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Using Spectroscopy to Understand the Source of CMEs

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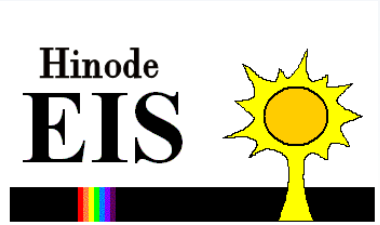
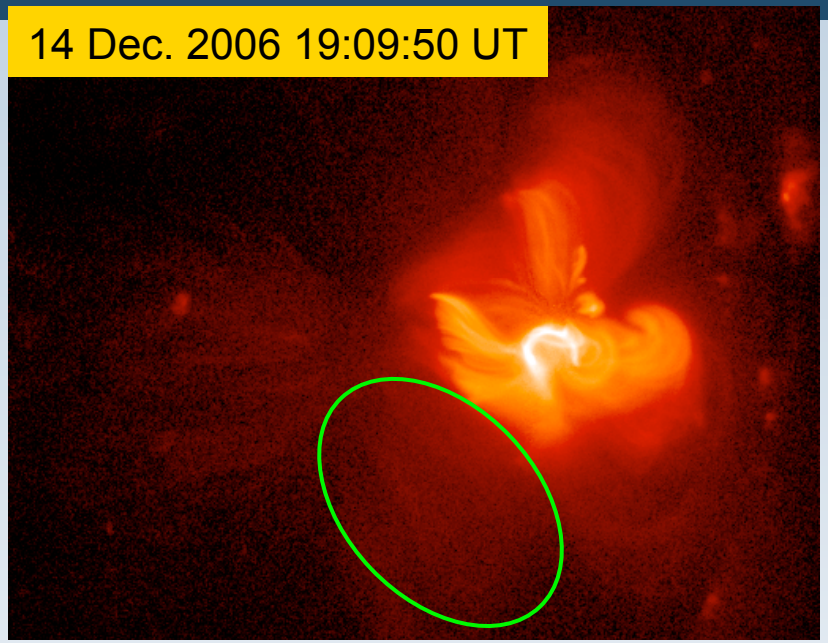
Coronal dimmings

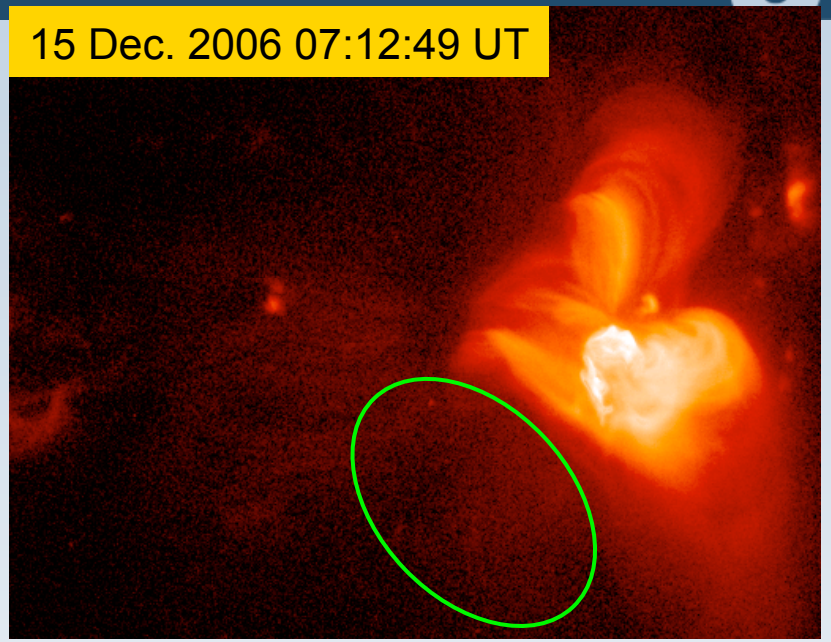
- Have been observed for decades.
- Appear suddenly, and are seen as a reduction in intensity in soft X-rays and EUV (predominantly).
- Often associated with CMEs – the eruption of the magnetic field leads to expansion of magnetic loops.
- Classic double-dimming events are rare but are understood to mark the footpoints of an erupted flux rope.
- Other cases are much more complex with secondary dimmings appearing remote from the eruption site.
- Indeed some slow-rise CMEs show no significant dimming.

