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Interactive comment on "High resolution global grids of revised Priestley-Taylor and Hargreaves-Samani coefficients for assessing ASCE-standardized reference crop evapotranspiration and solar radiation" *by* Vassilis G. Aschonitis et al.

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Comment R2.1: This study analyses the global relationship between ETo annual maps obtained by means of three different methods (ASCE PM, P-T and H-S), with the purpose of determining the accuracy of the methods based on poor data availability (P-T and H-S). In addition, the manuscript includes a calibration exercise to obtain revised coefficients at the global scale for P-T and H-S equations based on the obtained ASCE

PM data. The research topic is highly relevant given the relevance of estimating the atmospheric evaporative demand (AED) with accuracy since AED is an important hydroclimatic variable with strong implications in aridity conditions and climate change processes. The manuscript is in general well written, the figures show high quality and it has a good structure. The authors use a high amount of data for analysis and validation, including gridded datasets and meteorological networks in California and Australia. The manuscript is a bit long and sometimes it is different to follow but independently of formal issues I find major methodological problems in the manuscript, which are related to the treatment of the data used, the spatial resolution of the gridded products and the assessment of the uncertainty in the ETo estimations. I am including some detailed issues below about these issues.

Response: We would like to thank the reviewer for the precise comments related to methodological problems since he gave us the opportunity to provide more justifications, clarifications and details about the methods and data used in this work. We carefully considered all the comments and we followed all his recommendations in order to improve the manuscript and reduce any uncertainties related to methodological issues about the spatial resolutions. More details are given to the responses of the following specific comments. We also suggest the reviewer to check carefully the responses to the comments of Reviewer 1, since his suggestions led to substantial changes in the manuscript.

Comment R2.2: I would recommend the authors to work at coarser spatial resolution to reduce the strong uncertainty associated to the selected high resolution (1 km) of final products. Page 4: I find highly problematic to interpolate the low resolution 0.5âŮę data for wind speed, humidity and solar radiation to 1 km. The results of the bilinear interpolation of the 0.5âŮę data does not really increase the necessary spatial resolution of these variables to be compared with the high resolution of tmax and tmin data (in any case high resolution temperature data from the global dataset used is also affected by spatial errors and uncertainties, which should be also taken into account). The 1 km interpolated wind speed, humidity and solar radiation has a spatial resolution completely unreal. These variables are essential to be taken into account to estimate ETo spatial patterns since ETo is usually more sensitive to these variables than to temperature (McVicar et al., 2012a and b). For this reason, I consider that 1 km gridded maps generated in this study show high uncertainty, which is not quantified/provided in this study. The authors are computing Eto by PM equation as reference to be compared with H-S and P-T methods, but there is not any assessment of the error in the PM estimations related to the data inaccuracies and the poor resolution of the input climate data. I think these problems would be solved (not completely since an assessment of uncertainty should be taken into account) if authors consider to focus at coarse (0.5âŮę) spatial resolution, which avoids unnecessary interpolation of wind speed, radiation and humidity variables and the outputs would be useful for continental to global assessments. Thus, the results of figures 8-10 confirms that interpolation of low resolution variables have strong influence on the comparability of different ETo estimations, which can be associated to the poor interpolation approach applied to the coarse climate variables.

Response: We agree with the reviewer that the bilinear interpolation method may not be the most appropriate method to increase the resolution of wind speed, solar radiation and humidity data and we also agree that 1 km raster resolutions are in general an exaggeration for describing climatic variables. The basic reason that led us to show the results of both $\sim$1 km (30 arc-sec) and 0.5 deg was to cover the complete range of resolutions observed in the initial data. In addition, the aim was to provide ETo rasters of 1 km for comparative purposes with other studies, which have also provided 1 km resolutions of global ETo for the same period using other methods and the same sources of data. For example, Zomer et al. (2008) provided 1 km resolution maps using the Hargreaves-Samani method based on the temperature data of Hijmans et al. (2005). The bilinear interpolation used for global solar radiation, specific humidity and wind speed data of Sheffield et al. (2006) provided insignificant improvement but allowed to develop 1 km rasters of exact spatial arrangement with the 1 km rasters of temperature, especially in the coastlines and small islands. This has provided an

improvement of $\sim$4% in the RMSE of ASCE-ETo estimations obtained from the map, when compared with the respective values of stations (Fig.R1a,b). This improvement seems negligible for the total validation dataset, but it was significant when it was examined for some individual stations located in regions of 0.5 degree pixels with high internal topographic-temperature variability. In order to avoid any criticism about the interpolation method used for increasing the resolution of solar radiation, humidity and wind speed data, we decided to remove any results and discussion about the finer resolutions keeping only the results for 0.5 degree resolution. For this reason all the results and all the maps and tables presented in the revised version correspond only to the 0.5 deg resolution. The comparisons between the ETo values of rasters (0.5 degree) and stations for both reference crops were added in the supplementary material (see Fig.S2g,h) and their reference in the text can be found in Page 10, lines 25-26.

[FIGURE R1, PLACE HERE]

Fig.R1 Comparison of ETo ASCE-short values (mm month-1) between the 140 stations (both CA-USA and Australia stations) and (a) the produced rasters of 30 arc-sec resolution and (b) the produced rasters of 0.5 degree resolution.

