UCL Department of Space and Climate Physics
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Outflows related to coronal mass ejections

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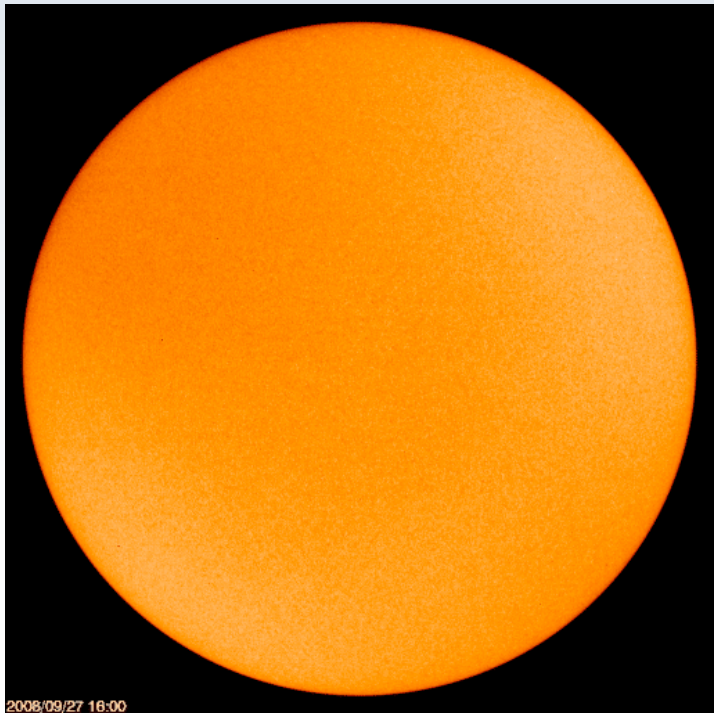
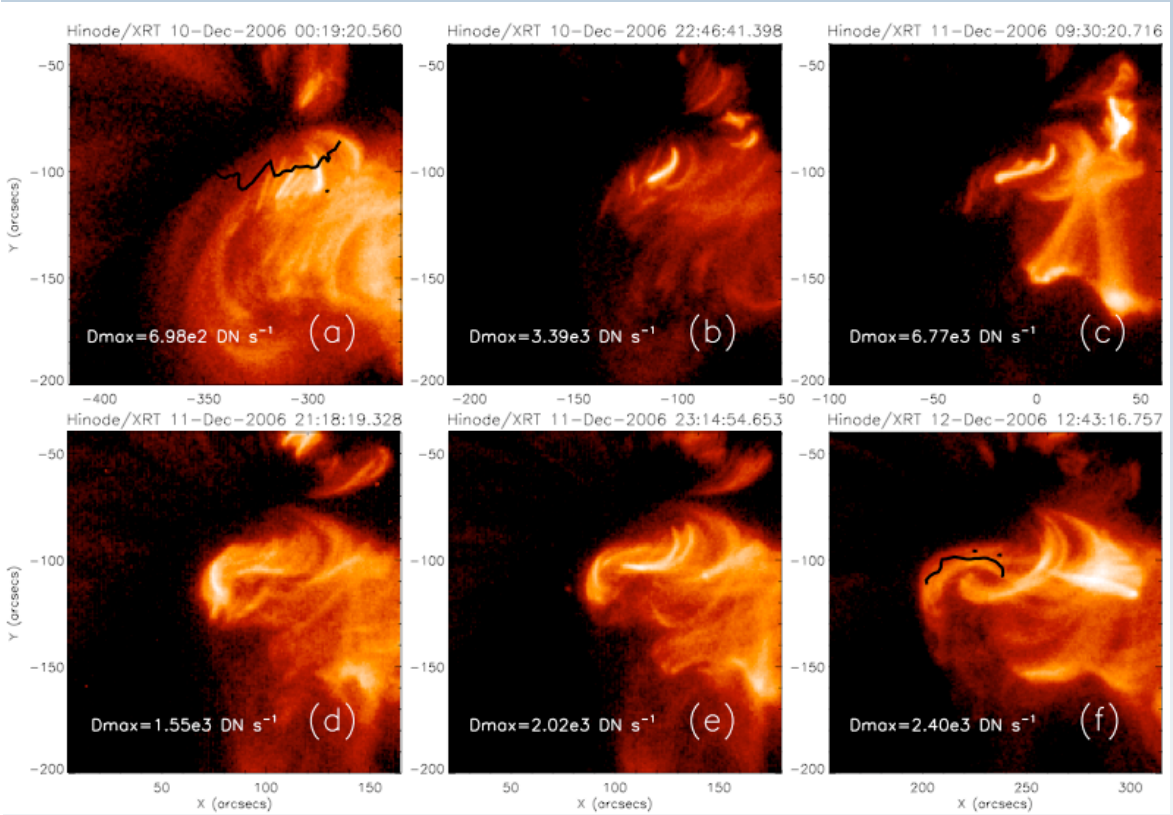
Build-up phase & trigger
Response in the atmosphere

NASA headline: ***Spotless Sun: Blankest Year of the Space Age***
Where are all the CMEs??



The build-up to large flares and CMEs



XRT observations of sheared field formation:

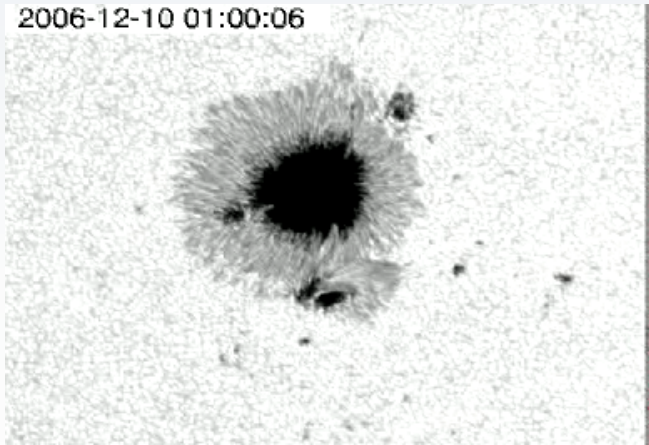
(Su et al., 2007)

