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SIGNATURES OF SOLAR EVENT AT MIDDLE AND LOW LATITUDES IN THE EUROPE-AFRICAN SECTOR, DURING GEOMAGNETIC STORMS, OCTOBER 2013.

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TELECOM Bretagne UPMC SORBONNE UNIVERSITÉS Université Mohammed V AGDAL - RABAT l'X ÉCOLE POLYTECHNIQUE UNIVERSITÉ PARIS-SACLAY ICTP CRASTE-LF EMI GIRGEA

OUTLINE

•ISWI dual GPS frequency's stations
•ISWI Magnetometers (AMBER)
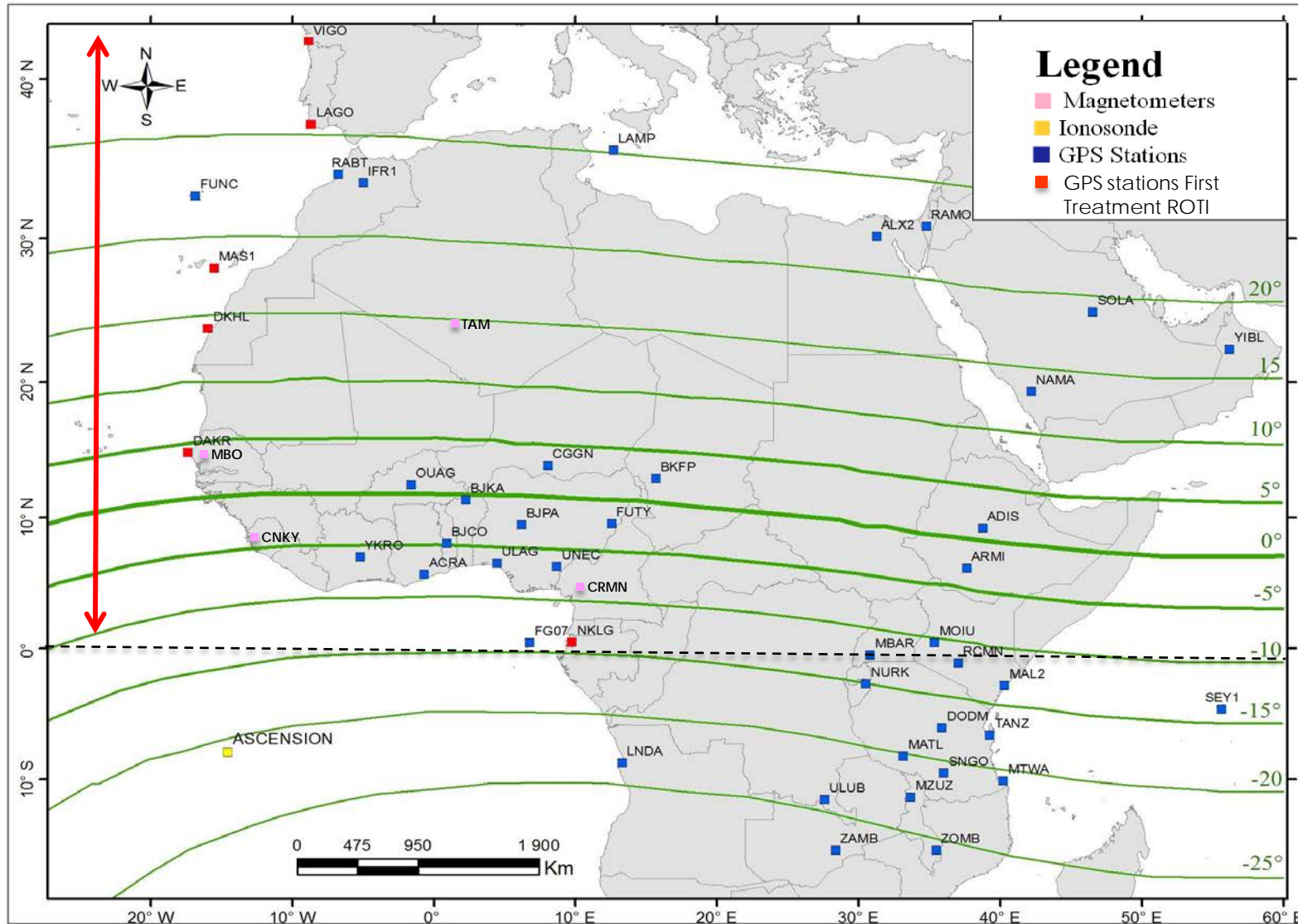
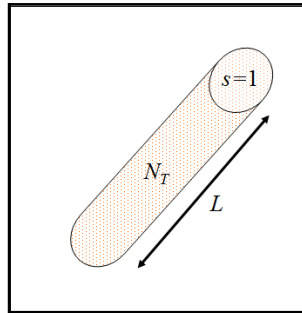$$I_r^s(f) = \frac{40.3 \cdot TEC}{f^2}(f) = cP^s(f) + T_r^s + I_u^s(f) + \alpha_u^s(f)$$

