Climate warming after the end of the twentieth century?

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Abstract

By the application of step slope models for the study of global and Northern hemispheric temperature anomalies series, structural break points around 1910, 1945, 1965 and 1997 with abrupt change of the temperatures are obtained. After the break point near 1997 the temperatures show a slow increase or a flat course. This gives rise to the question about the stopping of the warming process, in spite of the increase of the concentration of carbon dioxide (CO2) in the atmosphere. In the present paper a linear regression model is used to describe the temperature progression. The model includes the atmospheric carbon dioxide amount, the atmospheric optical depth, the solar radiation, the Southern oscillation index, the Atlantic multidecadal oscillation (AMO) index and the Pacific decadal oscillation index as explanatory variables. It is demonstrated that the influence of AMO, superimposed over the permanent warming process, generates the most important climate variability including an abrupt warming after 1997. After removing the AMO influence the Northern hemispheric temperature anomalies are very similar to the anomalies observed at the Southern Hemisphere characterized by a continuous warming process due to the CO_2 increase

Introduction

The most important climate data centers are the Goddard Institute for Space Studies (GISS) at NASA, the National Climatic Data Center (NCDC), both of USA, and the Hadley Centre at the Metoffice of UK which collabotrates with the Climate Research Unit of the University of East Anglia (HadCRUT). The temperature time series of the three centres are similar and show clearly cooling or warming periods at decadial timescales. Here we used only the data set of NCDC.

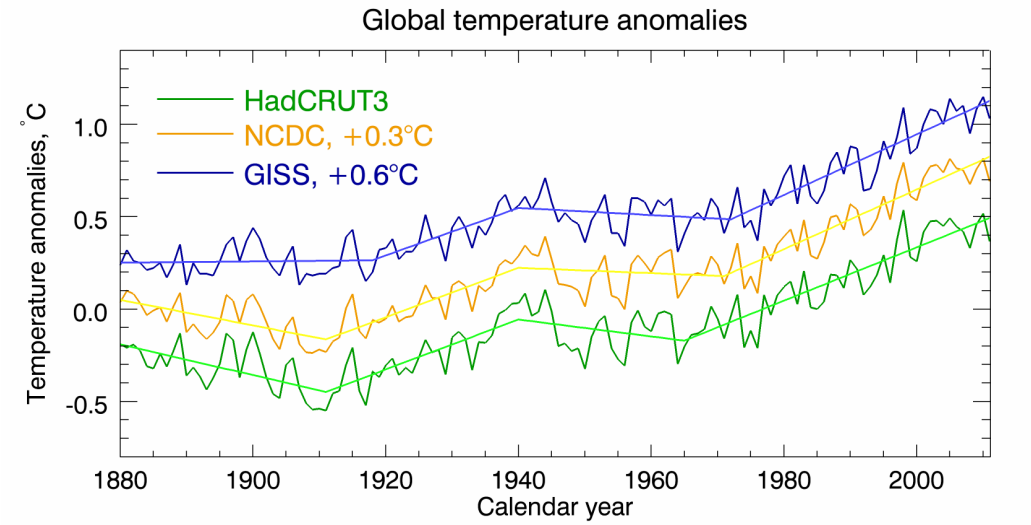

Fig.1. Observed global temperature anomalies of the three most important Climate centres are similar and show periods of warming and cooling seperated here by piecewise regression

The warming and cooling of the atmosphere are generated by processes associated with:

- changes in the greenhouse gas concentrations (mainly of CO2, NO2 and CH4);
- volcanic eruptions;
- changes of the solar activity (open solar magnetic field);
- changes of the solar dimming/brightening by aerosols;
- interaction with the oceans;
- cloudiness.

In the science community there is not consensus about the main climate forcing generated the cooling period 1940-1975

Main Goal

In the present study we are investigating the influence of some ocean oscillations on the hemispheric temperature anomalies and the global climate

Regression model

We use a simple linear regression model to describe the temperature forcing as:
$\Delta T = const + \beta_1 \log(CO_2 / 280\,ppmv) + \beta_2 TSI + \beta_3 AOD + \beta_4 SOI + \beta_5 AMO + \beta_6 PDO$,where the following quantities are used as explanatory variables:

- logarithm of the Carbon dioxide (CO2) concentration related to the preindustrial value of 280 ppmv;
- the changes of the total solar irradiation (TSI);
- the Atmospheric optical depth (AOD), which describes the volcanic emissions;

the following indexes describing the ocean temperature influence:

- the Southern oscillation index (SOI), to include the El Niño and La Niña effects;
- the Pacific decadal oscillation (PDO) index;
- the Atlantic multidecadal oscillation (AMO) index.

In the regression we don't include other greenhouse gases beside CO2 because of the similar development of their atmospheric concentrations. The obtained results regarding CO_2 therefore have a character approximately like an effective concentration. The regression was carried out for the Northern Hemisphere (NH) temperature anomalies and for the anomalies for the Southern Hemisphere (SH)

Regression results

For NH and SH significant influences of CO_2, AMO, SOI are obtained. Most of the volcanoes are located in the NH and influence only the Northern temperature. It is interesting that the solar irradiation impact on the temperature is significant only for the Southern Hemisphere. The AMO influence is approximately five times stronger on the NH than on the SH. The SOI has a stronger influence on the SH temperatures as it was expected.

