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IS THERE RELATION BETWEEN THE SANTA MARTA EDDY AND THE EXTREME CLIMATE EVENTS IN THE SOUTH OF BRAZIL?

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ABSTRACT

Some authors have shown that air–sea interaction at ocean fronts and eddies exhibits positive correlation between sea surface temperature (SST), wind speed, and heat fluxes out of the ocean, indicating that the ocean is forcing the atmosphere. Beside of this, some authors have shown that predictions based on El Niño effects alone in the south of Brazil is not sufficient to ensure an appropriate level of accuracy. The relation between extreme events in the south of Brazil and the Santa Marta Eddy, observed along Paraná and Santa Catarina States shelf break, is studied based on satellite tracked drifter data for 1993-2009 and on information of Civil Defense of Paraná, Santa Catarina and Rio Grande do Sul States for 1993-2007. Preliminary results indicate that the Santa Marta eddy seems to play some role in the extreme climate events of south of Brazil.

Key-words: Mesoscale eddy, extreme climate events, sea surface temperature anomaly.

1. INTRODUCTION

Intense oceanic mesoscale eddies, commonly referred to as rings, have been described in connection with the Brazil Current, a western boundary current. Schmid et al. (1995) used data from different platforms and instruments to describe the Vitória eddy (~20 ºS); Stech et al. (1996) based on AVHRR images and current meter moorings and Souza and Robinson (2004), based on drifters and sea surface temperature (SST) data, described the São Tome Eddy (~ 22ºS); Lentini et al. (2002) used 6-year time series of sea surface temperature fields derived from AVHRR images to present morphologic aspects related to 43 warm-core rings detected near the Brazil-Malvinas Confluence (~36 ºS); Assireu et al. (2003) and Assireu (2003) used satellite-tracked drifters data to estimate the lifetime, size, tangential and translational velocity of eddies in the region of the Santa Marta Cape (~27-28 ºS).

The impact of ocean-atmosphere interactions on weather and climate has received attention. Park and Cornillon (2002) showed that the observed acceleration of the wind over warm core rings and deceleration over cold core rings is found to be consistent with that predicted by the planetary boundary layer model of *Brown and Foster* (1994). Park et al. (2006) pointed out that wind stress curl due to ring modifications causes dipolar Ekman pumping sufficient to influence ring translation and decay processes, a feedback

mechanism between ocean and atmosphere. Chaudhuri et al. (2009), based on numerical simulations, demonstrated a significant correlation between warm core-rings (WCR) occurrences and variations in large-scale atmospheric forcing related to the state of the North Atlantic Oscillation (NAO). Natural disasters in South Brazil have been focus of assessment due to socioeconomic and environmental impacts caused to society (HERRMANN, 2006; SAUSEN et al, 2009). To our knowledge, no study on the possible relation between rings observed along the Brazil Current and the extreme events occurring in the south of Brazil has been carried out. Therefore, the goal of the present study is to investigate some qualitative correlation between the Sta. Marta Eddy and the occurrence of extreme climate events of the south of Brazil.

2. DATASET

The dataset analyzed in this study has three major components: (a) satellite-tracked drifters observations, (b) extreme climate events data, and (c) satellite image.

2.1. Drifter data

Data from 114 surface drifters, launched between 1993 and 2009, amounting to 16,728 daily drifting positions, were used in this study. Geographically, the highest data density is in the Brazil Current region (Fig. 1a) and is nearly evenly spaced seasonally, with exception to summer (Fig. 1b). The data utilized are provided by different projects: COROAS (Oceanic Circulation for the Western Region of the South Atlantic), National Program for Buoys (PNBÓIA), INPE/PETROBRAS, IEAPM (Research Institute of the Navy) and MONDO (Oceanic Monitoring by Drifters - www.prooceano.com.br/mondo) Project, Table 1.

2.2. Extreme climate events

Analysis of extreme climate events of the period from 1993 to 2007 was carried out based on Reckziegel (2007) and Herrmann (2006), and based on the information of the Civil Defense of Paraná (PR), Santa Catarina (SC) and Rio Grande do Sul (RS) states available in their websites. For some years, the data related to number of droughts for RS, was not specifically separated for months. Therefore, for 1997, 1999, 2004 and 2005, the data was not considered in the analysis. For these years the values were expressed as a mean value for January-May (1997), January-March (1999), January-May (2004) and January-March (2005), reaching high values as 224, 233, 402 and 458, respectively.