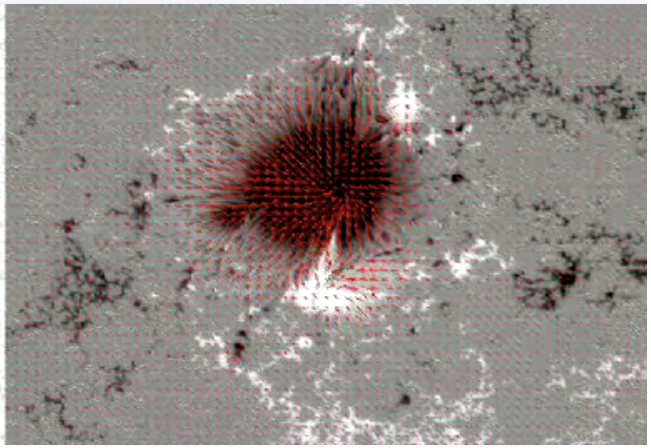
SOT observations of

Emerging flux, West-to-east Motion, CCW Rotation in the Lower sunspot

Kubo et al., 2007

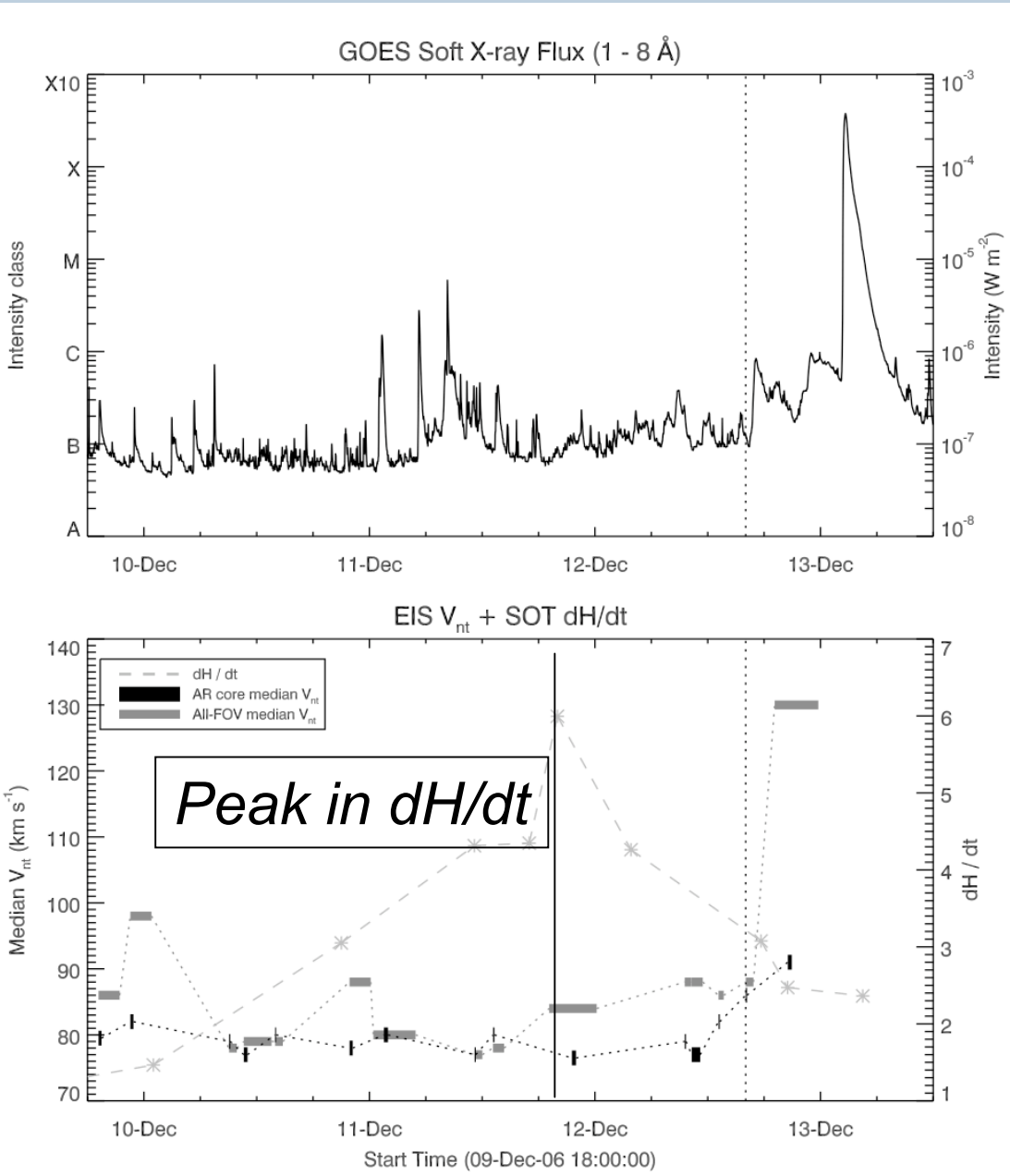
Hinode EIS





Pre-flare behaviour before an X-class flare

- *The helicity saturates a day before the X-class flare (Magara & Tsuneta, 2008) -* ***listen to Magara-san's talk tomorrow!***
- *Following saturation the turbulence in the corona starts to increase.*
- *This is measured 12 hrs before the flare starts! Harra et al., 2008*



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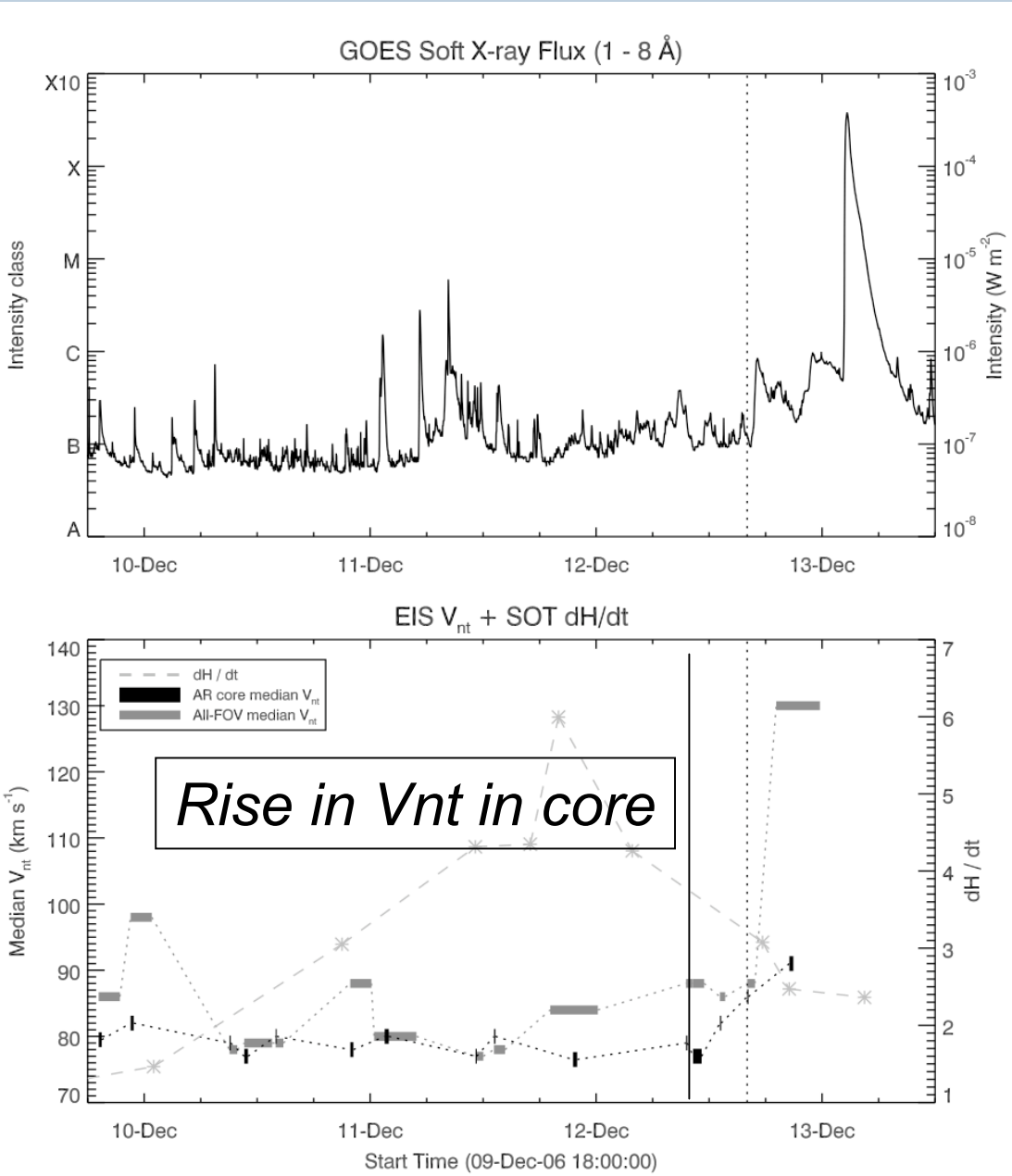

