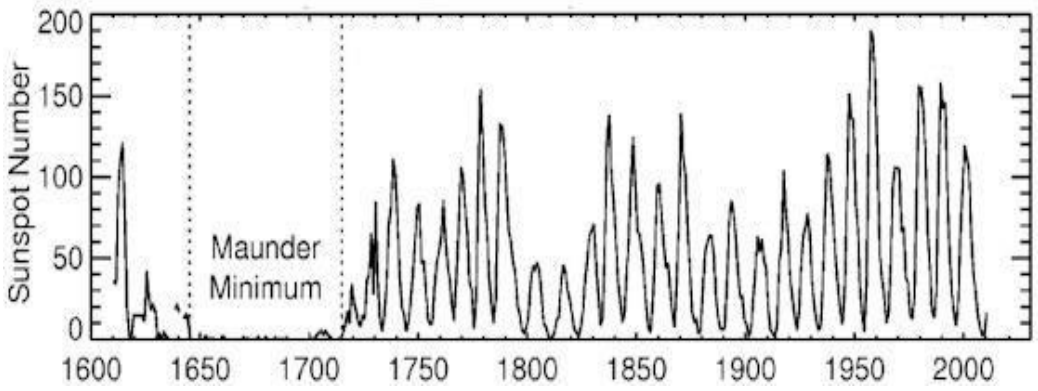
→ MEASUREMENTS AND OBSERVATIONS IN THE 21st CENTURY CONFERENCE

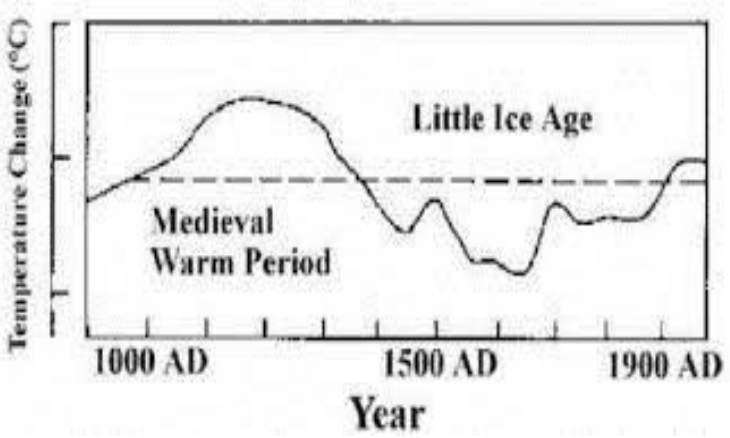
# Observation and measurement of solar activity for study of climate

Bakhram Nurtaev
Institute of Helioclimatology, Germany
E mail:nurtaev@gmx.net

21 November 2016 | ESA–ESRIN | Frascati (Rome) Italy

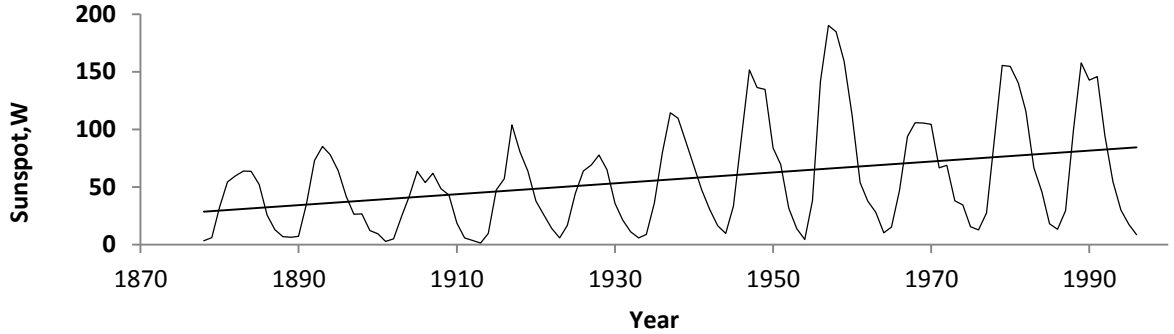
# History of sunspot observation



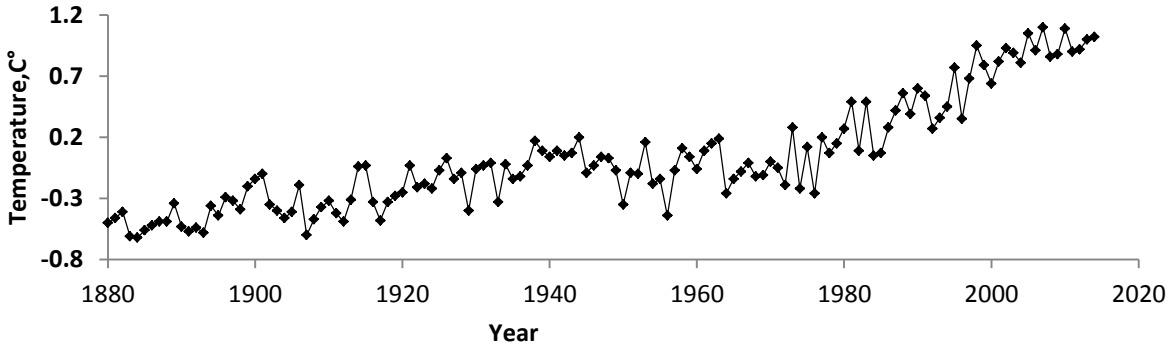




The sunspot number time series is the longest record made in science. Almost 400 years of sunspots observation provides a useful tool for studying solar dynamics, space weather and climate change.

