

# Reconnection Outflows in the Extended Corona and Magnetotail



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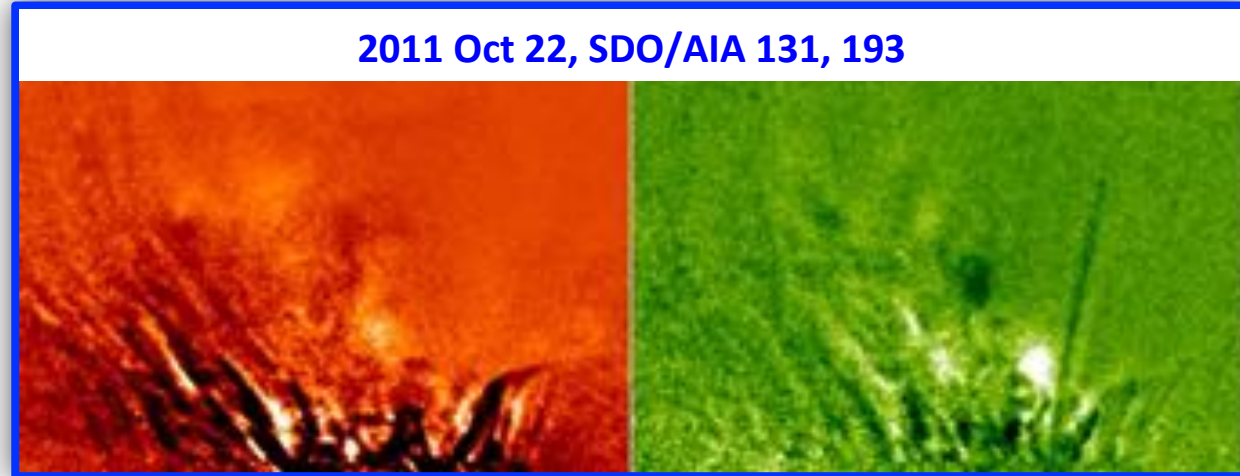
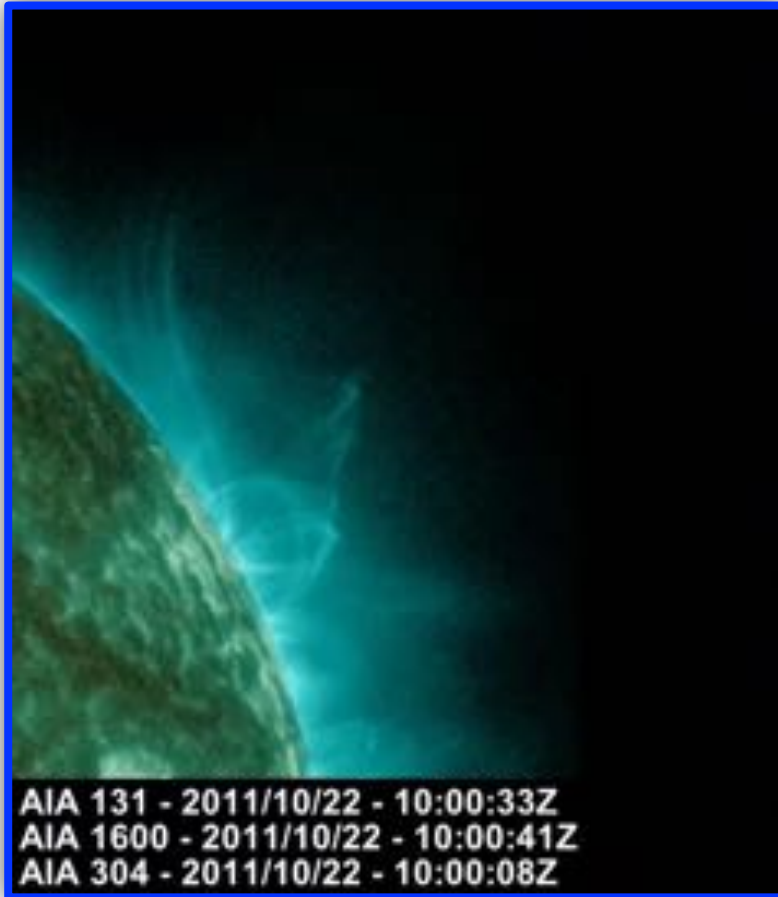


# Supra-Arcade Downflows (SADs) and Downflowing Loops (SADLs) Observations

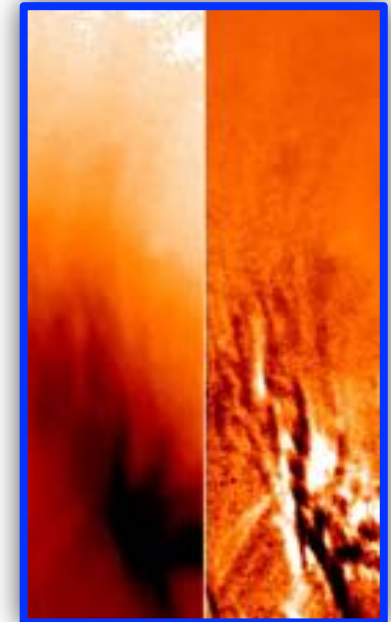
2012 Jan 27, SDO/AIA 131, 193, Hinode/XRT



# Supra-Arcade Downflows (SADs) and Downflowing Loops (SADLs) Observations



↑  
Hot AIA channels. (2-10 MK)  
Run-mean-differenced  
Reverse-scaled



SADs appear as voids carved out in the plasma sheet by the SADLs.

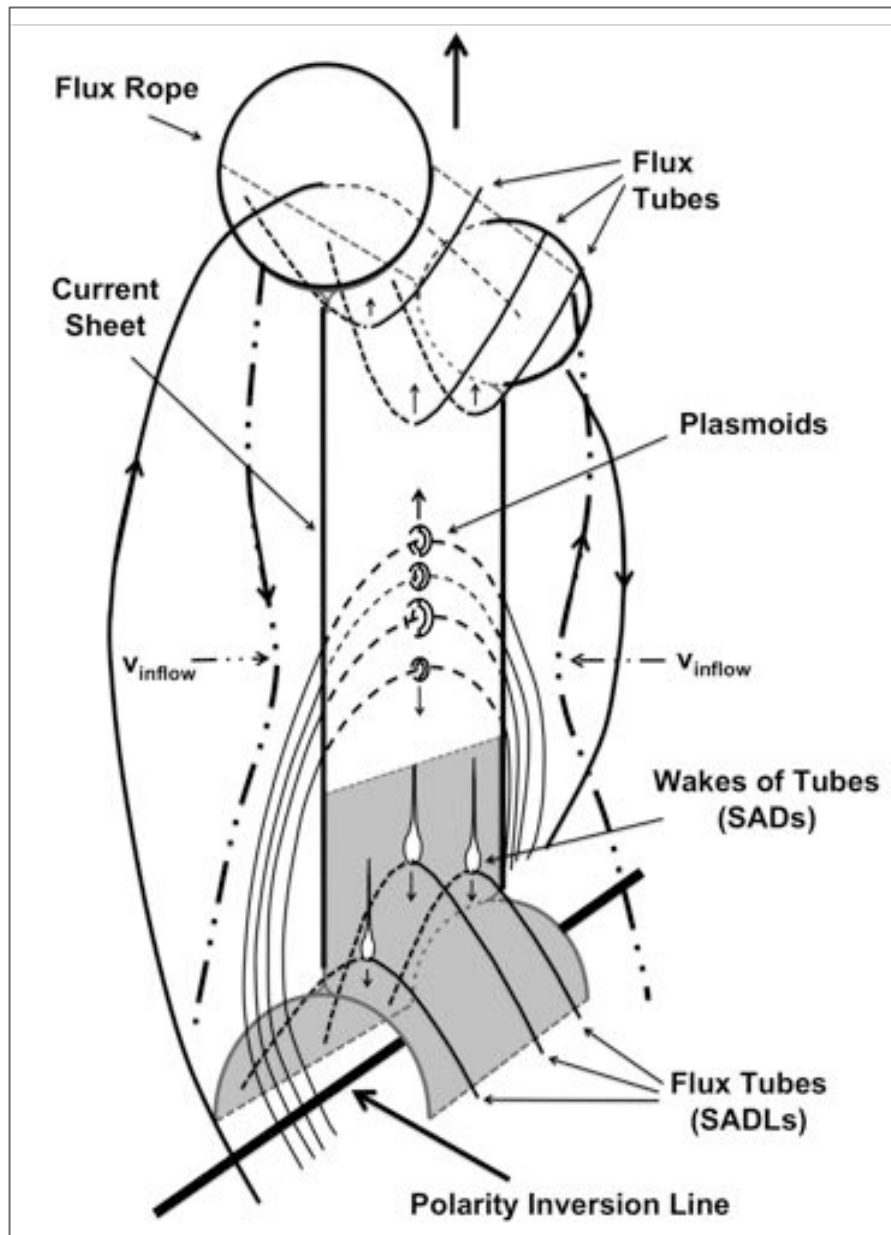


# SADs + SADLs

- **Key features**

- Different from plasmoids
- Observationally associated with inflows (as outflows)
- Significant correlations with particle acceleration and heating (temporally and spatially), thanks to RHESSI and radio observations

Fig 1



## Basic reconnection scenario, post initial flux rope formation and release.

- Field lines reconnect across the current sheet to form outflowing flux tubes while plasmoids form along the current sheet.
- SADs are formed as the flux tubes (SADLs) retract through hot plasma in the fan (*otherwise, only SADLs are observed*).

