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WEST AFRICAN MONSOON AND SST VARIBILITY. A NUMERICAL STUDY OF THE RESPECTIVE ROLES OF THE ATLANTIC AND PACIFIC OCEANS

Sylwia Trzaska# [1], Bernard Fontaine [1], Serge Janicot [2]
[1] Centre de Recherches de Climatologie, CNRS/Université de Bourgogne, Dijon, France
[2] Laboratoire de Météorologie Dynamique, Ecole Polytechnique, Palaiseau, France

1. INTRODUCTION

Interannual variability of the West African Monsoon has been statistically and physically linked for a long time to the occurrence and intensity of particular SST anomaly (SSTA) patterns such as the cross-equatorial SST anomaly gradient in the Atlantic or ENSO variability (see Rowell *et al*. 1995, Fontaine and Janicot 1996 for a review). Diagnostic analyses show however that these forcings are unstable in time over the last 50-years (Janicot *et al*. 2001). Questions arise:

1. What could explain the instability of the teleconnections ?
2. How do the aforementioned SST variabilities modulate their respective impacts over West Africa?

These topics are documented here via AGCM outputs in the divergent circulation frame since it allows to unify a global view of the modification of the E-W overturnings during an ENSO event and a more regionally anchored view of the West African Monsoon as a meridional overturning driven by low level boundary (thermal and moist) conditions.

2. EXPERIMENTAL DESIGN

A series of 16 numerical experiments have been performed with the AGCM Arpege-Climat (T42, 11 levels in the troposphere, Déqué *et al.* 1994) in August, the peak of the rainy season in the Sahel. The model has been forced with specific SSTA based on EOF decomposition in order to better document the respective Atlantic, Pacific and Indian SST forcings (cf. Trzaska *et al*. 1996 for the experimental design). The global experiments document: +AE+ (–AE-) northward (southward) oriented transequatorial (atlantic) and extratropical (global) SST anomaly gradients with Indian Ocean globally cooler (warmer); TE+ (TE-) ENSO-like pattern in the Pacific embedded in the same global extratropical northward (southward) SSTA gradients with cooler (warmer) Indian oceans. The basin-wide experiments +ATL, -ATL, IND and PAC document respectively the northward and the southward equatorial SSTA gradients in the Atlantic, overall warming of the Indian Ocean and ENSO-like pattern in the Pacific.

3. RESULTS

Divergent Circulation anomalies at the equator are shown in the figures 1 and 2.

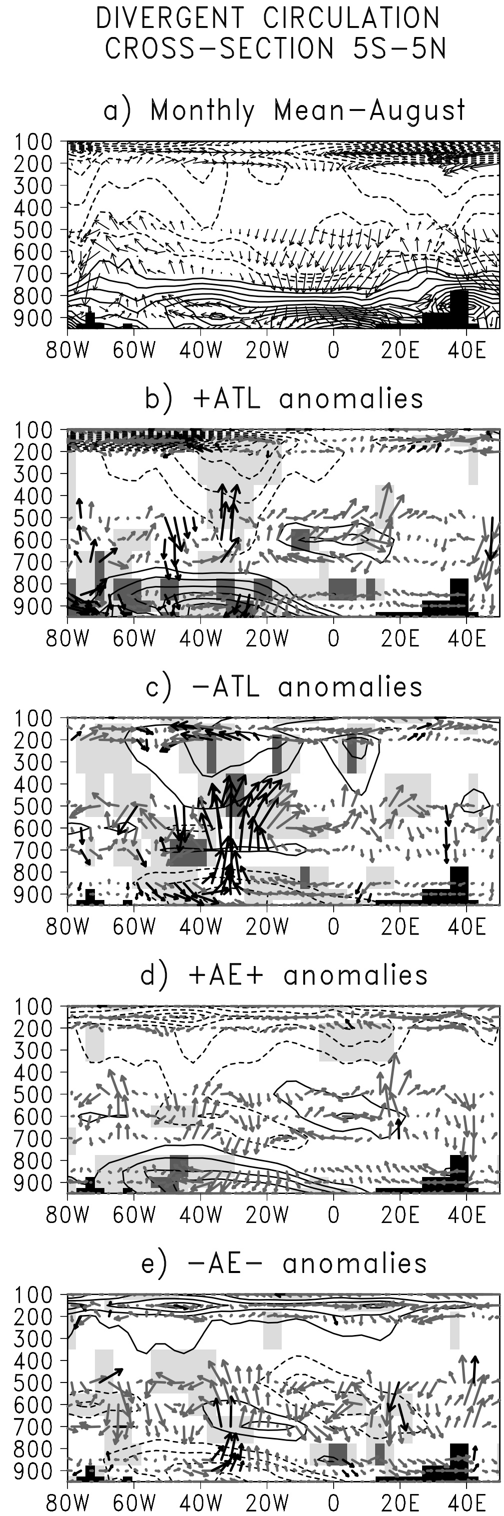

FIGURE 1*: Equatorial Cross-Sections (5S-5N) of the Divergent Circulation simulated by ARPEGE-Climat in August. ; monthly mean (a) and anomalies forced by SSTA : +ATL (b), -ATL (c), +AE+ (d), -AE- (e) ; contours - meridional component (spacing 0.25 m/s, 0-level omitted) ; vectors - vertical and zonal components (arbitrary scaling) ; anomalies significant at p=0.05 are : shaded for horizonal flux (light shading for zonal or meridional, dark shading for zonal and meridional) ; bold vectors for vertical velocity*

