Modelling daily precipitation features in the Volta Basin of West Africa

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Motivation

The analysis of the monthly or annual precipitation amount does not provide any adequate information for agricultural sector in the Volta Basin. Therefore, rainfall modelling must be performed on a daily basis to account for the intra-seasonal rainfall distribution. As an example, the dry spells occurrences with durations of more than 6 days within the following month after planting are calculated, because they are essential for the survival of the plants (Laux et al., 2008A).

Important plant physiological needs are calculated and condensed to maps for agricultural decision support. These maps can assist farmers in their decision when, where and what to plant (Laux et al., 2008B).

Methodologies

- Markov chain model (zero and first order) and gamma distribution for modelling rainfall occurrence and rainfall amount
- Effective Drought Index (EDI) to derive important drought properties
- Copula approach to model drought events more realistic considering jointly drought duration and drought intensity

Results

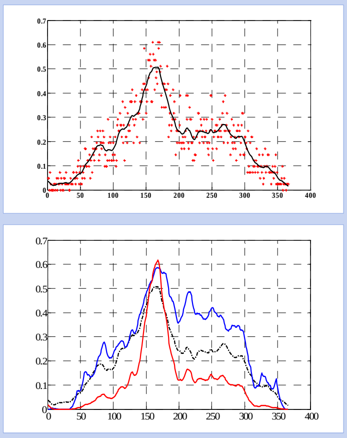

Fig. 1: Top: Overall rainfall probability (zero-order Markov model) for each day of the year at Accra, based on rainfall data (1961-1999) with a threshold of 1 mm for a rainy day, observed (*) and fitted fitted (-) using Fourier series with four harmonics (top).

Bottom: 1st order Markov chain of Accra. The red line stands for the fitted probability of rain, if it is followed by a dry day and the blue line for the fitted probability of rain, if it is followed by a wet day. The black line is depicting the fitted overall rainfall probability (for comparison).

A clear seasonal cycle of the rainfall probabilities can be observed (Fig. 1). The overall chance of rain during the major rainy season (June) is approximately twice the rainfall probability during the minor rainy season (Sept/Oct.). Excepted for the peak of the major rainy season (around DOY 160), the probability of rain following a rainy (dry) day is greater (lower).

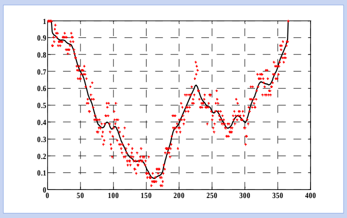

Fig. 2: Observed (*) and fitted (-) dry spell occurrence probability within the following 30 days for each day of the year at Bole, based on daily rainfall data from 1961 to 1999.

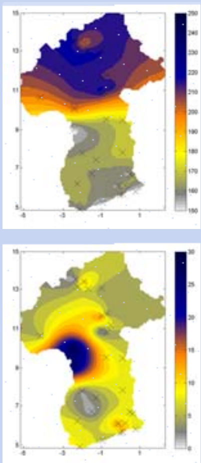

Fig. 3: ToP: Date [Day of Year] with minimum dry spell occurrence probability for the following 30 days, representing the optimal planting date.

Bottom: Probability [%] of dry spell occurrence for the next 30 days. External drift kriging, including distance-to-sea information, was applied for spatial interpolation.

The dry spell occurrence probability and the date (DOY) is calculated for each station (e.g. illustrated for Bole, see Fig. 2). Both measures are interpolated using EDK. The obtained maps provide very important information for farmers about the best choice of the planting date to avoid total crop failure. In the north-western region of Ghana, planting should be started around DOY 150, however, the probability of dry spell occurrence is 30%.

Probabilities of rainfall exceeding 5mm per day are calculated. The results are presented in condensed form for the months in which more than 95% of the rains fall (Fig. 4).

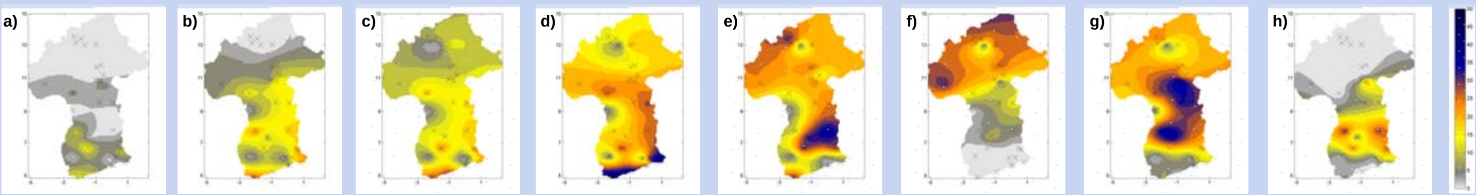

Fig. 4: Spatial distribution of rainfall occurrence probabilities [%] exceeding 5 mm/day in the Volta Basin for the month of a) March, b) April, c) May, d) June, e) July, f) August, g) September, and h) October. External drift kriging, including distance-to-sea information, was applied for spatial interpolation.

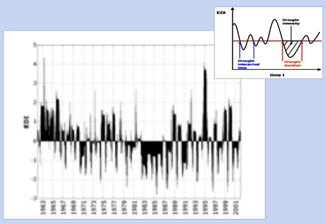

Fig. 5: Effective Drought Index (EDI) for Northern Burkina Faso.

Based on the EDI time series (Fig. 5), drought intensity, drought duration and drought interarrival time are calculated for 5 different regions within the Volta Basin. Strong linear dependencies between drought duration (DD) and drought intensity (DI) can be found (Fig. 6). The events are accumulated in the lower marginals. A Clayton copula model is estimated to account for the joint distribution of DD and DI under consideration of the marginal distribution. On that basis, regional drought return periods are derived.

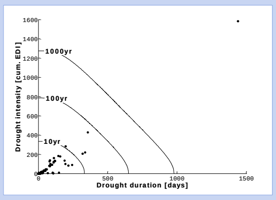

Fig. 6: Isolines of drought return periods in northern Burkina Faso. The dots represent the past drought events (99 events from 1961-1999).

References

Laux, P., Kunstmann, H. & Bárdossy A. (2008A): Predicting the Regional Onset of the Rainy Season in West Africa; International Journal of Climatology, Vol. 28, issue 3, pp. 329-342.

Laux, P., Wagner, S., Wagner, A., Kunstmann, H. & Bárdossy A. (2008B): Modelling Daily Precipitation Features for the Volta Basin in West Africa; submitted to International Journal of Climatology.