

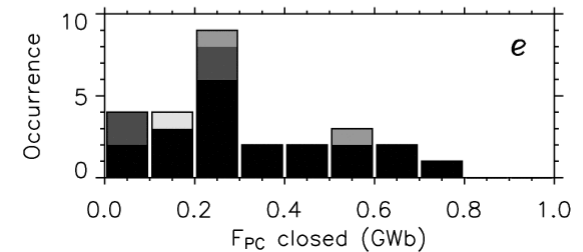
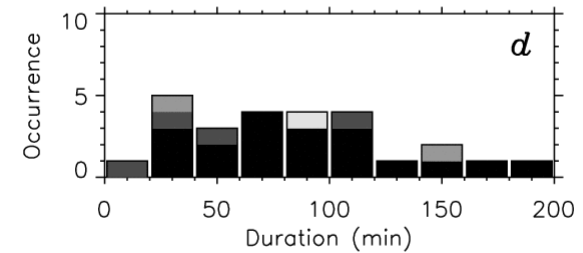
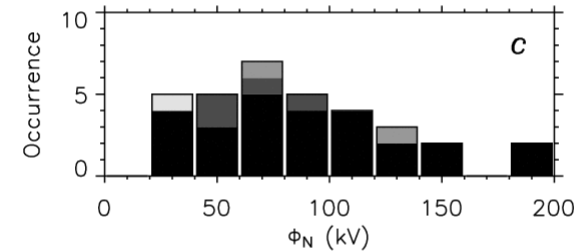
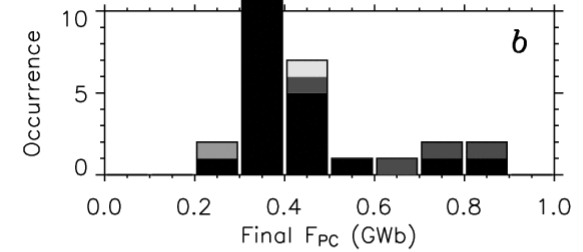
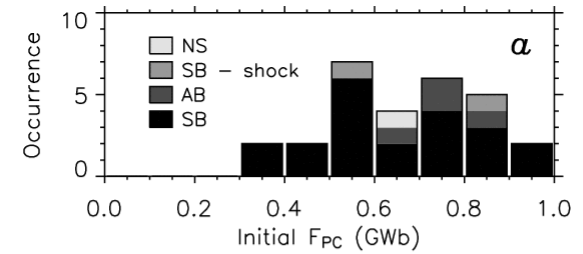
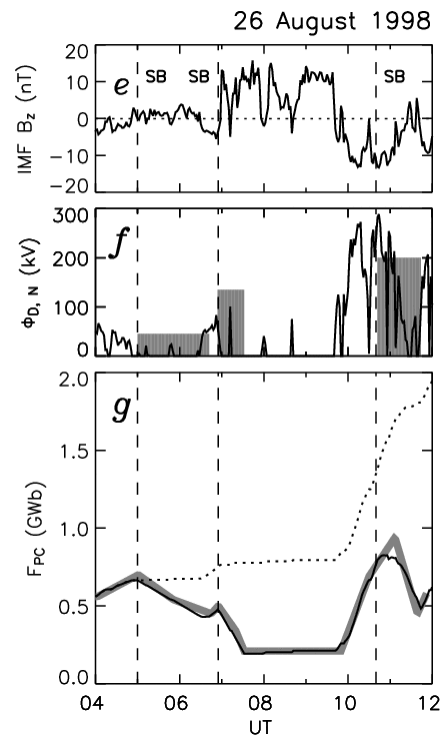
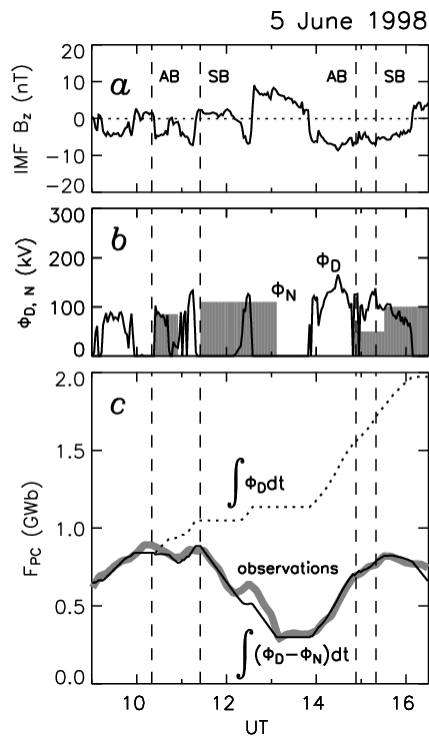
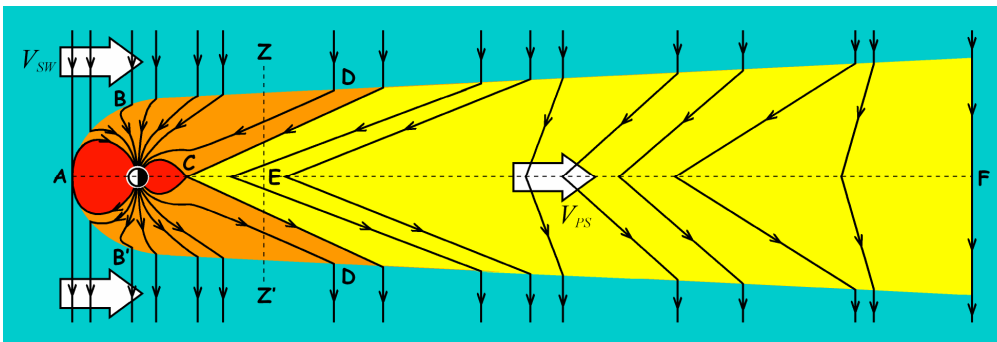
Flux closure during a substorm observed by Cluster, Double Star, IMAGE FUV, SuperDARN, and Greenland magnetometers

