

Nanoflare distributions over solar cycle 24 based on AIA/SDO DEM analysis

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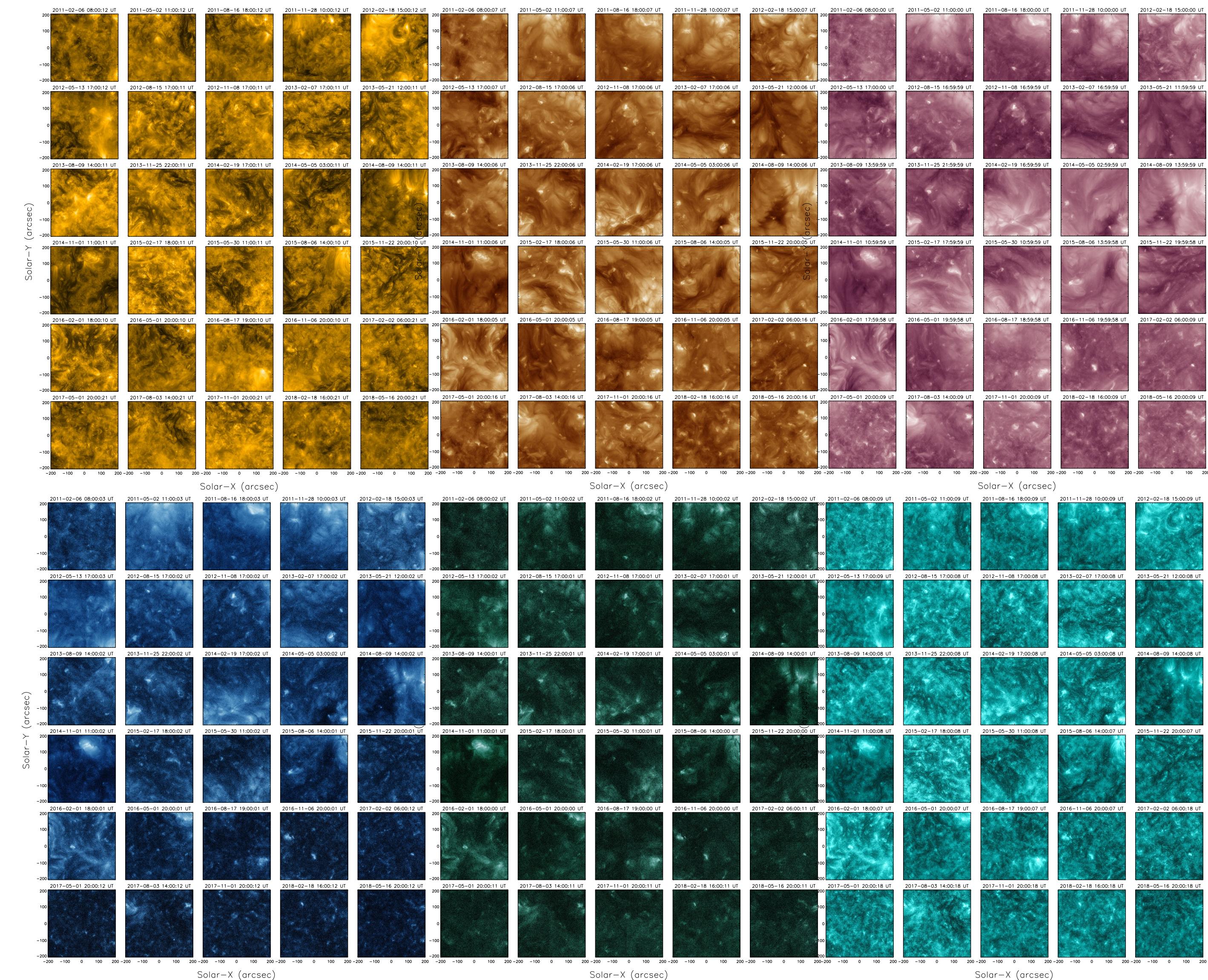
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Data

