Assessing the Impact of Climate Change on the Frequency of Droughty and Wet Weather Patterns in the Volta Basin

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Motivation

Global warming is likely to change the occurrence probability and the magnitude of extreme weather patterns. Extreme weather patterns are responsible for droughts and floods, and they can substantially reduce the quantity and quality of crop yield. The reliable estimation of the future regional occurrence frequencies of the extreme weather patterns is therefore of crucial importance for sustainable food production and should be considered for farming management strategies.

Methodologies

Multi Objective Fuzzy Rule-Based Classification (Bárdossy et al., 1995; Laux et al., 2007) was performed conditioning large-scale meteorological variables to local rainfall in the Volta Basin. First, the basin was separated into 5 manageable regions with similar rainfall characteristics to compensate the effects of the chaotic character of the spatial rainfall distribution affected by local convective systems. The best predictor variable for each region was taken to identify droughty and wet weather patterns. The past (1961-1990) occurrence frequency of the extreme weather patterns, calibrated using the NCEP/NCAR reanalysis data, is compared to expected occurrence frequencies using ECHAM5 data driven by the business-as-usual scenario A1B for 2011-2040. Results are exemplarily shown for the northernmost region in Burkina Faso (PC1).

Results

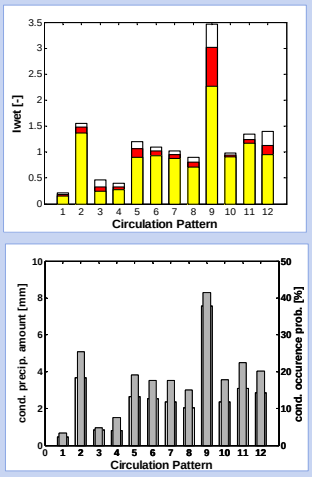

Fig. 1: CP conditional mean wetness index [-] (yellow bar = minimum value, red bar = mean value, white bar = maximum value) (top); conditional precipitation amount [mm] (white bars) and conditional rainfall occurrence probability [%] (grey bars) (bottom) for region PC1. The predictor variable is the eastward component of moisture flux in 500hPa.

According to the calculated performance parameters (Fig. 1), one can observe the very wet pattern CP9 leading in about 40% of all cases to rainfall with an average amount of 8mm per day in the northernmost region of Burkina Faso. Furthermore, CP2 is relatively wet (~ 4mm per day). CP1, CP3 and CP4 are patterns linked to very droughty conditions. They are holding average rainfall probabilities of about 5% and mean rainfall rates of less than 1mm per day. The driest and wettest CP composites can be found in Fig. 2.

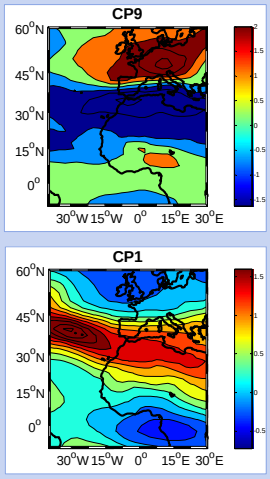

Fig. 2: Mean anomaly composites of the wettest (top) and driest CP (bottom) in the northernmost region of Burkina Faso using the eastward moisture flux in 500hPa.

The decadal and the interannual variability of the past CP occurrences are shown in Fig. 3. During the severe drought at the end of the 1970s until the mid 1980s the wet CP9 is totally missing, whereas the frequency of droughty patterns is enhanced. Prior to the application of the weather pattern classification to future GCM output, the *stationarity prerequisite* must be checked. The mean patterns as well as the main variability modes of ECHAM5-A1B (2011-2040), ECHAM5-control run (1961-1990) and NCEP/NCAR (1961-1990) are found to be similar (not shown here).

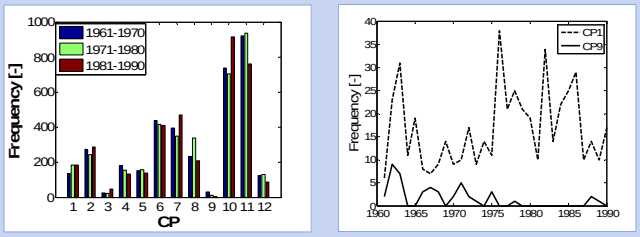

Fig. 3 (left): Decadal occurrence frequencies of the derived weather patterns using NCEP/NCAR reanalysis data for northern Burkina Faso (1961-1990); (right) Interannual variability of the wettest (driest) pattern CP1 (CP9).

Both, drastic changes in the occurrence frequencies of wet as well as droughty weather patterns are expected for the future (Fig. 4). Excepted for the droughty pattern CP1, all the extreme weather patterns are increasing. This is due to the higher moisture capacity of warmer air masses affected by global warming.

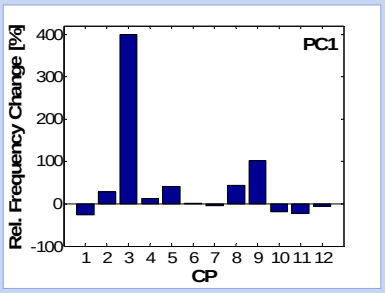

Fig. 4: Rel. change of the occurrence frequency of weather patterns of the future (2011-2040) compared to the past (1961-1990) in northern Burkina Faso.

References

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- Bárdossy, A.; Duckstein, L.; & Bogárdi, I. (1995): Fuzzy rule based classification of atmospheric circulation patterns. International Journal of Climatology, 15:1087-1097.