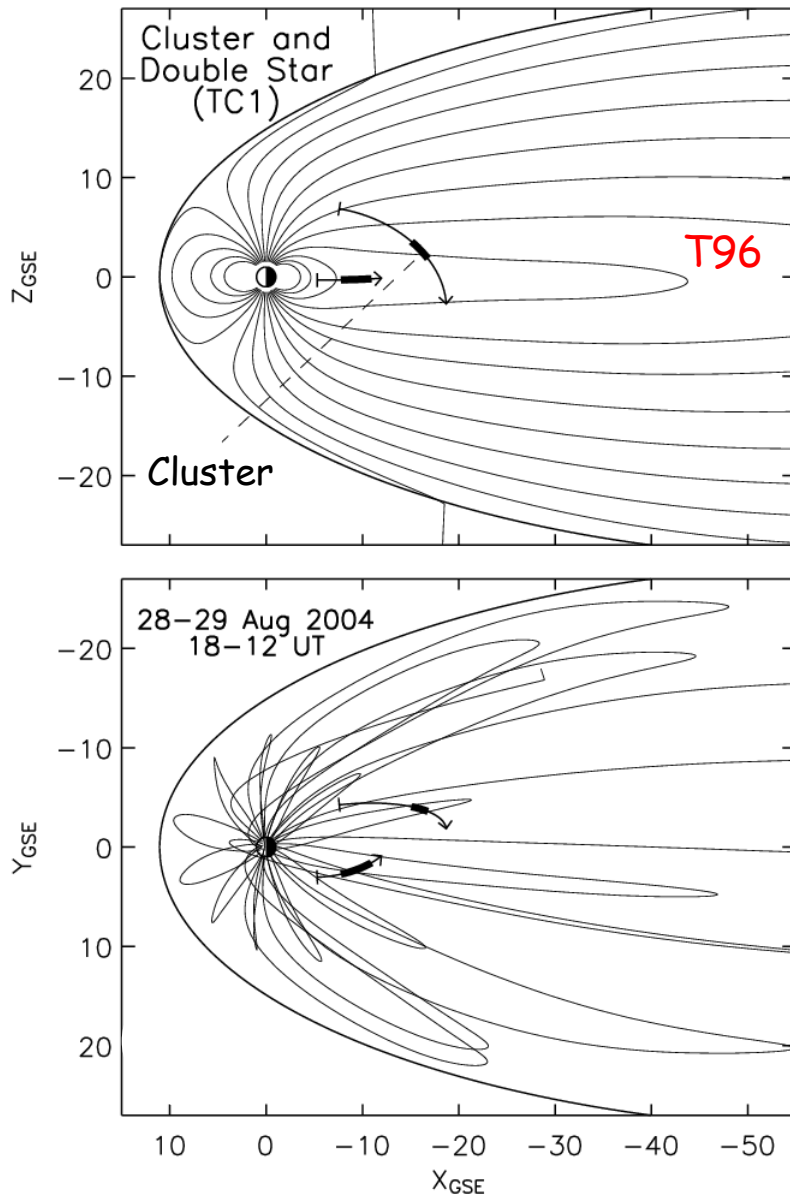
S. E. Milan¹, J. A. Wild², B. Hubert³, C. M. Carr⁴,
E. A. Lucek⁴, J. M. Bosqued⁵, J. F. Watermann⁶,
and J. A. Slavin⁷

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⁶Danish Meteorological Institute, ⁷NASA GSFC



Flux transfer during substorms - statistical picture





28-29 August 2004

Cluster	18:00-12:00 UT
Double Star	00:00-06:00 UT
Highlighted	01:30-04:30 UT

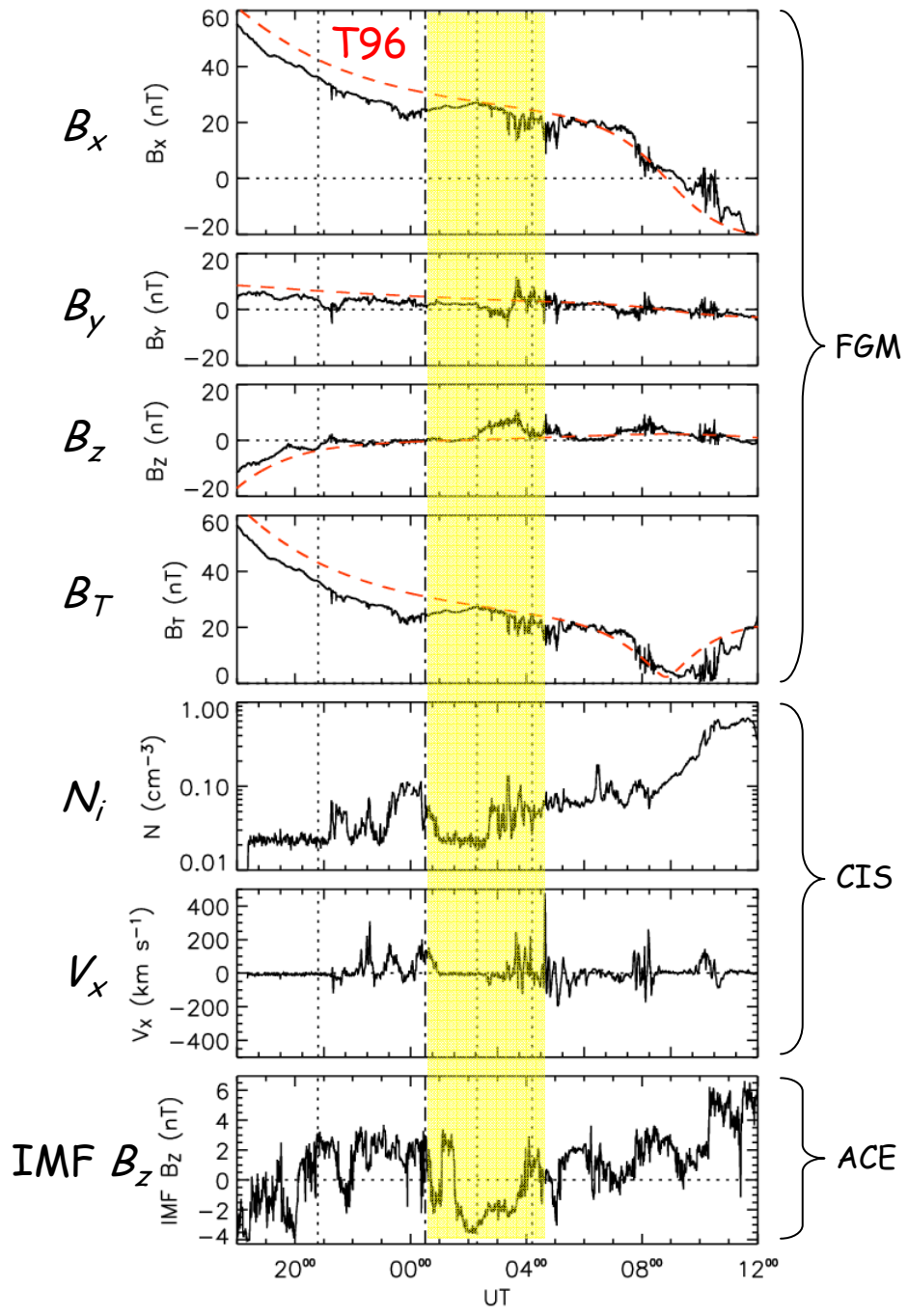
Excellent conjunction for study
of substorm dynamics in the
near tail

Event selection:

Cluster and Double Star in tail

Substorm onset (FUV)

