

# **Long-term solar and geomagnetic activity. Consequences on terrestrial climate at regional scale**

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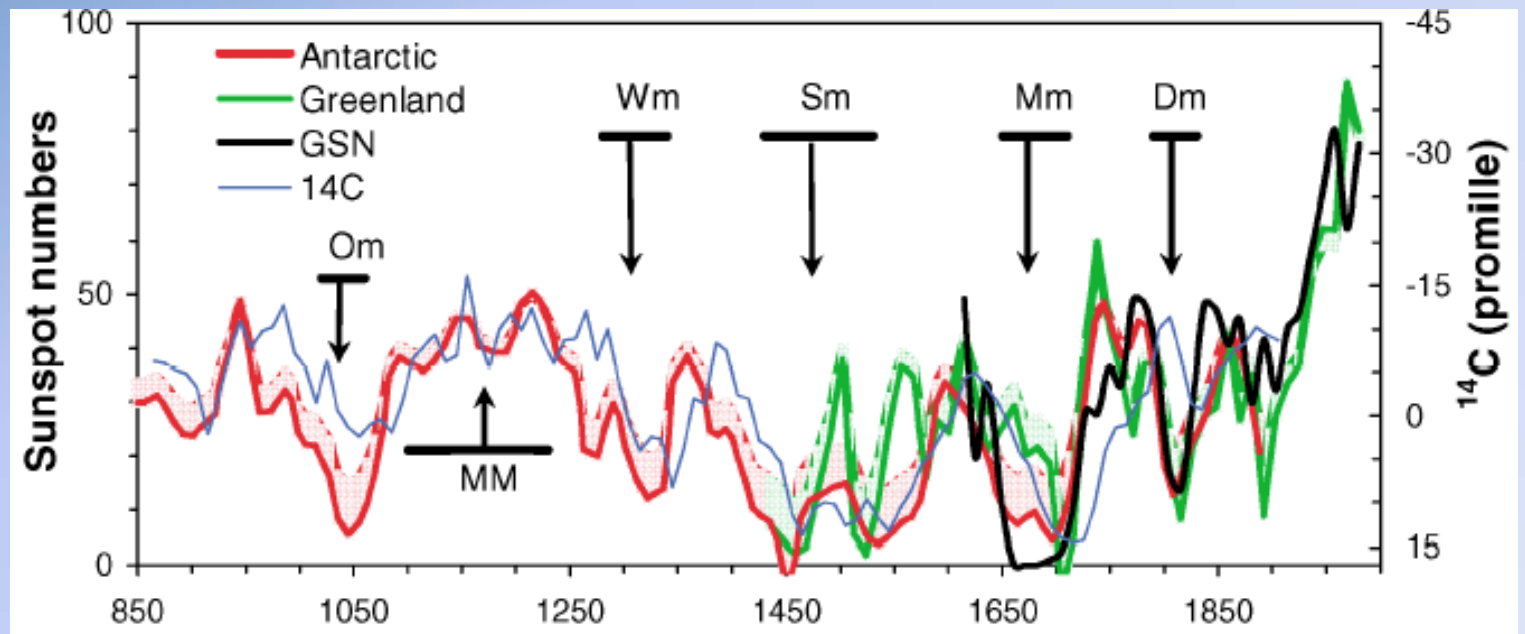
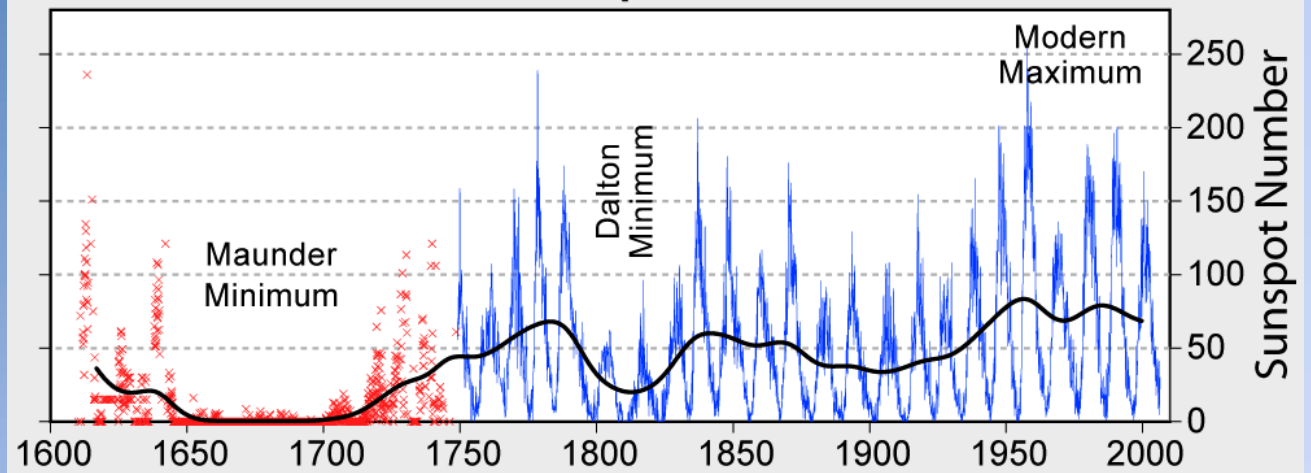
## Outline

- long-term evolution of solar/geomagnetic activities
- climate background
  - mean and variability
  - long-term variations of climatic parameters at local and continental scales
- intercomparison of solar/geomagnetic activity and climatic parameters
- conclusions

# Solar variability

- phenomena that take place on the surface of the Sun and in its atmosphere
- indices of solar activity

## 400 Years of Sunspot Observations

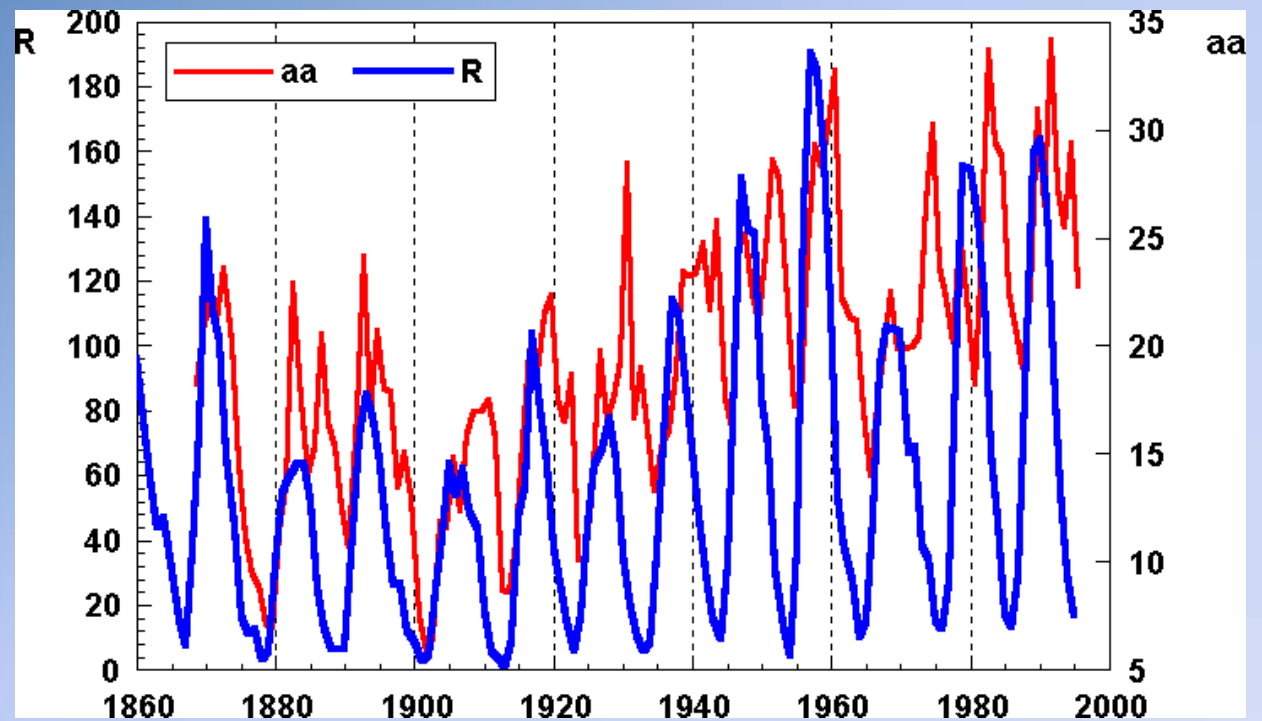


Usoskin et al., 2003

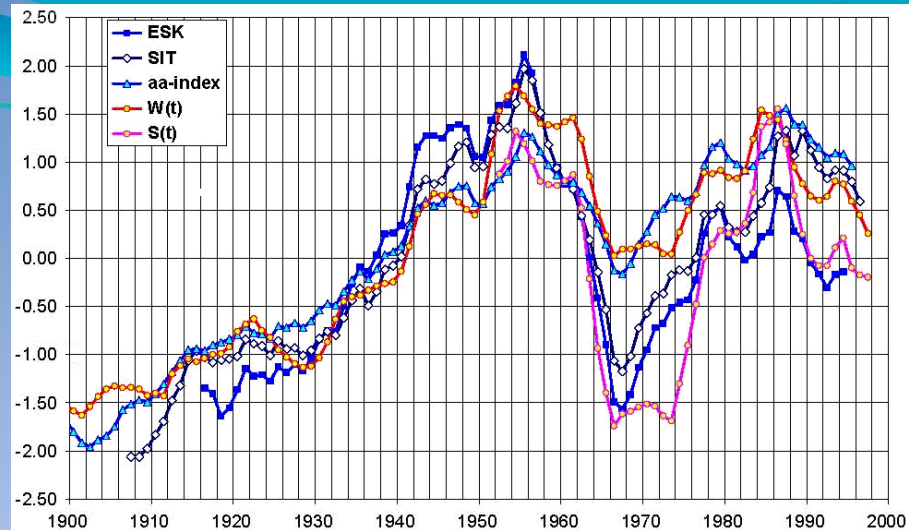
# Geomagnetic activity

- controlled by the Sun, via solar wind and heliospheric magnetic field. Its intensity depends on the phase of the solar cycle and is described by geomagnetic indices

