STRUCTURAL BREAKPOINTS IN GLOBAL AND HEMISPHERIC TEMPERATURE SERIES

R. Werner[1], D. Valev[1], D. Danov[2], V. Guineva[1]

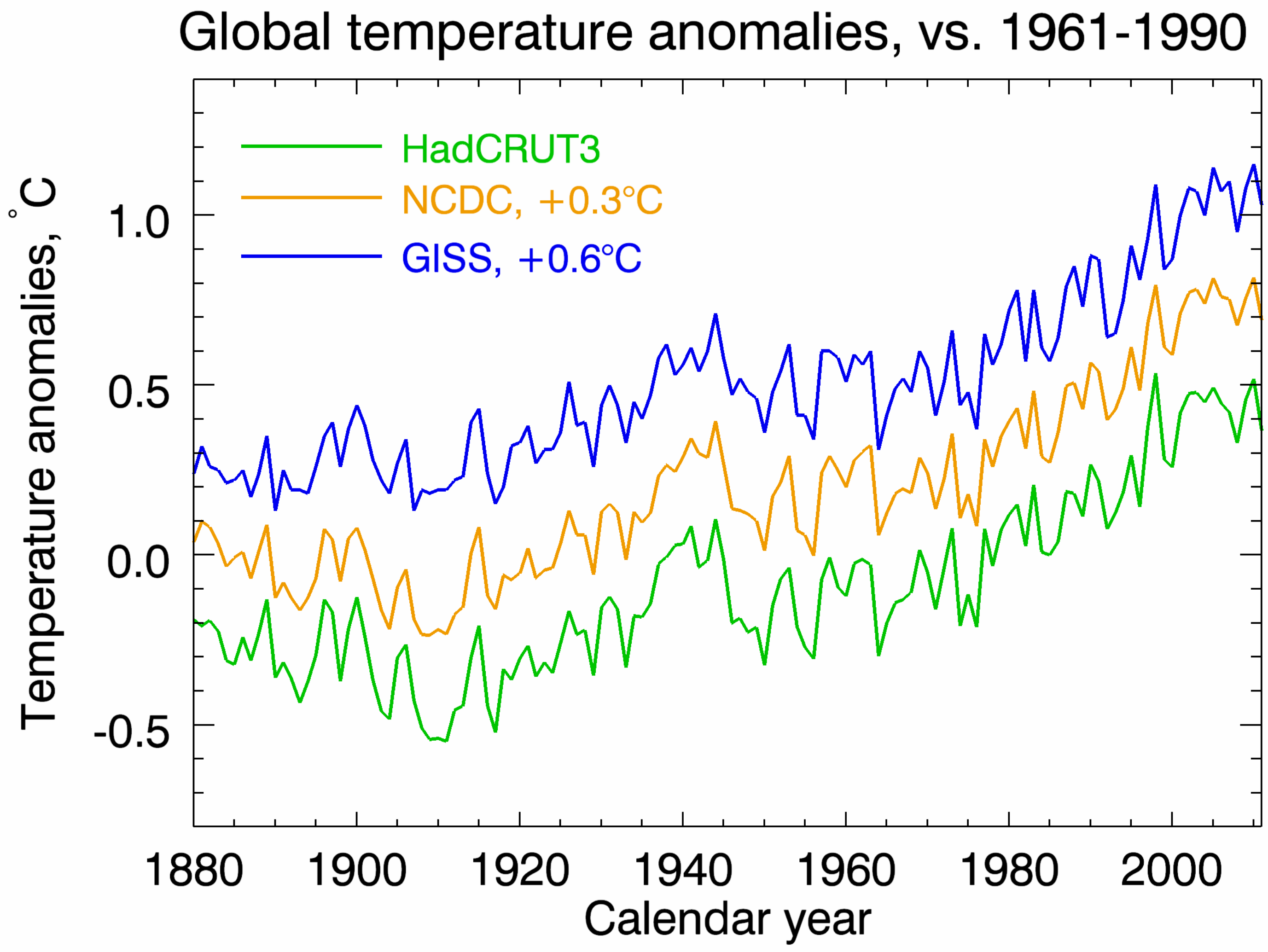
[1]Space Research and Technology Institute, Stara Zagora Department, BAS, Bulgaria
[2] Space Research and Technology Institute, Sofia, BAS, Bulgaria

Introduction

We have used the following global temperature time series:

- Met office Hadley Center and Climatic Research Unit (Hadcrut3) **http://www.metoffice.gov.uk/hadobs/hadcrut3/diagnostics/global/nh+sh/annual**
- National Climatic Data Centre (NCDC). **ftp://ftp.ncdc.noaa.gov/pub/data/anomalies/annual.land_ocean.90S.90N.df_1901-2000mean.dat**
- Goddard Institute of Space Studies (GISS) **http://data.giss.nasa.gov/gistemp/tabledata_v3/ZonAnn.Ts+dSST.txt**