2.3. Satellite Data

The satellite-derived sea surface temperature (SST) fields used in this study were based on the data collected by the Advanced Very High Resolution Radiometer (AVHRR) aboard the NOAA-11 polar orbiting satellite.

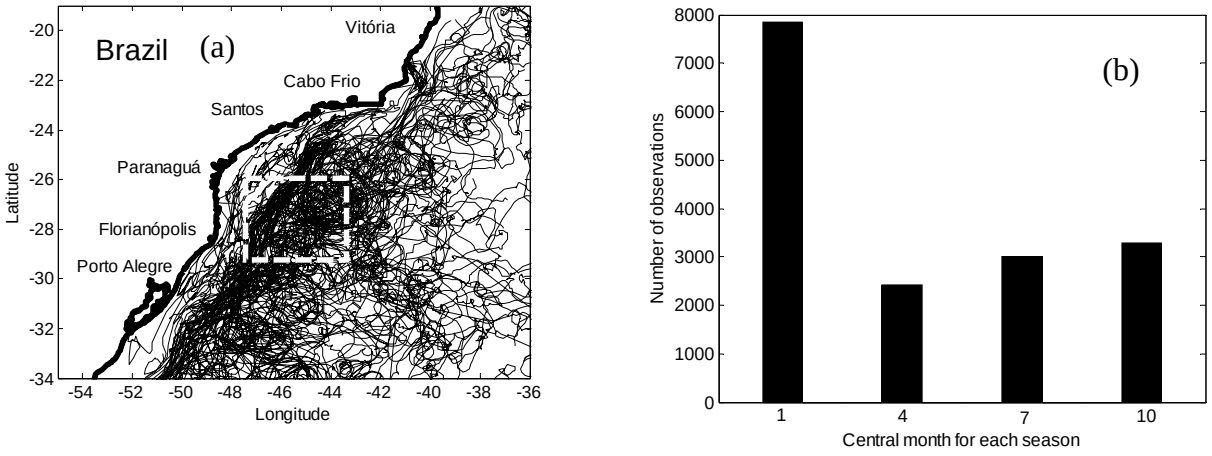

Fig. 1 – (a) Summary plot of 114 drifter trajectories (1993-2009). The white box indicates the area of this study where the Santa Marta eddy is detected. (b) Frequency distribution of position observations as a function of climatic season. The number 1, for example, indicates January (summer in the south hemisphere, corresponding to the months of December, January and February).

Table 1 - Launch of drifters for 1993-2009

Project	**Number of drifters**	**Year**
COROAS	15	1993-1994
PNBOIA	30	1997-2009
INPE/PETROBRAS	24	1997-1998
IEAPM	06	1997
MONDO	39	2007

3. RESULTS AND DISCUSSIONS

Four cyclonic eddies, corresponding to twelve cold rings, were detected using drifters (Fig. 2). The cyclonic eddies are dynamic features which move with the meander inducing upwelling on the outer shelf (Lee et al., 1981; Osgood et al., 1987). The rotational periods of the rings varied from 6 to 15 days and the eddy lifetimes ranged from 10 to 38 days. The major semi-axes varied between 19 km and 140 km and the minor semi-axes from 17 km to 90 km. The mean diameter of these cyclonic eddies is approximately 50 km, which coincides with the internal Rossby radius of deformation of this region (Houry et al., 1987). This, together with the intense topographic gradient in this region, would make it possible to interpret the Santa Marta Eddy as a quasi-stationary eddy-meander of the Brazil Current. However, along the analyzed years, based on 114 drifter trajectories, only 4 trajectories were captured by the rings. Thus, statistically, Santa Marta Eddy is seems as extreme events and will be treated here as such. The 1997-1998 El Niño was the strongest in the known history (Kane, 2002) and the 1992-1993 El Niño was also strong. Two of the four eddies were detected in these years.

