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ESTIMATION OF THE IMPACT OF LAND-SURFACE FORCINGS ON TEMPERATURE TRENDS IN ARGENTINA

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1. INTRODUCTION

Trends on the time scale of decades are due to either natural climate variability or to anthropogenic factors, so that their attribution is quite difficult (e.g., IPCC, 2001). Long-term trends can be masked by decadal changes in circulation. Furthermore, two of the most important anthropogenic activities that impact surface temperatures are the increase of greenhouse gases, and changes in land surface physical properties due to land use changes such as urbanization, agricultural practices, deforestation, etc., and their impacts are also very difficult to separate. It has been a hard task to detect a clear climate signal attributable to land cover change, except for a distinct warming in mega cities, likely due to urbanization.

Temperature analyses show that the extratropical regions in the Southern Hemisphere, and in particular southern South America, have undergone much less warming than the Northern Hemisphere, even during the winter when the strongest warming is apparent in the NH (Fig.1).

2. DATA AND METHOD

For the surface observations, we use the daily surface maximum and minimum surface stations temperatures from the National Weather Service of Argentina over most Argentinean provinces for 1961-2000. For the NNR, we use the global daily surface maximum and minimum temperatures at the Gaussian grid, also for the period 1961- 2000.

No attempt to correct station measurements for non-climatic changes such as station location or time of observations was made (beyond standard quality control) since Kalnay et al (2006) have shown that such changes, though large in magnitude, do not affect the regional distribution of observation or OMR trends.

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The analysis method is to interpolate linearly the grided reanalysis data to observational sites and obtain monthly data means by averaging daily data. We only consider sites that at least have total of 70 % of months of observations per decade. We compare the daily maximum and minimum temperatures of 48 surface stations located below 500 m in the contiguous provinces of Argentina, and the daily surface maximum and minimum temperatures on a Gaussian grid from the NNR interpolated to the stations locations, both for the period 1961-2000. Sites above 500 m showed correlations below 0.7 between observations and reanalysis therefore have not been considered. We remove from both observations and NNR data the annual cycle at each site, and only consider anomalies.

Temperature anomalies with respect to the 40-year mean annual cycle for each site and each data set have been computed. This eliminates most of the systematic errors since they appear in the annual cycle in the NNR. Following KC, trends were computed as changes in decadal averages in the anomalies in order to reduce random errors. The NNR has been constructed with a model and data assimilation system kept unchanged, but it is affected by changes in the observing systems, especially the introduction of the satellite observing system in 1979. Therefore, in the computation of temperature trends we exclude changes from the decade of the 1970's to the 1980's. The decadal trend averaged over two separate periods (1981-2000, 1961-1980) is computed for every station, with an overall average computed over all the stations.

For precipitation, we also use the daily precipitation from SMN over most Argentinean provinces for 1961-2000. Since the precipitation varies widely with location, we have introduced a normalization that allows the intercomparison of the precipitation trends in different stations. The total precipitation for each station is computed for each of the four decades, and then these values are divided by the total precipitation over 40 years, so that the normalized precipitation over 40 years is 1 for all stations. The trends are computed using normalized precipitation, with the same method as indicated above.

3. RESULTS

Figure 2 compares time series of 40 years of monthly mean temperatures anomalies for a station (Villa Ortuzar) situated in a park within the city of Buenos Aires, the largest city of Argentina, including the average decadal difference between observations and the NNR. The correlation between both series is 0.91. To help visualize the difference in trends, we added a constant to make the temperature average for the 1980s the same for both station and NNR, but this does not affect the trends. It can be seen that the NNR captures very well the intraseasonal, interannual and interdecadal variability but there is a growing gap between the NNR estimate and the station observations, so that for these two decades the OMR trend is 0.53°C/decade. Even before 1979 there is also good agreement between the two data sets (not shown) but problems are observed over regions with topography (KC, 2003); Rusticucci and Kousky, 2002). There is a significant jump between the 1970s and 1980s (before and after the advent of satellite data) which is, not surprisingly, much larger in the reanalysis over South America than over the US, where KC did not find such a jump in the surface temperature results.

