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SHORT-SCALE WAVE VARIABILITY IN THE SOUTH ATLANTIC OCEAN BASED ON EMPIRICAL ORTHOGONAL FUNCTION AND SINGULAR VALUE DECOMPOSITION

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1. OBJECTIVE

➢ Aiming at a better understanding of the ocean wave climate in South Atlantic and given the great importance that waves represent in all activities linked to the ocean, the present work has the goal to analyze the variability of the wave field in the South Atlantic Ocean from June 2006 to July 2007.

➢ In order to find the mechanism that drives the short-scale wave variability studied in this paper, we have tried to investigate if the SAM index has presented some relation to our data.

2. METODOLOGY

➢ The WAM model computes the two-dimensional surface wave spectrum F (*f*, θ, ø, λ, t). In deep water, the spectrum is usually forced by three source terms, S_{in}, S_{nl}, and S_{ds} and governed by the wave balance equation (HASSELMANN, 1962 and KOMEN et al., 1994):

$$\frac{dF}{dt} + \mathbf{v}_g \cdot \nabla F = S_{in} + S_{nl} + S_{ds}$$

$$M = \begin{bmatrix} x_{11} & x_{12} & \cdot\;\cdot\;\cdot & x_{1p} \\ x_{21} & x_{22} & \cdot\;\cdot\;\cdot & x_{2p} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ x_{n1} & x_{n2} & \cdot\;\cdot\;\cdot & x_{np} \end{bmatrix}$$

Figure 1: Each row is one map and each column is a time series of observations.

➢ As wind input, the wind stress field calculated by the CPTEC atmospheric global model with resolution T126L28 has been used.

➢ The simulations were carried out in the **hot start** mode of model, i.e., the results of a day have taken in consideration the sea state of earlier days. In order to do this a **spin-up of 30 days** has been employed.

3.2 The SVD analysis

➢ The greatest eigenvalues in the coupled analyzes occurred between the *swell* and T_p fields, with the four leading modes explaining 68% of the total variability. The second greatest correlation in the coupled analysis occurred between *Hs* and *Tp*, where the four principal modes have explained 61% of the variability.

