Atlantic multidecadal oscillation influence on climate

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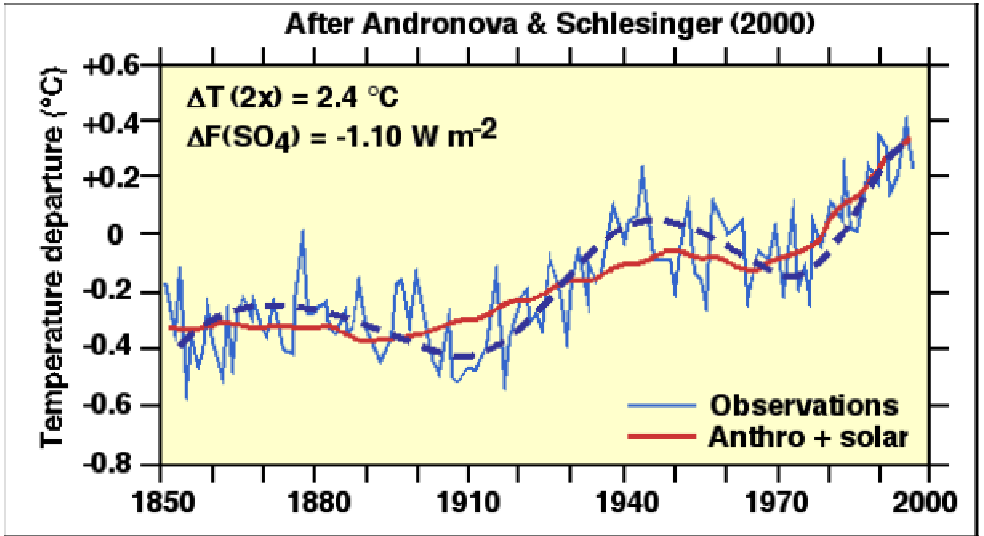
Introduction

Some milestones of the short Atlantic multidecadal oscillation (AMO) history

1994: Schlesinger and Ramankutty have discover an oscillation with a period of 65-70 years by singular spectrum analysis of the North Atlantic surface temperature. They have suggested that it arises from internal ocean-atmosphere variability.



Introduction

Some milestones of the short AMO history

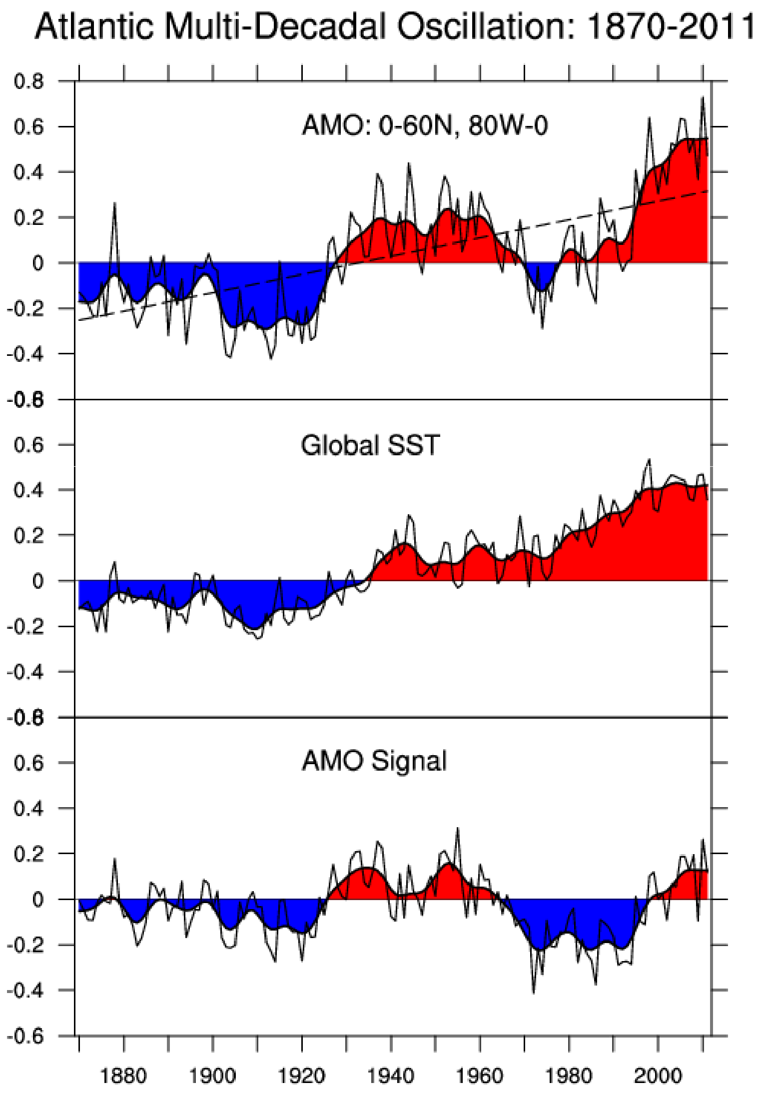
2000: Delworth and Mann have identified 60-110 years oscillations in paleoclimatic North Atlantic temperature reconstructions.

from 2011: AMO like structures are found by climate models suggesting that the origin of AMO is the Atlantic meridional overturning circulation.

2013: Zhou and Tung included the Atlantic multidecadal oscillation in a temperature regression model.

Introduction

AMO definitions



1. The Atlantic multidecadal Oscillation is defined as detrended mean Sea surface temperature over the North Atlantic. Enfield et al. *Geophys. Res. Lett*. 28(10), 2077-2080, 2001.

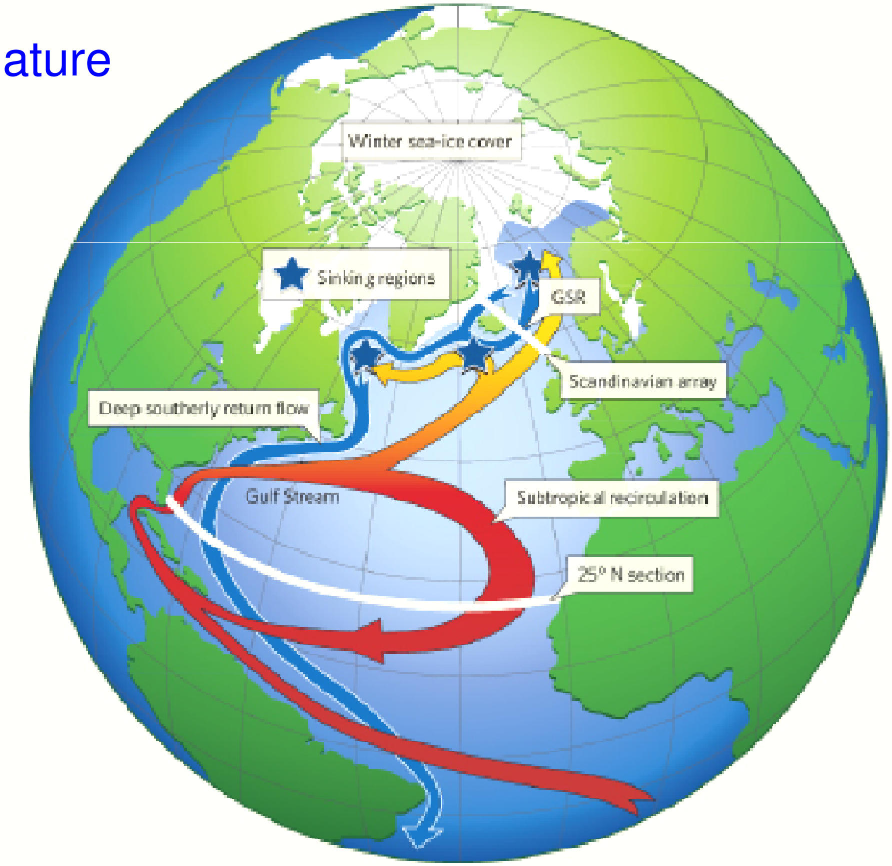
2. AMO is the difference between the mean Northern Atlantic temperatures and the global Sea surface temperatures (SST) Trenberth, K.E. and D.J. Shea ,*Geophys. Res. Lett.* **33**, L12704, 2006,

