Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-15-AC2, 2016

Hydrology and Earth System Sciences
Open Access
Discussions

Interactive comment on "Recent changes and drivers of the atmospheric evaporative demand in the Canary Islands" *by* S. M. Vicente-Serrano et al.

S. M. Vicente-Serrano et al.

svicen@ipe.csic.es

Received and published: 25 May 2016

Interactive comment on "Recent changes and drivers of the atmospheric evaporative demand in the Canary Islands" by S. M. Vicente-Serrano et al. Anonymous Referee #2

The manuscript deals with an analysis of the atmospheric evaporative demand (AED) over the Canarian Island for the period 1961-2013. Basis are meteorological data (monthly, p4l96) from 8 stations which are used as inputs for the FAO-56 Penman-Monteith equation to derive monthly AED. While the paper is generally well written, I feel there are a number of conceptuals issues that need to be resolved and addressed before a possible acceptance.

Thanks for your positive assessment of our manuscript and strong effort providing constructive comments. Addressing your comments has helped improved our revisions.

Please find below our answers to each comment and if you have any residual concerns please feel free to raise those points.

- As the FAO-56 is a non-linear equation that has been developed for daily inputs, how do authors justify the application of monthly average input values?

The FAO-56 equation can be obtained from daily and monthly records, as Allen et al., 1998 stated: "the FAO Penman-Monteith equation requires air temperature, humidity, radiation and wind speed data for daily, weekly, ten-day or monthly calculations". Several previous studies focused on drought using ETo at larger spatial scales have also computed the Penman Monteith ETo using monthly values for some variables. Using monthly averages instead of higher temporal resolution of data (e.g., daily) has not a relevant influence on the ETo estimations. An example is showed below for the ETo calculations in two stations of the Canary Islands (Los Rodeos and Izaña) for the 1978-2010 period based on the raw climatic data. The figure shows the relationship between the monthly ETo sum from daily measurements and the calculations from the average of monthly climate variables, which justifies the equality of applying both procedures. This is clearly observed for the ETo monthly values (including seasonality) but also considering monthly standardized anomalies in which seasonality is removed. In addition, we would like to remark that obtaining high quality and homogeneous time series of the necessary variables for calculating ETo on a daily basis is highly problematic since there are not robust methodologies to homogenize climate variables at the daily scale, whereas testing and correcting homogeneity using monthly records is reliable. Given high agreement of both daily and monthly ETo estimations but stronger robustness and homogeneity of monthly series, it seems recommendable to use monthly climate records in climate change studies.

- As some of the input variables (Rn) have to be estimated from other parameters, some of the discussion about these relationships (p.14) need to be provided earlier in the text.

The estimation of the Rn is the exception in relation to the other variables needed to apply the FAO-56 Penman-Monteith equation. Rn is indirectly estimated by means of sunshine duration records. We agree with the Reviewer#2 and the implications of this method are discussed in depth in the discussion section. Furthermore, in the revised manuscript we have moved some of this discussion to the section of methods.

- While in general there are many graphical illustration for plenty of aspects, I actually miss graphs with the temporal dynamics and developments of input variables into the FAO-56 equation. Where can I see the trend for Rn, T, wind speed, rH? This would be important as they are the controlling variable in the equation.

This is included in Table 7 (Table 8 in the revised manuscript). This table shows the magnitude of change for air temperature, relative humidity, sunshine duration and wind speed in °C, %, hours and m s-1 decade-1, respectively, over the 1961-2013 period. This is analysed for the different available meteorological stations but also for the regional series. In addition, Table 8 also includes the statistical significance of the observed changes at the confidence 95% confidence level.

- Why are authors relating calculated ET0 with variables that have been used to calculate ET0 before (or used to derive inputs from where ET0 is calculated) - see for example Fig. 6. Why don't authors simply calculate the sensitivities (partial derivatives) of FAO-56 with respect to the driving variables. I simply did that and only from using a temperature increase of 0.6 âŮęC (keeping specific water content constant) and some realistic Rn, T , ra, rs – values (I used the original PM formula) I could derive the changes in ET0 stated by the authors. I feel a sensitivity study in this way including trend analysis of the inputs would be more compact and informative for the readers.

