# The Climatic Conditions of the Solar Industry Development in Lower Volga Region

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The article discusses the assessment of climatic conditions for the solution of problems of solar energy, especially spatial and temporal distribution of the radiation regime on the territory of Lower Volga.


Solar panels in Madrid, Spain


Ouarzazate Solar Power Station, Morocco


Sunsynchronous Solar panels, California

Insolation is the short-wave fluxes incoming from the Sun to the ground. This energy is in the form of electromagnetic waves as known as solar radiation. The unit of measurement of radiation is watts per square meters ($W/m^2$).

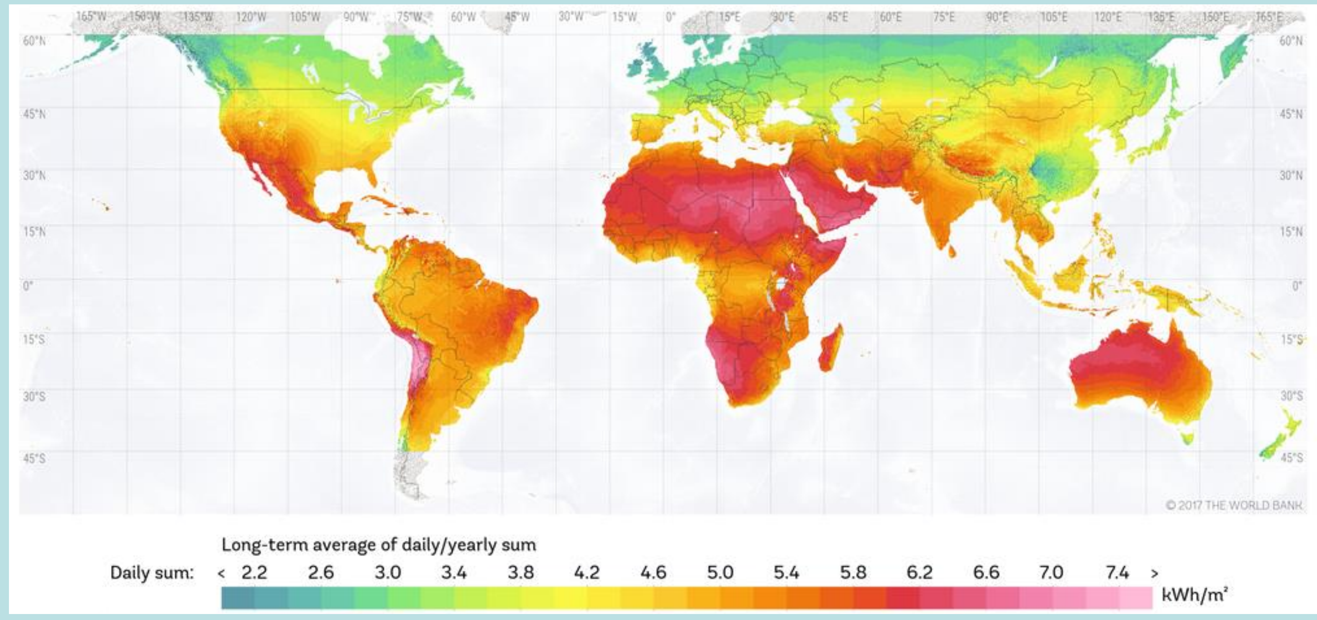
The study and measurement of solar insolation have several important applications, including the prediction of energy generation solar power panels, the heating and cooling of construction and buildings. Information about solar insolation uses for climate modeling and weather forecasting.

**Types of solar insolation:**

**Direct Normal Insolation (DNI)** is measured at the surface of the Earth at a given location with a surface element perpendicular to the Sun. Direct irradiance is equal to the extraterrestrial irradiance above the atmosphere minus the atmospheric losses due to absorption and scattering.