Introduction

AMO source:

- planetary resonance (Scafetta, 2010, http://arxiv.org/pdf/1005.4639.pdf)
- solar activity (Weng, 2012, Adv.Atm.Sci.4, 887-908)
- internal variation (Knudsen, 2011, nature comm., DOI: 10.1038/ncomms1186)

Simulations with Climate models show that AMO is probably generated by the Atlantic Meridional Overturning Circulation (A-MOC)



Regression analysis of the temperature series

Linear regression:

$$T = const + \beta_1 * \ln(CO_2/280\,ppmv) + \beta_2 * AMOI + \beta_3 * PDOI +$$
$$+ \beta_4 * TSI + \beta_5 * SOI + \beta_6 * AOD + \varepsilon,$$

T: GISS, NCDC, HadCrut temperature data sets

CO_2: Carbon dioxide concentration, Mauna Loa (Keeling, Tans)

AMOI: Atlantic multidecadal oscillation index, Kaplan SST v2

PDOI: Pacific decadal oscillation index, Mantua, Zhang, 1997

TSI: Total solar irradiance, Wang et al., 2005

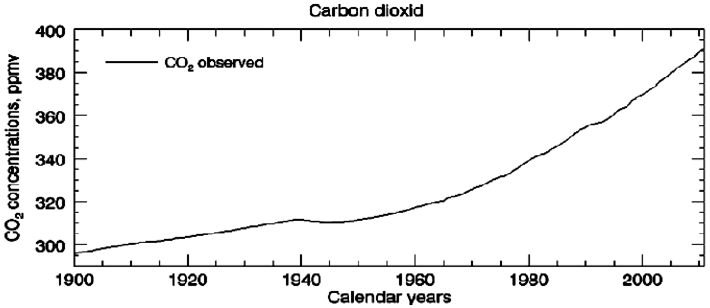
SOI: Southern oscillation index, Trenberth,1984

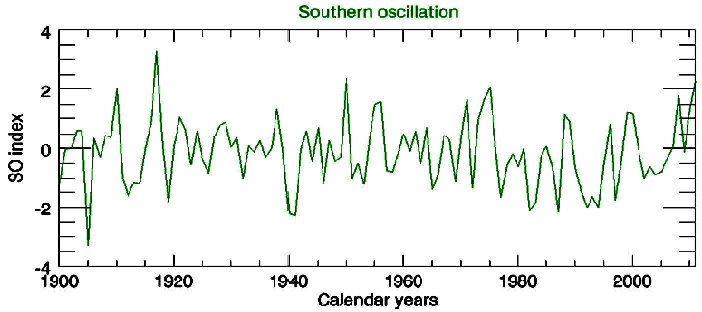
AOD: Atmospheric optical density Sato, 1993

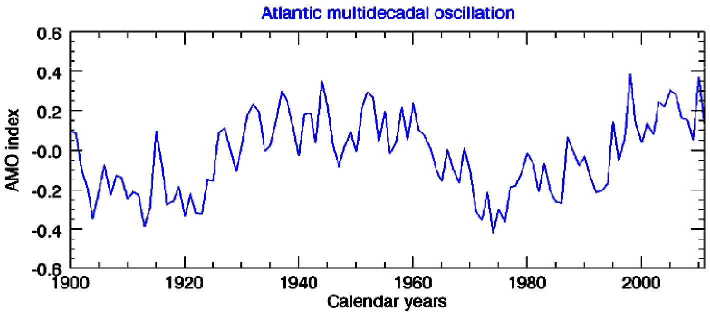
ε : residuals with autocorrelation structure

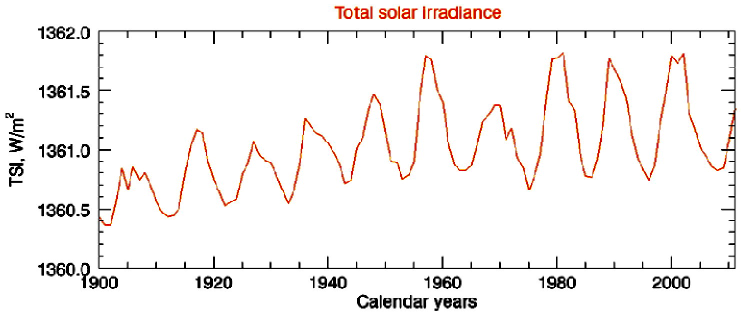
Regression analysis of the temperature series

