South Atlantic Dipole Changes From 1851 to 2010

Anderson Bier[1] and Tercio Ambrizzi[1]

[1]USP University of Sao Paulo

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Abstract

The South Atlantic Dipole (SAD) is the main mode of coupled variability between ocean and atmosphere on interannual and interdecadal timescales on the South Atlantic Ocean. Its oceanic component is characterized by a dipole of sea surface temperature (SST) anomalies between tropics and extratropics, while the atmospheric part is linked with the South Atlantic Subtropical High (SASH) variability. Some other important factors can influence the SAD, for instance, variations in the Atlantic Meridional Overturning Circulation (AMOC), which may alter the distribution of physical properties of the ocean such as the SST. Given the current background of anthropogenic global warming, some features have contributed to alter AMOC, such as Greenland's continental ice melting and also the increase in Agulhas Leakage. Therefore, this work aims to identify possible changes in the SAD pattern during the period after industrial revolution (1851-2010). The SAD is the first mode found through the Singular Value Decomposition (SVD) of SST and Mean Sea Level Pressure (MSLP). This analysis was performed at intervals of 30 and 10 years, in order to encompass the interannual and interdecadal cycles of the SAD oscillation, at the same time that it is possible to analyze possible changes in the SAD throughout the study period (1851-2010). Preliminary results show strong signs of changes in the SAD configuration, both in its oceanic and atmospheric components, which probably have impacts on the climate of the adjacent continents, which will be further studied later. The analysis performed with NOAA-CIRES 20th Century Reanalysis V2c indicate a clockwise rotation of the SST anomaly dipole pattern, while the associated MSLP anomalies show a northwestern shift over the study period.

South atlantic dipole changes from 1851 to 2010

Anderson Augusto Bier (bier.anderson@iag.usp.br), Tercio Ambrizzi (tercio.ambrizzi@iag.usp.br)
Programa de Pós-graduação em Meteorologia - Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo

INTRODUCTION

The South Atlantic Dipole (SAD) is the main mode of coupled variability between ocean and atmosphere on interannual and interdecadal timescales on the South Atlantic Ocean. Its oceanic component is characterized by a dipole of sea surface temperature (SST) anomalies between tropics and extratropics, while the atmospheric part is linked with the South Atlantic Subtropical High (SASH) variability. Some important factors can influence the SAD, for instance, variations in the Atlantic Meridional Overturning Circulation (AMOC), which may change the distribution of physical properties of the ocean such as the SST. Given the current background of anthropogenic global warming, some features may contribute to alter AMOC, such as Greenland's continental ice melting, the increase in Agulhas Leakage and variations in the wind-driven circulation. Therefore, this work aims to identify possible changes in the SAD pattern during the period after industrial revolution (1851-2000).

MATERIALS & METHODS

DATASETS

- NOAA-CIRES 20th Century Reanalysis V2c (Compo et al., 2011). Time length: 1851-2000
- ERA-20C Reanalysis (Poli et al., 2016). Time length : 1911-2000

METHODS

Singular Value Decomposition (SVD)

- The SVD method aims to find covariability patterns between two different variables.
- The SAD is the first mode of covariability found through the SVD of SST and Mean Sea Level Pressure (MSLP) over the South Atlantic (denoted here as SVD1)
- This analysis was performed at intervals of 30 years throughout the whole datasets length (1851-2000 for NOAA-CIRES 20th Century and 1911-2000 for ERA-20C), in order to encompass the interannual and interdecadal cycles of the SAD oscillation, at the same time that it is possible to analyze possible changes in the SAD throughout the study period.
- Domain: 5°N–45°S e 20°L–60°O (Figure 1)

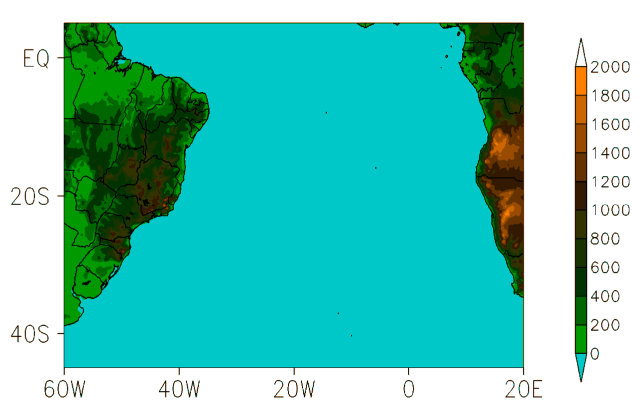


Figure 1. Domain used for the SVD method. The figure shows the land relief, with altitude described in meters.