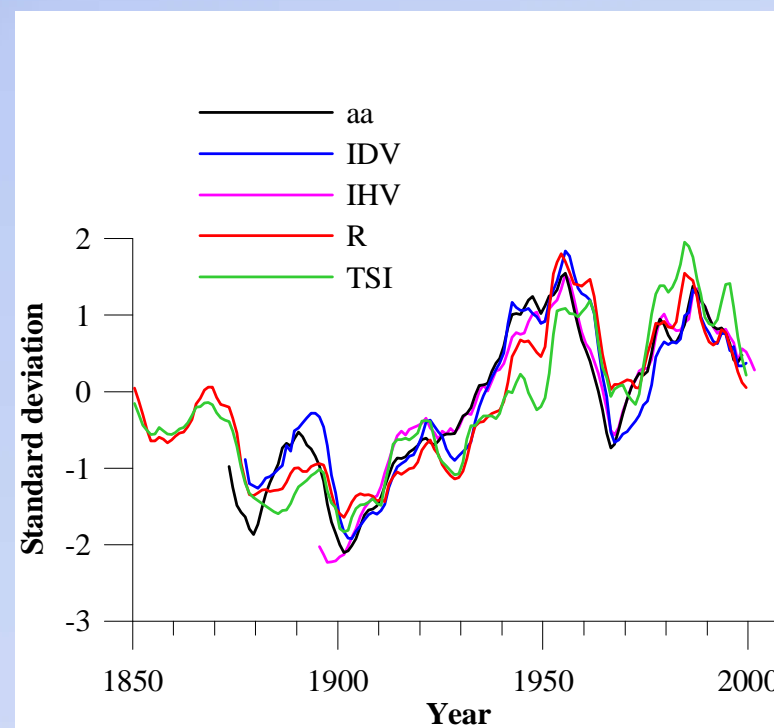
- good correlation with the solar activity (R) in terms of 11-year averages, but differences in each solar cycle



- in terms of 11-year running averages there is a long term similarity between aa, R, the solar irradiance and the geomagnetic indices designed to characterize the solar quiet daily variation.