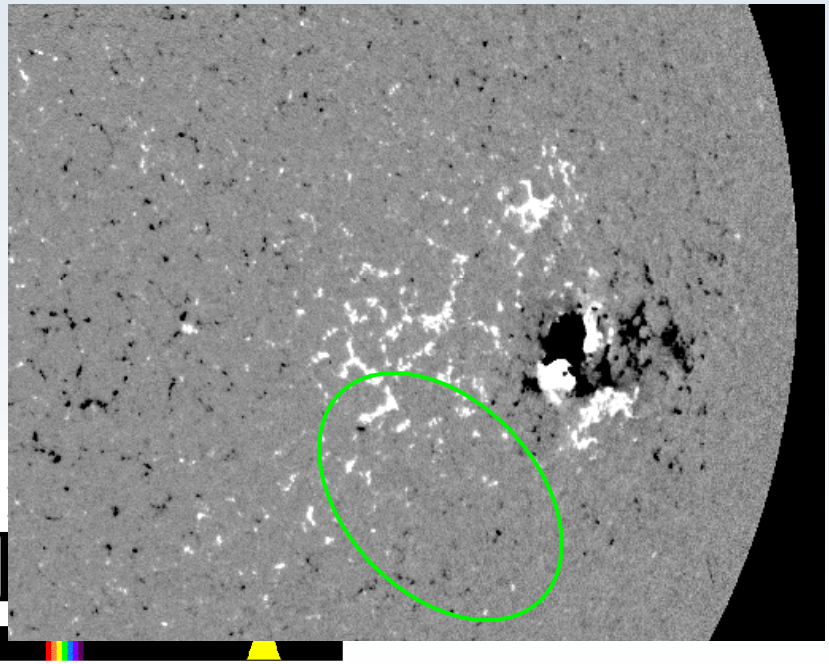


This talk will review recent spectroscopic results from Hinode on dimming regions.

Coronal Mass Ejection -what is the source?







