

IRIS Technical Note 32

Co-aligned IRIS, SDO and Hinode data cubes

Milan Gošić
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1. Introduction

1.1 About this guide

The purpose of this guide is to provide detailed instructions how users can find, download, browse and analyze co-aligned IRIS, SDO/AIA and Hinode/SOT level 2 data. The IRIS team at the Lockheed Martin Solar and Astrophysics Laboratory (LMSAL) has produced new data cubes consisting of the Hinode/SOT and SDO/AIA images co-aligned with the simultaneous IRIS observations. These datasets all have the same IRIS level 2 FITS format and therefore can be accessed and examined using the IRIS SolarSoft software. In this guide we will give step by step instructions how to access, read and visualize the newly created data. In particular, we will describe:

- How to find data using SolarSoft IDL routines;
- How to acquire data sets using either SolarSoft or Heliophysics Coverage Registry (HCR);
- How to read data and visualize them using SolarSoft routines or Crisp Spectral Explorer (CRISPEX, <http://folk.uio.no/gregal/crispex/>).

This guide mostly relies on the IRIS user guide (ITN 26, <http://iris.lmsal.com/itn26/>). Hence, we recommend that users have up to date IRIS branch of SolarSoft IDL installation (SSW, <http://www.lmsal.com/solarsoft/>). If the IRIS package is not installed, details how to do it and load IRIS routines into an IDL session can be found in ITN 26. The guide will be updated and/or expanded as needed.

1.2 Synopsis of the IRIS, Hinode and SDO missions

The Interface Region Imaging Spectrograph (IRIS) is a NASA satellite designed to study the solar transition region, i.e., the region between the chromosphere and the corona. The main goal of the IRIS mission is to understand how the upper solar atmosphere is heated from 3000 K in the chromosphere to over one million K in the corona. To achieve this, IRIS takes simultaneous spectra in three passbands, in the near ultraviolet band (NUV) from 2783 to 2834 Å and in the far ultraviolet, from 1332 to 1358 Å (FUV 1) and from 1389 to 1407 Å (FUV 2). In addition to this, it records slit-jaw images (SJI) using filters whose spectral windows are centered on Mg II k 2796 Å (SJI 2796), far Mg II h wing at 2832 Å (SJI 2832), at 1330 Å (SJI 1330), and 1400 Å (SJI 1400). This way, IRIS samples the Sun from the photosphere up to the transition region, which makes it possible to study the dynamics and energetics of the transition region at high spatial and temporal resolutions and its coupling to the other solar atmospheric layers.

IRIS observations are perfect complements to the observations obtained with Hinode and the Solar Dynamics Observatory (SDO). The Hinode satellite is a solar mission of

the Institute of Space and Astronautical Science (ISAS) of the Japan Aerospace Exploration Agency (JAXA). The Hinode satellite carries three instruments: the Extreme ultraviolet Imaging Spectrometer (EIS), the X-Ray Telescope (XRT) and the Solar Optical Telescope (SOT). The XRT and EIS instruments are dedicated to transient eruptive phenomena and the dynamics of the transition region and corona. On the other hand, the SOT is focused on emergence and evolution of magnetic structures in the solar photosphere and chromosphere. The scientific goals of the Hinode mission are to understand the processes of magnetic field generation and energy transport from the photosphere to the corona, and to determine the mechanisms responsible for eruptive phenomena such as flares and coronal mass ejections.

The SDO mission is developed and launched under NASA's Living With a Star (LWS) program. This spacecraft have three instruments: the Atmospheric Imaging Assembly (AIA), the Extreme ultraviolet Variability Explorer (EVE) and the Helioseismic and Magnetic Imager (HMI). AIA is composed of an array of 4 telescopes. They provide full-Sun images of the solar corona in 7 EUV wavelengths every 12 seconds. EVE measures the EUV spectral irradiance while HMI obtains full-disk, high-cadence Dopplergrams, broadband continuum filtergrams, longitudinal and vector magnetograms. The main objectives of the SDO satellite are to investigate the origin of solar activity and understanding of the Sun's interior. In addition to this, SDO helps us understand coupling between the solar variability and changes in Earth's climate.

When coordinated, these three satellites have the same observational target, acting as a single observatory. This gives a unique opportunity to study various solar phenomena at very high temporal and angular resolution, and different spectral regions. In this way it is possible to follow the evolution of solar magnetic fields from the photosphere up to the corona and heliosphere. Therefore, it is essential and would be of great help for the entire solar community to gather all coordinated observations obtained by the three satellites, fully process and format them for easy and convenient scientific usage. To this purpose, the IRIS team at LMSAL has produced new data cubes containing co-aligned simultaneous IRIS, Hinode/SOT and SDO/AIA observations. These datasets all have the same IRIS level 2 FITS format and therefore can be accessed and examined using the IRIS SolarSoft software. In this guide we will give step by step instructions how to access, read and visualize the newly created data.

1.3 Hinode and SDO data cubes co-aligned with IRIS observations

The newly created data products consist of IRIS observations co-aligned with the simultaneous SDO/AIA and Hinode/SOT filtergrams available for a given time period. Detailed description of co-alignment process can be found in IRIS Technical Note 22¹. We will here briefly summarize the basic idea.

