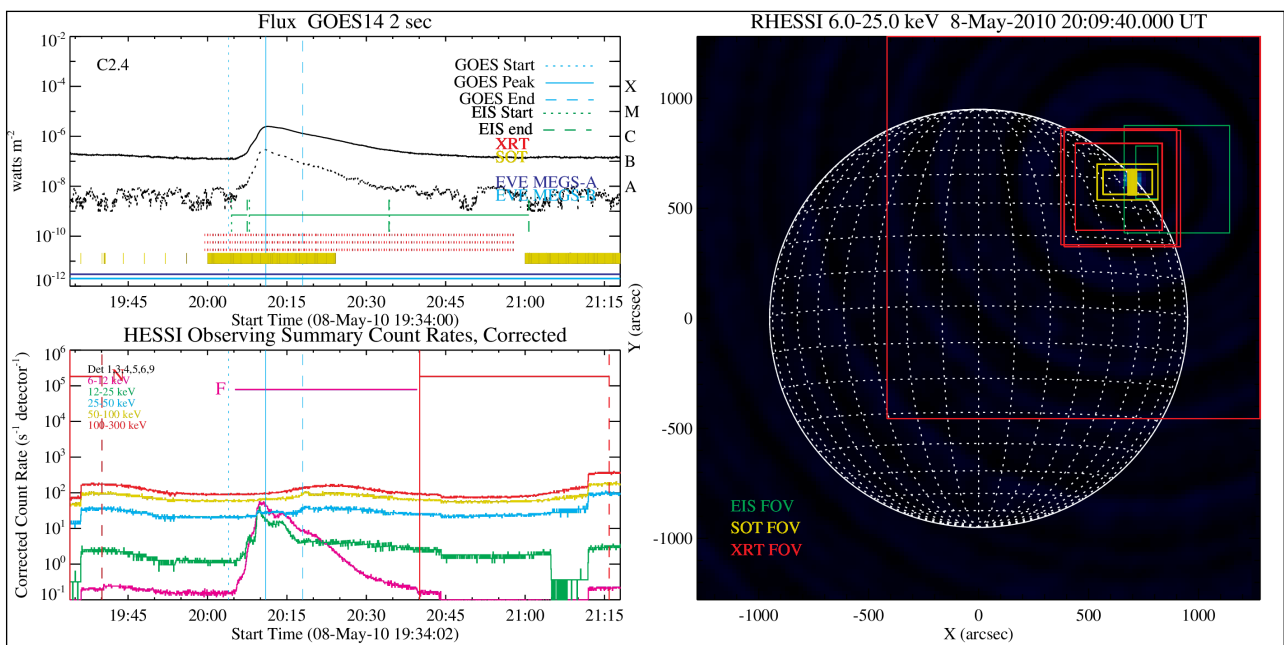


Solar Flare Finder

Retrospectively searching archival databases for solar flares jointly observed by GOES, RHESSI, Hinode, SDO and IRIS

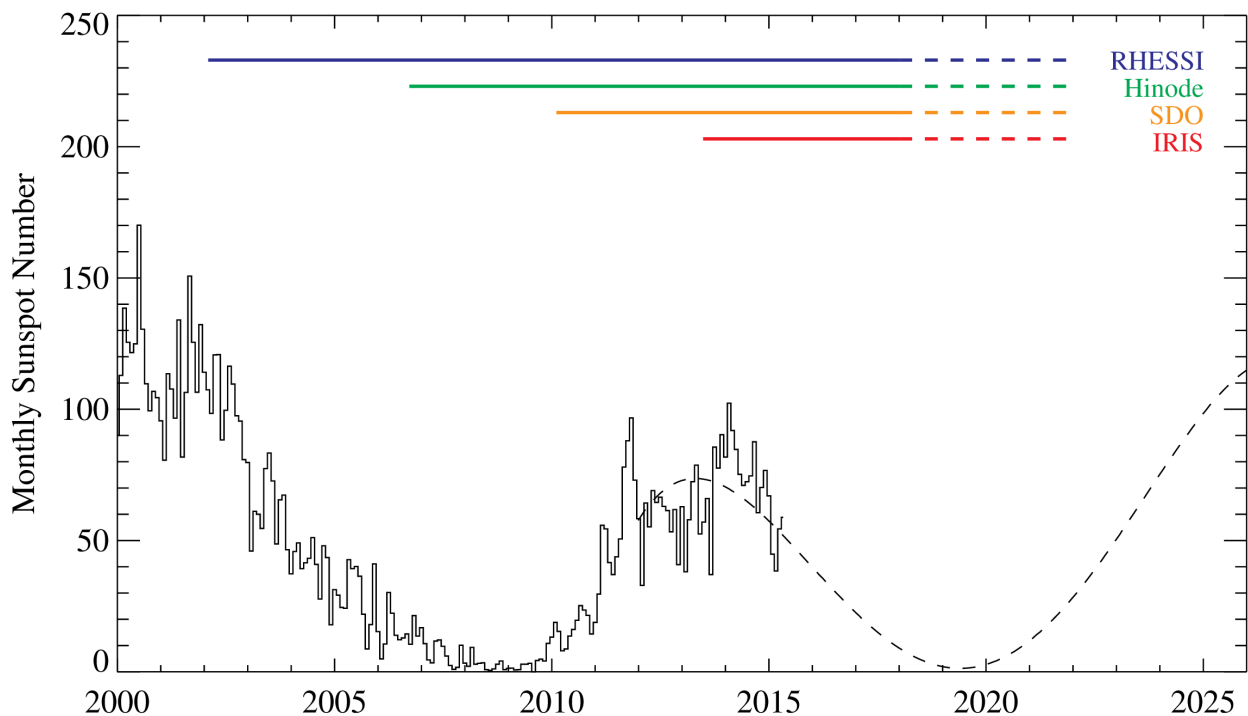
Ryan Milligan - 13 May 2016 - r.milligan@qub.ac.uk