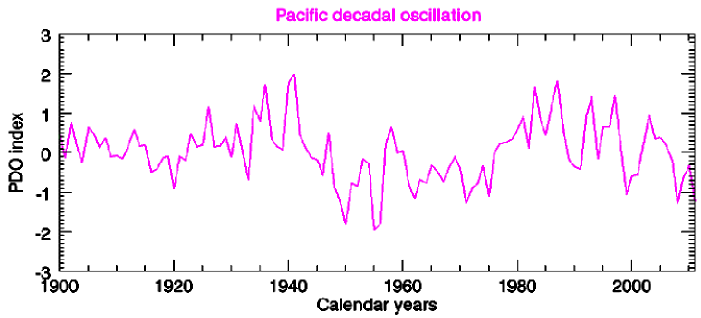
Predictor evolution

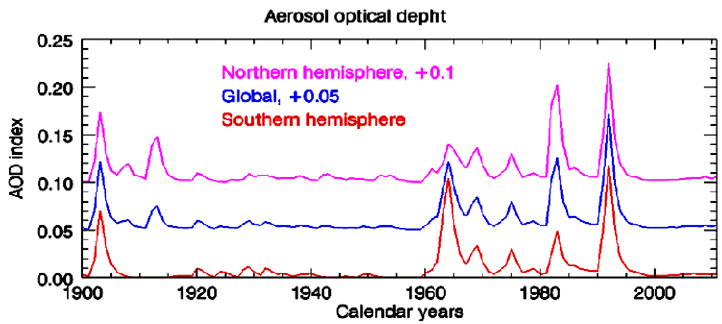




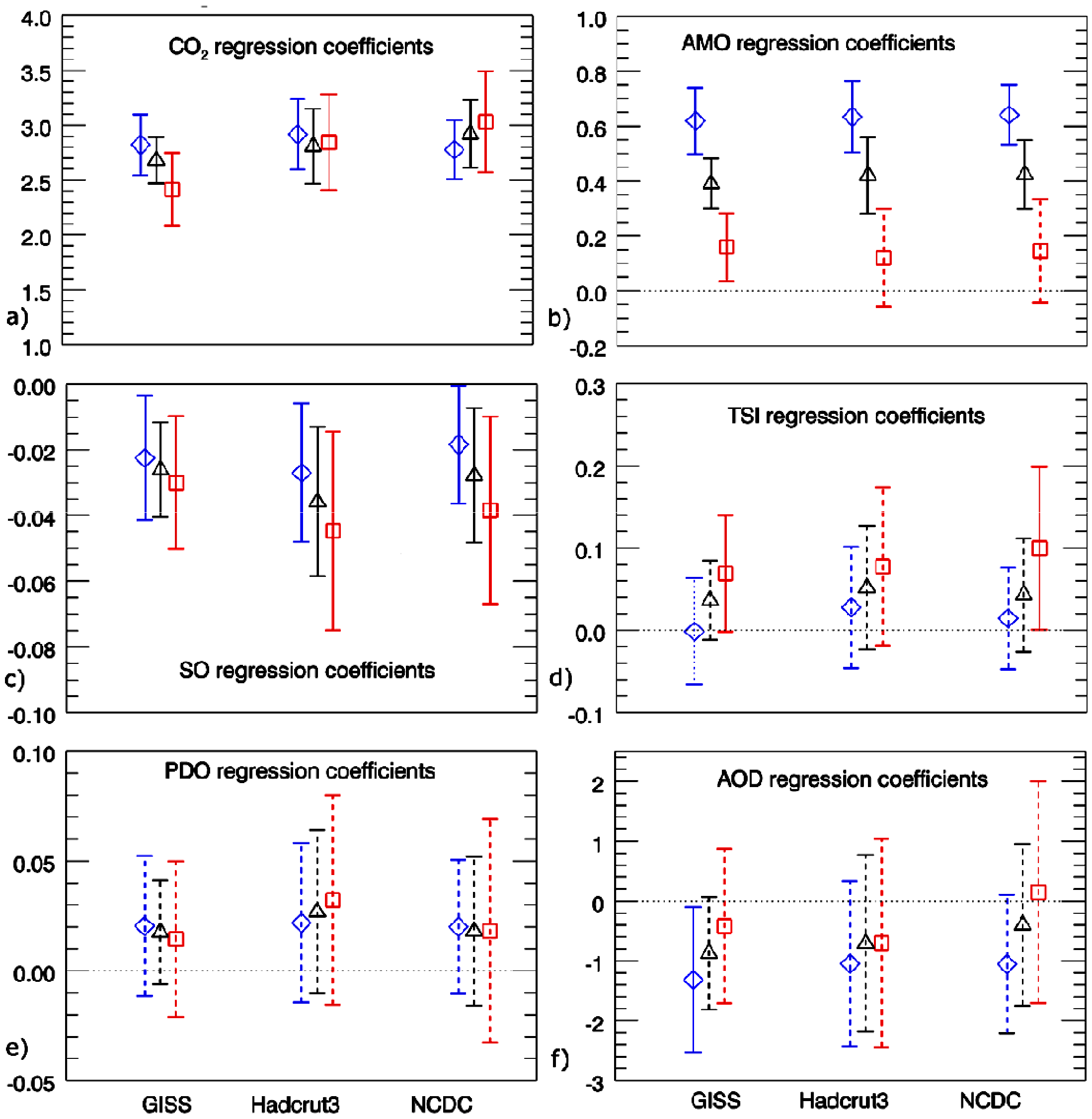




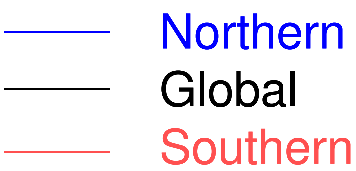




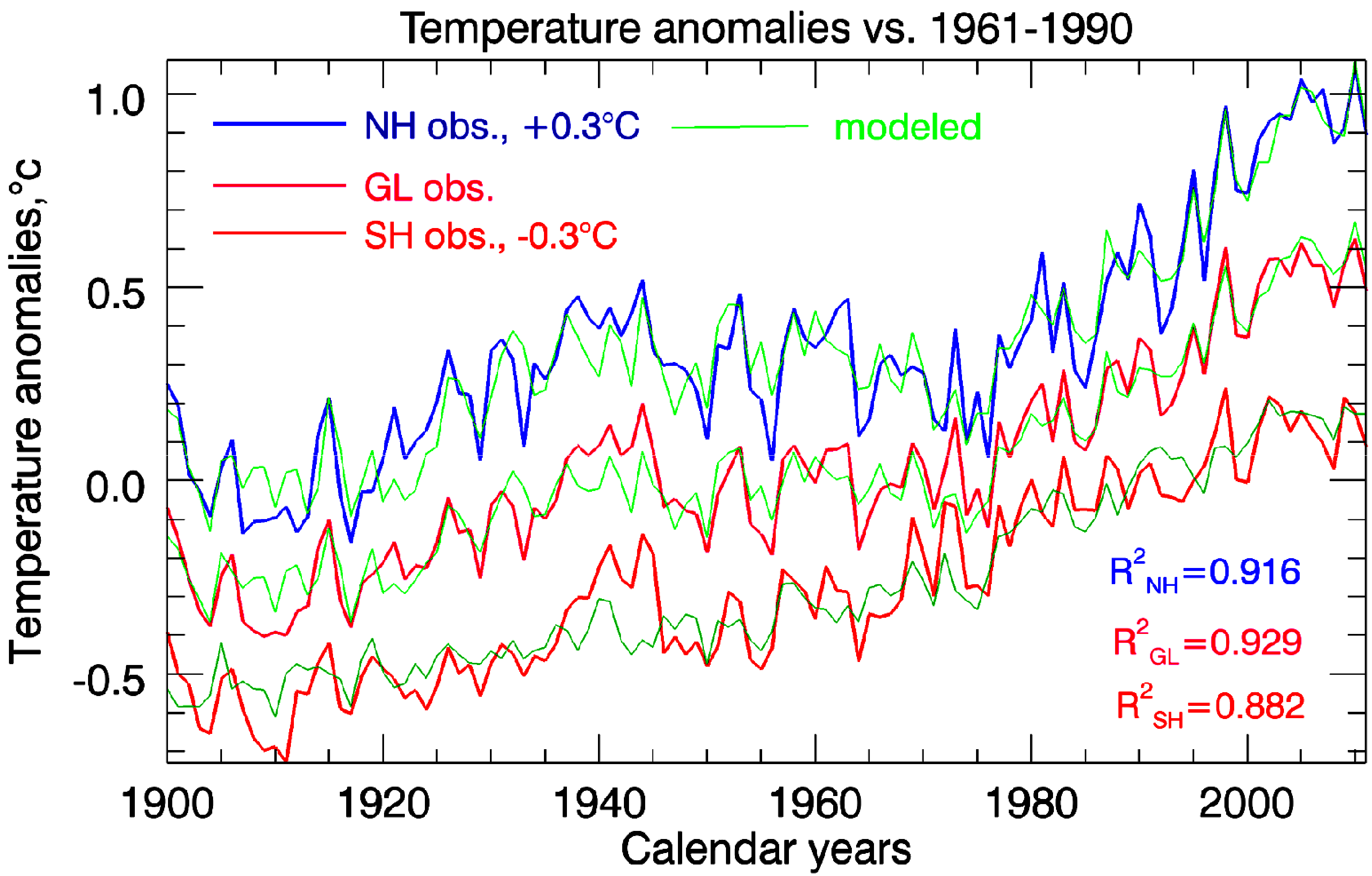
Regression analysis of the temperature series



