Predicting Flares

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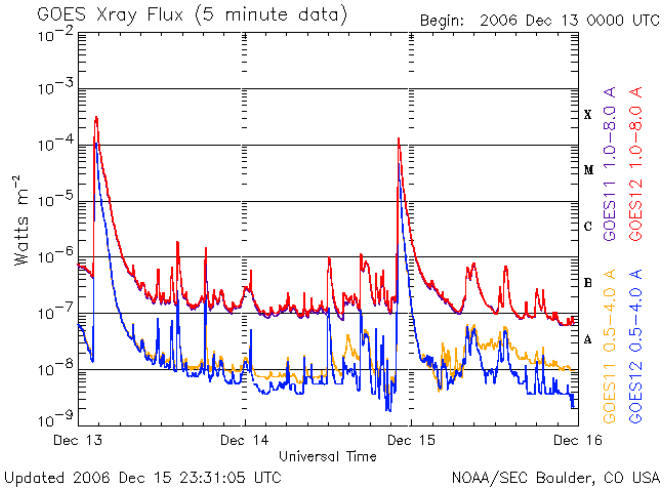
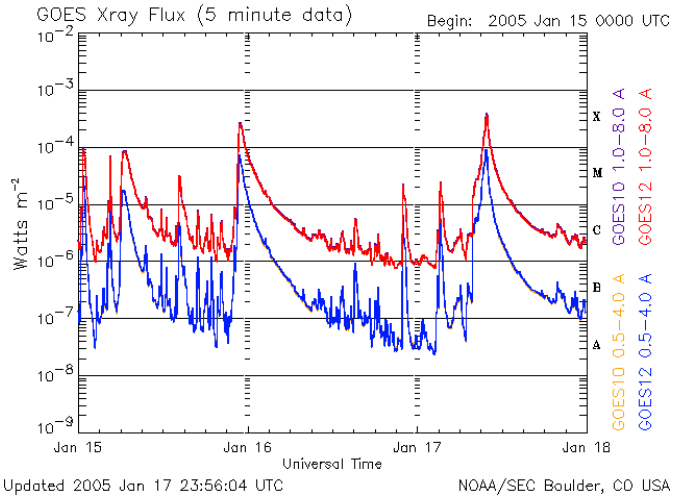
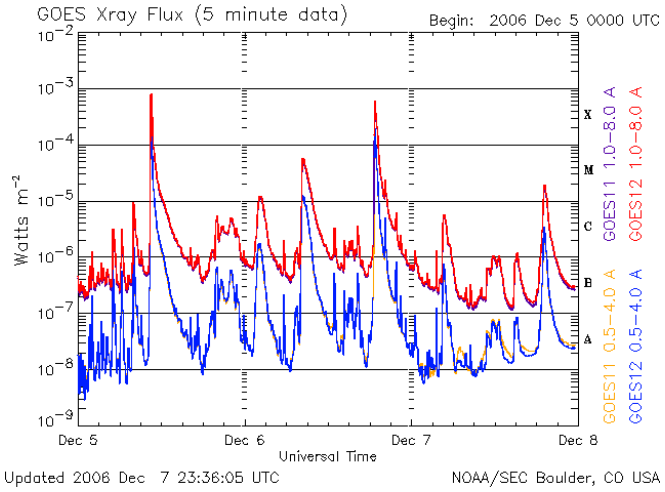
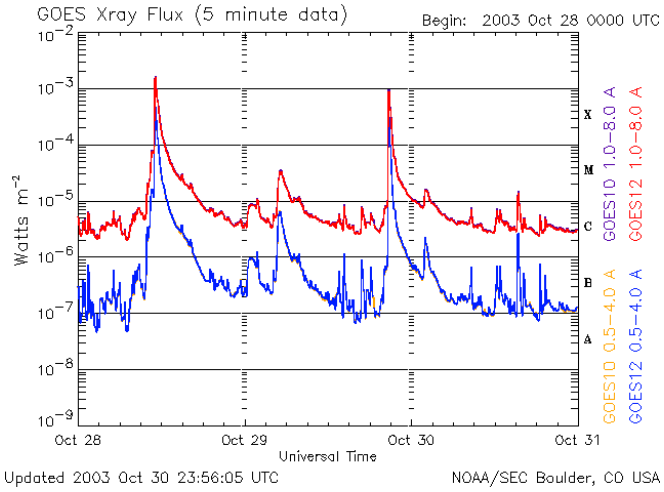
When do large flares happen?