Hinode EIS

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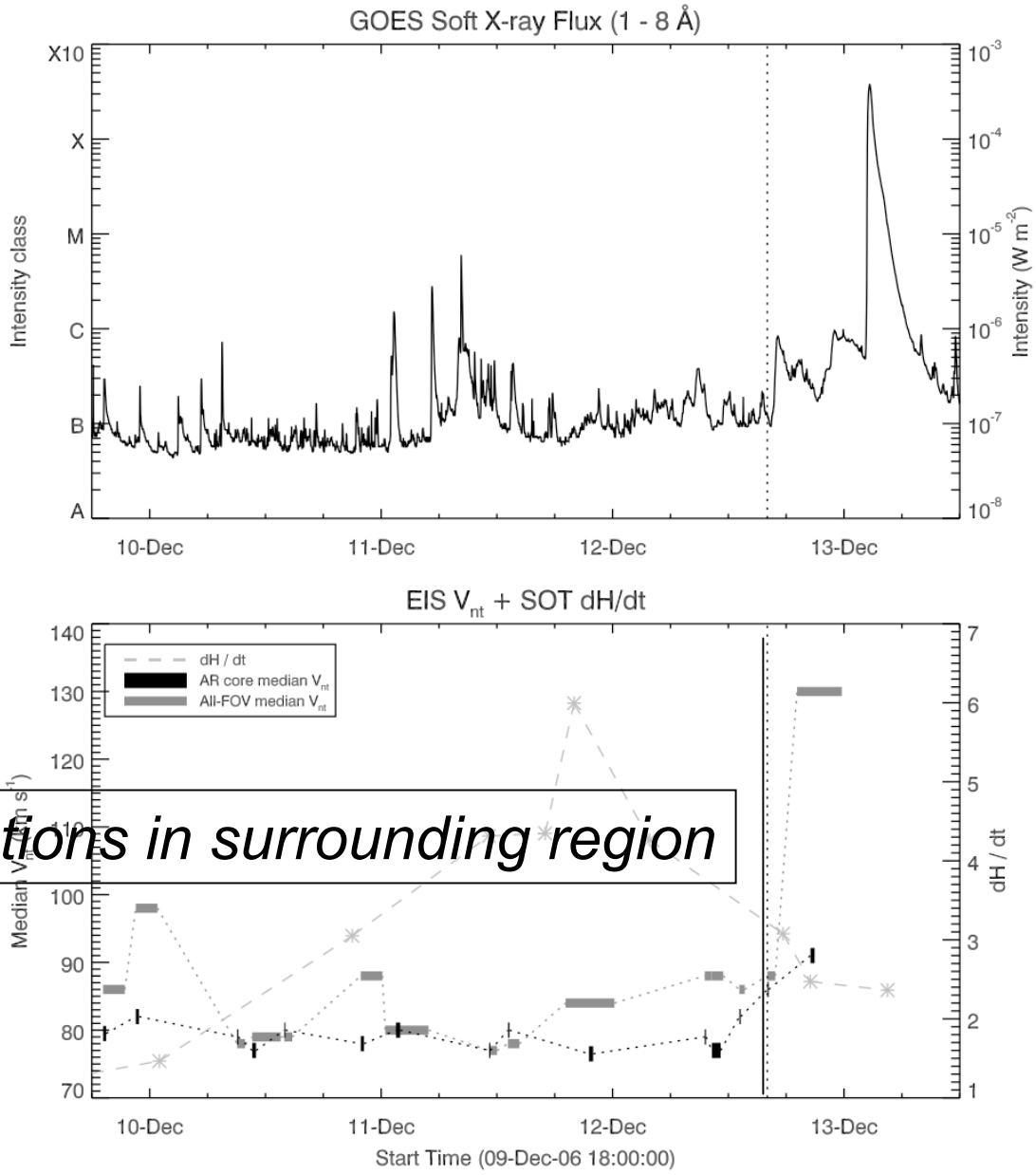
See Sterling-san's poster!