AIA/SDO

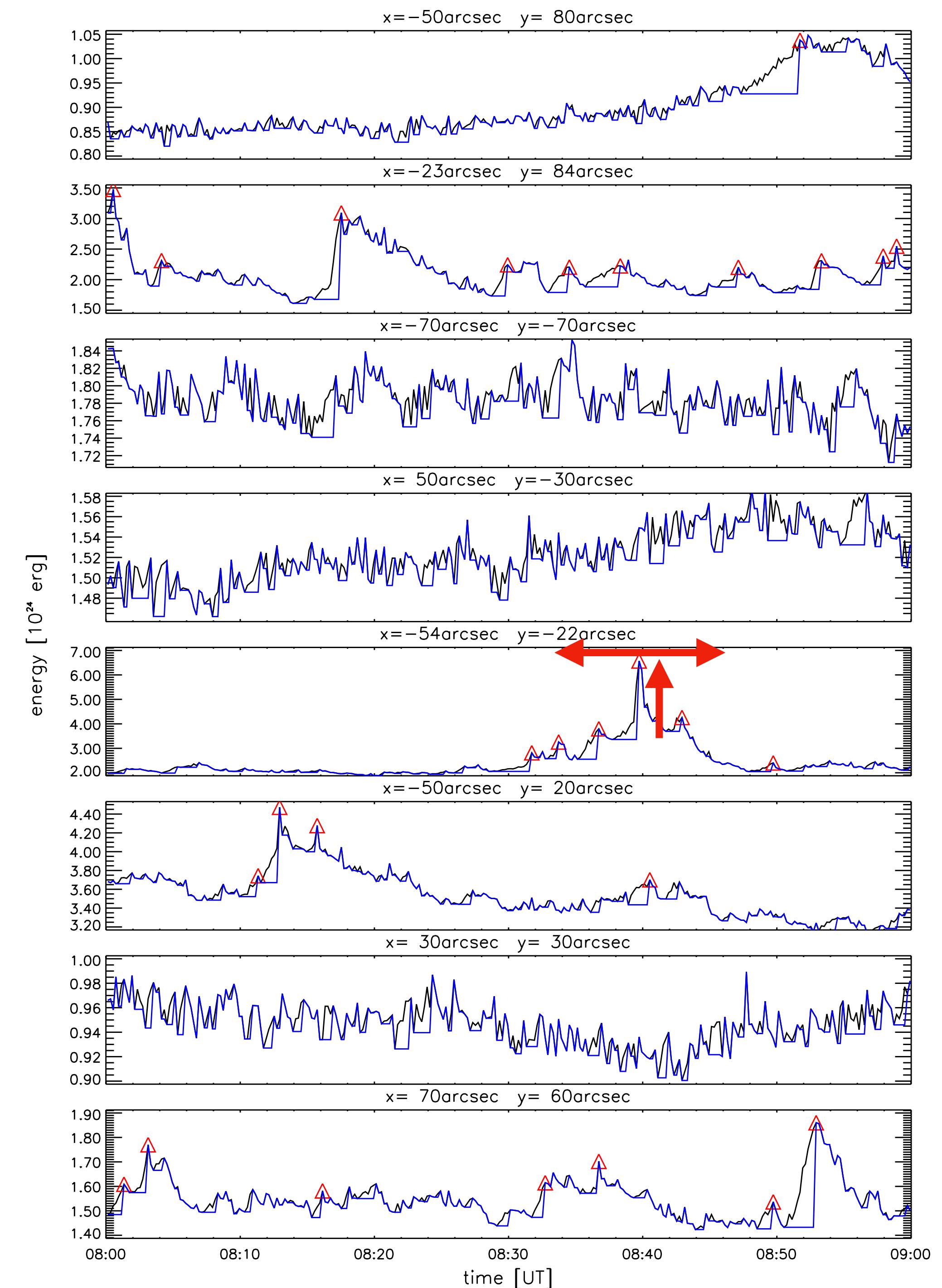
- 400" x 400" field-of-view
- 2 hour observation
- Image cadence of 12 seconds
- 30 image series evenly distributed from 2011 to 2018
- Each series in 6 EUV wavelengths



Methods

Event Detection

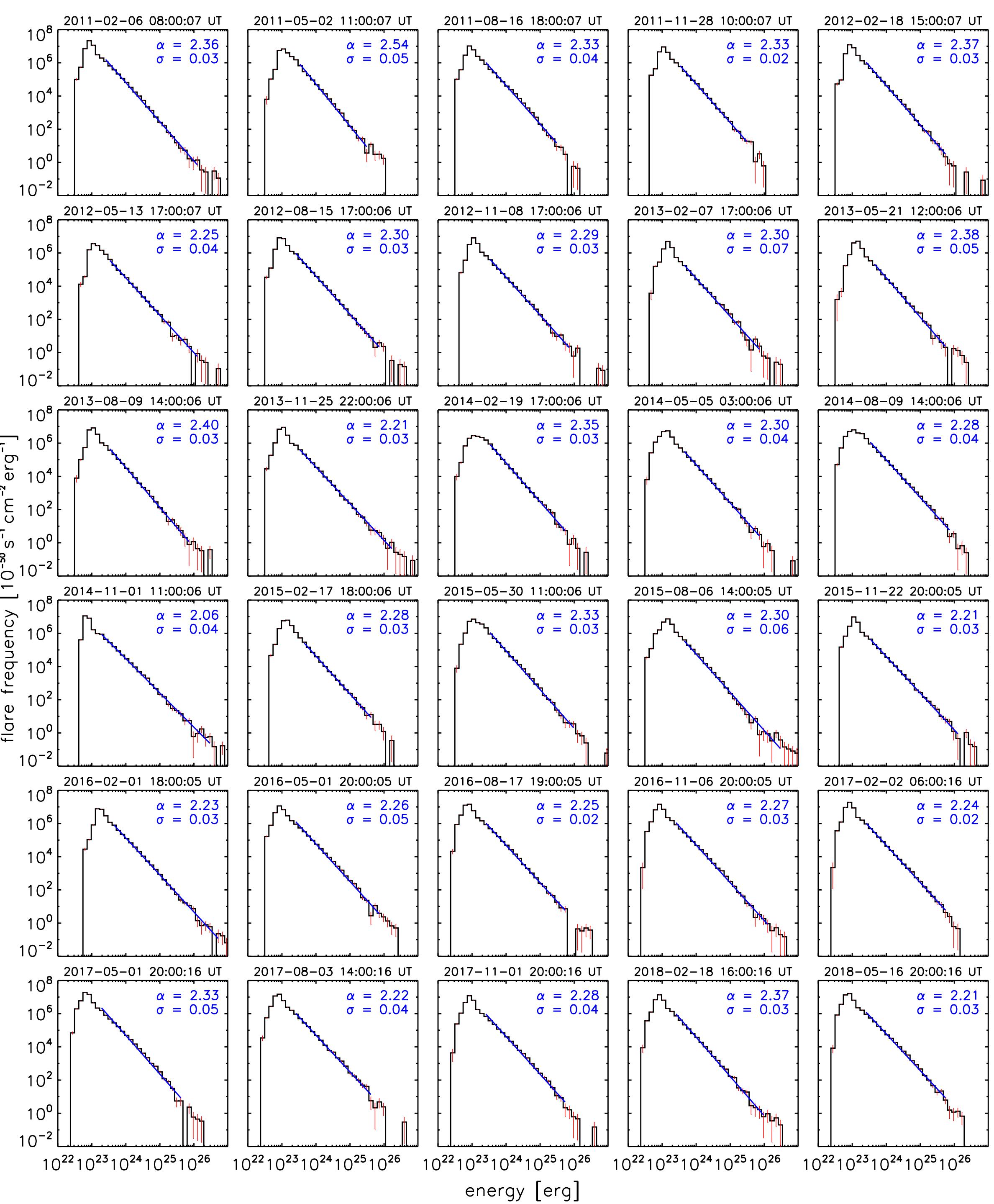
- DEM from inversion algorithm by Hannah and Kontar (2012)
- Thermal energy evolution:
$$E_{th} = 3k_B T \sqrt{EM \cdot A \cdot s_{eff}}$$
- Threshold based event detection algorithm
- Adjustable event detection interval, threshold factor, and combination interval