The only reference about the finer resolutions is given in section 5. Data availability, where we added the following text "Apart from the 0.5 degree resolution raster datasets, the database contains the same datasets at finer resolution (30 arc-sec, 2.5 arc-min, 5 arc-min and 10 arc-min). These finer datasets are provided in order to cover the observed resolution range in the initial climatic data (e.g. the temperature data of Hijmans et al. (2005) are provided at 30 arc-sec resolution). The finer resolutions were produced using bilinear interpolation on solar radiation, humidity and wind speed data of Sheffield et al. (2006). This interpolation method is not the most appropriate for such purposes. The data of finer resolutions can only be used as a tool to assess uncertainties associated to temperature variation effects within a 0.5 degree pixel or to estimate average values of the coefficients for larger territories in order to capture a better representation of the coastlines or islands that do not exist in 0.5 degree resolution (use of values from individual pixels is not recommended). A complete list of the datasets is provided in the Table S5."

Comment R2.3: I have also doubts on the use of the coefficients calculated in this study to calculate ETo using H-S and P-T equations. The authors obtain the calibration coefficients for the period 1950-2000 and assume stationary climate conditions. Nevertheless, under climate scenarios in which input climate variables change (I refer to wind speed, relative humidity and incoming solar radiation) under a non-stationary scenario, the obtained coefficients would not be useful to calculate ETo based on scarce climate data. Different studies have showed recent changes in solar radiation (Wild et al., 2013), wind speed (McVicar et al., 2012b) and atmospheric humidity (Willet et al. 2014). Given that the main objective of this study is the re-calibration of the H-S and P-T equations, it would be necessary that authors provide not only the recalibrated coefficients but also a measure of the accuracy considering the errors in the interpolated variables used in P-M calculations.

Response: We agree with the reviewer that climate change effects can significantly affect the prediction accuracy of the coefficients. This was the reason why we included data from 2000-2016 for all stations in the validation procedure (see periods of observations for each station in Table 1 of the manuscript). We also have to mention that more than 50% of stations in the total validation dataset have more data from years after 2000, while there are 4 stations with data only for the period ∼2000-2016. Taking into account these specific features of the validation dataset, we cannot reject the hypothesis that the revised coefficients have a good explanatory power even for the years 2000-2016, since they improved significantly the ETo predictions in comparison to the standard coefficients and gave better results from other models that use additional parameters (see new additional models in Table 2 and comparative results in Table 5 of the manuscript; the additional models were added after the request of Revier 1). We also thought to break the validation datasets into two periods (before and after 2000), since the produced ETo rasters and the revised coefficients correspond to

1950-2000, but this idea could not be implemented for two reasons: âĂć The database of Australian stations provides freely available online only the mean monthly values of the parameters for the total periods of observations and not the complete records of monthly values for each specific year. âĂć The available data from CIMIS database for the stations of California-USA start after 1982 (Table 1 in the manuscript), and cover less than 36% of the total period 1950-2000, while they correspond to the late years of the specific period. It is well documented that climate differences were also observed even during the 1950-2000 (through comparisons between 1950-1975 and 1975-2000) in many parts of the world (Hang et al., 2000; Norrant and Douguédroit, 2006; Sheffield and Wood, 2008; You et al., 2011). Thus, we also did not divide the California-USA data into two periods in order to avoid any arguments that would probably occur based on the observation periods. Since we followed the recommendation of the reviewer to remove the finer resolution results of 30 arc-sec (1 km) and present only the 0.5 degree results, we also performed an accuracy analysis for the internal parameters of ASCE-ETo between the values provided by the 0.5 degree rasters data (Hijmans et al. 2005; Sheffield et al. 2006) and the respective data of stations (Fig.R2 below). The temperature data of 30 arc-sec resolution were also converted to 0.5 deg for this analysis. Fig.R2a,b,c,d,e,f provides the respective comparisons for the mean monthly values of Tmax, Tmin, Rs, Rn, DE (vapour pressure deficit es-ea), and u2 between stations data and rasters of 0.5 degree resolution. The Rs values of both rasters and stations given in Fig.R2c are those after correcting the ones exceeding the clear sky solar radiation Rso (i.e. when Rs/Rso>1, Rs=Rso), as it is required before ASCE-ETo estimations (Allen et al., 1998; 2005). Additionally, the values of u2 given in Fig.R2f are those after adjusting the raster values of Sheffield et al. (2006) and Australia stations data from z=10 m to 2 m height using the formula (Allen et al., 1998; 2005):

$u2=4.87*uz/(\ln(67.8z-5.42))$ (Eq.R1)

The original wind data of Sheffield et al. (2006) and Australia stations are given for z=10 m, while the data of California stations were already given at 2 m height. The comparisons for the Tmax, Tmin, Rs, Rn, DE (vapour pressure deficit es-ea), and u2 between stations data and rasters of 0.5 degree resolution were added in the supplementary material (see Fig.S2a,b,c,d,e,f) and their reference in the text can be found in Page 10, lines 25-26.

[FIGURE R2, PLACE HERE]

Fig.R2 Comparison of mean monthly values between rasters data (0.5 degree resolution) and stations data for (a) the maximum monthly temperature Tmax, (b) the minimum monthly temperature Tmin, (c) the solar radiation Rs, (d) the net solar radiation Rn, (e) the vapour pressure deficit DE=es-ea, and (f) the wind speed at 2 m height u2.

