Geomagnetic disturbance effects in geo-electric field variations at low latitudes.

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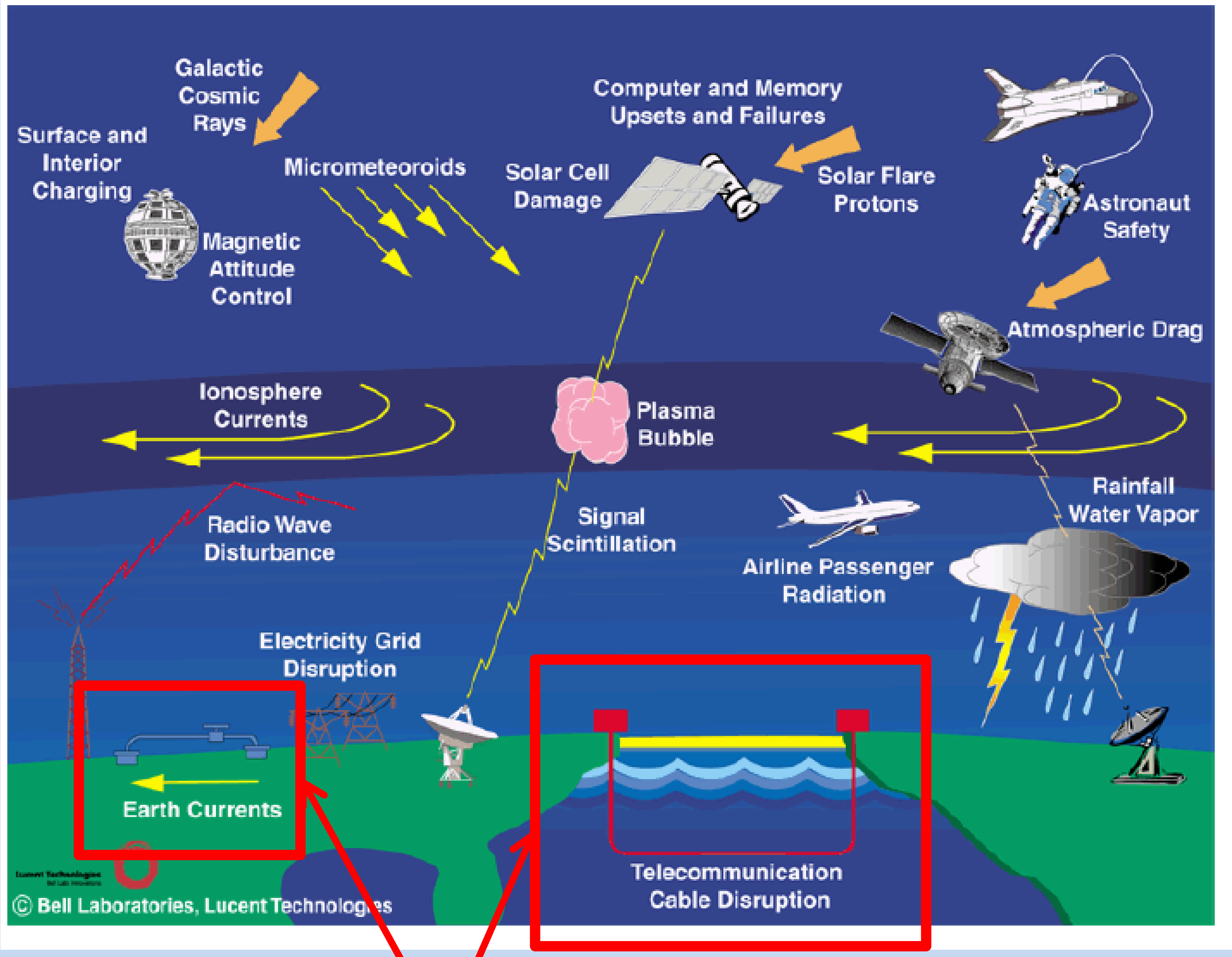


Space weather related induced current are in general poorly addressed

-Intense space weather events (geomagnetic storms and sub-storms) are potential sources of electric induction within the earth.

These events cause intense geomagnetic field variations which induce electric currents in the conducting layers of the Earth.

$$\vec{\nabla} \times \vec{E} = -\frac{d\vec{B}}{dt}$$ Maxwell's equation

Disruptions of technological equipments dues to "Geomagnetically Induced Currents (GICs)" are experienced in the Scandinavian countries since mid XIXth century (Pulkkinen, 2003).

Due to their harmful impacts on technological devices, the GICs have been mostly investigated at high latitudes (Pulkkinen et al., 2001a, 2001b, 2003, 2007; Kataoka and Pulkkinen, 2008; Pirjola, 2000; 2002; 2005; Wilk et al., 2008, 2009).

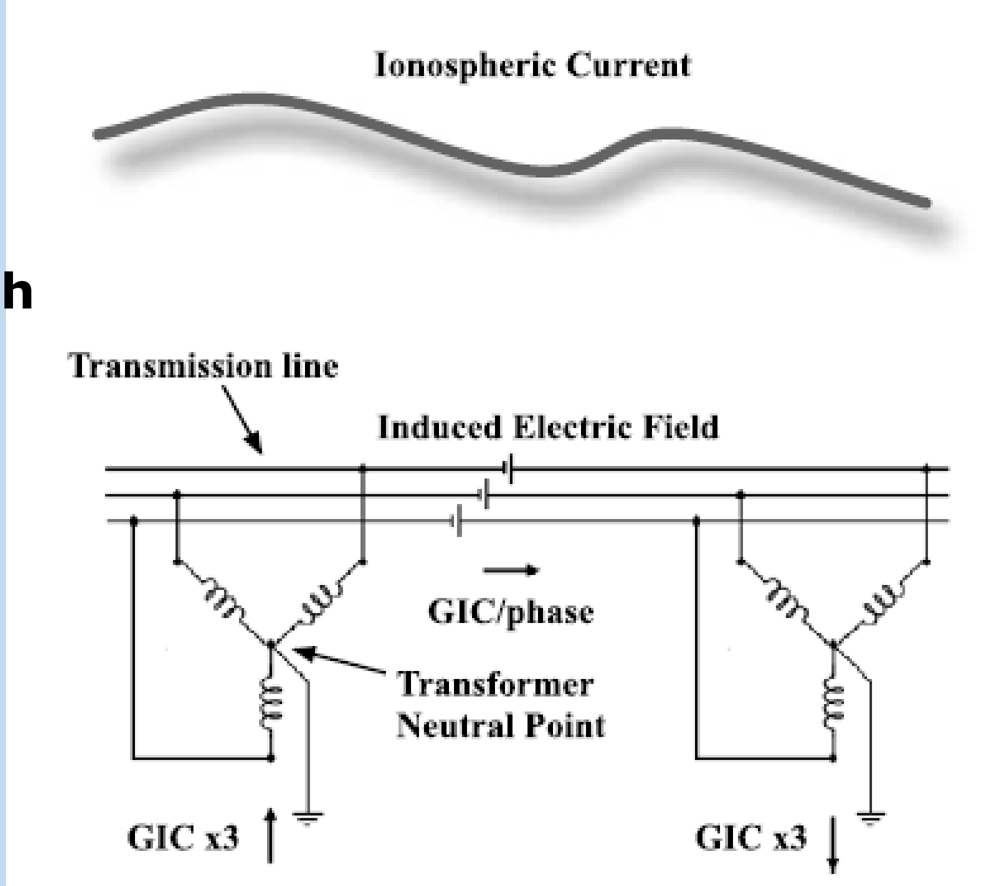
Magnetosphere-ionosphere coupling generates intense currents such as auroral electrojets in the high latitude ionosphere.

