Catalogue of hot jets in the solar corona

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We present a catalogue *of plasma jets in the solar corona with a temperature above 0.5 MK, containing primary information about the events and basic parameters of jet*

https://solar.sao.ru/coronal-jets-catalog/

The study of plasma jets in the solar atmosphere is an actively developing scientific field both in the context of fundamental plasma physics and in the field of plasma astrophysics. This direction is also of great importance for the development of methods for predicting space weather. Coronal jets are phenomena regularly observed on the Sun at all phases of the solar activity cycle, both in the quiet Sun and in coronal holes and active regions.

Catalogue content

The catalogue includes: primary information about the event from HEK (Heliophysics Events Knowledge base), observed jet parameters, and associated eruptive phenomena.

The catalogue contains data obtained with the SDO/AIA high-precision EUV telescope, the results of extrapolation of magnetic fields based on photospheric observations of the magnetic field using the SDO/HMI instrument, and the data from the ground-based radio telescopes and spectrometers, including RATAN-600, SRH, and NoRH.

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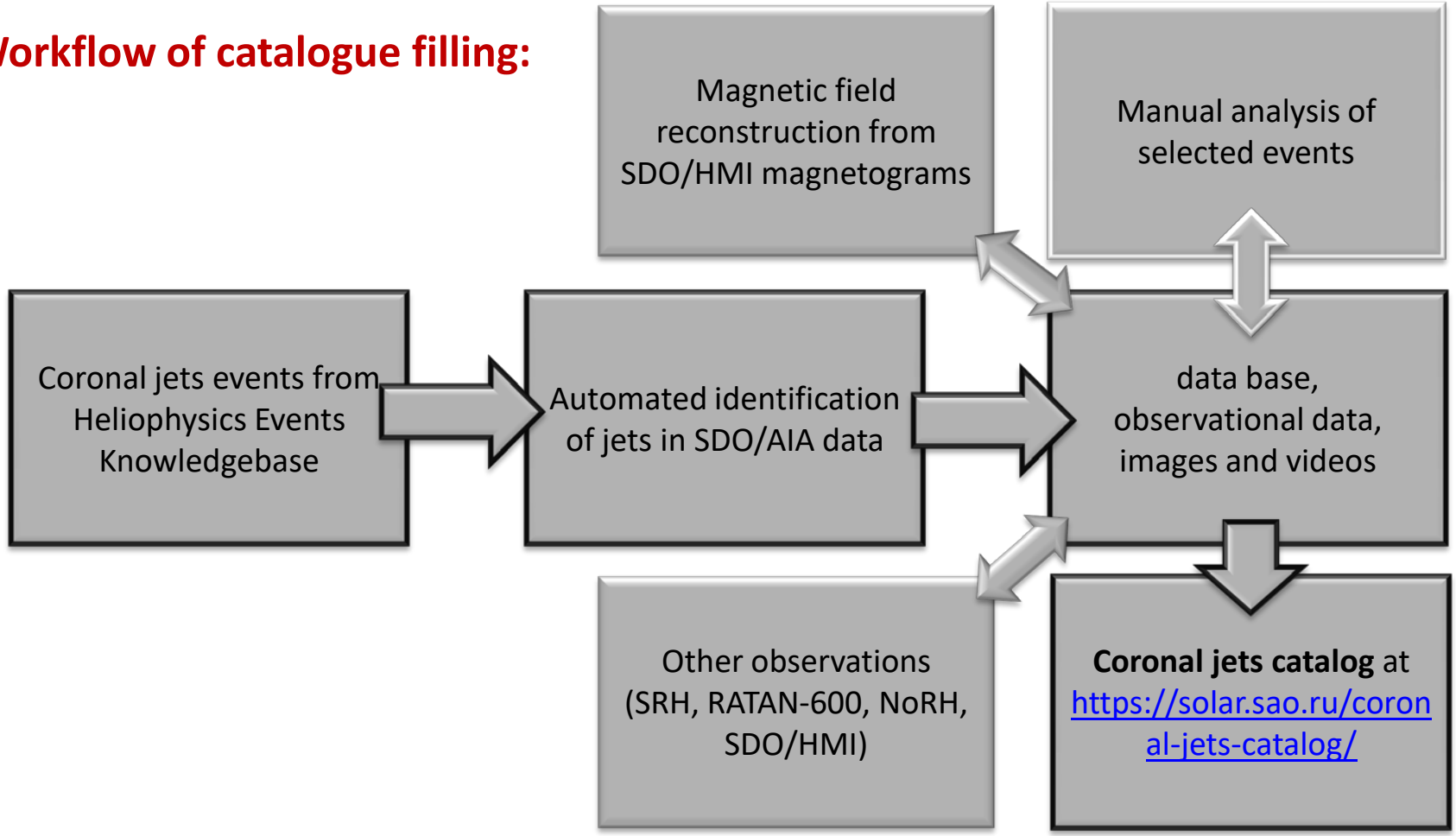
HEK su	Start date-time	Start time	End date-time	X [arcsec]	Y [arcsec]	Longitude	Latitude	RATAN observation	SRH/SSRT obs	NoRH obser	SDO/AIA	Mag.fie
open	03-01-20 07:15	7:15:07	03-01-20 08:31	-854	-683	-87.8	-38.6	5 obs 07:33:04 - 11:02:35				
open	18-04-19 10:30	10:30:10	18-04-19 11:15	915	234	79.6	13.3	31 obs 07:10:43 - 11:15:27			171-3	
open	17-04-19 21:55	21:55:21	18-04-19 00:50	872	23	65.7	-0.9					show
open	17-04-19 08:15	8:15:08	17-04-19 08:59	810	25	57.8	-1.4	31 obs 07:11:06 -11:15:32			171 304 211 1	show
open	26-10-16 05:31	5:31:05	26-10-16 07:33	786.9	189.1	56.98	13.99		show	!7GHz R+L		show

