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The Most Energetic GOES/XRS Flares

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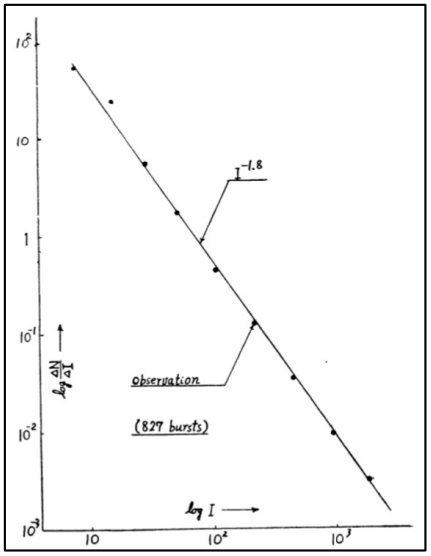
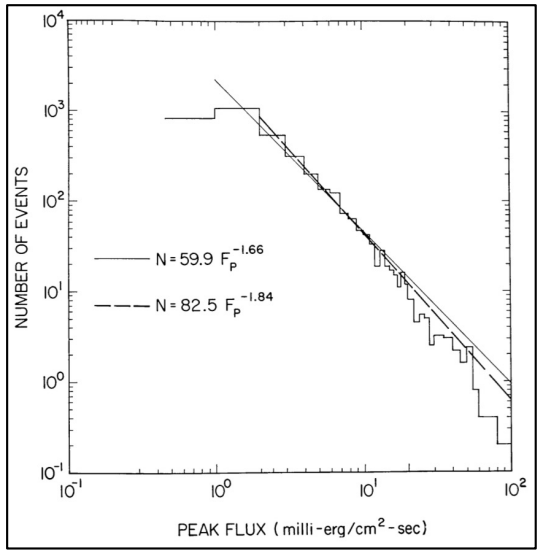
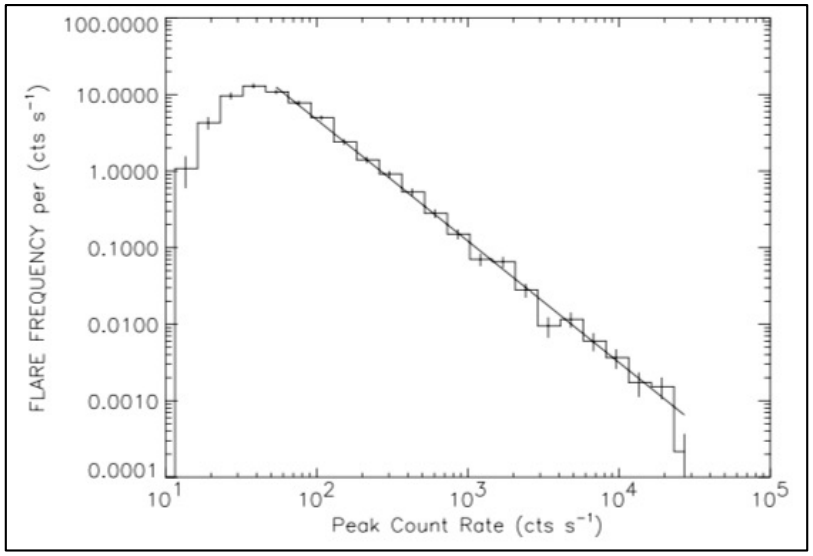
Flare Occurrence Distributions