For the cases of Tmax, Tmin, Rs, Rn and DE (Fig.R2a,b,c,d,e)„ the comparisons between rasters and stations are satisfactory, if we consider that rasters provide values of 0.5 degree (~50 km) pixels of the period 1950-2000 while stations data cover also the period from 2000-2016. In the case of u2, the correlation between rasters and stations data was not good. We examined with various ways the wind data in order to explain the possible sources of this problem. We derived some findings when comparing the mean monthly u2 values of all California-USA (Fig.R3a) and Australia (Fig.R3b) stations, separately. Fig.R3a shows that the total average raster values of mean monthly u2 from the pixel positions of CA-USA stations are higher than the respective measured u2 values, while in Fig.R3b for Australia stations is observed the opposite trend. These differences are the main reason why the regression line in Fig.R2f is above the 45 degrees line for the values <2.5 m s-1 (the majority of points belong to CA-USA stations) and below the 45 degrees line for the values >2.5 m s-1 (the majority of points belong to Ausralia stations). This opposite trend between the two validation datasets was also the reason of the high RMSE in Fig.R2f. To avoid any possible misunderstanding that could arise from the merged California and Australia datasets, we also give the results of Fig.R1b separately for CA-USA and Australia stations in Fig.R4a,b, respectively. Despite the difference in u2 values between CA-USA stations and rasters (Figs.R3a), the regression line in Fig.R4a of ETo presents a good slope and intercept

probably because the wind differences are counterbalanced with differences in other parameters of ETo. In the case of Australia stations (Fig.R4b), the higher observed u2 values from stations in comparison to rasters are probably the reason for the observed downward deviation of regression line from the 45o degrees line.

[FIGURE R3, PLACE HERE]

Fig.R3 Comparison of mean monthly u2 values through Box-Whisker plots: (a) between 0.5 degree rasters (Sheffield et al., 2006) and California-USA stations, (b) between 0.5 degree rasters (Sheffield et al., 2006) and Australia stations.

[FIGURE R4, PLACE HERE]

Fig.R4 Comparison of ETo ASCE-short values (mm month-1) between (a) the produced rasters of 0.5 degree and the 60 stations of CA-USA and (b) the produced rasters of 0.5 degree and the 80 stations of Australia.

Some justifications about the low correlation between wind data of rasters and stations (Fig.R2f) and the observed differences in Figs.R3a,b are the following: âĂć Part of this difference may be associated to climate change effects since the larger part of wind data from stations, especially for Australia stations, represent the period after 2000 while the rasters correspond to the period 1950-2000. âĂć The representativity of wind speed rasters of 1950-2000 produced by the model of Sheffield et al. (2006) may be low at 0.5 degree resolution due to the scarce existing wind data at global scale during the total period of simulation and especially for the years belonging to the first half of the total period. âĂć An additional factor responsible for the differences in Figs.3a,b may be the conversion of wind raster data of Sheffield et al. (2006) from z=10 m to 2 m using Eq.R1. The degree of accuracy of this equation is unknown when is applied at global scale and for a pixel of 0.5 degree resolution, which may contain high topographical variability. The error, which may be introduced by the use of Eq.R1 is impossible to be assessed. âĂć In the case of CA-USA stations, the mean monthly u2 values (measured directly at 2 m height) were estimated after removing extremely high observed values, which were flagged by the CIMIS database as unreasonable extremes. Additionally, in some months of some stations, u2 values were missing. We also observed that many of these extreme and missing values were during months of extreme rainfall events. Many of these months were associated to extreme hurricane events, which are very common in California (at least 54 catastrophic events for the period 1950-2015, with extremely high wind speeds). For example, the Guillermo hurricane of 1997 led to wind speeds of ∼70 m s-1 (https://en.wikipedia.org/wiki/List_of_California_hurricanes). We had already mentioned in the initial version of the manuscript that we removed flagged values from CA-USA data in order to make comparisons with the given ETo values provided by the CIMIS database (Page 10, lines 13-21 and Fig.S1 in the supplementary material). On the other hand, we believe that in the climatic model of Sheffield et al. (2006), which is expanded also in the oceans, such events were included (the degree of inclusion is unknown) and this may be probably an additional reason of the larger pixel values observed in the wind rasters at the positions of CA-USA stations (Fig.R3a). âĂć In the case of Australian stations, the AGBM database (Australian Government – Bureau of Meteorology) provides 12 values of mean monthly wind speeds of the total observation periods for 9am and another 12 values for 3pm local time (the website mentions that wind speeds are generally measured at 10 m height). Thus, we estimated the average value of 9am and 3pm conditions in order to get the mean monthly wind speeds and then we used Eq.R1 to adjust them at 2 m height. Thus, it is unknown the degree of error by averaging the 9am and 3pm conditions in order to get the mean monthly wind speeds and also unknown the possible error by the use of Eq.R1 locally at the position of stations. This equation is usually not calibrated for meteorological stations with anemometers positioned above 2 m height.

Such uncertainties may also exist in the case of DE=es-ea (Fig.R2e), since Sheffield et al. (2006) provides data of specific humidity that were directly converted to actual vapour pressure ea using the equation of Peixoto and Oort (1996). This equation uses the additional parameter of atmospheric pressure as internal parameter. The atmospheric pressure in the case of rasters was estimated based on elevation data

of 1 km resolution that were further converted to 0.5 degree resolution. The use of ea data from 0.5 degree resolution pixels may also added additional error, especially when there is large topographic variability within the 0.5 degree pixel. On the other hand, the ea of stations was estimated by relative humidity and temperature data.

