Summertime Temperature Variability In South America Between 1948 – 2007

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Introduction

Climate change has been studied over South America (SA; 60°S-10°N; 90°W-20°W) mainly in the context of deforestation in the Amazon (Nobre et al. 1991 and others). There have been few studies about climate change which consider the whole of SA and which focus on temperature. In this work we investigate how the air temperature at 2 meters above the Earth's surface in SA varies in the NCEP/NCAR reanalysis dataset (Kalnay et al. 1996). It is important to emphasize that El Niño Southern Oscillation (ENSO) is the most important coupled ocean-atmosphere phenomenon to produce climate variability over SA on an interannual timescale. In this paper we also consider therefore if ENSO significantly affects temperature variability over SA.

Methodology

The temperature variability at 2 meters above the Earth's surface in the NCEP/NCAR reanalysis is investigated in SA between 1948 and 2007. Hereafter, air temperature at 2 meters above the surface will be referred to only as "temperature". The means and the standard deviations of the temperature in December-January-February (DJF) during 1948-1975 and 1976-2007 are calculated for each month and the results presented in this paper are the average of the DJF for the years considered. This division into these periods is based on the work of Obregon and Nobre (2003) who verify the occurrence of climate change in the mid 1970's from station precipitation data in SA. To evaluate the temperature variability in the second period only (1976-2007), this period is further subdivided into 1976-1991 and 1992-2007 and a similar analysis is conducted. We also consider the temperature of the last seven years (2001-2007). The period between 2000-2006 is considered as the globally warmest of the last 100 years (IPCC AR4 2007). The year 2007 was the least warmest of the past seven years for the majority of SA and the global value for 2007 is the 5th warmest in the 128-year period of record (Lawrimore 2008). To evaluate the influence of natural variability and/or an anthropogenic influence in the results, we also perform an analysis involving the four strongest El Niño and the three strongest La Niña events observed between 1976 and 2007 for the DJF season. We consider the La Niña events: 1975-1976, 1988-1989, 1998-2000 and the El Niño events: 1982-1983, 1986-1987, 1991-1992, 1997-1998.

Results

The spatial patterns of the summertime temperature in SA are nearly similar in both periods, 1948-1975 and 1976-2007 (Figure 1a, 1b). However, there are some notable differences. Over the majority of SA, the mean temperature is between 21°C and 24°C in the period 1948-1975. In this period, we observe temperatures between 18°C and 21°C over the mountain regions of Rio Grande Sul (Serra Gaúcha) and over the "Serra da Mantiqueira". Temperatures above 24°C are observed in the northern part of the Amazon region, east and north of Northeast Brazil (NEB) and east of the Andes Cordillera. In the period 1976-2007, we observe a change in the temperature pattern in SA, with southward (in tropical South America (TSA) and subtropical south America (SSA)), and eastward displacement of the 24°C isotherm (Figure 1b). Thus, in this period the temperature over most of the continent is above 24°C and the area with temperatures below 24°C decreased in size. In the "Serra Gaúcha" and "Serra da Mantiqueira" the temperature is above 21°C. Over most of the continent and the west part of the South Atlantic Ocean the temperature is warmer in this second period. The temperature difference between 1948-1975 and 1976-2007 is significant particularly over Brazil, Argentina and part of Chile, with temperature differences above 0.6°C and 1.2°C respectively (Figure 1c). The last value is higher than the increase in the total global temperatures (0.76°C increase) from 1850-1899 to 2001-2005 estimated by the IPCC AR4 (2007). We also observe a warming above 0.6°C over the South Atlantic Ocean, with a pattern that resembles the SACZ (Chaves and Nobre 2004; Chaves and Ambrizzi 2005).

The spatial patterns of the temperature are similar in the periods 1976-1991 and 1992-2007 (Figure not shown). However, in the period 1976-1991 the 27°C isotherm is located in the north of Argentina , while it is found along the SA north coast between 1992-2007 . Thus, we observe cooling in SSA and warming in TSA in the period 1992-2007 when compared with 1976-1991. Considering a similar number of ENSO events between the periods 1976-1991 and 1992-2007, the results above suggest a non-ENSO influence and may be indicative of a human influence on the South American climate.

