Response to Anonymous Referee #1

Authors would like to thank the anonymous referee #1 for the detailed review and useful comments which certainly improve the manuscript. Modifications and improvements are incorporated in the revised version of the paper as mentioned below for each of the comments.

General comments

Comment: This kind of analysis, however, is insufficient to warrant publication in HESS. There is a long history and a vast literature on empirical Indian monsoon prediction, which the study could have drawn from methodologically. Instead, the authors merely provide little more than a data mining study for the numerous variables involved. Exploiting the correlations for a proper statistical model would have been the step necessary for a valuable HESS contribution. From the authors' own suggestion: "The developed relationships between rainfall and indices or large-scale atmospheric variables would be useful in the development of rainfall forecasting models as presented in Singhrattna et al. (2005b) and Zehe et al. (2006b)."

Response: The literatures on the Indian monsoon have been considered and included in the manuscript. Since temperature influences atmospheric circulation and monsoon rainfall (Mason and Goddard, 2001; Smith and O'Brien, 2001; Saravanan and Chang, 2000; Harshburger et al., 2002; Gershunov, 1998), this paper develops relationships between rainfall in the study basin and large-scale SST anomalous indices. In the revision, the modified k-nn model is developed to forecast rainfall with the identified SST indices. The relationships with other large-scale atmospheric variables are currently being investigated which ultimately will lead to development of a statistical model to forecast rainfall with a set of selected predictors including large-scale SST. Authors plan to submit a separate paper in near future.

Gershunov, A.: ENSO influence on intraseasonal extreme rainfall and temperature frequencies in the contiguous United States: Implications for long-range predictability, J. Climate, 11, 3192-3203, 1998.

Harshburger, B., Ye, H., and Dzialoski, J.: Observation evidence of the influence of Pacific SSTs on winter precipitation and spring stream discharge in Idaho, J. Hydrol., 246, 157-169, 2002.

Mason, S. J., and Goddard, L.: Probabilistic precipitation anomalies associated with ENSO, B. Am. Meteorol. Soc., 82, 619-638, 2001.

Saravanan, R., and Chang, P.: Interaction between tropical Atlantic variability and El Niño-Southern Oscillation, J. Climate, 13, 2177-2194, 2000.

Smith, S. R., and O'Brien, J. J.: Regional snowfall distributions associated with ENSO: Implications for seasonal forecasting, B. Am. Meteorol. Soc., 82, 1179-1191, 2001.

Revision: In the Introduction section in the revised manuscript, authors have cited the above papers to show the evidence of influences by the anomalous SST on the monsoon rainfall via the atmospheric circulations. The literatures on the Indian monsoon have been also included in the manuscript. Please see the Introduction section of the revision. In addition, for the contribution of HESS publication, authors have proposed the nonparametric model, namely, modified k-nn model to simulate rainfall at each selected stations using the identified predictors from the cross-correlation analysis. Please see section 4.3 in the revised manuscript.

Specific comments

Comment: The abstract is overloaded.
Response: The abstract will be shortened.
Revision: The abstract is shortened in the revision. Please see the revised paper.

Comment: The introduction misses outlaying the main purpose of the study. So it remains unclear whether the topic is seasonal weather forecast (e.g.) or climate change.
Response: The paper is on seasonal weather forecast. The introduction is improved to reflect this clearly.
Revision: The purpose of the study which is development of relationships between rainfall and SST indices and the rainfall forecasting is made clear in the revision. The relevant text in the Introduction section reads as "…The links between large-scale atmospheric variables and local hydroclimates are widely studied and reported to diagnose the variability of regional hydroclimate…".

