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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Trends in evaporative demand in Great Britain using high-resolution meteorological data" *by* E. L. Robinson et al.

Anonymous Referee #3

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The authors develop a high resolution data set of required meteorological grids for Great Britain (GB) and then use these to drive potential evapotranspiration (ETp) formulation, specifically Penman-Monteith (ETp_PM) to understand the drivers of changes of ETp_PM. While this manuscript (MS) has some potential to make a very solid contribution to the international understanding of drivers of large-area trends of atmospheric evaporative demand (AED – note I would use this phrase in the title), currently it does not reach that potential. The topic of the MS is very well suited for publication in HESS, yet the current MS needs much improving, via a total major overhauling revision, to ensure that the resultant MS meets the standards required for publication in HESS. I would like to see the following issues resolved / considered thus allowing me to recommend acceptance to HESS; I hope that the authors rise to the challenge. Ultimately this has the potential to be a very good and very influential HESS paper.

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Discussion paper

1) Major: while using ETp_PM to parameterise some of the resistance terms the authors have incorrectly equated Allen's FAO-56 crop reference evapotranspiration (ETo) as a form of ETp. They are different concepts, and cannot be equated. Nowhere in (Allen et al., 1998) does it suggest that ETo replaces estimates of ETp. After downloading the FAO-56 report from http://www.fao.org/docrep/X0490E/x0490e00.htm please searched for the term 'potential evaporation' and it is only found twice in the body text and in these two instances the authors are not equating crop reference evaporation with potential evaporation. Additionally in Chapter 1 of (Allen et al., 1998) they state (on page 30 of the PDF file) "The use of other denominations such as potential ET is strongly discouraged due to ambiguities in their definitions." This can be found by searching for the word 'potential' in the FAO-56 report. This illustrates basic conceptual misunderstandings.

To achieve the ultimate goal of understanding GB AED trends, there are a number of ways to improve this: (a) parameterise the ETp_PM resistances as function moisture availability; (b) use the Penman formulation of ETp (denoted ETp_P herein).

2) Major: the current use of these FAO-56 derived prescribed land surface conditions implicitly implies that the land-cover for all of GB from 1961-2012 was covered by 'A hypothetical reference crop with an assumed crop height of 0.12 m, a fixed surface resistance of 70 s m–1 and an albedo of 0.23. The reference surface closely resembles an extensive surface of green grass of uniform height, actively growing, completely shading the ground and with adequate water. The requirements that the grass surface should be extensive and uniform result from the assumption that all fluxes are one dimensional upwards' (quoted from Allen et al. FAO-56 report, 1998, p 23). When looking at time series remote sensing of albedo (e.g., AVHRR GIMMS 3g) and Lidar imagery of vegetation height (Simard et al 2011) and any GB land-cover map (e.g., http://www.ceh.ac.uk/services/land-cover-map-2007) it is obvious these assumptions are not scientifically warranted. If the authors continue to use ETp_PM then I would suggest that they parameterise the resistances in more dynamic and appropriate fash-

ion, or else they could use the ETp_P formulation.

Simard M, Pinto N, Fisher JB and A. B (2011) Mapping forest canopy height globally with spaceborne lidar. Journal of Geophysical Research 116(G04021), doi:10.1029/2011JG001708.

2a) Why not a 2014 or 2015 end date in the time series?

3) Major: what is the justification for ignoring changes in albedo? The land-cover induced changes in albedo are likely important for dynamics of AED in GB and currently these are ignored. I suggest you use AVHRR estimates of albedo which are available from 1981 to ensure that you provide realistic estimates to the calculation of net radiation. This may mean your study covers from 1981 to 2015.

4) Major: in the form of cross-plots please compare observed annual trends of the main meteorological parameters from a series of at least 50 stations across GB with the annual trends exacted from the derived grids. This would be a new figure and would provide quantitative confidence to the reader that the input grids are replicating / capturing trends observed at meteorological stations. Without such cross-plots the reader does not know how accurate your input grids are.

5) Major: to assess the accuracy of the grids you could calculate the PenPan model (Rotstayn et al 2006; Roderick et al 2007) and assess compare the observed trends with modelled PenPan trends. This would allow you to independently validate the trends of AED (which is estimated by ETp, ETo or measured by pan evaporation (Epan) rates) and would be a very strong contribution to your MS.

Roderick, M.L., Rotstayn, L.D., Farquhar, G.D., Hobbins, M.T., 2007. On the attribution of changing pan evaporation. Geophys. Res. Lett. 34, L17403. doi:10.1029/2007GL031166.

