Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.

Introduction

- Tropical Atlantic variability (TAV) modes can influence atmospheric circulation impacting the precipitation regimes over South American and the intensity of the meteorological systems associated;
- First fundamental mode of the Tropical Atlantic (TA) called “Atlantic Zonal mode”;
    - The zonal mode was estimated using the ATL3 index, calculated by the monthly sea surface temperature anomaly (SSTa) within 3ºS - 3º N and 20º W - 0 (Zebiak, 1993);
- Second fundamental mode of the TA called “Atlantic Meridional Mode (AMM)”;
    - The AMM index was obtained by the difference of the monthly SSTa between the North (5-20ºN) and South (20º S - 5º N) Atlantic (Servain et al., 2000) → Interhemispheric dipole structure.

Objective main

- The objective of this work was to analyse the centennial variability and trends of the zonal and meridional modes in the TA Ocean and their influences in the precipitation, focusing on the North and Northeast of Brazil.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]

[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.

[2] University of São Paulo, Oceanographic Institute - IO.

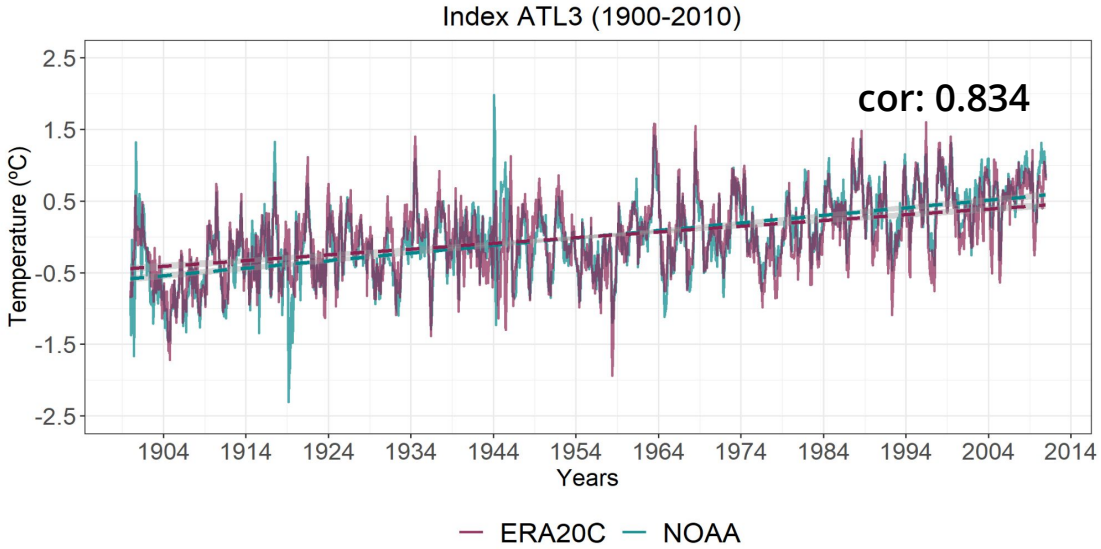


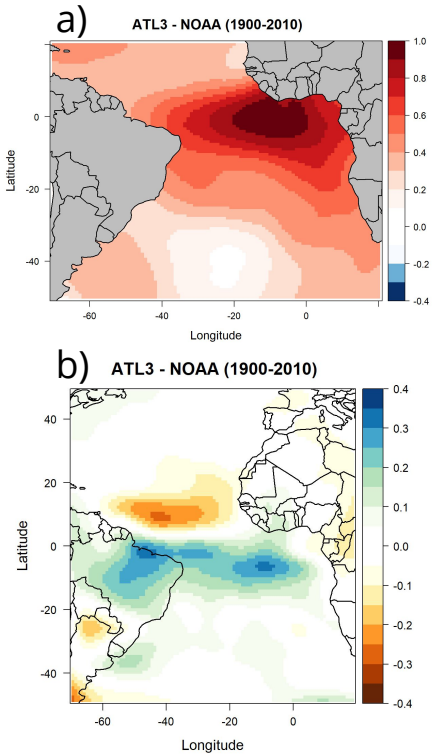
Figure 1. Time series for the ATL3 index for the period 1900-2010. The time series was obtained with the average monthly TSM anomaly within the region (3º S - 3º N and 20º W - 0º). The regression lines in pink for ERA20C reanalysis and blue for NOAA.

