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Interactive maps of solar activity based on KMAS data

I.A. Berezin*

Kislovodsk Mountain Astronomical Station, Kislovodsk, 357722, Russia

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The *obsun.ru* web service that provides interactive 3D visualization of solar activity based on data from the Kislovodsk Mountain Astronomical Station (KMAS) has been presented. The service combines modern technologies (Django, Vue.js, and Three.js) with archival observations that cover more than 100 years of solar activity, offering tools for analyzing sunspots, flocculi, filaments, prominences, and coronal structures. The system provides rapid data updates (1–2 h delay), multilayer visualization (including synoptic magnetic field maps and coronal models), and interactive features for quantitative analysis.

Keywords: Astronomical databases

1 Introduction

In the last century, the main source of data on solar activity for a wide range of researchers were periodic publications of manuscript maps and summaries. Such periodicals served as a basis for research, but their preparation took weeks, and analyzing the morphology of solar activity tracers required painstaking work by astronomers. Here are some examples of such periodicals:

- *Cartes Synoptiques de la Chromosphère Solaire* published by the Paris Observatory contained synoptic maps of solar filaments from 1919 to 2003, scanned images can be found online (Coffey & Hanchett, 1998).
- *Greenwich Photoheliographic Results* contained daily measurements of sunspot and facula positions and areas from 1874 to 1976 (Willis et al., 2013).
- The monthly bulletin of the USSR Academy of Sciences *Solar Data* presented mainly data from the Kislovodsk Mountain Astronomical Station of the Pulkovo Observatory (KMAS), which functioned as part of the Soviet Sun Service. These were maps of the Sun on which the objects measured at KMAS were plotted:

*Email: iberalex@ya.ru

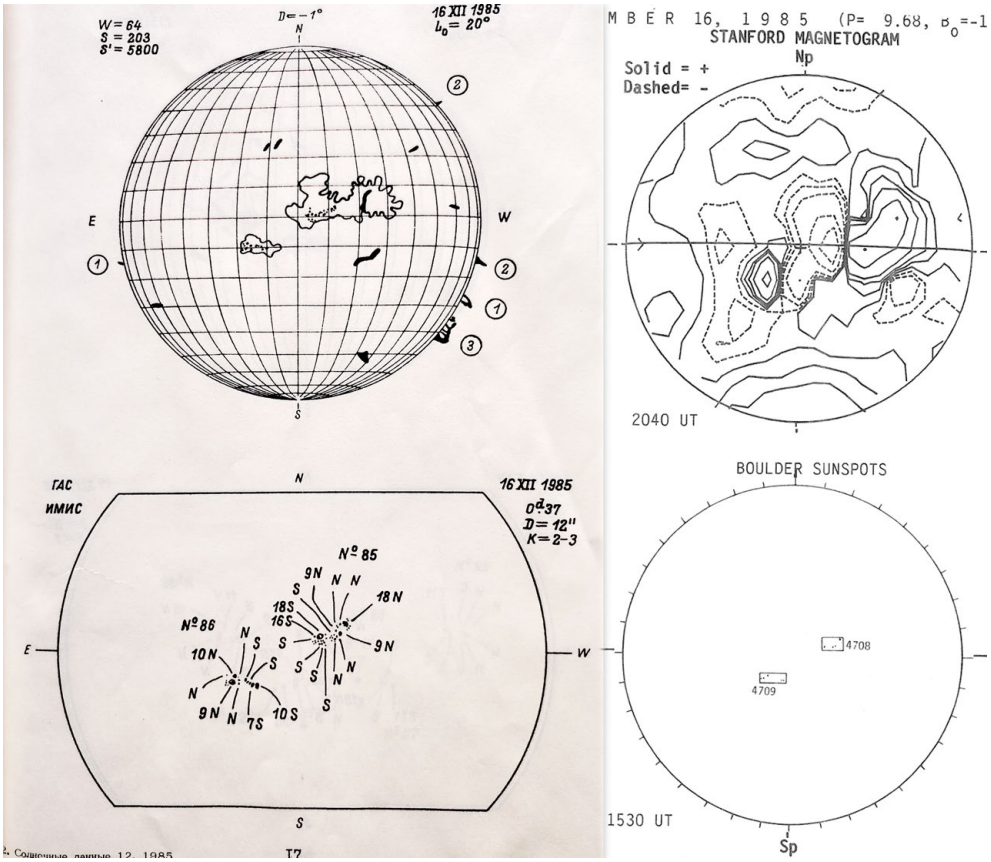


Figure 1 Left panel: page from *Solar Data*, showing the solar activity map and sunspot map for December 16, 1985; right panel: page from *Solar-Geophysical Data*, showing the magnetic field and sunspot map for the same date.

spots, calcium flocculi, filaments, prominences, and coronal intensities (Fig. 1, left panel). The Bulletin also contained graphs and tables of solar activity indices and scientific articles. The journal was published from 1954 to 1996.