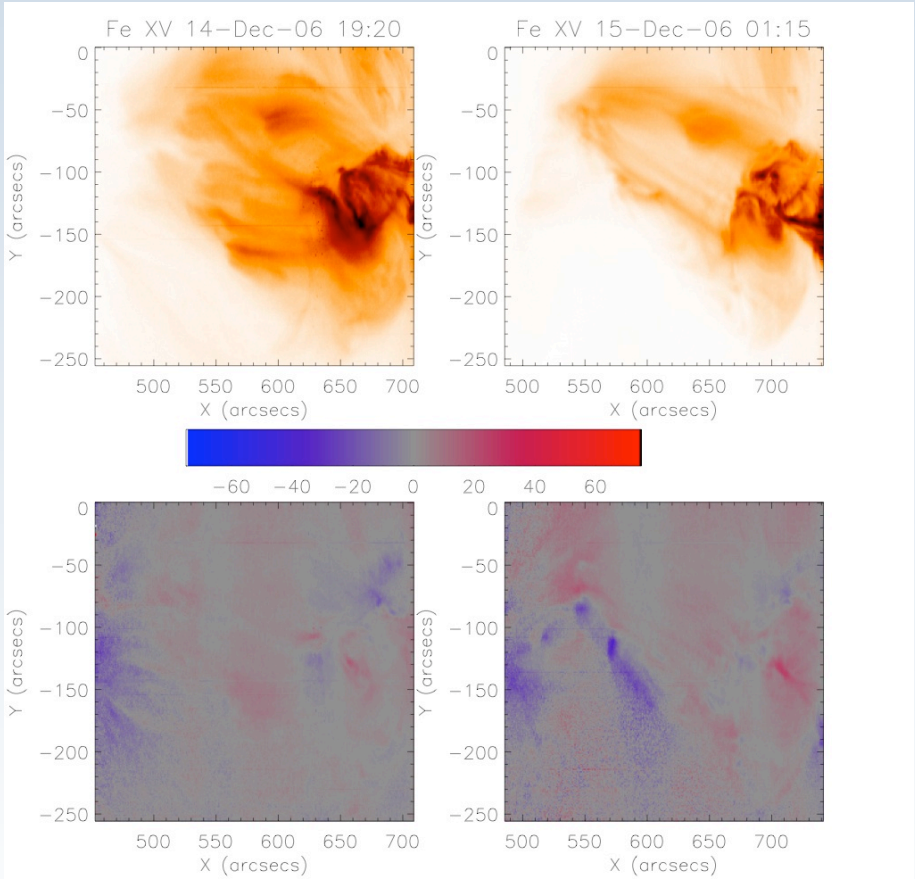
Hinode/XRT & SOHO/MDI

Changes in the coronal strucure due to the CME