A similar analysis on all surface stations indicates a 40-year correlation of about 0.8 except in mountainous regions, where it is lower than 0.7, which is why we only include stations located below 500 m (not shown).

Figure 3 shows the 40-year trend for the minimum and maximum temperatures for all the location included in this study. The top panel shows the station observations trend, the NNR trend, and their difference, attributed at least partially to land-surface changes, including land-use and precipitation. The decadal trends averaged over two separate 20-year periods (1981-2000 and 1961-1980) are computed for every station and averaged in circles centered in each station site with an average computed over all the stations. Our results suggest that in Argentina (except in Patagonia) the minimum temperature increased over these 40 years by about 0.06^{o}C/decade. However, the NNR which reflects the changes associated with atmospheric temperature changes (both due to changes in circulation and greenhouse warming) indicates that the lower atmosphere over Argentina underwent relative cooling of –0.08^{o}C/decade, with Patagonia being relatively warmer. The observation minus reanalysis trends (OMR) indicates strong warming (except in Patagonia) with an average of +0.14^{o}C/decade, which would be attributable to changes in the land-surface, not included in the NNR.

For the maximum temperature (Fig. 3, bottom) the observations show a cooling trend of about –0.15^{o}C/decade, stronger in the north than in Patagonia. The NNR trend (reflecting changes in circulation and greenhouse warming) shows warming south of 35S, and strong cooling to the north, with an average of –0.19^{o}C/decade. The OMR trend shows mixed cooling and warming in Tmax, with an average of +0.05^{o}C/decade.

Figure 4 (on top) shows the 40-year trend of the mean temperature, indicating an overall negative trend, moderate for the observations (-0.04 ^{o}C/decade) and much stronger for the NNR (-0.14 ^{o}C/decade). The observational trend is similar (but not identical) to that of Fig. 1, partly because the trends are computed differently in our case, without the 1980s minus 1970s trend. The OMR trend suggests that surface changes have resulted in contrasting warming north of 40S and cooling in the south, with an average of +0.09 ^{o}C/decade. [Nevertheless, in the observations, there is a contrast between the Center/coastal Patagonia showing cooling and a warming in the Northeast of Argentina along the Paraná River.]

The diurnal temperature range (DTR), Figure 4 at the bottom, has a very strong negative trend of about -0.21^{o}C/decade in the observations, but an increase in DTR in Patagonia. The NNR trends are similar but the increase in DTR extends further north, with an average of –0.11 ^{o}C/decade. The corresponding OMR trends are very negative over the wet pampas and mostly positive in Patagonia, with an average of –0.10 ^{o}C/decade, suggesting that land changes and greenhouse warming contribute almost equally to the overall decrease in DTR.

The precipitation decadal trend averaged over two separate periods (1981-2000, 1961-1980) is computed for every station, and averaged over all the sites. Figure 5 shows the precipitation trend with an increase in most of the country with the maximum values toward the northeast of the region. Also it is not possible to definitively attribute to the precipitation changes, our results suggest that increase in precipitation at least in part would tend to decrease the maximum temperature and increase the minimum temperature, because precipitation contribute to an increase in the heat storage capacity of the surface. In Argentina the border of region devoted to the practice of agriculture has extended by more than 300 Km in the last twenty years.

4. SUMMARY

We have carried out a comparison of trends in the NCEP/NCAR reanalysis anomalies and observation anomalies for Argentina. Although it is not possible to definitively attribute the differences between the observation and the NN-Reanalysis temperature trends solely to land use, including urbanization, agriculture and irrigation, the results obtained are not incompatible with such an interpretation. To the extent that both urbanization and irrigated agriculture contribute to an increase in the heat storage capacity of the surface, they should contribute to an increase in the minimum temperature, a decrease in the maximum temperature, and a reduction in the diurnal temperature range shown in our estimates over most of the Argentina territory.

Also it is not possible to definitively attribute to the precipitation changes, our results suggest that increase in precipitation at least in part would tend to decrease the maximum temperature and increase the minimum temperature, because precipitation contribute to an increase in the heat storage capacity of the surface.

