Polar Patches

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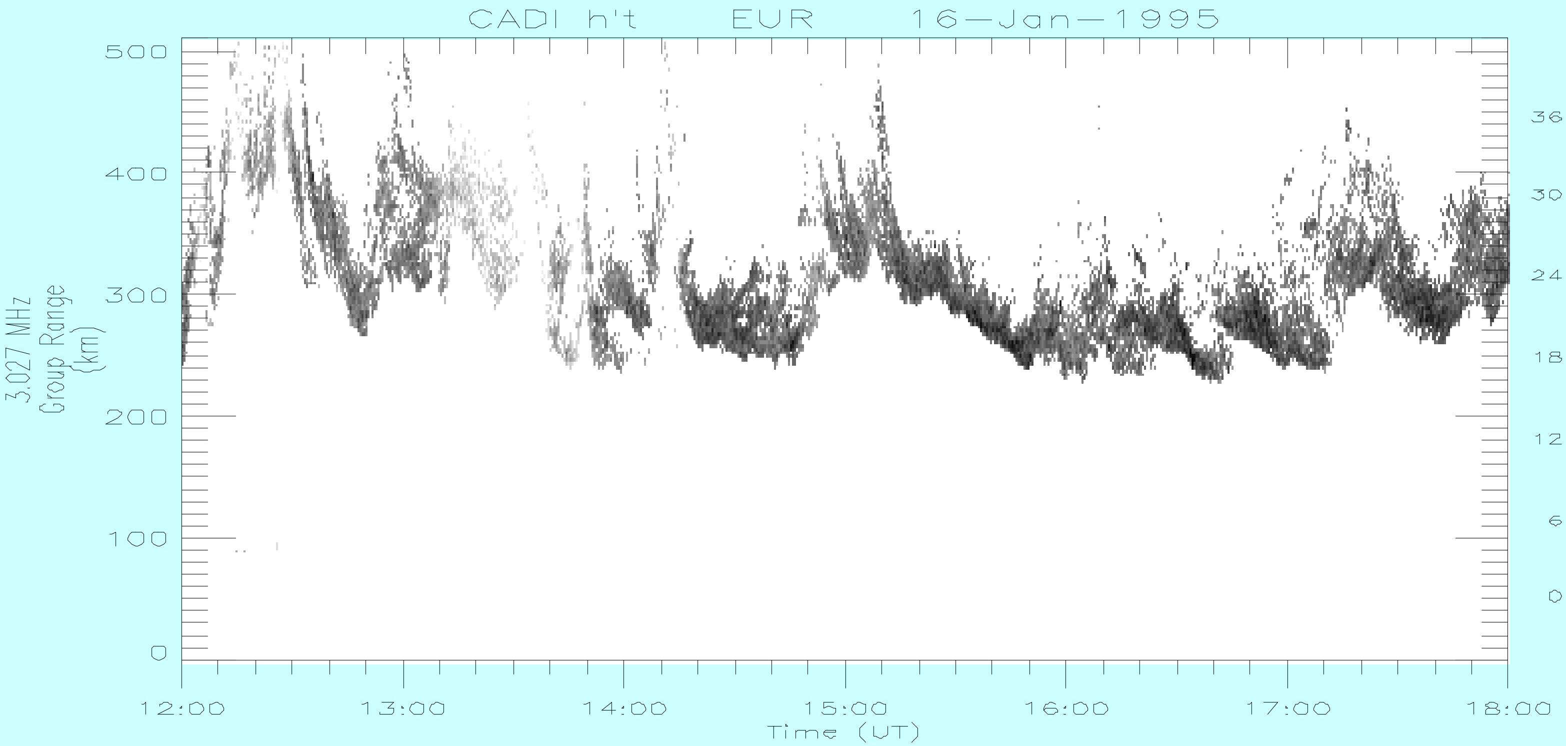
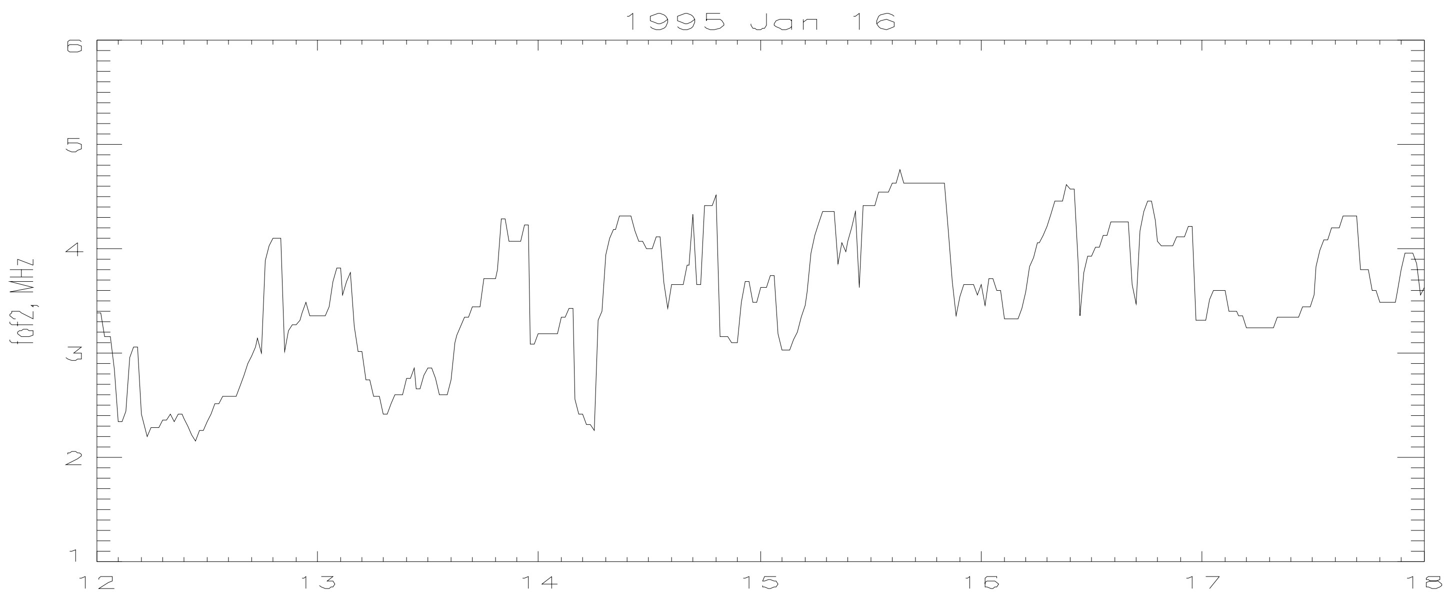
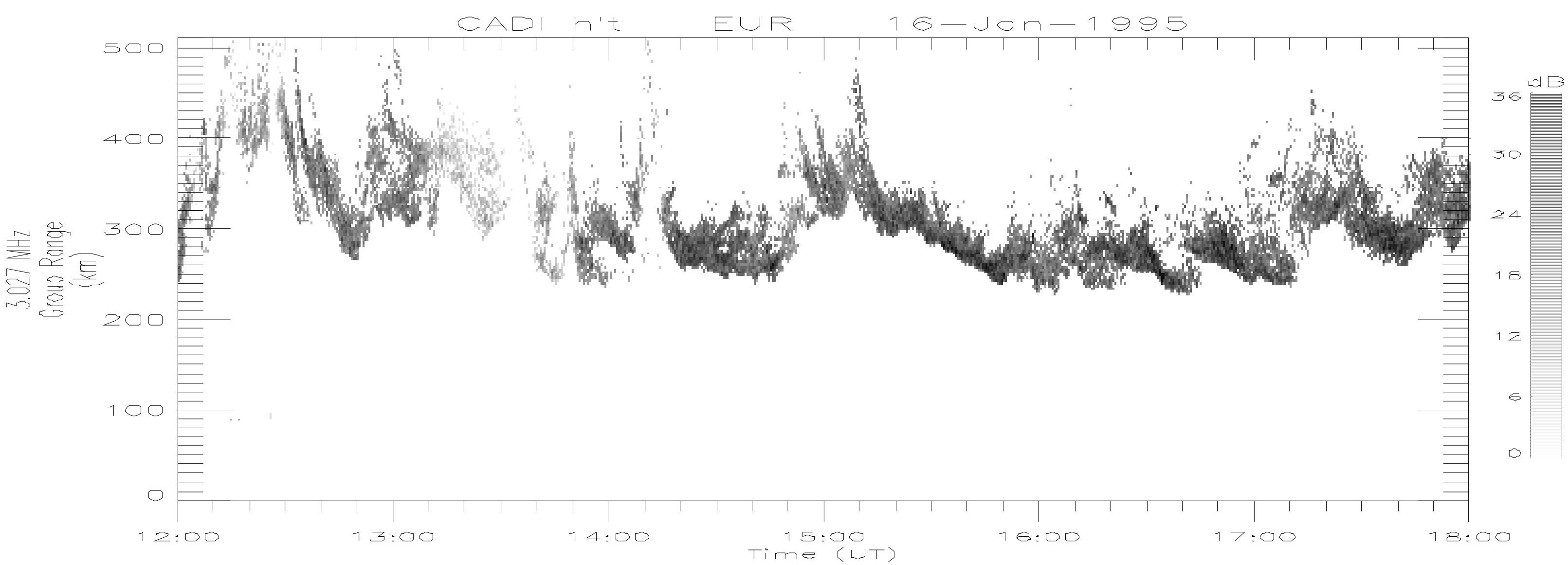
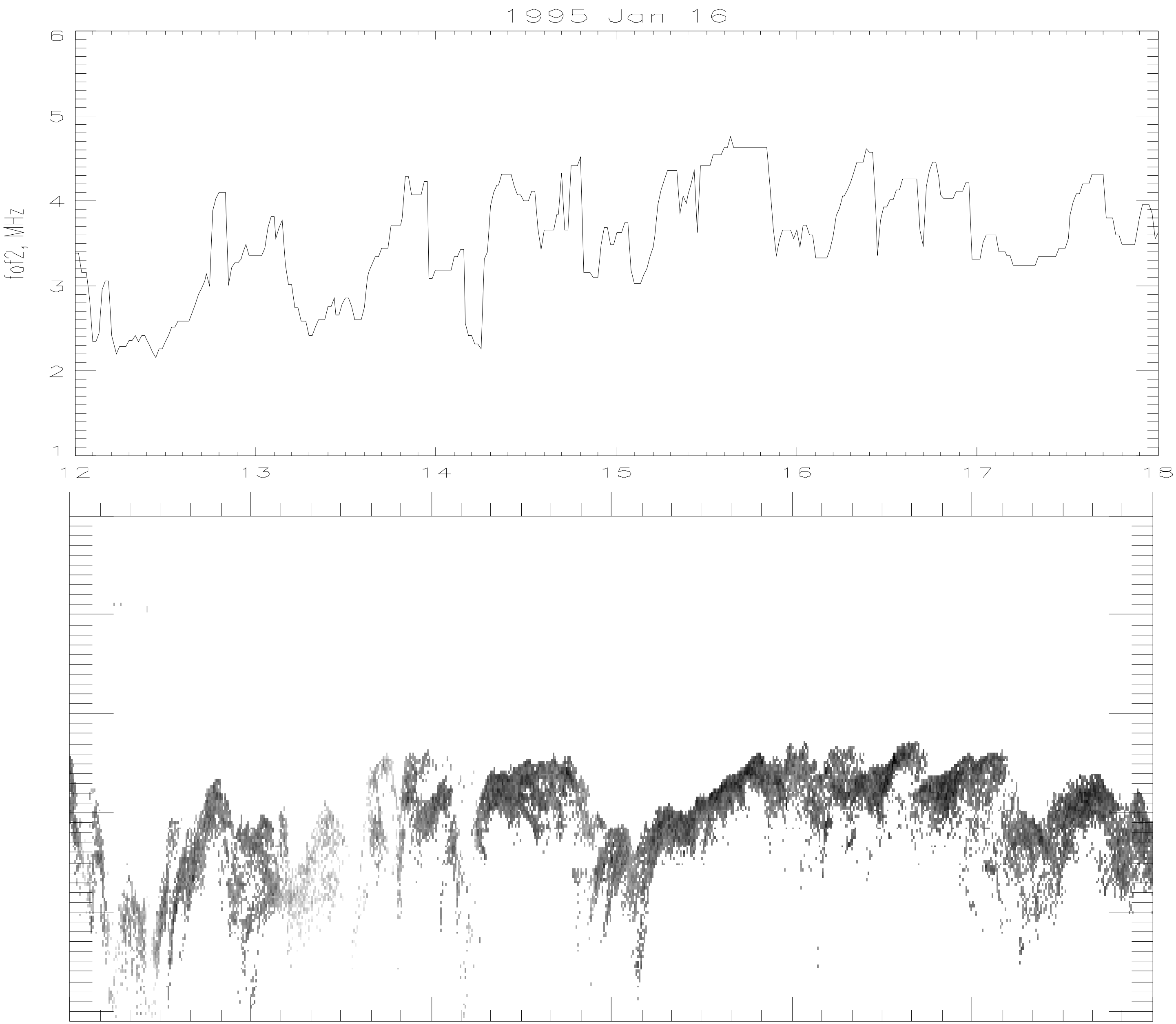



