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Hydrology and Earth System Sciences Discussions

Interactive comment on "Köppen versus the computer: an objective comparison between the Köppen-Geiger climate classification and a multivariate regression tree" *by* A. J. Cannon

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The author introduces a partitioning algorithm (the Multivariate Regression Tree, MRT) to come up with a classification of the climates of the world. He compares them to the traditional classification based on the Koppen-Geiger (KG) rules. When evaluating

the two classifications with respect to the monthly climatologies of precipitation and temperature, the MRT classification shows a better reproduction of these climatologies than the KG classification, in particular for precipitation. This is an interesting and well written paper, which I would certainly recommend for publication after addressing some minor comments.

1. My main comment concerns the choice of the predictands for the MRT and the subsequent comparison between MRT and KG. The author argues that the main goal of such a classification is to obtain regions of high intra-annual climatological homogeneity, where the climatological characteristics are represented by the monthly climatologies of temperature and precipitation. The MRT, based on the same predictors as the KG classification, is consequently grown such that these monthly climatologies are optimally predicted. While this is certainly a reasonable target for such a classification, it is not the one at which KG aimed (their classification relied much on vegetation types, for example). A better reproduction of these predictands by the MRT (compared to KG) is therefore natural in my view. Could the discussion of the comparison be adapted in this sense? For example, I would not describe it as "objective" (as done in the abstract), which in my understanding would only apply to the comparison of two classification approaches aiming at the same target.

As the two reviewers raise this same point, I will respond to both here. I definitely agree that the comparison is somewhat unfair, as the goal of the MRT and KG classifications are ultimately different. That said, the KG classification, in part due to its use of simple rules based on climate variables, has – in my eyes – come to be seen (and used) more as a general purpose global climate classification than as a climate classification designed to discriminate vegetation types. The revised paper will address this in more detail throughout. For example, historical background on the goals of the KG classification, explicit caveats regarding the "objectivity" (or lack thereof) of the comparison, and modifications to the discussion and conclusions will be included.

In addition, the two classifications will be evaluated quantitatively in terms of a proxy

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of global vegetation cover, in this case Normalized Difference Vegetation Index (NDVI). A preliminary analysis has been completed for the review comments. Global values of NDVI from the NOAA AVHRR satellite were obtained and long-term annual mean and intra-annual monthly standard deviations calculated for the period 1982-2000. Values of explained variance (EV) based on the MRT and KG classifications are shown in the appended Figure. The KG system performs better in terms of the annual mean at the 5 class level, but the MRT system pulls "even" at the 13 and 30 class levels. On the other hand, the MRT performs better in terms of intra-annual variability at the 5 and 13 class levels, but the KG system is comparable at the 30 class level. Ultimately, then, the MRT appears to perform better in terms of climate and equally well in terms of vegetation at the 30 class level.

2. P2348L3: Not being an expert in this field: Is it true that the binary data clustering is the most common one?

In terms of divisive monothetic clustering, historically this has been the case due to the long history of association analysis in ecology. With the realization that CART – in particular the MRT – can be used as a more general form of unsupervised cluster analysis (Chavent, 1998) rather than just as a predictive model, this will likely change.

3. P2348L9f: Could you give a reference for "association analysis"?

The reference to "Williams, W. T. and J. M. Lambert, 1959. Multivariate Methods in Plant Ecology: I. Association-Analysis in Plant Communities. Journal of Ecology, 47(1): 83-101" will be added.

4. P2348L17ff: Is this auto-associative MRT relevant for your study? If so: Does the non-distinction between X and Y mean that X = Y (was a bit unclear to me)? If not: Could it be removed from the text?

The climate variables that define the KG classification were used as both predictors and predictands in a variant of the analysis, so this made sense to include originally.

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For sake of brevity, the auto-associative analysis was removed, so this is, as you say, no longer relevant and can be removed.

5. Section 3: From what I understand, MRT is like a multivariate extension of CARTs. If this understanding is correct, could it be emphasized in this section?

Yes, a MRT is identical to a CART model with a multivariate rather than univariate predictand. I will emphasize this in the revision.