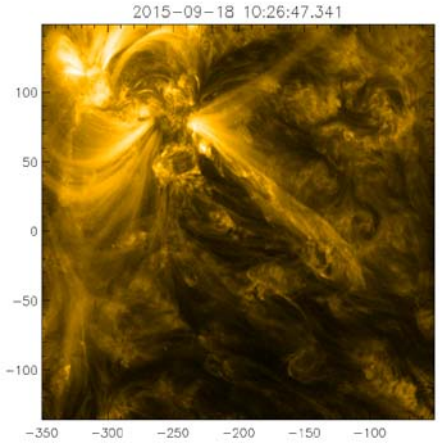
Workflow of catalogue filling:

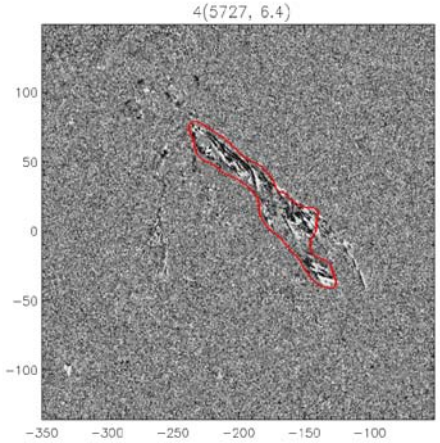


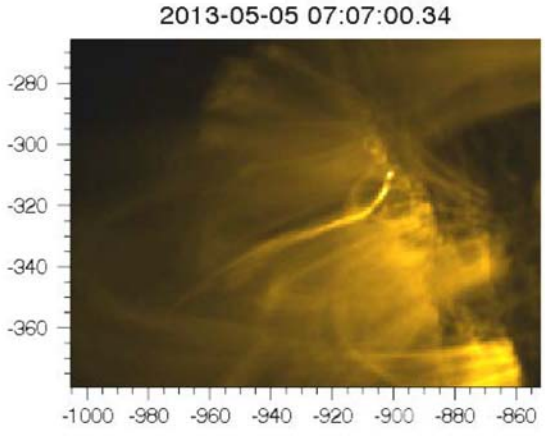
Detailing and visualizing jets on SDO/AIA data

