Role of the Atlantic cold tongue on the nature and variability of West African Monsoon rainfall onset

Session C3
W217A

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INTRODUCTION

The Atlantic cold tongue (ACT) is a dominant feature of the eastern Equatorial Atlantic that develops in boreal Spring and peaks in boreal summer. The ACT is a key feature of the West African monsoon (WAM), impacting the evolution and intensity of the rainfall in the West African region. This poster summarizes some recent work concerned with improving our knowledge and understanding of the nature and variability of the ACT including how this relates to the onset of seasonal rainfall in the Guinea coast region in spring and in the Sahel region in summer. It summarizes the key points arising from a series of recent papers dealing with these topics: Brandt et al (2010), Caniaux et al. (2011), Thorncroft et al. (2011) and Nguyen et al. (2011).

ANNUAL CYCLE OF THE COLD TONGUE AND ITS INFLUENCE ON WEST AFRICAN MONSOON RAINFALL

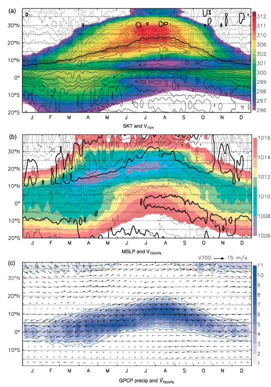

Figure 1: Hovmöller diagrams of ERA-Interim (10°W-10°E).

KEY RESULTS: Rainfall onset at the coast in April is linked with acceleration of low-level cross-equatorial southerly winds (see Fig 1(a)), important for establishing the ACT, discouraging convection near the Equator and transporting moisture towards the coast. Rainfall peak is maintained at the coast, rather than moving inland, due to persistent warm water in the coastal region.

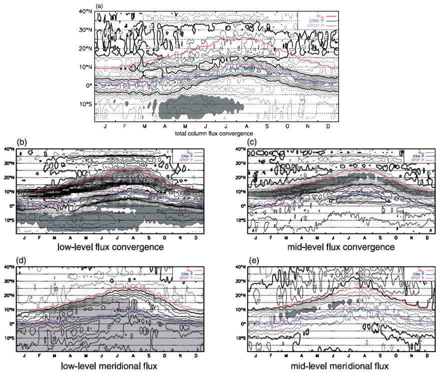

Figure 2: Hovmöller diagrams of (10°W-10°E) of vertically integrated moisture convergence (a,b,c) and meridional moisture fluxes (d,e).

KEY RESULTS: The annual evolution of the moisture fluxes , associated convergence and rainfall is strongly impacted by the ACT (and heat low). The ACT strongly regulates the timing and intensity of the coastal rainfall in Spring. The heat low and its associated shallow meridional overturning circulation strongly impact the profile in moisture flux convergence north of the rainfall peak – establishing a second minor peak in moisture flux convergence there.

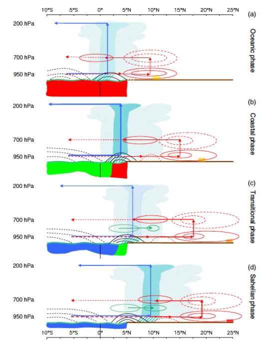

Figure 3: Schematic highlighting four phases of the WAM; contours depict moisture flux convergence; arrows indicate the sense of the meridional overturning circulations.

KEY RESULTS: The WAM is viewed in terms of four key phases (a) an *oceanic phase* between November and mid-April when the rain band is broad with peak values just north of the Equator; (b) a *coastal phase* between mid-April and the end of June when the rainfall peak is in the coastal region around 4°N (over the ocean); (c) a *transitional phase* during the first half of July when the rainfall peak decreases and (d) a *Sahelian phase* between mid-July and September when the rainfall peak is more intense and located around 10°N.

INTERANNUAL VARIABILITY OF THE COLD TONGUE AND ITS ROLE ON MONSOON ONSET AT THE GUINEA COAST

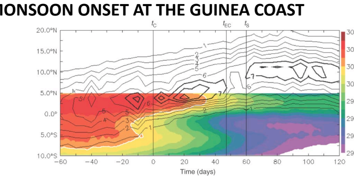

Figure 4: Composite diagram for the period 1982-2009 of NOAA OIV2 SST (shading) and GPCP precipitation. Vertical lines at day 0, day +46 and day +60 represent the coastal onset (t_c), the end of the coastal phase (t_{ec}) and Sahelian onset (t_s).

