Formation of a polar magnetic field in solar cycle 24

Information about the Kislovodsk Astronomical Station

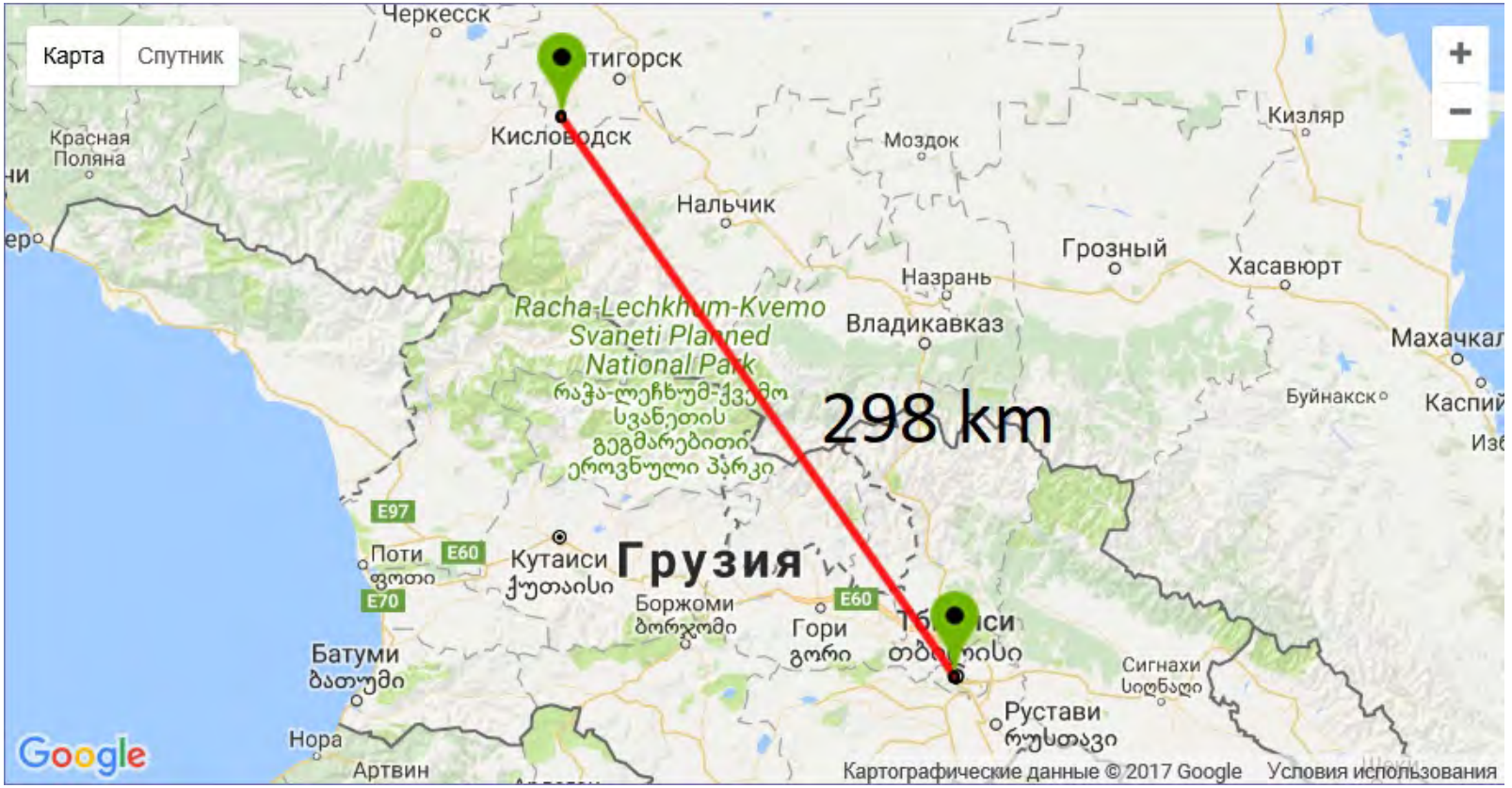
Evolution of regions with an open magnetic flux over 130 years

A.G. Tlatov

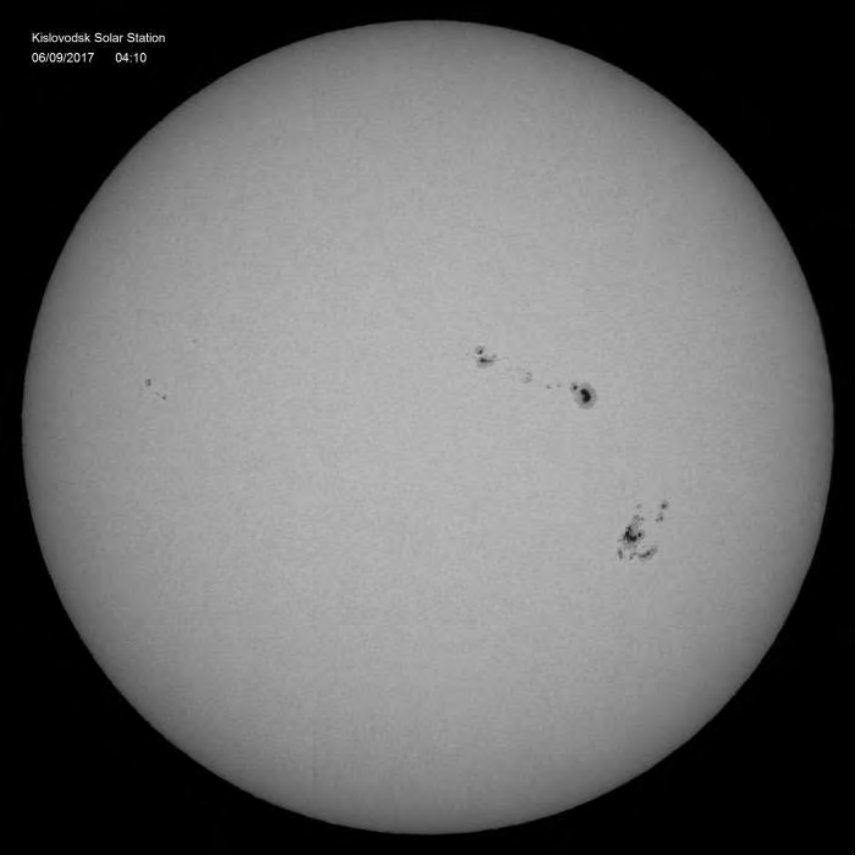
Kislovodsk mountain astronomical station

of the Pulkovo obsrervatory, Russia

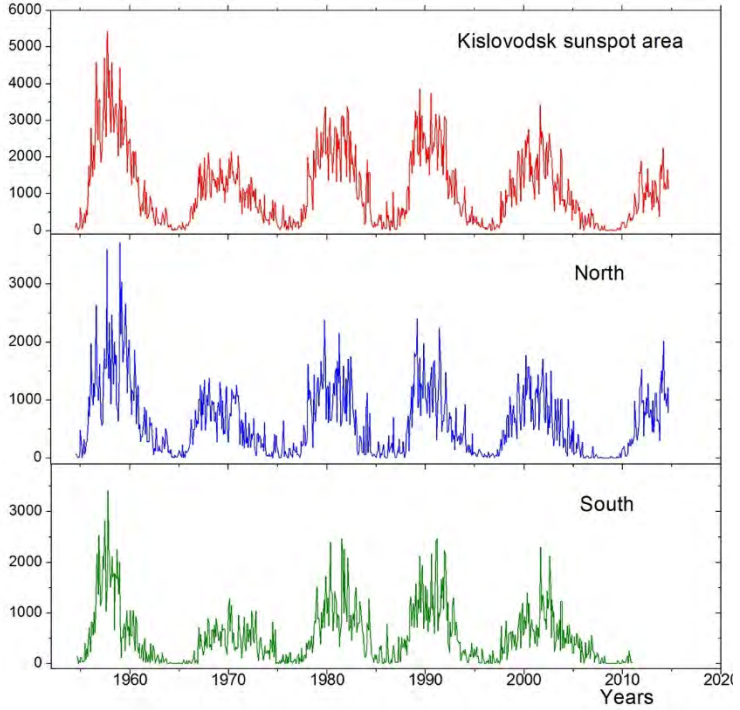
September 25-29, 2017, Tbilisi, Georgia

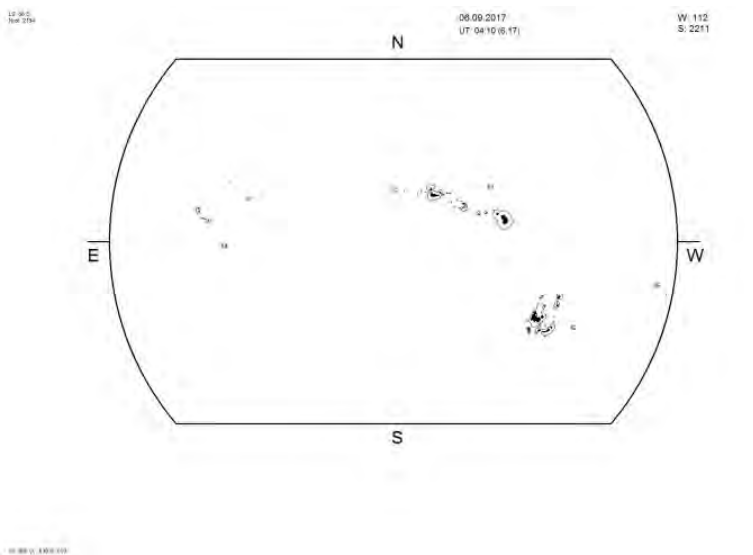


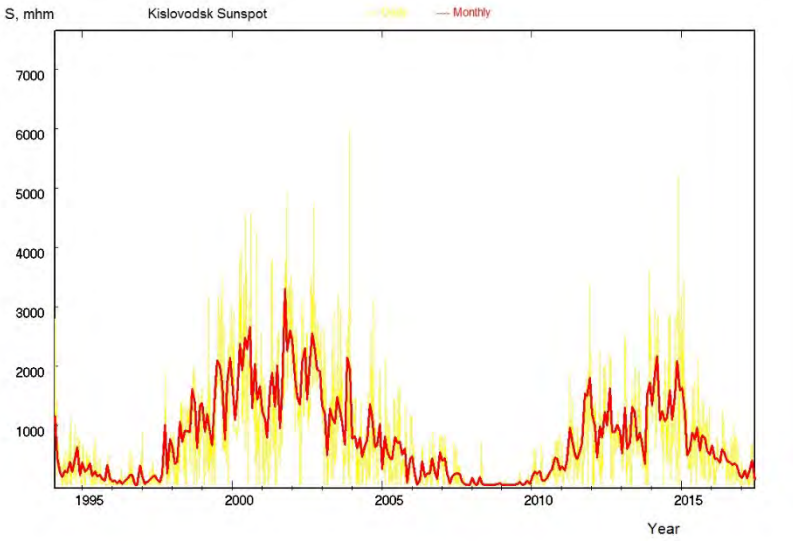
The Kislovodsk mountain astronomical station was founded in 1948, at an altitude of 2,096 meters.
Observations: Predominantly synoptic observations of the Sun



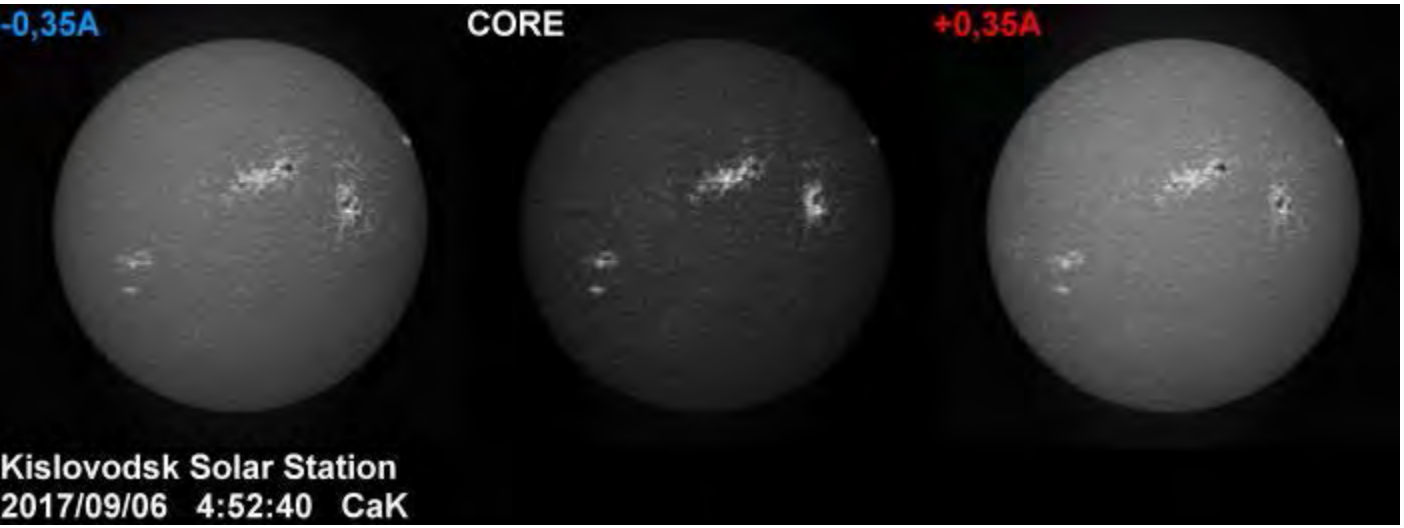
Observations of sunspots since 1948
The best stability of areas of sunspot groups.