ROTI Index

Total Electron Content

$$N_T = \int_L N_e \, dl$$

1 TECU = 10^{16} electrons m^{-2}

■ Pseudo-range

$$P_u^s(f) = \rho_u^s + c\left[b_u(f) - b^s(f)\right] + T_u^s + I_u^s(f) + \alpha_u^s(f)$$

- Geometric distance
- Pseudo range (m)
- Receiver bias + clock offset
- Satellite bias + clock offset
- Ionospheric group delay
- Tropospheric delay
- Other contributions (relativistic effects, multipaths, …)

RINEX   DCB   What we want
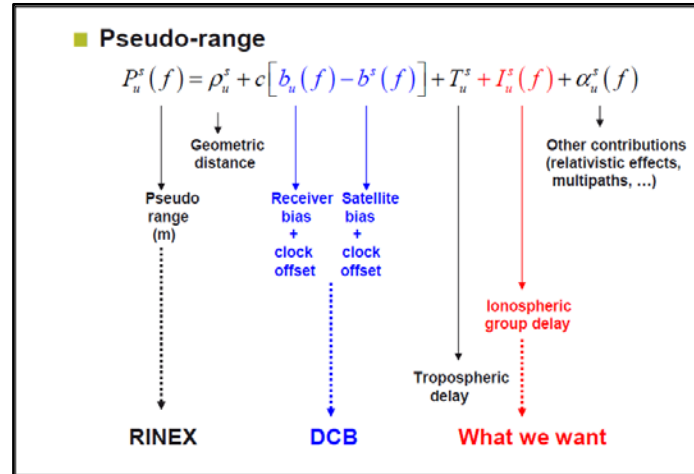
$$I_r^s(f) = \frac{a.STEC}{f^2}$$

ROTI (tecu/min): Rate of change Of TEC Index

$$STEC = a\frac{f_1^2 f_2^2}{f_1^2 - f_2^2}(L_1 - L_2) \qquad \textbf{1}$$

ROTI is computed each 30s by using phase measurements

$$ROT = \frac{STEC_{k+1} - STEC_k}{time_{k+1} - time_k} * 60 \qquad \textbf{2}$$

It is a proxy of scintillation index

$$ROTI = \sqrt{\langle ROT^2 \rangle - \langle ROT \rangle^2} \qquad \textbf{3}$$

Scintillations disturb GPS signal

(Pi et al., 1997)

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ROTI and Kp indices October 2013