Obtained regression coefficients for the combined land/ocean temperature anomalies

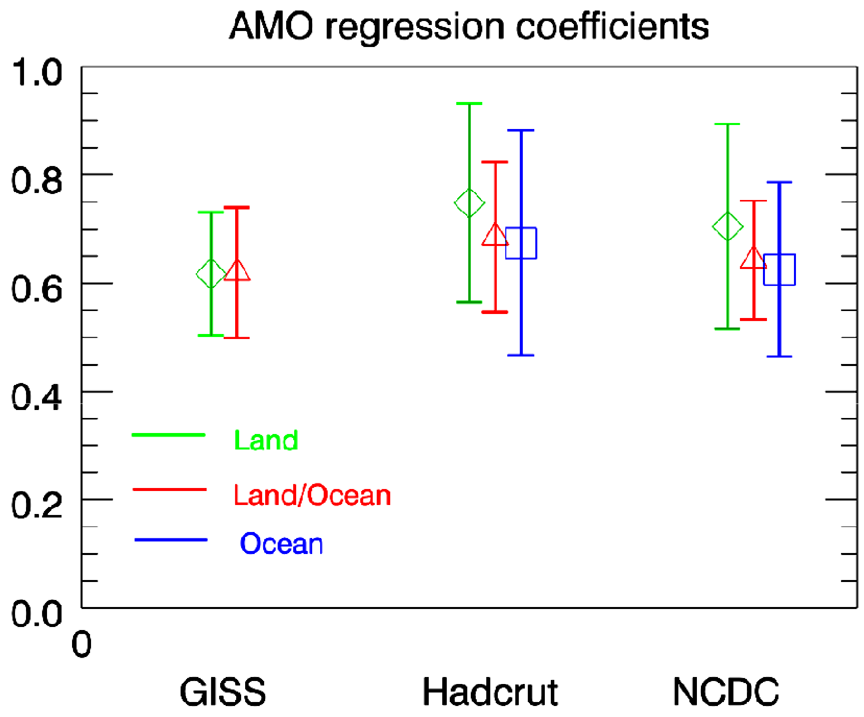


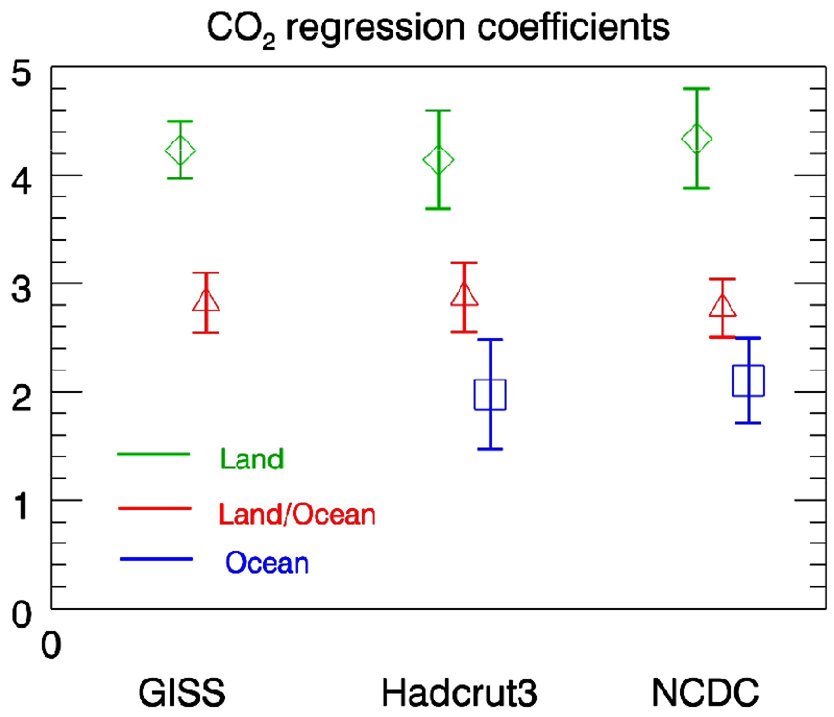
Regression analysis of the temperature series



Regression analysis of the temperature series

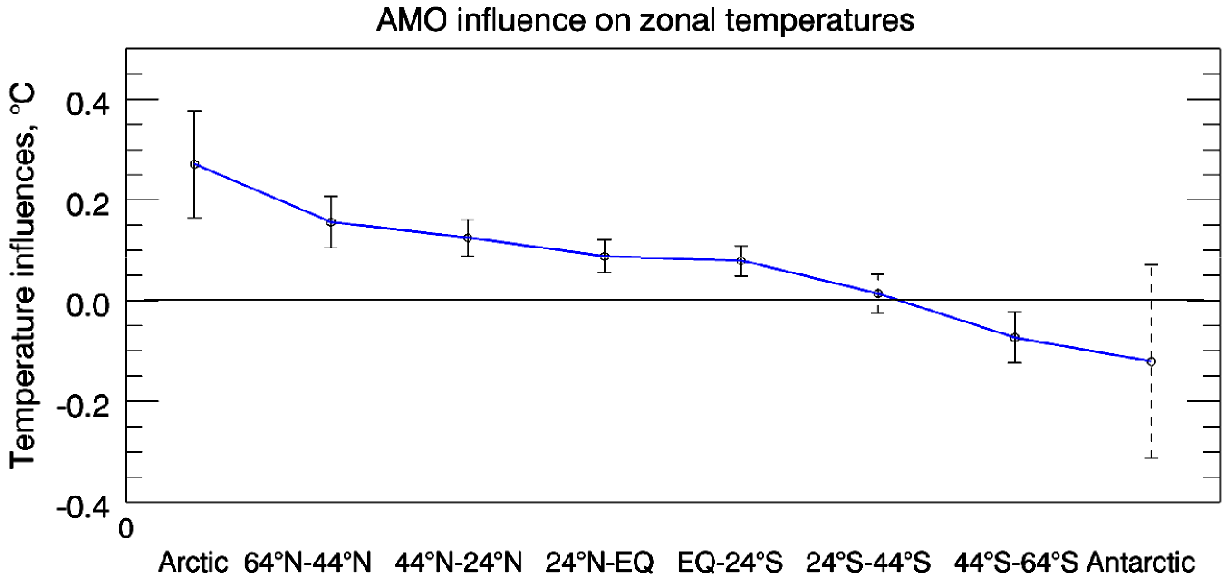
AMO and CO_2 influence on the Northern hemisphere temperature