1995 Jan 16
fof2, MHz
1
2
3
4
5
6
12
13
14
15
16
17
18


CADI h't EUR 16-Jan-1995
3.027 MHz
Group Range
(km)
0
100
200
300
400
500
12:00
13:00
14:00
15:00
16:00
17:00
18:00
Time (UT)
dB
36
30
24
18
12
6
0


1995 Jan 16
foF2, MHz
1
2
3
4
5
6
12
13
14
15
16
17
18

‘Official’ patch definition:-

- Doubling of electron density[1]
- Size > 100 km

1 Doubling electron density ≡ 40% increase of fof2

Patch Formation Theories

The obvious way: $dN_e/dt = N_e$ div $V_{convection}$

Doesn't work as shown here:-

$$V_{convection} = ExB/B^2$$

$$\therefore dN_e/dt = N_e \nabla.V_{convection} = N_e \nabla.(ExB/B^2)$$

$$= N_e\{ [(B.\nabla xE) - E.(\nabla xB)]/B^2 - 2 (ExB/B^2)\nabla B/B\}$$

$$\Uparrow \qquad\qquad \Uparrow$$

$$- dB/dt \qquad\qquad 1/c^2 \text{ x } dE/dt$$

All 3 terms are negligibly small

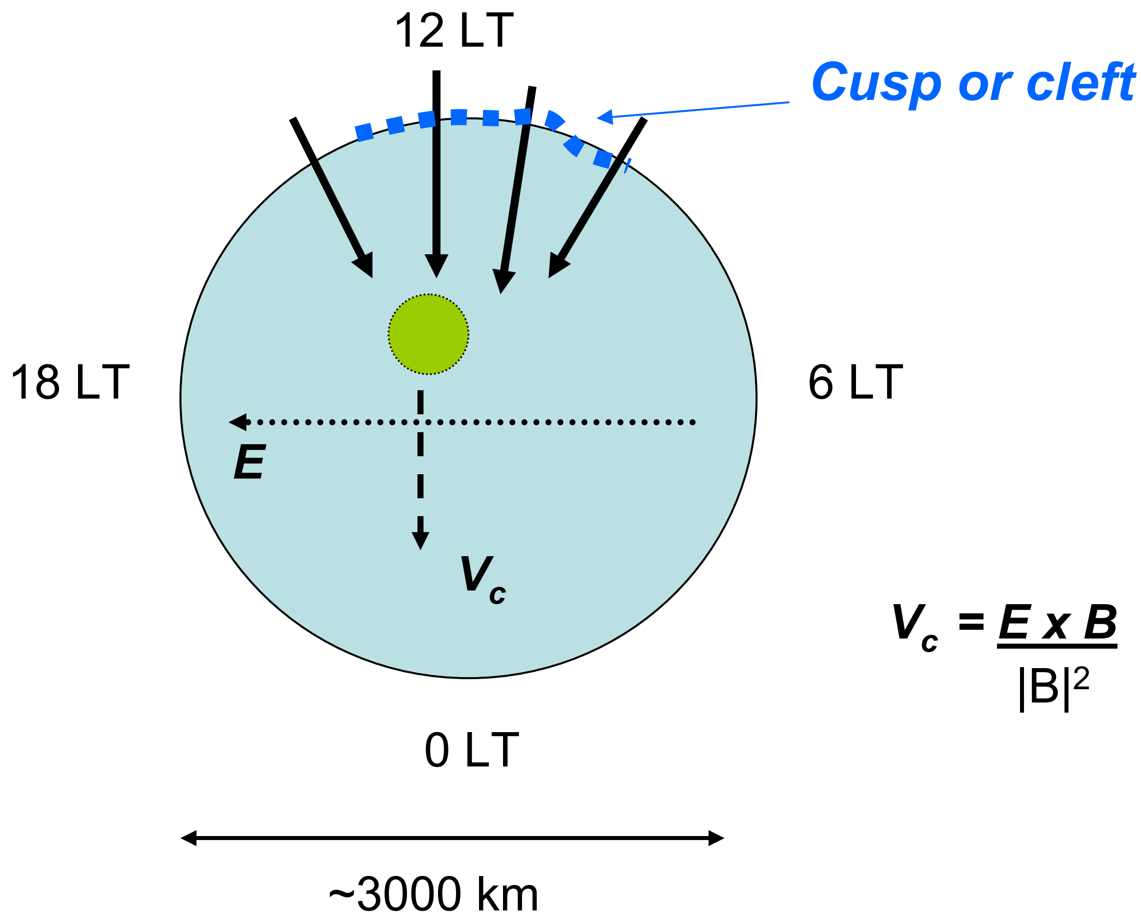
Therefore can't produce patches by divergence of convection

Patch Formation Theories

A) IMF changes
- **By changes (Sojka)**
- **Bz changes (Anderson)**

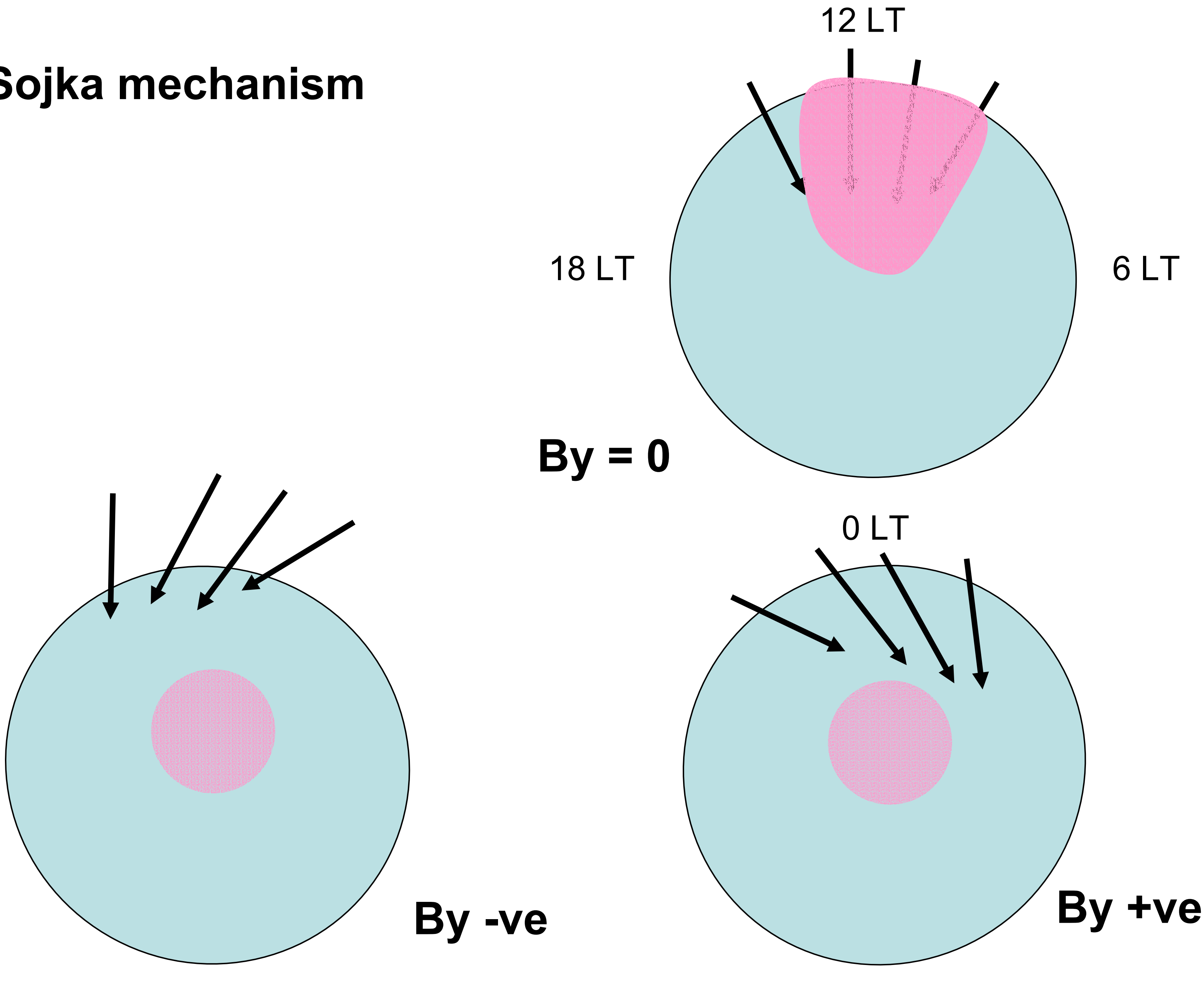
B) CUSP/CLEFT Processes
- **flow channels (high speed flow)**
- **precipitation**

Note: All these mechanisms produce the patches before they enter the polar cap.