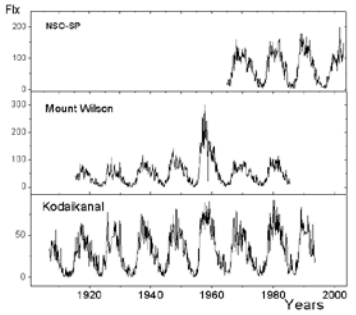


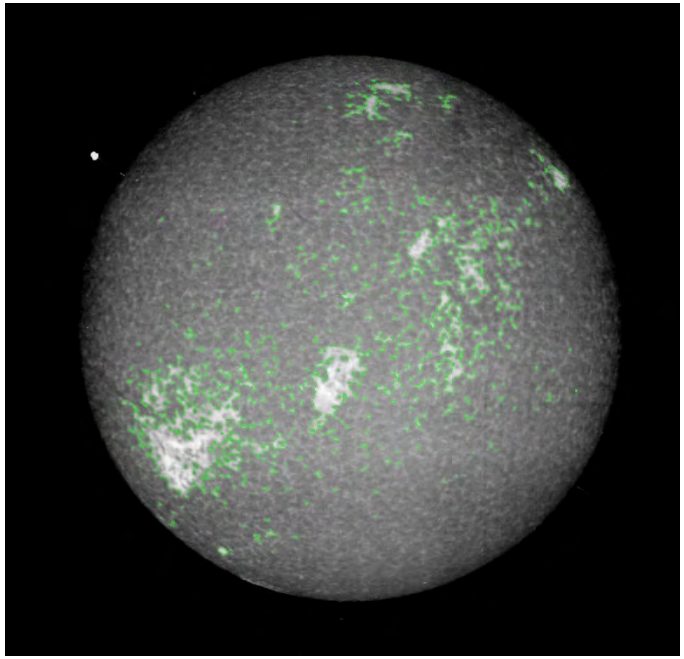


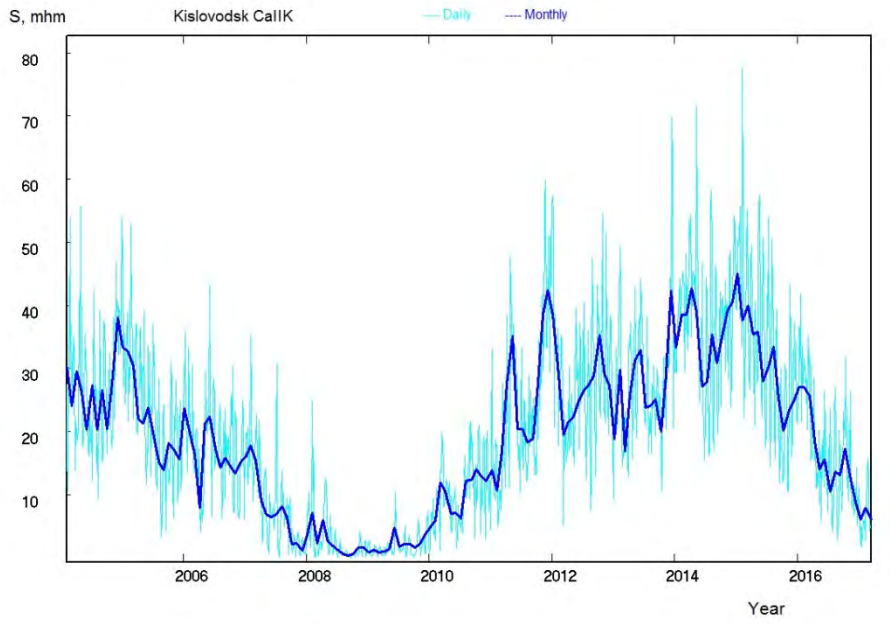


Observations in the CaIIK line since 1957

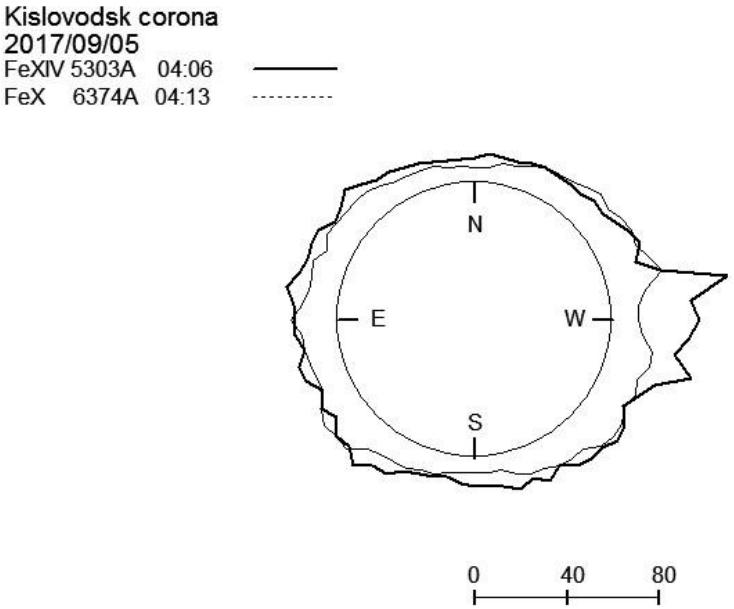


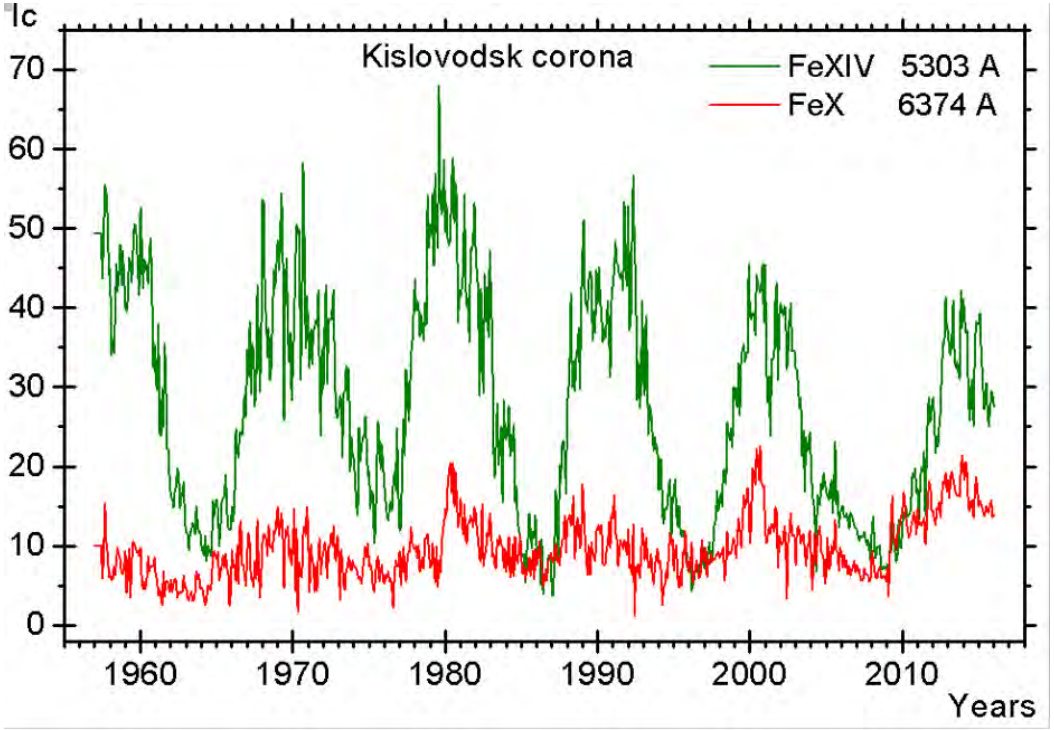




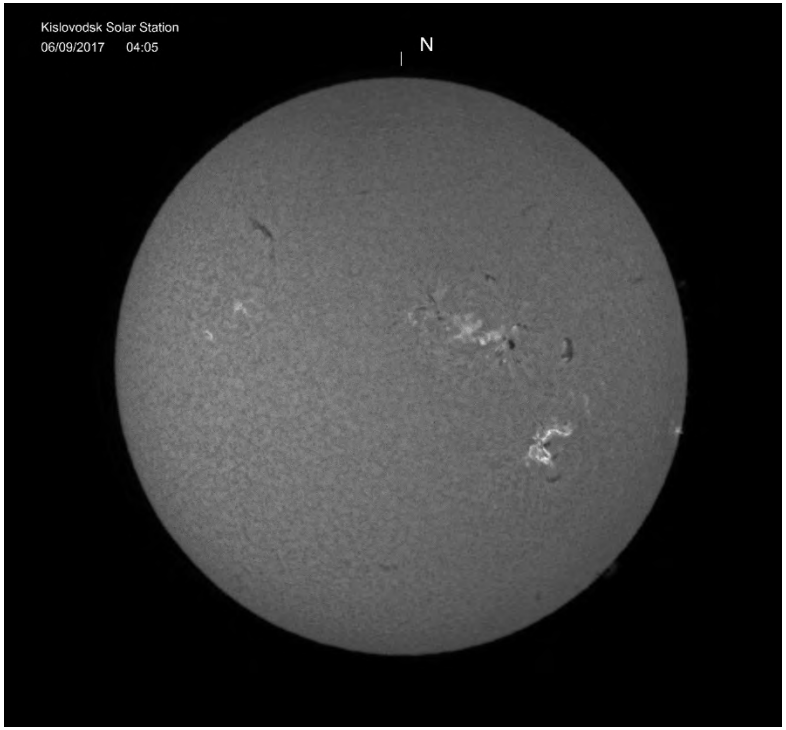


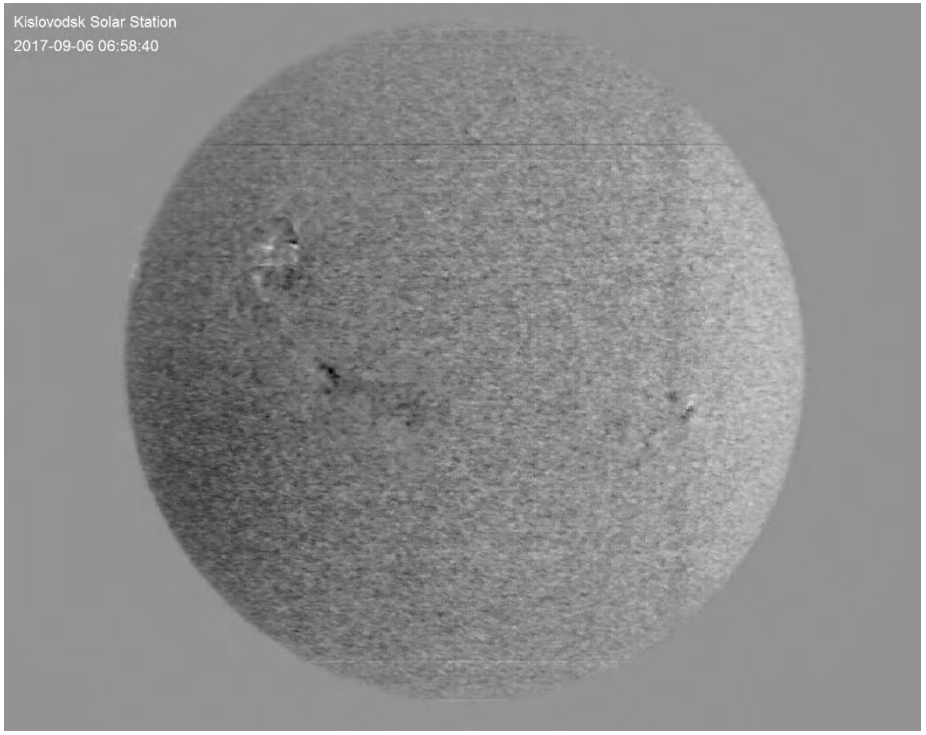
Observations of the solar corona in lines 5303A and 6374A



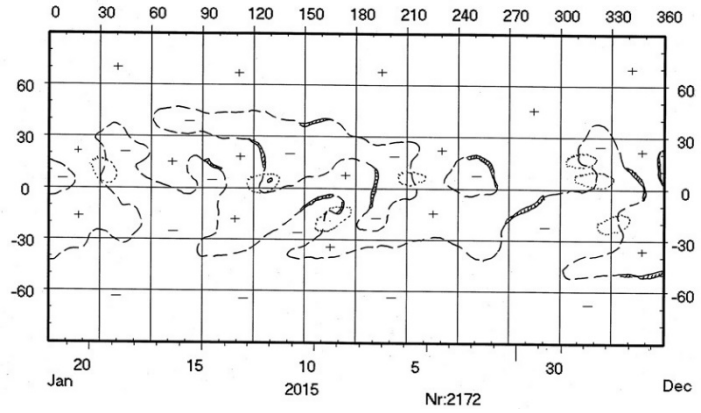


Observations in the H-alpha line of 1957-

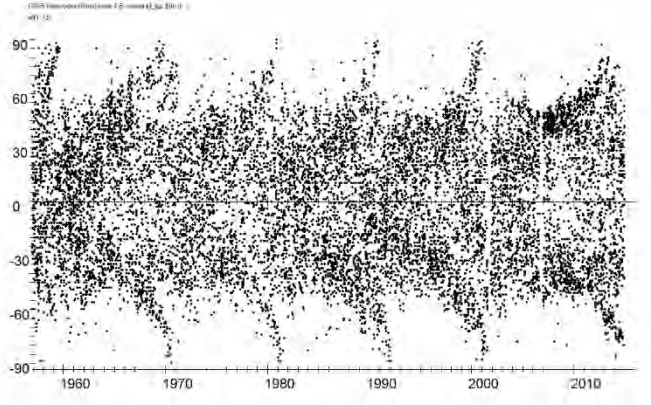




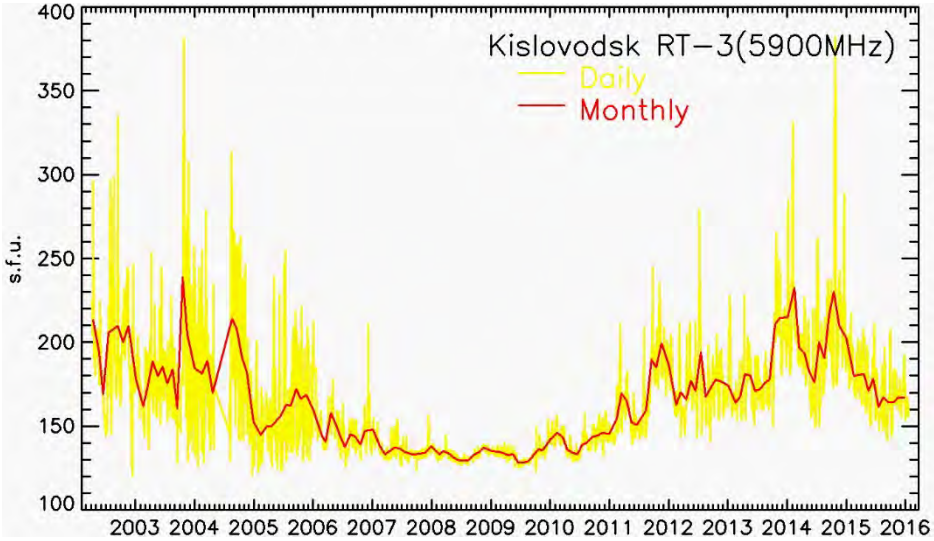
Filter observations



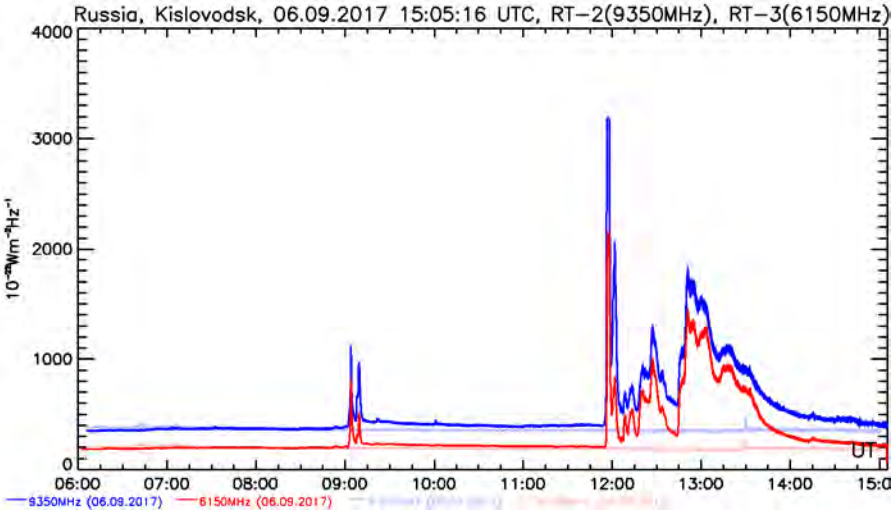
Patrol spectroheliograph allows you to determine the speed of the CMS.

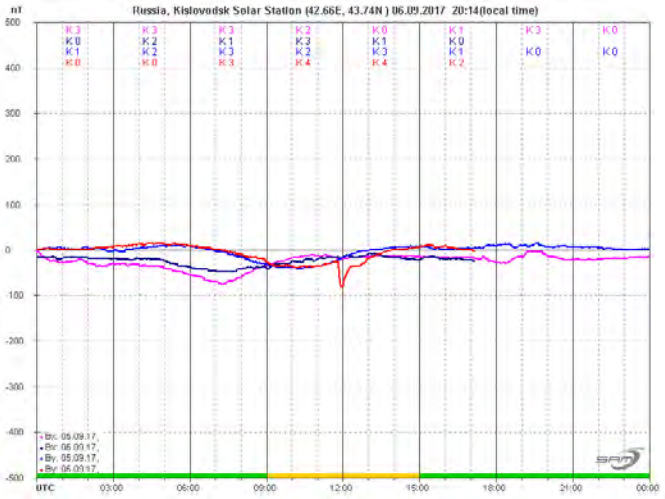


Observations by radio telescopes at waves of 5 and 3 cm.