Introduction

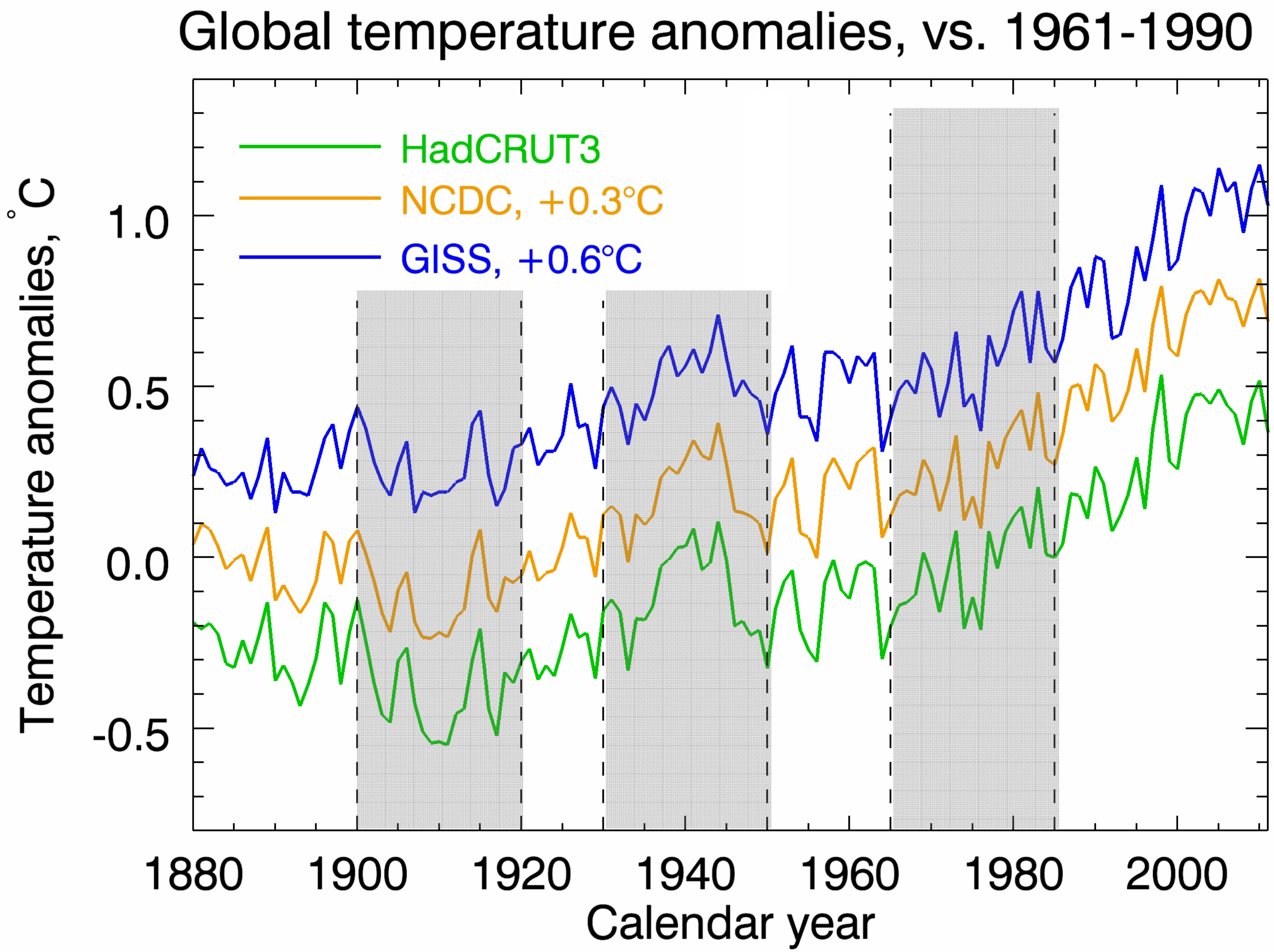


Introduction

Possible reasons of cooling and warming:

- Greenhouse gases (CO_2, N_2O, CH_4)
- Solar activity (open solar magnetic field)
- Volcanic aerosols (Atmospheric optical depth)
- Solar dimming, solar brightening (Aerosols)
- Cloudiness (low or high clouds)
- Cosmic rays
- Interaction between atmosphere and ocean (Pacific decadal oscillation index, El-Nino index, Atlantic oscillation index)