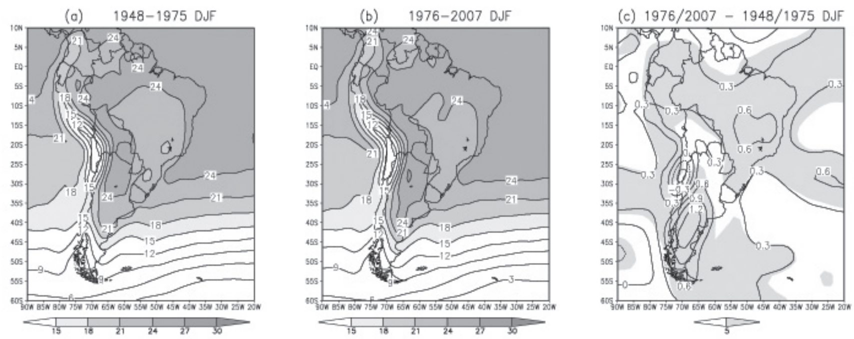

Figure 1 - Mean air temperatures at 2 meters above the Earth's surface (°C) in DJF during (a) 1948-1975, and (b) 1976-2007 and (c) the difference of the mean temperature between these two periods In Figure 1c shaded areas represent statistical significance at the 5% level.

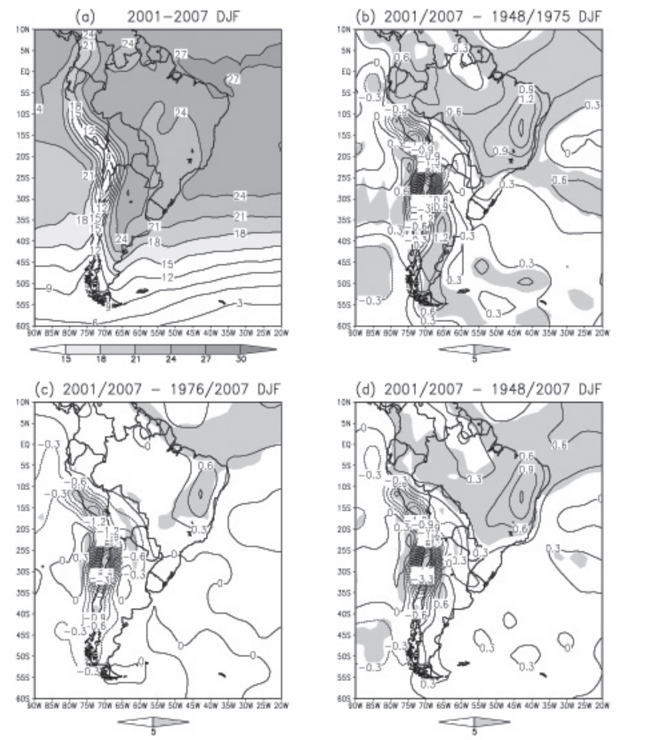

Figure 2 - (a) Mean air temperature at 2 meters above the Earth's surface (°C) in DJF for 2001-2007, (b)the difference of the mean temperatures (°C) between 2001-2007 and 1948-1975, (c) the difference of the mean temperatures (°C) between 2001-2007 and 1976-2007, (d) the difference of the mean temperatures (°C) between 2001-2007 and 1948-2007. For (b), (c) and (d) the shaded areas represent statistical significance at the 5% level.

The mean temperature for DJF for the period 2001-2007 is shown in Figure 2a. In this period a warming over almost the whole of SA is evident (compare Figure 2a with Figure 1a, 1b) with an increase of the area with temperatures above 24°C over the continent. We also observe an increase of the area with temperatures above 27°C in the North Atlantic Ocean near the northern coastline of SA. However, over the central Andes Cordillera the area with lower temperatures gets cooler, with temperatures below 6°C for the period 2001-2007.

The temperature differences in DJF between 2001-2007 and 1948-1975, 1976-2007 and 1948-2007 (Figure 2b, c, d) show in each case, warming in TSA mainly in NEB and over the equatorial North Atlantic Ocean. These temperature differences are greater when 2001-007 is compared with the 1948-1975 period, with values above 1.4°C in North East Brazil (NEB) (Figure 2b). In part of the SSA region the warming is observed with values above 1.2ºC and 0.6ºC compared with the periods 1948-1975 and 1948-2007 respectively. We observe cooling over part of the SSA region, mainly over the Andes Cordillera, in the period 2001-2007 when compared with the periods 1976-2007 and 1948-2007 (Figure 2c, 2d).

