Clim. Past Discuss., 10, C518–C523, 2014
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10, C518–C523, 2014

Interactive Comment

Interactive comment on "CREST: Climate REconstruction SofTware" *by* M. Chevalier et al.

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Received and published: 21 May 2014

Dear reviewer,

Thank you for the constructive comments you provided on this manuscript. You have raised some interesting questions, which we respond to below.

R#1: In their paper submitted to Climate of the Past, the authors present an interesting study on climate reconstructions. The statistical relation between a taxon and a climate variable is obtained by the pdf-method. In the second step a pollen-type pdf is created out of the single species pdfs. The reconstructed climate variables are verified e.g. with the RMSE and its normalized version. With their software CREST it is possible to analyze climate reconstructions for the southern African continent. The analyzed 20 variables are split in the categories temperature and moisture. One presented result is that those parameters which have direct impacts on the plants are better for reconstructions. The assumption was being made that the taxon/pollen-type depends only on one climate variable. The pdf is expressed as an univariate function. This is a big restriction as the plant growth needs at best a measure for temperature (e.g. the coldest and warmest quarter) and a measure for moisture (e.g. annual precipitation) at the same time. I suggest that the authors should think about including two or three dimensional pdfs to their software to get the relation between a taxon/pollen-type and a certain climate state.

MC: We are aware that using multi-dimensional pdfs could greatly increase the accuracy of the method. We have been thinking of a way to include this feature in a future development of CREST, but it is far from straight-forward. For example, one aspect of our method consists in selecting a different set of 'responsive taxa' for each variable. This necessary step is incompatible with the fitting of multidimensional pdfs for all pollen-types, but this is integration of such calculations in one form or another is a clear goal for future versions of CREST. We decided to publish this version with univariate pdfs because, while there is always room for improvement, we are confident that in its current state CREST can already provide extremely useful results. A related study published last year highlights the usefulness of using univariate pdfs (Truc et al., 2013). The authors developed a similar method and applied it to a pollen sequence from South Africa. Their reconstructions for temperature and precipitation fitted well – both in trends and amplitude - with other regional records. We are currently working with CREST on several pollen sequences from southern Africa and the results are very promising and coherent.

R#1: The formula for weighting climate values could be useful in the text.

MC: We did not provide the formula because we considered that the explanation we gave on page 7 lines 15-17 was clearer. "The climate values (a total of N) are sorted into J bins of equal width. A weight kj is defined for each bin as the ratio of N with the number of pixels nj in the bin j." We have now included it.

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R#1: If the authors follow the definition after Kühl et al. (2002) the expectation value and standard deviation (Eqt. 1 and 2) are not correct.

MC: After revisiting the article of Kühl et al. (2002), we realized that we did not use the same equations. We will modify text accordingly.

R#1: Is the weighting also valid for non normally distributed variables?

MC: To test the effects of the weighting, we reconstructed the 3381 samples presented in the paper with and without it. Its impact was largely positive, especially for precipitation, for which we used lognormal psdsp. In southern Africa, truly wet areas are very rare, so the distribution of climate is really disequilibrated (cf the histograms on Fig 9 in the manuscript). Upweighting those wet pixels allowed us to better identify taxa that were truly specific to arid climates.

R#1: Climate variables (with positive values only) which do not follow a normal distribution can be transformed before fitting a pdf. The precipitation distributions e.g. in Fig. 1A are close to zero which makes it difficult to fit the log-normal distribution, as this is only valid for values larger than zero. There are several ways to do transformations, e.g. explained in Gentle (2003). It would be worthwhile to mention this option as the results could be improved for the precipitation measures.

MC: This is an interesting comment. For now, we only propose two distributions for the pdfsp: 1) a normal shape and 2) a lognormal shape. We adopted this lognormal shape to deal with the issue of variables that are strictly positives and right-skewed such as precipitation. We looked at other options, like beta distributions (Austin and Gaywood, 1994) but such distributions are much more complex to fit and need four parameters to be determined. We have written CREST in a way that this list of distributions can be extended and/or modified by any user (with a bit of knowledge in python coding). The choices presented in the article seem to be working in our study area, but since the distributions have only been tested in southern Africa, we do not exclude that other shapes could be more appropriate in other part of the world and/or variables. We will try to emphasize this more clearly in the text so that the reader understands that the options we propose are not exhaustive, and one can define other distributions. This is also something we will consider for future versions of CREST.

R#1: It did not become clear to me how to calculate the weighting and the pollen percentage in the third step (Eqt. 7). What exactly is t? This should be shown more explicitly.

MC: We used ‘t’ in the text for ‘time’ but it was meant to represent a sample. This specification is missing in the text and will be added. We will also clarify this by replacing ‘t’ by ‘s’. We added that variable to represent the changes in pollen percentages among samples. The pdfpol are identical all along the study but each pdfvar depends on a particular sample.

In our model we wanted to take into account the variations of pollen percentages instead of just presence/absence. Most of the changes observed in a pollen diagram are variations in the percentages rather than replacement of taxa. But since taxa may have very different pollination rates (orders of magnitude) using percentages directly is suboptimal. Thus, we had to “normalize” the percentages relative to this pollination rate. The pollination rate is largely unknown for most species so we “estimate” it with the percentages. To do so, for each taxon we calculate the mean percentage when it is present in a sample to estimate how much pollen is produced in average (0% are not included in that mean). This value will be related to the pollination rate. Then, we divide all the percentages by this mean value and we have a value that represents “how much” of the plant was present. Truc et al. (2013) used a similar approach but instead of the mean value, they normalized percentages by the maximum. We consider that this approach is too sensitive to outliers so we opted for a more conservative strategy.

R#1: Which time period is taken for the analyses in CREST?

MC: In the paper, the botanical data comes from field observations and herbarium specimens, some of which date to the 18th century. The climate data are

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averages from 1960-1990 or 1950-2000, depending on the station records (see http://www.worldclim.org/methods for more information).

R#1: A formula for the Moran's Index should be given to get a better understanding.

MC: The equation will be added in the manuscript as well as a brief description of it.

R#1: In section 3 the software CREST is briefly described. I like the approach of building a tool like this with an output consisting of figures and texts. As this manuscript should present the major characteristics of CREST the authors could go more in detail what can be changed by the users. MC: We tried to be synthetic in our presentation of the software but we may have oversimplified the description of CREST. We will work on this section to highlight what elements the user can define.

R#1: What does it mean to change the shape of the pdf of the species?

MC: Changing the shape of the pdf means that one can choose which type of distribution should be used for each variable. It corresponds to the shape of the pdfsp: normal, lognormal or any other distribution added by a user.

R#1: Is it or will it be possible to use own botanical and meteorological data sets in CREST?

MC: That is one of the main advantages of CREST, with the user being able to design their own database. In addition, CREST can access any local (data stored on the same computer) or distant (data stored on a server) database; including MySQL, SQLite3 and Microsoft Access (.mdb) databases. We will clarify the text to be more explicit on this point.

R#1: The following points should be corrected: R#1: - adding the missing 1/2 in exponential function (Eqt. 3)

MC: We have added it and rechecked all the equations.

R#1: - adding the missing literature references (e.g. lines 32, 368)

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MC: Added.

R#1: - checking abbreviations and indices (e.g. lines 116, 171, 304)

MC: Corrected.

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Interactive comment on Clim. Past Discuss., 10, 625, 2014.