Results

- Positive trends for the ATL3 index considering the period of 1900-2010 for the two centennial reanalyses (NOAA ERSST v4 and ERA20C);
- The patterns are similar in both reanalyses with 0.834 correlation.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.



Results

- The first mode in the Tropical Atlantic (TA) → corresponds to 21.3% of explaining variability;
- Figure 2a shows ATL3 pattern → calculated with correlation between ATL3 index and monthly SSTa;
- The correlation between ATL3 index and monthly precipitation anomaly (Figure 2b) shows the positive anomaly in the northeastern Brazil → related to a positive SST in the region influencing the position of the ITCZ.

Figure 2. Correlation between ATL3 index and monthly anomaly field at the period 1900-2010 with NOAA reanalyses (a) Sea Surface Temperature (SST) and (b) precipitation.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.

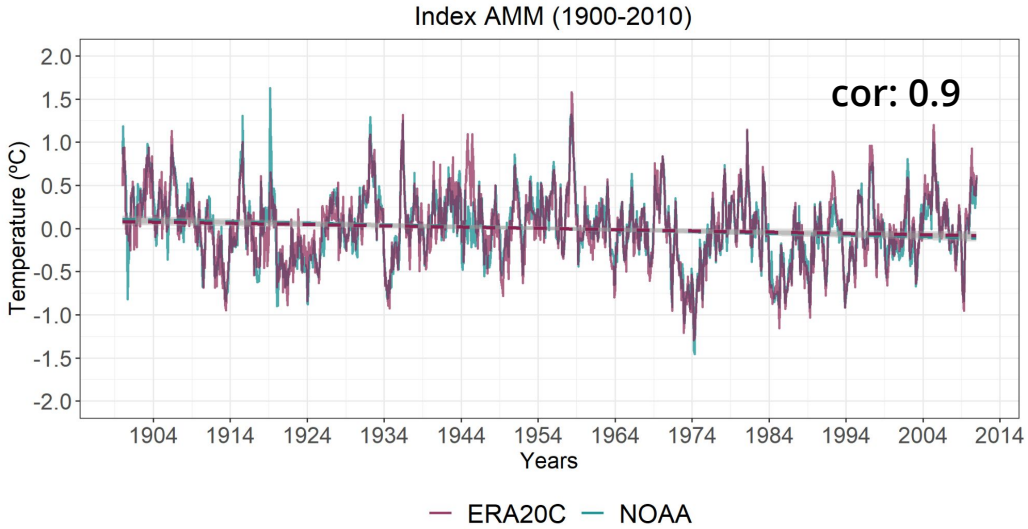


Figure 3. Time series for the AMM index for the period 1900-2010. The series was obtained with the average monthly TSM anomaly in the tropical Atlantic regions north (tn) and tropical south (ts), being 5-20° N and 20° S - 5 °N respectively for 60° W - 10° E. The regression lines in pink for ERA20C reanalysis and blue for NOAA.

Results

- The negative trend in AMM index in both reanalyses;
- Large correlation between ERA20C and NOAA ERSST v4.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.

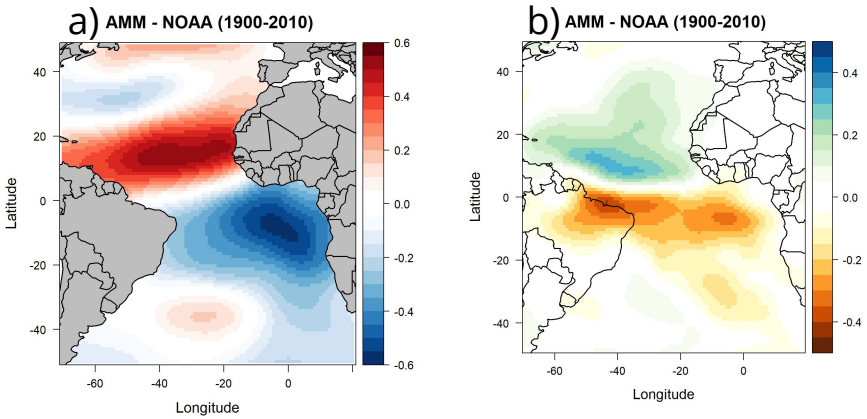


Figure 4. Correlation between AMM index and monthly anomaly field at the period 1900-2010 with NOAA reanalyses (a) Sea Surface Temperature (SST) and (b) precipitation.