Comment: Selecting from a set of 36000 calculated correlations those that are "significant" is a rather poor and misleading undertaking, because for any given significance level p, p percent would turn out to be significant by pure chance - which in this case would be as much as 1800. This may explain some of a number of inconclusive results of the study (such as the large September-October difference).
Response: This is a good suggestion. We have to admit that we did not consider this aspect. However, to improve the methodology, the predictor selection can be done associated with the maximum absolute correlations for each SST index from 12 lag periods and indicating the significant levels of those correlations. In the revised manuscript, these results is presented and discussed with respect to the significant levels of identified predictors and corresponding lead periods.
Revision: The approach and methodology of predictor selection is changed in the revision. The identified predictors are associated with the maximum absolute correlations from five indices and 12 lead periods. The predictors are selected for each month of rainfall and individual stations. Please see section 4.2 in the revised manuscript for details.

Comment: The actual size of the correlations is often not reported (only whether being significantly nonzero). Similarly, negative and positive correlations are treated equally, which is somewhat counter intuitive and needs explanation.
Response: The actual correlations are reported in the revised paper. The positive and negative correlations are treated equally with respect to their relationships but they reflect the significance and corresponding lead periods of indices.
Revision: In the revision, the actual correlations and the corresponding significant levels are reported (see Table 2). The negative and positive correlations are explained in detail in section 4.2. The relevant text reads as "…The positive and negative correlations are treated equally with respect to their relationships, but they reflect the significance and corresponding lead periods of indices…".

Technical details

Comment: 6660, 21: Is the first sentence (the study) about seasonal forecasts or climate change?

Response: The study is about seasonal forecasts. This is corrected in the revised paper.
Revision: The first sentence is revised accordingly and now reads as "…The links between large-scale atmospheric variables and local hydroclimates are widely studied and reported to diagnose the variability of regional hydroclimate…".

Comment: 6661, 16: Consider to move paragraph up.
Response: This was considered but finally not moved.
Revision: The paragraph is kept as it was in the original manuscript to have logical flow of text.

Comment: 6665, 12: In this context one would like to know how large the correlation actually is, and not whether it is significantly nonzero.
Response: The cross-correlations of monthly rainfall among selected stations ranged between 0.462 and 0.959. This information is included in the revision.
Revision: The range of correlation coefficients is included in the revised manuscript. The text in section 4.1 reads as "…since monthly rainfall of all selected stations are well correlated at 95% significance level by the Fisher's Transformation (Haan, 2002) with the coefficients of correlation varying from 0.46 to 0.96,…".

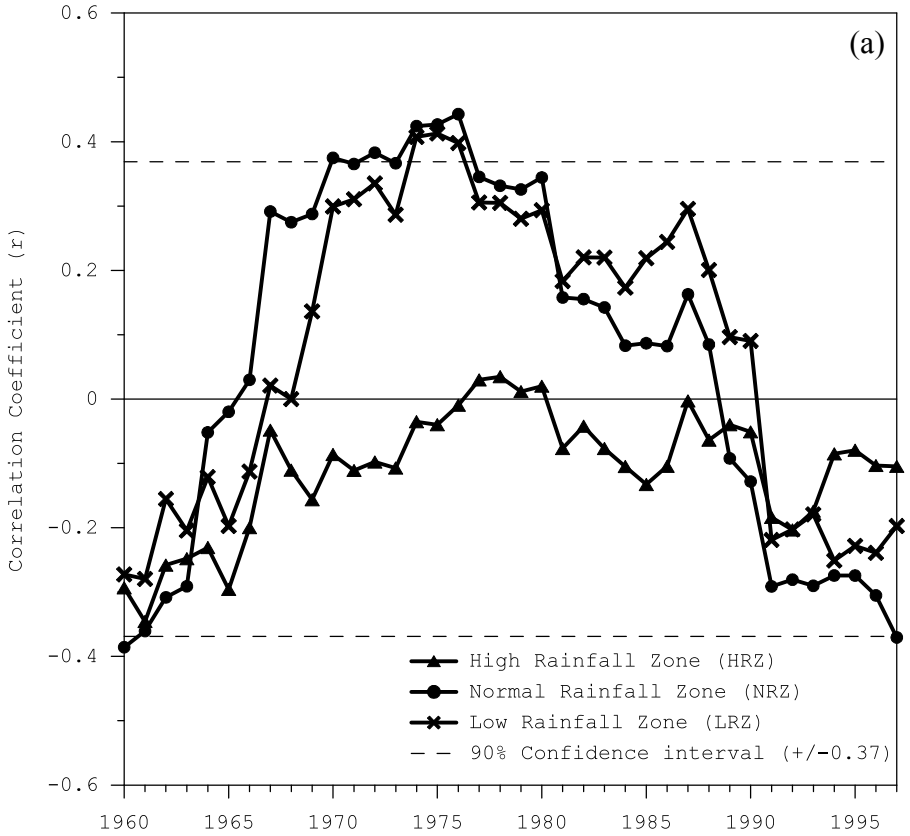
Comment: 6666, 5: This procedure is highly problematic. Choosing from so many candidate correlations is bound to render a considerable amount of them as spurious, depending on the chosen significance level.
Response: The methodology for selection of predictor in the revision considers the maximum absolute values of correlations of each index among 12 lead periods and will indicate the significant levels of the selected correlations.
Revision: The manuscript is revised and the predictors are selected based on the maximum absolute correlations from five indices and 12 lead periods for each of the 12 months and 50 stations in the study area. The confidence levels of correlations are also reported. Please see section 4.2 in the revised manuscript.