A significant temperature impact of the PDO for both hemispheres was not observed. A very important result is, that the NH temperatures when AMO is removed, have a very similar course to the SH temperatures (see Fig .4). As it is seen the strong cooling during 1945-1970 is also removed. The warming produced by CO_2 (or some CO_2 equivalent) over the NH and SH is equal (in the frames of the precision) and persists continuously. The temperatures show only short term variations around the temperature increase produced by CO_2.

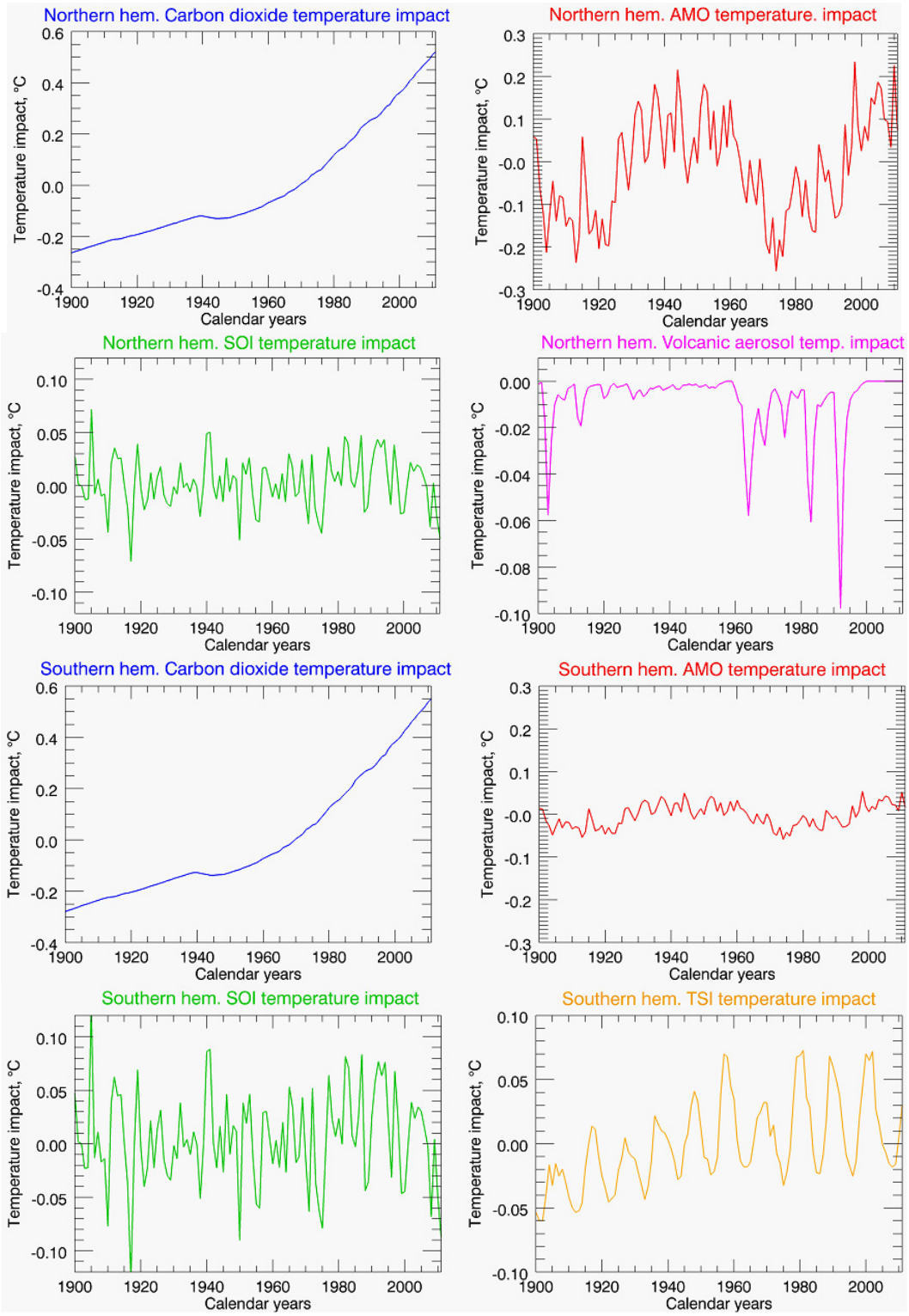

Fig. 2. Impact of the significant explanatory variables to on NH temperature anomalies (top) and the same for the SH temperature anomalies (bottom). The significance was estimated taking into account the residuals autocorrelation (compare also Fig.3), where AR(1) processes are assumed to describe the residuals