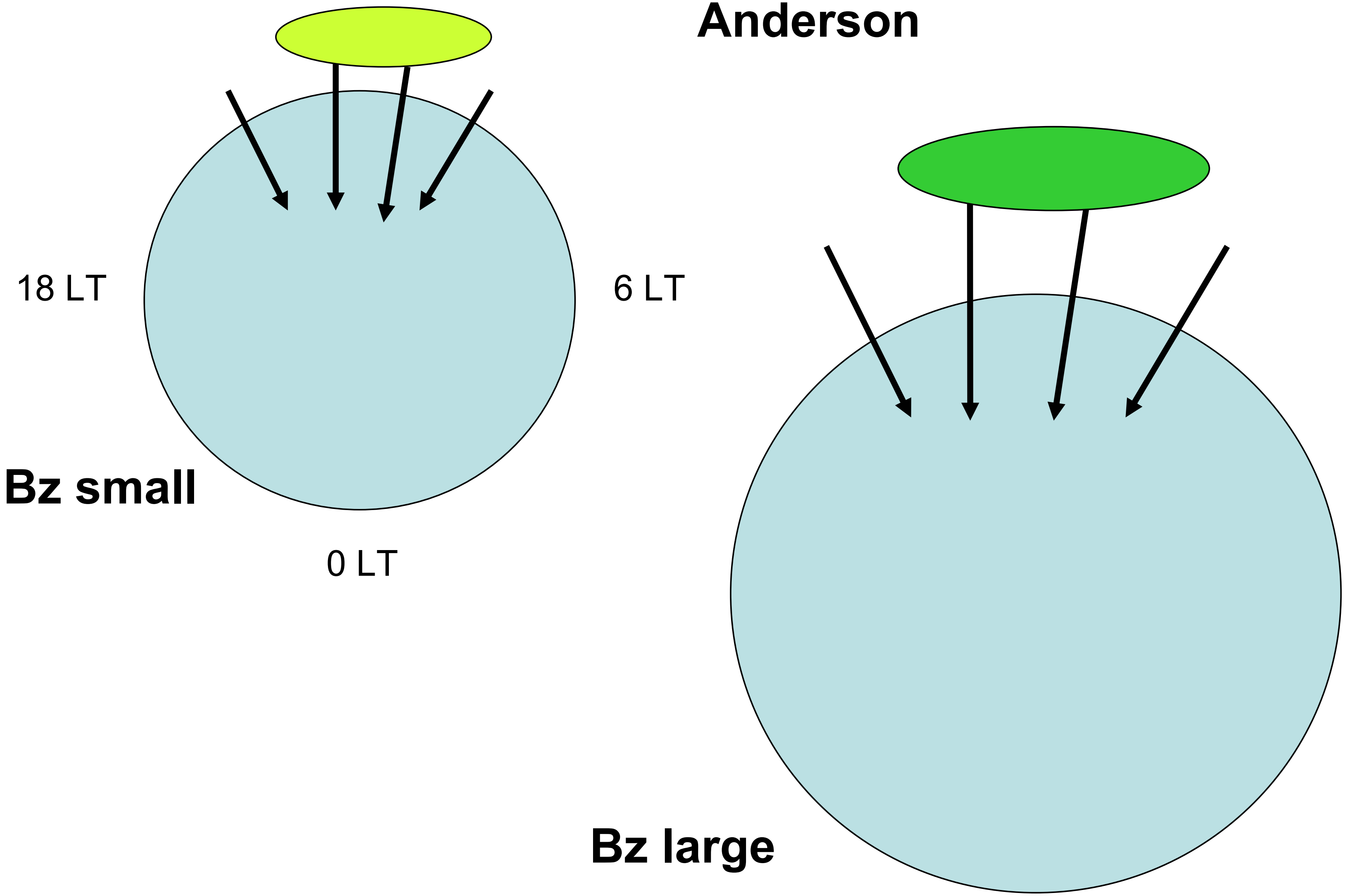


$$V_c = \frac{\mathbf{E} \times \mathbf{B}}{|B|^2}$$

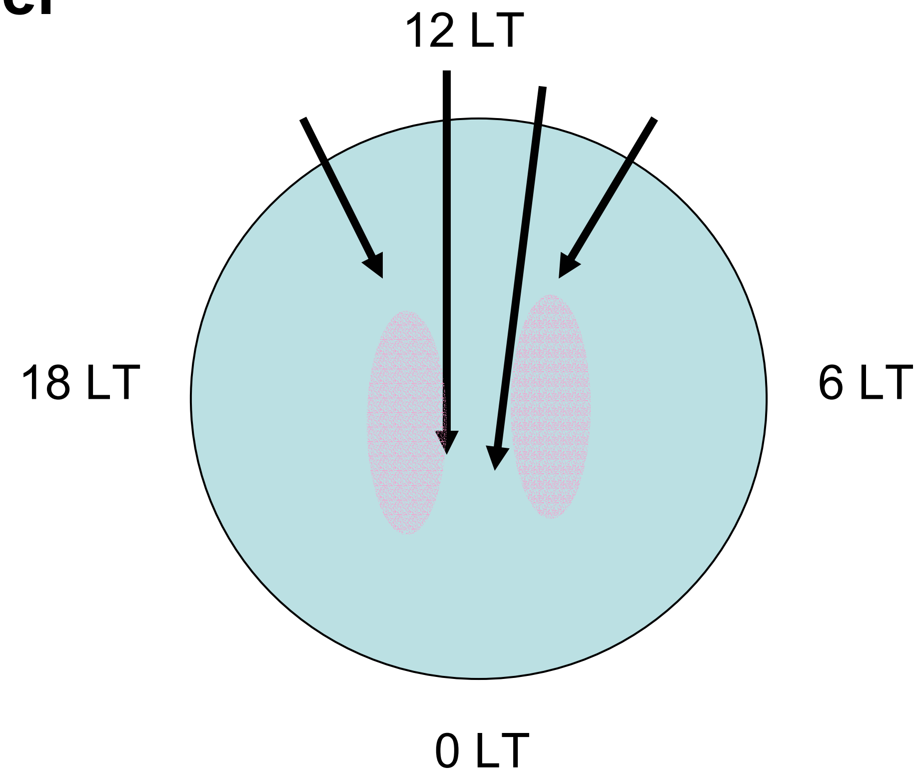
Sojka mechanism



Anderson

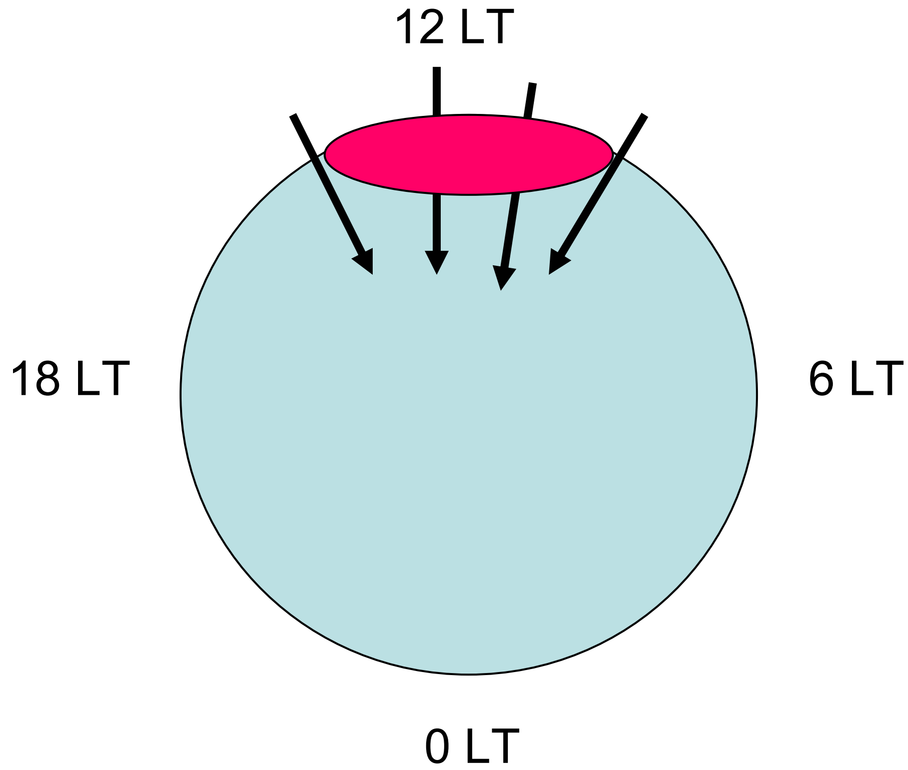


Flow channel



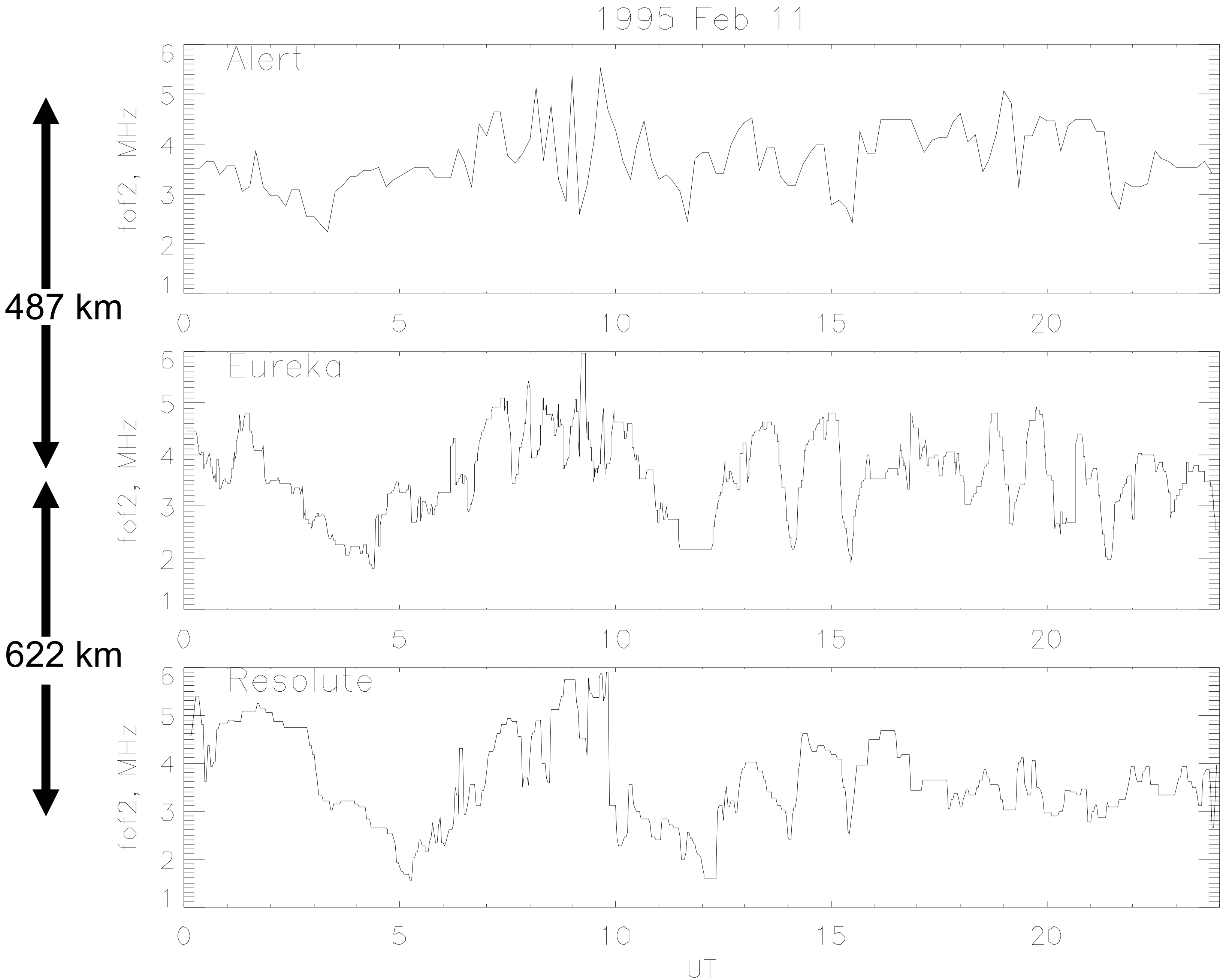
High speed -> heating -> enhanced recombination -> depletion of ionization