Cross-correlation between IRIS and AIA filtergrams is accomplished using XCEN/YCEN and FOVX/FOVY keywords from IRIS level 2 and AIA level 1.5 data. Because of minor errors in the headers, the current generation of these co-aligned data cubes might have co-alignment errors between SDO/AIA and IRIS observations of up to 5 arcsec, but usually less. To provide context for the IRIS field of view (FOV), the AIA data cubes have a slightly larger FOV than IRIS (± 50 arcsec in both x and y directions), and start 10 minutes before the IRIS observations and end 10 minutes later. This way, AIA images cover the entire IRIS observational period and FOV with its surroundings. When

¹ IRIS Technical Note 22 (ITN 22) can be downloaded from <http://iris.lmsal.com/documents.html>

necessary, AIA data cubes are corrected for solar rotation tracking and IRIS roll angles. Final AIA data products include the following channels: 94 Å, 131 Å, 171 Å, 193 Å, 211 Å, 304 Å, 335 Å, 1600 Å and 1700 Å. HMI line-of-site (LOS) magnetograms and intensity maps will also be included in future updates of the data cubes.

Co-alignment of Hinode/SOT and IRIS images is similarly achieved through use of the header information in the Hinode/SOT and IRIS images. For these co-aligned datacubes, the headers of the Hinode/SOT images are updated with results from cross-correlation between SOT Ca II H images with the AIA 1700 Å channel. This co-alignment does not always work perfectly, with errors possible of 10-15 arcsec, but usually much less. The co-alignment between Hinode and IRIS data is not perfect due to uncertainties of the pointing information in the headers of the IRIS and Hinode/SOT data. For observations taken around the solar disk center, the offsets can be up to about ± 5 arcsec in x and y directions. They increase for observations recorded closer to the limb. Therefore, the cubes may need a small co-alignment tuning by the user. This co-alignment imperfection will be addressed in future updates. Similarly to the SDO/AIA cubes, the different duration of observational sequences, IRIS roll angles and solar rotation tracking are taken into account. Processed SOT observables are BFI filtergrams (Ca II H 3968 Å, G band 4305 Å and CN band 3883 Å), and NFI LOS magnetograms along with Stokes I and V images. Future updates will also include SOT Spectro-Polarimeter (SP) data².

These new SDO/AIA and Hinode/SOT data cubes are formatted in the same way as IRIS level 2 data. This makes it possible to examine all observations using the same IRIS SolarSoft routines. In addition, all cubes can be used along with level 3 IRIS data and examined with **CRISPEX**.

² Please note that since February 25th, 2016, only SOT-SP observations are available due to the loss of the SOT-FG camera.

2. Finding and downloading IRIS-SDO-Hinode co-aligned data cubes

Co-aligned IRIS, SDO and Hinode data cubes can easily be found using the IRIS search webpage (<http://iris.lmsal.com/search>). The detailed description of the search engine and how to use it is provided in ITN 26. Briefly, it consists of several selection widgets that allow the user to specify the start and end of a time range of interest, and to filter the list of results returned by the search engine. Among other options, the user can define the cadence, target region, exposure time, type of rasters and slit-jaw images. The latest version of the search engine introduces the option to find all IRIS observations for which co-aligned SDO or Hinode data cubes are available by simply checking the appropriate option buttons. These buttons are shown in Figure 2.1, highlighted with the red box and the magnified region. They are normally hidden under the “More” button, which opens up to provide more options when clicked.

SDO/AIA and Hinode/SOT level 2 data co-aligned with a given IRIS observational sequence can be retrieved using IRIS SolarSoft package or via the corresponding HCR web page. Before we request the data cubes, we can also check their availability using the following SSW IDL command:

```
IDL> hcr=iris_time2hcr('1-jul-2015','1-sep-2015',/
expand_eventid,limit=2000,/struct)
```

The first two arguments in the upper command define the time range within which we want to search for data cubes. In this particular case, the search is performed for a period of two months, between 2015 July 1 and 2015 September 1. The optional keyword `/struct` implies that the resulting variable `hcr` will be returned as an IDL structure of 2000 return elements as defined by the keywords `/expand_eventid` and `limit=2000`. The most important tag names contained in `hcr` are:

- **PARENTURL** - gives the urls for the IRIS level 2 FITS files;
- **SDO_SSW_JOBID** - provides job IDs of SDO cutouts, also used as input parameter in various IRIS SolarSoft routines;
- **URL_SOTSP_CUBES** - the urls for the Hinode/SOT SP level 2 data cubes (when available);
- **URL_SOT_CUBES** - the urls for other available SOT level 2 data;
- **URL_SDO_CUBES** - the urls for SDO data sets;
- **STARTTIME** - starting time of IRIS observational sequence;
- **STOPTIME** - ending time of IRIS observation;
- **OBSID** - OBS ID for IRIS observational sequence;
- **FULL_OBSID** - full IRIS OBS ID;
- **SCIOBJECTIVES** - Scientific goals defined by the corresponding HOP and/or IHOP;
- **EVENTID** - contains event ID, also used to create link to HCR Event web page;
- **UMODES** - IRIS unique observational modes executed for a given OBS ID;
- **TARGET** - target region on the Sun.