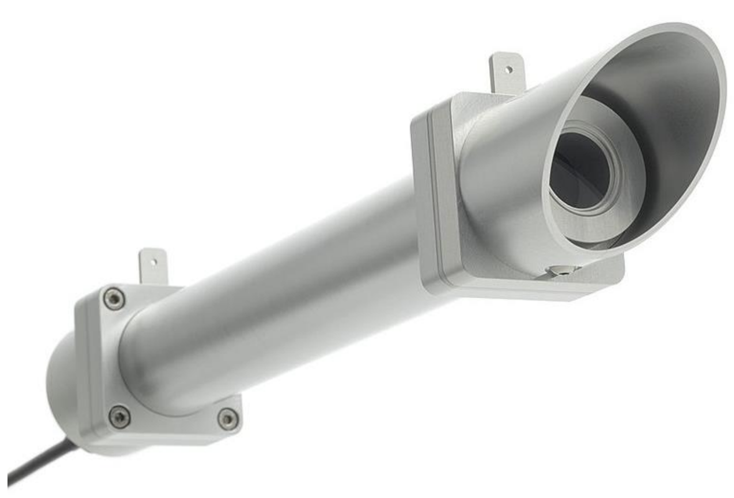
**Diffuse Horizontal Insolation (DHI)** is the radiation at the Earth's surface from light scattered by the atmosphere. It is measured on a horizontal surface with radiation coming from all points in the sky excluding DNI

**Global Horizontal Insolation: GHI=DHI+DNI*cos(z)**




**There are several methods for monitoring solar insolation:**

1. Ground meteorological observation, which uses special equipment for measuring direct and diffusion solar radiation incoming from sky.
2. Measuring short wave fluxes from satellite scanners and radiometers.


A pyrheliometer, used to measure Direct Normal Insolation


A pyranometer, used to measure global irradiance

The most useful archive for detailed analyses of insolation reason is CERES (Clouds and the Earth's Radiant Energy System) derived from NASA satellite "Aqua". This archive contains annual and mean monthly data of solar insolation, clouds etc. (et cetera). Spatial (geographical) resolution of each climatic values is 1.5 degrees. In this case, we analyzed about 600 values of insolation for Saratov region.

**Annual and seasonal variation of solar insolatioat the Earth's surface during 2012 - 2017 in Samara (Fig.1) and Petropavlovsk – Kamchatsky (Fig. 2)**

**The correlation coefficients between solar insolation at the Earth's surface during 2012 - 2017 in Samara (Fig.3) and Petropavlovsk –Kamchatsky (Fig. 4)**