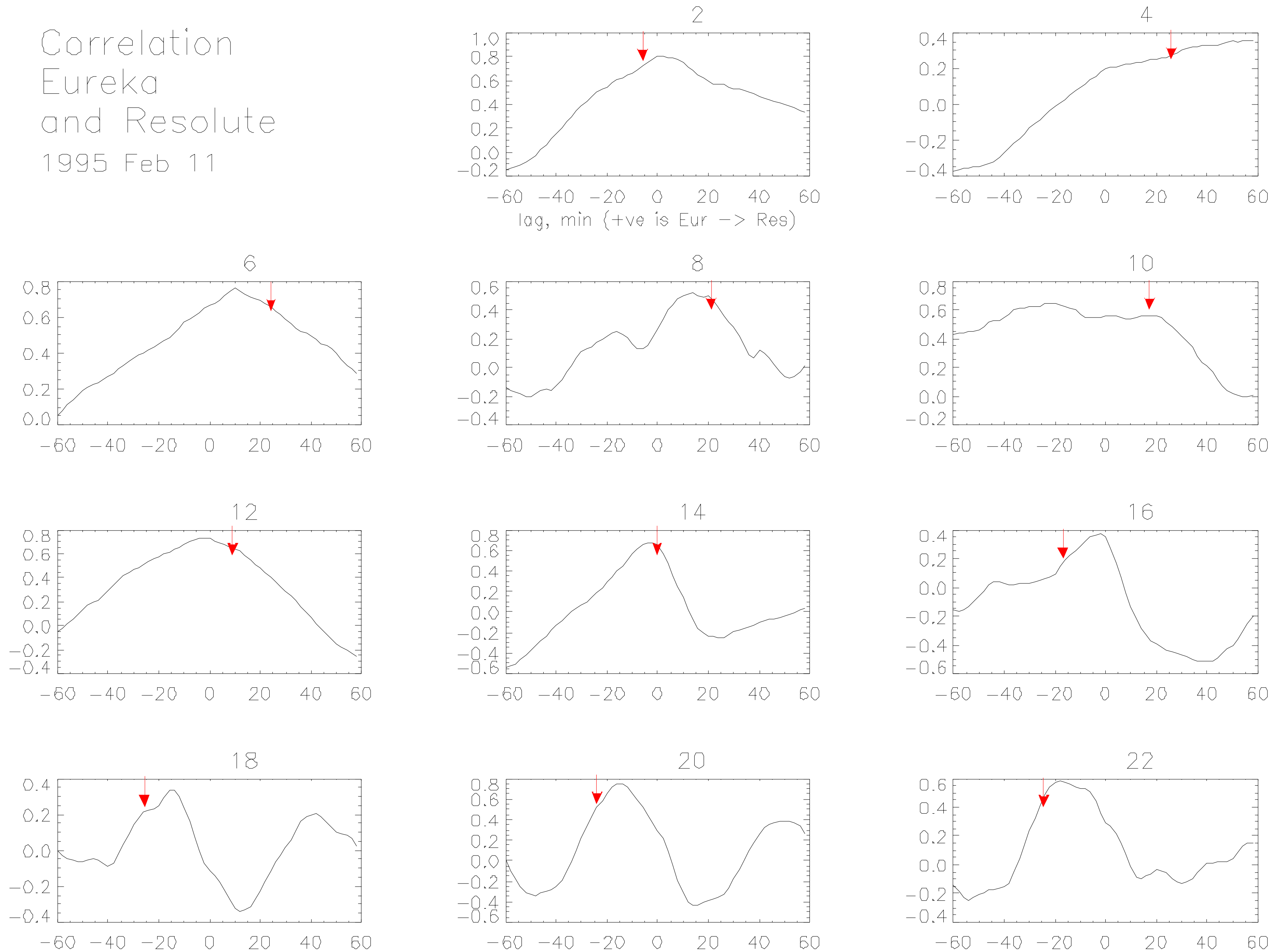
Precipitation

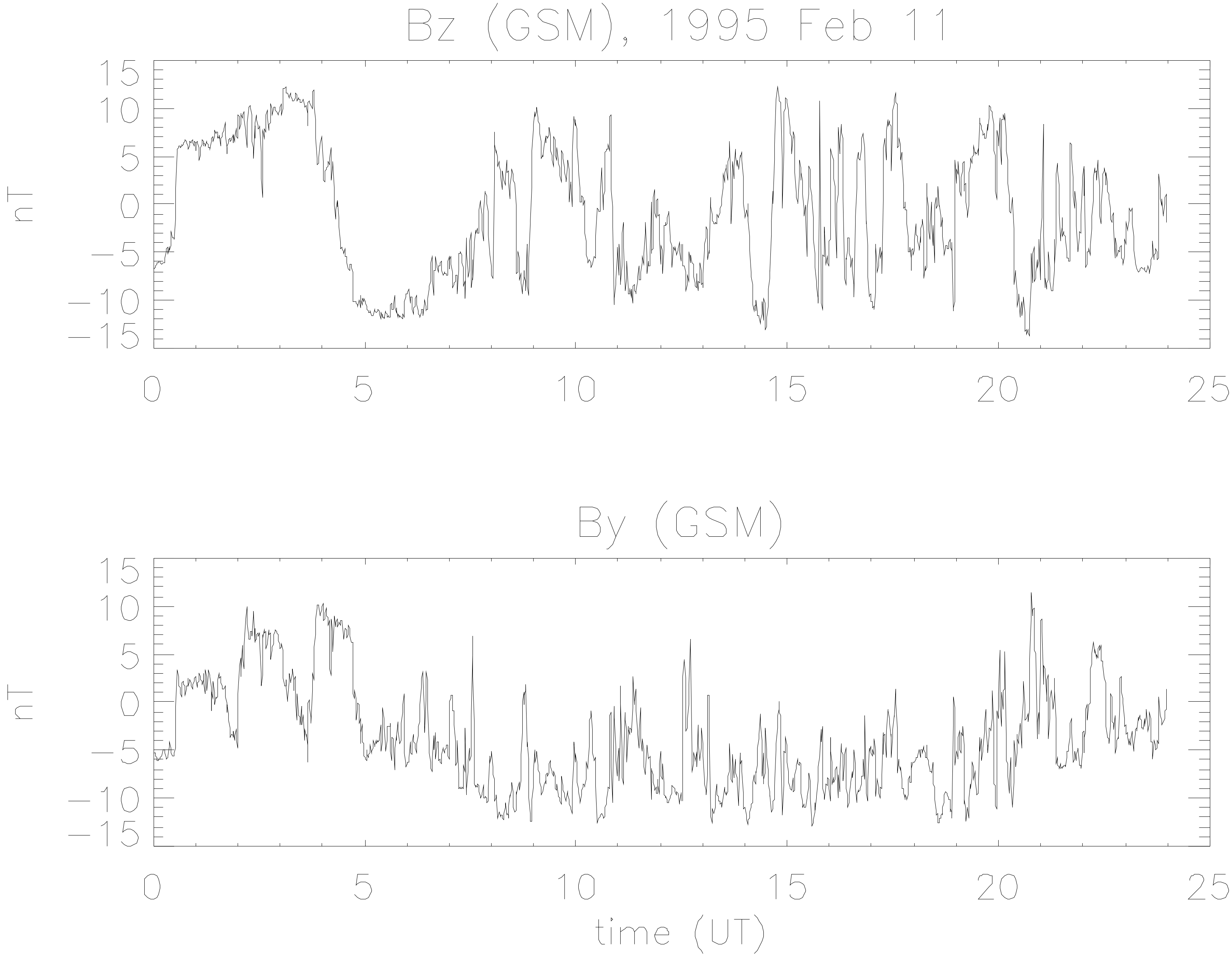


Patches appear to be both enhancements and depletions of ionization

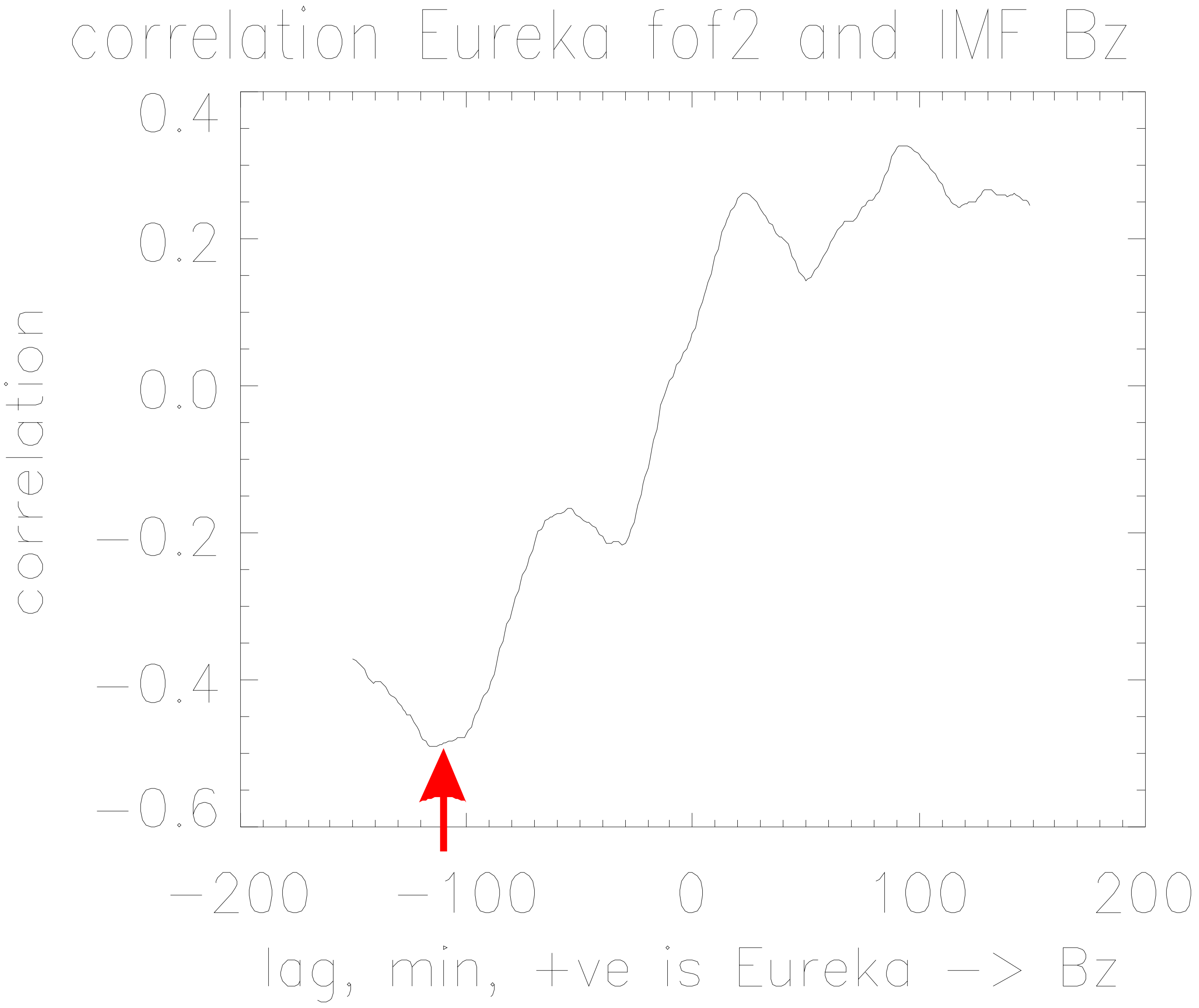
Example #1 : A well behaved day


1995 Feb 11
Alert
Eureka
Resolute
fof2, MHz
UT
487 km
622 km

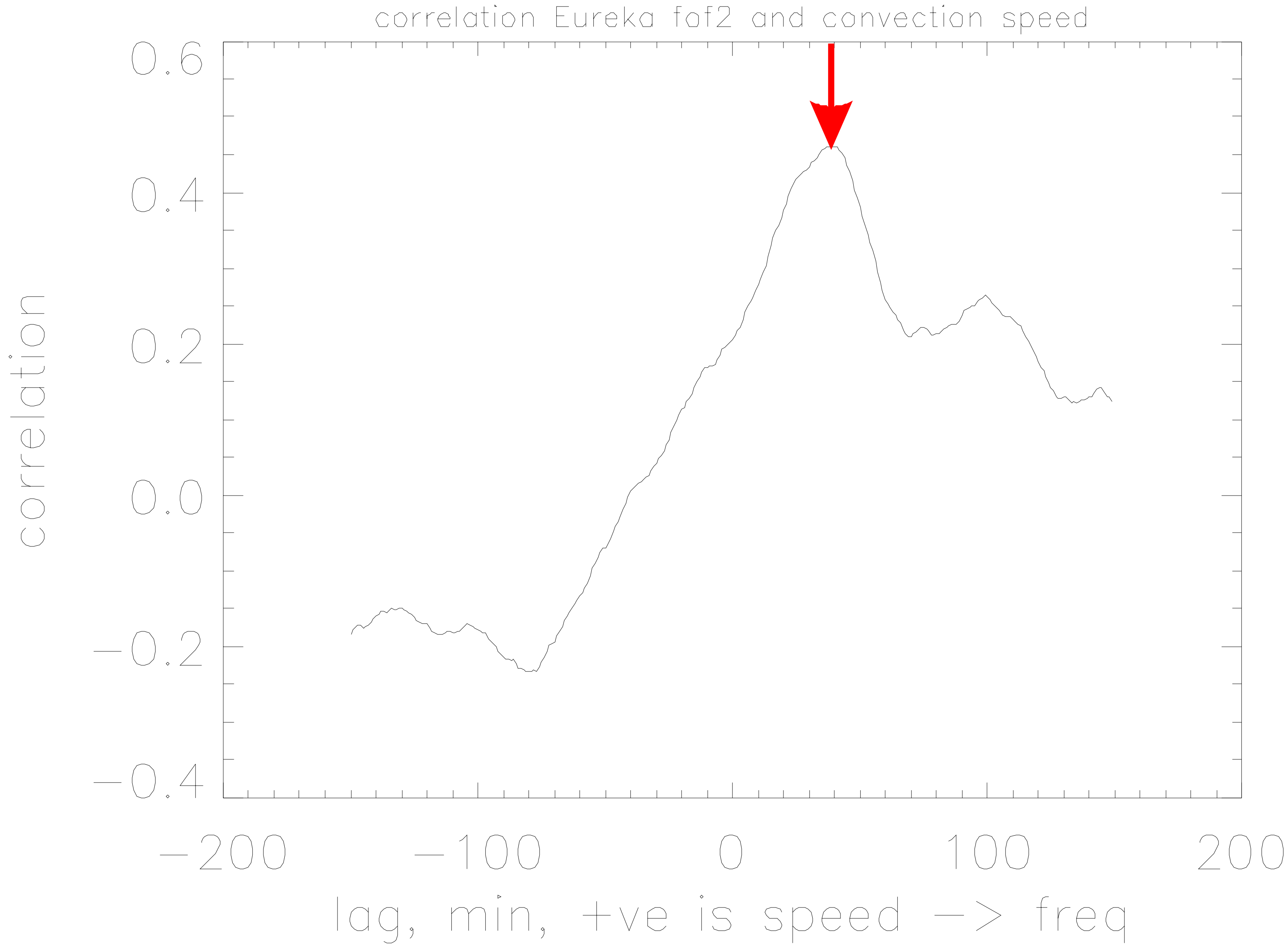

Correlation
Eureka
and Resolute
1995 Feb 11
2
4
lag, min (+ve is Eur -> Res)
6
8
10
12
14
16
18
20
22



