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Discussions

Interactive comment on "Satellite based analysis of recent trends in the ecohydrology of a semi-arid region" *by* M. Gokmen et al.

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Reflections to the comments of Reviewer # 2

The authors would like to thank Reviewer 2 for his/her valuable and constructive comments. We have considered the comments of Reviewer 2, and hereby try to correspond to them within our knowledge. Based on the comments, we also made the necessary revisions in the manuscript, the quality of which has improved considerably. We hope that our replies and revisions will satisfy the Reviewer.

Anonymous Referee #2 This study analyzes the trends in the actual and potential evapotranspiration (ET), precipitation and a vegetation index (NDVI) in an endorheic basin (Konya) in central Turkeyfor the eleven-year period between 2000 and 2010. The study

utilizes data from different sources including satellite-based products, surface meteorological observations and reanalysis data. Although the data have different resolutions, they were interpolated to a common resolution of 1 km, a relatively high resolution amongst such studies. The major ïňĄndings of the study are that both ET and NDVI increase over the croplands while they decrease over the wetlands during the period, and that these changes occur in spite of the fact that neither precipitation nor potential ET changes over the same period. The manuscript is well written, and the topic is interesting and a worthwhile contribution to the ïňĄeld, therefore I recommend the publication of the paper. Nevertheless, I would like the authors to address the following points, which, I think, may help improve the paper a bit further.

1. The period is relatively short for a trend analysis, especially when the climate parameters are considered. The reason for this (satellite data availability) has been mentioned in the paper. Also mentioned is the fact that there are other studies that considered short periods in their trend analysis. These are ïňĄne. I just wonder, though, how the temporal change of some parameters look for the signiïňĄcant change areas. Is it possible to make a plot that shows the temporal change in the parameters for irrigated crop and wetlands, for instance? The climate events such as drought may have a signiïňĄcant impact on the trends when relatively short periods are considered (see for instance, Voss, K. A., J. S. Famiglietti, M. Lo, C. de Linage, M. Rodell, and S. C. Swenson (2013), Groundwater depletion in the Middle East from GRACE with implications for transboundary water management in the Tigris-Euphrates-Western Iran region, Water Resour. Res., 49, doi:10.1002/wrcr.20078).

Reply of the Authors (1):

As requested by the author, we plotted the temporal changes in ET, P, NDVI and P corrected ET (ET-P) for irrigated crops and wetlands. In the plots, we considered the significant changes areas ($p<0.1$) for ET for all the parameters to enable inter-comparison. Firstly below set of figures show the temporal changes in the average ET, P, ET-P and NDVI for irrigated crops. Based on the temporal changes of P, the years 2009 and 2010 are noticed as the wettest while 2008 is the driest. The effect of wet and dry years can be clearly noticed when we plot the temporal change of ET-P (as an indication of the supplementary irrigation to the cropland). The deviations in the supplementary irrigation can be clearly seen in the driest 2008 (much higher supplementary irrigation), and in the wettest 2009 and 2010 (much less supplementary irrigation). With respect to the temporal changes of NDVI, a consistent increase with little variation is observed, confirming intensification of irrigated agriculture irrespective of drought.

[Figure 1 somewhere here]

Fig. 1 The temporal changes in ET, P, ET-P and NDVI for irrigated crops in the signiïňĄcant change areas ($p<0.1$ for ET).

Also for the wetlands (below figure), the effect of wet years (i.e. 2009 and 2010) is clearly observed in the ET temporal changes as deviation from the decreasing trend. When we subtract P from ET, R2 increases from 0.36 to 0.55 together with an increase in the slope of the decrease. The average NDVI for wetland (in the significant change areas for ET) show relatively slighter decreasing trend, which can be partly attributed to the wettening in the last two years of the study period.

[Figure 2 somewhere here]

Fig. 2 The temporal changes in ET, P, ET-P and NDVI for wetlands in the signiïňĄcant change areas ($p<0.1$ for ET).

2. I am not quite sure whether the following sentence in the abstract (and other sections) is justiïňĄed by the ïňĄndings of this study, given the fact that the study does not involve a complete water budget calculation for the basin: ": : :which in turn caused drying out of the some of the wetlands and the natural vegetation which mostly depend on the groundwater, the main source of irrigation water as well." The link is through groundwater, and the study is not quantitative in that regard. The sketch in Figure 13 is good but it is subjective.

Reply of the Authors (2):

As noted by the Reviewer, this study does not include a complete water budget estimation for the basin. In fact, prior to this study, we had also conducted a spatially distributed water budget calculation, which is in publication with below reference:

Gokmen, M., Vekerdy, Z., Lubczynski, M. W., Timmermans, J., Batelaan, O., and Verhoef, W.: Assessing groundwater storage changes using RS-based evapotranspiration and precipitation at a large semi-arid basin scale, Journal of Hydrometeorology, 2013, (in publication).