Taking into account all the aforementioned observations, we would like to summarize our conclusions related to the specific comment: âĂć Apart from the wind speed data, it was found an adequate correspondence between the 0.5 degree raster data of Tmax, Tmin, Rs, Rn and de of 1950-2000 with the respective values of stations, which are expanded until 2016. âĂć As regards the wind speed data, the discrepancy between rasters and stations can be justified: a) either by possible wind differences before and after 2000, b) or by the effect of Eq.R1, which is used to adjust the wind rasters and the wind data of Australia stations from 10 to 2 m height, c) or by uncertainties in the Sheffield et al. (2006) wind data due to the scarce existing wind data for calibrating their model at global scale during the period of 1950-2000 (especially for years before 1975), d) or by uncertainties introduced after eliminating extreme wind values in the data of CA-USA stations, e) or by uncertainties introduced after averaging the 9am and 3pm wind conditions in the data of Australia stations, f) or by combinations of all the aforementioned cases. Thus, uncertainties exist in both rasters and stations wind data, which can not be solved. These specific problems were included in the discussion section. Despite the differences in the wind speed data between rasters and stations, the observed correlation between ETo ASCE-short of 1950-2000 (0.5 degree resolution) and the respective values of California-USA and Australia stations (which are expanded until 2016) is adequate for a global scale application (Fig.R1b), if we consider a) that the ETo values of rasters were obtained from large pixels (∼50 km) and b) that uncertainties, especially in the wind datasets, exist not only in the raster datasets but also in the stations datasets. In order to prove that the re-adjusted coefficients of P-T and H-S methods are valuable, we included other models of reduced parameters from the literature in order to perform comparisons (see new additional models in Table 2 and comparative results in Table 5 of the manuscript). In order to provide information about the aforementioned uncertainties related to the data that may affect the validity of the revised coefficients, we added a new section in the Discussion with title "Uncertainties in the data used for calibrating and validating the revised coefficients of P-T and H-S methods"

Finally, we would like to stress that this study used the published data of Hijmans et al. (2005) and Sheffield et al. (2006) that have been used by too many other studies (7129 and 186 citations, respectively, source: SCOPUS, last accessed 12/6/2017). We believe that we used the best available global information for developing the rasters. Additionally, we clearly state that our products of reference evapotranspiration and revised coefficients correspond to 1950-2000 and thus we leave the choice to the readers/users for using them for more recent periods. Finally, we observed that Fick and Hijmans (2017) just published a new version of their database for the period before 2000 including solar radiation, humidity and wind speed at 1 km resolution. Thus, we believe that there may be not problems related to the fact that our raster products do not include information after 2000, or because the wind rasters showed discrepancies with observed data, which mainly cover periods after 2000.

Comment R2.4: - Page 8. Really I do not find useful the annual coefficients in areas that show strong climate seasonality (as in the majority of world regions). - In addition, there are not seasonal accuracy statistics, which can be much more relevant than annual ones.

Response: Before we proceed to any justifications about the use of annual coefficients, we would like to mention that the stations that we used in this study, present adequate seasonal variability, which can be visualized in the graphs of Fig.R5a,b,c,d. Figs.R5a,b show the box-whisker plots of mean monthly ETo ASCE-short values for the California-USA and Australia stations, respectively, while Figs.R5c,d provide the respective frequency (number of stations) for classes that describe the maximum difference (Δmax) between maximum and minimum values of mean monthly ETo ASCE-short of the respective stations. Taking into account Fig.R5a,b,c,d, and especially R5c,d, we believe

that the validation dataset includes stations of high seasonality. Based on Figs.R5c,d, more than 50% of the stations present Δmax of ETo-short greater than 150 mm month-1.

[FIGURE R5, PLACE HERE]

Fig.R5 (a) Box-Whisker plot of mean monthly ETo ASCE-short (mm month-1) for California-USA stations, (b) Box-Whisker plot of mean monthly ETo ASCE-short (mm month-1) for Australia stations, (c) frequency (number of stations) for each class that describes the difference between maximum and minimum values of mean monthly ETo ASCE-short for California-USA stations and (d) frequency (number of stations) for each class that describes the difference between maximum and minimum values of mean monthly ETo ASCE-short for Australia stations.