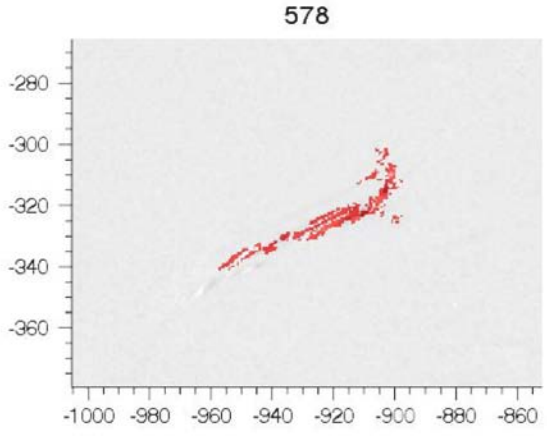
- To obtain detailed information about jets, we used sequences of EUV images with a pixel size of 0.6" and a 12-second cadence, obtained by the AIA instrument of the SDO mission.
- An original method was developed to distinguish jets and automatically determine their parameters. The IDL code implementing the presented method is placed at https://github.com/coronal-jets
- The method is based on the search for contrasting details in "running difference" images (the difference in intensity at consecutive instants of time). As a result, a report is generated containing a list of found events with their characteristics. For each event, a visualization of the dynamics seen in AIA data is provided in different spectral lines (in the form of video files in “mp4" format and as separate frames in "png" format), including the full intensity and the running difference of successive images, with a visual selection of the found jets.
- The method is applied to all of events in the catalogue. Currently wavelength 171Å is proceeded. The results (parameter lists and visualization) are available in the catalogue.

Examples of automatic identification of a coronal jet in SDO/AIA images in the 171 Å channel

