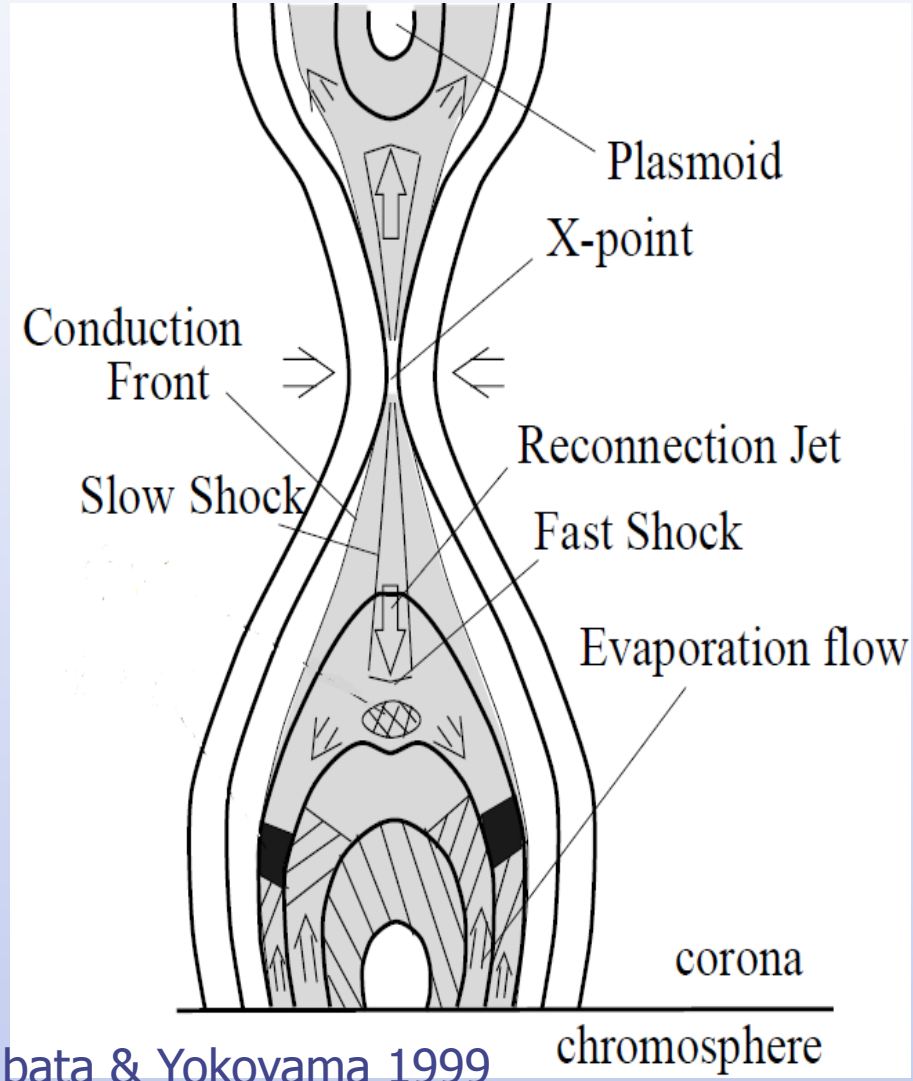
Observations of coronal rain associated with solar flare by Hinode/SOT

Kyoko Watanabe
ISAS/JAXA, Japan

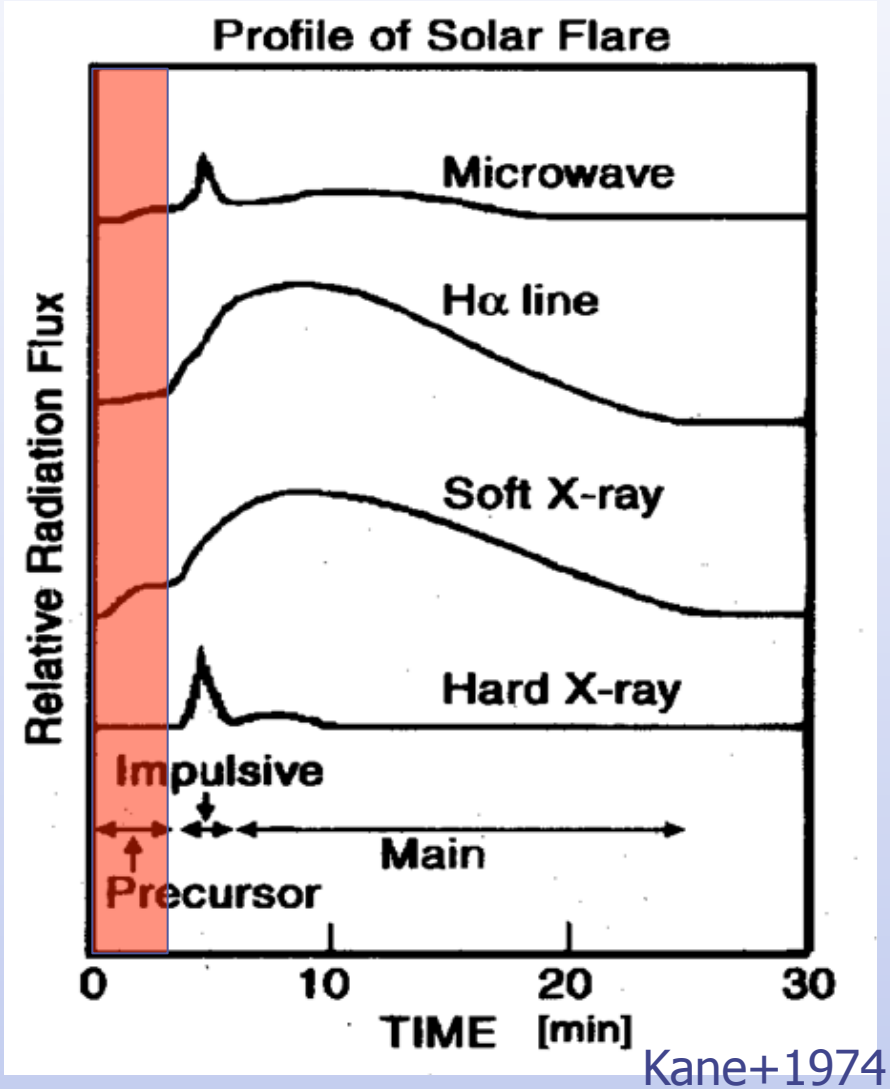
Basic Processes of Solar Flare

① Primary plasma heating & particle acceleration

- Take place in the corona (reconnection points etc.)



Shibata & Yokoyama 1999



Kane+1974

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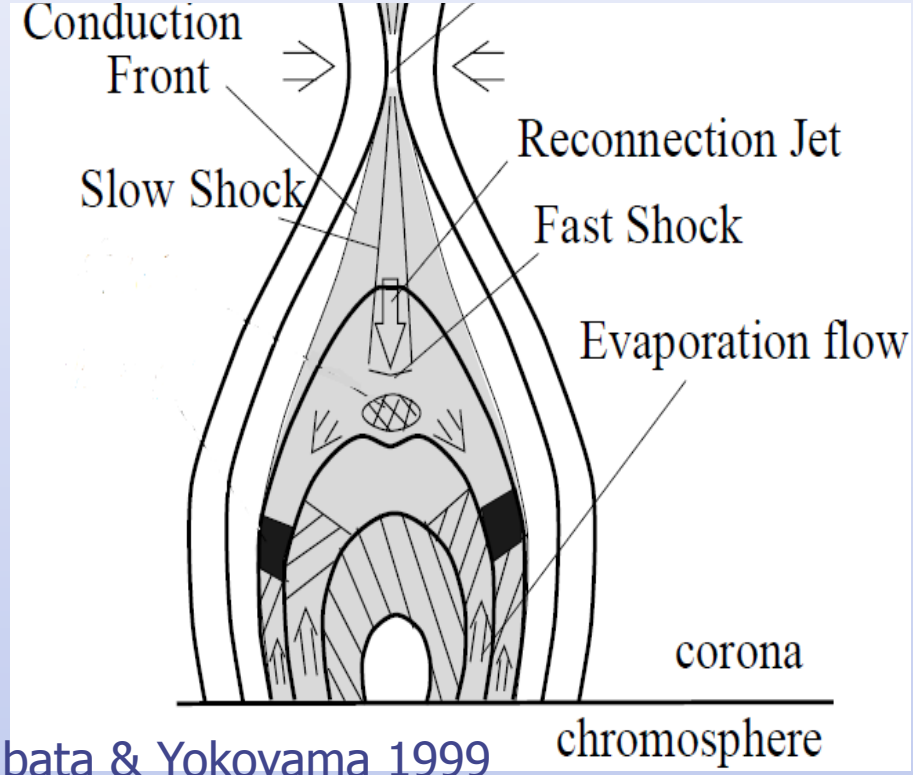