We also have to stress that the revised coefficients of H-S and P-T methods are not just annual averages of the mean monthly coefficients but partial weighted averages (p.w.a.), which give more weight to the monthly coefficients of the months with higher ETo during the year excluding the coefficients of colder months that present unreasonably high or low coefficients (see procedure of Eq.7 in the manuscript for estimating the weighted averages). Thus, based on our experience and after handling with the stations and the raster data, we believe that the p.w.a. annual coefficients are very useful in areas of strong seasonality. The detailed reasons for selecting the annual p.w.a. coefficients were incorporated in the new subsection of the Discussion with title: "Reasons for using annual p.w.a. coefficients instead of monthly or seasonal ones in the case of H-S and P-T methods" It is also important to note that the derivation of annual coefficients is a pure optimization problem when stations data are used. For example, Cristea et al. (2013) derived coefficients of the P-T method for 106 stations that represent a range of climates across the contiguous USA. The coefficients were estimated by minimizing the sum of the squared residuals between the benchmark FAO-56 and P-T (optimization method) using data only for the period April-September. The obtained optimized values of the coefficients were interpolated in order to make a map of the apt coefficient (the map is not available for comparisons). In this study, the maps of the coefficients are produced based on raster data and not stations data, which means that optimization should be performed pixel by pixel (∼62000 pixels globally for the 0.5 degree resolution excluding Antarctica). This procedure would require special programming since readily available tool to perform this procedure does not exist in commercial or free GIS software packages. This is the main reason for using as an alternative method the Eqs.7 in GIS environment, since it can be calculated easily in raster calculators incorporated in the GIS packages while approximates to the optimized values because it gives more weight to the monthly coefficients of the warmer months. A solution could be the development of a tool for GIS purposes using rasters data that could be able to run using 24 rasters; 12 for the benchmark ETo and another 12 for the P-T or H-S ETo formula without the 1.26 and 0.0023 factors, respectively, in order to provide optimized annual values of their coefficients (for a global application filters to remove unreasonable values are also required). Finally, we have to clarify that Figs.8-10 in the manuscript include results of mean monthly values of each month of each station and not one value per station. We mention this because in the second part of the comment the reviewer notes that "there are not seasonal accuracy statistics, which can be much more relevant than annual ones". All the statistics that we provided in this study concern comparisons between observed and predicted mean monthly values by the models (160 stations $\times$ 12 mean monthly values = 1680 observations were tested for each parameter). We believe that the monthly comparison includes also the seasonal one. Seasonal separation would create a problem due to the different seasons between northern and southern hemisphere. Comparative statistics per season would also create a great expansion of the article in the results but also in the discussion section, which are already large after the addition of the additional models (request of the reviewer 1). Additionally, we would like to present the seasonal statistics in new studies where we will present further analysis related to optimization methods and other new models separately for California and Australia stations. In order to provide something relevant to seasonal variations to the reviewer, we prepared

the Figs.R6 and R7, which will not be included in the manuscript. Fig.R6a and R6b give the average monthly ETo based on the mean monthly estimations from California and Australia stations, respectively, using the ASCE-short method, the P-T(p.w.a.s.), the H-S(p.w.a.s.) and VAL3 model (best model according to Table 5a in the manuscript). Similarly, Fig.R7a and R7b give the average monthly Rs based on the mean monthly observations from California and Australia stations, respectively, and based on the Rs estimations using the radiation formula of H-S with revised coefficients.

[FIGURE R6, PLACE HERE]

Fig.R6 Monthly average ETo based on mean monthly estimations using the ASCE-short method, the P-T(p.w.a.s.), the H-S(p.w.a.s.) and VAL3 model (best model according to Table 5a in the manuscript) for (a) the 60 stations of California and (b) the 80 stations of Australia (For Australia the graph starts from July).

[FIGURE R7, PLACE HERE]

Fig.R7 Monthly average Rs based on mean monthly observations and based on the radiation formula of H-S with revised coefficients for (a) the 60 stations of California and (b) the 80 stations of Australia (For Australia the graph starts from July).

Figs.R6,7 give a general indication about the seasonal variations in the ETo and Rs estimations by the models separately for California and Australia datasets, while they also provide a general overview about the underestimation/overestimation of each model per month in comparison to the benchmark values (ASCE-short or observed Rs). We believe that the general variation that was succeeded by the models is satisfactory in the context of a global application and any observed deviations are adequately justified by the uncertainties related to the data. The only thing that we have to address is the response of P-T(p.w.a.s.) model. The P-T(p.w.a.s.) was not as good as the H-S(p.w.a.s.) (the same thing was also observed between the standard H-S and P-T methods). The prevalence of H-S can be attributed to the fact that the majority of stations from Table 1 are located in territories with negative DMAD values (Fig.5a) giving a general advantage to H-S method for more robust estimations (this explanation is also mentioned in the manuscript, for more details see Page 20, lines 1-10). In the case of Australia the bad performance is evident during the cold months, but it presented better performance on the warmer months (DJF) in comparison to H-S(p.w.a.s.) and VAL3.

Other major corrections made in the text: 1. Some affiliations changed because some authors were transferred to other institutions or because one of the Institutions changed name. 2. The abstract reformed in order to be more descriptive. 3. Any analysis related to finer resolutions below 0.5 degrees was removed from the text following the comments of reviewer 2. For this reason, the 30 arc-sec resolution maps given in Figs.2,3,4,5,6,7 were substituted with the ones of 0.5 degree resolution with respective changes in the range of values in their legends. Any discussion about the comparison of different resolutions was also removed from the discussion section. Additionally, all the results and tables changed based on 0.5 degree resolution. Similar changes were also made in the supplementary material. The only reference about the finer resolutions is given in section 5. Data availability, where we added the following text: "Apart from the 0.5 degree resolution raster datasets, the database contains the same datasets at finer resolution (30 arc-sec, 2.5 arc-min, 5 arc-min and 10 arc-min). These finer datasets are provided in order to cover the observed resolution range in the initial climatic data (e.g. the temperature data of Hijmans et al. (2005) are provided at 30 arc-sec resolution). The finer resolutions were produced using bilinear interpolation on solar radiation, humidity and wind speed data of Sheffield et al. (2006). This interpolation method is not the most appropriate for such purposes. The data of finer resolutions can only be used as a tool to assess uncertainties associated to temperature variation effects within a 0.5 degree pixel or to estimate average values of the coefficients for larger territories in order to capture a better representation of the coastlines or islands that do not exist in 0.5 degree resolution (use of values from individual pixels is not recommended). A complete list of the datasets is provided in the Table S5." 4. The reviewer also commented that the manuscript is quite long (Comment R2.1). For this