More studies are necessary, including a comparison of changes in population, urbanization, increase of areas for agriculture, and plausible changes in high latitudes regional circulation, to attribute the recently observed changes in temperature and precipitation over Argentina, to changes in land surface use.

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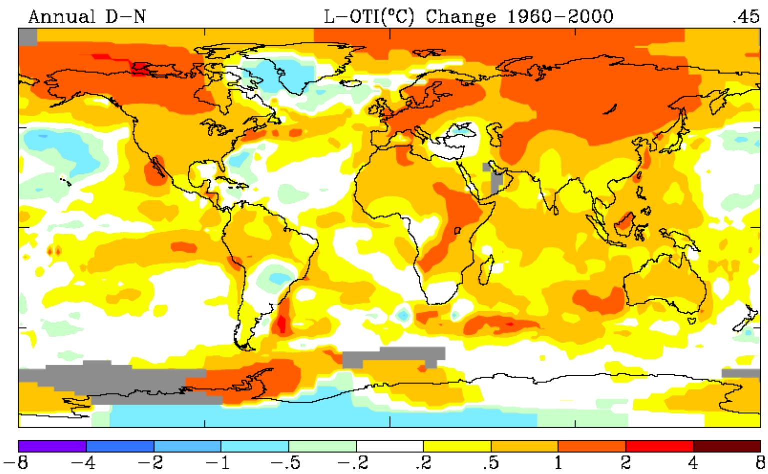
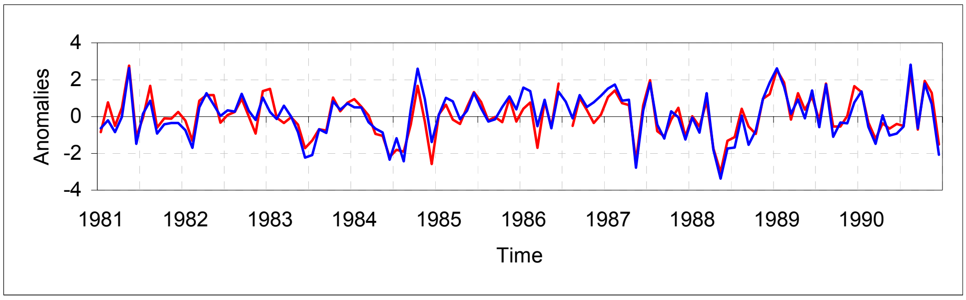


Figure 1: Trend of the surface temperature between 1960 and 2000 obtained from http://data.giss.nasa.gov/gistemp/maps/, with a smoothing parameter of 1200km. The global average trend is 0.45/4=0.04C/decade.

Tmean (obs) – Tmean (NNR) = 0.00



Tmean (obs) – Tmean (NNR) = 0.53

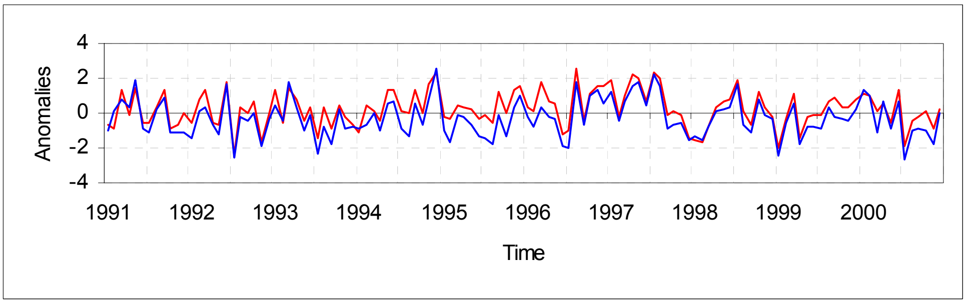


Fig. 2: Comparison of the monthly averaged temperature anomalies for the NNR (blue) and stations (red), shifted so that they have the same average during the 1980's. The station is situated in a park within the city of Buenos Aires, the largest city of Argentina.