Introduction

Scientists interested in the investigation of physics of solar flares could be forgiven for being overwhelmed by the amount of data returned by our current fleet of solar satellites. Unless one is actively planning spacecraft operations or monitoring the Sun's activity, it can be difficult to keep track of which flares might have been observed by which instruments. Similarly, efforts by the Max Millennium Program for Solar Flare Research (and others) to coordinate telescopes in space and on the ground to observe a flaring active region simultaneously have not always proven fruitful. This can be due to a combination of factors such as coordinating across multiple time zones, planning schedules being uploaded days in advance, the slit of a restoring spectrometer not crossing a flares footpoints/ribbons during the impulsive phase, and so on.

As such I have developed a search algorithm which retrospectively cross-references metadata from multiple instruments to search for flaring events (perhaps, accidentally) observed simultaneously. This will allow researchers to search for multi-wavelength datasets with which to address a given science question, rather than working on a simply "interesting" flare. This manual describes the techniques applied, and ultimately how to search for events with a given set of properties.



Instruments

- **GOES:** full disk; multiple satellites (GET_GEV.PRO)
- **RHESSI:** full disk; suffers from eclipse and SAA passes (HSI_WHICHFLARE.PRO)
- **SDO/EVE MEGS-A:** full disk; no longer operating as of 26 May 2014
- **SDO/EVE MEGS-B:** full disk; limited duty cycle; now responding to flare trigger (http://lasp.colorado.edu/eve/data_access/evewebdata/interactive/megsb_daily_exposure_hours.html)
- **Hinode/EIS:** Rastering instrument; limited FOV; eclipses; planning schedules (EIS_LIST_RASTER.PRO)
- **Hinode/SOT:** Limited FOV; eclipses; planning schedules (SOT_CAT.PRO)
- **Hinode/XRT:** Limited FOV (sometimes); eclipses; planning schedules (XRT_CAT.PRO)
- **IRIS:** Rastering instrument; limited FOV; eclipses; planning schedules (IRIS_OBS2HCR.PRO)