Using the standard IDL routine `where`, one can now select observations that contain only SDO/AIA or Hinode/SOT data cubes overlapping with IRIS measurements. Let us, for example, find only SDO/AIA and IRIS co-aligned data. The IDL command would look like this:

```
IDL> fg=where(hcr.url_sdo_cubes ne '!NULL')
```

The screenshot shows the 'INTERFACE REGION IMAGING SPECTROGRAPH IRIS DATA SEARCH' page. On the left, there are various search filters like 'Raster', 'Cadence', 'Exposure Time', and 'Spectral Lines'. In the center is a solar image with overlaid observation tracks. On the right is a table of observations with columns: Time, Goal, OBS Desc., X,Y, RX, RY, Raster Cad, Step Cad, Fast SJI, and OBSID. A red box highlights the 'Co-Aligned Cubes' section in the bottom right, where 'AIA' and 'SOT-FG' are checked under the 'Co-Aligned Cubes' heading.

Time	Goal	OBS Desc.	X,Y	RX	RY	Raster Cad	Step Cad	Fast SJI	OBSID
22:44-03:43 +1d	AR Coordination with Hinode	Medium coarse 4-step raster	882°,-298°	6°	62°	37s	9s	1330: 37s	3660109122
2015-08-04 07:59-10:58	SST Coordination, High Datarate	Very large dense 96-step raster	-174°,104°	33°	174°	539s	6s	1400: 17s	3620006865
2015-08-04 16:38-17:31	BBSO coord - filament in AR 12394	Very large dense 96-step raster	-163°,144°	33°	174°	1583s	16s	2796: 33s	3620261465
2015-08-04 17:47-19:42	BBSO coord - filament in AR 12394	Large sit-and-stare	-159°,145°	0°	119°	16s	16s	2796: 33s	3620261403
2015-08-05 11:09-16:06	AR12394 tracking, with Hinode	Large coarse 8-step raster	55°,94°	14°	119°	73s	9s	1330: 18s	3860109380
2015-08-05 16:59-17:52	BBSO Coord - filament in AR12394	Very large dense 96-step raster	47°,142°	33°	174°	1583s	16s	2796: 33s	3620261465
2015-08-05 18:14-20:04	BBSO Coord - filament in AR12394	Large sit-and-stare	60°,130°	0°	119°	16s	16s	2796: 33s	3620261403
2015-08-05 21:16-02:19 +1d	AR12394 Tracking, with Hinode	Large coarse 8-step raster	142°,97°	14°	119°	72s	9s	1330: 18s	3860109380
2015-08-06 05:09-05:27	A1: QS Monitoring	Large coarse 64-step raster	-2°,2°	127°	119°	1084s	17s	1330: 68s	3882010194

Figure 2.1: The IRIS search webpage where search options for SDO and Hinode co-aligned data cubes are selected (red box).

In case we want to extract observations that also have Hinode/SOT measurements, we can attain it this way:

```
IDL> fg=where(hcr.url_sdo_cubes ne '!NULL' and hcr.url_sot_cubes ne '!NULL')
```

here `fg` contains the subscripts of the `hcr` structure corresponding to the selected observations:

```
IDL> print, hcr[fg].full_obsid
20150630_235415_3630104144
20150701_010951_3860258353
20150701_044923_3860008374
20150701_163217_3820006080
...
20150812_083319_3660108059
...
20150831_230936_3660607351
```

This gives us all data cubes from July 1 to September 1 of 2015 that have coordinated and co-aligned IRIS, SDO/AIA, and Hinode/SOT observations. For demonstration purpose, we will proceed further using the observational sequence whose index is 62 and full IRIS OBSID = 20150805_110921_3860109380³. More information on this particular dataset, such as starting time, scientific objective and target for example, can be extracted using the following command:

³ Since new data sets are regularly being generated and/or updated, the OBSID list and indices may change.

Heliophysics Events Knowledgebase Coverage Registry (HCR)

HEK
HCR
Planned
Recent
Popular
Recommended
HCR Search
Help

Observation Details

Overview	Where	Raster	SJI wavel: cadence, # images	Data Links	Coaligned Data
<p>2015-08-05 11:09:21-16:06:17</p>	<p>AR12394 tracking, with Hinode OBS 3860109380: Large coarse 8-step raster</p>	<p>x,y: 55",94" Max FOV: 134"x119" Target: AR Nearby Events</p>	<p>FOV: 14"x119" Steps: 8x2" Step Cad: 9.1s Raster Cad: 73s, 245 ras Linelist: y38_03</p>	<p>Annotate</p> <p>Raster 1009 MB 1330 169 MB 2796 199 MB</p>	<div style="border: 2px solid red; padding: 5px;"> <p>SOT_FG 208 MB (Ca II, G-Band) AIA 1777 MB</p> </div>

Annotations
[SS Raster over sunspot oscillations](#)

Quicklooks
Context

1330: 18s, 980 imgs

2796: 18s, 980 imgs

Figure 2.2: Upper part of the HCR web page for IRIS observation with OBSID 20150805_110921_3860109380. The red box on the right side shows the link to SOT/ FG and AIA FITS files.

```
IDL> info=get_infox(hcr[fg[62]], 'starttime, sciobjectives, target', /
more)
```

```
STARTTIME          SCIOBJECTIVES          TA
2015-08-05 11:09:21 AR12394 tracking, with Hinode AR
```

