4A.5

RELATIONSHIPS BETWEEN DEEP SOIL WETNESS, MONSOON DYNAMICS AND RAINFALL, AND THEIR POTENTIAL USE FOR IMPROVING SEASONAL FORECASTING IN WEST AFRICA

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1. INTRODUCTION

The correlation of 0.61 found between observed JAS Sahelian rainfall in year 0 and SON Guinean rainfall in year –1 over the period 1968-1998 (Philippon and Fontaine 2002), led us to analyze the preseason evolution of Deep Soil Wetness (DSW) and Moist Static Energy (MSE) fields at 1000 hPa over West Africa. This diagnosis uses the Climatic Research Unit (CRU) rainfall database (Hulme 1992), the Global Soil Wetness Project (GSWP) dataset (Drimeyer et al. 1999) and the NCEP/NCAR reanalyses (Kalnay et al. 1996). From the results, new types of predictors for the Sahelian rainy season in particular, are defined and entered in statistical models.

2. PRESEASON SIGNALS

We supposed that the 8 months delay between the SON Guinean rainy season and the next JAS Sahelian one could pass through land properties sensible to soil wetness. The first step was to compute lag correlations between a Deep Soil Wetness (DSW) index covering the Guinean-Sudanese band and an observed (Hulme database) or modeled (NCEP/NCAR outputs) Sahelian Rainfall Index (SRI: 12.5-17.5N/18.75W-18.75E). It appears that SRI is positively associated with DSW during the preceding fall and winter. When performing composite analyses on the DSW field, a spreading of positive anomalies over the Sudanese-Guinean belt from November to March is noticeable before an abnormally wet rainy season over the Sahel (figure 1).

In a second step we considered monsoon energetics (through the Moist Static Energy content) since, in lower levels it is favored by soil wetness. Correlations between the MSE field at 1000 hPa and the DSW index previously used are presented for March in figure 2: the location of DSW positive (negative) anomalies tend to shift northward the strongest MSE meridional gradient. The importance of these gradients for the monsoon dynamics has been shown by Emanuel (1995), Eltahir and Gong (1996) through dynamical models. On their side, Fontaine and Philippon (2000) have detected specific changes in the seasonal phase of the gradients during spring. Before the wet Sahelian rainy season stronger MSE gradients are recorded in April (figure 3, right panel), whereas dry rainy seasons are rather preceded by weaker gradients shifted northward. Significant changes can also be observed in the components of the MSE, particularly in the geopotential height (figure 3, left panel) or temperature (not shown).

Through this analysis it appears that numerous regional atmospheric and continental signals occur before the July-September Sahelian rainy season. It is of interest now to check whether these signals can improve rainfall forecasting statistical models.

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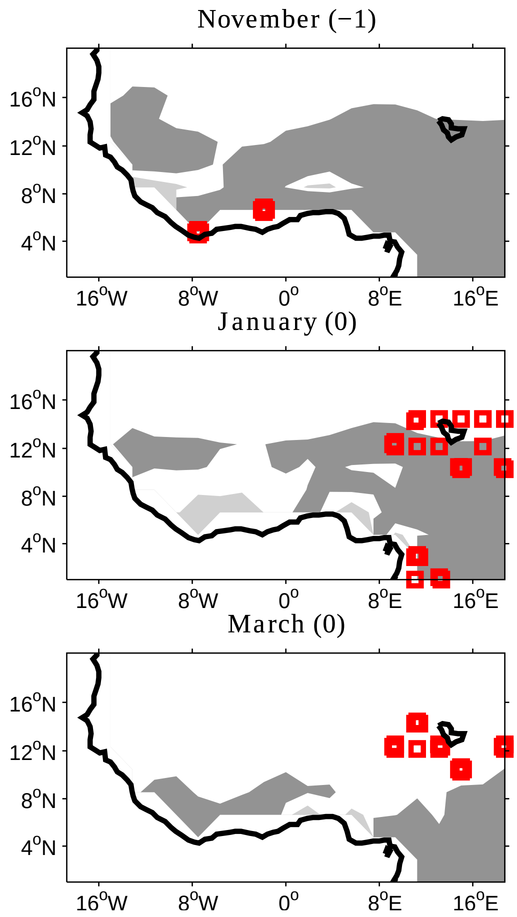

