TEMPERATURE VARIABILITY OVER SOUTH AMERICA AND ENSO - 1979 TO 2017

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Climate change is one of the most important themes of our time due to its multiple consequences. Recently, the World Meteorological Organization (WMO) reported that the year 2017 was considered the third warmest on record globally and the warmest for a situation of non-occurrence of the El Niño phenomenon, while the year 2016 was the warmest year on record.

Chaves et al. (2008, *Clivar Exchanges*) and Collins et al. (2008, *J. Climate*) investigated the variation in the air temperature at 2 meters above the Earth's surface in South America (SA) varied in the National Centers for Environmental Prediction (NCEP)/National Centers for Environmental Prediction (NCAR) reanalysis dataset between 1948 and 2007. The results presented in these studies indicated that climate change over SA may be due to not only natural variability of the climate but also human activity.

In this work, the objective is to evaluate the temperature variability over SA and adjacents sea (ASSEA; 90ºW a 20ºW e 60ºS a 10ºN; Fig. 1) and its association with the ENSO (El-Niño/Southern Oscillation) phenomenon between 1979 and 2017. The analysis included the tropical/Northern (TSA; 90ºW-20ºW and 20ºS to 10ºN) and subtropical/southern of the ASSEA area (SSA; 90ºW to 20ºW and 60ºS to 20ºS). To compare the climate change over ASSEA with global changes, the temperature variation over the entire planet is shown too. The subperiods 1979 to 2005 and 2006 to 2017 are also analyzed.

The air temperature 2 meters above the surface provided by the NCEP/Department of Energy (DOE) reanalysis was used (https://www.esrl.noaa.gov/psd/data/gridded/reanalysis/). The resolution of the NCEP/DOE reanalysis is T62L28, with nearly 2.5◦ latitude × 2.5◦ longitude and 28 vertical levels. In NCEP/DOE reanalysis, simulations are initiated in 1979, which is also when environmental satellite data began to be produced on a large scale (Kanamitsu et al. 2002, *Bull AMS*).

The Oceanic Niño Index (ONI; Huang et al. 2017, *J. Climate*) was used to evaluate the association between temperature variability over SA and ENSO. The ONI is a three-month running mean of ERSST.v4 SST anomalies in the Niño 3.4 region (5◦N to 5◦ S, 120◦ to 170◦ W). This dataset was obtained from http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php. The annual value of the ONI was determined considering the average of the 12 values of the three-month running mean (DJF, JFM, FMA, …, NDJ). SA was considered (90◦to 20◦W and 60◦S to 10◦N) as well as, distinctively, tropical/northern SA (90◦ to 20◦W and 20◦S to 10◦N) and subtropical/southern SA (90◦to 20◦W and 60◦ to 20◦S).

The average of the monthly values was considered to determine the annual temperature. After that, the temperature anomalies for each year were determined. For the year 2017, the months from January to November were considered, since the month of December 2017 was not available until early 2018. The association between the annual temperature of the regions and the ENSO was determined by linear correlation between the time series of the annual temperature anomaly and annual ONI. The correlation between the two time series was also considered while removing the El Niño (ONI ≥ 1.0: 1982, 1987, 1997, and 2015) and subsequent years (1983, 1998, and 2016) and La-Niña years (ONI ≤ –0.5: 1985, 1988, 1989, 1999, 2000, 2007, 2008, 2010, and 2011). The new time series have 23 elements and will be referred to as reduced series. The Student's t-test was used to determine the significance of the correlation.

In the NCEP/DOE the average temperatures for the **GLOBE, ASSEA, TSA** and **SSA** were **14.70, 19.17, 24.42 and 13.99°C**, respectively, between **1979-2017**; **14.58, 19.14, 24.36 and 14.01°C** between **1979-2005** and **14.96, 19.22, 24.57 and 13.96°C** between **2006-2017 (Table 1)**.