Before we explain how to obtain links to the data and download them, we can get more familiar with the measurements visiting its HCR web page. The URL can easily be obtained using:

```
IDL> print,ssw_hcr_make_query(eventid=hcr[fg[62]].eventid)
http://www.lmsal.com/hek/hcr?cmd=view-event&event-id=ivo%3A%2F%2F%20F%20s%20o%20t%20.l%20m%20s%20a%20l%20.c%20o%20m%20%20F%20V%20O%20E%20v%20e%20n%20t%20%23VOEvent%20IRIS%2020150805%20110921%203860109380%202015-08-05T11%3A09%3A212015-08-05T11%3A09%3A21.xml
```

The extracted link points at the web page shown in Figure 2.2. As mentioned before, here we can see details of the corresponding IRIS observational run. On the right side of the page, there is a section called “Co-aligned data” which contains links to the SOT/ FG and AIA data cubes (red box). Clicking on the links will automatically initiate downloading of the corresponding co-aligned datasets. In addition to this, at the bottom of the same page (Figure 2.3), there are four AIA thumbnails. They lead to their associated quick-look movies (QLM) giving insights on AIA co-aligned filtergrams. The rest of the AIA QLMs can be accessed following the link “SSW page” enclosed by the red box. Some of these AIA QLMs are presented in Figure 2.4.

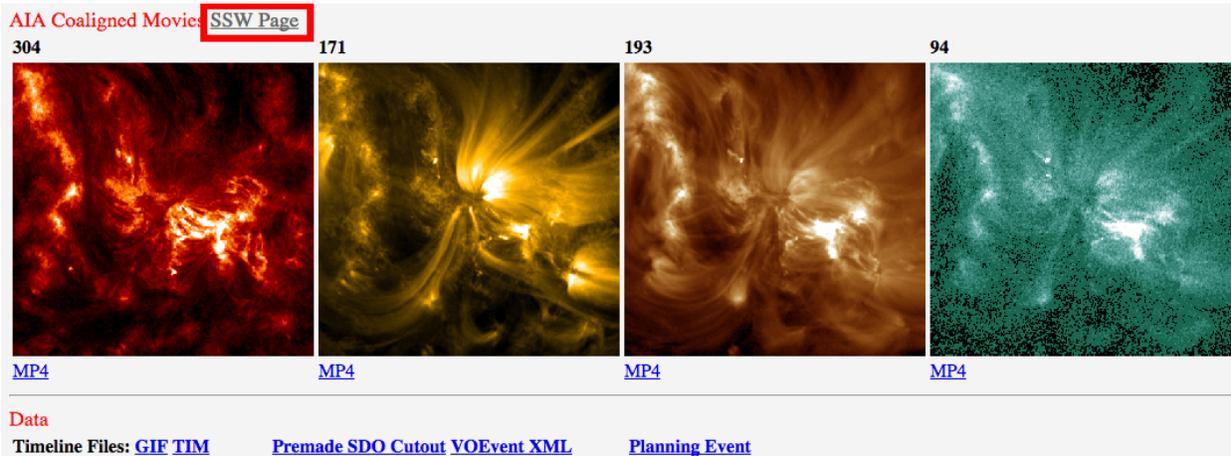


Figure 2.3: Bottom part of the HCR web page for IRIS observation with OBSID 20150805_110921_3860109380. The red box indicates the link to all AIA quick-look movies.

After getting familiar with the IRIS and SDO/AIA datasets, we can proceed with the download process. As already mentioned, the data can be downloaded directly from the associated HCR pages. However, there are two more alternatives. One of them is using SolarSoft commands through which we can obtain URLs to the IRIS, SDO and Hinode index web pages. From there we can download the data using a web browser. To get the parent folder of IRIS level2 data we can type:

```
IDL> iris12url=str_replace(hcr[fg[62]].url_sdo_cubes,'/aia/','/')
IDL> print, iris12url
http://www.lmsal.com/solarsoft//irisa/data/level2/2015/08/05/20150805\_110921\_3860109380/
```

Similarly, `www` folders containing co-aligned SDO/AIA and Hinode/SOT data cubes can be obtained by:

```
;SDO/AIA data
IDL> sdol2url=hcr[fg[62]].url_sdo_cubes
IDL> print, sdol2url
http://www.lmsal.com/solarsoft//irisa/data/level2/2015/08/05/20150805\_110921\_3860109380/aia/
```

and:

```
;Hinode/SOT data
IDL> hinodel2url=hcr[fg[62]].url_sot_cubes
IDL> print, hinodel2url
http://www.lmsal.com/solarsoft//irisa/data/level2/2015/08/05/20150805\_110921\_3860109380/hinode/
```

The second alternative way to get AIA and/or Hinode data cubes is to use IRIS SolarSoft routines. The files will be downloaded to the current local folder as `*.tar.gz` files. The command to do it would look like this:

```
;download AIA data
IDL> l2sdo=iris_time2files(hcr[fg[62]].starttime,hcr[fg[62]].stoptime,
level=2,/compressed,/urls,/aia)
IDL> sock_copy,l2sdo
```

