Journal of the Georgian Geophysical Society, ISSN: 1512-1127
Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 21(1), 2018, pp.34-40

Helioclimatology of Japan

Bakhram S. Nurtaev

Institute of Helioclimatology, Frechen,Germany
nurtaev@gmx.net

ABSTRACT

This paper examines terrestrial temperature change and associated phenomena of their relationship to solar radiation indices in Japan. We analyzed the temperature variability of different weather stations across Japan over hundred years in dependence from solar activity and found high positive correlation between temperature trends and sunspots. The study based on the instrumental temperature records data and empirical observations for sunspots over the same time.

Key words: Temperature anomalies, sunspots, air temperature, climate trend, sun-earth system.

1. Introduction

The sun is the primary source of the energy that drives the biological and physical processes in the world—in oceans and on land it fuels plant growth that forms the base of the food chain, and in the atmosphere it warms air which drives our weather.

Over the all history of mankind the Sun was responsible for climate variations, such as four seasons change, long warm summer or cold long winter.

The major driving force of the atmospheric circulation is solar heating which provides the continuous movement of air. The simplest example of the influence of the sun to the earth daytime and night temperatures in the Sahara deserts where the diurnal range can be as great as 38°C and more than 10°C in Germany.

The number of sunspots increase and decrease over time in a regular, approximately 11-year cycle, called the solar or sunspot cycle. The exact length of the cycle can vary. More sunspots mean increased solar activity.

The sun provides 99.97% of the earth's energy budget. The current world energy consumption is equivalent to 0.007 % of the incident solar energy, Taylor, 2005 [1]. The existence of a positive relation between the surface air temperature of the Northern hemisphere and the solar activity in the period 1881-1988 is shown in [2], Georgieva 1998. According to many of the recent publications in the field of solar-terrestrial relationships, the solar activity forcing can substantiates a third to half of the observed global heating, Lean et al 1995, [3], Cliver et al 1998, [4],Ring et al 2002, [5].

The Sun warms land, ocean, ice on the surface of Earth, the atmosphere overlies it. All of these interact to produce regional and local alteration of climate around the surface of the Earth. Sunlight is more intense at the equator than at the poles, creating a marked difference in temperature, which causes energy to spread out from the hotter equator towards the colder higher latitudes. This energy transfer drives both atmospheric circulation and ocean currents. On time scales of decades to centuries, air temperature fluctuations depend directly or indirectly from changes in solar radiation. Many meteorological parameters vary in dependence from location with different periods and most variations are small and difficult to detect.

Processes in the Sun–Earth system are interrelated, and the state of every component affects physical and other processes within the system.

According to an ongoing temperature analysis conducted by scientists at NASA's Goddard Institute for Space Studies (GISS), the average global temperature on Earth has increased by about 0.8° Celsius since 1880 (Fig.1).

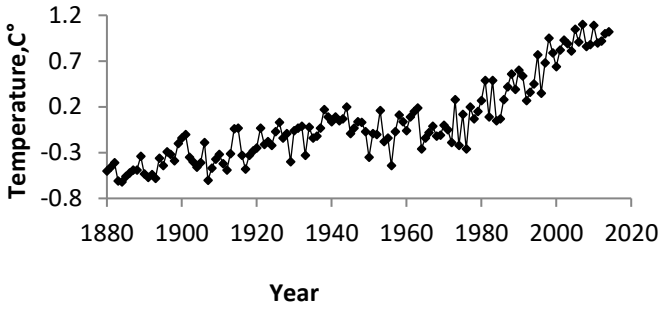


Fig. 1. Global land and ocean temperature anomalies trend over the period 1878-2008

Average annual solar radiation arriving at the top of the Earth's atmosphere is roughly 1366 W/m². Analysis of Total Solar Irradiance (TSI) data over the period 1878–1996 shows a long-term increase trend on 1 W/m², Krivova et al 2010 [6]. This is a huge amount of energy, taking into account the Earth's total land mass. Increase of TSI during this period of time is equal approximately 51 Terawatts (TW) power in second on Earth's surface. For comparison, currently, our civilization consumes around 17.7 Terawatts (in 2014) of power taken from all sources of energy, namely oil, coal, natural gas and alternative energies such as solar, wind, hydropower and others the World Counts,2014 [7]. Earth's average temperature rose by 0, 8 °C over this period. This coincidence has led us to hypothesis about the sun contribution to temperature trend.