Regression analysis of the temperature series

Latitude dependence of the AMO influence



Structural change analysis

Piecewise linear regression

$$T = \alpha + \beta_1 t + \sum_{i=1}^{k} \delta_i d_i (t - t_i^*)$$

$d_i = 1 \quad for \quad t \geq t_i$ and 0 elsewhere

The slope in the first segment is β_1

In the following segments the slopes are : $\beta_1 + \sum_{i=1}^{m-1} \delta_i$

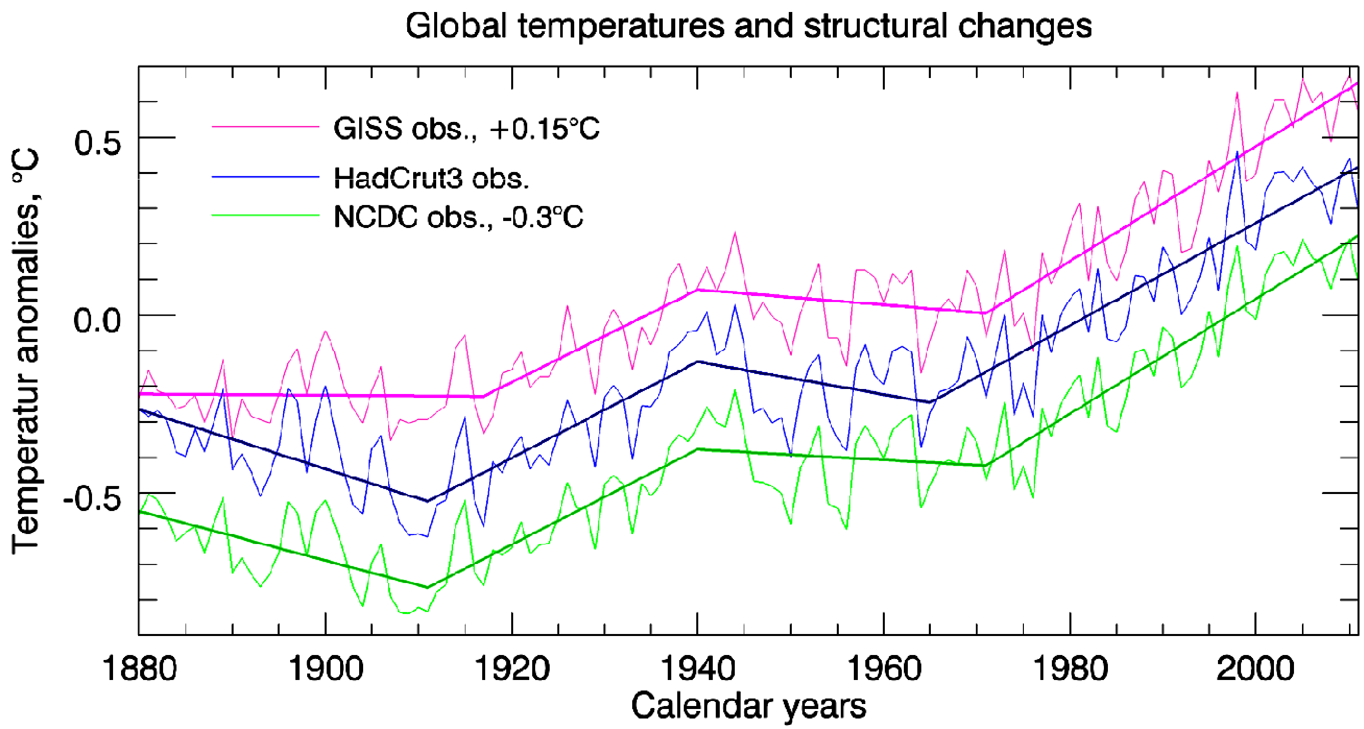
Break points: → minimal mean square deviation

Model: How many break points are observed?
→ Minimum of the LWZ criterion
(variant of the Bayes Schwarz
Information criterion, Liu et al. ,1997)

Structural change analysis

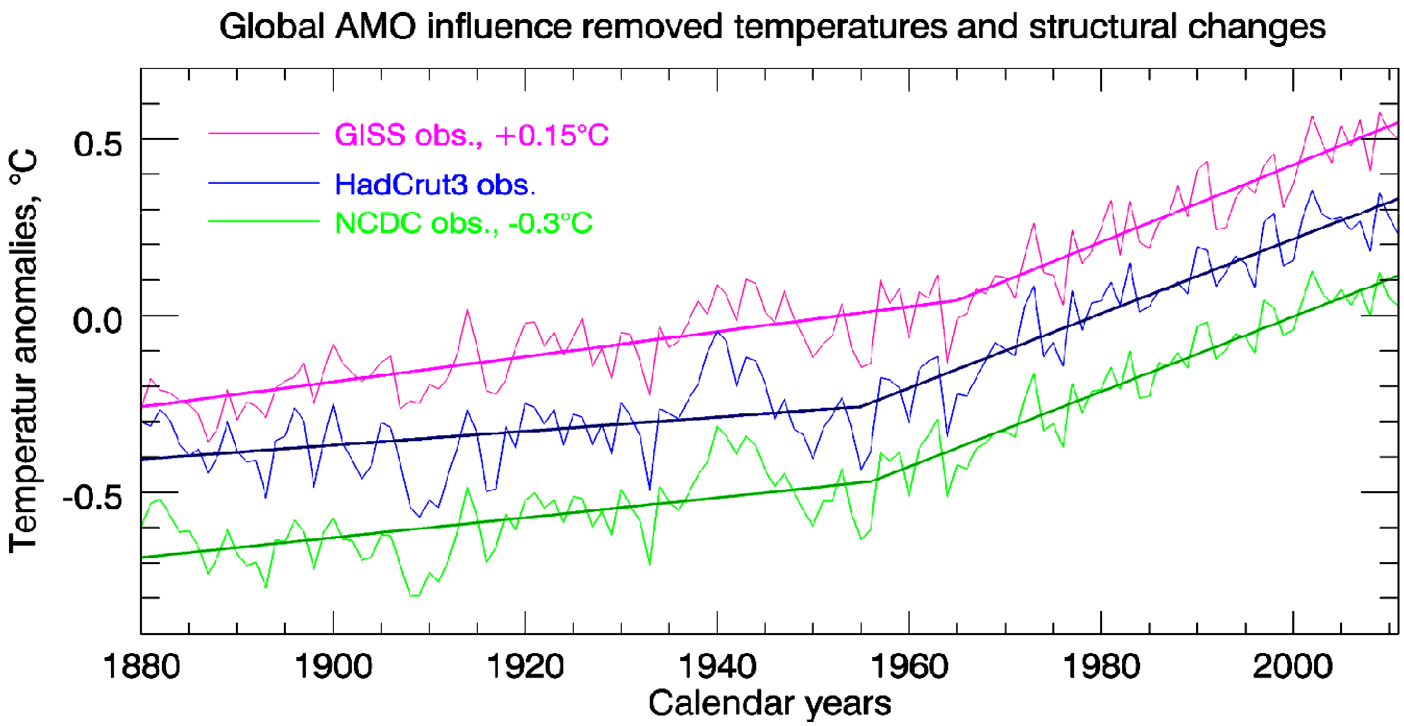
Structural changes in the global temperature series

