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Open Access Database for Different Types of Solar Wind

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Abstract.

The presented open access database summarizes different types of solar wind and their duration in the near-Earth space, including high-speed solar wind streams and slow solar wind. The categorization of the different flows is based on criteria related to experimental data of the main solar wind parameters. The database uses physical conditions to clearly define the beginning and end of each event. The aim of this database is to cover the last four 11-year solar cycles (cycles 20 to 24 and partially 25) for which there are in situ satellite observations.

Keywords: *Open acces database, solar wind types.*

1. Introduction

Research related to space weather and space climate is based on available experimental data on solar activity, solar wind parameters, and geomagnetic activity. At present, several catalogs and databases exist for various aspects of solar activity:

- Hess & Zhang ICME-CME catalog (Hess and Zhang, 2017) - Available at http://solar.gmu.edu/heliophysics/index.php/GMU_CME/ICME_List/.
- Richardson & Cane ICME Catalog (Richardson and Cane, 2010) - Available at http://www.srl.caltech.edu/ACE/ASC/DATA/level3/icmetable2.htm.
- USTC ICME Catalog (Chi Y. et al., 2016) - Available at http://space.ustc.edu.cn/dreams/wind_icmes/.
- Jian's ICME and CIR Catalogs - Available at http://www-ssc.igpp.ucla.edu/~jlan/ACE/Level3/.
- Lepping & Wu MC and MCL lists (Lepping and Wu, 2010): Available at https://wind.nasa.gov/mfi/mag_cloud_pub1.html.
- Yermolaev's large scale solar wind phenomena catalog (Yermolaev Y.I., et al. 2009)- Available at ftp://www.iki.rssi.ru/pub/omni/.
- NASA - OMNI database (King and Papitashvili, 2005; Papitashvili et al., 2020).
- Data Analysis Center for Geomagnetism and Space Magnetism, Geomagnetic Equatorial Dst index, Kyoto University (Ahn et al., 2002) – Available at https://wdc.kugi.kyoto-u.ac.jp/dstdir/.

The information related to the various manifestations of solar activity is in large quantity and is constantly supplemented with new experimental data in these catalogues and databases. However, a complex approach is required for a number of studies, considering, for example, different types of solar wind simultaneously with geomagnetic disturbances. This was essentially the motivation for the creation of an open-access database that combine three main types of solar wind - the slow solar wind, High speed solar wind streams (HSS) and Coronal mass ejections (CMS) along with solar wind parameters, geomagnetic indices, sunspot numbers f10.7 and etc. The identification of the various solar events themselves will be based on the criteria already established. All identified events, as well as information on geomagnetic and ionospheric disturbances of various magnitudes, will be entered into a freely accessible database that will allow relatively easy access and rapid processing. This database will cover the last five 11-year solar cycles (cycles 20 to 24 and the beginning of 25) for which in situ satellite observations are available.

2. DATABASE for different solar wind types

The freely available database of the various manifestations of solar activity, including the slow solar wind, High speed solar wind, and Coronal mass ejection, can be accessed at the following address: https://spaceclimate.bas.bg/SW/catalogs.php.

In order to create a model of the catalog that meets the requirements of easy data processing, implementation of a suitable search engine, and at the same time a clean and sufficiently well-structured interface, extensive research was conducted on similar catalogs and databases on the Internet. The positive and negative sides of the investigated databases were systematized. From the point of view of quality-assured operational work with the database, a search engine was developed, through which it is possible to search for the individual physical parameters of the solar wind according to various criteria.

The database layout for searching individual solar wind events, was developed and structured as follows:

A) Search engine for solar cycle determination (***Fig. 1***)

Figure 1. *Interface of the DATABASE for Different Solar Wind Types.*

This featured search engine consists of 6 buttons that structure the available data into six 11-year solar cycles for the period from 1964 to 2022.

B) Detailed search for the available solar parameter data (***Fig. 2***)

After selecting data for a particular solar cycle, an active page opens with an implemented search engine pointing to the available experimental data for solar wind parameters. The search is performed by activating the "Add condition" button. The next step is to select the number and type of parameters to search for.

The search engine allows you to choose between 1 and all available parameters for the search. For each parameter, a specific condition can be entered to match the data.

C) Data visualization (***Fig. 3***)

Data visualization is actively linked to the search engine. After entering the numerical conditions for the various solar parameters as well as the time period, the average daily data corresponding to these conditions are visualized directly below the search engine. These data are displayed in tabular form. The size of the table can be additionally adjusted.

In detail, the database contains the following information: The first four columns correspond to the time range, respectively the first column gives information about the year (YEAR), the second about the day of the year (DOY), the third about the month (Month) and the fourth about the day of the month (Day). The fifth column (SW type) gives information about the type of solar wind (fast solar wind, slow solar wind and coronal mass ejections). The following columns

of the table visualize experimental data for different parameters of the solar wind and are respectively - properties of the magnetic field (scalar B [nT], Bx [nT], By [nT], Bz [nT]), the temperature (Temperature [K]), density (Density [N/cm^3]), speed (Speed [km/s]), pressure (Flow pressure), plasma beta (Plasma betta). Experimental data for geomagnetic indices (Kp index, Dst index [nT], ap index [nT], AE index [nT]) are also shown at the end of the table.

