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Intercontinental Atmospheric Processes in the Tropics: African Influence on South America

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1. Introduction

While there is a large body of literature on the influence of Pacific and Atlantic sea surface temperatures on South American climate, the role played by zonal intercontinental processes has largely been overlooked. Cook et al.(2004) examined the nature of intercontinental teleconnections between Africa and South America. The strongest interaction occurs during austral summer (January) in which the presence of Africa is found to introduce a large (up to 50 percent) suppression of rainfall over the Nordeste region of Brazil, and rainfall enhancement on the northern coast and with in the South Atlantic convergence zone (SACZ).

Some of the questions addressed in this study are :

- What is the influence of topographical features of Africa on South American climate?
- What are the influences of variabilities in surface moisture distribution over Africa on South America?
- What are the physical processes responsible for the interactions?

The approach used to address these questions is climate modelling with idealized boundary conditions.

2. Model Description and Simulation Design

A series of simulations with a version of the GFDL R30 L14 atmospheric GCM are discussed. Simple physical parameterizations, with the bucket hydrology at the surface and moist convective adjustment scheme, are used. The model is integrated with prescribed zonally uniform SSTs derived from observations and all continents except Africa and South America are replaced by ocean surface. This removes complications associated with zonal SST gradients and land surfaces of other continents.

The *Control* simulation includes realistic prescription of land surface features of both continents, including climatological soil moisture from observations. The *FlatAfrica* experiment is designed to isolate the influence of African topography on South America. The former is removed while the other surface features of the continent are maintained. The *WetAfrica* and *DryAfrica* experiments involve up to 20 percent increase and decrease, respectively,of the climatological soil moisture distribution over northern parts of tropical Africa.

3. African Topography

Significant convective thermal forcing is introduced over central and southern Africa by the presence of topography. This forcing is absent over the northern highlands. The irrotational part of the anomalous wind displayed in Fig 1.a has a significant southerly component over tropical Atlantic and results in a northward shift of the ITCZ. The circulation associated with topography has its descending part over northeastern tip of South America. So the overall response of this component of wind is intensification of the Walker like circulation across the Atlantic Ocean.

The precipitation perturbation over South America resulting from the presence of African topography is displayed in Fig 1.b Its influence is particularly large over the northeastern parts of South America where the rainfall is up to 6mm/day (about 80 percent) lower. The precipitation deficit is a consequence of descending part of the anomalous circulation discussed. The perturbation extends well into the northern-central parts of the continent. The anomalous divergence over northeastern South America (Fig 1.a) drives anticyclonic a flow which leads to flow of moisture towards the northern and central regions of the continent. The warm land surface then favors precipitation and low pressure over those regions. The other important role of African topography is its influence on the zonal background flow. The

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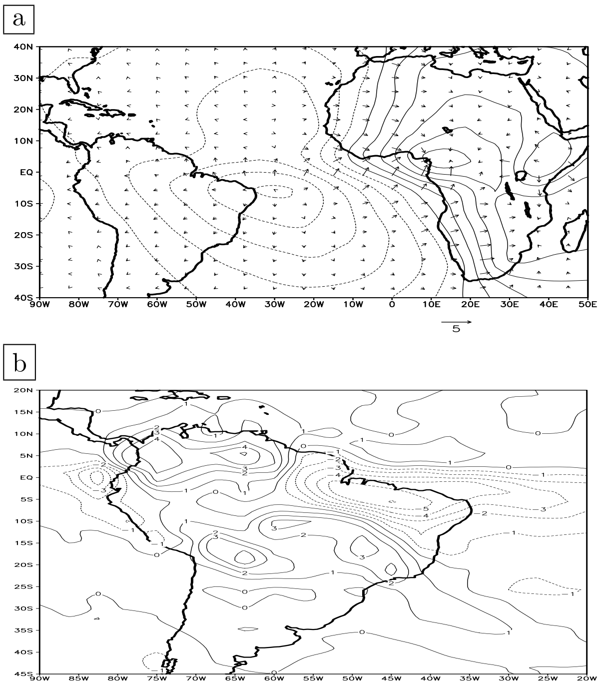

FIG. 1. *Control* minus *FlatAfrica* **(a)** Irrotational wind (m/s) at 866hPa and velocity potential, **(b)** Precipitation (mm/day)

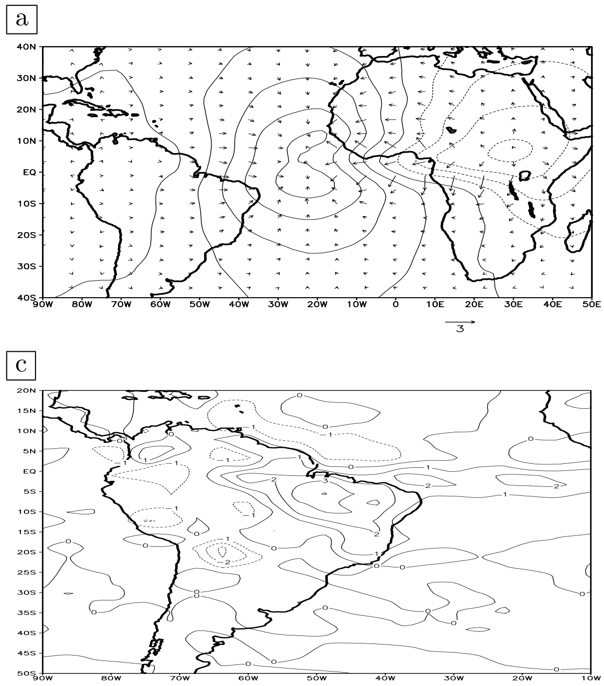

FIG. 2. *WetAfrica* minus *Control* **(a)** Irrotational wind (m/s)at 866hPa and velocity potential, **(b)** Precipitation (mm/day)

equatorial westerly components of the pair of the cyclones generated by the obstruction of the easterly flow by topography significantly weaken the easterly trade winds over the Atlantic Ocean. This has important implications on the strength of the ITCZ because the convection is ultimately driven by sensible and latent heat transfers from the surface which in turn are sensitive to the magnitude of the surface winds.

4. Surface Moisture

The effect of wetter surface conditions on the local distribution of convective heating is considered first. Convection is suppressed over the region of cooling while the now available moisture converges to the relatively warmer region to the south. This gives rise to the dipolar structure of the vertically integrated convective heating (precipitation). The surface temperature gradient is accompanied by the southward shift of the local ITCZ. The irrotational component of the anomalous wind and velocity potential are displayed in Figure 2.a. The weakening of the Walker circulation is apparent. This anomalous circulation has a northerly component which is particularly strong over the Gulf of Guinea and it gets weaker farther west. Anomalous precipitation over South America associated with wet surface conditions over Africa is shown 2.b. The north-eastern part of the former gains up to 3mm/day (about 40 percent of the climatological value).

In the *DryAfrica* experiment dry surface conditions over Africa increase the local surface temperature and enhance precipitation. The circulation associated with the resulting thermal forcing doesn't have strong cross equatorial flow which would influence the position of ITCZ as in the *WetAfrica* case.

5. Conclusion

The results of this study show that while the primary mode of climate variability over tropical South America is connected with the dynamics of the local ITCZ, the later is strongly influenced by African topography and surface conditions. A more comprehensive analysis of this problem is given in Hagos (2004)

REFERENCES

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