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Interactive Multi-Instrument Database of Solar Flares

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Abstract Solar flares represent a complicated physical phenomenon observed in a broad range of the electromagnetic spectrum, from radiowaves to γ-rays. For a complete understanding of the flares it is necessary to perform a combined multi-wavelength analysis using observations from many satellites and ground-based observatories. For efficient data search, integration of different flare lists and representation of observational data, we have developed the Interactive Multi-Instrument Database of Solar Flares (https://solarflare.njit.edu/). The web database if fully functional and allows the user to search for uniquely-identified flare events based on their physical descriptors and availability of observations of a particular set of instruments. Currently the data from three primary flare lists (GOES, RHESSI and HEK) and a variety of other event catalogs (Hinode, Fermi GBM, Konus-Wind, OVSA flare catalogs, CACTus CME catalog, Filament eruption catalog) and observing logs (IRIS and Nobeyama coverage), are integrated, and an additional set of physical descriptors (temperature and emission measure) is provided along with observing summary, data links and multi-wavelength light curves for each flare event since January, 2002. We think that the created instrument will allow researchers significantly speed up the search of events of interest for statistical and case studies.

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1. Introduction

Among many interesting heliospheric phenomena solar flares and related events (Coronal Mass Ejections(CMEs), Solar Energetic Particles (SEP), Hard X-ray and gamma radiation) are of particular interest because they can cause many problems for the terrestrial environment initiating return currents and breaking power grids at high latitudes, disturbing the magnetosphere, and damaging satellites equipment. For better understanding of solar flares and their prediction, it is crucially important to analyze multi-wavelength observations, as different physical processes are reflected at different energies. For example, in the Standard flare model, hard X-ray radiation represents bremsstrahlung emission of accelerated particles, and carries information about acceleration processes associated with magnetic energy release. At the same time, observations of visible and ultraviolet spectral lines allow us to understand photospheric and chromospheric responses to the energy release.

Flare events are observed by a variety of space- and ground-based instruments in different wavelengths. Usually, flare lists are created for specific routinely-observing instruments. Currently, the primary flare catalog is based on soft X-ray emission peaks (so-called X-ray flare classes) observed by the Geostationary Operational Environmental Satellites (GOES, Bornmann *et al.*, 1996). The GOES X-ray instruments have observed the solar activity for several decades, and created the largest database of solar flares. Another example of flare-observing instruments is the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI, Lin *et al.*, 2002), launched in 2002. It observes the X-ray radiation of flares in a wide range of energies, from 6 keV to >300 keV. The satellite detects the events and has its own flare list not integrated with the GOES flare list. Two instruments onboard the Solar Dynamics Observatory (SDO) observe solar flares in EUV bands: the Extreme Ultraviolet Variability Experiment instrument (EVE, Woods *et al.*, 2012) observes the EUV spectra of the integrated solar emission, and the Atmospheric Imaging Assembly (AIA, Lemen *et al.*, 2012) instrument observes high-resolution images in several EUV bands. The flare data from both of these instruments are stored in independent data catalogs. In the EVE data, the flares are detected as enhancement of the EUV emission, and in the AIA data the flare events are detected using image processing algorithms and summarized in the Heliophysics Event Knowledgebase (Hurlburt *et al.*, 2012). Some of these events are linked to the GOES database.

The Virtual Solar Observatory (VSO, http://sdac.virtualsolar.org/cgi/search) collects data from many space missions and ground-based observatories, allowing to search for available data for a particular time range. However, it is not designed to search among flare properties. The RHESSI browser (http://sprg.ssl.berkeley.edu/~tohban/browser/) allows to look at RHESSI and Fermi data products, and also to check the observational coverage by Hinode and IRIS of detected flare events. However, it still does not allow to search for flares with the particular properties.

Many problems of the flare physics require to perform analysis using data for a particular set of instruments, or/and for a sample of flares with particular characteristics: for example, for all events having GOES class $\geq$ C5.0 and observed by RHESSI, or for the flares observed in EUV by the IRIS satellite and the Nobeyama radio telescope. To address this type of problems, we develop a new interactive multi-instrument database of solar flares.