Reasonable SuperDARN coverage



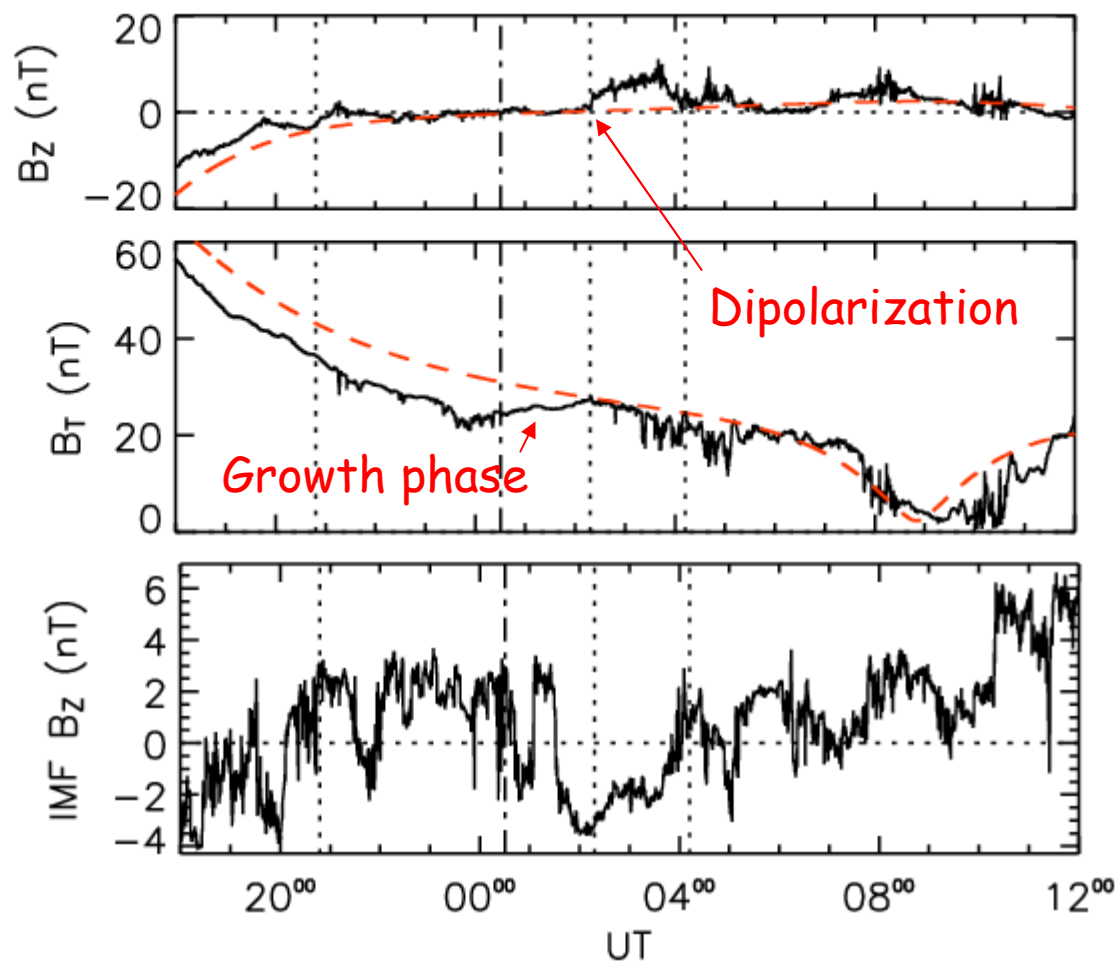
Cluster overview

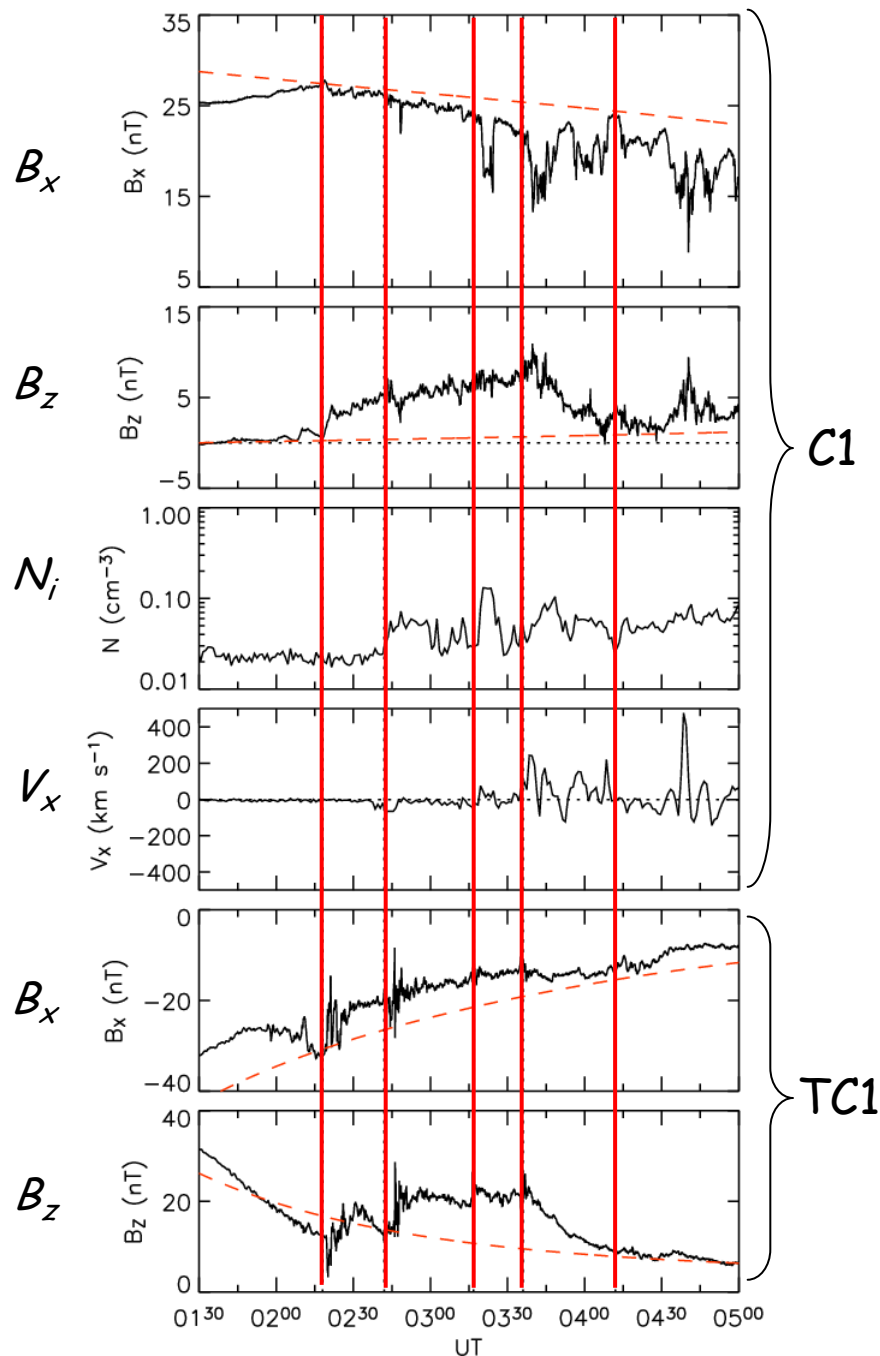
A first substorm (dipolarization) is observed at 20:40 UT;
Cluster encounters plasma sheet

Southward turning of IMF leads to increase in B_T in tail:
"growth phase", including plasma sheet thinning

Second dipolarization at 02:20 UT;
shortly after Cluster encounters plasma sheet again