Eruptions in surrounding region

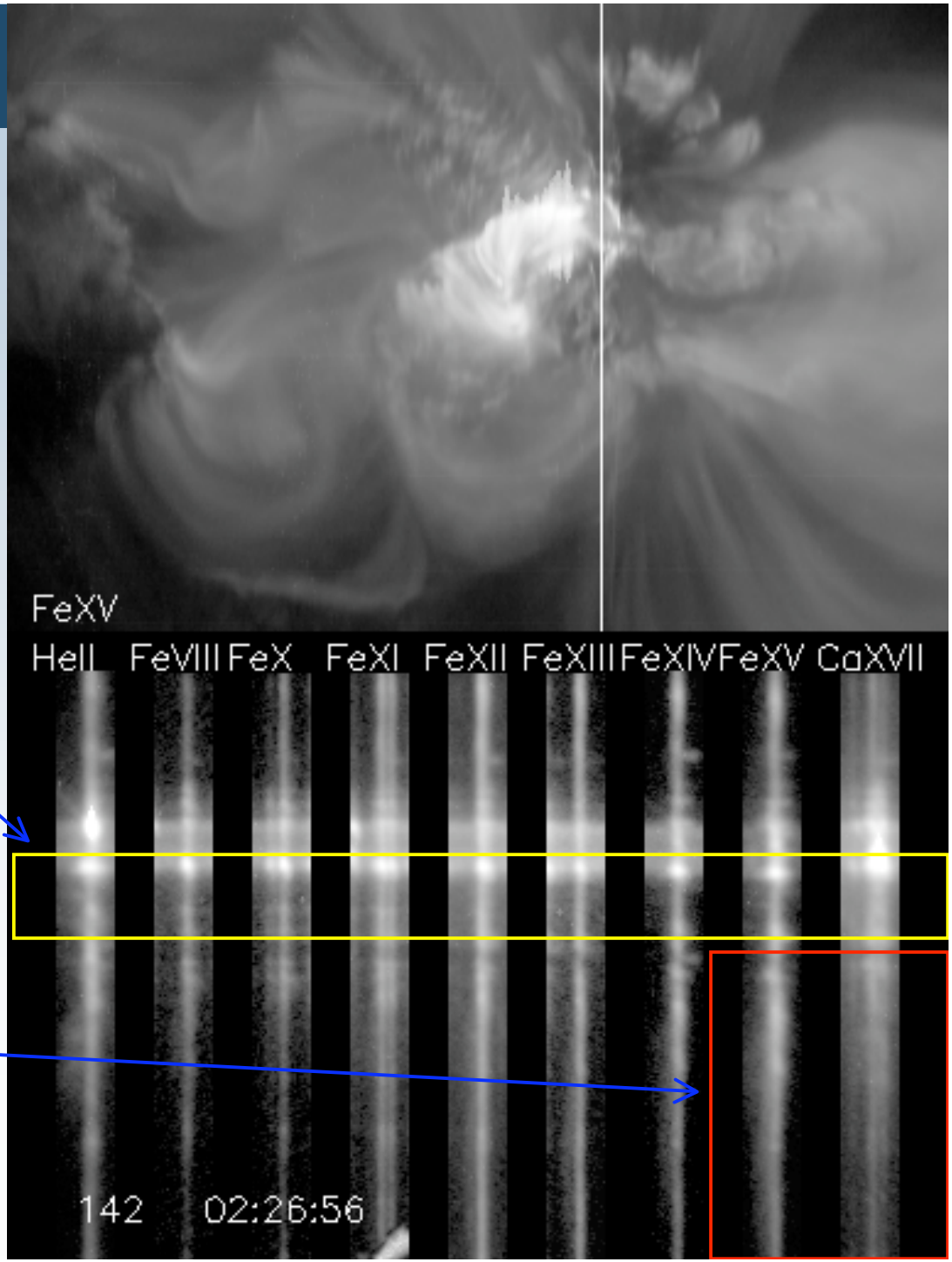
Hinode EIS

Evidence of an MHD shock wave

Two kinds of blueshifts (BSs) are observed in the impulsive phase of the flare - one related to an ejection - the other an MHD fast-mode shock wave? (Asai et al., 2008)

MHD fast mode shock wave

- 02:22 – 02:24UT
- Seen only in high-temperature lines
- Faint
- The shell like structure moved along the slit at 450km/s



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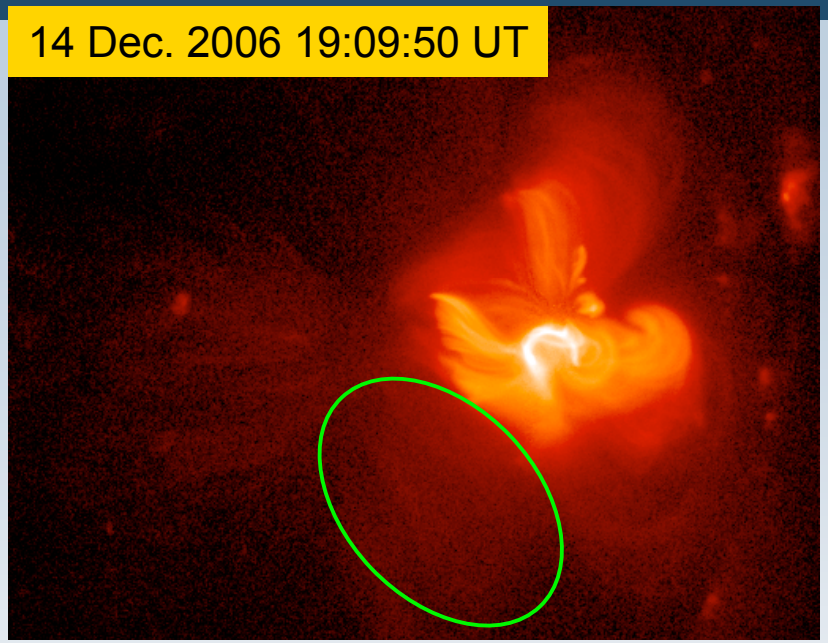
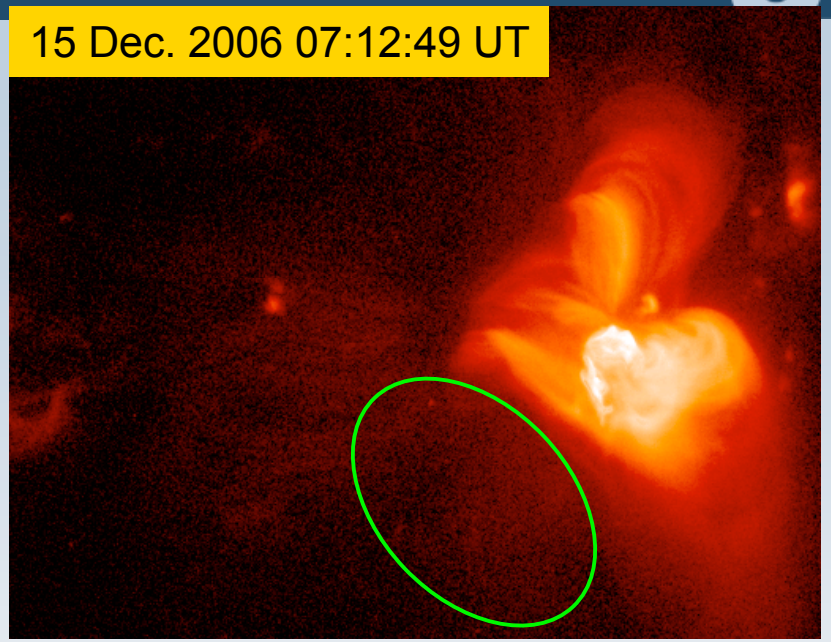
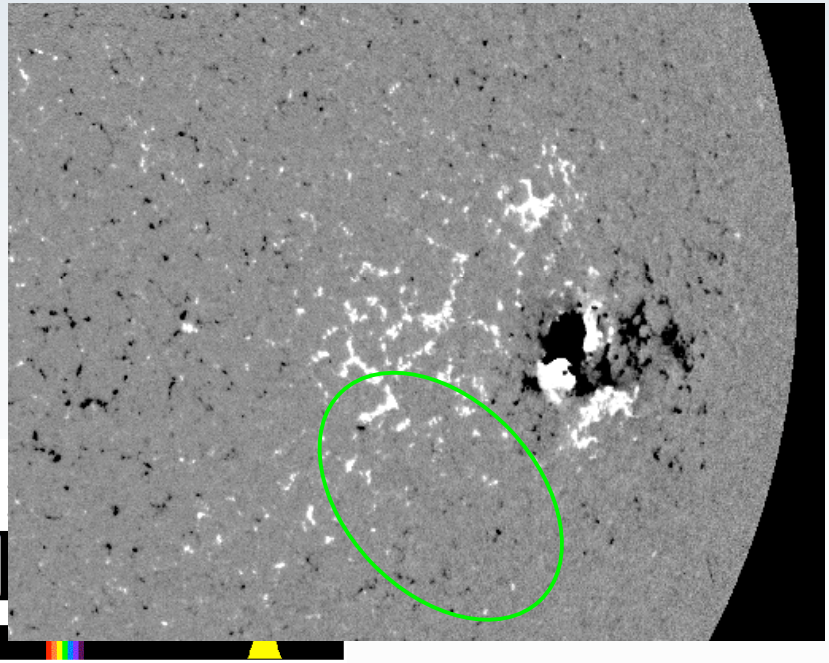
Coronal Mass Ejection - contribution to solar wind?