This is not the first attempt to solve such types of problems. For example, the Owens Valley Solar Array (OVSA, Hurford, Read, and Zirin, 1984; Gary and Hurford, 1990) legacy radio bursts database (Nita, Gary, and Lee, 2004) allows for search of events based on their physical parameter ranges, and the Solar Flare Finder tool (http://hesperia.gsfc.nasa.gov/sff/), recently developed by Ryan Milligan as a part of Solar SoftWare package for Interactive Data Language (SSW IDL, Freeland and Bentley, 2000), allows to select the flaring events simultaneously observed by GOES, RHESSI, SDO/AIA, Hinode, SDO/EVE and IRIS, and to see their data summaries. Besides all its advantages, there are several points which could be significantly improved, such as implementation of user-interactive filters, more convenient representation of the output set of events, independence of the searching tool from the software etc. We address these points in the developed database.

Figure 1 represents the basic structure of the database, and each block of this Figure is explained in the paper. In Sec. 2, we describe the flare and flare-related event lists, as well as actual data, which serve as daily input for our database. In Sec. 3, we explain the daily processing of the event lists and data: integration of the flares from different lists, calculation of additional event descriptors, preparation (smoothing) of the light curves. The processed data are stored in MySQL database allowing convenient and fast interaction. In Sec. 4, we describe the developed web interface, the structure and logic of queries for our database, and the structure of the output data available for user. The query example is also presented in this section. Finally, we proceed to the conclusion part (Sec. 5).

2. Data collection and Storage

In this Section, we describe the catalogs of events used as input. The complete and up-to-date list of the integrated event sources can be found via the link https://solarflare.njit.edu/datasources.html and summarized in the Table 1.

2.1. Primary Event Lists

The event sources are divided in “primary” and “secondary”. The primary event sources are daily-updated actual lists of flares independently detected by GOES, RHESSI and SDO/AIA instruments. The secondary event sources include partial flare lists, the flare lists derived from the primary ones, and catalogs of flare-related phenomena (such as Filament eruptions or CMEs).

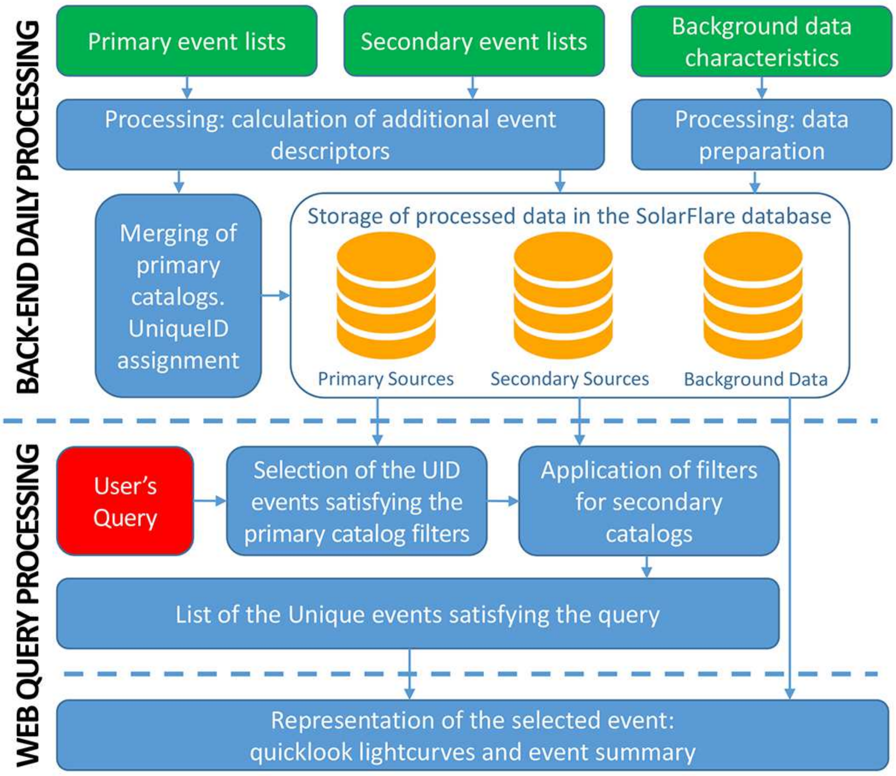

Figure 1. Schematic representation of the Interactive Multi-Instrument Database of Solar Flares (IMIDSF).