3. 3 Time Series

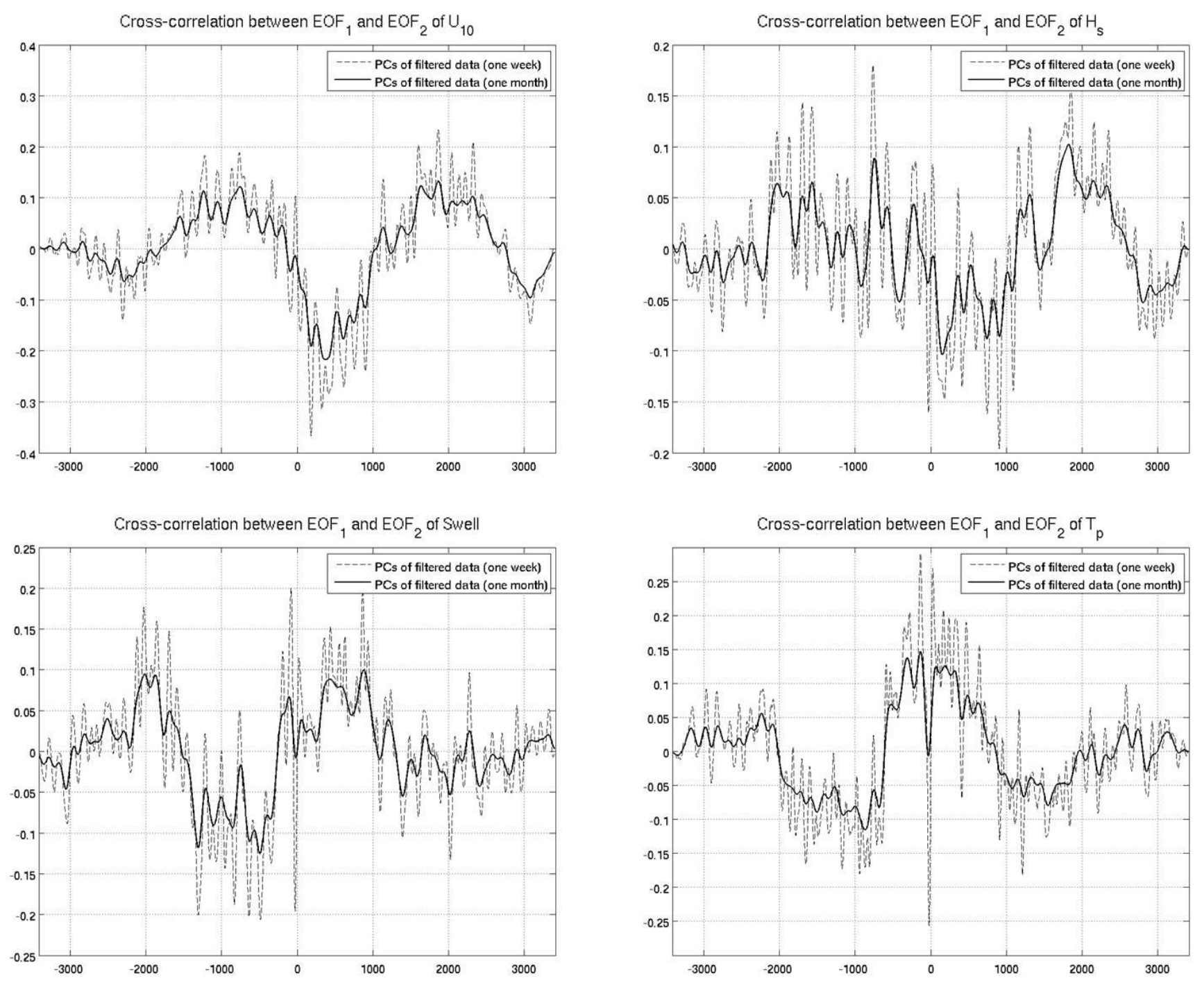

Figure 6: Cross-correlation functions of the 1st and 2nd PC's time series of U_{10}, H_s, *Swell* and T_p in the South Atlantic Ocean.

➢ In order to identify the mechanisms that drive the short-scale variability of H_s and *swell* in the South Atlantic Ocean, the corresponding cross-correlation functions of the 1st and 2nd principal component time series have been computed.

➢ *Swell* and T_p have showed very similar phase velocity and time scale (Fig. 12).

➢ The cross-correlation functions have showed that in each 12.5 days there were 6 strong signs (or one in the two days gap), and it lead us to assume that the spatial patterns of all variables have short-scale variability.

➢ The U_{10} and H_s positive signs were associated to T_p and *swell* negative signs. This behavior happens because the *swell* is generated by non-local winds. When the local wind intensity is high, the momentum transfer from atmosphere to the surface layer ocean, in this area, is also higher.

4. CONCLUSIONS

➢ The biggest eigenvalues occurred were between swell and Tp and between Hs and Tp, indicating a strong correlation between these variables.

➢ From spatial patterns were noticed contributions of swell from Pacific, Indian and North Atlantic Oceans.

➢ The application of cross-correlation function of PC's time series has provided the information that a maximum oscillation happen in each two day. We guess that these short and synoptic scales can have some relation to the extratropical cyclone variability.

➢ The SAM (-) tendency added with the also negative correlation coefficient with all variables analyzed sugesst that the storms have shifted toward midlatitudes, and, consequently, there is larger chance to occur swell events.

➢ The leading potential mechanism that drives the short-scale variability of Hs and swell in the South Atlantic Ocean is the extratropical cyclone amount variability.

➢ The application of EOF and SVD method's for obtaining leading modes of short-scale spatial temporal variability of oceanic waves appear to be pioneer in the South Hemisphere.