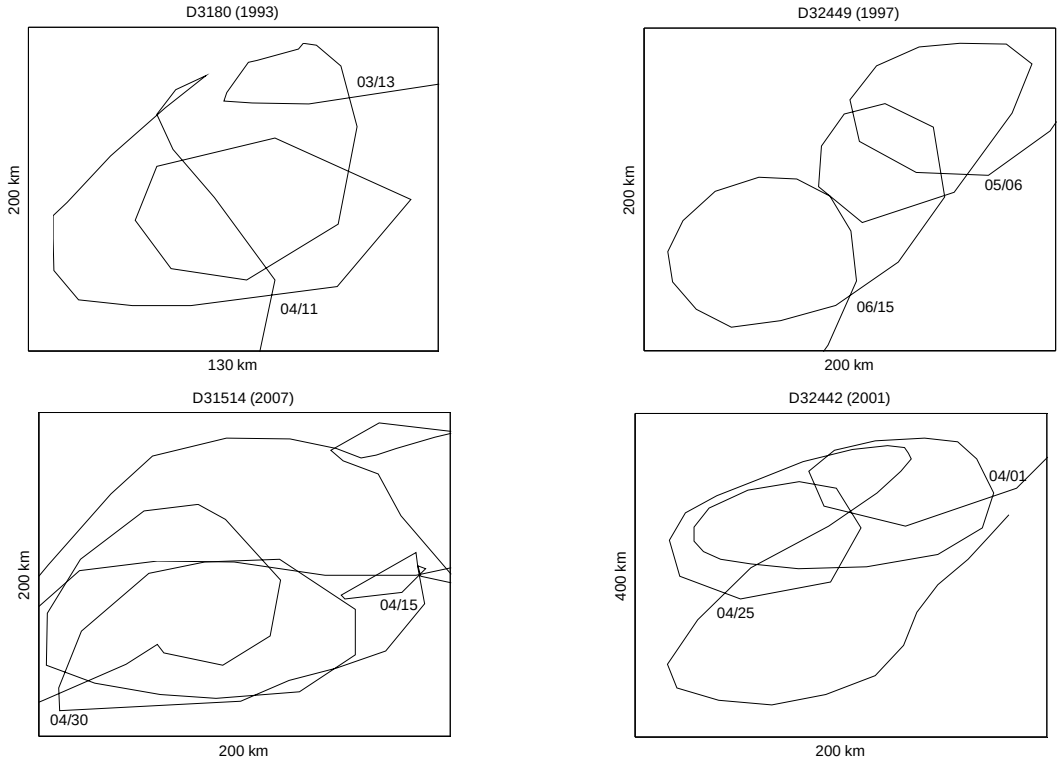

Fig. 2 – Eddies detected by drifters. The dates on the right hand panels indicate the beginning and end of each eddy.

Due to their highly synoptic coverage, daily AVHRR/NOAA infrared images are used to identify features such as meanders, eddy and fronts in the studied area. These images help us to confirm the cold-core characteristics of the Santa Marta eddy.

In order to investigate the possible relation between the Santa Marta Eddy and extreme climate events, data from disastrous droughts, storms and floods were summarized jointly with information about the occurrence of El Niño, La Niña and eddy, for the south of Brazil (Fig. 3).

The number of droughts in March-April months (Fig.3a) was larger for period of weak El Niño, while for May (Fig. 3c) it was larger for 1997, the year that the El Niño was the strongest in the known history. The number of storms in May-June (Fig. 3b) was the highest in 1997, followed 2000 and 2005, periods of moderate La Niña and weak El Niño. For the flood numbers in April (Fig. 3d), if we eliminate the year 1998, the strongest El Niño, a significant number of flood are observed in the periods of moderate and weak El Niño and La Niña. Based on these results, no clear relation between El Niño and droughts, storms and floods could be observed for the first semester (periods of eddy detection), from 1993 to 2007 years. Thus, as anticipated by Kane (2002), our results shown that predictions based upon El Niño effects alone in the south of Brazil are not easy.