FIGURE 1: Composite maps of Deep Soil Wetness with respect to wet (std value >0.5: 69-70-71-74-75-78-88-89-94-95-98) minus dry (std value <-0.5: 68-72-73-77-79-82-83-84-87-90-97) years in the Sahel. Positive (negative) differences are displayed in dark (light) shading. The black squares define grid-points where differences are significant at the 95% level (regarding the Student t-test).

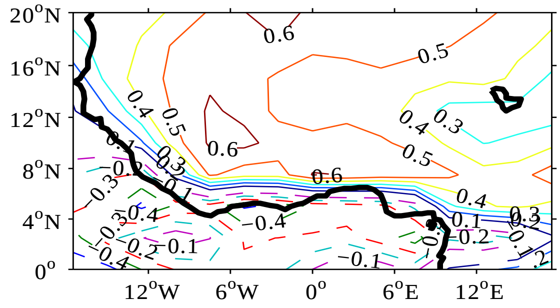

FIGURE 2: Linear correlation coefficients between March values of a Deep Soil Wetness index (5-12N/15W-15E) and the MSE field at 1000 hPa.

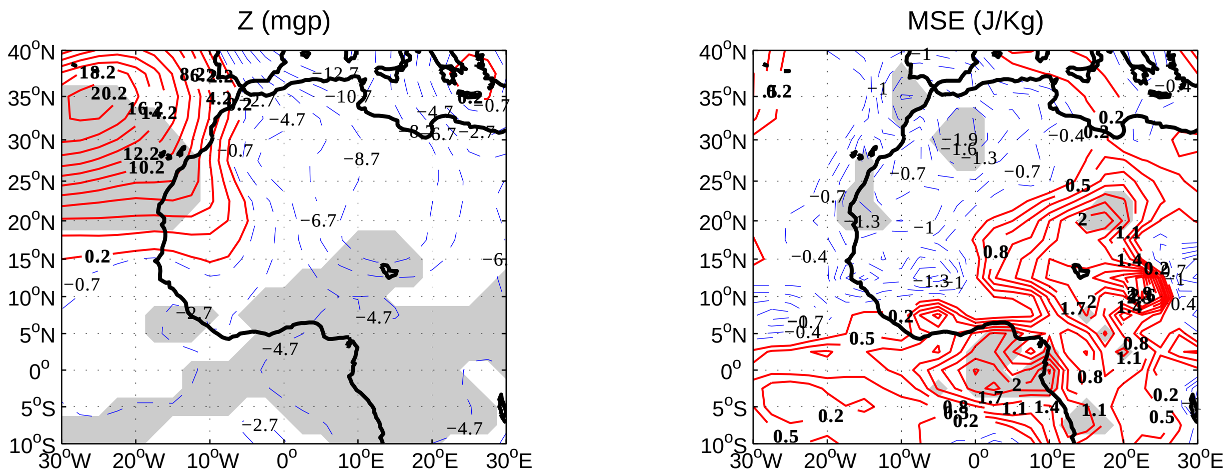

FIGURE 3: composite maps of geopotentiel height (Z) and MSE fields at 1000 hPa in April with respect to wet minus dry years in the Sahel. Positive (negative) differences are displayed in plain (dotted) lines. Shading: difference significant at 95% (Student t-test).