Introduction



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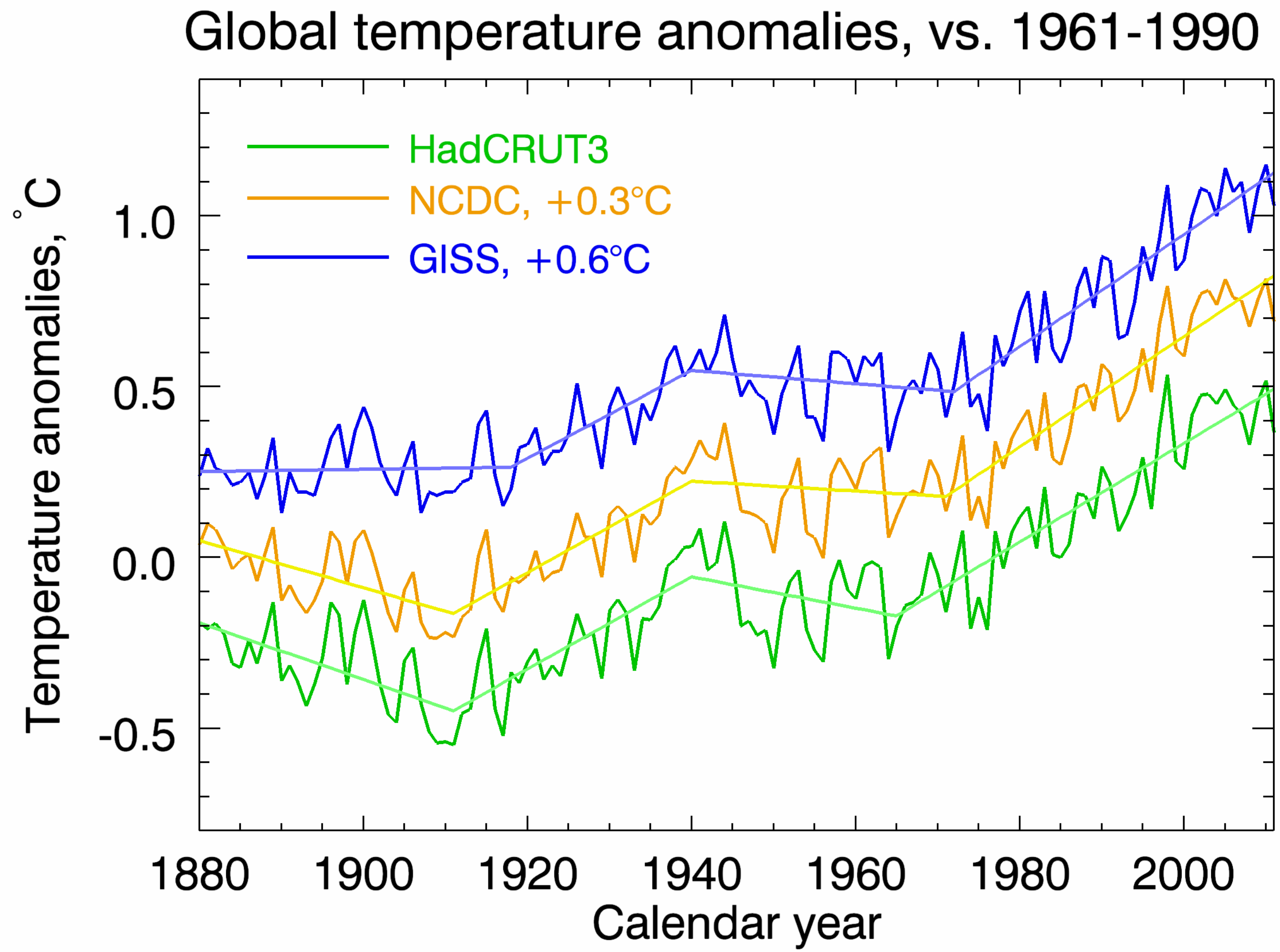

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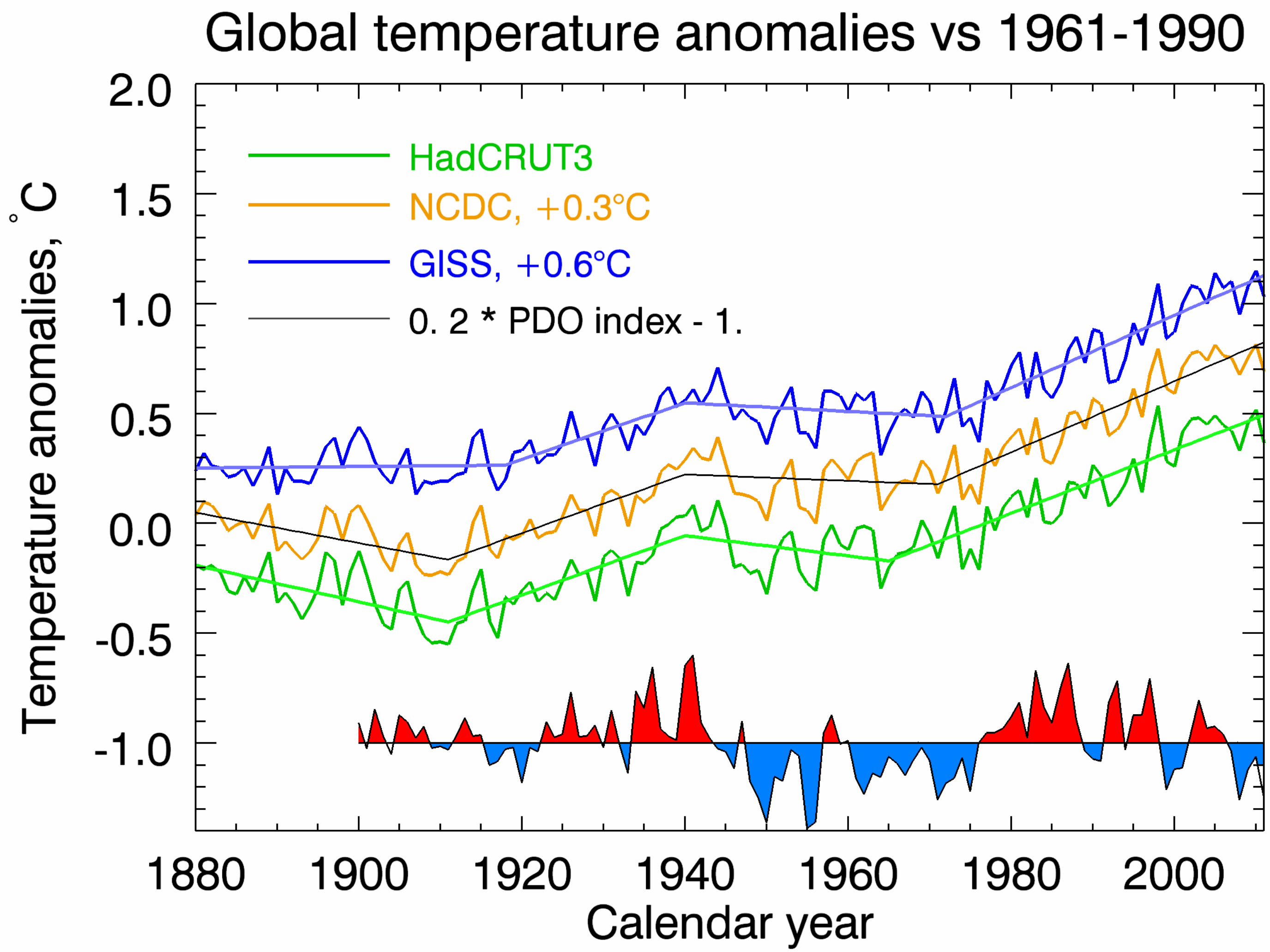