Independent from the above mentioned study, the mentioned statement in the Abstract is based on following findings of the current study:

1) According to Fig. 11b, in the wetlands (polygons with purple colour), there is no correlation between ET and P, implying that the wetlands receive either supplementary groundwater and/or surface water inputs to sustain the excess ET.

2) Groundwater abstraction for irrigation is a fact in the region as shown by the distribution of wells in Fig. 2b (more than 90,000 wells according to the inventory of regional water authority, DSI)

3) Inter-comparison of ET and NDVI trends per different land covers in Figure 14 (will be Fig. 15 in the revised manuscript) consistently reveal that there is significant ET and NDVI increases in the croplands, while the significant decreasing trend of both ET and NDVI occurred in the wetlands.

4) The decreasing trend of ET and NDVI over wetlands cannot be explained by the trends in P or PET according to Figs 12c and d (Figs 13a and b in the revised manuscript). Based on the above findings, it was our conclusion that the contrasting trends between croplands and wetlands (both NDVI and ET) can mainly be explained by the competition for the same depleting water resources (i.e. groundwater), as shown in the conceptual diagram in Fig 13 (Fig. 14 in the revised manuscript). If the argu-

ments are not found sufficient to suggest such a statement, we can also remove it.

3. I think it would be better to give more information (more than citing a reference) about the model evaluation because this study depends heavily on model estimated ET, and the reader readily needs to know more on the model performance.

Reply of the Authors (3):

The following explanation will be added in the ET data description section (section 2.3.1) at p. 6202 lines after 18:

"Gokmen et al. (2012) reported an overall relative error (rRMSE) of 26% for SEBS-SM (which was originally 36% for SEBS) according to the comparisons with observations from the Bowen ratio stations installed in in the Konya basin. With respect to the yearly ET, SEBS-SM estimated a lower yearly ET than the original SEBS depending on the water stress conditions. The magnitude of lowering by SEBS-SM was proportional to the aridity of the area (mean: ∼-120 mm, max: ∼-400 mm), and was better matching with the low yearly precipitation values in these areas (Gokmen et al., 2013)."

4. One of the shortcomings of this study is that it depends on LCLU map that represents the 2006 conditions. We don't know how the LCLU and/or crop pattern changed in the basin over the period. Did you attempt to obtain/produce LCLU maps from satellite observations?

Reply of the Authors (4):

We did not attempt to produce LCLU maps in the context of this study mainly due to following reasons:

- The use of moderate size spatial resolution (i.e. 1 km) as the base of spatially distributed analysis. For such a medium scale, mixed-pixel effect would anyway cause problems in the land cover based assessment of the trends even if we obtained the LCLU maps of different periods because of the heterogeneous and patchy distribution of croplands.

- The land cover data we used was obtained from the Ministry of Environment of Turkey, who implemented a large scale project (covering the whole country) to prepare LCLU maps according to CORINE standards using relatively high resolution RS data (SPOT data with 30 m resolution) combining with topographic, soil maps and field data. Producing and validating the accuracy of such LCLU maps in the context of our study was not feasible in terms of cost and time.

- In addition, the common practice of crop rotations (e.g. sugar beet is generally grown once in every five years in a field) complicates the assessment of LCLU changes using simplified methods.

- Finally, it's our plan to assess LCLU, crop pattern and the related eco-hydrological changes in further detail using finer scale RS data (e.g. LANDSAT, ASTER) in future.

5. How do you explain ET becoming smaller over Lake Beysehir?

Reply of the Authors (5):

There are two possible explanations for the decreasing of ET over Lake Beysehir:

1. As it can be seen in Fig. 12d (cross-relation of ET vs. P trends), there is decreasing trend of P ($p < 0.25$) in the northwest of Lake Beysehir, which also partly cover the lake surface. Because Lake Beysehir is a shallow lake (max. depth is 10 m), the surface area of the lake changes depending on the water input to the lake. As a result, the decreasing trend of P in and around the lake can possibly cause decrease in the depth and surface area of the lake, and the overall ET from the lake.

2. In addition, Lake Beysehir is an important water resource to provide drinking and irrigation water and its outflow is managed by the water authority. Any increase in the water uptakes from the lake can also cause reductions in the depth and surface area of the lake, affecting the ET from the lake.

Despite these general explanations, there is still need for a detailed research to reveal the interacting control of the lake characteristics (e.g. depth, mixing, turbidity) and weather conditions (i.e. wind, air temperature, radiation) on the dynamics of evaporation from the shallow lakes.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 6193, 2013.

