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Climate change and deforestation in West Africa: a space-time trend analysis of rainfall series from Côte d'Ivoire and Liberia

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Abstract

Rainfall series (1920-1990) from 11 stations from Côte d'Ivoire and 19 stations from Liberia have been analysed for pseudo-cyclic trends. Standardized deviations from the station's mean through time were plotted separately for the Ivorian stations where extensive deforestation occurred and the Liberian stations where deforestation was less extensive. The 5 year running mean through these deviations did not show a different pattern for the two sets of stations. It is thus concluded that the droughts of the seventies and eighties in West Africa are to be related to decadal variations in ocean surface temperature, and not to deforestation or more intensive land use on the African continent.

1. INTRODUCTION

The Sahelian droughts in the seventies and eighties have been reported by many authors (Faure & Gay 1981, Lhomme 1981, Nicholson et al. 1988, Adejuwon et al. 1990, Olivry et al. 1993). Analysing rainfall and river discharge time series dating back from 1920 and 1840 respectively, Faure & Gay concluded that decadal rainfall is subject to a pseudo-cycle with a period of approximately 30 years, with the last minima in the decades 1910-1920, 1940-1950 and 1973-1983. Hubert et al. (1989) stressed the *pseudo*-cyclic nature of this oscillation by calling them segments with varying length and amplitude.

Many authors related the decrease in rainfall between 1950 and 1985 to large scale deforestation in the rain forest zone and to changed land use in the savanna zone in West Africa (Monteny & Casenave 1989, Savenije 1995, Bruijnzeel 1995). The hydrological cycle is interrupted because evapo-transpiration from deforested land is less than from full grown forest, and as a consequence runoff increases and more rainfall water is drained back directly to rivers and to the ocean in stead of re-evaporating and penetrating further north into the continent. It remains questionable whether the magnitude of evaporated moisture is significant compared to the moisture transported inland by the maritime air masses. Savenije estimated the horizontal velocity of these air masses at 17 km per day. I believe that this velocity (average wind speed) may be 10 times faster, thus multiplying by 10 the amount of maritime moisture transported onto the

continent and reducing by a factor 10 the impact of evaporated moisture. Wet and dry years in West Africa may be more related to oscillations in ocean surface temperature (SST; Können pers. comm.).

In this paper I will compare rainfall series from Liberia with those from Côte d'Ivoire. In the former country deforestation was much less extensive and for stations near the coast, the influence of deforestation inland is of course nihil. If the droughts in the seventies have also been recorded in Liberia, then deforestation cannot have been the cause. Correlation can then be sought with decadal variations in SST, possibly related with ENSO-events in the Atlantic ocean (Folland et al. 1986).

Although the determinants of rainfall remain ill identified, there is a need to predict rainfall quantities and distribution in the coming decades. This prediction can be based on extrapolation of trends detected in measured rainfall time series. This regression type of approach supposes that no major change occurred in the climate system and in driving forces of rainfall in West Africa which in the light of global climate change remains questionable. Prediction can use cyclic or linear trends, or both. Does the pseudo-cyclic trend allow to predict the nineties to be rainier again, with a probable next drought in 2005-2010?

2. STUDY REGION

The West-african rain forest block covers south Sierra Leone, all of Liberia, southern Côte d'Ivoire and south-west Ghana. Most of it is situated in lowland, 0 to 500 m above sea level. This biome has an equatorial climate at 4 to 8° North and receives between 46 dm rain near the Liberian coast and 13 dm near the forest-savanna boundary. The dry season is centred on January and lasts one to three months (van Rompaey 1994).

Eighty percent of the rain forest cover has been cleared since 1900, most of it since 1950 (van Rompaey 1993). This makes the region the most deforestated in the tropical world. The largest remaining forests are found in east Liberia and western Côte d'Ivoire. Ghana has smaller forest reserves but in better condition and under more professional management.

3. RAINFALL SERIES

Thirty rainfall stations were studied, some with series starting in 1920. The period 1950-1980 is best documented. Year to year variability (standard deviation divided by mean in %) ranges from 10 to 20 % without a clear gradient over the region. Yearly totals and their five year running mean have been graphed station by station. To study the homogeneity between stations annual rainfall figures have been normalised by subtracting the station's mean and dividing by the station's standard deviation. The normalised deviations were plotted in two graphs: one for all Liberian and one for all Ivorian stations (Fig. 1). For a given year deviations were averaged and a five year running mean was calculated through these averages to detect major trends.

