IAGA INTERNATIONAL SYMPOSIUM
"SPACE WEATHER AMD ITS EFFECTS ON SPACECRAFT"
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USE OF GEOMAGNETIC DATA IN THE STUDIES OF SPACE WEATHER IN VIETNAM

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PLAN OF PRESENTATION

INTRODUCTION

-*In 1996, the first 500kV power lines system was constructed in Vietnam;*

- *In 2000, the first petrol and gas pipe-lines was constructed in Vietnam*

-*Vietnam is a tropical country, in the low latitudes zone;*

- *Question: Is it possible that the space weather, expressed by the magnetic storms, impacts on the technologies in the low latitude zones?*

I.HANOI INSTITUTE OF GEOPHYSICS (HIG)

- *Belong to: Vietnam Academy of Science and Technology (VAST)*
- *Founded: in 1986*
- *Address: Hanoi – VIETNAM*
- *Staff: 120 members (20 Profs. and Drs.)*

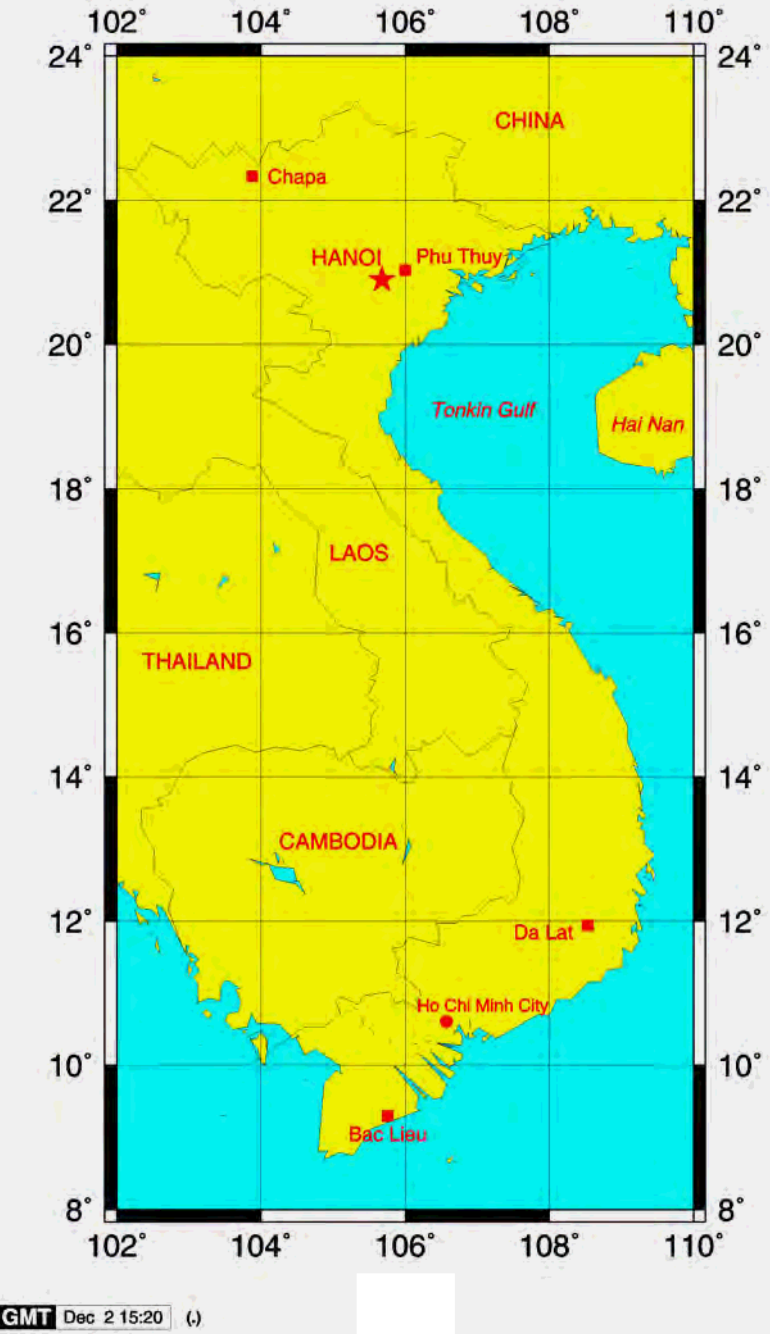
Organization of HIG

* **6 departments** *+ Seismology,*
  + Seismological Network,
  + Geomagnetism,
  + Applied Geophysics,
  + Geodynamics,
  + Atmospheric Physics.
* 30 Observatories and stations
  - *24 seismic stations*
  - *4 geomagnetic observatories*
  - *2 ionospheric stations*
  - *3 atmospheric physics stations*
  - *2 crust deformation stations*
* **Staff: 120 persons**

Geomagnetism Department

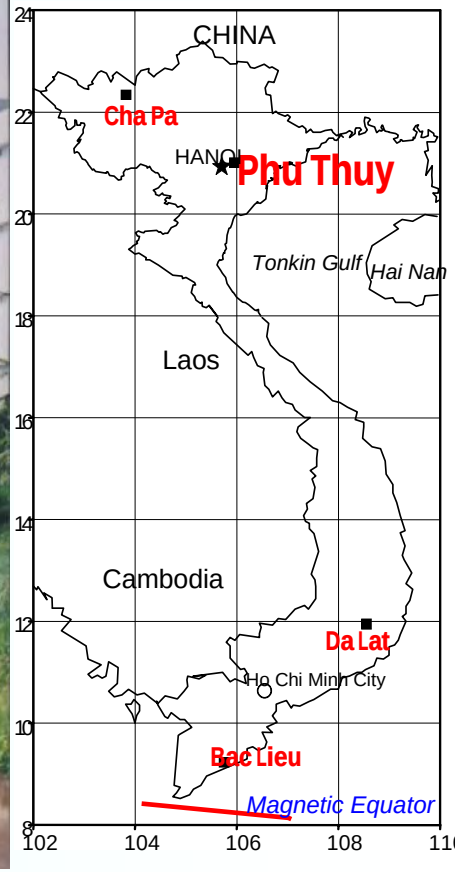
Organization structure: Sujects

- *Network of magnetic observatories*
- *Palaeomagnetism*
- *Time variations of the Earth's magnetic field*
- *Main field and its secular variation*
- *Normal geomagnetic field and geomagnetic anomalies*
- *Magnetovariational method for investigation of electrical conductivity in the Earth's crust (M.V. method)*
- *Application (magnetotelluric…)*
- *Ionospheric studies*
- *Space weather: Impacts of magnetic storms on high electric power-lines and petrol and gas pipe-lines*
- *Atmospheric studies with GPS*



I.2. MAGNETIC OBSERVATORIES

PMO PHU THUY
Planetary Magnetic Observatory
Main building



PHU THUY PMO

Magnetometer and sensor Pavilion

PHU THUY PMO

Absolute Measurement Pavilion

PHU THUY OBSERVATORY
INSTRUMENTATION

(φ = 21°02'N; Λ = 105°57'E; h = 5 m)

** FOUNDATION: 1961*

** INSTRUMENTATION:*

- For field recording:

- From 1961 – 1993 : + MBC Bobrov (Russia)

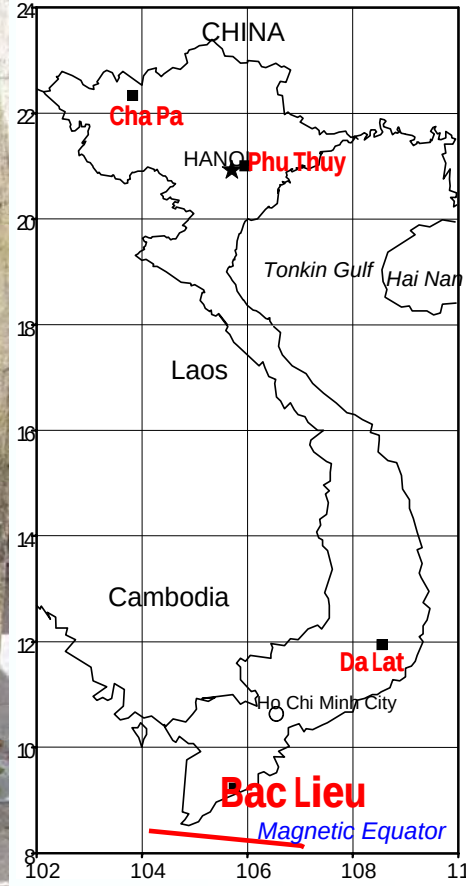
- From 1993 (France) + Scalar Magnetometer SM90R (Rez.: 0.01nT)
+ Vector Magnetometer V312 (Rez.: 0.1nT)
+ Digital recorder GEOMAG-390

- From 2001: + Scalar Magnetometer SM100 (Rez.: 0.01nT)
(France) + Vector Magnetometer VM300 D (Rez.: 0.1nT)
+ Digital logger ENOII + GPS

- For absolute measurements:

- From 1995 : + Fluxgate DI-MAG 93-02 (1'')
(France) + Geometrics G816 (0,25 nT)

BAC LIEU Observatory
Magnetometer House



BAC LIEU EQUATORIAL OBSERVATORY
Installation of the equipments

BAC LIEU OBSERVATORY INSTRUMENTATION

(φ = 9°17'N; Λ = 105°44'E; h = 5 m)

* ***FOUNDATION:*** ***1988***

* ***INSTRUMENTATION:***

- ***For magnetic field recording:***

  + ***From 1988 – 1997 : MBC Bobrov (Russia)***

  + ***From 1998 :***

    • ***Fluxgate Magnetometer FRG-601 (0.01nT)***

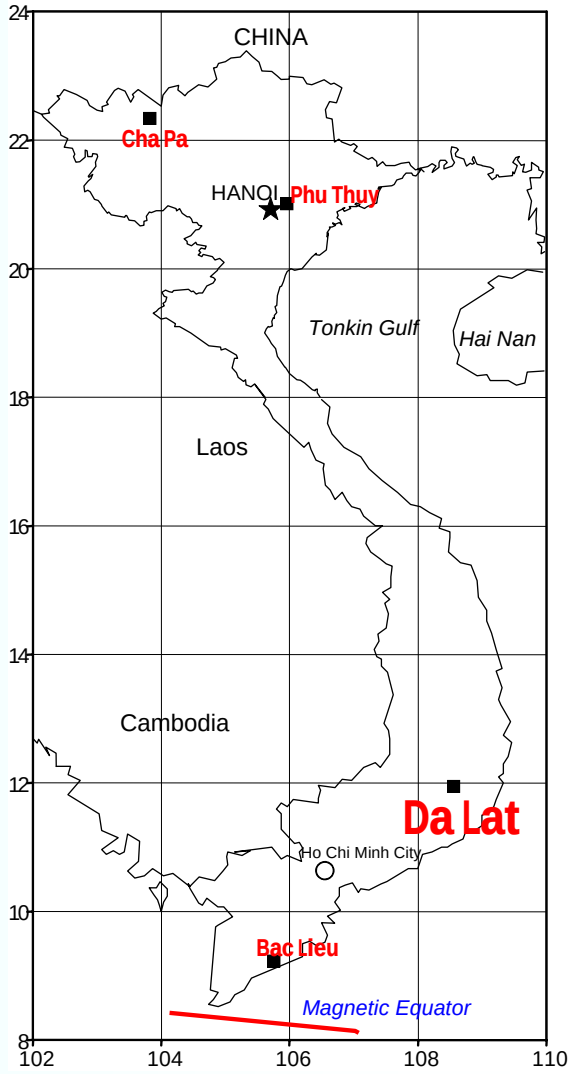
    • ***Digital Recorder DCR-3 MO***

  [PEER (Penetration of polar Electric fields into Equatorial Region) project of Prof. Yumoto, Japan]

- ***For ionospheric recording:***

  + ***From 11/2005 – 3/2006: • SKI-02098 (SEALION Programme - Prof. Maruyama and Ishii)***

DALAT OBSERVATORY



DALAT OBSERVATORY INSTRUMENTATION

(φ = 11°57'N; Λ = 108°29'E; h = 1550m)

* ***FOUNDATION:*** ***1981***

* ***INSTRUMENTATION:***

- For field recording:

- From 1981 - 2003: ***MBC Bobrov (Russia)***

- From 2003: ***+ Scalar Magnetometer SM100 (Rez.: 0.01nT) (France)***

+ Vector Magnetometer VM300 D (Rez.: 0.1nT)

+ Digital logger ENOII + GPS

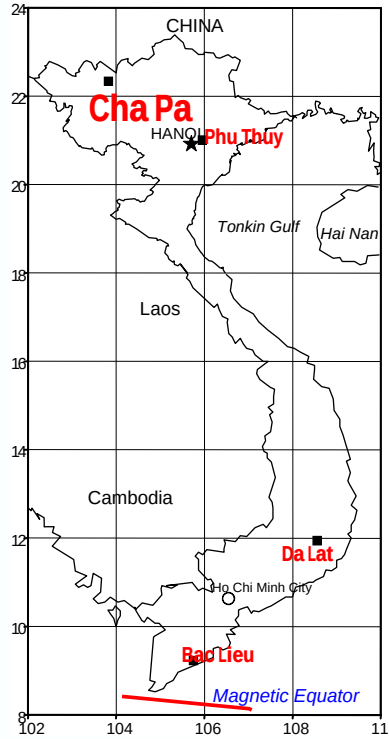
- For absolute measurement:

- From 1985 – 1995:

+ Declinometer (Germany)

+ Proton magnetometer MP2 (1nT) (Canada)

CHAPA OBSERVATORY
Absolute measurement House



CHAPA OBSERVATORY
Magnetometer House

CHAPA OBSERVATORY INSRUMENTATION

(φ = 22°20'N; Λ = 103°50'E; h = 1550m)

** FOUNDATION: 1957 (IGY)*

** INSTRUMENTATION:*

- For field recording:

+ From 1957 - 1968 : Askania (Germany)
+ From 1968 : MBC Bobrov (Russia)

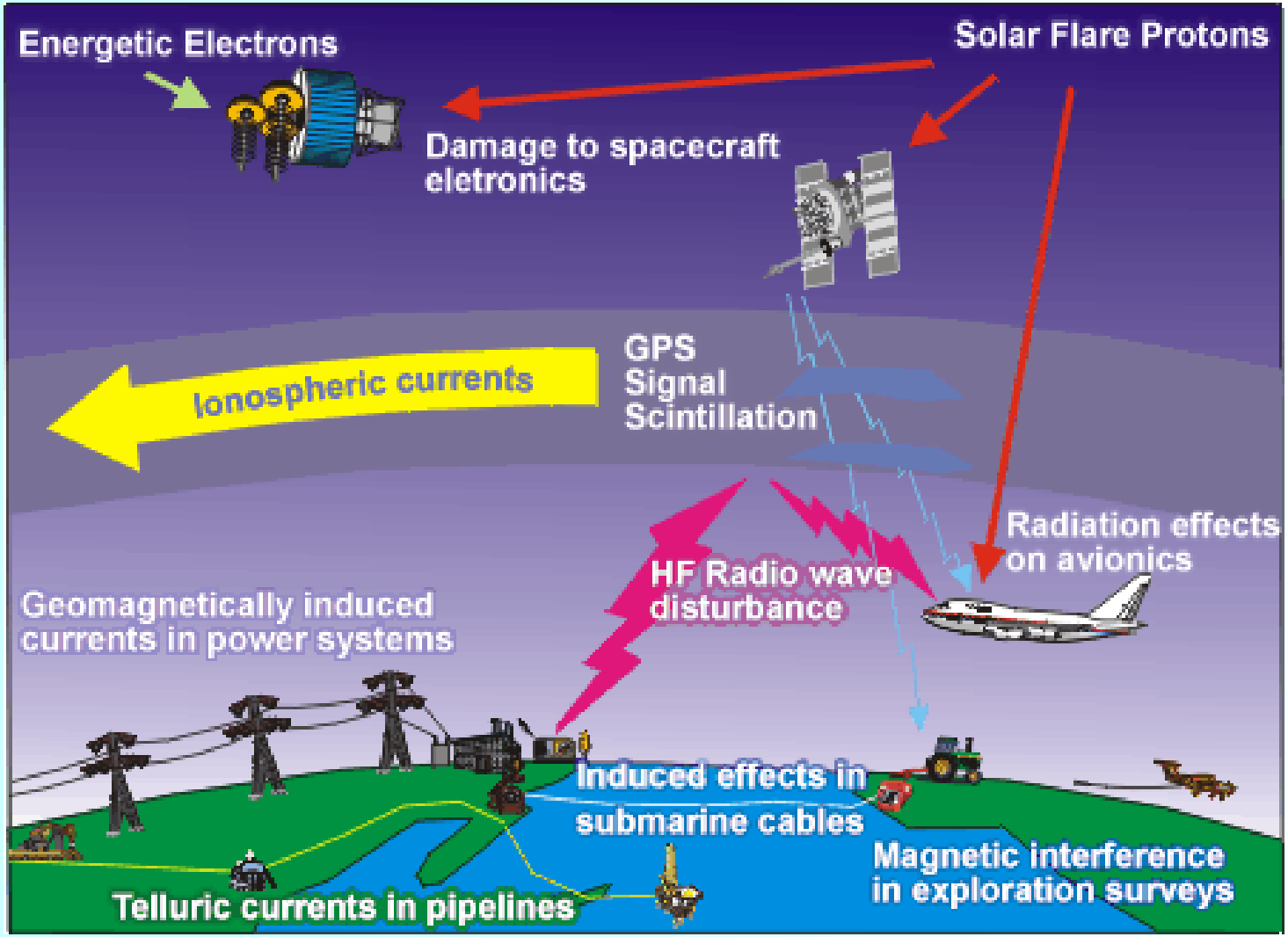
- For absolute measurement:

From 1957 – 1997:

+ QHM-241, QHM-140 (Denmark)
+ Declinometer (Germany)
+ Inclinometer (Germany)

II. USE OF MAGNETIC DATA FOR STUDYING THE SPACE WEATHER

SPACE WEATHER EFFECTS ON TECHNOLOGY

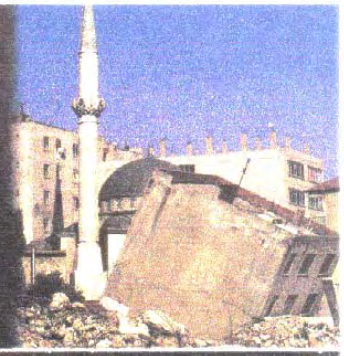


USGS
science for a changing world

GeoHazards
Golden

http://geohazards.cr.usgs.gov

Earthquakes



The U.S. Geological Survey National Earthquake Information Center, using data collected from the USGS National and Global Seismograph Networks, rapidly provides high-quality earthquake information to governmental, public, and private entities around the world to aid in understanding earthquake hazards and to support emergency response to earthquakes.