Main goals

- To found the structure changes at short times scales (abrupt changes) and at longer time scales (trends) without additional conditions
- To study the ocean influence on the temperature time series

Method

Piecewise regression model:

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

$$d_i = 1 \quad for \quad t \geq t_i^* \quad elsewhere \;\; 0$$

t_i^* are the *k* break points

ε is the noise, normally distributed

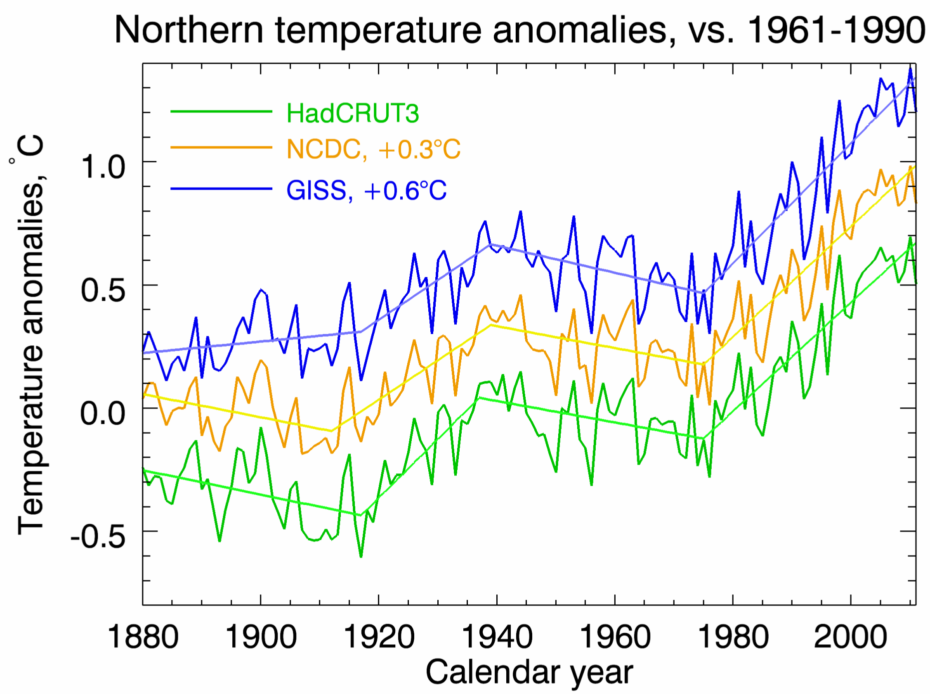
slope: $\beta_i = \beta_1 + \sum_{i=1}^{m-1} \delta_i$

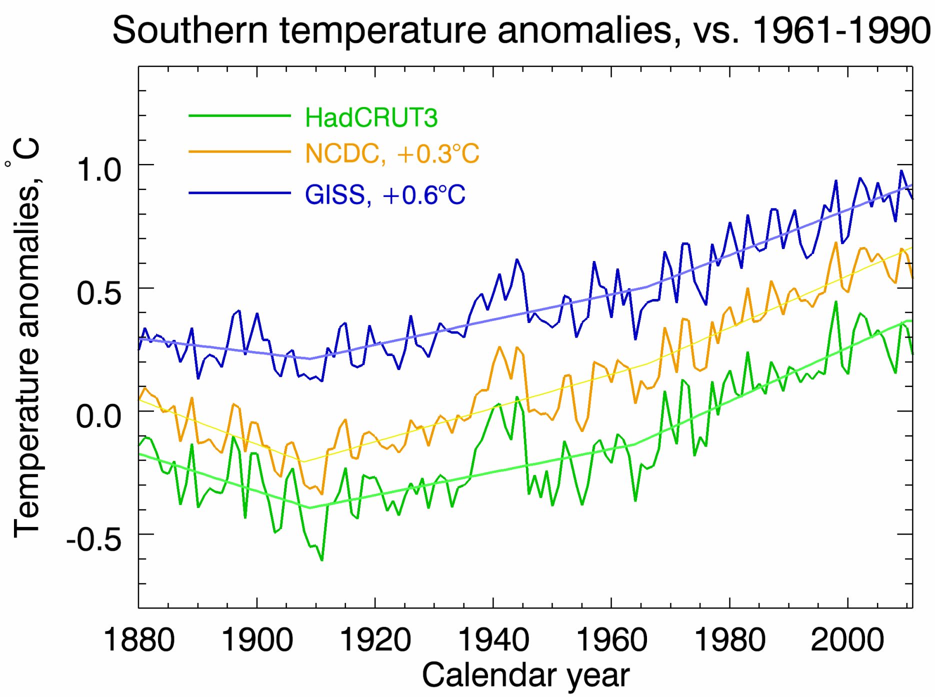
The location and the number of breakpoints are known in advance, however they are a priori unknown.