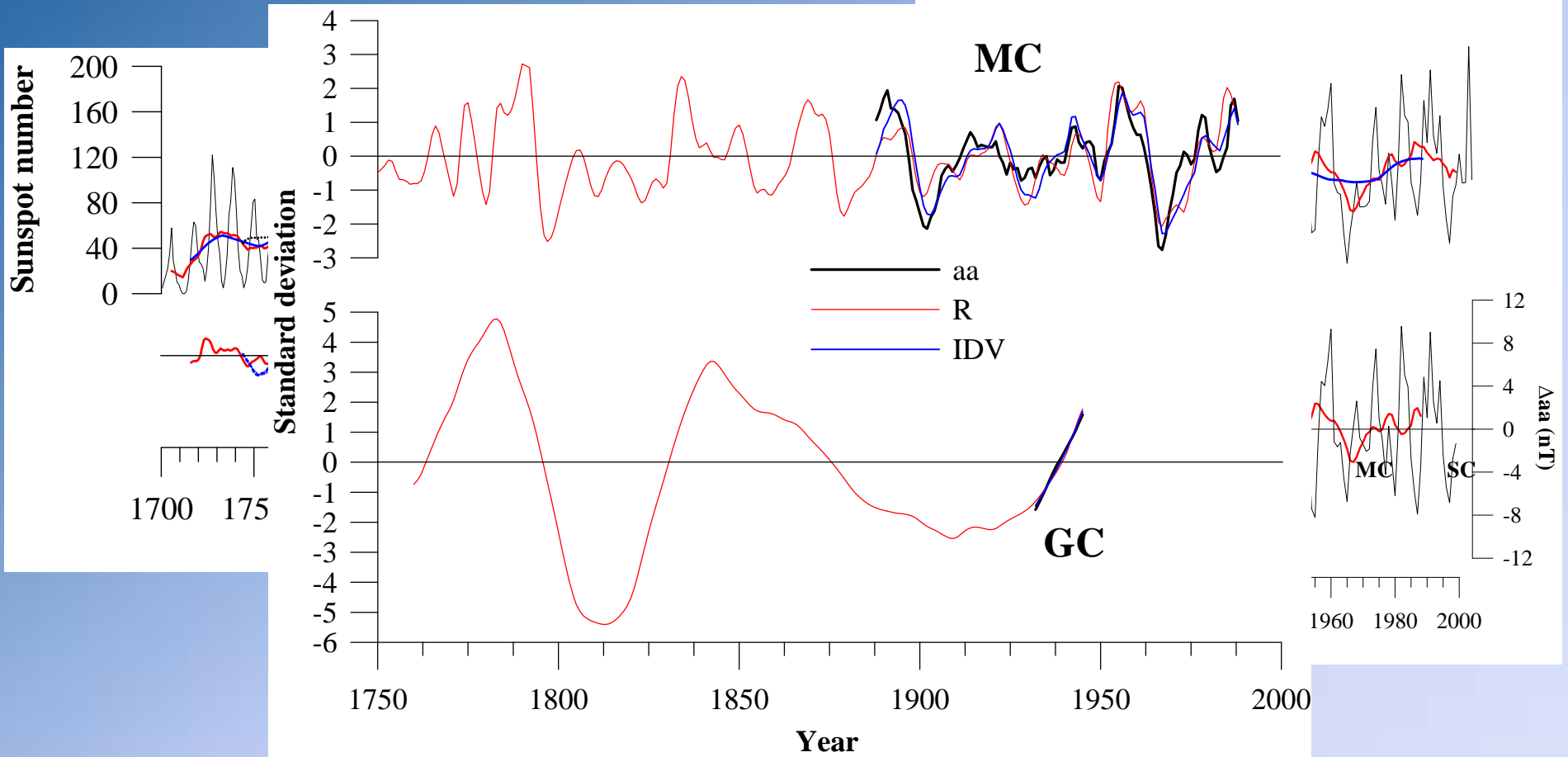


LeMouél et al., EPSL 2005

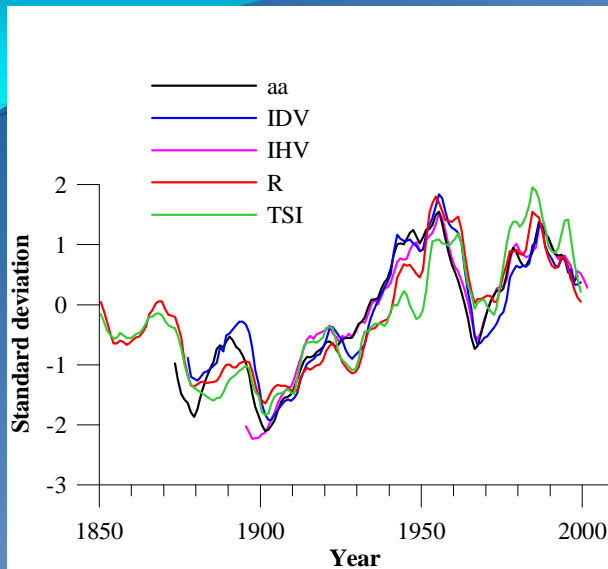


Demetrescu & Dobrica, JGR 2008

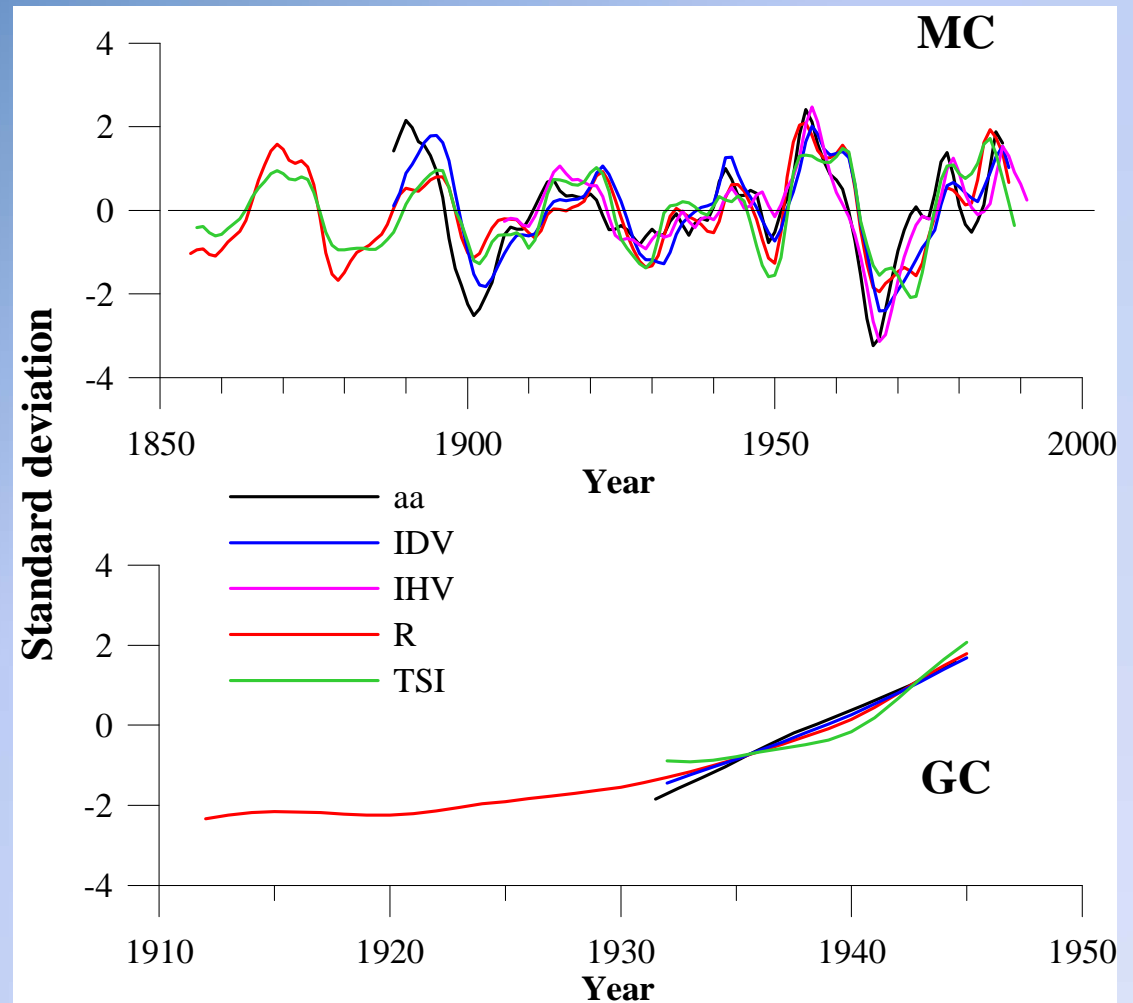
# Hale (MC) and Gleissberg (GC) cycles – successive 11-, 22-, and 78-year running averages and differences between them



## Hale (MC) and Gleissberg (GC) cycles



- the MC and GC signals are quite similar in R, aa, IHV, IDV, and TSI.
- the variation depicted by 11-year running averages of aa and R (and by consequence also of the other parameters mentioned) results from the superposition of Hale and Gleissberg cycles signatures in the corresponding time series.

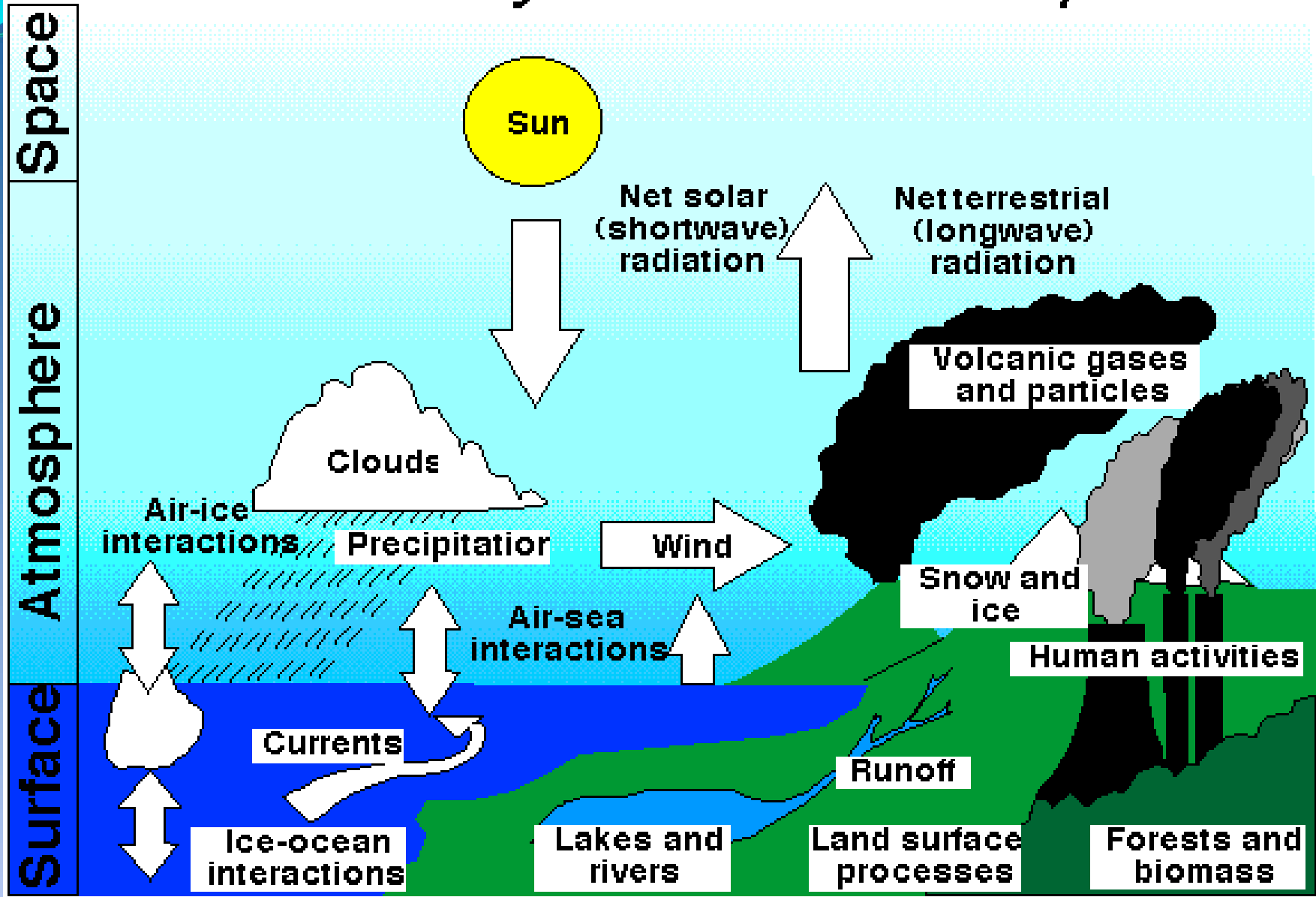


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# Earth's Climate System - Climate Components



## Climate, climate variability and climate change

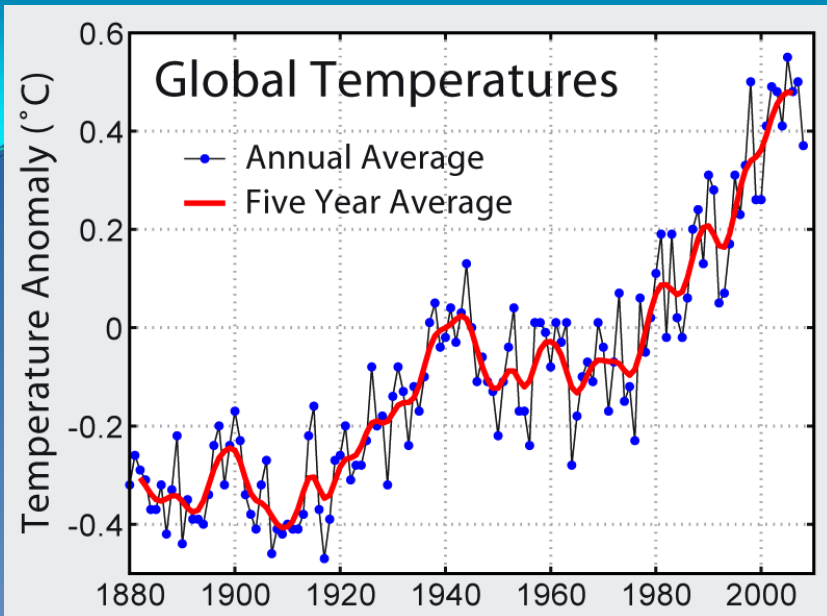
- climate variability: year-to-year differences in certain climatic variables within an averaging period; climate change: longer-term changes between averaging periods

- the observed changes in global climate are likely to be due to a combination of both natural and human causes (or forcings);

**Assesment of climate variability and climate change depends on the existence and accuracy of records of meteorological parameters**

- **Natural causes:** The Earth's climate varies naturally due to interactions between the ocean and the atmosphere, changes in the Earth's orbit, fluctuations in energy received from the sun and volcanic eruptions which affect the amount of energy reaching the Earth's surface.