Eventually, Cluster crosses neutral sheet 09:00 UT





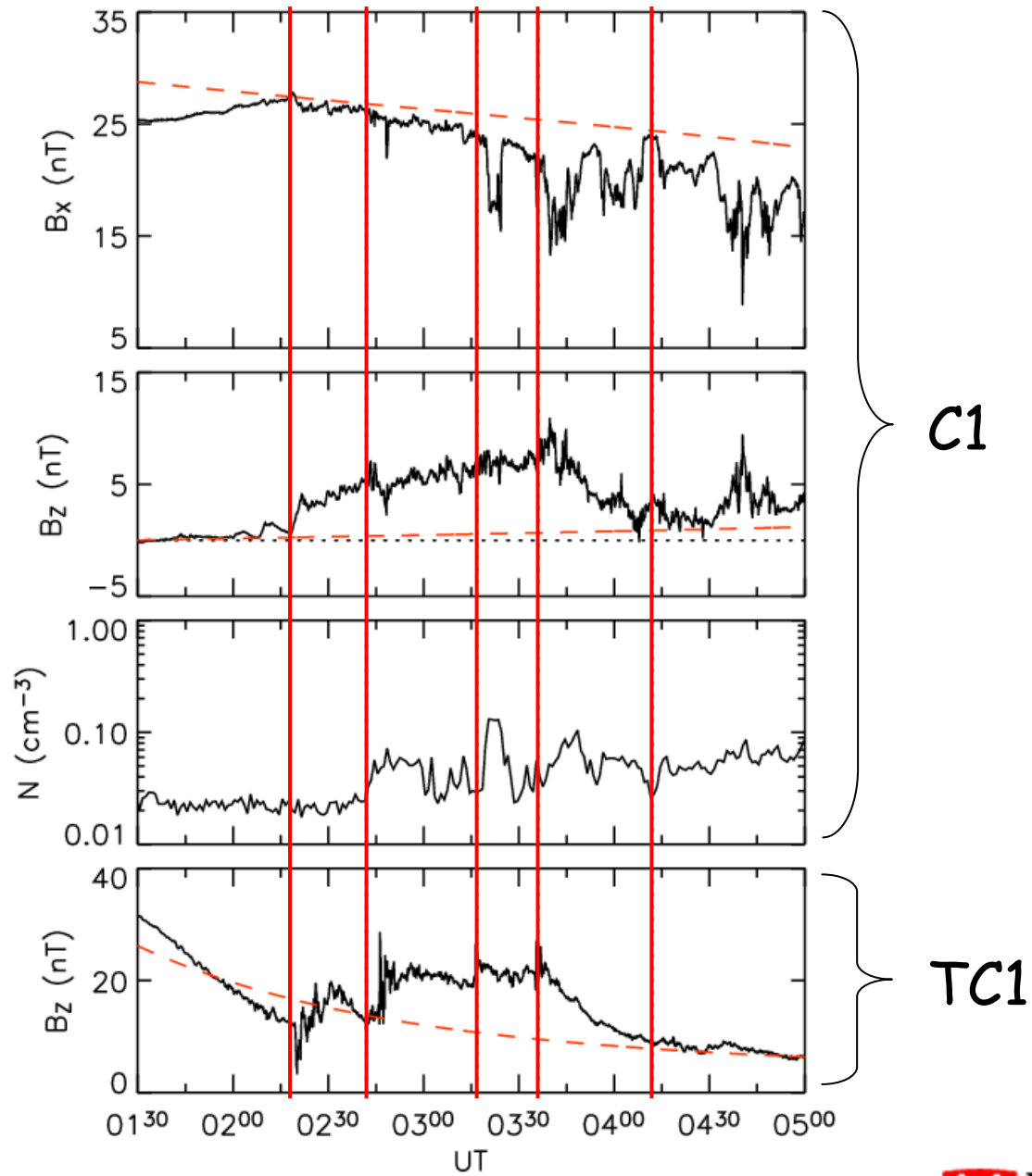
Magnetotail

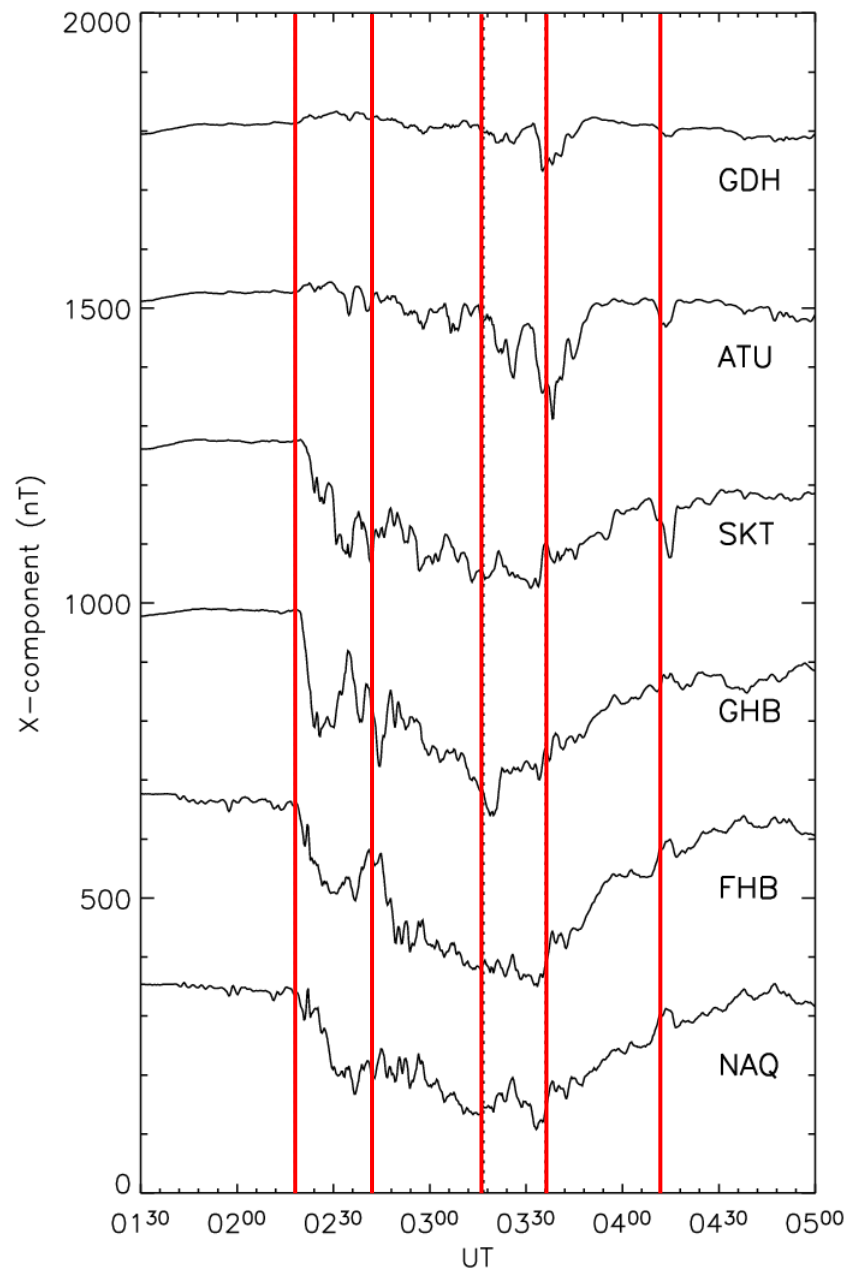
After 02:00 UT, TC1 sees a tail-like field develop