Results

Frequency Distributions

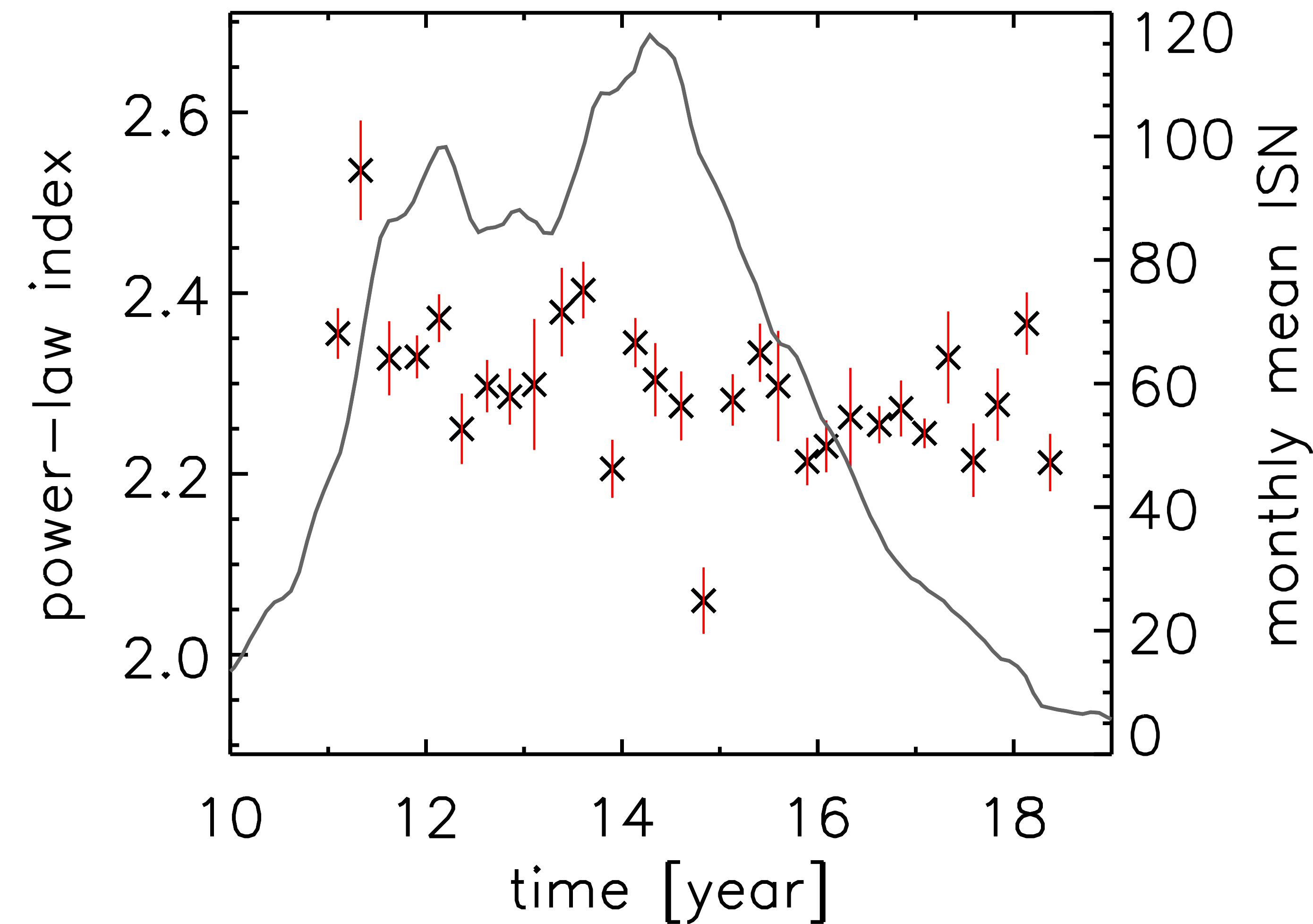
- Nanoflares frequency distribution for each data set
- Peak at about 10^{23} erg
- Low energy cut-off
- Continuous power-law up to at least 10^{25} erg
- Power-law index from linear fit
- $\alpha = 2.06$ to 2.54