Fig. 1

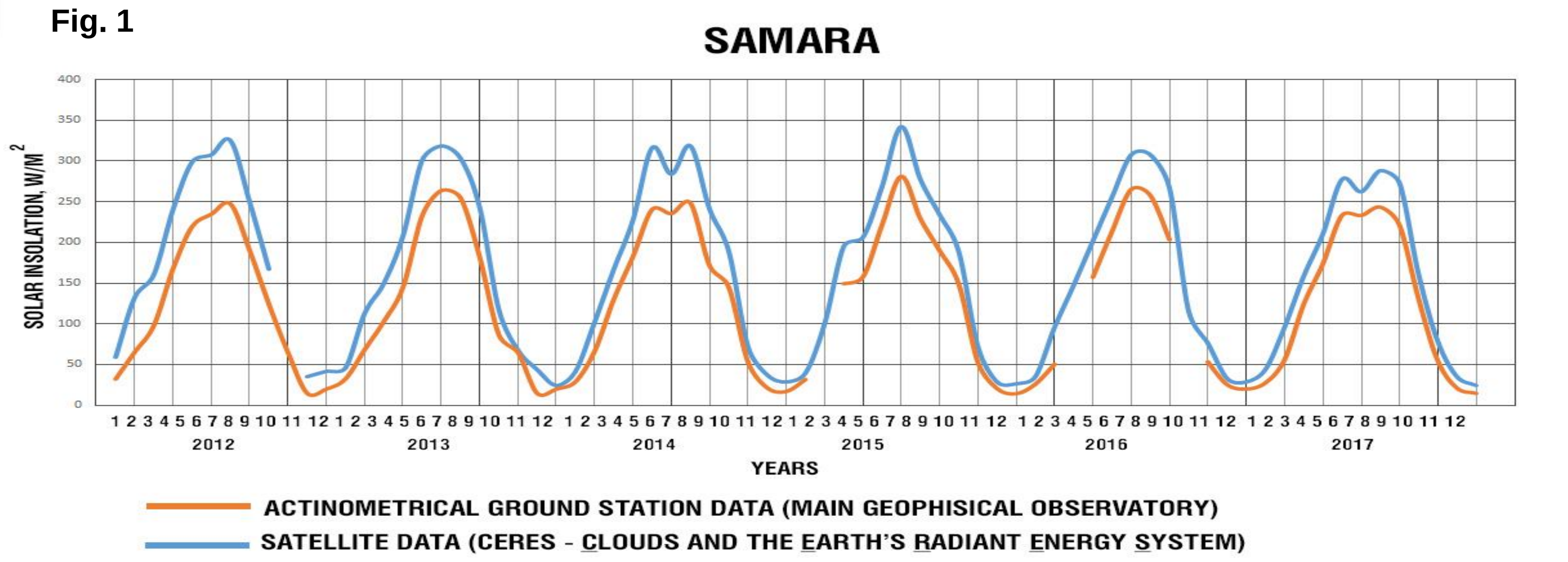



Fig. 3

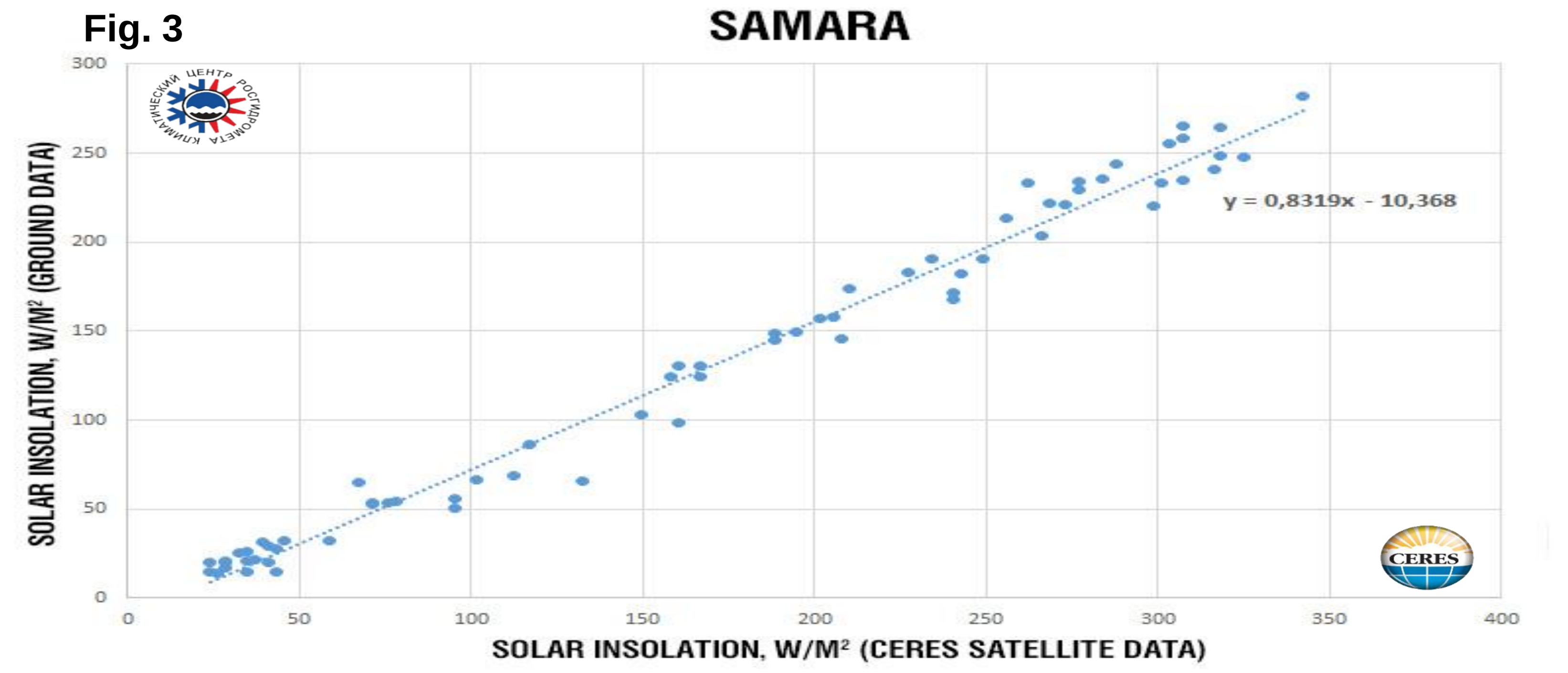