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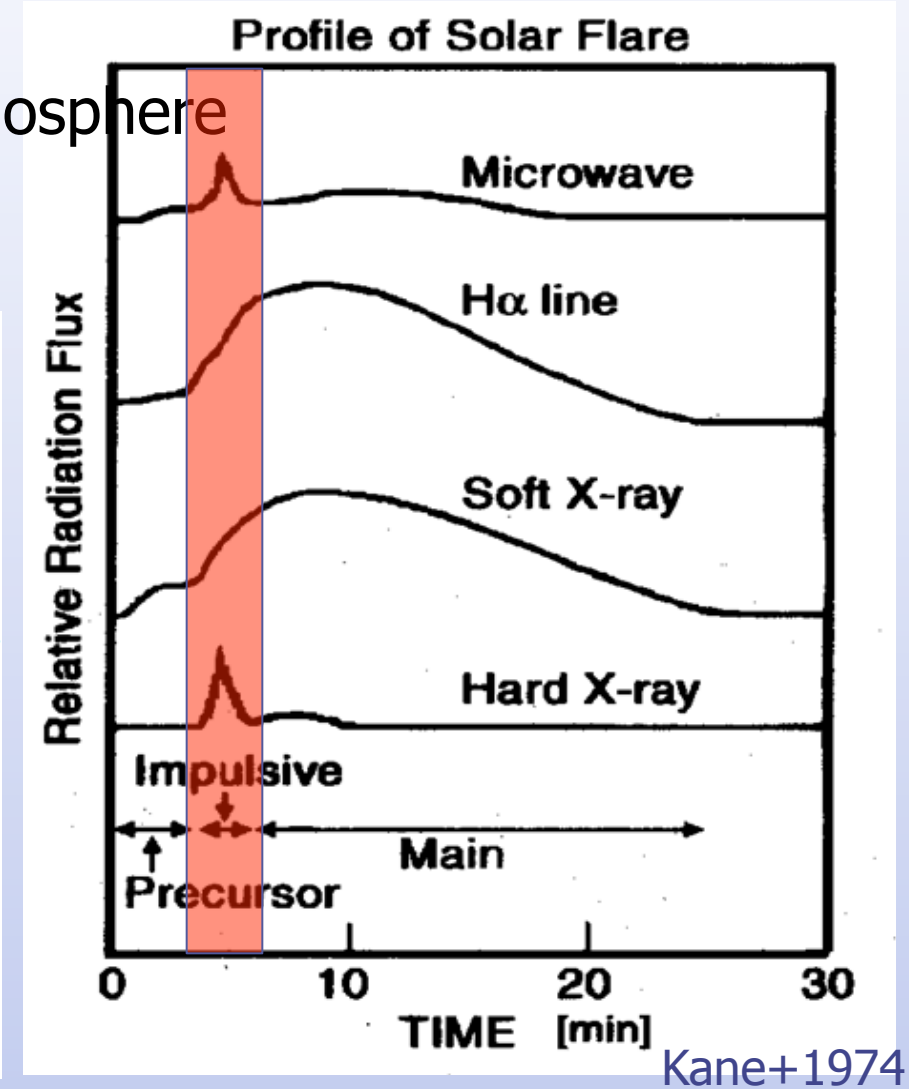

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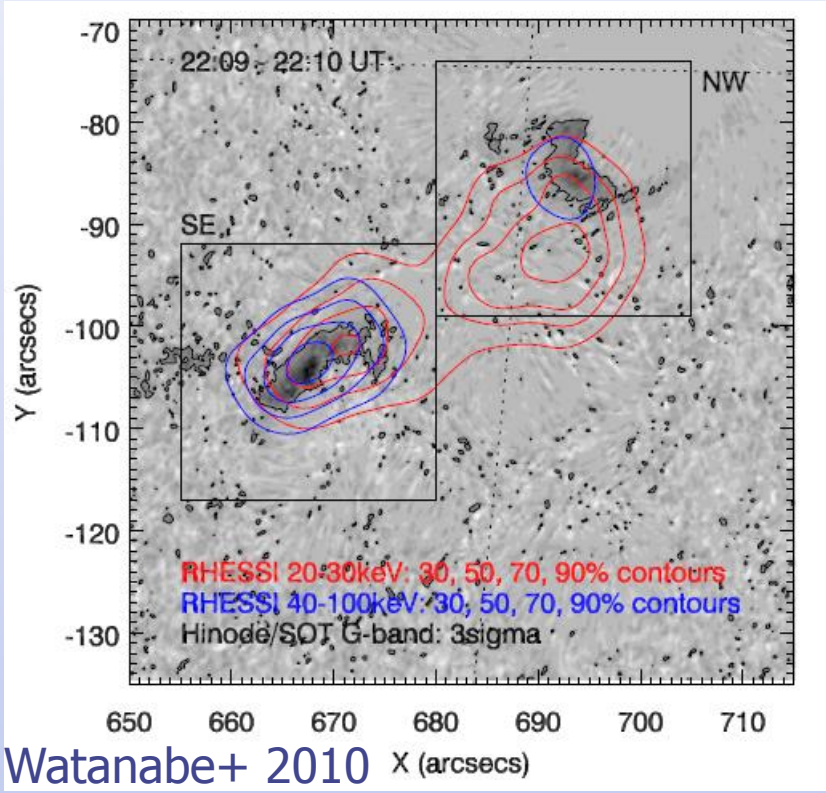
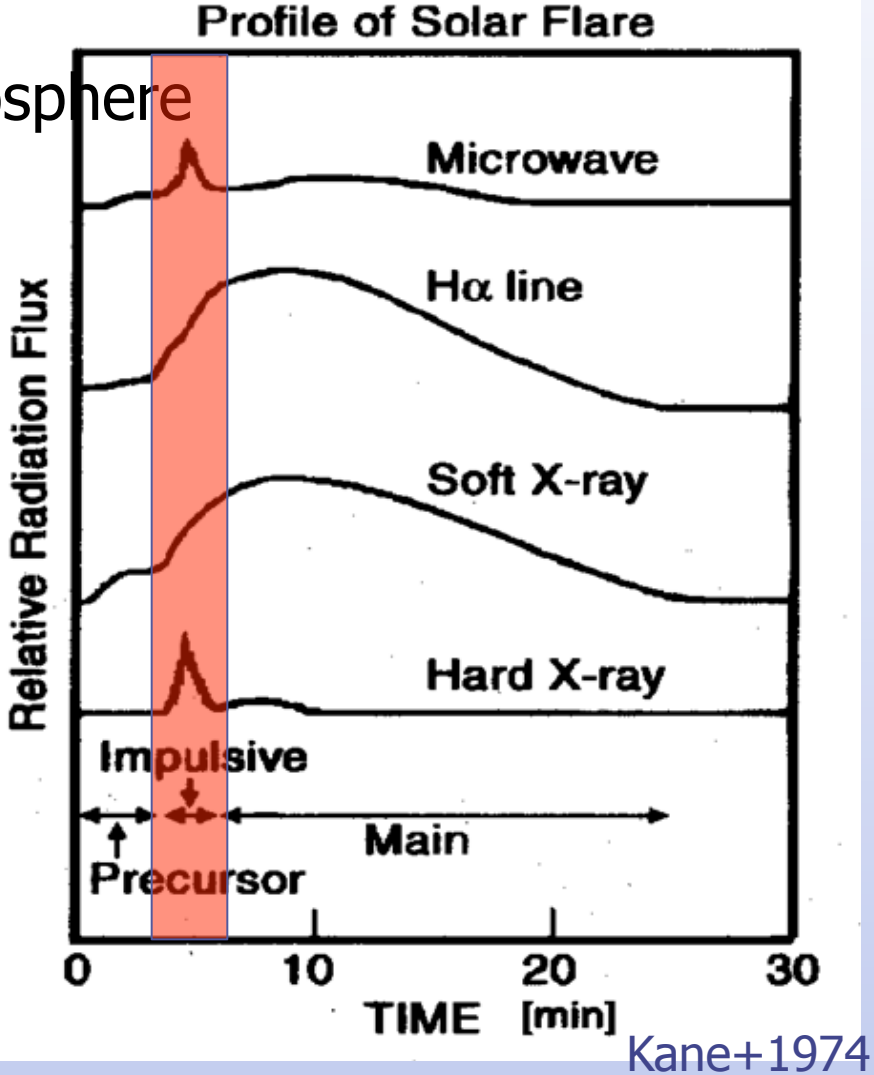


Watanabe+ 2010



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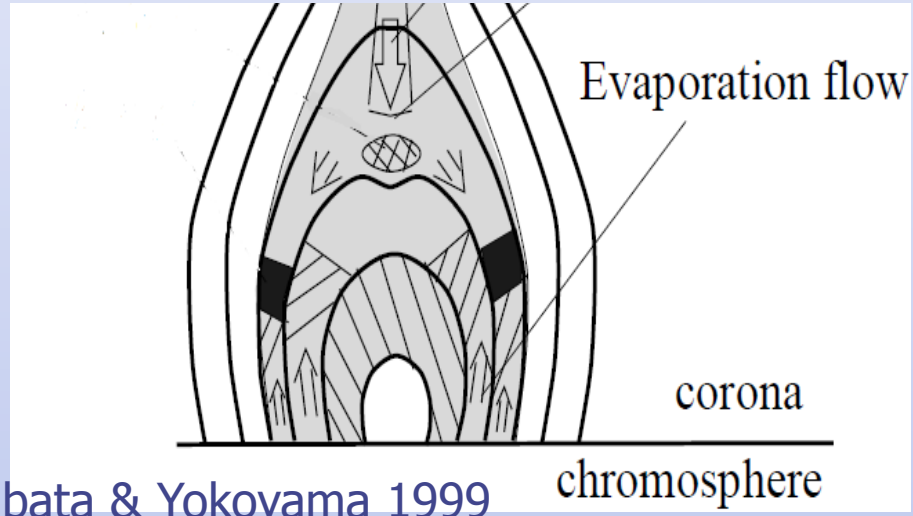

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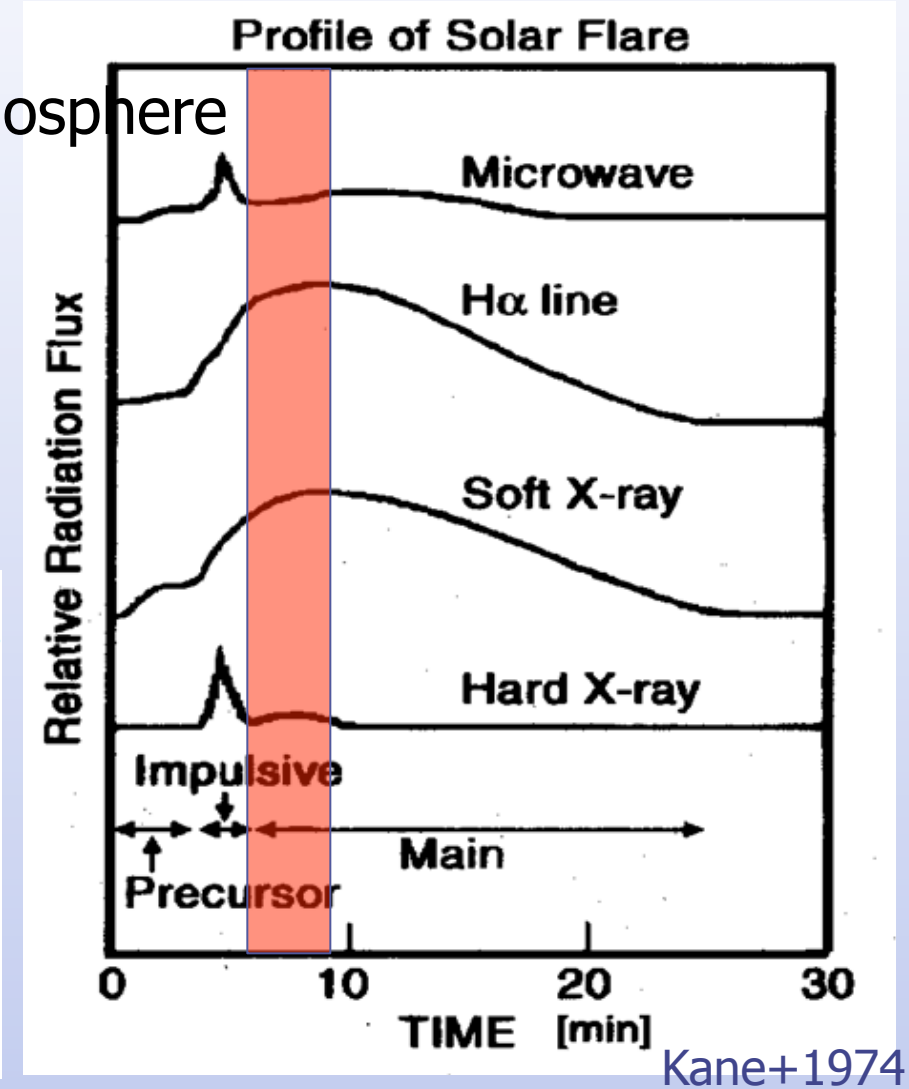

