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**Trend analysis in rainfall patterns in the Kara river basin (Togo and Benin) via  
Bayesian framework**

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**Abstract:**

Non-stationary analysis of hydro-meteorological phenomena using statistical and probability methods has been widely recognized to play an important role in characterizing adequately hydrologic and meteorological phenomena and still remains a powerful technique that provides basic information on planning, design and management of hydraulic and water resources systems. Moreover, Bayesian analysis appears to be a consistent framework for deriving complex statistical models and implementing uncertainties into induction problems. In this study, trend is investigated in annual rainfall and their extremes in the Kara river basin (North of Togo and Benin) between 1950 and 2010 using Bayesian inference. To this end, a time covariate is introduced through the Generalized Extreme Value (GEV) distribution to fit annual rainfall maxima (MAXAN) while Normal and Lognormal distributions were used for annual rainfall with a time covariate into the mean parameter. In both cases, Bayesian inference that combines prior information and the likelihood into a posterior distribution was used. The Metropolis-Hasting algorithm, a Markov-chain Monte Carlo (MCMC) method was used for posterior sampling. After assessing the convergence of the parameters by trace plot, the trend is investigated by computing the probability of positive and negative MCMC generated samples. Bayesian Kriging was also used for spatial analysis. The results show a good convergence of GEV parameters for MAXAN and a better convergence of Lognormal distribution parameters than those of Normal distribution. This means clearly that the MAXAN time series in the Kara river basin fit well the GEV distribution while the annual rainfall fits better the Lognormal distribution. In

general, no significant trend has been detected in rainfall extreme events except at the stations of Niamtougou and Kara where they are decreasing. The annual rainfall showed in general a decreasing trend. No significant correlation was found between MAXAN and annual rainfall but also between the stations. The spatial analysis shows that there is a strong spatial variation in terms of rainfall amount received by different stations. This can partially explain the absence of correlation between the stations. Also the isohyets have shifted from north to south on the decades 1970s and 1980s. This decrease in rainfall over the basin is the consequence of the big drought that has occurred in West Africa since 1970 and spread over 1980s. Nevertheless, there has been an increase in rainfall leading to the shift in isohyets northward from 1990s. The highest amount of rainfall in the basin is concentrated around the stations of Kara, Niamtougou and Kpwa-Aledjo located in mountainous regions. The rain at these stations is therefore influence by the relief. The results of this study which are those of a first direct assessment in the basin constitute good baseline indicators for the integrated river basin analysis, vulnerability assessment and the sustainable water resources management of the Kara river basin.

**Keywords:** *non-stationary analysis, rainfall patterns, Bayesian framework, the Kara river basin.*