Each event in the primary lists has the start, peak and end times. In most cases, the event coordinates and the active region number associated with the events are also known. We use three primary event catalogs:

- *GOES flare list.* The daily lists of events observed by the GOES satellite are available from June 2002 to present. The reported characteristics include the GOES class, the X-ray peak flux during the event, and the information about the active region and coordinates of the event (not for all events). The daily lists are available at the NOAA website.
- *RHESSI flare list.* The list of the flares observed by the RHESSI X-ray telescope from February 2002 to present. Besides the usual descriptors (the flare times and position), the catalog contains the highest energy band in which the flares were observed, the number of counts during the flares, and a variety of observational quality flags.
- *HEK SDO/AIA event list.* The events detected in the EUV images from the AIA/SDO instrument from February 2010 to present. Each of the events is characterized by a variety of different parameters (besides the common ones): the wavelength in which the event was detected, the coordinates in a

variety of coordinate systems, peak fluxes, web links to quick-look images and movies, etc.

The three primary event lists are integrated into a single database, and Unique Identifiers (UniqueID) are prescribed for each event, as discussed in Sec. 3.

2.2. Secondary event sources.

In addition to the primary event lists, the following secondary data sources are integrated in our catalog:

- *The Interface Region Imaging Spectrograph data* (IRIS, De Pontieu *et al.*, 2014). IRIS obtains the slit-jaw UV images as well as spectra of the Sun. The flare events are associated with IRIS observations based on the time and pointing stored in the form of instrument observing logs. The quicklook data web links allow the users to select desired events.
- *Hinode flare catalog* (Watanabe, Masuda, and Segawa, 2012). Among events observed by Hinode spacecraft, only the events that match the GOES list are included in the database. The information includes the availability of observations for each Hinode instrument, and quicklook data links.
- *Fermi Gamma-ray Burst Monitor (GBM, Meegan et al., 2009) solar flare catalog.* The list of the flares observed by the Fermi GBM in the 8 keV-40 MeV energy range from November 2008 to present. Includes duration of the observed flares and number of counts during the flares.
- *Nobeyama Radio-polarimeter light curves (Nakajima et al., 1994).* The polarimetric measurements from Nobeyama Radio Observatory are available for almost every day, usually approximately 8 hours per day.
- *OVSA legacy flare catalog* (Nita, Gary, and Lee, 2004), which includes short-time summaries of events observed by the Ovens Valley Solar Array in the 1-18 GHz microwave range, from 2001 to 2003 only.
- *Computer Aided CME Tracking (CACTus) catalog* (Robbrecht and Berghmans, 2004; Robbrecht, Berghmans, and Van der Linden, 2009). It collects records of CMEs detected from the LASCO/SOHO coronograph, and contains a variety of CME properties, including the onset time, principal angle, velocity, etc. The default event matching is currently based on the following rule: the recorded CME onset time falls between the flare start and end times in the primary catalog. The database user can interactively adjust the time interval.
- *Filament eruption catalog* (McCauley *et al.*, 2015). The matching with the flare list is based on the time and position of the eruptions. A variety of filament parameters are available. The catalog production was stopped on Oct, 19, 2014.
- *Konus-Wind flare catalog* (Aptekar *et al.*, 1995; Pal'shin *et al.*, 2014). Represents the flare records detected by the Konus-Wind satellite. Only events detected by GOES are considered from this catalog.

Our database is designed in such a way that it can support a continuously expanding number of sources for solar events of different nature: flare and flare-related event catalogs and information about the observational coverage by different instruments.

Table 1. Event catalogs currently implemented in the Interactive Multi-Instrument Database of Solar Flares (https://solarflare.njit.edu/).