Fig. 2

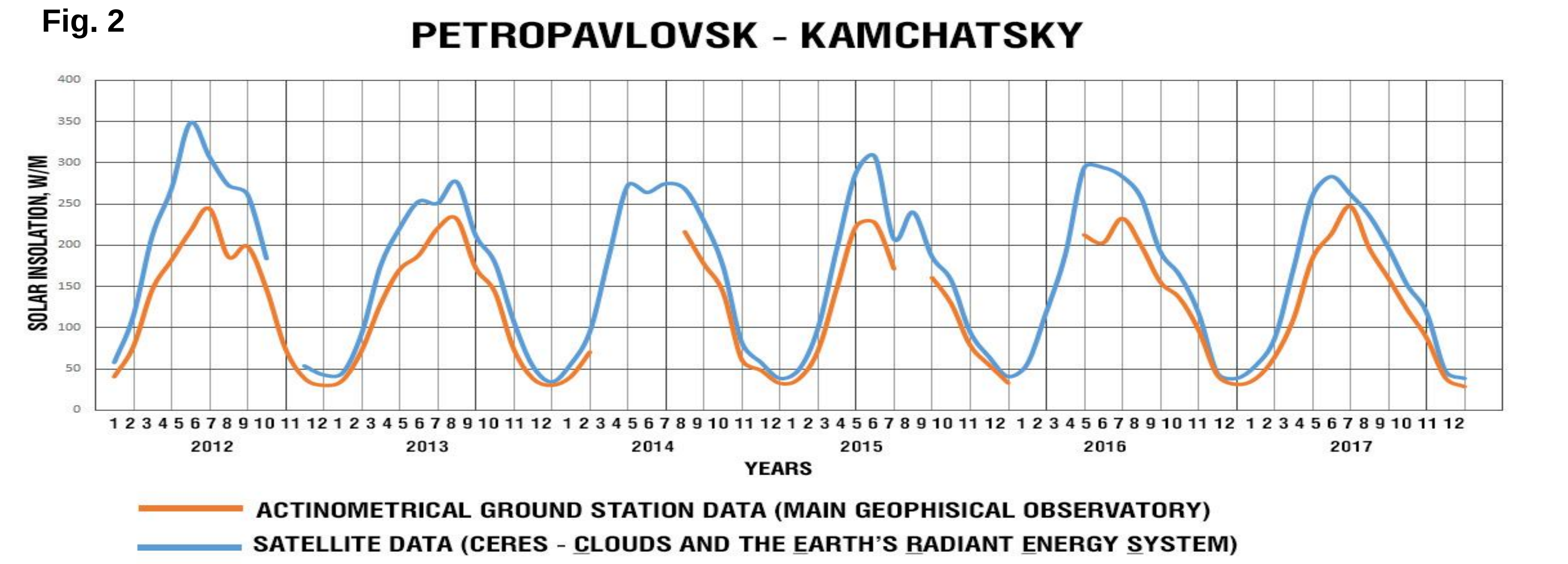
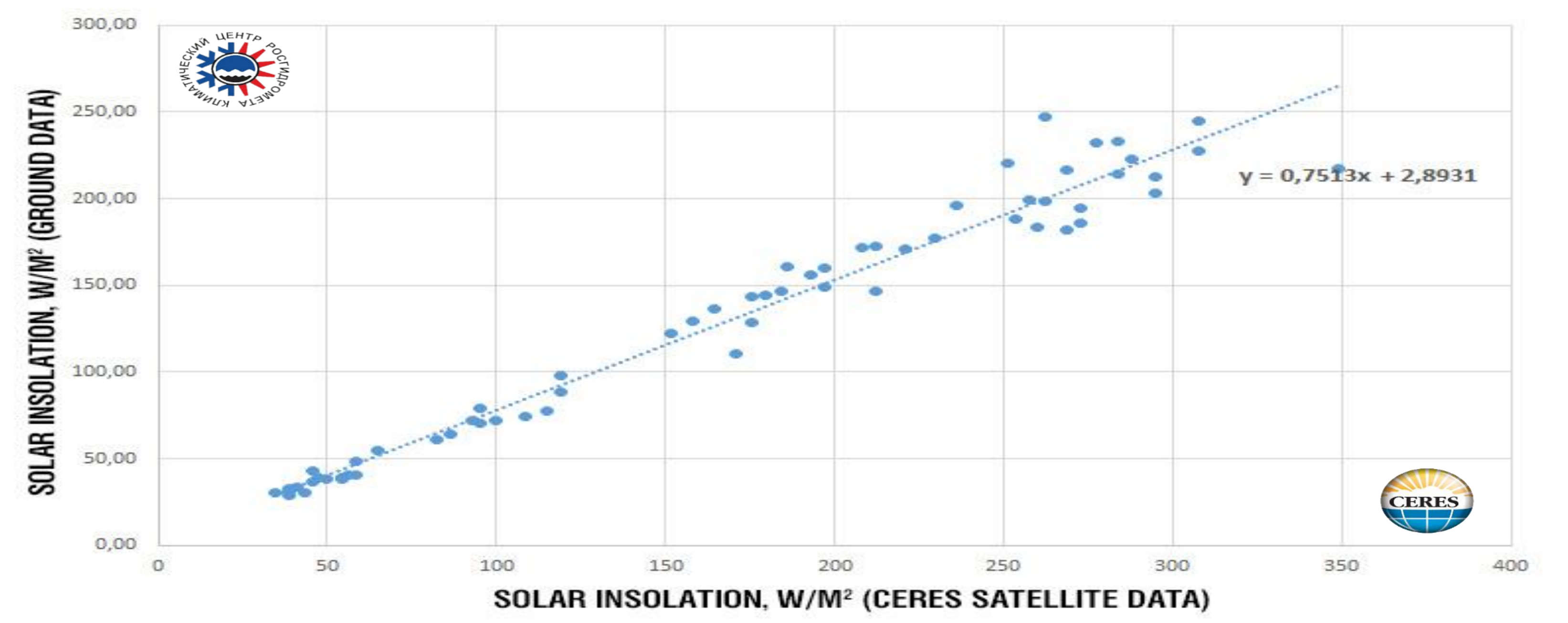