Rotstayn, L.D., Roderick, M.L., Farquhar, G.D., 2006. A simple pan-evaporation model for analysis of climate simulations: evaluation over Australia. Geophys. Res. Lett. 33,

L17715. doi:10.1029/2006GL027114.

6) Page (P) 3/Line (L) 2-9, why the strong UK / ecology focus, HESS is an international hydrology and earth system science journal not a regional hydrology and ecology journal. Improve the opening motivating comments by making them more attractive to HESS readers.

7) P3/L10, gridded meteorological datasets are not the only physical drivers of this, for example there have been changes in land-cover due to increased urbanisation in the UK since 1961 and this is also a physical driver.

8) P4/L22, what are the specific objectives of your study? That is in the last paragraph of your Introduction can you please explicitly state what your 'aim(s)' or 'objective(s)' or 'hypothesis (hypotheses)' is (are)? That is, specifically use one of these words. While you "present the method" (P4/L22), this is a little broader than having specific aims or objectives. Consider using a bulleted sentence structure to list these. Note the word 'question' is used in the following to generically mean aim / objective / hypothesis. Note the grammar of such a sentence follows (please pay careful attention to the use of colons, semi-colons and capital letters): (i) question 1 is interesting; (ii) question 2 is really interesting; and (iii) my Mum thought I should write something about question 3.

9) Improved structure: once you've explicitly used one the following words to state what your 'aim(s)' or 'objective(s)' or 'hypothesis (hypotheses)' is (are), then, assuming you have objectives, use these objectives to provide structure to your revised MS. For example, let's assume you have three objectives, then use them to structure your Methods section, Results section and Discussion sections, as follows. 1 Introduction 2 Study Site and Materials (have as many sub-headings as needed to introduce all the datasets used, their pre-processing – or maybe this needs to be 2 main headings, noting you might also need a "2 Theoretical Background" section too, in which case this would heading #3, and all others would increment by 1) 3 Methods 3.1 Objective 1 (4-8 words to summarise objective 1) 3.2 Objective 2 (4-8 words to summarise objective

2) 3.3 Objective 3 (and so on) 4 Results 4.1 Objective 1 (same words as 3.1) 4.2 Objective 2 (same words as 3.2 and so on) 4.3 Objective 3 5 Discussion 5.1 Objective 1 5.2 Objective 2 5.3 Objective 3 6 Conclusion

10) P4/L26-28. Some of these variables are likely daily extremes (such are air temperature to provide Tmax and Tmin), some could be daily averages (e.g., specific humidity) whereas others (Rs_in and Rl_in) are likely daily integrals. It would be best is you explicitly mentioned what the daily variable represents.

11) P5/L4, how do you define hours of bright sunshine? Can this be defined as Rs_in > XX W/^2? Plus also use 'precipitation' as opposed to 'rainfall' as the former is all encompassing.

12) P5/L18, what is 'too far'; please quantify this subjective phrase.

13) P5/L21, air temperature environmental lapse rates vary throughout the year (see McVicar et al, 2007, JoH, doi:10.1016/j.jhydrol.2007.02.018 and the references therein), and it would be best yours did too.

14) P6/L2, atmospheric pressure will vary with elevation and will also vary on a daily basis in GB and also on a longer-term basis in GB as a function of atmospheric stability / latitude (as you clearly show in Fig 1). This needs to be improved.

15) P6/L15, what where the empirical coefficients used?

16) P8/L27, why not calculate the daily extremes of Tair, which would be topographically corrected, and then calculate DTR = Tmax – Tmin?

17) Major: P7/L5-6, both references are to model Rl_in for clear-sky conditions. My understanding is that there are parts of GB for certain times of the year that are cloudy. This needs improvement.

18) P7/L16, you should be aware that the required topographic correction is temporally changing (McVicar et al 2010, GRL, doi:10.1029/2009GL042255).

19) P7/L23, what does 'natural neighbour interpolation' mean? This is first time I've ever seen these term, so you need to provide a citation to the algorithm or better explain what it means.

20) P9/L24, in a climate that is can be clear one day and cloudy the next day, or clear for a few days then cloudy for a few days following that, the ground (or soil) heat flux would be important. I'd prefer if you had a dynamic model for this, or at the very minimum, you need supporting citations that this is small component on cloudy days directly following several clear days in GB.