These currents are extremely enhanced during geomagnetic storms and sub-storms and cause very intense geomagnetic field variations.

As consequence, intense GICs flow, causing frequent disturbances in technological devices like telecommunication and pipe lines, power grid and transformers.

- GICs enter a power grid through earthed transformer neutrals ("earthing currents")

- flow along transmission lines ("line currents") to other transformers, and go back to the ground.



Wik et al. (2008)

Kappenman (2003) demonstrated the risk of large GIC occurrence associated with large geomagnetic impulses like Storm sudden commencement (SSC) at low- and mid-latitudes.

There are reports on GIC causing perturbation in technological structures in mid- and low-latitude (Ngwira et al., 2008; Torta et al., 2012, Trivedi et al., 2007).

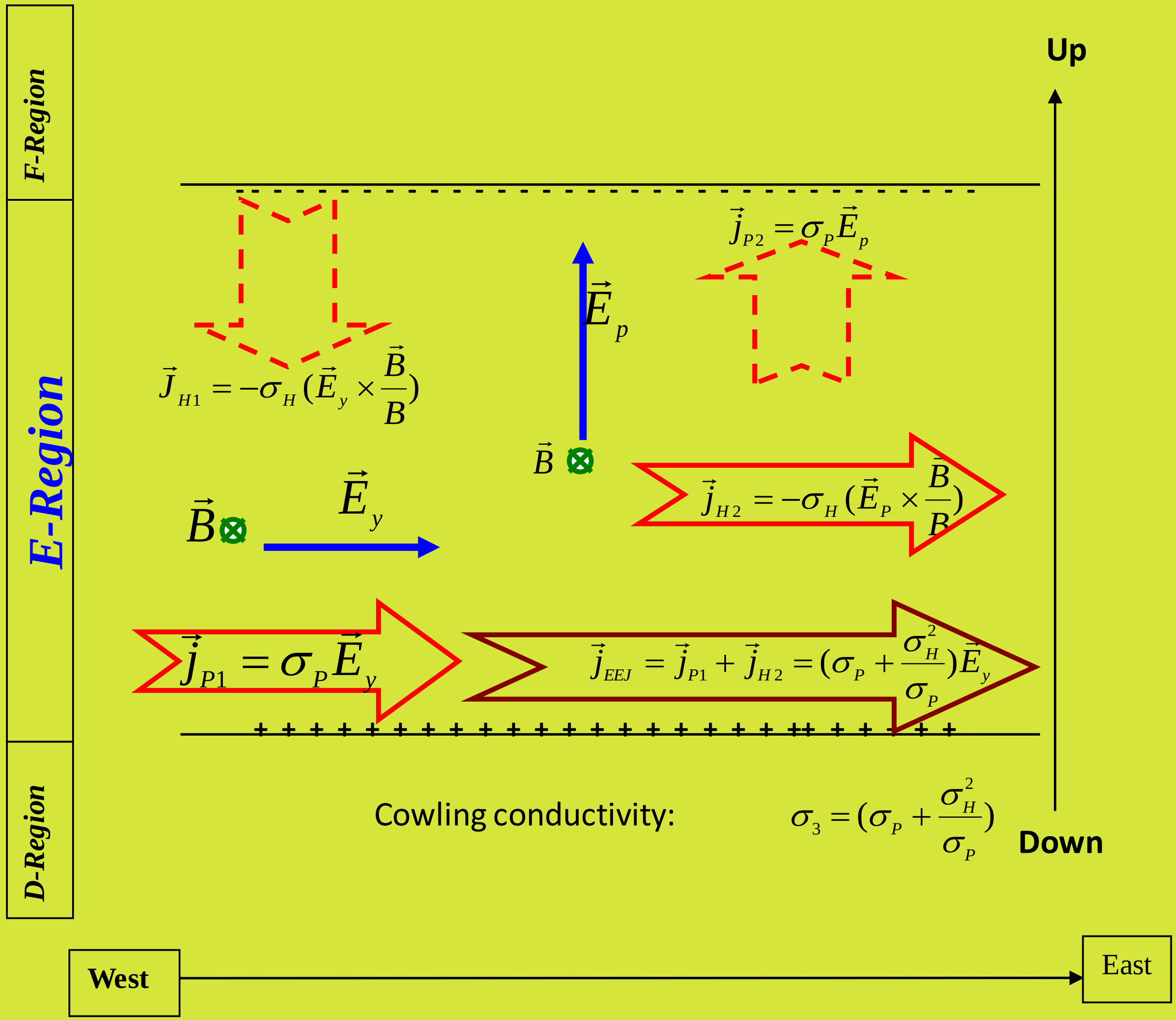
However, only few research works have been devoted to the induction effects of space weather related geomagnetic field disturbances at low latitude.

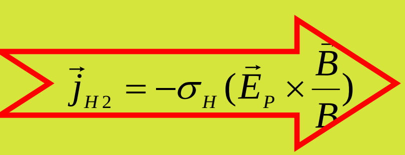
Most studies on the issue have mainly focused on the induction effects of the equatorial electrojet.

Most of those studies have concluded on very weak induction effect of the EEJ (Fambitakoye, 1973, Ducruix et al., 1977).