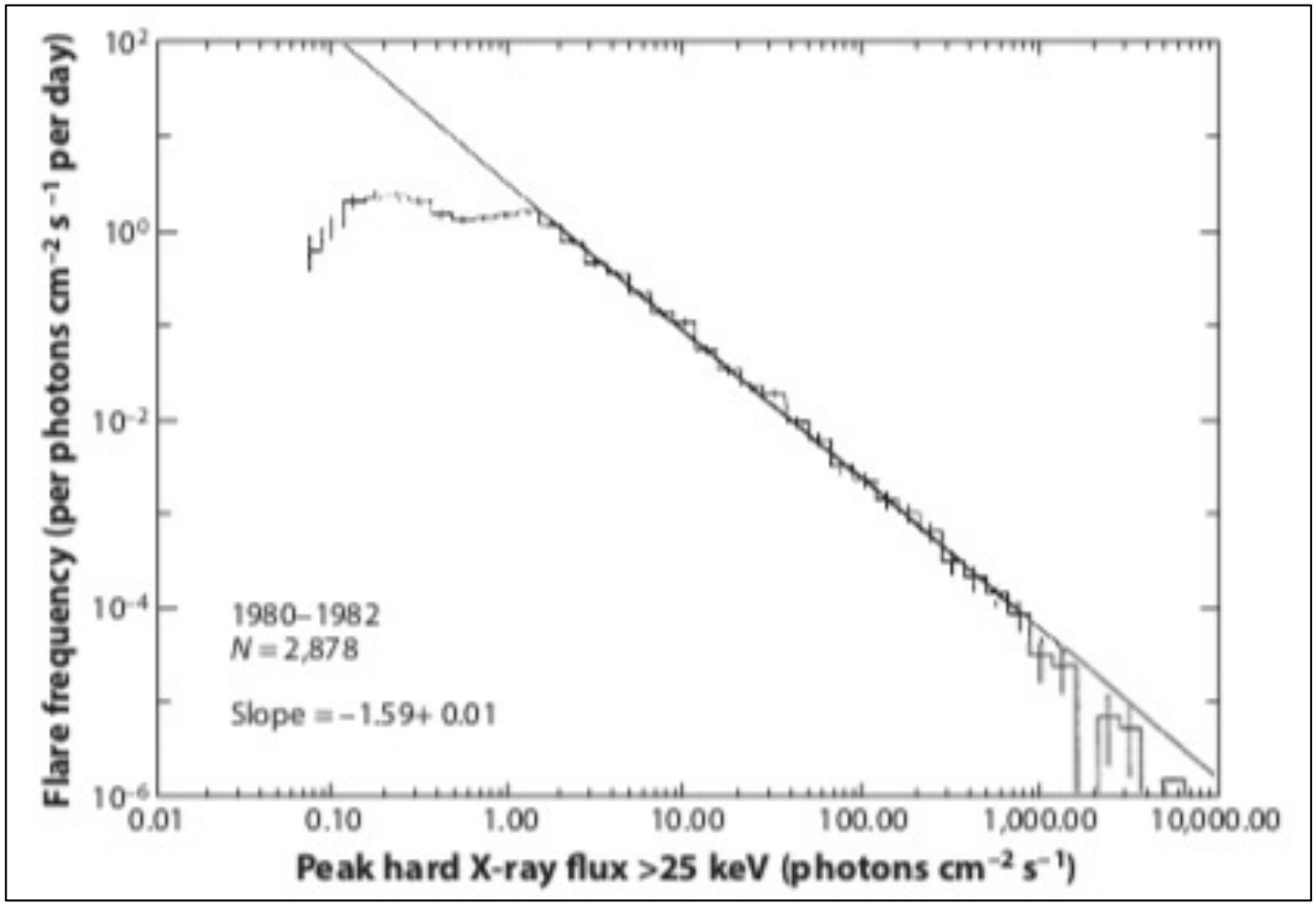
Akabane et al. 1956
(Microwaves, -1.8)

Drake 1971
(SXR, -1.7)

Crosby et al. 1997
(HXR, -1.6)

There have been many, many distributions of this kind, proxies for total event energy. Hudson (1991) argued that there must be a roll-over at the highest energies.