For the whole period (1979–2017), global temperatures were below (above) average before (after) 2001, except in 1998, when an El-Niño event considered to be very intense occurred (Bell et al. 1999, *Bulletin AMS*). The highest global temperatures occurred in 2015, 2016, and 2017, with temperatures above 15 °C. The year 2016 was the warmest, with a temperature of 15.25 °C, which may also be associated with the occurrence of El Nino in 2015/16. These results corroborate recent reports issued by governmental and nongovernmental organizations (e.g., WMO, NASA, NOAA and WWF) about global warming in the last three years and the year 2016 as the warmest year on the planet.

Over SA, the warming trend is not as evident as for the globe (Figure 2). However, it is noticed that in the past three years (2015–2017), the annual temperatures were near to or above that observed in the El Nino of 1998. Temperature variability over northern SA is also associated with El Nino, with higher values in years in which this phenomenon occurs. However, the temperature in this sector in the last three years was also above average. For southern SA, the interannual temperature variability is not accentuated and there are no periods lasting more than 5 years with significant anomalies of the same signal.

The global temperature and ONI time series (39 elements) have a negative and non-significant correlation (–0.13; Table 2). SA and its subregions time series have positive and significant correlations (95% confidence level) of 0.54, 0.39, and 0.49, respectively. For the reduced time series (23 elements), the means were 14.70, 19.15, 24.36, and 14.02 °C for the globe, AS, northern AS, and southern AS, respectively. Thus, it is observed that the mean did not change when the ENSO condition was removed from the analysis. The difference is not statistically significant (< 90% confidence).

On the other hand, the correlation coefficients for the reduced time series (Table 2)

are not significant for SA (0.05), northern SA (0.13), southern SA (0.06), or the globe (–0.06). In contrast to the previous situation, these results support the association between temperature variability over SA and ENSO, but also indicate that global warming is not related this phenomenon. Thus, the results presented here indicate that global warming in the period 1979 to 2017 is driven by a cause other than ENSO. However, over AS and its subregions, the temperature variation seems to be associated with ENSO and there is no evident trend of warming there during the period considered.

Key-Words: Climate Change; Reanalysis NCEP/NCAR; Reanalysis NCEP/DOE.

References

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Table 1 - Temperature average (ºC)

	Global	ASSEA	TSA	SSA
1979-2017	14.69	19.17	24.42	13.99
1979-2005	14.58	19.14	24.36	14.01
2006-2017	14.95	19.23	24.57	13.97

Tabela 2 - Correlation between temperature and NOI

	Global	**ASSEA**	**TSA**	**SSA**
1979-2017	-0.13	0.54	0.39	0.49
reduced series *	-0.06	-0.05	-0.13	0.06

*disregarding the years (1982, 1987, 1997 e 2015; ONI ≥ 1,0) and subsequent years (1983, 1998 e 2016) and (1985, 1988, 1989, 1999, 2000, 2007, 2008, 2010 e 2011; ONI ≤ –0,5).