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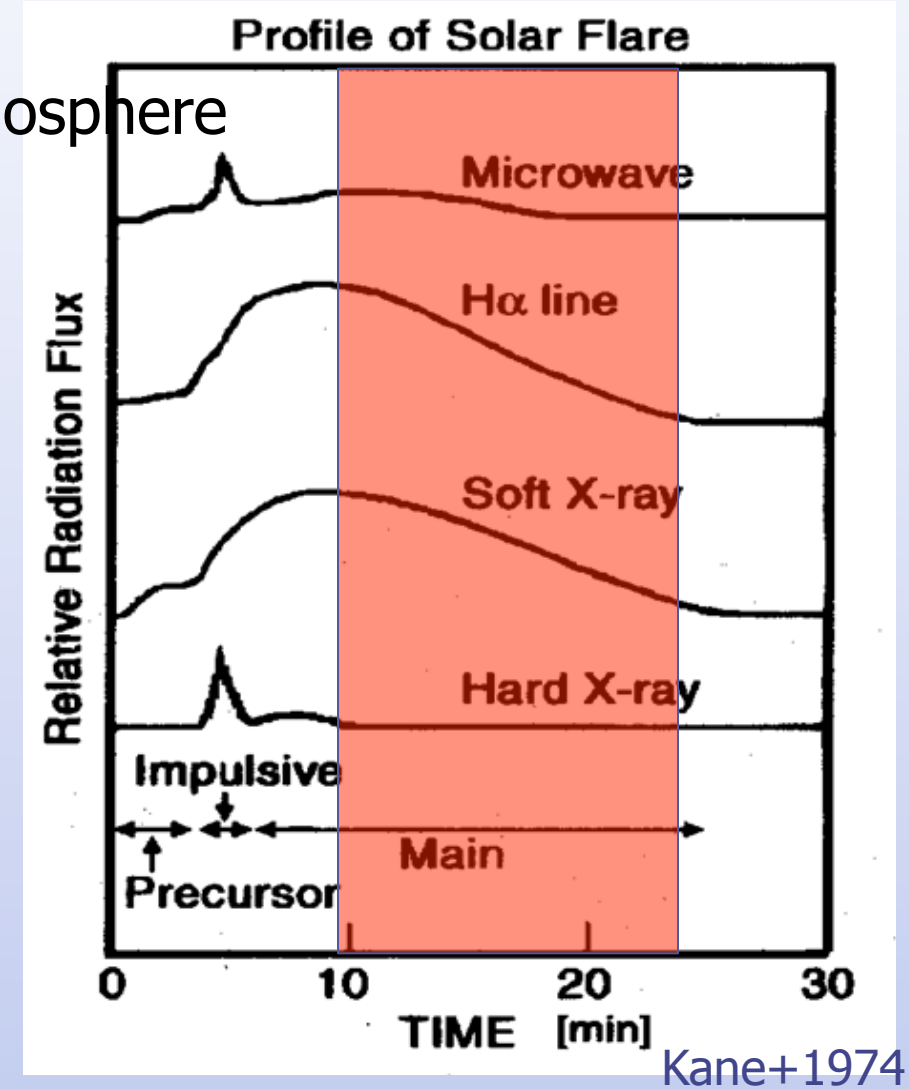
④ Plasma cooling > heating
- 10-30MK → 1-3MK
- Post-flare loops become detectable in EUVs



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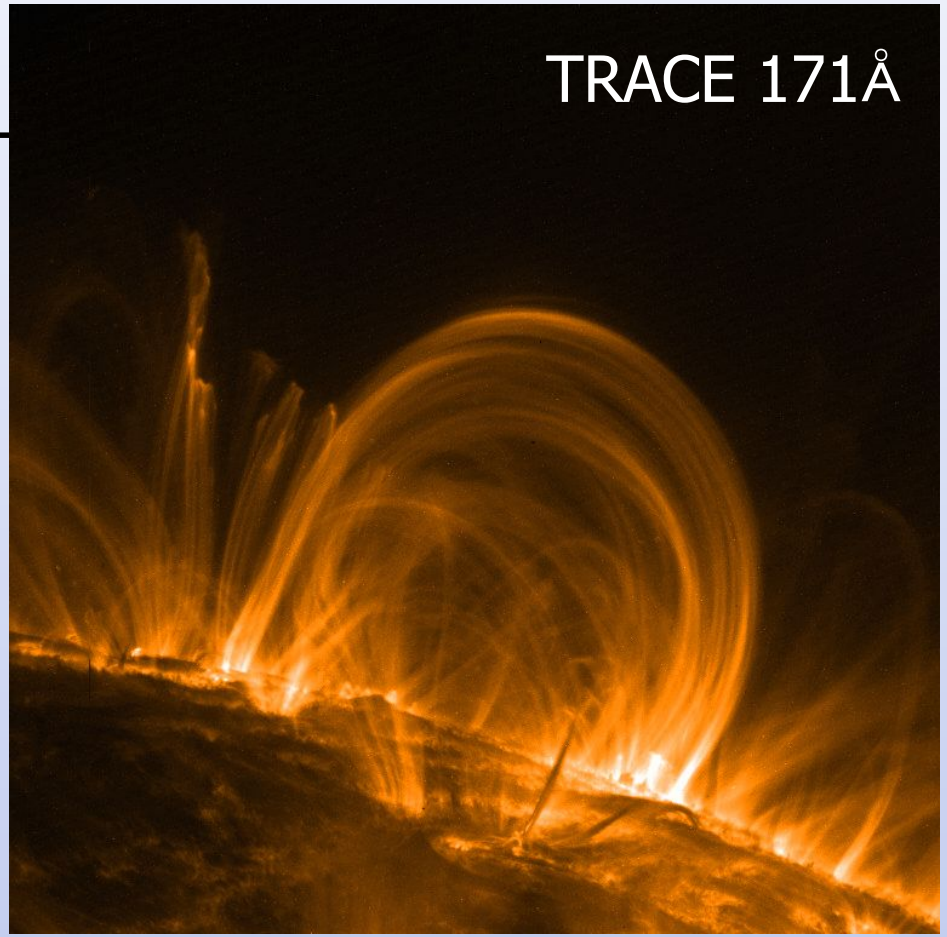

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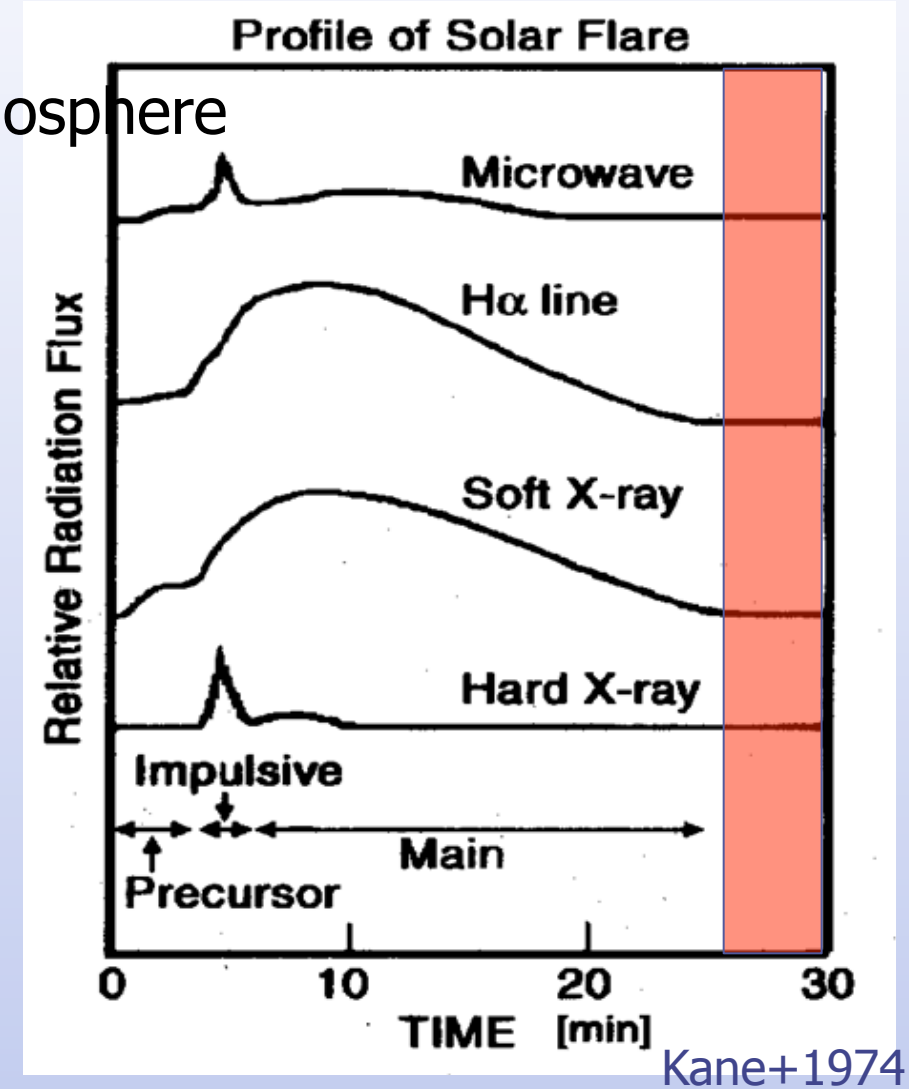


Kane+1974

Basic Processes of Solar Flare

① Primary plasma heating & particle acceleration
- Take place in the corona (reconnection points etc.)