Decadal and centennial-scale temperature anomaly variation and solar activity show good correspondence.

The main aim of present work is to verify the influence of solar activity on the Japan's surface.

2. Approach

Over the period 1878-1996 all weather stations in Japan show air temperature increase on 1.0-1.5°C.In this period was observed sunspots number increase on 40%.

The algorithm used to estimate solar radiation influence on temperature was developed by the Nurtaev, 2015, [8]. In order to determine the contribution of the Sun in temperature change we used the following method. One averaged solar cycle (sunspot cycle) is equal to one unit of measurement of solar activity and air temperature.

Relationships between evolution of the long-term mean air temperature and sunspots for one solar cycle can be calculated by comparison of following calculated values:

$$W = \frac{1}{n}\sum_{i=0}^{n} \mathrm{Wi} \quad (1)$$

$$T = \frac{1}{n}\sum_{i=0}^{n} \mathrm{Ti} \quad (2)$$

- where W – averaged sunspot number for one solar cycle; T – averaged air temperature for one solar cycle °C.

Our model describes temperature changes on time scales of decades to centuries that are due to the evolution of the sunspots. Models based on this assumption explain about 85% - 95% of all temperature changes observed in Japan on time scales of decades.

3. Long-term trends of temperature variability and solar radiation in Japan

Japan is an excellent test case given its remoteness from continents. Japan is surrounded on all sides by the sea. Isolation of Japan from continental landmass of Asia and ocean currents creates a specific climate system of the archipelago. Observations of Japan Meteorological Agency (JMA) show that annual average air temperatures nationwide rose by a rate equivalent to 1.15°C per century between 1898 and 2010.

Due to the large North South extension of the country, the climate varies strongly in different regions. The climate in most of the major cities, including Tokyo, is temperate to subtropic and consists of four seasons. The winter is mild and the summer is hot and humid. There is a rainy season in early summer, and typhoons hit parts of the country every year during late summer. The climate of the northern island of Hokkaido and the Sea of Japan coast is colder, and snow falls in large amounts. In Okinawa, on the other hand, the mean temperature of January is a warm 17 degrees Celsius.

Calculation of the temperature dependence from solar activity on the continents is complicated by many factors, such as global dimming, volcanic eruptions, orography and so on.

As presented in the study of Stanhill G. and Cohen Sh.2008, [9]: ”During the 20- th century sunshine duration in Japan increased by 10 %. Half of this increase occurred between 1900 and 1940 and was followed by a small and irregular decrease till 1950. Subsequently the increase of sunshine duration in Japan accelerated, especially since the mid 1980’s. This temporal pattern resembles the changes in the average air temperature both for Japan and more so for the Northern Hemisphere. The unknown mechanism coupling these two parameters merits further study”.

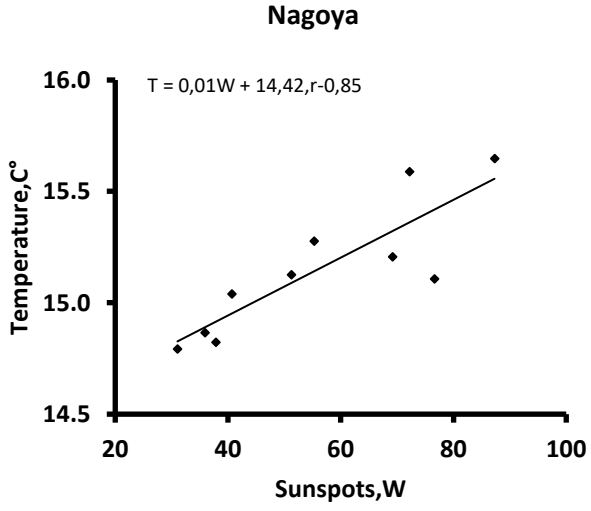
Global dimming is the gradual reduction in the amount of global direct irradiance at the Earth's surface that was observed for several decades after the start of systematic measurements in the 1950s.Global dimming worldwide it has been estimated to be of the order of a 4% reduction over the three decades from 1960–1990. It has been estimated that solar dimming due to rising aerosol concentrations in the atmosphere due to human action.

