International Journal of
Science and Engineering Investigations vol. 7, issue 81, October 2018
ISSN: 2251-8843

Observation and Measurement of Solar Activity for Study of Climate Trends

Bakhram Nurtaev
Institute of Helioclimatology
(nurtaev@gmx.net)

Abstract-The correlation between observed sunspot numbers and measured solar indices, radio flux F10.7 and Total Solar Irradiance (TSI) were analyzed in solar cycles 18, 19, 20, 21, 22, 23. In both cases, measured solar indices show close relationships to sunspot numbers. Then, there were compared the sunspot numbers in solar cycles 1 to 23 with reconstructed Total Solar Irradiance over the same period. The relationship between these parameters also has a very strong positive correlation. We also analyzed the interconnection between TSI and air temperature in many weather stations. Almost in all stations surface temperature show a close relationship with solar radiation.

Keywords- *Solar Cycle Observations, Solar Activity Indices, Air Temperature*

I. INTRODUCTION

The sunspot number time series is the longest record made in science. Almost 400 years of sunspots observation provides a useful tool for studying climate change. The source of the virtually all energy in climate system is radiation from the Sun. In fact 99, 97% of energy budget of the earth arrives from the Sun. The current world energy consumption is equivalent to 0.007% of the incident solar energy [1]. There is broad agreement that the energy from the Sun is very important to the Earth. The Sun warms our planet, heating the surface, the oceans and the atmosphere. This energy to the atmosphere is the primary driver of the Earth's weather. Global atmospheric circulation also strongly affected by the amount of solar radiation received at Earth. That amount changes based on the Earth's albedo, that is how much radiation is reflected back from the Earth's surface and clouds. The energy output of the sun is not constant, it varies over time and it has an impact on our climate. The amount of radiation given off by the Sun is changing with solar activity like sunspots and total solar irradiance. A reconstruction of total solar irradiance since 1610 to the present estimated by various authors an increase in the total solar irradiance since the Maunder Minimum of about 1.3 W/m² [2].This is a huge amount of energy, taking into account the Earth's total land mass - 510.072 million sq. km.

II. DATA AND METHODS

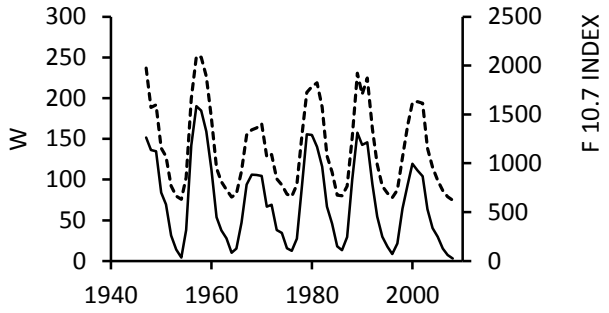
The sunspot number SSN (also known as the International sunspot number, relative sunspot number, or Wolf number) is a quantity that measures the number of sunspots and groups of sunspots present on the surface of the sun. In all calculations we used empirical observed original Sunspot number data, since first solar cycle started from 1755.

Solar irradiance is the total amount of solar energy at a given wavelength received at the top of the earth's atmosphere per unit time. When integrated over all wavelengths, this quantity is called the total solar irradiance (TSI) previously known as the solar constant. Regular monitoring of TSI has been carried out since 1978. Annual reconstructed solar constant time series data used in calculations is taken from [3].

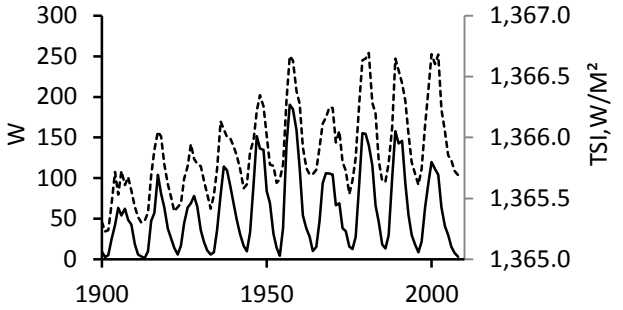
The F10, 7 cm index is a standard characteristic of solar activity using in research concerning the solar influence on Earth's climate. Comparison yearly averaged F10, 7 cm solar flux with yearly averaged Wolf's Numbers detected close correlation between these both parameters r=0, 99 over the period 1947-2008, Fig 1. The solar radio flux at F10.7 cm record extends back to 1947. The yearly-averaged solar radio fluxes 10.7 cm and Total Solar Irradiance show the same variations as sunspots. Figure 1 (a) and (b).