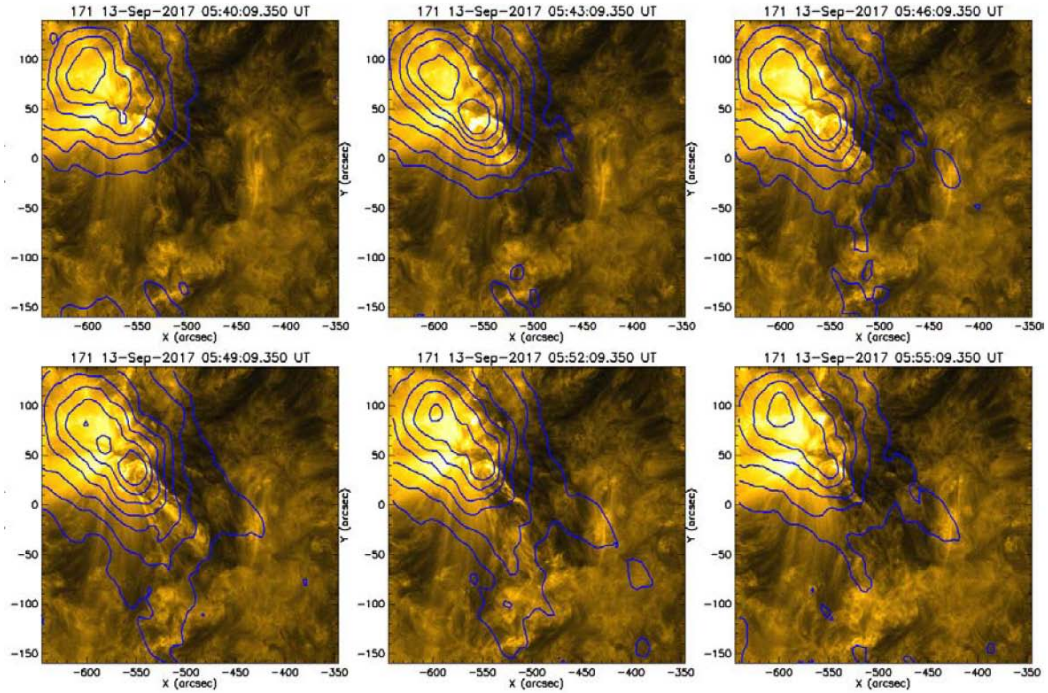






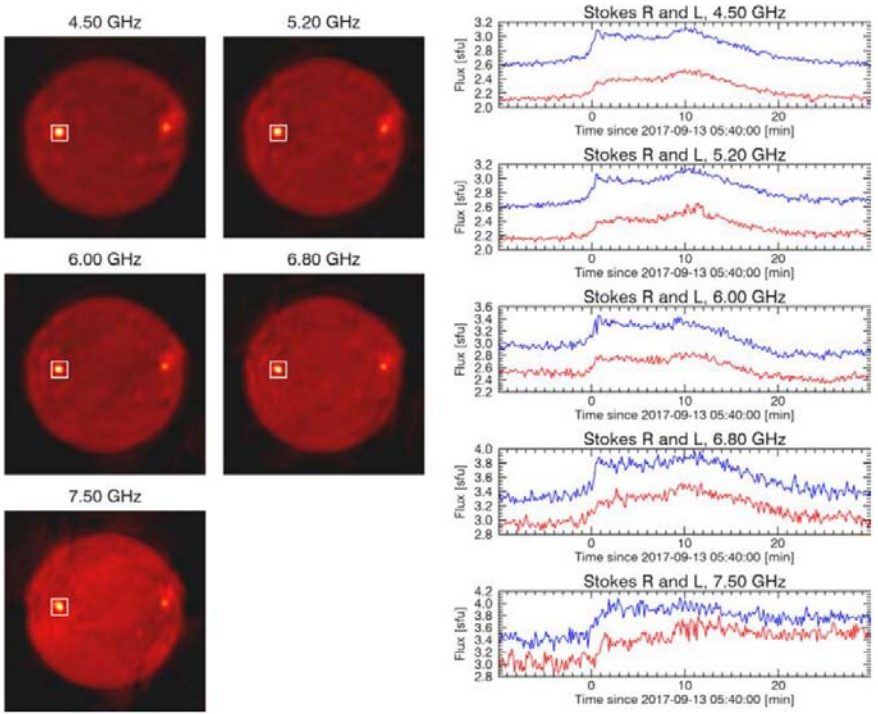


Example of radio observation at Nobeyama Radio Heliograph from Catalogue



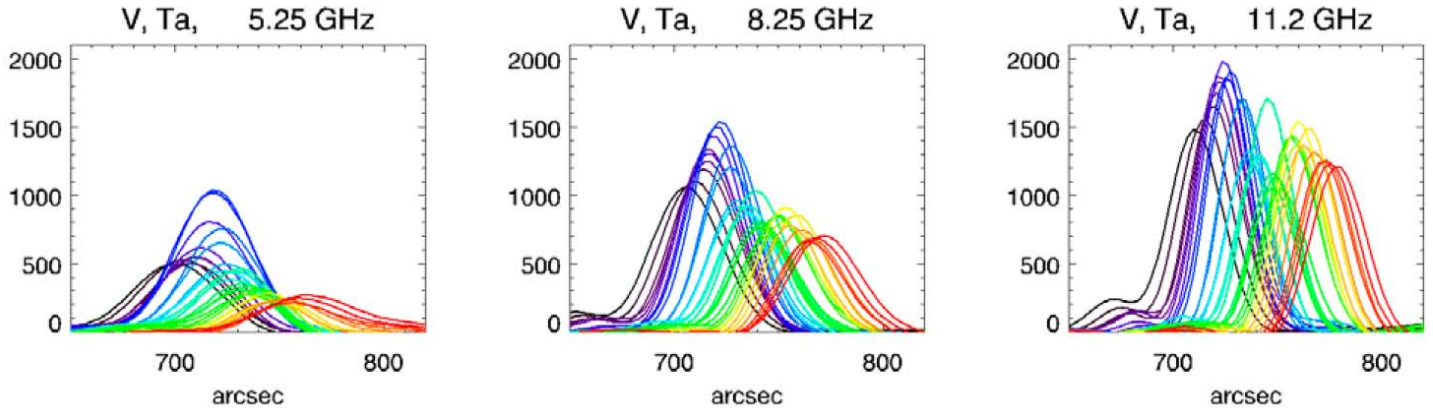
Radio maps of microwave radiation at a frequency of 17 GHz obtained by NoRH on September 13, 2017 for different stages of jet development and superimposed on SDO/AIA 171 Å images as contours. The radio brightness contours correspond to values from 10500 to 15000 K with an increment of 500 K

Example of radio observation at Siberian Radio Heliograph from Catalogue



Radio images of the Sun (left) from SRH for September 13, 2017. The active region in which the jet was observed is marked with a white rectangle. Microwave flux light curves for this region in the right (RCP, blue) and left (LCP, red) polarization are shown in the right panels

Example of radio observation at RATAN-600 (Radio telescope of Russian Academy of Sciences) from Catalogue