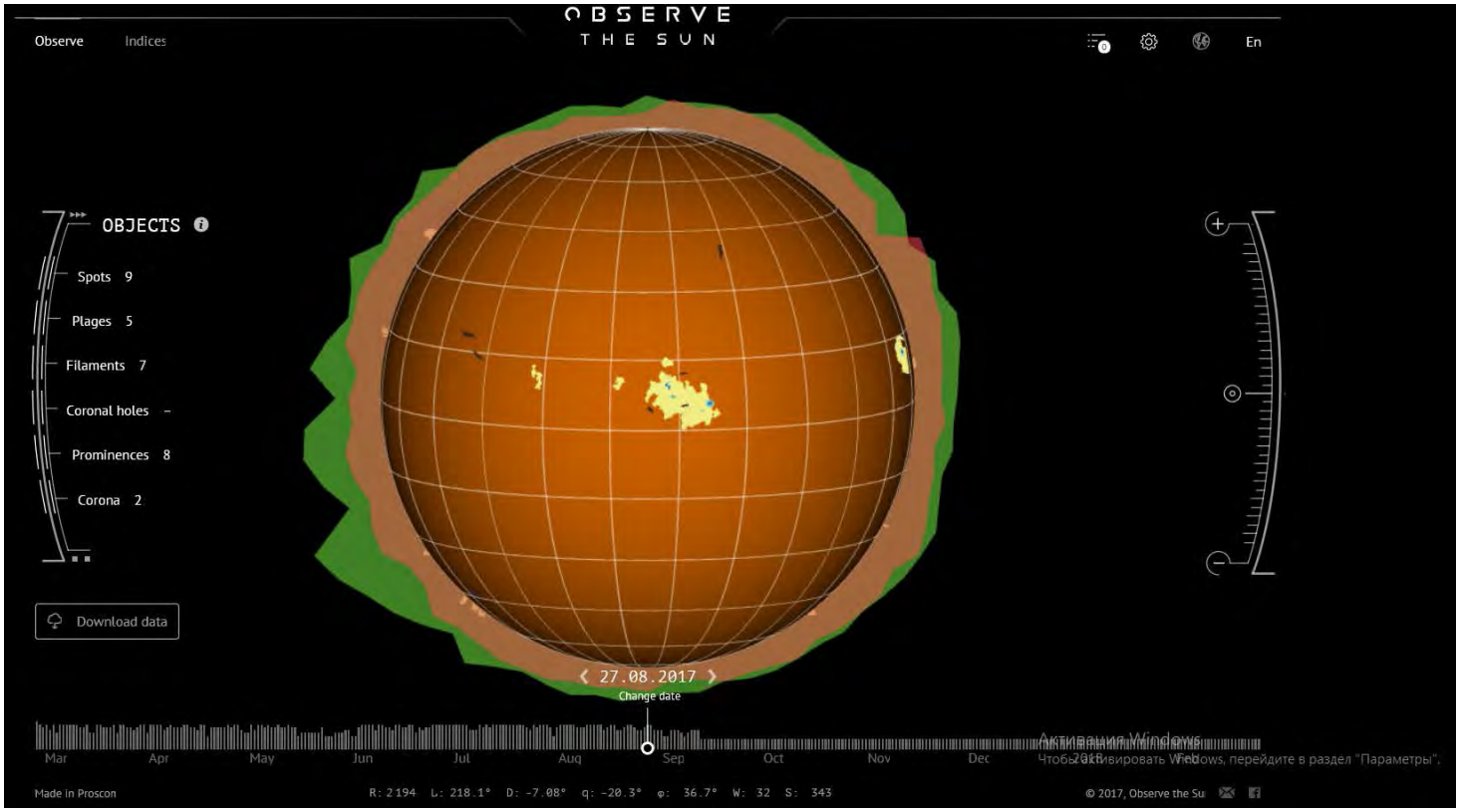
Flares 06.09.2017

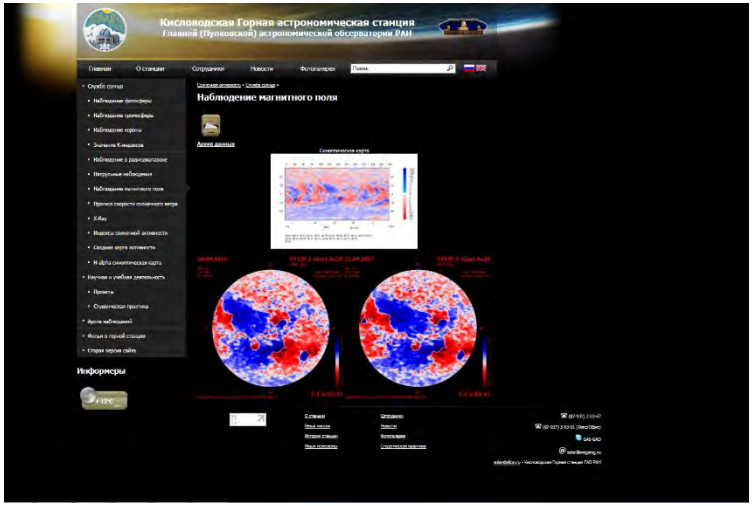


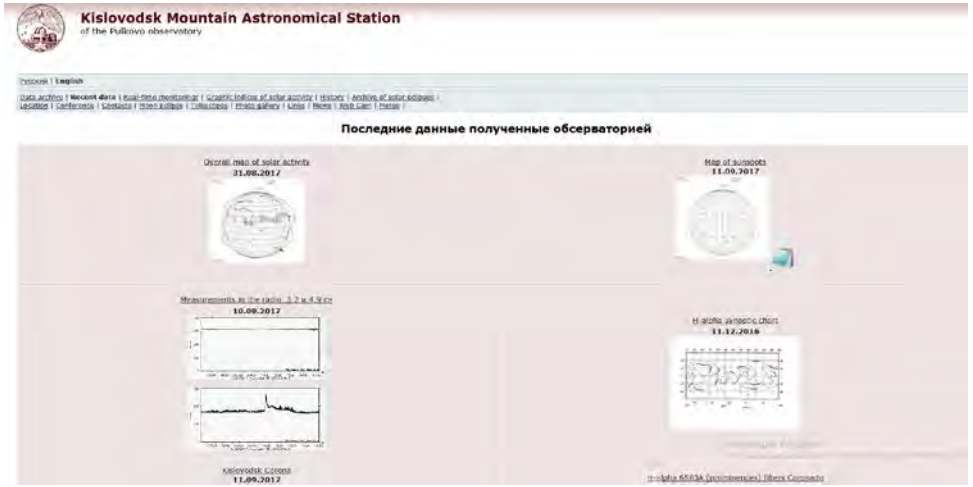


Magnetometer. Crash effect 06.09.2017

Internet pages of the Kislovodsk observations







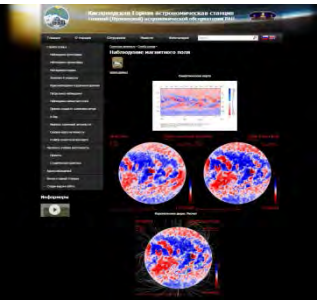
Observations of space weather drivers.

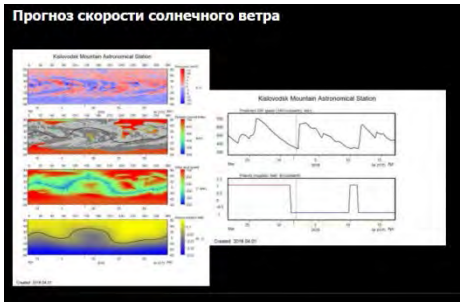
Magnetograph, observation of flares and coronal mass ejections in the optical range.

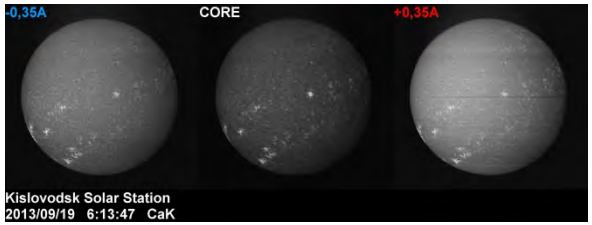
1) Observations of large-scale magnetic fields of the Sun on the STOP telescope (from July 1, 2014)

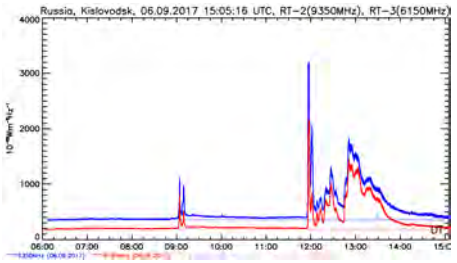
2) Observations of flares and coronal mass ejections on patrol telescopes (from July 2012)

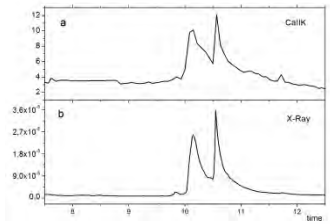
3) Monitoring flares on radio telescopes







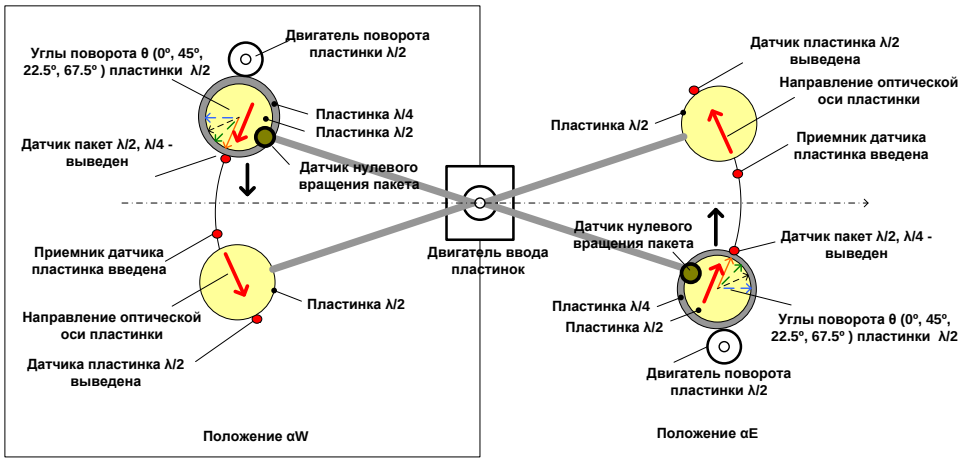




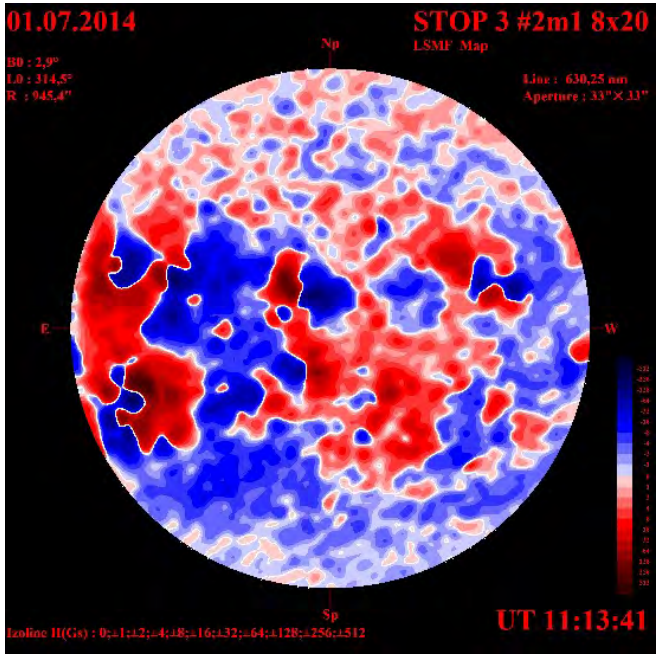
All these observations are processed online.

http://solarstation.ru/

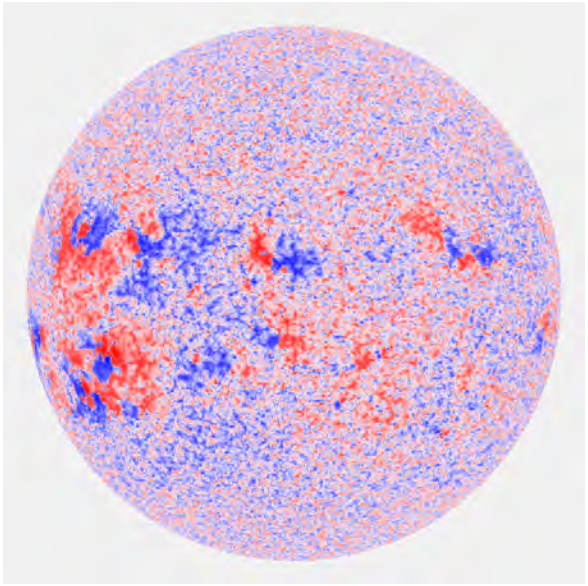
The STOP magnetograph of the original design allows observing the full disk of the Sun with a sensitivity of ~ 0.4 G.



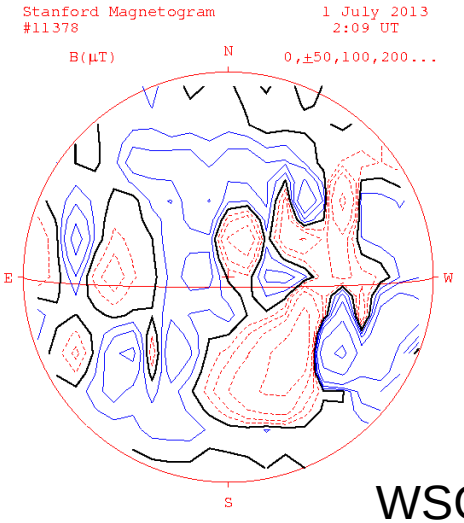
Comparison daily magnetic field maps 01.07.20014



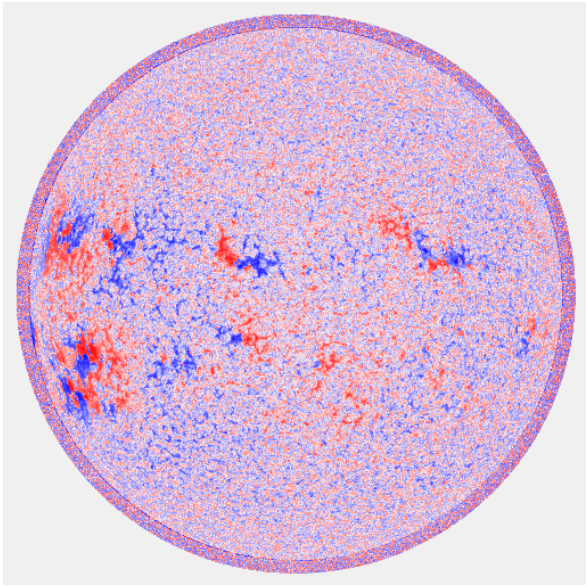
Kislovodsk, STOP



SOLIS

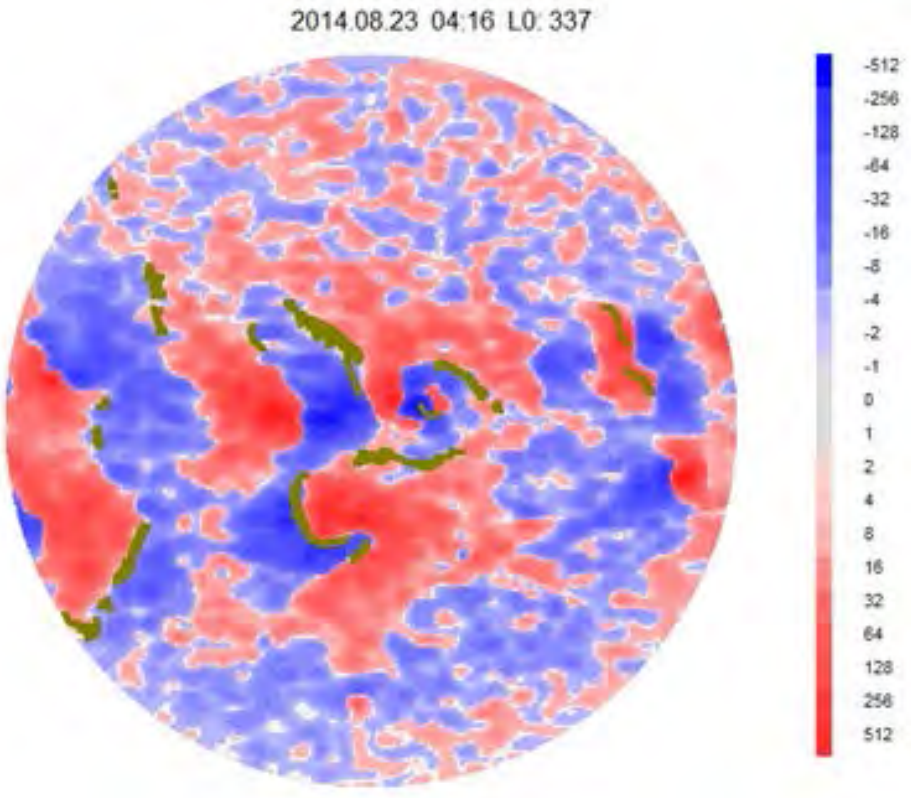


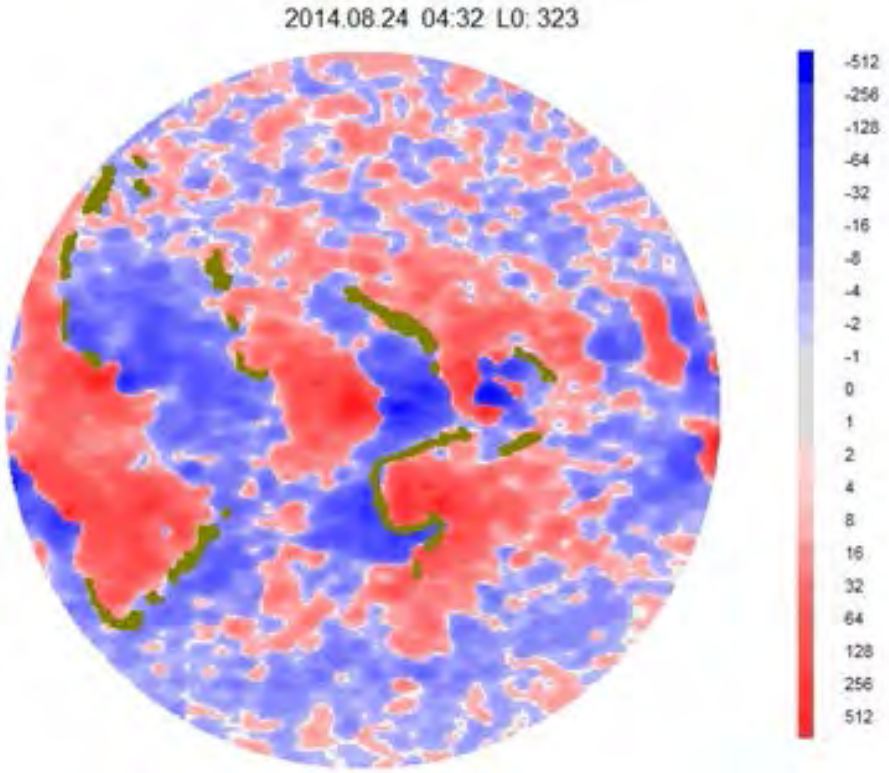
WSO



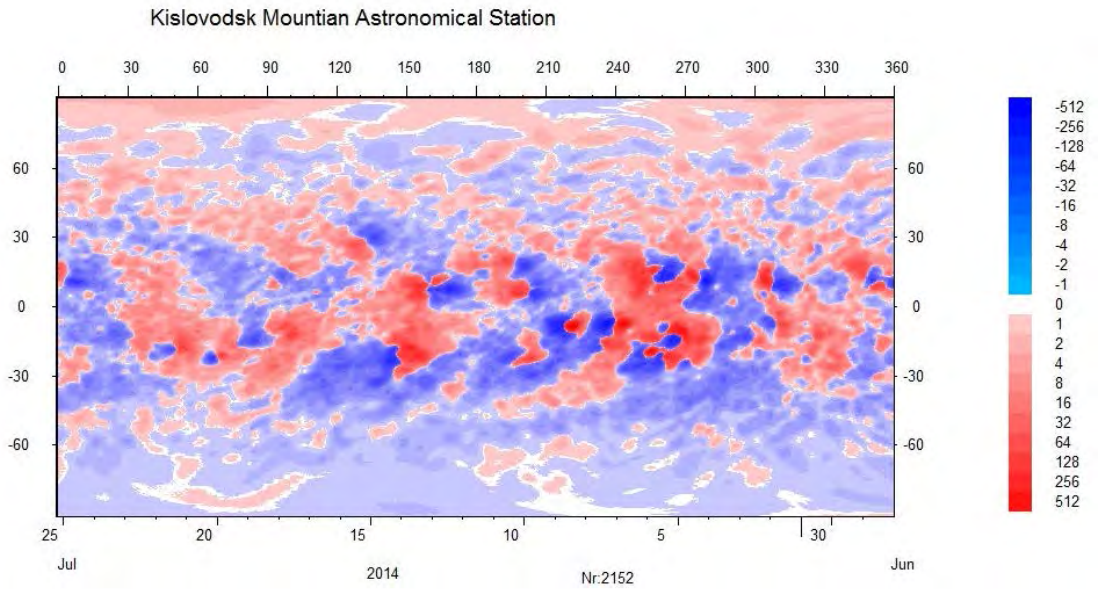
HMI

Verification the position of the polarity reversal line by the position of the filaments