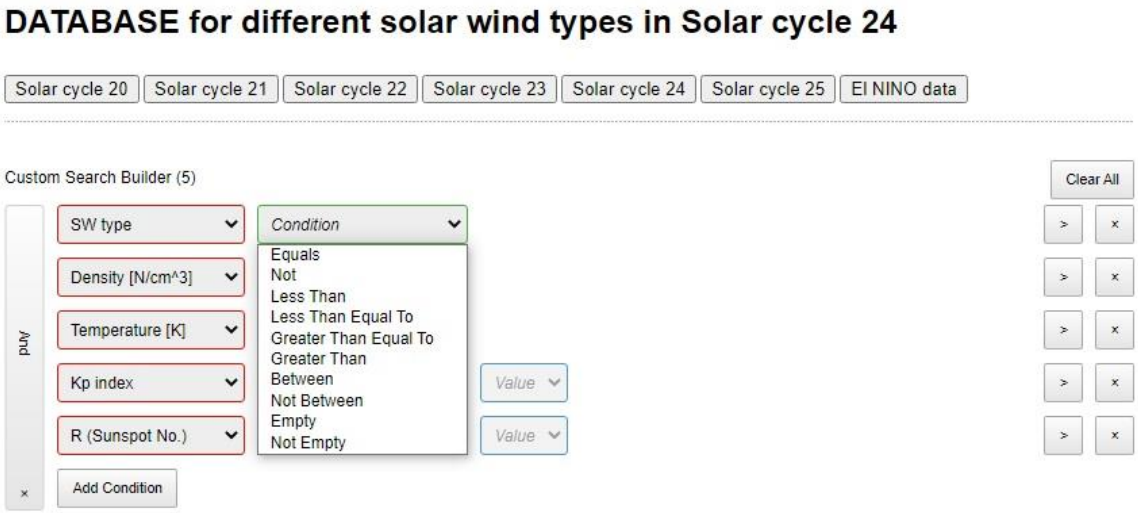

Figure 2. *Custom search builder.*

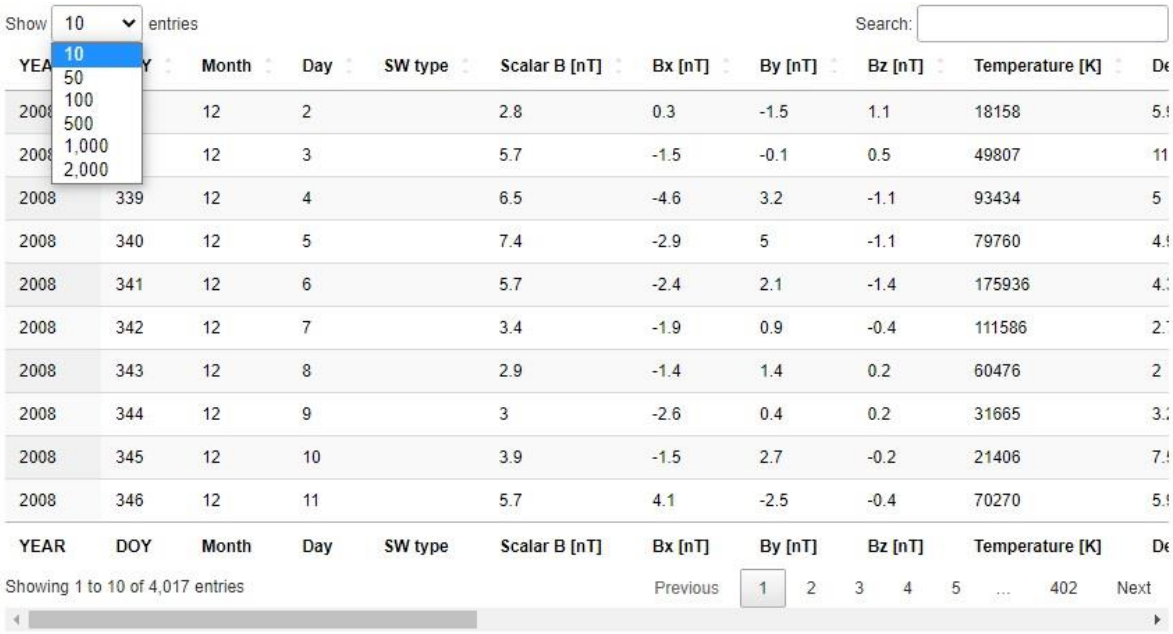

Figure 3. *Custom search builder.*

D) Download data

The system allows the visualized data to be downloaded in "*.csv" format.

The current filling of the catalog with raw data on solar activity, solar wind parameters, and geomagnetic activity follows the analysis of free experimental data and the application of criteria for determining solar wind fluxes. The data composing the catalog of solar events are contained in a suitable format on the server configuration storage space. The main source of

data related to solar wind parameters, sunspot numbers and part of geomagnetic indices is the database NASA:
- https://omniweb.gsfc.nasa.gov/form/dx1.html
The data for the geomagnetic indices Dst and AE are used from the Kyoto College database:
- https://wdc.kugi.kyoto-u.ac.jp/dstdir/

Conclusions

An open-access database of three types of solar wind fluxes and their associated solar plasma parameters and geomagnetic indices is presented.

The data presented are average daily values. Before being included in the database, the raw data are analyzed and the physical criteria developed to determine the periods of the various solar events are applied.

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