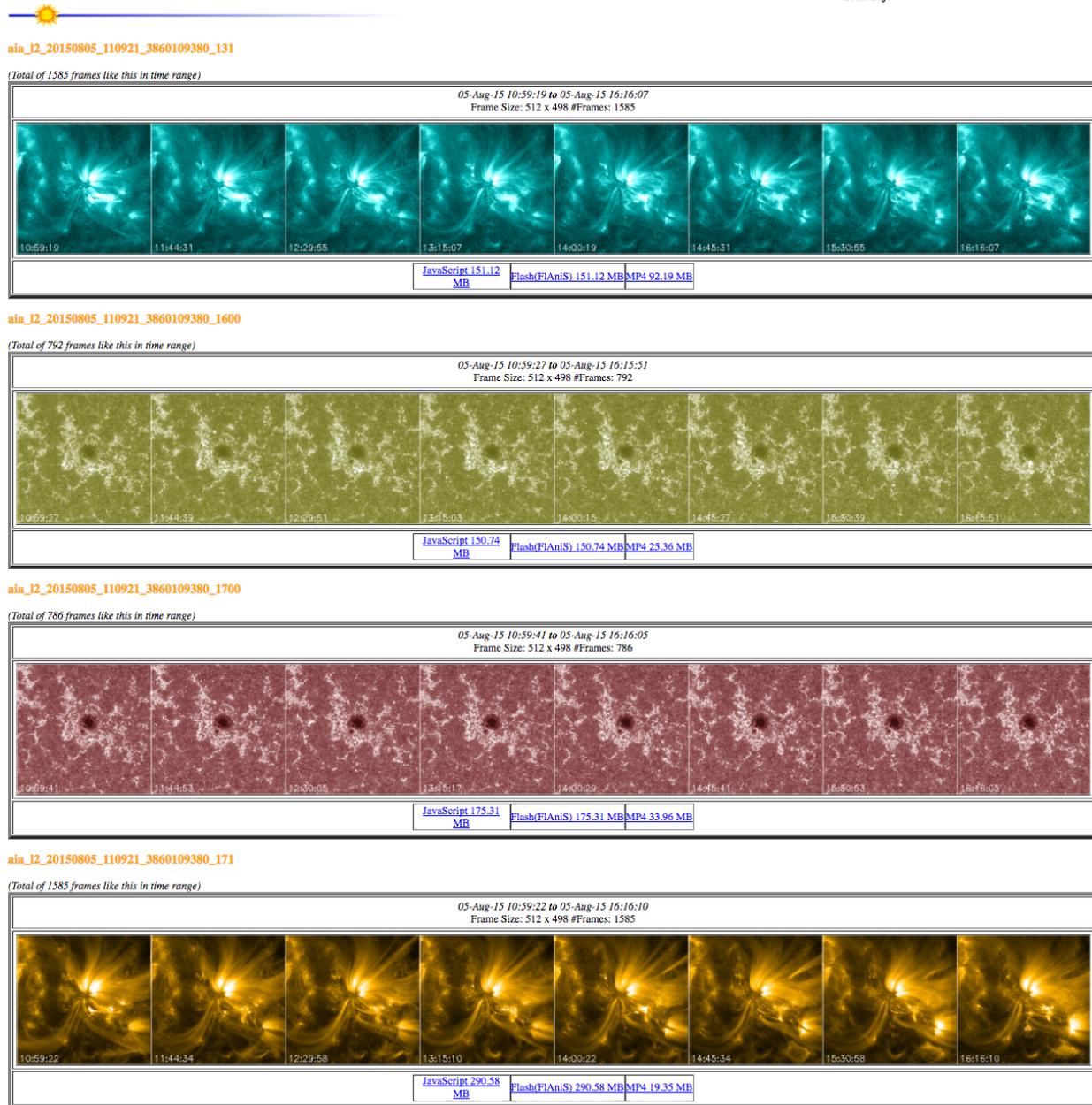


Figure 2.4: Examples of AIA quick-look movies located at SSW web page for SDO cutouts co-aligned with IRIS OBSID 20150805_110921_3860109380 measurements. The figure shows four of seven available movies.

```

;download Hinode/SOT data
IDL> l2sot=iris_time2files(hcr[fg[62]].starttime,hcr[fg[62]].stoptime,
level=2,/compressed,/urls,/sot)
IDL> sock_copy,l2sot

```

In the next Chapter, we will demonstrate how to read the downloaded co-aligned SDO/AIA and Hinode/SOT datasets and visualize them.

3. Reading and browsing IRIS-SDO-Hinode co-aligned data

3.1 Reading level 2 co-aligned SDO and Hinode datasets

One of the main advantages of the newly created data cubes is their structure, which is the same as IRIS level 2 SJI FITS files. This means that all data can be examined using the IRIS SolarSoft package. Therefore, to read SDO and Hinode data cubes into memory, one can follow the same instructions as in the case of IRIS SJI data cubes. For example, we can easily visualize SDO and Hinode datasets using `iris_xfiles` and `iris_ximovie`, since they will be recognized by IRIS software as slit-jaw files. Figure 3.1 shows `iris_ximovie` widgets displaying the Hinode/SOT (a), IRIS (b) and SDO/AIA (c) data cubes from the previous chapter as slit jaw sequences.