Taking into account above graph we have checked correlations between sunspots and solar radio fluxes 10.7 cm over the measured period from 1948 to 2008 and found a close correlation, r-0, 99, Figure 2.

Comparison of Total Solar Irradiance over the measured period 1978-2008 and observed original sunspot numbers revealed also close correlation r-0.95 over the same period, Figure 3 (a).We analyzed reconstructed Total Solar Irradiance data with sunspot numbers and found also close correlation, Figure 3 (b).

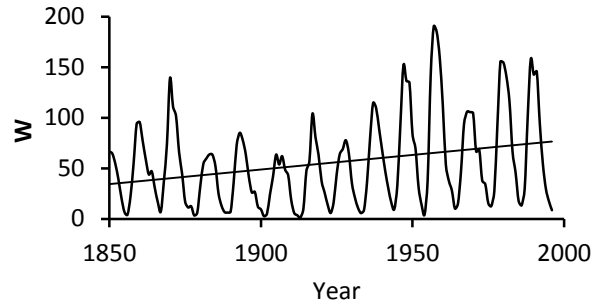


(a)

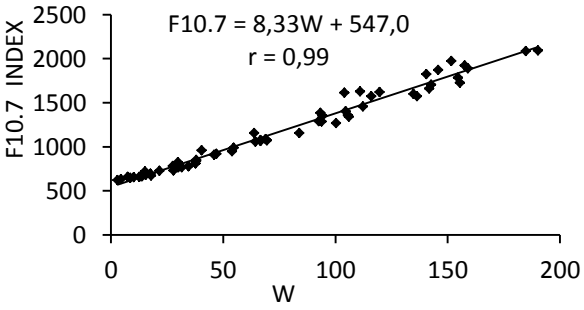


(b)

Figure 1. a) Sunspots W (solid line) and Solar Radio Flux at 10.7cm (dashed line), b) sunspots W and Total Solar Irradiance (dashed line) time series

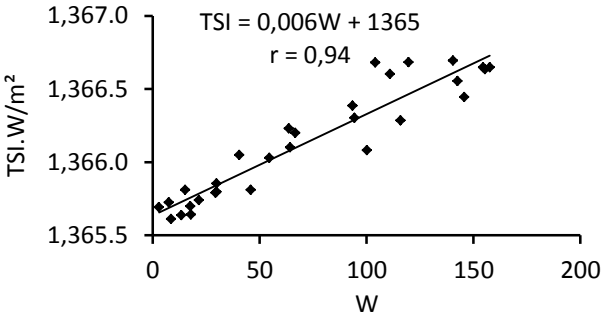


(a)

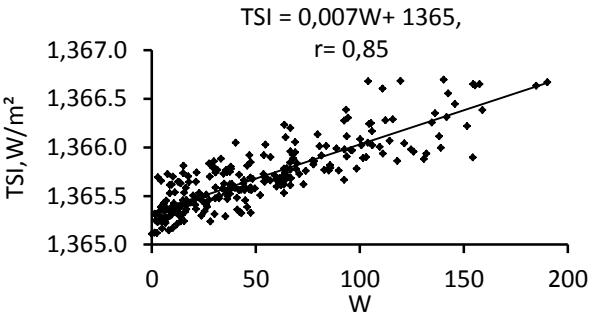


(b)

Figure 2. Sunspot trend. a) and comparison of yearly sunspot number and 10.7 cm Flux. b) over the period 1947-2008.