Corresponding author address : Sylwia Trzaska, Centre de Recherches de Climatologie, 6 bd Gabriel, 21000 Dijon, France ;
e-mail : Sylwia.Trzaska@u-bourgogne.fr

- The reversal of the SSTA gradient in the tropical Atlantic leads to an enhanced/reduced meridional circulation in the western part of the basin (fig.1 b,c,d,e). Western Africa is affected when global anomalies are used (fig.1 d,e vs fig 1 b,c) with zonal shifts of the middle level (directly linked to the west African monsoon, Trenberth *et al.* 2000) and an increase/decrease of the upper-level northerly flows.

- The warming of the Indian Ocean (cf. Casey et Cornillon 2001) leads to a significant increase of the zonal circulation in the eastern part of the domain (fig.2a) and of the low-level and mid-level meridional overturning over West Africa (20E-20W). Inspection of the extraequatorial latitudes (not shown) shows a reduction of the meridional extend of the latter. Thus weaker meridional and stronger zonal circulations are simulated.
- Pacific-only anomalies lead to a direct zonal circulation anomalies over Atlantic and Africa, consistent with the results of Goddard and Graham (1999) and Rowell (2001). Weak subsidence and reduced northerly upper-level flow are simulated over Africa. Vertical anomalies depict an eastward shift of the main subsidence in the central Atlantic.

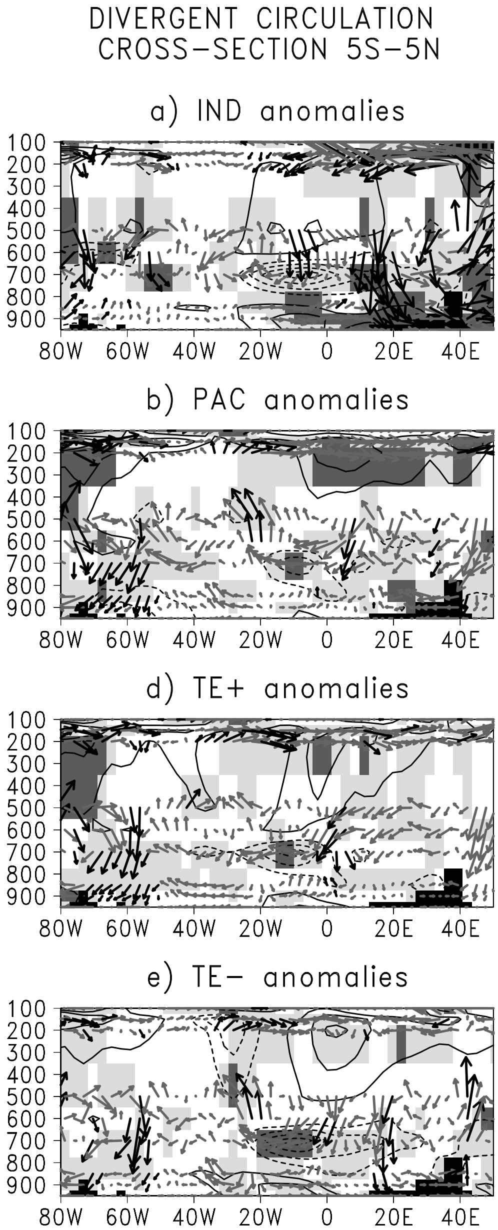

FIGURE 2 : *same as fig.1 but for (a) IND, (b) PAC, (c) TE+ and (d) TE- experiments*

- Global experiments (fig.2c,d) lead to similar anomalies with stronger impacts on the mid- and low-level meridional overturning over Western Africa, similar to the IND case. In the warmer southern and Indian oceans context stronger subsidence and meridional anomalies are observed. Monsoon is inhibited by an upper-level subsidence and low-level zonal divergence.

CONCLUSION

The results confirm previous analyses but show that: 1- The main impact of the reversal of the Atlantic SSTA gradient is observed in the western Atlantic in the coherence of the southern Hadley cell, hence ITCZ location.

2- The ENSO-related SST variability mainly affects the zonal location of the main climatological subsidence over central Atlantic

3- The recent long term warming in the Indian Ocean modulates 1 & 2 by forcing east-west anomalous circulations modifying the subsidence location in the Atlantic region and generating more zonally oriented circulation over Africa.

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