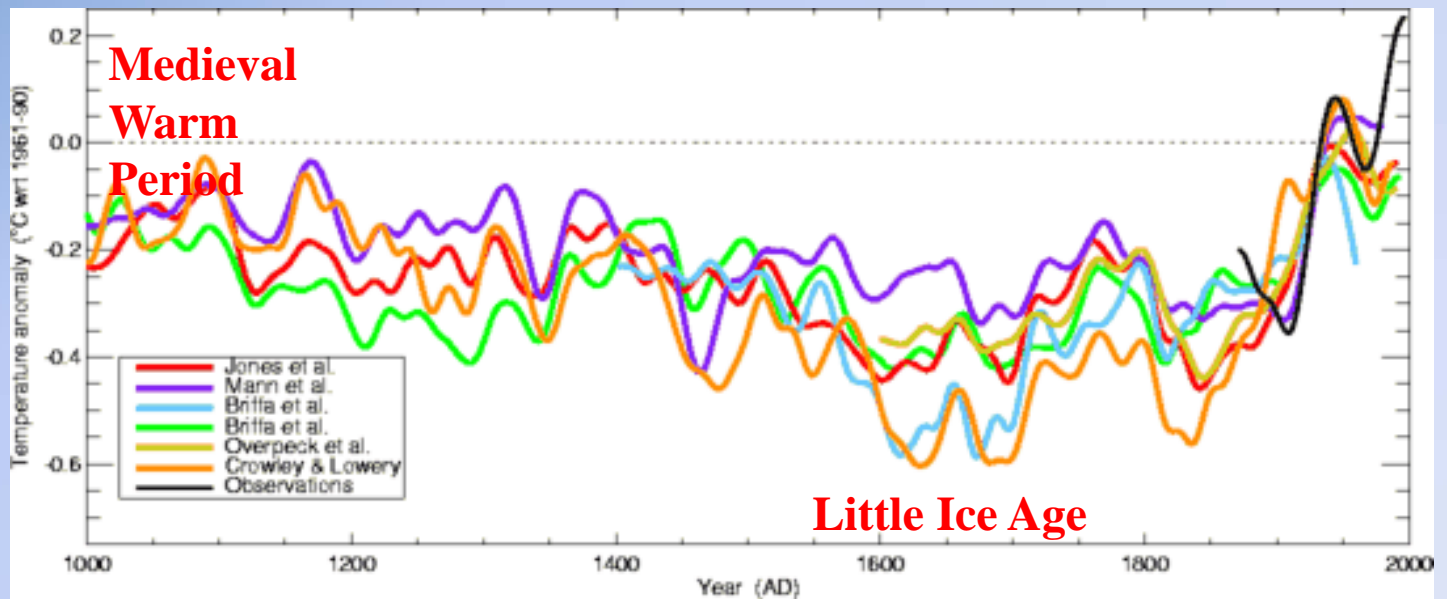
- **Human causes:** The main human influence on global climate is likely to be emissions of greenhouse gases, changes in land use.



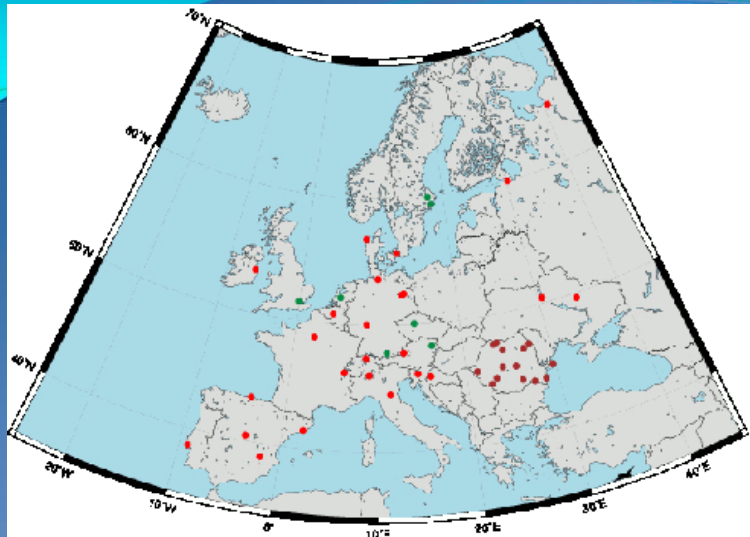
- Inter-annual timescales
- Decadal timescales
- Centennial timescales

## Paleoclimate

- reconstructions based on proxy data: tree-rings, ice cores, corals



# Long-term variations of climatic parameters

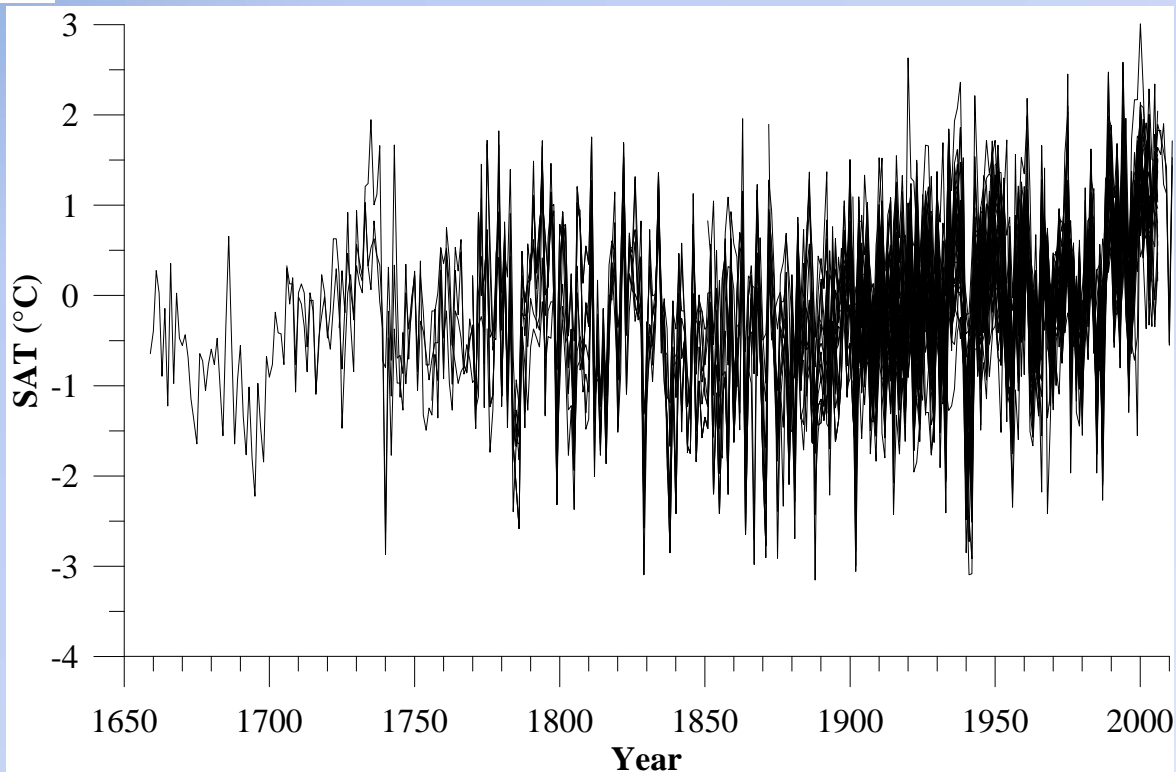


- daily means of surface air temperature from 24 European stations (red dots) during the period 1901-2006 ([www.eca.knmi.nl/dailydata/](http://www.eca.knmi.nl/dailydata/));
- yearly means from 14 Romanian stations during the period 1850 - 2004 (brown dots);
- yearly means from Central England (1659-1999), De Bilt (1706-2011), Uppsala (1723-2011), Stockholm (1756-2011), Prague (1770-2002), Vienna (1775-2002) and Hohenpeissenberg (1781-2002) (green dots).