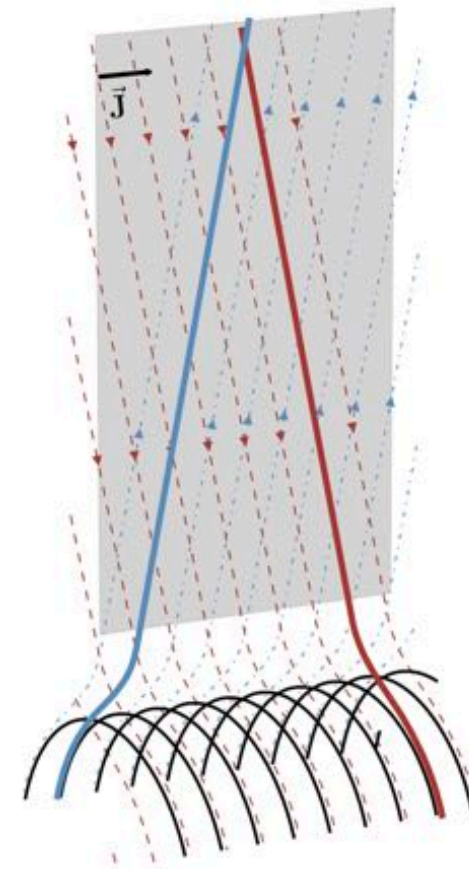


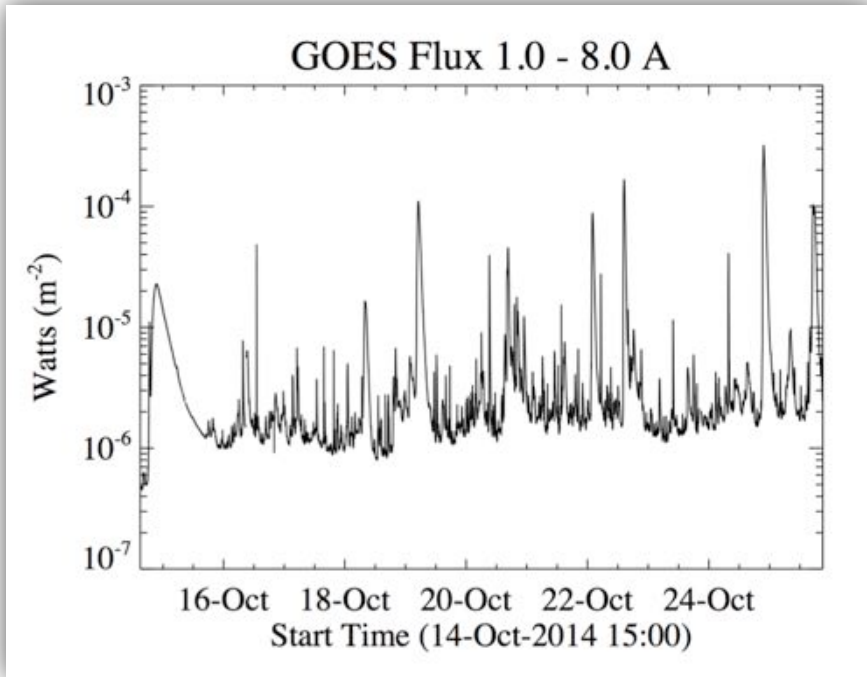
Fig 2: A. Kobelski

# SADs in the Extended Corona...

SADs in the lower corona are typically observed well after reconnection has occurred.

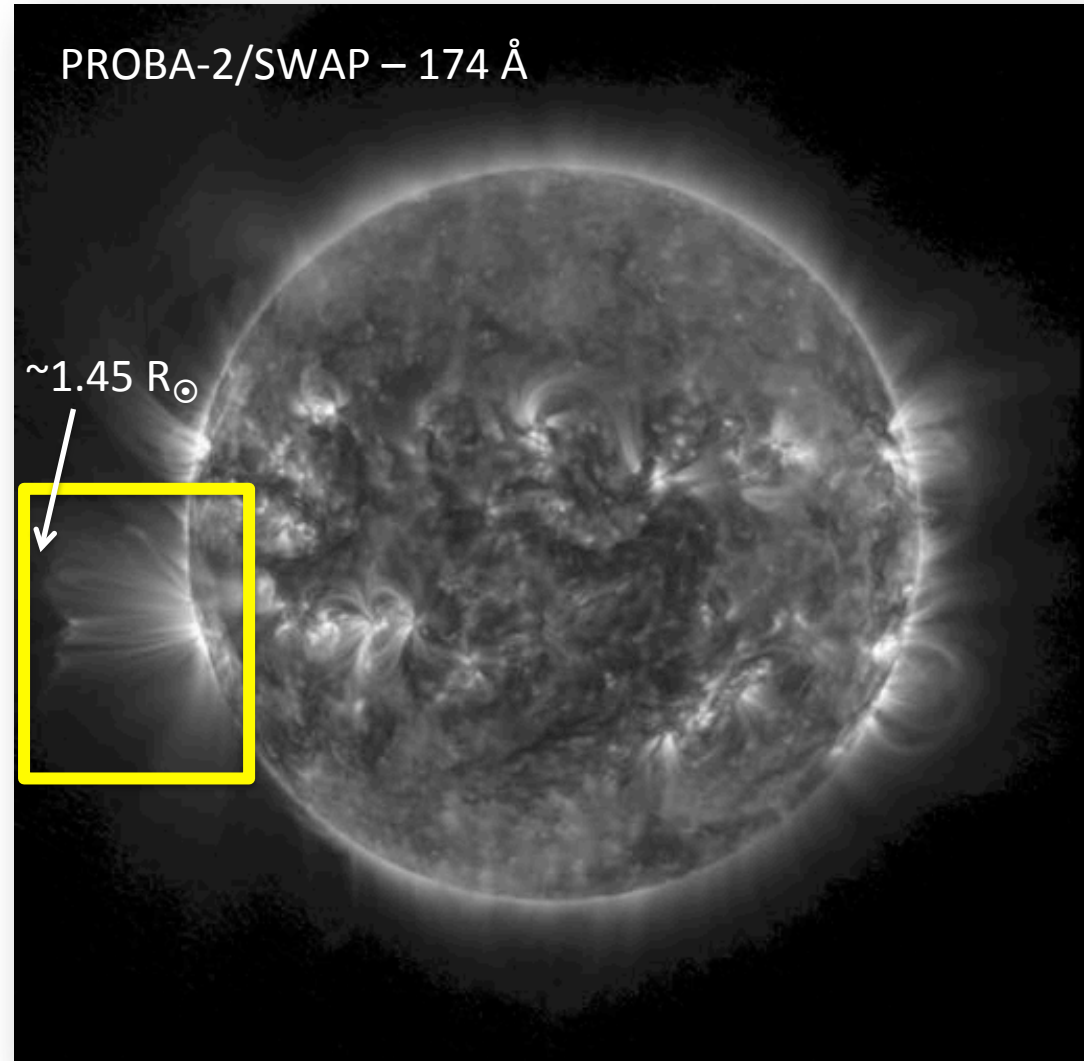
In the extended corona, we are better able to observe the migrating reconnection sites.

WL coronagraphs allow us to see reconnection develop behind the CME while looking directly at the density.



## “Giant Arches” Flare – 2014 Oct 14

Fig 1



# SADs in the Extended Corona...

LASCO C2

PROBA-2/SWAP

AIA 131 Å

A

A: Flattened from a year's worth of data

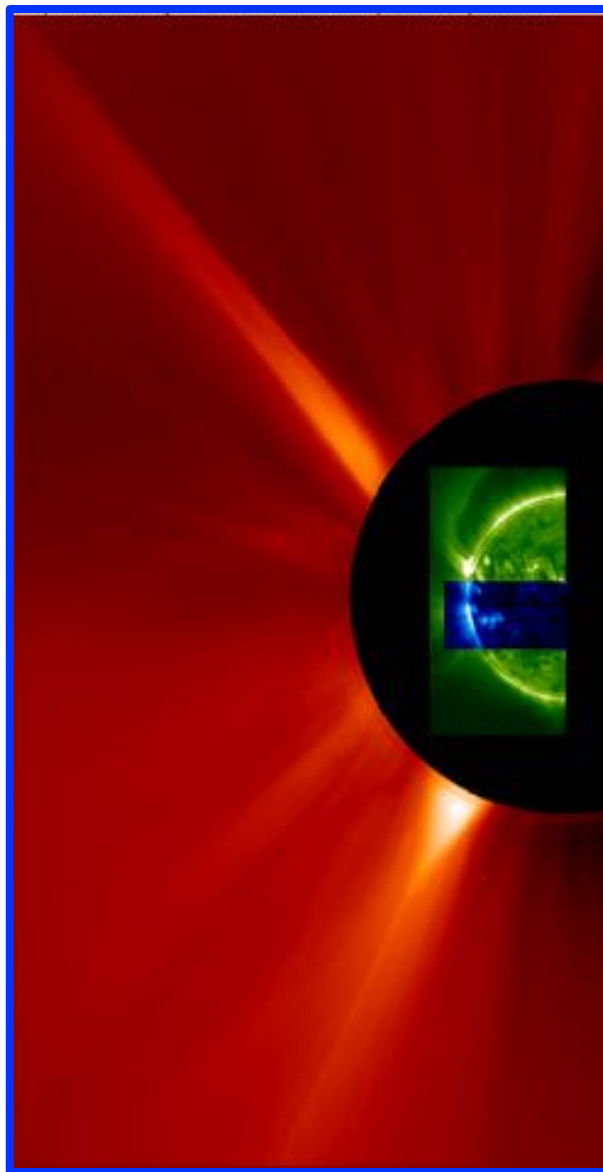
Cleaned (cosmic rays, background stars, planets)

