

Anonymous Referee #1

Comment

The present article deals with aridity in Pakistan, certainly an important issue that merits publication in HESS. However, in its present form, this MS has too many drawbacks and a very limited benefit to the readers.

Reply

Thanks for your valuable time and constructive comments on our manuscript. The manuscript has now been revised according to the comments. The details of the revisions made are given under each comment. Revisions are marked in Red.

Comment

This is due to several reasons such as, confusing definitions of the two seasons Rabi and Kharif (p.23, 1.21-25). Once Rabi is defined as Nov.-May and later as Dec-Mar.; Kharif is defined as Apr.-Oct. and then as Jun.-Sep. To which definition one should refer?

Reply

In order to avoid the confusion, we have defined both in section “2.1 Description of the Study Area” as below:

“Rabi and Kharif are the two major cropping seasons of Pakistan (Chaudhry and Rasul, 2004). The Rabi season commences in November and finishes in May while the Kharif season starts in April and finishes in October (Nabeel and Athar, 2018). Besides cropping seasons, there are two major rainy seasons, i.e. winter and monsoon which coincide with the Rabi and Kharif season. Winter precipitation begins in December and lasts till March is important for Rabi crops while Monsoon precipitation begins in June and lasts till September is important for Kharif crops. Winter precipitation occurs due to the moist wind from the Mediterranean Sea in the west and north of Pakistan (Hussain and Lee, 2014). On the other hand, monsoon precipitation occurs due to the moist wind from the Bay of Bengal which contributes 60% of total precipitation of the country (Sheikh, 2001). The agro-economy and the livelihood of farmers constituting 43% of the total population of Pakistan depend on winter and monsoon precipitation (Ahmed et al., 2018a).”

Comment

Non-comparable presented maps and partial information in some charts. Figure 1 - I assume that the six different height categories were selected in order to present equal areas in each category. This caused that range of each category is arbitrary and unusual. However, I could cope with this figure as we don't have to compare it to other maps. It is more severe with the rest of the maps. Figure 2 - The same problem as with the previous.

It is impossible to compare among the precipitation maps (2a-2c) or the PET maps (2d-2f) in the different seasons. Furthermore, I suggest the authors to present the precipitation and the PET in the different seasons (2b-2c and 2e-2f, respectively) as a percentage of the annual totals and not as absolute values. This will be more explicit. In their present form, these maps are completely useless.

Reply

Thanks for your suggestion. We have revised figure 2b-2c and 2e-2f as a percentage of annual totals of precipitation and PET as below:

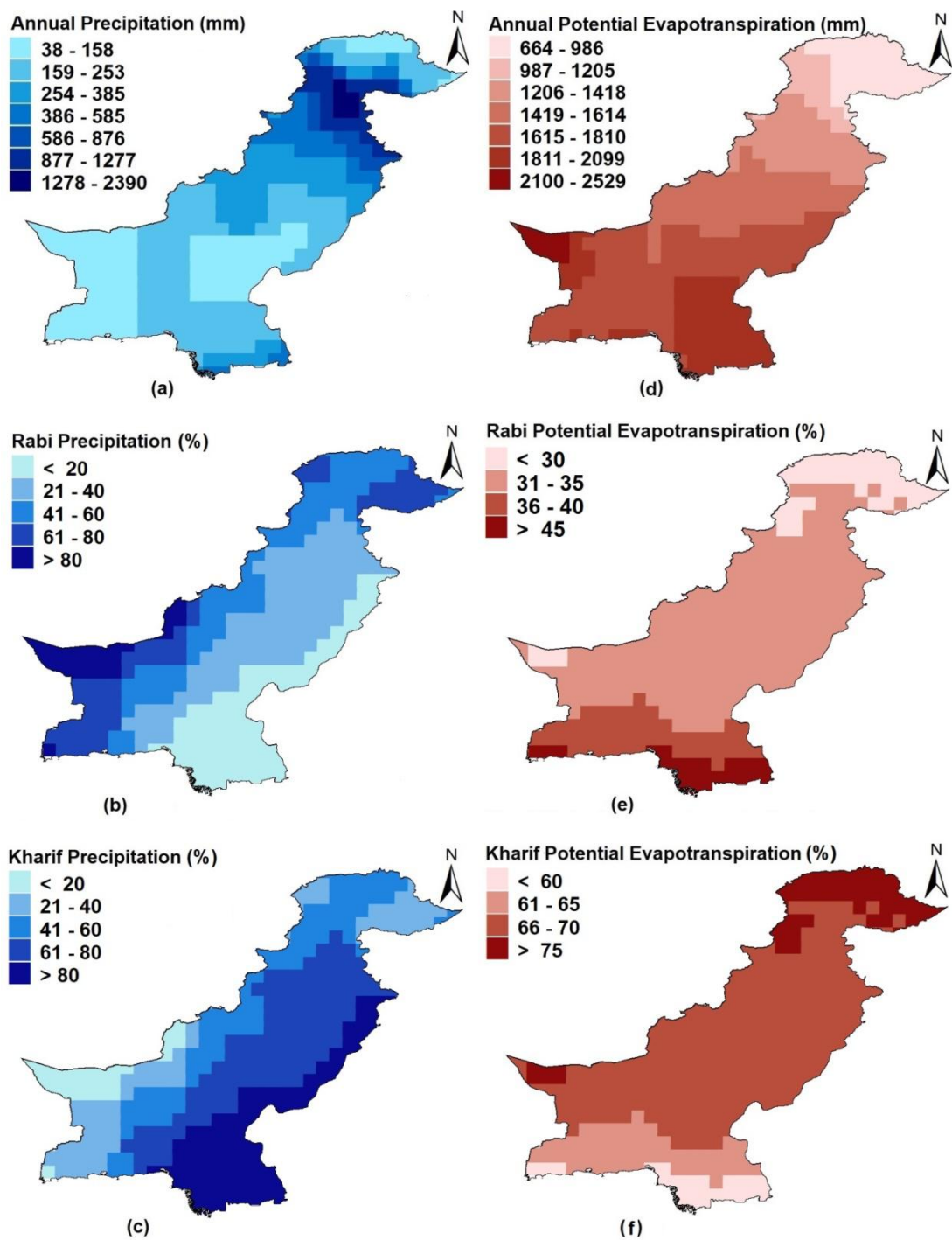


Figure 2. Spatial distribution of (a) annual, (b) Rabi and (c) Kharif precipitation; and (d) annual, (e) Rabi and (f) Kharif potential evapotranspiration in Pakistan

Comment

Section 4.5 and Figure 6 and 7 – The authors present a moving average of 11 years of aridity, precipitation and PET trends. I don't understand why they chose increments of 50 years, why not calculate a moving average of 11 yrs. (or any other duration) for the entire period? Such a calculation would result in a less "fuzzy" behavior of the trends and enable to better locate the drier or wetter periods. Apparently there is no reason to assume that trends change with increments of 50 years.

Reply

To omit the confusion, we have added a new sub-section (3.4) to describe the issue of 50 years moving window with 11- years interval in method section for clarity as below:

“3.4 Relationship of Aridity Trends with Precipitation and PET

The relationships of precipitation and PET with aridity are assessed using a moving window of 50-year with 11-year interval over the study period, i.e., 1901-1950, 1912-1961, 1923-1972, 1934-1983, 1945-1994, 1956-2005 and 1967-2016. The main purpose of considering a 50-year window is to decipher the changing pattern in the relationship over the study period. The 11-year interval was considered to assess the relationship for the whole period (1901-2016).”

Besides 50-years moving window, we also assessed the aridity, precipitation and PET trends for the period 1901 to 2016 and presented results in section 4.2.

Comment

Furthermore, a comparison of Figures 6 and 7 reveals that the trends during Kharif are by far more important in determining the entire year trends. Figure 7 is misleading as the vertical axes of a, b and c (Rabi) are different from those of d, e and f (Kharif) and give the impression of trends of the same order of magnitude in both period, which is not the case.

Reply

Thanks for the comment. To avoid the confusion, we have revised figure by keeping same vertical axis in figure 8 and 9 (previously figures 6 and 7). Furthermore reviewer 2 suggested using neutral color as below:

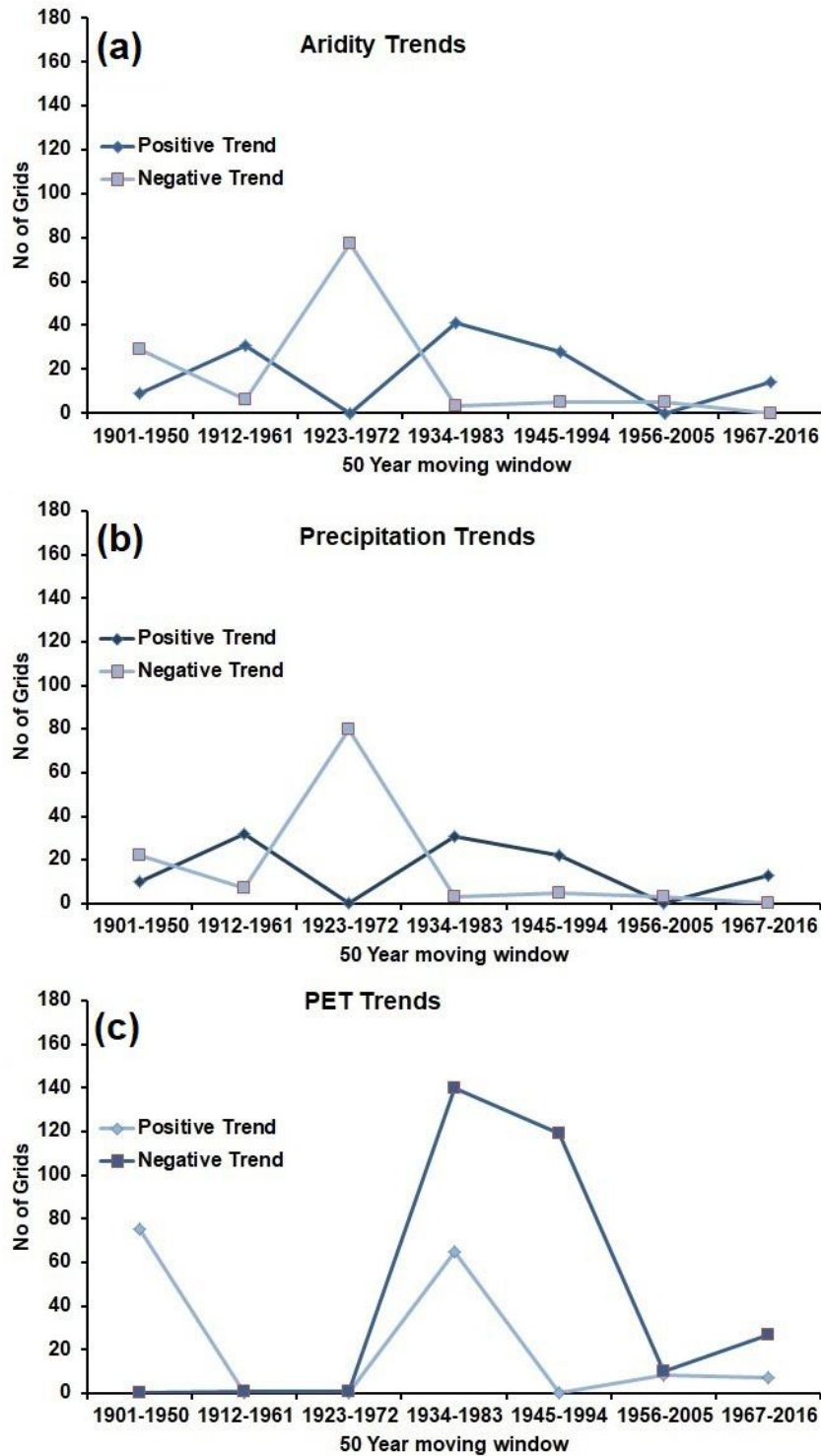


Figure 8. Number of grids where annual aridity, precipitation and PET are changed **significantly** during different time periods