- Reference: Björnsson and Venegas (1997)

Wavelet Analysis

- Applied to the SVD expansion coefficients
- Aims to evaluate changes in the periodicity of the SAD oscillation.
- Reference: Torrence and Compo (1998)

RESULTS

NOAA-CIRES 20th Century Reanalysis V2c

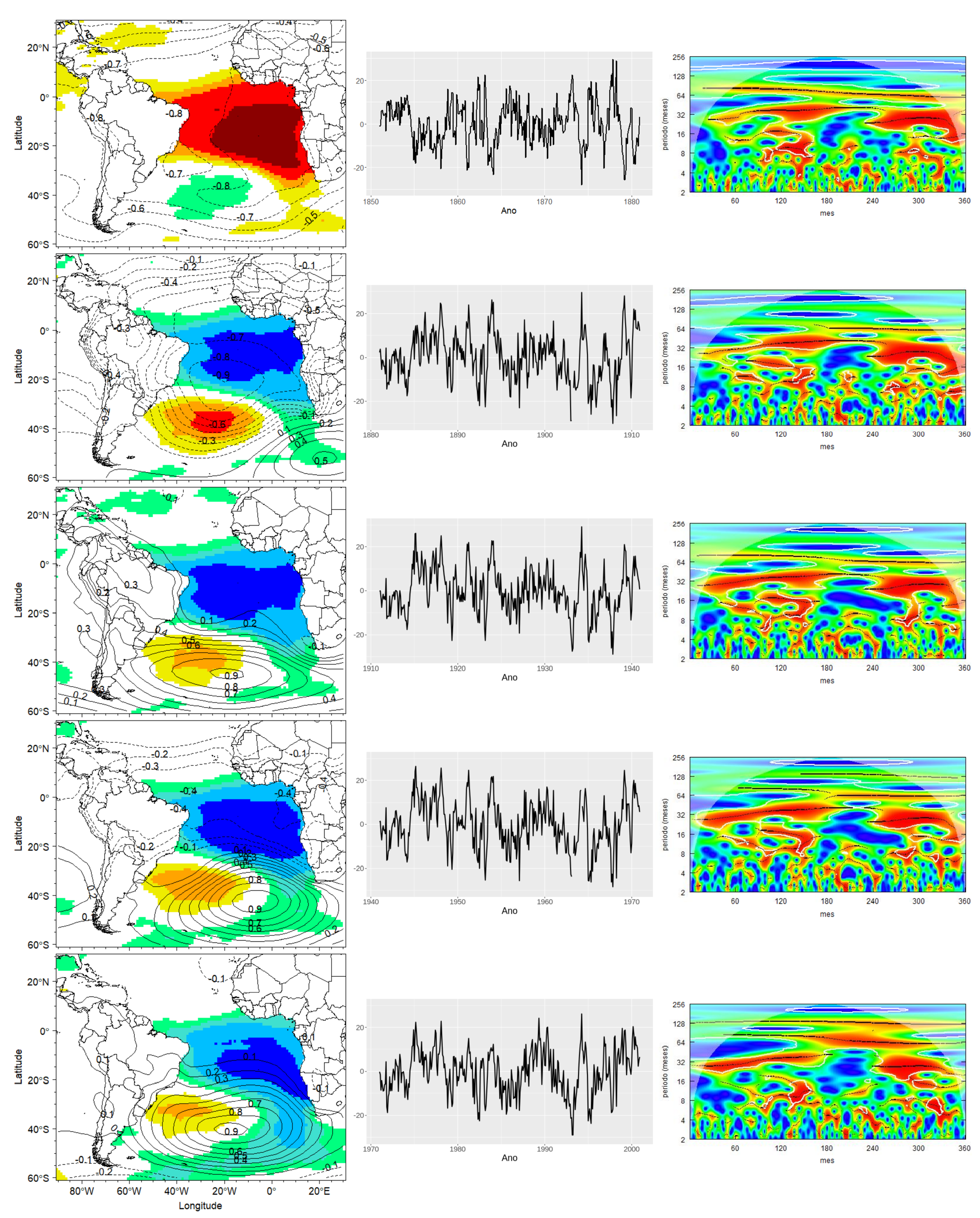
a) 1851-1880

b) 1881-1910

c) 1911-1940

d) 1941-1970

e) 1971-2000



- Ocean-atmosphere coupling characteristic of SAD is not verified in the first two intervals (1851-1880 and 1881-1910).
- Clockwise rotation of the SST anomaly dipole associated with SAD over the last 3 intervals (1911-1940, 1941-1970 and 1970-2000)
- MSLP monopole northwestward shift during the last 3 intervals
- Quase-continuous peak on an interannual scale (~32 months) and continuous peaks on an interannual (~70 months) and interdecadal (~130 months) scales for the whole period analyzed.
- Interdecadal peak has been deepening over the whole study time length.
- Interannual peaks has been decreasing over the whole study time length.