Attenuated disk

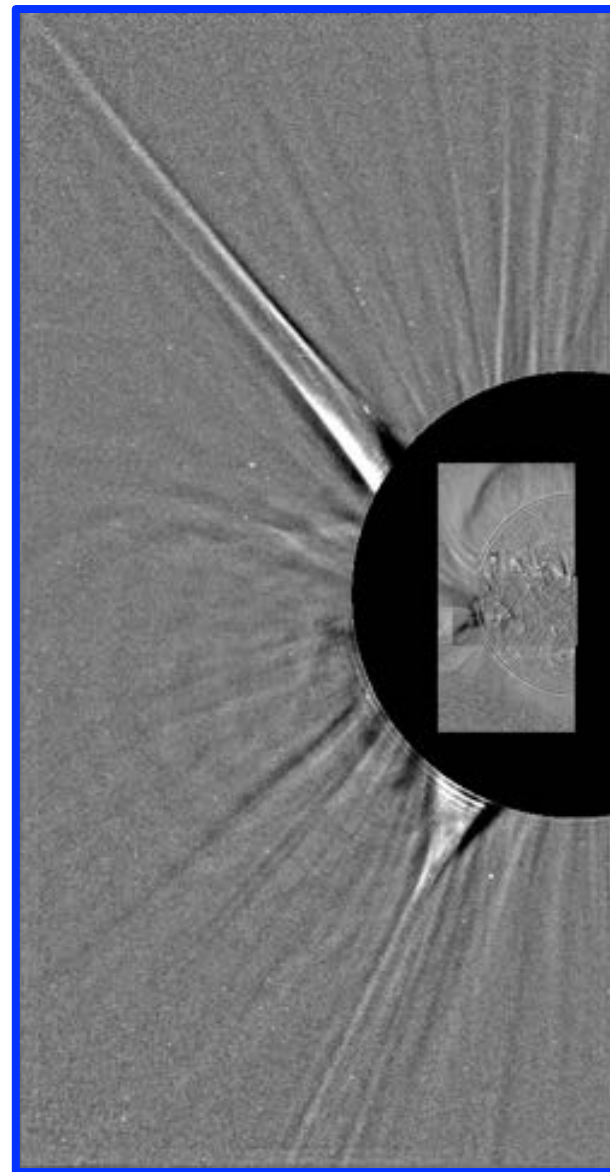
B: All that +  
Run-mean-differenced

- Both Scaled

**Downflows in C3 as well!**



B

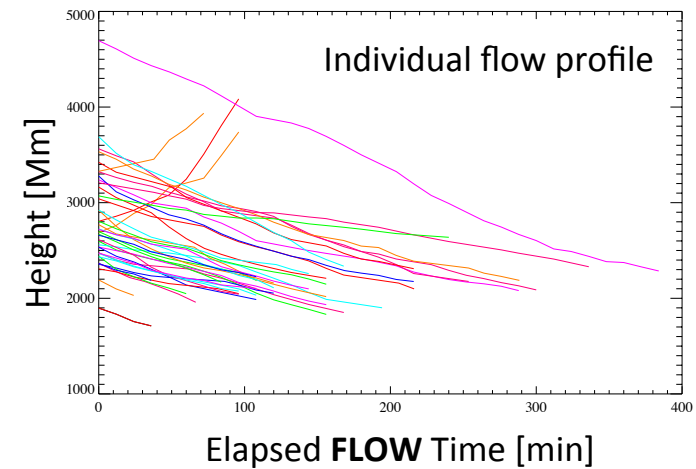
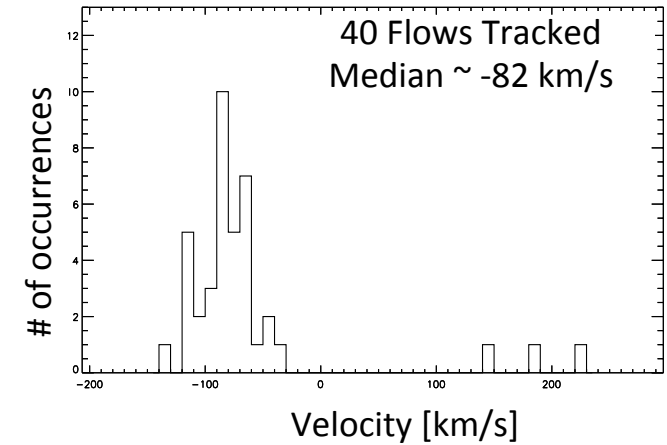
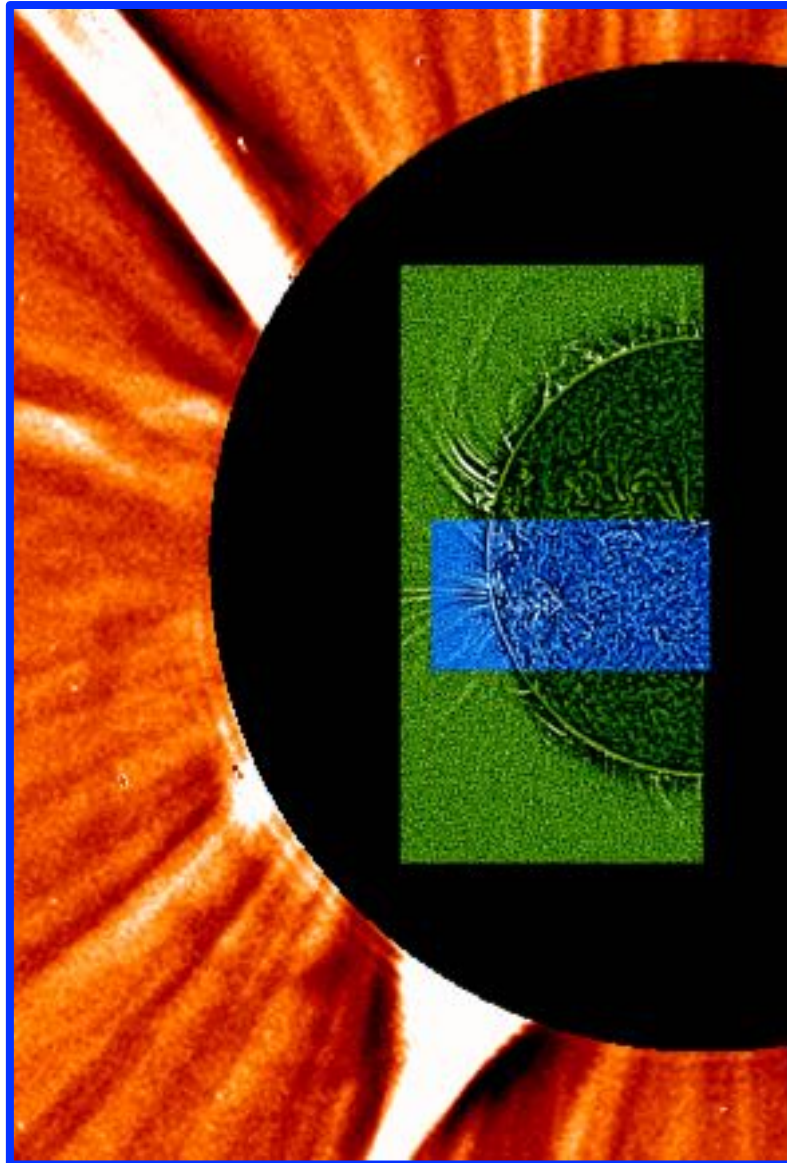
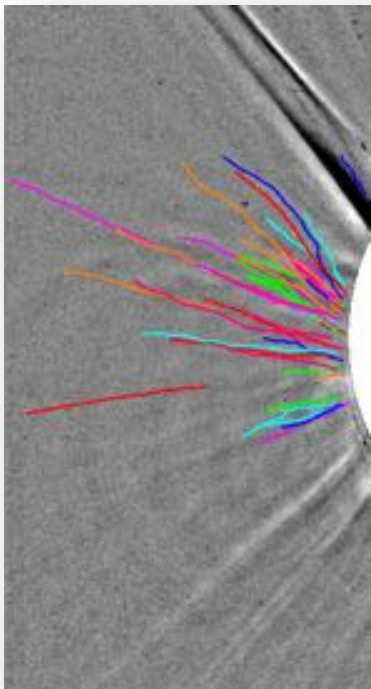


# SADs in the Extended Corona...

LASCO C2  
PROBA-2/SWAP  
AIA 131 Å

C

C: Smooth-Differenced  
Extracted  
Scaled



+ Initial heights increased with time.