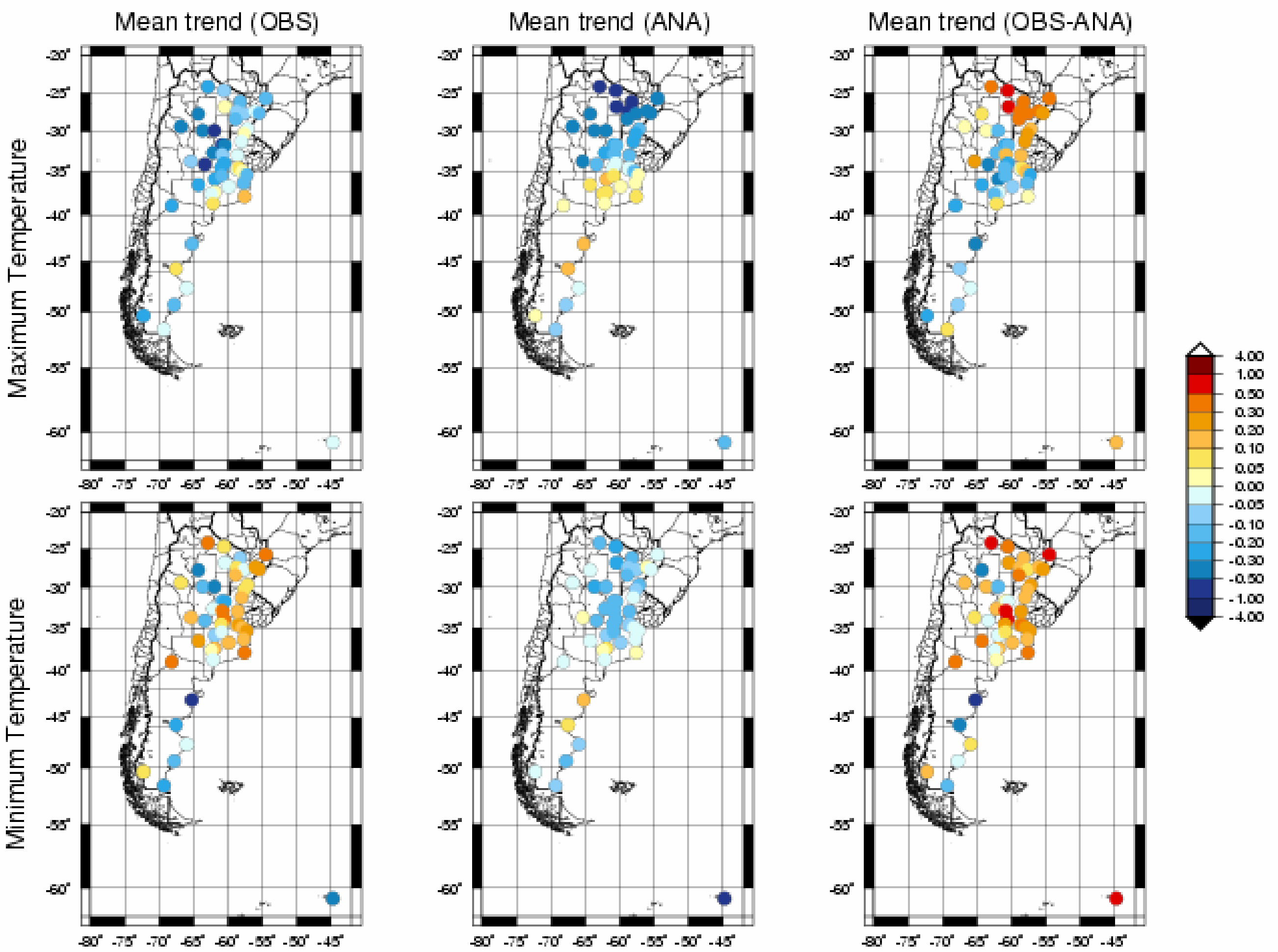


Figure 3: Top panel trend of the surface maximum temperature between 1960 and 2000 obtained from: observations (left), NNR (center) and OMR (right). Bottom panel trend of the surface minimum temperature between 1960 and 2000 obtained from: observations (left), NNR (center) and OMR (right).