ROTI Green / Kp : geomagnetic activity -red

Geographic Latitude	Geomagnetic Latitude (IGRF) (Inclination)	ROTI INDEX - 10/2013
42.18 N	+30.18	VIGO
37.09 N	+25.74	LAGO
27.76 N	+18.59	MAS1
23.68 N	+14.85	DKHL
14.68 N	+ 04.92	DAKR
0.35 N	- 5.68	NKLG
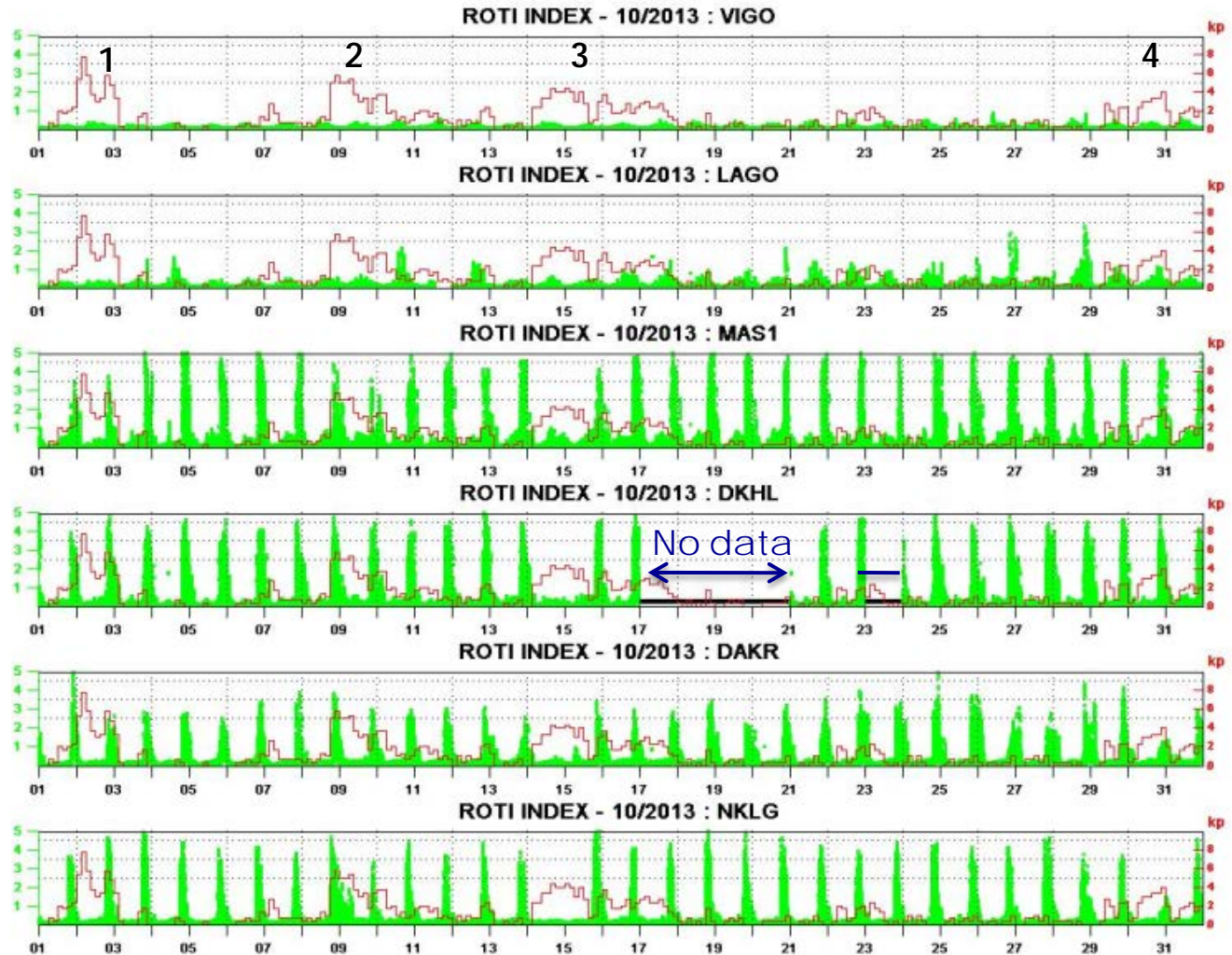
Disappearance of scintillations only on October 14
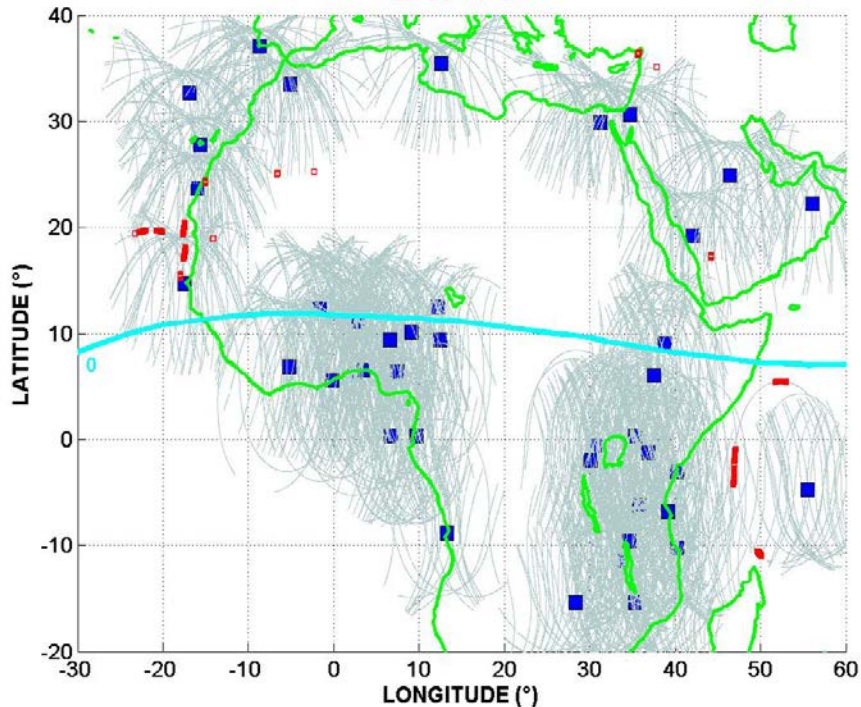