21) Major: P11/L26, yes but all of GB all year will not adhere the prescribed crop reference land-surface conditions used in FAO-56. They are very different concepts under the AED umbrella. I strongly suggest that you use AVHRR GIMMS 3g based estimates of LAI in the modelling (Zhu et al 2013).

Zhu, Z. C. et al. Global Data Sets of Vegetation Leaf Area Index (LAI)3g and Fraction of Photosynthetically Active Radiation (FPAR)3g Derived from Global Inventory Modeling and Mapping Studies (GIMMS) Normalized Difference Vegetation Index (NDVI3g) for the Period 1981 to 2011. Remote Sensing 5, 927–948, doi: 10.3390/rs5020927 (2013).

22) P11/L27, some recent papers have made head-way into the interception issue, and you may find them of value.

F.L. Pereira, F. Valente, J.S. David, N. Jackson, F. Minunno and J.H. Gash (2016) Rainfall interception modelling: Is the wet bulb approach adequate to estimate mean evaporation rate from wet/saturated canopies in all forest types? Journal of Hydrology 534 (2016) 606–615, http://dx.doi.org/10.1016/j.jhydrol.2016.01.035

van Dijk, A.I.J.M., Gash, J.H., van Gorsel, E., Blanken, P.D., Cescatti, A., Emmel, C., Gielen, B., Harman, I.N., Kiely, G., Merbold, L., Montagnani, L., Moors, E., Sottocornola, M., Varlagin, A., Williams, C.A., Wohlfahrt, G., 2015. Rainfall interception and the coupled surface water and energy balance. Agric. For. Meteorol. 214–215,

402–415. http://dx.doi.org/10.1016/j.agrformet.2015.09.006.

Zhang, Y., Peña-Arancibia, J.L., McVicar, T.R., Chiew, F.H.S., Vaze, J., Liu, C., Lu, X., Zheng, H., Wang, Y., Liu, Y.Y., Miralles, D.G., Pan, M., 2016. Multi-decadal trends in global terrestrial evapotranspiration and its components. Sci. Rep. 6, 19124. http://dx.doi.org/10.1038/srep19124.

23) P12/L26, the aridity index has been around for a long time, I suggest more historic references could be used here, see Oldekop (1911) whose scientific contribution is the basis for the following.

Vazken Andréassian, Ülo Mander, Taavi Pae (2016) The Budyko hypothesis before Budyko: The hydrological legacy of Evald Oldekop. Journal of Hydrology 535 (2016) 386–391, http://dx.doi.org/10.1016/j.jhydrol.2016.02.002

24) P13/L3, these areas are considered 'equitant', those that straddle the water-limited and energy-limited regimes, see McVicar et al 2012, Ecohydrology, doi:10.1002/eco.1298).

25) P23/L23-25, you should mention that these findings are using reanalysis output as input, and that these outputs have been shown to have limited capacity to capture trends in a key aerodynamic variable, wind speed, and that this limitation has been documented in the both northern (Pryor et al., 2009, JGR-Atm, doi:10.1029/2008JD011416) and southern (McVicar et al , 2008, GRL, doi:10.1029/2008GL035627) hemispheres.

26) P16/L12-15, these is certainly very interesting ecological insights, yet given that HESS is an international hydrology and earth system science journal not a regional hydrology and ecology journal I question the value to the HESS readership.

27) I would like a very short Conclusion section (note singular like your Introduction section, with both containing multiple ideas) added.

28) Table 1, for the radiation components while in essence they are assumed to be

representative of being at the surface (i.e., 0 m height) they are usually observed at 1.2 m (or thereabouts) above the land-surface.

29) Figure 1, place parts (a) to (h) on sub-plots and then use these in the caption and in the text. For wind it's all uniform, can you reduce the range shown to have more colours on the sub-plot. In Scotland there is an area with low specific humidity, yet some of this area has very high daily precipitation; is this correct? What is happening here?

30) Some of the maps could be made larger to fill both columns of the HESS published page.

31) Figure 7, it would be useful to provide the equation for the GB linear regression. You wish to consider providing the other regional linear regression statistics in the Supplementary Material; these are hard number that other may cite. Also for Figure 8

32) Figure 11, what to the left-most bars in each of the sub-plot indicate? I've read the caption four times and don't get it, I've asked a colleague and they read it 3 times and did not get it. I mean what is the non-coloured bar that is the left-most on each sub-plot mean? In the top-left sub-plot, you have two bars for ETp_PM for England, the left-most is only black and the one directly next to it has pink background for part of it; what is the difference between these two.

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