Figure 3 shows the mean temperature difference between the strongest La Niña and El Niño events in the period 1976-2007. We observe warming in SSA, mainly over the central part of Argentina, with values above 0.6°C, and cooling in TSA, with values around -0.6°C. This difference has statistical significance at better than the 10% level. Comparing the values of mean temperature difference between ENSO extremes with the values of the mean temperature difference between the periods above (Figure 1c, 2b, 2c, 2d and 3), we see that the values are slightly greater between the periods than those associated with the difference between extreme ENSO events. As ENSO events are associated with the hypothesis of natural climate change; the values of the difference between positive and negative phases of these events should be higher and also with greater statistical significance when compared with the two long periods considered. Thus, this result indicates that this phenomenon cannot be largely responsible for these temperature differences between the different periods.

4. Conclusions

This work shows how the air temperature at 2 meters above the Earth's surface in SA varies in the NCEP/NCAR reanalysis dataset between 1948 and 2007. In DJF during 1948-1975, over the majority of SA, the mean temperature is between 21°C and 24°C. However, in the period 1976-2007, the mean temperature over most of SA is above 24°C, with warming in the TSA and SSA regions. Thus, even considering the occurrence of a greater number of El-Niño events in the period 1976-2007, the warming observed in this period could not be associated to this phenomenon. The analysis also shows cooling in the SSA latitudes and warming in the TSA latitudes in the period 1992-2007 compared with the period 1976-1991. The results presented here indicate that the climate change over SA may not only be due to the natural variability of the climate but it may be a result of human activity. Indeed, there has been more land use change and greater carbon dioxide release in the most recent period. It is possible that changes in the observational networks could influence the results, however to verify this hypothesis it would be necessary to examine dataset from meteorology stations over a long period of time. Even with undetermined causes, the most important finding in this

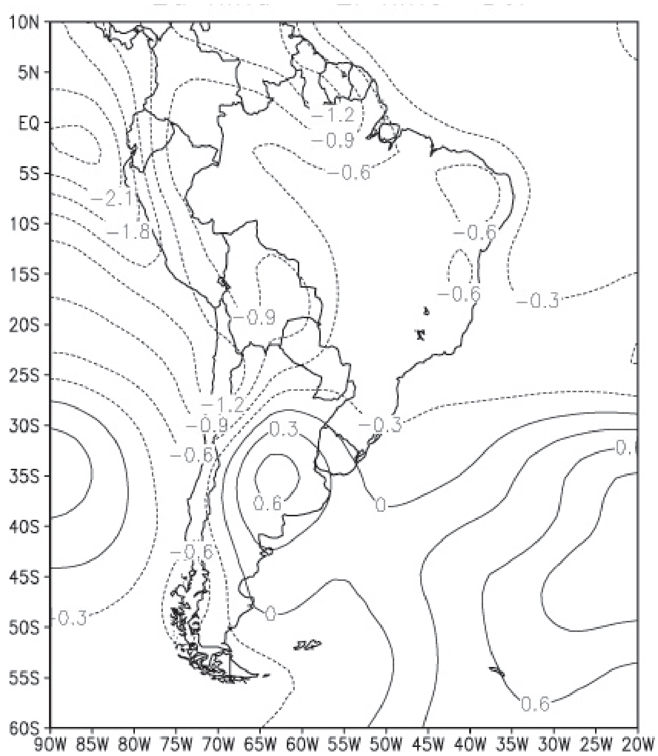

Figure 3: Temperature differences (°C) between the strongest La Niña and El Niño events observed between 1976 and 2007

work is the demonstration that a change in the temperature patterns of SA occurred between 1948-2007.

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References

IPCC Fourth Assessment Report. (*IPCC AR4*) 2007: Climate Change 2007: Synthesis Report.

Chaves, R. R., and P. Nobre, 2004: Interactions between the sea surface temperature over the South Atlantic Ocean and the South Atlantic Convergence Zone. *Geophys. Res. Lett.*, **31**, L03204, doi:10.1029/2003GL018647.

Chaves, R. R.; T, Ambrizzi, 2005: Atmospheric response for two convection schemes in sensitivity experiments using SST anomalies over the South Atlantic Ocean. *CLIVAR Newsletter Exchanges*, **33**, 25-27.