3. RESULTS AND DISCUSSIONS

3.1. The EOF analysis

Spatial-temporal variability of the significant wave height (H_s), velocity of the wind at height 10 meters (U_{10}) , Swell and peak period (T_p):

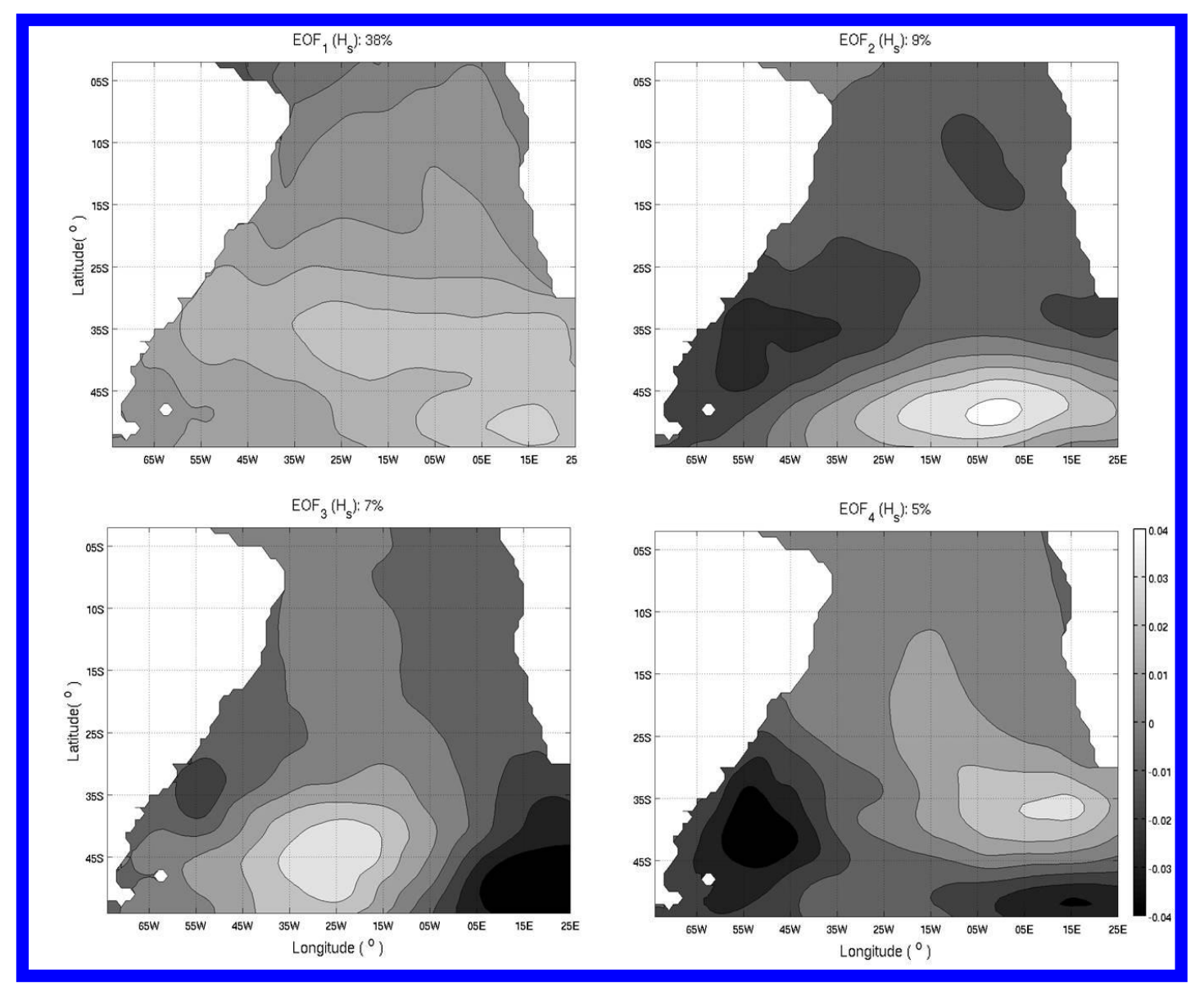

Figure 2: Leading modes of variability of significant wave height in the South Atlantic Ocean.

