WCRP OPEN SCIENCE CONFERENCE
(CLIMATE RESEARCH IN SERVICE TO SOCIETY, 24-28 OCTOBER 2011, DENVER, COLORADO, USA)
SESSION C39: UNDERSTANDING AND CHARACTERISING PAST, PRESENT AND FUTURE CLIMATE EXTREMES THROUGH OBSERVATIONS AND MODEL SIMULATIONS

Dry spells analysis: Multi-scale detection, attribution of impacts and sources of uncertainty using an integrative approach

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Introduction

The analyses of rainfall in the last one and half decade have revealed the persistence of « dry days episodes » (dry spells, DS) in the seasonal distribution of rainfall events (Salack *et al.* 2011a). This poster reports results of studies which objectives were to (i) improve our understanding of DS space-time distribution, (ii) detect DS implications in rainfall patterns (Salack *et al.* 2011b), (iii) estimate DS impacts on local millet production and associated uncertainties using crop and climate models (Salack *et al.* 2011c). DS analysis is essential for drought monitoring and food crisis allevation in the Sahel and Sudan zones of West Africa.

Data and Methods

Data consists of 87-raingauge daily data and 8 Regional climate models (RCM) ensemble simulations (fig. 1). The raingauge network is divided into catchments of different dimensions (fig. 2). Following a multiple scale extraction algorithm (equation 1), the raingauge data is assessed to detect the intraseasonal starting dates (STDATE), duration (L), seasonal frequency of occurrence (F) and interannual oscillations of dry spells (DS) at station, 1°x1°, 2°x2° and rainfall regions. Both observed and 8-RCM ensemble simulation rainfall are used to force crop models in order to identify and estimate the potential impacts of DS on millet production.

The integration of 8-RCM ensemble rainfall to a crop model (SARRAH) shows how much the biases in the distribution of DS is propagated into impact assessments studies on potential millet yield at local scale.

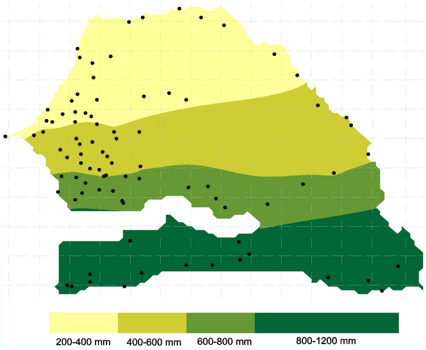


Fig. 1: Agroclimatic zones (colors), raingauge location (dots) and RCM grid mesh over Senegal (grey lines).

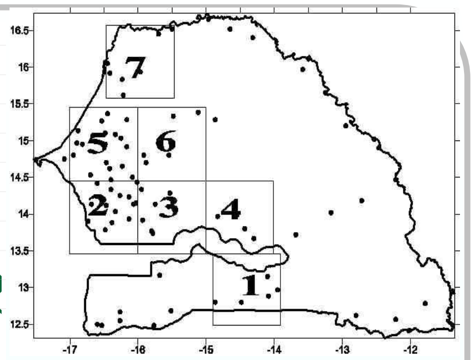


Fig. 2: Degree square catchment setting for multiple scales diagnostic of dry spell. Boxes 1-7 are 1°x1° (GB1-7) and boxes 2, 3, 5, 6 make a 2°x2° degrees (B2x2).

Algorithm of local to and multiple sites (regional) dry spells extraction

$$RRD_{N\alpha} = \begin{cases} 0 & if \quad \sum_{j=1}^{M} RD_{ij} \le M(1-\alpha) \\ 1 & otherwise \end{cases}$$

The raingauge network of each catchment (fig 2) is crypted into a binary matrix of 0 and 1 elements for dry and rain day respectively (*RD*). Equation 1 is used to define regional dry spell ($RRD_{N\alpha}$). *M* is the total number of raingauge per region, $RD_{i,j}$ is a dry (rainy) day at each raingauge, *N* is the day of the calendar, α =]0,1] represents the fraction of the raingauge network of the region or box (fig. 2). More details can be taken from in Salack *et al.* (2011b).

Results and Discussions

1. Multiple scales characteristics of dry spells

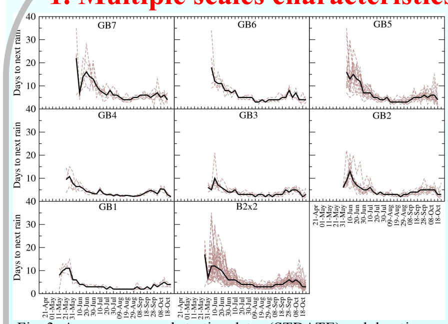


Fig. 3. Average seasonal starting dates (STDATE) and duration of local dry spells observed at individual (dotted lines) and area average (black thick line) over sub-regional raingauge networks (GB1-7 & B2x2).

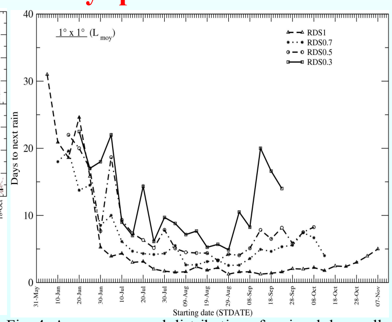


Fig. 4. Average seasonal distribution of regional dry spells, RDS, for different fractions of the local raingauge network of a 1°x1 region (i.e GB5).