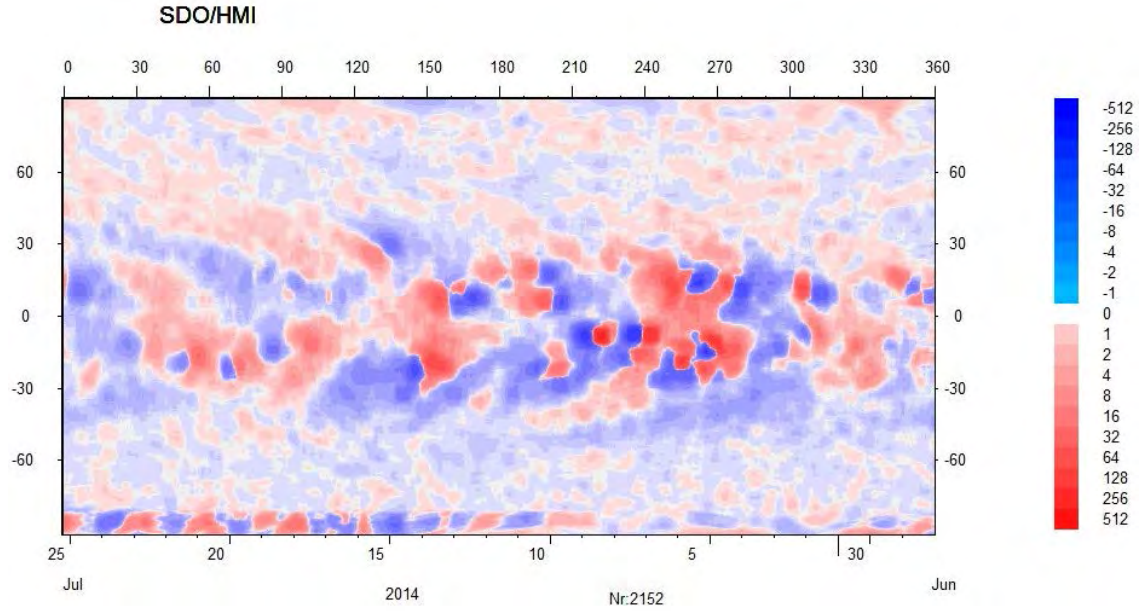




Comparison of synoptic maps of magnetic field



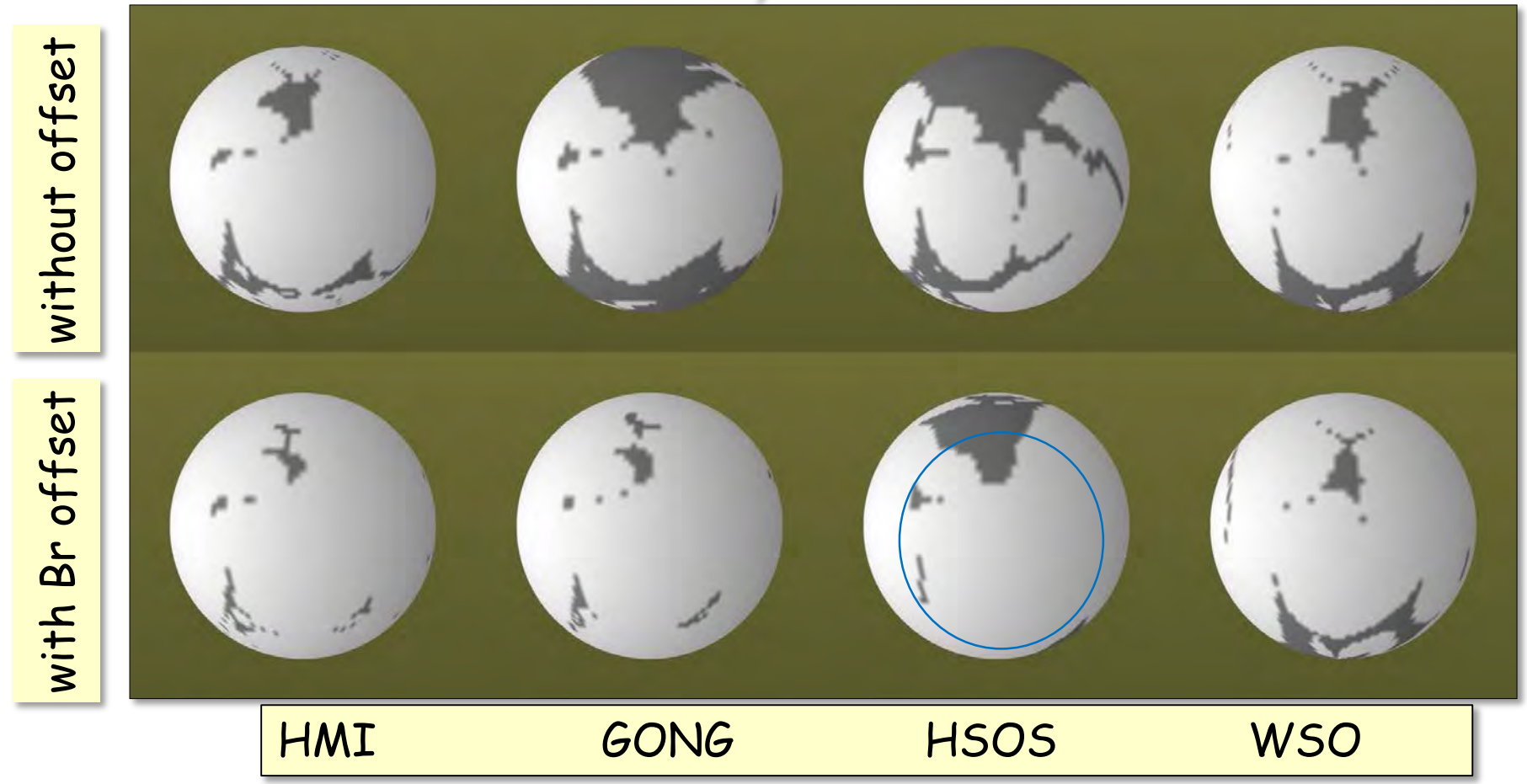
Kislovodsk

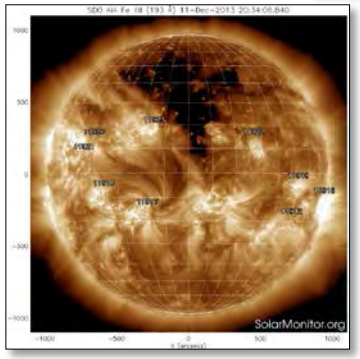


HMI/SDO

Perhaps Kislovodsk is better at measuring large-scale magnetic fields

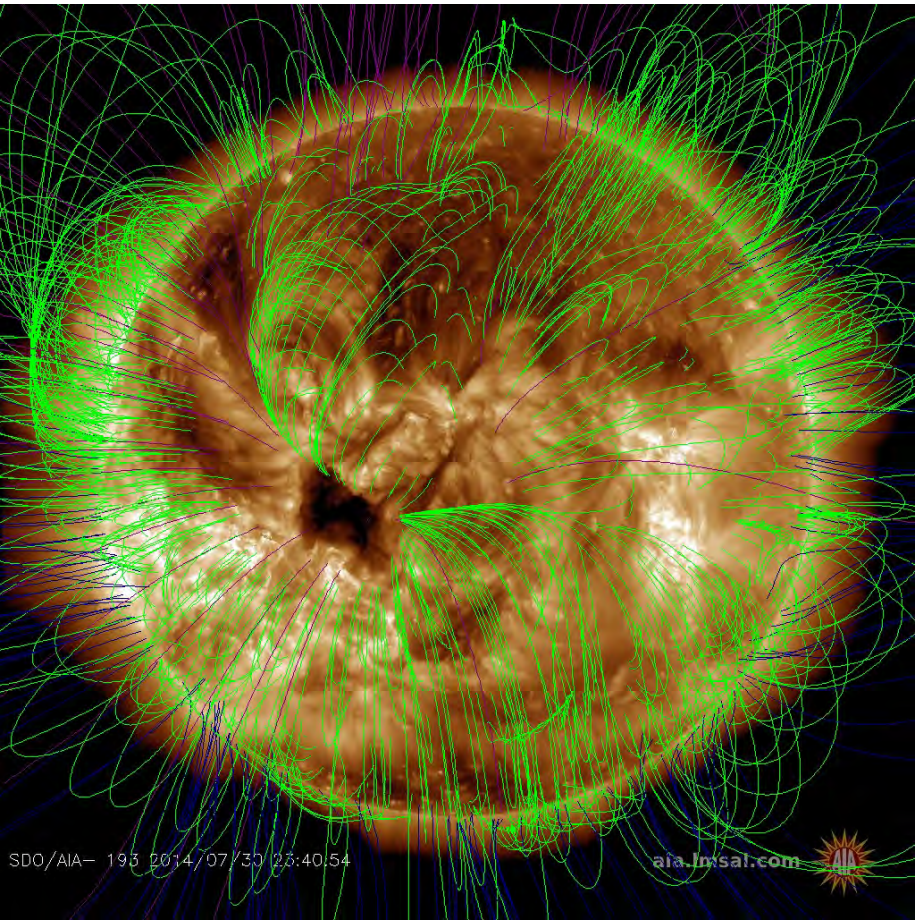
PFSS coronal hole, CR2144 L090





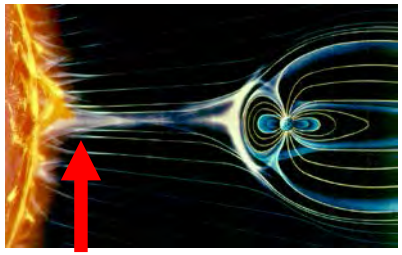
Different magnetographs give different configurations of regions with an open magnetic flux. For the forecast of Cosmic Weather this is a critical factor.

Hayashi et al. 2016

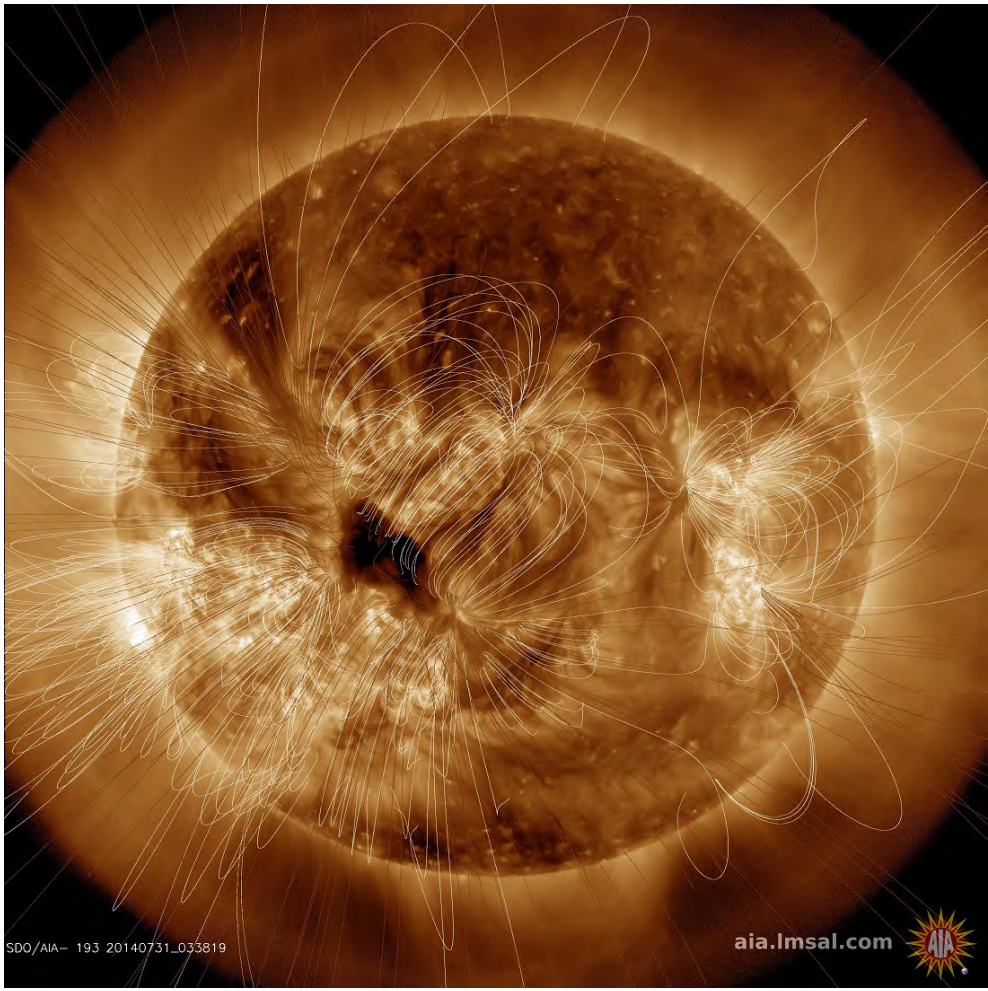


Kislovodsk

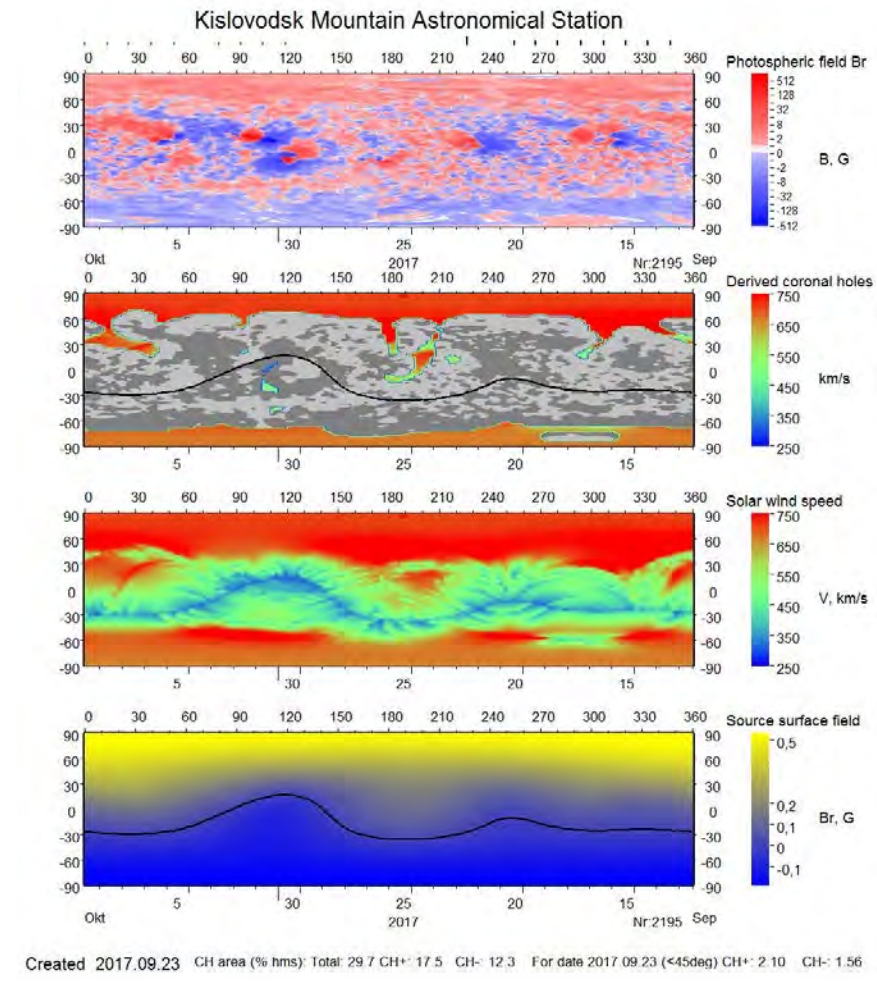
Determining areas of the open configuration of magnetic fields on daily data