Geomagnetism

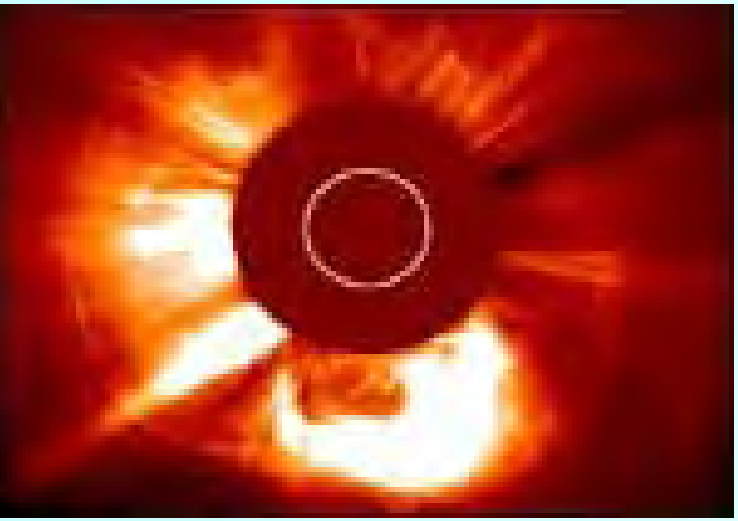
The U.S. Geological Survey National Geomagnetic Information Center collects geomagnetic data from a global network of more than 70 geomagnetic observatories, including 13 U.S. stations. USGS scientists use these data to provide near real-time warnings of magnetic storms and to construct modern magnetic charts of the world.

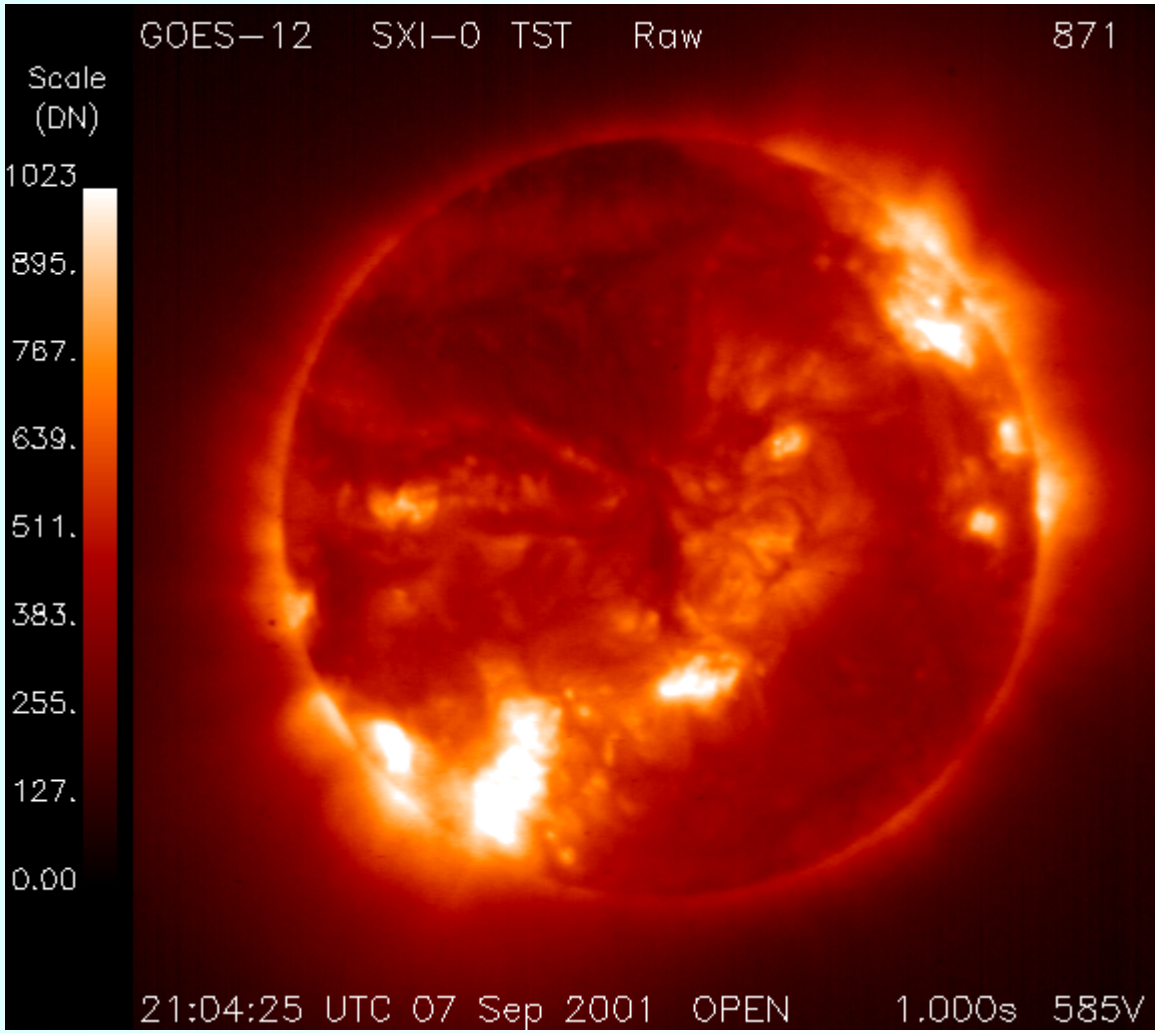
Landslides

The U.S. Geological Survey National Landslide Information Center collects comprehensive, worldwide landslide information and distributes that information to academia, industry, and public entities concerned with landslide hazards, risk assessment, emergency response, and mitigation.