Source Name	Dates presented	Source web link
	Primary flare lists	
GOES flare list	Jan, 2002 — current time	ftp://ftp.swpc.noaa.gov/pub/warehouse/
RHESSI flare list	Feb, 2002 — current time	http://hesperia.gsfc.nasa.gov/hessidata/dbase/
HEK flare list	Feb, 2010 — current time	https://www.lmsal.com/isolsearch
	Secondary event catalogs	
IRIS observing logs	Jul, 2013 — current time	http://iris.lmsal.com/search/
Hinode flare catalog	Nov, 2006 — July, 2016	http://st4a.stelab.nagoya-u.ac.jp/hinode_flare/
Fermi GBM flare catalog	Nov, 2008 — current time	https://hesperia.gsfc.nasa.gov/fermi/gbm/qlook/
Nobeyama coverage check	Jan, 2010 — current time	ftp://solar-pub.nao.ac.jp/pub/nsro/norp/xdr/
OVSA flare catalog	Jan, 2002 — Dec, 2003	http://www.ovsa.njit.edu/data/
CACTus CME catalog	Jan, 2002 — current time	http://sidc.oma.be/cactus/
Filament eruption catalog	Apr, 2010 — Oct, 2014	http://aia.cfa.harvard.edu/filament/
Konus-Wind flare catalog	Jan, 2002 — Jul, 2016	http://www.ioffe.ru/LEA/Solar/index.html

2.3. Background Data Characteristics

The aim of the developed database is not only to collect and integrate the flare records from different sources. We also want the users to receive an overview of the event they potentially want to study, i.e. to look at some data for the event. The flare catalogs themselves contain many useful links. For example, each HEK flare record contains the links to the quicklook movies and images obtained by AIA/SDO. Our approach is to contribute to the flare overlooks and present additional data for each event.

For the beginning, we decided to work with the light curves. Here is the summary of the time plots we provide for each event (if covered by the instrument):

- *GOES X-ray light curves* (two channels 0.5-4 Å and 1-8 Å).
- *Temperature and Emission Measure determined from the GOES X-ray data in a one-temperature approximation.*
- *SDO/EVE ESP light curves* (four diode channels: 18 nm, 26 nm, 30 nm, 36 nm).
- *Nobeyama Polarimeter data* (six frequency bands, two polarizations: 1 GHz, 2 GHz, 3.75 GHz, 9.4 GHz, 17 GHz, 35 GHz, I and V polarizations for each frequency).

Each of the described sources is daily-updated. The Temperature (T) and Emission Measure (EM) for the events are computed using Temperature and Emission measure-Based Background Subtraction Algorithm (TEBBS, Ryan *et al.*, 2012) described in Section 3. For the SDO/EVE ESP light curves, we apply 10-second averaging in order to obtain smoother behavior of the data. The same approach is used for the Nobeyama Polarimeter data. The characteristics describing the flare evolution provide useful information for selecting particular events for further detailed studies.

2.4. Data Storage and Queries

For quick access to the flare records and data, we store the data in a MySQL database. Each catalog is created as a separate relation, and proper indexes are created to speed up the search. A web interface allows the user to query and visualize the results. A typical query of the entire dataset takes just a few seconds, as well as for producing the data overview page for each event.

3. Data Enrichment and Processing

Besides the routine daily updates of the event lists, we perform additional processing and enrich the stored data. First, we calculate physical descriptors of the events (coordinates, Temperature and Emission Measure peaks and their times for GOES events) in addition to those stores in the lists. Second, we match the events from three primary lists and assign unique identifiers (UniqueID) for each uniquely-matched event. These procedures are described in this section.

3.1. Determination of Coordinates for the GOES Events

The GOES flare list reports the events determined from the integrated X-ray light curves and includes coordinates only for some events. However, in most cases, the NOAA active region number where the flare occurred is known and reported in the list, but without its coordinates. To estimate the coordinates of the event based on the active region number, we utilize the Solar Region Summary (SRS) files. Such files are formed every day half-an-hour after midnight and report the current active regions, and their locations at 00:00 UT. Using these angular coordinates, we compute the position of the active region at the flare start time, assuming the Carrington rotation period $T \approx 27.3$ days, and taking into account the variations of the solar radius with time.