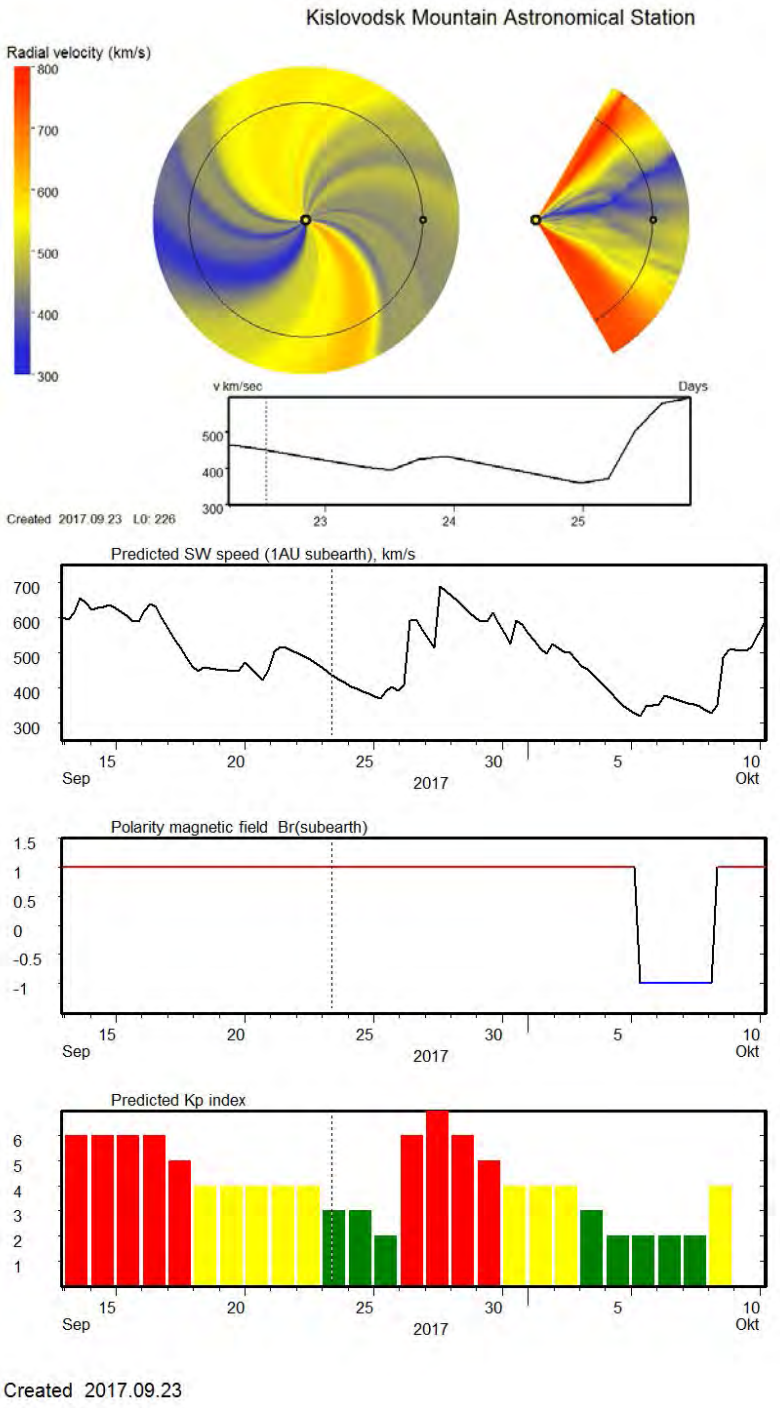


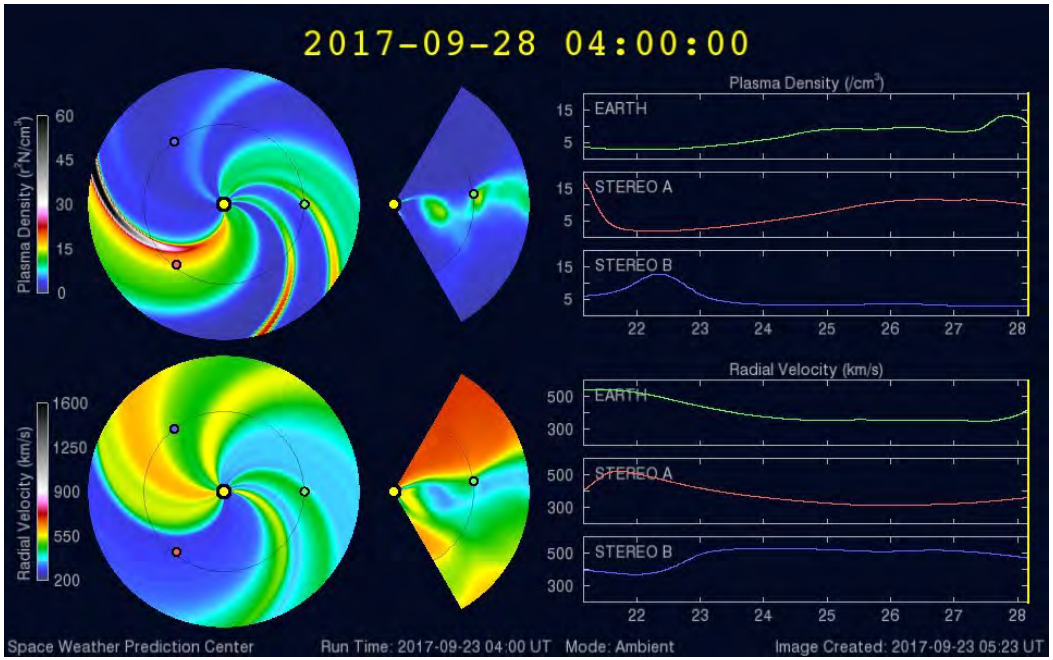
HMI/SDO

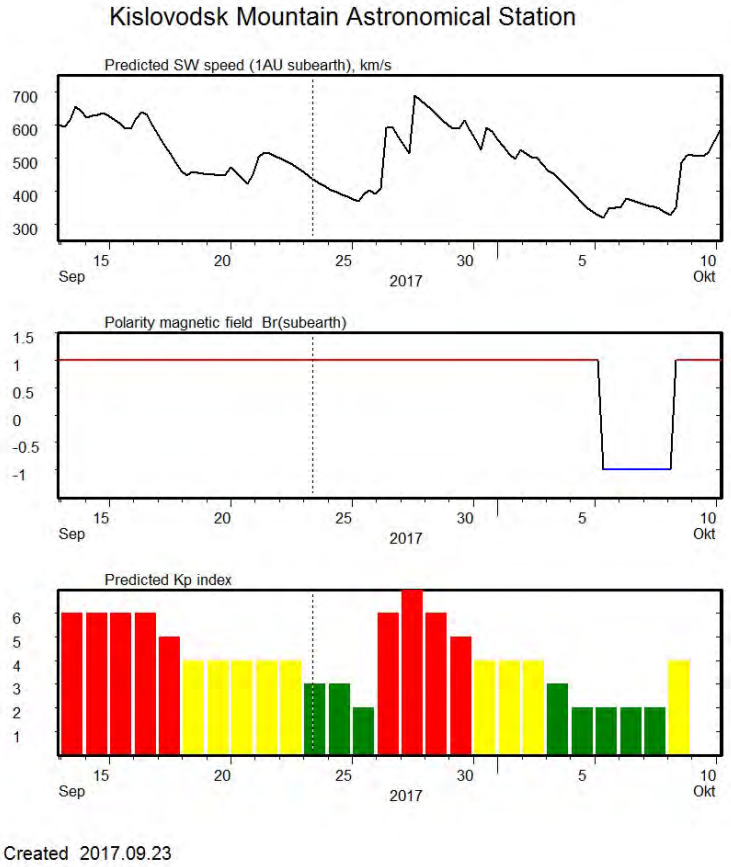


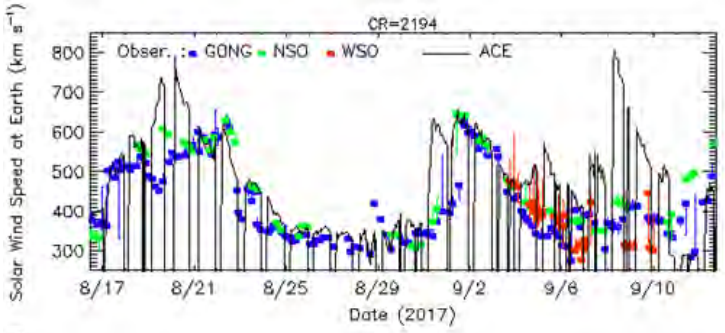
We have created a system for predicting the parameters of the solar wind and space weather according to our observations.

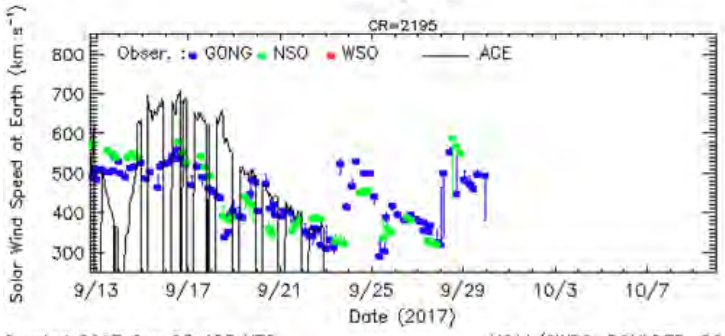








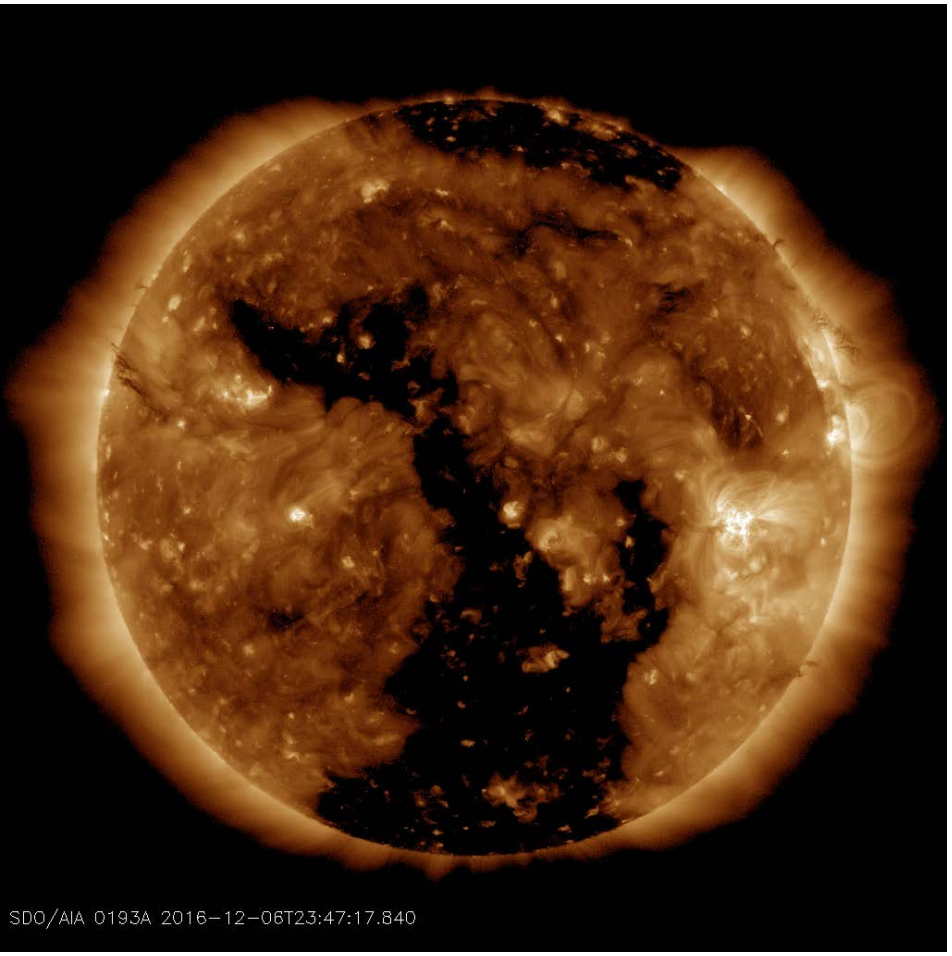


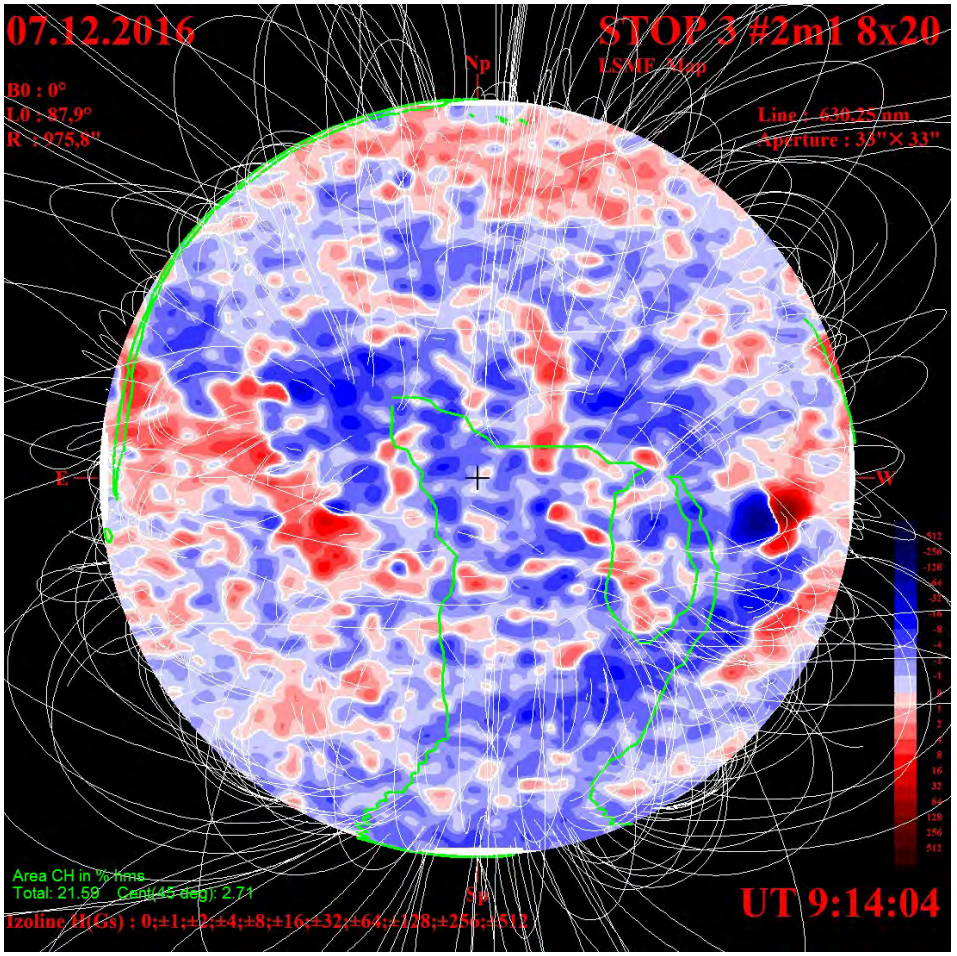


Created 2017 Sep 23 425 UTC NOAA/SWPC, BOULDER, CO, USA

Comparison with the forecast WSA, and WSA-ENLIL for 23.09.2017

The sources of high-speed solar wind are the regions of "open configurations" of magnetic fields.

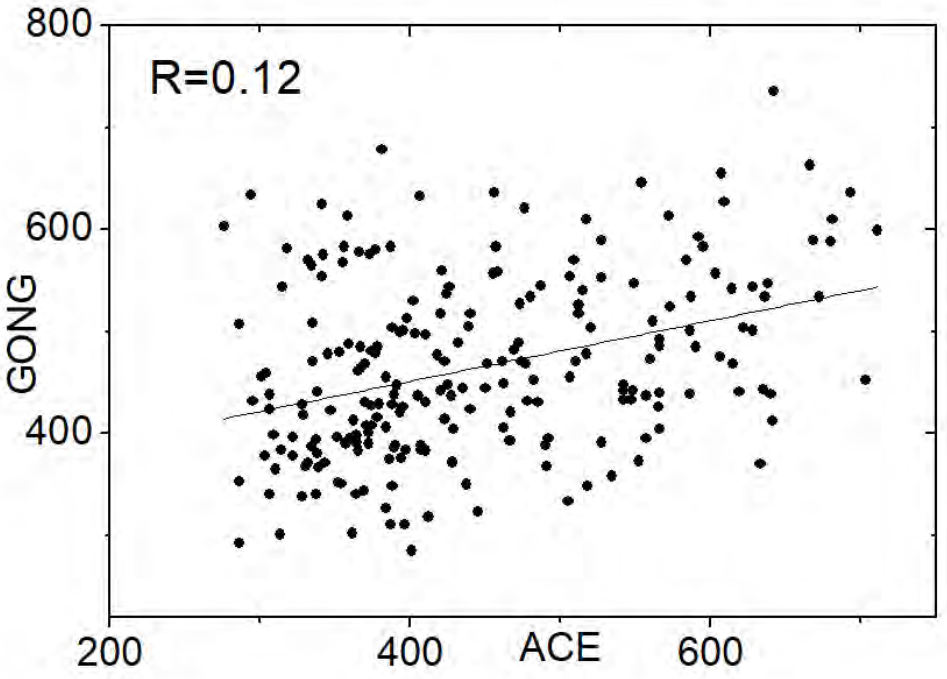


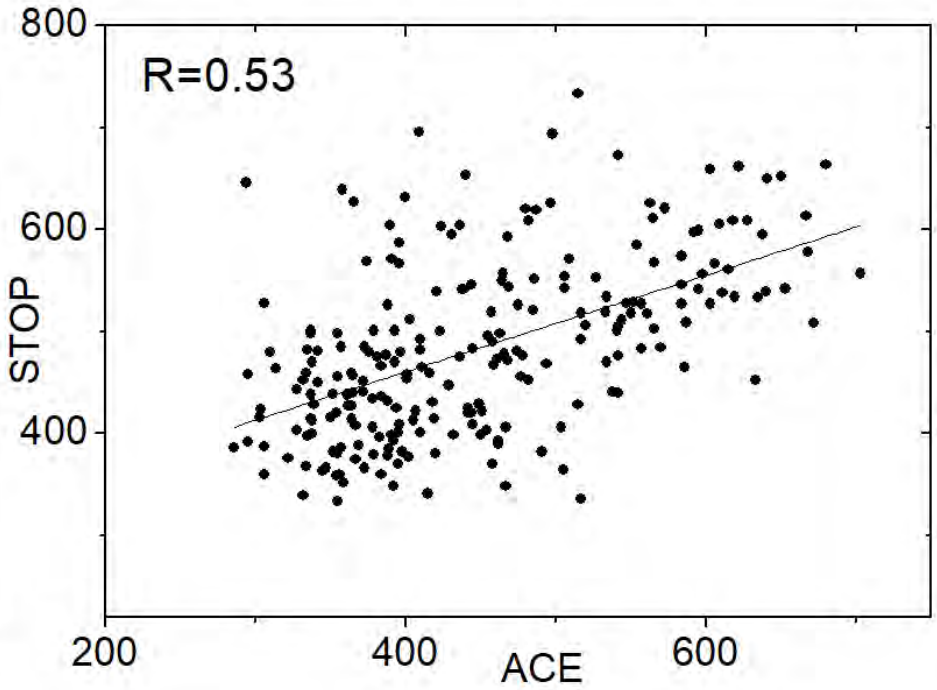


Observed and calculated CH for 2016.12.07

According to the observations of the STOP magnetograph, it was possible to create models for calculating the coronal magnetic field, which give a fairly good prediction of the sources of high-speed solar wind.