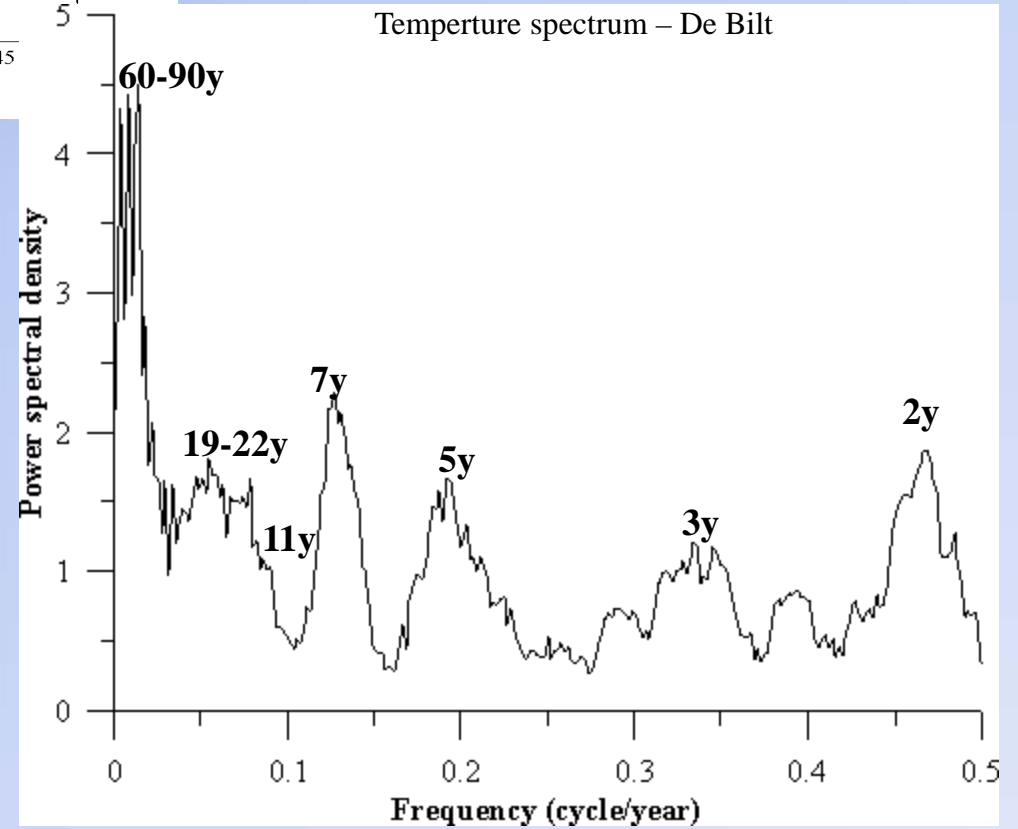
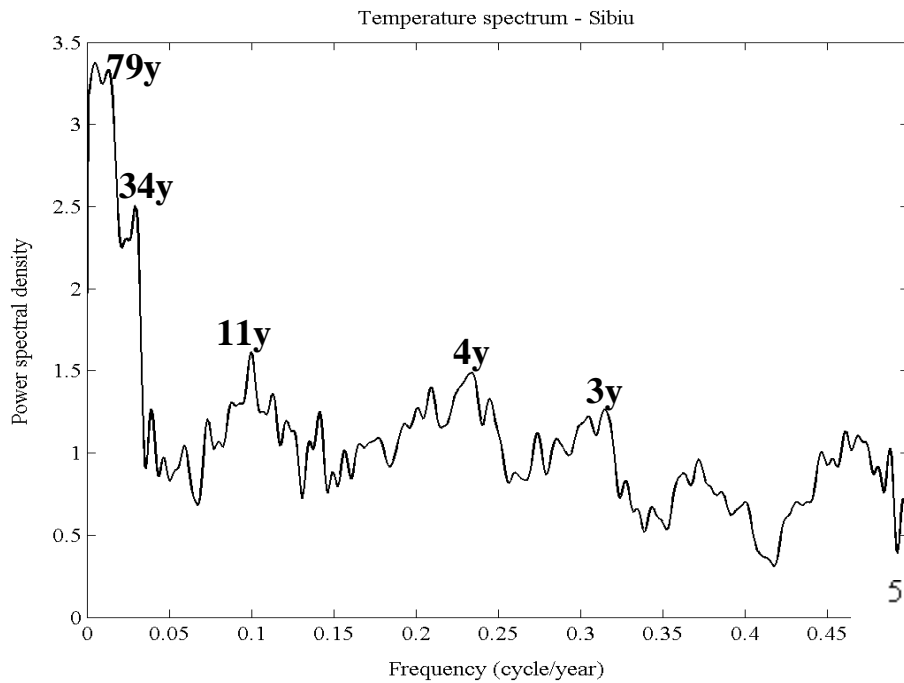
- coherence of the variation at all stations
- existence of interdecadal and longer variations

1650 1700 1750 1800 1850 1900 1950 2000  
Year

Anomaly relative to the mean  
over the time interval 1961-1990

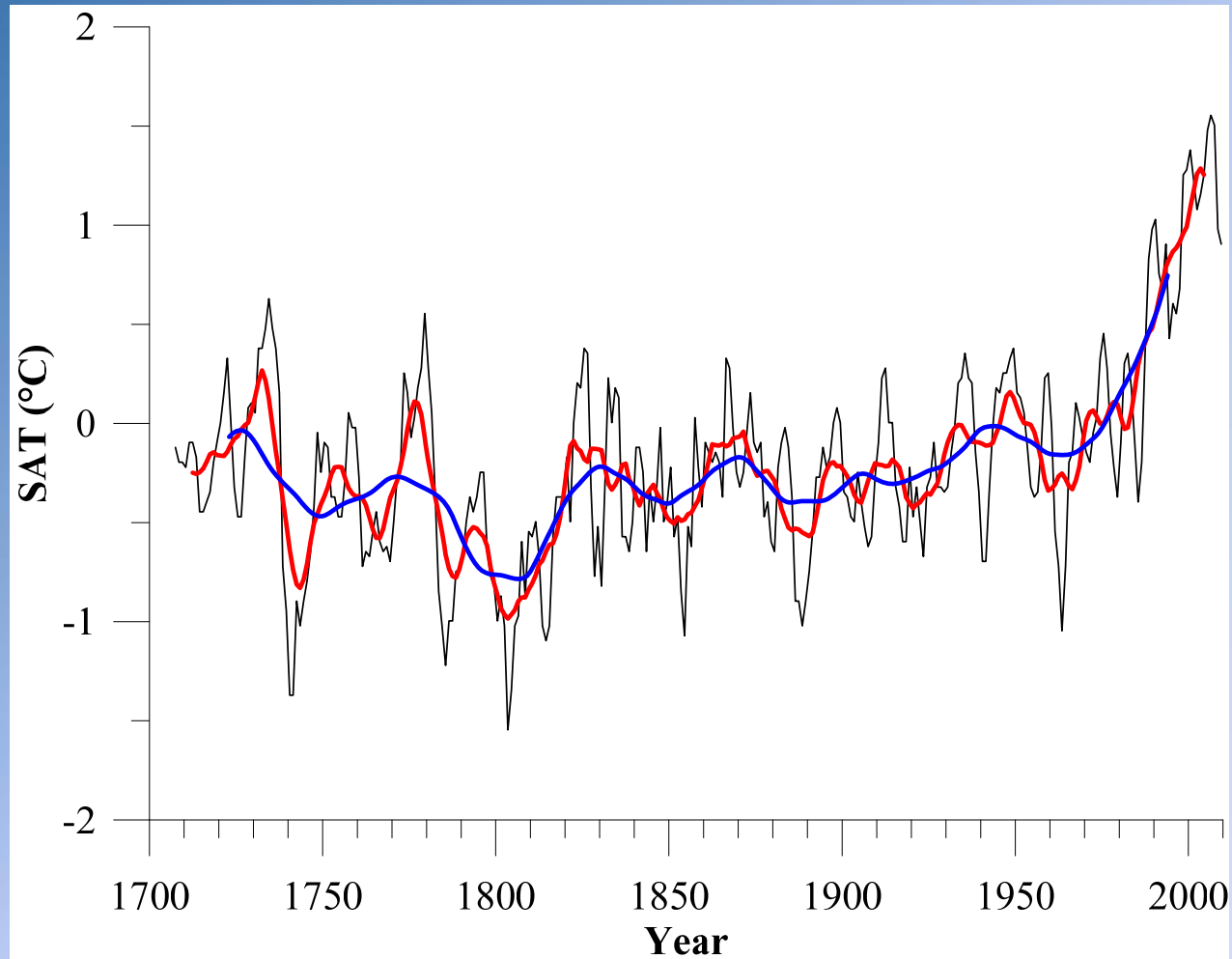


## Periodicities in climatic parameters – multi-taper method (MTM)



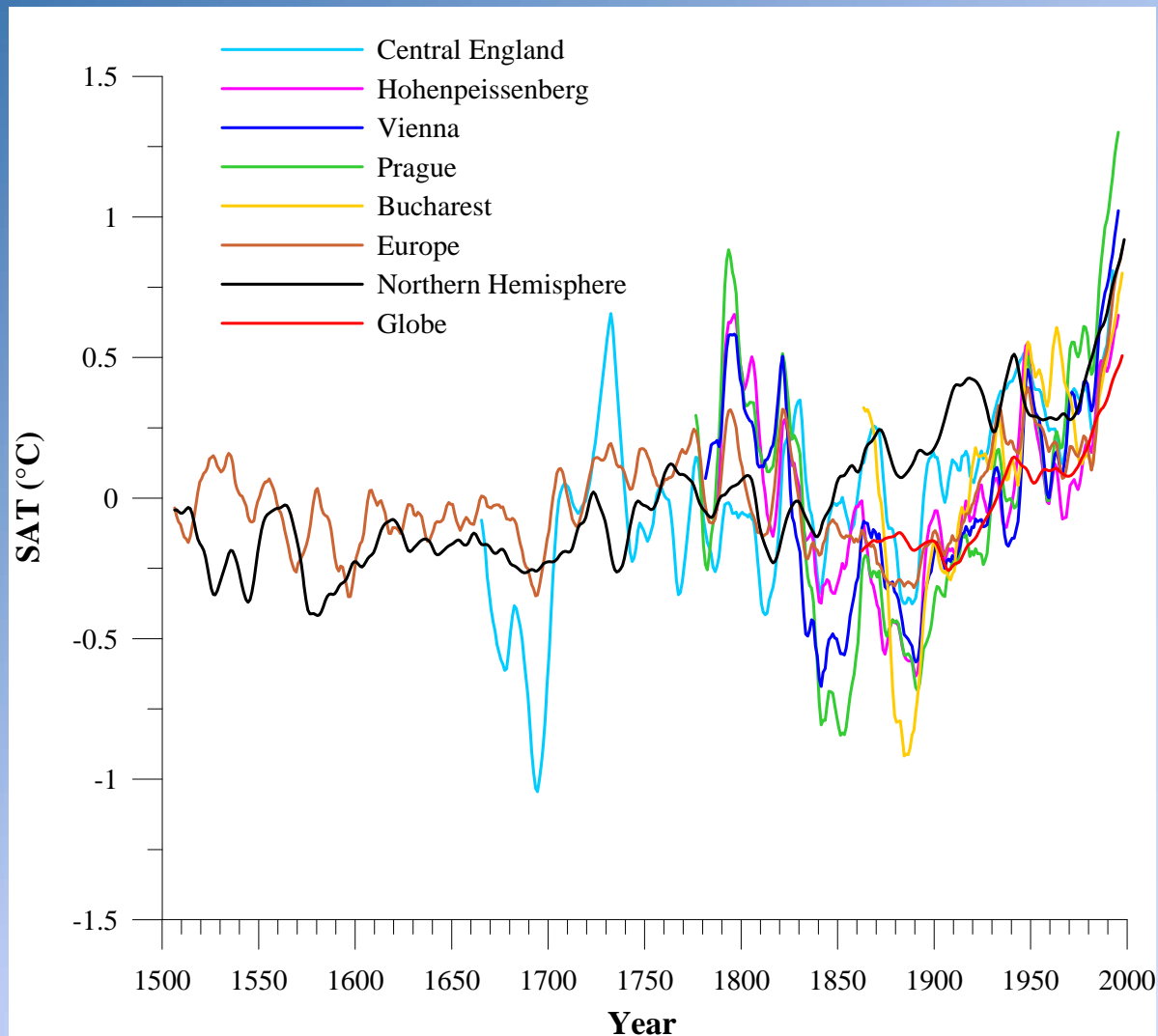
# Interdecadal and cenntennial trends in surface air temperature