(a)



(b)

Figure 3. Relationships of yearly averaged Total Solar Irradiance (TSI) from yearly averaged sunspot numbers (W) over the observed period 1978-2008(a) and yearly averaged TSI from sunspot numbers (W) over the reconstructed period 1755-2008 (b).

III. LONG TERM TEMPERATURE TRENDS IN DEPENDENCE FROM SOLAR INDICES

The period for which reasonably reliable instrumental records of near-surface temperature exist with quasi-global coverage is generally considered to begin around 1850. Earth's average temperature rose by 0,7 °C over this period. Global warming is affecting the higher latitudes more than any other part of the world. Temperature rise in low latitudes reach +4% and +7% in high latitudes.

Average amount of sunspots for one averaged solar cycle rose more than 30% over the period 1850-1996. More sunspots mean increased solar activity, more solar activity means more energy comes from the Sun. Less sunspots means that Earth gets less energy from the Sun. As an example can be considered the Maunder Minimum which roughly coincided with the middle part of the Little Ice Age, during which Europe and North America experienced colder than average temperatures.

Taking into account strong correlation between sunspots and TSI as well as the hypothesis about solar activity influence on temperature variability, we examined empirical inverse model relationships between long- term mean air temperature and TSI, both for 11 year averaged solar cycle, for the longest instrumental record of air temperature in Geneva and Basel. These parameters demonstrate close correlation, Figure 4.

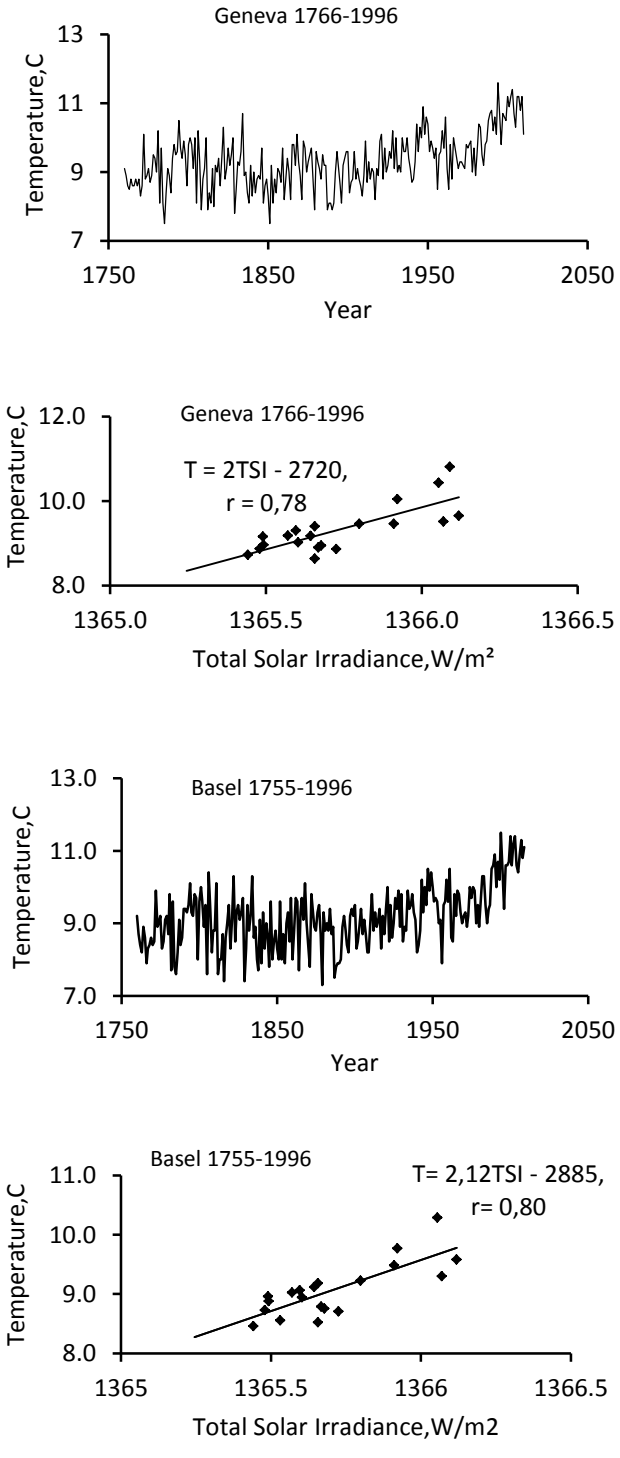


Figure 4. Air temperature time- series in Geneva and relationships of air temperature from Total Solar Irradiance