② Secondary heating process ← energy injection to the chromosphere
- ① propagate to the chromosphere
- Observed in gamma-rays, HXRs, UV & WL

③ Chromospheric evaporation ← providing materials to the corona
- Formation of prominent flare loops in soft X-rays

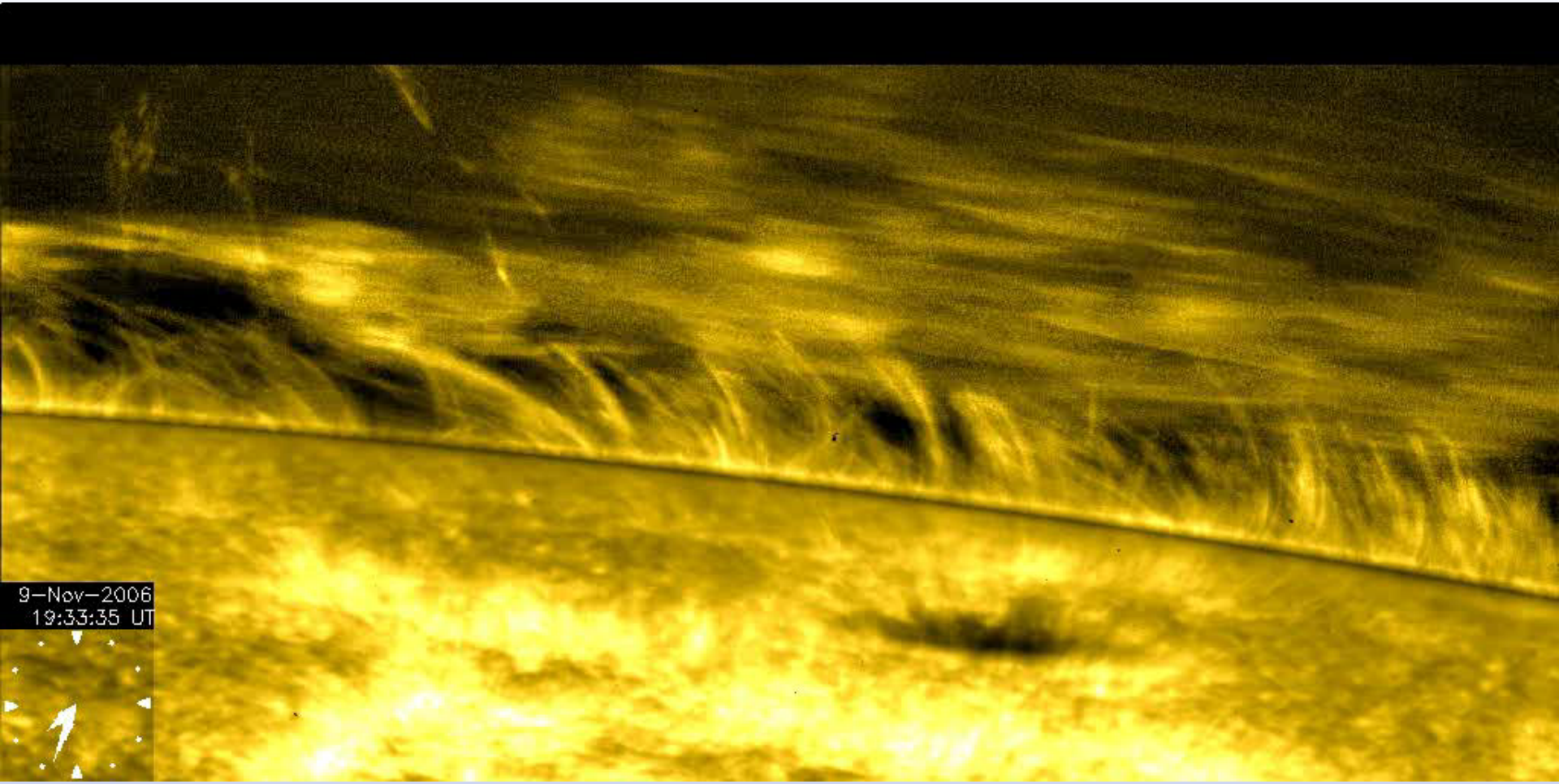
④ Plasma cooling > heating ← coronal rain
- 10-30MK → 1-3MK
- Post-flare loops become detectable in EUVs

⑤ Loop decay & precipitation
- Visible in UV & Hα

"Physics of the Solar Corona"
2005, Markus Aschwanden
Chapter 16:
Flare Plasma Dynamics

