Response on comments of reviewer #1 in the interactive Discussion of the manuscript ‚Climatic changes between 20th century and pre-industrial times over South America in regional model simulations'

First, we would like to thank the reviewer for his/her constructive comments on our manuscript. Please find below a point-by-point response on the comments raised in the review:

The basic idea behind this work is a good one - to get an idea of PI-to-PD climate changes in southern South America using a regional model forced with appropriate boundary conditions. the results are fairly clear (as summarized above). However, The presentation has some major shortcomings including:

1) Comparisons with existing related experiments and observations are lacking. There is considerable literature dealing with observed and/or simulated 20th and 21st century trends in Southern Hemisphere and South American climate and circulation and their possible relation to changes in GHG (including ozone) – e.g. Marshall, 2003; Cai and Cowan, J. Clim. 2007 and references therein; IPCC AR4 report (Chap. 11.6.3) among many others. What is important here is that the large-scale circulation changes in the S. Hemisphere relating to altered GHG concentrations have been explored in by others and are qualitatively consistent with those found in the CCLM results. The results in the present paper would be considerably strengthened if cast in the context of these other results.

In the first version of the manuscript our focus was primarily related to the past climate, i.e. to periods that are further back in time. We put the result therefore in the context of those studies that were carried out for earlier periods like the last glacial maximum or the mid-Holocene. In the new version of the manuscript we however explicitly included the suggestions of the reviewer, for instance related to changes in the Southern Annular Mode during the 20th century (Thompson and Wallace, 2000, Thompson et al., 2000) and related climatic effects, also including changes in SST patterns (Hall and Visbeck, 2002, Sen Gupta and England, 2006) . We also addressed the issue of changes in ozone concentrations (Marshall et al., 2004; Cai and Cowan, 2007), although this point could not be analysed in our model study because the driving global model and the regional model do not include interactive ozone modules. Additionally, also the basic results that were drawn from the IPCC AR4 (Christensen et al., 2007) for potential climatic changes focussing on central and southern South America are now presented in the new version. As already outlined by the reviewer or results concerning the GHG changes between PI and PD times are in qualitative agreement with those found for future studies, for instance related to an intensification of the zonal circulation and the related intensification of the south Pacific and South Atlantic high pressure cells. We also spent more space in discussing the effects of changes in atmospheric circulation on changes in climatic parameters like precipitation and near-surface temperatures and what potential effects might have on the climate-circulationship.

2) Comparisons with proxy-derived inferences concerning LIA-to-modern climate changes in South America are confined to two short paragraphs (with three citations). Given the similarity of the CCLM results with other findings (previous paragraph), the paper would benefit from a more thorough discussion of the model results as they relate to proxy-derived inferences for LIA-modern precipitation and temperature changes in southern South America (for example, van Guten et al. Holocene 2009, among others).

Although in the earlier version of the manuscript we did not explicitly compare our results with single reconstructions our intention was to compare the model results with integrating comparisons – these kind of reconstructions were provided by Neukom et al., 2010(a,b) by integrating various kind of proxy data for climate field reconstructions. However, in the new version of the manuscript we dedicated an own section on the comparison between the model results and those reconstructed by proxy data, extending the studies to other ones including glacier studies (Vimeux et al., 2009; Masiokas et al., 20009), studies on lake sediments (Piovano et al., 2002; Mayr et al., 2005; Haberzettl et al., 2005; von Gunten et al., 2009) and tree rings (Boninsegna, 1995, Christie et al., 2010). We also provided an extra paragraph in the introduction including the general characteristics of the LIA in southern South America based on proxy evidence like cooler temperatures, glacial advances and changes in precipitation patterns.

3) I found the results section overly descriptive with insufficient attention to physical processes. Attention to this point would result in more concise and informative text.

In the re-worked version of the manuscript we explicitly addressed this point in several ways: First, the introduction includes in the first paragraphs a more thorough discussion of the driving physical processes that are important for the South American climate in the different regions. Besides the atmospheric circulation this now also encompasses the considering of the impact of sea surface temperatures on the South American climate. In the results section a complete new section has been included discussing the impact of wind-induced and non-wind induced changes on the total temperature and precipitation differences between present-day and pre-industrial times. Furthermore also climatic related and non-climatic, i.e. model-specific characteristics have been issued, like the potential impact of changes in sea-surface temperatures and the overestimation of the zonal circulation in the driving ECHO-G model on the climate-circulationship.