**Strong potential analogy with magnetotail substorms**  
(e.g., Reeves et al. 2008)

Fig 1

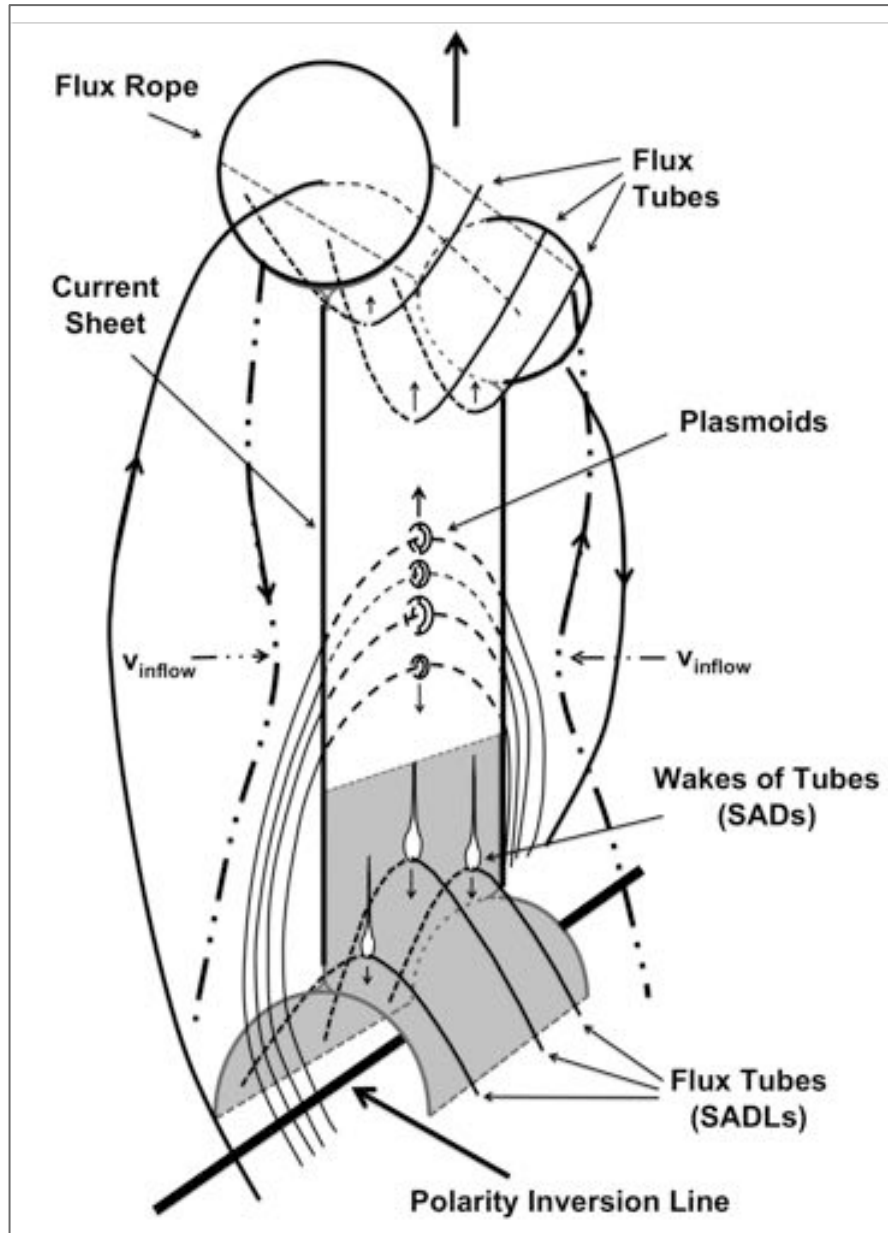


Fig 2

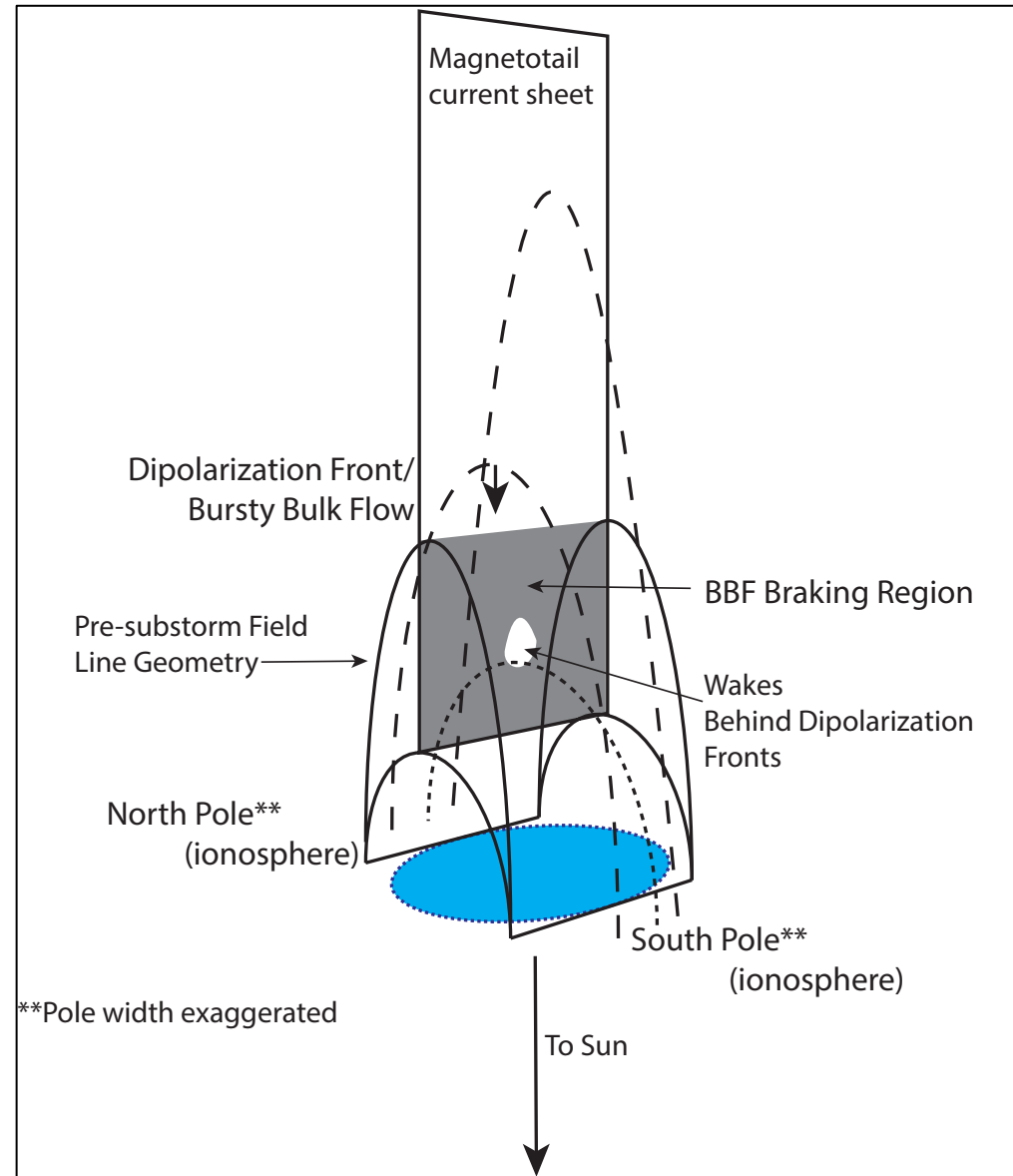
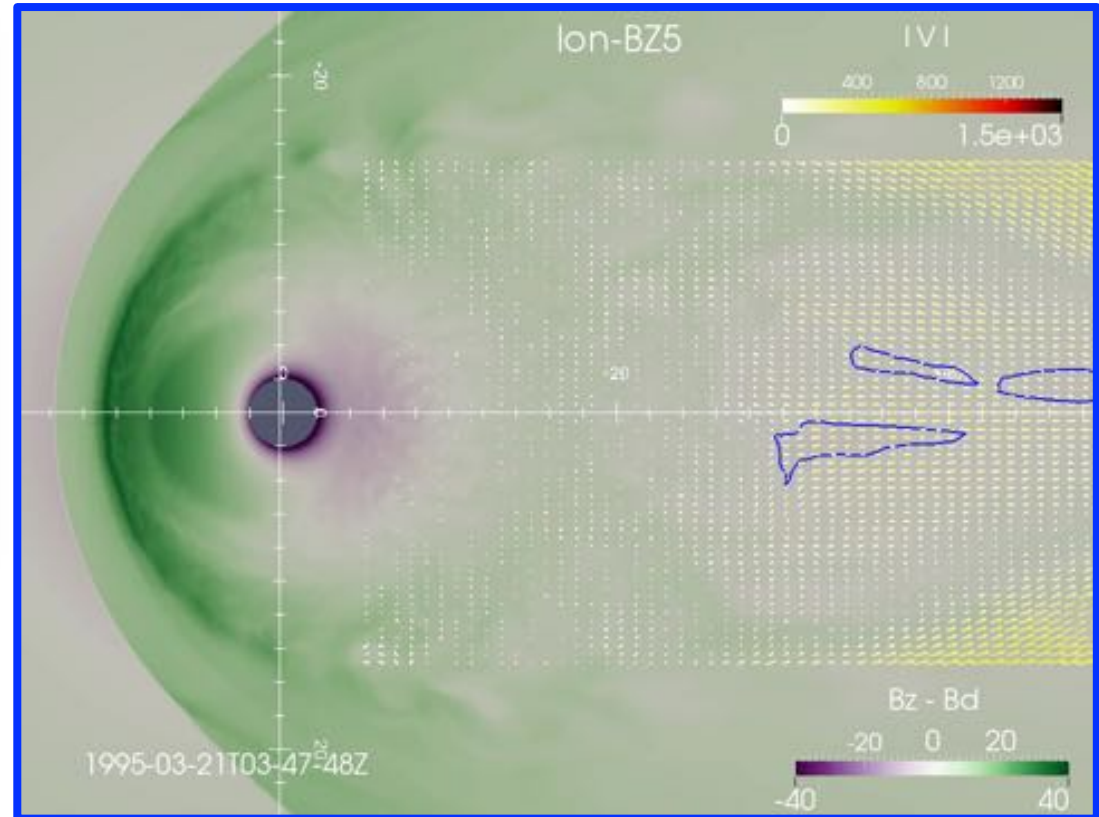
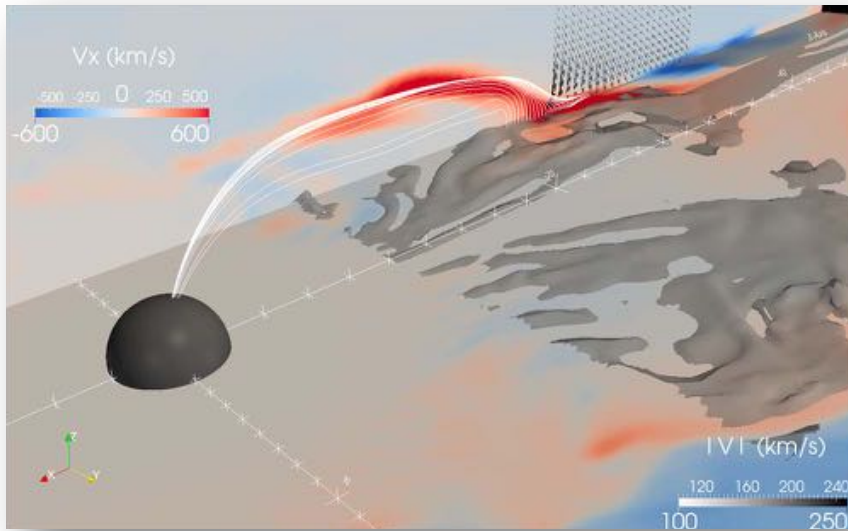