3.2. Temperature and Emission Measure for GOES Events

Important physical properties derived from the GOES X-ray observations are Temperature (T) and Emission Measure (EM) (Thomas, Crannell, and Starr, 1985; White, Thomas, and Schwartz, 2005). These parameters can be defined for each moment of time, and provide T and EM profiles for every flare. In our database, we characterize flares by the peak values of these parameters (T_{max} and EM_{max}), as well as by the times when these peak values are reached. To remove the background (non-flare) X-ray flux, we use the Temperature and Emission measure Based Background Subtraction (TEBBS) algorithm, initially proposed by Bornmann (1990) and improved by Ryan *et al.* (2012) based on the assumption that T and EM must grow during the flare impulsive phase. We have implemented in our database the algorithm proposed by Ryan *et al.* (2012). The corresponding GitHub repository is available for public access: https://github.com/vsadykov/TEBBS.git

As mentioned above, the algorithm receives all the physically-possible combinations of the background level, which provide growing T and EM curves after the flare start time. For each of these curves, we calculate the T and EM maximum values during the flare. The range of these values defines the physical interval for T_{max} and EM_{max}. To obtain "the best" curve representing the T and EM dynamics, we simultaneously minimize the deviation from the T_{max} and EM_{max} median values for all curves, and choose the one corresponding to the minimum mean deviation. For the best estimate curve, we compute T_{max} and EM_{max}, and the corresponding time moments, and store them in our database, together with the possible physical intervals of T_{max} and EM_{max}. An example of the TEBBS calculations for a C3.9 class flare is presented in Figure 2.

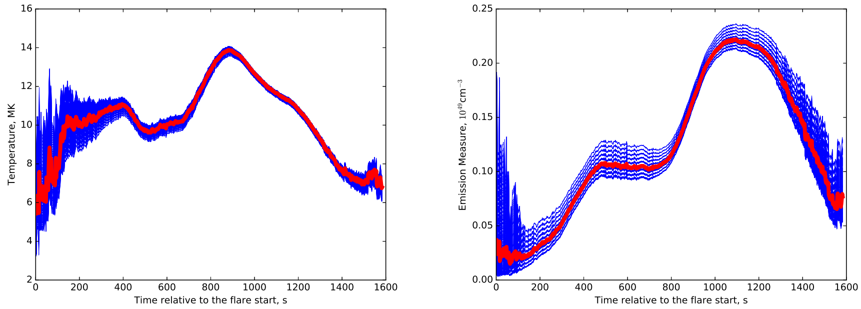

Figure 2. Example of the Temperature (right panel) and Emission Measure (left panel) calculations using the TEBBS algorithm for the SOL2016-02-15T04:02:00 event (C3.9 class flare). The blue curves represent the physically possible Temperature and Emission Measure solutions. The red lightcurves represent the best-estimate solution.

3.3. UniqueID Assignment and Relation to the SOL ID

The three "primary" catalogs (GOES, RHESSI and HEK flare lists) of the database are updated on daily basis. For every new flare event, we assign the Unique Identifiers (UniqueIDs) by integrating the information from these three different sources.

Each of the "primary" catalogs reports the events with the known start, peak, and end times. Also, the information about the event coordinates is provided or calculated as described above. This information is used to determine if the entries in these catalogs represent the same physical phenomenon, i.e. they happened at the same time in the same place, or they belong to different events.

For assigning the UniqueID, we introduce the following hierarchy order: NOAA GOES, RHESSI, and the HEK flare list. This order means the following: if a flare event is reported by GOES, then it labeled as a GOES event ("gev"). If an event is not in the GOES catalog, but reported by RHESSI, this event is labeled as a RHESSI event ("rhessi"). If an event is not reported by GOES and RHESSI, but recorded as a flare in the HEK database, this is labeled as a HEK event ("hek"). The UniqueID consists of two parts: the name of the primary instrument that observed the flare, and its start time. For example, the GOES event observed at some time "yyyy-mm-dd hh:mm:ss" will receive the UniqueID "gev_yyyymmdd_hhmmss", while RHESSI or HEK events will receive the "rhessi_yyyymmdd_hhmmss" or "hek_yyyymmdd_hhmmss" label, respectively. The advantage of such assignments is that this classification can be easily extended for any number of flare-reporting instruments.

