Heliophysics Events
Knowledgebase

Part I - First Steps to SDO data access and discovery

Mark Cheung on behalf of the LMSAL Helio-informatics Team
What is HEK?

**Heliophysics Events Registry (HER)**

- Tells you what features and events have been found on the Sun

**Heliophysics Coverage Registry (HCR)**

- Tells you what data sequences are available (AIA, HMI, SOT, XRT, TRACE and more).

HEK is the integrated system which
- directs scientists to the data they need without blindly downloading TBs of images, and
- allows users to report new features/events and to contribute information on existing ones (hence “knowledge”).
Architecture of the HER

• Various instruments deliver separate data streams

• Various Feature Recognition Methods (FRMs; human or algorithm) operate on individual data streams to find features/events

• Different FRMs report separate entries into the Heliophysics Events Registry. Each entry contains information about
  • Data source (Observatory, Instrument, Wavelength)
  • Spatio-temporal location
  • Feature Recognition Method
  • Users/third party clients (e.g. SolarSoft) use the Application Programming Interface to access HER.
Searching for events using the HER
http://www.lmsal.com/isolsearch
iSolSearch Layout
LMSAL >> Sungate >> iSolSearch

HEK home  Recently reported events  Search Events  Search Data  API

Search  Filters  Special

Start Date:
2003-11-05T00:00:00

End Date:
2003-11-06T00:00:00

Choose Event Types:
- Active Region
- CME
- Coronal Dimming
- Coronal Hole
- Coronal Jet
- Coronal Wave
- Emerging Flux
- Filament
- Filament Eruption
- Filament Activation
- Flare
- Loop
- Oscillation
- Sigmoid
- Spraysurge
- Sunspot
- Plage
- Other
- Nothing Reported

Search

Results

1. AR10486
2. AR10487
3. AR10488
4. AR10495
5. AR10497
6. AR10487
7. AR10495
8. AR10497
9. AR10486
10. AR10488
11. GOES M1.6 Flare
12. TRACE Flare
13. SXI Flare
14. GOES C4.7 Flare
15. SXI Flare
16. GOES M5.3 Flare
17. TRACE Flare
18. SXI Flare
19. CACTus CME
20. GOES C1.9 Flare
21. EIT Flare
22. CDAW CME
23. AR10487
24. AR10495
Welcome to iSolSearch -- a window into the Heliophysics Events Knowledgebase (HEK). iSolSearch and HEK are designed to guide heliophysics researchers to relevant solar data, and primarily to that acquired by the Solar Dynamics Observatory (SDO) with the Atmospheric Imaging Assembly (AIA) and the Heliospheric and Magnetic Imager (HMI).

- **Users Guide**
- QuickTime User Video
- SolarSoft USA
- API Documentation

- other links...
- Heliophysics Events Knowledge Base

Choose Event Types:
- Active Region
- CME
- Coronal Dimming
- Coronal Hole
- Coronal Jet
- Filament
- Filament Eruption
- Filament Activation
- Flare
- Loop
- Oscillation
- Sigmoid
- SpraySurge
- Sunspot
- Plage
- Other
- Nothing Reported

Search Panel

Display Panel

Search results (export)
1. AR10486
2. AR10487
3. AR10488
4. AR10495
5. AR10497
6. AR10487
7. AR10495
8. AR10497
9. AR10486
10. AR10488
11. GOES M1.6 Flare
12. TRACE Flare
13. SXI Flare
14. GOES C1.7 Flare (no pos.)
15. SXI Flare
16. GOES M5.3 Flare
17. TRACE Flare
18. SXI Flare
19. CACTus CME
20. GOES C1.9 Flare (no pos.)
21. EIT Flare
22. CDAW CME
23. AR10487
24. AR10495
Legend of event/feature icons
One-click time navigation
Switching between solar disk and Carrington grid views
Searching for events submitted by a person or recognition method
iSolSearch automatically searches for nearby observations
How to request data using the HCR

• First see if iSolSearch lists datasets that have already been created (next video)

• If existing datasets satisfy your needs, great.
How to request data using the HCR

• First see if iSolSearch lists datasets that have already been created.

• If existing datasets satisfy your needs, great.