# Direct observations for instrumental temperature record and sunspots 1880-2008



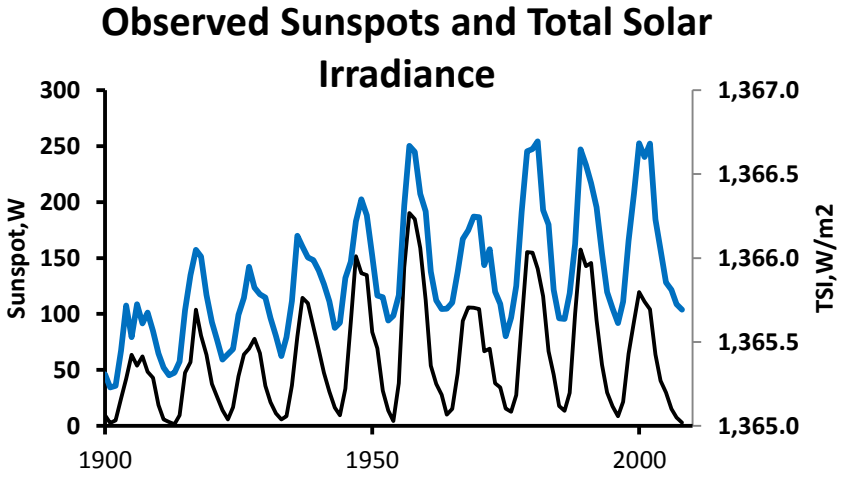

Yearly Smoothed Sunspot Number and Trend 1870-2008 Data Source (SIDC-Solar Influence Data Center)

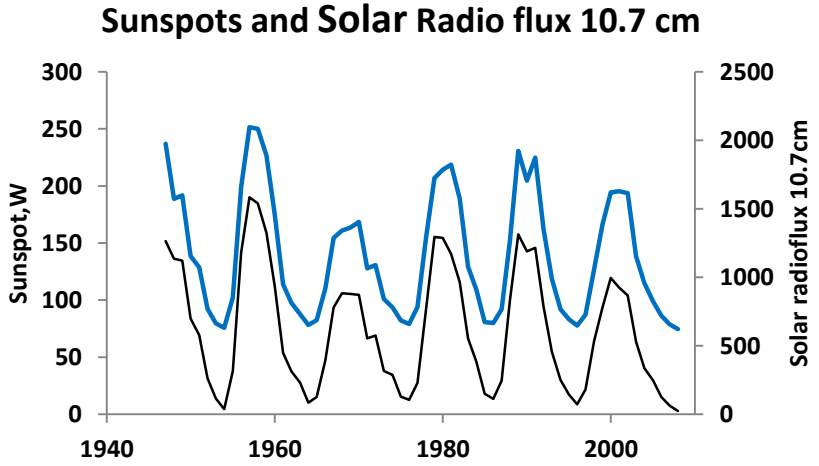



Global land and ocean temperature anomalies NOAA's National Centers for Environmental Information (NCEI)

# Measured solar indices

- **Total solar irradiance** (TSI) is a measure of the solar power over all wavelengths per unit area incident on the Earth's upper atmosphere. TSI monitoring using Nimbus 7 satellite began in November 1978
- The F10.7 has been measured consistently since 1947, The F10.7 Index has proven very valuable in specifying and forecasting space weather

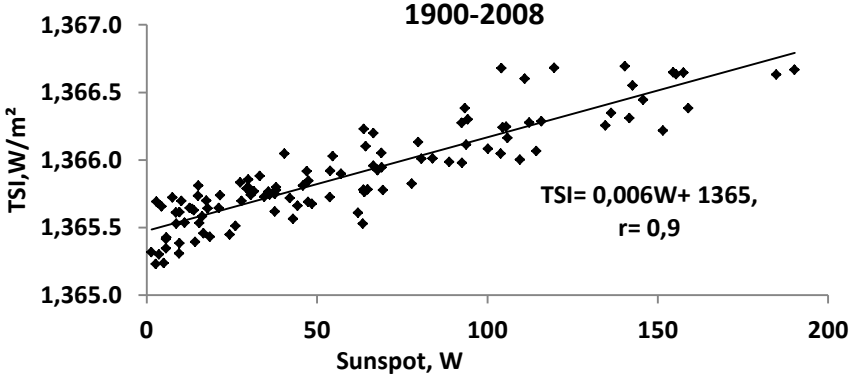


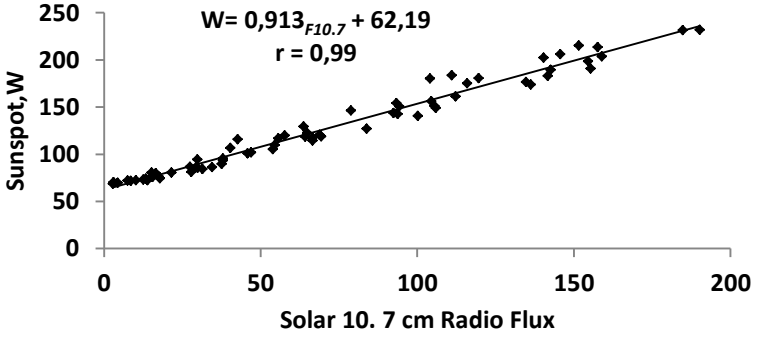

Sunspots-black line

# Relationships between observed and measured solar indices

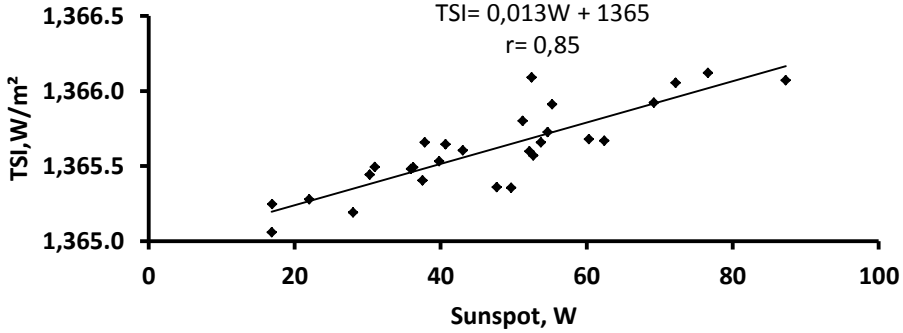
**Relationship between measured TSI and observed Sunspots 1900-2008**