Results

Frequency Distributions

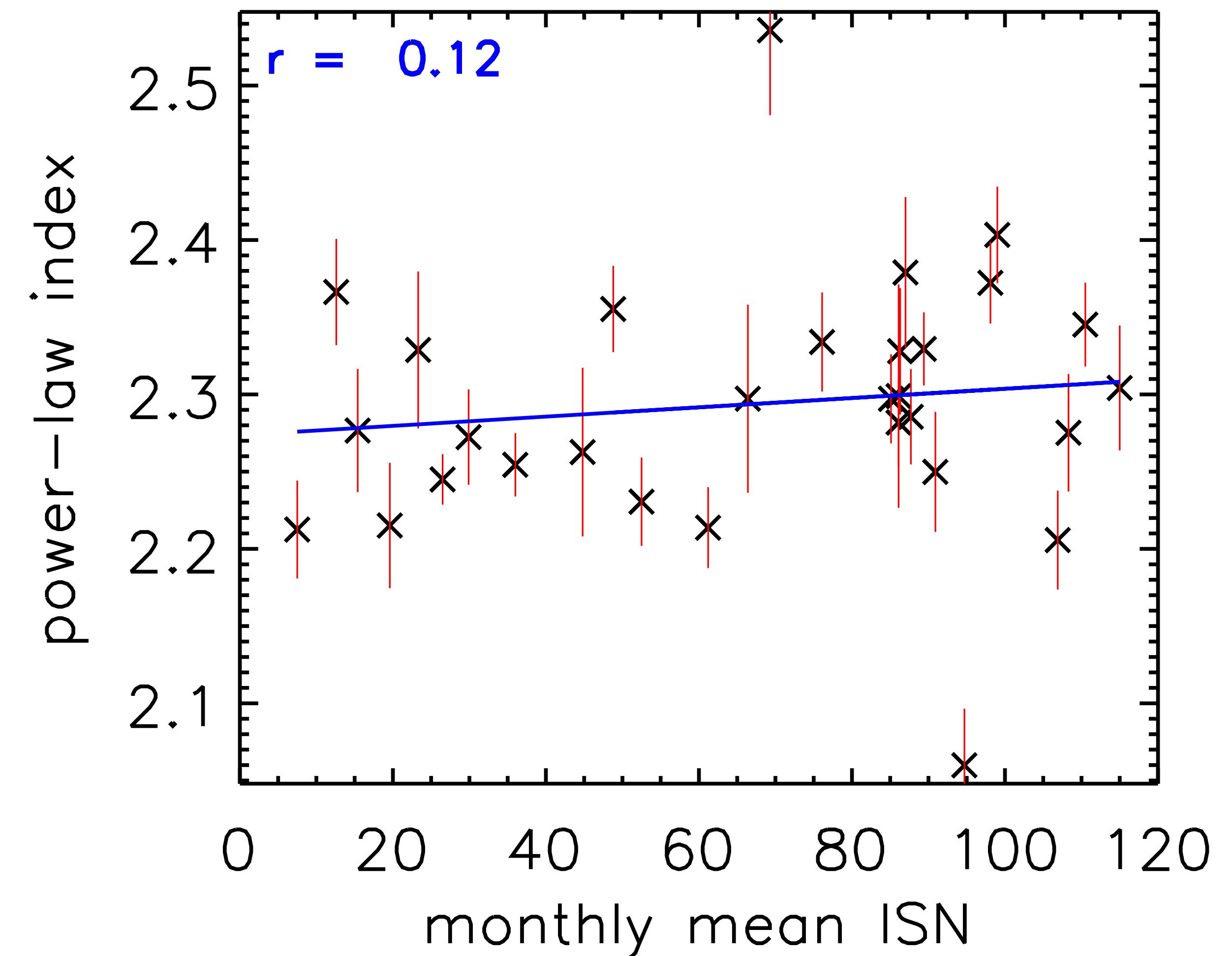
- Power-law index during solar cycle 24
- Mean sunspot number in gray



Results

Frequency Distributions

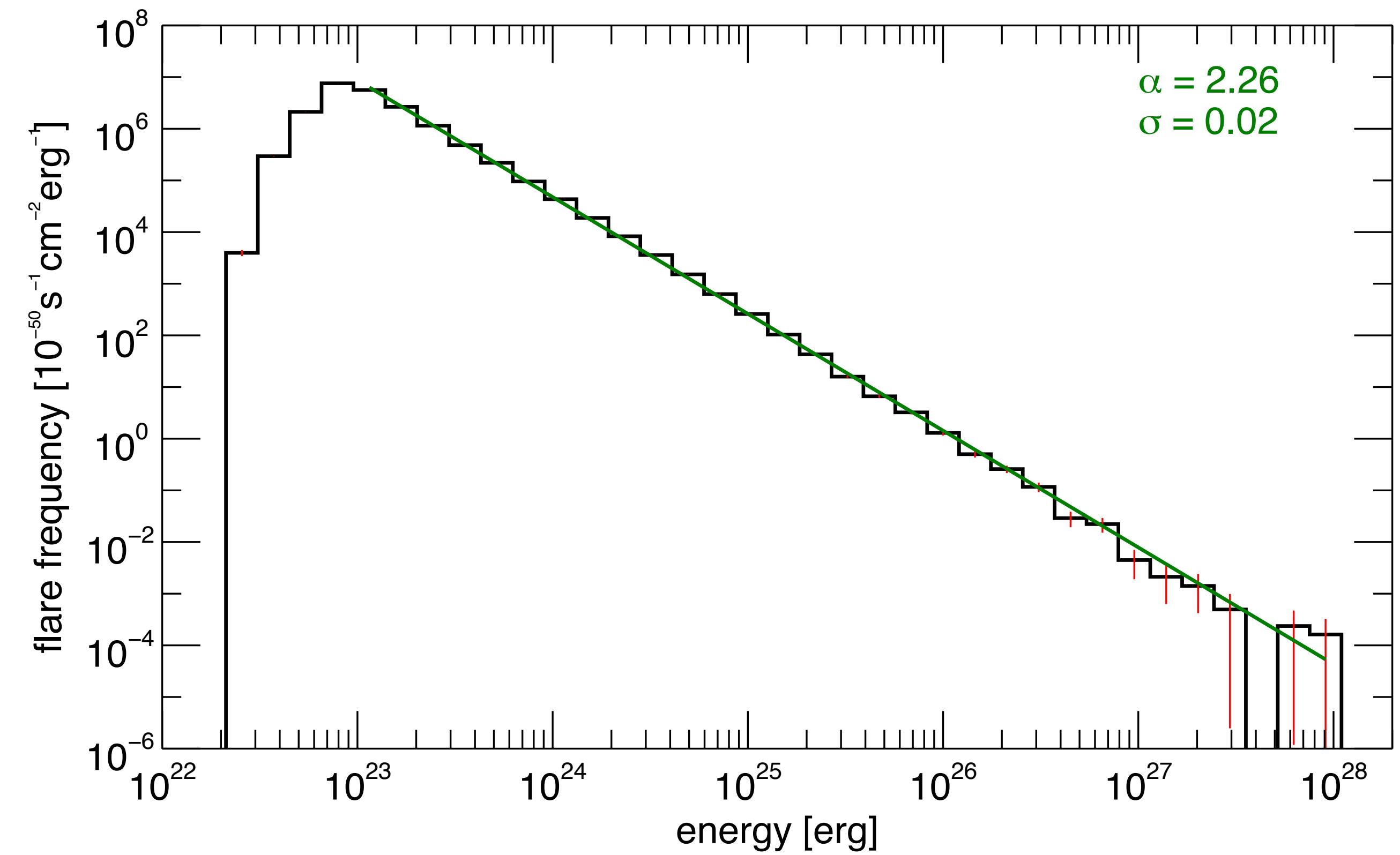
- Power-law index during solar cycle 24
- Mean sunspot number in gray
- No correlation ($r = 0.12$) to the sunspot number
- Matches solar flare observations (Crosby et al. (1993) and Veronig et al. (2002))



