **b) you add a statement of caution in the main text that the model does not show a stationary relationship (Fig S6)**
between LD accumulation and precipitation in SWWA, and that if this is really true it undermines the case for using
LD accumulation alone as a proxy for SWWA rainfall. This should be borne in mind when assessing the
reconstruction shown.
I would find it hard to accept a version that does not include such a statement in the main text, although of course you
30 **are welcome to argue against it if you feel you have a case.**

We thank the editor for these comments. We have respond to each of the minor points point-by-point below and attached a revised version of the manuscript. We agree that the statement of caution should be indicated in the manuscript.

To address this, we have added corresponding sentences in the manuscript Lines 255–257: "[Dome \(Supplement Section 5\)](#).
35 Furthermore, the CSIRO Mk3L simulations exhibit variability in the correlation between Law Dome accumulation and SWWA
precipitation on decadal to centennial timescales (Supplement Figure S6). Some caution is therefore needed in interpreting the
reconstruction. We choose 1850 CE to be the year that separates before and after the", and in the supplementary material Lines
63–67: "We calculate the mean of each region's nine cells for each member of ensemble and each ensemble mean and perform
6-year smoothing for each series (for consistency), and then calculate the 100-year running correlation (Figure S6). The model
simulations exhibit a lack of stationarity on decadal to centennial timescales, which should be considered when interpreting the
40 reconstruction. The lack of a strong or consistent correlation between the simulated Law Dome and SWWA precipitation is not
surprising, given the mechanism outlined in van Ommen and Morgan (2010). [Correlation is essentially connected with](#)"

Reviewer 1's comments:

1 I would like to thank the reviewers for their detailed answers and additional information that allow a better interpretation of their results. If I consider than the answers to my first two points are satisfactory, I still have
45 concerns about the point 3.

The authors show that the link between Law Dome accumulation and SWWA precipitation is stable and stationary over the past century (in particular in in the answer to my second point and lines 89-105 of the answer to point3). However, this is not the case for the climate model results over the past millennium. In the supplementary material lines 61-62, it is stated from climate model results that 'These show that the large scale circulation both matches the
50 pattern identified in van Ommen and Morgan (2010) and is stable through time'. We may agree (or not) that the large-scale simulated spatial pattern is stable in the examples shown Figure S5. It is clear that it is a prerequisite to use Law Dome accumulation as a robust proxy for SWWA precipitation (line 63 of the supplementary material). However, this is clearly not enough. The reconstruction is based on the link between Law Dome accumulation and precipitation in SWWA (line 197 of the main manuscript for instance), not between Law Dome accumulation and any large-scale
55 pattern. The correlation between the two variables (Law Dome and SWA precipitation) in the simulations varies between roughly -0.5 and +0.5 depending of the 100-yr period selected, showing a very strong non-stationarity in the link (Figure S6). The authors argue that it is not surprising but I wonder then how to justify using climate model results that Law Dome record can be used to reconstruct precipitation in SWWA for the whole period while there is no guarantee that the link will be the same in two different centuries. For instance, if the linear statistical model were
60 built from the climate model results using different 100-yr period instead of observations, we would obtain very different reconstructions.

I may admit that demonstrating the robustness of the link using modern data for the 20th century can be a justification for the statistical model but, as I understand it, the climate model results do not confirm at all the stationarity of this link for the whole millennium. The climate model may be wrong but at least it must be stated and
65 explained clearly. I thus strongly recommend adding a few lines stating that at the end of section 5 of the supplementary material. This conclusion on the instationarity if we consider climate model results, should also come as a caution on the robustness of the reconstruction in the main text as it is important for all the readers that may not check the supplementary information.

We thank the reviewer for this comment. We have added the statement of caution in both main text and the supplementary
70 material. Please refer to our responses to the Editor's comment above.

