

# LATENT AND SENSIBLE HEAT FLUXES IMPACT ON THE EXTRATROPICAL CYCLONES OVER SOUTH ATLANTIC OCEAN

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## 1. INTRODUCTION

The influence of the latent and sensible heat fluxes (LSHF) in the oceanic extratropical cyclones in the Northern Hemisphere has been studied by many authors (Nuss and Anthes, 1987; Rogers and Bosart, 1991; Crescenti and Weller, 1992; Neiman and Shapiro, 1993; Zhang et al., 1999 and others). Several experiments on numerical sensitivity show that the LSHF alone do not produce cyclogenesis, but they can contribute significantly in the initial phase of the cyclones, before the fast pressure decrease (Uccellini et al., 1987; Kuo et al. 1991), or in the fast deepening phase (Reed et al., 1993; Chang et al., 1996). However, others studies indicate little negative impact of the LSHF on the cyclones (Kuo e Low-Nam, 1990; Reed e Simmons, 1991). It occurs when the LSHF are upward to the cold side of the cyclones, contributing to decrease the temperature horizontal gradients in these systems (Nuss and Anthes, 1987).

With relation to the cyclones over the South Atlantic Ocean there are few studies (Saraiva, 1996; Piva, 2001; Oda, 2005; Reboita, 2008) that investigated the role of the LSHF in their life cycle. In general, these studies show that in the absence of the LSHF upward, the cyclones are weaker; but differ from the phase of the life cycle in which the LSHF is more important, i. e., initial or deepening phase of the systems.

In order to evaluate the impact of the LSHF on the extratropical cyclones over the South Atlantic Ocean, from a climatological point of view, two simulations with a Regional Climate Model (RegCM3) were performed. One consists of a control experiment and other the LSHF were turned off in the model.

## 2. METHODOLOGY

### 2.1 RegCM3

The RegCM3 is a primitive equation model, compressible and solved in the sigma-pressure vertical coordinate. For climate applications, different physical parameterizations scheme options are available (Pal et al. 2007). In this study, the surface turbulent fluxes over the ocean were parameterized using the Zeng scheme (Zeng et al., 1998) and the moist processes were parameterized using the Grell convective scheme (Grell, 1993) with the Fritsch-Chappell closure cloud model (Pal et al. 2007).

### 2.2 Simulations

Two simulations were carried out from September 1989 to the January 1991: one is the control (ExpCTRL) and other is the sensitivity experiment (ExpFlux). In this last one the surface turbulent fluxes in the ocean (LSHF) were turned off in the model.

The simulation domain covers the region between 84°W-15°E and 60°S-5°S. The atmospheric initial and boundary conditions are from R2 NCEP reanalysis (Kanamitsu et al. 2002). The R2 has a horizontal resolution of 2.5° x 2.5° degrees of latitude by longitude and 17 vertical levels (1000-10 hPa), at every 6 hours (00:00, 06:00, 12:00 and 18:00 UTC). Over the ocean, the sea surface temperature (SST) monthly mean has a horizontal resolution of 1.0° x 1.0° with optimum Interpolation Sea Surface Temperature - OISST V2 of the NOAA (Reynolds et al. 2002). The topography and land data are specified by using the 10 horizontal resolution global archives from, respectively, United States Geological Survey (USGS) and Global Land Cover Characterization (GLCC), described by Loveland et al. (2000).

The horizontal resolution employed in the simulations is 60 km and in the vertical has 18 sigma-pressure levels (model top at 80 hPa).

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### 2.3 Cyclones Identification

The algorithm initially developed by Sugahara (2000) to identify and track the extratropical cyclones and modified by Reboita (2008) was applied in the present work. This algorithm uses methodologies similar to those of Sinclair (1994, 1995 and 1997) in which cyclones are identified through relative vorticity minima near surface.