Further calculations of many stations in the Northern Hemisphere showed us that in almost all causes exist also strong correlations between solar indices: sunspots, Total Solar Irradiance and surface temperatures. In Figure 5 are shown relationships between solar activity and temperature trends in megacities.

In order to check contribution of solar activity on global temperature and sea level rise, we compared relationships between Total Solar Irradiance with Global Sea Level and Global Temperature Anomaly. In both cases, also detected close correlations, Figure 6.

IV. CONCLUSION

The sun radiates energy equally in all directions, and the Earth intercepts and receives part of this energy. Changes in sunspot cycles cause change the amount of solar radiation. In our study we used for all the indices the yearly and 11 –year averaged values. Such averages allowed us to take into consideration of all TSI and air temperature changes on uniform sampling basis.

Observed sunspots as well as measured solar indices can be conceived as an objective parameters for identification of solar radiation contribution in surface temperature variability, precipitation and river runoff [4].

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 [5].Total Solar Irradiance will equal -1365,48. (23 cycle -1366,09 .

This actually will lead to a decrease of the temperature on 0.5-0. 7 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.

REFERENCES

[1] Taylor, F. W. 2005: Elementary Climate Physics, Oxford University Press, Oxford, p. 232.

[2] Krivova N.A., Balmaceda L., Solanki S.K. (2007) Reconstruction of solar total irradiance since 1700 from the surface magnetic flux. A&A. 467, pp 335–346.

[3] The Royal Netherlands Meteorological Institute (KNMI) http://climexp,knmi,nl/getindices,cgi?WMO=FUBData/tsi_wls_ann&STATION=reconstructed_solar_constant&TYPE=i&id=someone@somewhere&NPERYEAR=1

[4] Nurtaev B. 2015.Influence of climate variability on large rivers runoff. Proceedings of the International Association of Hydrological Sciences (IAHS), 2015. Vol.371. pp 211–214. doi:10.5194/piahs-371-211-2015.

[5] NGDC – NOAA National Geophysical Data Center: http://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-indices/sunspot-umbers/predicted/table_international-sunspot-numbers_monthly-predicted.txt (last access: March 2015), 2009.