To read the data we can use `read_iris_l2` routine. We will continue with the same IRIS observational sequence we used until now and load into memory the associated co-aligned Hinode Ca II H filtergrams:

```
IDL> dir_sot='/irisa/data/
level2/2015/08/05/20150805_110921_3860109380/hinode/'
;find Hinode/SOT files
IDL> f_sot=iris_files(path=dir_sot) ;find Hinode/SOT files
0  (...)sot_l2_20150805_(...)_CaIIHline_FG.fits      292 MB
1  (...)sot_l2_20150805_(...)_Gband4305_FG.fits      28 MB

;read Ca II H data into memory and retain NULL images
IDL> read_iris_l2, f_sot[0], index, data, /keep_null
IDL> help, data
DATA FLOAT = Array[631, 601, 202]
```

In the same way we can read AIA data cubes:

```
IDL> dir_aia='/irisa/data/
level2/2015/08/05/20150805_110921_3860109380/aia/'
;find all AIA level 2 FITS files
IDL> f_aia=iris_files(path=dir_aia)
0  (...)aia_l2_20150805_110921_3860109380_131.fits    453 MB
1  (...)aia_l2_20150805_110921_3860109380_1600.fits  226 MB
2  (...)aia_l2_20150805_110921_3860109380_1700.fits  224 MB
3  (...)aia_l2_20150805_110921_3860109380_171.fits   453 MB
4  (...)aia_l2_20150805_110921_3860109380_193.fits   453 MB
5  (...)aia_l2_20150805_110921_3860109380_211.fits   453 MB
6  (...)aia_l2_20150805_110921_3860109380_304.fits   453 MB
7  (...)aia_l2_20150805_110921_3860109380_335.fits   453 MB
8  (...)aia_l2_20150805_110921_3860109380_94.fits    453 MB

;read AIA 1700 observations
IDL> read_iris_l2,f_aia[2], index, data, /keep_null
IDL> help, data
DATA FLOAT = Array[392, 382, 786]
```

In both examples, IDL variable `data` contains the corresponding images while the associated headers are stored in `index` variable which is an IDL structure. `index` contains fits headers that have all keywords defined for Hinode and SDO/AIA observations as in their original data formats. However, in these new co-aligned data cubes, the headers normally have additional keywords. Their purpose is to provide specific information related to data reduction process, quality keywords, associated web

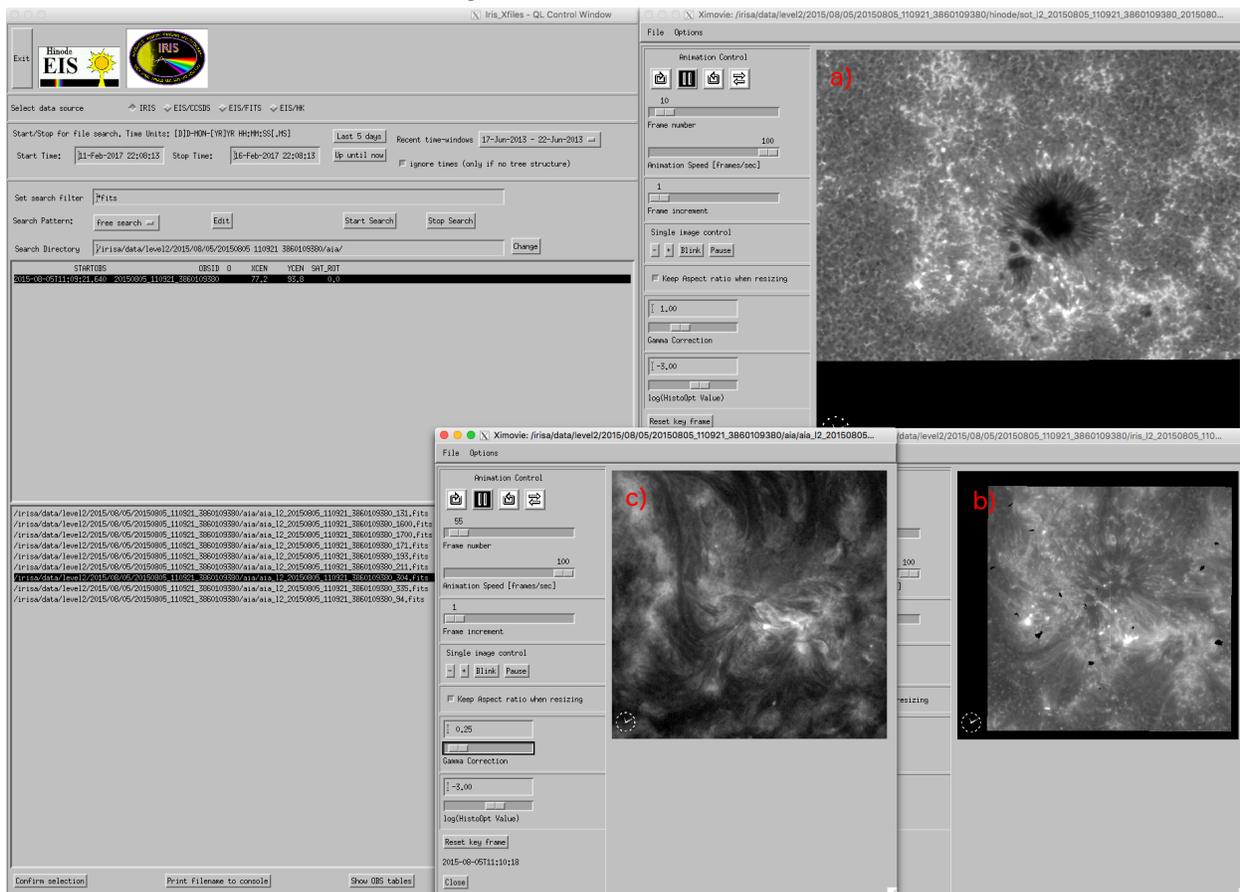


Figure 3.1: `iris_ximovie` showing selected Hinode (a), IRIS (b) and AIA (c) data sequences. `iris_ximovie` windows has been resized for a better arrangement of the panels.