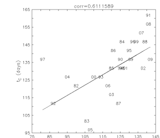

Figure 5: Scatter plot of coastal rainfall onset and cold tongue onset.

KEY RESULTS: The coastal onset is primarily driven by the development of the ACT. Variability in the time of the ACT onset is positively correlated with variability in the date of coastal rainfall onset. It is also positively correlated with the variability in the date of Sahelian rainfall onset (see below).

INTERANNUAL VARIABILITY OF THE COLD TONGUE AND ITS IMPACT ON MONSOON ONSET IN THE SAHEL

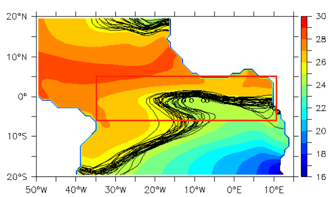

Figure 6: Mean SSTs at the time of peak ACT extension. Black lines denote the Annual mean extension of 25°C isotherm between 1982 and 2008 and dots mark the position where the ACT first appeared.

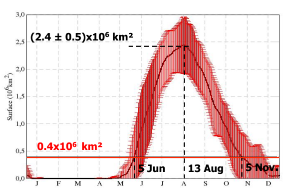

Figure 7: Seasonal evolution of surface of the ACT.

Definitions and Data used

Surface of the ACT: $S_{ACT} = \int_{A(x)} \delta(25°C - SST(x)).dA$

A(x): domain limited to the red area in Fig. 6

Onset date of the ACT: date at which $S_{ACT} > 0.4\times10^6$ km² (Fig. 7)

Data used: Reynolds (2007)' SSTs except in Figs. 9 and 10 for which HadISST1.1 (Rayner *et al.*, 2003) are used; winds are from NCEP1 (Kalnay *et al.*, 1996); WAM onset dates are from Fontaine and Louvet (2006)

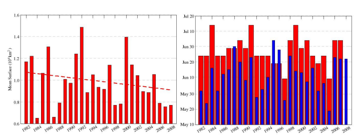

Figure 8: Interannual variability of the mean ACT extension (left) and comparison between mean ACT onset dates and Sahelian rainfall onset dates (right).

KEY RESULTS

1. The ACT is an area of anomalous cold SSTs, at and slightly south of the equator, covering a considerable area of the eastern tropical Atlantic (Fig.6; Fig.7). It forms a northward extension to the seasonal cooling of the southern hemisphere SSTs. Its appearance every year is remarkable, despite considerable interannual variability in extension (Fig.9) and onset date (Fig.10).
2. Cooling begins in May, lasts 3 months and reaches its maximal extension in mid-August; the ACT disappears in November-December after a somewhat longer warming period (Fig.7).
3. Over the past 27 years, the mean ACT onset is on 11 June ± 11 days, as the WAM onset is on 27 June ± 9 days (Fig.8 right). The Spearman rank correlation coefficient between the series of onset dates is 0.48 and reaches 0.80 when years of unclear WAM onset (see Fontaine et al., 2008; i.e. the ACT appears after the WAM onset) are excluded.
4. Late ACT and WAM onsets are associated with warm SST and convergent wind anomalies (Fig.9). A late ACT onset is associated with westerly wind anomalies in the western tropical Atlantic in boreal spring (Fig.9). A late WAM onset is associated with a SST dipole (warm SSTs in the ACT region and cool SSTs in the northeastern tropical Atlantic) (Fig.10).

Figure 9: Regression Maps of SSTs and winds onto the ACT Onset from March to October

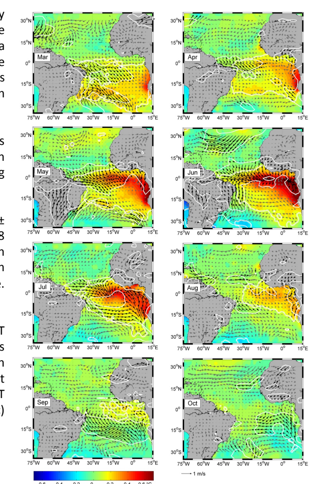

Figure 10: Regression Maps of SSTs and Winds onto the WAM Onset from March to October