Bz (GSM), 1995 Feb 11
nT
15
10
5
0
−5
−10
−15
0
5
10
15
20
25
By (GSM)
nT
15
10
5
0
−5
−10
−15
0
5
10
15
20
25
time (UT)



correlation Eureka fof2 and IMF Bz
0.4
0.2
0.0
−0.2
−0.4
−0.6
correlation
−200
−100
0
100
200
lag, min, +ve is Eureka −> Bz

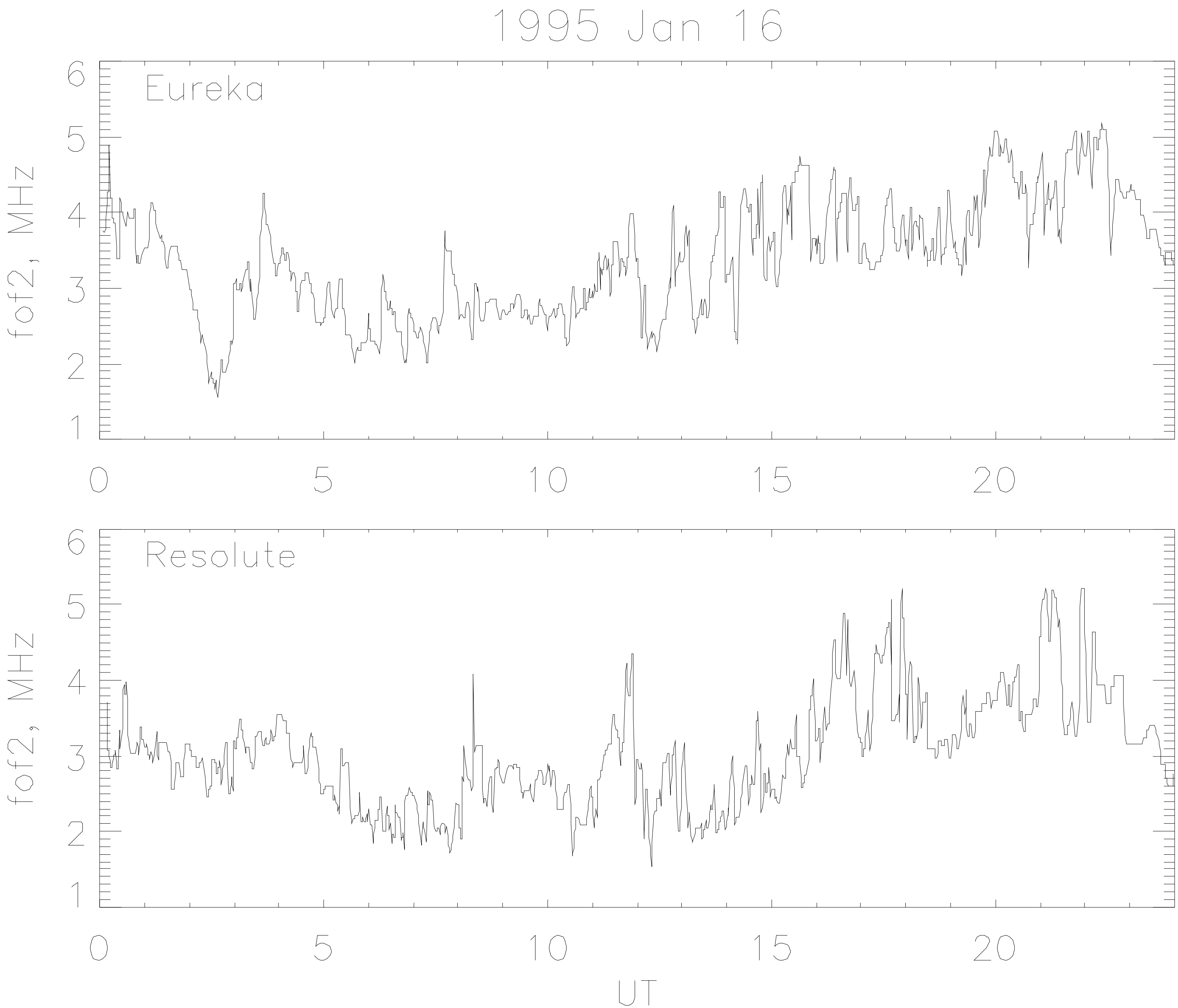


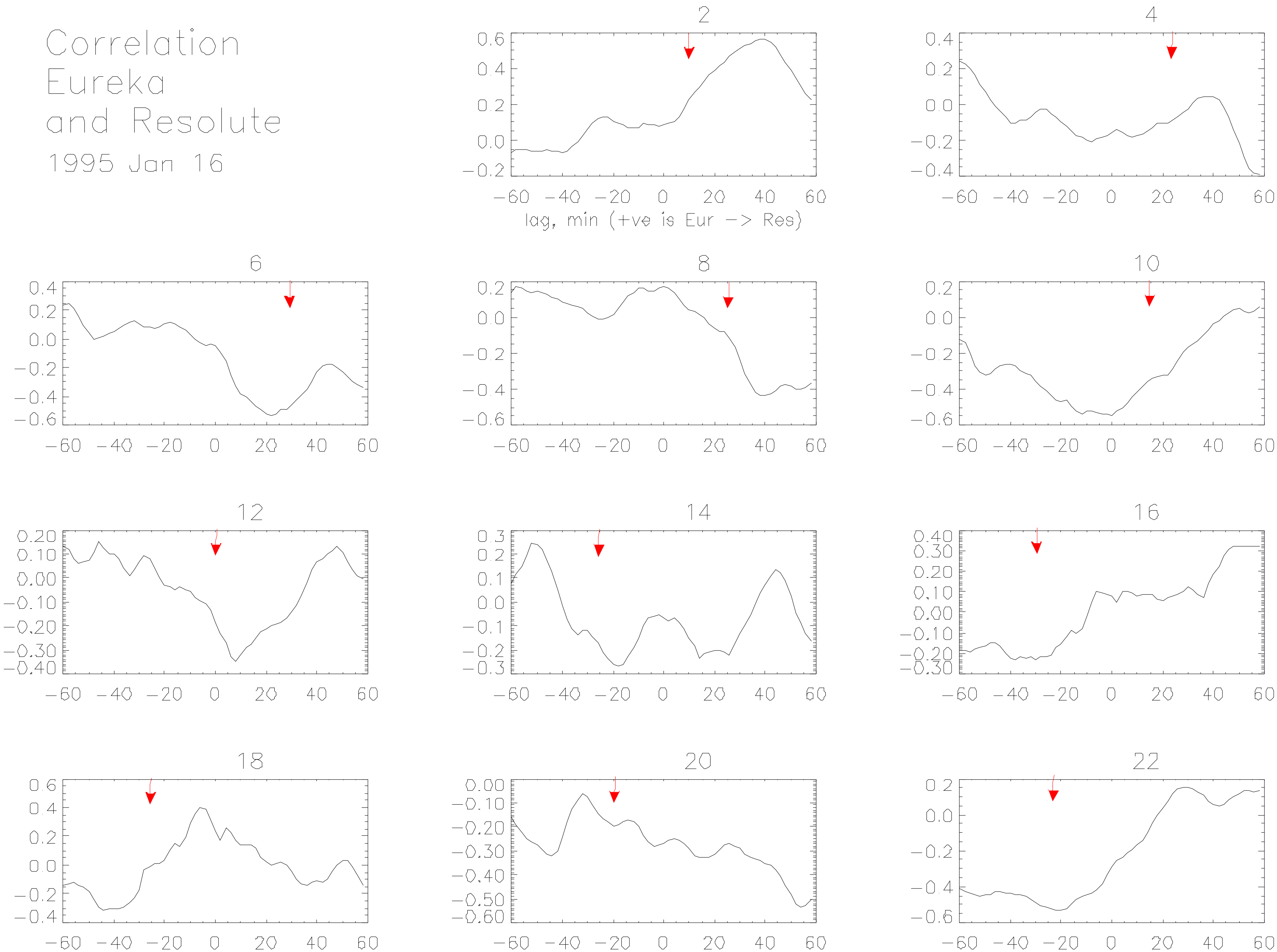
correlation Eureka fof2 and convection speed
0.6
0.4
0.2
0.0
−0.2
−0.4
correlation
−200
−100
0
100
200
lag, min, +ve is speed -> freq