The search of vorticity minimum ( $\zeta$ ) in the tracking algorithm is made by comparing each grid point with the 24 nearest points and the cyclones are identified when  $\zeta \leq -1.5 \times 10^{-5} \text{ s}^{-1}$  and their lifetime is higher than 24 hours. Once known the initial position of the cyclones one can determine the cyclones density which is the rate of the systems number in  $5^\circ \times 5^\circ$  regions by the same area. This study extends from January 1<sup>st</sup>, 1990 to December 31<sup>th</sup>, 1990.

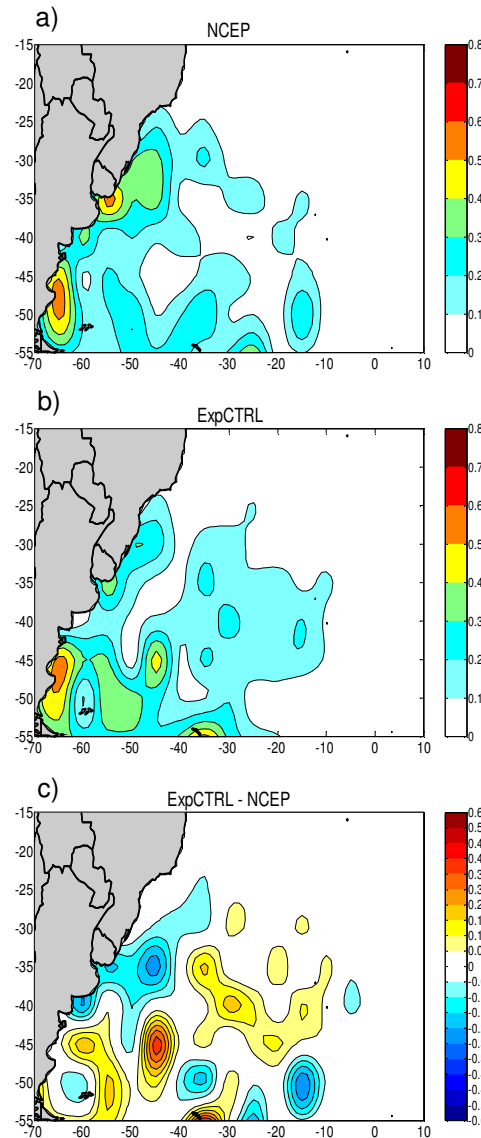
### 3. RESULTS

**Figure 1** presents the cyclones density in 1990 year for: (a) NCEP, (b) ExpCTRL and (c) ExpCTRL-NCEP. Higher cyclones density is found in the southern coast of Argentine and between Uruguay and south/southeastern of the Brazilian coast (**Figures 1 a-b**). The dynamic associated with the development of the cyclones in these regions is presented in Reboita (2008).

RegCM3 underestimates the cyclones density from the northern coast of Argentine to the coast of Uruguay and near the  $35^\circ\text{S}$  and  $45^\circ\text{W}$  (**Figure 1c**). On the other hand, around  $45^\circ\text{S}$  and  $45^\circ\text{W}$  and in the center of South Atlantic there is an overestimation. According to Reboita (2008), the higher density in the center of South Atlantic is due to the RegCM3 overestimation of the latent and sensible heat fluxes when compared to NCEP reanalysis. Thus weak systems in the NCEP appear more intense in the RegCM3 and are included in the climatology of the model. Although the simulation has some differences with relation to NCEP, this will not affect the present study because the sensibility experiment (ExpFlux) will be compared with the control experiment (ExpCTRL).

Comparing both simulations (**Figure 2**), a decrease in the cyclogenesis frequency is observed in the ExpFlux, particularly in the central sector of the South Atlantic. The suppression of the LSHF is unfavorable to the cyclogenesis due to increase in the static stability of the atmosphere and the decrease in the moist availability.

