Characterization of Solar Eruptions found with EruptionPatrol/Characterize

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from Hurlburt, 2016 (in prep)
Structured event description compatible with Heliophysics Events Knowledgebase (HEK, Hurlburt et al 2012)

An "eruption" is a region \(\{\Delta x, \Delta t\}\) centered at \(\{x,t\}\) with a speed > 4km/sec found in AIA 304 images using EruptionPatrol with a 20 minute cadence.

- **EruptionPatrol** (Hurlburt 2015)
  - Computes 2D velocities using opflow3D method (Hurlburt & Jaffey 2015) on 2 minutes of AIA data (10 images)
  - Currently running as part of SDO Event Detection System

- EruptionCharacterize (Hurlburt 2016) analyzes and characterizes EP results
Statistical Analysis

- 21,156 regions identified between 2010-05-15 and 2014-11-15. The sample excludes eruptions occurring between 2011-05-31 and 2011-06-30, where the cadence of the 304 channel was changed, as well as those occurring during eclipses.
Overall, the velocity distribution confirms the inverse square distribution reported in EP. The maximum speed over the period was 109 km/sec. The peak of the distribution is around 5km/sec, which is close the detection threshold of 3.6km/sec. This suggests that distribution continues to rise for decreasing speed below this.
Cluster Analysis

The results of a cluster analysis based upon these three properties (speed, size and duration) using the clust_wts and cluster modules in IDL is displayed on the right. The free parameter in these modules is the number of clusters. After some experimentation we chose a total of 32 clusters for display (one revealed missed spacecraft maneuvers that have been excluded). Box plots are used to show (top) the range of sizes in each cluster sorted by size; (middle) the range in speed and (bottom) in duration in the same order. The three quantities display positive correlations, but with significant scatter. The median speed and duration increase monotonically with size for most of the range.
Connections to Flares

- There is a strong relation between size and speed of eruptions and flare probability. We display (left) the fraction of eruptions in each cluster that contain M- or X-class flares within one hour centered (green) at the eruption start time, (red) at 30 minutes prior, (blue) at 30 minutes after and (yellow) at one hour after. The bubble area is proportional to the fraction for all flares (B-X class). Flare probability versus (center) size of eruption and (right) duration using the same colors and sizes.
Conclusions

❖ We have expanded upon our automated method for finding and characterizing eruptions in the lower solar corona. Both the initial detection (EruptonPatrol) and the characterization (EruptionCharacterize) are deployed in the SDO/AIA Event Detection System (EDS). The methods have been found to produce significantly more accurate and more consistent results than those obtained by human reviewers and provides more complete characterization of eruptions.

❖ The results from both are available through SDO/HEK web services. Websites using these services include those at LMSAL (www.lmsal.com/hek), helioviewer.org and the virtualsolar.org.
HEKsearch can identify eruption (ER) with temporal and spatial ranges, with selectable detection methods. Here Eruption Characterize events within a bounding box circumscribing the solar disk and with the “Long” somewhere in the description. The results can then be sorted by time or score. The score is derived from the IntensMax field with a value of 1 corresponding to about 100 km/s.
The size displays a peak near 200Mm and drops rapidly below 120Mm. This is near the effective resolution of 120Mm used when deriving the velocities, so we expect that our method under-represents flows well below this value. The distribution suggests that there we will not see flows on scales below 120Mm. Note that the area reported is that defined by the threshold of 3.6km/sec, so we would expect the loss of resolution to be partly compensated by the peak speed of the flow. This may explain the gradual decline between our resolution and 80Mm. It can be seen that regions larger than 1200 Mm occur less than once over four years.
A similar trend is seen in the observed lifetimes. The longest single eruption lasted for over 3 hours, and there is a consistent decrease in frequency between 4 and 100 minutes.