2 **Line 75. Something seems missing before ‘More recently, this work has been extended’ as the previous lines discuss the teleconnection pattern while the sentence is devoted to the ice coring.**

We thank the reviewer for this comment. "This work" refers to the work has been done by van Ommen and Morgan (2010), which proposed a 750-year (1250–2000) DSS snow accumulation reconstruction. Roberts et al. (2015) extended this work and
75 proposed a 2035-year (22BCE–2012CE) DSS snow accumulation record. To be more clear, we change the corresponding sentence in Lines 76–77: "rain from north/north-westerly directions (van Ommen and Morgan, 2010). More recently, van Ommen and Morgan (2010)'s work has been extended using a longer 2035-year accumulation record from the Law Dome core (Roberts et al., 2015). As"

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Reviewer 2's comments:

3 **Line 52: Thank you for adding the discussion of other drivers of SWWA rainfall here—however the lead into this paragraph could be improved to be clearer on this point. Best to start with something along the lines:**

85 **“Variability in the SAM is not the sole driver of SWWA rainfall anomalies; for example local Indian Ocean sea surface temperatures can also play a role. In particular, negative sea surface temperature anomalies.....”**

Thank you for this comment. We have changed it accordingly.

Lines 50–51: "Variability in the SAM is not the sole driver of SWWA rainfall anomalies; for example local Indian Ocean sea surface temperatures can also play a role. In particular, negative sea surface temperature anomalies in the eastern Indian Ocean and positive"

90 4 **Table 3 and lines 202–209: Thank you for adding the explained variance % metrics in both the table and the text here. I agree that 30-40% is a sizeable contribution for reconstructing SWWA rainfall variability. The wording here could be tightened up a little though:**

95 **“The square of the correlation coefficients have shown the explained variance is maximum at around 30–40%. This is a significant fraction of the variance, although the tropics and subtropics can also play an important role in driving rainfall changes in SWWA (Smith et al., 2000; England et al., 2006; Ummenhofer et al., 2008). Thus using the Law Dome ice core snow accumulation proxy to reconstruct the SWWA rainfall focuses in on the SAM-related component of the rain-bearing systems, not the tropical / subtropical components. However, explaining 30–40% of SWWA rainfall variations is a valuable contribution to our ability to reconstruct past climate, so we construct a linear model for SWWA rainfall and DSS snow accumulation”.**

100 Thank you for this comment. We have changed it accordingly.

Lines 186–191:"at the 5% probability level (Supplement Figure S4). The squares of the correlation coefficients show that the explained variance is around 30-40%. We note that the tropics and subtropics can also play an important role in driving rainfall changes in SWWA (Smith et al., 2000; England et al., 2006; Ummenhofer et al., 2008). Using Law Dome accumulation to reconstruct SWWA rainfall therefore focuses on the SAM-related component of the rain-bearing systems, not the tropical or subtropical components. However, our analysis shows that it makes a valuable contribution to our ability to reconstruct past climate and so we construct a linear model for SWWA rainfall and DSS snow accumulation."

5 **Line 322 and Figure S7. Thank you for following up on my suggestion to explore the latest BoM rainfall data during 2016 – 2020. Best to tighten the wording to read:**
"This drought **continued during 2015-2020** (Figure E7)".
110 **because as time goes on, the drought may eventually be broken, and then the statement would become invalid.**

Thank you for this comment. We agree. We have changed it accordingly.

Lines 306–307:"reduction in the mean rainfall at around 1971 CE resulted in a prolonged drought in SWWA. This drought continued during 2015–2020 (Supplement Figure S7). To highlight dry epochs of an equivalent duration to the observed drought to date, we

115 **6 Nice final sentence added to the paper, thank you for sorting that. This paper will make a valuable contribution to the literature.**

Thank you very much. Your comments have improved this manuscript.

References

- 120 Roberts, J., Plummer, C., Vance, T., van Ommen, T., Moy, A., Poynter, S., Treverrow, A., Curran, M., and George, S.: A 2000-year annual record of snow accumulation rates for Law Dome, East Antarctica, *Climate of the Past*, 11, 697–707, 2015.
- van Ommen, T. D. and Morgan, V.: Snowfall increase in coastal East Antarctica linked with southwest Western Australian drought, *Nature Geoscience*, 3, 267–272, 2010.