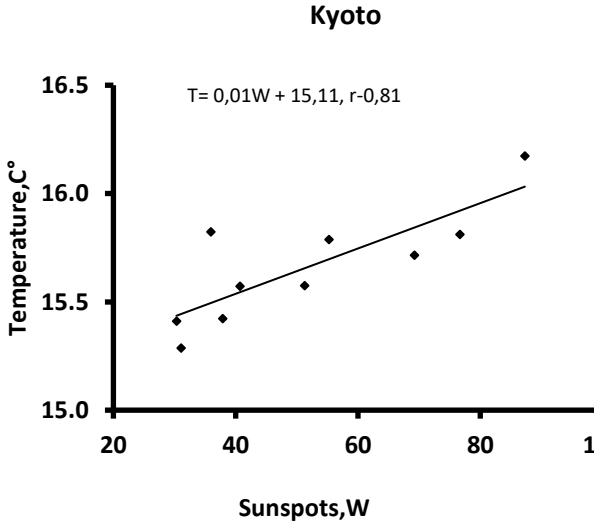
The uniqueness of Japan as object of study of influence of solar activity on temperature is lack of global dimming. The absence of the widely reported global dimming phenomenon has a regional aspect.

I n order to avoid numerous errors such as intracyclic fluctuations, lag of air temperature changes through thermal inertia of the oceans water we averaged observed sunspots and measured air temperature for one solar cycle. Annual values of data measured in Japan between 1878 and 1996 were used as a proxy for air temperature to study trends and changes in solar forcing at the Earth’s surface.

Temperature change on the weather station in simplified form can be conceived as a process of solar radiation warming the surface during the day and the surface radiating that heat back out at night. On this process also is superimposed the process of heating from surrounded areas, mass transfer of heat by wind (westerlies and easterlies), as well as with some lag time a heat transfer from the upper layers of the ocean.

Our study show the temperature change has a positive correlation with solar activity almost the entire area of Japan (Fig.2,3).The exception is the middle and northern part of the Hokkaido Island possibly due to volcanic activity of the Kuril Islands.