Seidel and Lazante 2004

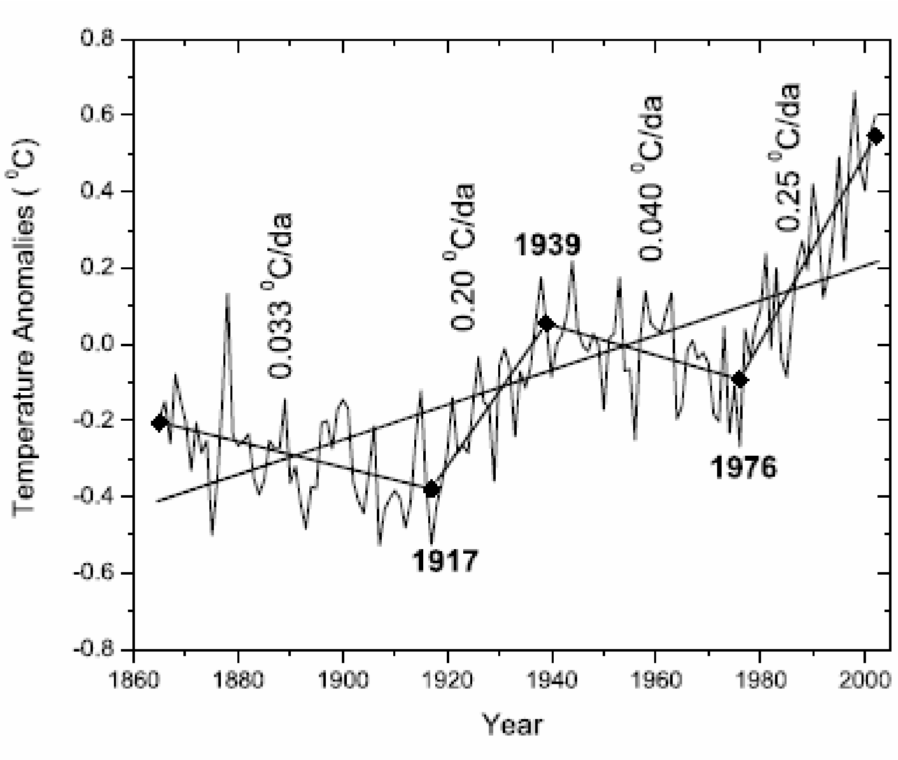
Results

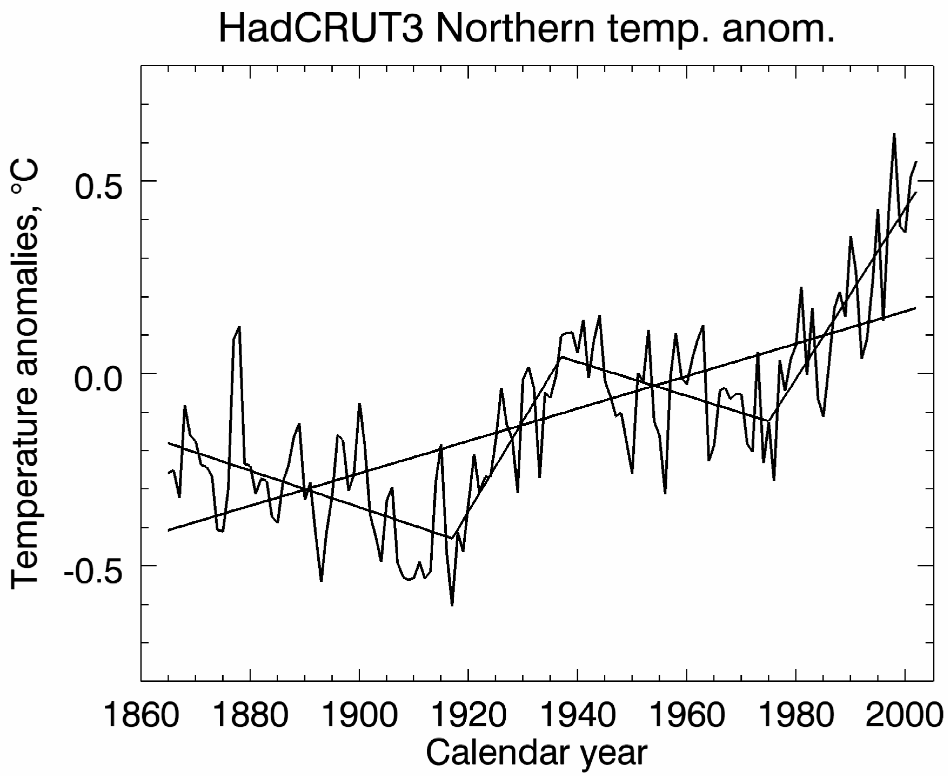
Structure changes at long time scales