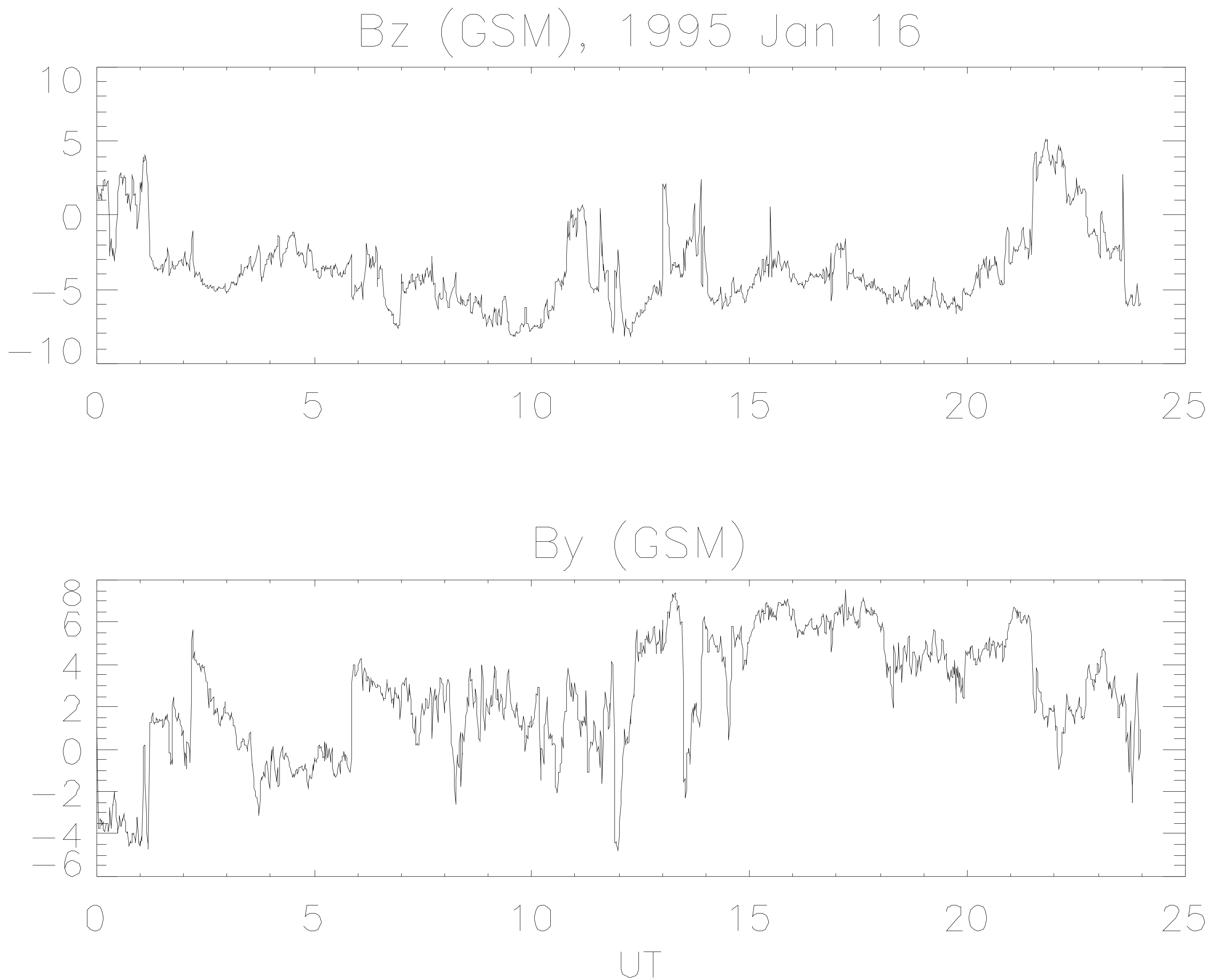
? Is it convection speed or IMF Bz that is creating patches ?

Reminder: None of the mechanisms are obviously related to convection speed (unless it is very fast)

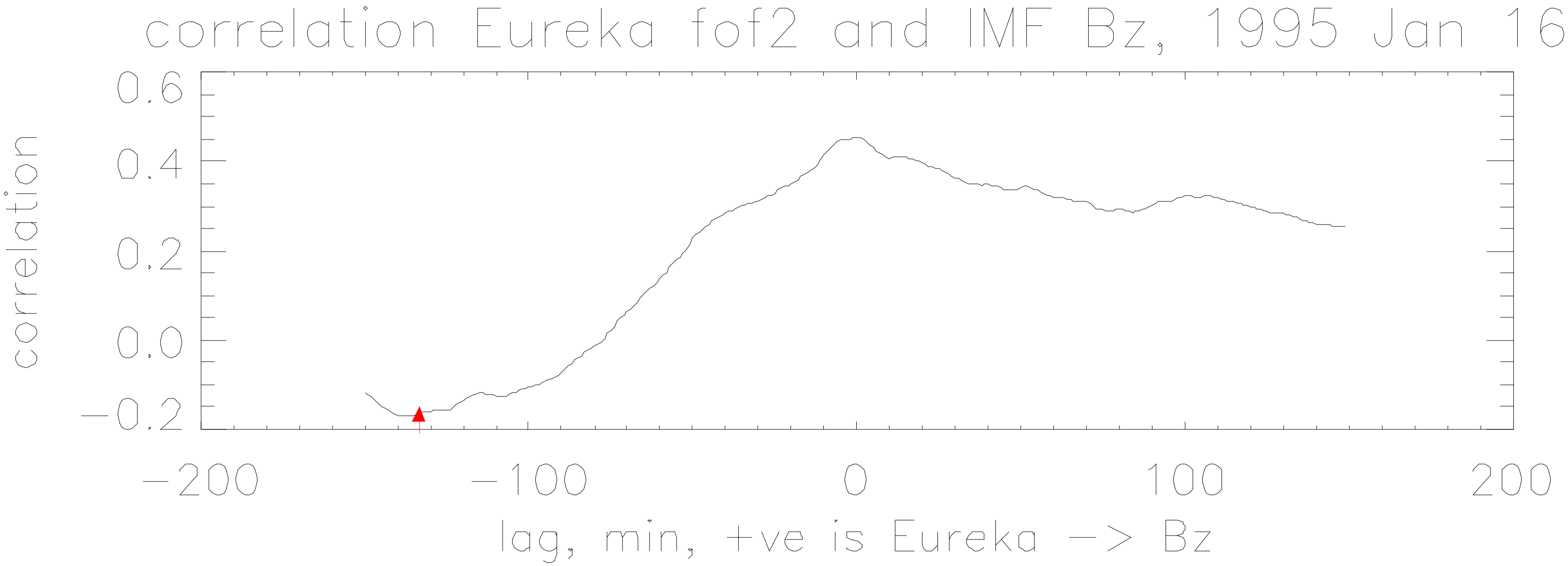
Example #2 : A less well behaved day


1995 Jan 16
Eureka
fof2, MHz
1
2
3
4
5
6
0
5
10
15
20
Resolute
fof2, MHz
1
2
3
4
5
6
0
5
10
15
20
UT

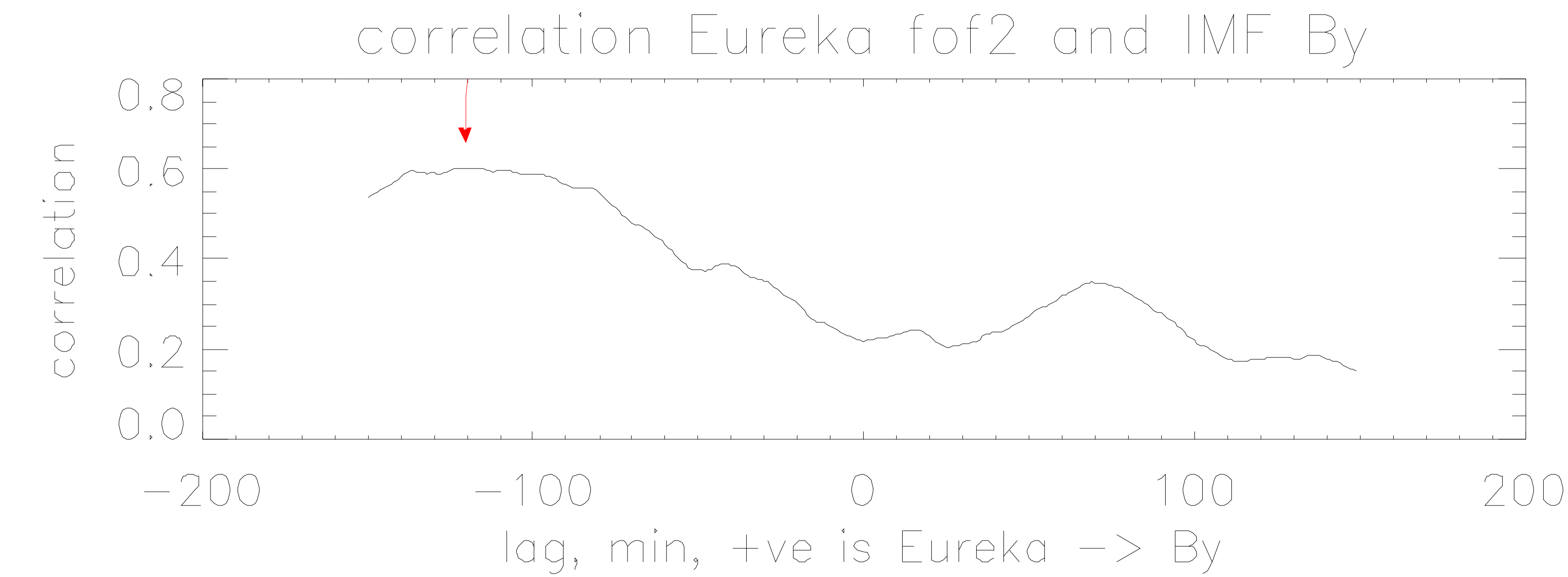

Correlation
Eureka
and Resolute
1995 Jan 16
2
4
6
8
10
12
14
16
18
20
22
lag, min (+ve is Eur -> Res)