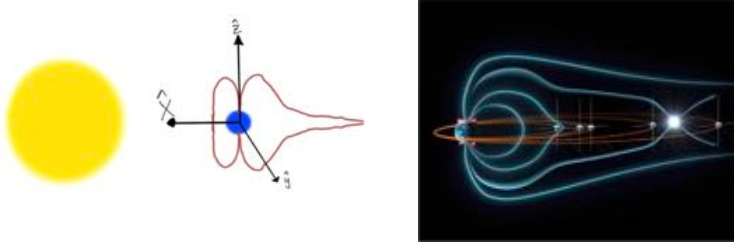
Fig 1: Savage et al. 2012

Fig 2: Courtesy of A. Kobelski, Reeves et al. 2008

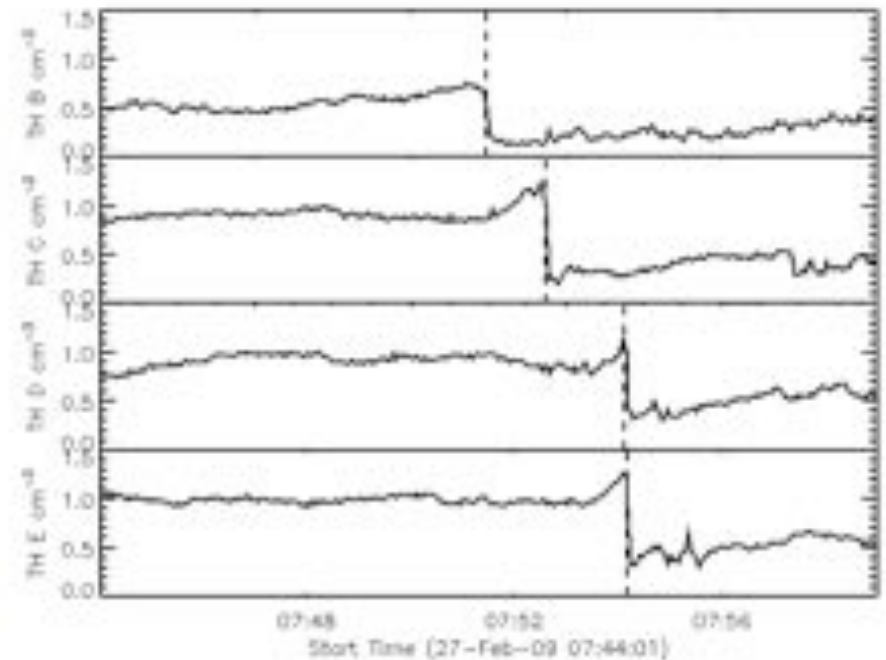
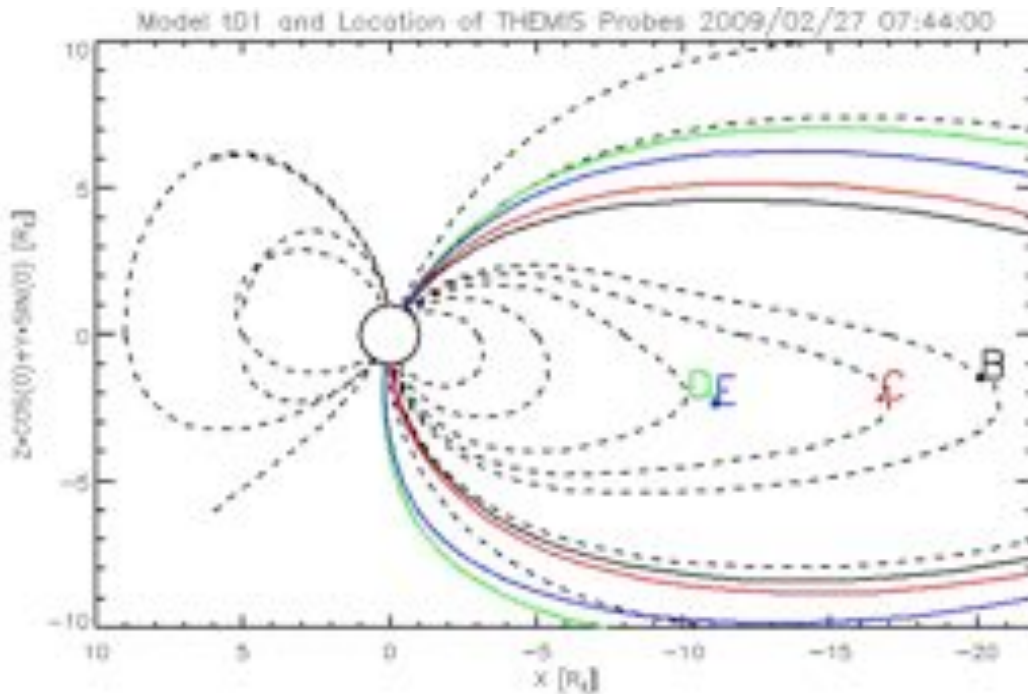
# Using THEMIS for comparison to *in situ* data



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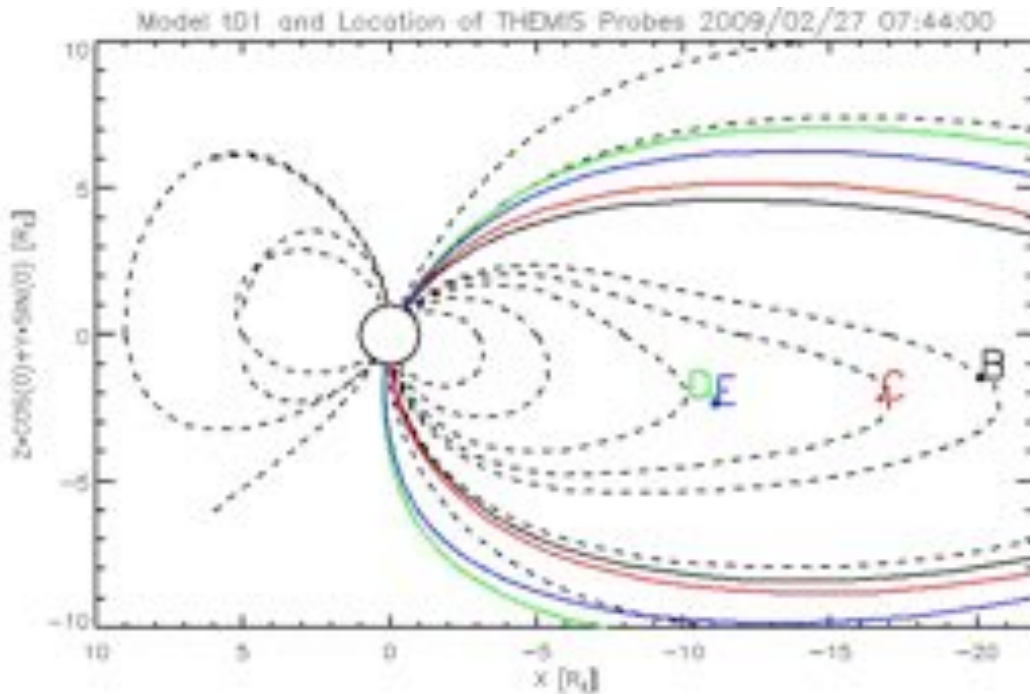
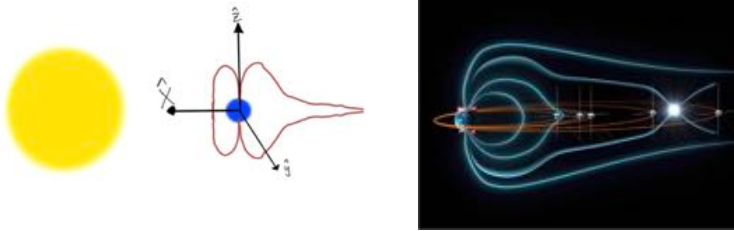