reason, we removed the accuracy analysis by splitting the stations based on their elevation, and we also removed the Taylor diagrams analysis since the criteria that we give in Table 5 are more than enough. 5. We added another 8 models of short reference crop evapotranspiration for comparative purposes after the request of Reviewer 1. 6. The Discussion section was completely reformed in order to create subsections (request of reviewer 1). 7. An error was found in the coordinates of Australian station Paynes Find station (A-69) of the validation dataset and the associated coefficients extracted from the specific coordinates. The position of the station was corrected in Fig.1 and any information related to the station was corrected. An additional arithmetic error was found and corrected in the ETo ASCE estimations of Australian stations. We performed a detailed check for all stations data, all the calculations/equations used for rasters development, all the calculations/equations used for analyzing stations data.

References Allen, R. G., Pereira, L. S., Raes, D., and Smith, M.: Crop Evapotranspiration: Guidelines for computing crop water requirements. Irrigation and Drainage Paper 56, Food and Agriculture Organization of the United Nations, Rome, 1998. Allen, R. G., Walter, I. A., Elliott, R., Howell, T., Itenfisu, D., and Jensen M.: The ASCE standardized reference evapotranspiration equation. Final Report (ASCE-EWRI). Pr. In: Allen RG, Walter IA, Elliott R, Howell T, Itenfisu D, Jensen M (Eds.) Environmental and Water Resources Institute, 2005. Task Committee on Standardization of Reference Evapotranspiration of the Environmental and Water Resources Institute, 2005. Fick, S. E.,and Hijmans, R. J.: WorldClim 2: New 1-km spatial resolution climate surfaces for global land areas. International Journal of Climatology, Article in Press, 2017, DOI: 10.1002/joc.5086 Hang, X., Vincent, L. A., Hogg, W. D., and Niitsoo, A.: Temperature and precipitation trends in Canada during the 20th century. Atmosphere - Ocean, 38 (3), 395-429, 2000. Hijmans, R. J., Cameron, S. E., Parra, J. L., Jones, P. G., and Jarvis, ÎŚ.: Very high resolution interpolated climate surfaces for global land areas. Int. J. Climatol., 25, 1965-1978, 2005. McVicar, T. R., Roderick, M. L., Donohue, R. J., and Van Niel, T. G.: Less bluster ahead? ecohydrological implications of global trends of terrestrial near-surface wind speeds. Ecohydrology, 5, 381-388, 2012a. McVicar, T. R., Roderick, M. L., Donohue, R. J., Li, L. T., Van Niel, T. G., Thomas, A., Grieser, J., Jhajharia, D., Himri, Y., Mahowald, N. M., Mescherskaya, A. V., Kruger, A. C., Rehman, S., and Dinpashoh, Y.: Global review and synthesis of trends in observed terrestrial near-surface wind speeds: implications for evaporation. J. Hydrol., 416-417, 182-205, 2012b. Norrant, C., and Douguédroit, A.: Monthly and daily precipitation trends in the Mediterranean (1950-2000). Theor. Appl. Climatol., 83, 89-106, 2006. Peixoto, J. P., and Oort, A. H.: The climatology of relative humidity in the atmosphere. J. Climate, 9, 3443-3463, 1996. Sheffield, J., Goteti, G., and Wood, E. F.: Development of a 50-yr high-resolution global dataset of meteorological forcings for land surface modeling. J. Climate, 19(13), 3088-3111, 2006. Sheffield, J., and Wood, E. F.:. Global trends and variability in soil moisture and drought characteristics, 1950-2000, from observation-driven simulations of the terrestrial hydrologic cycle. J. Climate, 21, 432-458, 2008. Wild, M., Folini, D., Schär, C., Loeb, N., Dutton, E.G., and König-Langlo, G.: The global energy balance from a surface perspective, Clim. Dyn., 40, 3107-3134, 2013. Willett, K. M., Dunn, R. J. H., Thorne, P. W., Bell, S., De Podesta, M., Parker, D. E., Jones, P. D., and Williams, C. N.: HadISDH land surface multi-variable humidity and temperature record for climate monitoring. Clima. Past, 10, 1983-2006, 2014. You, Q., Kang, S., Aguilar, E., Pepin, N., Flugel, W.-A., Yan, Y., Xu, Y., Zhang, Y., and Huang, J.: Changes in daily climate extremes in China and their connection to the large scale atmospheric circulation during 1961-2003. Clim. Dyn., 36 (11-12), 2399-2417, 2011. Zomer, R. J., Trabucco, A., Bossio, D. A., van Straaten, O., and Verchot, L. V.: Climate change mitigation: A spatial analysis of global land suitability for clean development mechanism afforestation and reforestation. Agr. Ecosyst. Environ, 126, 67-80, 2008.

Please also note the supplement to this comment:
http://www.earth-syst-sci-data-discuss.net/essd-2016-59/essd-2016-59-AC2-supplement.pdf

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Interactive comment on Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2016-59, 2016.