pages, etc. Further, the Hinode fits headers for example, have among others, two new keywords that together form the link to the corresponding HCR page:

```
IDL> print, strjoin([index[0].sotlink1, index[0].sotlink2])
http://www.lmsal.com/hek/hcr?cmd=view-event&event-id=ivo%3A%2F%2F%2Fsot.lmsal.com%2FVOEvent%23VOEvent\_ObsS2015-08-04T21%3A04%3A00.000.xml
```

It is important to note that both Hinode and AIA headers have four keywords defining the time range when the observations were recorded:

- **DATE_OBS** - the time of the first available exposure in the respective Hinode or SDO level 2 file;
- **DATE_END** - the time of the last exposure;
- **STARTOBS** - gives the time when the coordinated IRIS OBS started;
- **ENDOBS** - the time when the coordinated IRIS OBS ended.

3.2 Browsing co-aligned SDO and Hinode data cubes with CRISPEX

Co-aligned SDO/AIA and Hinode/SOT datasets cannot be converted into level 3 data since they do not include spectroscopic data, but it is possible to use them in `CRISPEX` along with level 3 IRIS image and spectral cubes. Level 3 IRIS data can be generated

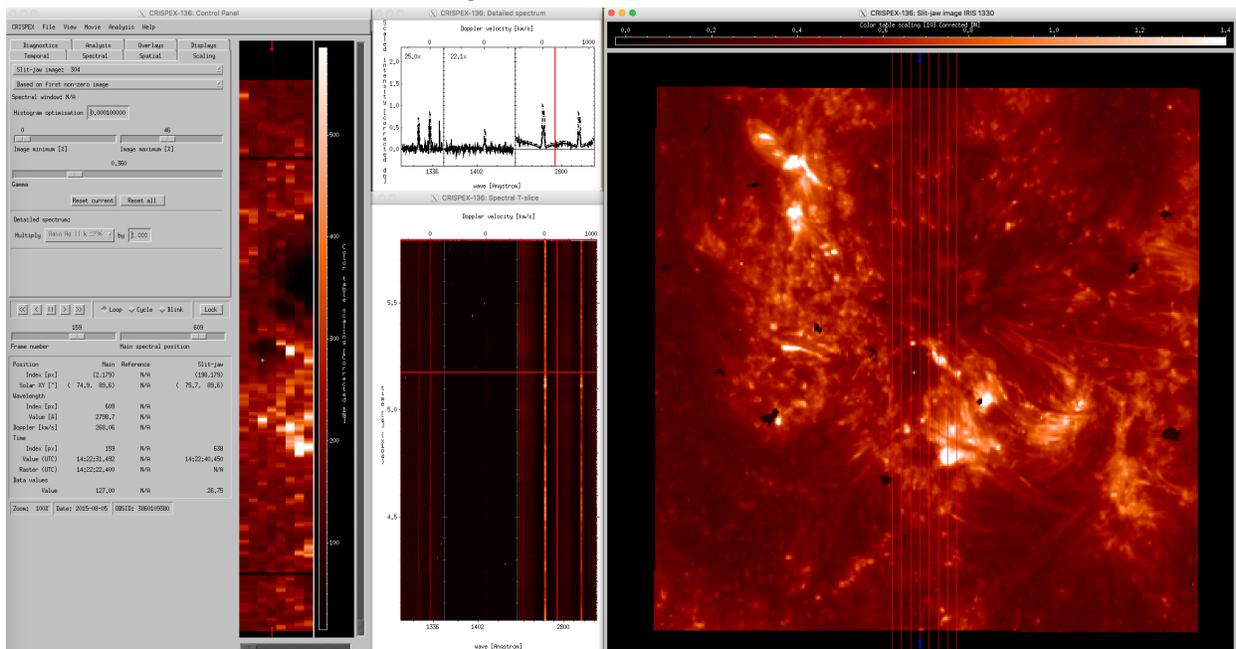


Figure 3.2: CRISPEX windows for IRIS OBSID 20150805_110921_3860109380 with large coarse 8-step raster. The middle column shows spectral windows (upper panel) and λ - t diagrams (bottom panel). IRIS SJI 1330 Å are used as reference images (right panel).

either via `iris_xfiles` or `iris_make_fits_level3` routine. Here we will demonstrate it using the latter option. First we select IRIS raster files and check the spectral windows indices:

```
IDL> dir='/irisa/data/level2/2015/08/05/20150805_110921_3860109380/'
;select IRIS raster files
IDL> f = iris_files('*raster*.fits', path=dir)
;extract the spectral windows and print them
IDL> wi=iris_obj(f[0])
IDL> wi->show_lines
Spectral regions (windows)
 0  1335.71  C II 1336
 1  1343.26  1343
 2  1349.43  Fe XII 1349
 3  1355.60  O I 1356
 4  1402.77  Si IV 1403
 5  2832.79  2832
 6  2826.73  2826
 7  2814.51  2814
 8  2796.20  Mg II k 2796
```