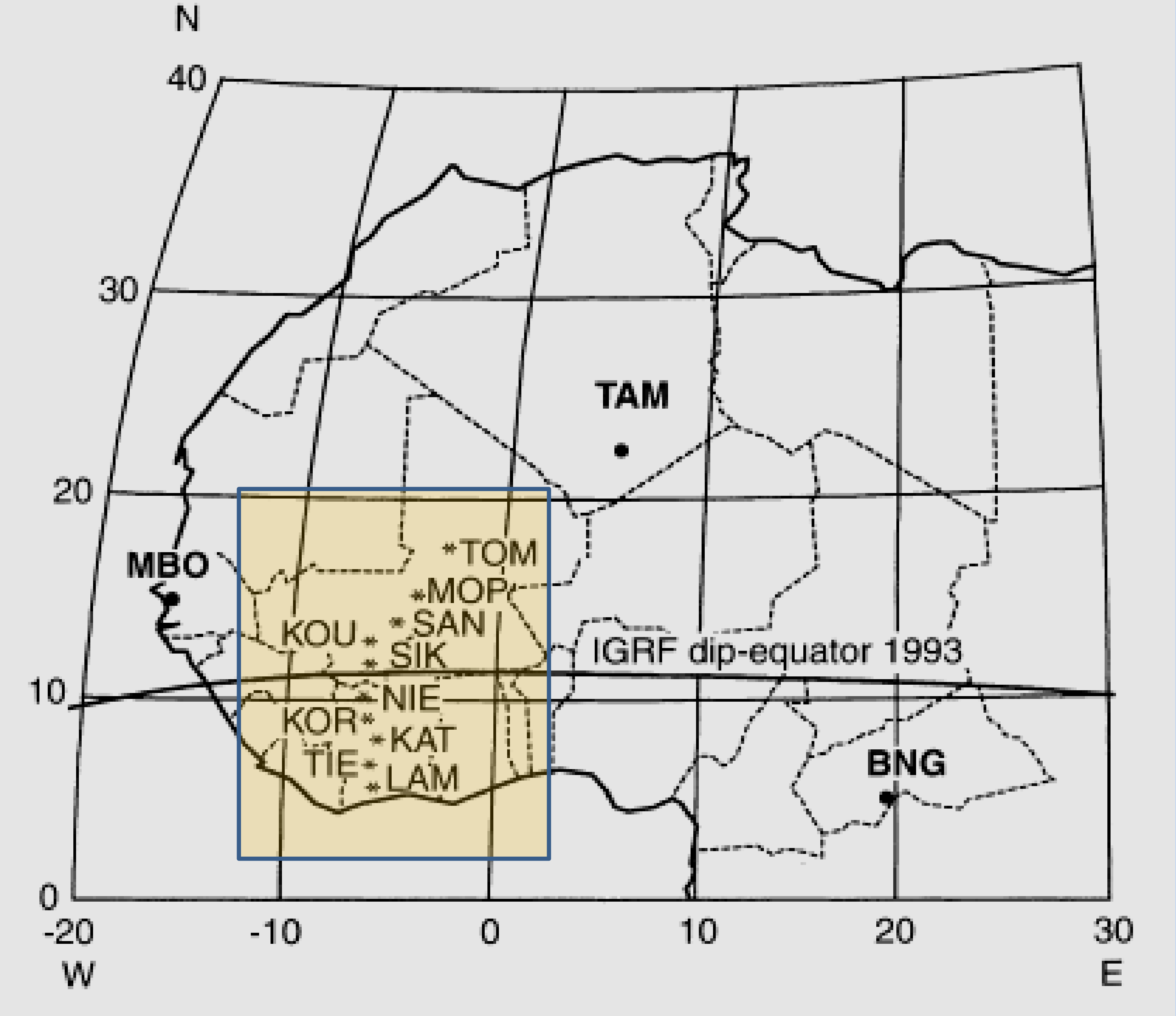
In this talk, I present the induction effects of a geomagnetic storm and a solar flare effect in the **geo-electric field** variations observed in West Africa.

Mechanisme de l'EEJ





Supplément de courant dû à la configuration horizontale de $\vec{E}_y$ et $\vec{B}$ à l'équateur magnétique.



The West African network of stations for the geomagnetic and telluric field measurements during IEEY.

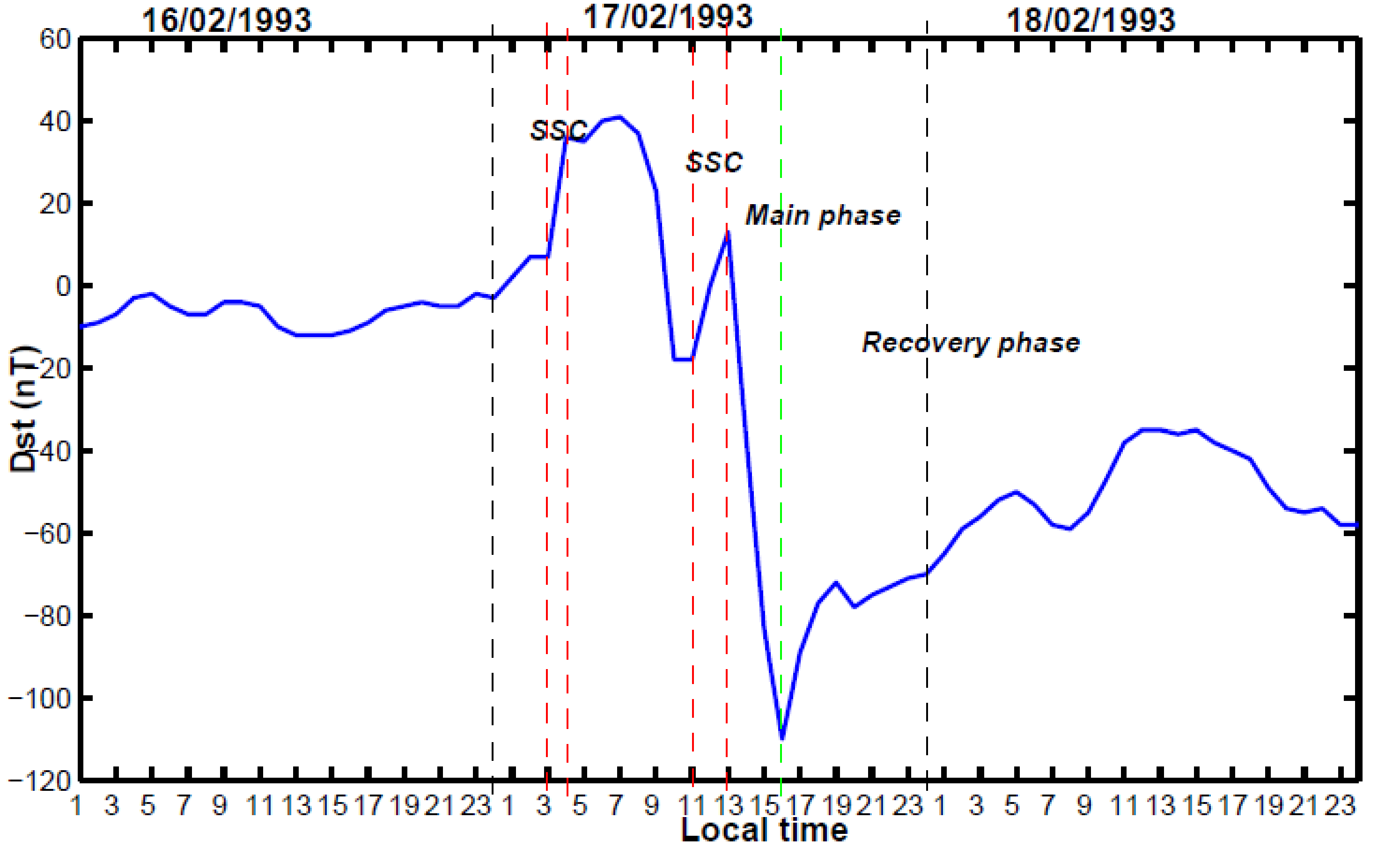
Stations	Station Codes	Geographic		Dip-Latitude (°)
		Latitude (°N)	Longitude (°W)	
Tombouctou	TOM	16.733	3.000	6.76
Mopti	MOP	14.508	4.087	4.02
San	SAN	13.237	4.879	2.45
Koutiala	KOU	12.356	5.448	1.38
Sikasso	SIK	11.344	5.706	0.12
Nielle	NIE	10.203	5.636	-1.30
Korhogo	KOR	9.336	5.427	-2.38
Katiola	KAT	8.183	5.044	-3.85
Tiebissou	TIE	7.218	5.241	-5.04
Lamto	LAM	6.233	5.017	-6. 30