Results

Combined Distribution

- Combination of all previously shown frequency distributions
- Power-law slope $\alpha = 2.26$
- 10^{23} erg to 10^{28} erg
- Five orders of magnitude in thermal event energy
- $\alpha > 2$ means small events dominate the energy input
(Hudson, 1991)



Results

Comparison with other studies

- Nanoflare Studies:
 - TRACE: Parnell and Jupp (2000)
 - SOHO/EIT: Benz and Krucker (2002)
 - TRACE: Aschwanden et al. (2000)
- Microflare Studies:
 - Yohkoh/SXT: Shimizu (1995)
 - RHESSI: Hannah et al. (2008)

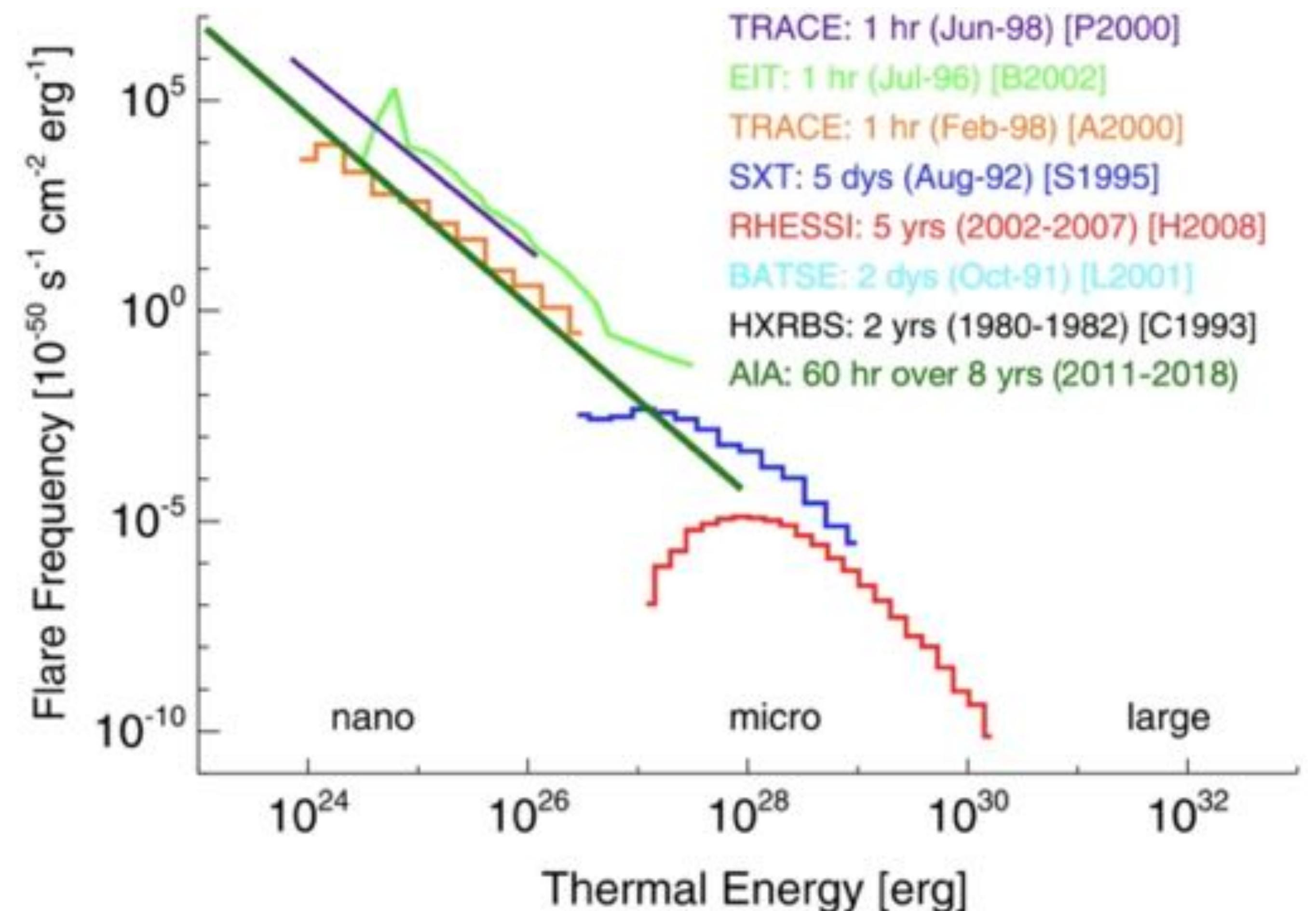
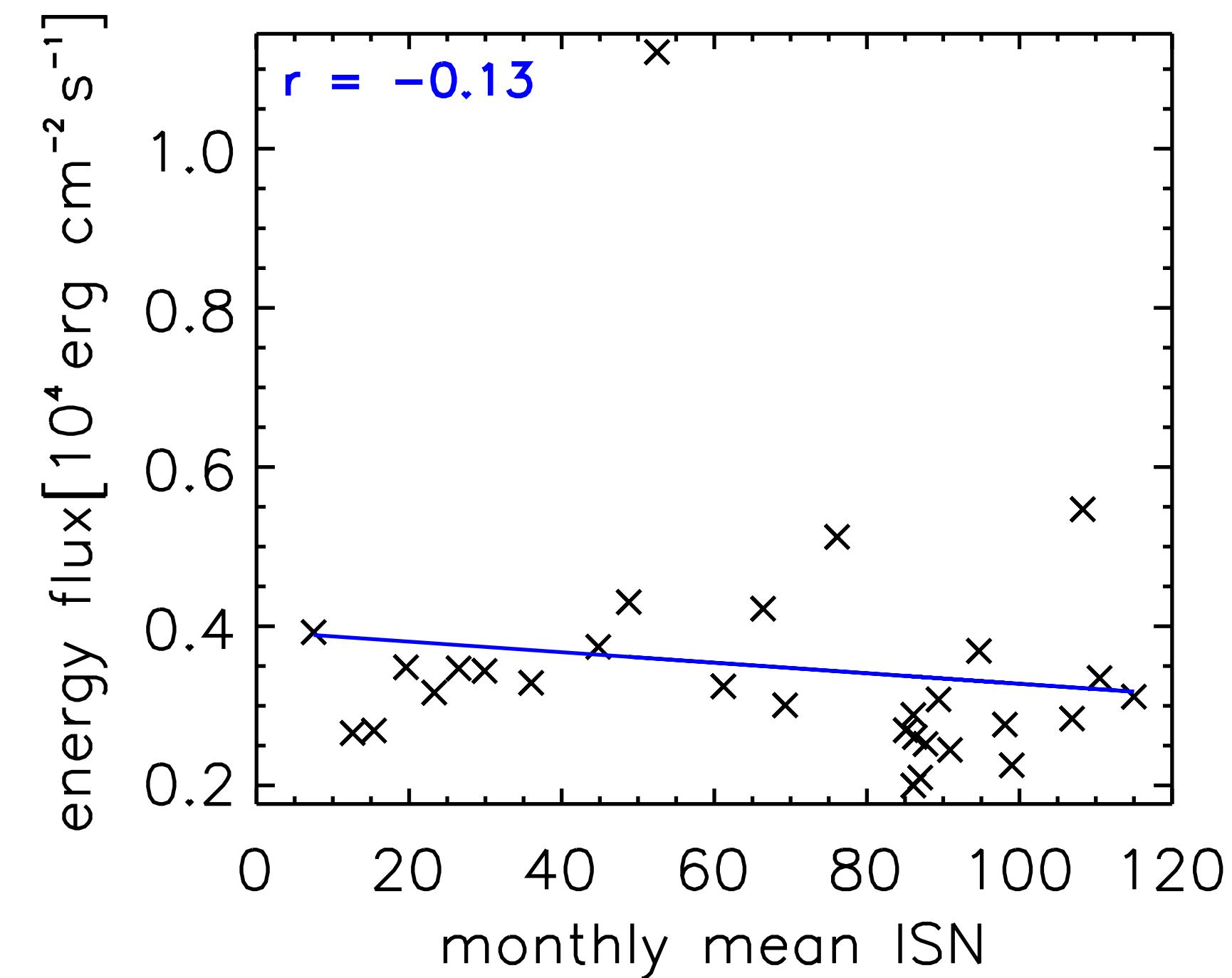
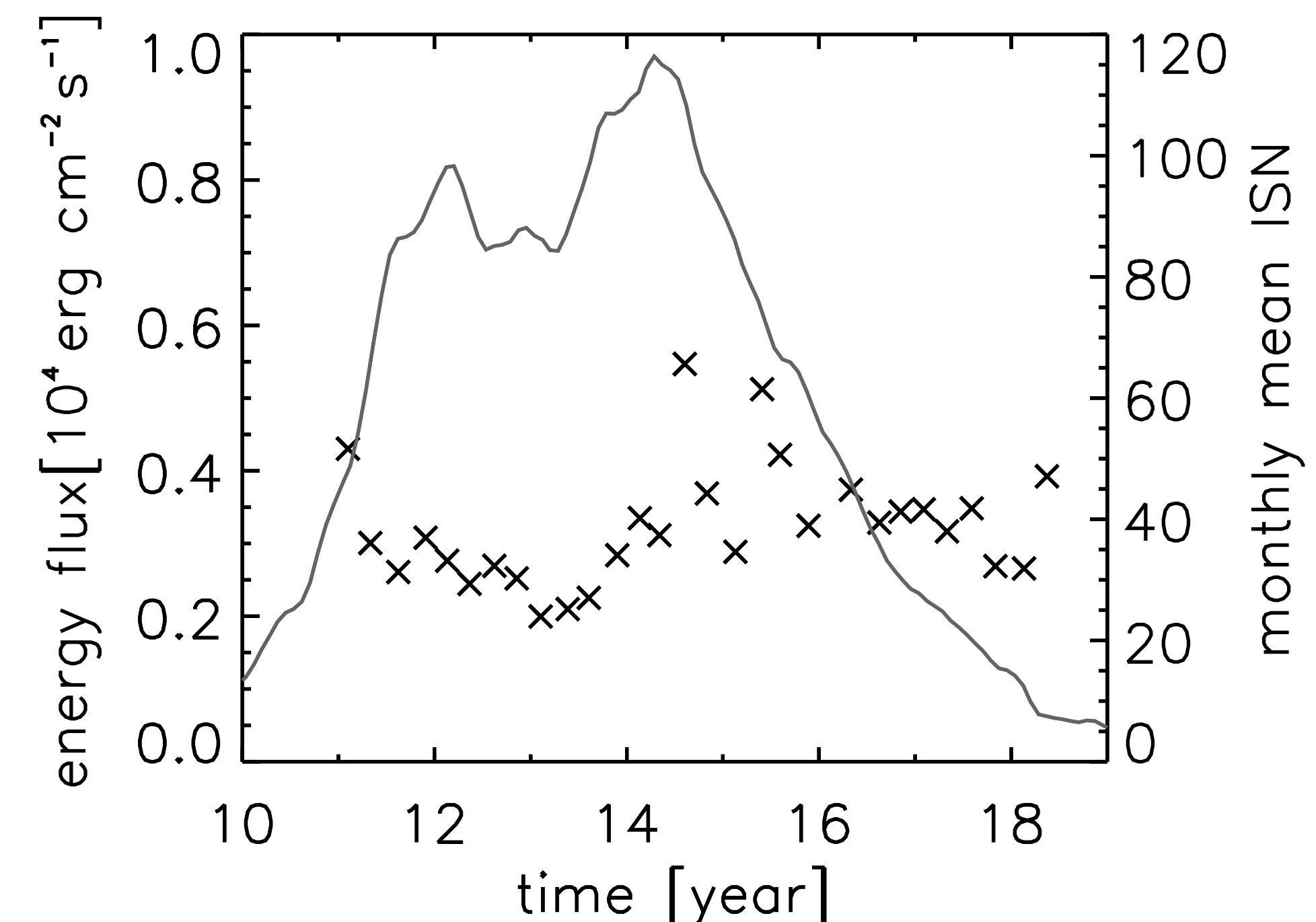