6. P2350L15: Does "exhaustive" mean "not greedy"? I am a bit confused, later on P2356L3 you talk of a greedy optimization.

Sorry, this is a bit of jargon that needs to be clarified. In this context, "greedy" means that the goal of the optimization is to maximize the reduction in error as each new rule is added. A non-greedy optimization would allow previous rules to be modified as new ones are added to further reduce the overall error of the entire tree. It's somewhat analogous to the difference between forward stepwise regression and forward/backward stepwise regression. "Exhaustive" means that all possible values of all predictors are tested as potential rules in the search process.

7. P2351L25f: Such predictive aspects are also shared by CARTs.

Yes. See (5).

8. P2353L25ff: How do you calculate the CIs for EV?

CIs for EV are based on an approximation of the standard error from Olkin and Finn (1995)

$$SE = \sqrt{\frac{4}{n_{eff}} EV\,(1 - EV)^2}$$

in which the number of samples n has been replaced by an estimate of the effective number of samples

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$$n_{eff} = n\frac{1 - r_1 r_2}{1 + r_1 r_2}$$

where r_1 and r_2 are estimates of the lag-1 (i.e., nearest neighbour) spatial autocorrelation of the observed and predicted gridded fields.

9. P2355L26ff: Many of the following sentences would in my view better fit in Section 3.

Agreed.

10. A very minor comment: Although I am not at all skeptical about the application of MRT in this context, I would personally express its prospects as an essential means of education for future students rather as a hope, not as something at eye level with KG (concerning the last sentences of the abstract and Section 6) ;-)

Agreed. This was stated with tongue firmly planted in cheek, so a rewording is needed. :)

11. Fig. 6: Would it make sense to arrange either the MRT or the KG diagrams such that the pairs in each row correspond to each other in terms of the "winners" from Table 2?

Yes, this makes sense.

12. Fig. 10: Why don't you show the CIs here? I didn't quite understand how this figure is computed – is it averages over the single month EVs?

These are indeed averages over the single month EVs. This needs to be clarified in the text and caption. It is not immediately clear to me on how a proper CI could be added. I could conceivably plot "error bars" that indicate the range of intra-annual variability, perhaps an estimate of the standard error based on the 12 monthly *EV* values?

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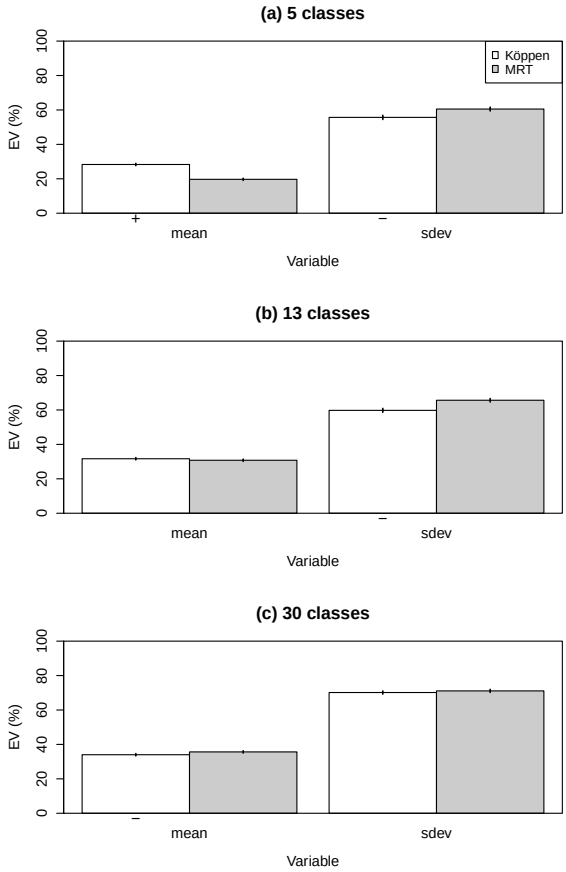

Fig. 1. EV of the MRT and KG classifications in terms of annual mean NDVI and intra-annual standard deviation of monthly NDVI.

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