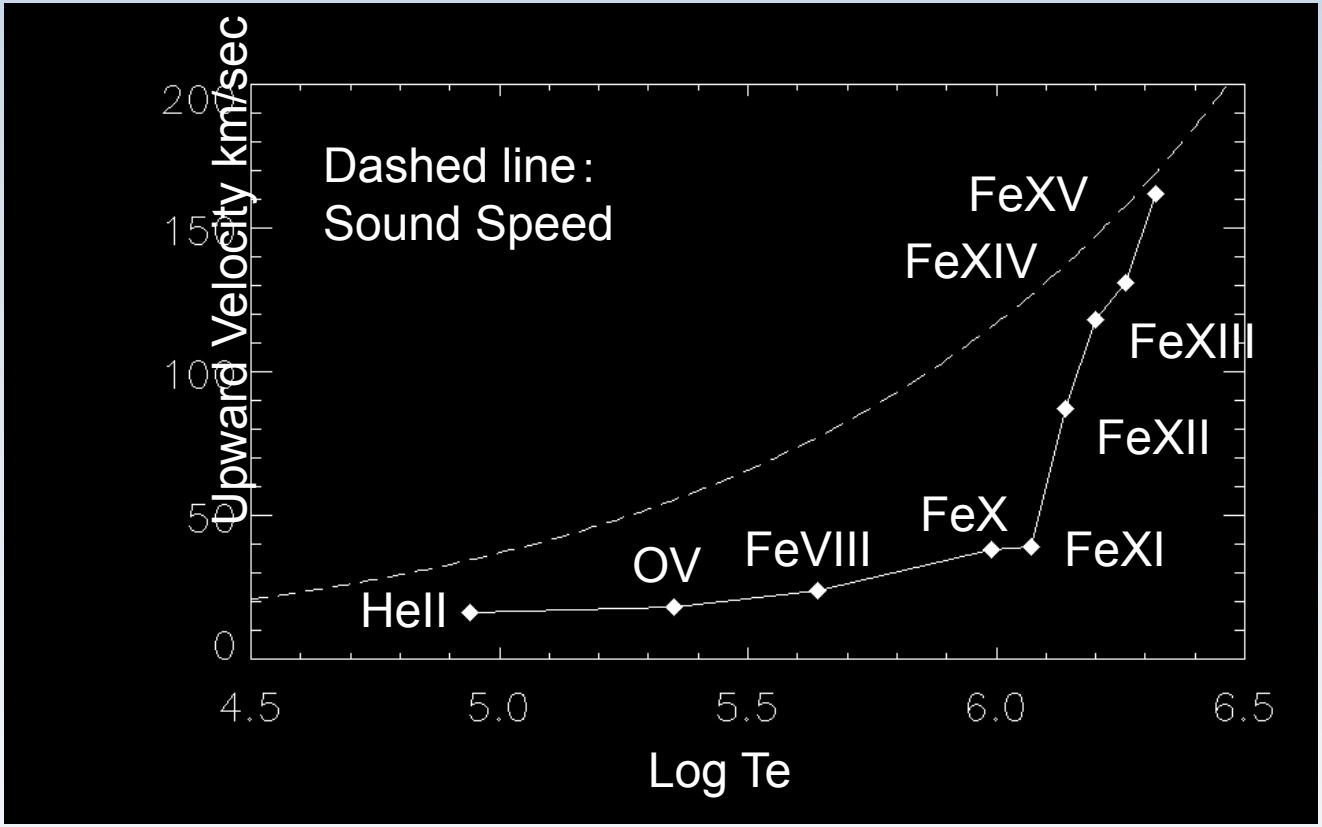
The outflow in the secondary dimmings is seen