**Relationship of sunspots from Solar 10.7 cm Radio Flux, 1947-2008**

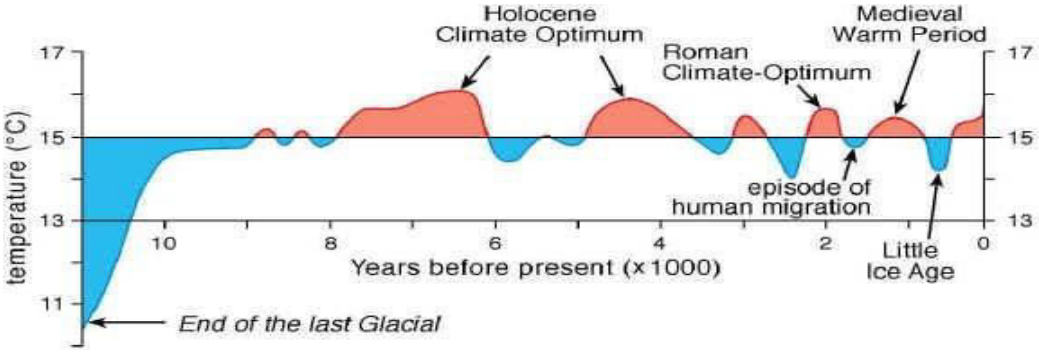



**Relationship between reconstructed TSI and sunspot number over 1700-2008**



# Why we study solar-climate connection?

| Source of energy | Average power( W/m²) |
|---|---|
| Solar EM radiation | 240 |
| Energetic particles | 0,001 |
| Geothermal | 0,06 |
| Anthropogenic | 0,02 |

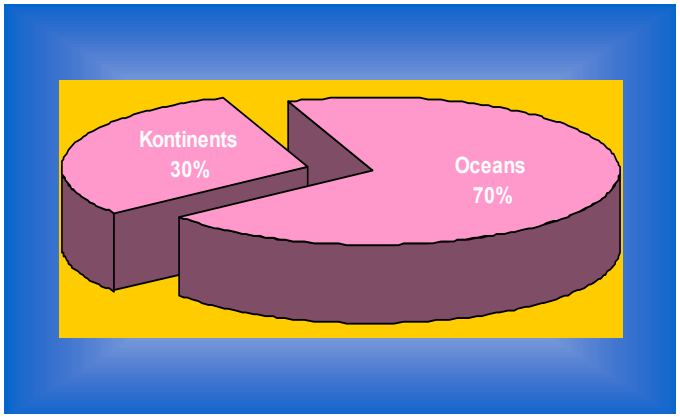


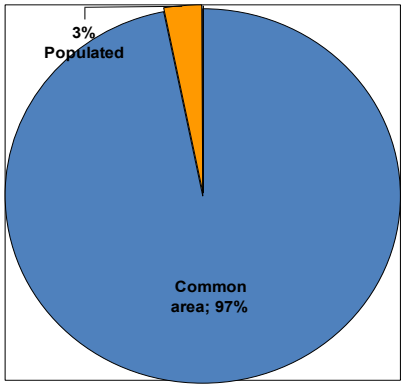

*Average near-surface temperatures of the northern hemispere during the past 11.000 years (after Dansgaard et al., 1969, and Schönwiese, 1995)*

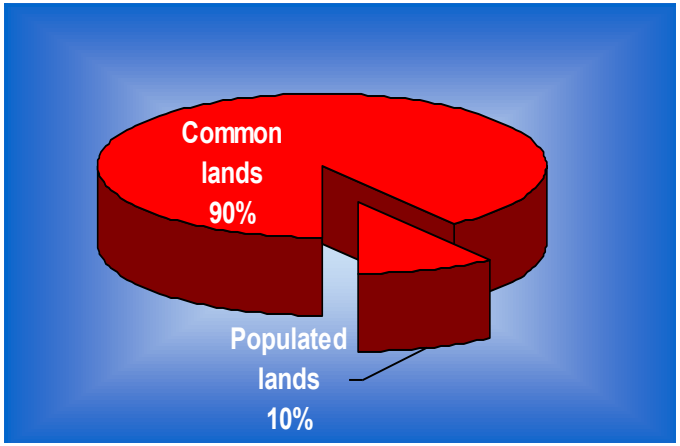
**Table 1.**
**The average power at the surface of the Earth for the four main sources of energy entering the climate system. F. W. Taylor .Elementary Climate Physics.2005**

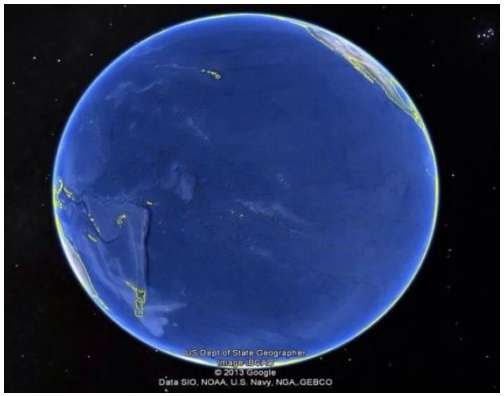
# Why we study solar-climate connection?

GRUMP data indicate that 3% of the Earth's land surface is occupied by urban areas, or that urban areas occupied 1-2% of the Earth's total land area. (*Global Rural Urban Mapping Project,2005*)