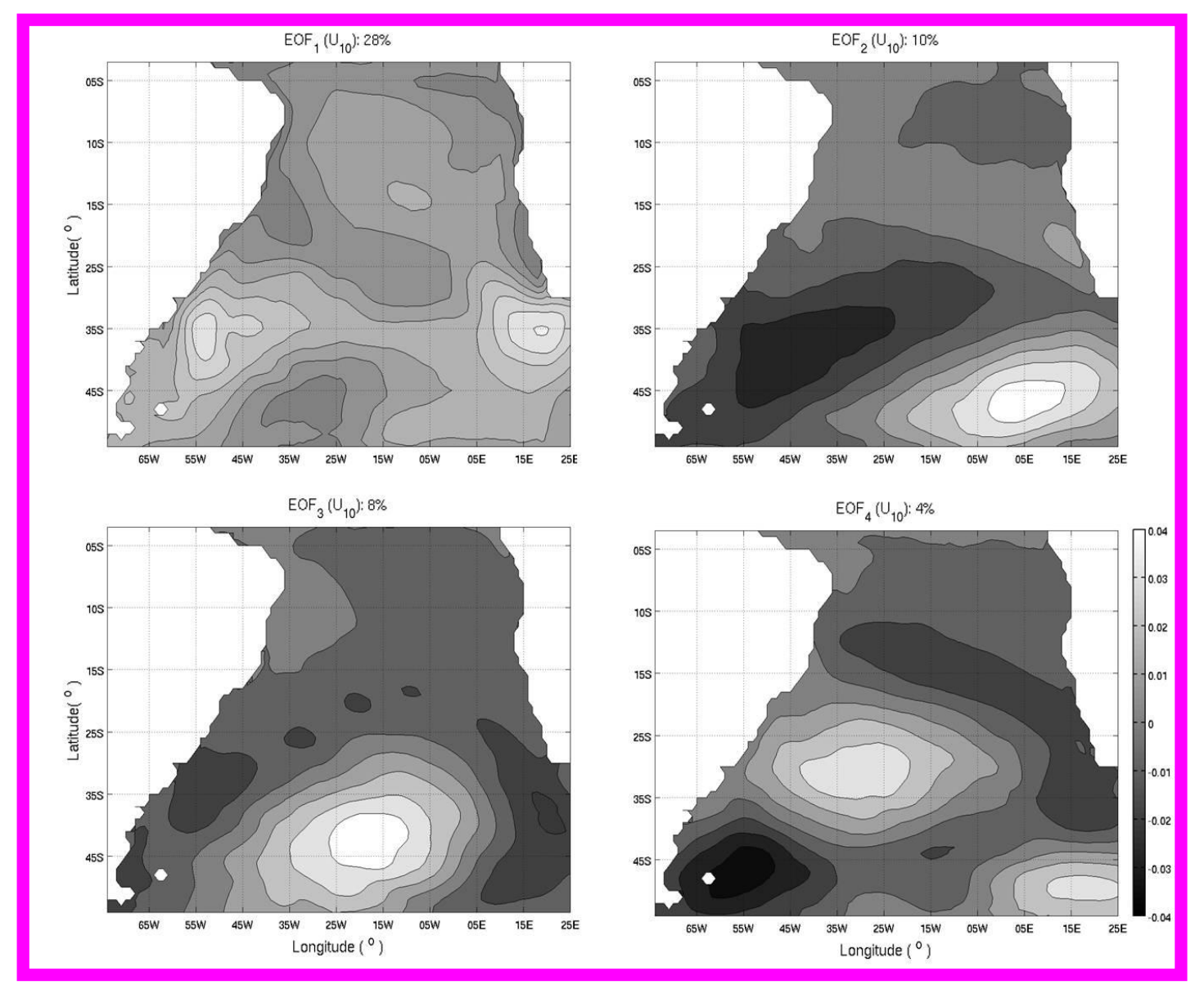

Figure 3: Leading modes of variability of the wind at height 10 meters over the South Atlantic Ocean.