- There are outflows in the dimming region before the CME erupts – but they are weak.
- The dimming region shows clear structure. The strongest outflows at the footpoints of the loops.

Harra et al., 2007



Temperature dependent outflow.

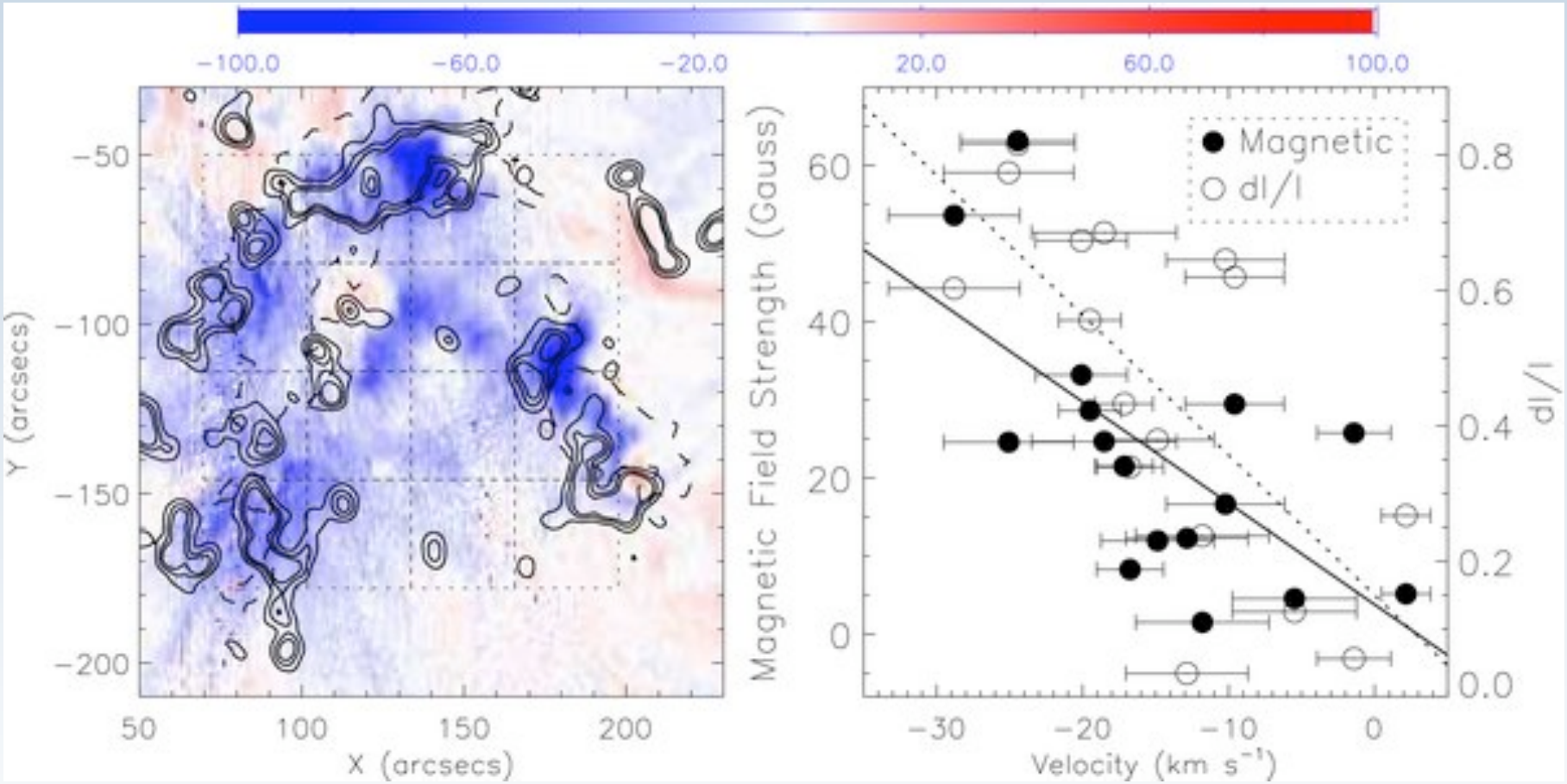


The upflows are very sensitive to temperature!

Link between coronal heating and solar wind formation?