Hinode/XRT & SOHO/MDI

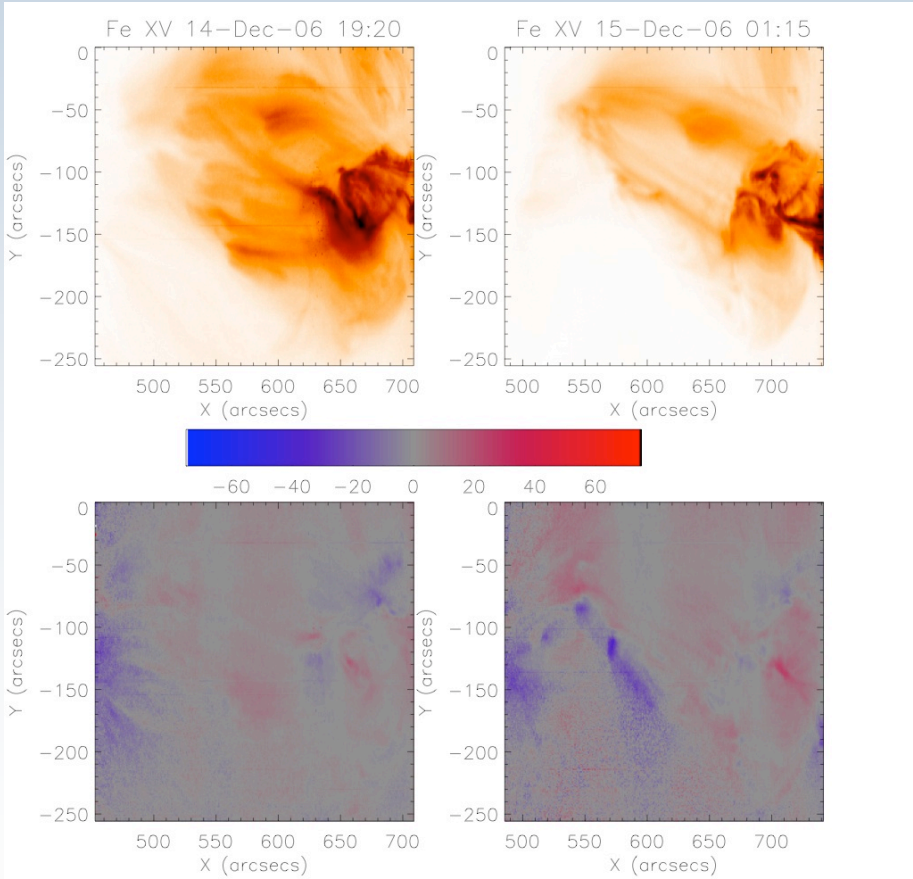
Changes in the coronal strucure due to the CME

The source region of the CME is seen

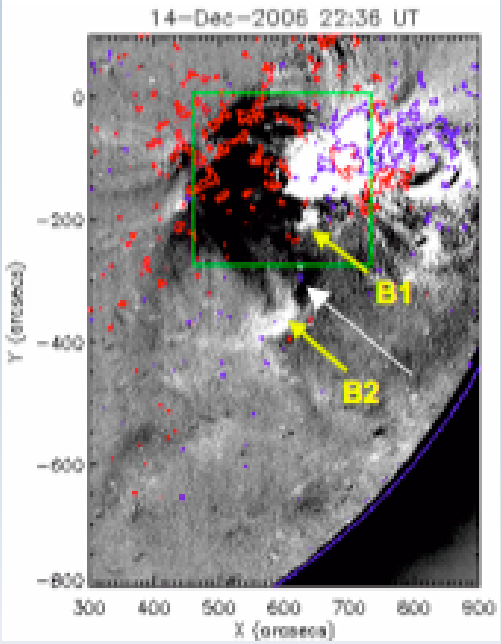
- Before: faint long loops seen at the end of the active region - outflows observed - tens km/s
- After: dimming observed - both small loops at the edge of the AR and the long, faint loops are disrupted. Stronger outflows up to 50 km/s seen.

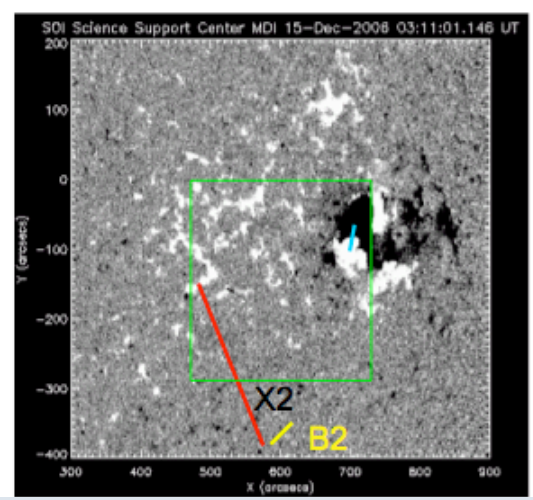
We can now see structure and measure quantitatively the source regions of CMEs. Harra et al., 2007

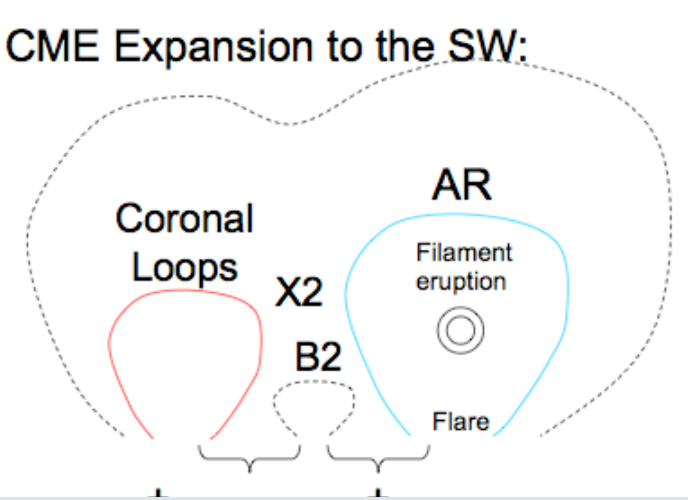
See Scott McIntosh's poster



Interpretation?