Comment: 6667, 19: Please specify exactly what is meant by "±0.26". - Fig. 5 is stretched horizontally so that the displayed correspondence of variables is misleading.
Response: The +0.26 and -0.26 are the upper and lower bound of the 95% confidence levels of correlation.
Fig. 5 is presented in the same range of x-axis (rainfall) to compare the amount of dry season rainfall among three zones.
Revision: The explanation of "±0.26" is included in section 5.1.2 in the revision and reads as "…Figure 5 shows a strong inverse relationship between the dry season rainfall and MAM temperature with significance at 95% confidence level which the upper and lower bound of significance is +0.26 and -0.26, respectively…".
No revision is made in Fig. 5.

Comment: 6667, 23: Why do you show a moving window here instead of total correlations?
Response: The moving window correlations can show the variability and development of relationships between temperature and rainfall over decades, whereas the total correlations obtained from the entire time series cannot show the changes of their interdecadal relationships.

Revision: The reason of doing the moving correlations is described and included in section 5.1.2 of the revised manuscript. The relevant text reads as "…Figure 6 shows the 20-year moving window correlations between the MAM air temperature and the MJJ and ASO rainfall to address the variability and development of relationships over decades…"

Comment: 6667, 26: You explained how temperatures can drive monsoon precipitation. But what is 'vice versa' here? In Fig. 6, the curves are hardly distinguishable.
Response: The meaning of "vice versa" is …if the air temperature during MAM is low, the MJJ and ASO rainfall are expected to decrease. This is clearly described in the revised manuscript.
The legends in Fig. 6 are changed to make it more distinguishable.
Revision: The "vice versa" is deleted to avoid ambiguity and it has been clearly described. The revised text now reads "…For the NRZ and LRZ, as the positive correlations indicate, the higher MAM air temperature increases the MJJ and ASO rainfall, whereas the lower MAM air temperature decreases the MJJ and ASO rainfall…".
The legends in Fig. 6 are changed to make the curves distinguishable as shown below.