The procedure of the UniqueID assignment is the following:

1. Query GOES flare list events for their coordinates and active region numbers. Then, sort the events according to their GOES X-ray class in the descending order. For each event (hereafter parental event) assign the UniqueID "gev_yyyymmdd_hhmmss" according to the event. Then,

   a) For each "gev" event, find all events in the RHESSI and HEK fare catalogs overlapping in time, from the start to end times, and obtain their coordinates and active regions. This is a list of candidate events corresponding to the parental event.

   b) For each candidate event compare the coordinates and active regions with the parent event. The events are assigned the same UniqueID as the parent event if they have the same active regions and their location differs by no more than $\delta = 250''$. This value was chosen experimentally, and it is approximately equal to the size of a large active region. If one of the compared events (parental or candidate) has coordinate or/and active region information missing, the corresponding condition is thought to be satisfied.
2. Repeat the procedure for the events for which the UniqueID is still not assigned, using the RHESSI flare catalog. For these events, assign UniqueIDs in the form "rhessi_yyyymmdd_hhmmss".
3. Repeat the procedure for the remaining set of events for which the UniqueID was still not assigned, using the HEK register. The HEK register contains events overlapping in time (for example, reported for different SDO/AIA channels, or from different locations), thus the matching procedure is still needed. For the matched events, assign UniqueIDs "hek_yyyymmdd_hhmmss"

The procedure of the UniqueID assignment for new events is repeated on a daily basis. Nevertheless, a complication may happen if one of the events is reported with a delay of one day or more. If this is the case, the UniqueIDs of the events overlapping with such event are cleaned, and the UniqueID assignment starts for all the events with empty UniqueIDs.

The same UniqueID may be defined for several GOES, HEK and RHESSI events. For all such overlapping, we keep the maximum and minimum values for each of the coordinates among all the matched events.

The last thing needed to be mentioned is how our UniqueIDs correspond to other event IDs. The Solar Object Locator (SOL), which in its simplest form contains only the event time, is one of the widely-used identifiers. Because it is not documented whether the event time should correspond to the start, peak or end time, although, for display purposes, we use the flare start time as a default reference time, we assign and maintain in the database the correspondence between our UniqueID and these three possible versions of the SOL IDs.

4. Query Structure and Processing

In this chapter, we discuss the structure of the query engine. This part is the most important for the construction of the Web API, because it should be efficient, fast and user-friendly. The current implementation presents the final list of events in a convenient form, works fast, and it is constructed in such a way that adding new catalogs does not require changes of the code structure.

To perform a query, the user needs to fill the request form in the Web Application site: a web request form available at https://solarflare.njit.edu/webapp.html. In the request form, the user selects the desired time interval (including the possibility to select the whole time range, starting from January 1st, 2002). After this step, the user may apply additional search filters such as disc location, availability of the uniquely-matched events in different catalogs, as well as ranges of various physical parameters, and execute the query by pressing the submit button.

4.1. Primary catalogs, Filters and Appearance of the Additional Fields

The "primary" flare catalogs (GOES, RHESSI and HEK flare records) are updated on a daily basis and have the flare records detected by their own algorithms. The descriptors of the primary catalogs are displayed independently on the user's selection of filters. For example, if the user is searching for all events listed in the RHESSI flare catalog, the output may have empty GOES or HEK fields. All fields will be populated only if the appearance in all three catalogs is selected.

The on-the-fly generation of additional search field corresponding to specific event descriptors for the other catalogs happens on user's choice. For example, let us consider the case of a user looking for the events listed in the Hinode catalog. In such cases, the descriptor fields related to the Hinode catalog (number of observed frames, corresponding quicklook link etc.) will appear in the final table, as additional columns. This strategy allows us to make the tables as short and informative as possible based on the user's query. Almost each of the parameter fields may be tuned during the query: the filters allow not only to check the appearance of the event in a certain catalog, but also to select events having particular physical characteristics.

The initially-constructed table (based on the primary catalogs) is the backbone for the query: we simply discard from this table the event records which do not pass additionally selected filters. This allows us to check the selected filters one by one, without pulling them into one large query. This structure has one more advantage: we can add the filters for new-uploaded catalogs/lists without disturbing the working system. Addition of a new event table just requires a new independent block in the query engine.