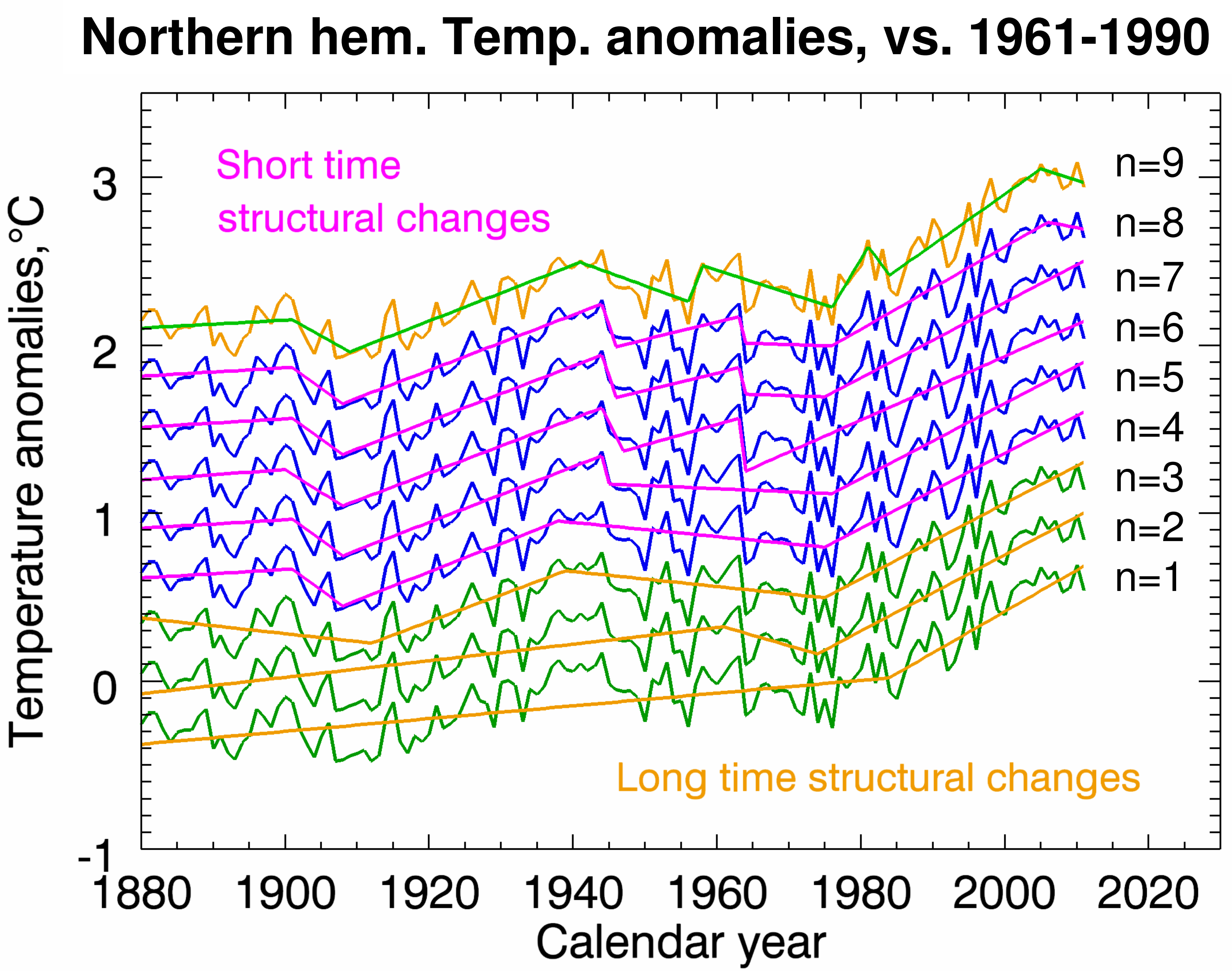
Results





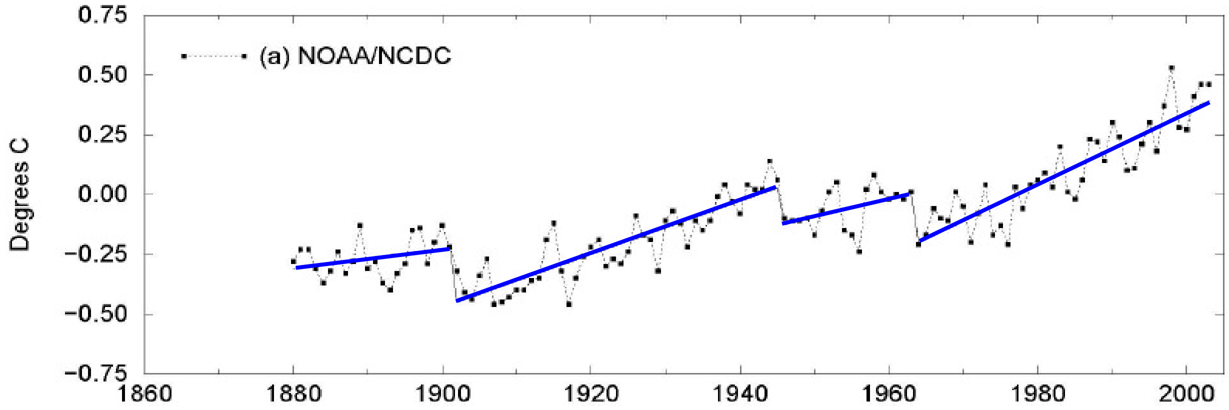
A.R.Tomé and P.M. Miranda,
Nonlin. Proc. in Geophysics,
12, 451–460, 2005