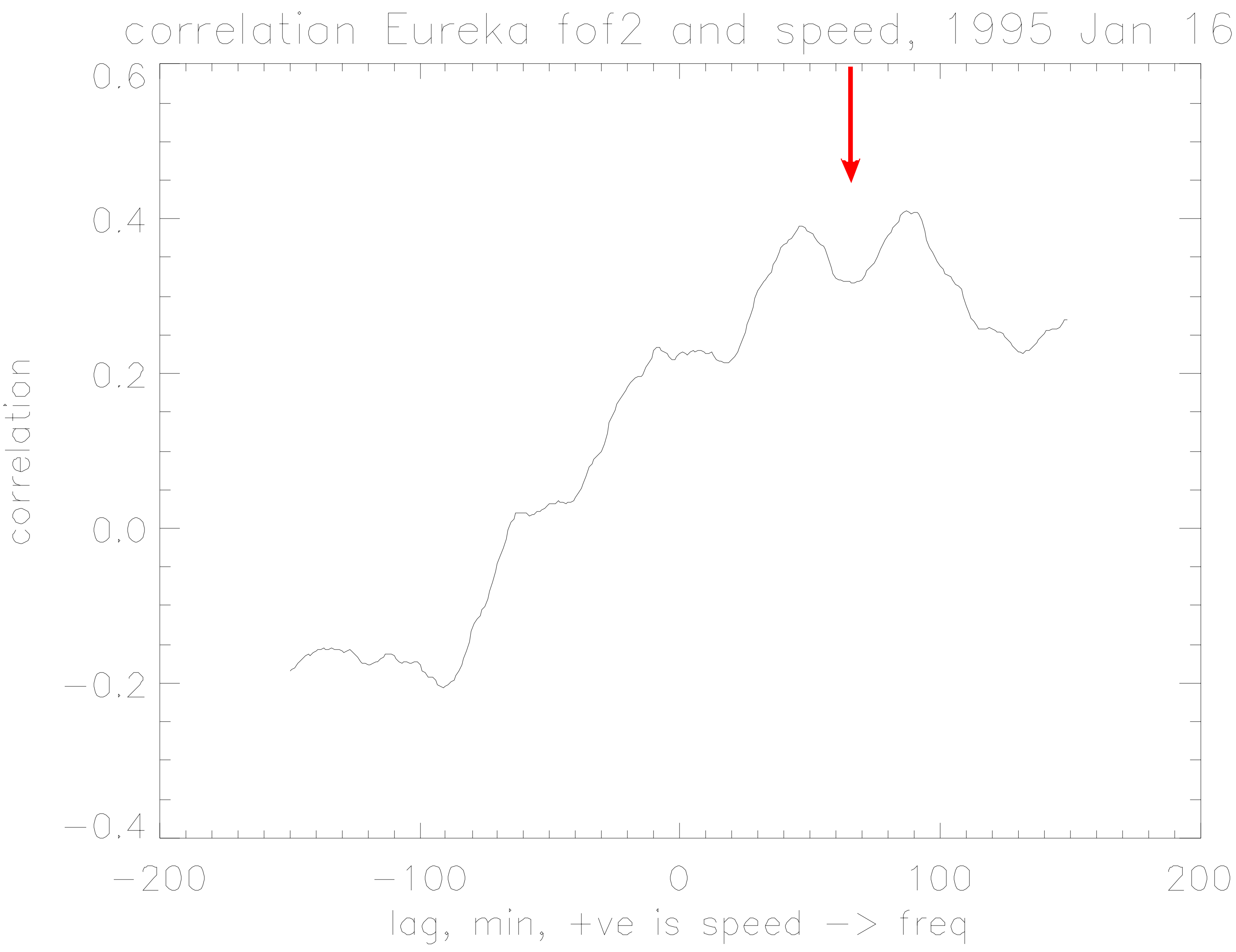
Bz (GSM), 1995 Jan 16
10
5
0
−5
−10
nT
0
5
10
15
20
25
By (GSM)
8
6
4
2
0
−2
−4
−6
nT
0
5
10
15
20
25
UT



correlation Eureka fof2 and IMF Bz, 1995 Jan 16
correlation
0.6
0.4
0.2
0.0
−0.2
−200
−100
0
100
200
lag, min, +ve is Eureka −> Bz



correlation Eureka fof2 and IMF By
correlation
0.8
0.6
0.4
0.2
0.0
−200
−100
0
100
200
lag, min, +ve is Eureka −> By


correlation Eureka fof2 and speed, 1995 Jan 16
0.6
0.4
0.2
0.0
−0.2
−0.4
correlation
−200
−100
0
100
200
lag, min, +ve is speed −> freq

Summary

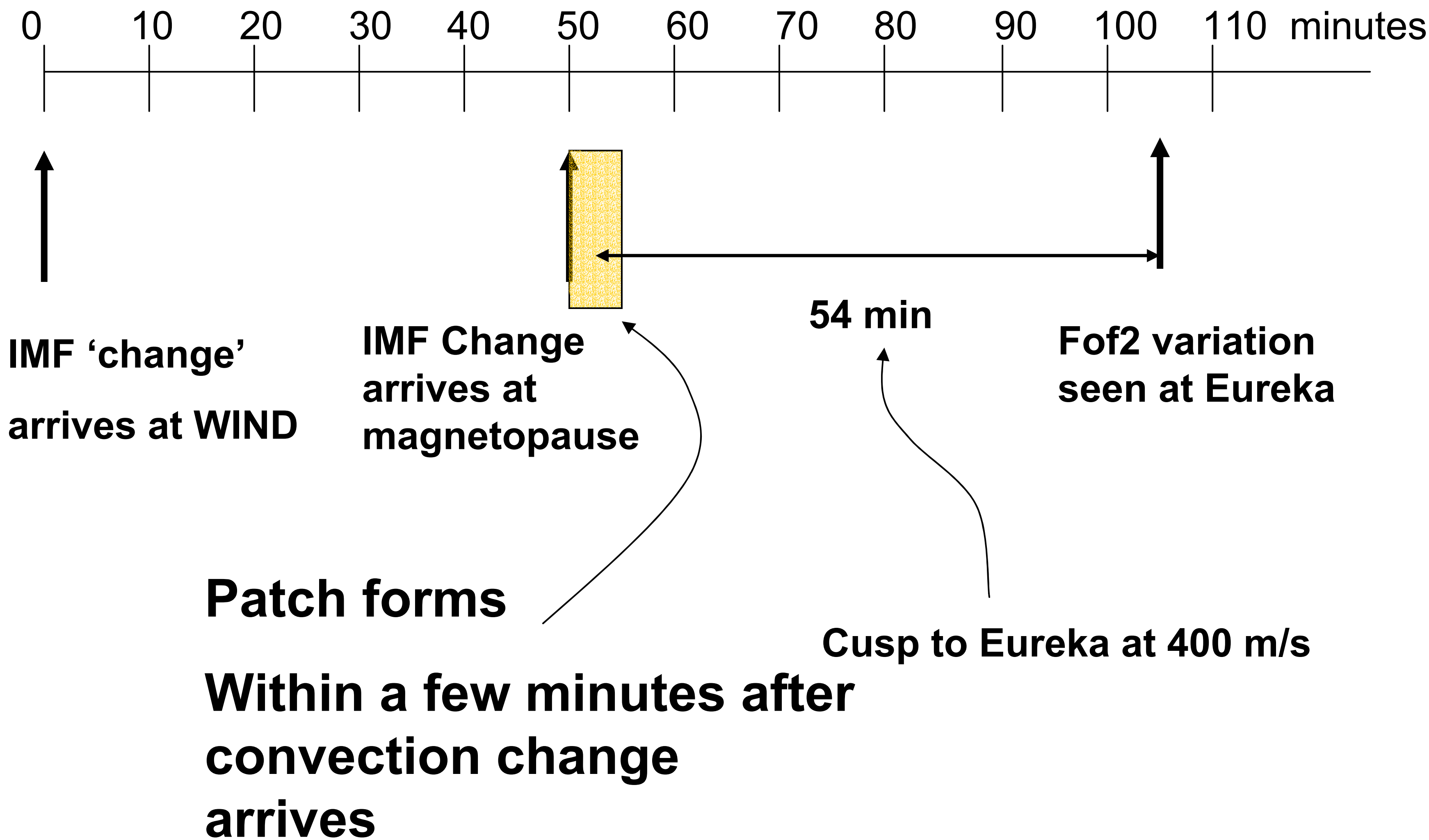
• Days with large IMF Bz variations show well behaved patches

• Most days have poorly behaved patches with low inter-station correlations

• However, there is usually weak correlations between patch fof2 and both IMF and convection speed

•Short period patch features correlate very poorly (very poorly behaved) [shown by filtering before correlation]

Typical timing



Discussion and conclusion

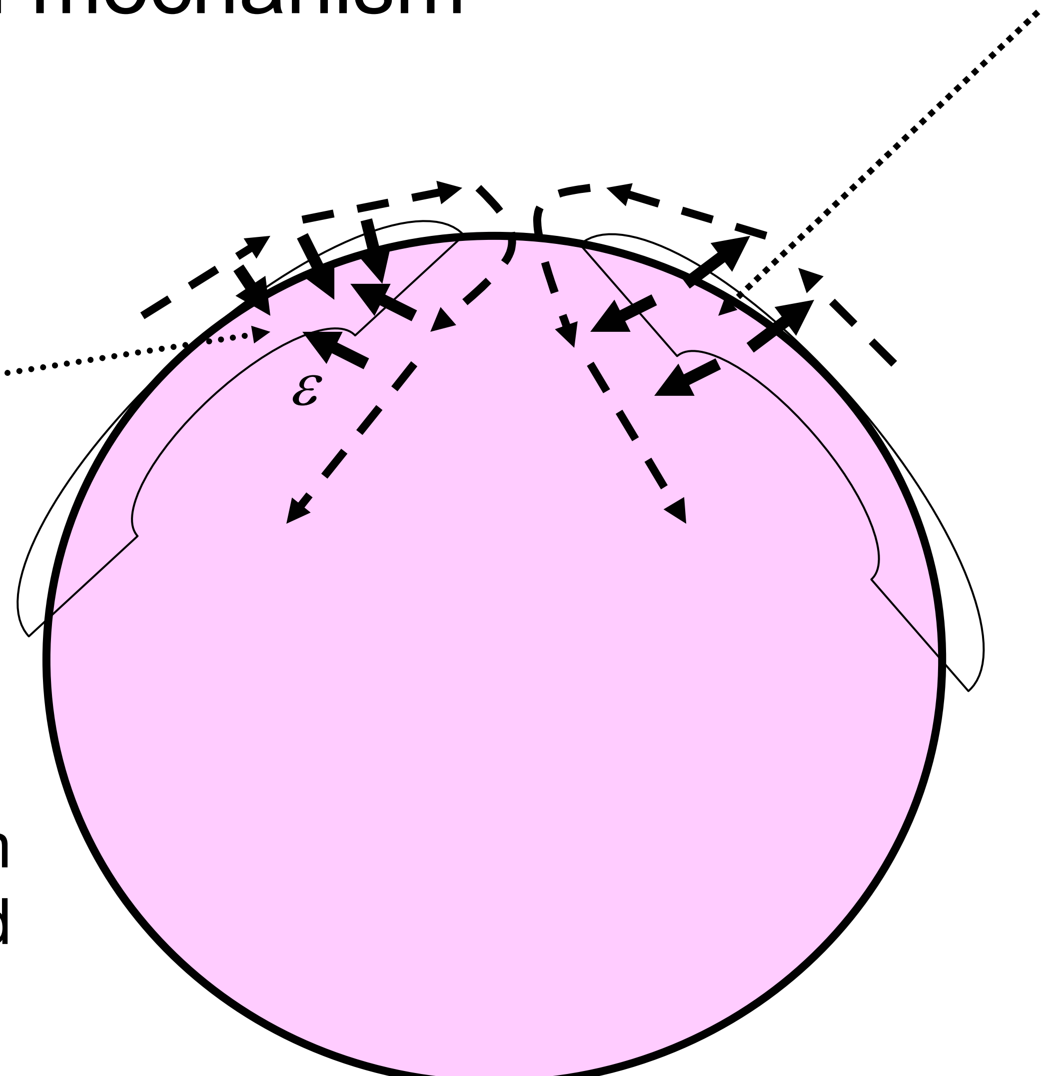
Large patches are created at the CUSP by IMF variations.