## Density at each spacecraft

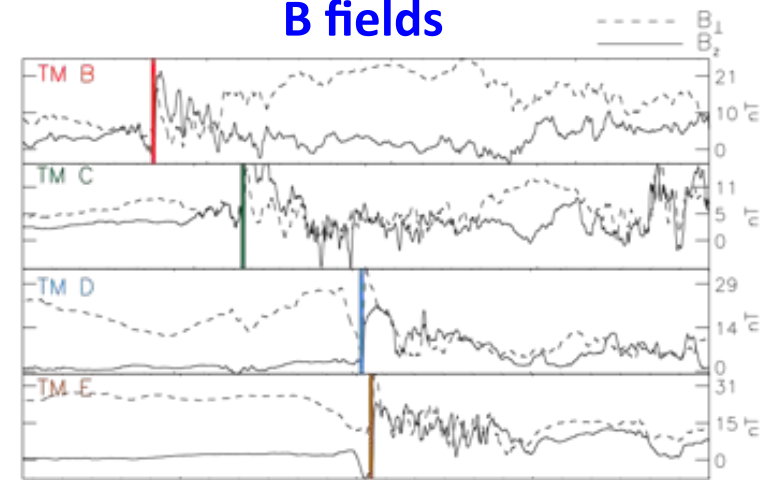


Substantial density drop following the dipolarization event!

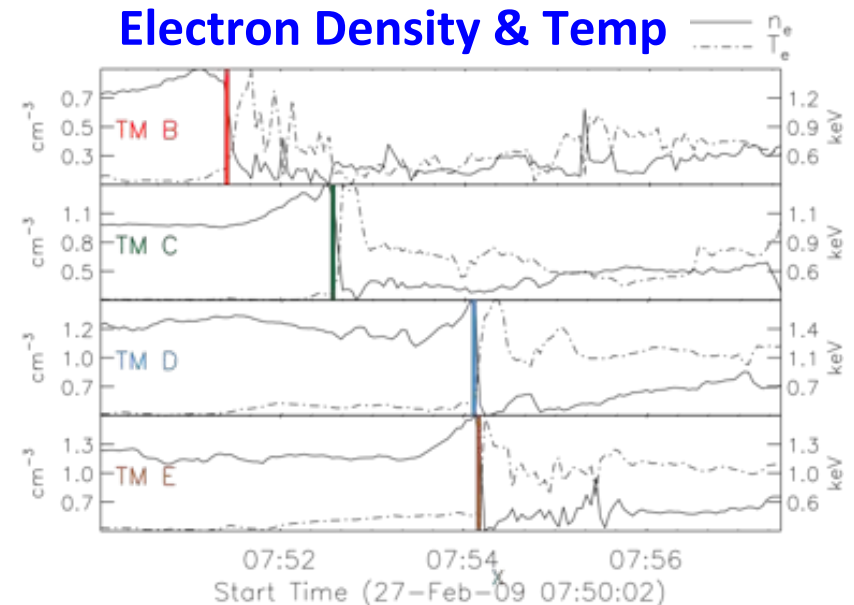
# Using THEMIS for comparison to *in situ* data



## B fields



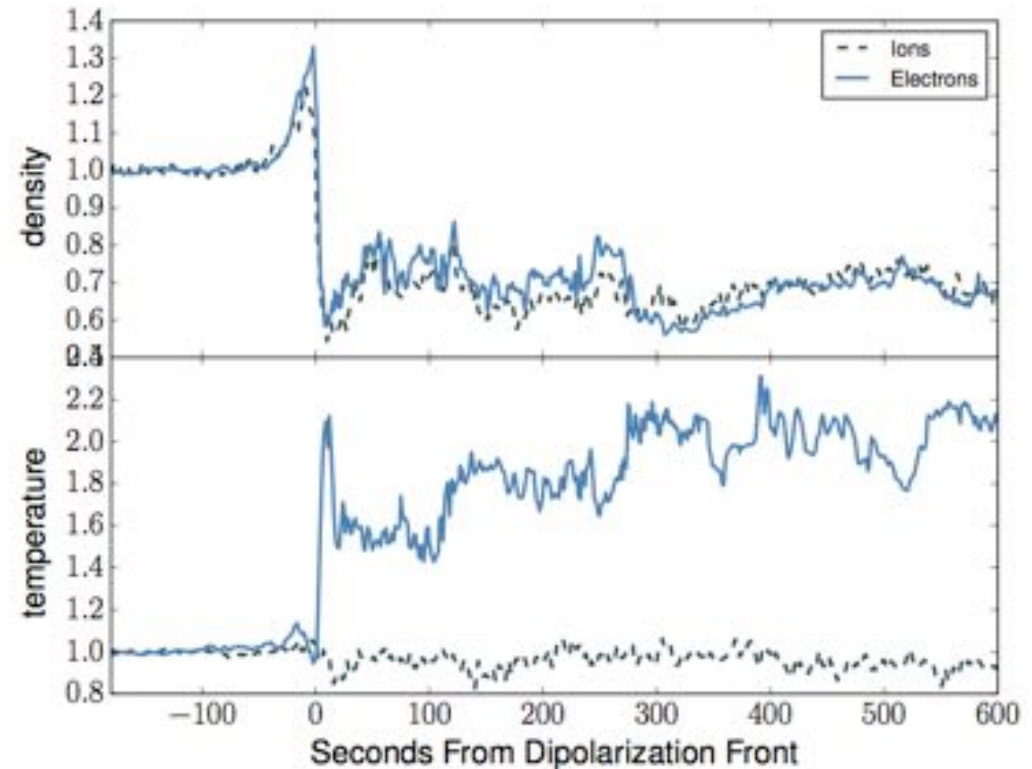
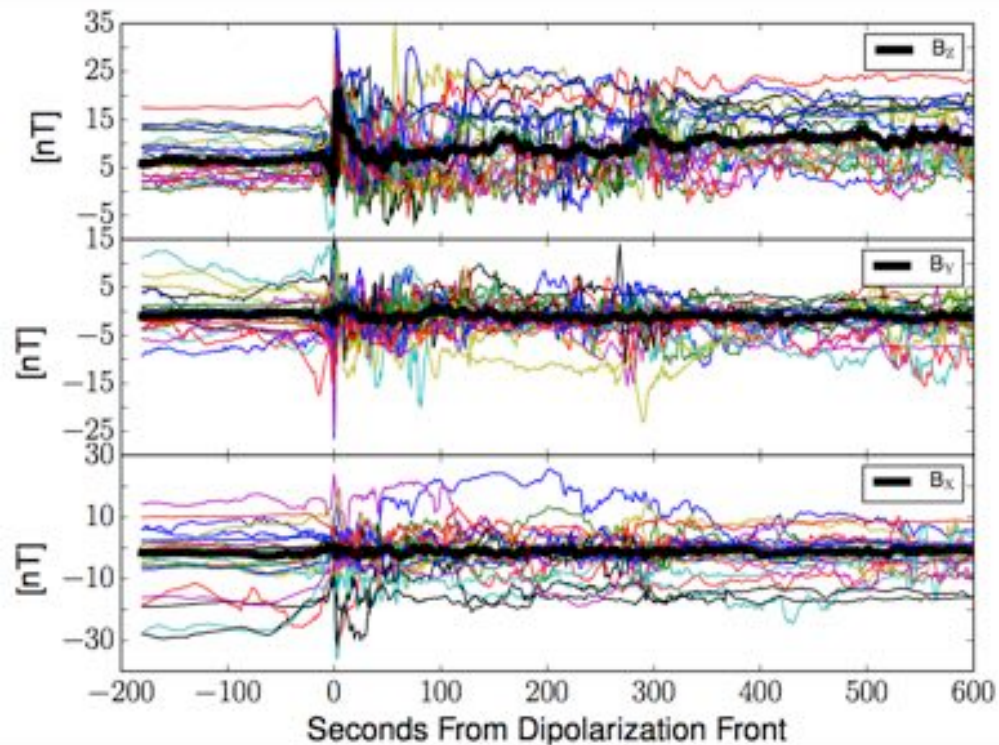
## Electron Density & Temp



Dipolarization fronts defined by reversal in B field.

Electron densities drop. Temperatures increase as front passes.