11-, 22-years successive running averages



- decadal variation:  $\sim 1^{\circ}\text{C}$
- interdecadal variation:  $\sim 0.3\text{-}0.4^{\circ}\text{C}$

## Interdecadal and cenntennial trends in instrumental and reconstructed temperatures



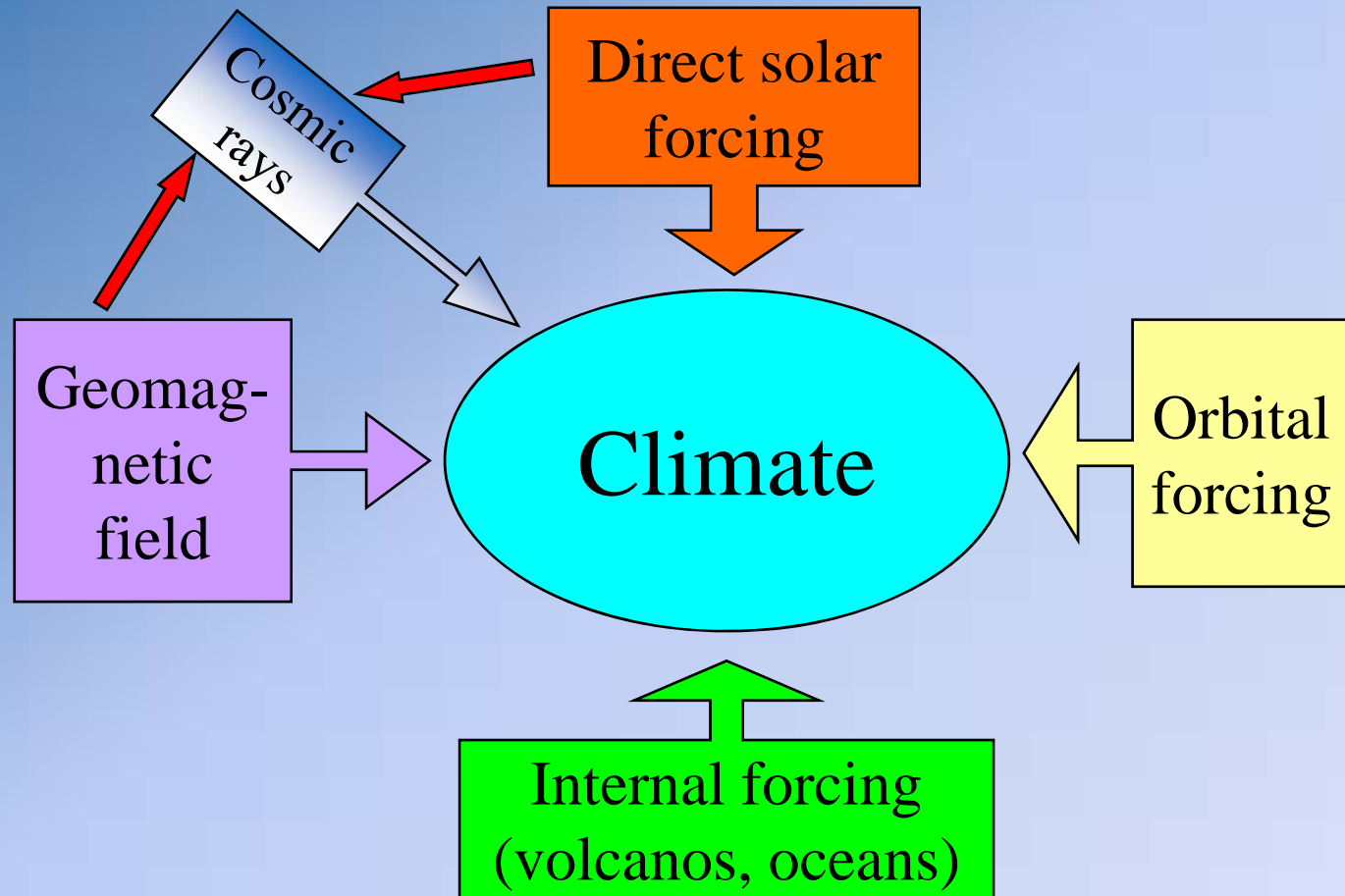
- the similarity of the variation pattern, as well as amplitude differences, that can be understood in terms of large-scale atmospheric circulation patterns.

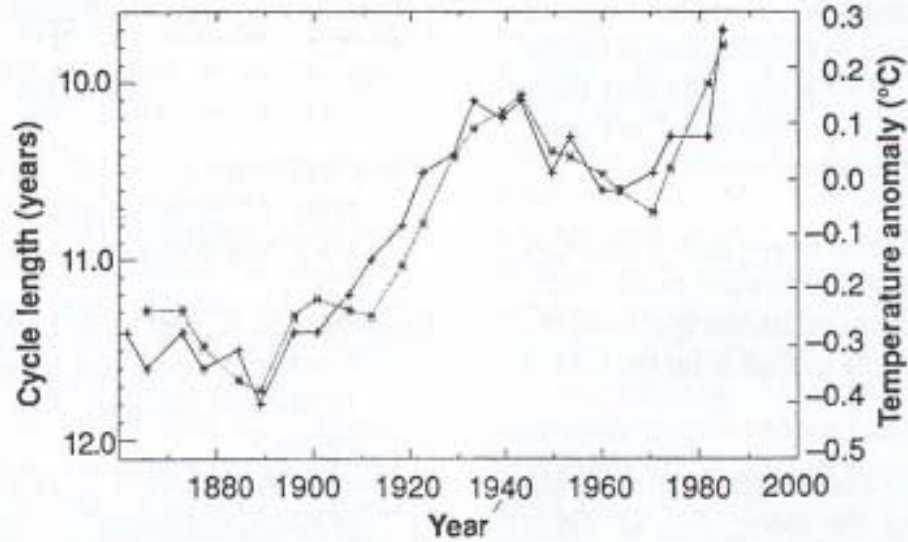
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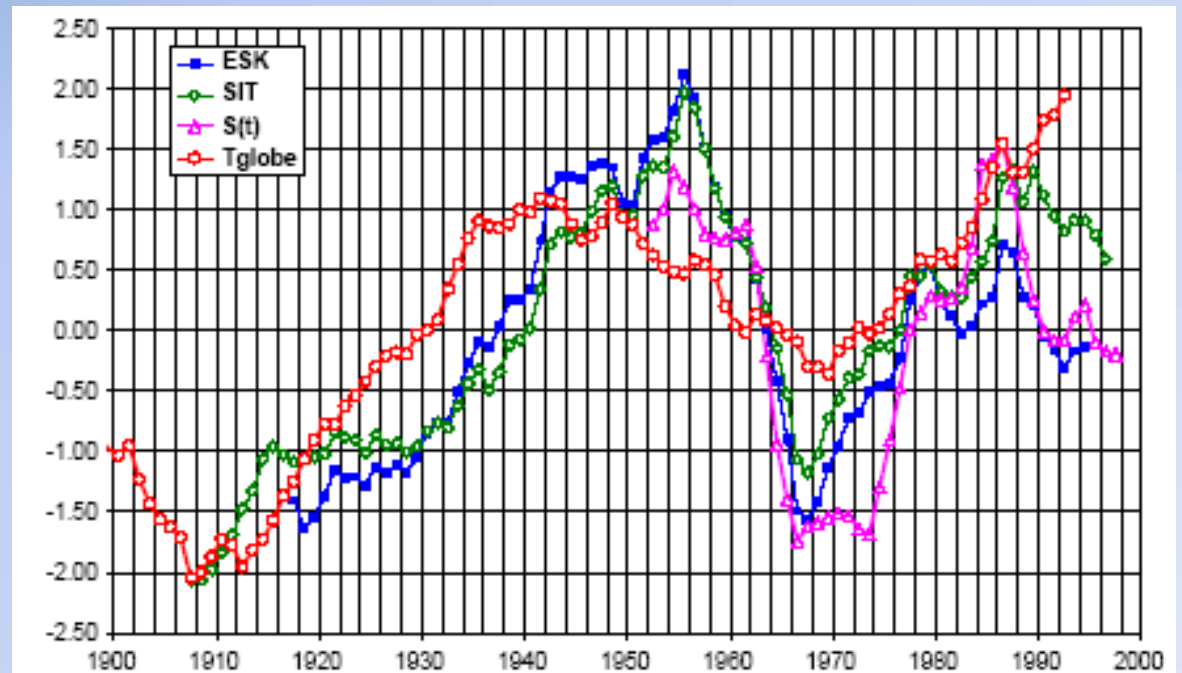