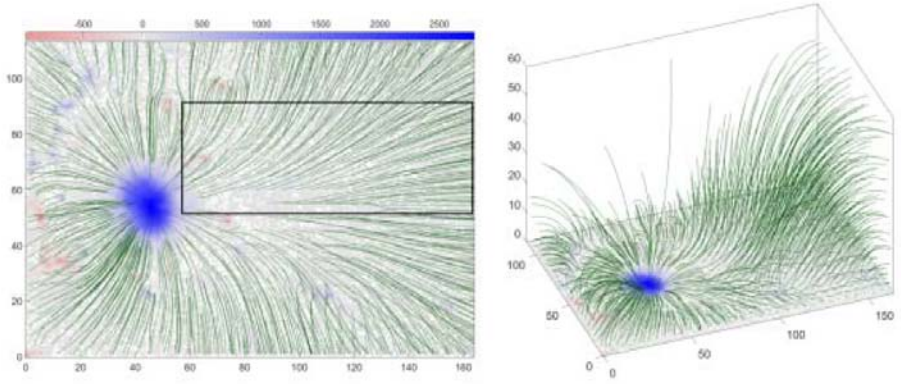


RATAN-600 scans of antenna temperatures of polarized radiation in AR 12738 on April 17, 2019 at frequencies of 5.25, 8.25, and 11.20 GHz. Different colors indicate observations in different azimuths: 31 records in a time span 07:11–11:15 UT with a step of 8 min. The left-to-right shift of the scans is a projection effect associated with the Earth rotation and depending on the orientation of a radio telescope antenna. Jet passage time corresponds to a radiation increase in blue scans

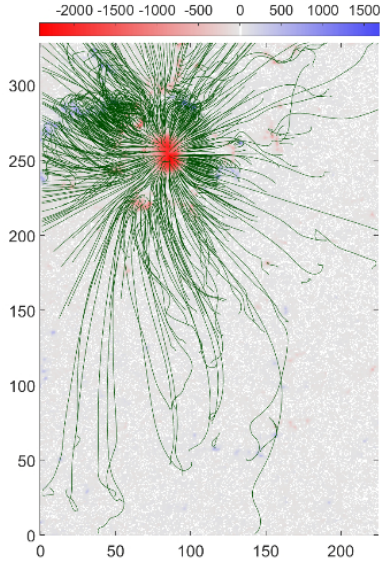
Magnetic field data reconstructed into the corona from photospheric megnetograms

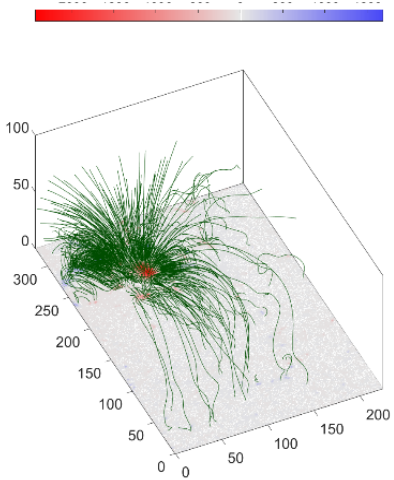
- Potential reconstruction: magnetic field in vacuum, assumes absence of currents and any forces. Describes the structure and connectivity of the magnetic field in the solar corona in the zero approximation *(Alissandrakis, Astron. Astrophys. 100, 197, 1981).*
- Nonlinear force-free field (NLFFF) approach: stationary magnetic field configuration, in which all acting forces except the magnetic one are zero, and electric currents are flows along magnetic field. This approach describes well plasma of the coronal part of slowly evolving solar active regions *(Wheatland et al., Astrophys. J., V. 540, P. 1150, 2000; Wiegelmann, Astrophys. J., V. 540, P. 1150, 2000)*.
- Jet-like event in an active region observed on the Sun's disk not close to the limb: the catalogue contains the NLFFF-reconstructed magnetic field data for a number of events, based on the original implementation of the NLFFF – method, developed and tested by us in *(Fleishman et al., Astrophys. J., V. 839, id. 30, 2017).*
- The field reconstruction results for specific time moments are presented as
  - A set of in the IDL-readable “sav” file format and are ready for use in the GX-simulator package *(Nita et al., Astrophys. J., V. 799, article id. 236, 2015);*
  - A set of pictures of magnetic field lines plotted over photospheric magnetic field.