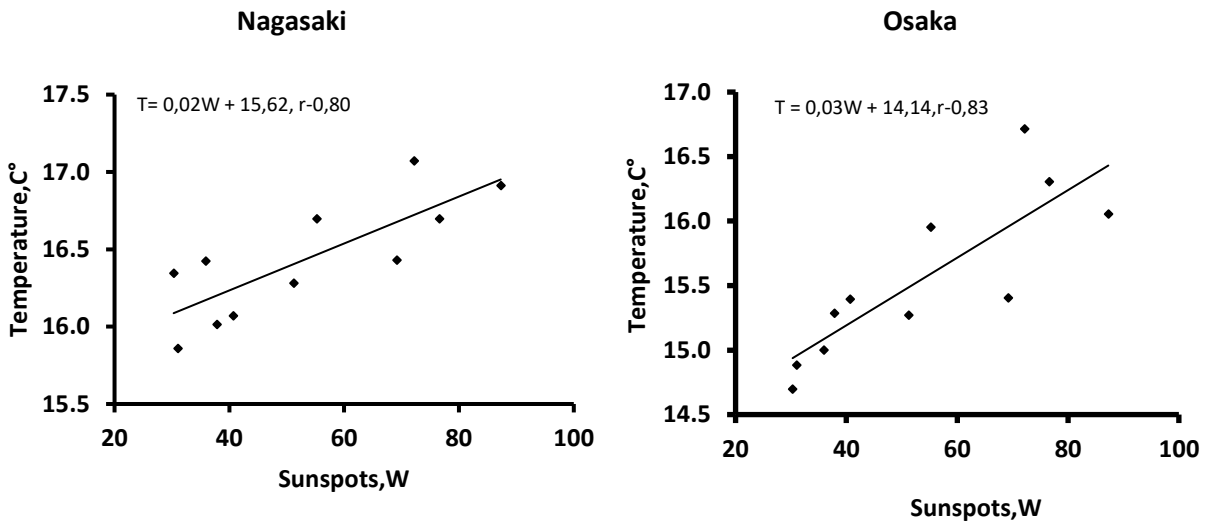
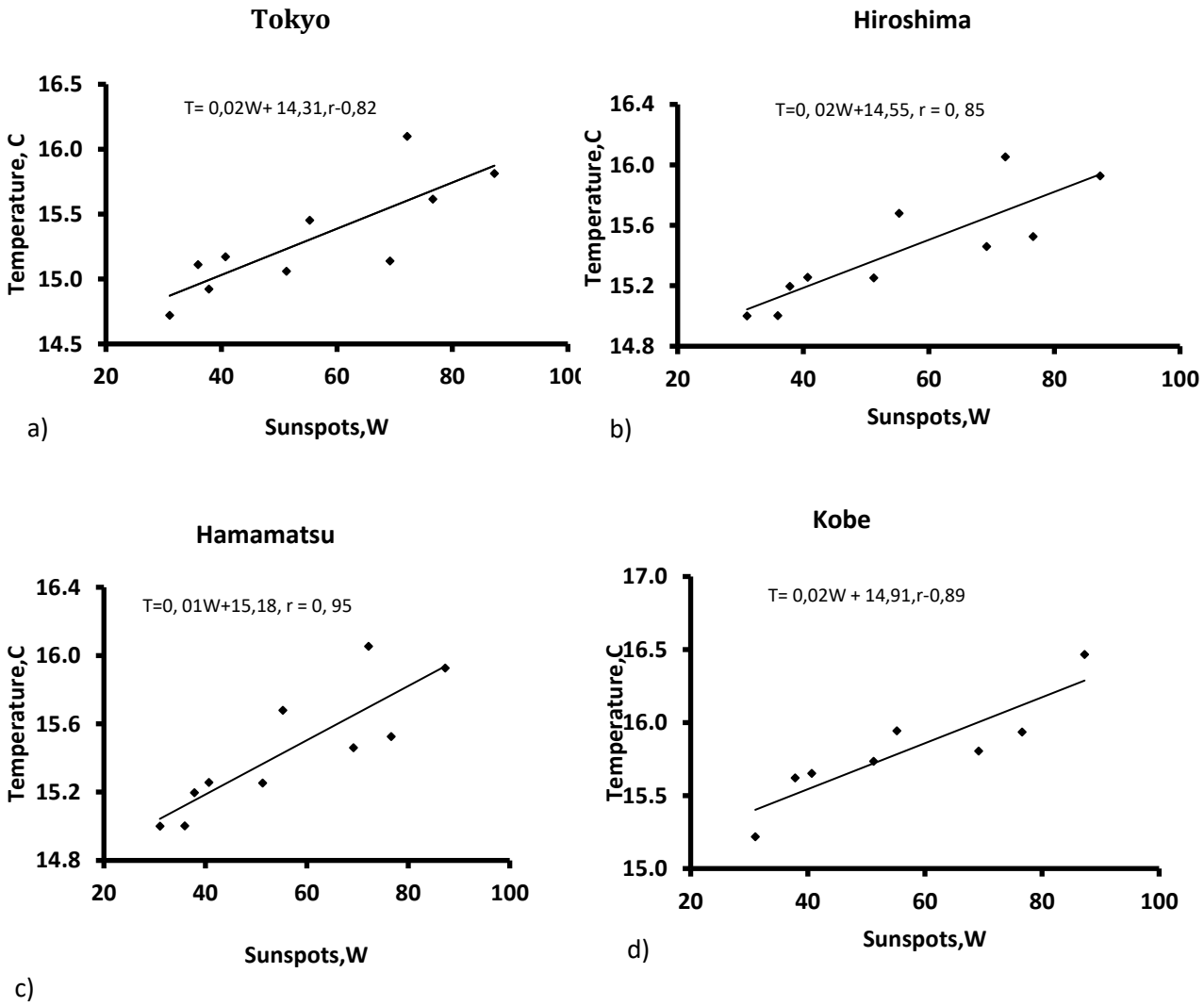


Fig. 2. Relationships of air temperature of different weather stations of Japan from solar activity over a period of many years 1878-1996.

Where - T air temperature in C°, W-sunspots number, r - coefficient of correlation.