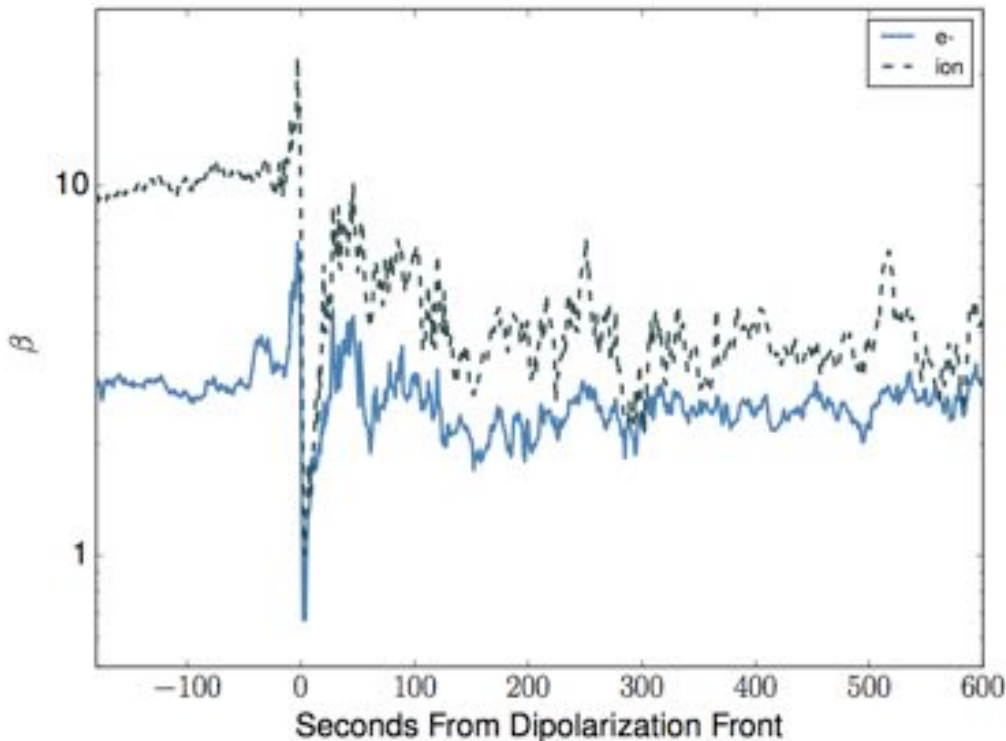
# Using THEMIS for comparison to *in situ* data



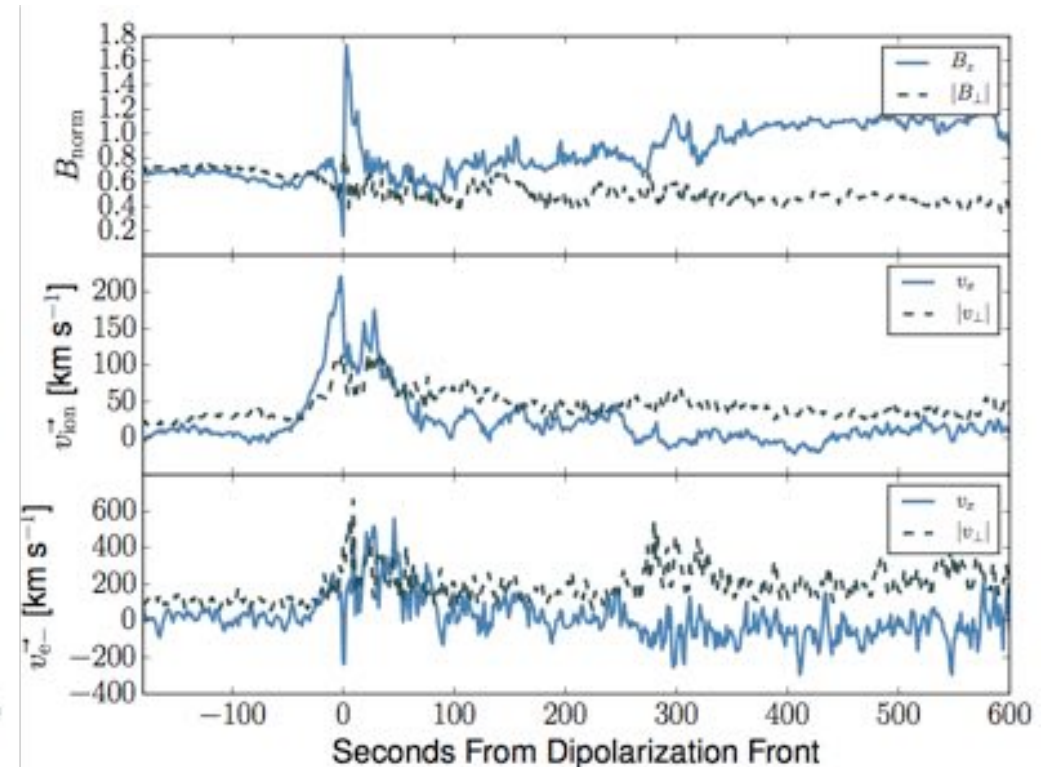
Combination of 6 events observed by up to 5 THEMIS spacecraft  
(listed in Runov et al., 2011)

# Using THEMIS for comparison to *in situ* data

Plasma Beta



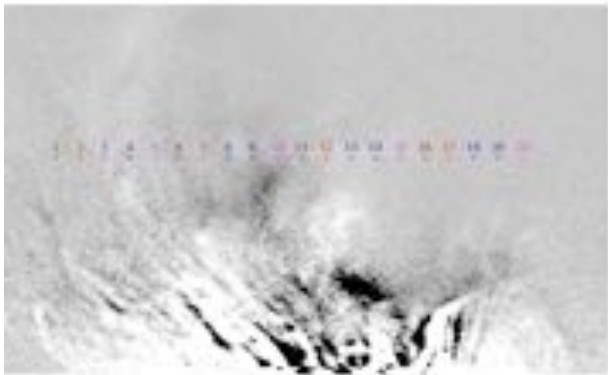
$B_{\text{norm}}$ , Ion velocity, Electron velocity



Combination of 6 events observed by up to 5 THEMIS spacecraft  
(listed in Runov et al., 2011)