Models with three break points were chosen as adequate

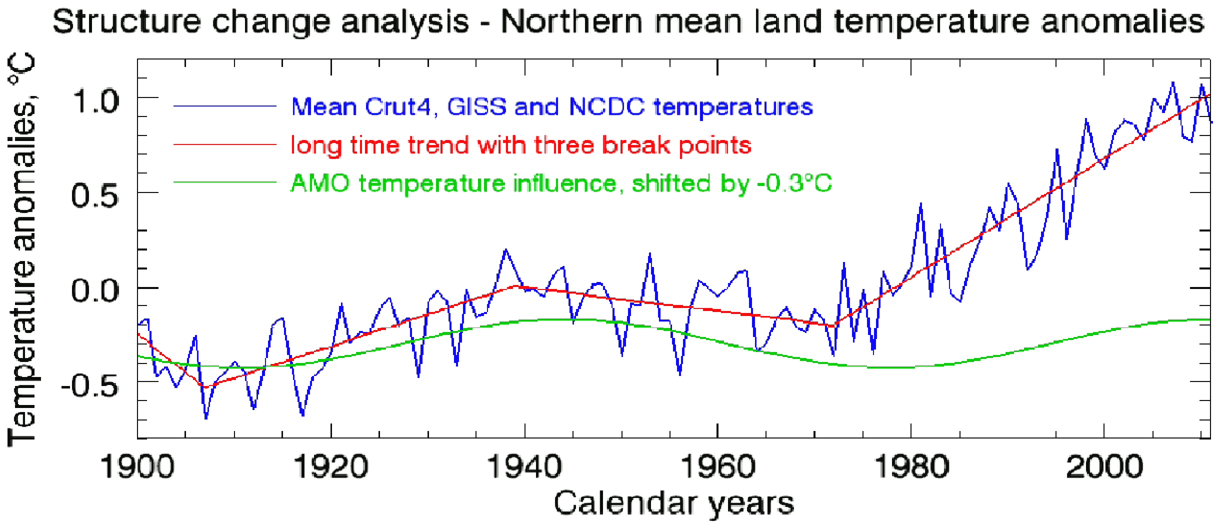


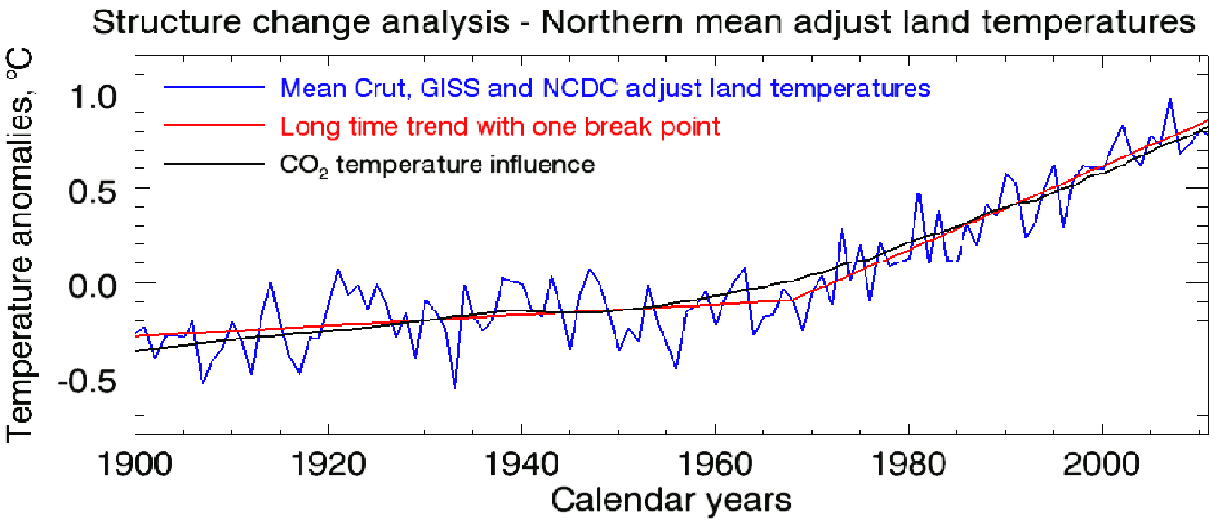
Structural change analysis

After removal of the AMO temperature influence the series show only one break point