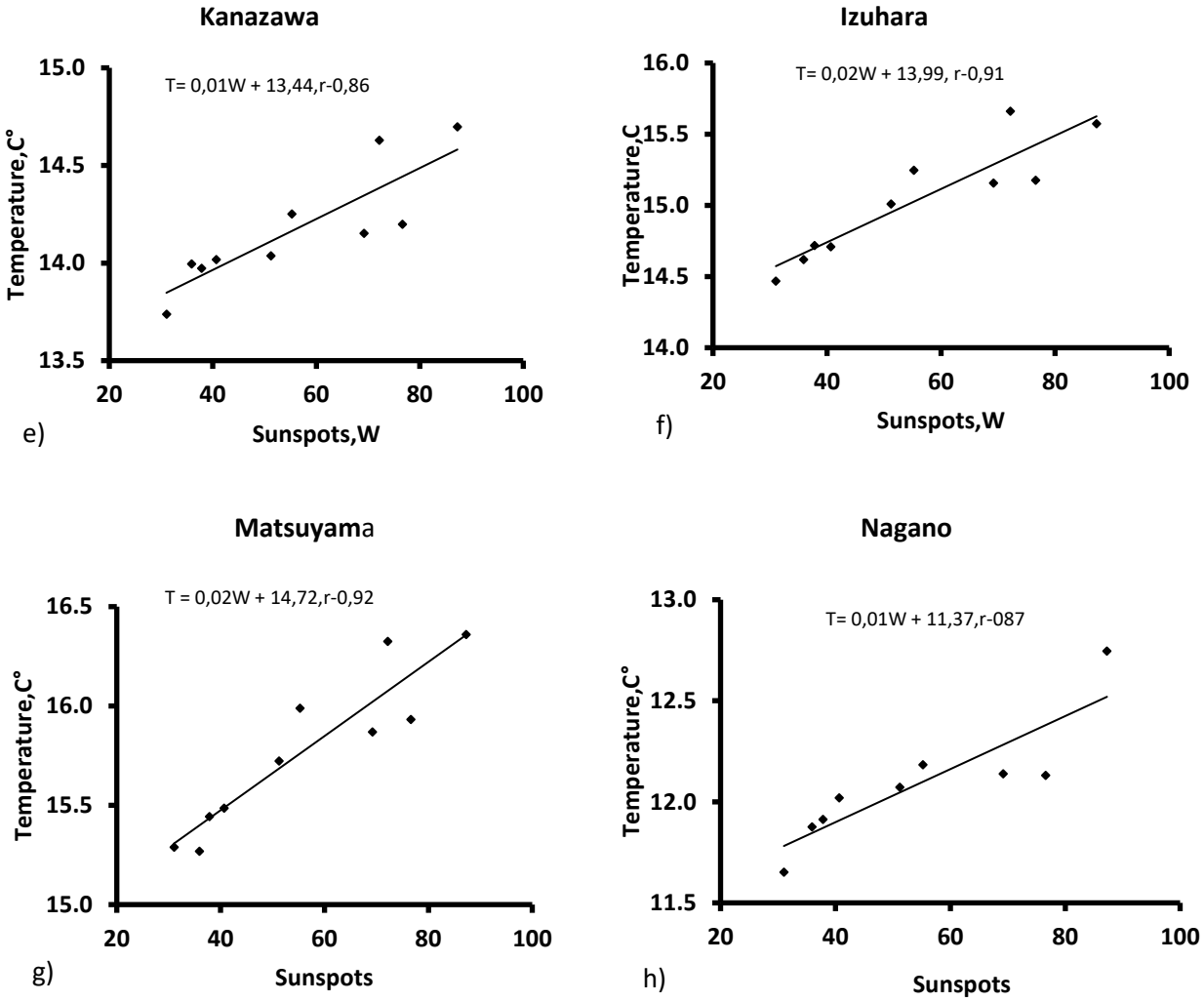


Fig. 3. Relationships of air temperature of different weather stations of Japan from solar activity over a period of many years 1890-1996.

Where - T air temperature in C°, W - sunspots number, r - coefficient of correlation.

3. Discussion

Climatic changes on the Earth everyone become more obvious. And the reason of them is not industrial activity of the mankind. It is possible even, what not warming is caused by a greenhouse effect, and, on the contrary, the greenhouse effect is caused by warming of a climate, event because of changes of various space and geomagnetic influences on our planet. For last two millennium Europe has gone through three climatic epoch with respective alterations of solar activity: VIII-XII centuries (a small climatic optimum); XIII-XVIII centuries (a small glacial age); since XIX century till our days (warming of a climate). The coldest time of this period - with 1645 for 1715. The cause of all of the above variables was the solar radiation and indicator of the sun activity is sunspots.