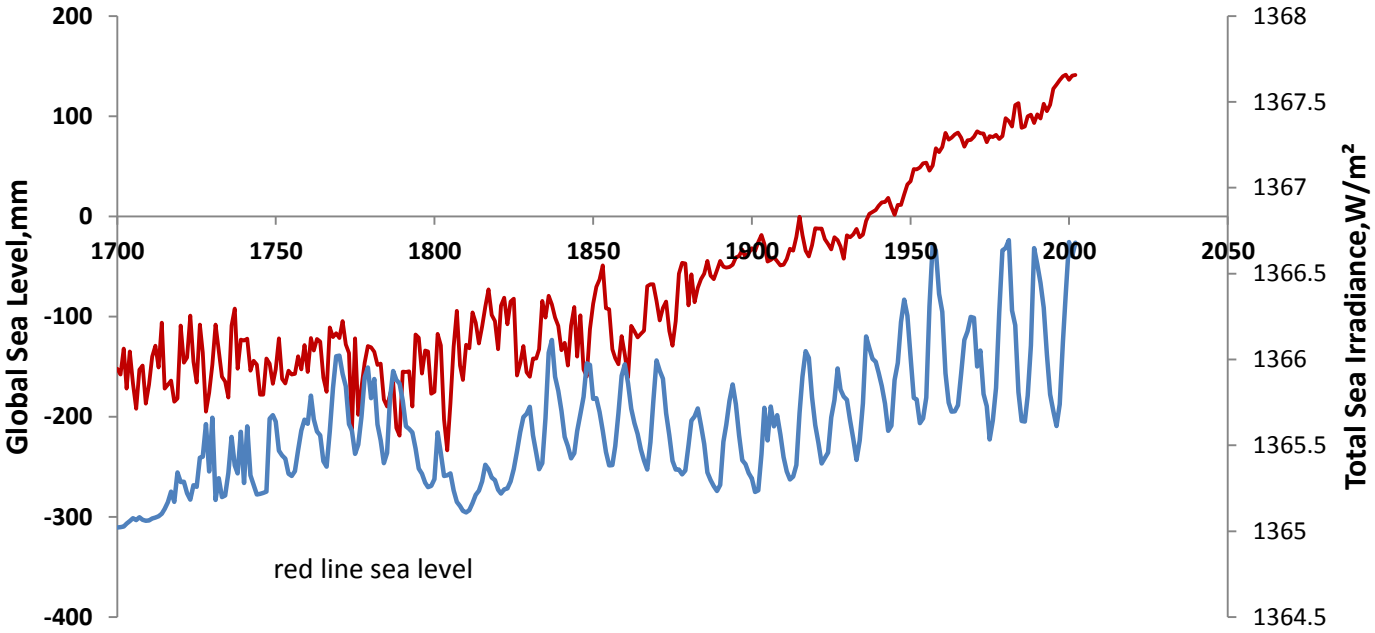



View of the Pacific Ocean from space

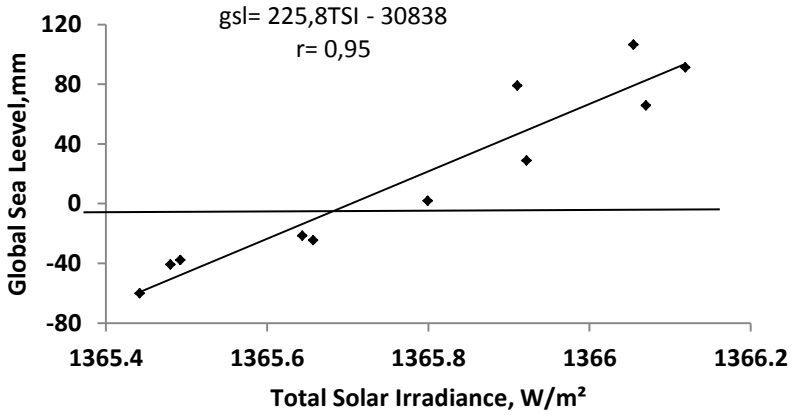
# Global Mean Sea Level and Total Solar Irradiance Time Series



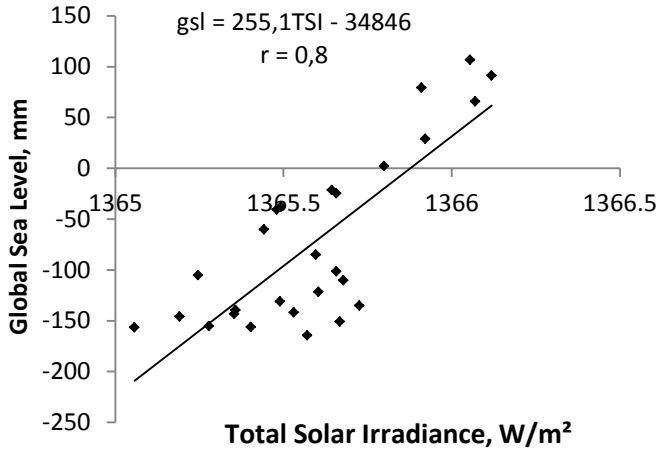

The ocean is the heart of the hydrological cycle, holding about 97% of the Earth's water. The large heat capacity of the ocean delays the effect of warming trend in lower atmosphere.

# Solar-terrestrial connections

## Relationship of Global Sea Level from Total Solar Irradiance




Global Sea Level in dependence from TSI over observed period 1878-2008

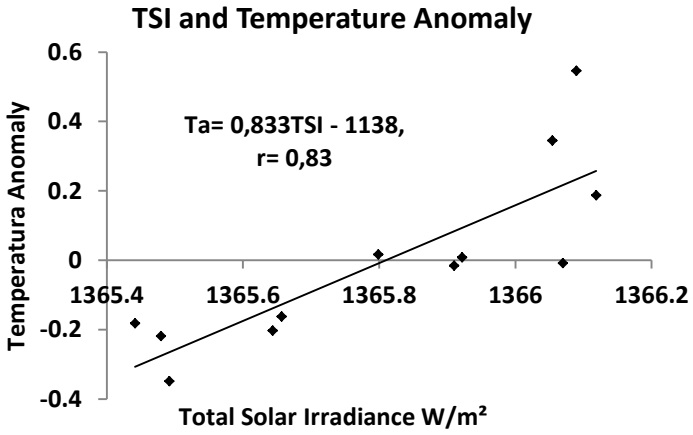


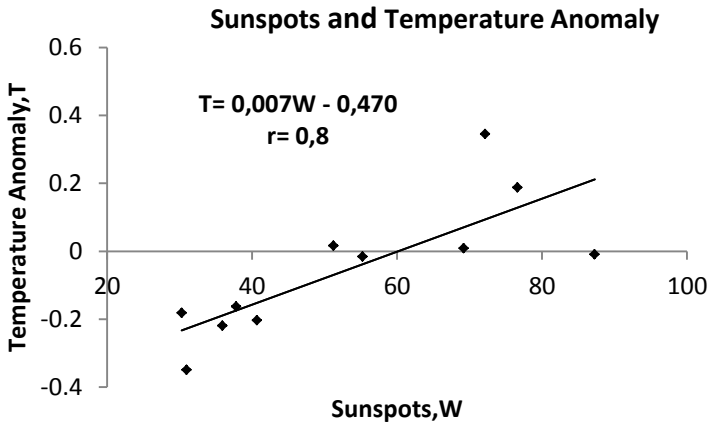

Global Sea Level in dependence from TSI reconstructed period over 1700-2008

*Database Royal Netherlands Meteorological Institute KNMI, http://climexp.knmi.nl, from Permanent Service for Mean Sea Level*

# Solar-terrestrial connections

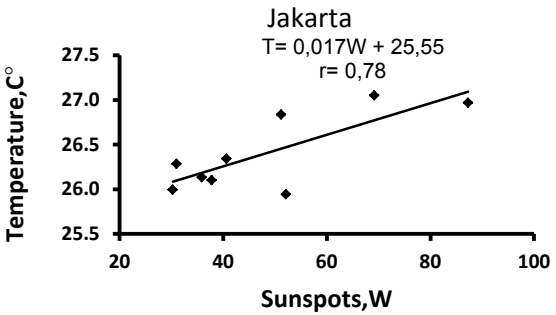
## Relationships of temperature from solar indexes

