Space Weather of the Heliosphere: Processes and Forecasts
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The Forecast of Space Weather According to Ground-Based Observatories

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Abstract. The space weather forecast can be conditionally divided into three components: 1) The forecast of recurrent slowly varying events which are associated with the topology of a large-scale magnetic field; 2) Evaluation of fluxes of ultraviolet and extreme radiation; 3) Detecting and determining the parameters of eruptions and CME. All three components can be observed and evaluated by ground-based telescopes. In this article we describe the telescopes of the space weather service in Kislovodsk Mountain Astronomical Station. Telescope-magnetograph STOP for the forecast of recurrent events and patrol telescopes-spectrographs for detecting CME and estimating hard radiation fluxes.

Keywords. Sun, space weather, ground-based observation

1. Overview

At present one of the most urgent tasks in the study of solar-terrestrial relationships is the study of the nature of space weather variations caused by solar activity. Space weather effectively affects space vehicles, also on Earth, its strongest manifestations are localized in the polar regions. From the solar corona continuously expires corpuscular stream in the form of solar wind (SW). In the case of low activity when there are no flare disturbances on the Sun leading to sporadic coronal mass ejections (CMEs) into the interplanetary medium, the so-called quiet solar wind forms a quasi-stationary pattern in the interplanetary space. From the point of view of the prediction of magnetic disturbances on Earth as an important part of space weather, a stationary SW state is favorable, because it has a tendency toward 27-day event recurrence (recurrent forecast).

The Sun is also a source of radiation in the X-ray and ultraviolet ranges, which can have a negative impact on technological systems. The estimation of these flows, as well as the forecast of their intensity for the next few days, is the subject of space weather service (SWS). The SWS should be based on continuous observations of solar activity, and also include an operative process of primary data analysis and the formation of activity indices. There are two main components of the SWS forecast. Firstly, this definition of the parameters of SW, when there are no flares and CME on the Sun, the so-called quiet solar wind. The second component is the accounting of flares and CMEs. It should be noted that in the case of solar activity, the CME plasma interacts with the plasma of the quiet solar wind. The spread in this case depends on the background state interplanetary medium, which must be considered when modeling disturbance.

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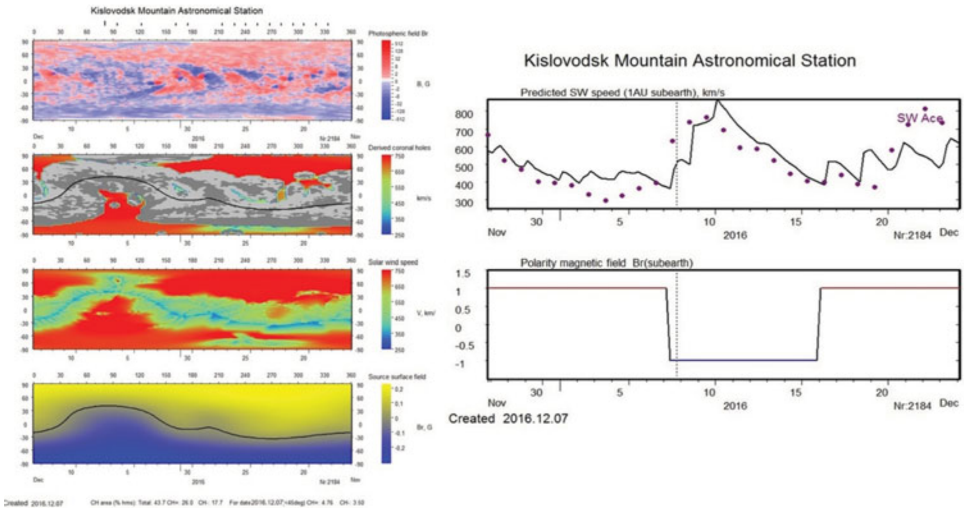

Figure 1. Example of operational calculations of the photospheric magnetic field, positions of open magnetic flux structures, solar wind speed at the source surface, and the polarity of magnetic field on the source surface according to Kislovodsk data.