Figure adapted from Hannah et al. (2011)

Results

Energy Flux

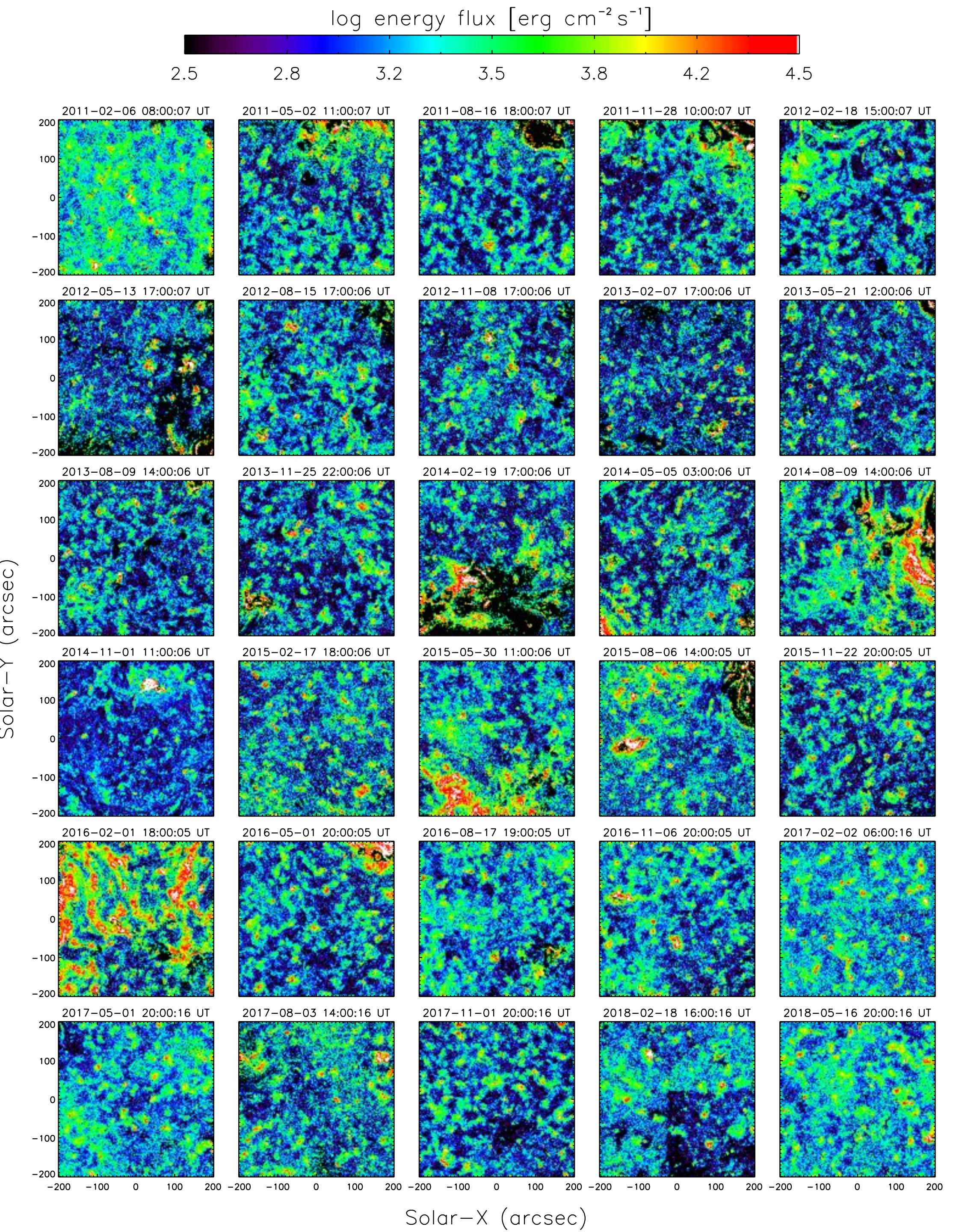
- In individual data sets:
 2×10^3 to 4×10^3 erg cm $^{-2}$ s $^{-1}$
- No correlation to the sunspot number
- In the combined data set:
 3.2×10^3 erg cm $^{-2}$ s $^{-1}$
- 1% of required heat input
(3×10^5 erg cm $^{-2}$ s $^{-1}$)