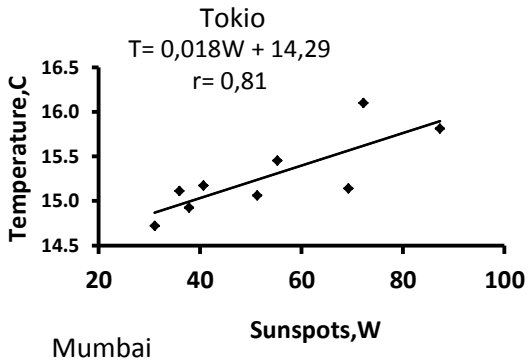


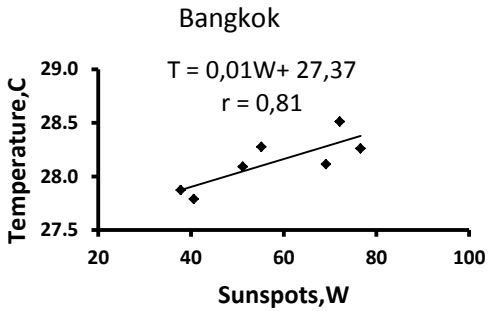



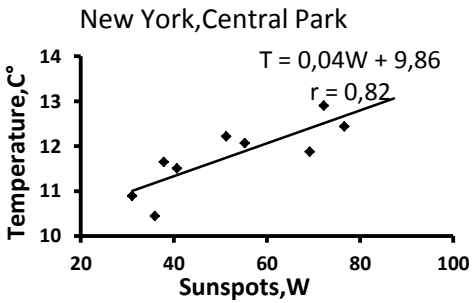

*Temperature Anomaly Data of NOAA's National Centers for Environmental Information (NCEI) over the period of 1880-2008*

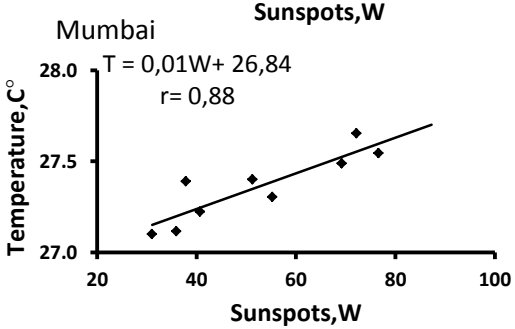
# Helioclimatology of megacities 1878-2008 *NASA Data*