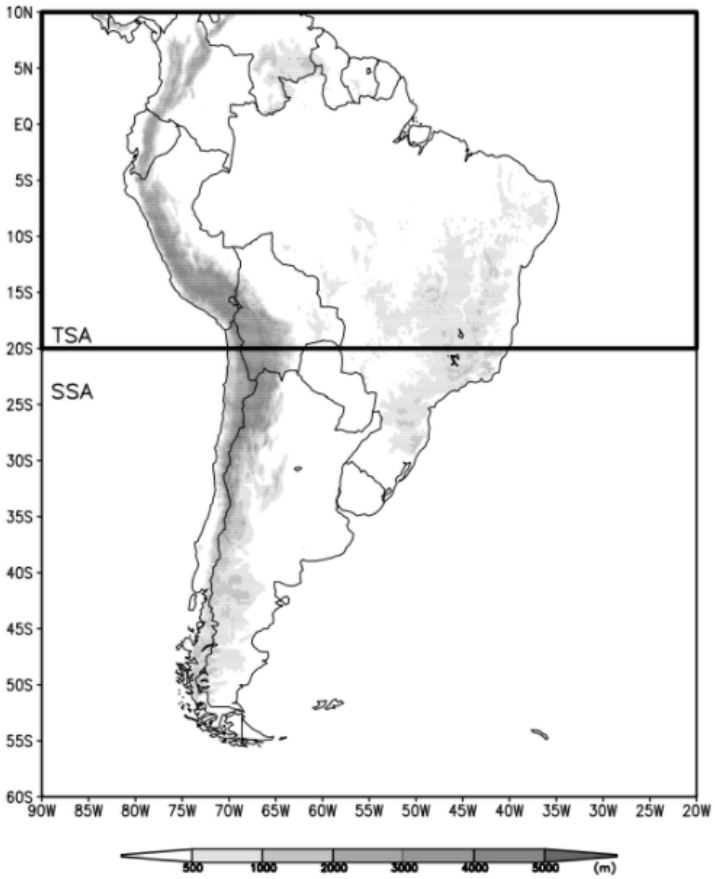

Figure 1 - South America with tropical (TSA; 20°S–10°N, 90°–20°W) and subtropical (SSA; 60°–20°S, 90°–20°W) areas. Shades of gray represent topography in meters.

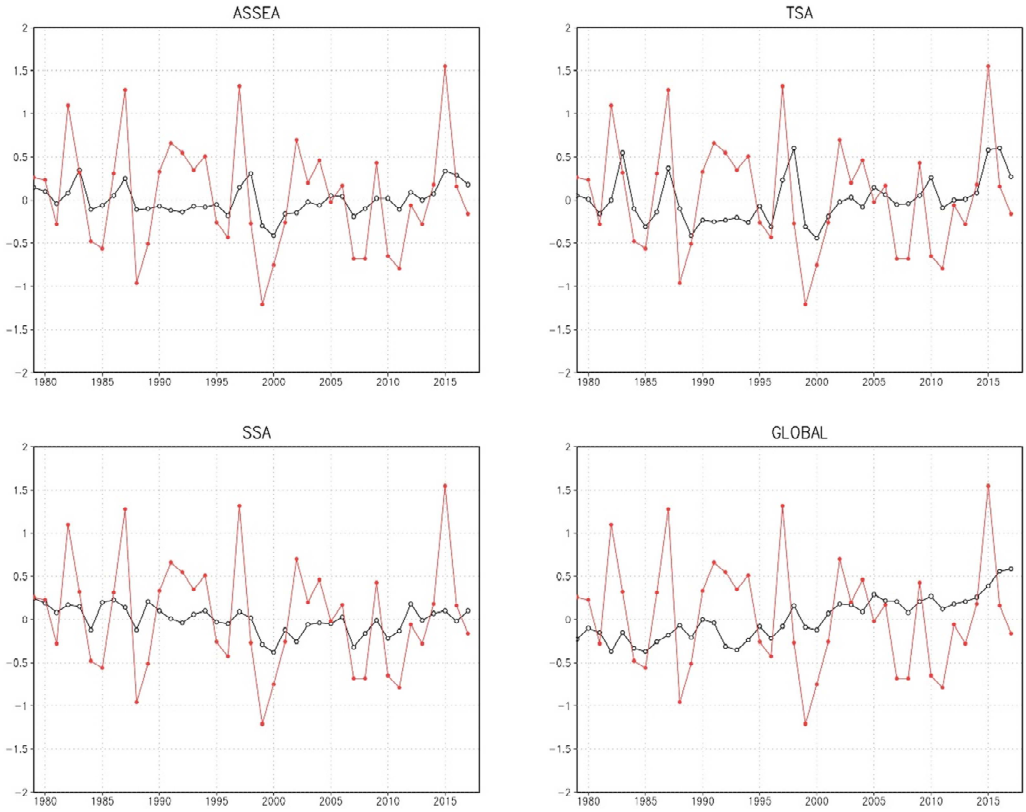

Figura 2 - Time series of NOI (red) and temperature anomalies (ºC, 1979-2017) for South America, TSA, SSA and global.