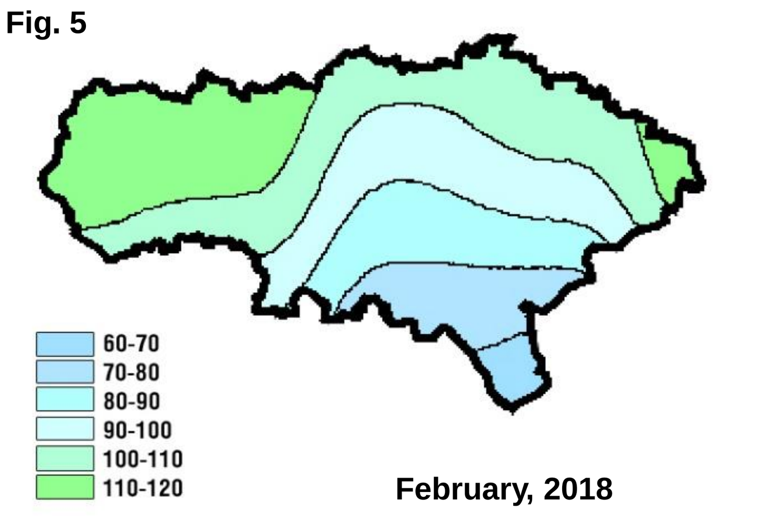

Fig. 4




Satellite data were compared with reference ground values for Samara and P.-Kamchatsky (ground meteorological database from WRC). This comparison has shown good correlation. For P.-Kamchatsky coefficient of correlation is 0.99 and 0.94 for Samara. It means that CERES data can be used for estimate regime of incoming solar radiation in Saratov region.