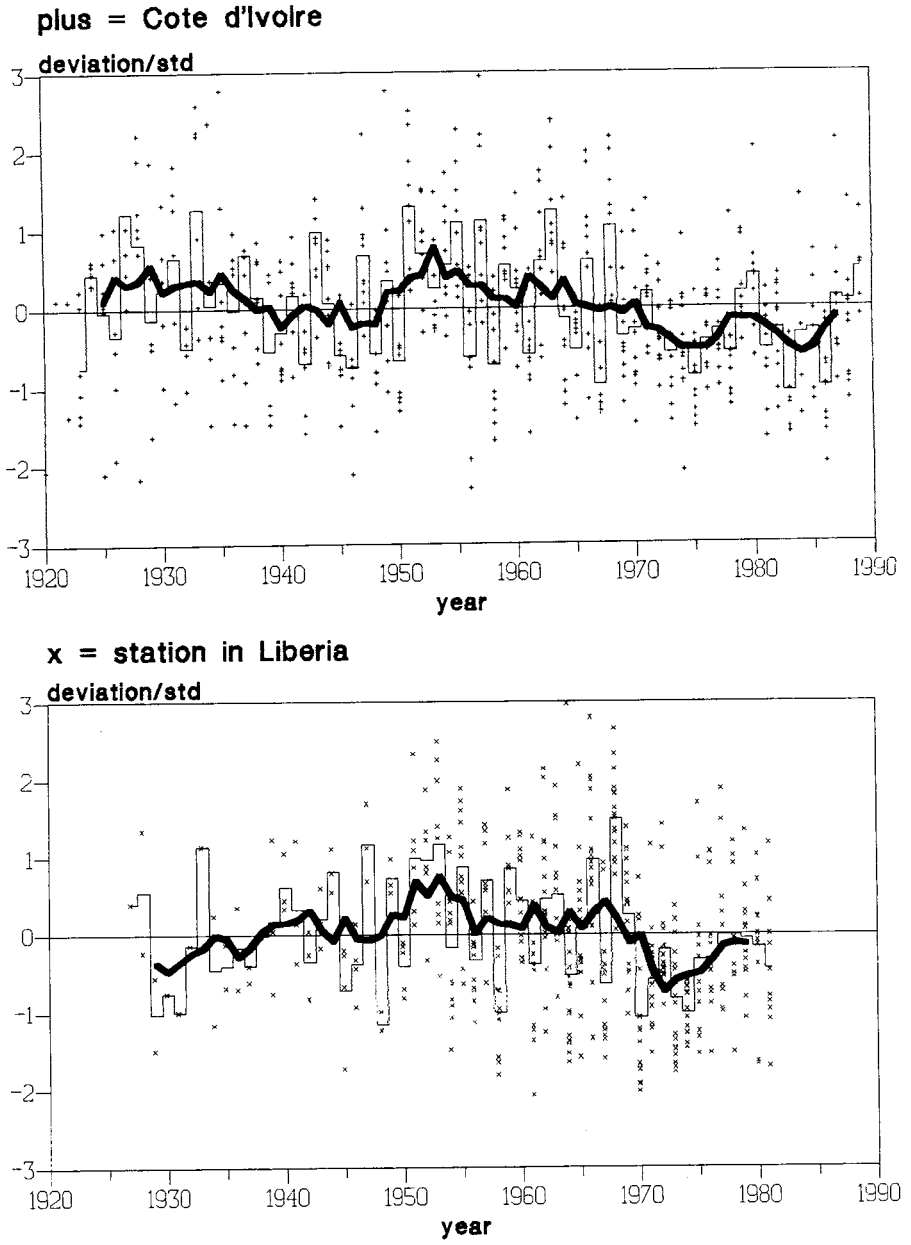

Figure 1: Standardized yearly deviations from the station's mean, above for 11 stations in Côte d'Ivoire(extensively deforestated), below for 19 stations in Liberia (less deforestated). The stepped curve gives the yearly mean for all stations. The bold curve gives the 5 yr running mean of the latter mean.

4. RESULTS

When considering the years separately, drought or rainfall appeared to be regionally coherent. To a large extent the stations are consequently wet or dry in given years. Between subsequent years large differences can occur. There seems not to be any short-term interannual autocorrelation. Wet and dry years may occur immediately after each other.

At a decadal scale the running mean shows wet and dry decades. The decades '25-'35, '55-'65 had more wet years; the decades '40-'50, '75-'85 had more dry years and drier years. This decadal variation was found both in the deforested Côte d'Ivoire as in the still forested Liberia. Many individual dry years coincide however with ENSO events as listed by Quinn & Neal (1987) for the Pacific.

5. CONCLUSIONS

It is likely that after the past decadal rainfall minimum 1975-1985 more wet years will occur in the 1990-2000 decade. Given the deforestation-independent decadal variability, downward rainfall trends caused by deforestation are very hard to detect. Studies based on 1950-1980 data lead to false conclusions because both causes were cooperative in reducing rainfall. Rainfall monitoring in 1990-2000 may provide a definitive answer as in this decade both causes are opposing.

The decadal variation seems to be more related to ENSO-events, sea surface temperature and ocean currants. If these are changed by global climate change, then the above prediction of future rainfall in West Africa may have to be revised.

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