- The H, D and Z components of the geomagnetic field

- The Ex (NS) and Ey (EW) components of the geo-electric Field.

Geomagnetic field variations during the 17 February, 1993 storm

The Dst index from 16 to 18/02/1993



17/02/1993, 2 SSC at 3:00LT and 12:00LT start the process of a moderate geomagnetic storm :

Am = 64nT

During the main phase of the storm the Dst minimum value is **-110nT** around 16:00UT

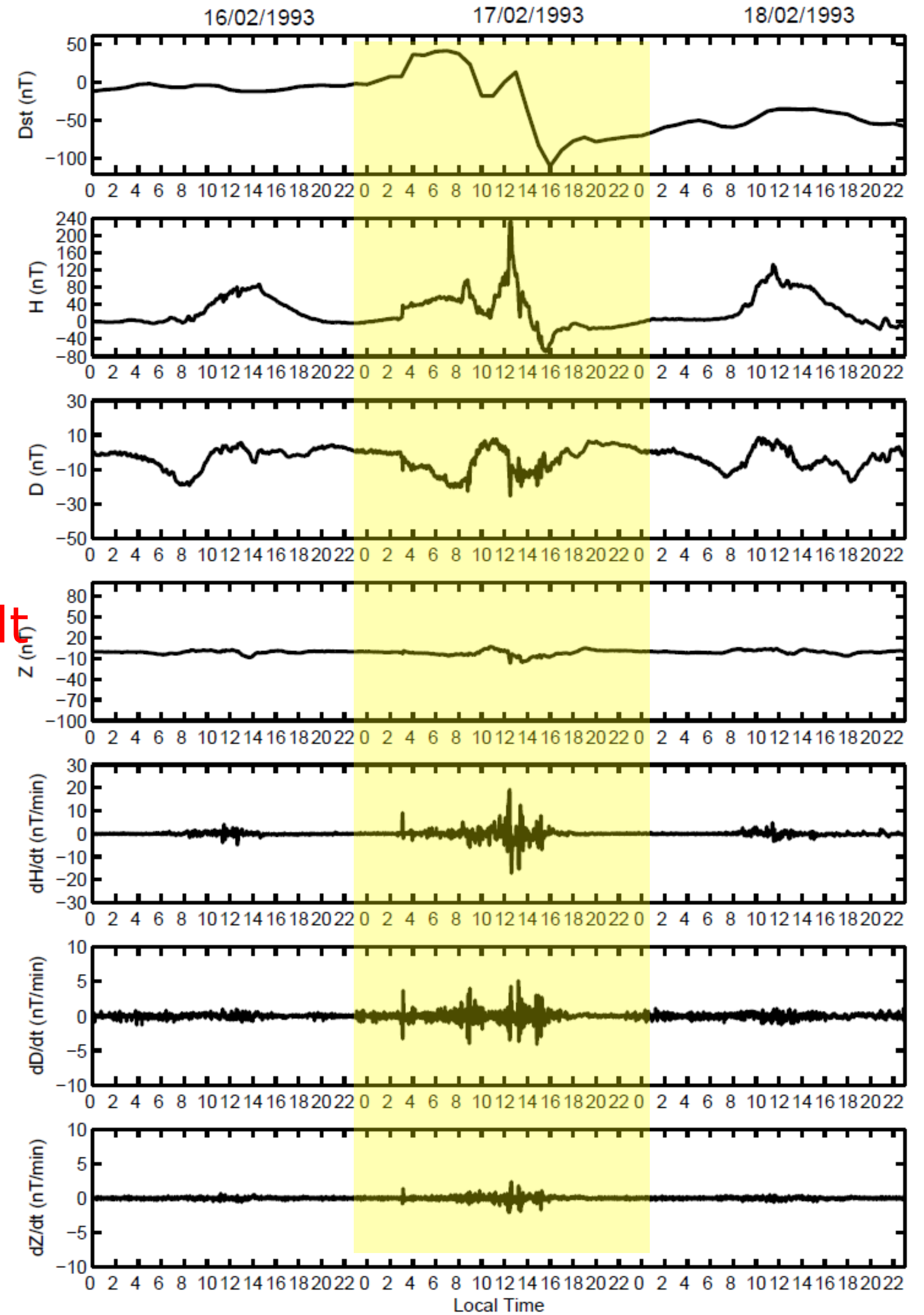
The geo-electric field can be determined from ground-based geomagnetic field according to:

$$\vec{\nabla} \times \vec{E} = -\frac{d\vec{B}}{dt}$$ Maxwell's equation

Dst index and variations of H, D and Z components and the time derivatives dH/dt, dD/dt and dZ/dt 16-18/02/1993 at **SIK (0.12° dip-lat)**