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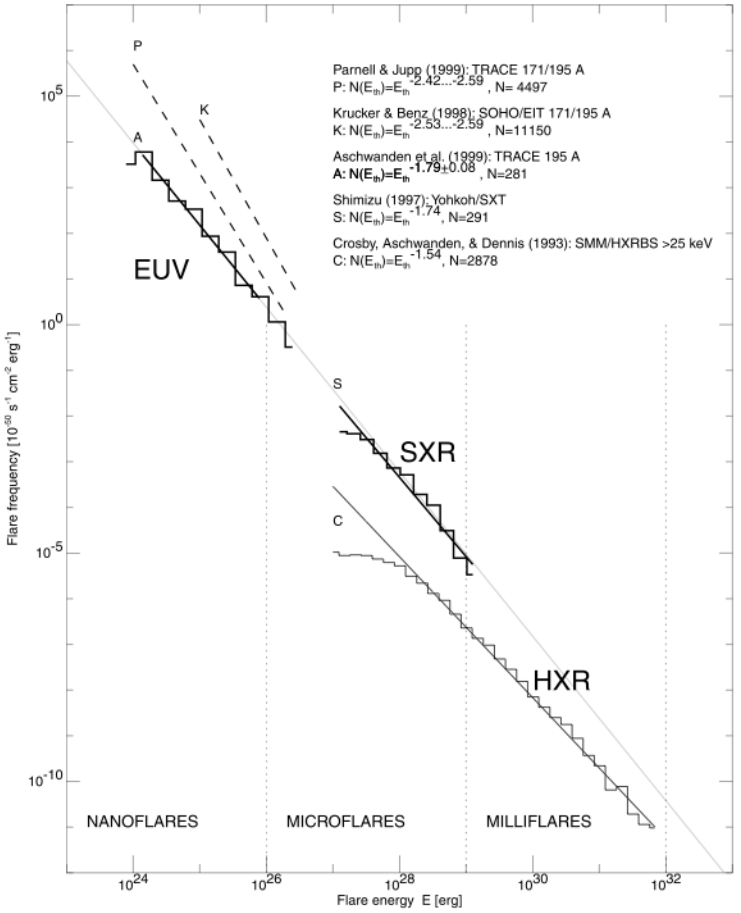
Flare Frequencies

- Flare frequency-energy distribution power law holds over multiple decades (Aschwanden 2000)
- Can determine flare rates from numbers of events measured
- Individual active regions (ARs) have power law indices close to whole Sun value (Wheatland 2000)



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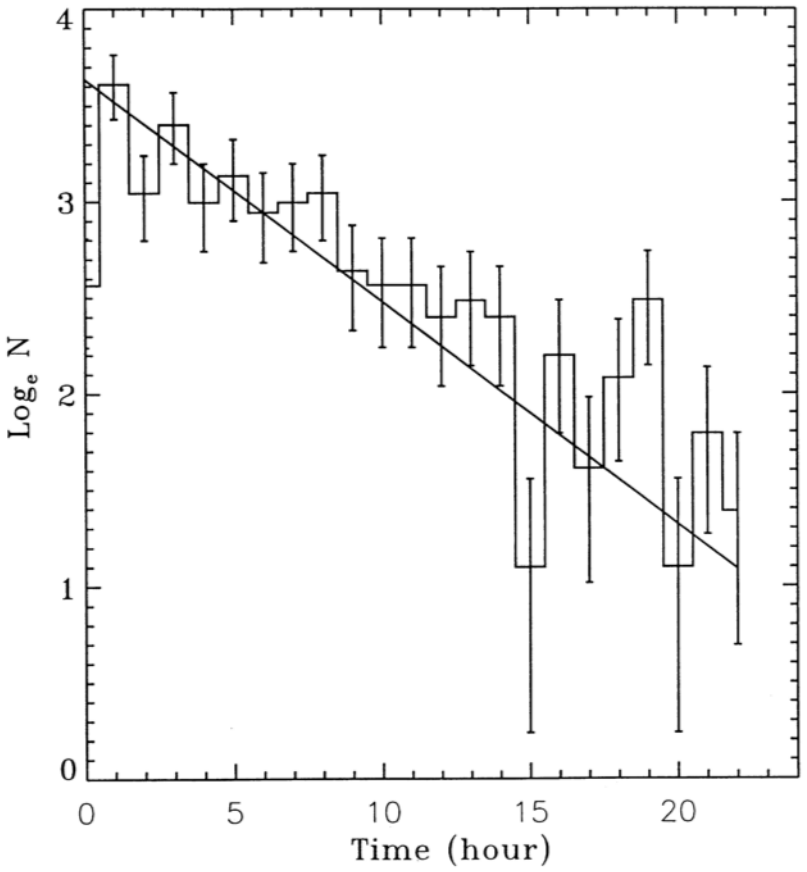
Flare Timings and Probabilities

- Flare frequency-waiting times show Poisson-like exponential distribution (Moon et al. 2001)
- Can determine probability of one or more flares above a given energy cut-off (Gallagher et al. 2002)

  $\varepsilon = 1 - \exp(-\lambda \Delta T)$

- Used with mean flare rates for each McIntosh class
  - no variation within class



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Bayesian Probabilities

$$\underset{(1)}{\text{prob}(\lambda|D, I_{AR})} = \underset{(2)}{\text{prob}(D|\lambda, I_{AR})} * \underset{(3)}{\text{prob}(\lambda|I_{AR})} / \underset{(4)}{\text{prob}(D|I_{AR})}$$