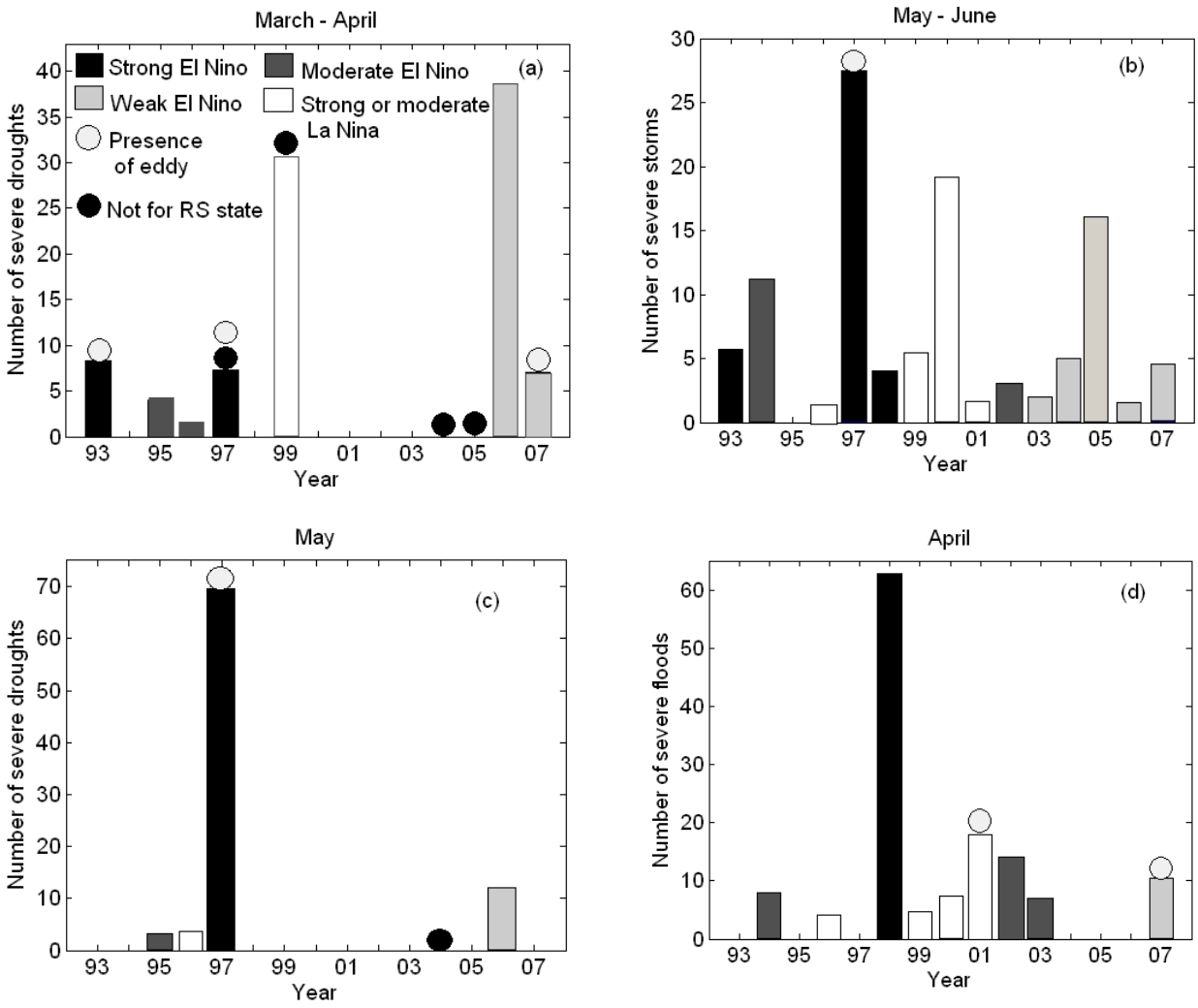

Fig. 3 – Number of extreme climate events for months with the presence of eddy. Paraná and Rio Grande do Sul data ranged from 1993 to 2007. Santa Catarina data ranged from 1993 to 2003.

The rings were detected by the drifters in both period of strong and weak El Niño (Fig. 3 - a,b,c,d) and for periods of strong or moderate La Niña (Fig. 4d). Thus, the occurrence of eddy does not seem related with these events. Note that there are some coincidence between the presence of eddy and the extreme climate events (Fig. 3). Since the eddy can alter significantly the SST in the coast of the south of Brazil, this seems to play some role in the extreme climate events of the south Brazil and may not have any relation to El Niño. The "year not analysed" (Fig. 3) correspond to those years without information specifically for months of interest.

4. CONCLUSIONS

Analysis based on the eddy occurrence and the extreme climate events in the south of Brazil suggests that a considerable influence arises from SST anomaly due to cold-core rings detected near the Paraná and

Santa Catarina shelf break, named here the Santa Marta Eddy. Only a weak and qualitative relation between El Niño/La Niña effects and natural disasters with the eddy occurrence was observed at the period analyzed. However, this conclusion needs further investigation. A more detailed characterization of phase lags or leads, in order to find out the relation between cause and effect is in progress and will be communicated later. The contribution of the warm-core rings formed in the Brazil-Malvinas Confluence also deserves further investigation.

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