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Ethnographic context and spatial coherence of climate indicators for farming communities – A multi-regional comparative assessment

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ABSTRACT

Accurate seasonal predictions of rainfall may reduce climatic risks that farmers are usually faced with across the tropical and subtropical zones. However, although regional-scale seasonal amounts have regularly been forecasted since 1997/98, the practical use of these seasonal predictions is still limited by myriad factors. This paper synthesizes the main results of a multi-disciplinary ethnographic and climatic project (PICREVAT). Its main objective was to seek the climatic information – beyond the seasonal amounts – critical for crops, both as an actual constraint to crop yields and as identified by the current and past practices and perceptions of farmers. A second goal was to confront the relevance and significance of this climatic information with its spatial coherence, which gives an upper bound of its potential predictability. The ethnographic and climatic analyses were carried out on three very different fields: North Cameroon (mixed food crops associated with a cash crop – cotton – integrated into a national program); Eastern slopes of Mt Kenya (mixed food crops, with a recent development of maize at the expense of sorghum and pearl millet); and Central Argentina (mixed crops and livestock recently converting to monoculture of transgenic soybean, referred to as *soybeanization*).

The ethnographic surveys, as well as yield–climate functions, emphasized the role played by various intra-seasonal characteristics of the rainy seasons beyond the seasonal rainfall amounts, in both actual yields and people's representations and/or crop management strategies. For instance, the onset of the rainy season in East Africa and North Cameroon, the season duration in the driest district of the eastern slopes of Mount Kenya, or rains at the core (August) and at the end of the rainy season in North Cameroon have been highlighted. The dynamics of farming systems (i.e. *soybeanization* in Central Argentina, increasing popularity of maize in East Africa, recent decline of cotton in North Cameroon) were also emphasized as active drivers; these slow changes could increase climatic vulnerability (i.e. soybean is far more sensitive to rainfall variations than wheat, maize is less drought-

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resistant than sorghum or millet), at least for the least flexible actors (such as the non-capitalized farmers in Central Argentina). The cross between ethnographic surveys and climatic analyses enabled us to identify climate variables that are both useful to farmers and potentially predictable. These variables do not appear to be common across the surveyed fields. The best example is the rainy season onset date whose variations, depending on regions, crop species and farming practices may either have a major/minor role in crop performance and/or crop management, or may have a high/low potential predictability.

Introduction

All societies are somehow vulnerable to climate, but the exposure to climate hazards is expected to be larger for tropical and subtropical countries, where a large fraction of gross national product and food supply is provided by rain-fed agriculture (Cutter, 1996; Reilly and Schimmelpfennig, 1999; Salinger et al., 2005; Sivakumar et al., 2005; Fussel and Klein, 2006). In these countries, climatic vulnerability (Turner et al., 2003; Adger, 2006; Gallopin, 2006) is mostly related to rainfall variations and is often very high in semi-arid areas, where low-income populations strongly depend on very scarce and variable water resources (Camberlin, 2010). In that context, seasonal rainfall forecasts (Goddard et al., 2001, 2003; Barnston et al., 2010) are a potential tool for farmers to reduce risks and to optimize gains (Glantz, 1977; Dilley, 2000; Luseno et al., 2003; Meinke and Stone, 2005; Hansen et al., 2006, 2009; Challinor, 2009; Sultan et al., 2010a,b; Roudier et al., 2011, 2014), even though several issues (e.g. scales and timing of forecasts, translation of expert forecasts into decision-making processes at the farm scale, etc.) currently limit the usefulness of even near-perfect seasonal forecasts (Lamb, 1981; Blench, 1999; Broad and Agrawala, 2000; Singh et al., 2009).

Current seasonal rainfall forecasts focus on the regional (i.e. at least several stations and/or a few grid-points covering an area usually larger than 10^5 sq km) and seasonal scales (interannual anomalies averaged over 3 consecutive months, Goddard et al., 2001, 2003; Barnston et al., 2010). These spatio-temporal scales filter out some of the unpredictable noise related to internal atmospheric dynamics and small-scale processes, and enhance the potentially predictable signal related to the forcing of boundary surfaces, including sea surface temperatures (SST). By definition, a temporal sum, as seasonal amount, integrates all rainy events across a season and is thus the most comprehensive variable from the statistical point of view. Its spatial coherence at the interannual time scale gives an empirical upper bound of potential predictability, if we assume that any slow boundary forcing may induce a quasi-constant homogeneous signal at regional-scale (Moron et al., 2006, 2007). Nevertheless, the highest rainfall, close to the mean annual peak, is not necessarily spatially coherent and may reduce the potential predictability of seasonal amounts.

A regional-scale seasonal amount anomaly is not necessarily the "optimal" variable from the farmer's point of view. The rainy season onset date prediction is usually considered by farmers to be more relevant than that of the seasonal amount anomaly (Ingram et al., 2002). Any given intra-seasonal characteristic (ISC) is, by definition, included in the seasonal amount as a specific component of the rainy season (for the onset, the temporal phase of its starting stage), but it may not necessarily convey its predictable part (Moron et al., 2009a,b; Marteau et al., 2009). Additionally, the usefulness of any ISC of the rainy season may not be the same for smallholders and commercial farmers. It may also differ between those engaged in a multi-cropping system and those who have adopted a (monocultural?) system, or between those cultivating a well-adapted and drought-tolerant crop such as sorghum, and those cultivating a less adapted and highly sensitive crop such as maize, but which provides an higher net gain in optimal climate conditions. Considering all these contexts, we cannot deny that the most relevant and useful climate variable for farmers does not maximize the signal-to-noise ratio from the climatic point of view and vice versa.

In this paper we synthesize the main results of a multidisciplinary framework, the PICREVAT project (January 2009–June 2013), combining statistical analyses of interannual and intra-annual variability of rainfall and of crop-rainfall relationships (papers by Boyard-Micheau et al., 2013; Moron et al., 2013; Camberlin et al., 2014; Philippon et al., 2015a,b; Hernández et al., 2015) with ethnographic surveys (papers by Leclerc et al., 2013, 2014; Mwongera et al., 2014; Hernández et al., 2015). All the agro-climatic and ethnographic analyses were carried out on three contrasted fields: (1) North Cameroon in the Sudano-Sahelian belt, mixing cotton with subsistence crops (mainly sorghum and maize); (2) Kenya and North Tanzania (Camberlin et al., 2009, 2014; Philippon et al., 2015a,b) with a focus on eastern slopes of Mt Kenya, where small-scale subsistence farming is based on mixed cropping systems but maize has gradually surpassed traditional (and less drought-vulnerable) crops like sorghum and pearl millet (Leclerc et al., 2013, 2014; Mwongera et al., 2014); and (3) central Pampa in Argentina, where the farming system has recently shifted from mixed crops and livestock to dominant transgenic soybean cropping system (Magrin et al., 2005; Pengue, 2005, 2006; Caviglia and Andrade, 2010; Hernandez et al., 2015). A major goal of PICREVAT was to analyze the critical climatic information for crops, both as a constraint on yields through a classical production-function approach linking observed yields and climate variations (Mendelsohn et al., 1994), and as explicitly identified by local farmers and stakeholders, either through their farming practices or their perception/memory of any adverse