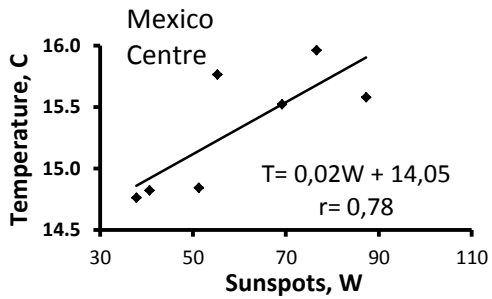


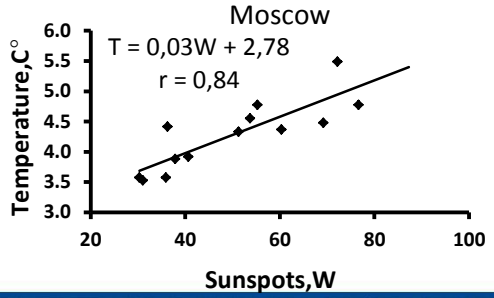



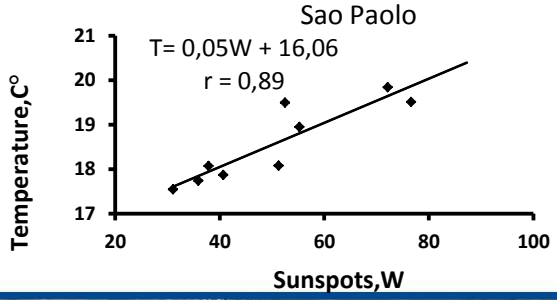



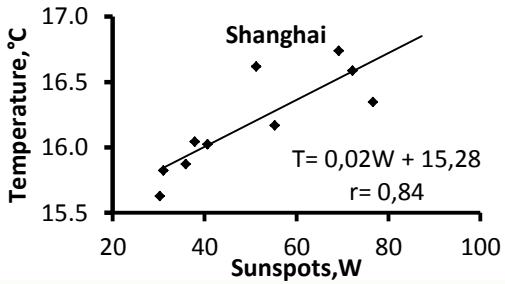



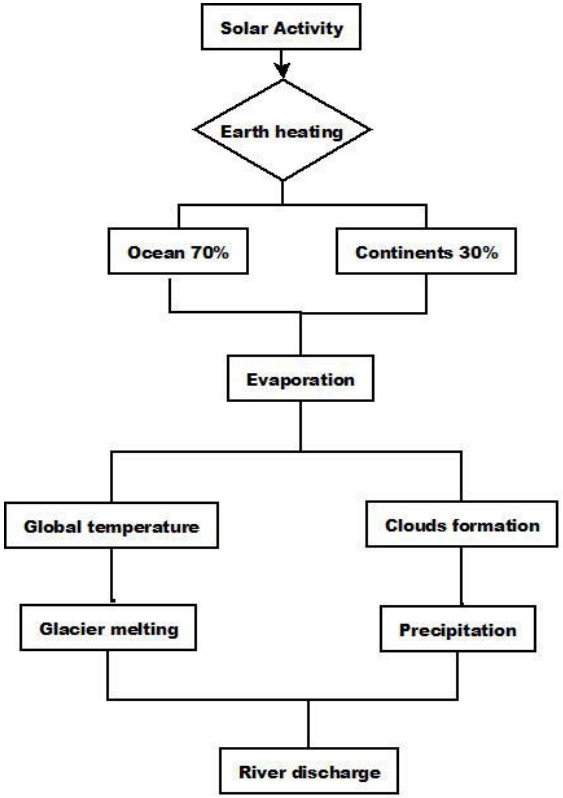



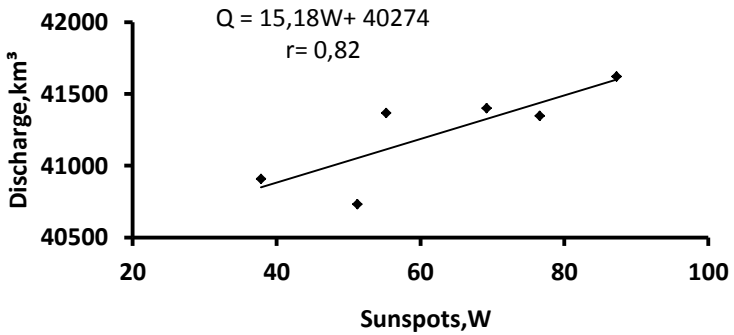



# The sun and water cycle

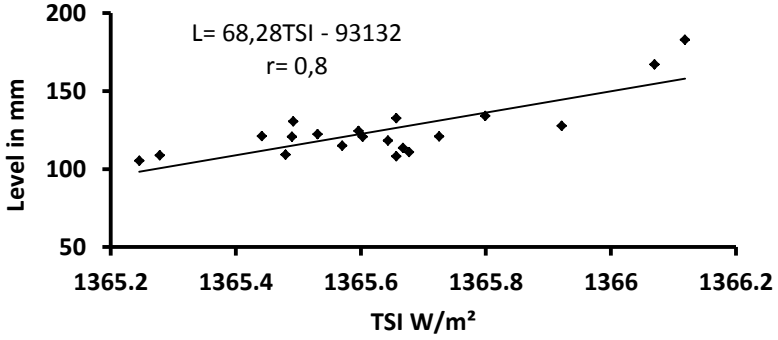
The ocean is the heart of the hydrological cycle, holding about 97% of the Earth's water. The large heat capacity of the ocean delays the effect of warming trend in lower atmosphere.




## Scheme of river runoff formation

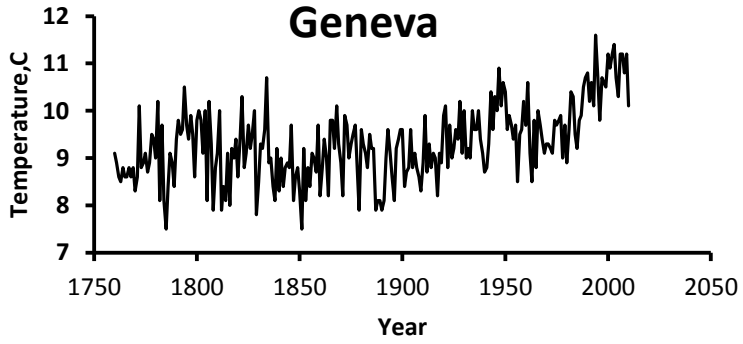


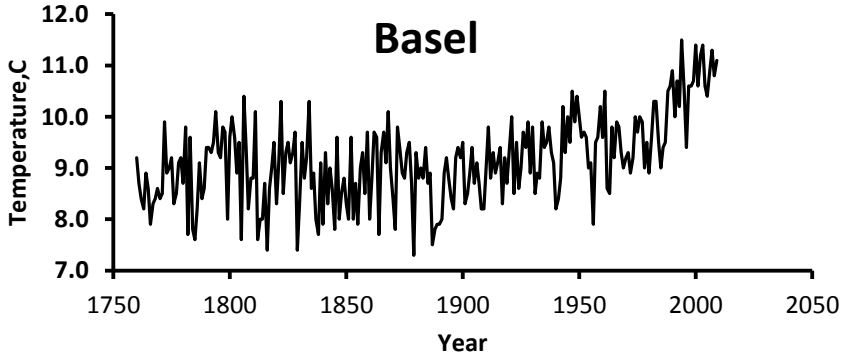

**Relationship of global water inflow in ocean from solar activity 1921-1985**

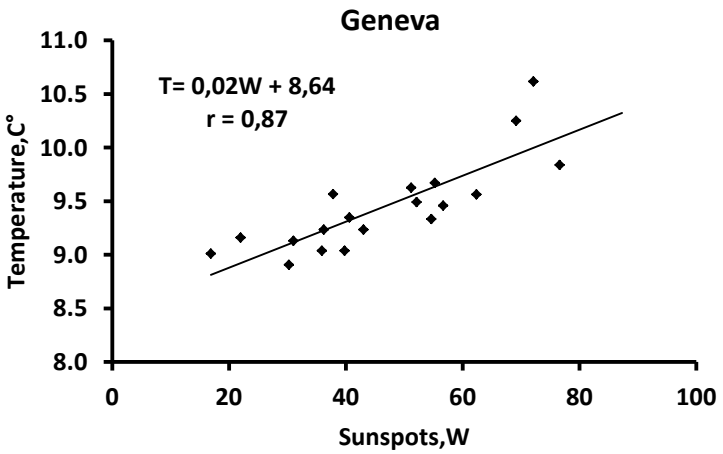


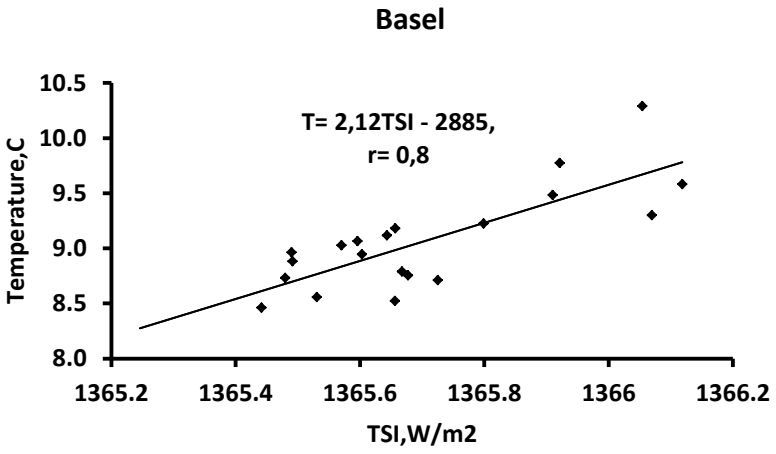

**Baikal Lake level in dependence on Total Solar Irradiance 1755-1986**

# The longest instrumental record of temperature in the world1755-1996 and relationships to solar radiation *(HISTALP Data)*