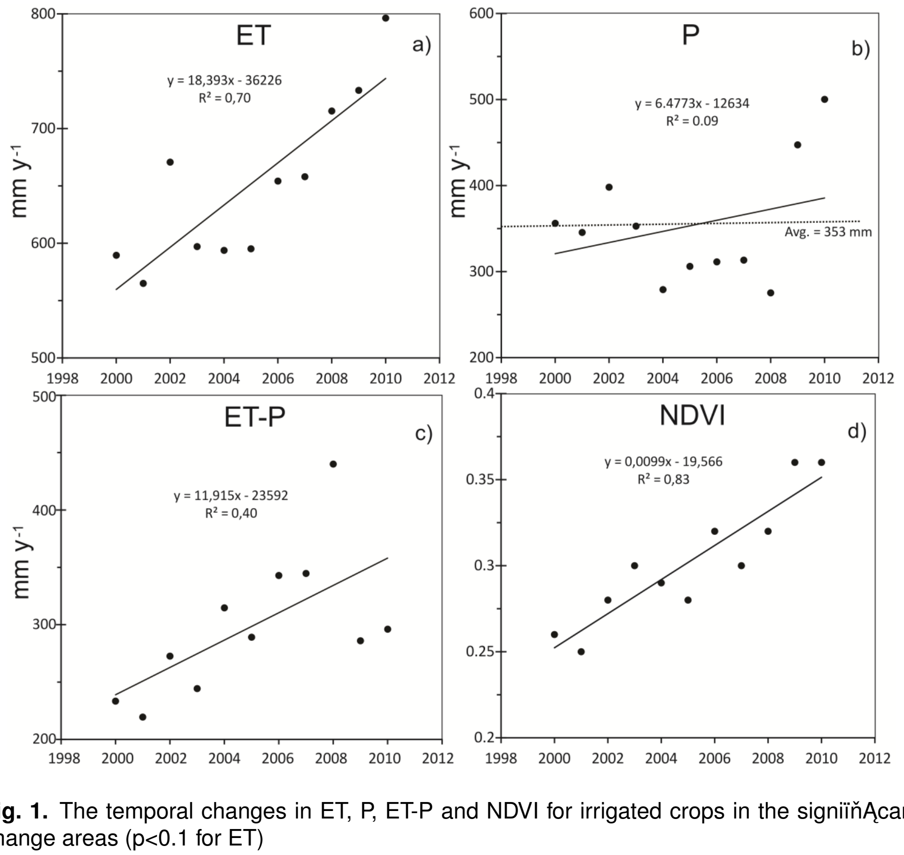

Fig. 1. The temporal changes in ET, P, ET-P and NDVI for irrigated crops in the signiïňĄcant change areas ($p<0.1$ for ET)

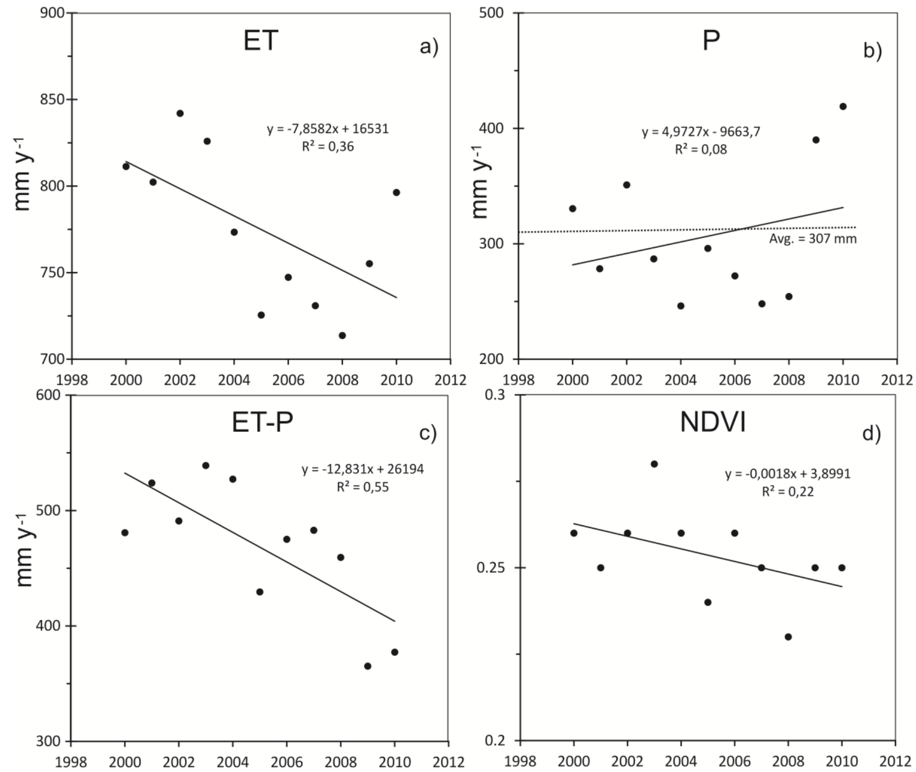

Fig. 2. The temporal changes in ET, P, ET-P and NDVI for wetlands in the signiïňĄcant change areas ($p<0.1$ for ET)