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Hydrology and Earth System Sciences Discussions

Interactive comment on "Technical note on probabilistic assessment of one-step-ahead rainfall variation by Split Markov Process" *by* R. Maity and D. Prasad

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Reply to the Interactive comment by Referee #2 (Dr Sayang Mohd Deni)

The manuscript entitled "Technical note on probabilistic assessment of one-step-ahead rainfall variation by Split Markov Process" by R. Maity and D. Prasad presents an interesting and new stochastic approach to assess daily rainfall variation. The Split Markov Process (SMP) is proposed to investigate the transition between states (mainly based on the rainfall amount) and sub-states (changes in the magnitude of daily rainfall). This is acceptable considering that the novelty of the paper relies on that proposed approach. Even though, to reach the standards of the Hydrology and Earth System

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Interactive Discussion

Discussion Paper

Sciences Discussions, many questions have to be addressed by the author. Major changes in the methodology, results and conclusions are expected by the reviewer, the algorithms and computations have to be more accurately introduced and justified with the aim of exposing more convincing reasons to reinforce conclusions derived by the authors. I think that extended discussion of several aspects of the method and some additional data analysis and graphics would substantially improve the paper.

Specific comments: Comment#1. Lack of discussion on the most recent works in the application of Markov chain model for daily rainfall data in the literature review (see Kottegoda et al (2004); Deni et al (2009) etc.). In most cases, the daily rainfall can be described by the first order Markov chain model; however, there are cases where this model failed to fit the observed data. As an alternative, the use of the Markov chain model of higher order often improved these inadequacies (see Wilks, 1999; Hayhoe, 2000). Not only in the literature review, but also, it is expected that the Authors should provide with some ideas on applying the SMP for the higher order of the Markov model in the Conclusions section.

Response: In the revised manuscript, the recent works of Markov chain model application are cited. The list is made as exhaustive as possible with recent citations. The discussion on higher order of SMP is also incorporated in the conclusion section.

Comment#2. It would be very useful to see the topographical map of the rainfall station. Moreover, it would be better to include more stations in the analysis.

Response: Three more stations (Jabalpur, Sambalpur and Puri) are included in the analysis and the results are updated accordingly. The topographical map showing all these raingauge stations is not available. However, topographical information for all the raingauge stations is incorporated in the revised manuscript. Khandwa raingauge station is located in the Nimar district in Madhya Pradesh, India. Similar to the major part of Madhya Pradesh, Khandwa is having more or less plain topography. Average altitude of Khandwa is 316 m above mean see level. Among the newly incorporated

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stations, Puri is a costal station. It is located on the sea coast of Bay of Bengal and having an almost flat terrain. It is just few meter above the mean sea level. Sambalpur is having an undulating topography with approximate altitude 188 m above the mean sea level. It is about 300 km away from the coastal line. Jabalpur is located on the banks of the perennial Narmada River and approximate altitude is 393 m above mean see level. The entire area is low rocky and barren hillocks with slopes differing in grade from 2 to 30 per cent. Jabalpur and Khandwa are far away from the coast and located in the interior part of Indian land.

Comment#3. No explanation on the completeness of the data record. Is the record complete for the analysis period or are there gaps in the data set?

Response: The data set is complete and there is no missing data. This information is incorporated in the revised manuscript, while mentioning the data source of Indian Meteorological Department (IMD).

Comment#4. Markovian processes are commonly used to model the property of dependence in a time series. In this light, it is necessary to include the Markov chain property and assumptions in the beginning of the analysis. In the case of SMP, what is the method used in checking the property? Also, it is better to include the testing on the assumption of the Markov process, i.e. the stationarity and homogeneity (if more than one station) in the revised paper.

Response: Basic assumption is the first order stationarity of the data. However, homogeneity of the data across different stations is not a necessary requirement if SMP is being applied to a specific station. It is mentioned in the revised manuscript at the beginning of the SMP. Also, as per the suggestion of the reviewer, stationarity of the data set is checked and the results are incorporated in the revised manuscript. The entire period of the data is divided into five parts and the mean daily rainfall is computed for each period. Mean is also computed for entire length of data (1901-1999). The p-value (in parentheses) is obtained for the null hypothesis that the mean is equal to the

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mean for entire period (1901-1999) for that station at 5% significance level. Results are shown in Table 5 of the revised manuscript. It is found that almost for all the cases the mean does not differ from the overall mean (except two cases). Thus, it can be safely assumed that the data is first order stationary. The methodology of SMP is applied to a specific station, thus the homogeneity of the data is not checked. On the other hand, being located over different parts of the country, the daily rainfall characteristics need not be homogeneous. However, as found in the revised analysis, SMP is performs almost equally for all these stations.

Comment#5. It is also suggested to include the descriptive analysis on the rainfall pattern such as the mean, median, coefficient of variation, skewness, kurtosis etc.

Response: As suggested, these properties are incorporated in the revised manuscript for all the stations incorporated in the revised manuscript. These are shown in Table 4 of the revised manuscript. It is found that the station Sambalpur is having maximum mean rainfall whereas the kurtosis (measure of peakedness) is maximum for Jabalpur. For Khandwa station, mean rainfall is lowest with the maximum coefficient of variation.

Comment#6. The algorithms and computations of the SMP have to be more accurately introduced and justified. It is also interesting to demonstrate the numerical examples on the calculation of the transitional probability matrix and the estimation of the probabilities using SMP.

Response: This section is updated. Numerical examples are also included in the revised manuscript. The steps are elaborated to make it easy to understand. Two new sections – "2.3 Numerical example: Calculation of the transitional probability matrix for SMP" and "2.4 Numerical example: Estimation of probabilistic range of daily rainfall using SMP" are incorporated in the revised manuscript.

Comment#7. The plot in Figure 3 should be improved before publication. It would be interesting to compare various methods (RMSE, MAE, etc) in analysing the prediction performance.

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Response: As suggested, other measures are also incorporated and presented in figure 3. The variations of RMSE, MAE along with MSE are shown in revised figure 3. This is done for all four raingauge stations considered in the revised manuscript.

Comment#8. The conclusion is relatively too short. It should be more discussion on the physical and hydrological interpretation of the findings or any conclusions drawn from the analysis. This section should be enriched by information about potential application of the higher order of Markov chain model and taking into account other locations as well as various applications in other field of study.

Response: As suggested, the conclusion section is revised with more points. Discussion on higher order markov chain model is also incorporated in the revised conclusion section.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 189, 2011.