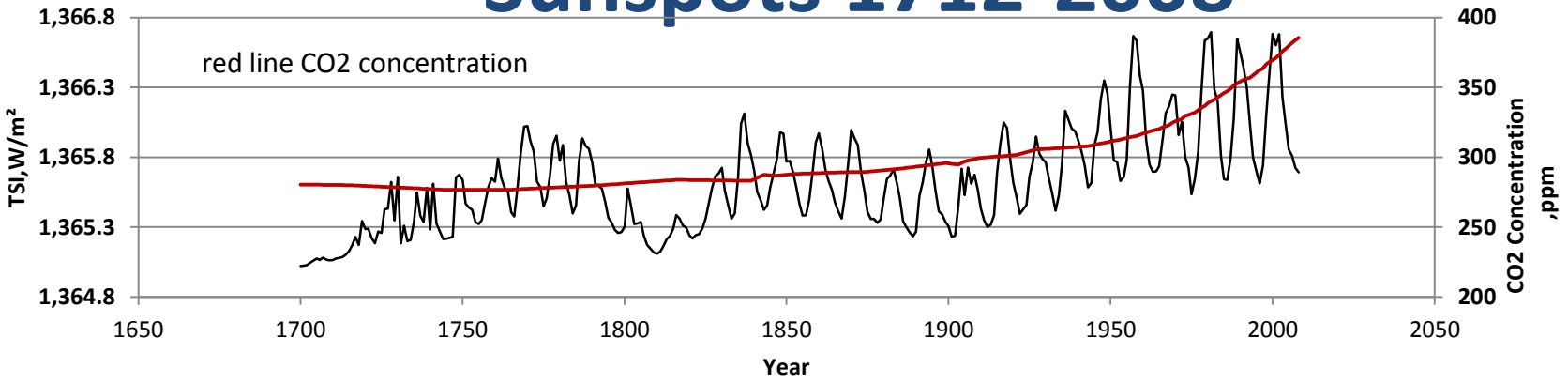


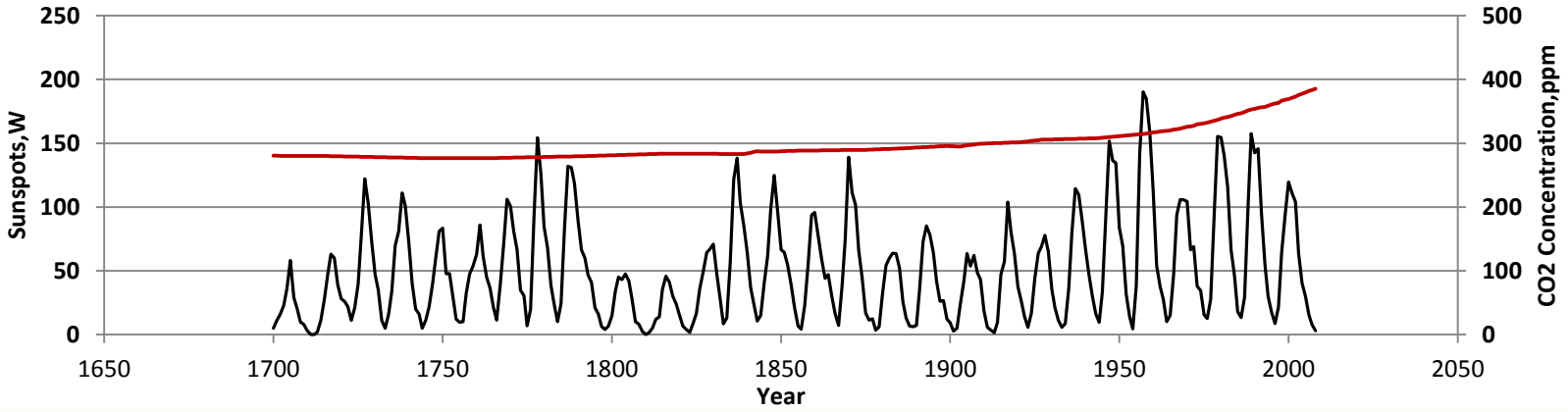



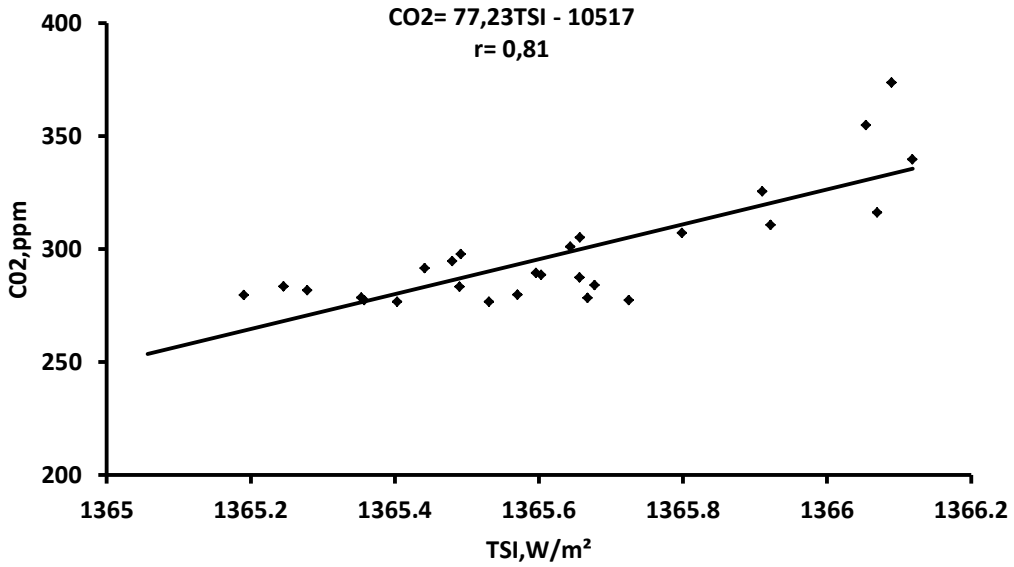



# CO2 concentration-Total Solar Irradiance and Sunspots 1712-2008



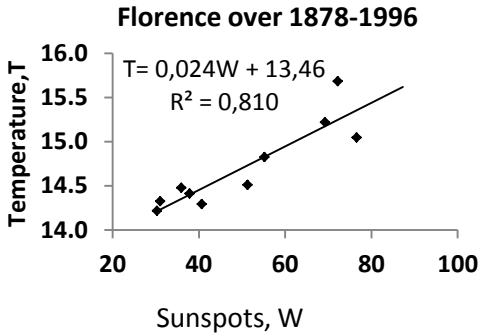



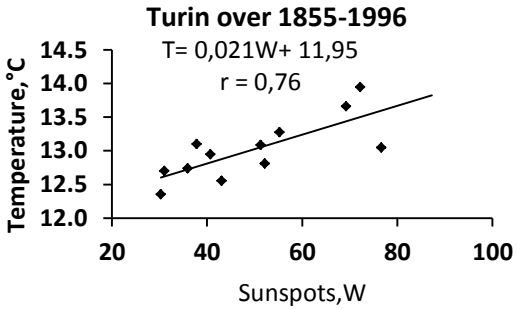
# Dependence of CO2 concentration from Total Solar Irradiance 1712-2008