At 02:20 UT, C1 and TC1 both observe a dipolarization; C1 remains in the lobe

Thereafter, TC1 observes a succession of dipolarizations, each preceding an encounter of the plasma sheet by C1

Both C1 and TC1 B_z components relax after 03:45 UT





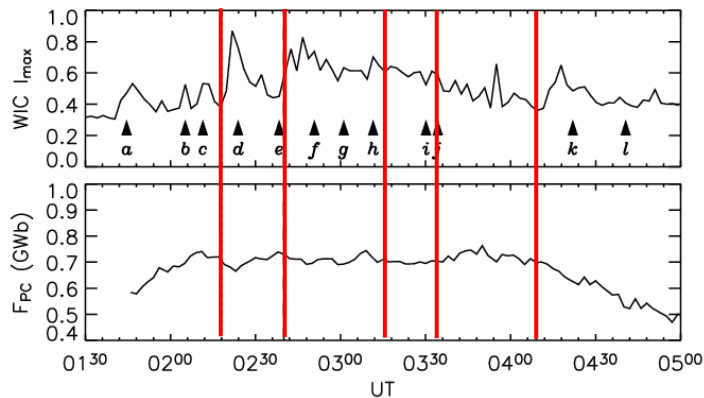
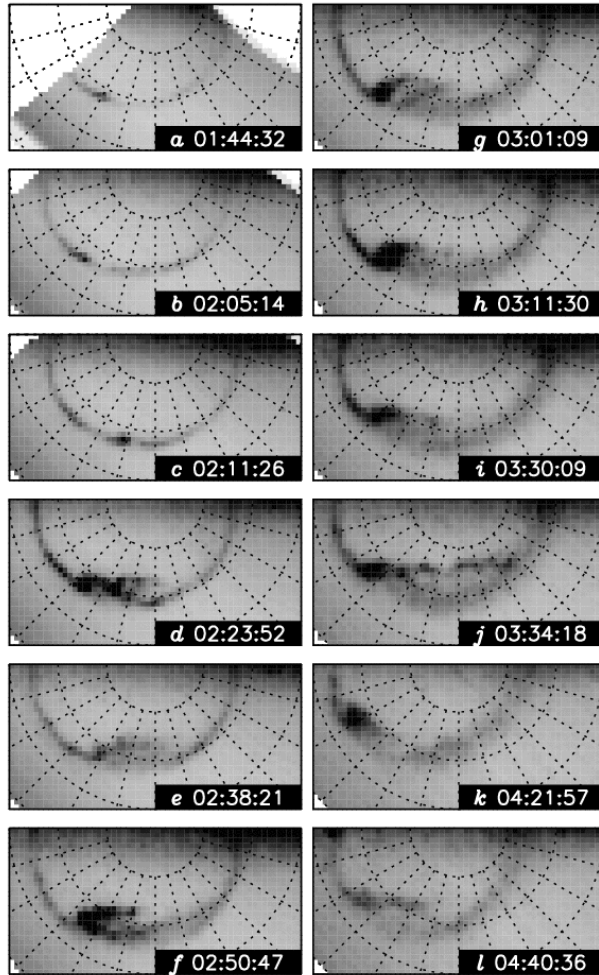
Greenland magnetometer chain

All dipolarizations have clear magnetic signatures on the ground

The first gives rise to a modest 200 nT bay

The major re-intensification results in a bay of 300-400 nT
(westwards electrojet, substorm current wedge)

Bays associated with subsequent dipolarizations are seen at increasing latitudes

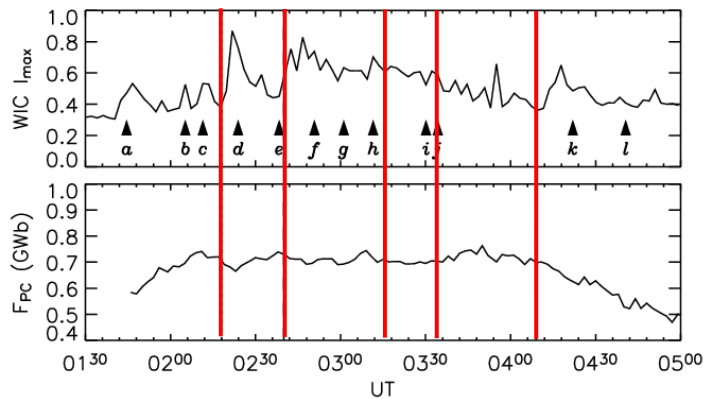
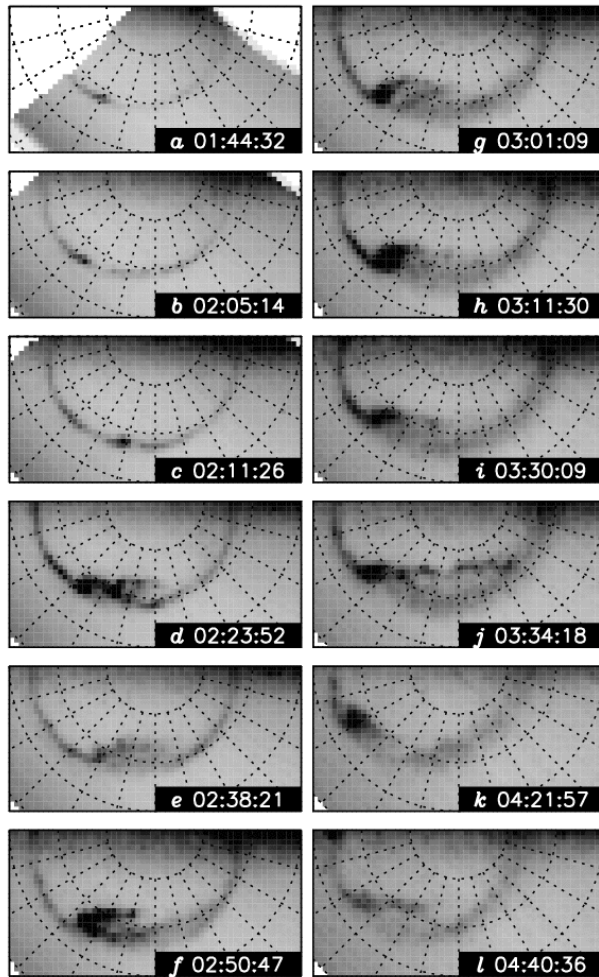


Aurora

The IMAGE spacecraft was imaging the Southern Hemisphere aurora

WIC images show initial brightenings, a first onset, a major re-brightening and the subsequent development of a westward-travelling surge

