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Interactive comment on "Circum-Indian ocean hydroclimate at the mid to late Holocene transition: The Double Drought hypothesis and consequences for the Harappan" *by* Nick Scroxton et al.

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This comment is correct, we made a mistake in summarising the differences between our new synthesis and the results of Giesche et al, (2019) and have ended up mis-representing their paper. Giesche et al., 2019 does indeed propose a reduction in the winter monsoon around 4.2 kyr BP. They also propose a similar 'double drought' idea, suggesting that this winter drought occurred alongside a summer decrease in rainfall, although there are considerable differences in what climate signals are determined droughts. We are happy to correct our work and take the opportunity to discuss in

more detail and more nuance, where our interpretations agree, and where they do not.

We feel that largely the two studies agree, as might be expected as Giesche et al (2019) provide two of the records used in our composite. A secular trend of decreasing summer rainfall, an increase in winter rainfall at 4.6-4.5 kyr BP, a winter rainfall drought around the 4.2 kyr event, an increase in rainfall between 3.5 and 3.0 kyr BP are all consistent. Where the two studies disagree are in the timing of the summer rainfall drought. Giesche et al's double drought is a combination of winter rainfall drought on top of a secular trend of decreasing summer rainfall, perhaps with an slight acceleration and peak at around 4.2 kyr BP – ie. two simultaneous droughts. While we do not doubt the secular trend in decreasing summer rainfall, our analysis suggests that an acceleration in the summer rainfall decline began later at 3.97 kyr BP, peaking at 3.6 kyr BP. Our double drought is therefore sequential rather than simultaneous: winter then summer droughts, both superimposed on the long term drying trend.

We propose making the following changes to the manuscript: 1) Citing Giesche et al 2019 on the winter monsoon paragraph of section 4.3 (Line 271) 2) Citing Giesche et al 2019 on the winter rainfall drought leading to harsher stress on more northerly Harappan sites (Line 299) 3) Replacing the two paragraphs that end the section 4.4 discussion (lines 352-362) with the following:

"The Double Drought hypothesis builds on recent high resolution paleoclimate work in the region. Both Giosan et al. (2018) and Giesche et al. (2019) proposed an increase in winter rainfall at 4.5 kyr BP and suggested that the increase plays a role in the flourishing of the Mature Urban phase of the Harappan civilisation which starts coincidentally. While we don't interpret either PC1 or PC2 as direct measures of winter rainfall, both show an increase (wetting signal) between 4.6 and 4.5kyr BP, corroborating their findings. The traditional view of Indian subcontinental rainfall at the mid-late Holocene transition is that the 4.2 kyr event represents a decline in summer monsoonal rainfall. However, Giesche et al. (2019) indicated an additional winter rainfall drought starting around 4.3 kyr BP and peaking at 4.1 kyr BP. Giesche et al. (2019) also inferred that a winter drought would have impacted the more northerly Indus valley civilisation centres more heavily than those in Gujarat. Giosan et al., (2019), however, proposed that the period of increased winter rainfall lasted to 3.0 kyr BP. PC1 in our analysis is interpreted as a summer monsoon proxy and so does not directly measure or infer winter rainfall. However, the absence of a signal in the likely summer rainfall dominated PC1 agrees with the idea of a winter rainfall drought dominating the region at this time. Similarly, the PCA does not allow for firm conclusions about whether winter rainfall returns at 3.9 kyr BP. The most likely mechanism for winter drought, a change in westerly disturbances from the Mediterranean forced by the 4.2 kyr event came to an abrupt end at 3.9 kyr BP, and therefore a return of abundant winter rainfall is likely, presumably continuing to 3.0 kyr BP (Giosan et al., 2019).

Giesche et al, (2019) also proposed a decrease in summer rainfall at the time, as part of a long-term trend since at least 4.8 kyr BP, peaking at 4.2kyr BP, with a return to pre-excursion values by 3.0 kyr BP. There is little doubt that there was a gradual decrease in monsoonal rainfall, likely resulting from decreasing northern hemisphere insolation over the course of the Holocene. Our PC1, and several individual records also agree with at least a partial recovery by 3.0 kyr BP. Our synthesis disagrees with Giesche et al., (2019) on the timing of the summer rainfall drying on top of the secular trend. Giesche et al (2019) suggest shortly after 4.2kyr BP, i.e. a simultaneous double drought. Whereas the regional PCA suggests drying beginning at 3.97 and peaking at 3.6kyr BP, i.e. a sequential double drought. As discussed in Giesche et al., (2019) and Section 4.2 above, numerous hydroclimate paleoclimate records from the region support one or more of the three droughts (secular trend, 4.2-3.9kyr BP anomaly and 3.9kyr BP step change). To reconcile the exact timing of these rainfall fluctuations and their seasonality, further study is required with paleohydroclimate proxies with less ambiguous seasonality than speleothems and foraminifera.

Nether the less, our Double Drought Hypothesis is consistent with broader climatic changes in ‘upstream’ areas of Indus valley rainfall; changes in winter mid-latitude

westerlies are interpreted as influencing winter rainfall, while changes in tropical Indian Ocean hydroclimate are interpreted as influencing summer monsoonal rainfall."

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