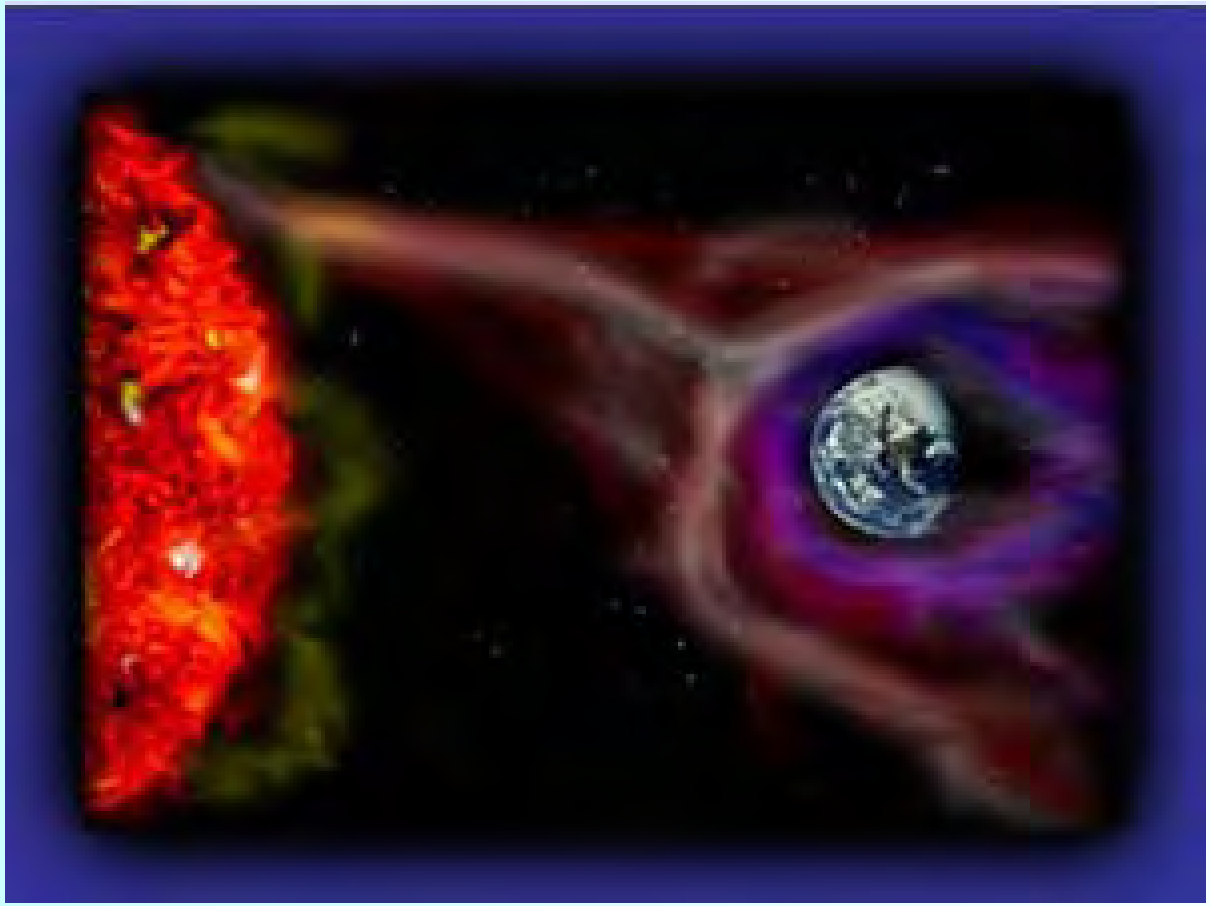
Geohazards

SOLAR PROMINENCE

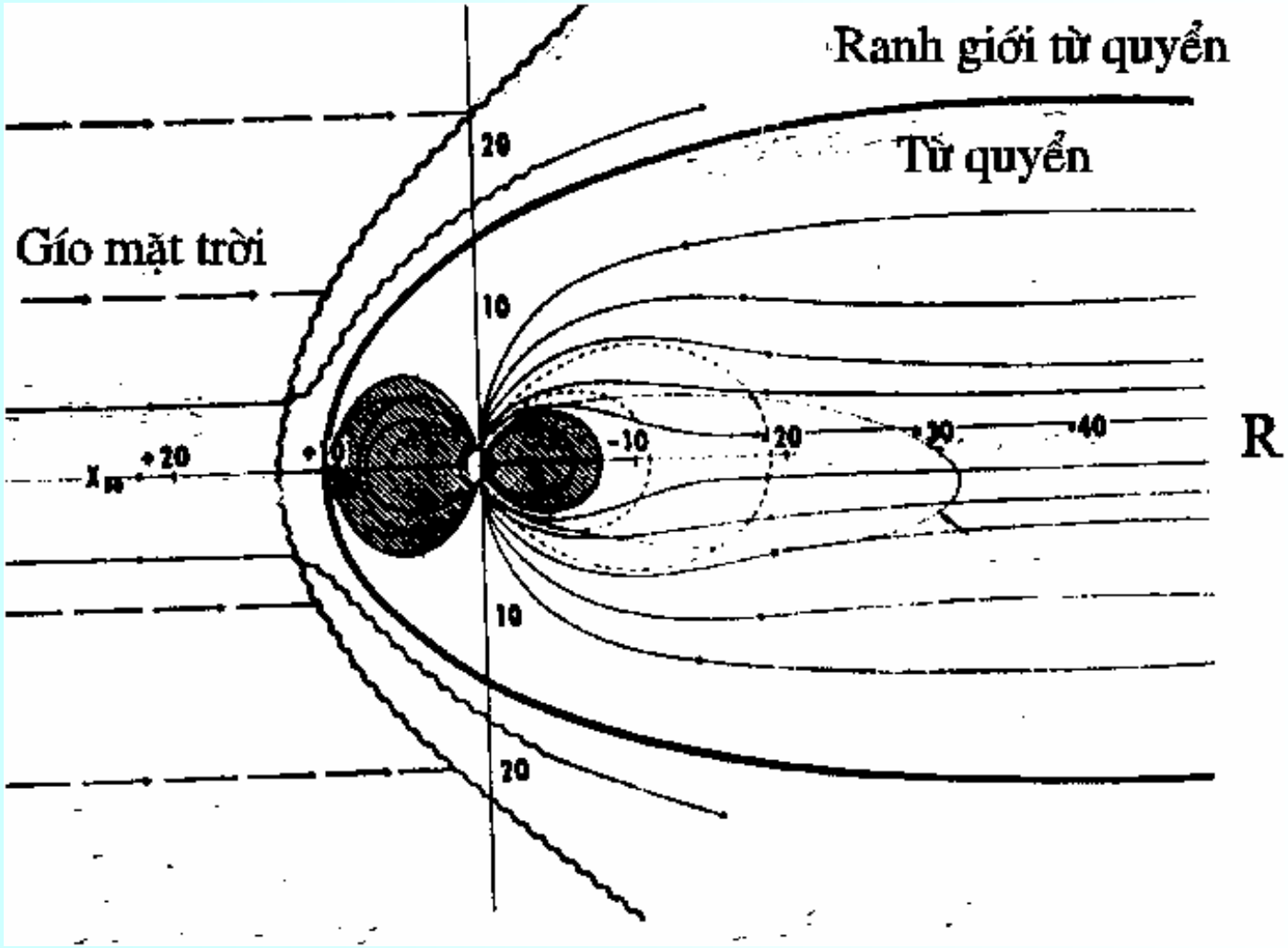




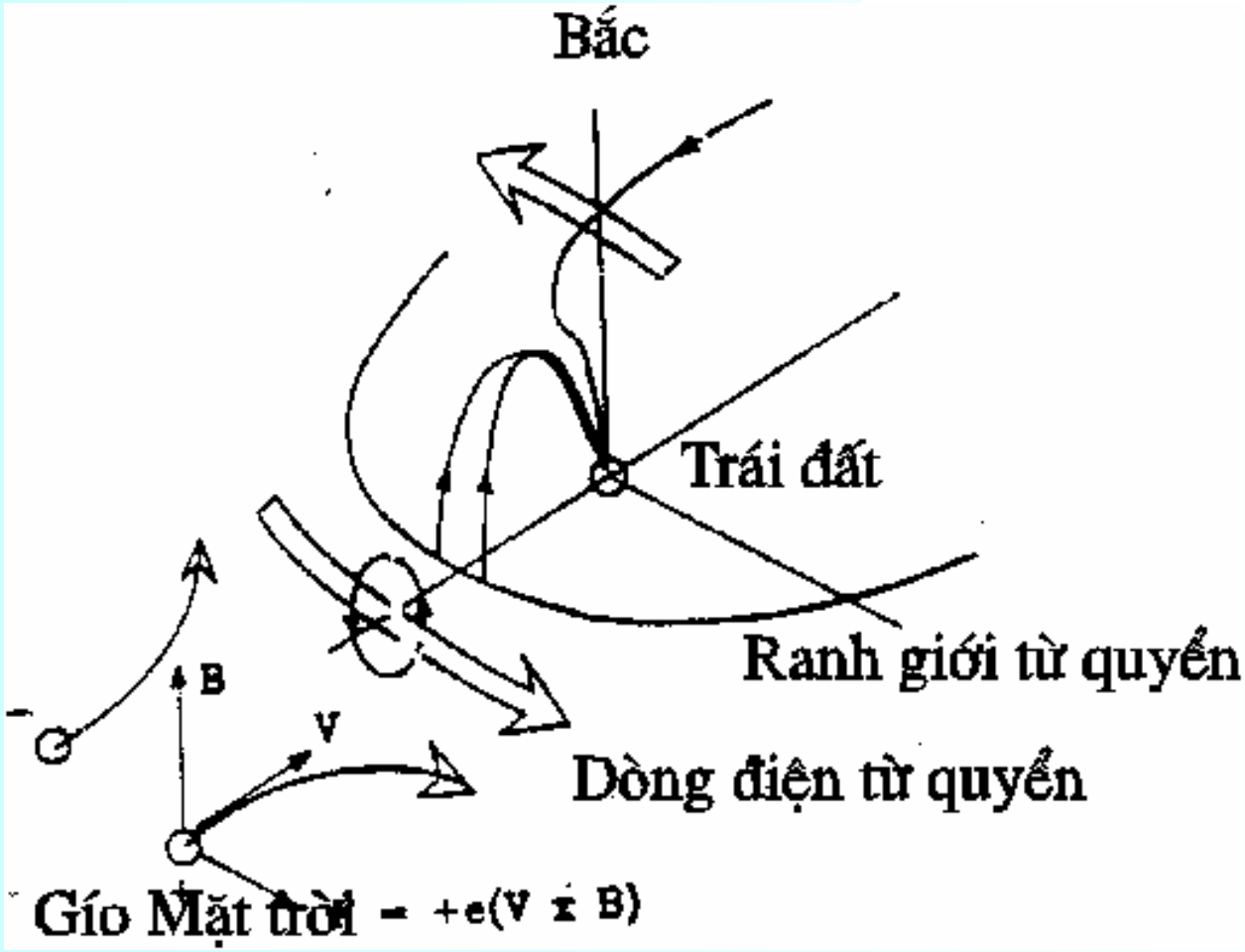
SUN - EARTH



solar wind - earth

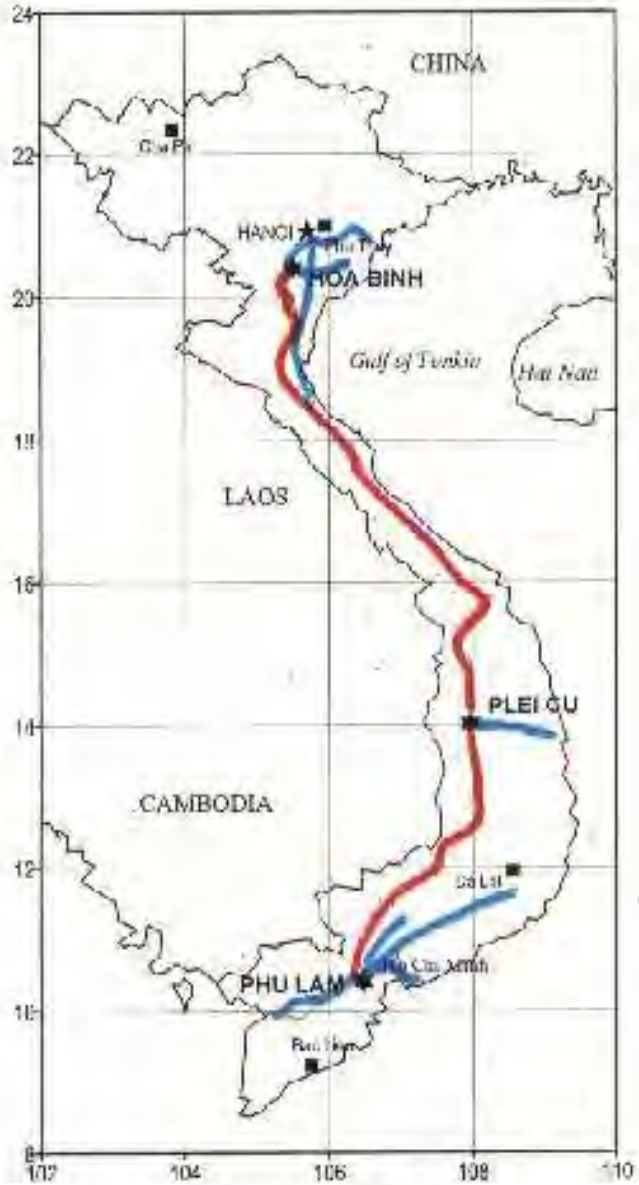


Formation of ring currents



II.1.IMPACTS OF THE MAGNETIC STORMS ON THE 500KV POWER SYSTEM

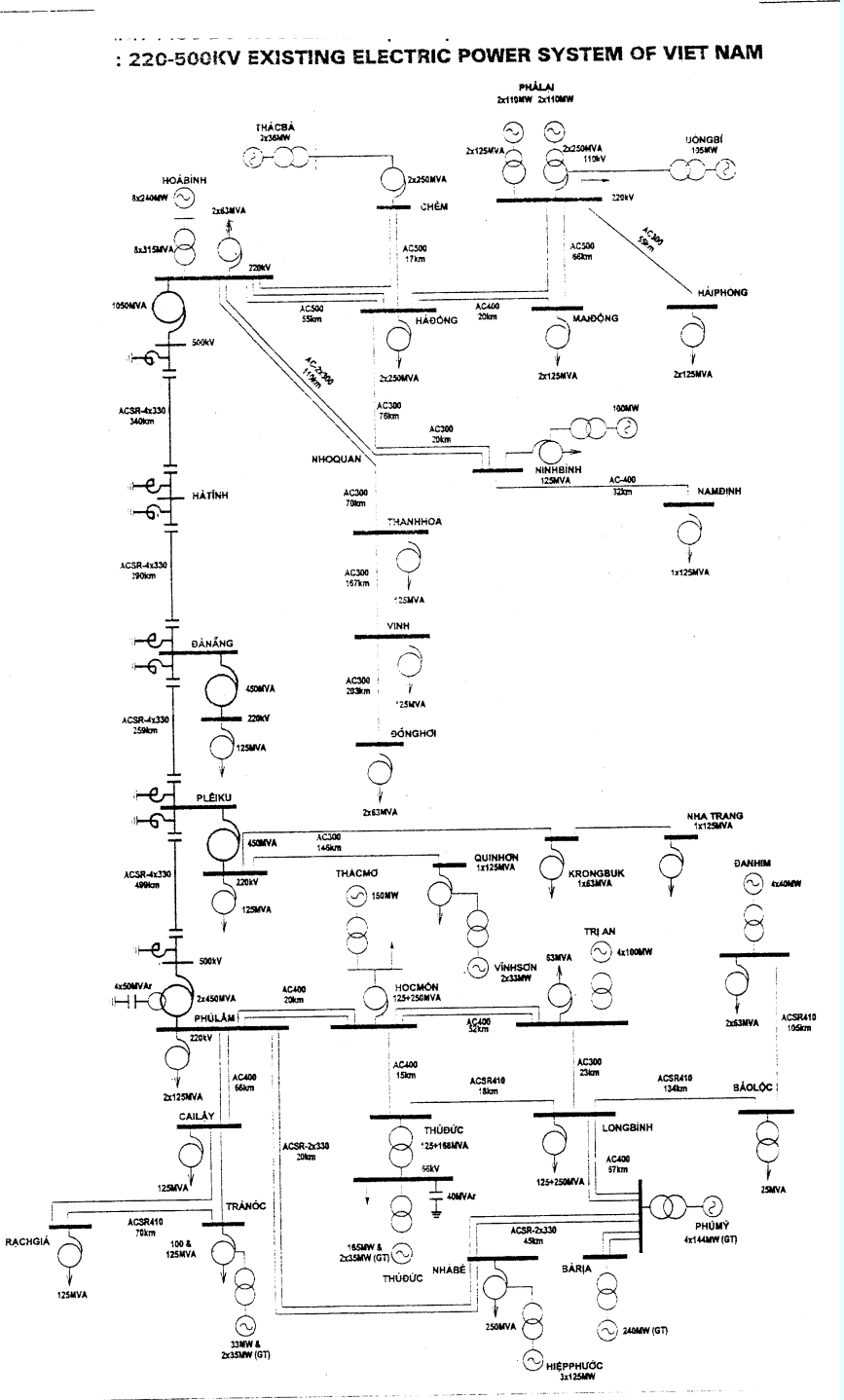
Vietnamese 500-220 kV power line network



■ : Magnetic Observatory

✱ : 500 kV power transformer station

Vietnam 500-220kV power line network (1)



Vietnam 500-220kV power line network (2)

Magnetic storms effects on the man made technologies

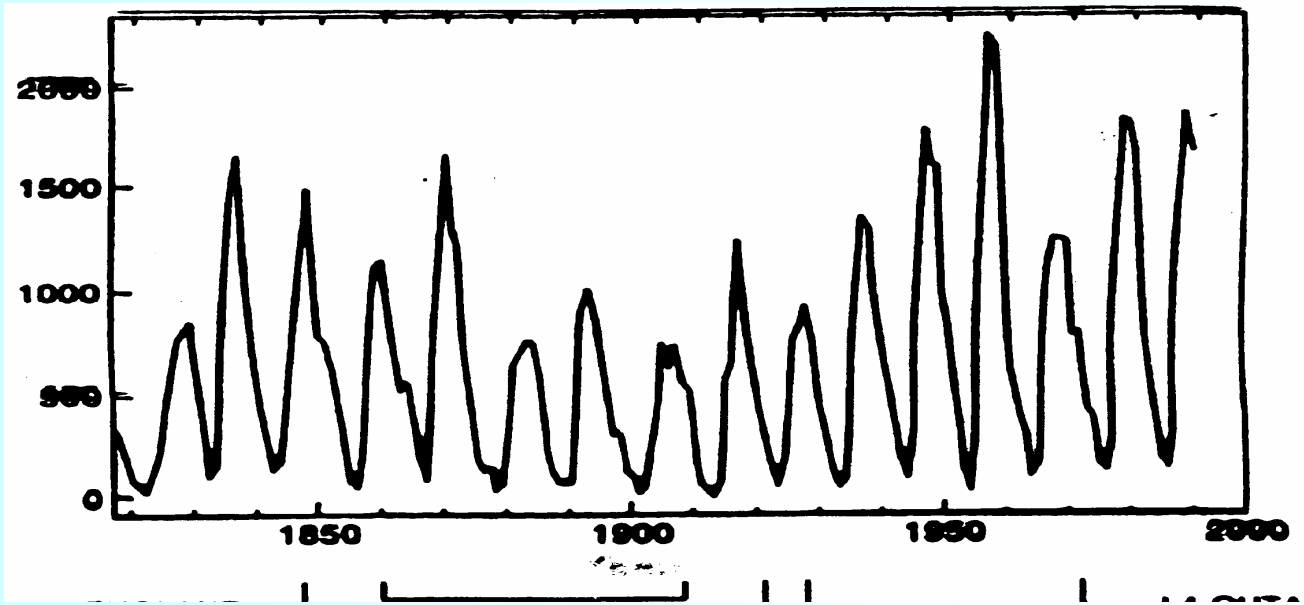
1858,59 Telecommunication petrified in Europe

1940 USA power System blackout

1957 Hydro Toronto System blackout

1989 Hydro-Quebec System blackout

Sunspots



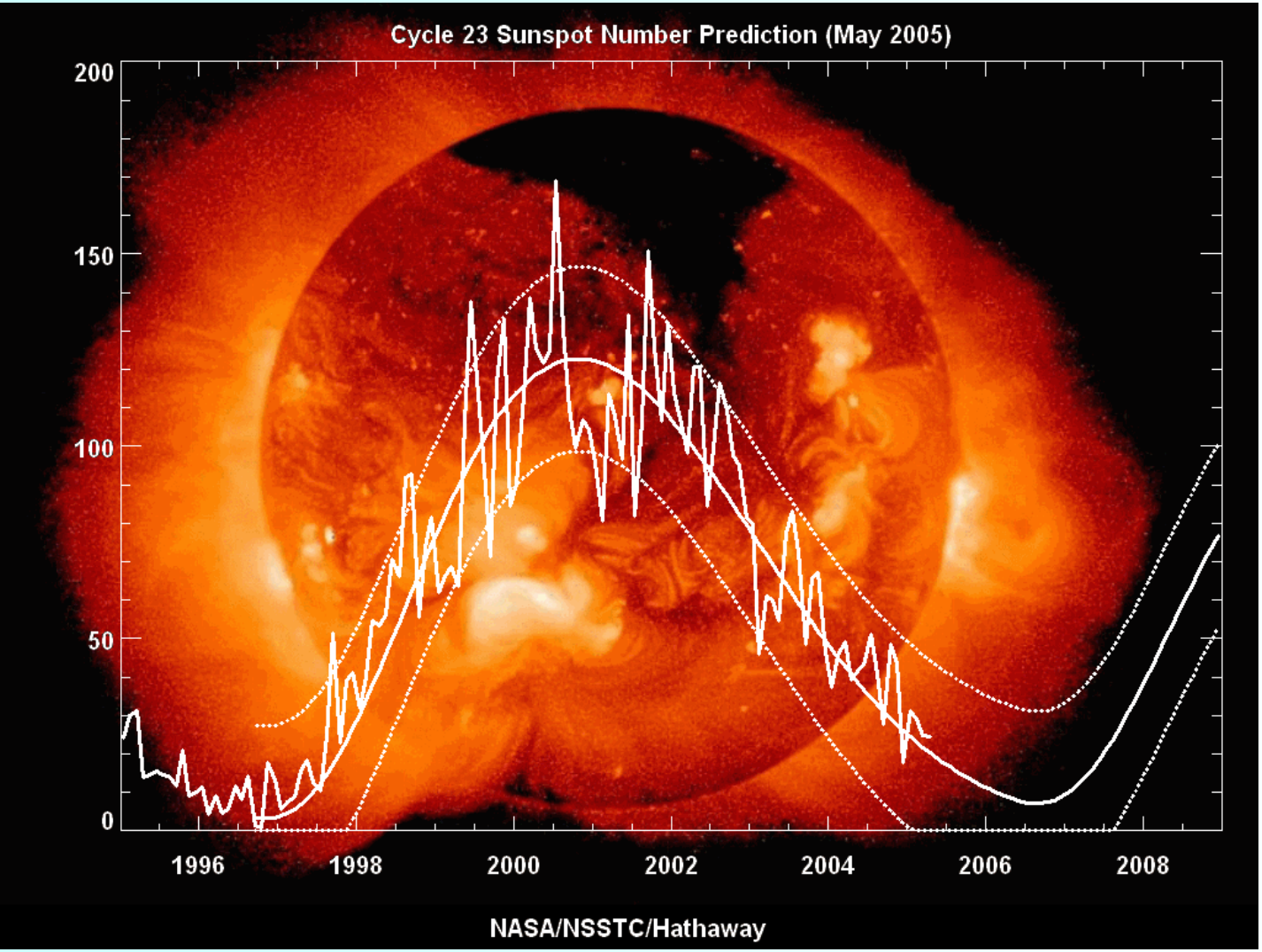
1847 : Outage of of electric telegraf in Florence-Pisa

1860-1907 : electric telegraf goings-on in Europe

1918,1929 electric telegraf goings-on in Europe

1972 : Outage of L-4 Sys. in USA

cycle 23 sunspot number



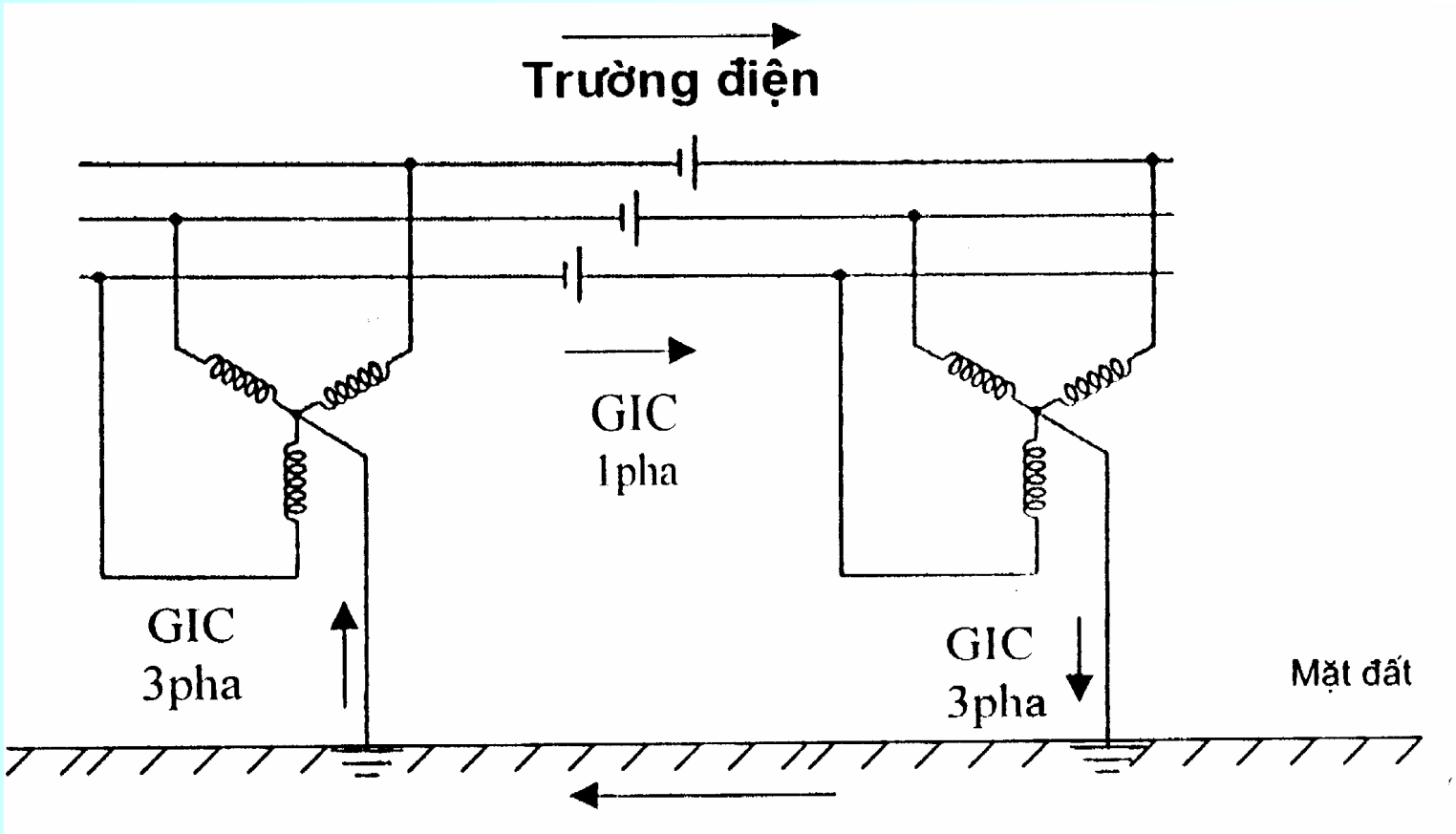
objectives of studies

- *Do the GICs appear in the 500 - 220 kV power-system of Vietnam;*

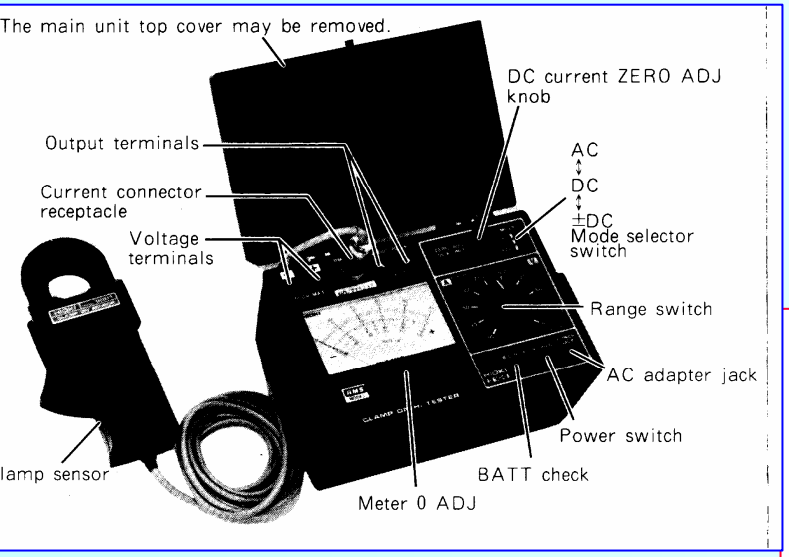
-If GICs appear in the system, which are the range of theirs values? Can be they harmful to the system?