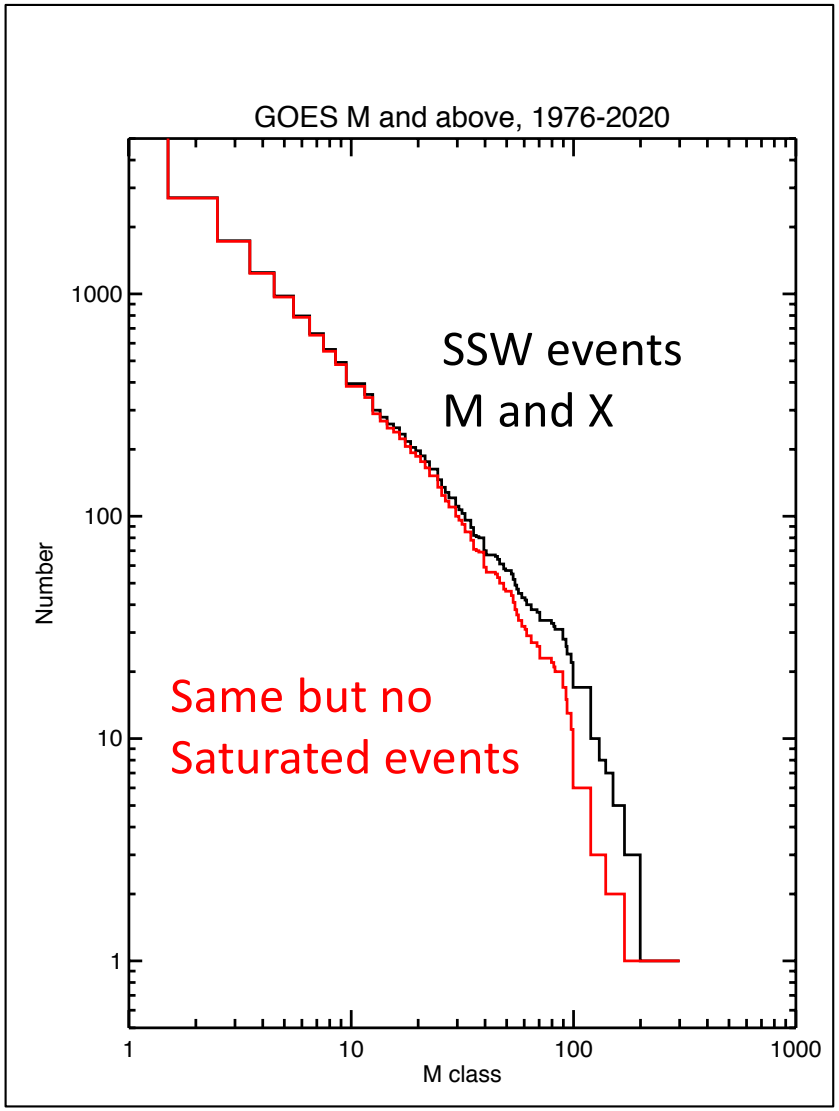
Hints of a Steepening

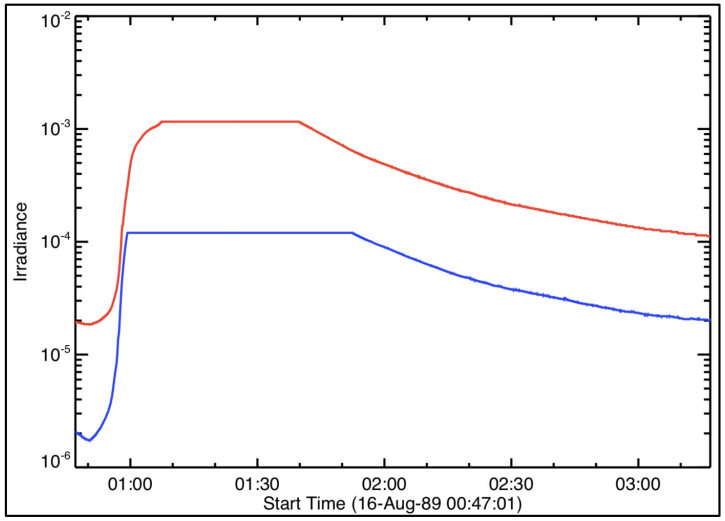


Crosby et al. 1993

The Problem

- The GOES/XRS data provide a long database on major flares, and they define event energies quantitatively, for 1976-present
- Unfortunately, the key 11 events at the top of the scale saturated the sensors
- We have determined a mean time profile for 153 well-observed >X2 events and made uniform corrections for the saturation