• If not, click on the “Request data” link in the Summary Panel or go to:

• http://www.lmsal.com/get_aia_data
How Events/Features are reported

- Automatic detection algorithms
- Feature Finding Team (will) provide(s) modules that sift through AIA and HMI data
- Codes running at other institutions (on SDO data or on data from other observatories) can also remotely submit events.
- Already in place: Flares (SSW Latest Events, FFT), Filaments, ARs (transcribed from NOAA list as well as ones detected in EUV images)...
- Features/events are (http-)posted to HER
- Human annotation
- Panorama/Annotator (see separate video).
Human Annotation of Events using EVACS/Panorama
SSW Event Creation

IDL>; Create IDL structure for a Flare event
IDL>event = struct4event('fl')
IDL>; Populate the structure with required values
IDL>event.required.OBS_Observatory = 'TRACE'
IDL>event.required.OBS_Instrument = 'TRACE'
IDL>event.required.OBS_ChannelID = 'TRACE 171'
IDL>event.required.OBS_MeanWavel = '171'
IDL>event.required.OBS_WavelUnit = 'Angstroms'
IDL>event.required.FRM_Name = 'Karel Schrijver'
IDL>event.required.FRM_Identifier = 'Karel Schrijver'
IDL>event.required.FRM_Institute = 'LMSAL'
IDL>event.required.FRM_ParamSet = 'n/a'
IDL>event.required.FRM_DateRun = '2007/01/03 12:00:00'
IDL>event.required.FRM_Contact = 'schryver at lmsal dot com'
IDL>event.required.FRM_URL = 'n/a'

About the observation

About the Feature Recognition Method
SSW Event Creation (continued)

IDL>event.required.Event_StartTime = '2006/10/10 23:45:13'
IDL>event.required.Event_PeakTime = '2006/10/10 23:47:54'
IDL>event.required.Event_EndTime = '2006/10/10 23:55:20'
IDL>event.required.Event_CoordSys = 'UTC-HPC-TOPO'
IDL>event.required.Event_CoordUnit = 'arcsec'
IDL>event.required.Event_Coord1 = '-400'
IDL>event.required.Event_Coord2 = '300'
IDL>event.required.Event_C1Error = '4'
IDL>event.required.Event_C2Error = '4'
IDL>event.required.BoundBox_C1LL = '-440' ;Coordinates of lower-left
IDL>event.required.BoundBox_C2LL = '260'  ;Corner of bounding box
IDL>event.required.BoundBox_C1UR = '-360' ;Coordinates of upper-right
IDL>event.required.BoundBox_C2UR = '340'  ;Corner of bounding box

About the location of the event
SSW Event Creation (continued)

IDL>; If you want, add a description
IDL> event.description="My first flare"

IDL>; If you want, add up to ten references
IDL>; You must provide a name, link and type for each reference
IDL>; Must choose between "html", "image" and "movie" for reference_types.
IDL> event.reference_names[0] = "Publication"
IDL> event.reference_links[0] = "http://adswww.harvard.edu/"
IDL> event.reference_types[0] = "html"

IDL>; Now export the IDL structure to an XML file.
IDL> export_event, event, /write, outfile="Flare_example.xml"
IDL> end
Application Programming Interface

http://www.lmsal.com/hek -> Click on API on the banner.

A Heliophysics Events Knowledgebase to facilitate scientific discovery

List of Supported Feature/Event types and associated attributes

The full list of Event/Feature types and associated attributes can be found here.

Web API

Web developers who wish to create third-party web applications interacting with the Heliophysics Events Registry should consult the HER Web API wiki, which provides examples on how to query HER, how to submit events to HER as well as other functions.

SolarSoft IDL

For IDL SSW users

We are developing a number of software packages to help researchers use and contribute to the HEK project:

- **Ontology package**: SolarSoft API for reporting events and features to the Heliophysics Events Registry (HER), as well as querying HER.
- **Panorama**: an OpenGL based browser for viewing solar data
- **Annotator**: a Java tool for the creation of VOEvent XML files suitable for reporting features and events to HER.

SolarSoft Ontology package

For researchers interested in running their feature detection algorithms to produces entries which will be imported into the Heliophysics Events Registry (HER), we are providing the Ontology package, a collection of routines to be used within the SolarSoft environment. The Ontology package is treated like any other SolarSoft package. To add the Ontology package to an existing installation of SolarSoft, do To add the ontology package into your Solarsoft installation, append the keyword ontology to your definition of the SSW_INSTR environment variable.

Start up Solarsoft first:

IDL> load package ontology into $solarsoft
Heliophysics Events
Knowledgebase
Part 2 - Advanced Usage of HEK

Mark Cheung on behalf of the LMSAL Helio-informatics Team
Introduction

• In this tutorial, you will learn to
  • Export iSolSearch (HER) queries to SolarSoft and JSON.
  • Learn how to construct a HER query from scratch
  • Perform HER queries with filters
  • Do complex queries (e.g. Flares in/near Coronal Holes)
  • Render your query results on iSolSearch

• The material covered in this tutorial will be helpful for the laboratory exercise.
Exporting HER queries to SolarSoft
Exporting HER queries to Javascript Object Notation (JSON) and XML

In iSolSearch, click on “Export” and selection JSON or XML.