Loop-like dimmings end in persistent brightenings

magnetic configuration favourable for reconnection

-> provide evidence for the reconnection scenario(Attrill et al., 2007, van Driel-Gestelyi et al., 2008)

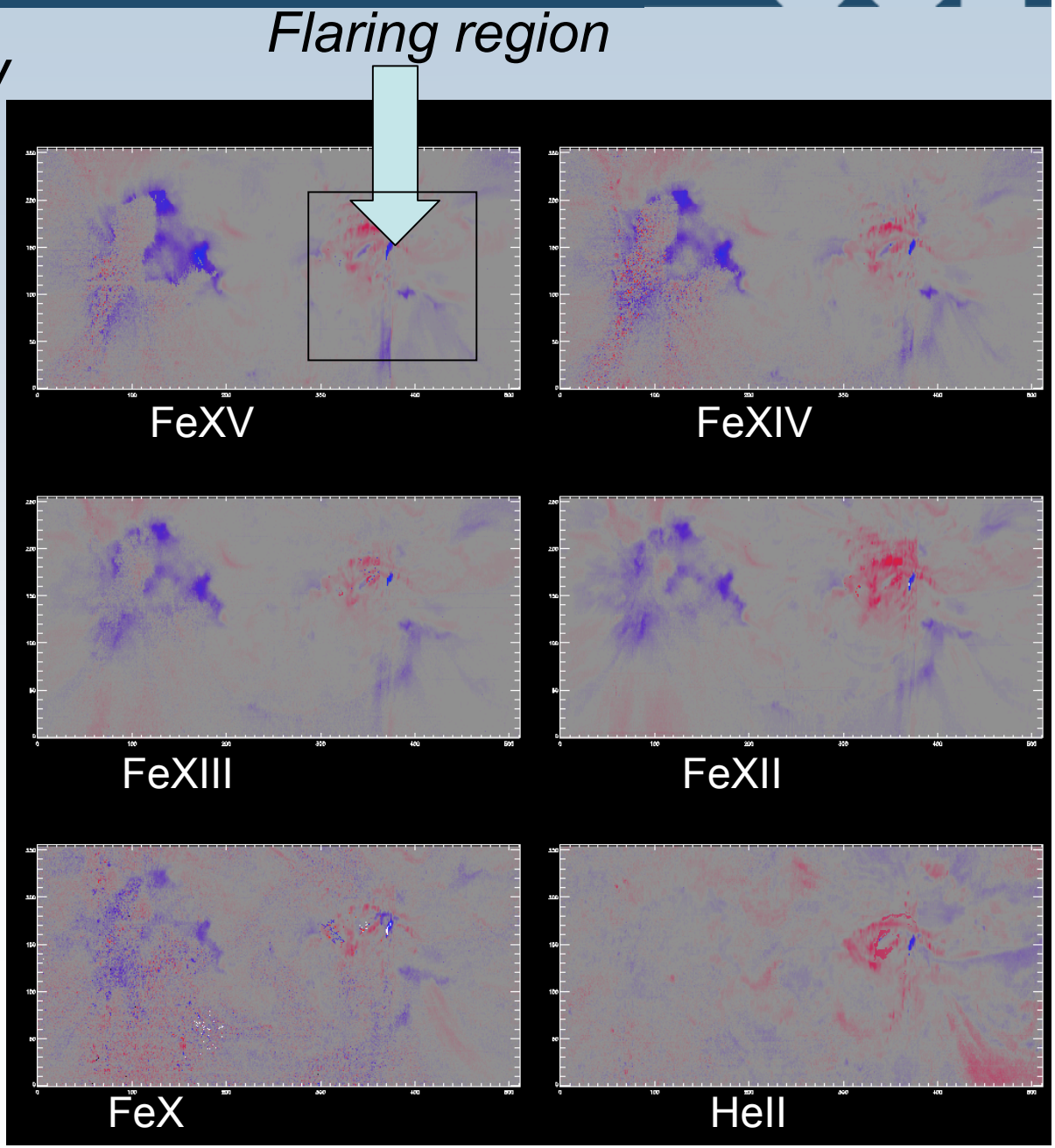
Hinode EIS

The plage region became a constituent of the CME, providing mass via the plasma up-flows seen with EIS.

Important for determining the makeup of a CME.

Long-lasting outflow

The large flare on the 13th Dec causes significant responses away from the flare site - including inducing large outflows.
Imada et al., 2007



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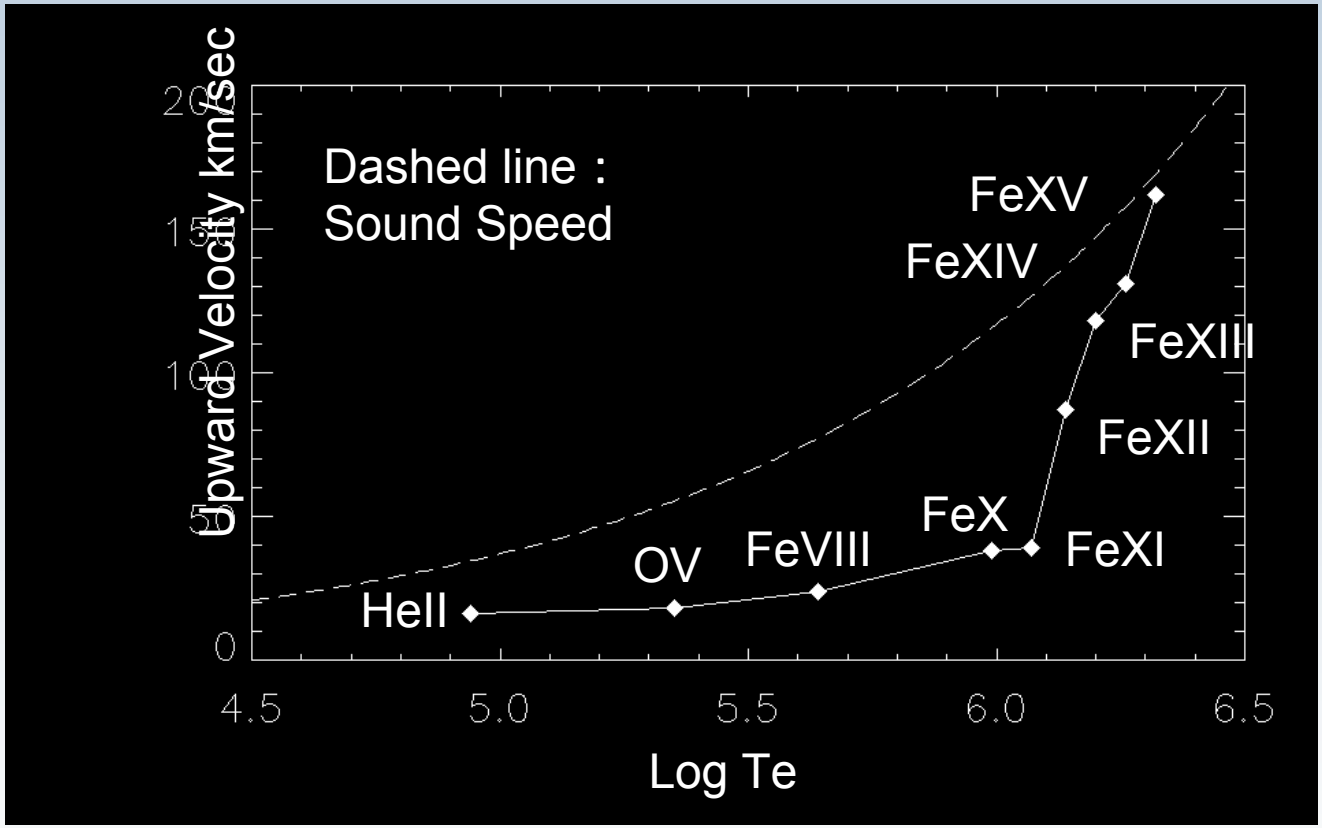
Temperature dependent outflow.