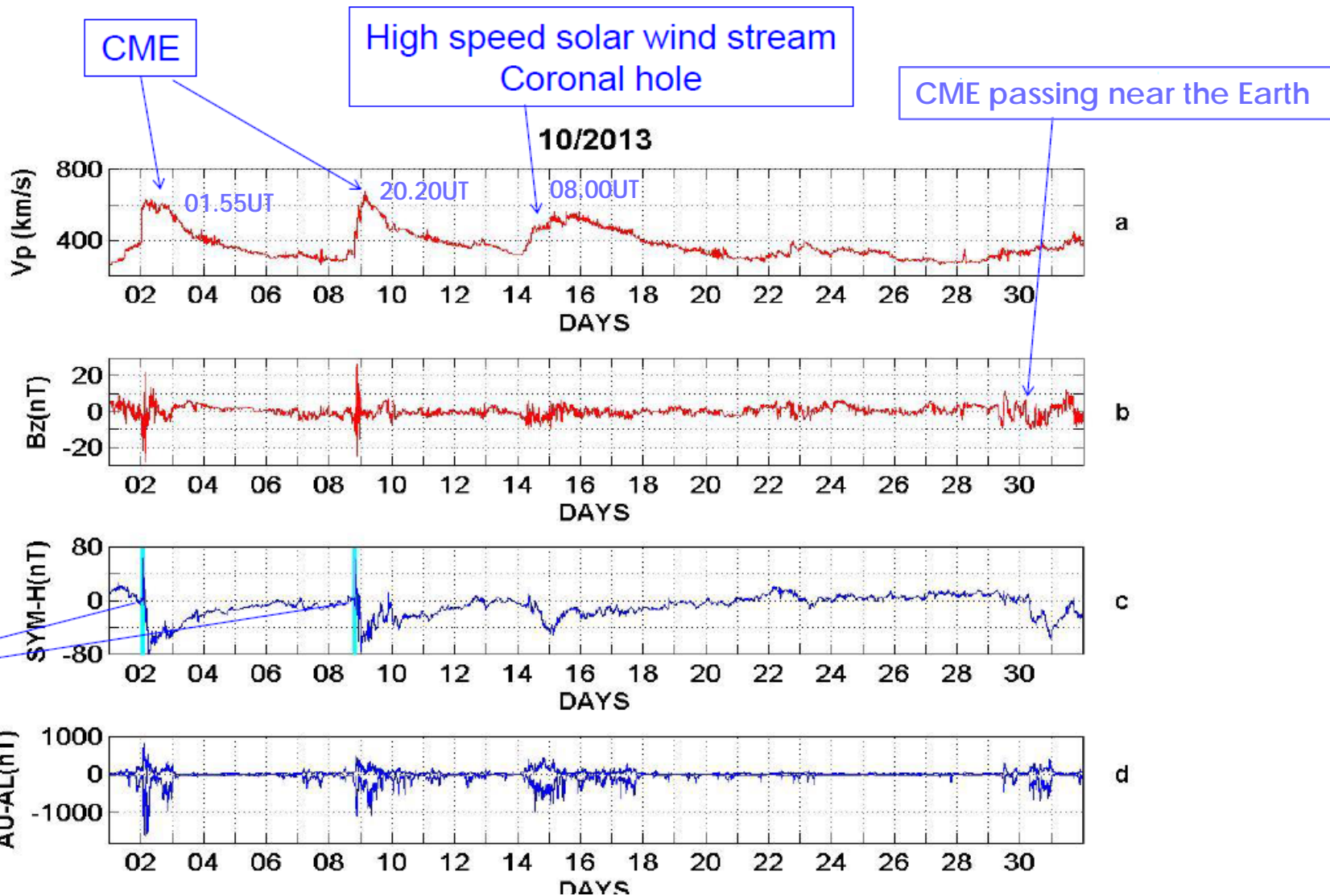
5
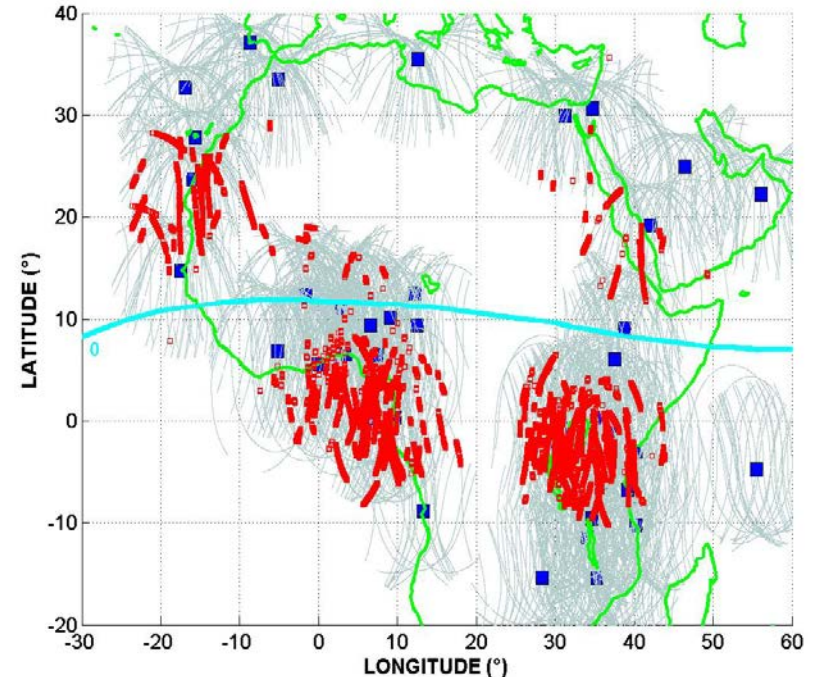
- **Maps of Tracks of GNSS satellite with Pseudorandom noise (PRN) codes and scintillation timing.**