➢ The second and third modes of H_s, can be related to zonal changes of the Anticyclone of South Atlantic Ocean and of the Brazil-Malvinas Confluence region.

➢ STERL and CAIRES (2005) found that the first global EOF of H_s explained 15% of the global wave variability with a spatial pattern very similar to the one in the present paper.

➢ The first mode of variability of U_{10} is related to the first mode of H_s, as the second mode of U_{10} is to the second mode of H_s.

➢ The spatial pattern of the EOF_3 of U_{10} started appearing in the EOF_3 of H_s, but became really similar to the EOF_4 of H_s, what showed that there is a time lag for the ocean surface to respond to an atmospheric forcing.

➢ The EOF_1 of U_{10} and of H_s relate to the the EOF_1 of sea level pressure found by VENEGAS *et al.* (1997), i.e., 12% of the variability of U_{10} and 38% of variability of H_s are associated to changes of intensity and spatial-temporal of the Anticyclone of the South Atlantic.

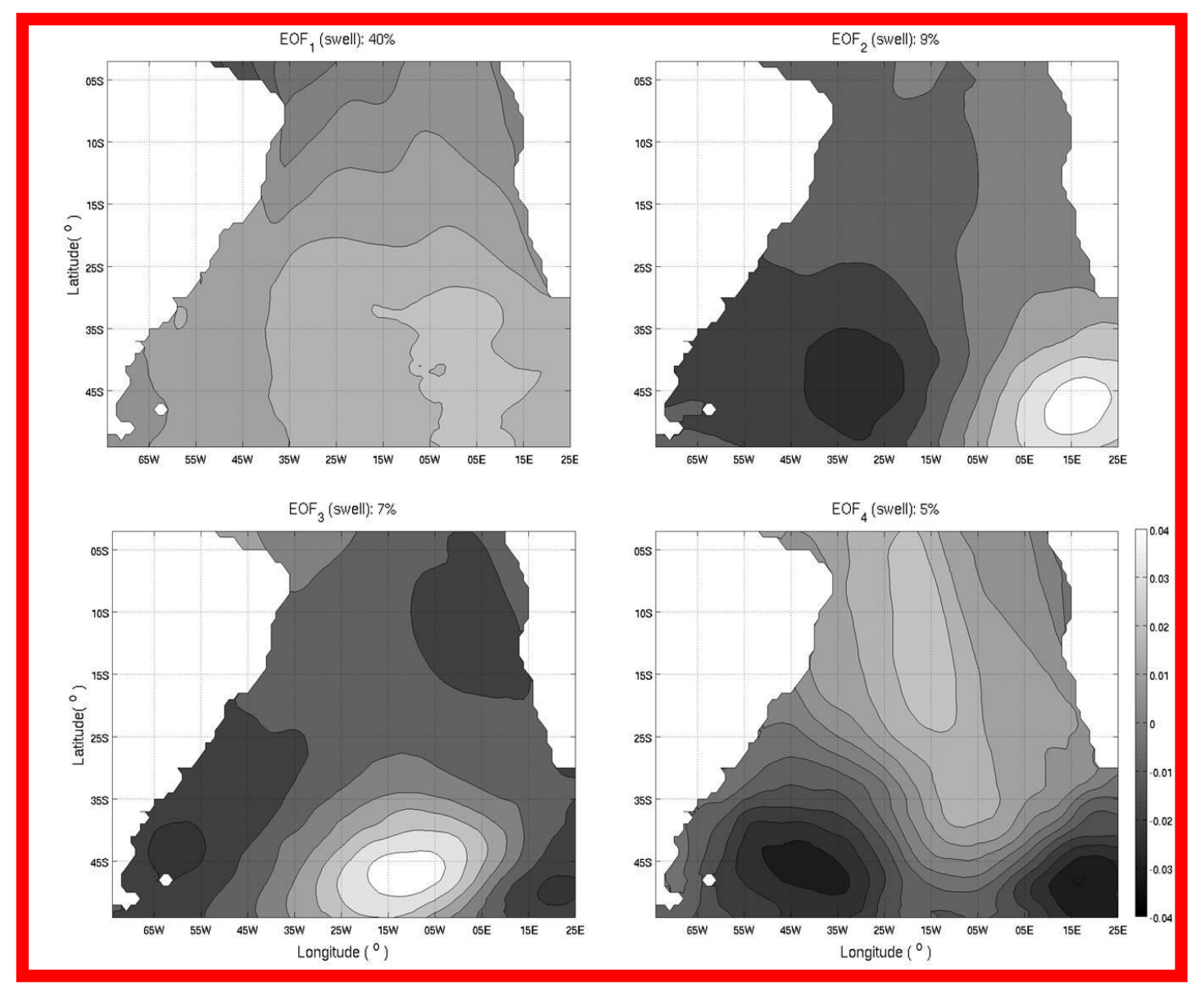

Figure 4: Leading modes of variability of swell in the South Atlantic Ocean.