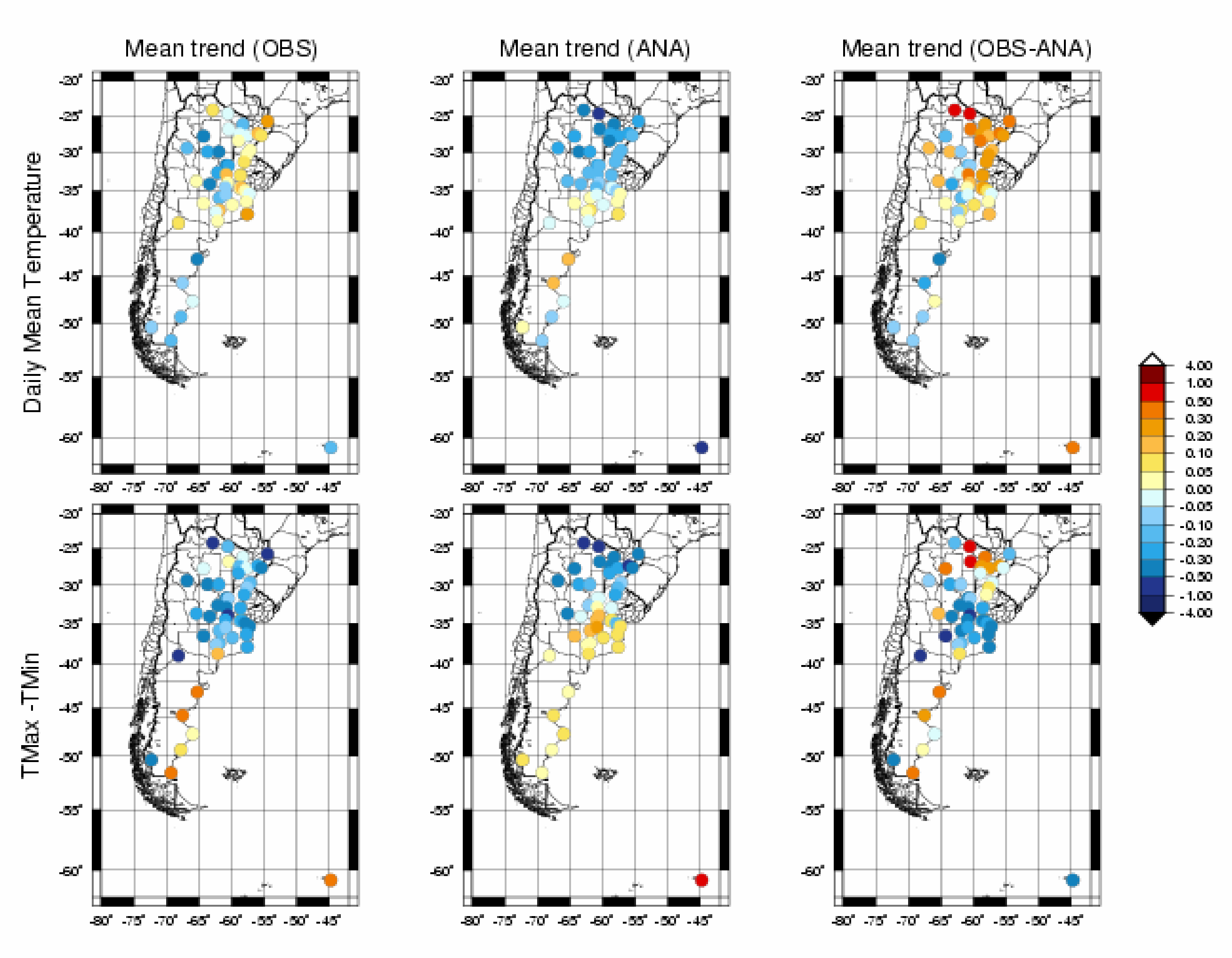


Figure 4: Top panel trend of the surface daily mean temperature between 1960 and 2000 obtained from: observations (left), NNR (center) and OMR (right). Bottom panel trend of the surface DTR between 1960 and 2000 obtained from: observations (left), NNR (center) and OMR (right).