- **Scintillation (ROTI>1.5tecu/min) are provided for each track (read color).**

The solar wind parameters and geomagnetic indices October 2013

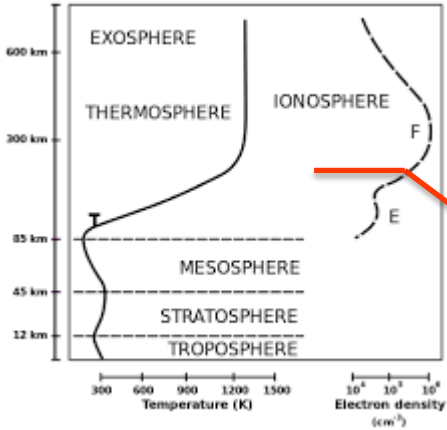# Variations of virtual height h′ of the F$_2$ layer during October 2013, between 15h and 24h, every 15 min at 4 MHz.

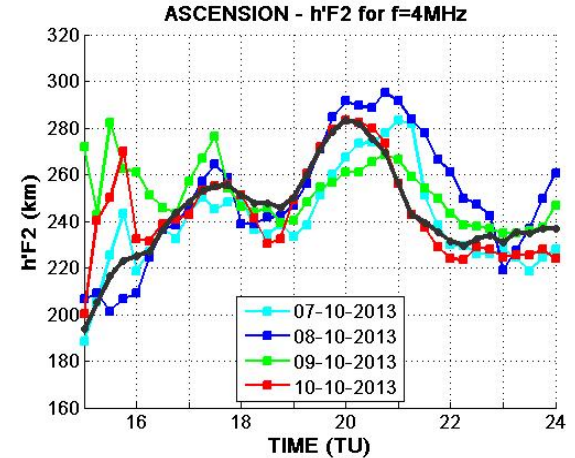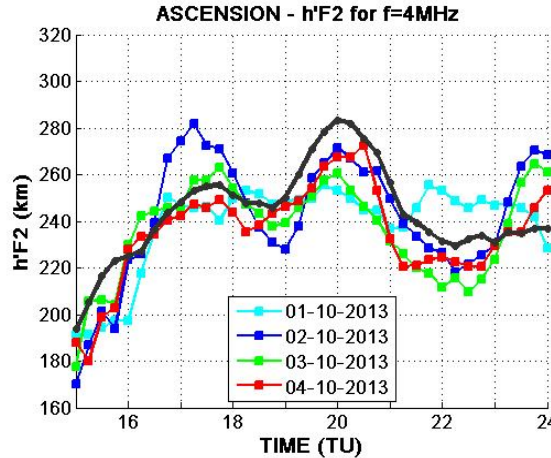### Ionosonde "Ascension Station" Geographic Coordinates (14.5 W, 7.95 S)

Atmospheric and Ionspheric layers

CME with SSC on October 2 at 01.55UT

CME with SSC on October 8 at 20.22 UT
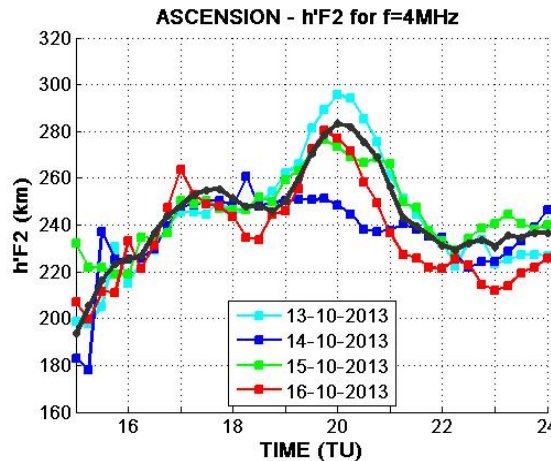
High speed solar wind on October 14 at 08.00UT