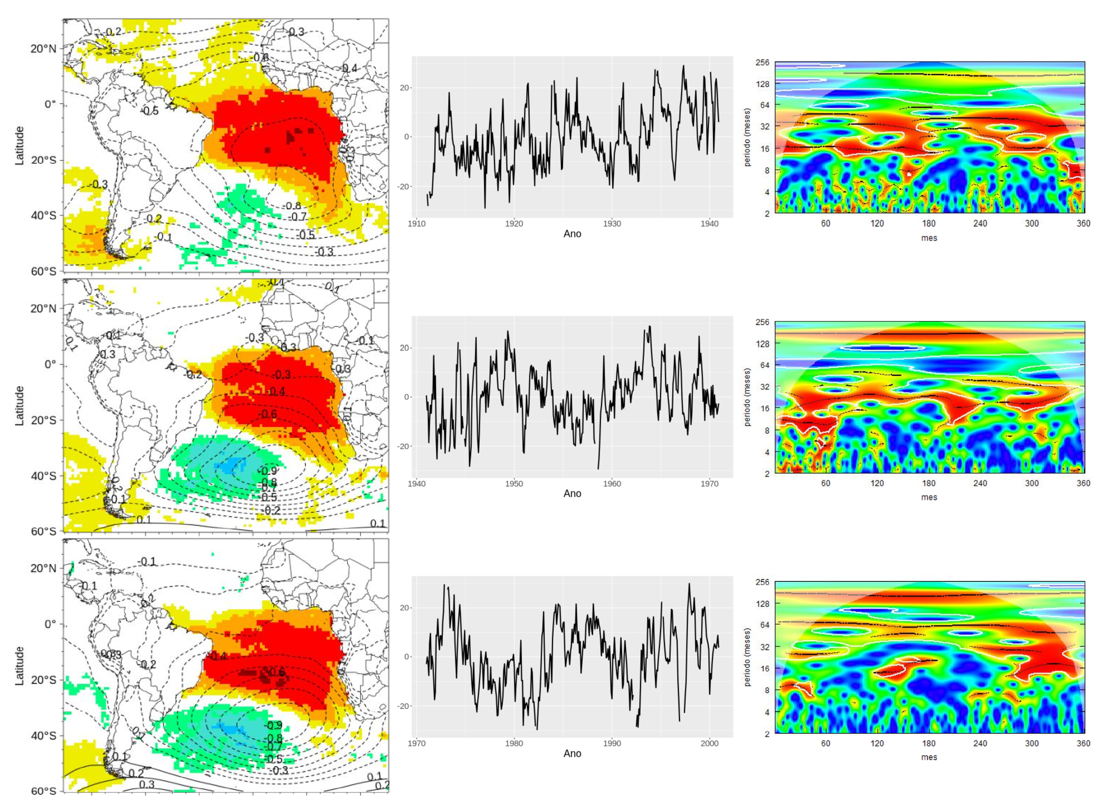
Figure 2. Homogeneous correlation between SVD_{1SST} and SST anomaly (shaded) and between SVD_{1MSLP} and MSLP anomaly (contours) (left figures), SVD_{1SST} expansion coefficient time series (middle) and the power spectrum obtained by wavelet analysis (right side), for the periods a) 1851-1880, b) 1881-1910, c) 1911-1940, d) 1941-1970 and e) 1971-2000.

ERA-20C Reanalysis

a) 1911-1940

b) 1941-1970

c) 1971-2000



- SST pattern did not show significant changes (1911-2000).
- The atmospheric component (associated with SASH), in turn, showed a slight southward shift over the period, as opposed to the same period in CONJ1.
- Quase-continuous peak on the interannual scale (~32 months) and continuous peaks on the interannual (~ 70 months) and interdecadal (~130 months) scales for the whole period analyzed.
- Interdecadal peak has been deepening over the whole study time length.
- Interannual peaks has been decreasing over the whole study time length.

Figure 3. The same as in Figure 2 but for the periods a) 1911-1940, b) 1941-1970 and c) 1971-2000, and for the ERA-20C Reanalysis.

SUMMARY AND CONCLUSIONS

- Both SST and MSLP signals suggest a tendency for changes in the SAD pattern that may possibly be linked to AMOC and/or atmospheric circulation changes, which probably have impacts on the climate of the adjacent continents, which will be further investigated in this work.
- An interesting point of agreement between both datasets is the intensification of the interdecadal component of oscillation over the last century.
- The SAD annormal pattern verified in the first two intervals (1851-1880 and 1881-1910) for CONJ1, may be a result of the lower degree of reliability of such data compared with more recent data.

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