Hinode EIS

Relationship between outflows and magnetic field

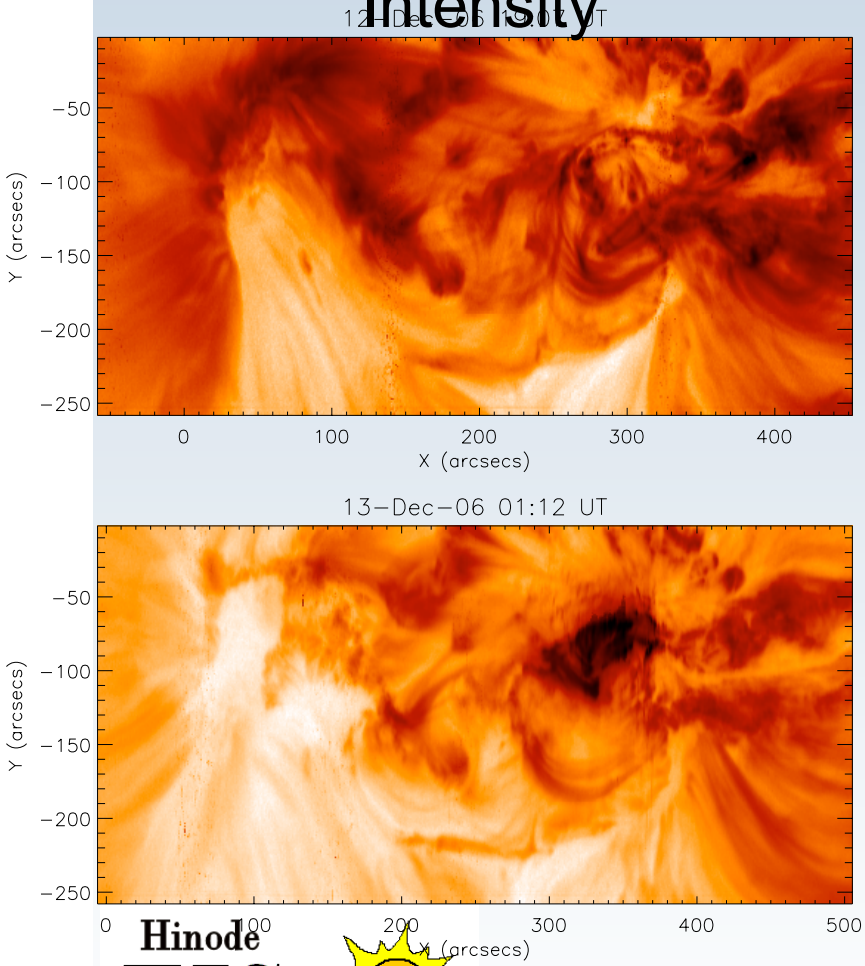


Hinode EIS

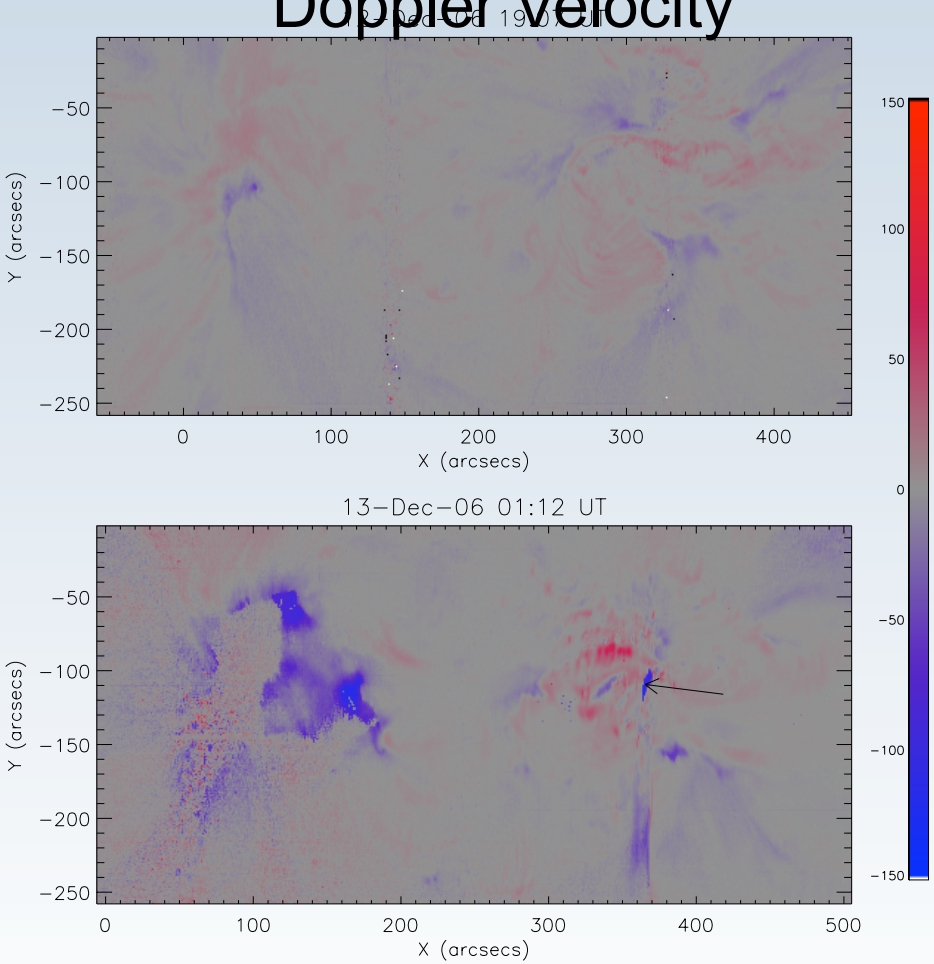
The correlation coeff between magnetic field and outflow is ~0.8, Jin et al., 2009