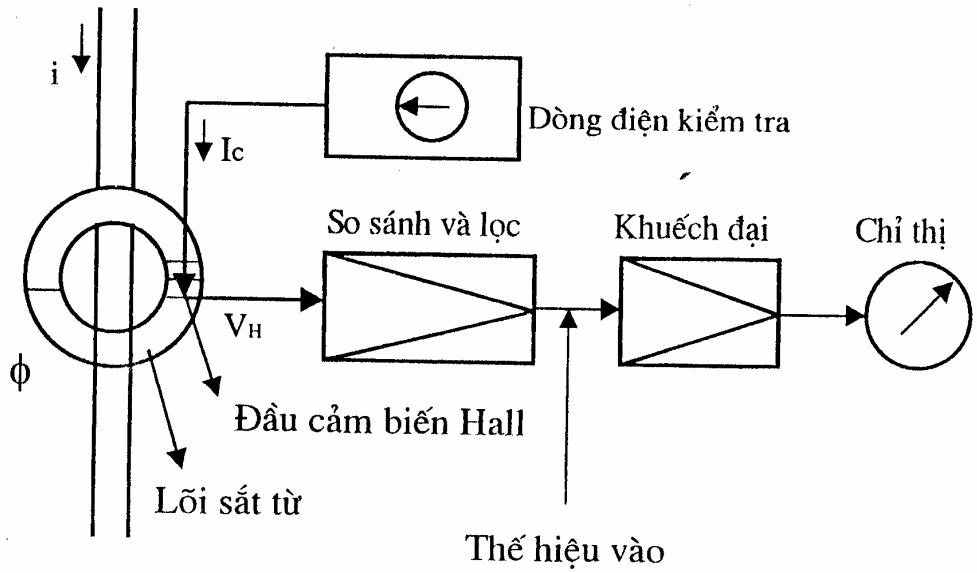
-The necessary measures to avoid the GICs bad effects?

basic of method



galvanometer



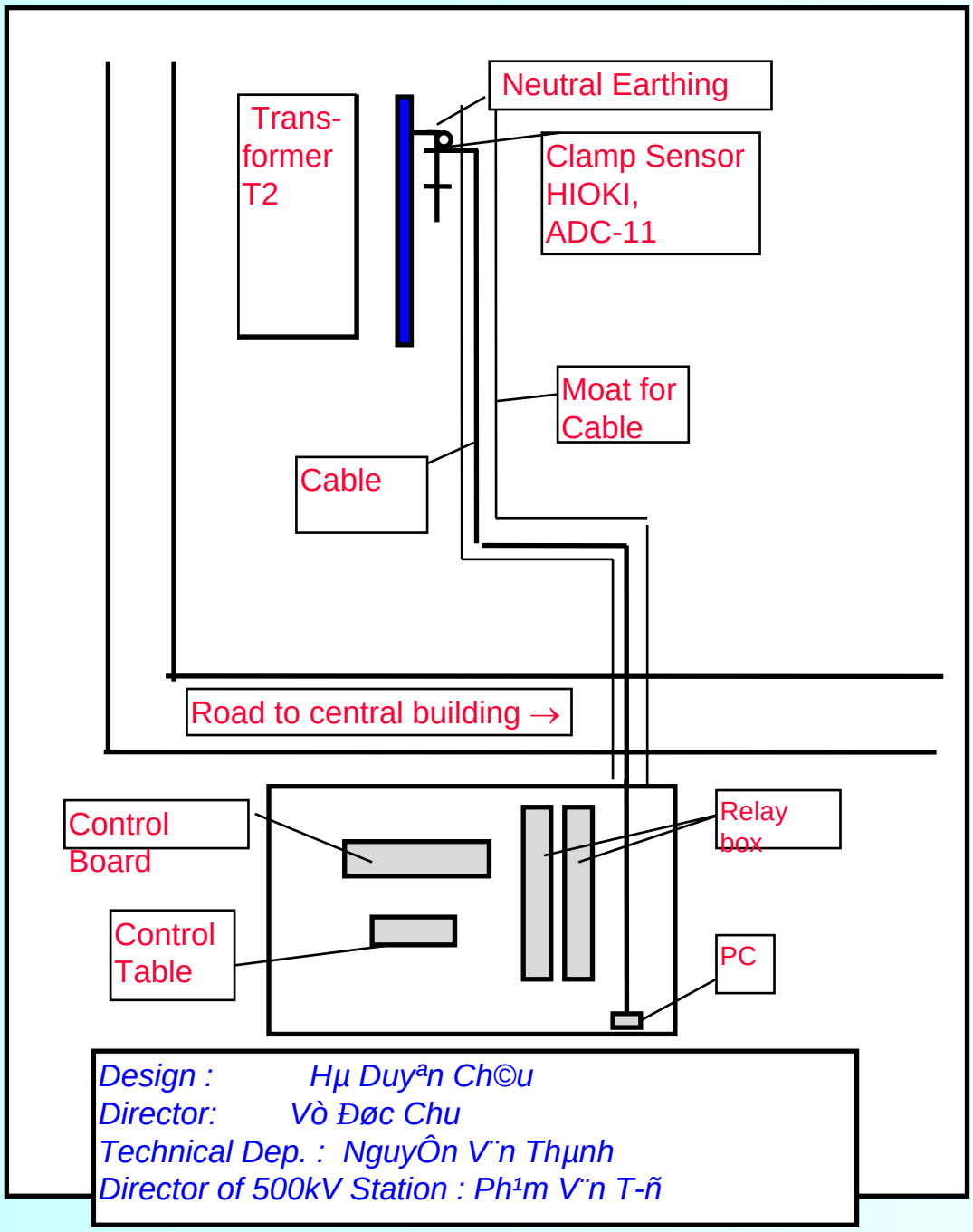


$$\Phi = \frac{i}{R_g + R_c}$$

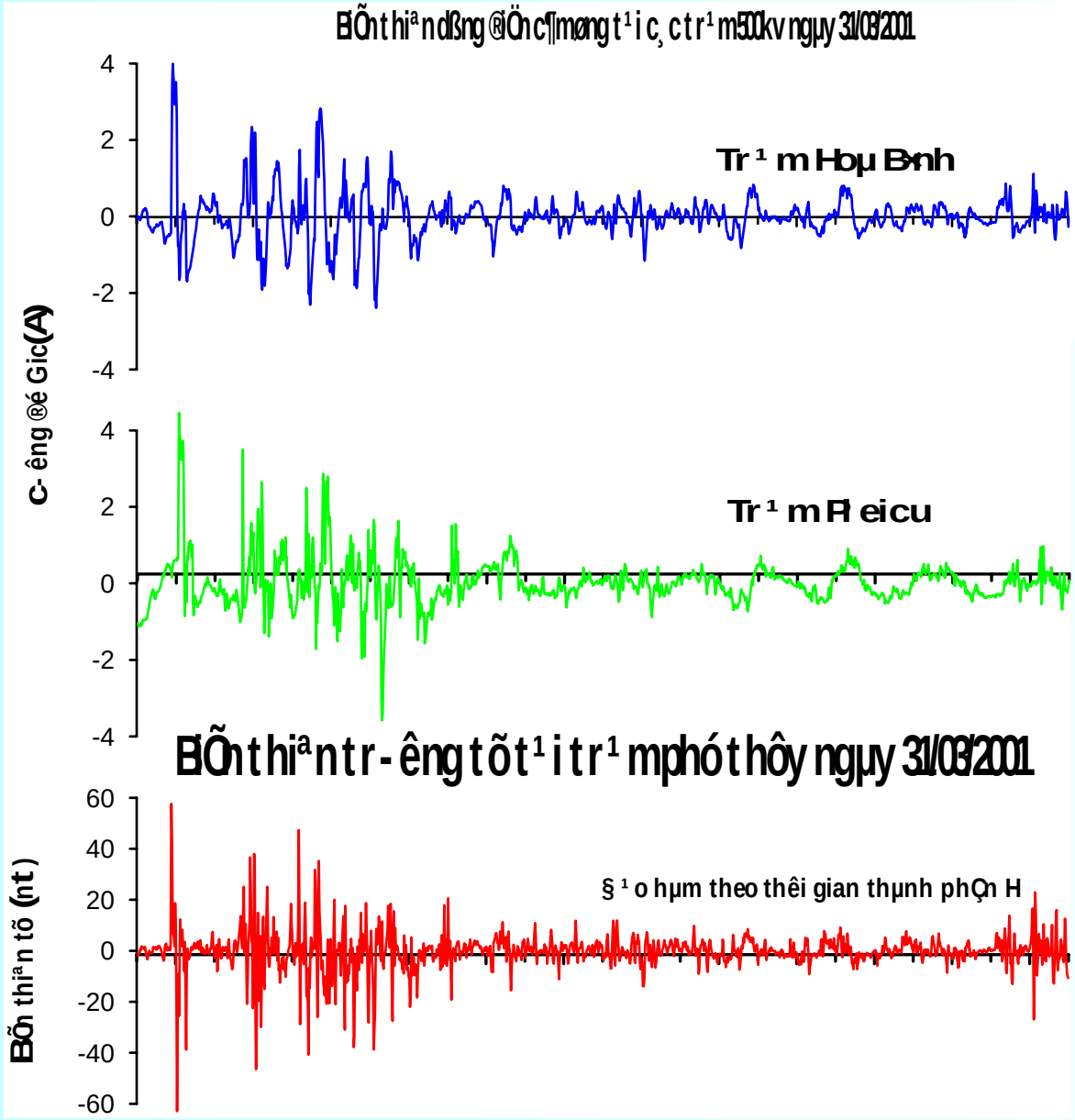
$$B_g = \frac{\Phi}{S_g} = \frac{i}{\left(R_c + R_g\right)S_g}$$

$$V_H = K.I_c.B_g = \frac{K.I_c.i}{\left(R_g + R_c\right)S_g} = Kc \times i$$

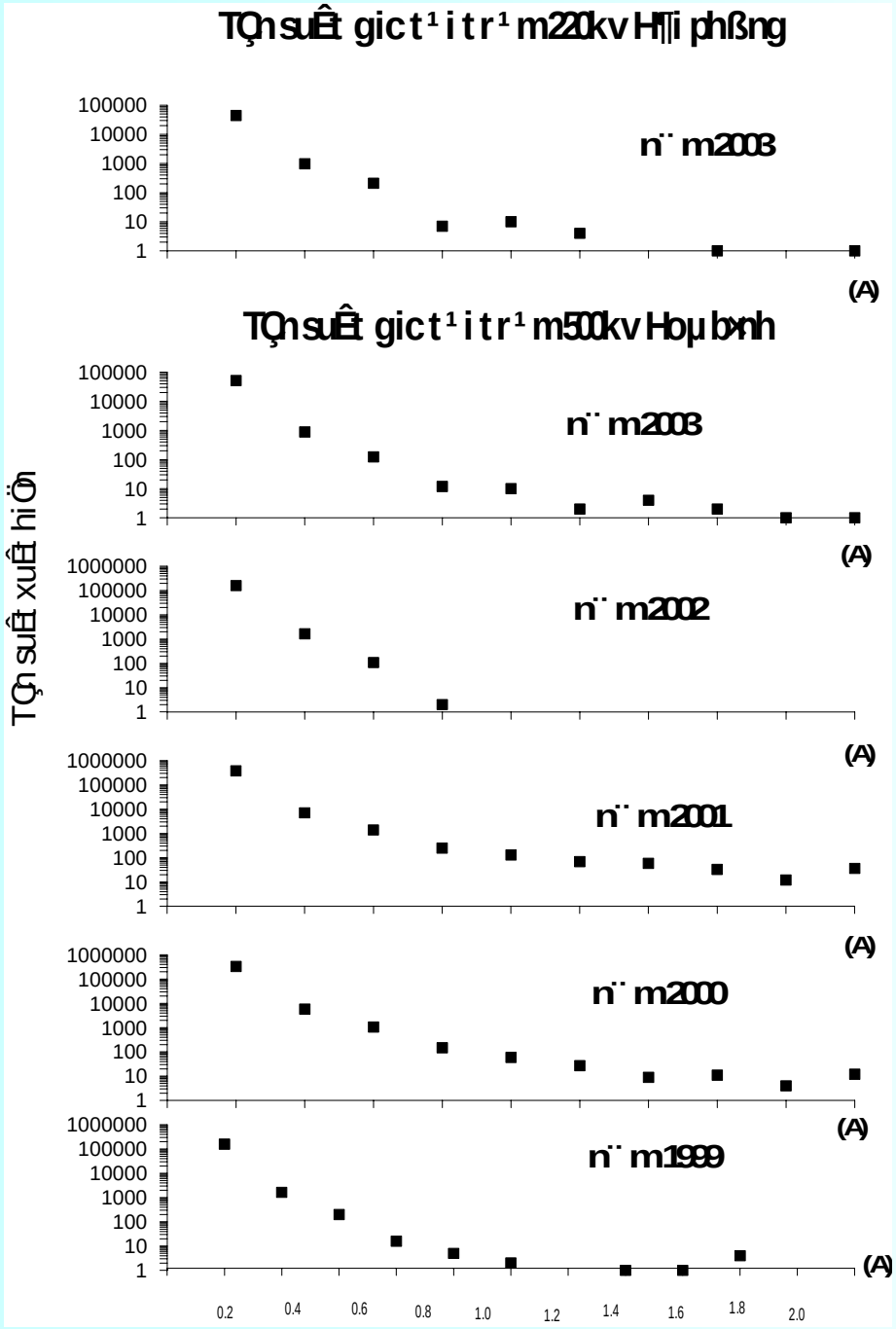
Equipments Installation Schema for GIC recording



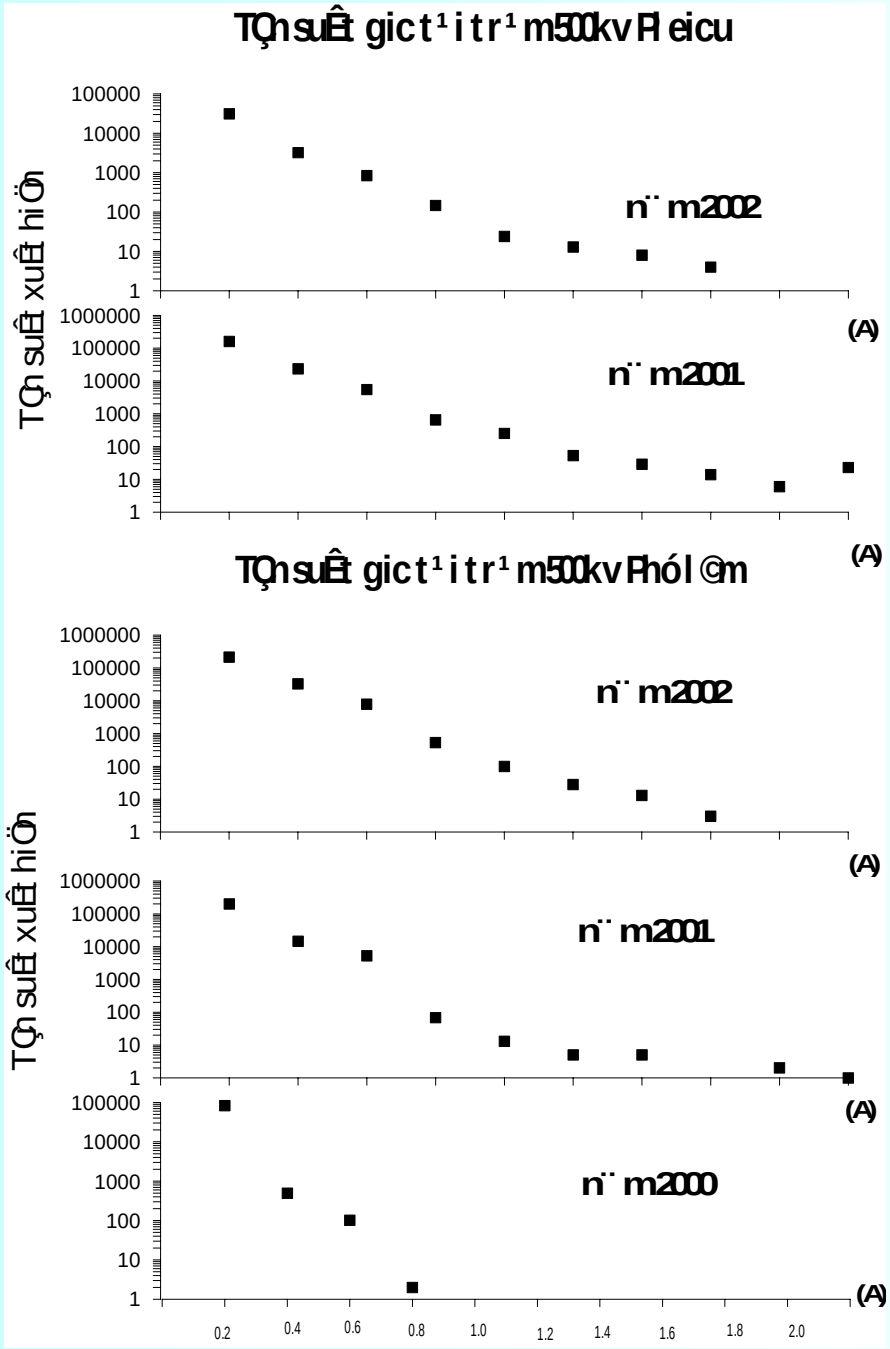
Design : Hµ Duy³n Ch©u
Director: Vò Đøc Chu
Technical Dep. : NguyÔn V˙n Thµnh
Director of 500kV Station : Ph¹m V˙n T-ñ