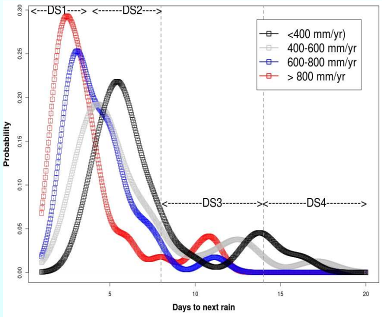


Fig. 5. Seasonal frequency of occurrence of dry spell categories in the agroclimatic zones of Senegal. DS1, 2 are short, DS3 are medium and DS4 are major dry spell categories.

Discussion 1

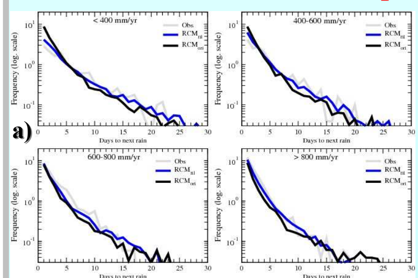
** Short dry spell category (DS=1-4 days, DS2=5-7 days) are more frequent in Aug-Sept (fig. 3&4).

** Medium category dry spells (DS3=8-14 days) are more frequent in Aug-Sept-October (fig. 3&4).

** Major category of dry spells (DS4 > 14 days) are prevelent in June-July.

** DS3 & DS4 have low seasonal frequency of occurrence at all rainfall zones (fig. 5). They are classified as extreme dry spells (extDS) because of their implications in crop yield loss (sivakumar 1992) and rainfall variability (Salack *et al.* 2011a, 2011b).

2. Attribution of impacts and sources of uncertainty in forecasting seasonal extreme DS oscillations



Discussion 2

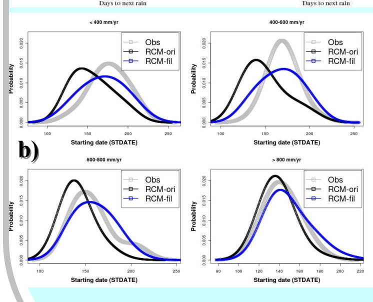
** Extreme dry spells (extDS) are associated to rainfall deficits (table1). They explain the maximum loss of millet yield in the Sahel and Sahel-Sudan regions of West Africa (Sivakumar 1992).

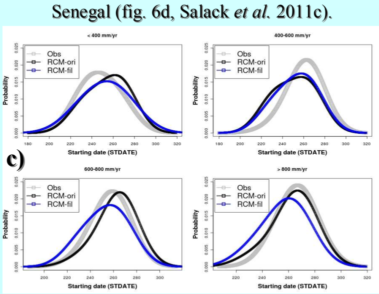
** Original 8-RCM ensemble forecasts are unable to describe very well the seasonal frequency-duration (fig. 6a) and starting dates of extDS (fig. 6b, c) in those regions, due to high level of noise (i.e < 1 mm/day) in RCMs' simulations. When the noise is filtered out from the original ouputs during post-treatments (RCM-fil), better results are found.

** The lack of good representation of DS in RCMs ensemble forecasts explains -40 to +40% of biases in crop model simulations of potential millet yield in Senegal (fig. 6d, Salack *et al.* 2011c).

Table 1: Contingency table on the interannual oscillation of extreme dry spell categories (found on at least 30% of the raingauge network) and the quality of rainy seasons. The green years are normal, the red years are dry and the yellow years very dry relative to the 1950-2010 mean over Sénégal (Salack *et al.* 2011b).

Quality of rainy season	DS4 Category (June-July)	DS3 Category (Aug-Sept)
DS4 Category (June-July)	1973, 1974, 1975, 1980, 1982, 1983, 1986, 1987, 1988, 1995, 2002	1972, 1976, 1977, 1991, 1992, 1997, 2007
DS3 Category (Aug-Sept)	1972, 1976, 1977, 1991, 1992, 1997, 2007	1952, 1956, 1957, 1960, 1961, 1964, 1968, 1985, 1989, 1990, 1993, 1998, 2000, 2001, 2003, 2004, 2006, 2008





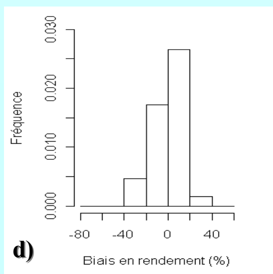


Fig. 6: Seasonal frequency and starting dates of extreme dry sepls (extDS) in different rainfall regions. **a)** frequency-duration diagram. b) starting date of DS4 in Jun-July **c)** starting dates of DS3 in Aug-Sept. **d)** millet production rates of biases due to frequency of rainfall events in the 8-RCM ensemble forecasts.

References

1. Salack S. *et al.* (2011a). Rain-based factors of high agricultural impacts: integration of local to sub-regional trends and variability. *Theo. App. Clim.* ***Doi. 10.1007/s00704-011-014-z***
2. Salack S. *et al.* (2011b). Multi-scale analyses of dry seplls in Niger and Senegal. *Secheresse* (**accepted**).
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4. Sivakumar MVK (1992). Empirical analysis of dry spells for agricultural applications in West africa. *J. climate 5: 532-539*

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