

## ***Interactive comment on “Global aridity synthesis for the last 60 000 years” by Florian Fuhrmann et al.***

**Anonymous Referee #3**

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Fuhrmann et al. collected published proxy data to assess changes in regional aridity for various regions. To make the data comparable and reduce the complexity, the authors developed an aridity index that is compared with modelled precipitation anomalies between MIS3 and the LGM and MIS3 and the preindustrial. Generally, the compilation and homogenization of aridity records and their comparison with the results of model experiments is an interesting approach. However, as outlined below, I feel that (i) the methods are not sufficiently described to allow a proper assessment of the approach and significance of the results, (ii) that the authors use unreasonable generalizations for the definitions of time slices and regions, and (iii) that there is no significant new information added by the paper. I recommend to reconsider the paper only after a fundamental revision.

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1) Parts of the paper are written in a very confusing style. For example, on p3/114 the authors describe that they “...use the original stratigraphy of all records”. On p3/116 they say “Speleothems are used for synchronisation between different archives of one region” which implies changes of the original stratigraphies.

2) Aridity index. The calculation of the aridity index is not sufficiently described, but as I understand from Table 1, the authors assign an integer value between 0 and 2 (or 0 and 1 for speleothem growth) to the different proxy records and then add the values(?). What do the authors mean with “...the original values have been recalculated into percentages, proportional to the maximum value of each specific dataset...”? Is the aridity index only calculated from speleothem growth, pollen and dust, or are other parameters included? In the methods section it is stated that “...isotope data like  $\delta^{18}O$ , Sea Surface Temperature (SST) reconstructions or Ice Raft Debris (IRD) data are added to complete the picture.” Are those records part of the aridity index? If not, to what have you included those data?

3) Uncertainty estimation. The uncertainty estimation needs better explanation. If the aridity index is binned into integer values between 0 and 5 (as I speculate), does it make sense that the error is smaller than 1 in some cases as for example shown in figure 2f?

4) Title: The title is misleading and not a good representation of the content. The data collection is far from being “global” since some of the most important regions (i.e. the Amazon) and much of the tropics (where aridity matters most) are not represented. I would suggest to find a title like “Regional aridity synthesis for the last 60 000 years”

5) I find some of the generalizations and associations of records with specific regions strange and do not understand why this is done at all: For example in Figure 5 the Susah Cave (located at 33N/22E close to the Mediterranean) is labeled with NW Africa, and a Bahamas cave with the Cariaco Basin. The Cariaco Basin is under the influence of the ITCZ, the Bahamas are not. These are different systems and thousands of km

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apart and do not necessarily anything to do with each other. The power of a compilation of high-resolution aridity records is that we may understand the regional response of the climate system to specific perturbations or forcings. Here, this useful information is compromised through an unreasonable combination of records from different systems and a very broad definition of time slices (see below).

6) The used LGM definition (24 to 14.7 ky) is very unfortunate and should be revised. The LGM has been previously defined to extend from 23 to 19 ka (Mix et al. 2001, *Quat. Sci. Rev.*, 20, 627-657). This time interval has been chosen, because the climate is comparably stable. The LGM definition of the authors, however, merges the actual LGM with Heinrich Stadial 1, during which the climate system was exposed to significant changes in external forcings and internal perturbations. The global deglacial warming starts at about 18.5 with the onset of HS1 shortly before the deglacial increase in atmospheric CO<sub>2</sub> (Shakun et al. 2012, *Nature*, 484, 49-54). The distribution of orbital insolation changes significantly and we see a change from a relatively strong AMOC to a weak AMOC with the onset of HS1 (McManus et al. 2004, *Nature*, 428, 834-837). Very likely, even the deglaciation of the Southern parts of the Ice sheets starts already during HS1 as evidenced by records related to river discharge at some of the more southerly locations (i.e. Menot et al. 2006, *Science*, 313, 1623-1625).

7) Comparison to model experiments. In my view, a comparison to model experiments only makes sense, if there is a coherency between the changes in boundary conditions applied to the model and those expected for the reconstructed time slices. This is not the case here: The model experiments have been performed with fixed boundary conditions. By contrast the definitions of the time slices (LGM: 24 000-14 700 yr b2k, MIS3: 60 000 – 24 000 yr b2k) are so broad that huge changes in boundary conditions and perturbations are present within each time slice. Hence it is impossible to pin down potential reason or mechanisms for the changes. The authors have done an effort to specifically compile high-resolution records and yet they lose all the information through unreasonable broad time slice definitions.

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More specific points:

-p1/l11: "In comparison, the MIS2 interval becomes arid in all northern hemisphere records, but the peak arid conditions of the Last Glacial Maximum (LGM) differ in duration and intensity among regions." This is not true. MIS2 includes the B/A interval which is clearly very humid. Peak arid conditions in much of the northern Hemisphere tropics occur during HS1, which should not be confused with the LGM

-p1/l17: "two focus" must be "two foci"

-p2/l13: "We present the 10 key regions..." Key for what? Many important "key" regions of global importance (i.e. the Amazon) are missing

-p4/l1: "The global climate structure is well documented within Greenland and Antarctica ice cores". I disagree with this statement. Ice cores represent the high latitudes. There is very little info about the tropics and subtropics, i.e the strength of the monsoons, neoglaciation etc.

-P5/l14: "Central Europe is one of the large feedback regions to North Atlantic climate changes" Do the authors mean that Central Europe is amplifying North Atlantic climate changes?

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