Structural change analysis

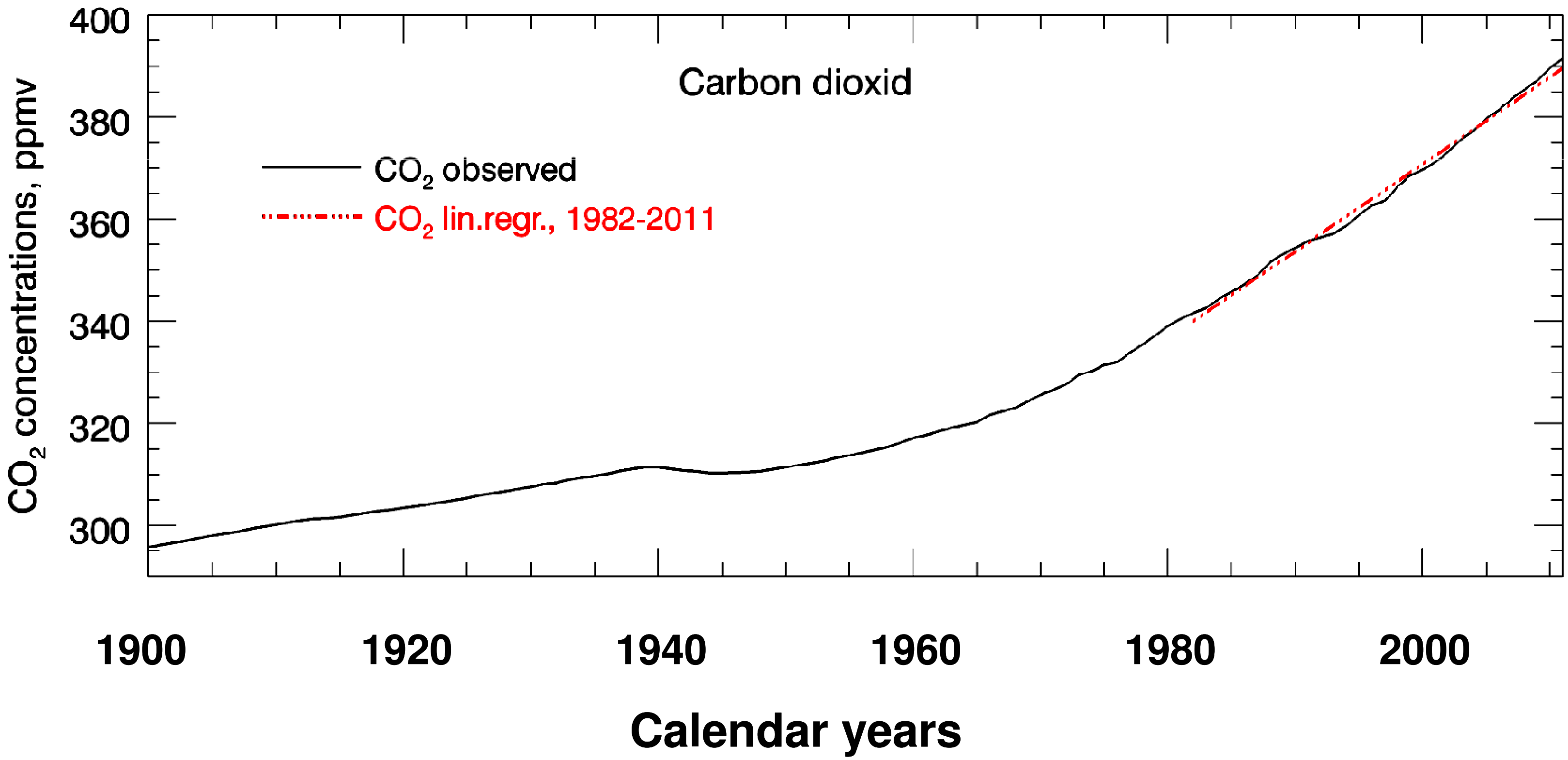




Temperature forecast

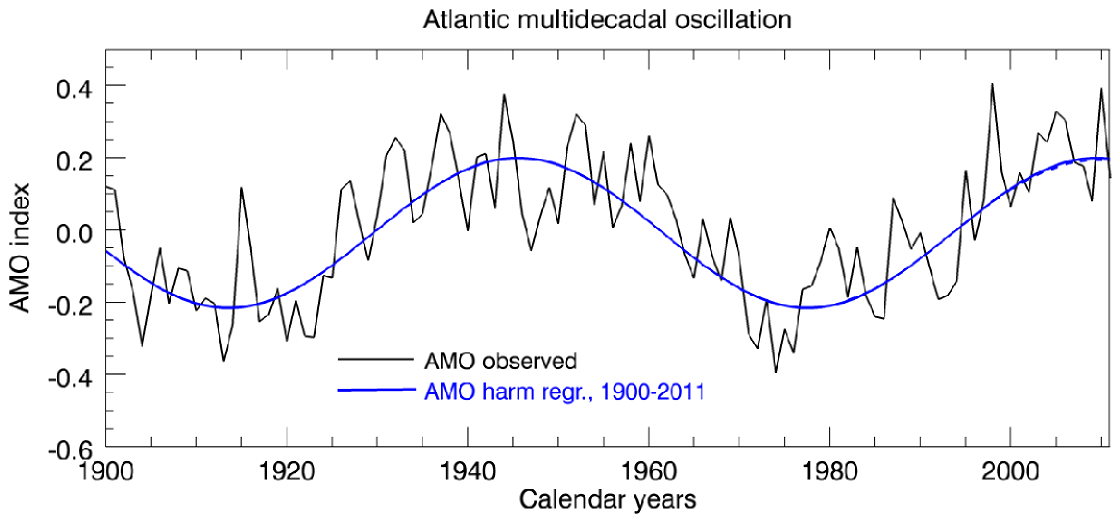
Long term changes are generated by CO_2 and AMO variations

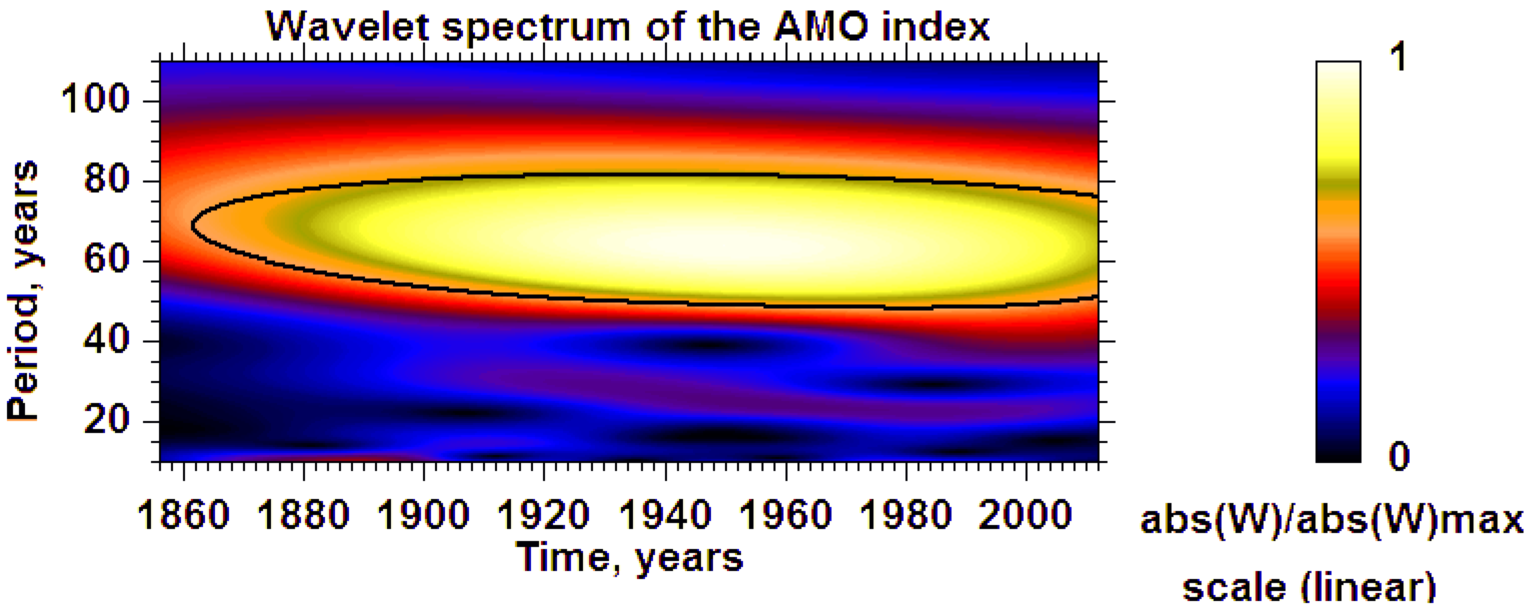
CO_2 evolution and extrapolation in the future