Results

- The second mode in the Tropical Atlantic explains 16.98% of the variability of the TA;
- Figure 4a shows the AMM pattern → correlation between AMM index and monthly SST anomaly;
    - This method and pattern are very similar to the Empirical Orthogonal Function (EOF);
- The precipitation related to AMM index in the positive (negative) phase presented negative (positive) anomalies in northeastern north Brazil.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]

[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.

[2] University of São Paulo, Oceanographic Institute - IO.

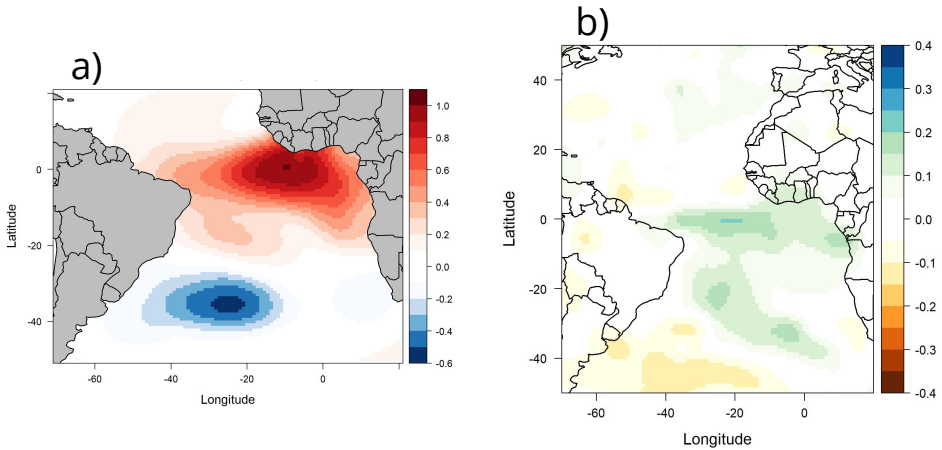


Figure 5. Correlation between ATL3 index and monthly anomaly field at the period 1998-2015 (a) Sea Surface Temperature (SST) and (b) precipitation. The SST and Index fields with NOAA ERSSTv4 reanalyses, and precipitation field with TRMM.

Results

- Considering at the period 1998-2015 because the dataset Tropical Rainfall Measuring Mission (TRMM) started in 1998;
- The patterns were very similar to Figure 2. However, the positive precipitation anomaly did not over the continent;
- The same result and discussion between Figure 2 → The ITCZ was influenced by the ATL3 index because of positive SST anomaly southern TA.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.

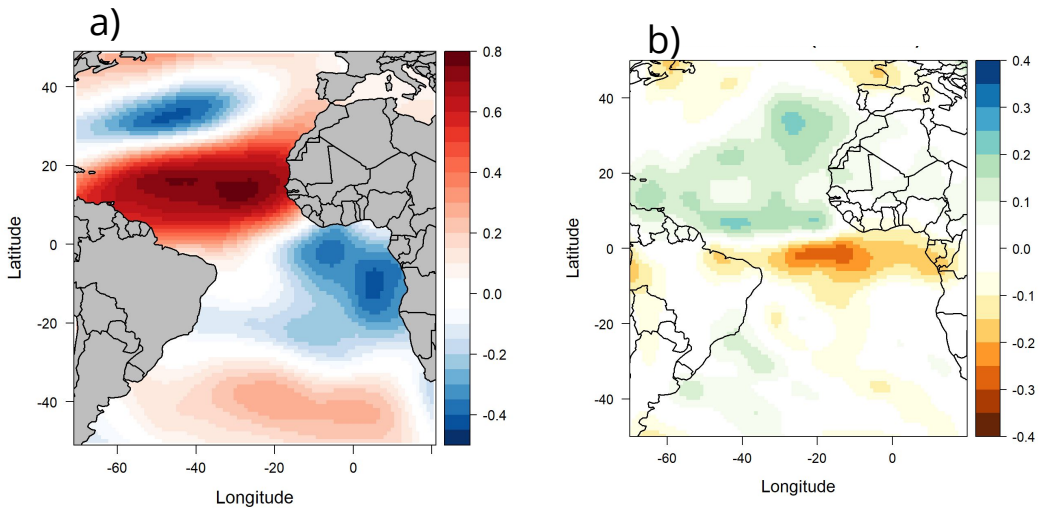


Figure 6. Correlation between ATL3 index and monthly anomaly field at the period 1998-2015 (a) Sea Surface Temperature (SST) and (b) precipitation. The SST and Index fields with NOAA ERSSTv4 reanalyses, and precipitation field with TRMM.