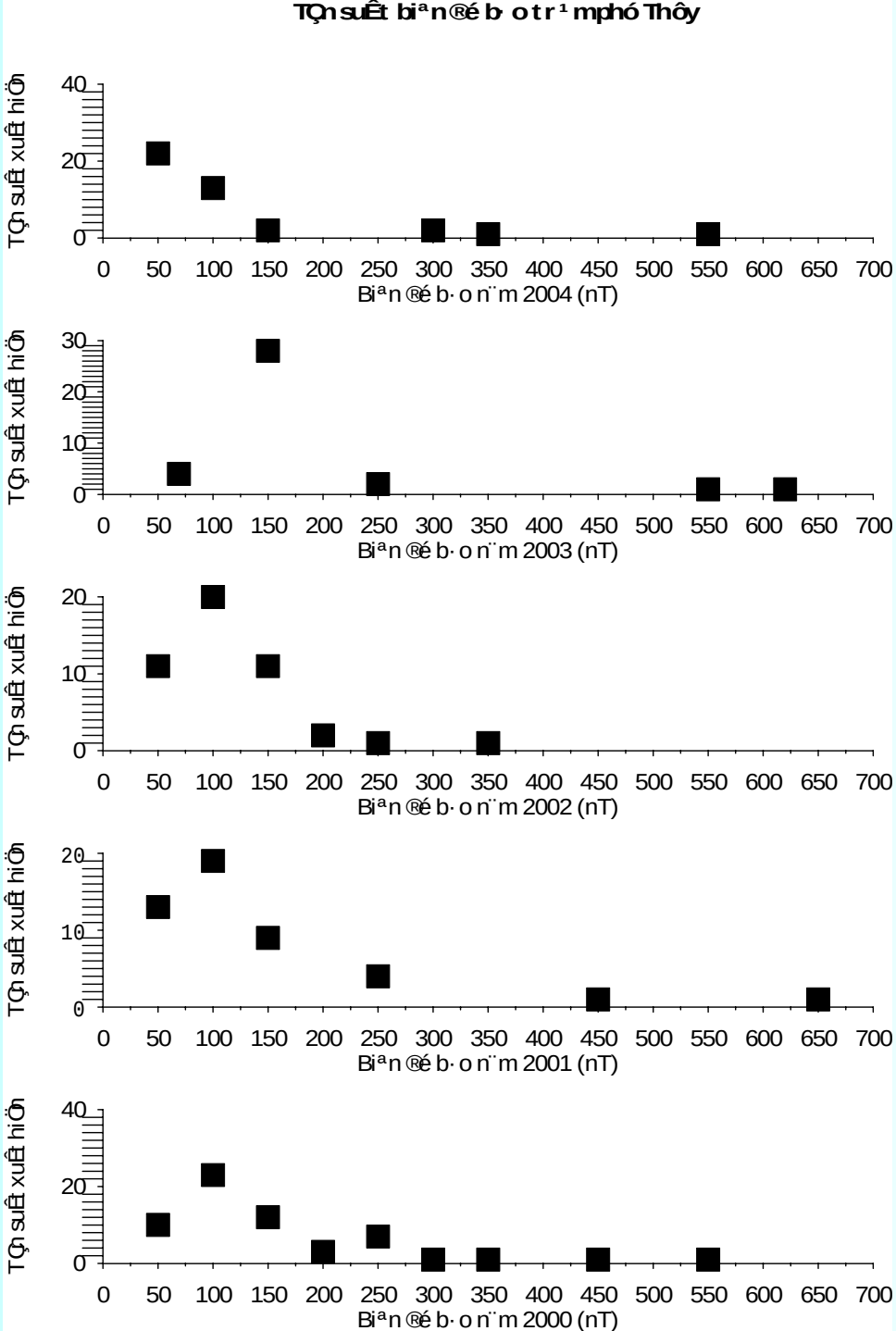
Example of GIC obtained in VN



GIC appariton frequency at 220kV HAi Phong and 500kV Hoa BInh stations



GIC appariton frequency at 500kV pleiku and phu lam stations



magnetic storms appariton frequency at phu thuy station

CALCULATION OF THE GEOELECTRIC FIELD AND GIC AT HOA BINH TRANSFORMER

$$E_y(t) = -\frac{1}{\sqrt{\pi\mu_0\sigma}} \int_{-\infty}^{t} \frac{g_x(u)}{\sqrt{t-u}}\, du$$

Assumption:

+ Earth: a half-space with a constant conductivity σ and;

+ geomagnetic variation field propagates as a vertical plane wave in Earth

g_x: time derivative of magnetic component X (dB_x/dt)

Practical formula:

B_n magnetic field at time t_N , $t_{n-1} < t < t_n$;

Electric field at time t_N, if the sampling interval is T:

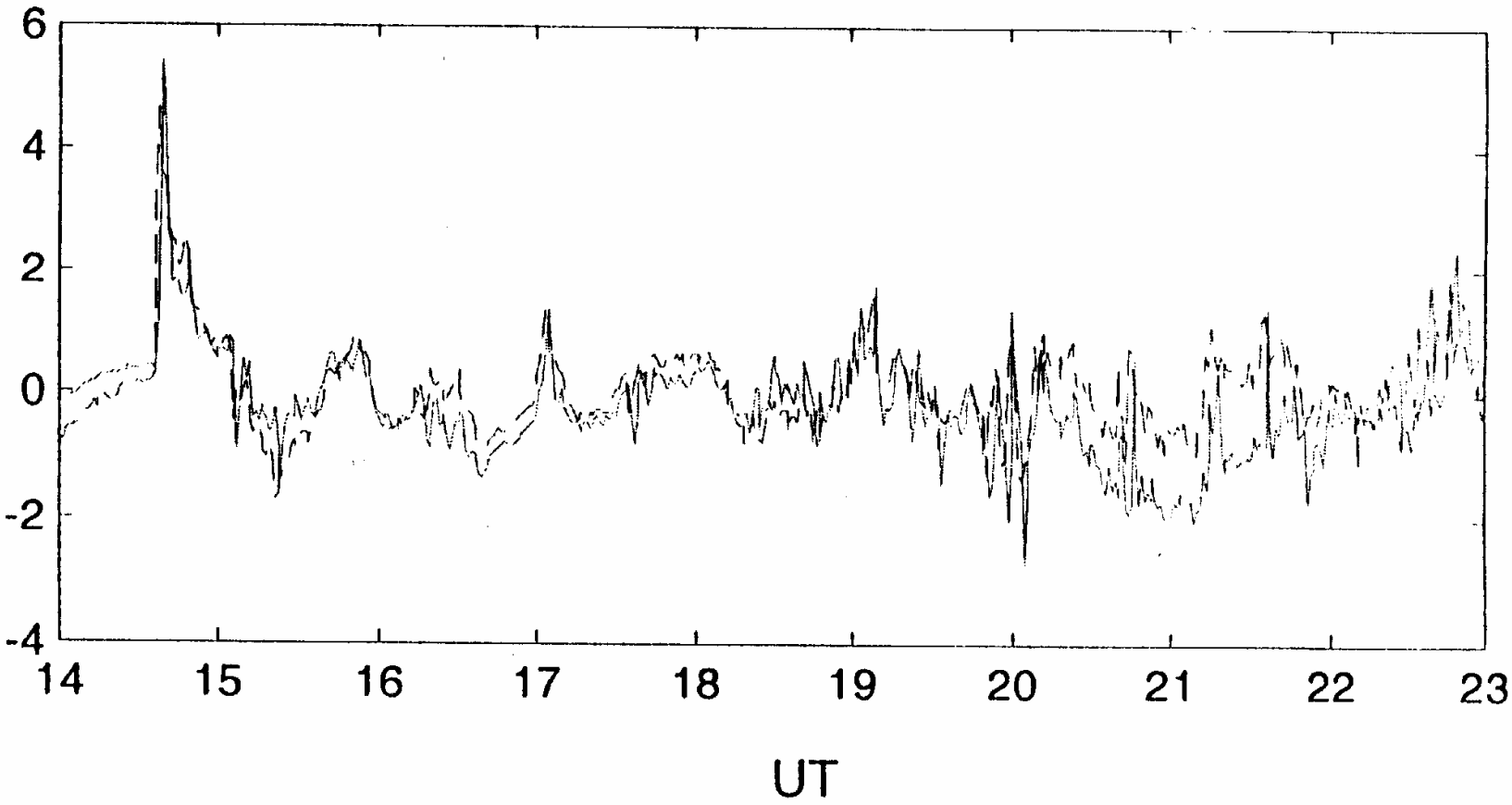
$$E_y(t_N) = \frac{2}{\sqrt{\pi\mu_0\sigma T}} \left(R_{N-1} - R_N - \sqrt{M}\, b_{N-M} \right)$$

where $b_n = B_n - B_{n-1}$, $$R_N = \sum_{n=N-M+1}^{N} b_n \sqrt{N-n+1}$$

M: number of earlier values to be included, M = 100 enough.

$I = a.E_x + b.E_y$

Example of GIC calculated and recorded in Vietnam for the July 15, 2000 in Hoa Binh 500kV transformer station

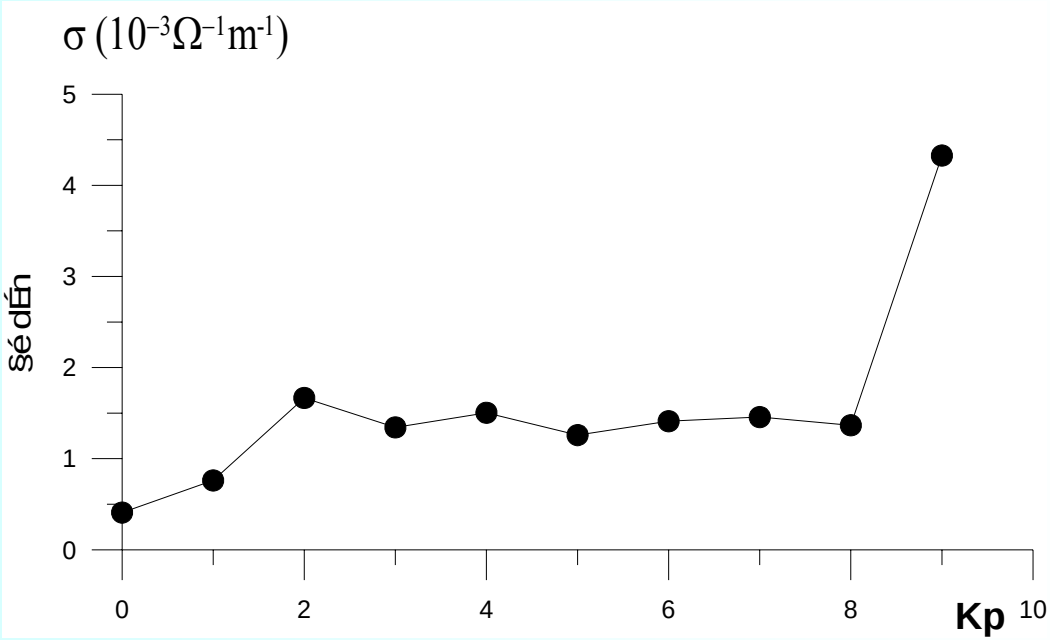


——— : GIC calculated; — — — : GIC recorded

$\sigma = 1,3 \times 10^{-3} \Omega^{-1} m^{-1}$

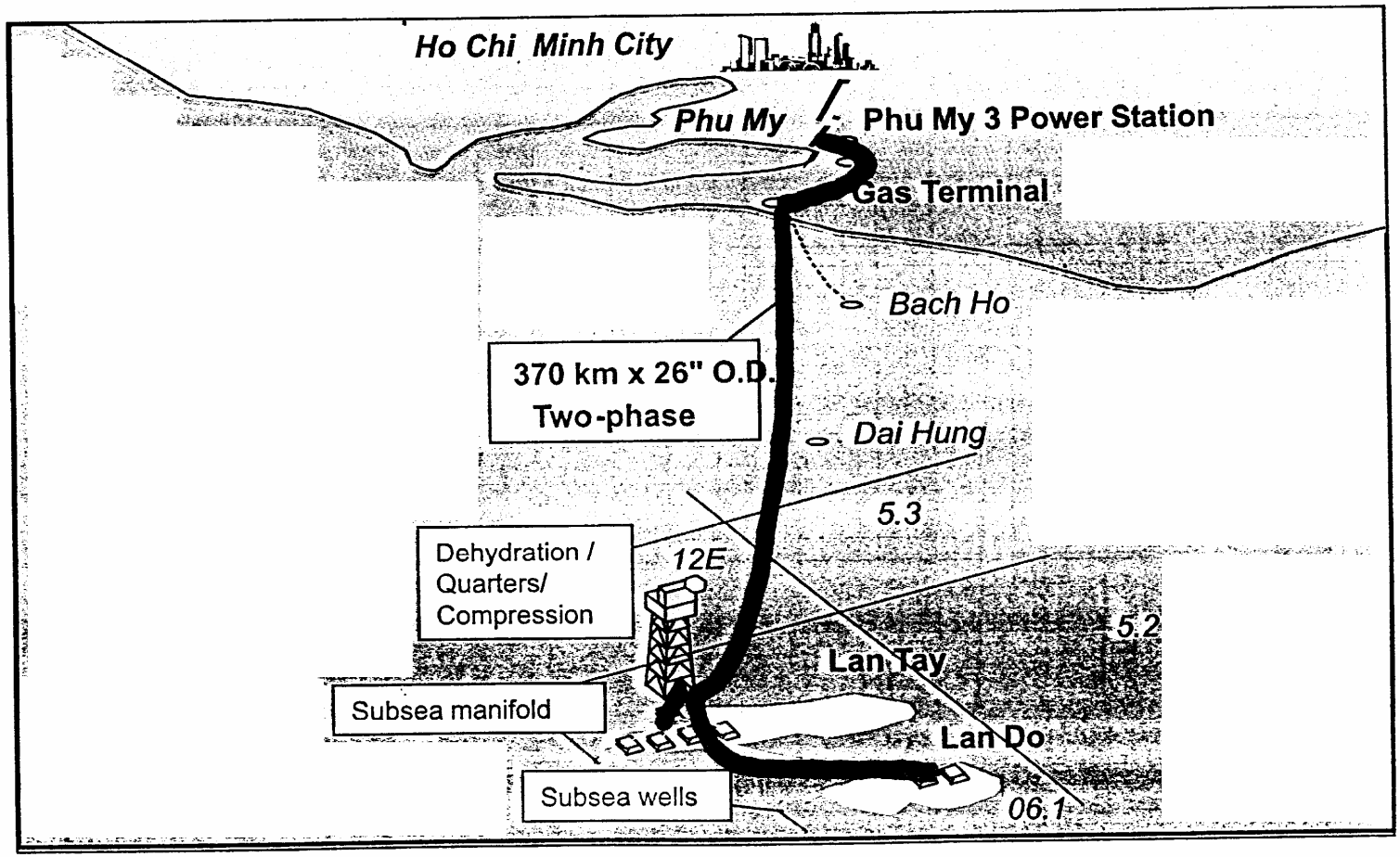
dependence of conductivity on magnetic activity Kp

Kp	0	1	2	3	4	5	6	7	8	9
σ **(× 10^{-3} Ω^{-1} m^{-1})**	0,409	0,761	1,666	1,343	1,504	1,259	1,411	1,456	1,366	4,326

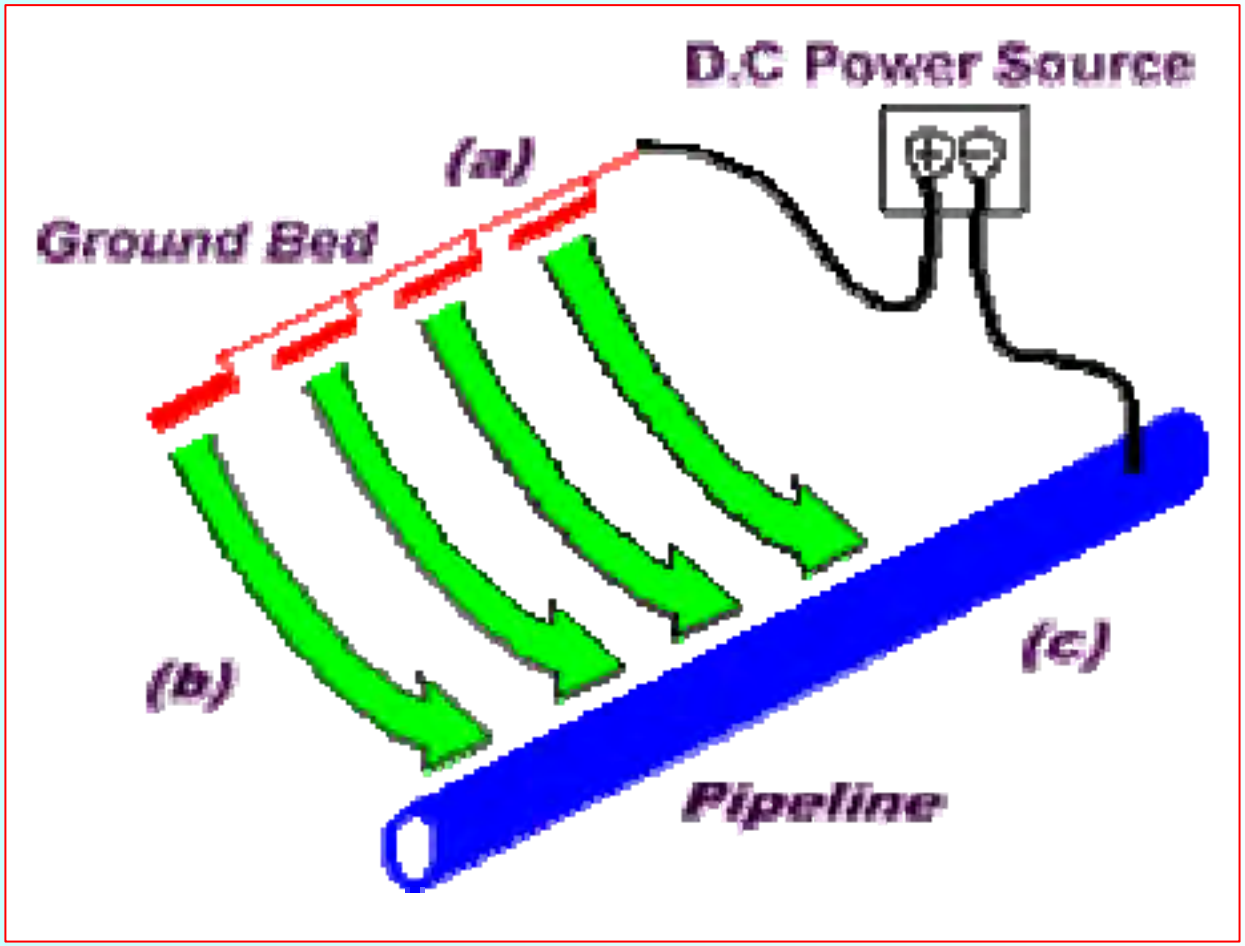


II.2. Impacts of the magnetic storms on petrol and gas Pipe-lines

Hình 6.18: Trang thiết bị hiện có ở bể Nam Côn Sơn



Cathodic Protection Method - CPM



How does magnetic storm influence on the pipe-line?