The 1st SSC at 3:00LT : ~35nT, dH/dt=10nT/min

The 2nd SSC at 12:00UT: ~120nT, dH/dt = 40nT/min



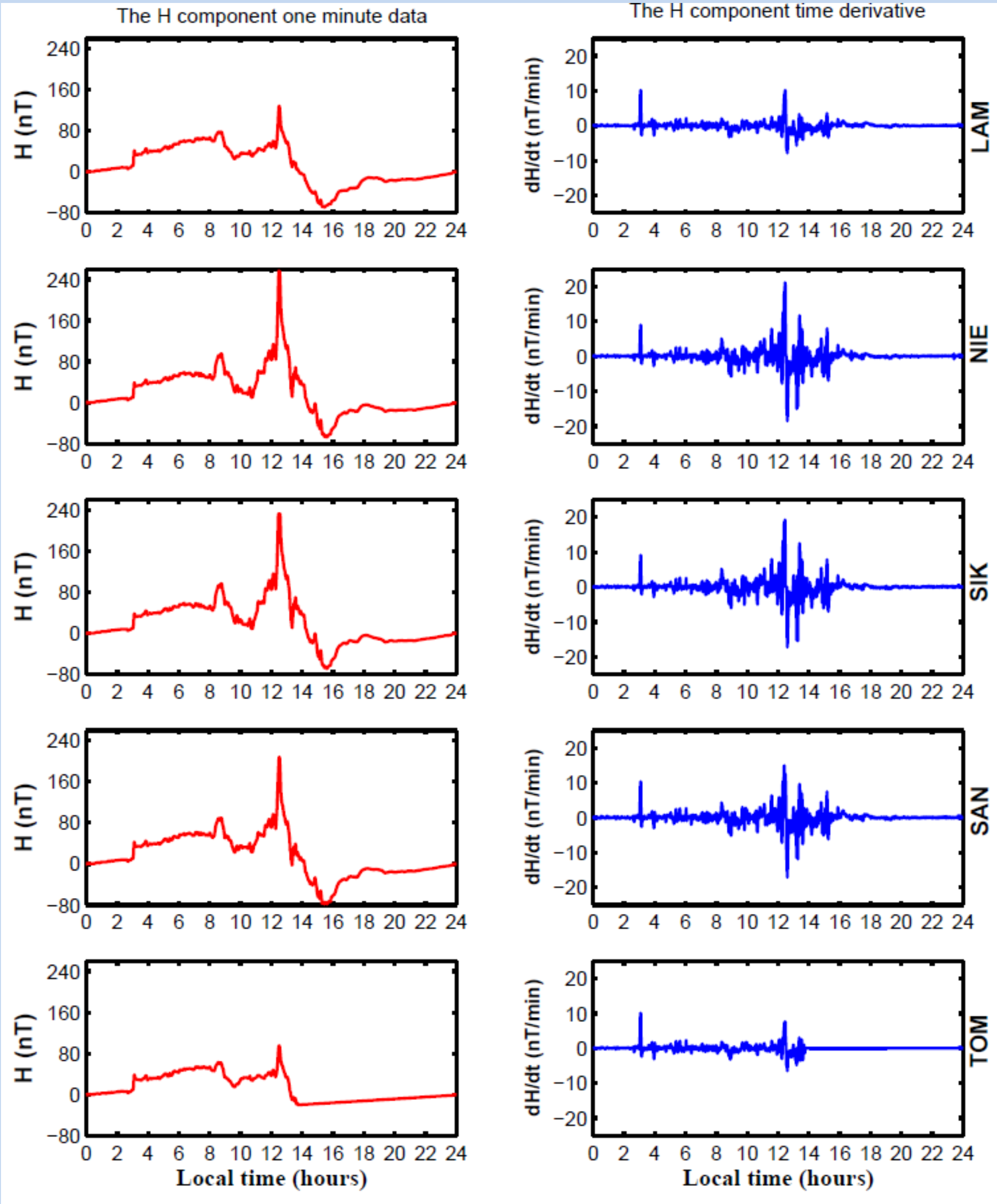
Geomagnetic field variations during the 17 February, 1993 stormC

Variations of H and dH/dt

LAM, -6. 30° dip-lat
NIE, -1.30°dip-lat
SIK, +0.12° dip-lat
SAN, +2.45°dip-lat
TOM, +6.76°dip-lat

- The amplitude of nighttime SSC effects does not change from one station to another.

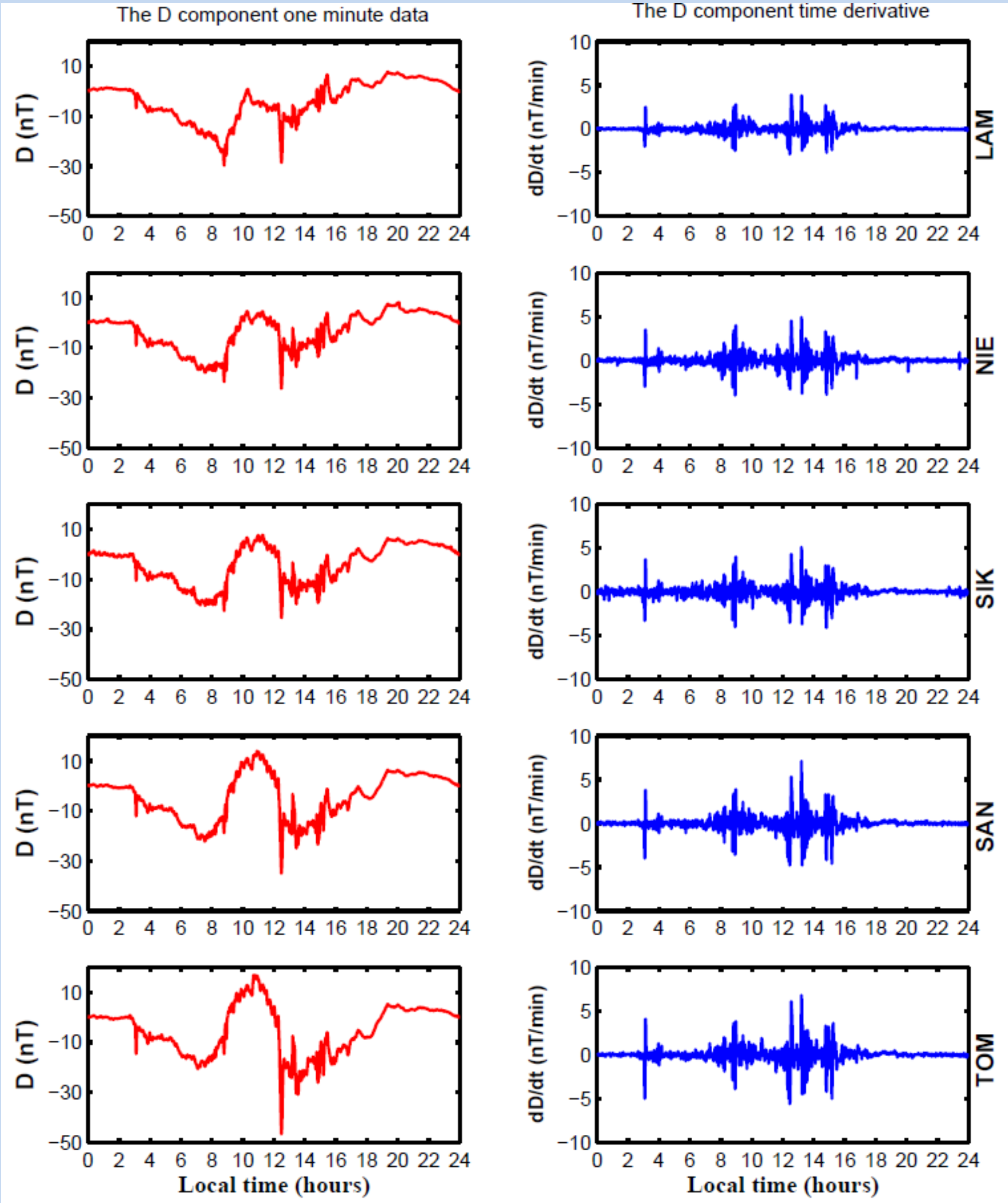
- The daytime SSC reflects the influence of the equatorial electrojet



