Moisture sources for subtropical cyclogenesis over the Southwestern South Atlantic

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1. Introduction

Subtropical cyclones (SCs) - non-frontal cyclones with warm core at low levels and cold core at upper levels of the troposphere. They form in association with a blocking pattern in upper levels, a cut-off low in 500 hPa and intense surface fluxes/warm air advection near surface (Evans and Guishard, 2009)

South Atlantic basin (1979-2011): most SCs develop near the southeastern coast of Brasil (Fig. 1). Summer is the most active season (2 cyclones per year) , followed by autumn and then spring. No SCs were detected in the most active region during winter (Fig. 2)

SCs in South Atlantic develop over relatively cool SST . The mean (~22ºC) is 4ºC below the classic threshold for tropical cyclogenesis.

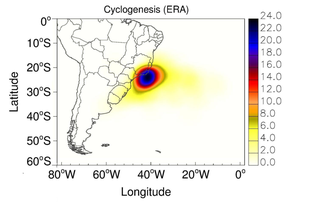

Fig. 1 - Subtropical cyclogenesis density (cic rad^{-2})

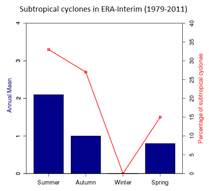

Fig. 2 - Seasonal mean

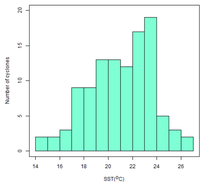

Fig. 3 - Frequency distribution of SST at the cyclogenesis time

Surface heat and moisture fluxes in the cyclogenesis days are near the climatological value, or even weaker (Fig. 4). This suggests that the evaporation from the underlying ocean may not be the main mositure source for the development of SCs in this region.
However, a great amount of moisture is advected by the northeasterly and northwesterly atmospheric flows and converge over the cyclogenetic region. (Fig. 5)

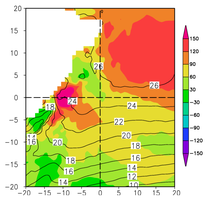

Fig. 4: Storm-centered composite of surface heat and moisture fluxes (shaded, W m^{-2}) and SST (contours, ºC), for all summer SCs.

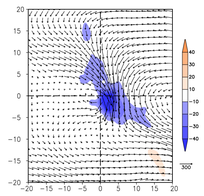

Fig. 4: Storm-centered composite of vertically integrated moisture flux (vectors, in 10^5 kg m^{-1} s^{-1}) and its divergence (shaded, in kg s^{-1}), for all summer SCs.

? Where does the environmental moisture in subtropical cyclogenesis days come from?

2. Data and methodology

Data: ERA-Interim reanalysis, from 1979 to 2011 (1.5º)

Methodology:

1)Tracking of all cyclones, using a vorticity based tracking algorithm (Reboita et al., 2010) and identification of subtropical cyclones: Cyclone Phase Space (CPS – Hart, 2003).

2)Determination of moisture source and sink regions: Lagrangian FLEXPART model (Stohl et al., 2005), with ERA-Interim wind field as input.

$$E - P \approx \frac{\sum_{N=1}^{K}(e-p)}{A}$$

E – P > 0 (hot colors): parcels are gaining moisture

E – P < 0 (cold colors): parcels are losing moisture

Lagrangian analysis determine the specific humidity variations in air parcels up to seven days before the subtropical cyclogenesis events. Maps are composites to all events in summer and autumn (68 and 39 events, respectively). Only these two season are presented, as the spring pattern is very similar to the summer.

3. Results

Where does the moisture come from?

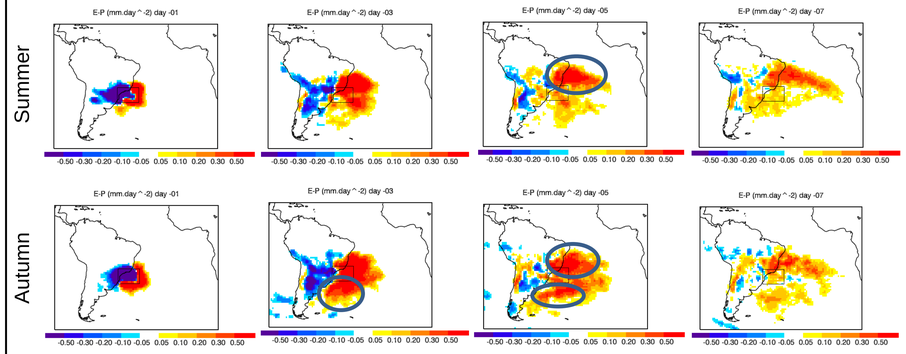

Fig. 6 - Backward analysis using 7-days retrointegrated averaged values of (E-P).
Day 0 corresponds to the cyclogenesis day

What is the wind pattern that transport the moisture?