It is difficult to separate effects of IMF By, Bz and convection speed changes

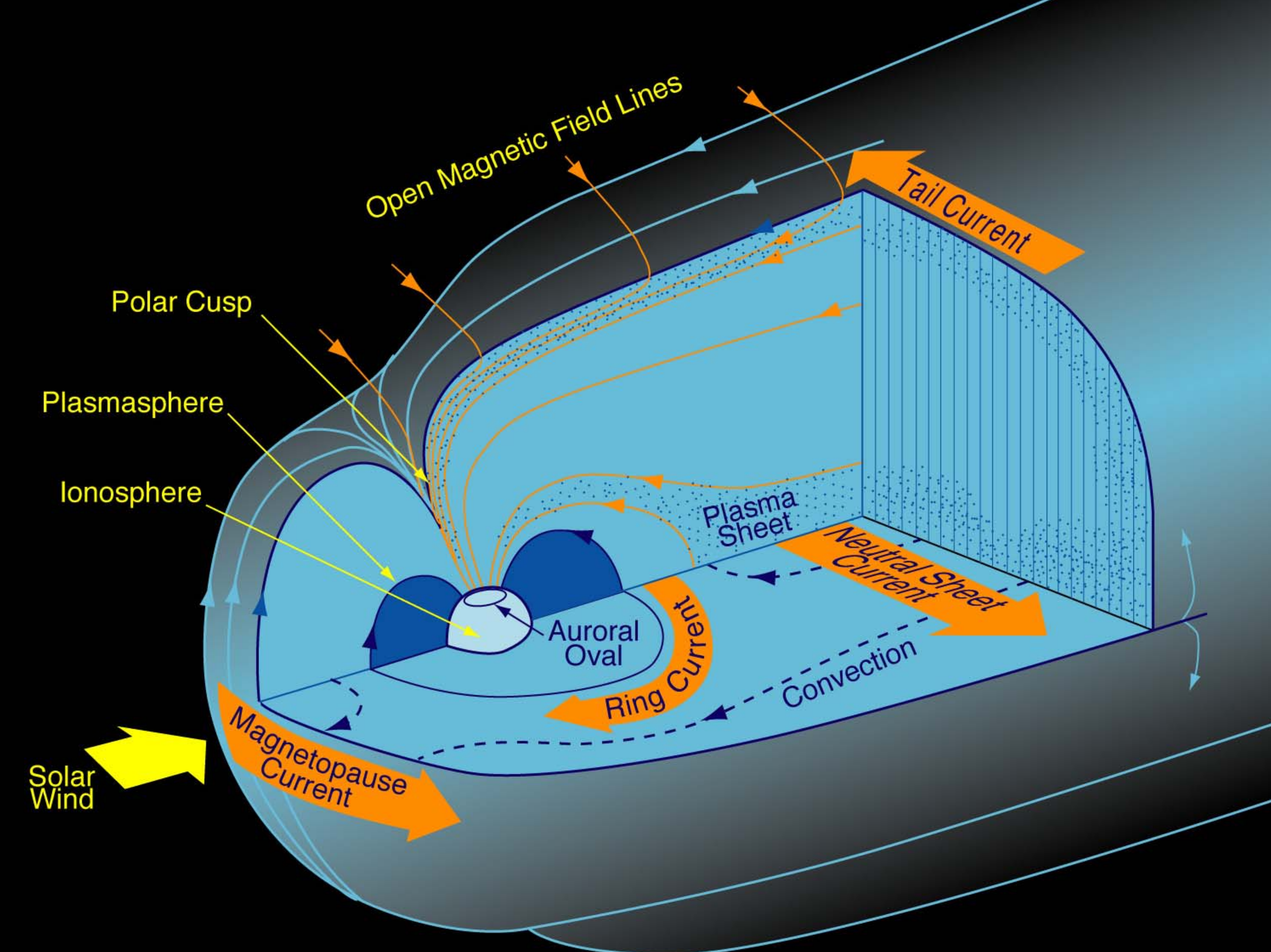
No one mechanism seems to work for all patches

Small scale patches are produced locally within the polar cap (gradient drift instability?)

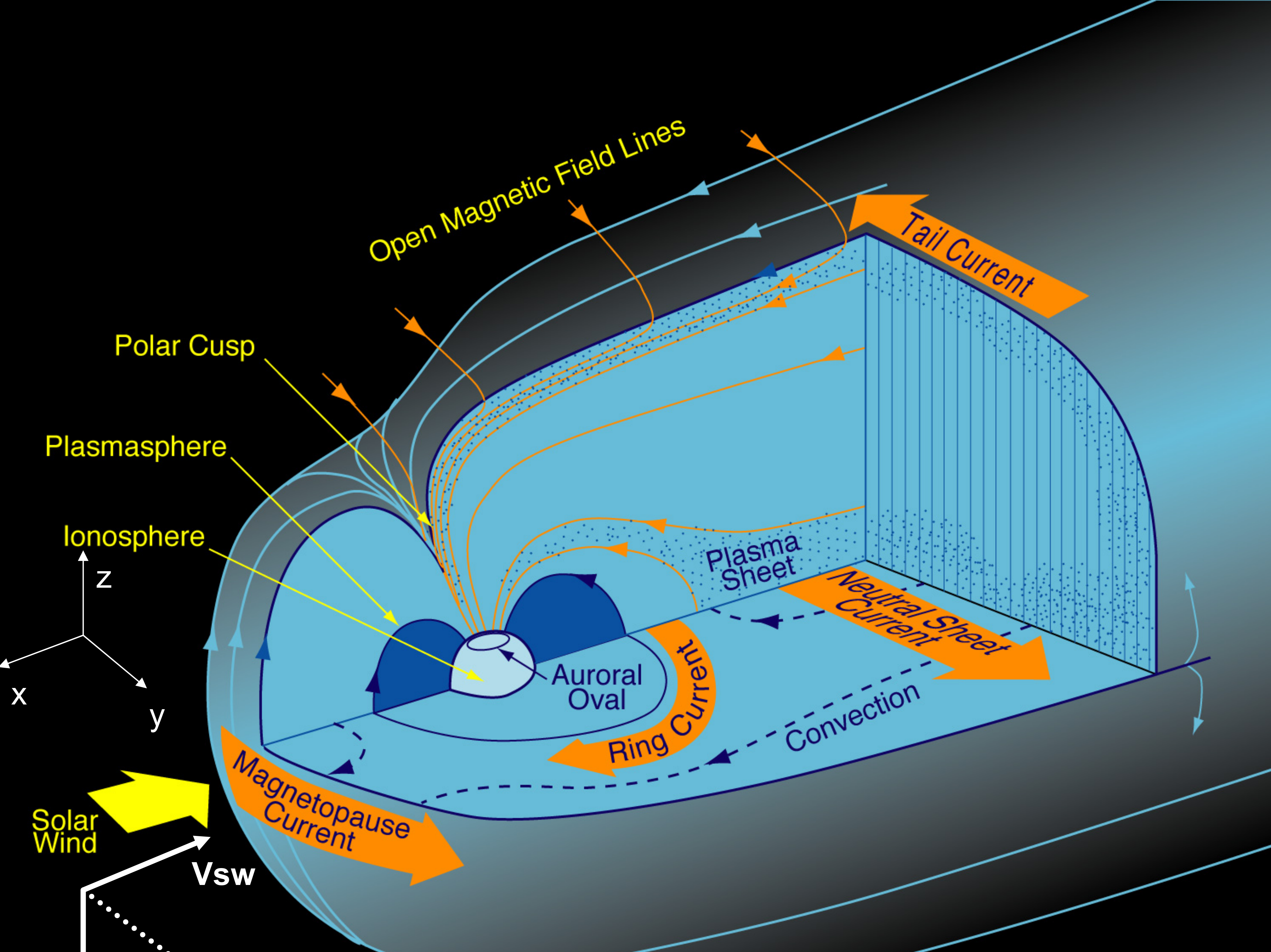
New proposed mechanism

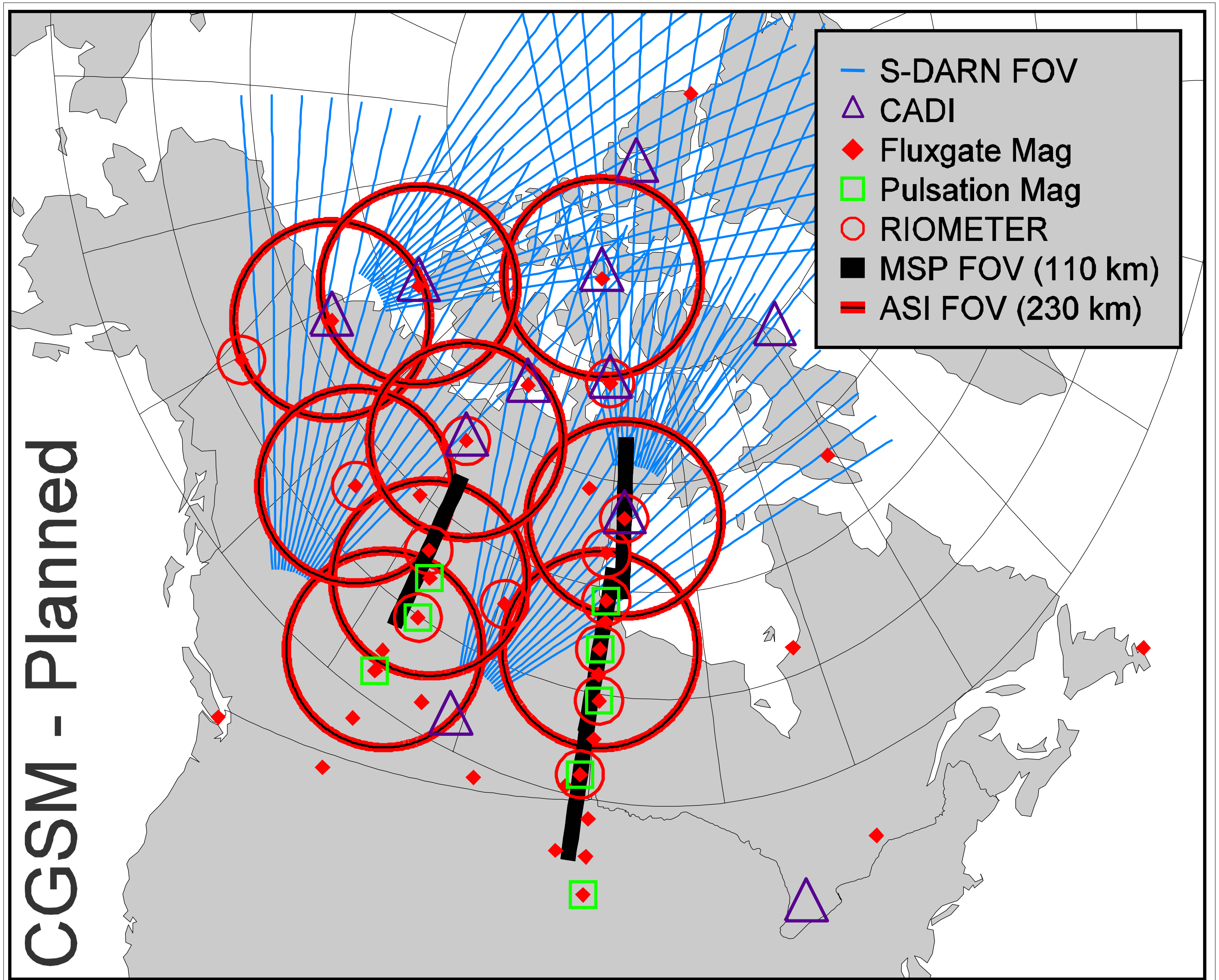


Alternative Influx from enhanced or depleted (by By changes) produces patches



Open Magnetic Field Lines
Tail Current
Polar Cusp
Plasmasphere
Ionosphere
Plasma Sheet
Neutral Sheet Current
Auroral Oval
Ring Current
Convection
Magnetopause Current
Solar Wind


Open Magnetic Field Lines
Tail Current
Polar Cusp
Plasmasphere
Ionosphere
Plasma Sheet
Neutral Sheet Current
Auroral Oval
Ring Current
Convection
Magnetopause Current
Solar Wind
Vsw
z
x
y


CGSM - Planned
S-DARN FOV
CADI
Fluxgate Mag
Pulsation Mag
RIOMETER
MSP FOV (110 km)
ASI FOV (230 km)