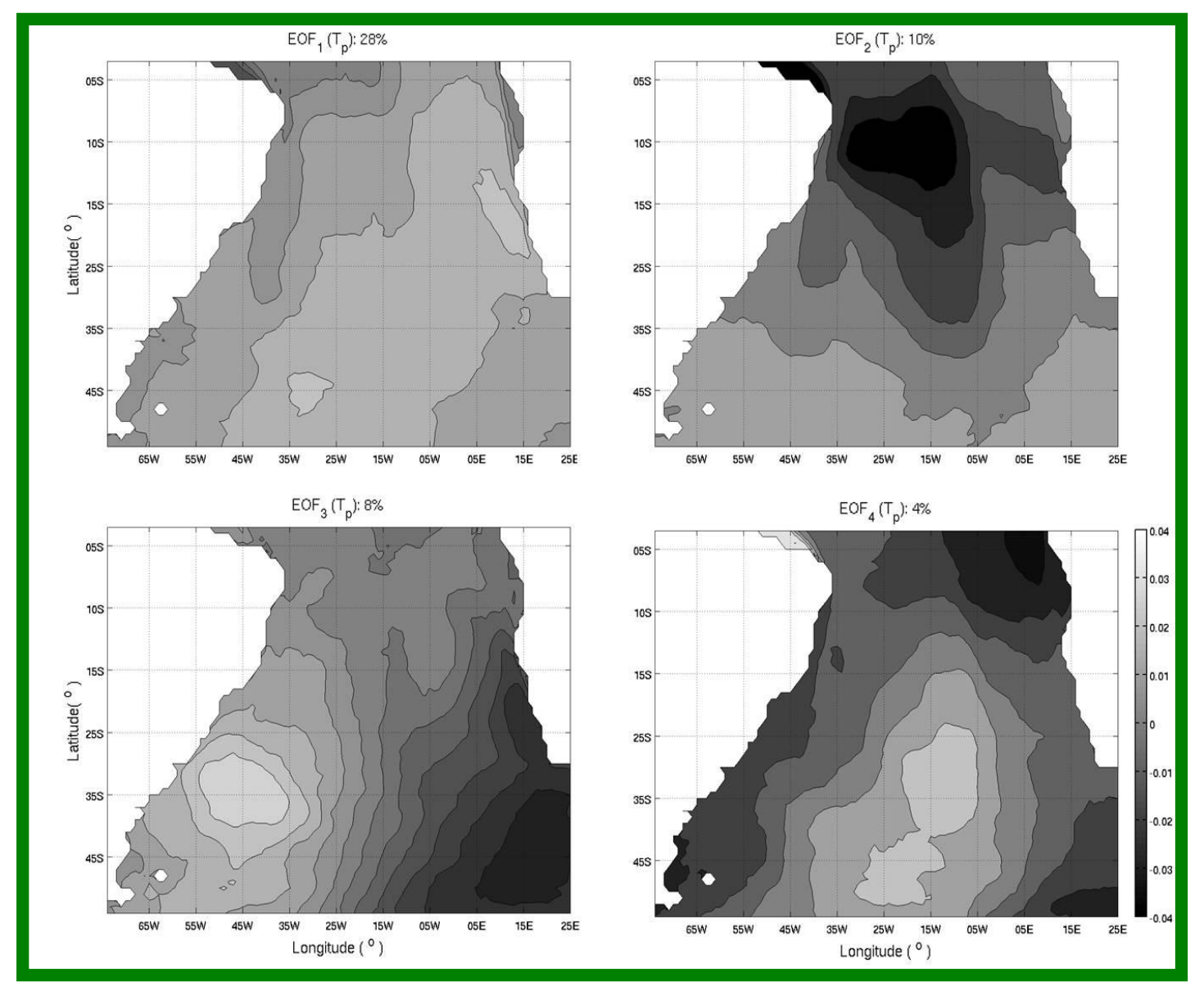

Figure 5: Leading modes of variability of peak period in the South Atlantic Ocean.

➢ The EOF_1 of swell has showed a correspondence between the propagation directions of swell and the dominant directions of storms.

➢ The first mode of variability of swell is directly associated to the Pattern III of tracks proposed by PARISE *et al.* (2009). As well as the second and third modes of variability of swell relate to Pattern I of tracks.

➢ The positive anomalies observed in the EOF_1 and EOF_2 showed the contribution of swell in the Indic Ocean (ALVES, 2006), which modifies the wave climate of the Atlantic Ocean.

➢ The EOF_1 of T_p shows the variability of incident swells on the African coast (10°S to 25°S) possibly generated by extratropical cyclones.

➢ The EOF_3 of T_p explains the presence of swell reaching regions near the coast and confirms the contribution of swell from the Pacific Ocean and its relation with the Pattern I of storm track from PARISE *et al.* (2009).