- *Solar-Geophysical Data* was published monthly from 1955 to 2009 by the US National Geophysical Data Center (NGDC) and was a summary of observational data on solar activity (Fig. 1, right panel), selected solar wind and interplanetary magnetic field characteristics, and major geomagnetic activity indices.
- Handwritten summary maps of solar activity are still generated by the US Solar Service and published by The National Geophysical Data Center (NGDC)[1].

Modern technology has made it possible to move from hand-drawn raster images to accurate vector data. For example, the iSolSearch[2] service displays a summary of

[1]https://www.ngdc.noaa.gov/stp/space-weather/solar-data/solar-imagery/composites/full-sun-drawings/

[2]https://suntoday.lmsal.com/

registered solar events based on data from the Solar Dynamics Observatory. The coordinates of events are displayed on a two-dimensional map of the Sun, and especially large objects (coronal holes) are mapped as a contour. KMAS summary maps of solar activity are published on the observatory website[3] in the form of digital images and as a three-dimensional interactive map on the ObserveTheSun[4] service. This approach maintains continuity with traditional methods, but eliminates their key limitations – slow preparation and impossibility of quantitative analysis.

2 Interactive solar maps

This paper presents the web service *obsun.ru*[5], which offers the user an interactive three-dimensional map of solar activity, combining in a single space all key tracers: from sunspots to coronal structures. Conceptually, the service is a development of ObserveTheSun, mentioned in the introduction. The main idea is to present all measured classical tracers of solar activity in the form of detailed contours on a three-dimensional map of the Sun.

The technological basis of the service is a modern stack Django + Vue.js + Three.js, providing both reliable data storage and processing (including archived observations for more than 100 years), and intuitive 3D visualization. Particular attention is paid to efficiency – data from KMAS instruments appear in the system with a delay of no more than 1–2 hours. The site also presents historical data series for more than 100 years of solar observations. The site is deployed on the KMAS server and SQLite is used for data management.

The user interface is built around a central element, a three-dimensional model of the Sun (Fig. 2). By rotating this globe (holding down the left mouse button) and changing the scale with the mouse wheel or using the interface elements (Fig. 2b), the researcher can study in detail any object on the map. The system automatically calculates and displays current heliographic coordinates both for the Earth position (L0, B0, P) and for the user cursor (L, B) (Fig. 2f).

Visualization flexibility is provided by a set of switches:

- Surface texture selection from a basic coordinate grid to synoptic magnetic field maps (Fig. 3) from the KMAS STOP data and historical solar filaments sketch maps in the H_α line (Fig. 2c);
- Filtering of displayed objects (Fig. 2d): sunspots, calcium flocculi, filaments, prominences, coronal holes according to SDO/AIA193 data or Potential-field Source-surface (PFSS) modeling data, coronal intensity in red and green lines, magnetic field lines according to PFSS (Fig. 3).

The panel (a) is intended for date selection. You can change the year, month, day and hour by dragging, mouse wheel or click, as well as by arrows on the keyboard. When you open the site, the date corresponding to the most recent data in the database is automatically set. You can set the date corresponding to the oldest and

[3]http://solarstation.ru/sun-service/map
[4]https://observethesun.com/
[5]https://obsun.ru/