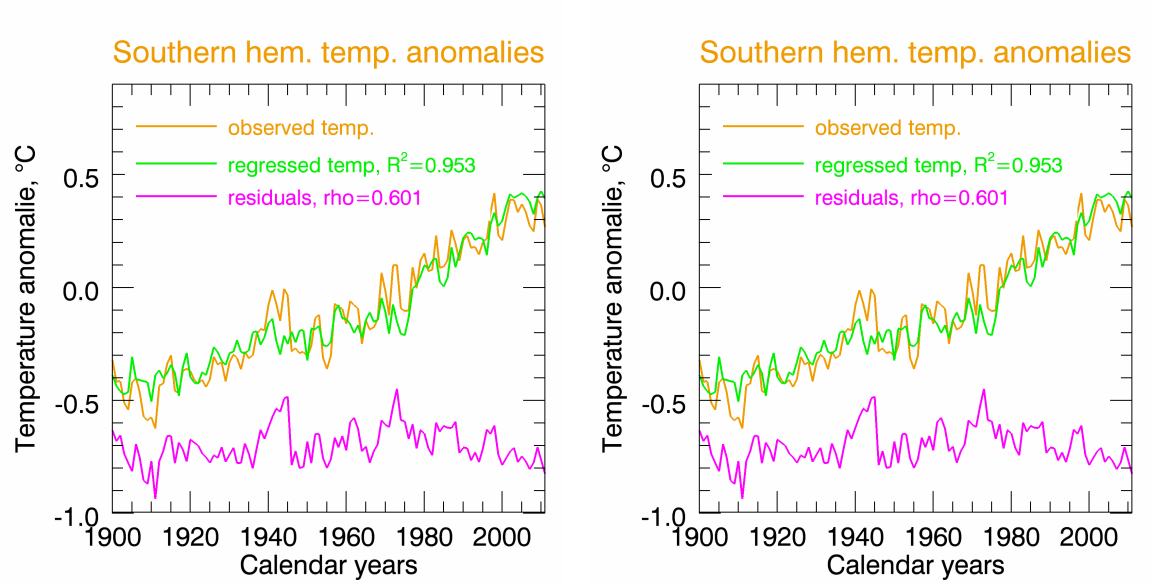

Fig.3. Comparison of the observed temperature anomalies with the modeled ones by linear regression (at left for the NH and at right for the SH). R2 is the estimated determination and rho - the auto-regression coefficient estimated by the auto-correlation at the lag 1.

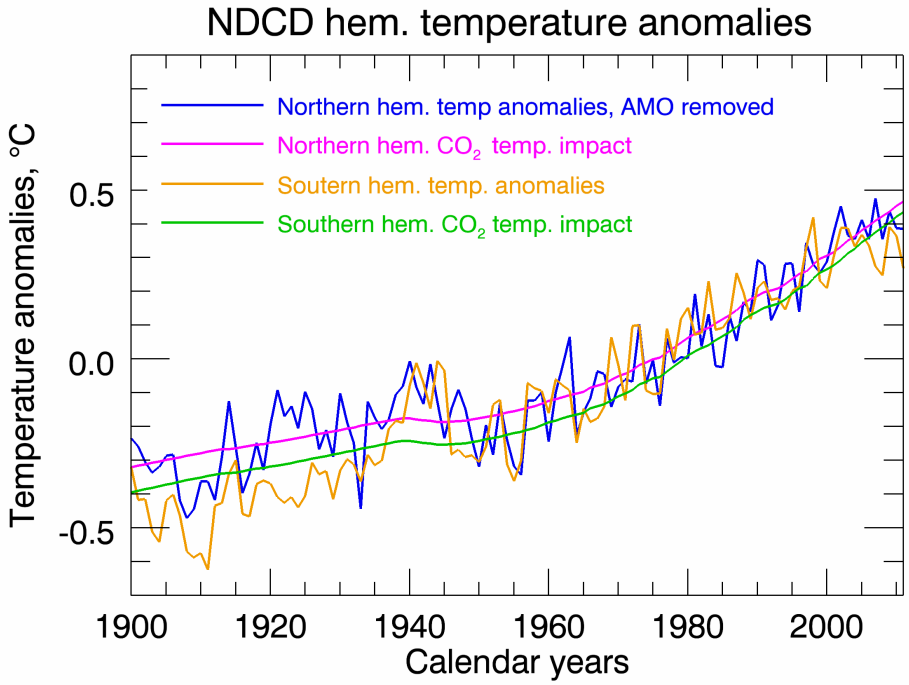

Fig. 4. The NH temperature anomalies, where the AMO influence was removed in comparison with the SH temperature anomalies and the temperature changes generated by CO_2

Conclusions

AMO has a significant influence on the NH. After removing the AMO temperature impact in the NH, the temperature has a similar course as the one of the SH. It was demonstrated that the cooling period 1940/1975 is a result of AMO. The warming produced by CO2 is approximately equal in the NH and in the SH. An interruption of the warming process couldn't be found. The slow increasing of the NH temperatures after 1998 is mainly a result of the AMO influence superimposed on the continuous warming process and it is imposed on the global temperatures.