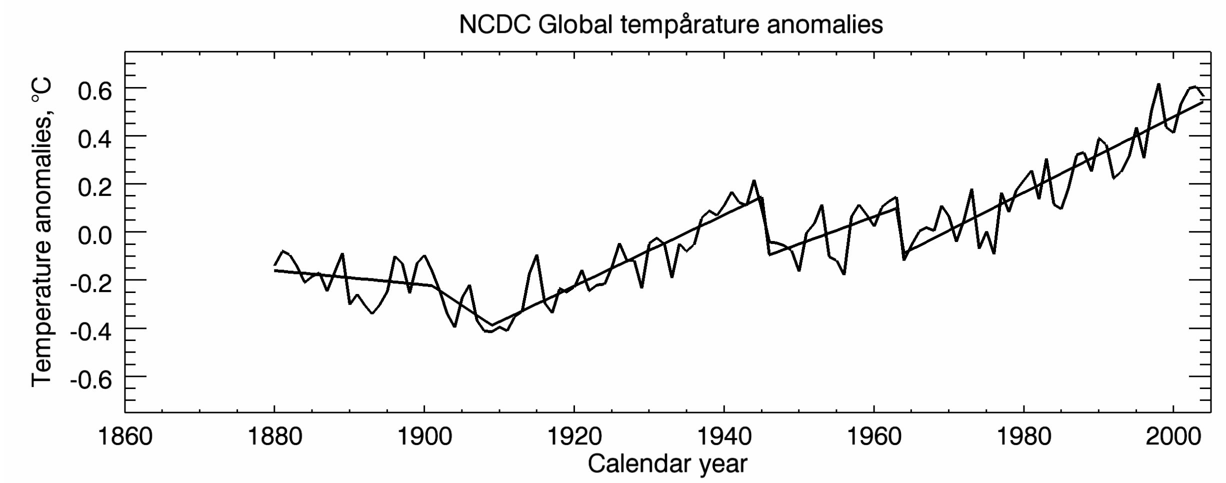
Results



Northern hem. Temp. anomalies, vs. 1961-1990
Short time
structural changes
n=9
n=8
n=7
n=6
n=5
n=4
n=3
n=2
n=1
Long time structural changes
3
2
1
0
-1
1880
1900
1920
1940
1960
1980
2000
2020
Calendar year
Temperature anomalies,°C

Results





M.J. Menne, Abrupt global temperature changes and the instrumental record, 2009.

Results

Simple linear regression model to estimate the AMO influence on the temperature anomalies:

$$\Delta T = \alpha + \beta_1 t + \beta_2 AMO + \varepsilon$$

t: time

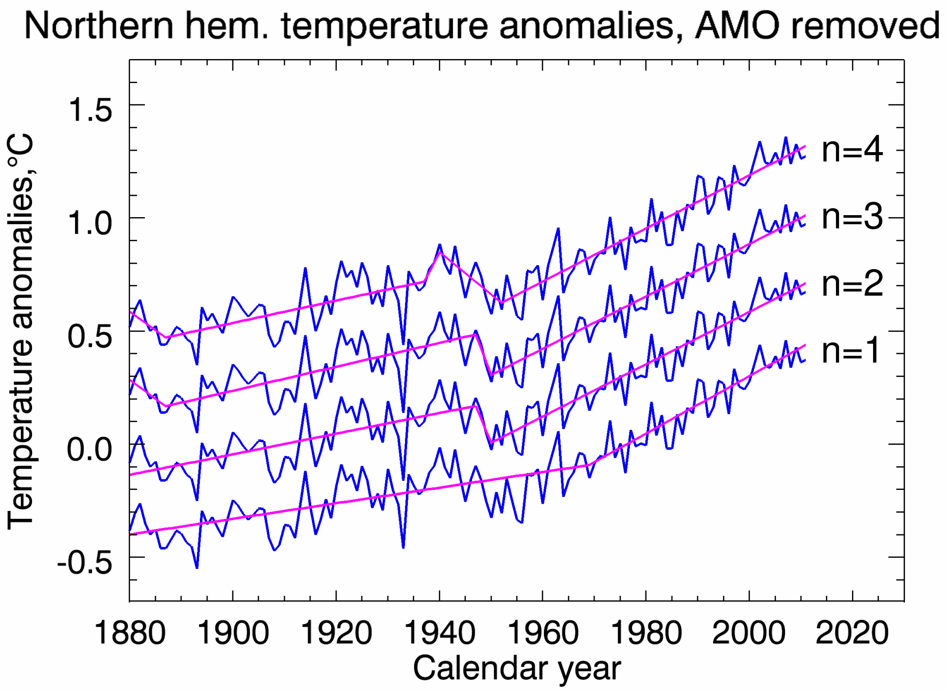
AMO: Atlantic multidecadal oscillations,
detrended SST of the North Atlantic 0º-70º N, 80ºW-0º
http://www.esrl.noaa.gov/psd/data/timeseries/AMO/

ε: residuals

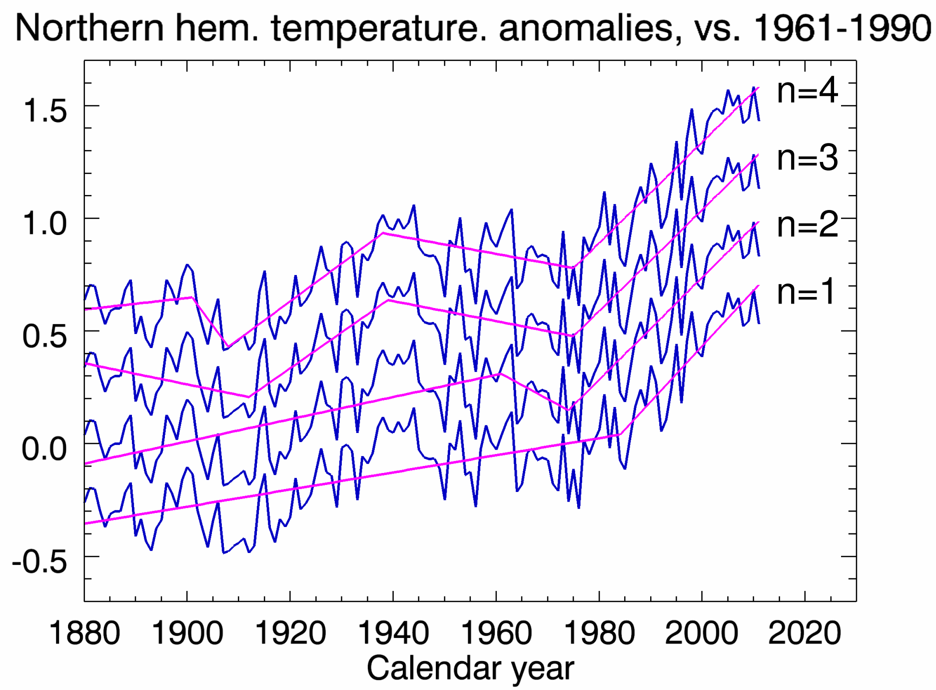
A more realistic model you can find at the poster:

Climate warming after the end of the twentieth century?