Despite the relevance of the topic: it is not much literature published in world about sun climate model. Together with the thesis how humanity is altering climate it is important to realize that solar variation may play significant role in the background natural variability.

Clearly also that we observe influence of sun on climate (day-night, summer-winter, equatorial-polar temperature), but have no definitive method for evaluation of this connection.

4. Conclusion

Based on the NASA raw series of the annual surface air temperatures from 1878 to 1996 it was found statistically significant relationships between the air temperatures on the one hand and the sunspots on the other hand.

During the study we developed a module for quantifying solar activity and surface temperature interaction.

Particular importance was to quantify to choose length and to derive adequate parameterizations of these quantities as a function of temperature control parameters. All these ingredients were imposed in a set of empirical equations for available weather stations of Japan with observations period at least 100 years for finding temperature trends for further forecasting of surface temperature.

Thus, naked- eye sunspot observations can be taken as a reliable basis for studying the processes taken place in climate change.

In accordance with NGDC forecasting the solar cycles 24 and 25 will be very weak NGDC–NOAA National Geophysical Data Center, 2009, [10].

Averaged sunspot numbers were calculated as W = 35 for the solar cycle 24 and for the solar cycle 25 less than W = 35, NGDC (2009). This actually will lead to a decrease of the temperature in all studied cities on 1-1, 5°C in the both averaged solar cycles.

References

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

[2] Georgieva K. A relation between solar activity and temperature in Northern hemisphere in the period 1881-1988, Bulg. Geophys. J., 3, 1998, pp. 114-119.

[3] Lean J., Beer J., Bradley R. Reconstruction of solar irradiance since 1610: implications for climate change. Geophys. Res. Let., 22, 1995, pp. 3195-3198.

[4] Cliver E.W., Boriakoff V., Bounar K.H. Geomagnetic activity and the solar wind during the Maunder Mini Minimum. Geophys. Res. Lett. 25, 1998, pp. 897-900.

[5] Ring D. H., Lean J., Lonegran P., Shindell D. On the relative importance of solar and anthropogenic forcing of climate change and ozone between the Maunder minimum time period and today, American Geophysical Union, Spring meeting 2002, Abstract GC41B-02.

[6] Krivova N. A., Vieira L.E.A., Solanki S.K. Reconstruction of solar spectral irradiance since the Maunder Minimum. Journal of Geophysical Research (Space Physics), 15, A12112, 2010, 11 p.

[7] The World Counts, 2014, http://www.theworldcounts.com/stories/current_world_energy_consumption

[8] Nurtaev B. Influence of climate variability on large rivers runoff. Proc. IAHS, 371, 2015, pp. 211-214.

[9] Stanhill G., Cohen Sh. Solar radiation changes in Japan during the 20th century: Evidence from sunshine duration measurements. Journal of the Meteorological Society of Japan, Vol. 86, No. 1, 2008, pp. 57–67.

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

ჰელიოკლიმატოლოგია იაპონიაში

ბ.ს. ნურტაევი

რეზიუმე

სტატიაში განიხილება იაპონიაში ჰაერის ტემპერატურის ცვლილებები და და მათი კავშირი მზის აქტივობის ინდექსებთან. გაანალიზებულია ჰაერის ტემპერატურის ცვალებადობა სხვადასხვა მეტეოსადგურებზე მთელს იაპონიაში ასობით წლების განმავლობაში მზის აქტივობასთან კავშირში და გამოვლენილია მაღალი დადებითი კორელაცია ტემპერატურულ ტენდენციებსა და მზის ლაქების რაოდენობას შორის. კვლევა დაფუძნებულია ჰაერის ტემპერატურასა და მზის ლაქებზე ინსტრუმენტული დაკვირვებების მონაცემებზე ერთი და იგივე დროს.

Гелиоклиматология в Японии

Б.С. Нуртаев

Резюме

В статье рассматриваются изменения температуры воздуха в Японии и их связи с индексами солнечной активности. Проанализирована изменчивость температуры воздуха на различных метеостанциях по всей Японии в течение сотен лет в зависимости от солнечной активности и обнаружена высокая положительная корреляця между температурными тенденциями и количеством солнечных пятнен. Исследование основано на базе данных инструментальных наблюдений за температурой воздуха и солнечными пятнами за одно и то же время.