HARMONIC ANALYSIS OF CLIMATOLOGICAL TEMPERATURE OVER ANTARCTICA: PRESENT DAY AND GREENHOUSE WARMING PERSPECTIVES

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INTRODUCTION

It has long been recognized that the Earth's climate is strongly linked to surface conditions in high latitudes. For instance, Antarctica holds 90% of the world's fresh water and along with its surrounding sea ice, is among the major drivers of the planetary seasonal albedo dynamics.The different seasons provide a range of modelling challenges in the Antarctic. An assessment of errors in the simulation of the seasonal cycle may therefore help to explain inter-model differences in projections of future change.

Our goal in the present paper is, therefore, to provide an additional evaluation of climate simulations from six GCMs.
We focus upon the simulated seasonal cycle of surface temperature and its relationship with the atmospheric circulation over Antarctica under present day (PD) and greenhouse warming (GW) conditions.
This is motivated by the fact that the model reliability in simulating PD extra-tropical climate variability will have to be carefully considered when temperature and large-scale circulation are projected for the future GW interval.
Furthermore, it is important to identify possible model bias in the simulated present day Antarctic climate conditions. For analysis of future projections we have chosen model simulations conducted with the IPCC SRES-A2 greenhouse gas concentration scenario. The SRES-A2 high emissions scenarios is considered among the "pessimist" greenhouse gas concentration scenarios.

METHODOLOGY

Models investigated in this study are part of the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4) effort, and form the World Climate Research Programme's (WCRP's) Coupled Model Inter-comparison Project phase 3 (CMIP3) multimodel data set. CCCma, CSIRO , HadCM3, MIROC-MEDRES, CCSM, and the GFDL, were chosen based upon an weighting criteria, in which the weighting was constructed from comparison between observation-based estimates and the modelled climate according to some measure of their performance. CCCma, CSIRO , HadCM3, CCSM, and GFDL have weight values among the top ten models that better reproduced the observed Antarctica climate. As previously discussed all models contain forcing by greenhouse gases and tropospheric sulfate aerosols.

In order to study the seasonal spatial variability of t2m we have applied harmonic analyses. As discussed by Aslan et al. (1997), the Fourier transformation or harmonic analysis decomposes a time-dependent periodic phenomenon into a series of sinusoidal functions, each defined by unique amplitude and phase values. The proportion of variance in the original timeseries data set accounted for by each term of the harmonic analysis can also be calculated.

RESULTS AND DISCUSSION

Based on ERA40 and NCEP/NCAR Reanalysis (NNR) and simulations from CCCma, CCSM, CSIRO, HadCM3, MIROC-MEDRES and GFDL, our results demonstrated that the amplitude of the annual and the semi-annual harmonics delivered by the ERA40 and NNR are dominated by distinct seasonal variability. The first harmonic amplitude of near surface temperature (t2m) according the NNR is located over the Plateau of East Antarctica, whereas analyses for ERA40 show maximum amplitude over the west Antarctic ice sheet. This indicate a bias in the ERA40 in regarding the amplitude of the seasonal cycle over the Antarctic continent. A comparison between the modeling results and the NNR data demonstrates that the models simulate satisfactorily the amplitude of the first and second harmonics, however, the modeling results differ among themselves in terms of the amplitude values. Larger seasonal variability is identified for CCCma, HadCM3 and MIROC-MEDRES with values as high as 20C over the Antarctic plateau. We have further identified that the CSIRO models does not deliver the seasonal amplitude of t2m as reproduced by the other models, which is primarily due to its overestimation of the cloud cover and weak seasonal changes of precipitation. Calculations of the harmonic analysis based upon greenhouse warming conditions revealed that there is no substantial seasonal difference between the amplitude of the first harmonic as projected by greenhouse warming and present day simulations over the Antarctic continent. Over the polar ocean, however, the amplitude of the first harmonic is reduced in all climate models under future conditions. In order to narrow down the uncertainties on future climate projections, analyses of the cloud forcing which include the shortwave and longwave radiation, and the surface mass balance may provide substantial information on the cause of the discrepancies as simulated by climate models over the Antarctic region.