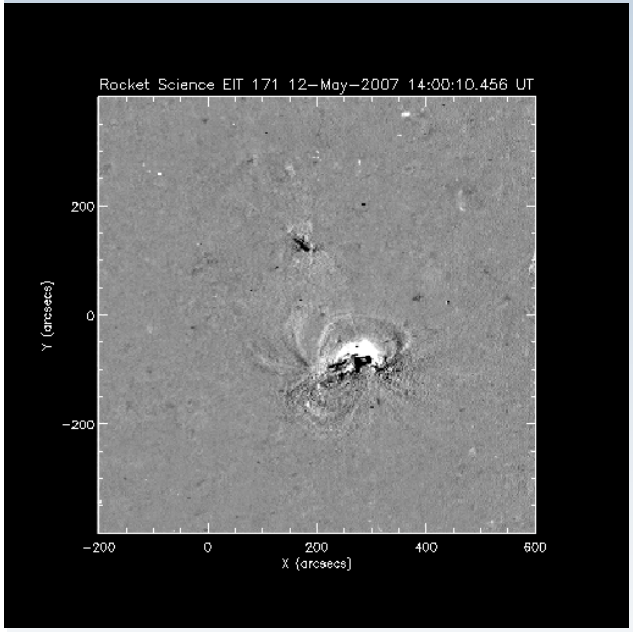
The upflows are very sensitive to temperature!

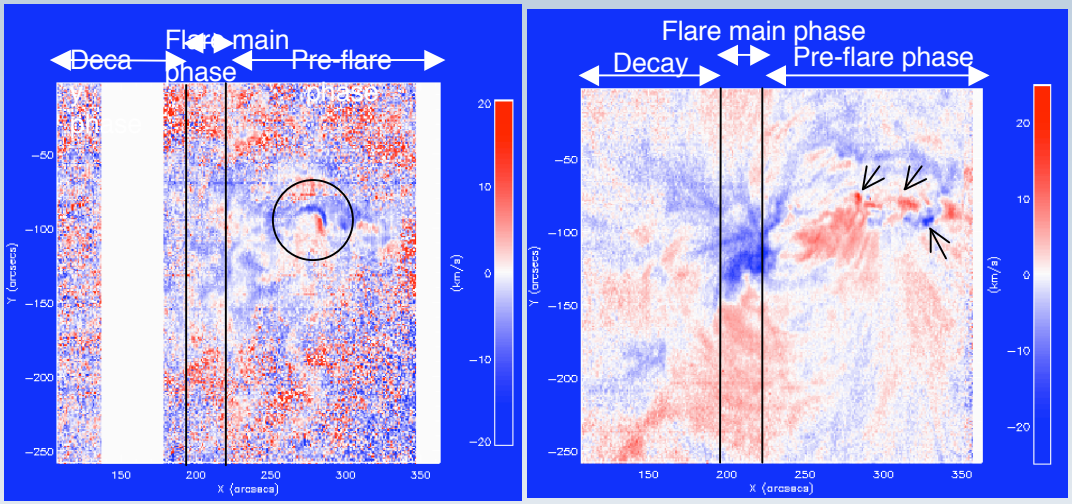
For an explanation see **Shibasaki-san's poster**!

Hinode EIS

Activity in this extended solar minimum!

How small preflare activity can lead to large-scale disruption



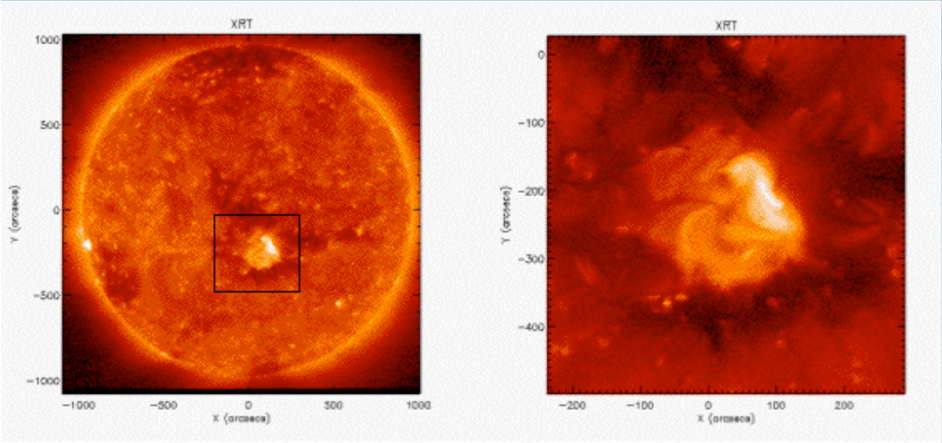


•The flare loops expand and interact with IC loops and nearby bipole (Wallace et al., 2008)