## Natural climate forcings

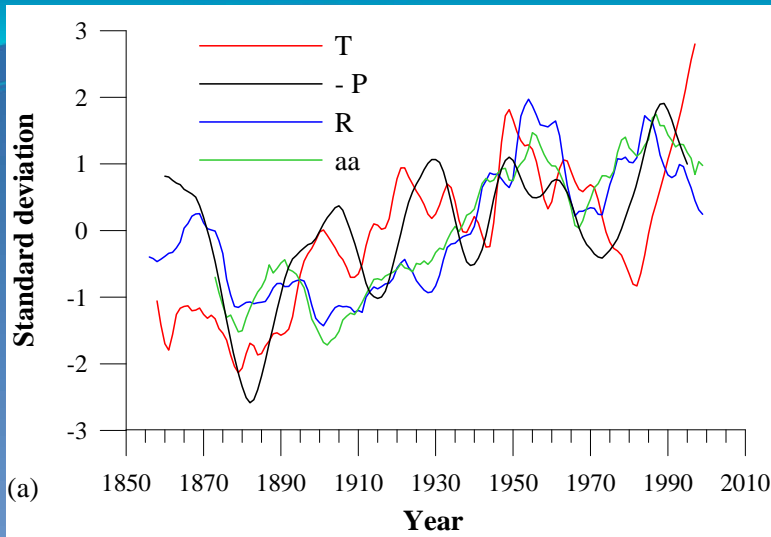




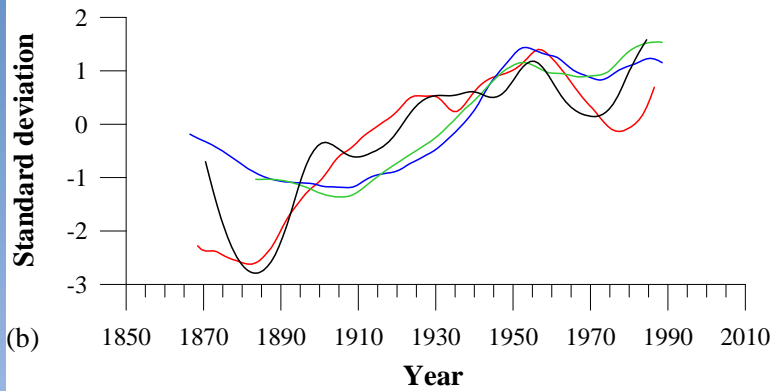
- the well known correlation between solar and geomagnetic activities and the surface air temperature (Friis-Christensen and Lassen, 1991; Le Mouél et al., 2005)



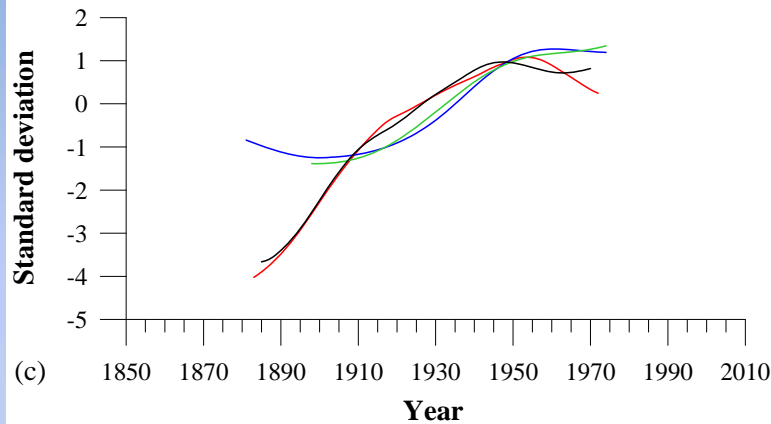
# Interrelationship of surface air temperature and geomagnetic/solar activity



(a)



(b)

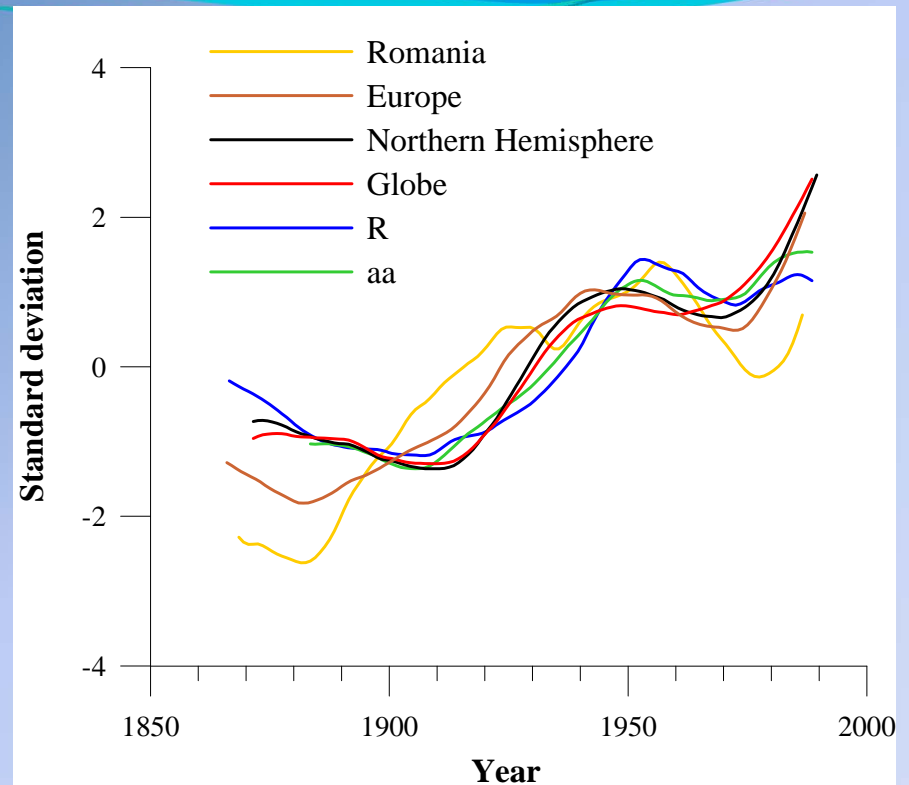
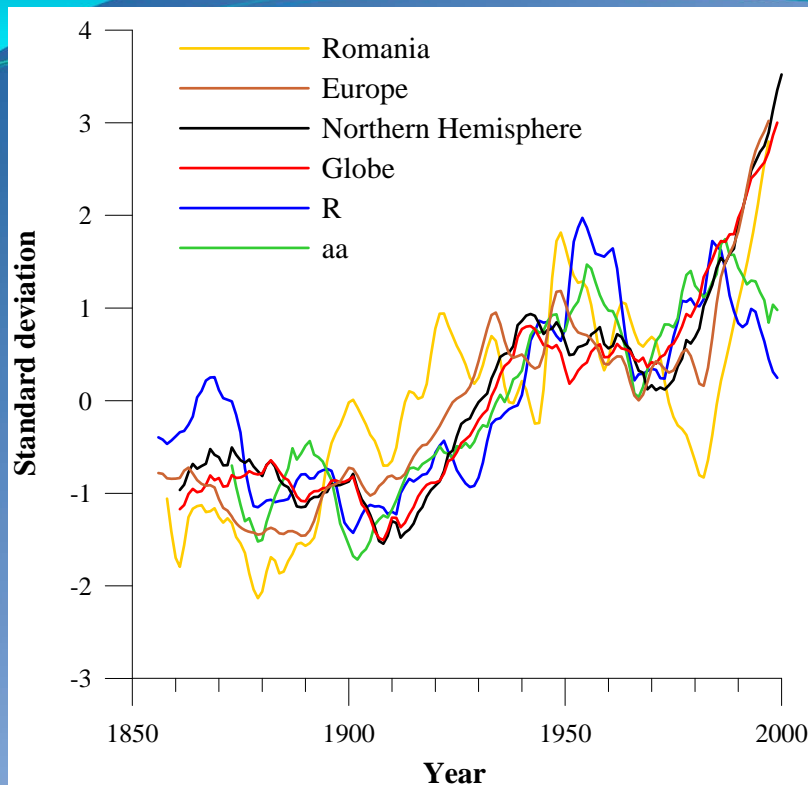


(c)