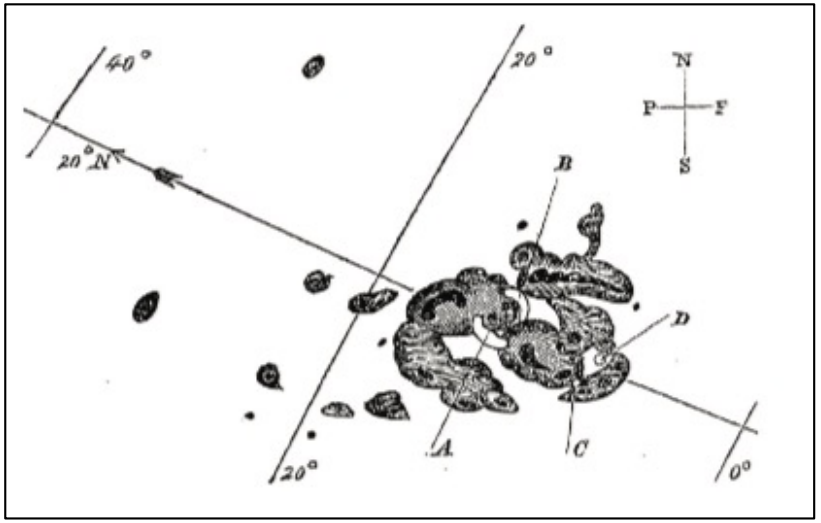


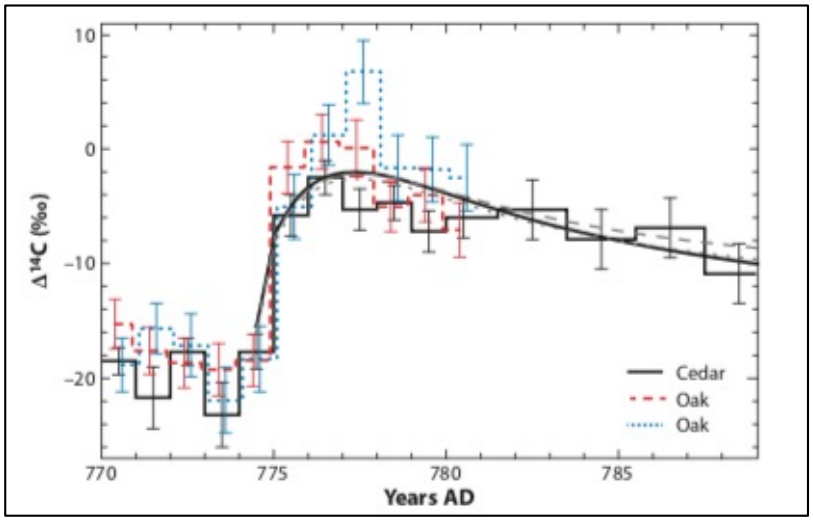


Why is this important?

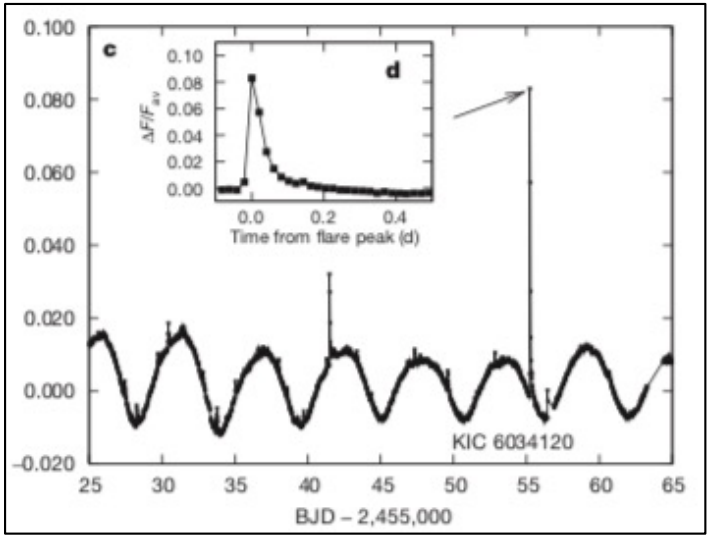
- Solar extreme events threaten us…
- Recent discovery of tree-ring events (Miyake et al. 2013), e.g. 776 CE
- Stellar superflare events suggest that such events might occur if we wait long enough (Maehara et al. 2013)