3. 4 The SAM index

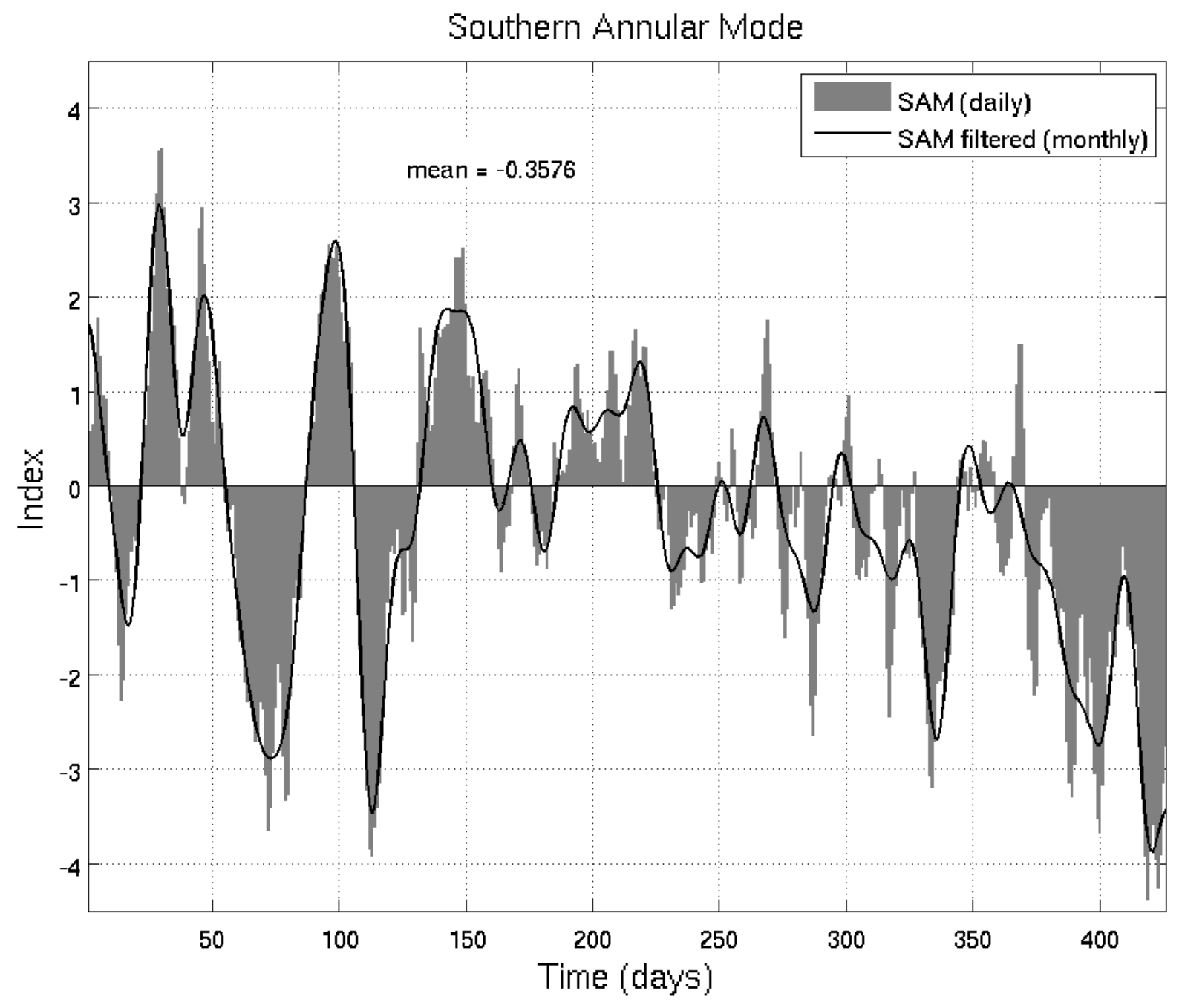

Figure 7: Daily Southern Annular Mode from June 2006 to July 2007 (from NOAA) and a filtered time series with one month window.

➢ The beginning of the time series (winter) shows an alternance of positive and negative signs; the middle of the series (summer) is characterized by positive and small signs which decreases until reaching strong and negative signs (in the next winter).

➢ REBOITA *et al.* (2009) identified that during the SAM (-) the cyclogenetic belt around the Antarctic continent is more scattered than for the neutral and positive phase and there is a higher cyclone density at midlatitudes. In the SAM (+) the systems are closer to the Antarctic continent and the cyclone path moves southward.

➢ Hence, if the SAM time series decrease this means that the storm tracks are going toward midlatitudes and, consequently, there is a higher probability to *swell* events occur.

5. REFERENCES

➢ ALVES, J.H.G.M., 2006. Numerical modeling of ocean swell contributions to the global wind-wave climate. Ocean Modelling, 11, pp. 98-122.