CME passing near the Earth

Prompt Penetration of Electric Field effect (PPEF)
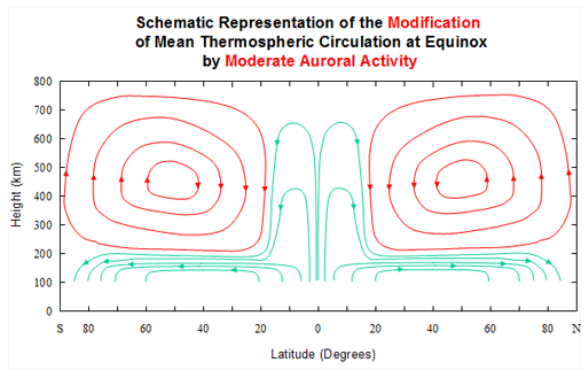The disturbance is simultaneously observed at all latitudes at the beginning of the storm.

Disturbance Dynamo Electric Field Effect (DDEF)
The disturbance is observed several hour after the beginning of the storm at low latitudes
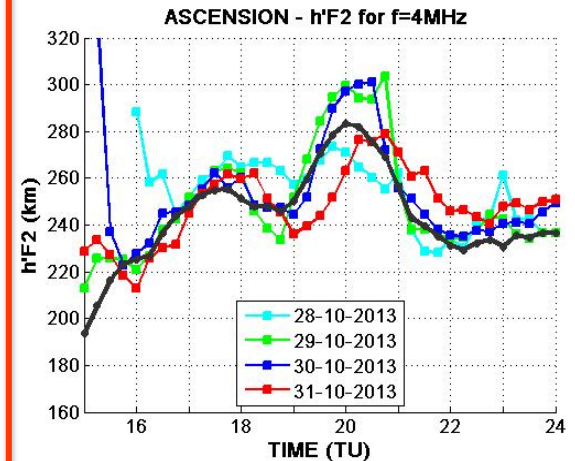
H component along a latitudinal magnetic chain