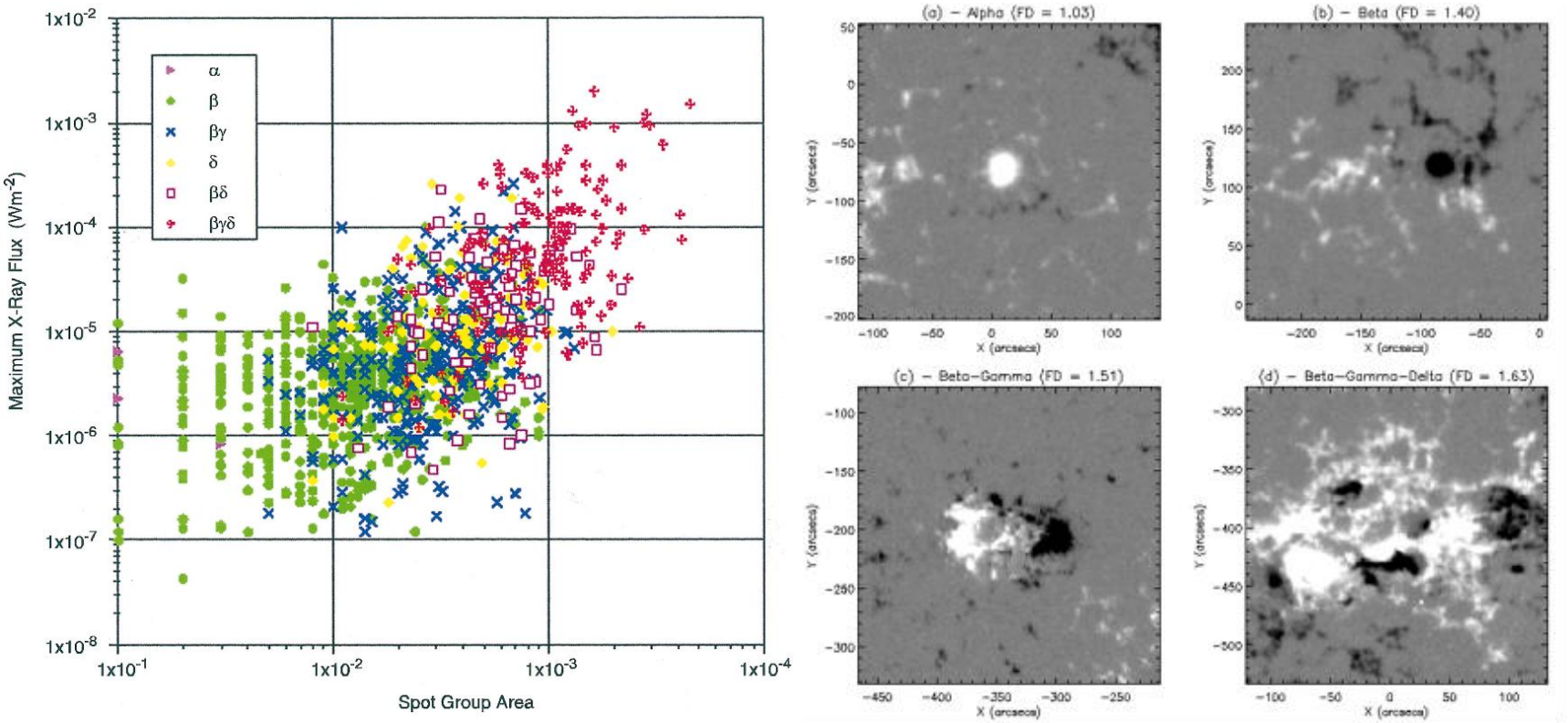
(1) – probability distribution of flare rate given flare data and AR info.
(2) – probability distribution of flare data given flare rate and AR info.
(3) – probability distribution of flare rate given AR info.
(4) – probability distribution of flare data given AR info. (normalisation term)

- Can construct prob($D|\lambda, I_{AR}$) by combining the phenomenological eqns. (Wheatland 2004)

- Can convert probability distribution of flare rates (1) into the probability distribution of flare probabilities from the previous relation for Poisson-based flare probabilities

$$\lambda = \ln(1 - \varepsilon) / \Delta T$$

Conditions for Flaring



- Peak flare magnitude vs peak spot area (Sammis et al. 2000)
  - Big, bad, and ugly?

Data for Analysis

- GOES X-ray flare event listings
  - flare times, flare magnitudes, associated AR
- Solar EUV images
  - flare locations and AR association (backward extension of Sam Freeland's *SoHO*/EIT flare location archive beyond 2002)
  - From mid-2009, *PROBA2*/SWAP 171Å images at nominal 1-min cadence
- NOAA SWPC AR summaries
  - number of spots, total spot area, longitudinal extent, location, McIntosh and Mt Wilson magnetic classifications
- *SoHO*/MDI AR magnetograms
  - peak and average |B|, length and curvature of neutral line, peak and average dB/dl along neutral line, fractal dimension

Final Data Product

- Automated code updating with additional X-ray events and AR evolution
- AR-specific flare probabilities hosted on ***www.SolarMonitor.org***
  - Comparison with NOAA SWPC and Poisson-based predictions