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Rainfall and runoff variability in Ethiopia

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Rainfall and river flow variability have been deeply investigated and and the impact of climate change on both is rather well known in Europe (EEA, 2012) or in other industrialized countries. Reports of international organizations (IPCC, 2012) and the scientific literature provide results and outlooks that were found contrasting and spatially incoherent (Manton et al., 2001; Peterson et al., 2002; Griffiths et al., 2003; Herath and Ratnayake, 2004) or weakened by limitation of data quality and quantity. According to IPCC (2012), in East Africa precipitation there are contrasting regional and seasonal variations and trends, though Easterling et al. (2000) and Seleshi and Camberlin (2006) report decreasing trends in heavy precipitation over parts of Ethiopia during the period 1965-2002. Literature on the impact of climate change on river flow is scarce in Africa and IPCC Technical Paper VI (IPCC, 2008) concluded that no evidence, based on instrumental records, has been found for a climate-driven globally widespread change in the magnitude/frequency of floods during the last decades (Rosenzweig et al., 2007), though increases in runoff and increased risk of flood events in East Africa are expected. Some papers have faced issues regarding rainfall and river flow variability in Ethiopia (e.g. Seleshi and Demaree, 1995; Osman and Sauerborn, 2002; Seleshi and Zanke, 2004; Meze-Hausken, 2004; Korecha and Barnston, 2006; Cheung et al., 2008) but their investigations are commonly geographically limited or used a small number of rain and flow gauges with the most recent data bound to the beginning of the last decade. In this study an attempt to depict rainfall and river flow variability, considering the longer as possible time series for the largest as possible number of meteo-stations and flow gauge evenly distributed across Ethiopia, is presented. 25 meteo-stations and 21 flow gauges with as much as possible continuous data records were selected. The length of the time series ranges between 35 to 50 and 9 to 49 years for rainfall and river flow, respectively. In order to improve the poor linear correlation model to describe rainfall gradient with altitude a simple topographic parameter is introduced capable to better depict the spatial variability of annual rainfall and its coefficient of variation. The small rains (Belg) were found to be much more unpredictable than the long, monsoon-type rains (Kiremt) and hence much more out of phase with the variation of annual precipitation amount that is significantly influenced by the Kiremt rains. In order to investigate the long term trends, rainfall anomalies were calculated as Z score for annual, Belg and Kiremt precipitation for all the stations and average values are calculated and plotted against time. The three Z trend lines obtained show no marked deviation from the mean as only an almost negligible decreasing trend is observed. Rainfall intensity in 24 hours is analyzed and the trend line of the maximum intensity averaged over the maximum value of each year recorded at each meteo-station is constructed. These data indicate a general decrease in daily rainfall intensity across Ethiopia with clear exceptions in a few selected areas.
The same procedure, based on the Z scores, used to analyze rainfall variability is applied also to the river flow data and a similar result is obtained. If compared with rainfall, annual runoff shows a much wider range of variation among the study rivers. This issue is discussed and possible explanations are presented.