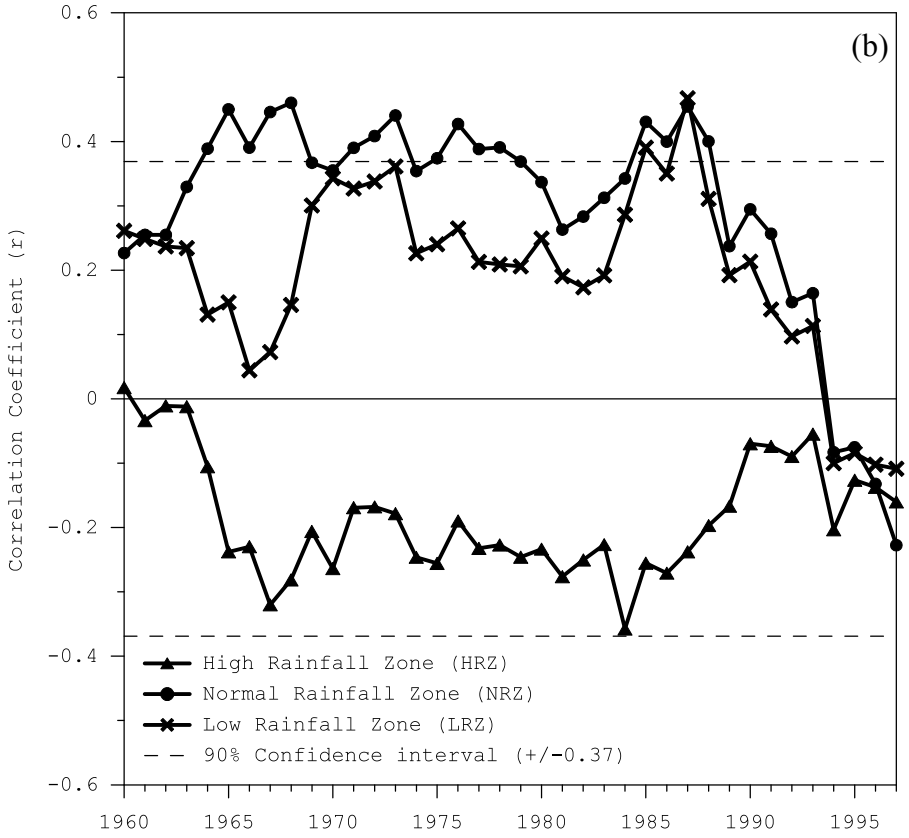


Figure 6. Correlations of 20-year moving window between MAM temperature and (a) MJJ rainfall and (b) ASO rainfall.

Comment: 6668, 9: The statement "The negative correlations ..." is unclear.
Response: The negative correlations between ASO rainfall in HRZ and surface temperature over the study basin shown in Fig. 7a are consistent with the negative correlations from 20-year moving window analysis shown in Fig. 6. In the revision, authors make it clearer for readers.
Revision: The revised manuscript describes clearly the statement as above. The relevant text in section 5.1.2 of the revised manuscript reads as "…The negative correlations between ASO rainfall in HRZ and surface temperature over the study basin shown in Fig. 7(a) are consistent with the negative correlations from 20-year moving window correlations shown in Fig. 6, which verify the quality of data…".

Comment: 6668, 14: If correlations are better or more consistent with the SST then why isn't SST considered in the first place?
Response: This study considered the SST in terms of the standard SST indices which are the large-scale anomalous SST over different regions of the Pacific Ocean and Indian Ocean – i.e. NINO1+2, NINO3, NINO4, NINO3.4 and ION. The study did not consider other variables. Authors are currently analyzing other large-scale variables to develop a statistical forecasting model.
Revision: No revision is made.

Comment: 6668, 27: The trend analysis here starts somewhat unmotivated from the context.

Response: The idea of trend analysis here was to investigate if there has been any trend in MAM temperature (Fig. 9) and rainfall during dry (November to April) and wet (MJJ and ASO) season (Fig. 8 and Fig. 10, respectively).
Revision: The rationale of trend analysis is added in section 5.1.2 of the revised paper. The relevant paragraph starts as "…To support the influences of temperature on the seasonal rainfall and to investigate the variability of seasonal hydroclimate over the decades, the trend analysis of seasonal rainfall and temperature is carried out…"

Comment: 6668, 28: The time series obviously exhibit inhomogeneity, as evidenced by the sharp change in lag-1 autocorrelation around the year 1980.
Response: Fig. 8 shows the standardized anomaly time series of dry season rainfall and not the correlogram.
Revision: No revision is made.

Comment: 6670, 24: The large difference between September and October is very likely indicative of the low significance of the reported correlations (see comment 6666, 5).
Response: The methodology is revised as mentioned above, and this has changed the results. The revised paper discusses the results.
Revision: The methodology is revised as mentioned earlier. The new results are shown in Table 2 in the revised manuscript.