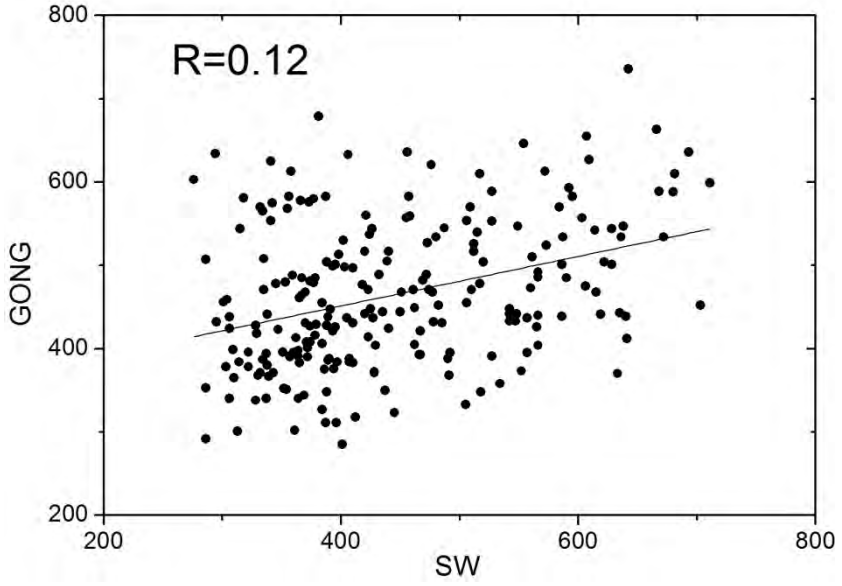
Different input data can provide different extrapolations of coronal structures in the photosphere and source surface as well as influence the results near the Earth. It is important to make a few remarks about the WSA model. It is necessary to note that the simulation results depend on the spatial resolution of the magnetograms, which are not the same for different observatories.

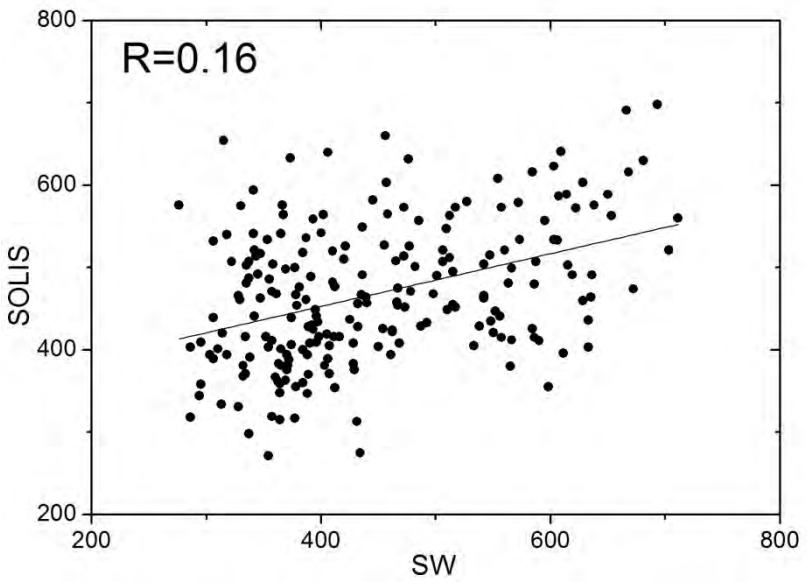


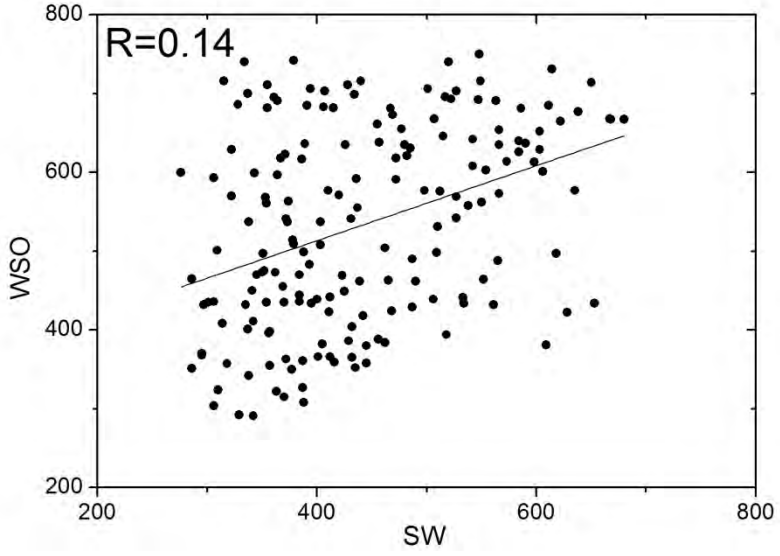


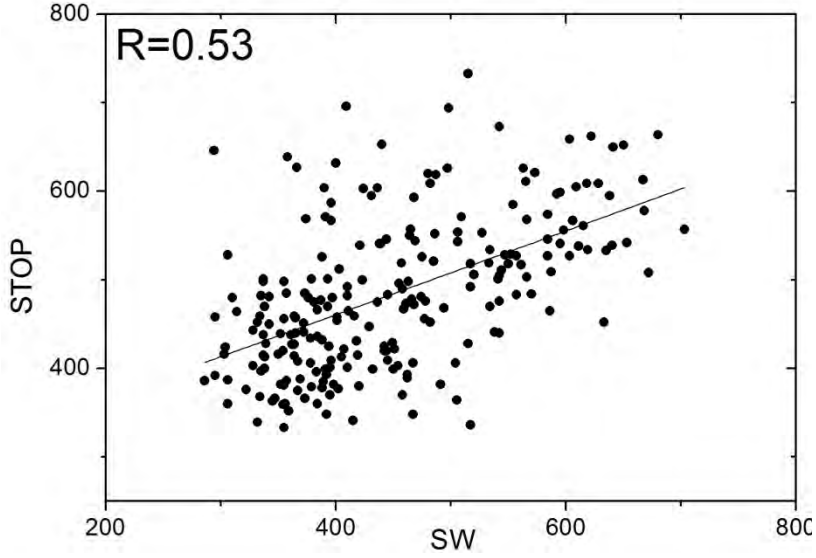
Comparison of the reliability of solar wind speed forecasts according to Kislovodsk and GONG data for 2016 with ACE data. Kislovodsk data have significantly better correlation.

The forecast for Kislovodsk seems the best (?)









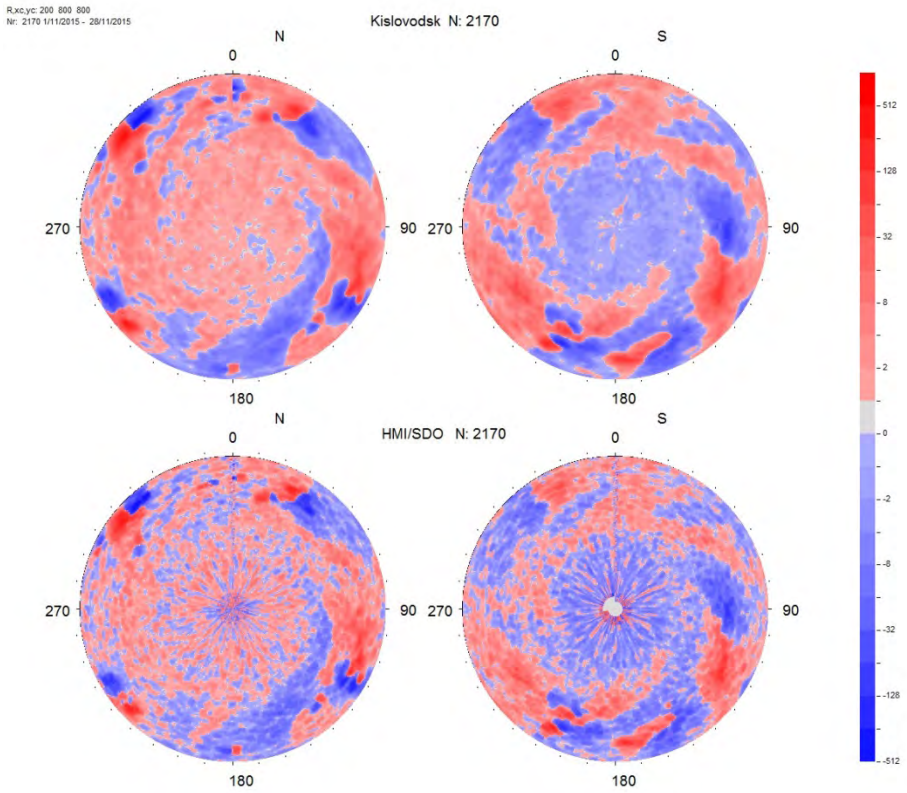
Currently, there are several synoptic magnetographs full disk. Characteristics of the most currently used in comparison with the characteristics of the telescope STOP.

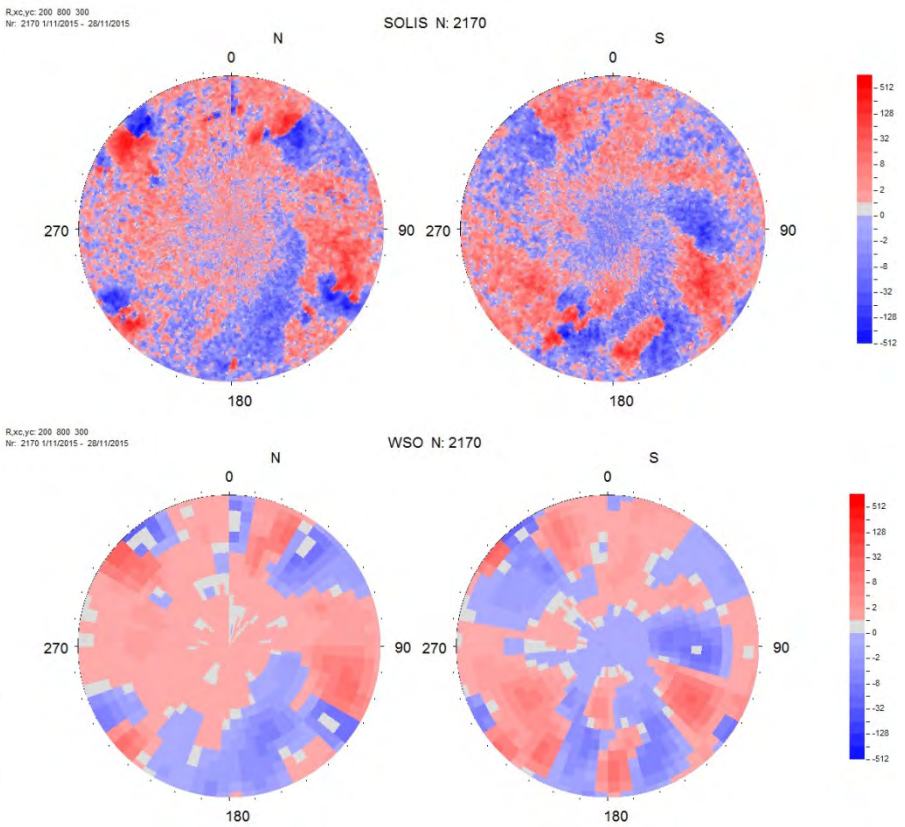
Observatory	WSO	MDI	HMI	SOLIS	GONG	STOP
Start obs.	05.1975	12.1995	02.2010	2003	1995	07.2014*
Place	Ca, USA	L1 point	Геостац.	USA	netw	Kisl
Spectr. Line	FeI5250/5247	NiI6768A	FeI6173	FeI 6301.5-6302.5	Nilline at 6768 Å	FeI 6301.5-6302.5
Resolution	3 min	4”	1”	1-2”	8”	33x6”
Regime	Daily	96-min	45 & 720 sec.	Daily	1 hr	Daily
Sensitivity	0.05G	7G	10G	1-2G	1G	0.5G

Polar field, Kislovodsk, HMI/SDO, SOLIS, WSO Nr 2170

Kislovodsk

SOLIS



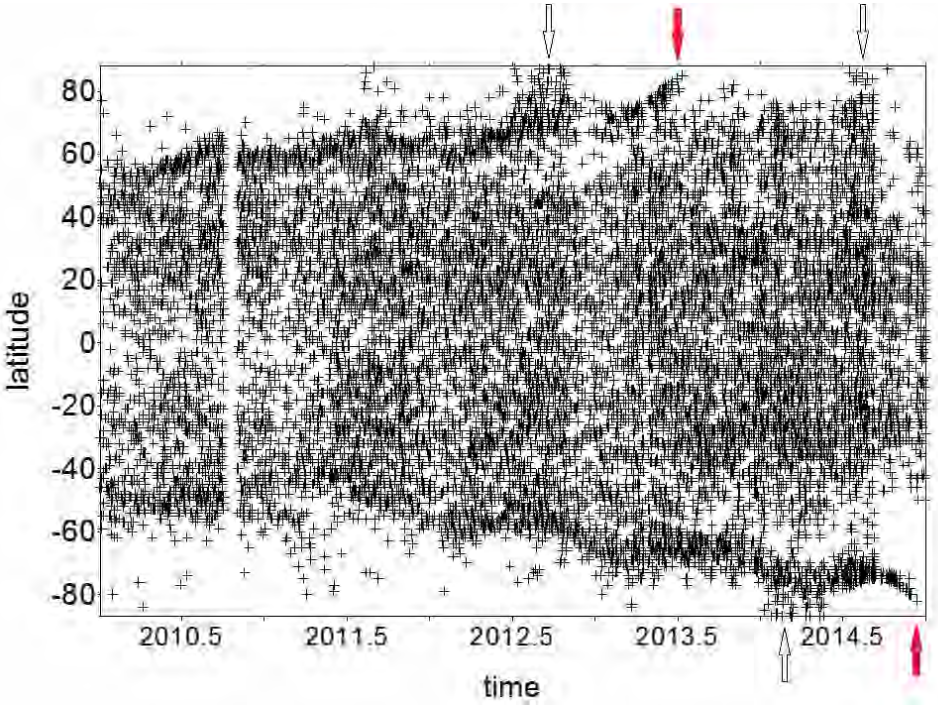


HMI/SDO

WSO

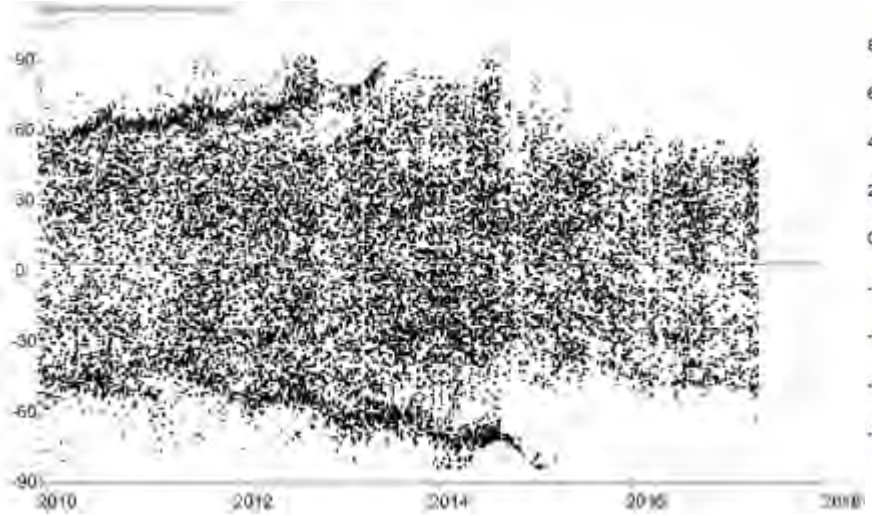
Another important factor is the accuracy of measuring weak large-scale magnetic fields. This is particularly important for determining the magnetic fields in polar regions of the Sun.