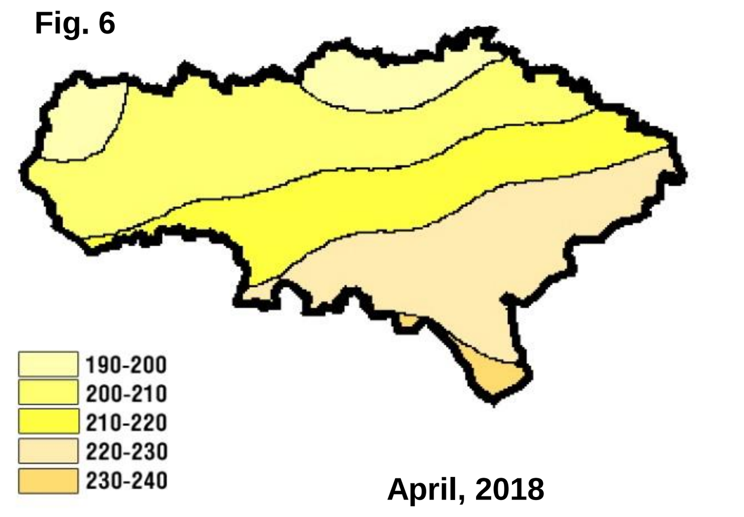
**Maps of monthly averaged values of insolation ($W/m^2$) during 2018 in Saratov region**