Results

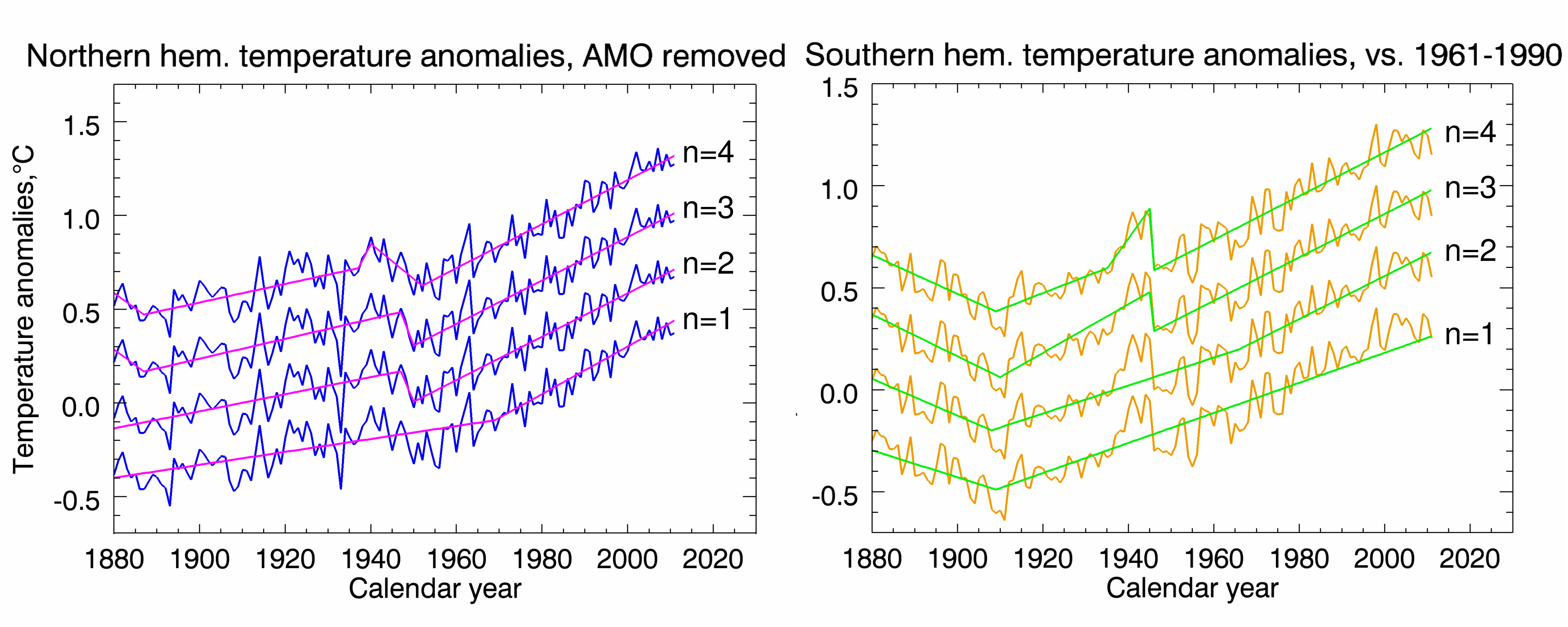


Northern hem. temperature anomalies, AMO removed
Temperature anomalies, °C
1.5
1.0
0.5
0.0
-0.5
n=4
n=3
n=2
n=1
1880
1900
1920
1940
1960
1980
2000
2020
Calendar year



Northern hem. temperature. anomalies, vs. 1961-1990
1.5
1.0
0.5
0.0
-0.5
n=4
n=3
n=2
n=1
1880
1900
1920
1940
1960
1980
2000
2020
Calendar year

Results


Northern hem. temperature anomalies, AMO removed
Temperature anomalies, °C
1.5
1.0
0.5
0.0
-0.5
n=4
n=3
n=2
n=1
1880 1900 1920 1940 1960 1980 2000 2020
Calendar year
Southern hem. temperature anomalies, vs. 1961-1990
1.5
1.0
0.5
0.0
-0.5
n=4
n=3
n=2
n=1
1880 1900 1920 1940 1960 1980 2000 2020
Calendar year

Conclusions

- Piecewise linear regression models allow to describe long time changes and also changes generated by fast fluctuations.
- Structural break points are obtained near 1910, 1940 and 1970 for structural changes at long time scales for the Global and Northern hemisperic temperature anomalies. For the Southern anomalies breakpoints are found approximately at 1910 and 1970
- The locations of structural breaks are close to the ones known from science publications, based on methods similar to the methods used here, but without additional conditions (Karl et al., 2000) or by other structure models (Tome and Miranda, 2004 and 2005, Seidel and Lazante, 2004, Menne et al., 2009, Stockwell 2009).

Conclusions

- By removing the AMO influence on the temperature anomalies at the Northern hemispere it was shown, that some of the long and short time variations are generated by the warming or cooling of the Atlantic.

- The time structure of the Northern hemispheric temperature anomalies after removing the AMO is similar to the Southern hemispheric temperature anomalies.

Thank you very much for your attention