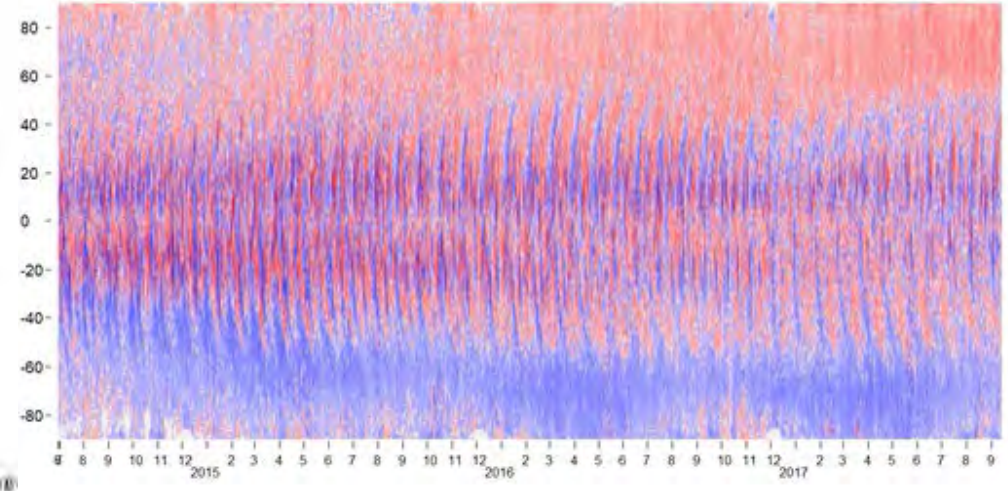
3-fold polarity reversal in the northern hemisphere in cycle 24

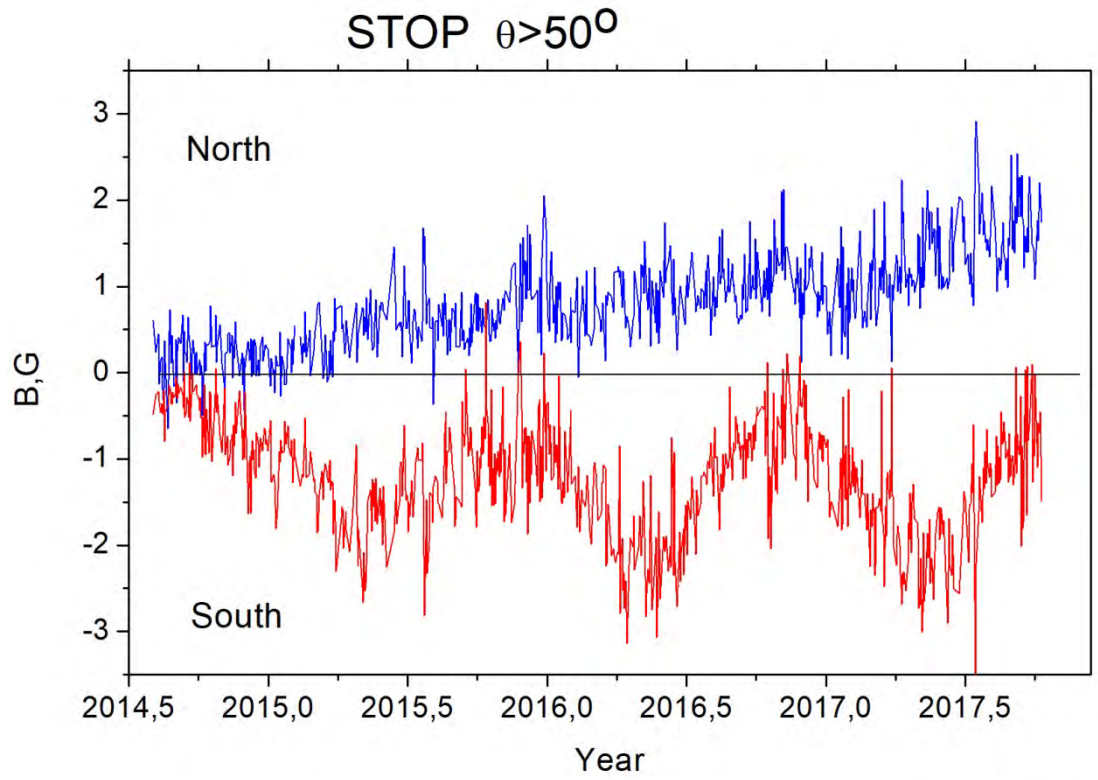


Observations of the prominence in the northern hemisphere show 3 waves of drift. The entire magnetic field in the northern hemisphere has become positive in 2015.

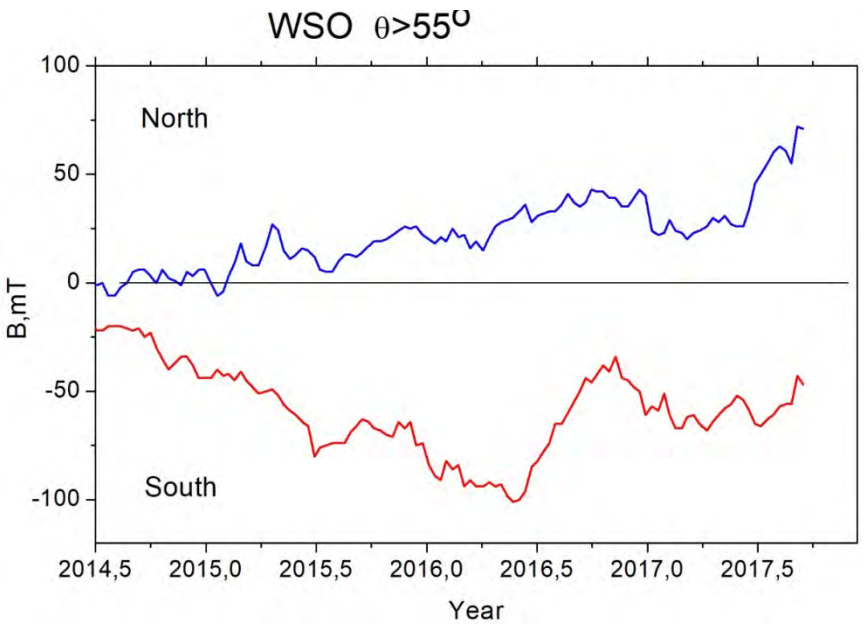
Tlatov at al., G&A 2015

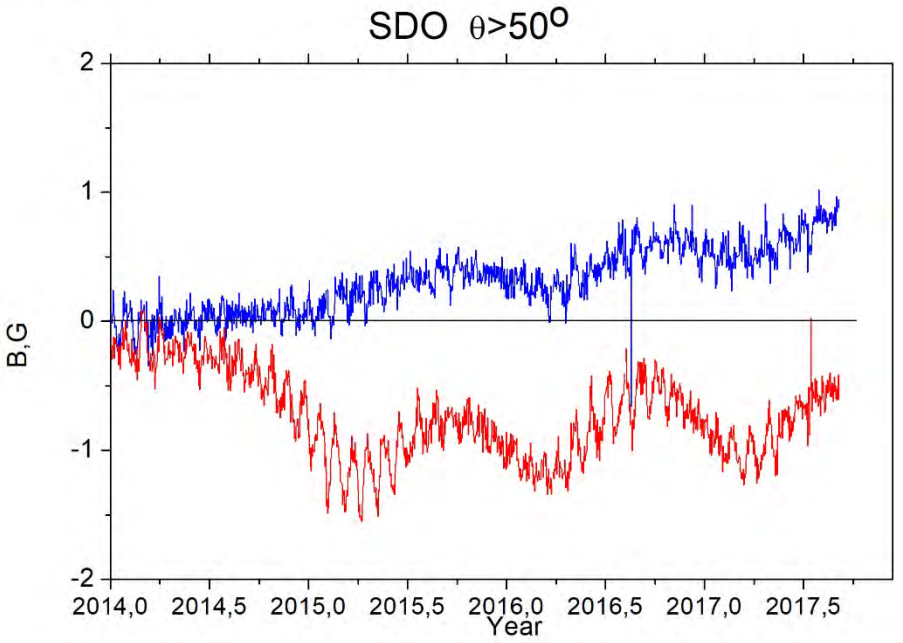


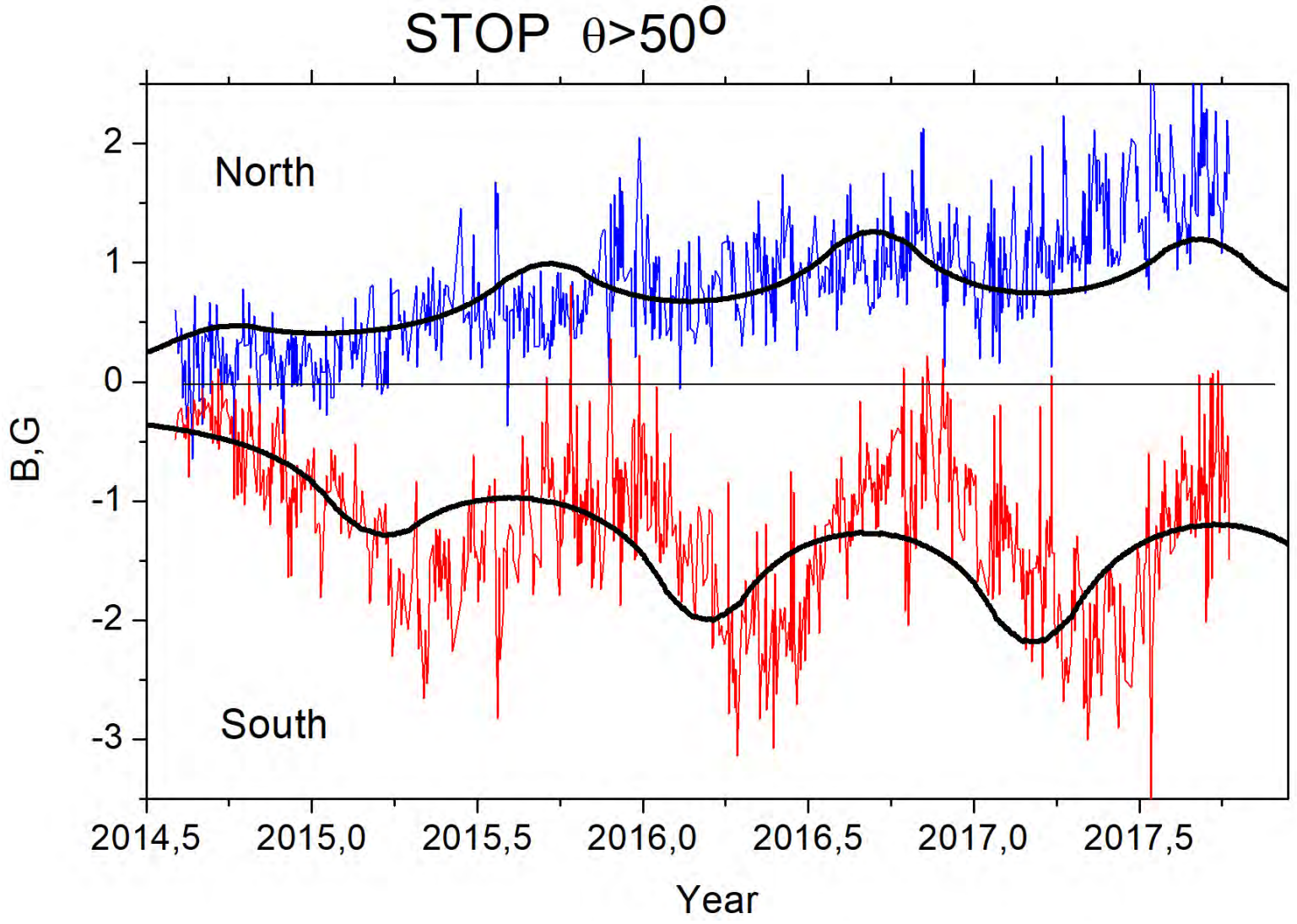




1. The magnitude of the magnetic field in the northern hemisphere increases more slowly than in the southern hemisphere.
2. The amplitude of annual modulation in the southern hemisphere is much higher than in the western hemisphere.

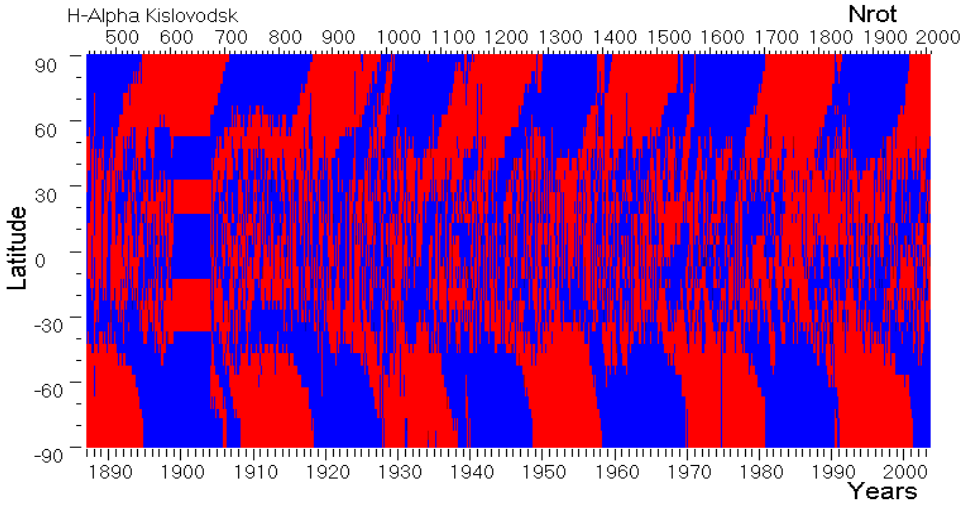


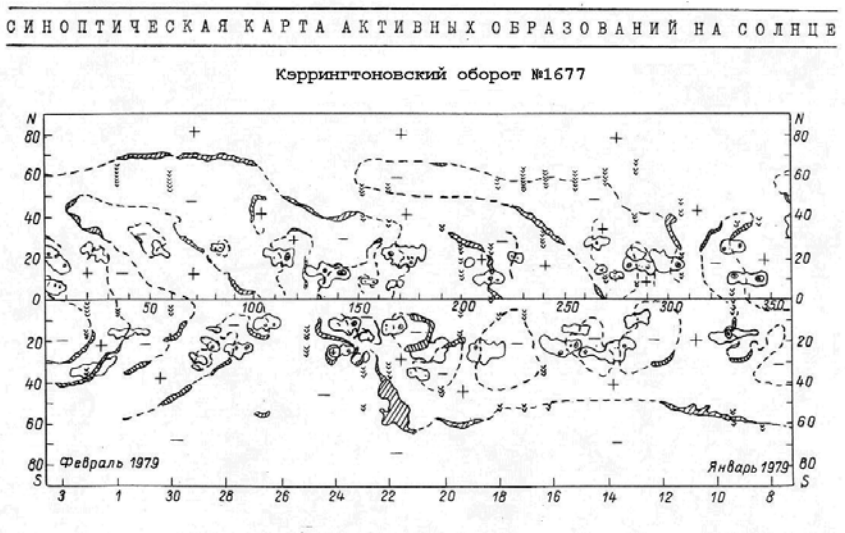


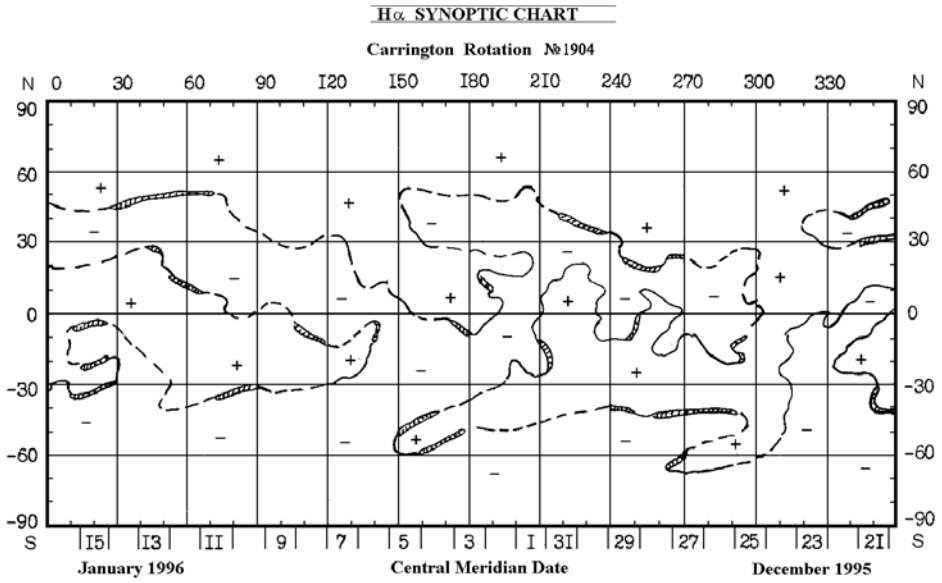


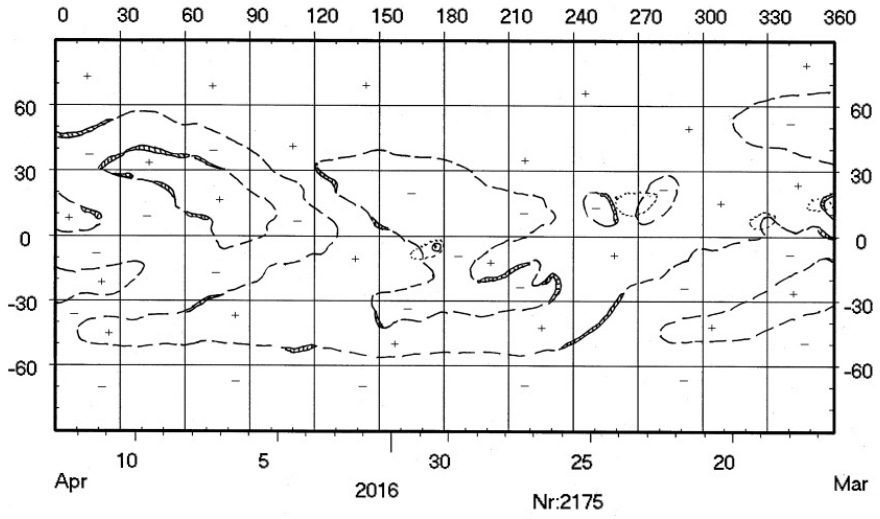
Perhaps a large-scale magnetic field at the poles has a horizontal component.