To verify the phase of the cyclones life cycle in which the LSHF have higher impact, the relative vorticity of the center of cyclones was compared along their lifetime for both simulations (**Figure 3**). Differences begin to appear after 12 hours of the cyclones genesis and it peaks near 36 hours. This result indicates that the LSHF has more influence during the maturation stage of the cyclones than in its initial phase which is in agreement with Piva (2001).



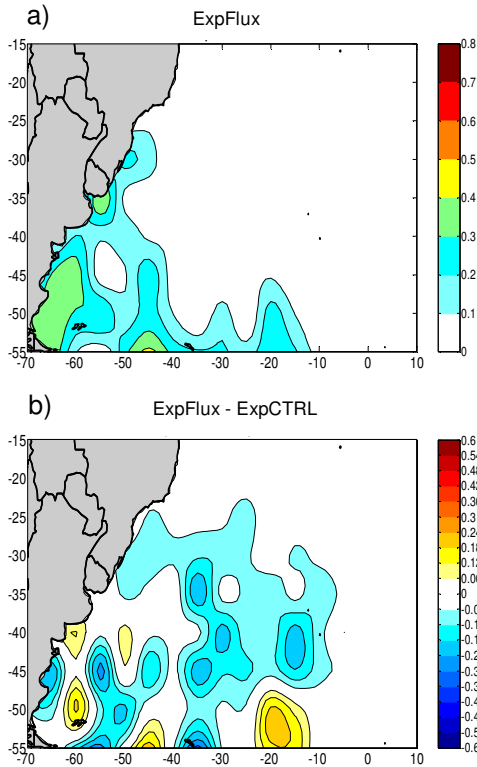
**Figure 1.** Cyclogenetic density ( $10^{-4} \text{ km}^{-2}$ ) in 1990 year: a) NCEP and b) ExpCTRL. c) ExpCTRL-NCEP.

Differences between the two experiments can also be verified in the lifetime and the distance

travelled by cyclones (figures not shown). Smaller lifetime and traveled distances are observed in the ExpFlux.

#### 4. CONCLUSIONS

The impact of the LSHF on the extratropical cyclones over the South Atlantic Ocean, from a climatological point of view, was evaluated using two simulations with the RegCM3, (a) a control experiment and (b) a sensitive experiment where the LSHF was turned off. Comparing both simulations, a decrease in the cyclones frequency was observed in the experiment without the LSHF, particularly in the central sector of the South Atlantic. In general, the cyclones in both experiments present similar relative vorticity in the beginning, but along of their life cycle, the cyclones with no fluxes are weaker. This result suggests that in the South Atlantic Ocean, the LSHF seems to be more important during the maturation phase of the cyclones and not in their initial development.



**Figure 2.** Cyclogenetic density ( $10^{-4} \text{ km}^{-2}$ ) in 1990 year: a) ExpFlux and b) ExpFlux - ExpCTRL.

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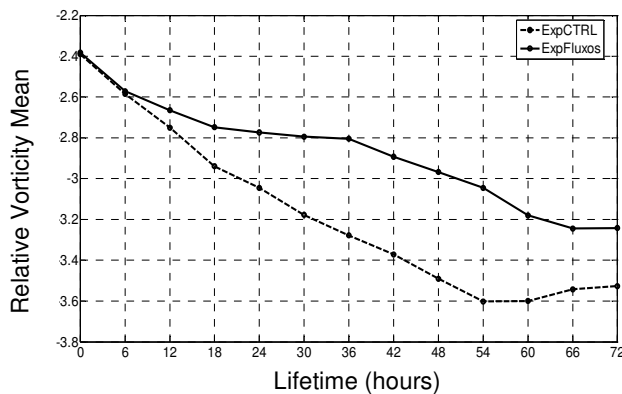
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**Figure 3.** Comparison between the relative vorticity average ( $10^{-5} \text{ s}^{-1}$ ) in the lifetime of the cyclones over Southern Atlantic Ocean in 1990 year in the ExpCTRL (dot line) and ExpFluxo (continuous line).

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