Series	R	aa
T	0.53	0.56
P	-0.56	-0.60

Series	R	aa
T	0.64	0.65
P	-0.72	-0.75

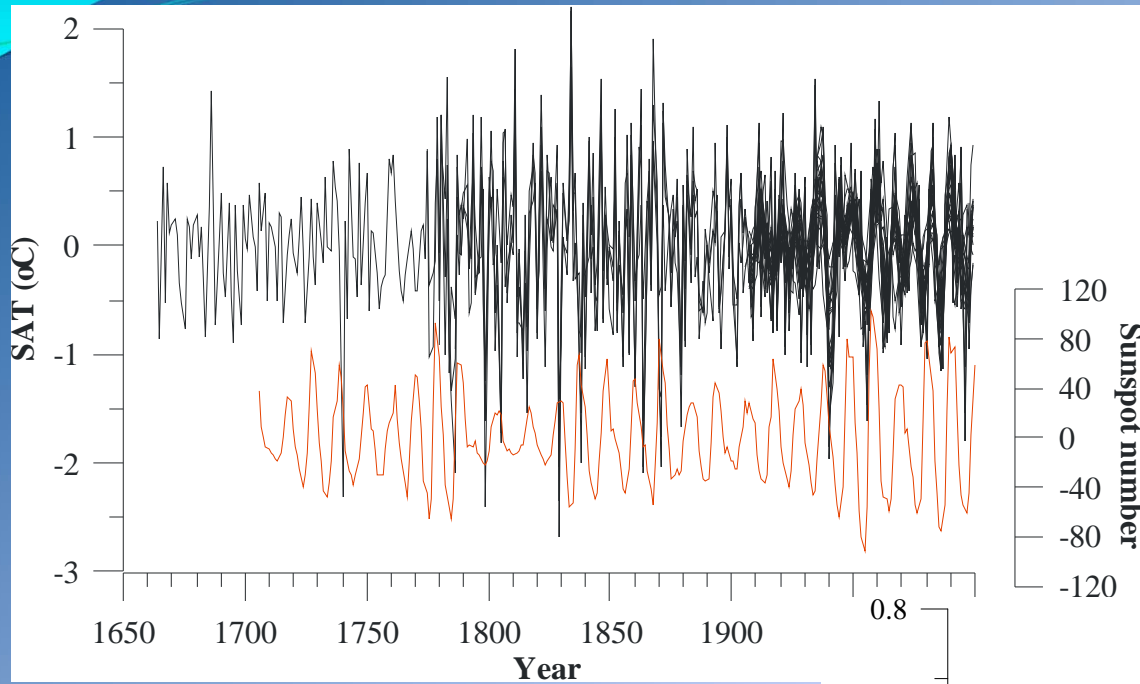
Series	R	aa
T	0.66	0.94
P	-0.74	-0.96



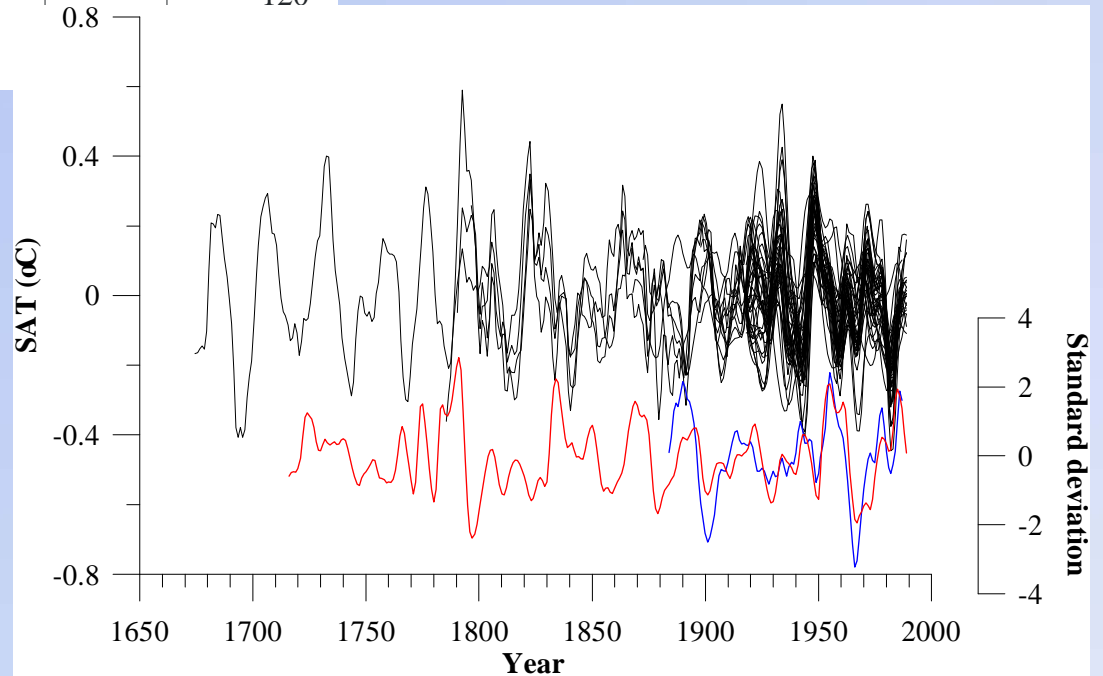
Dobrica et al., JASTP 2009

- marked discrepancy in trend after 1980-1990; possible emergence of the effect of anthropogenic greenhouse gases;
- a faster increase of temperature in comparison to solar and geomagnetic activities before 1940-1950;
- differences in case of local temperature variations as compared to averages at larger geographical scale.

## 11-year cycle



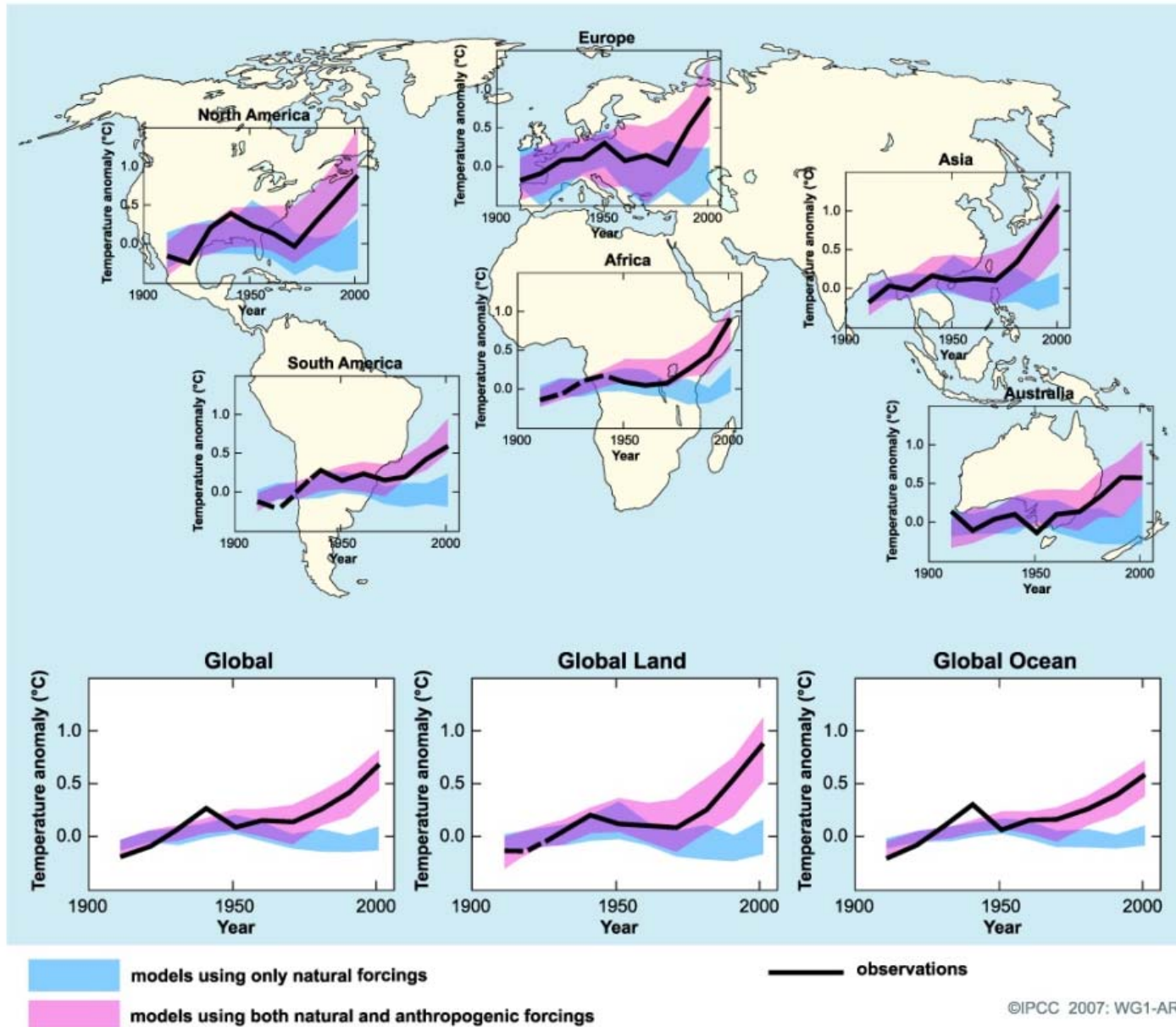
## 22-year cycle



- strong and coherent solar signals have been found at Schwabe and Hale solar cycles timescales, with peak to trough amplitudes of several degrees, and, respectively of 0.6-0.8 °C;

## GLOBAL AND CONTINENTAL TEMPERATURE CHANGE

GCM results



## Conclusions

- There are signals of a response in climate to solar/geomagnetic activity on decadal, interdecadal and centennial timescales.
- The similarity of the variation pattern, as well as amplitude differences, can be understood in terms of large-scale atmospheric circulation patterns, influenced by solar/geomagnetic forcing.
- The study of solar/geomagnetic-climate links is important in the context of climate change detection/attribution.
- Recent “Global Warming” is very unlikely to be due solely to solar/geomagnetic variability.