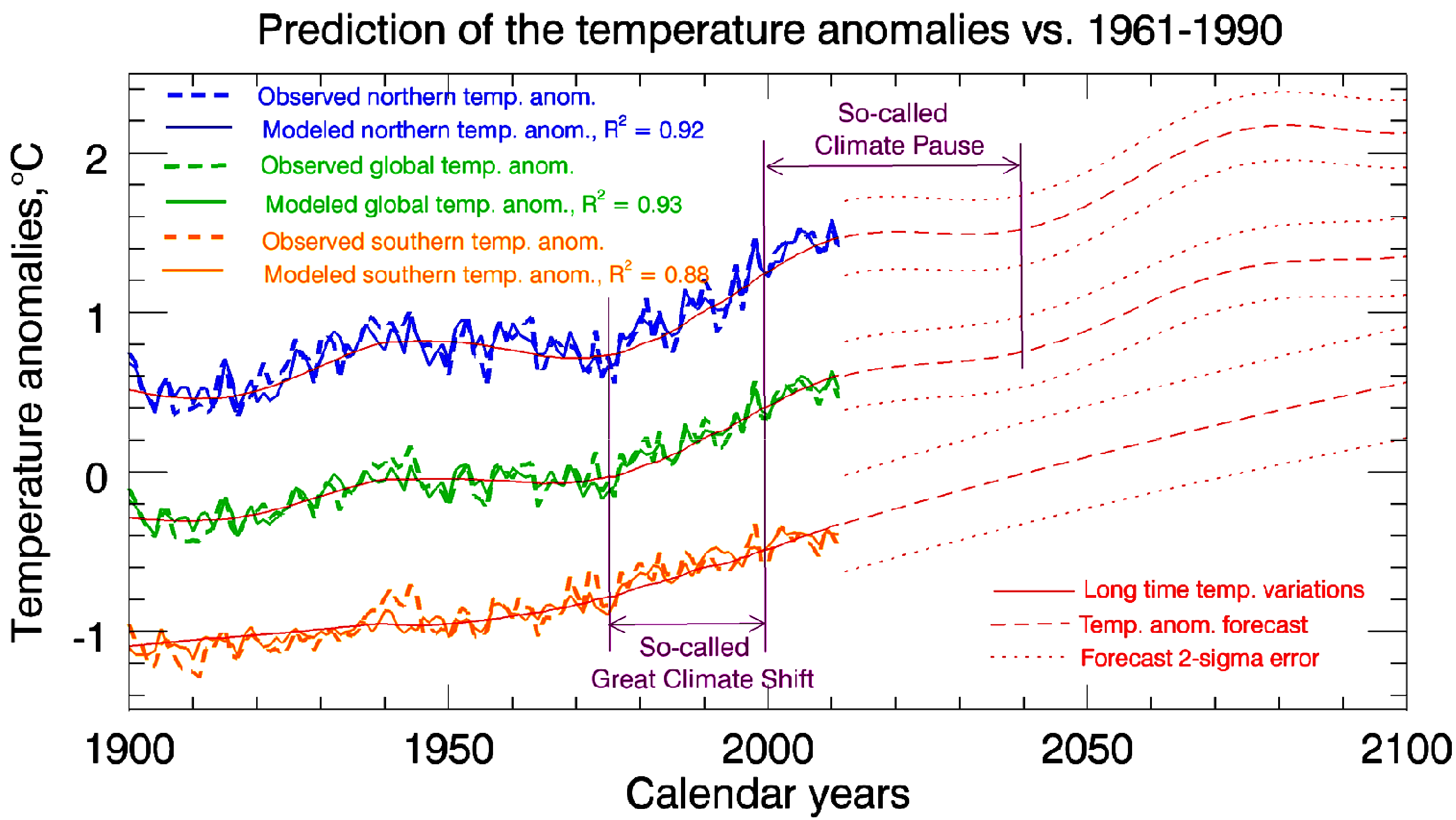
Temperature forecast

AMO index periodicity





Temperature forecast



Temperature trends

		Trends for 1979-2005 in deg./dec.		
		Obs. temp.		Adj. temp.
		cited in IPCC AR4	this paper	this paper
Land	Met Office	**0.328**±0.087	**0.356**±0.099	**0.240**±0.062
	NCDC	**0.344**±0.096	**0.350**±0.099	**0.241**±0.060
	GISS	**0.294**±0.074	**0.312**±0.086	**0.197**±0.044
Land/Ocean	Met Office	**0.234**±0.070	**0.258**±0.072	**0.153**±0.038
	NCDC	**0.245**±0.062	**0.246**±0.067	**0.148**±0.031
	GISS		**0.269**±0.074	**0.152**±0.042
Ocean	Met Office	**0.190**±0.134	**0.201**±0.062	**0.099**±0.032
	NCDC		**0.183**±0.050	**0.090**±0.023

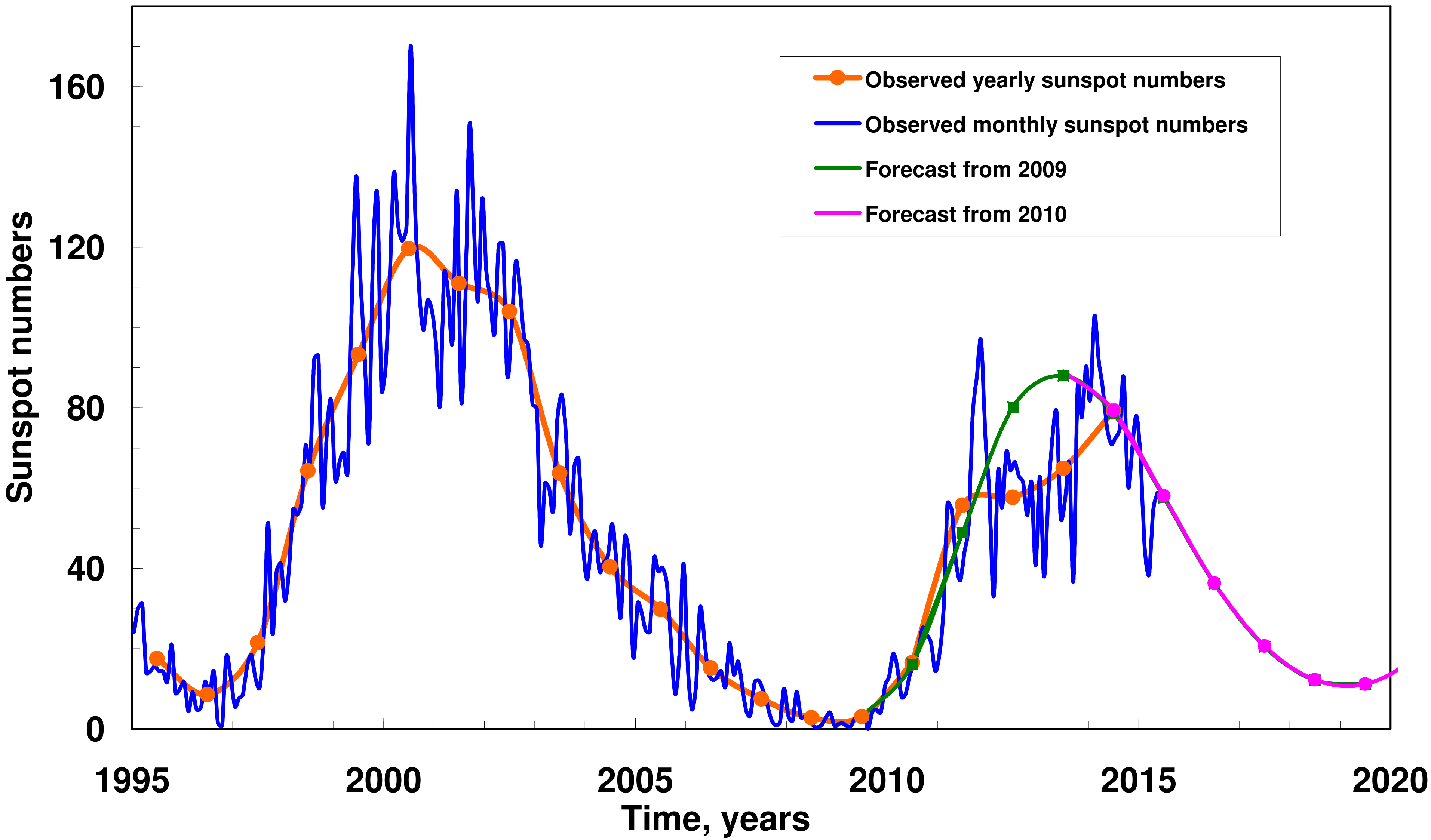
Long time trends (1901-2005) published in the IPCC AR4 Report (2007) are not significantly different from the obtained here ones based on observed and adjusted temperature data sets.

Conclusions

- ✓ AMO shows a strong quasi-period of 64 years during the time span from 1900 up to 2011.
- ✓ AMO has an important influence on the temperature evolution and on the structural changes.
- ✓ AMO has to be removed from temperature time series for the determination of temperature trends (warming rates).
- ✓ The global warming rate for the time period since 1980 was determined to 0.14±0.02°C/decade, 20 % lower than the reported in IPCC AR4, due to the AMO warming additional to this of CO_2.
- ✓ The great climate shift is caused mainly by the increasing part of the positive phase of AMO. The stronger temperature increase since about 1960 in the AMO removed series is related to the increase of CO_2.
- ✓ The climate pause since about 2000 is related to the AMO oscillation. Its duration is expected to be to about 2035/2040.

Werner et al., JASR, 55(12), 2961-2973, 2015

Sunspot number prediction from 2009/2010



Thank you very much for your attention