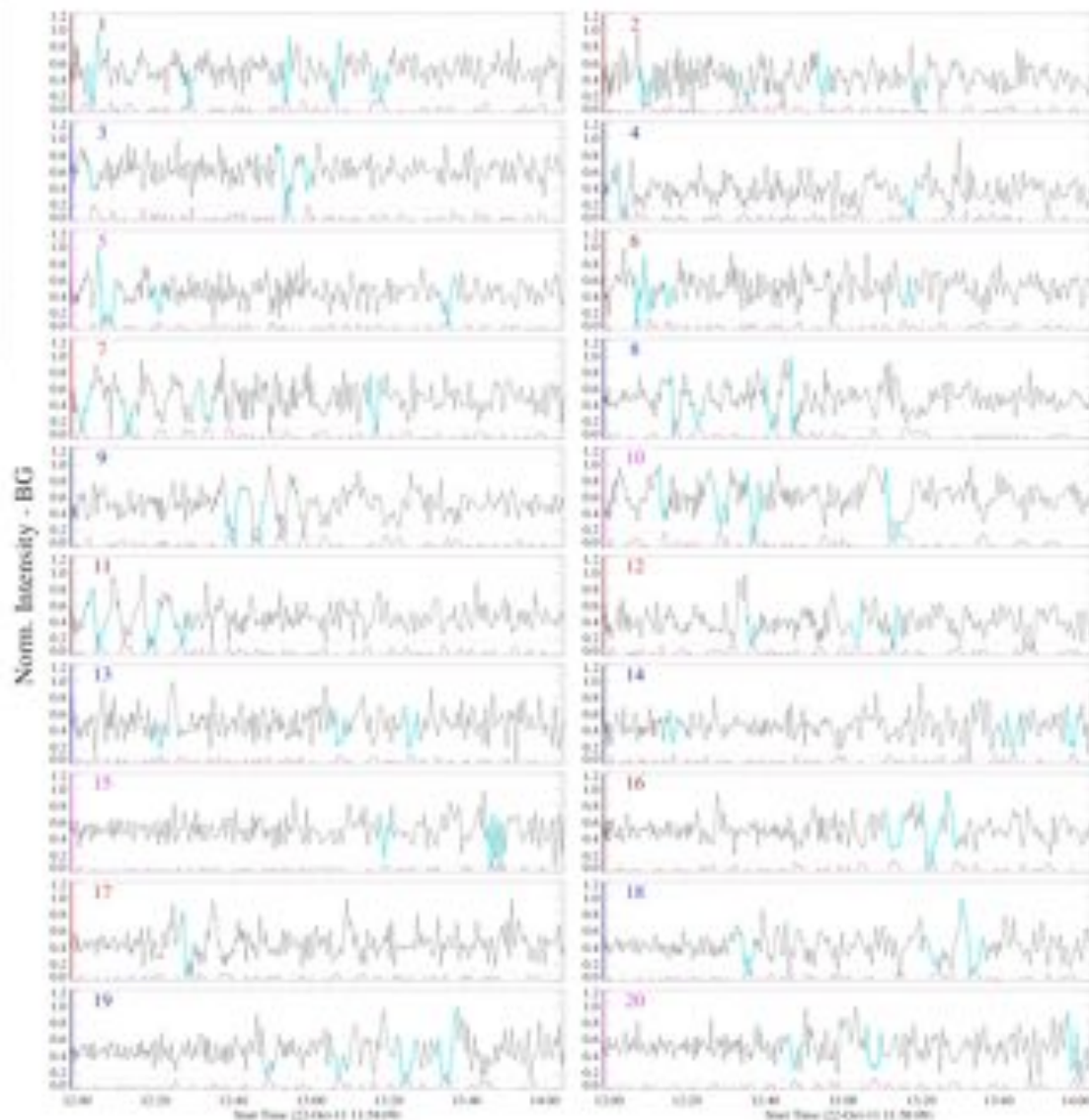


# Mimicking *in situ* data sets in the corona



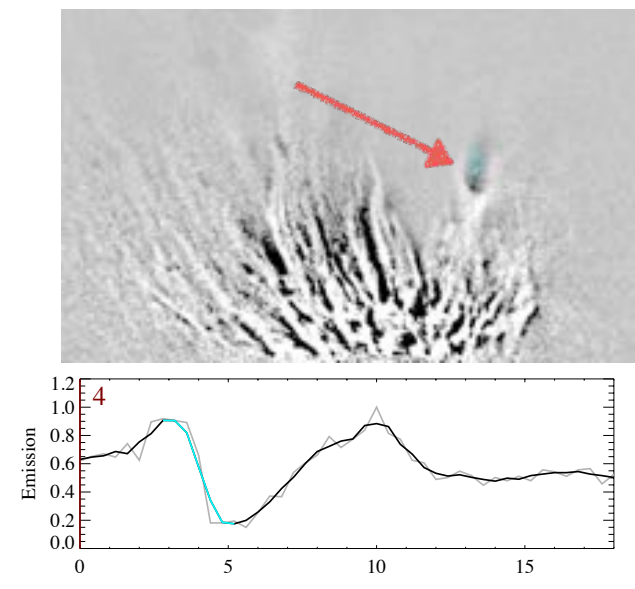
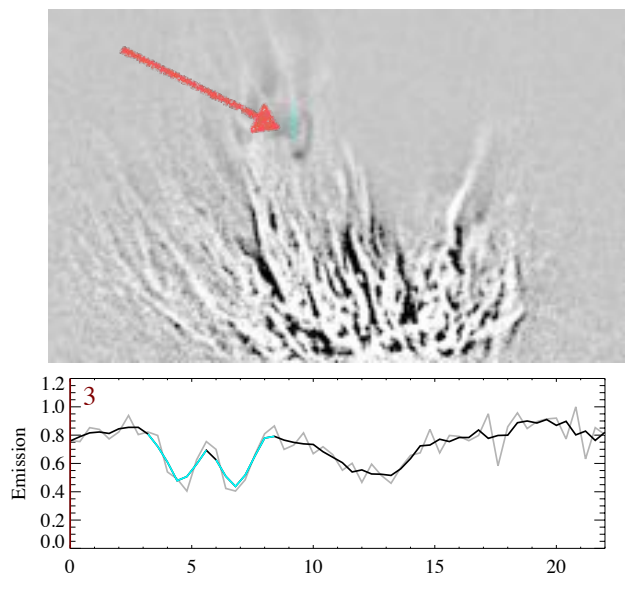
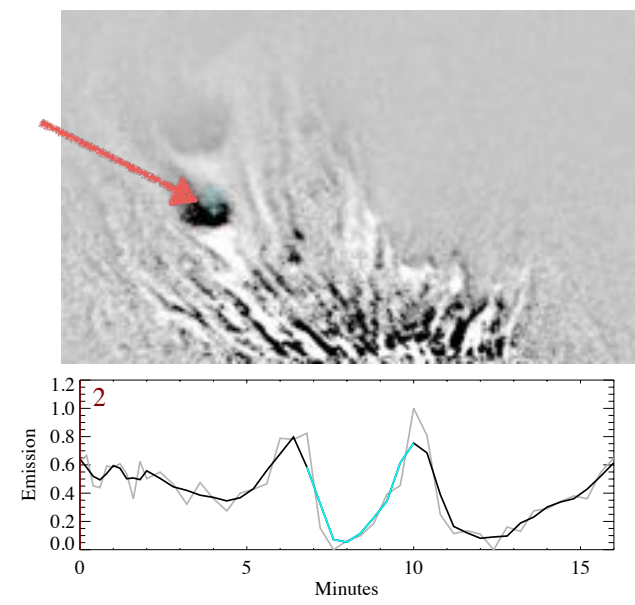
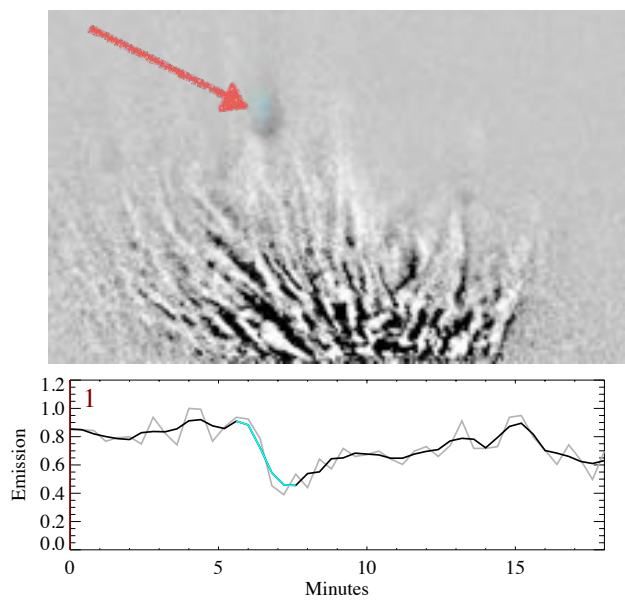
## Fake “satellites” placed in the fan.

- Lightcurves measured and normalized via smoothing
- Convolution function used to automatically detect SAD profiles in lightcurves (cyan indicates a detection)
- Lightcurve plots trace density changes
- Not perfect, but neither is *in situ* data





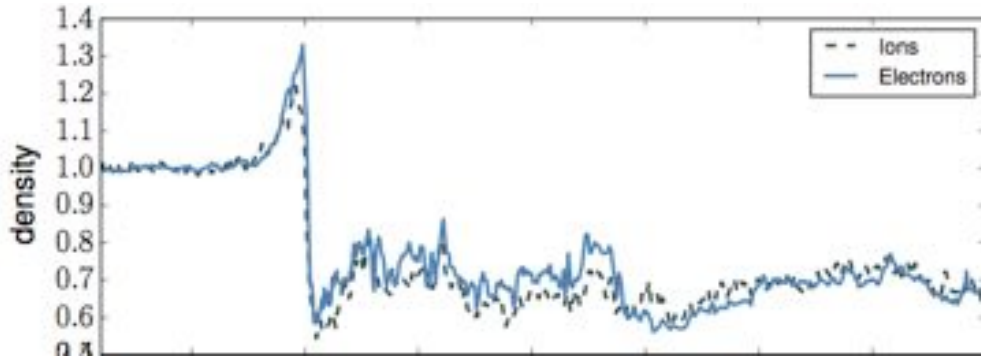
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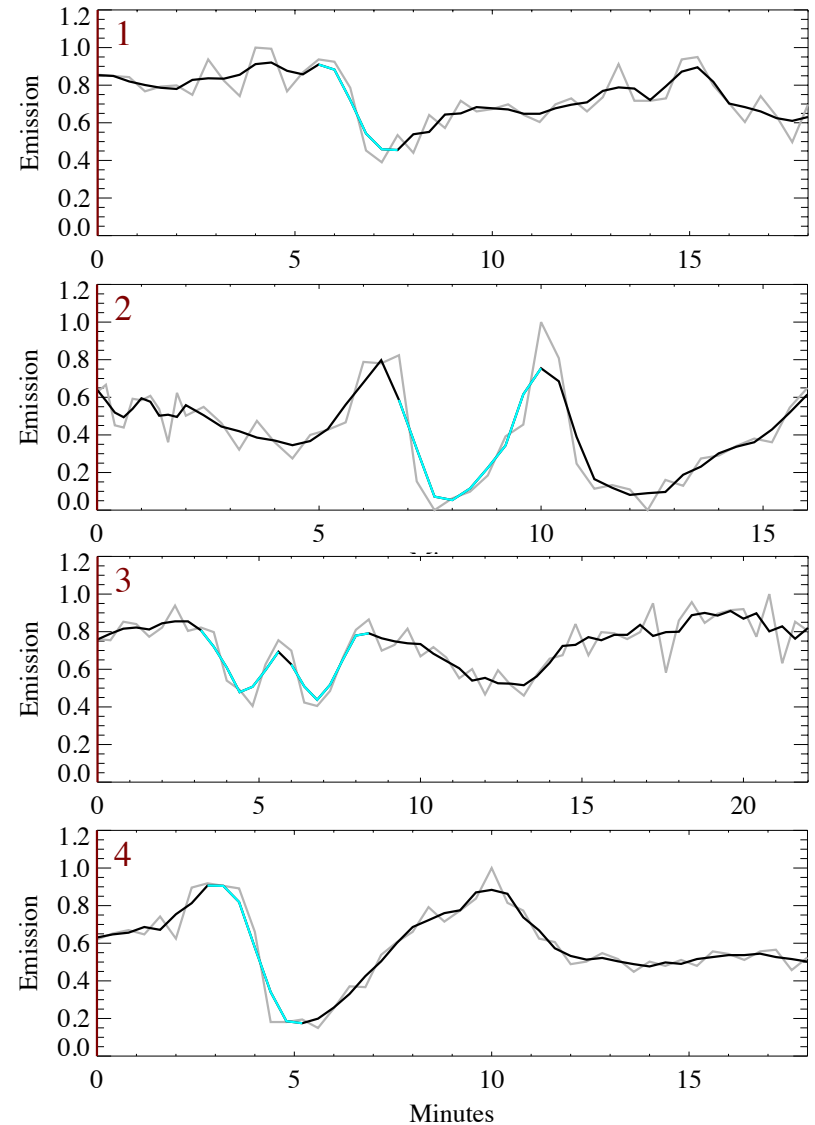


# Quick comparison

## Dipolarization Fronts



## SADs



Immediate future... Temperatures.



# Take aways

- Continuation of shrinking loops can impart energy into the current sheet **long** after the eruption and **high** into the corona.
- *In situ* magnetotail data being used to inform remote sensing coronal data (and eventually vice versa...)
- COSIE instrument would immensely add to our transitional corona knowledge