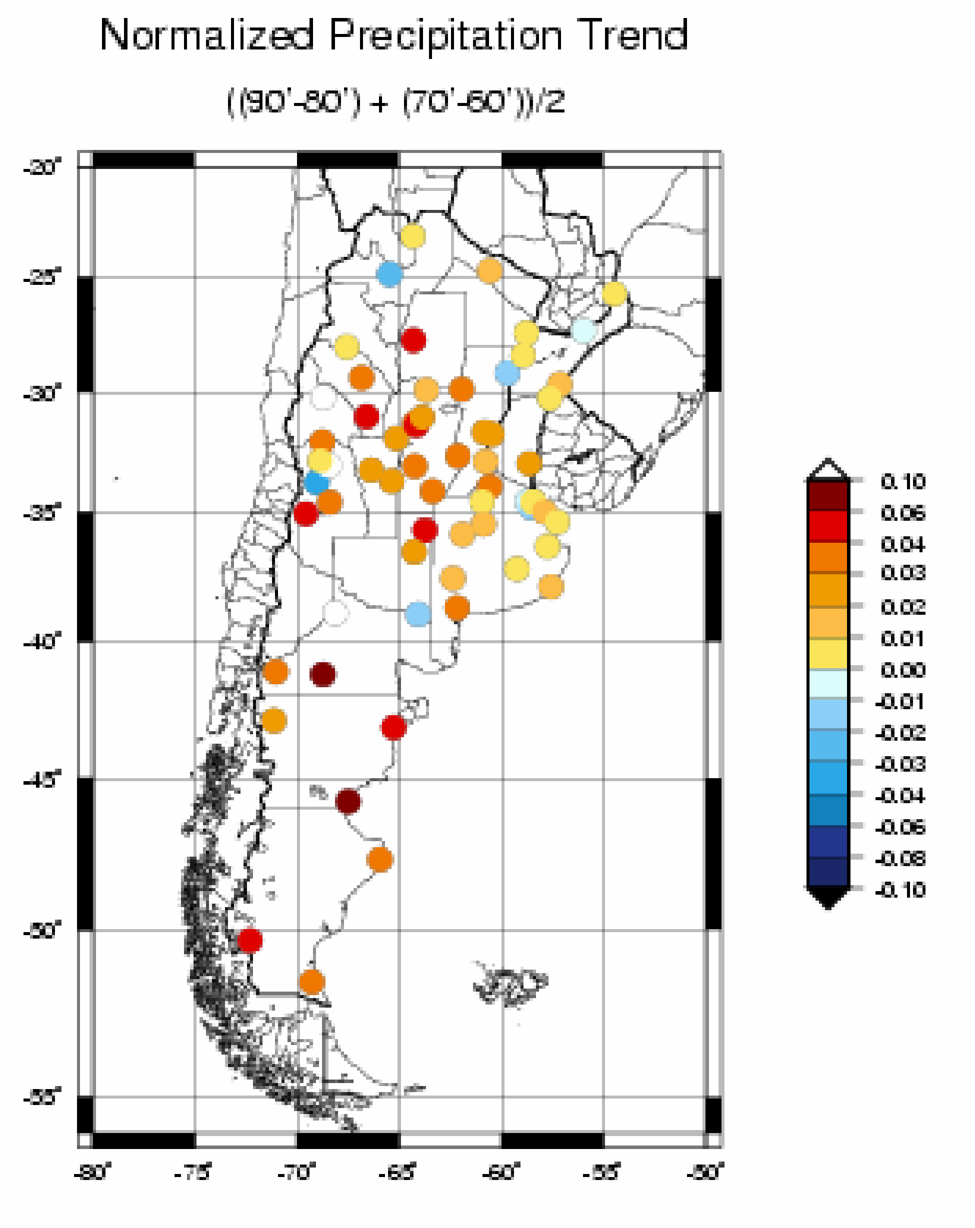


Figure 5: Normalized precipitation trend between 1960 and 2000 obtained from observations. The total precipitation for each station is computed for each of the four decades, and then these values are divided by the total precipitation over 40 years, so that the normalized precipitation over 40 years is 1 for all stations. The trends are computed using normalized precipitation for the total length of observations.