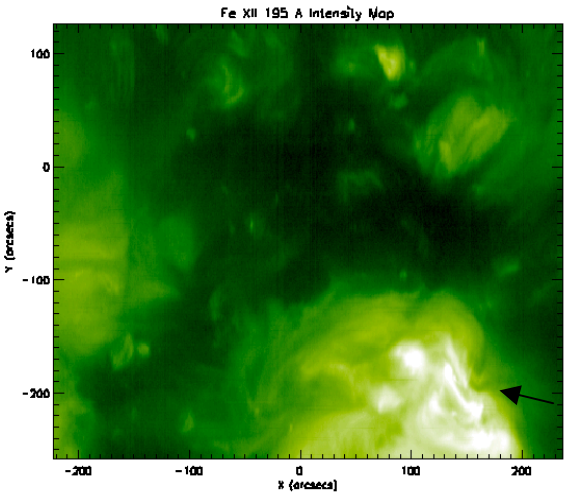
•Small-scale pre-flare brightenings and flows are seen in the corona.
•Flux rope shows twist preflare (Cf Williams et al., 2008)
•Pre-flare activity corresponds to where magnetic flux is seen to emerge 24 hours earlier. Wallace et al., 2008.
•**See Alison's poster!**

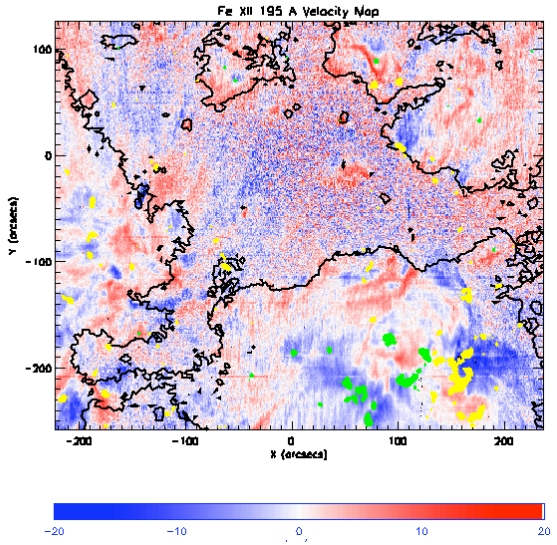
*See **Laura Bone's** poster - filaments merging to trigger flare/CME*
A. Bemporad's talk today! Both flares in May 2007

Upflows in an Active Region - Coronal Hole Complex:CME Precursor?



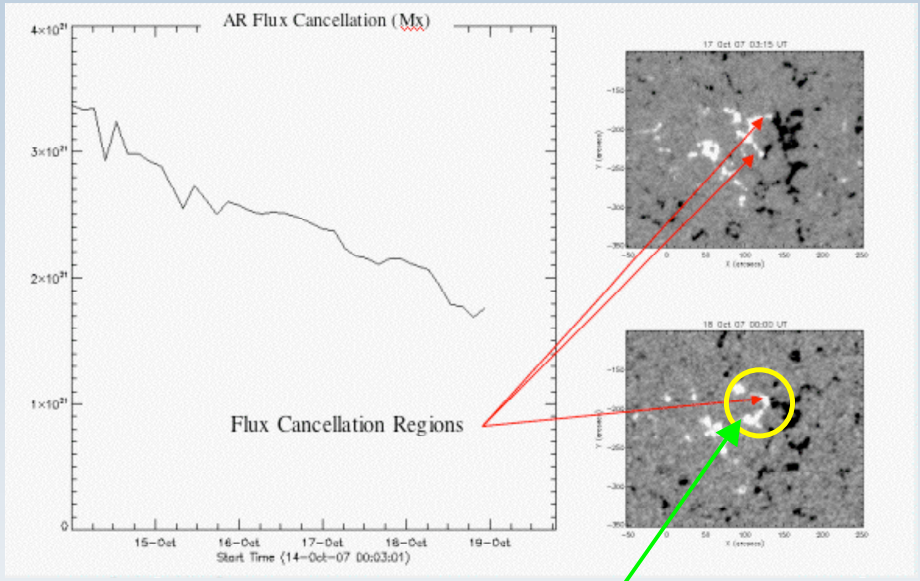
Highly sheared, mature active region embedded in an equatorial coronal hole observed by EIS from 15 to 18 October 2007.



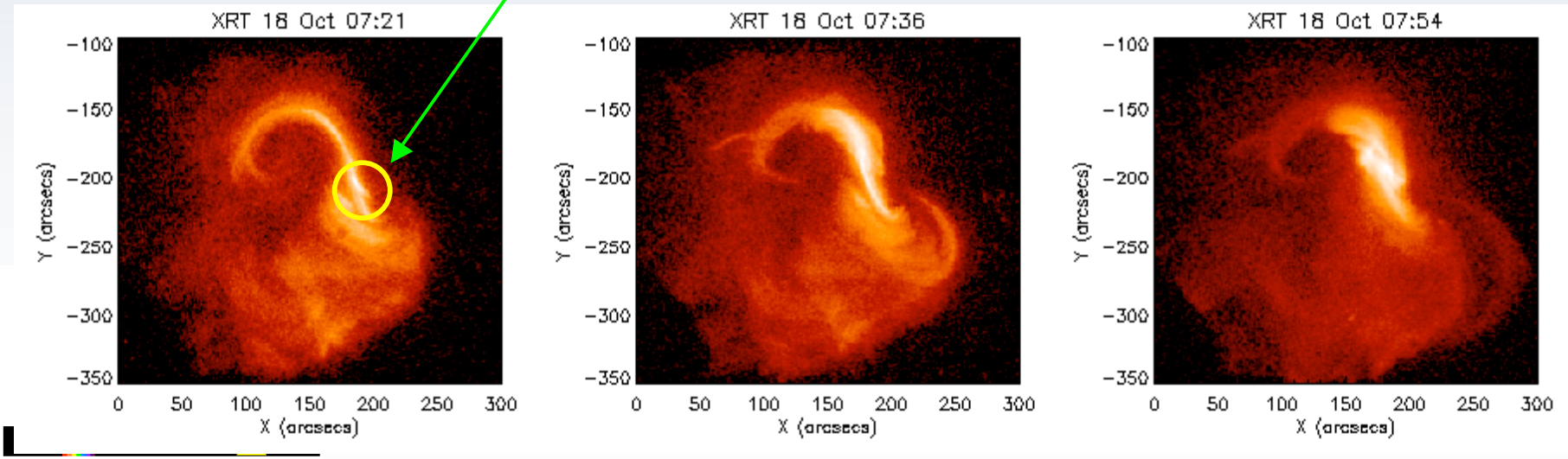


Intensification of upflows over negative magnetic field concentration 4.5 hrs before the CME.

Baker et al., 2008 - see poster!



-Flux falls by 10%/day for 3 days prior to the CME
-Accelerated expansion of AR prior to eruption can lead to enhancement of compressive forces and cause intensification of upflows.
-Comparison with simulations carried out. See Deb!



Summary

- ***Despite a long solar minimum Hinode is making progress on understanding flare/CME trigger.***
- ***The outflows and Vnt show early changes before eruption - even for tiny events.***
- ***We look forward to some more activity!***

Hinode EIS