Geomagnetic field variations during the 17 February, 1993 storm

variations of D and dD/dt

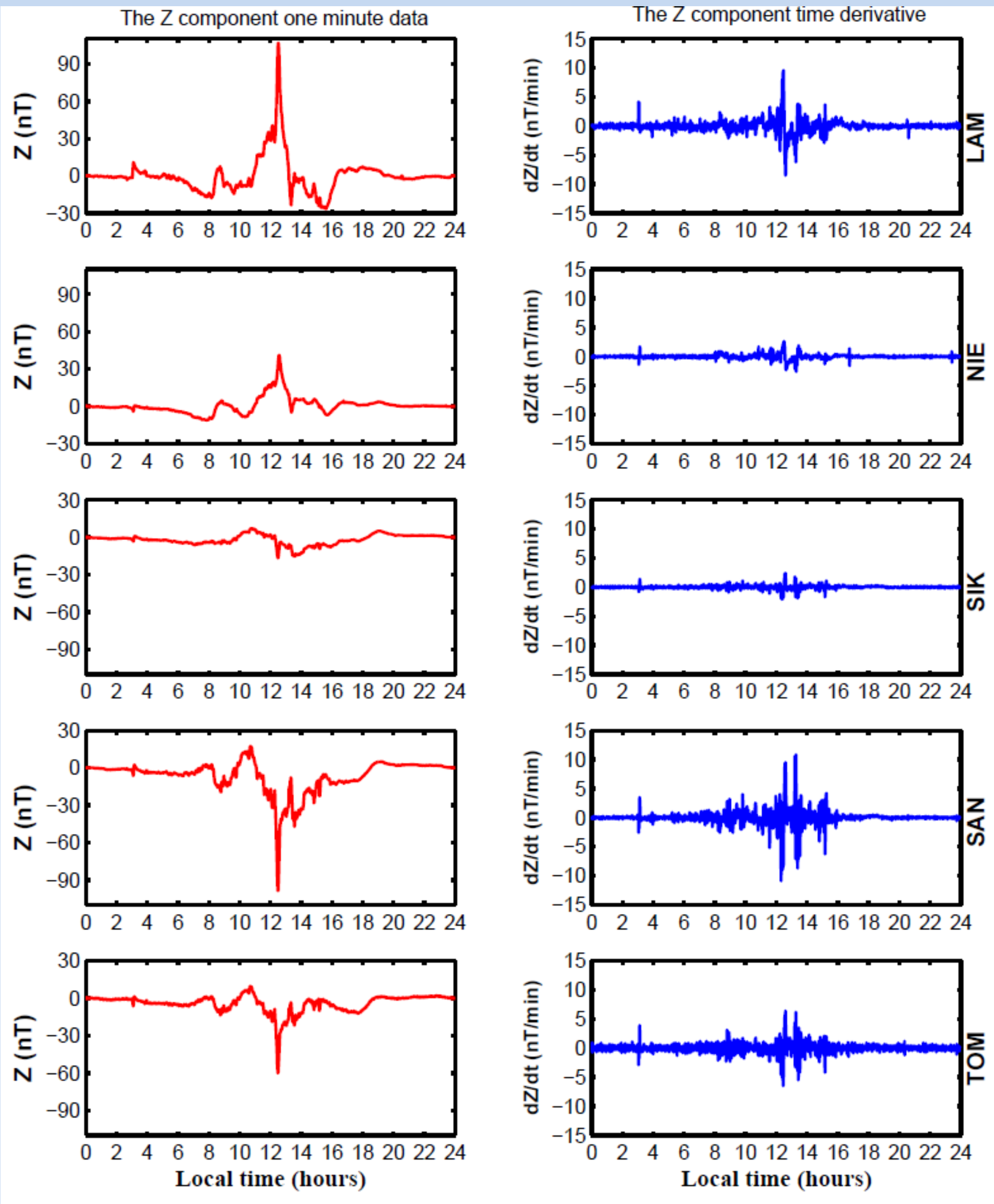
LAM, -6. 30° dip-lat
NIE, -1.30°dip-lat
SIK, +0.12° dip-lat
SAN, +2.45°dip-lat
TOM, +6.76°dip-lat



Geomagnetic field variations during the 17 February, 1993 storm

variations of Z and dZ/dt

LAM, -6. 30° dip-lat
NIE, -1.30°dip-lat
SIK, +0.12° dip-lat
SAN, +2.45°dip-lat
TOM, +6.76°dip-lat