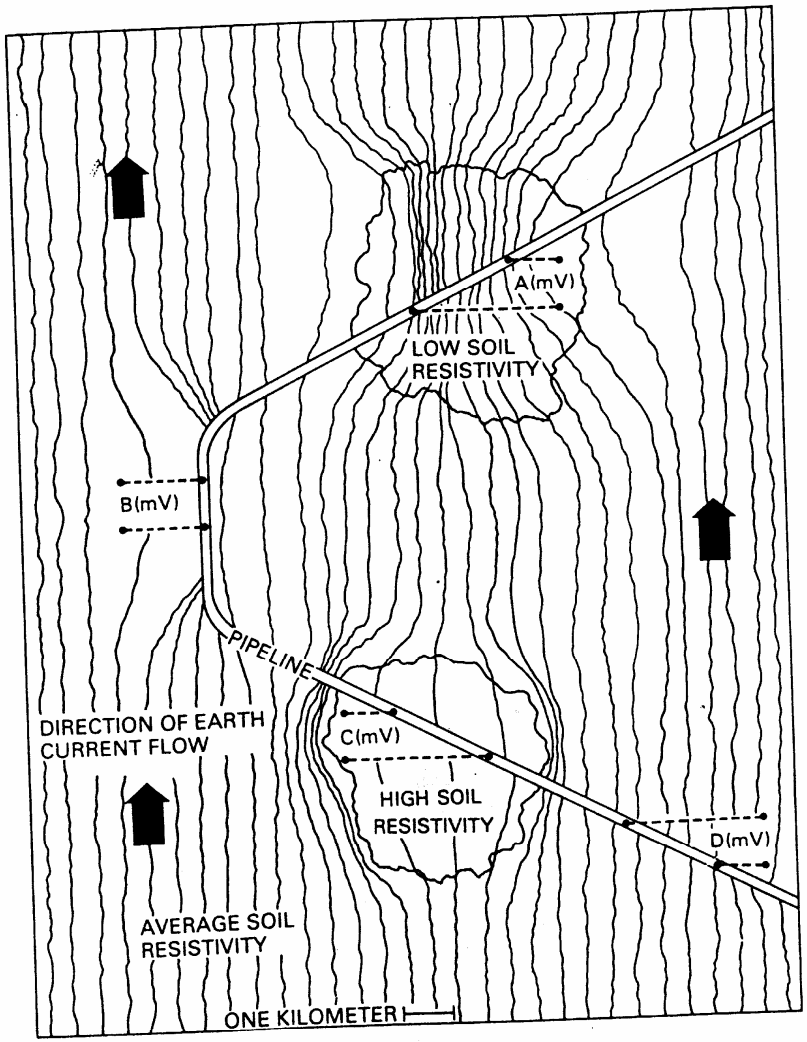
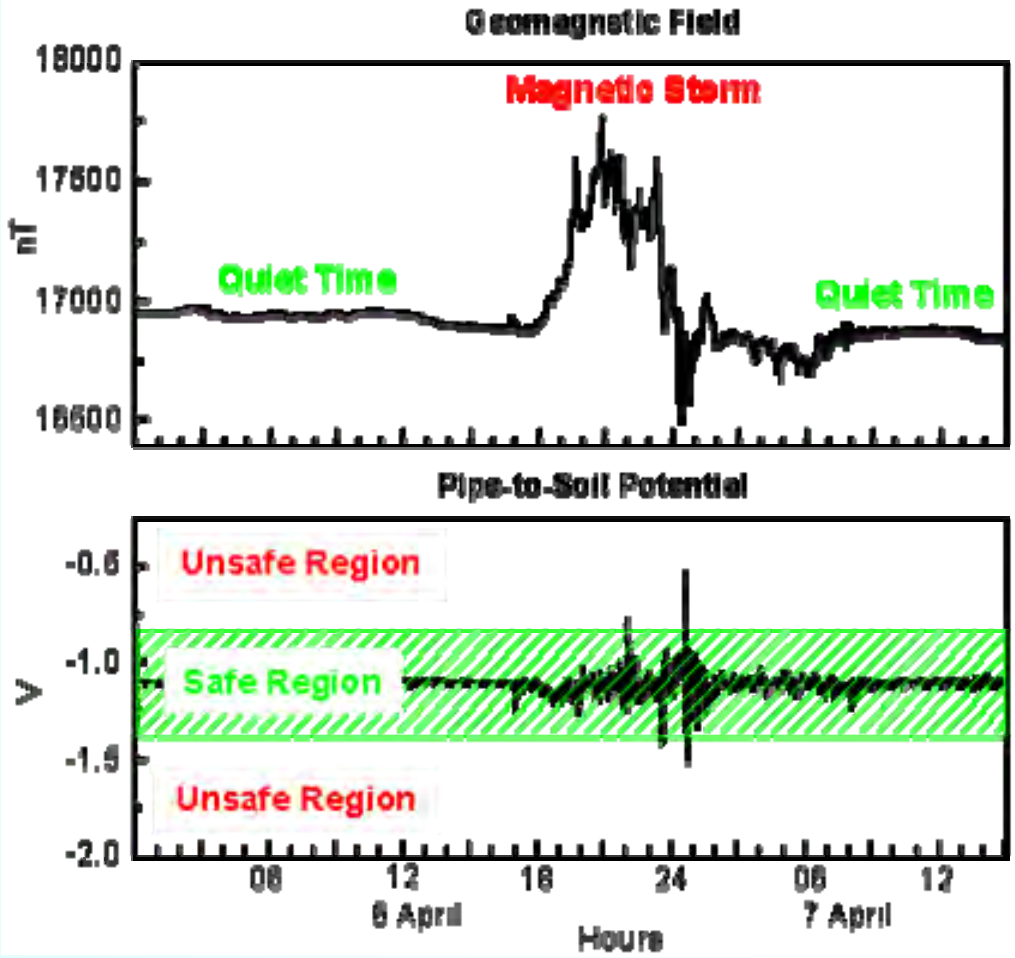
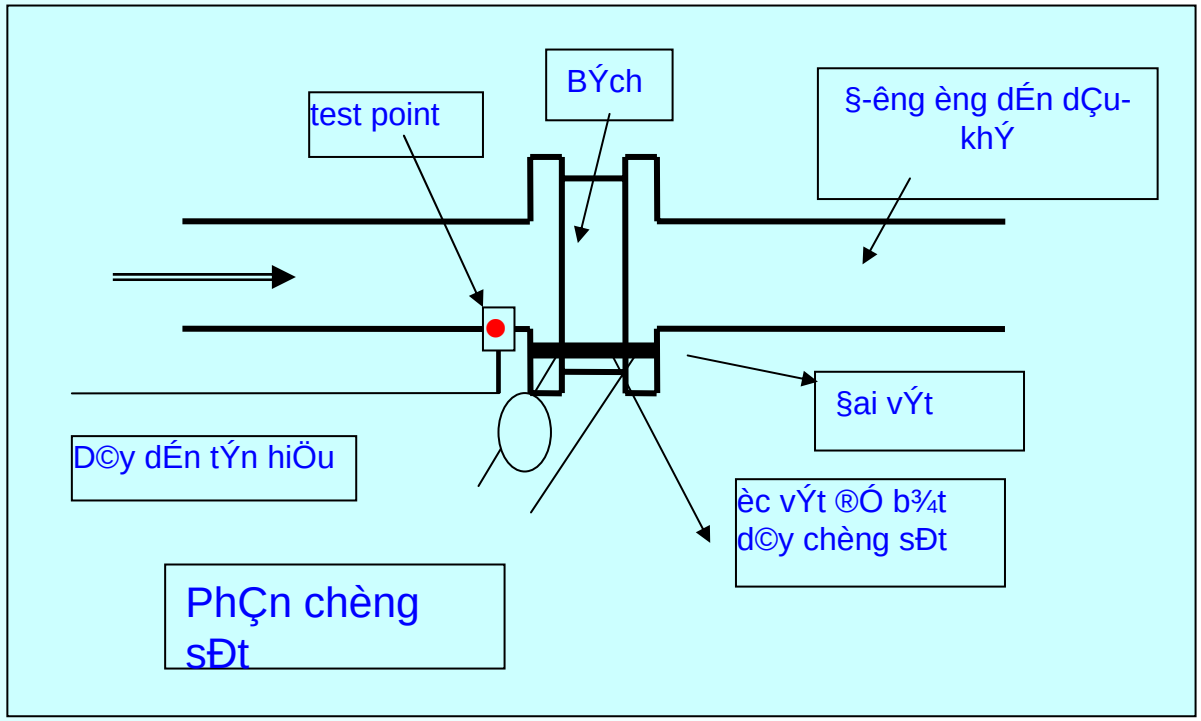


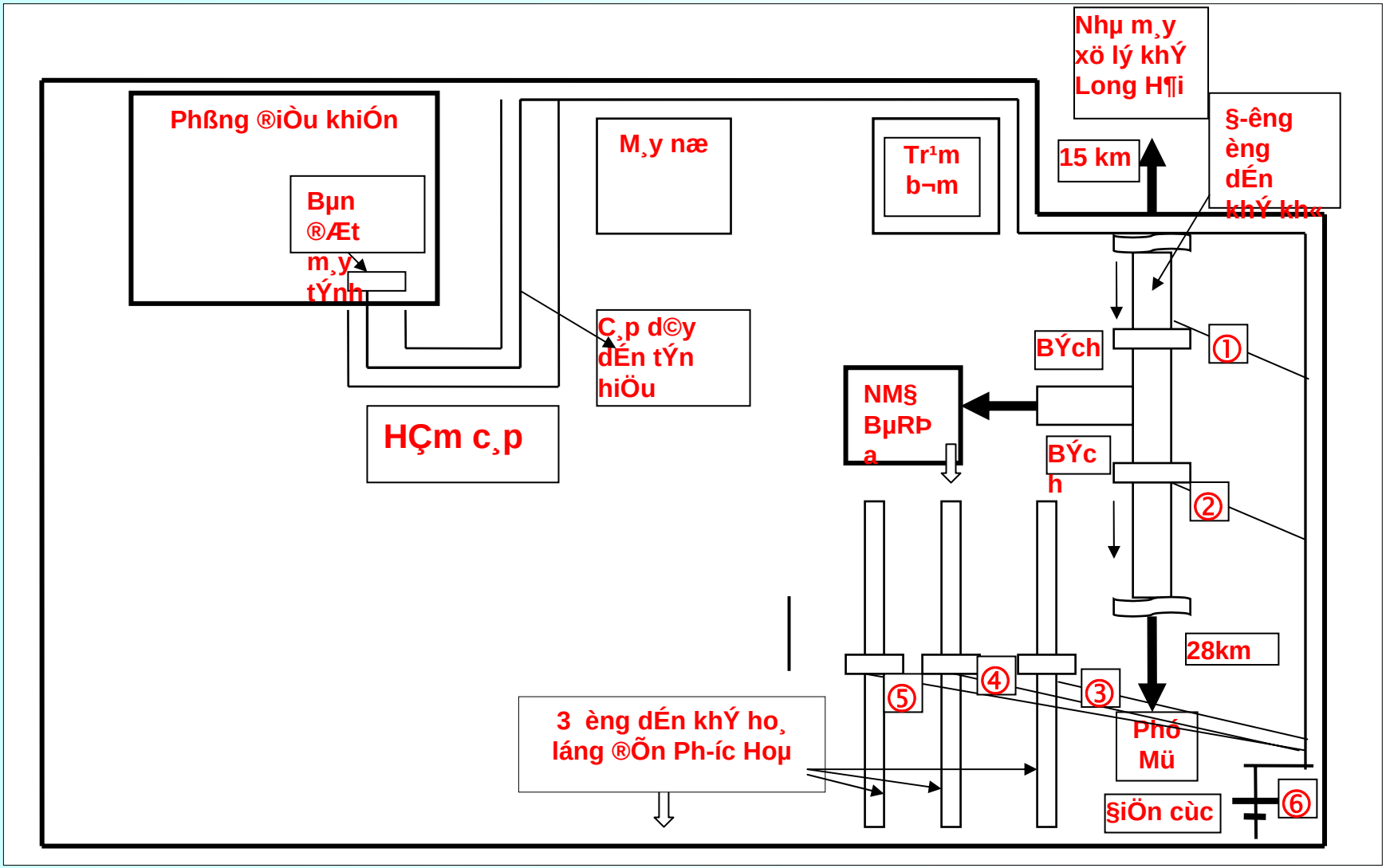
Fig. 14. Diagram to illustrate how differences in soil resistivity and pipeline axis direction create conditions that can modify the measured potential differences (and therefore the current flow) in a pipeline. The potential measurements in mV km^{-1} are indicated by A, B, C, and D. Each location could give a different value of potential (and current) for a single value of source field (indicated by large dark arrows) because of the different pipeline directions and different conductivity characteristics of the soil in the region grounded to the pipe (figure redrawn from Smart, 1982).