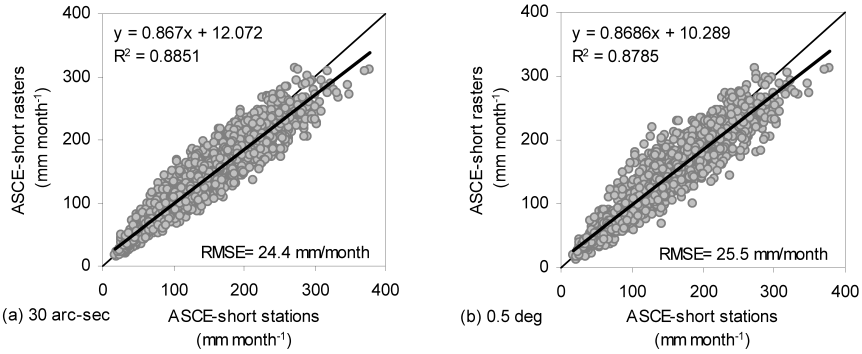

Fig. 1. FIGURE_R1

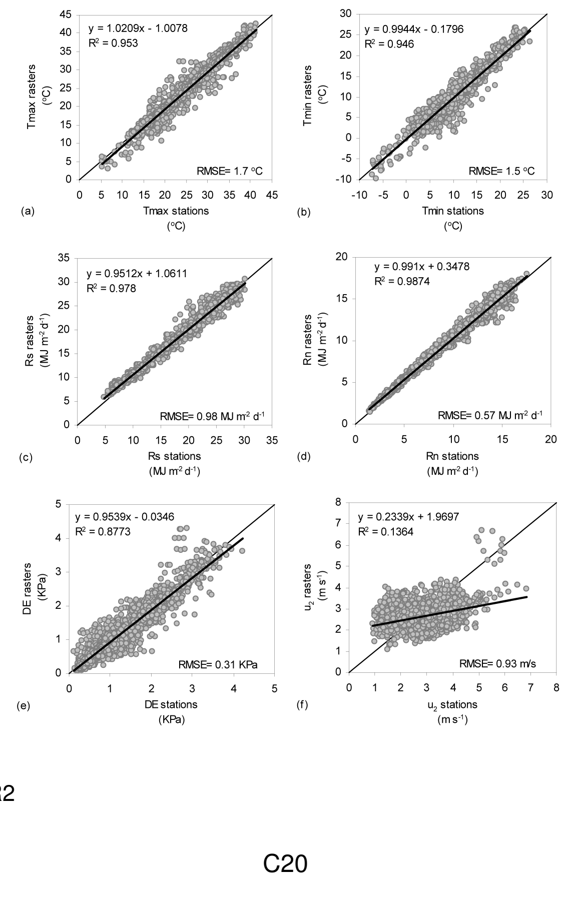

Fig. 2. FIGURE_R2

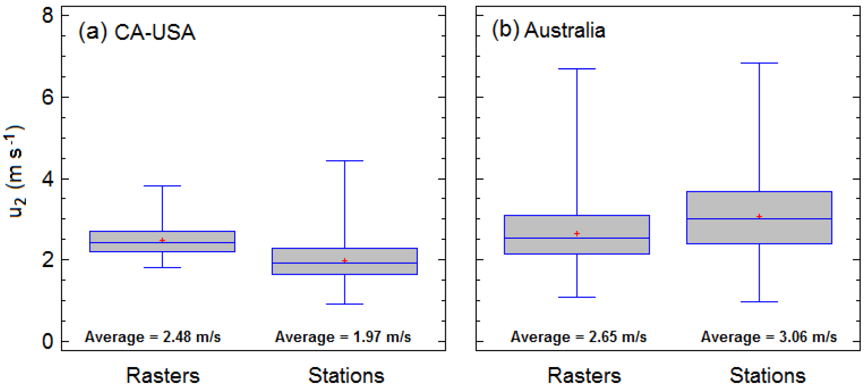

Fig. 3. FIGURE_R3

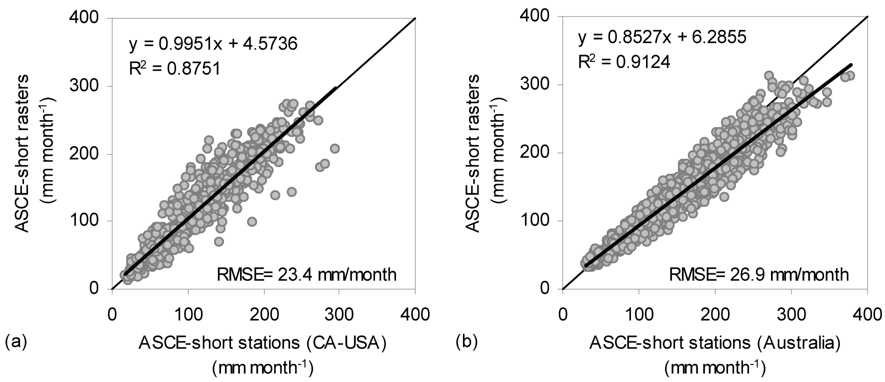