Fig. 5



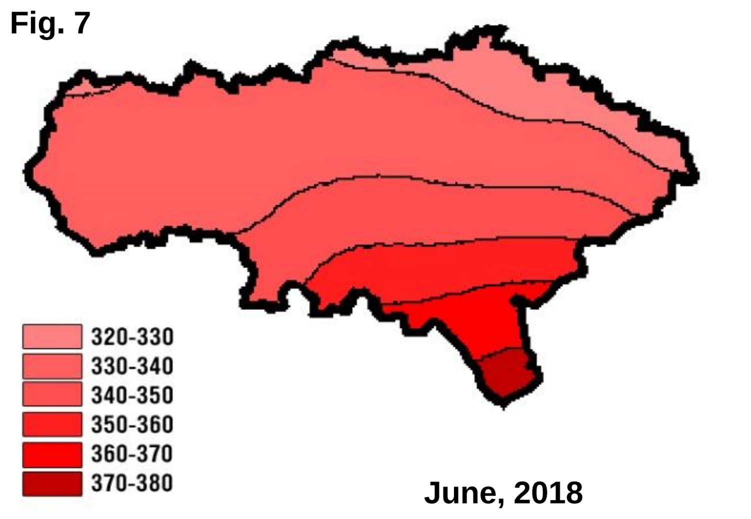

February, 2018

Fig. 6



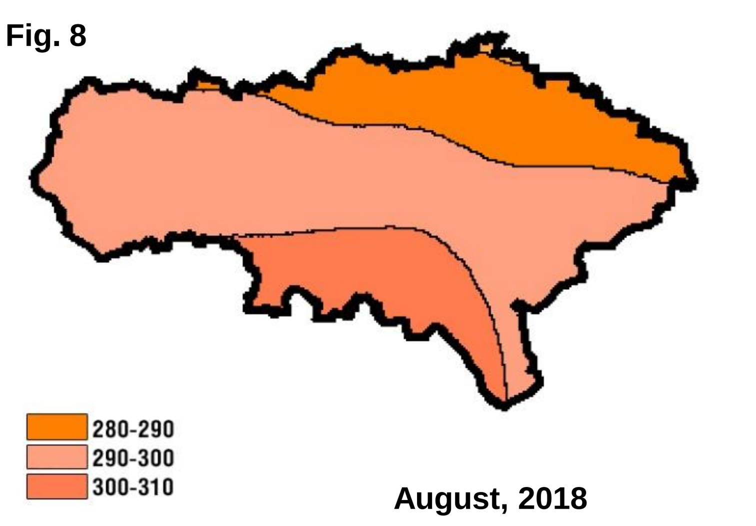

April, 2018

Fig. 7



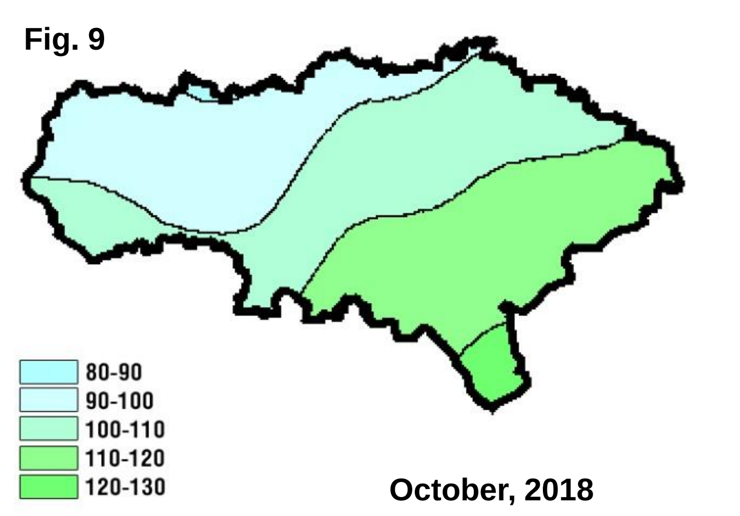

June, 2018

Fig. 8



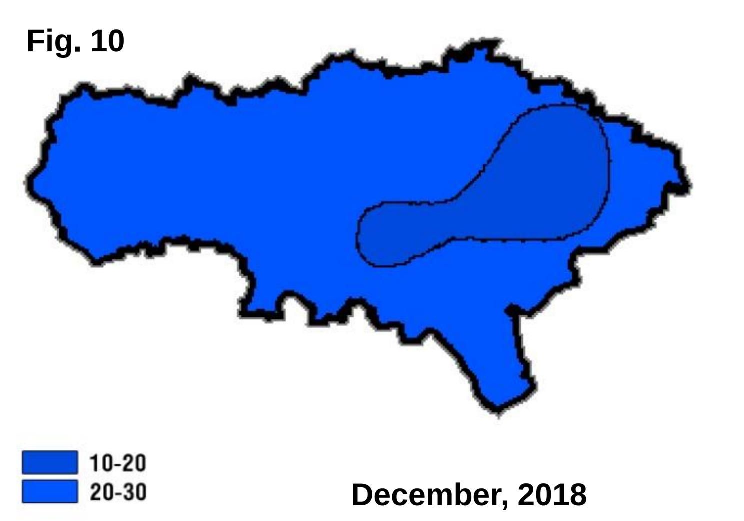

August, 2018

Fig. 9




October, 2018

Fig. 10




December, 2018

In interpolation satellite data and creation of maps were used MapInfo program. It was created 12 monthly maps of solar insolation for our region.

6 maps demonstrate annual variation of isolation. It can be seen differences between the warm and cold seasons.

The biggest values of ground solar radiation are observed in the summer months. Values of insolation in June ranges from about 320 to 380 $W/m^2$ (Fig. 7).

Distribution of energy is not always having a latitudinal character, which can be explained by cloudiness and other weather features. The highest insolation values are observed in the south of the Saratov region in the Algay district.

The smallest values of ground solar radiation are observed in the winter months. For example, values of insolation in February is not more than 30 W/m2 (Fig. 10).

**Solar energy has a strong spatial and temporal variability, so it is very important to study it to assess the possibility of power panels.**