4) Important technical points regarding the analysis and experimental set-up are not stated. For one example, the paper does not describe the ECHO-G simulations or the forcings used for these; are these from time slice simulations with only CO2 changes or transient simulations including irradiance changes as well? Or perhaps the CO2 changes were only made in CCLM (this seems unlikely). A table describing the experiments and forcing data sets would be useful and would make the text more concise.

In the re-worked version, as suggested by the reviewer, we included an additional table describing the setup of the ECHO-G and the CCLM model – for the ECHO-G model the solar constant and CO_2 concentrations was slightly higher because this simulation was already carried out in another context taking into account also changes in solar activity. Both ECHO-G simulations are time slice experiments and during the integration no change in external forcing parameters occurs. For the regional model the only change in the experiment setup relates to changes in the CO_2 content of the atmosphere. The orbital forcing was set to present-day conditions for both simulations, because changes between 1750 and the second half of the 20^{th} century are not very large.

*** The text on figures labeling contour levels, colors, latitude and longitude is generally too small to read, even when the web version is magnified. Inability to read the values portrayed in figures is a hindrance for reviewers.*

In the process of converting the word-document to pdf the quality of the figures unfortunately declined. In the re-worked version all figures have been reproduced with higher resolution and quality including the enlargement of labels referring to latitude and longitude and labelling of colour bars

** Fig. 2b upper left, comparing simulated and observed precipitation in Antofagasta (observed annual average of a few mm), has some problem.*

The reason why the station shows very little precipitation in the GPCC data set is related to the fact that little precipitation was measured at the station during the 1993–1997 period. However, the amount is in general lower than 1mm. For the ERA40+CCLM simulation no precipitation was simulated, i.e. all values are zero and are located directly over the x-axis in the Figure. We mentioned this issue explicitly in respective section within the text in the new version.

** The introduction needs to be tightened up, points are raised that are not followed up on later in the paper and some of the text does not seem relevant (e.g. relating to the mid-Holocene). Finding from other altered GHG simulations could be briefly introduced here (what sort of changes do we expect?). A more concise summary of the general idea of LIA-modern climate change would be useful, and would set the stage for later discussion relating the model results and proxy-based inferences.*

These points have been addressed in the new version – As outlined in the first comment, it has been taken care that also studies addressing the GHG aspect have been included, for instance IPCC, 2007, studies investigating the impact of changes in SAM/AAO in the 20th century and also those investigating the impact of ozone changes. Moreover, the paragraph introducing LIA conditions based on empirical evidence has been extended, introducing the basic character for both, temperature and precipitation based on different kinds of proxy data. This general idea is then elaborated in greater detail in the results section where also a complete new paragraph has been dedicated for the comparison between empirical data and model results.

** The shortness of the 5-year ERA-40 driven simulation should be pointed out – how representative are annual cycles drawn from a sample of five?*

We agree with the reviewer that the amount of five years is very limited for any statistical robust conclusions. However, it should indicate that the CCLM model is able to reproduce the main climatic features of the South American climate. The bias and the potential reasons leading to the ERA40-driven biases have been addressed in greater detail in the new version, also including references to studies carried out for other regions (Anders et al., 2009; Jaeger et al., 2008) with the version of the regional climate model used in the present study. Another important comparison is however the one for the longer, 30 year long present-day simulation, because this model setup between ECHO-G and CCLM is eventually used for the analysis of climatic changes between present-day and pre-industrial times. It has also been emphasised that the bias structure between the ERA40-driven and the GCM-driven simulation might be different due to the different biases inherited by the driving models.

** One might point out how large (or small) the 280-330 ppm changes in CO2 are in comparison to 20th century changes.*

The changes within the 20th century and those in between pre-industrial times relate to a change of 35 ppm from 1900 to 1975 and a change of 15 ppm between 1750 and 1975. Therefore the change during the 20th century is around ¾ of the total PI – PD CO_2 change. We mentioned this point in the section about the experiment setup that most of the increase happened in the course for the 20th century because the increase prior to 1900 was rather moderate.

** The spatial resolution of the CRU, GPCC and NCEP-reanalysis data used for comparisons should be noted and related to the results*

This information has been added in the introduction to the validation section – the base for the CRU and GPCC data set refers to a horizontal resolution of 0.5° x 0.5°, whereas the NCEP data set for sea level pressure has a horizontal resolution of 2.5° x 2.5°.