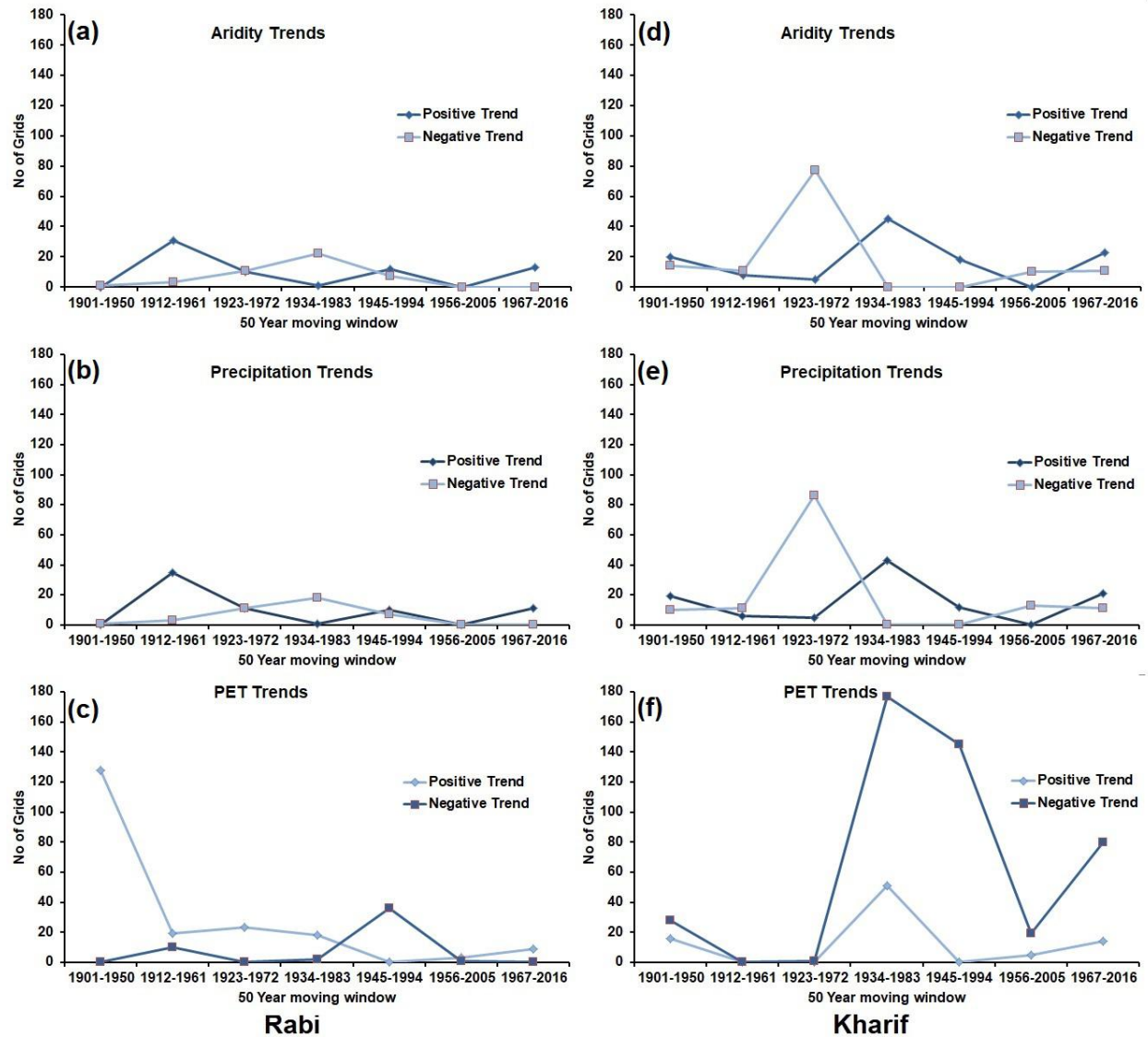


Figure 9. Number of grids where annual Rabi and Kharif aridity, precipitation and PET are changed significantly during different time periods

Comment

The results presented in Figure 8 and Table 1 contradict the postulated in the introduction regarding increased aridity in Pakistan (p.2) and the results cited from Haider and Adman (2014). Overall there is no tendency over the majority of the territory (88%) and in those regions with a tendency it is mainly towards a reduction in aridity. Therefore,

large parts of the introduction are irrelevant. Concluding that aridity depends mainly on precipitation (p.23, 1-14-15) is very trivial.

Reply

Thanks for your comment. We have addressed the issue in introduction section as below:

“Both increasing and decreasing trend in aridity has been reported in different regions of the world due to climate change. Several studies reported an increase in aridity in global (Dai, 2013; Trenberth et al., 2014) and regional (Ramarao et al., 2018; Jiao et al., 2016) scales. On the other hand, decrease in aridity is also reported in USA (Finkel et al., 2016), China (Yin et al., 2018) and some regions of Iran (Tabari and Taleae, 2013). In recent years, an increase in aridity in some regions of Pakistan has been reported (Haider and Adnan, 2014). However, it was just anticipation based on the assumption that rising temperature has intensified PET and thus an increase in aridity. The magnitude of temperature rises and the changes in regional precipitation pattern determines the changes in the aridity of an area. Therefore, it is required to assess the changes in aridity in regional scale considering the changes in both temperature and precipitation due to global warming.

Also to this, the issue of reduction in aridity is discussed in discussion section as below:

“The aridity is found to increase (drier) and decrease (wetter) in different regions and seasons with the changes in precipitation and PET. Overall, 11.75%, 7.57%, and 9.66% areas are found to shift to wetter while 0.52%, 4.44%, and 0.52% areas to drier condition for annual, Rabi and Kharif respectively. It is important to mention that a large area has a wetter trend in recent years particularly in the semi-arid or sub-humid regions which mean more area become wetter in recent years. However, some areas in the arid region are found to become drier. This indicates that few dry regions are becoming drier and a large relatively wet area is becoming wetter. A similar finding has been reported by Liu et al. (2018b) in neighbouring China. Overall, a large area in the northeast of Pakistan has become wetter and a few locations in the south become dried during 1901 - 2016.”

Also in conclusion:

“(6) Overall, there is a wetting tendency over a large area in the northeast and drying tendency at few locations in the southwest. Therefore, it can be remarked that Pakistan has become wetter from 1901 to 2016.”

Besides, we re-structured the sentences to mention in result that the changes in precipitation have a higher impact compared to PET in determining the aridity of Pakistan. In conclusion, we mentioned:

“The time-varying trends in aridity reveal that the influence of precipitation is high on the aridity compared with PET.”

Comment

The authors should consider editing the text by a native English speaker.

Reply

Thanks for your comment. The manuscript has now been proofread by a native English speaker. All the grammatical mistakes have been corrected. The English language has been improved.