Schematic Representation of the **Modification** of Mean Thermospheric Circulation at Equinox by **Moderate Auroral Activity**
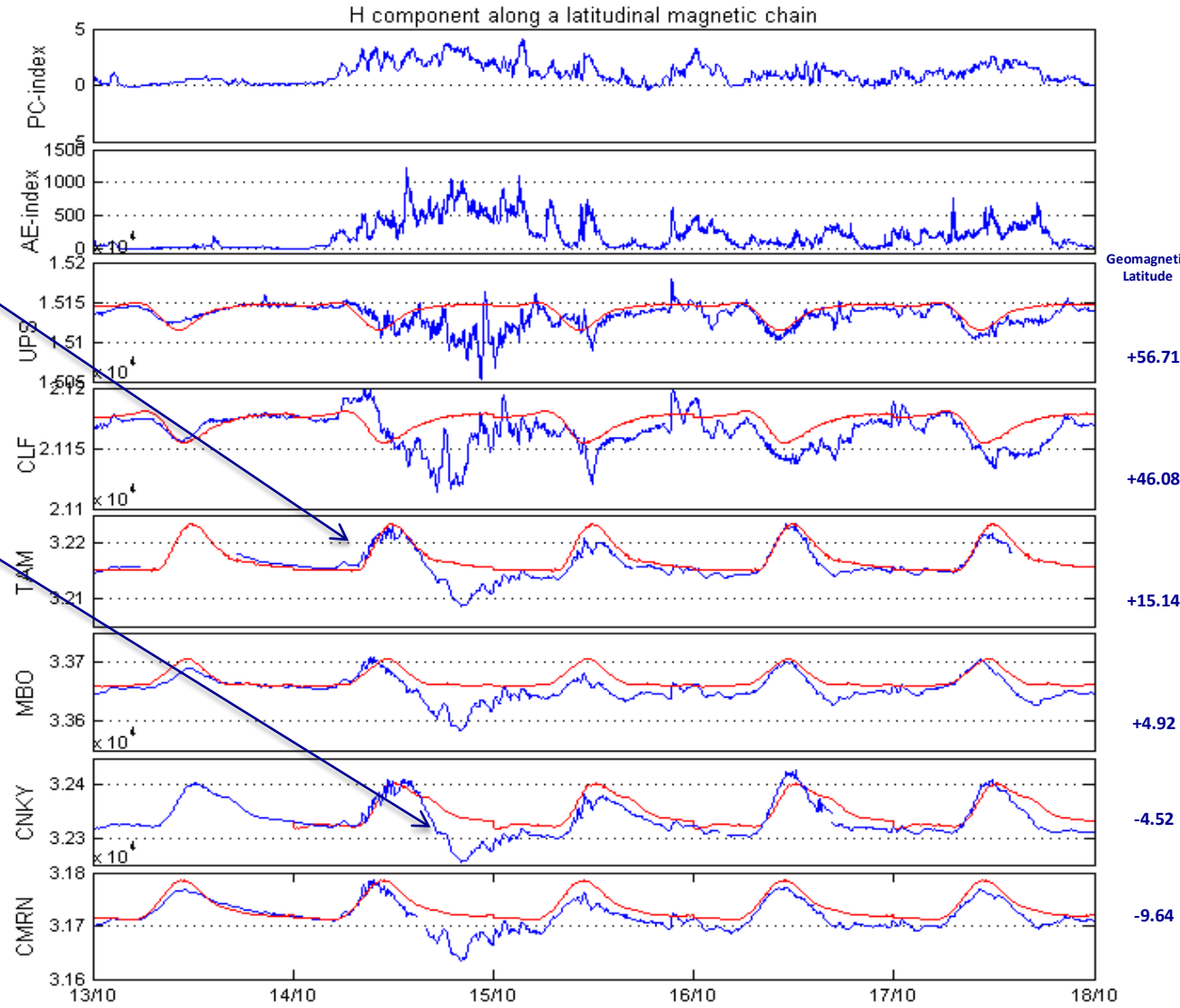
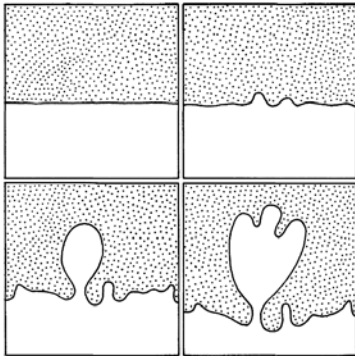# Equatorial Ionosphere during magnetic quiet time (post Sunset)

PRE : Pre reversal enhancement

Intense uplift of the eastward electric field +Height increase in the equatorial ionosphere

Growth rate of the Rayleigh Taylor instability => Irregularities in plasma

Plasma Bubble (Kelley 2009)

Scintillations Phase

depletion of electronic density
Gradient of electronic density
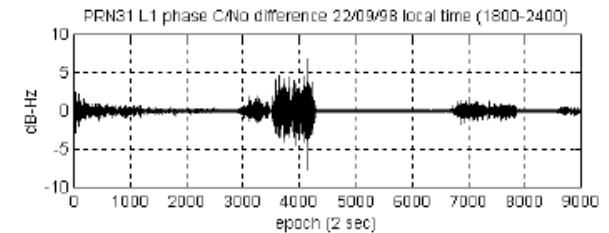=> Spread F, Scintillations

Figure 4.9b Sequential sketches made from photos of the hydrodynamic Rayleigh-Taylor instability. A heavy fluid is initially supported by a transparent lighter fluid.

during October 14th 2013

no uplift of the F2 layer

DDEF (D_{dyn})
Disturbance Dynamo Electric Field
associated to the **high speed solar wind** ⟶ westward electric field

inhibition of scintillation over whole Africa

Conclusion

- The inhibition of scintillations over Africa only on October 14 is due to DDEF (Disturbance Dynamo electric field associated to the high speed solar wind).

- This process creates a westward electric field opposite to the regular eastward electric field at the origin of the lift up of the F layer and at the origin of scintillations.

Perspective

- A statistical study of correlation between inhibitions of scintillations (no uplift of the F2 layer) and solar event (high speed solar wind stream and Coronal Holes) .

Thank you for your attention

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