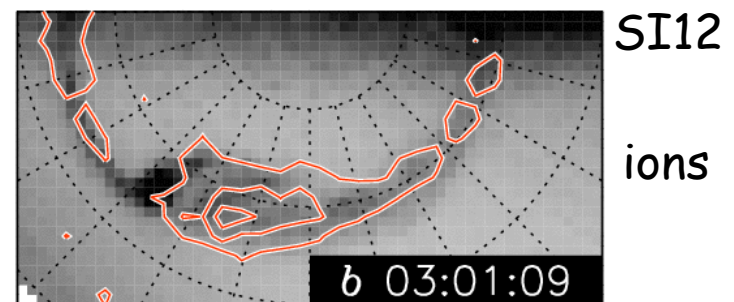
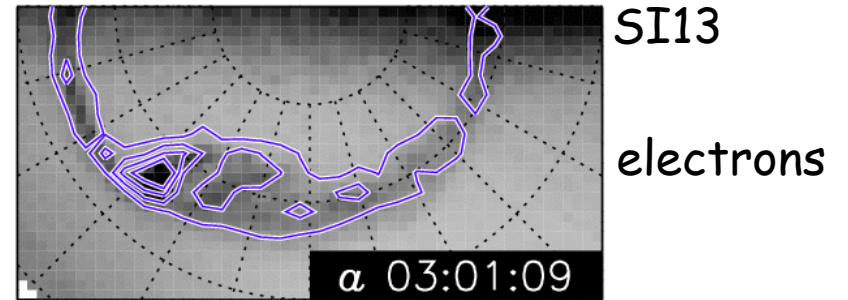
Estimates of the polar cap area and open flux reveal the growth phase (dayside reconnection rate ~ 70 kV), and eventual destruction of open flux (nightside reconnection ~ 70 kV)

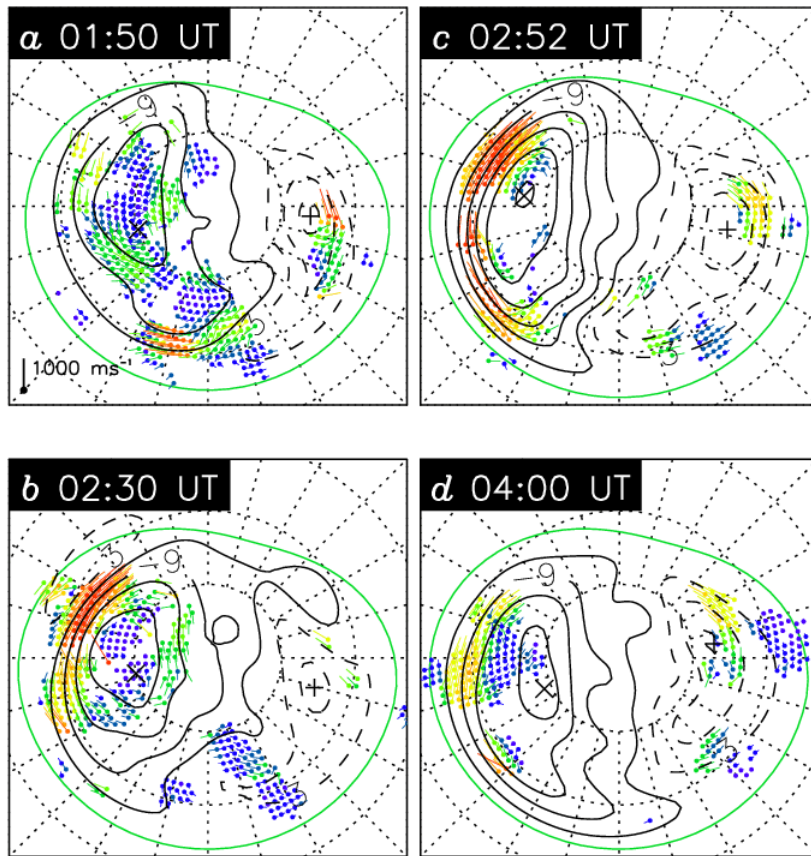


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SI12 and SI13 channels reveal locations of ion and electron precipitation: substorm current wedge?