In Kislovodsk maps of the polarity of the magnetic field by H-alpha line observation for the period 1887-2016 were reconstructed.

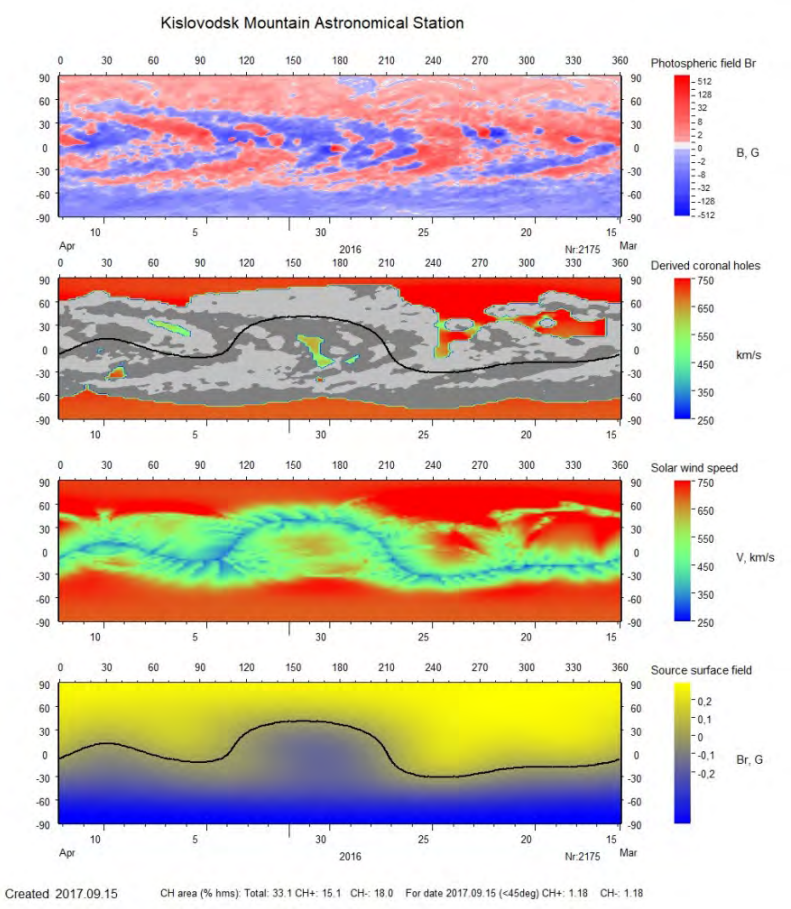




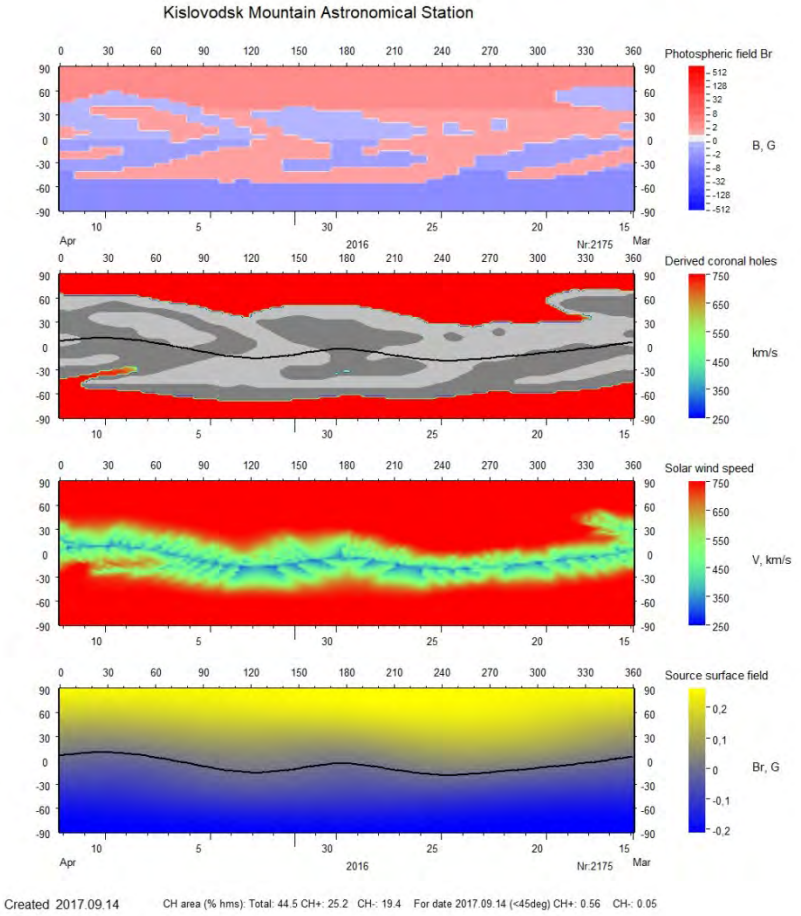




STOP



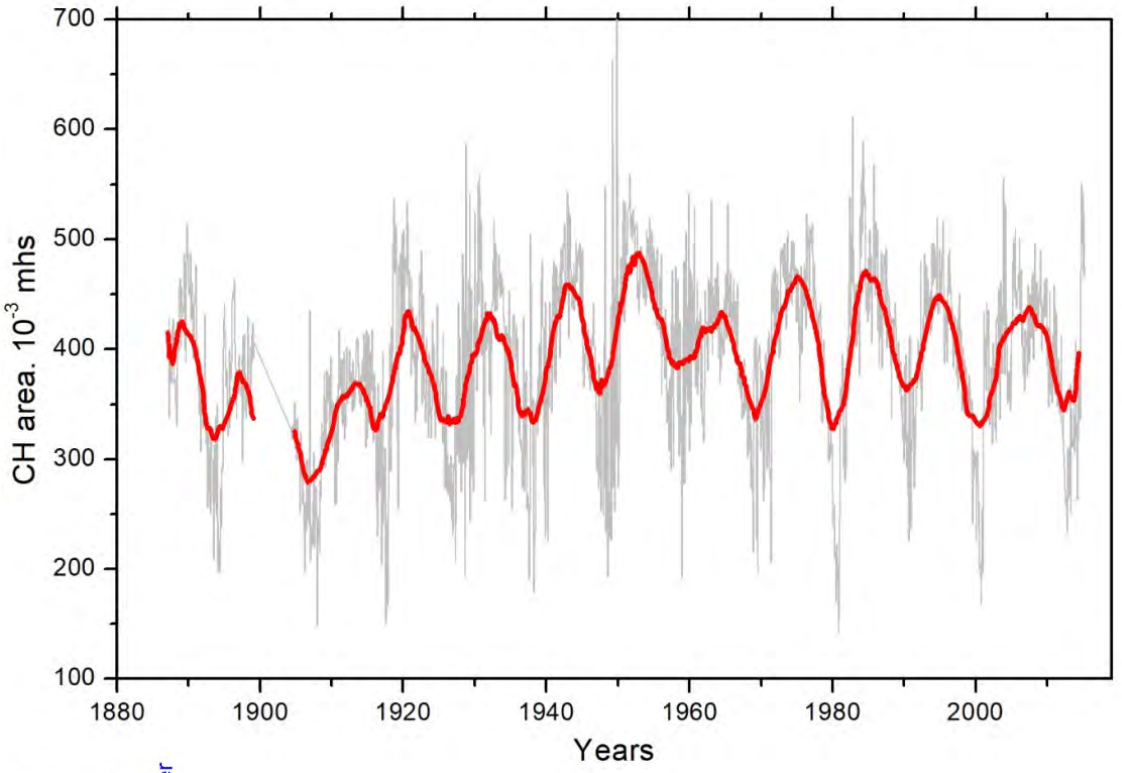
H-alpha

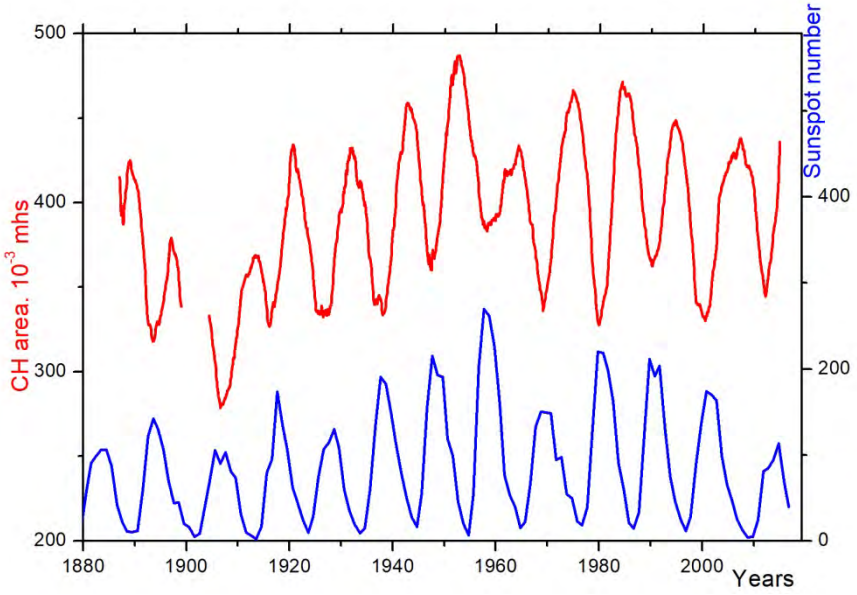


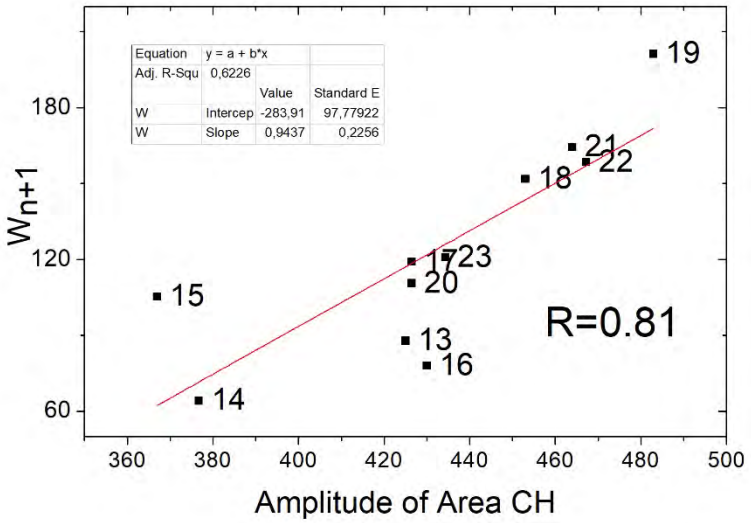
We can reconstruct regions with an open configuration of the flux of magnetic field from the data of H-alpha maps

The area of the regions with an open configuration of the flux of the magnetic field has an 11-year periodicity.
The maximum values were ~ 1953, before the 19th cycle of activity

The larger the area of areas with an open magnetic flux, the greater the amplitude of the next cycle of activity.

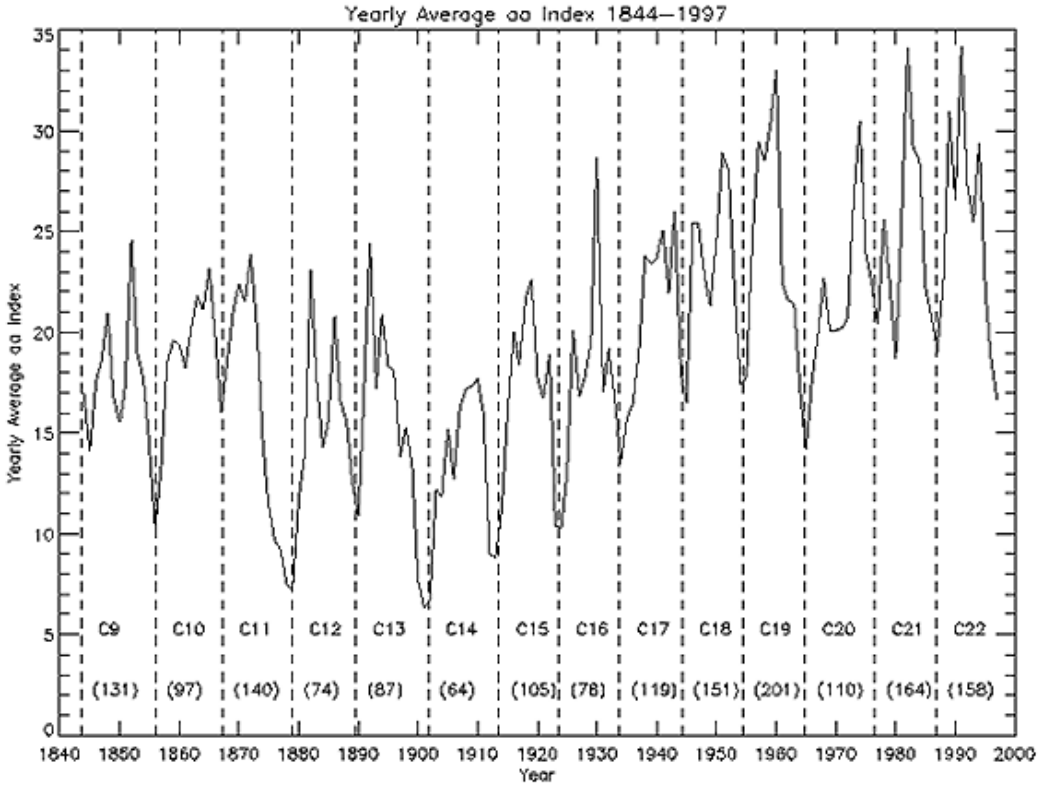


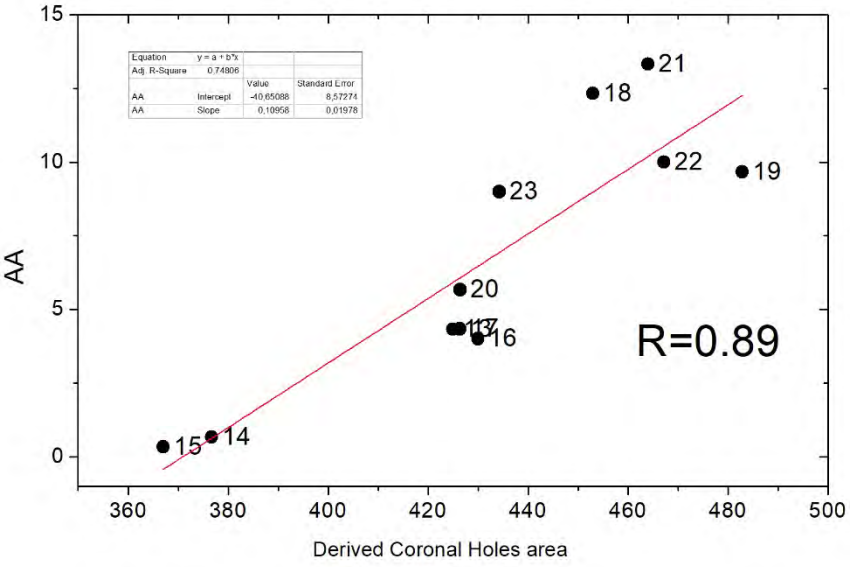


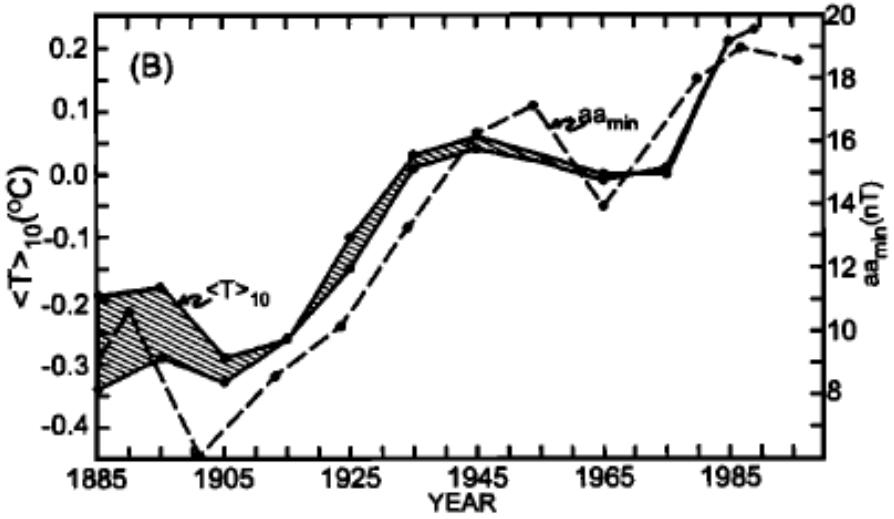


The area of the open regions has a good correlation with geomagnetic indices in the era of minimum activity.

This fact explains the physical mechanism of the method of forecasting solar activity by the Ohl-method.







Conclusions

1. Kislovodsk Observatory conducts almost all kind of synoptic solar observations from the photosphere to the corona.
2. We have developed methods for forecasting space weather based on ground-based observations at Kislovodsk.
3. In the 24th cycle of activity, a different behavior of the polar field is observed in the northern and southern hemispheres.
4. The data on area of regions with open magnetic flux has been reconstructed for the period of more than 100 years. These data can be used for prediction of the future activity cycle.
5. Areas with open magnetic flux have long-term modulation and can be used to explain long-term variations of geomagnetic indices.