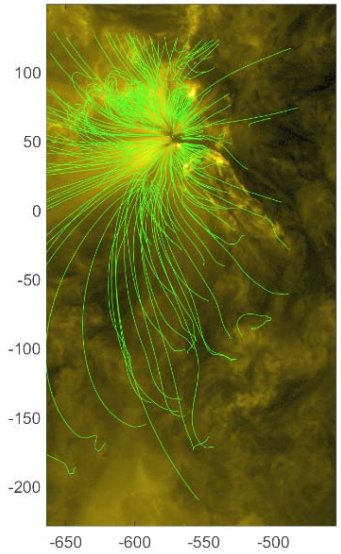
Examples of potential reconstruction magnetic field:



Examples of Nonlinear force-free field (NLFFF) approach:







Catalogue: database with navigation (web interface)

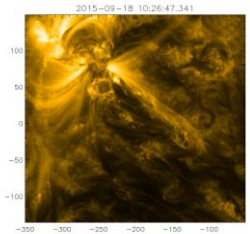
Extended Catalogue: Event List

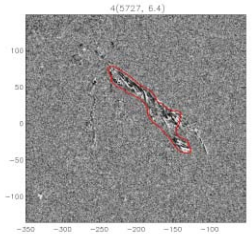
Show 25 entries

#	Date	Starting Time	Ending Time	Longitude	Latitude
1	2010-05-04	05:49:56	06:52:19	-25.9	85.4
2	2010-05-17	20:11:42	21:12:17	13.3	38.4
3	2012-08-29	21:30:35	22:30:35	28.2	82.2
4	2012-09-01	03:20:23	04:10:23	-86.8	26.1
5	2017-01-18	19:51:18	20:04:52	-4.6	8.3
6	2017-08-24	08:16:08	10:56:00	-25.9	6.5
7	2019-04-17	08:15:01	08:59:25	57.8	-1.4

Event 2019-04-17 08:15:01 - 08:59:25

Date	2019-04-17
Start Time	08:15:01
End Time	08:59:25
Jet Time	
Longitude, degrees	57.8
Latitude, degrees	-1.4
X, arcsec	810
Y, arcsec	25
Source	HEK
SourceREF	
Comment	





Event 2019-04-17 08:15:01 - 08:59:25

Detail 1

Wave	Tstart	Tmax	Tend	movie_ref	sav_ref
171	08:27:09	08:43:21	08:54:09	Link	Link
193	08:27:04	08:42:40	08:51:04	Link	Link
				Link	Link

Details

Detail number	Waves	Time Interval	Location	Summary
1	171, 193, 211	08:27:04 - 08:54:09	X	summary
2	171, 193, 211	08:27:33 - 08:43:40	X	summary

Conclusions

• A multi-wavelength Catalogue of plasma jets with temperatures above 0.5 MK ("hot jets") in the Sun's corona has been created.

• To the moment, the catalogue is based on the data for the period of 2010-2020, which almost completely covers the 24th cycle of solar activity.

• The catalogue includes: primary information about the event, observed jet parameters, and associated eruptive phenomena.

• The catalogue contains data obtained with the SDO/AIA high-precision EUV telescope, the results of extrapolation of magnetic fields based on photospheric observations of the magnetic field using the SDO/HMI instrument, and the data from the ground-based radio telescopes and spectrometers, including RATAN-600, SRH, and NoRH.

•A new method of automatic jet detection in homogeneous time series of AIA images is developed. The method is applied to all of events in the catalogue. Currently wavelength 171Å is proceeded, other wavelengths will be proceeded in the nearest future.

• The catalogue is implemented on an online platform that provides open access.

Conclusions (continued)

• The catalogue includes the possibility of direct access to video information based on the visualization of three-dimensional data cubes of imaging telescopes (two spatial coordinates in the sky plane and time) and space-time maps (time-distance maps) built on several spatial slices (slits), as well as adding calculated parameters, including the results of extrapolation of photospheric magnetic sources. It is planned to continue filling the catalogue with data, including information about the X-ray radiation accompanying the jets.

• The purpose of the catalogue is to provide summary information about coronal jets to all interested researchers for further statistical analysis, determination of the characteristic parameters of jets, and in-depth study of individual events.

ACKNOWLEDGEMENTS and FUNDING

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