In the manuscript we already combined these two suggested approaches. On the one hand, we determined the relationship between ETo calculations and the interannual variability of the different meteorological variables; on the other hand, we also followed the approach using the PM equation, including trend analysis. This was explained in

the methods section:

"...we applied the PM equation while holding one variable as stationary (using the average from 1961 to 2013) each time. This approach provided five simulated series of ETo, one per input variable, which could be compared to the ETo series computed with all the data to determine the isolated influence of the five variables. Significant differences between each pair of ETo series (i.e., the original one and the alternative one in which one variable was kept constant) were assessed by comparing the slopes of the linear models, with time as the independent variable. A statistical test for the equality of regression coefficients was used following Paternoster et al. (1998). The significance of the difference was assessed at a 95% confidence level (p<0.05)."

Figures 7 and 8 show the results of this analysis.

- Authors state they applied the Mann-Kendall – did they check and correct for autocorrelation?

We considered the autocorrelation in the trend analysis applied to the series of (i) ETo, (ii) aerodynamic and radiative components of the ETo, and (iii) the series of the different climate variables (i.e., air temperature, relative humidity, wind speed and sunshine duration). This was applied using the FUME R package, which performs the modified Mann-Kendall trend test, returning the corrected p-values after accounting for temporal pseudorreplication (Hamed and Rao, 1998; Ye and Wang, 2004). This has been detailed in the revised manuscript.

Hamed, K.H. and A.R. Rao, (1998). A modified Mann Kendall trend test for autocorrelated data. Journal of Hydrology 204, 182-196. Yue, S. and C. Wang (2004). The Mann-Kendall Test Modified by Effective Sample Size to Detect Trend in Serially Correlated Hydrological Series. Water Resources Management 18, 201-218.

Overall, I feel there is still a large potential to improve the overall structure/concept of the manuscript as outlined above. As a result I suggest major revisions to the manuscript before publication.

Finally, we thank Reviewer#2 for the revision task and the useful comments raised for impro ving the results presented in this manuscript. Hopefully we have answered to all these major and minor concerns satisfyingly; otherwise we are available for further clarifications.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-15, 2016.

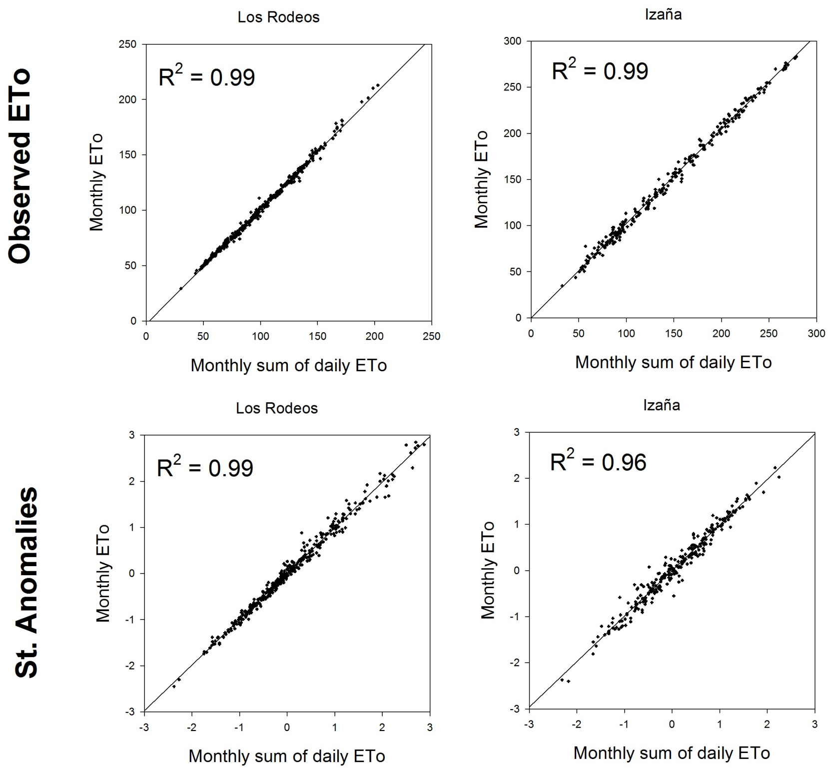

Fig. 1.