4.2. Final Table and Python Routine for Parsing

The final result of a query is presented in the form of a web table with moving headers. One can simply drag the table to the right to see various characteristics of the events. For better performance, we currently restrict the number of events appearing in the table to 1000. However, the full lists of events is available for downloading in the output file. We also added the possibility to sort the output table according to the flare characteristics. The sorting procedure represents another query to the server and includes all events, even if the number of events exceeds 1000. We added option for user to download the output table. In order to simplify the processing of the output file, we created a Python parser which reads the table and creates the structure corresponding to the events.

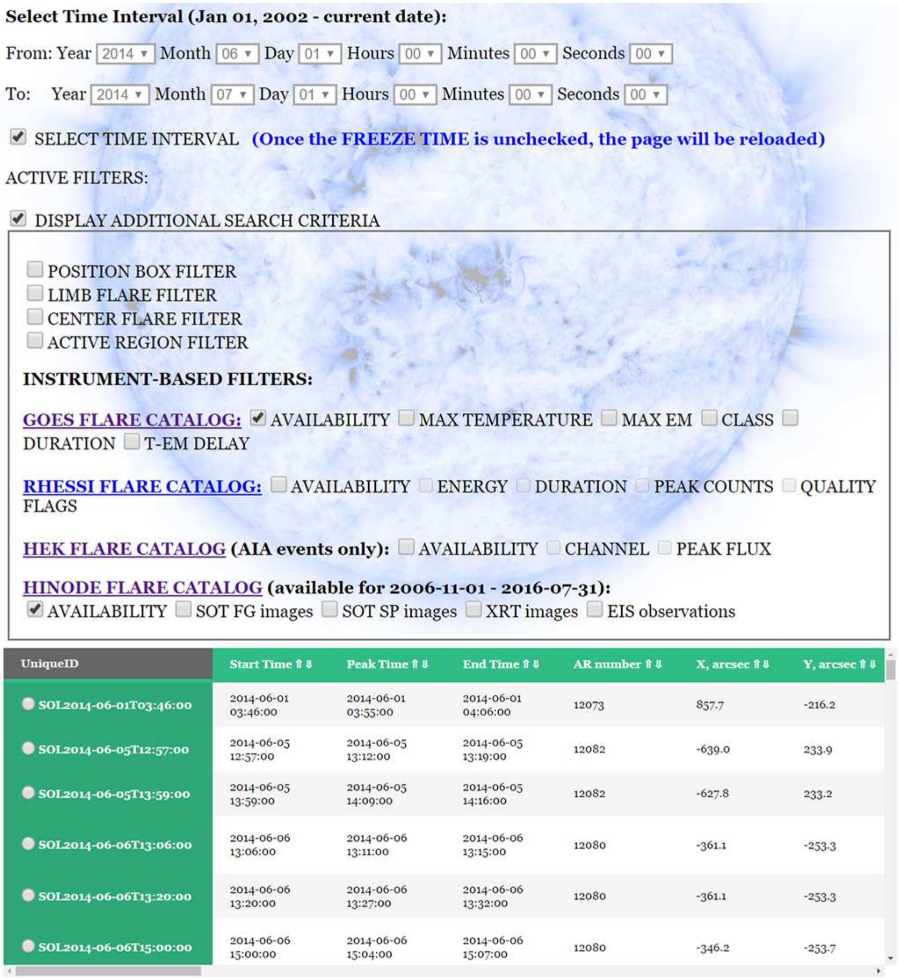

Figure 3. Example of the query for the flare events detected in GOES flare list in June, 2014, and mentioned in the Hinode flare catalog.

4.3. Detailed Visualization of a Selected Events

The main purpose of the created database is to integrate the entries from different catalogs, and to present the complete list of events satisfying a set of

Table 2. Results of the sample query (see text for details).

SOL ID	Flare Class	RHESSI highest energy	IRIS Raster Mode
SOL2015-02-04T02:08:00	M1.2	12-25 keV	dense
SOL2015-03-12T21:44:00	M2.7	25-50 keV	sit-and-stare
SOL2015-03-13T05:49:00	M1.8	25-50 keV	sit-and-stare
SOL2015-03-15T22:42:00	M1.2	25-50 keV	sparse
SOL2015-03-17T22:49:00	M1.0	50-100 keV	sparse
SOL2015-08-27T04:48:00	M2.9	25-50 keV	coarse

conditions specified by the user. However, from a practical perspective, it is very important to have a brief look at the event data, and decide whether a particular event is interesting for a case study or not. For this purpose, we created the possibility to look at the light curves of event obtained by different instruments. To proceed into the event page, one needs to select the event of interest from the summary table received in the previous stage, and click the "Plot Data" button.