Results

- Considering at the period of 1998-2015;
- The pattern of both fields (SST and precipitation) were very similar the Figure 3;
- The positive SST anomaly in the Tropical North Atlantic (TNA) was higher than Figure 3;
- The precipitation field is very similar.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.

Blue point - NOAA ERSSTV4
Pink point - ERA20C
Green point - ERAInterim

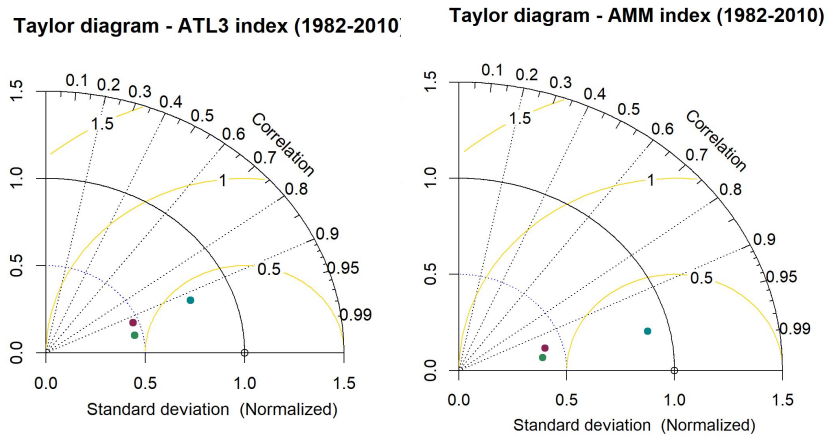


Figure 7. Taylor Diagram (Taylor, 2001) of the 3 reanalyses (NOAA, ERA20C and ERAInterim).

Results

- The indices were calculated for three reanalyses (NOAA ERSST v4, ERA20C and ERA-Interim) and compared to the observational dataset OISSTV2;
- All reanalyses represented the indices in agreement with observations, however, the statistical parameters were better for with the ERA-Interim;
    - The ERA-Interim is a newer reanalysis and finer resolution;
- The ERA-Interim has more observation interpolated.

Modes of variability in the tropical atlantic and its influence on the precipitation regime in Brazil

Andressa Cardoso[1] and Ilana Wainer[2]
[1] University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG.
[2] University of São Paulo, Oceanographic Institute - IO.

Conclusion

- ATL3 index influences positively the precipitation in the North and Northeast Brazilian regions, as the warmer SST drives the position of the ITCZ;
- AMM index influences positive (negative) the precipitation over northeastern Brazilian region in the negative (positive) phase of the mode;
    - Negative phase is warmer in South TA and influences position of the ITCZ;
    - The Positive phase occurs the opposite, and influences hurricane season in the TNA (Vimont and Kossin, 2007 and Lim, et al., 2018).
- The Era-Interim represents better both indices → Newer reanalysis and better resolution (more observational data);

Reference

LIM, Y.-K. et al.. Scientific Reports, v. 8, n. 1, 2018.

SERVAIN, J. et al. Journal of Climatology, v. 20, n. 9, p. 939–953, 2000

TAYLOR, K. E. Journal of Geophysical Research, v. 106, n. 7, p. 7183-7192, 2001.

VIMONT, D. J.; KOSSIN, J. P. Geophysical Research Letters, v. 34, n. 7, 2007.

ZEBIAK, S. E.. Journal of Physical Oceanography, v. 19, n. 4, p. 475–486, 1989

Thank you for your attention

Email: andressa.cardoso@iag.usp.br or cardoso.andressa.andrade@gmail.com for contact information
Twitter: @andressacardo1

Universidade de São Paulo

INSTITUTO DE ASTRONOMIA, GEOFÍSICA E CIÊNCIAS ATMOSFÉRICAS