RHESSI Flare Statistics &
The Hale Sector Boundary

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Motivation

- Lot’s of diagnostic info about flares from RHESSI
  - Magnitude, position, morphology, thermal & non-thermal energy etc
- How to make use of the data/statistics?
  - Don’t just want to produce frequency distribution & index~2
- Comparison to magnetic field features
  - The Hale Sector Boundary - preferential locations of activity
    - Dittmer 1974,
    - Svalgaard & Wilcox 1976
RHESSI Flare List - McTiernan

http://hesperia.gsfc.nasa.gov/hessidata/dbase/hessi_flare_list.txt

- Full list: 102,856 events (12-Feb-2012 to 25-Jan-2015)
- Below is 01-Jun-2002 to 01-June-2014 = 96,000 events
  - But only 69,694 “good” flares included in the movie/analysis
RHESSI Flare List

- Full list in SSW or here:
  - http://hesperia.gsfc.nasa.gov/hessidata/dbase/hassi_flare_list.txt

- Software details:
  - http://sprg.ssl.berkeley.edu/~jimm/hessi/hsi_flare_list.html

- Quick look images for RHESSI
  - http://sprg.ssl.berkeley.edu/~tohban/browser/?show=grth1+qlpct+qlpri+qli02+qlids&date=20150126&time=165220

```python
fl = hsi_flare_list(obs_time_interval = ['26-Jan-2015 16:00','26-Jan-2015 17:35'])
fl_data = fl -> getdata()
help,fl_data,/str
; First step need sflag=1
print,fl_data.sflag1
; For more use other flags and peak to back countrate
help,fl_data[0].flags
; Though which to use depends on flare magnitude (attenuator states) and time (detectors behaving?)
```
RHESSI Flare List

• **Positives**
  – Many real flares
  – Better contrast of flare to background at these high E - More small events
  – Other params already derived, can calculate more - Position, spectral properties

• **Careful !**
  – Many non-flares
  – Not full time coverage (SAA/Night/Anneals/Offpointing)
    • Best about 50-60% in sunlight
  – Need to be careful with parameters
    • i.e. Position is centroid in an energy range
Sector Structure

- Interplanetary magnetic field has a sector structure, reflecting its polarity relative to the solar direction.
  - Wilcox & Ness 1965

- At the photosphere this sector structure between the regions of different polarity seam on a baseball.
  - Svalgaard et al. 1974
Sector Boundary on the Sun

• From the measured magnetic field we can calculate where the boundary between opposite polarities is.
  – Winding around the surface looking like the seam of a baseball
Hale Sector Boundary

- Hale’s Law: Leading/trailing sunspots polarity depends on cycle per hemisphere
  - Odd: Northern: +/-, Southern: -/+  
  - Even: Northern: -/+ , Southern: +/-  

- Hale Sector Boundary is the location in each hemisphere where the change in sector magnetic polarity is same as the leading/trailing sunspots  
  - Svalgaard & Wilcox 1976
Analysis

• Found when +/- and -/+ sector boundary at solar meridian
  – Using 4.5 days after crossing detected at Earth
  – Svalgaard 1972 showed this was reasonable (but crude) proxy
  – http://www.leif.org/research/sblist.txt

• Then found subset of RHESSI flares that occurred within:
  – ±24hrs of each crossing and
  – In either Cycle 23 (<06/2009) or 24 (>06/2009)

• Plotted 1D and 2D histograms .........
2D Histograms

Cycle 23

Jun-2002 to Jan-2009

Cycle 24

Jan-2009 to Jun-2014

Even Cycle

-+ in North

+- in South
1D Histograms

- Restricting further to longitudes of ±25°

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**Cycle 23**

Jun-2002 to Jan-2009

-,- (N= 908)
+,- (N= 598)

**Cycle 24**

Jan-2009 to Jun-2014

-,- (N= 427)
+,- (N= 526)
• Not enough to show for Cycle 24, need to add from 06/2014
Summary

• RHESSI flare list a good resource
  – But requires extra work to be sure “good” flares extra info

• Been able to confirm flares “prefer” to occur near Hale Sector Boundaries
  – Only took 40 years (Dittmer 1974)

• But only looking at small subset of events due to proxy of when Hale Sector Boundary at meridian
  – Need to investigate relative distance to HSB for all flares
  – Work out likelihood of AR to flare if near HSB ?
  – This stuff related to “active longitudes” ?