Carrington 1859



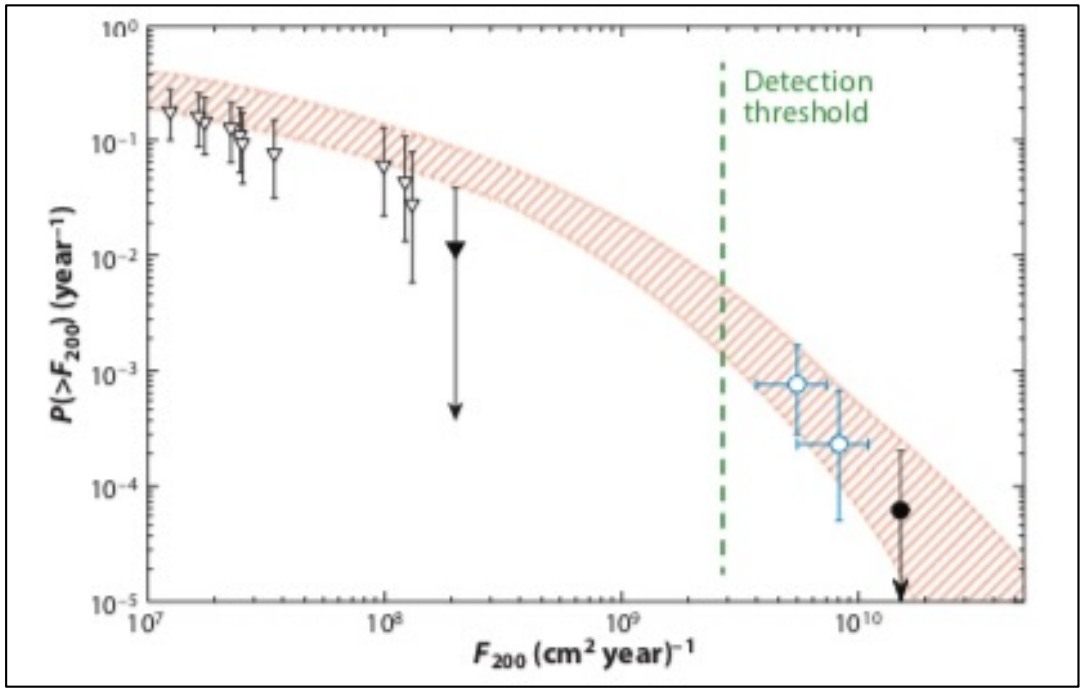


Miyake et al. 2013



Maehara et al. 2012

The SEPs view



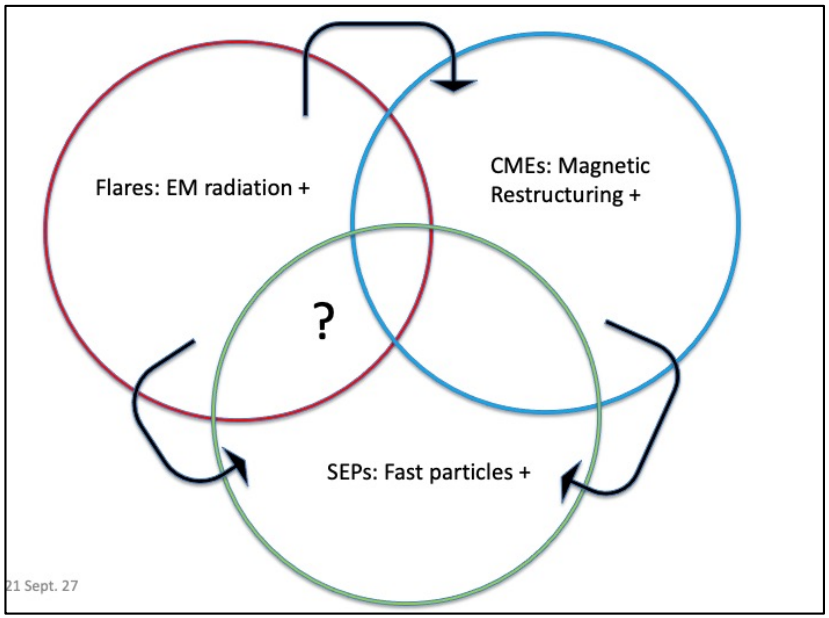
Usoskin, 2021

- As originally noted by Lingenfelter, the tree-ring radioisotope data suggest a roll-over in the SEPs fluences, on very long time scales