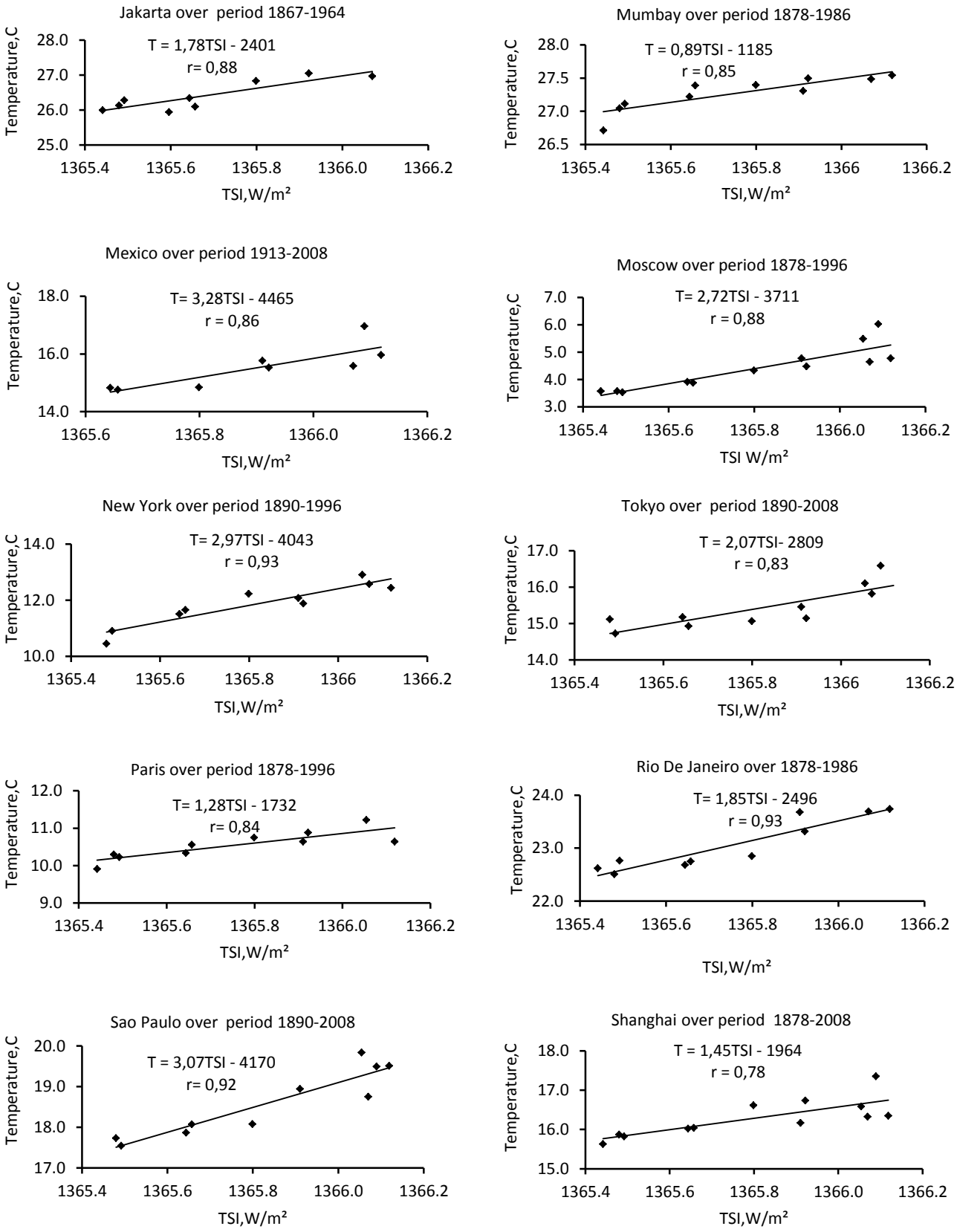
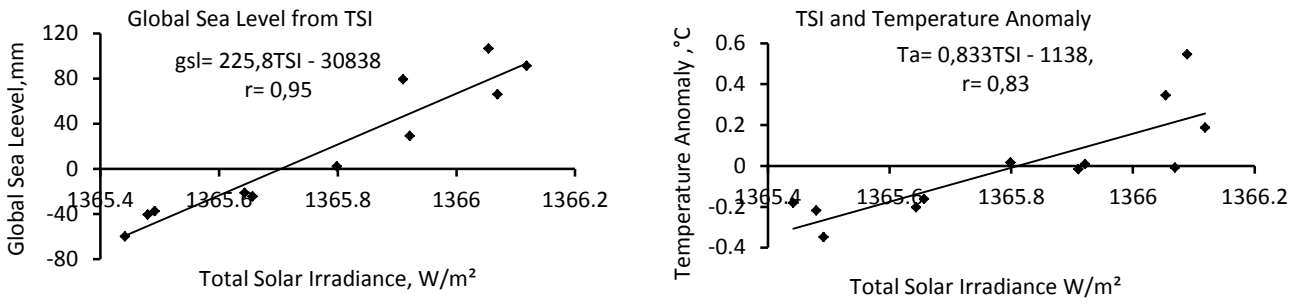


Figure 5. Dependencies of air temperatures in megacities from Total Solar Irradiance



(a) (b)

Figure 6. Relationship of Global Sea Level (gsl). a) and Temperature Anomaly, b) from Total Solar Irradiance over the period 1878-2008.