Reply to “The Sahelian drought may have ended during the 1990s”

The 1990s rainfall in the Sahel: the third driest decade since the beginning of the century

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INTRODUCTION

In the discussed paper (L’Hôte et al., 2002) the authors deal with the annual rainfall amounts over the last century and conclude that the drought that affects the Sahel since about 1970 was still going on during the 1990s. So, in this response, the answers to the two main questions in the discussion by Ozer et al. (2003) are addressed, which are about (a) the representativeness of the index used in the original study, and (b) the continuation or the end of the drought during the 1990s. Moreover, the authors recall and show that the recent floods in the Sahelian urban areas can be related to hydrological factors other than increases in the rainfall amounts.

SAHELIAN OR WEST AFRICAN RAINFALL?

The name Sahel has frequently been given to regions more southerly than the strictly-speaking Sahelian region, by similarity to the climatic impacts on the environment. For example, in Nicholson (1998), the Sahel region stretches southwards to 10°N, and is divided into three separate areas (northern, central and southern), in which average rainfall fluctuation time series are very similar to one another, and similar to the series of the Soudano-Guinean zone (more to the south). The area used by L’Hôte et al. (2002) is roughly identical to that used by Lamb (1985), which he called “Sub-Saharan area”. Except for Sarh, the 21 stations are far north of 10°N, which is a commonly used limit between Sahelo-Sudanian areas and more humid southern regions of West Africa (Janicot, 1992). Moreover, the rainfall reduction since 30 years now puts some of the formerly more humid stations into Sub-Saharan climate conditions (Tambacounda, Ouagadougou, and to a lesser extent Sarh and Bamako). Finally, in the present discussion about the Sahelian drought, Ozer et al. (2003) also refer to the station of Kolda in Senegal with about 1050 mm annual rainfall.

Nevertheless, the authors agree that the adjective Sahelian could be changed to “Sub-Saharan” or “Sahelo-Sudanian”.

CAN RECENT FLOODS IN SAHEL URBAN AREAS BE RELATED TO THE END OF THE DROUGHT?
Several authors have shown significant recent changes in the hydrology of the Sahelian rural and urban areas compared to that of the urban areas, yet these changes are not necessarily related to the rainfall amounts. For example, in a recent paper, Mahé et al. (2002) show that the runoff coefficient of a Sahelian river in Burkina Faso has increased by 108% between 1972 and 1996, despite the reduction of rainfall. This is due to changes in surface conditions, because of the increase in population and related agricultural activities, having a heavy impact on vegetation and groundwater. In another paper, Mahé et al. (2003) show that all the Sahelian rivers are affected by this phenomenon in both Burkina Faso and Niger.

With reference to the recent flood in Niamey, the reader is referred to the results of Le Barbé & Lebel (1997), showing that the lasting drought which has affected Niger for more than 20 years is associated with a decrease in the number of rainy events, rather than with a reduction in the mean event rainfall, and that this decrease is more pronounced for the core of the rainy season. Furthermore, in Niamey, as in most of the African towns, the population growth has been very high in the last 30 years, and people have settled in areas that are liable to flooding. So, the increase in floods in the towns seems related to demographic and anthropogenic factors rather than to an increase in rainfall, as shown for instance for other regions (Neppel et al., submitted). Under these conditions, a relationship between the recent floods in the Sahelian towns and the annual rainfall amounts is without doubt inadequate.

DOES THE DROUGHT REALLY CONTINUE UNTIL 2000?

According to several authors (Lubès-Niel et al., 1998; Paturel et al., 1998), the non-parametric Pettitt (1979) statistical test allows one to detect only one change point in a series. Therefore, in order to obtain an additional date of jump which is not the main one near 1970 corresponding to the great drought, it seems necessary to cut the 1921–2000 series. By cutting the 1921–2000 series after the negative jumps, as it is understood Ozer et al. did for five stations in Senegal and Niger, the Pettitt test shows that the rainfall average is higher during the 1990s, mainly because of two isolated wet years 1994 and 1999. But these calculations do not show that there are significant signs of a new period as wet as before the drought, because this wet period is not taken into consideration in the series. Applying the Pettitt test to each of the 21 stations of the index in the 1921–2000 period, the authors found the following distribution, which was not exhibited in the paper under discussion: (a) 18 stations with negative jumps between 1963 and 1971 (last years before drought), mode in 1969 for five stations, (b) one station without jump (Nguigmi), and (c) two stations with other dates of negative jumps: 1976 at Ouagadougou and 1961 at N’djamena. Using the Bayesian estimation of Lee & Heghinian (1977), which also shows only one jump, roughly the same results were obtained.

It is interesting to mention a few unpublished results of the original study using the procedure of segmentation of Hubert et al. (1989), which allows one to detect several jumps in a series. The procedure was applied at a 1% significance level of the Scheffe test on each of the 21 stations over the 1921–2000 period. Three years were found to have positive jumps after 1990: 1993 at Nema, Mauritania, 1995 at Sarh, Chad, and 1998 at Tombouctou, Mali. In L’Hôte et al. (2002), these results were omitted because only one, at Sarh, is significant, with regard to the need for at least five years after the jump. In fact, Nema cannot be retained either because (a) there is no jump detected with other methods (Pettitt and Lee & Heghinian tests), and (b) with Hubert’s procedure the series shows a lot of additional jumps which are very different from those at the other stations: 1949(+), 1958(−) and 1982(−), where (+) represents a positive jump and (−) a negative one.

In a recent paper, Ardoin et al. (2003) used Hubert’s segmentation procedure on 54 West
African rainfall stations over the 1975–1998 period and found only two stations with real positive jumps occurring in 1987: Thyou in Burkina Faso, with about 550 mm annual rainfall, and Kita in Mali (1000 mm). Using the permutation approach on 37 rainfall stations of the Senegal, Gambia and Upper Niger watersheds over the same period, 1975–1998, resulted in finding only four stations with significant statistical changes between the 1980s and the 1990s series. Hence, the conclusion that the drought was still going on during the 1990s.

CONCLUSION

The observations show that two humid years occurred during the 1990s (against one during the 1970s and none during the 1980s), so that the 1990s precipitation average is higher than during the 1980s and roughly equal to the 1970s. Nevertheless, only few statistical results, often calculated upon dry periods, by Ozer et al. (2003) and by Ardoin et al. (2003), suggest positive jumps for a few stations during the 1990s. By using Hubert’s segmentation procedure on the 80-year period (1921–2000), only one station out of 21 shows a significantly positive jump during the 1990s (but no jump is detected with the Pettitt test).

So, there are not yet significant statistical signs to say that a new positive jump towards wetter conditions, as before 1970, has occurred, or was occurring during the 1990s. The drought was still going on during the 1990s. To know, from a statistical point of view, whether the great drought may be ending, it will be necessary to update the calculations with the forthcoming years on long periods including at least two decades before the year 1970.

However, it would be a great hope if the few signs of a reduction in the drought intensity over the Sahelo-Sudanian areas during the 1990s augur the advent of a new humid period.

REFERENCES