Firefox Add-on for Inspection of JSON output

Add-ons for Firefox

Search for add-ons within all add-ons

JSONView 0.5

View JSON documents in the browser.

Add to Firefox

Meet the Developer

Learn why JSONView was created and find out what’s next for this add-on.

Meet Ben Hollis

See All Web Development Add-ons
Anatomy of a HER Web Query

- Example of query url:

  https://www.lmsal.com/hek/her?cosec=2&cmd=search&type=column&event_type=ar,ce,cj,cw,ef,fi,fe,fa,fl,os,sg,sp&event_region=all&event_coorsys=helioprojective&x1=-5000&x2=5000&y1=-5000&y2=5000&result_limit=40&event_starttime=2010-08-01T00:00:00&event_endtime=2010-08-02T00:00:00

  HER query service
  Output format: cosec=1 means XML
  cosec = 2 means Javascript Object Notation (JSON)

  Type of search and search parameters
  iSolSearch fetches a document with such a url when you click “Search”
Searching for events submitted by a person or recognition method (recap)
Defining Filters

- https://www.lmsal.com/hek/her?
cosec=2&cmd=search&type=column&event_type=ar,ce,cj,cw,ef,fi,fe,
fa,fl,os,sg,sp&event_region=all&event_coordsys=helioprojective&x1
=-5000&x2=5000&y1=-5000&y2=5000&result_limit=40&event_start
time=2010-05-01T00:00:00&event_endtime=2010-08-10T00:00:00
&param0=FRM_Name&op0==&value0=berger

Tells HER to return only events with FRM_Name (Feature Recognition Method Name) = berger (Tom Berger’s HEK username)
Defining Filters

- https://www.lmsal.com/hek/her?
cosec=2&&cmd=search&type=column&event_type=ar,ce,cj,cw,ef,fi,fe,fa,fl,os,sg,sp&event_region=all&event_coordsys=helioprojective&x1=-5000&x2=5000&y1=-5000&y2=5000&result_limit=40&event_starttime=2010-05-01T00:00:00&event_endtime=2010-08-10T00:00:00&param0=FRM_Name&op0==&value0=berger&param1=OBS_ChannelID&op1==&value1=304

Tells HER to return only events detect in the 304 Channel (in addition to the first filter)
Containment Search

- Example: Find Flares “contained” within reported Coronal Holes

- [Link](http://www.lmsal.com/isolsearch?hek_query=http://www.lmsal.com/hek/her?cosec=2&cmd=search&type=contains&event_type1=fl&event_type2=ch&event_starttime=2010-04-20T00:00:00&event_endtime=2010-05-25T00:00:00)
Containment Search

- Example: Find Flares “contained” within reported Coronal Holes

- http://www.lmsal.com/isolsearch?hek_query=http://www.lmsal.com/hek/her?cosec=2&cmd=search&type=contains&event_type1=fl&event_type2=ch&event_starttime=2010-04-20T00:00:00&event_endtime=2010-05-25T00:00:00
Rendering custom queries on iSolSearch

• http://www.lmsal.com/isolsearch?hek_query=<<query url>>

• Query url is any example, e.g. from the last slide

• http://www.lmsal.com/isolsearch?hek_query=http://www.lmsal.com/hek/her?cosec=2&cmd=search&type=contains&event_type1=fl&event_type2=ch&event_starttime=2010-04-20T00:00:00&event_endtime=2010-05-25T00:00:00
“Laboratory” exercise

• Choose a day between April and July 2010

• Use HER to search for Coronal Holes on that day

• Load the Coronal Holes into SolarSoft

• Note: Coronal Holes (namely open-field regions) from the PFSS model are reported once every 6 hours.

• Using SolarSoft routines, download ONE image for each of AIA’s EUV channels (don’t download a full day’s worth of images).

• Display the AIA images with coronal hole boundaries overlaid as contours. Do the dark EUV features in AIA images compare well with PFSS open-field regions?

• Hint: In the IDL structure returned from the HER query, look for attribute “HPC_BOUNDCC” (namely the bounding chaincode in Helioprojective coordinates). Go to the web API documentation page and look for section on “Notes on Bounding Chaincodes”.

Tuesday, August 10, 2010
For a narrated video tutorial, go to http://www.lmsal.com/hek

SolarSoft users and Developers: Click on API link (http://www.lmsal.com/hek/api.html) for information.