- If SEPs and flares scale together, could this longer record help to identify the flare energy cutoff?

- This may be a proxy to flare energies; others include geomagnetic storms and “crotchets’ (SFEs). See for example Cliver et al. (LRSP in preparation)

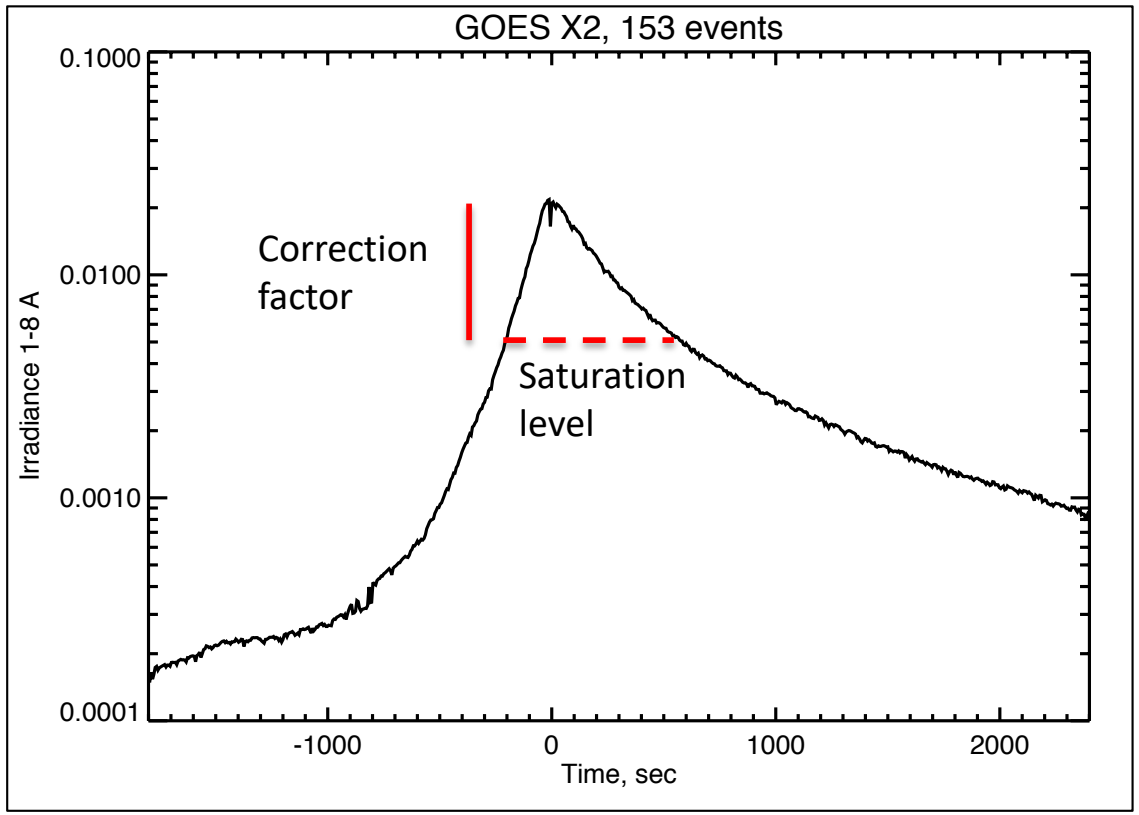
Is there a flare/CME scaling law?