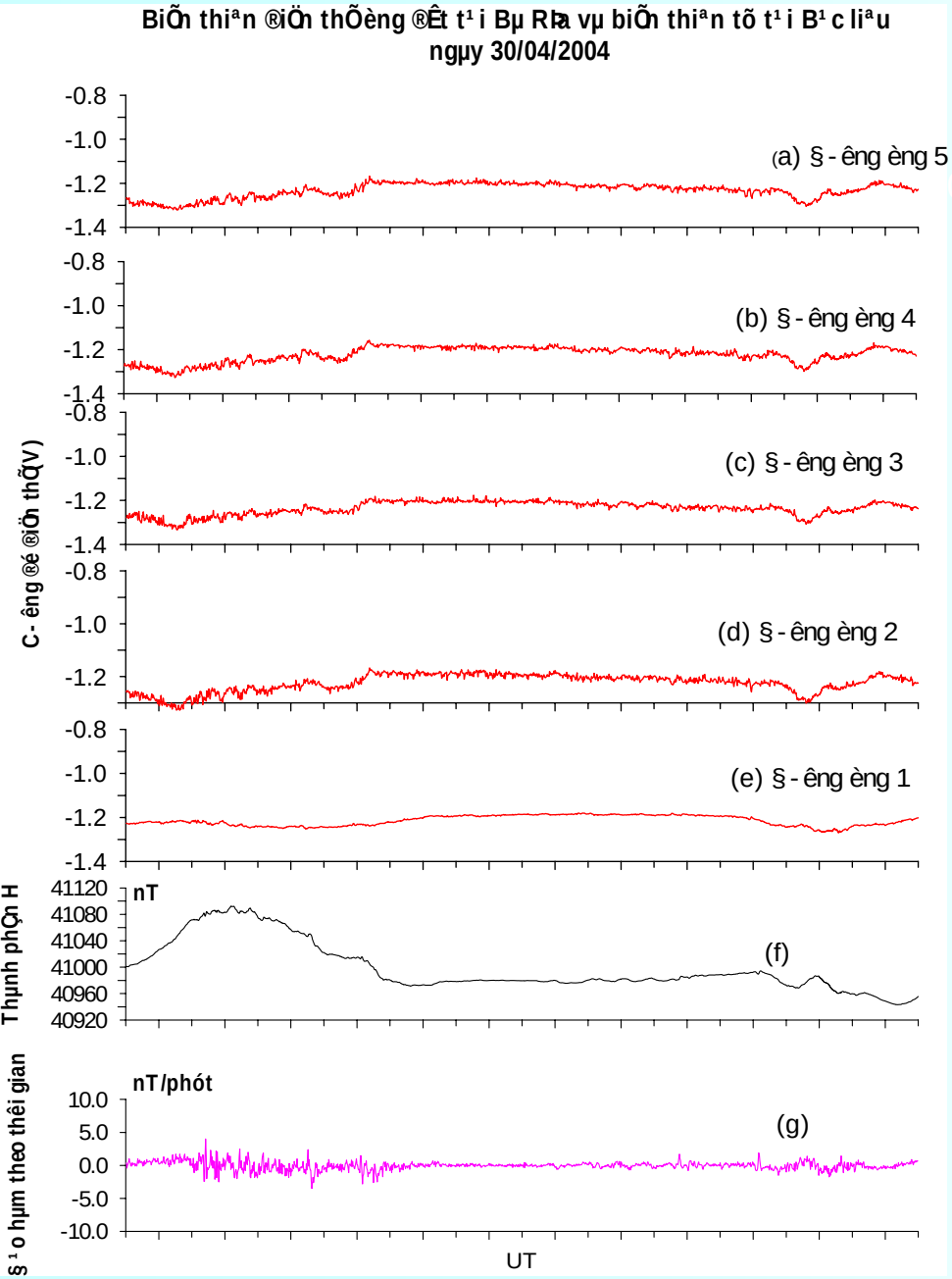
signal cable connection

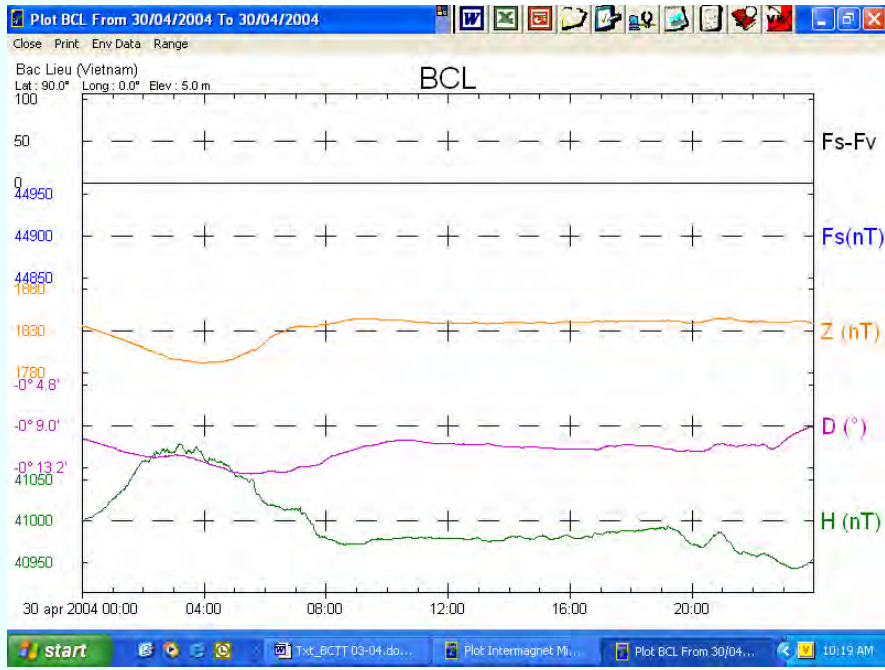


equipment installation

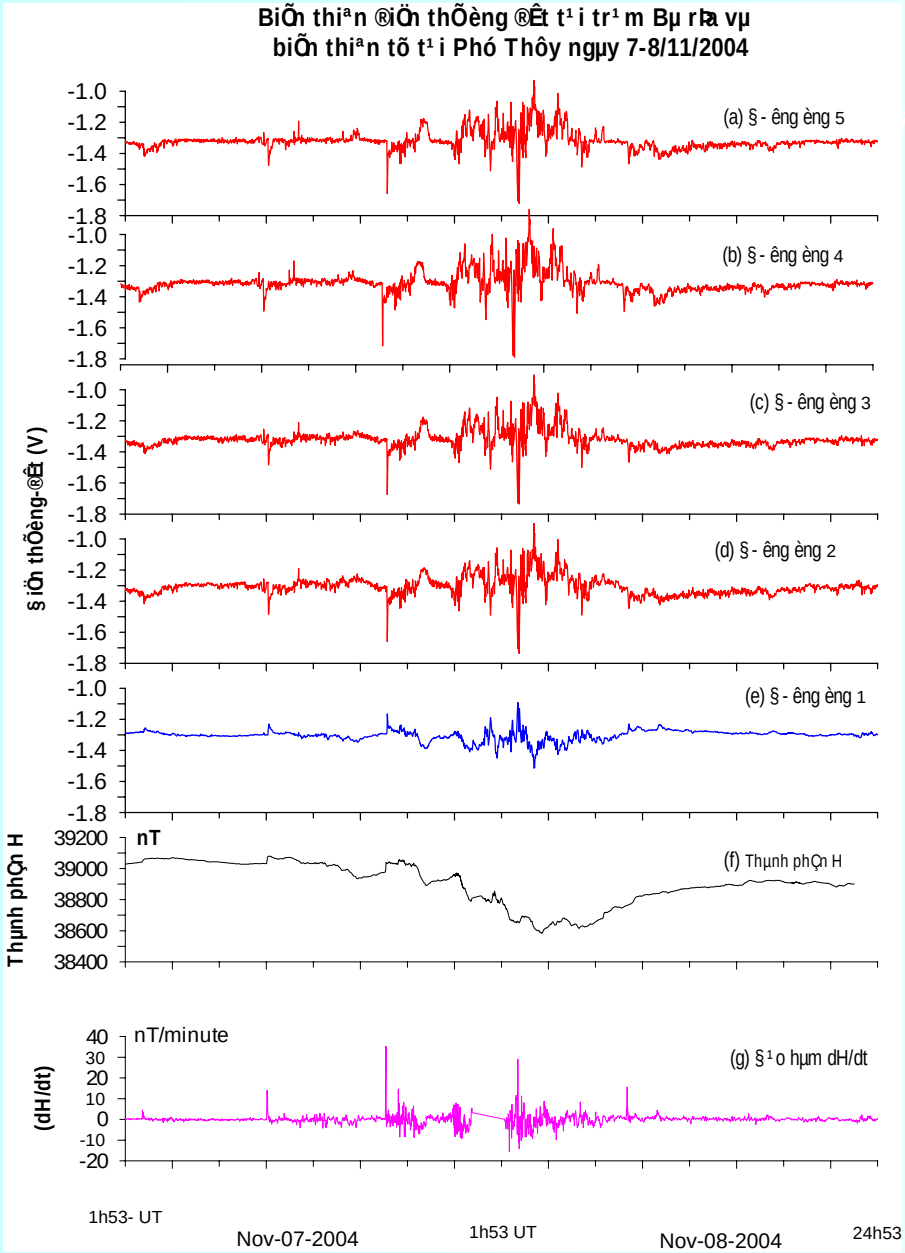


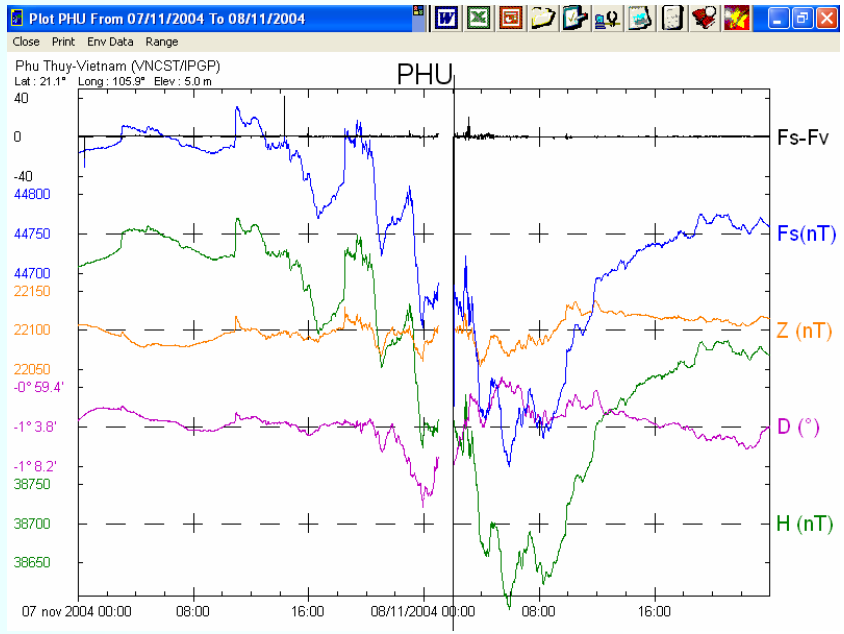
example: Pipe-to-sol potential at BaRia for a quiet day 30/04/2004





example: Pipe-to-sol potential at BaRia for a storm day 7/11/2004





correlation magnetic field – P-to-S potential

$$R = \frac{\sum_{i=1}^{N}\left((dH/dt)_i - \overline{dH/dt}\right)\left(U_i - \overline{U}\right)}{\sqrt{\sum_{i=1}^{N}\left((dH/dt)_i - \overline{(dH/dt)}\right)^2}\sqrt{\sum_{i=1}^{N}\left(U_i - \overline{U}\right)^2}}$$

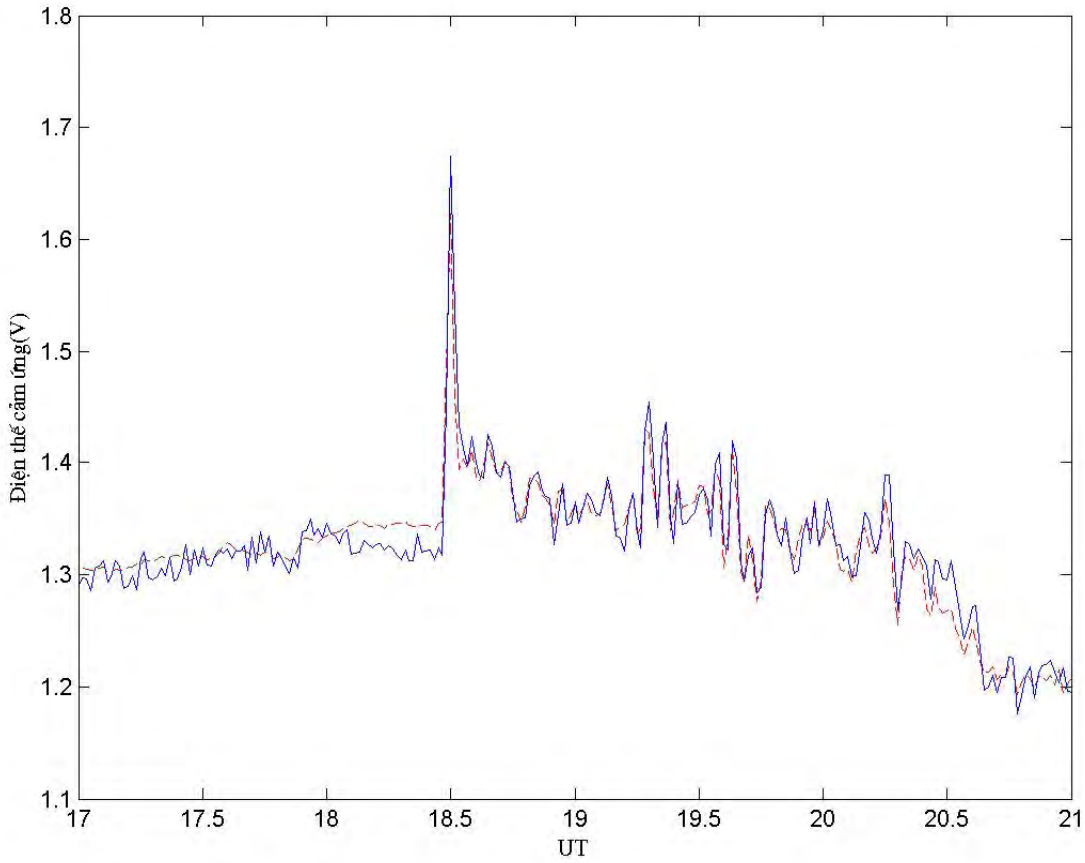
$(dH/dt)_i$: ®¹o hµm thµnh phÇn n»m ngang H;

U_i: ®iÖn thÕ èng - ®Êt

N: ®é dµi chuçi sè liÖu lÊy t-¬ng quan, N=1440;

$$\overline{(dH/dt)} = \frac{1}{N}\sum_{i=1}^{N}(dH/dt)_i \qquad \overline{U} = \frac{1}{N}\sum_{i=1}^{N}U_i$$

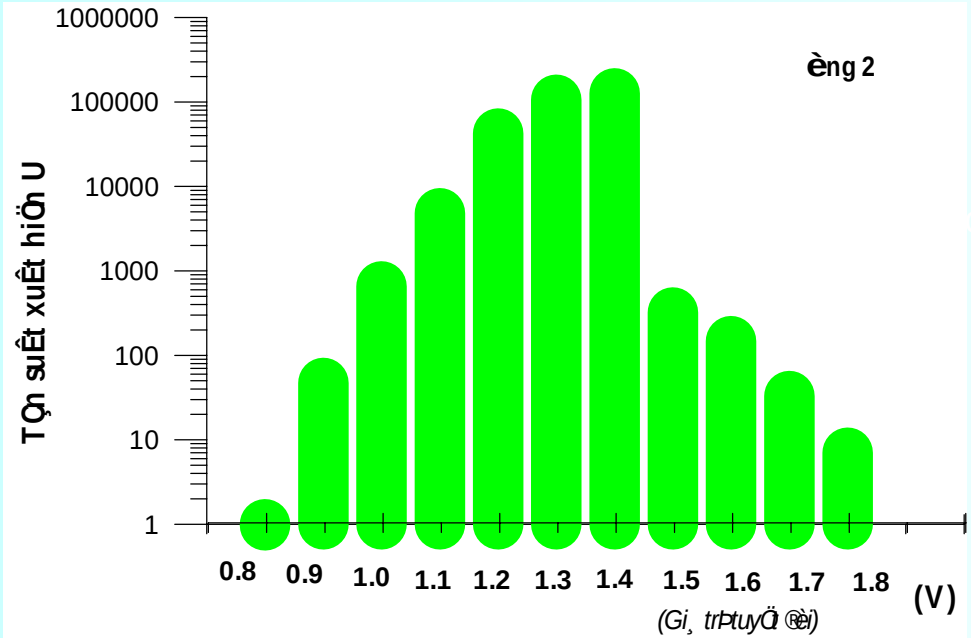
Example of P-to-S Potential calculated and recorded for November 11, 2004 in Ba Ria station

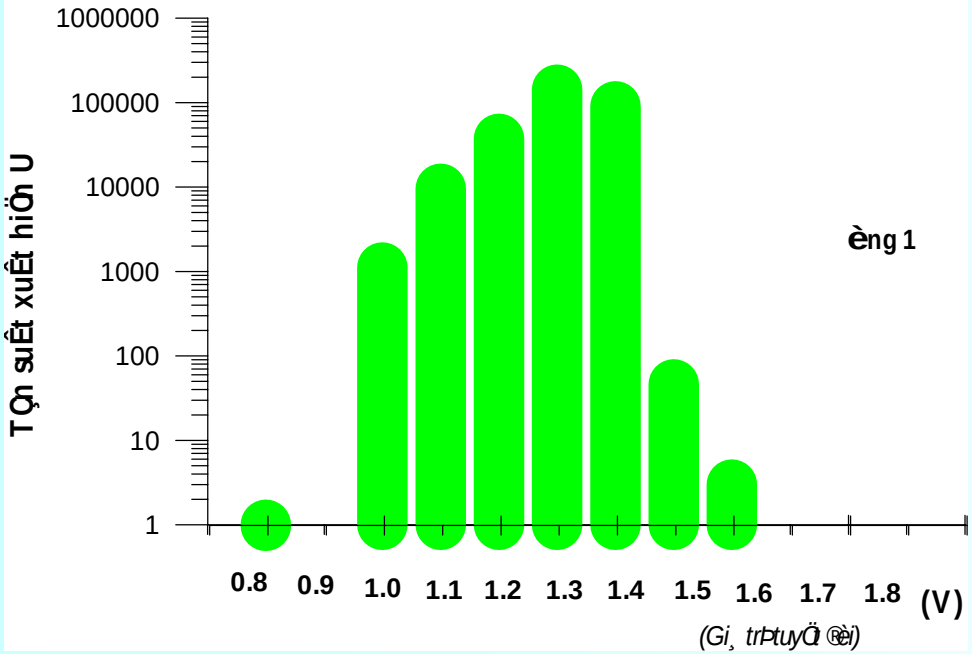


——— : P-to-S recorded ; — — — : P-to-S calculated

$\sigma = 2{,}9 \times 10^{-4} \Omega^{-1}\, m^{-1}$

apparition frequency of P-to-S potential V





CONCLUSION

- *The space weather, expressed by the magnetic storms, impacts on the technologies – high power systems and petrol-gaz pipe-lines not only in the high latitudes zones, but also in the low latitudes ones, as in Vietnam;*

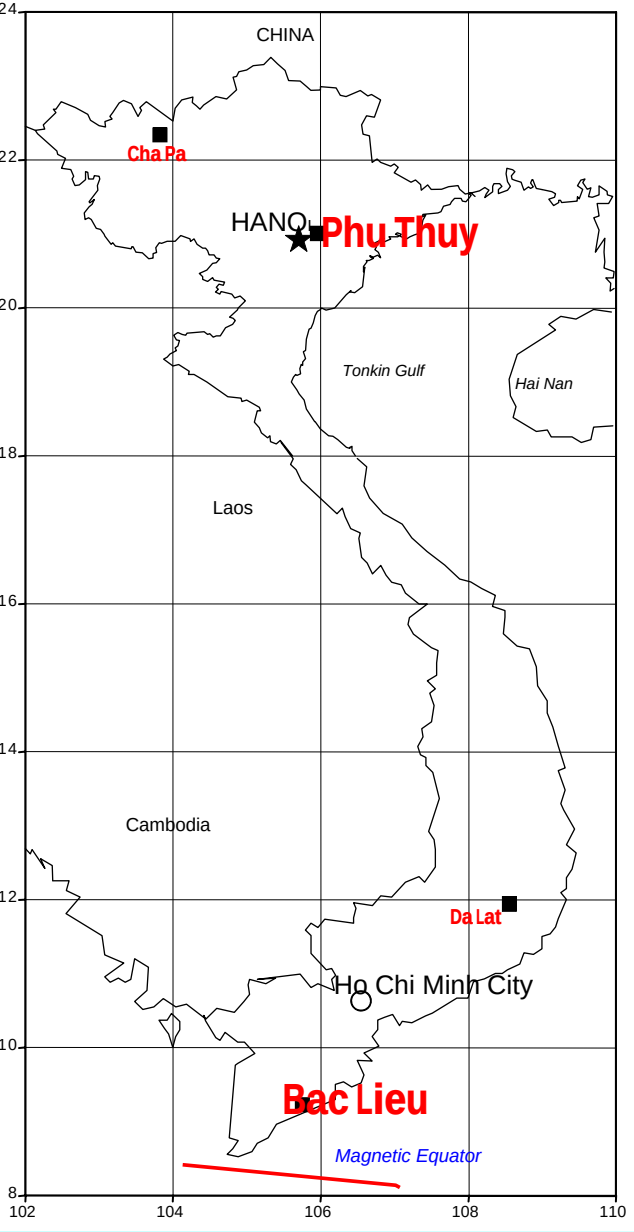
- *The strongest period of the 24th solar cycle (2010 - 2011) will come soon. One must have the necessary measures to limit the damages caused by the magnetic storms appearing in this period*