Kalnay, E., and Coauthors, 1996: The NCEP/NCAR 40-Year Reanalysis Project. *Bull. Amer. Meteor. Soc.*, **77**, 437–471.

Lawrimore, J. Global temperature highlights of 2007. *Weatherwise*, **61**, p.18, 2008.

Nobre, C. A., P. Sellers, and J. Shukla, 1991: Amazonian deforestation and regional climate change. *J. Climate*, **4**, 957–988.

Obregon, G., and C. A. Nobre, 2003: Rainfall trends in Brazil. *Bull. Amer. Meteor. Soc.*, **84**, 1008–1009.

Warming over India under Anthropogenic Climate Change

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Introduction

The monitoring and analysis of atmospheric temperatures on global and regional scales has acquired special importance in the last few decades owing to the clear indications of global warming in the post-industrial era. It has been concluded in the Intergovernmental Panel on Climate Change (IPCC) reports (IPCC, 2001 and also the 4th Assessment Report 2007), that the global mean surface air temperature has increased by 0.3°C-0.6°C during the 20th century, with many warmest years occurring in the last decade or so. In particular, the variability of surface temperature on regional and global scales is considered as of much importance as the monitoring of precipitation. The significant increase in the mean annual global surface air temperature during the past century is predominantly over the Northern Hemisphere (NH).

The South Asian sub-continent (5-35°N, 65-95°E) which is a major part of the NH is highly vulnerable to climate variability/change due to its dense human population. It lies in the torrid zone and hence has a very hot climate throughout the year. Also its economy and agriculture mainly depends on monsoon rainfall. Kripalani et al (2007a) have extensively analyzed the outputs of 22 models from the WCRP Coupled Model Inter-comparison Project 3 (CMIP3) dataset for the twentieth century simulations to study the ability of models to simulate present climate over south Asian region. Ten out of 22 models could simulate the monsoon rainfall over South Asian domain reasonably well. These are bccr_bcm2_0 (bcr), ccma_cgcm3_1(ccm), cccma_cgcm3_1_t63(ccm2), cnrm_cm3(cnr), mpi_echam5(ech), miub_eco_g(eco), inmcm3_0(inm), miroc3_2_hires(mih), miroc3_2_medres(mim), ukmo_hadcm3(ukc). (for details of the model- resolutions, data period etc please refer to Kripalani et al 2007a). Kripalani et al (2007b) have also examined these models for simulation of East Asian monsoon. The projections of South Asian monsoon precipitation in transient climate change experiments of 1% increase per year in CO_2 till doubling have been discussed by Kripalani et al (2005, 2007a). As the surface temperature plays a major role in monsoon circulation, the ability of the same ten models to simulate surface temperature has been examined in this study. The future projections by these 10 models over the Indian land region (land region in the area 5-35° N, 65-95°E) are examined for three twenty-first century climate change scenarios from 2000 to 2100

(i) SRES B1 (low forcing ie. CO_2 concentration about 550 ppm by 2100) ;
(ii) SRES A1B (medium forcing ie. CO_2 concentration of about 700 ppm by 2100) and
(iii) SRES A2 (high forcing ie. CO_2 concentration about 820 ppm by 2100) in two time slices 2031-2050 and 2081-2100.

Scenario A2 has a rapid increase of CO_2. A1B exhibits a much slower increase in CO_2 as compared to A2.

In order to study the projections we apply the techniques of multi-model ensembles (MMEs), taking the average of simulation results from multiple models. This averaging will help to reduce the individual model biases (and can also reduce the uncertainties arising due to different initial conditions).

Data

(i) The monthly surface temperature data for 10 models under present century '20c3m' experiments available for simulation times of one and half centuries (1860s -2000) and climate change experiments under SRES B1, A1B and A2 for the next century (2001-2100).
(ii) Surface temperature data from NCEP / NCAR Reanalysis data set used as observed data to validate the simulated model outputs.

Simulated surface temperature climatology

The economy and agriculture of the Indian land mass mainly depends on the summer monsoon precipitation received during the period of four months June through September. Also temperature is the major factor in various stages of the growth of crops. Hence it is interesting to study the surface-temperature variability over Indian region. Global coupled climate models provide a useful tool to study the future projections of climate. If the models are able to simulate the observed characteristic features then they can be used to estimate the future projections.

Annual Cycle

Figure 1 (page 18) compares the annual cycle of surface