- The physical connection between a flare and any SEPs associated with it is complicated

- Kahler (2013) concluded that the apparent scaling that *is* observed (his "big flare syndrome?") is not physically motivated.

How to fix the GOES saturation? Try scaling a mean time profile.



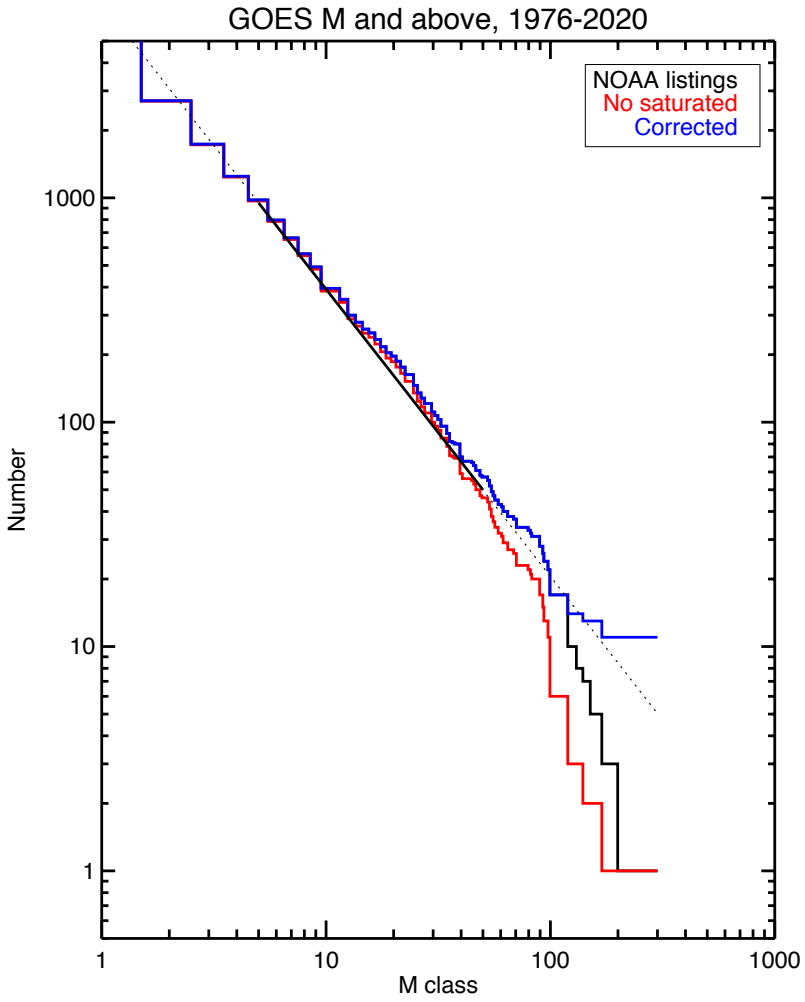
Unsatisfactory results

SOL1978-07-11T10:58	X15	-->	X120
SOL1984-04-24T24:01	X12	-->	X31
SOL1989-03-06T14:10	X11	-->	X51
SOL1989-08-16T01:17	X11	-->	X580
SOL1989-10-19T12:55	X11	-->	X193
SOL1991-06-01T15:29	X11	-->	X290
SOL1991-06-04T03:47	X11	-->	X193
SOL1991-06-06T01:12	X11	-->	X145
SOL1991-06-15T08:31	X11	-->	X89
SOL2001-04-02T21:51	X18	-->	X49
SOL2003-11-04T19:50	X18	-->	X167

This approach fails to match the individual timeseries well, and disagrees in detail with other proxies.

But, uncertainty estimates are possible, TBD.

Conclusions



- It is possible to scale the saturated GOES events from a mean timeseries shape

- The extrapolations based on scaling appear To eliminate the appearance of a rollover

- Within uncertainties we don't have any conclusion here; we remain unsure about the location of the high-energy steepening in flare energy distributions