3. SEASONAL RAINFALL FORECASTING MODELS

The regional signals identified in section 2 were synthesized into indexes and entered (along with Sea Surface Temperature indexes computed from GISST2.2 (Parker et al. 1995)) into statistical models as potential predictors. The methods used were the Multiple Linear Regression (MLR) with a stepwise procedure and the Linear Discriminant Analysis (LDA) (Ward and Folland 1991).The 4 retained regional indexes (Table 1) allow the two models to efficiently reproduce SRI variability over the recent period. Indeed, the multiple linear correlation coefficient and the Linear Error in Probability Space (Potts et al. 1996) (for MLR and LDA respectively) achieve, in cross-validation mode, 0.76, 0.44 and 0.55 (Table 2). Thus, these models improve significantly (gain of 20% explained variance) the more standard models which solely use SST Principal Component as predictors. They have been applied with success for the real-time forecasting of the 2001 Sahelian rainy season (Philippon and Fontaine 2001).

CONCLUSION

The aim of this paper was to present the investigation performed at the Centre de Recherches de Climatologie on the potential role of the continent on the Sahelian rainfall variability and its use for improving the rainfall forecasting statistical models. The preseason specific patterns detected in the Deep Soil Wetness and the Moist Static Energy fields allow us to build regional predictors particularly efficient for modeling the recent interannual variability of the Sahelian rainfall as well as in operational forecasts.

NAME	LOCATION
Z* *(april)*	27,5°N / 10°E *minus* 20°W
MSE* *(april)*	27.5°N *ms* 2.5°N / 0°
ATL* *(april)*	2.5°N *ms* 22.5°S / 0°
Guinean Rainfall Index *(sept-nov.)*	5°-7.5°N / 10°W-10°E

TABLE 1 : name and location of the four indexes used as predictors in MLR and LDA models. * denotes gradients.

	Z	MSE	ATL	GRI
R total	-0.5	-0.55	0.56	0.61
VIF	1.16	1.31	1.18	1.57
Regression coefficients	-0.28	-0.33	0.35	0.22

TABLE 2: total correlations between predictors and SRI, Variance Inflation Factor and regression coefficients of the predictors.

REFERENCES

Drimeyer, P. A., A. J. Dolman and N. Sato, 1999: The Global Soil Wetness Project: a pilot project for global land surface modeling and validation. *Bull. Amer. Meteor. Soc.,* **80,** 851-878.

Eltahir, E. A. B. and C. Gong, 1996: Dynamics of wet and dry years in West Africa. *J. Climate,* **9,** 1030-1042.

Emanuel, K. A., 1995: On thermally direct circulations in moist atmospheres. *Journal of Atmospheric Sciences,* **52,** 1529-1534.

Fontaine, B. and N. Philippon, 2000: Seasonal evolution of boundary layer heat content in the West African monsoon from the NCEP/NCAR reanalysis (1968-1998). *Int. J. Clim.,* **20,** 1777-1790.

Hulme, M., 1992: Rainfall changes in Africa: 1931-1960 to 1961-1990. *Int. J. Clim.,* **12,** 685-699.

Kalnay, E., and coauthors, 1996: The NCEP-NCAR 40 year Reanalyses Project. *Bull. Amer. Meteor. Soc.,* **77,** 437-471.

Parker, D. E., M. Jackson and E. B. Horton, 1995: The 1961-1990 GISST2.2 sea surface temperature and sea-ice climatology, Hadley Center, Technical note, 63, 28.

Philippon, N. and B. Fontaine, 2001: The Centre de Recherches de Climatologie statistical forecast of the 2001 July-September West African rainy season. *PRESAO-4,*Niamey, 20-25 May.

Philippon, N. and B. Fontaine, 2002: The relationship between the Sahelian and previous 2nd Guinean rainy seasons: a monsoon regulation by soil wetness? *Annales Geophysicae,* accepted.

Potts, J. M., C. K. Folland, I. T. Jolliffe and D. Sexton, 1996: Revised "LEPS" scores for assessing climate model simulations and long-range forecasts. *J. Climate,* **9,** 34-53.

Ward, N. M. and C. K. Folland, 1991: Prediction of seasonal rainfall in north Nordeste of Brasil using eigenvectors of sea-surface temperature. *Int. J. Clim.,* **11,** 711-743.