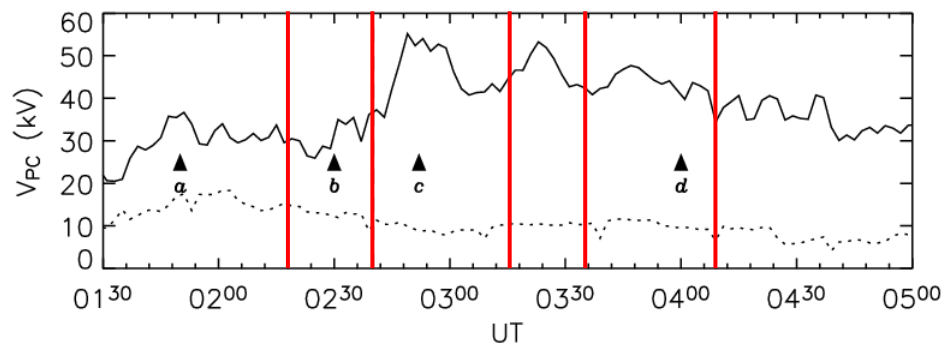


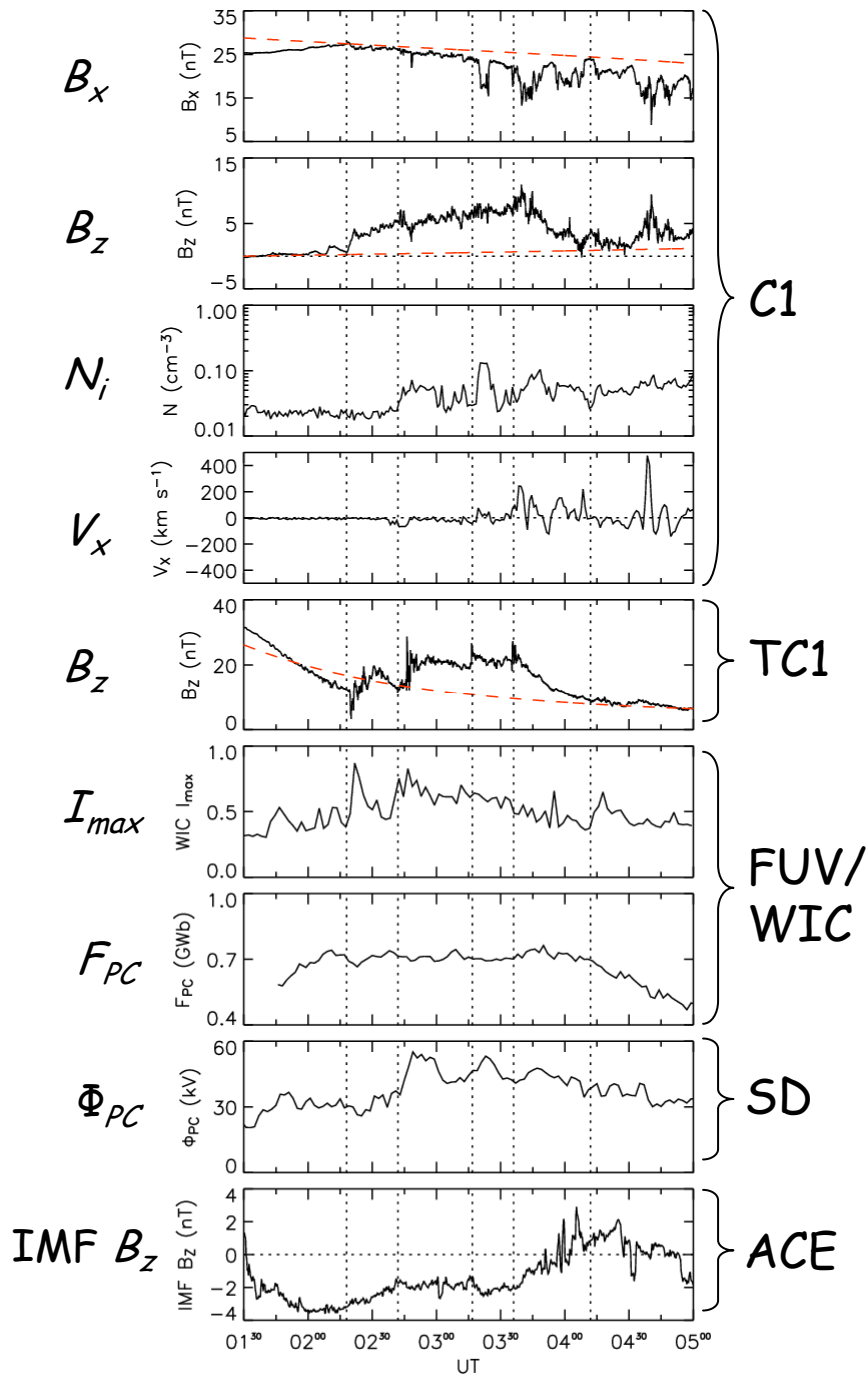
Convection

SuperDARN was measuring convection in the Northern Hemisphere

No convection response at time of first onset

Convection enhanced at rebrightening and remains elevated until 04:30 UT

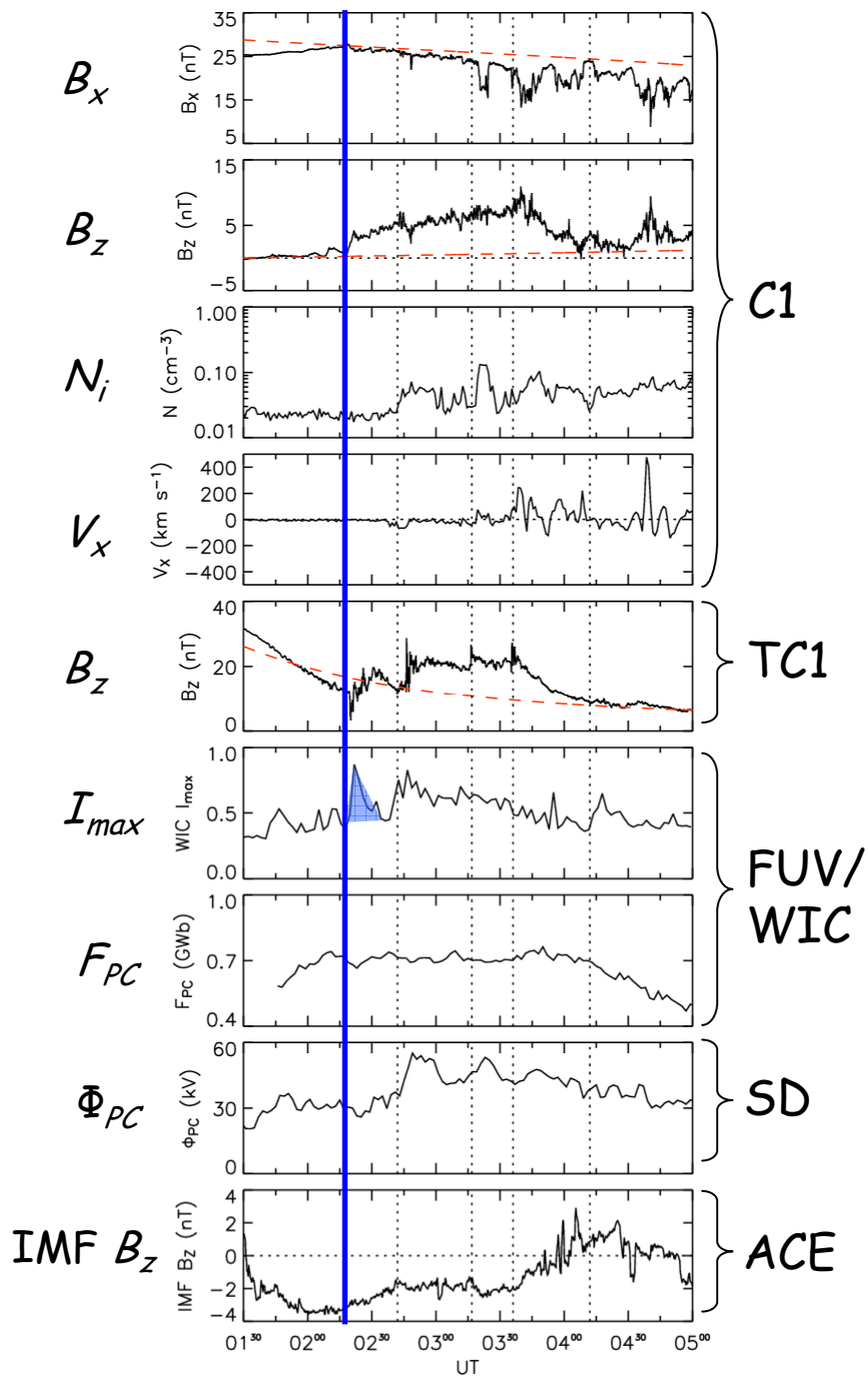




Synthesis

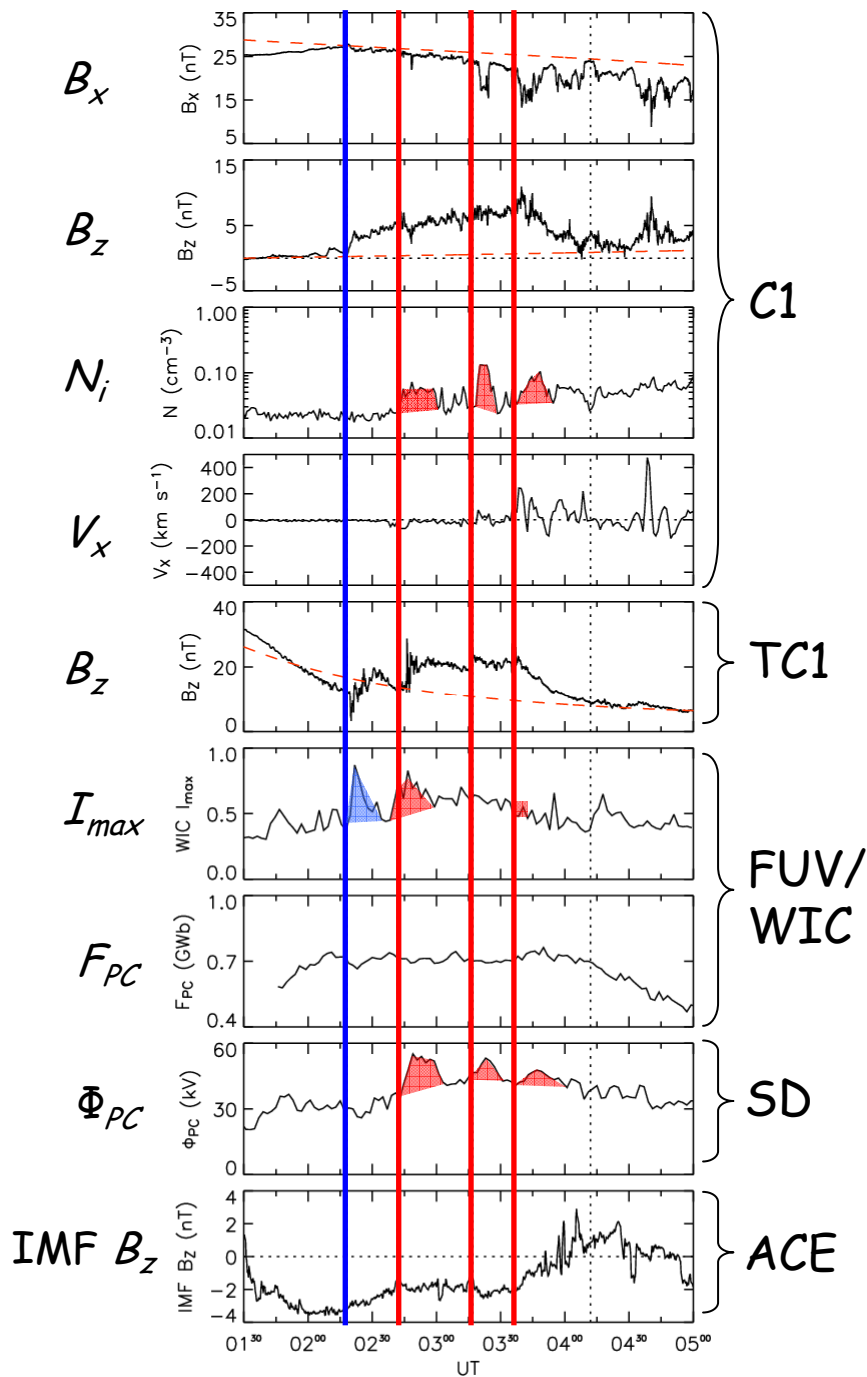
1. Initial dipolarization is onset of reconnection of closed flux
 - short-lived auroral signature
 - end of increase in B_x
 - no convection signature
 - no expansion of plasma sheet
2. Subsequent dipolarizations are bursts of reconnection of open flux
 - auroral signatures (PBIs)
 - convection signatures
 - cause expansions of plasma sheet