Coronal rain observations with Hinode/SOT

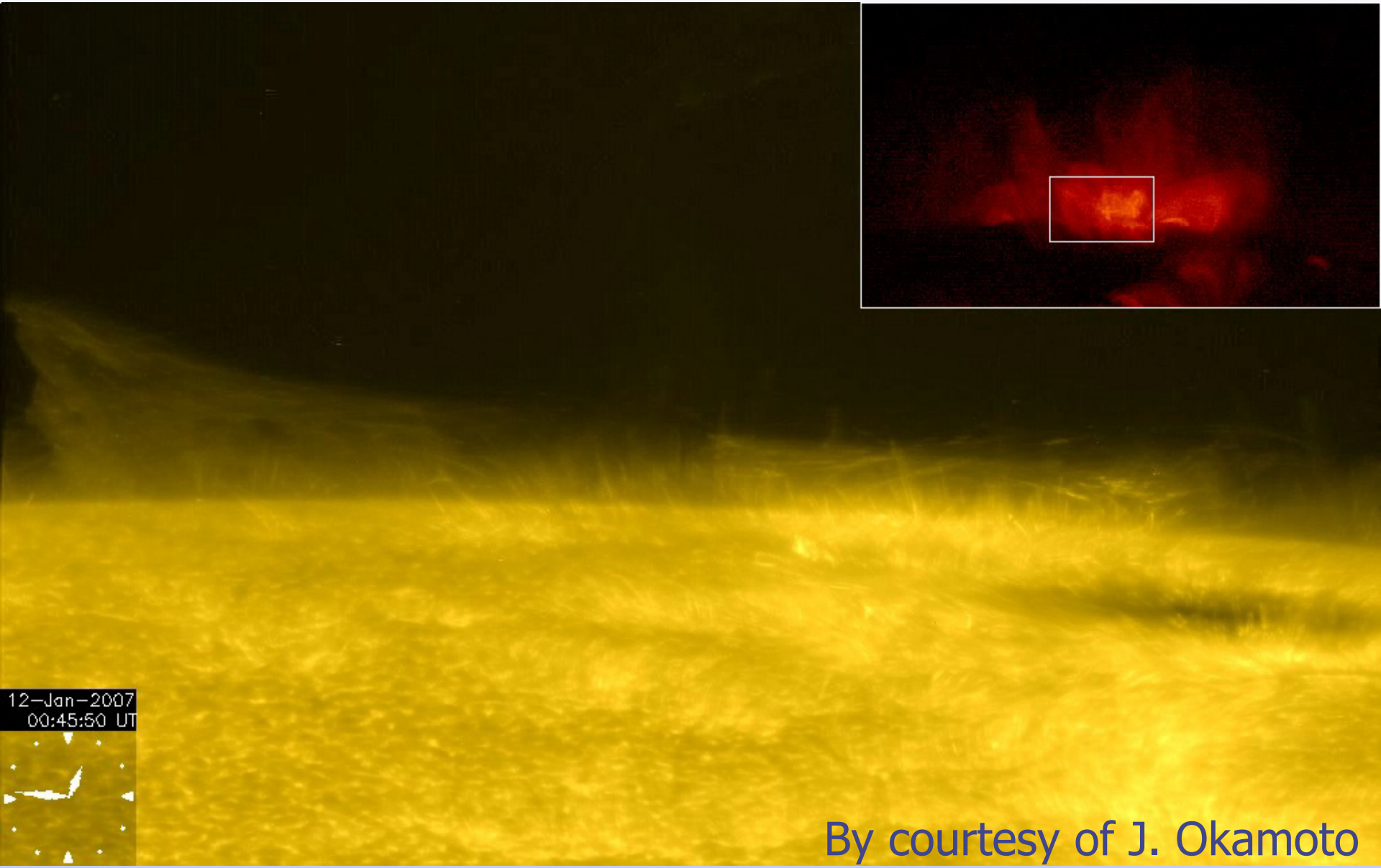
Prominence & Coronal rain



By courtesy of J. Okamoto

Coronal rain observations with Hinode/SOT

C-class flare & Coronal rain



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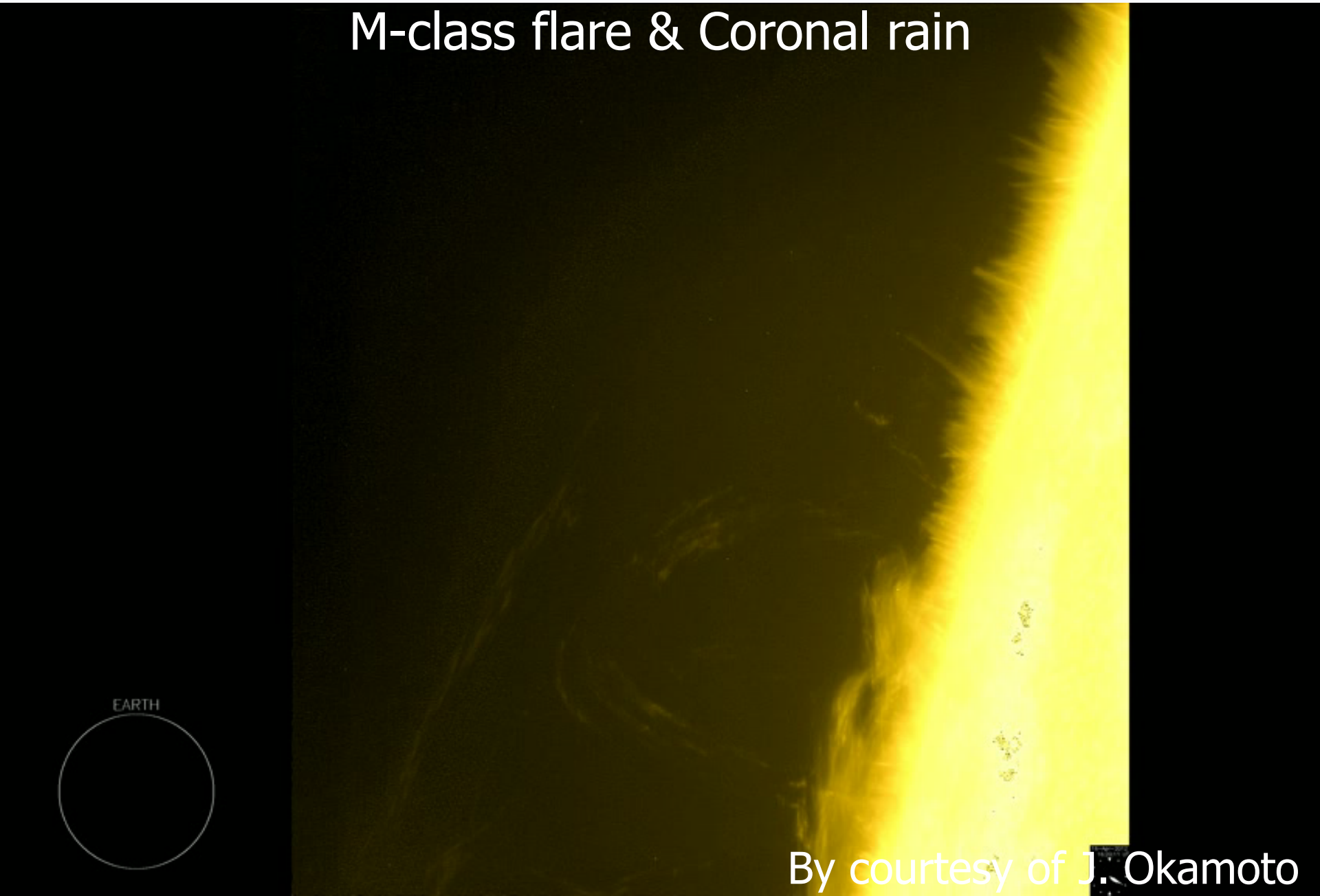
Coronal rain observations with Hinode/SOT



Coronal rain observations with Hinode/SOT

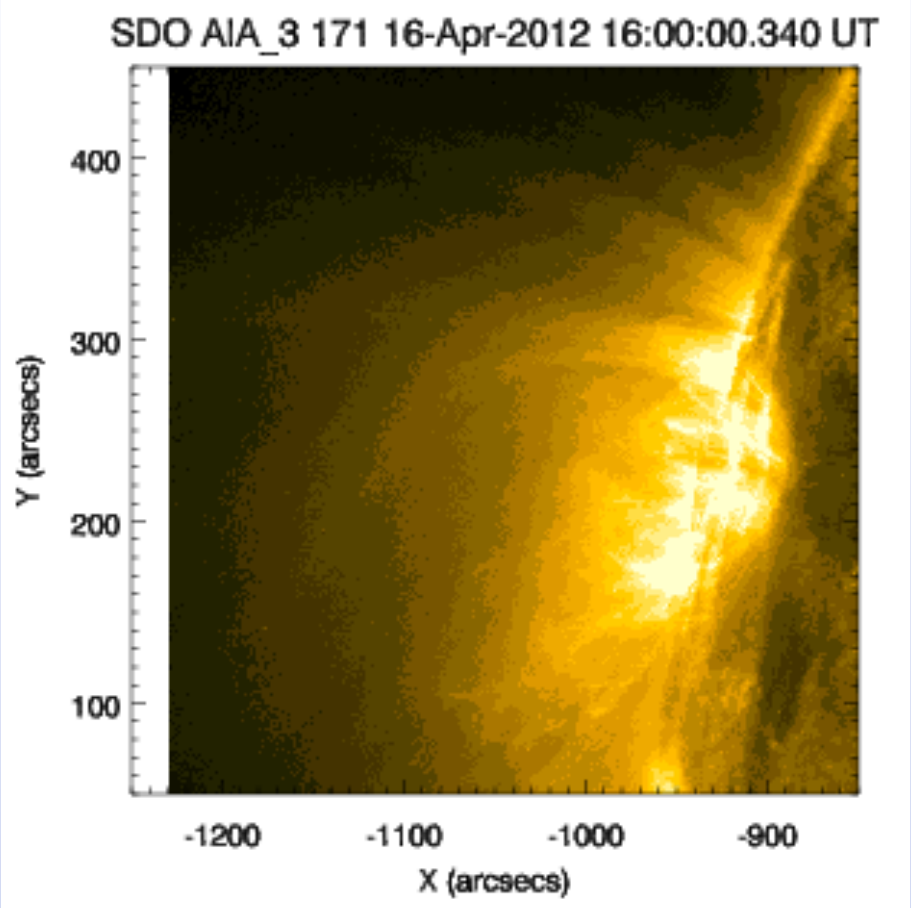
M-class flare & Coronal rain

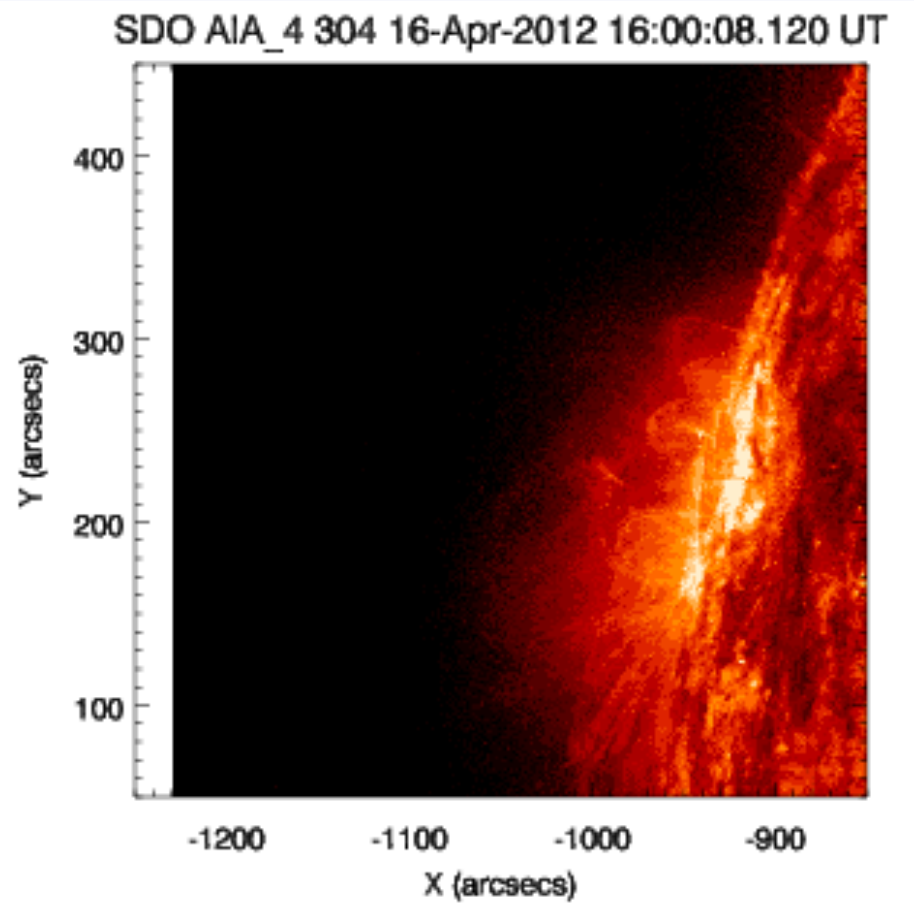
2012 Apr 16
M1.7-class flare

Falling Materials

1. pre-flare coronal rain
2. quick fall down of flare plasma
3. prominence falling
4. post-flare loops