Fig. 4. FIGURE_R4

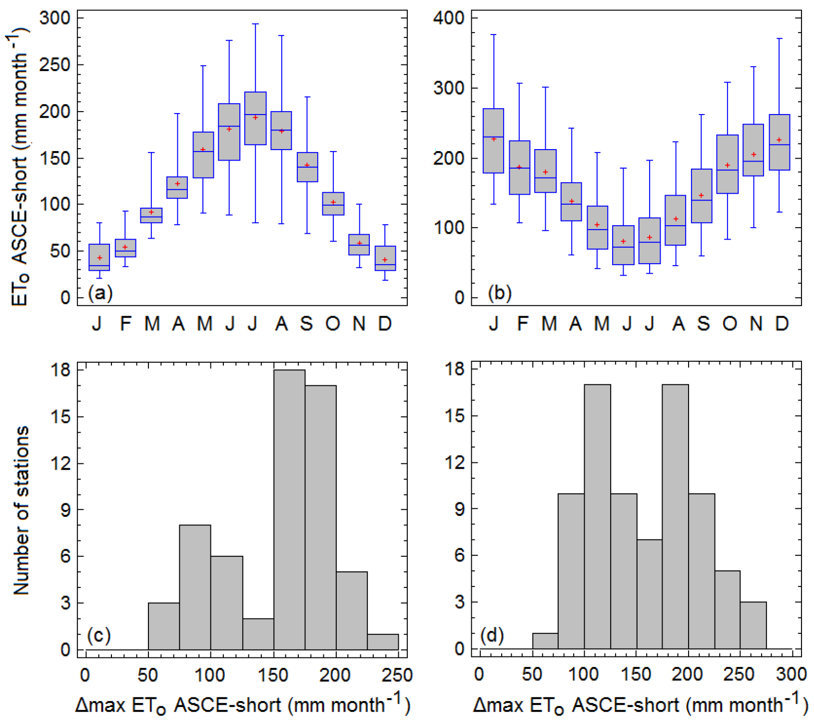

Fig. 5. FIGURE_R5

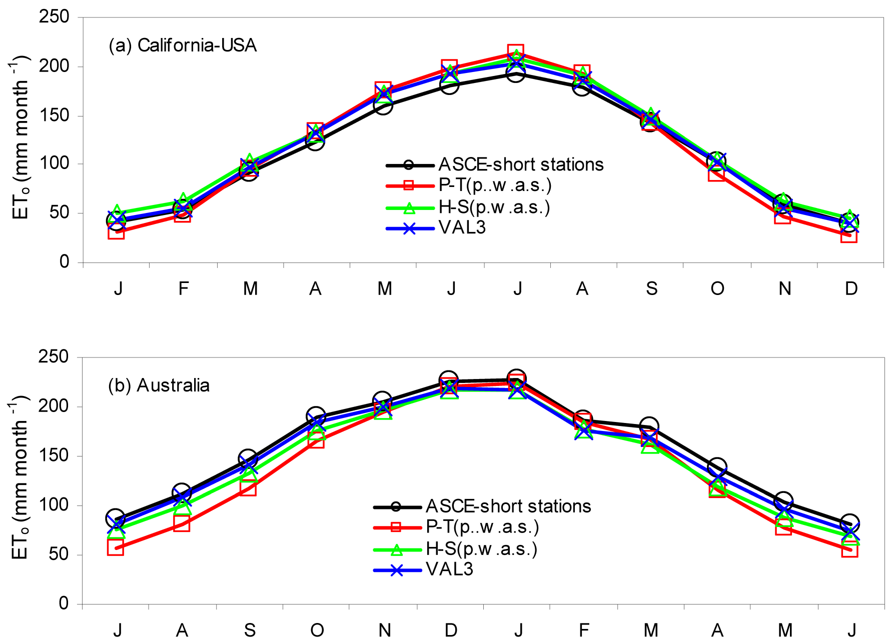

Fig. 6. FIGURE_R6

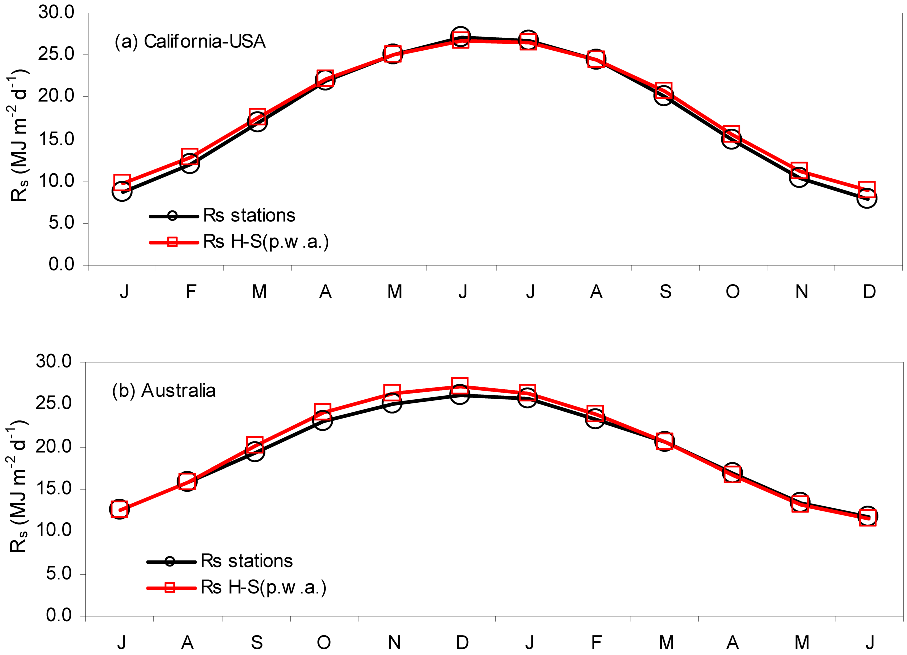

Fig. 7. FIGURE_R7