In this example, we will proceed with C II, Si IV 1403, and Mg II k spectral windows. Now we select IRIS SJI fits files and then call `iris_make_fits_level3` procedure to generate level 3 data that will be saved to the `~/Desktop/` folder:

```
;select IRIS SJI files
IDL> s = iris_files('*SJI*.fits', path=dir)
;create IRIS level 3 data
IDL> iris_make_fits_level3, f, [0, 4, 8], /sp, sjifile=s[0], wdir='~/Desktop/'
```

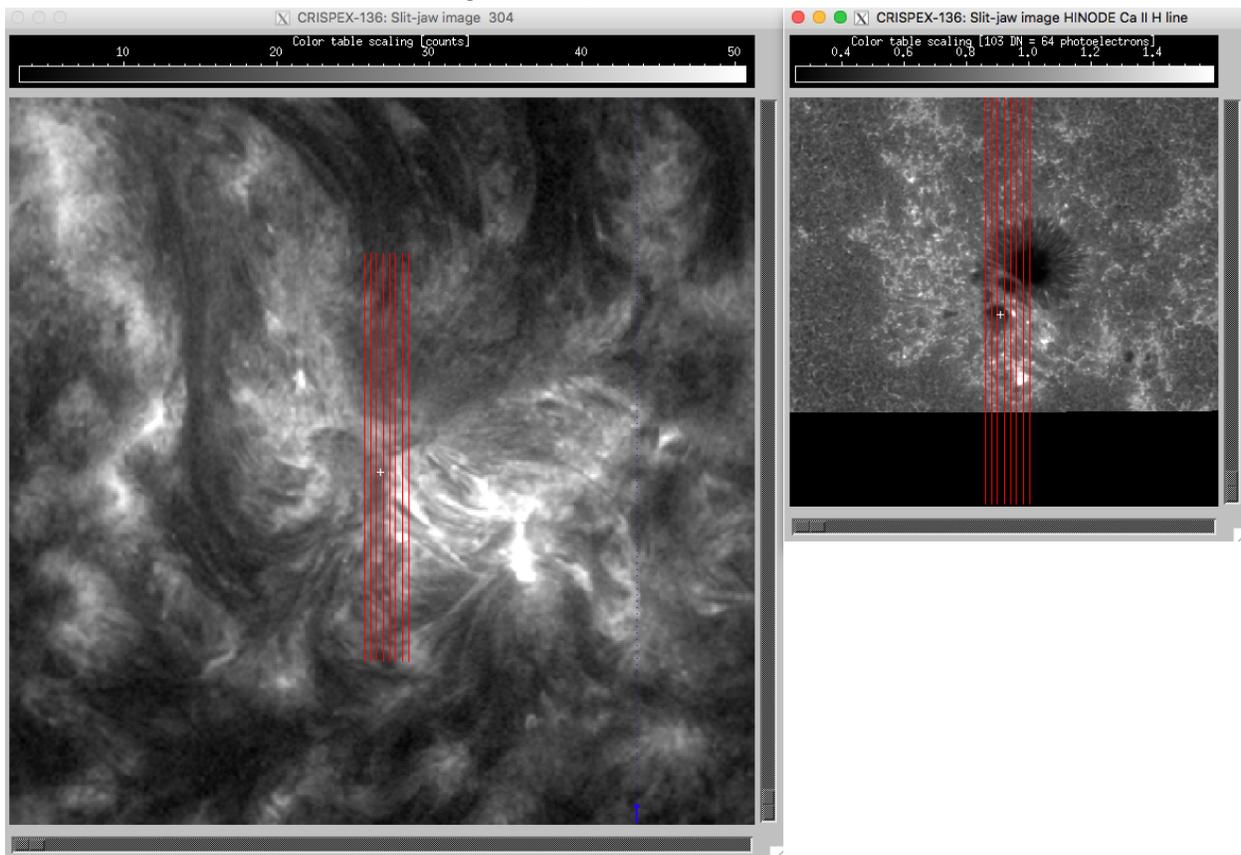


Figure 3.3: **CRISPEX** windows for IRIS OBSID 20150805_110921_3860109380. The left panel shows AIA and the right panel SOT data as reference images.

After selecting the newly generated level 3 data cubes, we can use **CRISPEX** to visualize the data (Figure 3.2):

```
;select IRIS level 3 data
IDL> cd, '~/Desktop/'
IDL> f = iris_files('/*13*.fits')
;call crispex
IDL> crispex, f[0], f[1], sjicube=s[0]
```

Since co-aligned SDO and Hinode datasets have the same structure as IRIS SJI level 2 data, they can be used as an argument for **CRISPEX**. For example, If we want to examine simultaneously IRIS raster files and SDO/AIA 304 Å observations, than we can use the following command:

```
IDL> crispex, f[0], f[1], sjicube=f_aia[6]
```

The resulting **CRISPEX** widget is shown in the left panel in Figure 3.3. If we want to explore IRIS rasters and Hinode Ca II H observations (right panel in Figure 3.3), then we can call:

```
IDL> crispex, f[0], f[1], sjicube=f_sot[1]
```

It is possible to simultaneously use up to six data cubes as reference cubes when **sjicube** keyword is fed by a vector of indices, for example:

```
IDL> crispex, f[0], f[1], sjicube=[s[0], s[1],...]
```