Geo-electric field variations in response to the geomagnetic field variations

In the practice, the geo-electric field is determined from ground-based geomagnetic field at the Earth's surface according to plane wave relationship between $\vec{B}$ and $\vec{E}$:

$$Ex = Z(\omega).D(\omega)/\mu_0$$

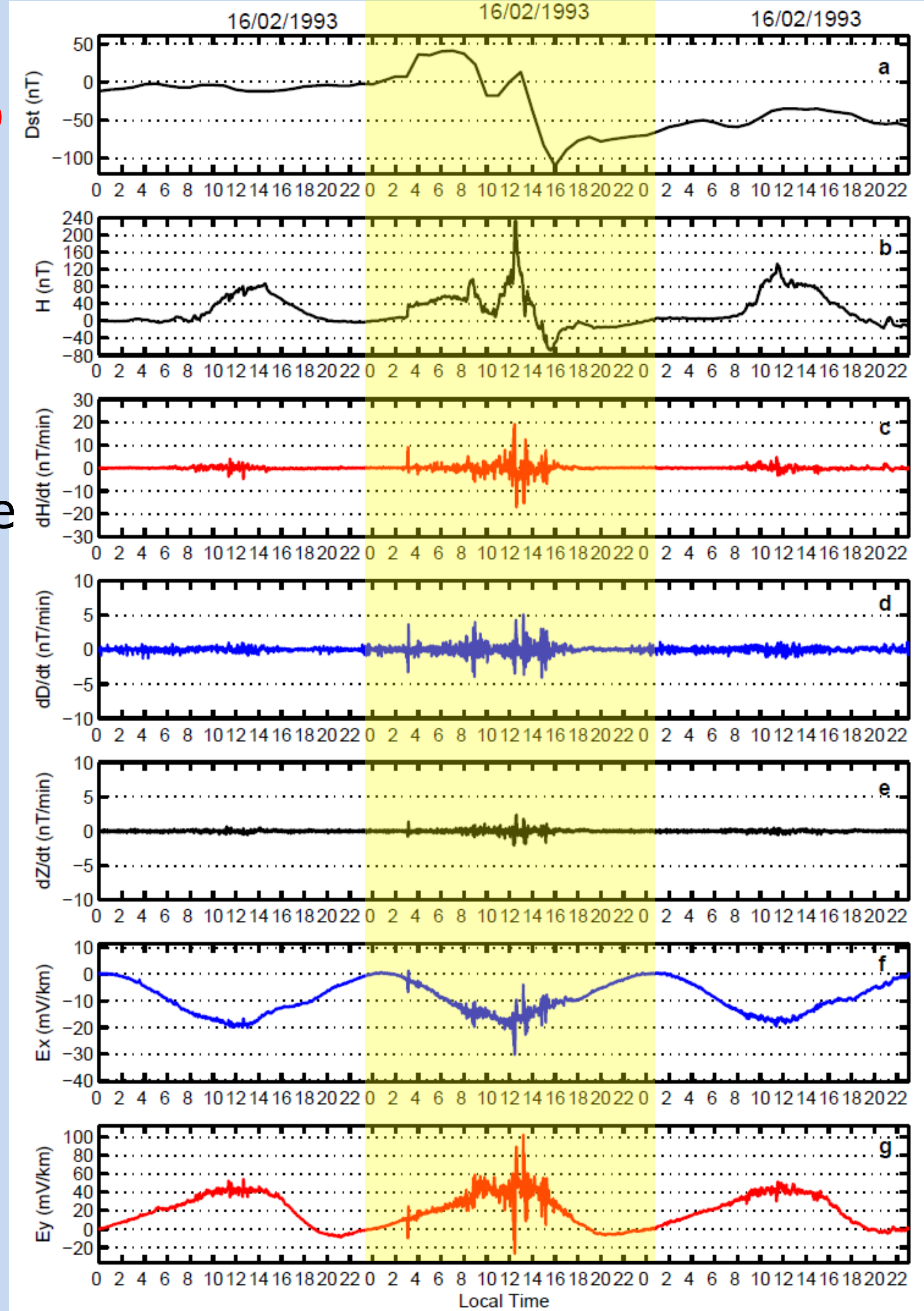
$$Ey = -Z(\omega).H(\omega)/\mu_0$$

ω angular frequency

Z impedance

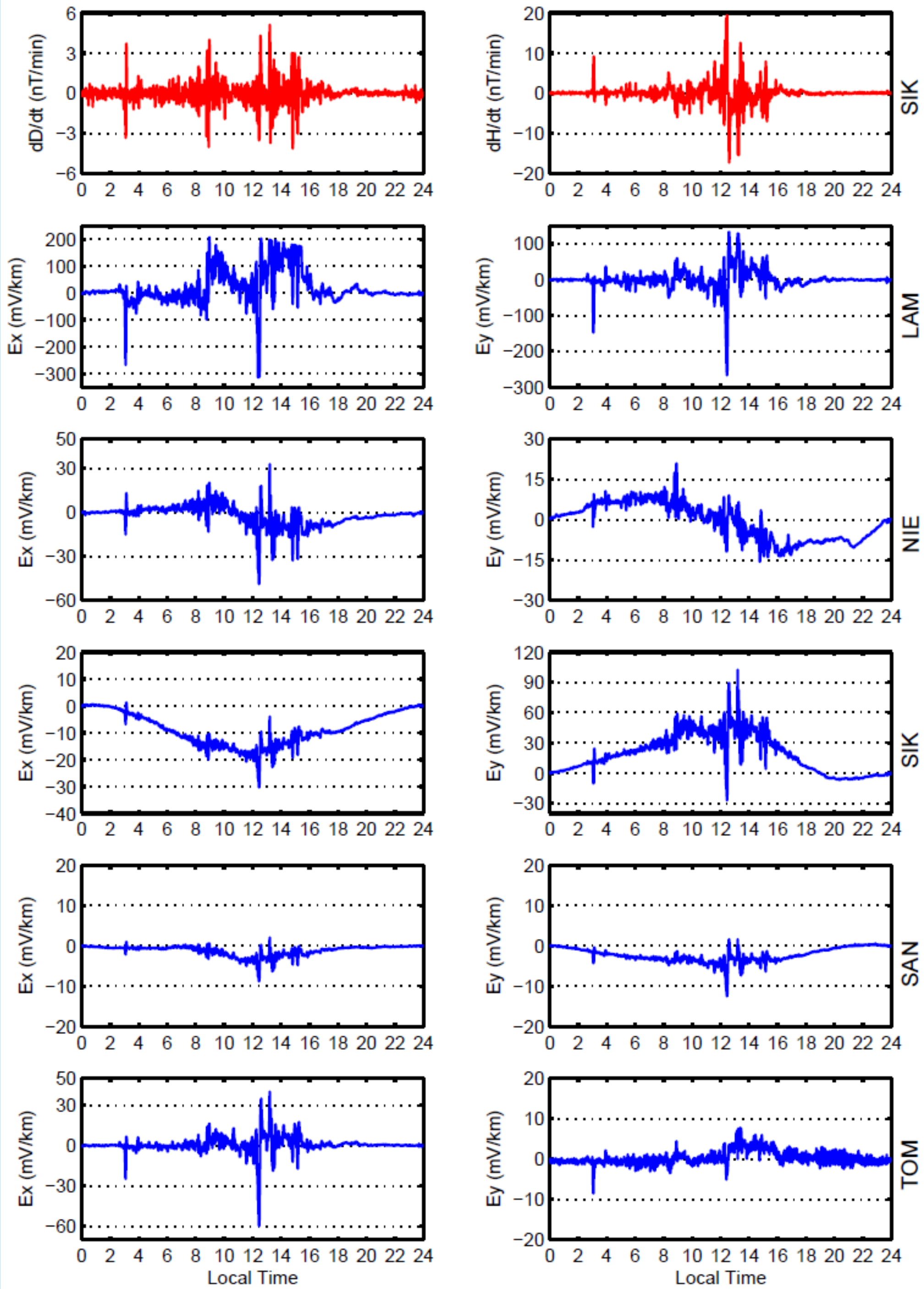
μ_0 MPV

Dst index and variations of **H**, **dH/dt**, **dD/dt**, **dZ/dt**, **Ex** and **Ey**, 16-18/02/1993 at **SIK** (**$0.12°$ dip-lat**)

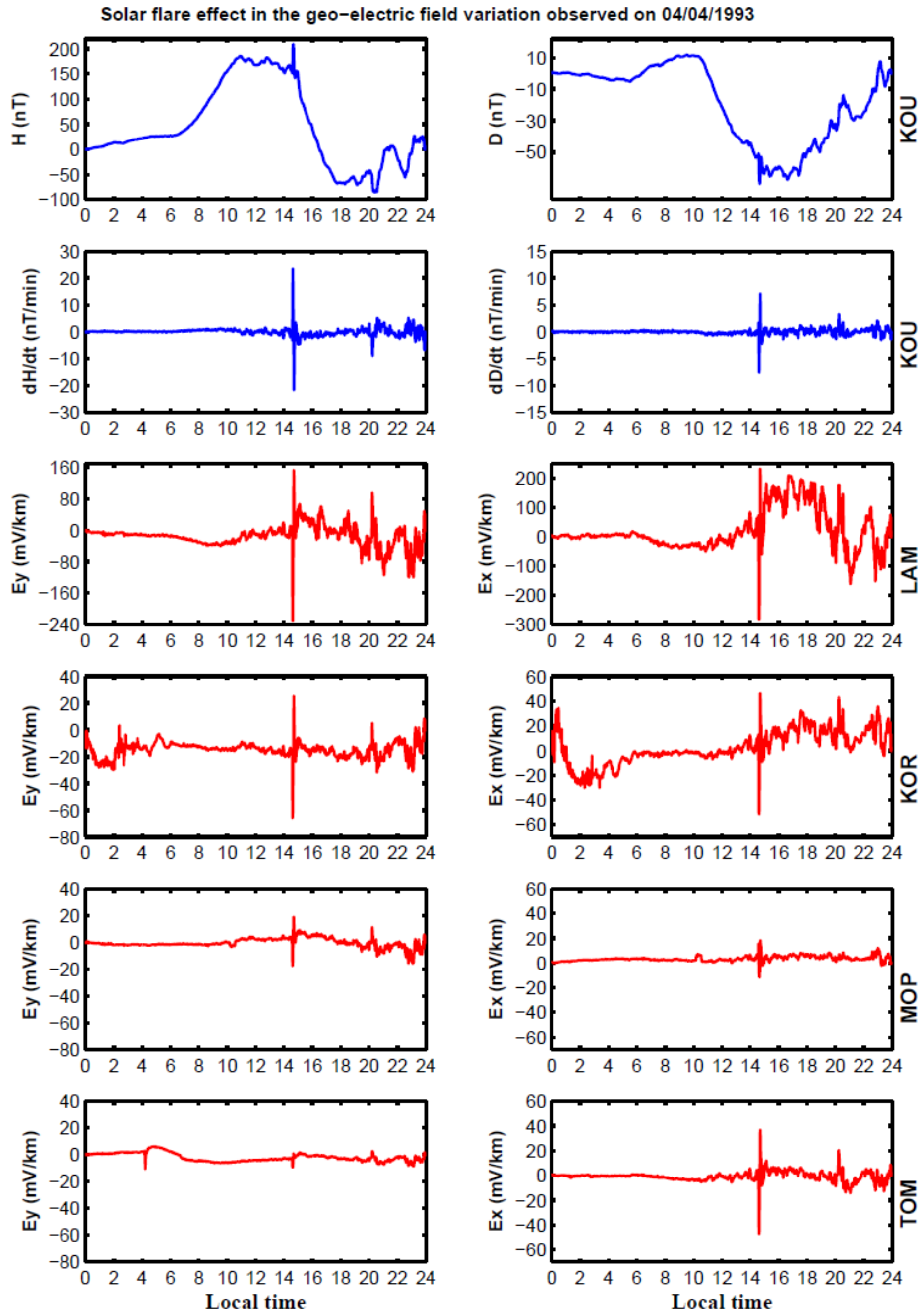


Dependence of the geo-electric field intensity on the *dip latitude???*

	3:00LT		12:00LT	
	Ex (mV/km)	**Ey (mV/km)**	**Ex (mV/km)**	**Ey (mV/km)**
LAM	**270**	**150**	**520**	**400**
NIE	30	8	70	19
SIK	8	30	20	**120**
SAN	---	---	10	14
TOM	30	10	95	8



Geo-electric field response to the solar flare effect (sfe) on 04/04/1993



Summary

- ✓ Intense space weather events are potential sources of electric inductions within the Earth at low latitudes.

- ✓ The most important induction effects at low latitudes are associated with brisk impulses (SSC and sfe) in the geomagnetic field variations.

- ✓ The SSCs can produce non negligible variations in geo-electric field, depending on the location.

- ✓ The geo-electric field intensity does not show any special latitudinal trend.

- ✓ The moderate geomagnetic storm on 17 February 1993, (minimum Dst index is -110nT), produced non-negligible geo-electric field variations at LAM, as responses to the daytime SSC : Ex=520mV/km and Ey=400mV/km.

THANK YOU