Determining the CME source

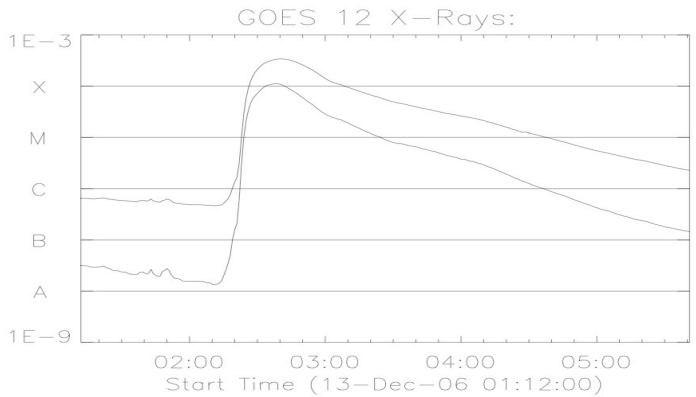
Intensity



Doppler Velocity



Hinode EIS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1E-3
X
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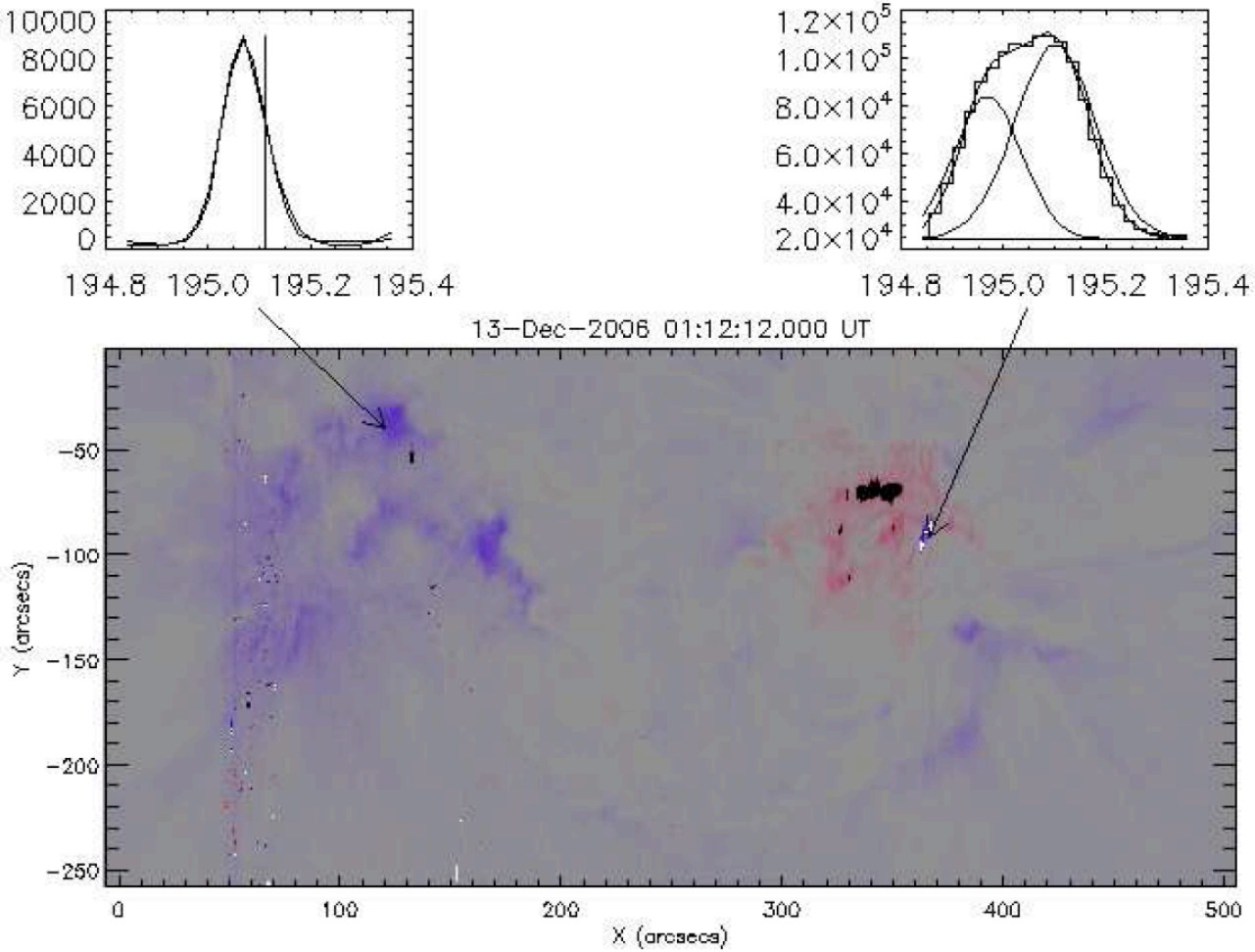
Start Time (13-Dec-06 01:12:00)


