Author's response to Anonymous Referee #1

We would like to thank this reviewer for their constructive comments and we have replied to each comment individually below. The reviewer comments are in black and our responses in blue.

This paper was extremely interesting to read and presents a new record from eastern South Africa spanning from the LGM to the present. I have a few minor comments:

Line 40 - 52: Instead of starting by discussing the uncertainties about regional climate, first motivate the study with why we should care about the region. What challenges to water availability might future climate change pose, and how can paleoclimate help us address those uncertainties?

- We will add an additional paragraph explaining why the region is important to the beginning of the introduction.

Line 61-65: There needs to be a citation for the evidence the claim that the Indian Ocean Walker circulation weakened in response to glacial forcings - see DiNezio and Tierney, 2014; DiNezio et al., 2018. In any case, your site may be too far south to be directly influenced by Walker circulation changes in the Indian Ocean.

- We will add the reference DiNezio et al. (2018) to this sentence.
- According to the conceptual models developed by Tyson (1986) and then by Cockcroft et al. (1987), a weakened Walker Circulation, having its ascending limb further east, reduces tropical-temperate interactions and results in a northward shift of westerly storm tracks and then dry conditions within the SRZ. Thus, we think that changes in the Walker circulation could influence the climate of the region.

I find the interpretation of the leaf wax data convincing - the d13C shifts are quite small and are unlikely to majorly influence the dD signature as a result of major shifts in apparent fractionation. The changes in dD are consistent with an amount effect and/or changes in evapotranspiration. It is interesting, however, that at least in Figure 4 it looks like the most modern dD value seems to look similar to LGM values. Can the authors comment on this?

- Yes, it is interesting that modern day δD_{wax} values are similar to those within the glacial period. Reduced precipitation over the last *c.* 2 ka is also evident in the precipitation stack (Chevalier and Chase, 2015), although values do not quite reach glacial values. Nevertheless, the aridity stack (Chevalier and Chase, 2016) indicates extremely arid conditions during the last few thousand years. Although this period is not specifically commented on within this paper, they stress the importance of temperature in controlling aridity. We speculate that the conditions between LGM and modern were not similar in terms of precipitation amount, but that temperature may have played a role in controlling the aridity, resulting in similar δD_{wax} values. Mean annual temperatures for the last *c.* 2 kyr cal BP were *c.* 2 degs C higher compared with those reconstructed for the LGM (see Chevalier and Chase, 2015). Thus, higher mean annual temperatures over the last *c.* 2 kyr cal BP would have increased ET, resulting in less 'effective precipitation' and drier conditions, despite possibly increased rainfall amount. Whereas during the LGM, lower temperatures would have reduced ET leading to apparently more humid conditions, despite actually reduced rainfall amount. This will now be discussed within the manuscript.

Figure 1 would be improved if it showed instead regional currents and winds for winter vs. summer and seasonal rainfall totals in two panels.

- We will change figure 1 as requested, it will improve and further aid the discussion and interpretation section. It will now show the different climatological features in summer and winter across the region as well as the rainfall zones.

I would like a more detailed discussion of all the regional time series included in Figure 4 in the discussion, especially on the stacks of regional aridity and precipitation.

- We will add more detailed discussion regarding the regional stacks and also regarding the pollen data (as requested from reviewer #2) into the discussion section (6.2).

Line 425 - 436: It actually appears to me that there is a reasonably good correspondence between SST and the dD record at your site during the deglaciation and in the early Holocene - there is just a lack of correspondence after 5 ka and during the LGM itself. It is therefore possible that SSTs played a key role in the response during the deglaciation itself.

- We agree and will better discuss SSTs as a driver of change within section 6.3. In addition, as requested by reviewer #2 we will use the SST record of Sonzogni et al. (1998), which actually shows a better correspondence with our data. Now we can see that lower SSTs during the last *c*. 5 ka may have actually played a role in driving aridity at Mfabeni.

Something that might be useful to consider as well - how might the westerlies, as a result of the wind-evaporation-SST feedback and/or changes in Ekman transport influence SSTs and local ocean dynamics? It is possible that there is a link between the two.

- Firstly, as a request of reviewer #2, we will remove mostly all reference to the westerlies providing more wind and resulting in increased ET. As the other reviewer pointed out, this hypothesis was problematic and we do not have a good independent proxy for wind strength in this region.
- We do not think that this discussion is within the scope of this paper. Nevertheless, high SSTs within the South Atlantic Ocean have previously been related to a poleward shift of the westerlies (see Walker, 1989) and moist conditions over the continent (Tyson, 1986).

As a broader point, calling the northeasterly flow into the region the ITCZ is probably overstated -the term means something very specific - a zonal band of rainfall most accurately applied to ocean regions (i.e. the marine ITCZ). It would be more accurate to characterize it as northeasterly flow that brings tropical moisture.

- We agree and will change all mention of the ITCZ to 'tropical rainbelt' (or tropical easterlies) (e.g. Nicholson, 2008).

References cited in this rebuttal:

Chevalier, M., Chase, B.M.: Southeast African records reveal a coherent shift from high- to low-latitude forcing mechanisms along the east African margin across last glacial–interglacial transition, Quaternary Sci.Rev., 125, 117-130, 2015.

Chevalier, M., Chase, B.M.: Determining the drivers of long-term aridity variability: a southern African case study. J. Quaternary Sci., 31, 143-151, 2016.

Cockcroft, M.J., Wilkinson, M.J., Tyson, P.D.: The application of a present-day climatic model to the late quaternary in southern Africa. Clim. Change, 10, 161-181, 1987.

DiNezio, P. N., Tierney, J. E., Otto-Bliesner, B. L., Timmermann, A., Bhattacharya, T., Rosenbloom, N., and Brady, E.: Glacial changes in tropical climate amplified by the Indian Ocean, Science advances, 4, 2018.

Nicholson, S. E.: The intensity, location and structure of the tropical rainbelt over west Africa as factors in interannual variability, International Journal of Climatology, 28, 1775-1785, 2008.

Sonzogni, C., Bard, E., and Rostek, F.: Tropical sea-surface temperatures during the Last Glacial Period: A view based on alkenones in Indian Ocean sediments, Quaternary Science Reviews, 17, 1185-1201, 1998.

Tyson, P. D.: Climatic Change and Variability in Southern Africa, Oxford University Press, Cape Town, 1986.

Walker, N. D.: Sea surface temperature-rainfall relationships and associated ocean-atmosphere coupling mechanisms in the southern African region., PhD, University of Cape Town, 1989.