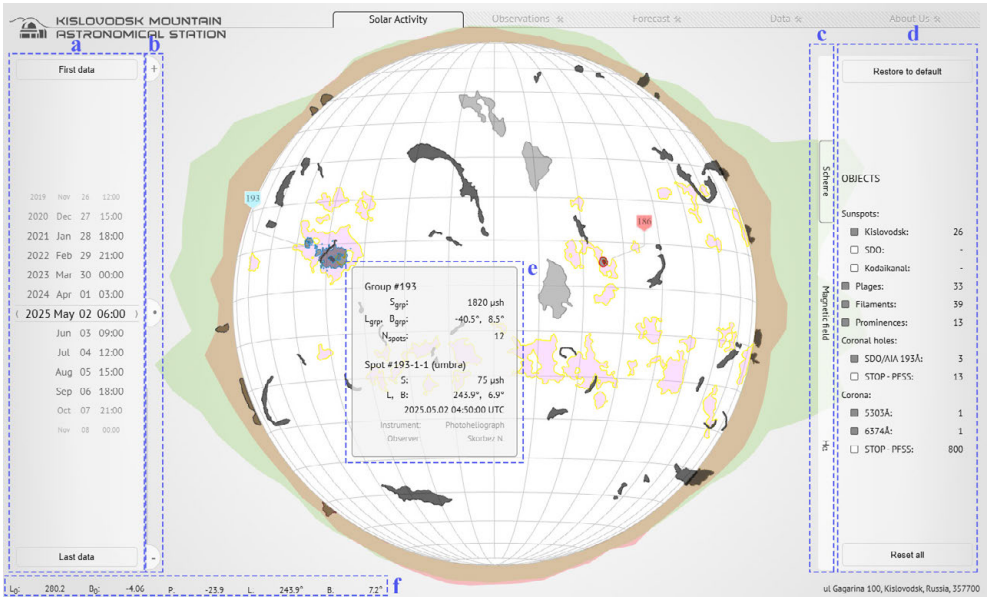


Figure 2 Screenshot of *obsun.ru* site with labeling of the main user interface elements: (a) date navigation, (b) camera control, (c) surface texture selection, (d) filtering of displayed objects, (e) pop-up window with information about the object, (f) Earth and cursor coordinates.

the most recent data using the corresponding buttons on the panel (a). Each object on the map is interactive – when you move the cursor, a panel with detailed information (coordinates, area, group identifier) is displayed (Fig. 2e), and groups of sunspots are additionally highlighted in color and labeled for easy navigation. We would like to emphasize the function of automatic focus on the selected active area by clicking on its identifier.

Thus, *obsun.ru* is not just a visualization tool, but a full-fledged analytical environment for solar activity research, combining scientific rigor with the convenience of modern web interfaces.

Conclusions

The development of *obsun.ru* service will be aimed at expanding functionality and improving data accuracy. The immediate plans include the following:

- Interface improvement: optimization of navigation, addition of tools for comparing data for different dates, adaptation for mobile devices;
- Additional data series: inclusion of data from other observatories for cross-verification;
- Openness: development of an API for data request and publication of data processing techniques.

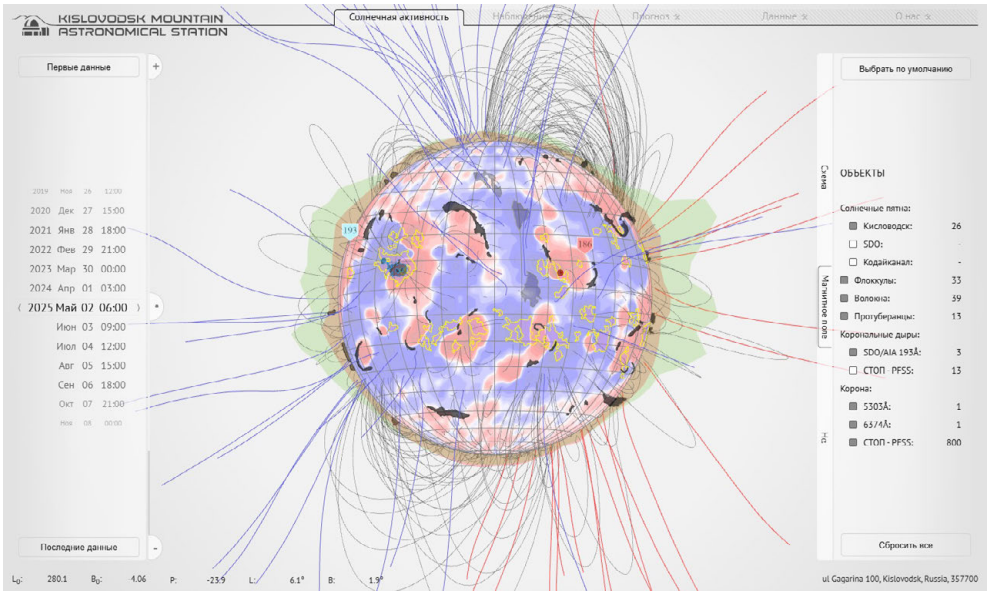


Figure 3 Screenshot of *obsun.ru* site with demonstration of synoptic map texture and magnetic field lines.

The service will continue to develop as a platform for professional analysis of solar activity, combining the historical traditions of KMAS observations with modern digital technologies.

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