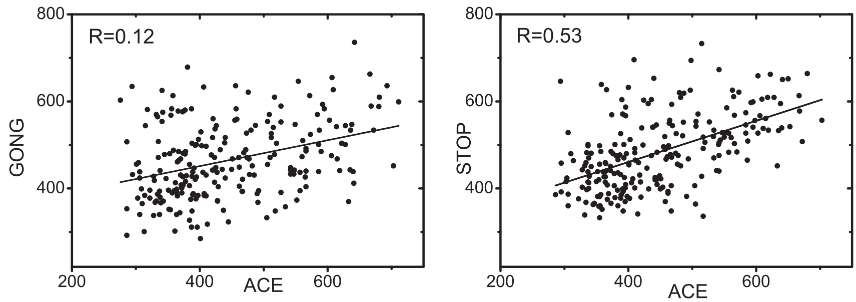

Figure 2. Comparison of the reliability of solar wind speed in km/sec forecasts according to Kislovodsk and GONG data for 2016 with ACE data. Kislovodsk data have significantly better correlation.

2. Forecast of Solar Wind Parameters According to STOP Magnetograph Observations

Large-scale solar magnetic fields have been regularly observed at Kislovodsk mountain astronomical station (KMAS) from July 1, 2014 (Tlatov *et al.* 2016). The telescope is mostly used to obtain full disk magnetograms of longitudinal largescale solar magnetic fields with the angular resolution of $\sim$ 30×6 arc.sec. The coronal magnetic field structure can vary significantly within one synoptic rotation because of the emerging active regions. For this purpose, series of daily updated synoptic maps are constructed at the KMAS, i.e., every day newly received magnetograms are integrated into the existing weather map. These maps have a resolution $2.5^o \times 2.5^o$(degrees of latitude and longitude). These maps are used to compute the coronal magnetic field in the PFSS and WSA models (Figure 1).

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 necessary to note that the simulation results depend on the spatial resolution of the magnetograms, which are not the same for different observatories (Figure 2).

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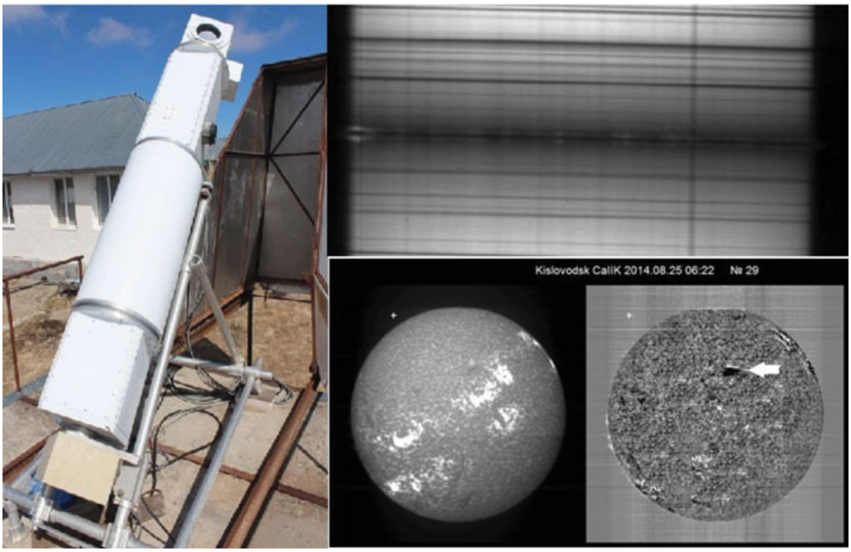

Figure 3. The Patrol telescopes observations on UV fluxes and coronal mass ejections. The use of an intensity difference in the wings of the spectral lines makes it possible to effectively detect the CME (see arrows).

3. Observation of coronal mass ejections and solar flares

Ground patrol telescopes which provide continuous observations with a periodicity per minute can be successfully used instead of satellite observations in the UV range Tlatov *et al.* (2015). Coronal mass ejections are the main cause of geomagnetic storms. The choice of the spectroheliograph scheme with registration of the spectral line profile, as a scheme of such telescopes, allows to significantly increase the contrast of the recorded eruptive events (Figure 3). At present, two patrol telescopes operating in the CaIIK and H-alpha lines have been installed in Kislovodsk.

4. Conclusions

This article discussed the main tasks of the space weather forecasting service, as well as the experience of using ground-based observations in Kislovodsk. Daily magnetographic observations are necessary to determine the parameters of quasi-stationary fluxes of solar wind forward by 3-7 days and the specification of physical conditions for models of CME propagation.

For predicting effects of solar flares and coronal mass ejections, a continuous 24-hour observation regime is ideal. For implementation, it is necessary to install patrol telescopes at observation posts, including the western hemisphere, with a total number of about 8. Patrol telescopes-spectrographs allow to determine the direction and speed of coronal mass ejections and to estimate the fluxes of cruel and UV radiation.

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