10000
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194.8 195.0 195.2 195.4
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-50
-100
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-200
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Y (arcsecs)
0
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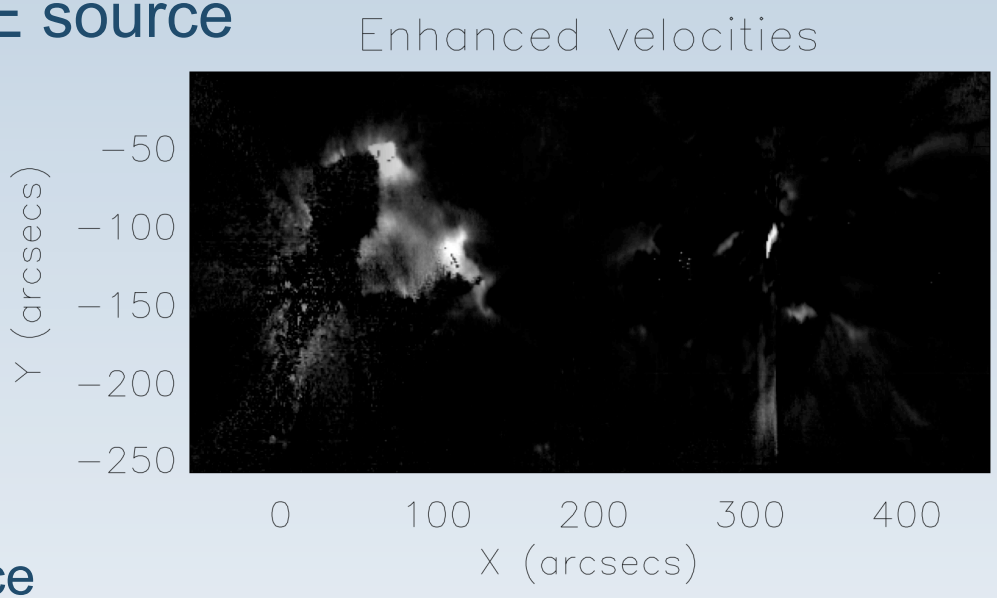
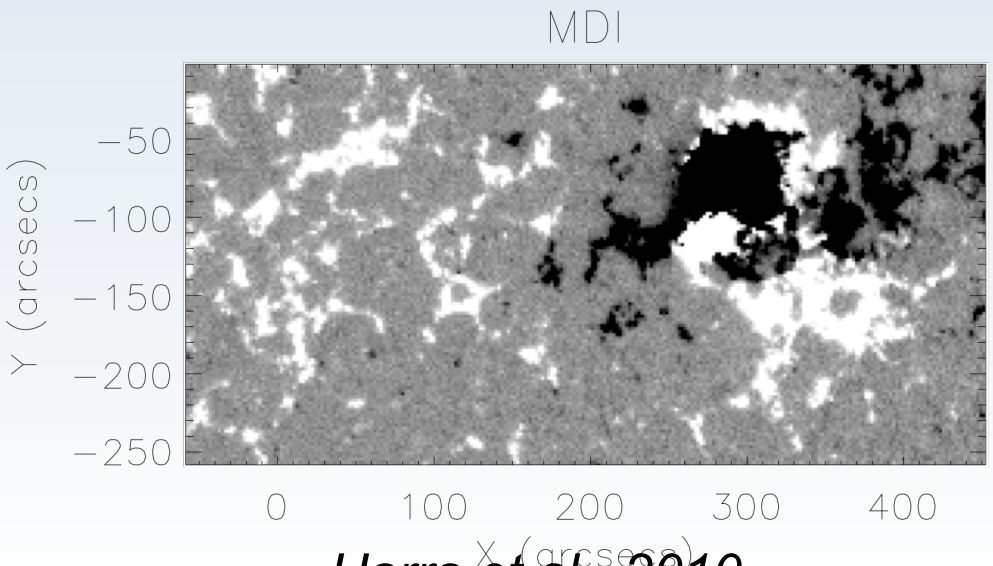
500
X (arcsecs)

The magnetic flux of the CME source

- The velocity difference image highlights the regions with the strongest upflow.
- The magnetic flux was determined from the solar source can be determined from the velocity difference.
- The magnetic flux form these regions matches that from the ICME.





Harra et al., 2010

Conclusions

- We can now measure the source region of a CME with more accuracy. The magnetic flux measured in this event is consistent with that in the magnetic cloud.
- Hinode is making new discoveries about physical processes in CMEs. The information on the velocities, line widths and temperature distributions provide good input to CME models.
- The data is open! If you want to use data or develop an observing programme, just contact me.

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Hinode EIS