Coronal rain observations with SDO/AIA





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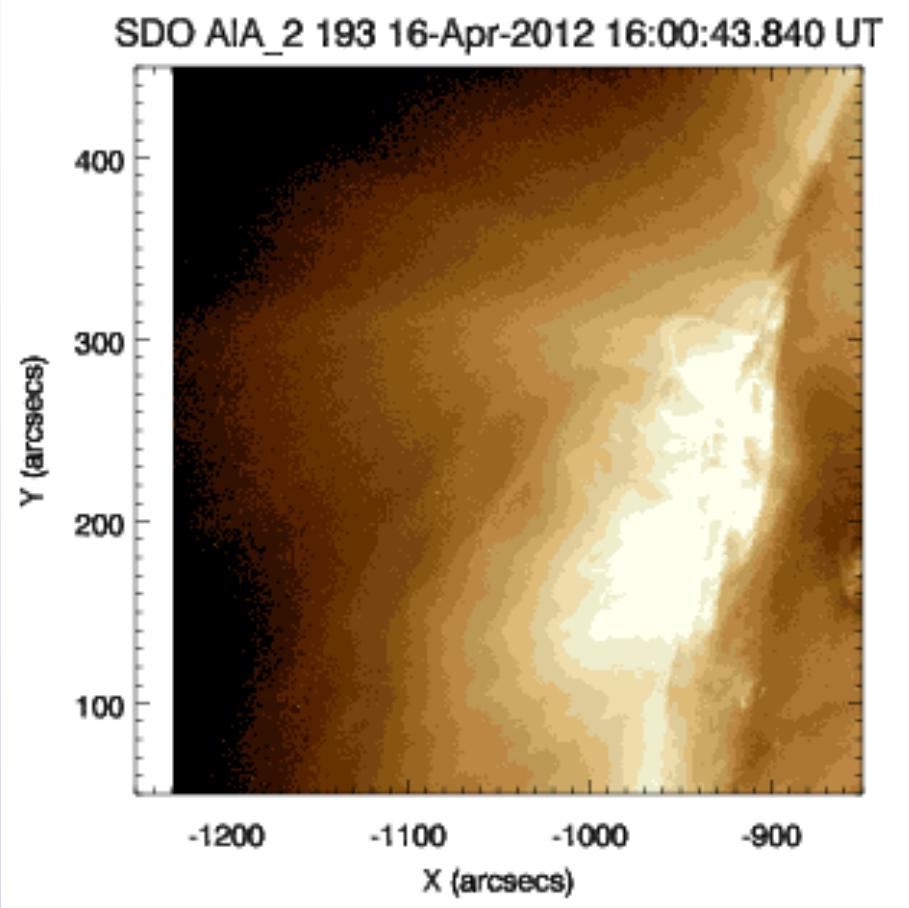
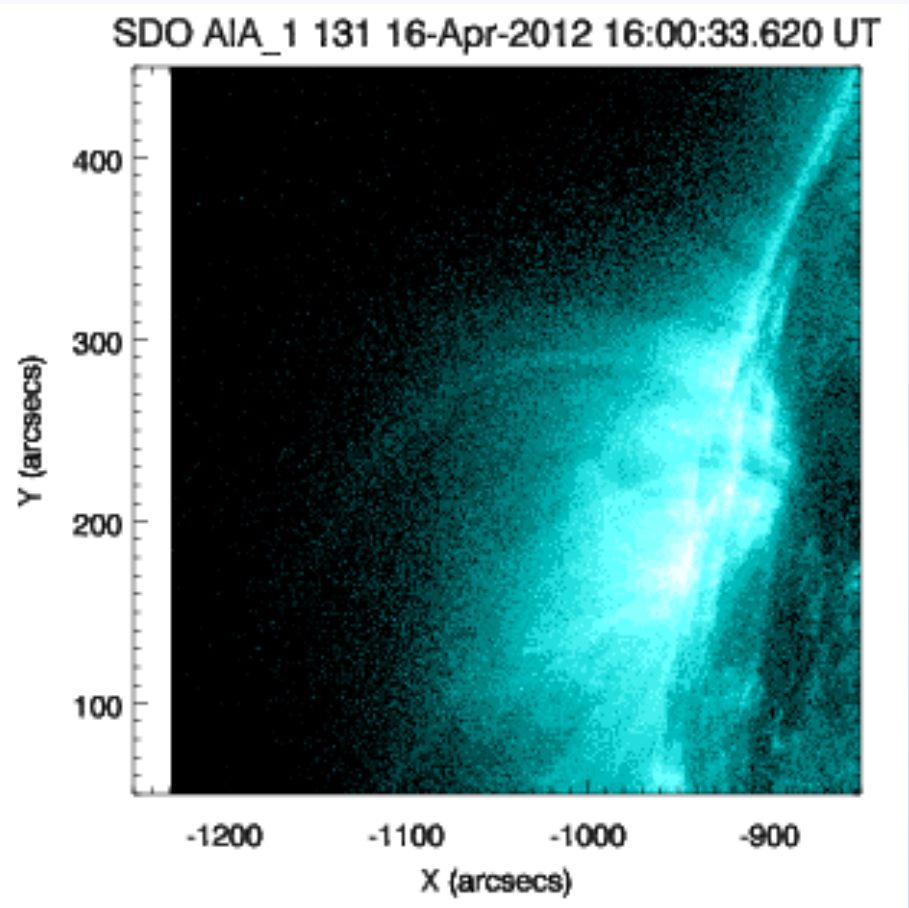
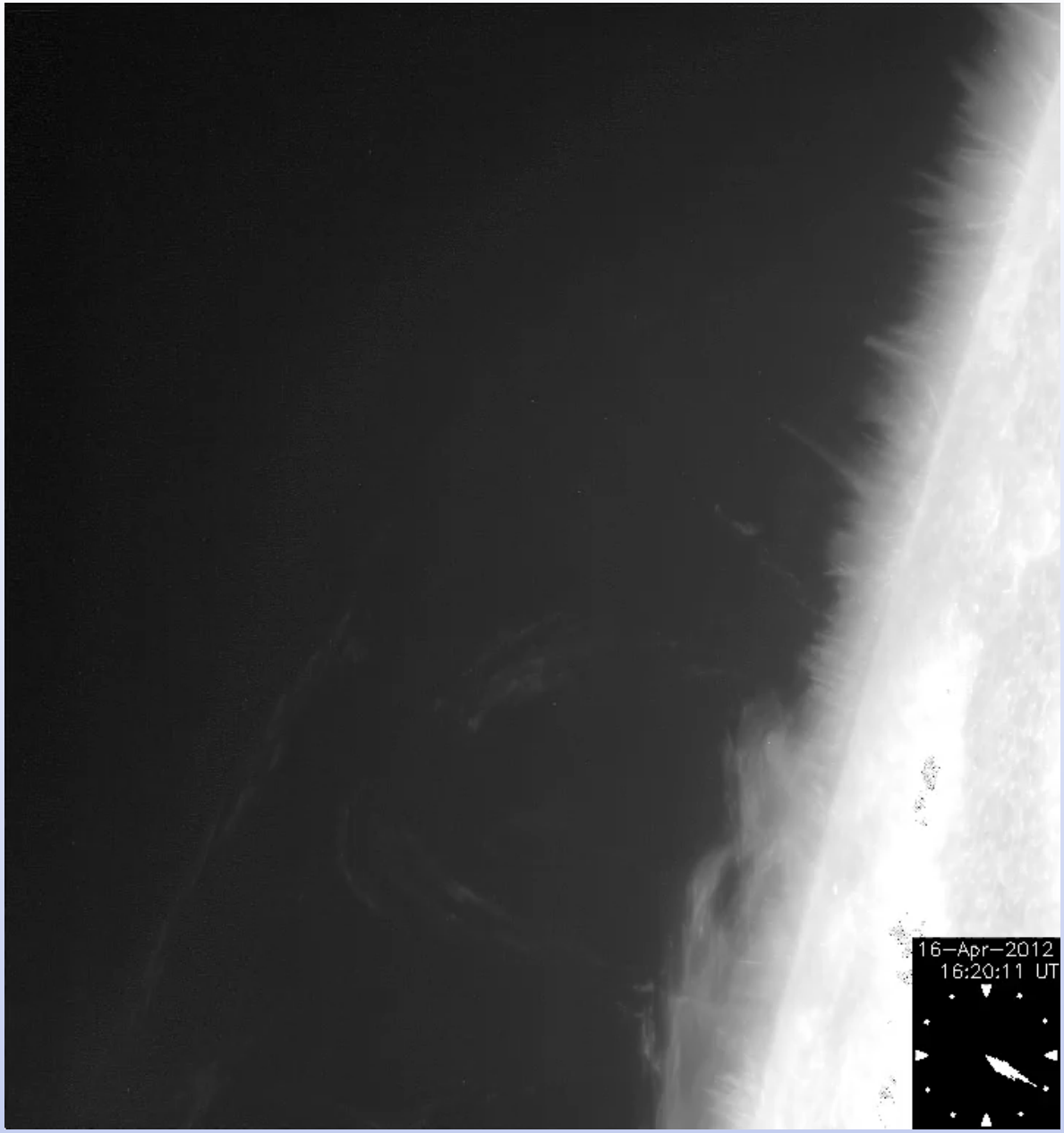
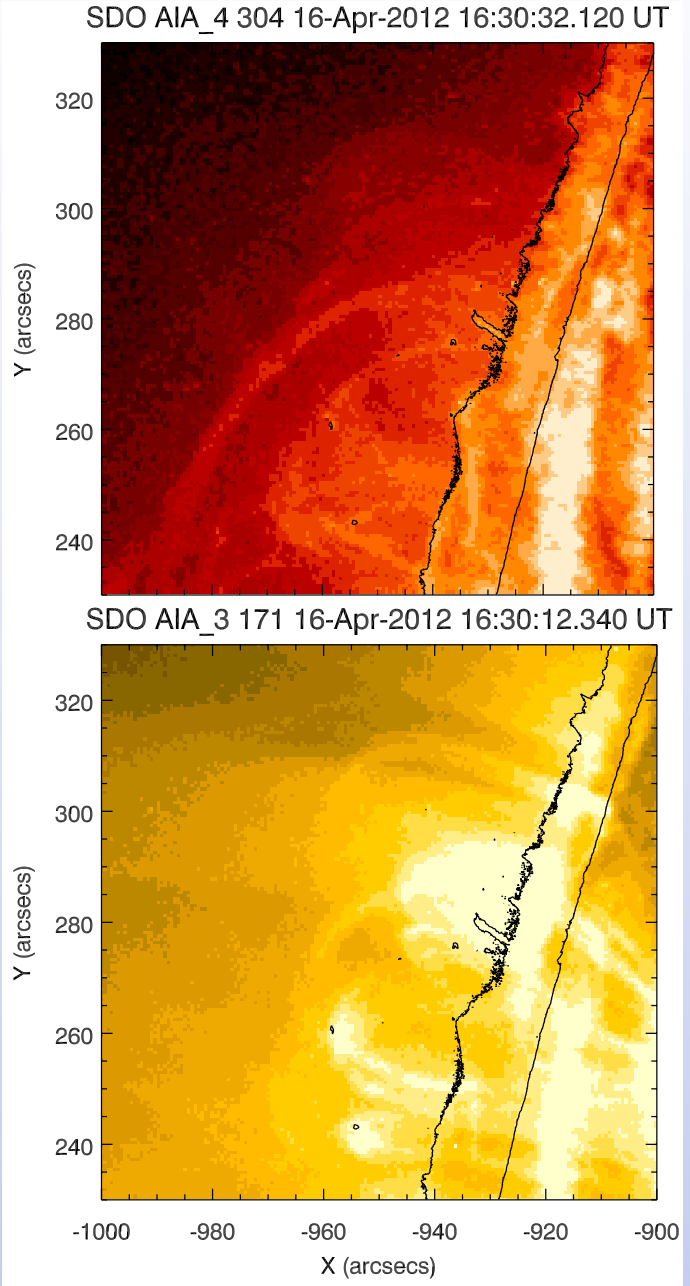