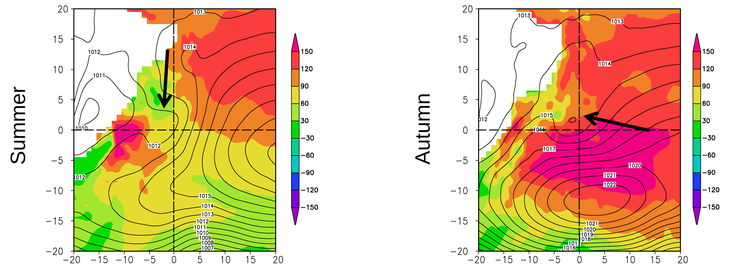

Fig. 7 – Storm-centered composites of mean sea level pressure (shaded, in hPa) and sensible and latent heat fluxes (shaded, in W m^{-2})

What is the most intense source of moisture, the local or the non-local one?

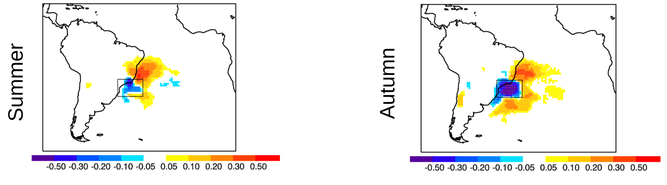

Fig. 8 – Backward 7-days mean **anomaly** of moisture **sources**

Hurricane Catarina: anomalous local and non-local sources of moisture

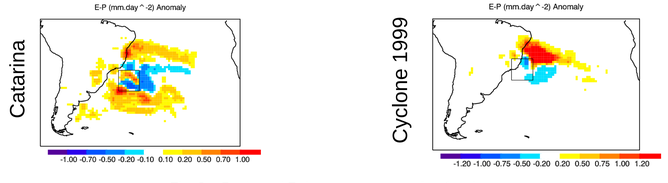

Fig. 9 – Backward 7-days mean **anomaly** of moisture **sources**

4. Conclusions

- At the South Atlantic Basin, subtropical cyclogenesis more frequent near the southeastern coast of Brasil; the most active season is summer (mean 2 cyclones/year) followed by autumn.

- SCs form in relatively cool SST (mean ~22ºC) with surface heat and moisture fluxes near the climatological mean value. Strong atmospheric moisture convergence is observed before and during cyclogenesis

- Atmospheric moisture comes from a region to the northeast of the cyclogenesis area. Its transport is enhanced by the pressure gradient between the incipient low and the South Atlantic Subtropical High. No contribution of the South American Low Level Jet is observed.

- In autumn, the northeastern source remains, while a second source region occurs southward of the cyclogenesis region. A persistent anticyclone enhances air-sea moisture exchangeand its transport

- In summer and autumn, the local source of moisture is reduced before the cyclogenesis, but the non-local source is intensified. The transported atmospheric moisture converging over the cyclogenesis region may balance the weaker local surface moisture flux in subtropical development.

- In Hurricane Catarina, both local and non-local moisture sources were increased, and this may have helped the cyclone to undergo complete tropical transition. In another ordinary SC, only the non-local source is intensified.

5. Outlook

? How will subtropical cyclones develop in the absence of non-local moisture source?

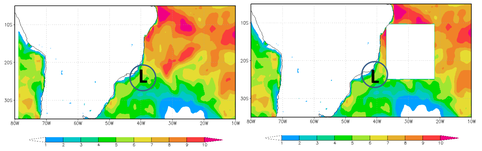

Fig. 10 – Surface moisture flux fields (shaded, in kg m^{-2} s^{-1}) for the (left) control experiment and (right) supressing the non-local source of moisture.

This question will be answered soon by numerical experiments (WRF-ARW model)

6. References

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