The main elements of this page are the two dynamic graphs reflecting the behavior of several event light curves: X-ray fluxes, Temperature and Emission Measure calculated for the GOES data using the TEBBS algorithm, light curves from the SDO/EVE/ESP instrument, and the Nobeyama Radio Polarimeter fluxes. The user can select which plot to display, and scale it accordingly. For the visualization, we are currently using the Google Charts tool.

The interactive web interface also allows the user to download all the displayed light curves. The downloaded file contains the GOES data with 2s resolution, and the 10s averaged Nobeyama and SDO/EVE/ESP data. Besides the graphs, we also provide the user with a detailed description of all overlapping events from the primary GOES, RHESSI and HEK lists corresponding to the same UniqueID. Besides the usual flare descriptors, the HEK database contains links to the flare quicklook images: we keep these links in our event summary page, which also can be downloaded.

4.4. Example of the Query

To demonstrate the capabilities of the developed Multi-Instrument Database of Solar Flares, we provide here an example of a multi-instrument query. Let us suppose that the user searches for all events that happened in 2015, had a GOES class $\geq M1.0$, were observed by RHESSI satellite, are mentioned in the HEK catalog, have spectra available from SOT/Hinode (mentioned in the Hinode flare catalog with corresponding marker for SOT SP observations), and were covered by IRIS and Nobeyama, at least partially. Such query returns six flares. Some descriptors of these flares are presented in Table 2. After the query, the user can check the events manually: see the lightcurves for each event, proceed to IRIS quicklooks, check if the event was covered by the IRIS slit positions, etc.

5. Conclusion and Future Plans

We have created an Interactive Multi-Instrument Database of the Solar Flares available to the community at https://solarflare.njit.edu/. This database allows to integrate a set of available solar flare lists and data in a convenient way, and includes the following main features:

- The integration of the flare events from different flare catalogs (GOES, RHESSI, HEK, Hinode, Fermi GBM, Konus-Wind, OVSA flare catalogs). The match of events from GOES, RHESSI and HEK primary flare lists, and assignment of Unique Identifiers (UniqueIDs) for flares. The queries provide "one flare — one result." After the UniqueID assignment, the flare reports are integrated with secondary flare catalogs (Hinode, Fermi GBM, Konus-Wind, OVSA) and flare-related events (Filament Eruption catalog, CACTus CME catalog), depending on the user's query.
- The search of the flare events based on their physical descriptors (both stored in the catalogs and calculated by our efforts) and availability of observations (currently IRIS and Nobeyama observational coverage check is available). The search allows the users to select the events of interest based on the predefined properties.
- The detailed look at the data (GOES, ESP/EVE and Nobeyama light curves, and temperature and emission measure derived from GOES data) for a particular event, and to its summary containing quicklook links stored in the primary catalogs, allows the user to form an initial opinion about the selected event, and to decide whether the event would be interesting for a case study.

The integrated catalogs generated by our database provide a tool to assist researches who study solar flares using large data archives. Firstly, the tool we have created allows the user to search for events having the parameters of interest for various statistical studies, handling all the catalog-creation tasks, or at least providing a catalog to start from. Secondly, it handles the summary for each event, allowing the researchers to understand if the particular event satisfies criteria for particular case studies. The form of the web API allows a platform- and software-independent search and overlook, which is also an advantage of our project.

As far as we know, there are almost no examples of such kind of query engines for solar flares. In this case, our database really provides a unique overlook of the flare data. Currently, there are many filters, catalogs and data processing modules already implemented in our database. However, the design allows further addition of the instrumental logs and sources without distortion of the current schema. Further expansion of the project is definitely in our plans.

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GBM, Konus-WIND, OVSA flare catalogs, Filament eruption catalog, CACTus CME catalog and Heliophysics Event Knowledgebase) for the possibility to work with their data. The research was partially supported by the NASA Grants NNX15AN48G, NNX14AB68G and NNX16AP05H.

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