➢ HASSELMANN, K. 1962. On the non linear energy transfer in a gravity wave-spectrum. Part 1: General theory. Journal of Fluid Mechanics, 12, pp. 481-500.
➢ KOMEN, G.J., CAVALERI, L., DONELAN, M., HASSELMANN, K., HASSELMANN, S., JANSSEN, PP.A.E.M., 1994. Dynamics and Modelling of Ocean Waves. Cambridge University Press, pp. 532.
➢ PARISE, C.K., CALLIARI, L.J., KRUSCHE, N., 2009. Extreme storm surges in the south of Brazil: atmospheric conditions and shore erosion. Brazilian Journal of Oceanography, 57(3), pp. 175-188.
➢ REBOITA, M.S; AMBRIZZI, T.; ROCHA, R.P. 2009. Relationship between the Southern Annular Mode and southern hemisphere atmospheric systems. Revista Brasileira de Meteorologia, 24, n.1, pp. 48-55.
➢ STERL, A and CAIRES, S. 2005. Climatology, variability and extrema of ocean waves: the web-based KNMI/ERA-40 wave atlas. International Journal of Climatology, 25, pp. 963-977.
➢ VENEGAS, S.A., MYSAK, L.A., STRAUB, D.N., 1997. Atmosphere - Ocean Coupled Variability in the South Atlantic. Journal of Climate, 10, pp. 2904-2920.

5. APOIO

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