Approach

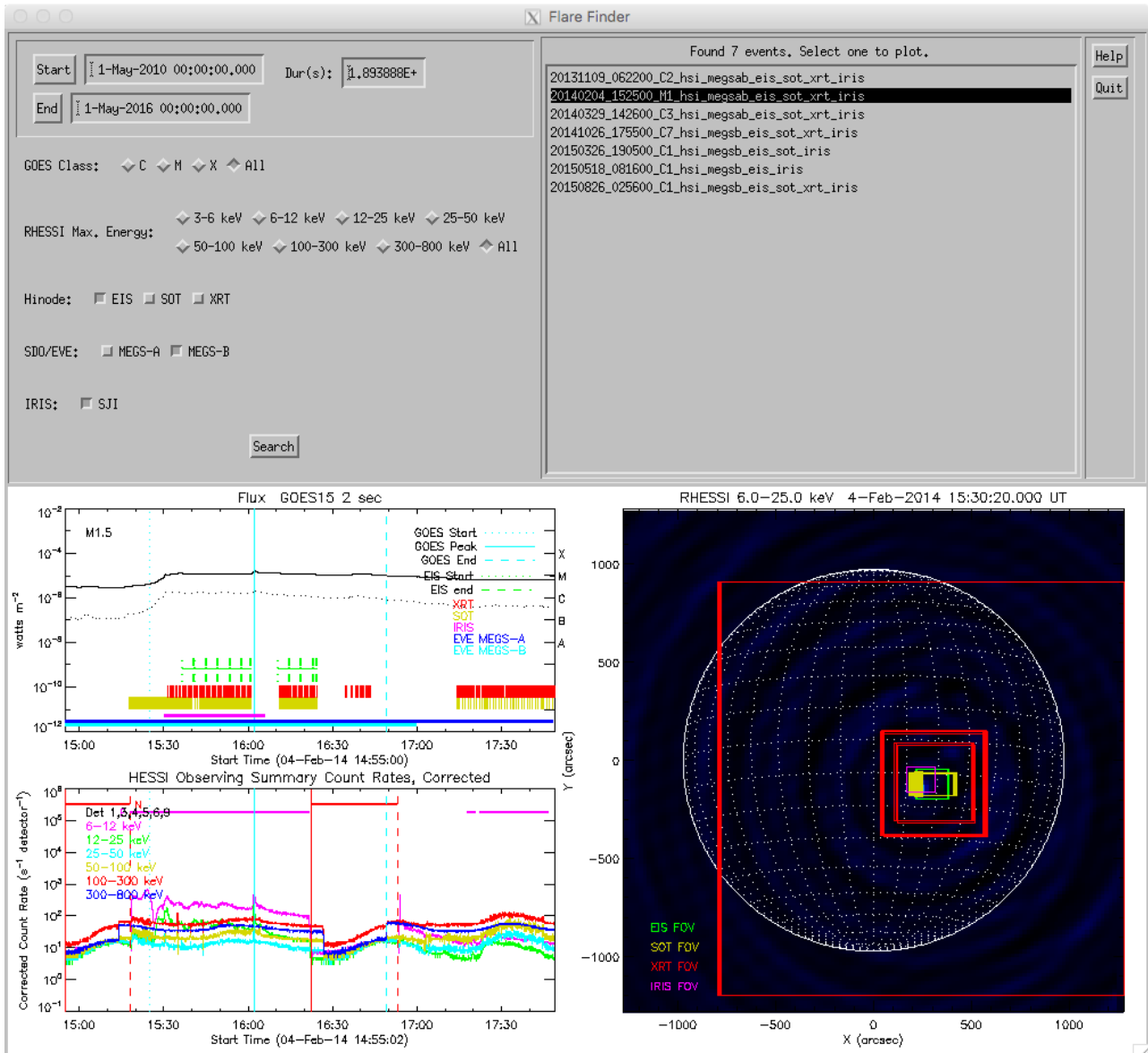
1. Starting with the complete GOES event list, which catalogs the start, peak and end time, as well as the classification of every solar flare within a given time range, beginning with the launch/ first light of SDO (1 May 2010).
2. Find the largest RHESSI flare that occurred within the rise time of the GOES event.
3. Check that RHESSI observed at least 50% of the rise phase (GOES start->peak) of the flare.
4. Get flare location from RHESSI images.
5. If the flare occurred between 1 May 2010 and 27 May 2014, it is assumed that SDO/ EVE MEGS-A observed it.
6. Concatenate all SDO/ EVE MEGS-B exposure times from the above online list. MEGS-B should have been exposed throughout the rise phase of the flare.
7. Check if any Hinode/ EIS rasters were taken during GOES start-30 minutes and GOES end+60 minutes. Make sure at least one raster begun/ ended during the flare itself (GOES start-> end) and that the flare occurred within the EIS FOV+/-20".
8. Check if any Hinode/ SOT images were taken during GOES start-30 minutes and GOES end+60 minutes. Make sure at least one image was taken during the flare itself (GOES start-> end) and that the flare occurred within the SOT FOV+/-20".
9. Check if any Hinode/ XRT image were taken during GOES start-30 minutes and GOES end+60 minutes. Make sure at least one image was taken during the flare itself (GOES start-> end) and that the flare occurred within the XRT FOV+/-20".
10. Check if IRIS was observing at all during the flare (GOES start->end) and did the flare occur within the IRIS FOV+/-20".
11. It is assumed that SDO/ AIA and SDO/ HMI were always observing the Sun during the time of all events considered.

Searching the database

A routine now exists in SSWIDL which opens a widget from which the user can search for flare(s) of different magnitudes and energies that were observed by various combinations of instruments. In IDL type;

```
IDL> flare_finder
```

and you will see this widget.



Click on the individual buttons for your required instrument and then hit "Search". A list of all the flares that conform to those criteria will appear in the window in the top right. Clicking on any of these filenames will plot a pre-made .png file depicting the timing and pointing of each of the observations that correspond to the chosen event.

Statistics

In order to get a handle on just how many flares have been observed by various combinations of instruments, it is useful to plot a - 6-set - Venn diagram (see below). Remember, it assumes that all flares cataloged here were observed by GOES and by RHESSI for at least 50% of the rise phase.