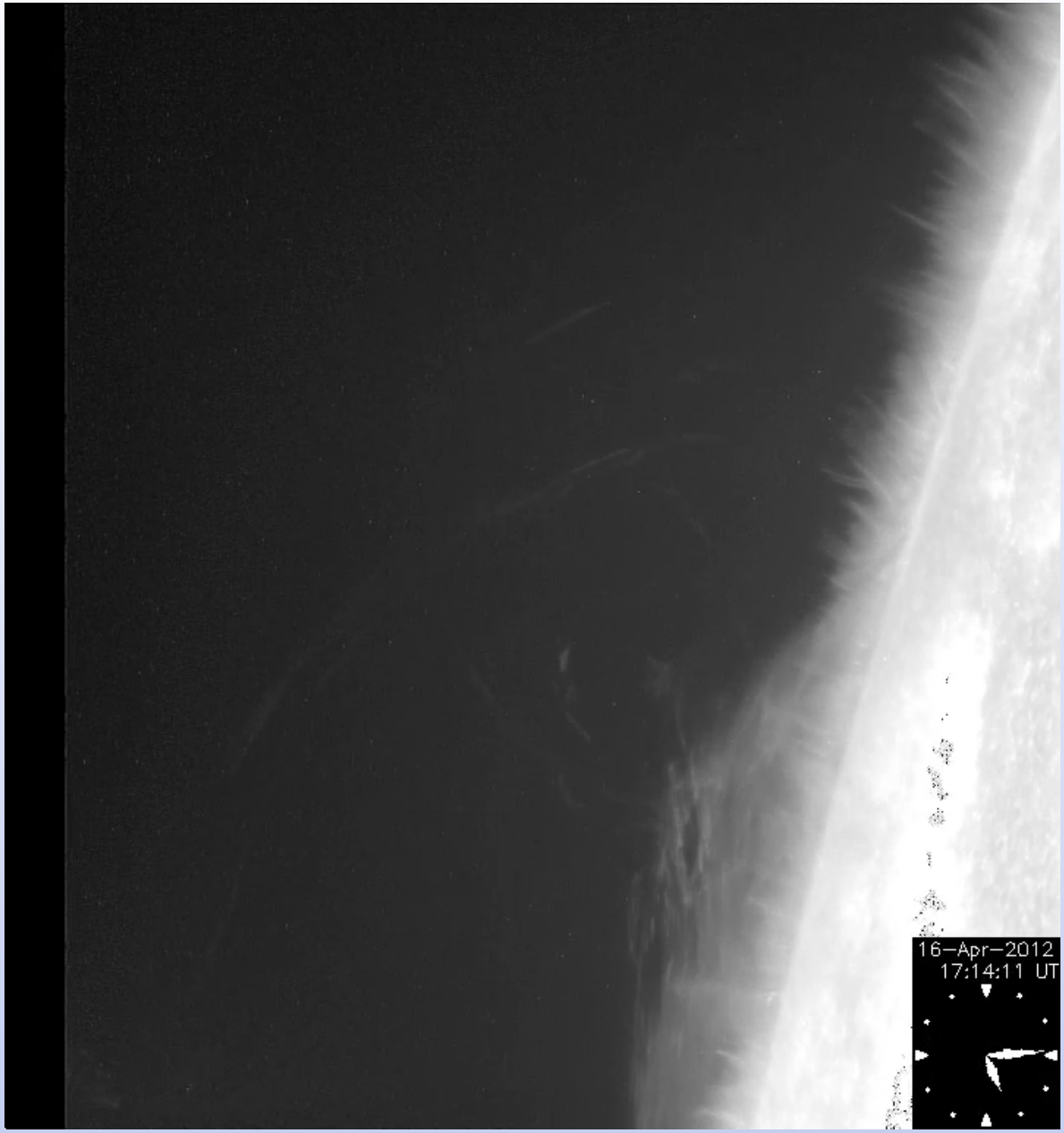


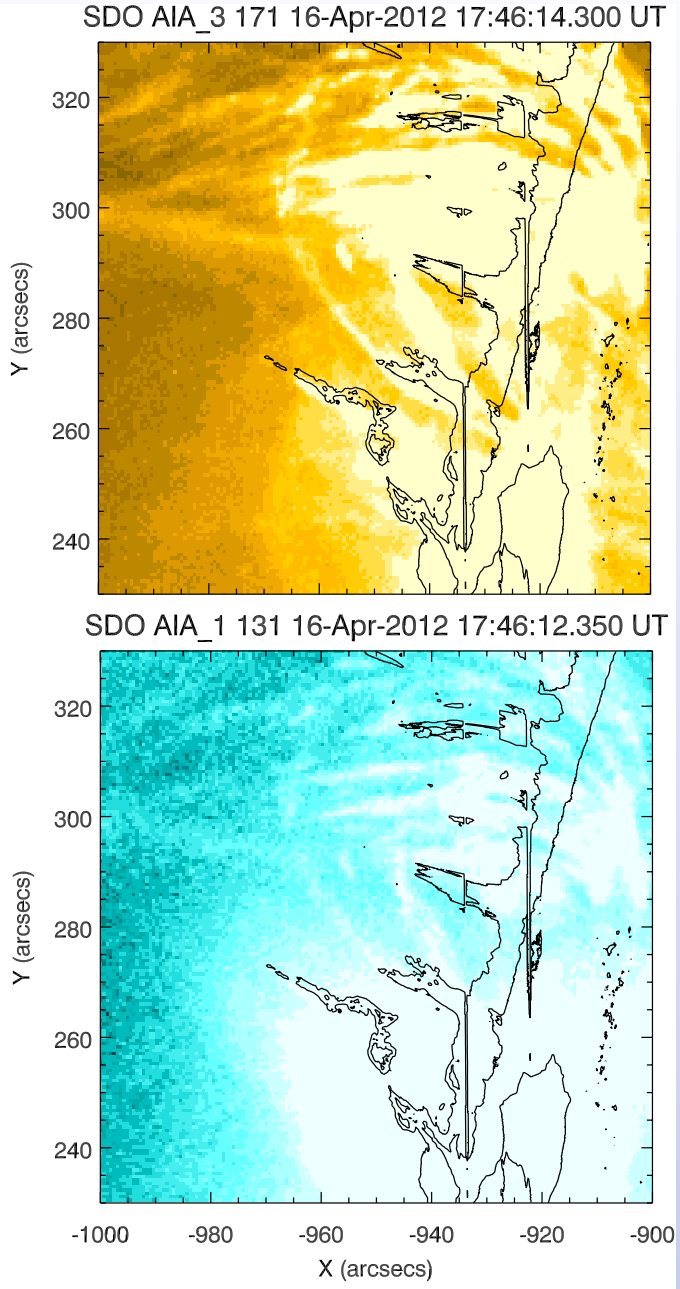
Pre-Flare Coronal Rain



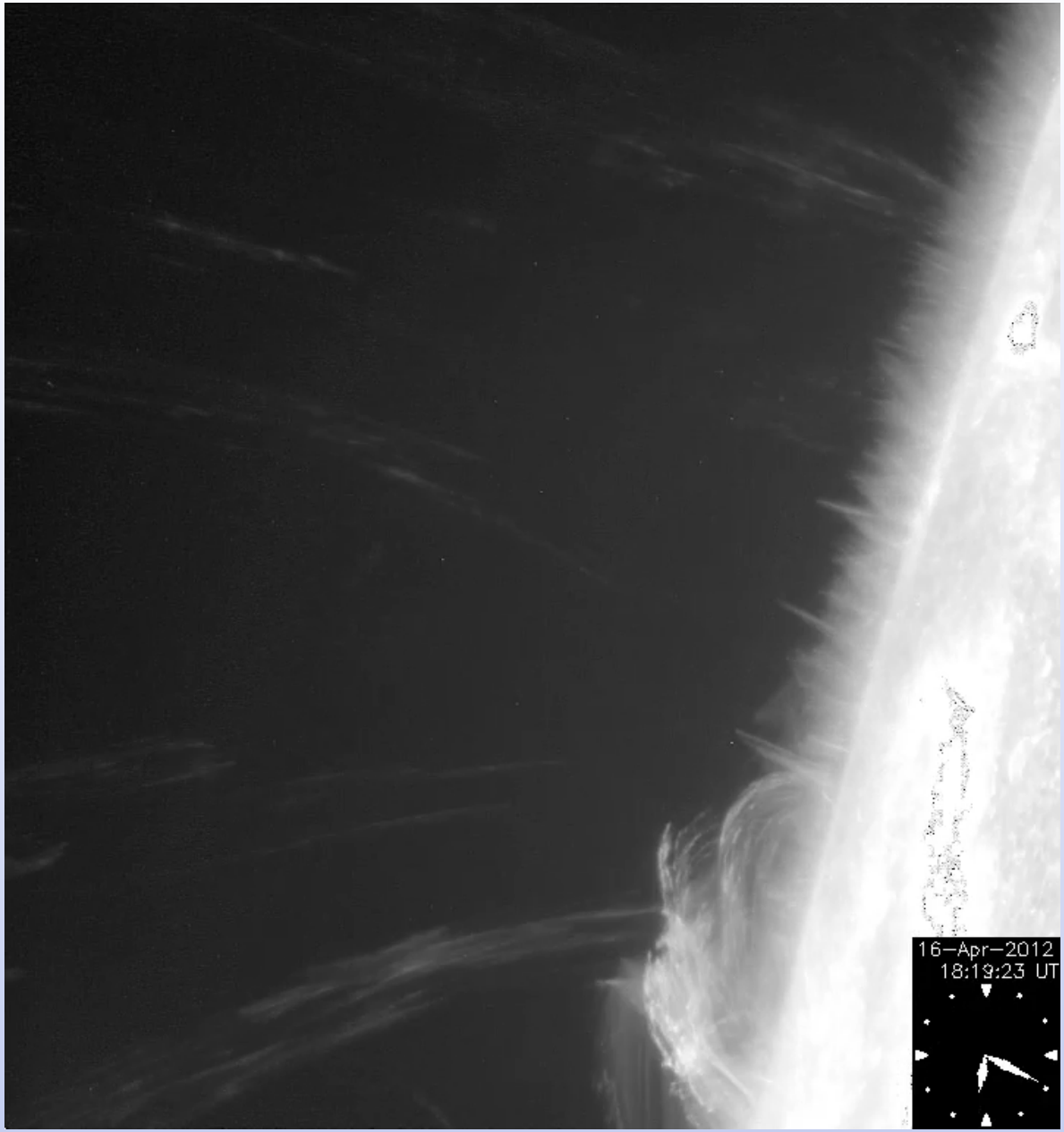


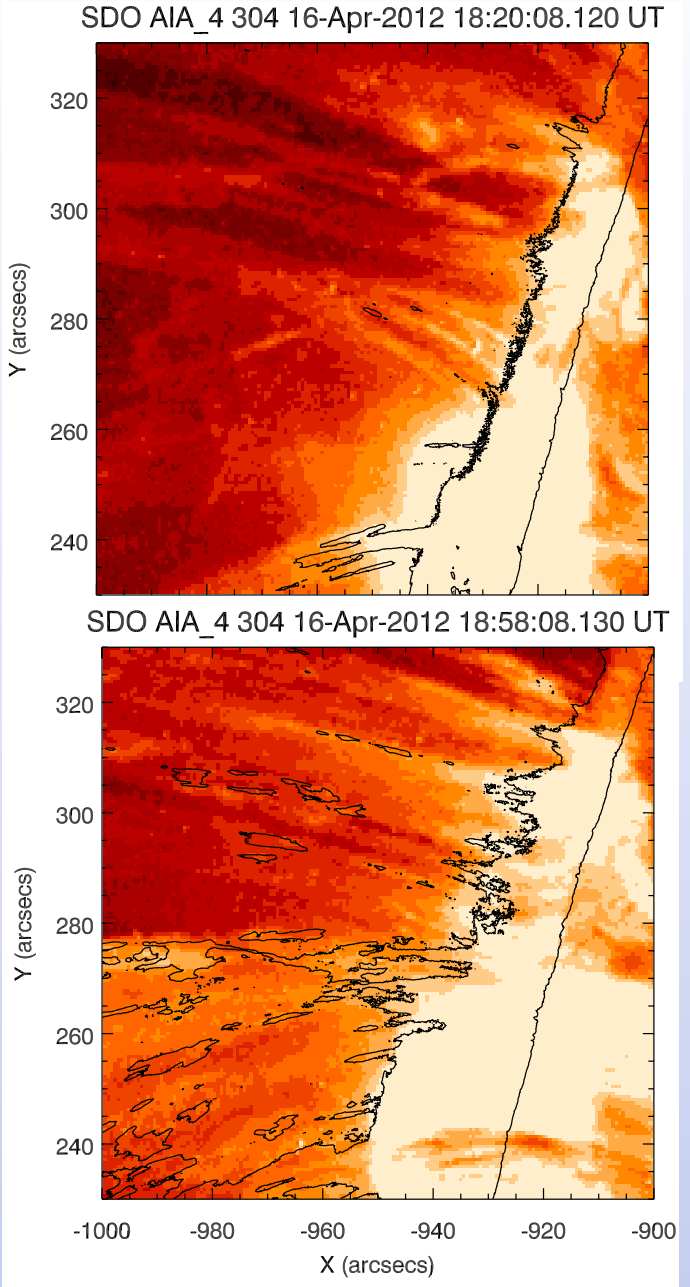
Flaring - Flare Plasma Falling



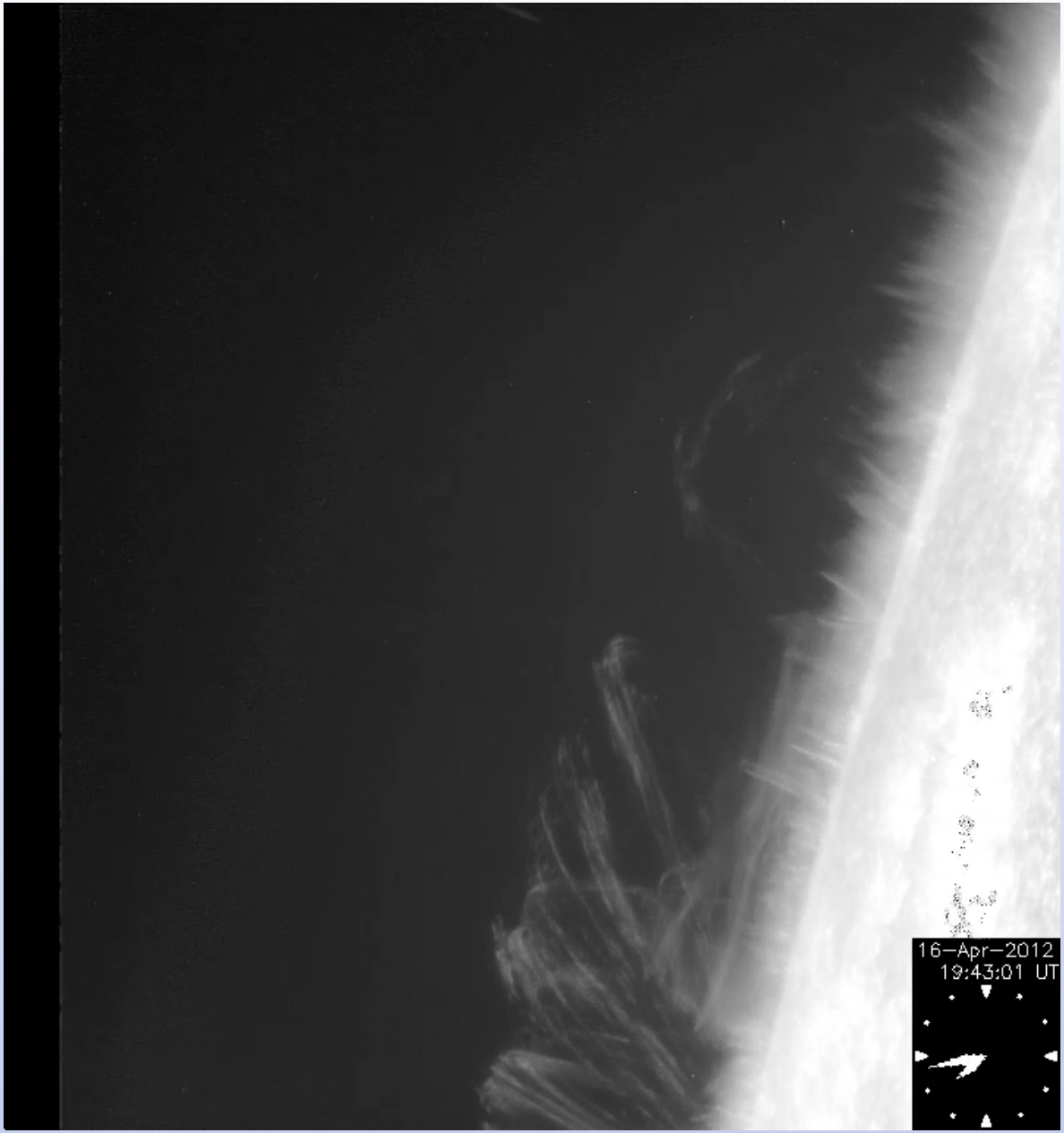


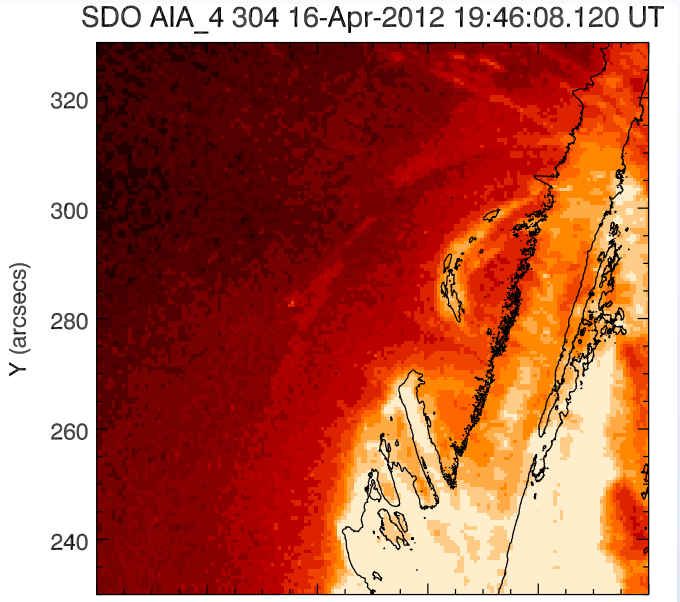
Prominence Falling

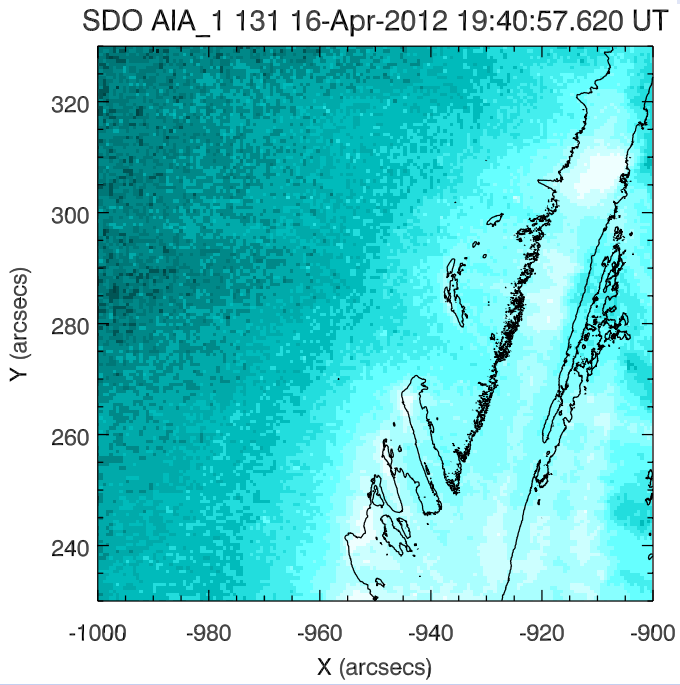




Post-flare Loops







Coronal rain candidates associated with solar flare observed by Hinode/SOT

GOES start	AR location	GOES	SOT
2007/06/02 10:28	S04E74	M1.0	63
2011/11/02 21:52	N20E77	M4.3	152
2011/11/03 10:58	N20E70	M2.5	87
2012/01/27 17:37	N33W85	X1.7	381
2012/04/16 17:24	N14E88	M1.7	92
2013/03/21 21:42	N09W88	M1.6	59
2013/06/07 22:11	S32W89	M5.9	196
2013/10/26 19:24	S09E81	M3.1	22
2014/03/13 19:03	N15W87	M1.2	203
2014/05/06 22:01	S10W87	M1.0	104
2014/10/29 09:54	S18W77	M1.2	160
2014/10/29 14:19	S16W81	M1.4	245
2014/10/29 16:06	S14W82	M1.0	140
2014/10/29 18:47	S13W77	M1.3	30
2014/10/30 00:34	S14W81	M1.3	35
2014/10/30 01:19	S14W88	M3.5	190
2014/10/30 04:17	S16W89	M1.2	100

Selection condition

- Limb flare (>70deg)
- ≧M-class flare
- SOT data existence >10 images

Green events

- flare mode obs. images available every 20 sec for each band (Ca, RGB)

- NOAA12192: 7 events