3. Prior to onset dayside reconnection dominates; after onset, dayside and nightside are equal; nightside continues after IMF turns northwards and dayside reconnection ceases
4. B_z relaxes after northward-turning: reconnection prior to this driven?





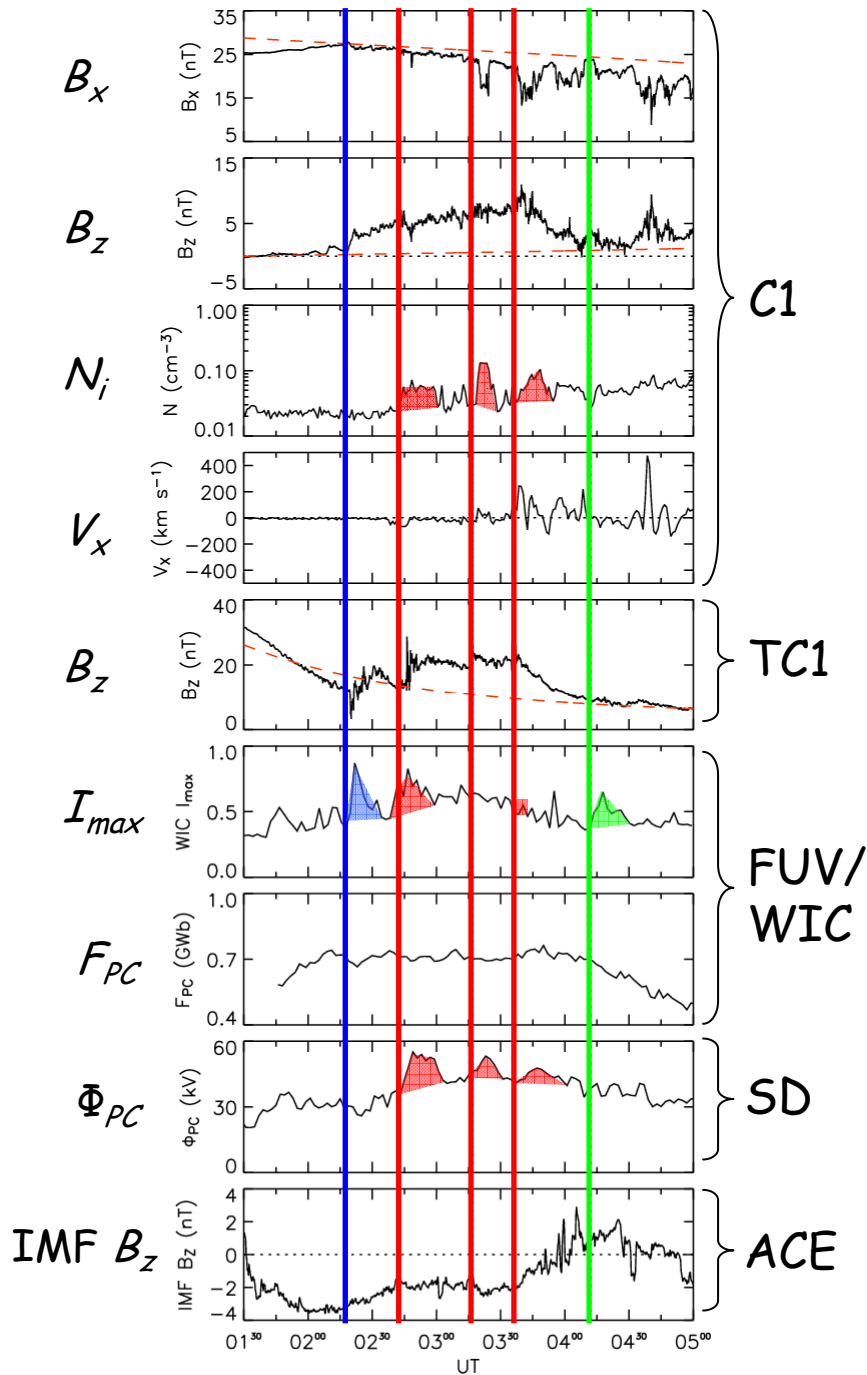
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Summary

A combination of Cluster, Double Star and ground observations reveals flux closure at a rate of ~ 70 kV during a prolonged period of substorm activity

Activity is prolonged due to on-going dayside production of open flux

Nightside reconnection occurs in 5 bursts, each responsible for closure of ~ 0.2 GWb of flux

First closed flux is reconnected, then 4 bursts of closure of open flux, each burst accompanied by dipolarizations and convection and auroral enhancements