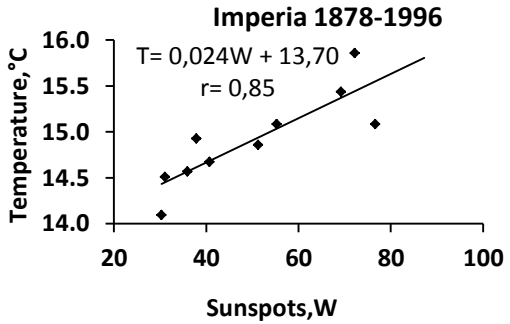


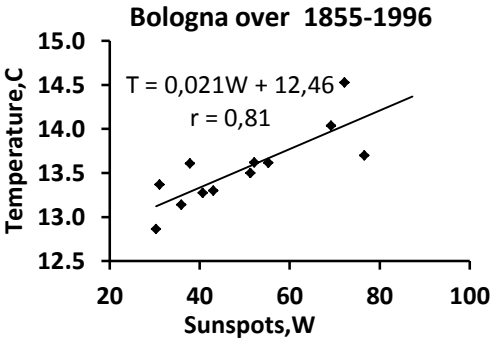
# Helioclimatology of Italy

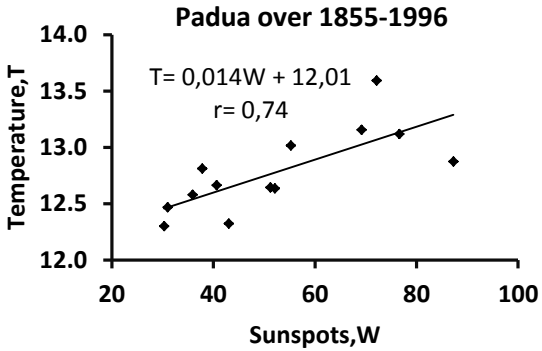
**Long term relationships of air temperature and sunspots over Italy. Temperature forecast for next 20 years-35 Sunspots Number**

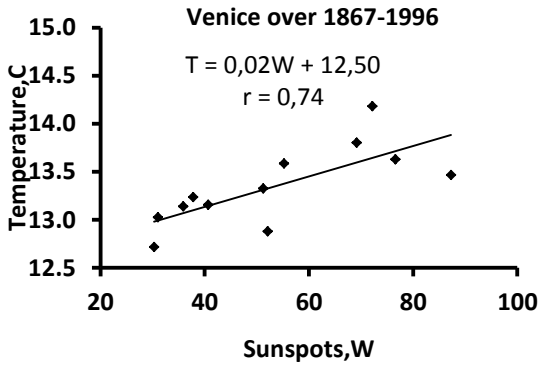


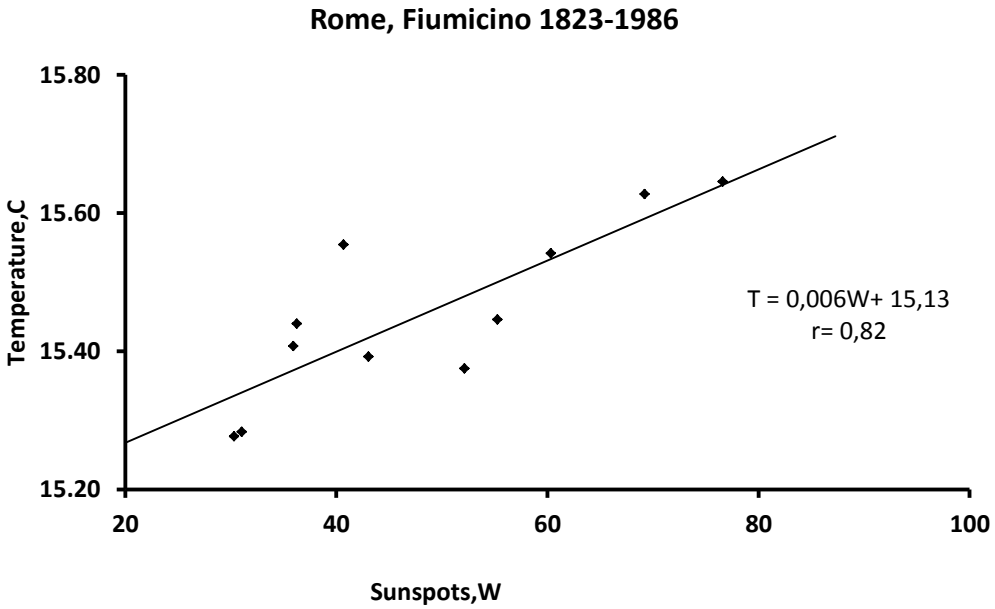




*HISTORICAL INSTRUMENTAL CLIMATOLOGICAL SURFACE TIME SERIES OF THE GREATER ALPINE REGION (HISTALP Data)*

# Helioclimatology of Italy



# Conclusion

• More sunspots deliver more energy to the atmosphere, by way of increased brightness of the Sun and solar wind what tend to warm the Earth. Solar activity affects the Earth in many ways, some which we are still coming to understand.

• In accordance with National Geophysical Data Center (NGDC) forecasting the solar cycles 24 and 25 will be very weak: averaged sunspot numbers W-35 for the solar cycle 24 and for the solar cycle 25 less than W-35 ,NGDC (2009). Total Solar Irradiance will equal -1365,48. (23 cycle -1366,09).

• This actually will lead to a decrease of the temperature on 1-1, 5 C in both averaged solar cycles. Temperature of air will be lower in the Northern Hemisphere.

The World Ocean level also will be lower, due to more snow and glacier accumulation on continents.