Results

Energy Flux - Spatial Distribution

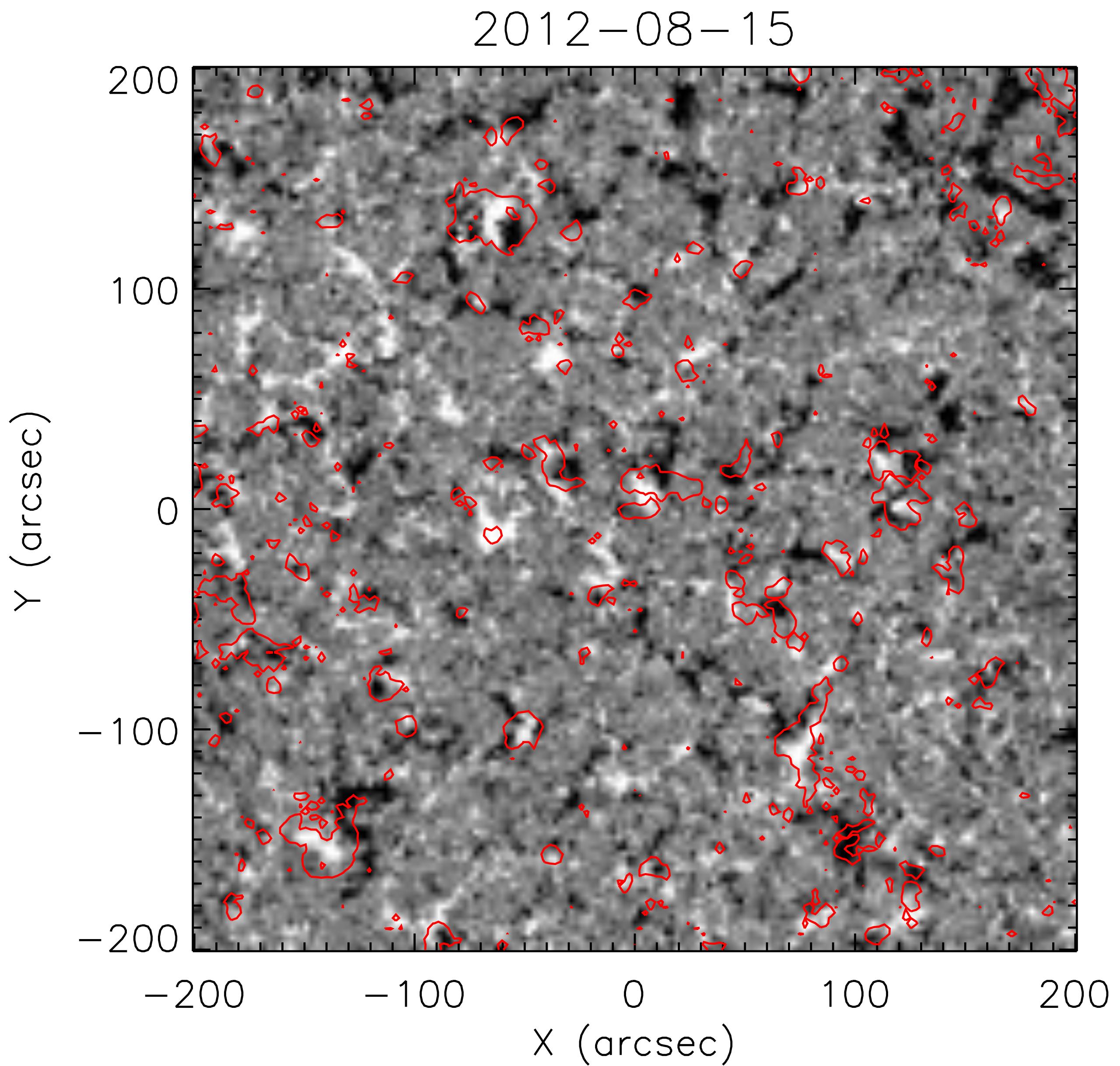
- Not distributed evenly: clusters
- Two orders of magnitude shown
(4×10^2 to 4×10^4 erg cm $^{-2}$ s $^{-1}$)



Results

Energy Flux - Spatial Distribution

- Areas with mean energy flux
 $> 5 \times 10^3 \text{ erg cm}^{-2} \text{ s}^{-1}$
- Magnetogram is saturated at $\pm 15 \text{ G}$
- boundaries of the magnetic network
- mixed flux regions of opposite polarities
- Consistent with magnetic reconnection



References

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