ACKNOWLEDGEMENTS

We thank the LOC, SOC, especially Prof. Ahmed Hady for having invited us to participate to the Symposium

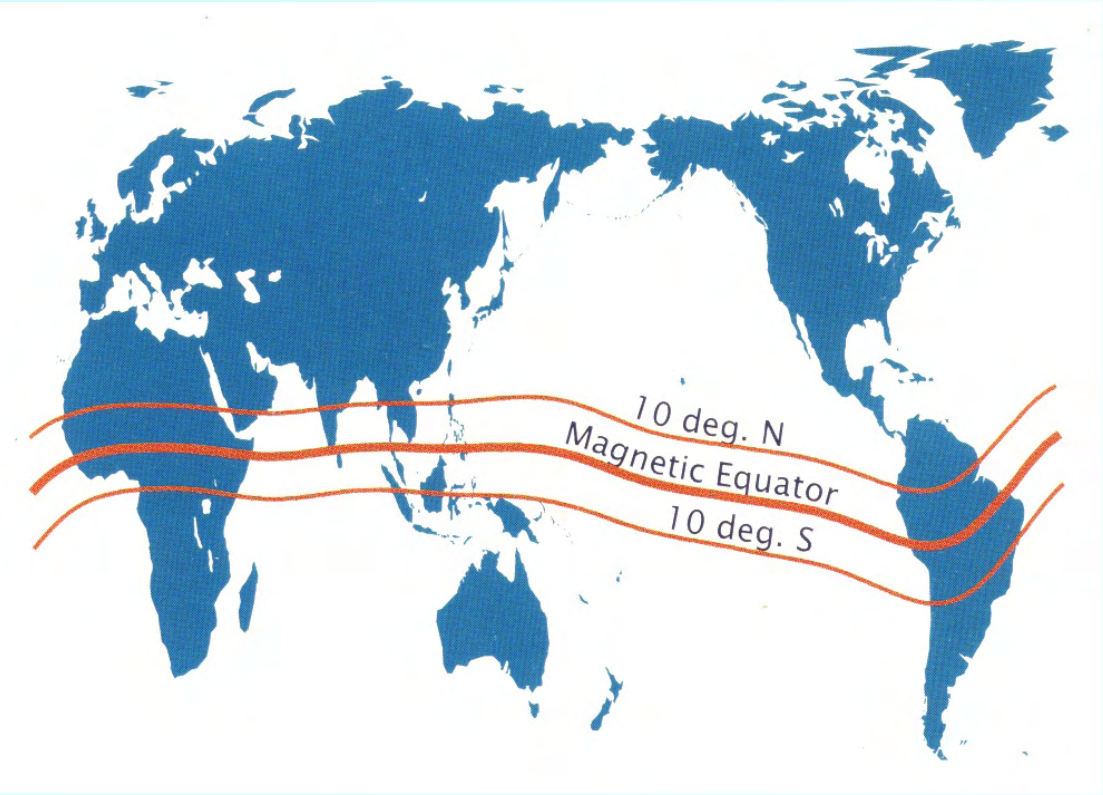
Thank You for Listening!

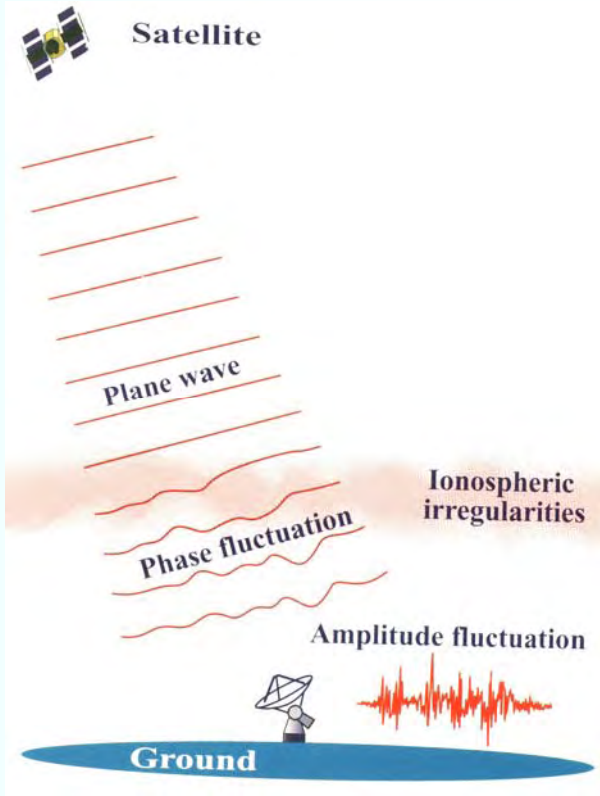
MAGNETIC-IONOSPHERIC OBSERVATORIES



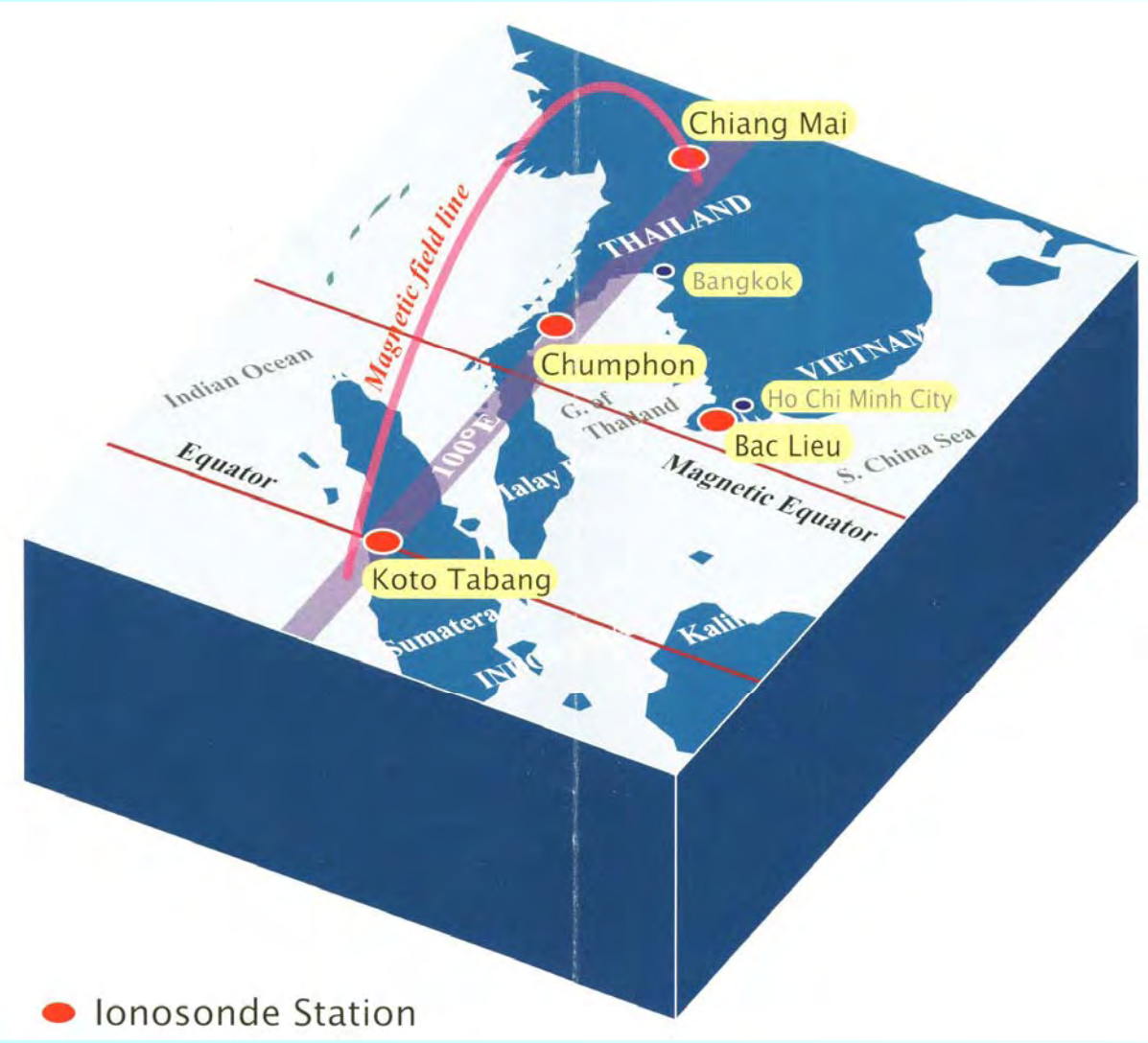
Nr.	Name	(φ)	(λ)	(Φ_m)	(Λ_m)	(h)
1	Phó	21°02'N	105°57'E	09°30'N	175°10'E	0m
2	Thôy	09°17'N	105°44'E	02°30'S	174°45'E	5m
	B¹c Li²u					

Ionospheric studies





Ionospheric studies 2



Ionospheric studies 3

Studying:

- on the onset conditions of equatorial plasma bubbles, which cause ionospheric scintillations;

- on the large day-to-day variability of equatorial anomaly;

- on disturbance dynamo and prompt penetrating magnetospheric electric fields and their ionospheric effects;

- on the zonally propagating ionospheric traveling disturbances (TID) by comparing data from Chumphon in Thailand and Bac Lieu, which are separated by 500 km along the magnetic equator, and from Chiang Mai in Thailand and Phu Thuy (separated by 500km along 21^{o}N latitude)

- on equatorial electrojet (EEJ) by comparing equatorial sporadic E (Es) traces on the ionogram and magnetogram data;

- on the additional layer, F3-layer, by comparing magnetogram data and ionograms;

- and on the development of equatorial anomaly by comparing foF2 at Bac Lieu and Phu Thuy

VÒ vÊn ®Ò ¨n mßn

Van de An mon

-Dßng ®iÖn trong èng: kh«ng g©y ¨n mßn;

-Dßng tõ èng vµo ®Êt (qua lç vá b¶o vÖ): g©y ra ®iÖn ph©n khi cã n-íc: $H_2O \Rightarrow H^+ + OH^-$; tõ ®©y kÕt hîp víi Fe cña èng t¹o ra $Fe(OH)_2$ vµ $Fe(OH)_3$ (rØ s¾t). L-îng Fe bÞ tiªu thô tû lÖ víi dßng ®iÖn ë anode.

- Peady (1967): 1 A (DC) phãng ®iÖn vµo chÊt ®iÖn ph©n trong ®Êt cã thÓ khö 20 pounds (kho¶ng 20 x 0.454kg = 9.09kg) thÐp/n¨m.

-Dßng DC tæc ®éng bµo mßn m¹nh h¬n dßng AC:

-$C = (4.7 \pm 1.3)T^{0.186}$. (C: PhÇn tr¨m bµo mßn ë cïng biªn ®é; T: chu kú dao ®éng (s)) T=5', 1h, 4h $\Rightarrow$ C= 14%, 22%, 28%. §èi víi f cao, vÝ dô f = 60Hz, ¨n mßn Ýt xuÊt hiÖn;

-§· nghiªn cøu:

+ Khi cã b·o tõ hoÆc nhiÔu lo¹n tõ, dao ®éng T = 1' ®Õn 60' cã tæc ®éng ¨n mßn m¹nh nhÊt.

+ Trong vïng xÝch ®¹o, biÕn thiªn Sq cã biªn ®é m¹nh nhÊt, g©y ra ¨n mßn èng dÉn trong vïng nµy.

kü thuËt ®o ghi GIC trong èng dÉn

Ky thuat do GIC

- ViÖc x¸c ®Þnh GIC ch¶y trong èng cã tÝnh chÊt quyÕt ®Þnh viÖc ®¸nh gi¸ sù bµo mßn t¹i ®iÓm èng nèi víi ®Êt;

-3 ph-¬ng ph¸p ®-îc sö dông nhiÒu nhÊt:

+ Ph-¬ng ph¸p thÕ hiÖu èng - ®Êt (pipe-to-ground Method): ®o hiÖu gi÷a ®iÖn thÕ ë ®iÓm nèi ®Êt vµ ®iÖn thÕ cÇn thiÕt ®Ó chèng ®ì nhiÒu dßng ®iÖn chảng l¸n nhau ë ®iÓm tiÕp xóc cña èng. §o ®ång thêi ®iÖn trë gi÷a 2 ®iÓm cho phÐp x¸c ®Þnh dßng ®iÖn ch¶y ra ngoµi èng g©y ra bµo mßn.

+ Ph-¬ng ph¸p l¾p “sun” (Shunt method): GIC ®-îc ®o qua mét ®iÖn trë thÊp (10^{-6} Ω) ®· biÕt nèi víi èng t¹i 2 ®iÓm c¸ch nhau vµi tr¨m mÐt.§o ®iÖn trë gi÷a c¸c ®iÓm tiÕp xóc sÏ x¸c ®Þnh ®-îc GIC chÝnh x¸c víi gi¶ thiÕt r»ng kh«ng cã ®iÓm nèi ®Êt nµo cña èng gi÷a c¸c ®iÓm tiÕp xóc cña sun.

+ Ph-¬ng ph¸p gradien tr-êng (Pipe-Field-Gradient Method): sö dông biÓu thøc tr-êng tõ xung quanh èng dÉn: $I = r^2(dB/dr)/200$ (I: dßng ®iÖn (A); r: kho¶ng c¸ch (m); dB/dr : gradien (nT/m).§o 2 gi¸ trÞ cña Z ®Ó x¸c ®Þnh ΔB vµ Δr.

eclipse October 24, 1995

1. In the Vietnam sector, the Total Solar Eclipse of October 24, 1995 provided an ideal opportunity for the observation of the eclipse effect on the geomagnetic field: a magnetically quiet day, with the eclipse occurring around local noon for a duration of about 2 minutes and the track of Moon's shadow passing parallel to the magnetic Equator.

2. The eclipse effect on the geomagnetic field was observed only in the region of magnetic Equator (within the distance of 400km from the magnetic Equator): the H due to the eclipse had a linear relation with H due to the Sq current.

3. At the local solar eclipse at Hanoi (obscuration 78%), foF1 changed in the same way as that of the local solar radiation.

4. These new results confirm the suggestion of Rastogi (1982) that the normal electric field in the Sq band remained unaffected, and the eclipse effect on geomagnetism in the region of the magnetic Equator was due to the decrease in the ionization in the Equatorial Electrojet Current.

SEISMOLOGY STUDIES

- *Compilation of seismic zoning maps, scale 1:1.000.000.*
- *Seismic hazard assessment of Indochina.*
- *Induced seismicity in reservoir regions.*
- *Influence of exploration to the buildings and constructions.*
- *Seismic microzoning of big cities.*
- *Strong ground motion.*
- *Long-term earthquake prediction.*
- *Study of velocity structure.*
- *Estimation of seismic hazard for design of constructions.*
- *Studies of tsunami*

Geomagnetic and Ionospheric studies

- *Effects of magnetic storms and variations on the 500kV power-lines and petrol-gas pipes-lines*
- *Compilation of the normal geomagnetic field and secular variation maps for the epochs 1991.5, 1997.5, 2003.5.*
- *Geomagnetic Equator*
- *Solar Eclipse 24/X/1995*
- *Ionospheric phenomena*
- *Geological interpretations of the magnetic data.*
- *Palaeomagnetic application to the problem of geotectonic interpretation.*
- *Magnetotelluric Applications to the tectonic and geophysical problems*
- *Magnetic bacteria*
- *Participation to: + the INTERMAGNET Program (Prof. LEMOUEL)*
  + the PEER (Penetration of polar Electric fields into Equatorial Region) (Prof. YUMOTO)
  + the SEALION Programme (Prof. MARUYAMA and Prof. ISHII)

Applied Geophysics studies

Using complex geophysical methods: Micro gravimetric, Electrical resistivity, VLF, Self potential method, GPR…for:

- Study of the deep geological structure by magneto telluric sounding and self-potential method.
- Study of the near-surface geological structure for dike/dam system
- Location system of old mining tunnel and potential groundwater
- Study of near-surface geological structure for geotechnical and environmental targets
- Study of soil stratigraphy study in Vietnam.

Atmospheric Physics studies

- Zoning, studying the characteristics of thunderstorm activities,

- Investigation of lightning for high television tower,

- Economic technical foundation of wind power,

- Total radiation distribution in Vietnam and its applications.

Geodynamics Studies

- *Investigation of the*

  + structural characteristics and

  + tectonic constrain field of the Earth's crust

  in the territory of Vietnam.

INTERNATIONAL COOPERATION

Carrying out the co-operation with colleagues from

- *France,*
- *China,*
- *Germany,*
- *Russia,*
- *United States of America,*
- *Japan*
- *Taiwan*
- *New Zeland and*
- *ASEAN countries (in the future: Thailand, Indonesia, …)*

in many geophysical and geological researches in the territory of Vietnam and abroad

PHU THUY IONOSONDES

Periods	1962-1966	1967-1994	1995-2002
Ionosonde	IRX Hungary	AIC Russia	IPS-71 Australia
Frequency range (MHz)	1-20	1-18	1-45
Impulse Length (μs)	50 or 100	50-70	40
Impulse Frequency (Hz)	50	50	50
Receptor Sensibility (μv)	10 with S/N=3/1	10 with S/N=2/1	-100 — -150 db
Altitude range (km)	300-1400	250-1500	70-1500
Minimum power (Kw)	5	2.5	2.5

History of Foundation of HIG

- *1957: founded Department of Geophysics*

  (In the same time: established the Chapa geophysical observatory)

- *1982: Foundation of the Centre for Geophysical Research (CGR)*

- *1986: Foundation of the Hanoi Institute of Geophysics (HIG)*

II. GEOMAGNETISM DEPARTMENT (1)

Staff

22 persons (13 in Hanoi and 9 in the observatories):

- *Professor : 1*
- *Associate professor : 2*
- *Doctors : 7*
- *Engineers : 7*
- *Technicians : 10*

Director : *Ass.Prof.Doctor Ha Duyen Chau*

(Email: chau@igp.ncst.ac.vn)

BAC LIEU Observatory
Magnetometer House

VIETNAM ACADEMY OF SCIENCE AND TECHNOLOGY

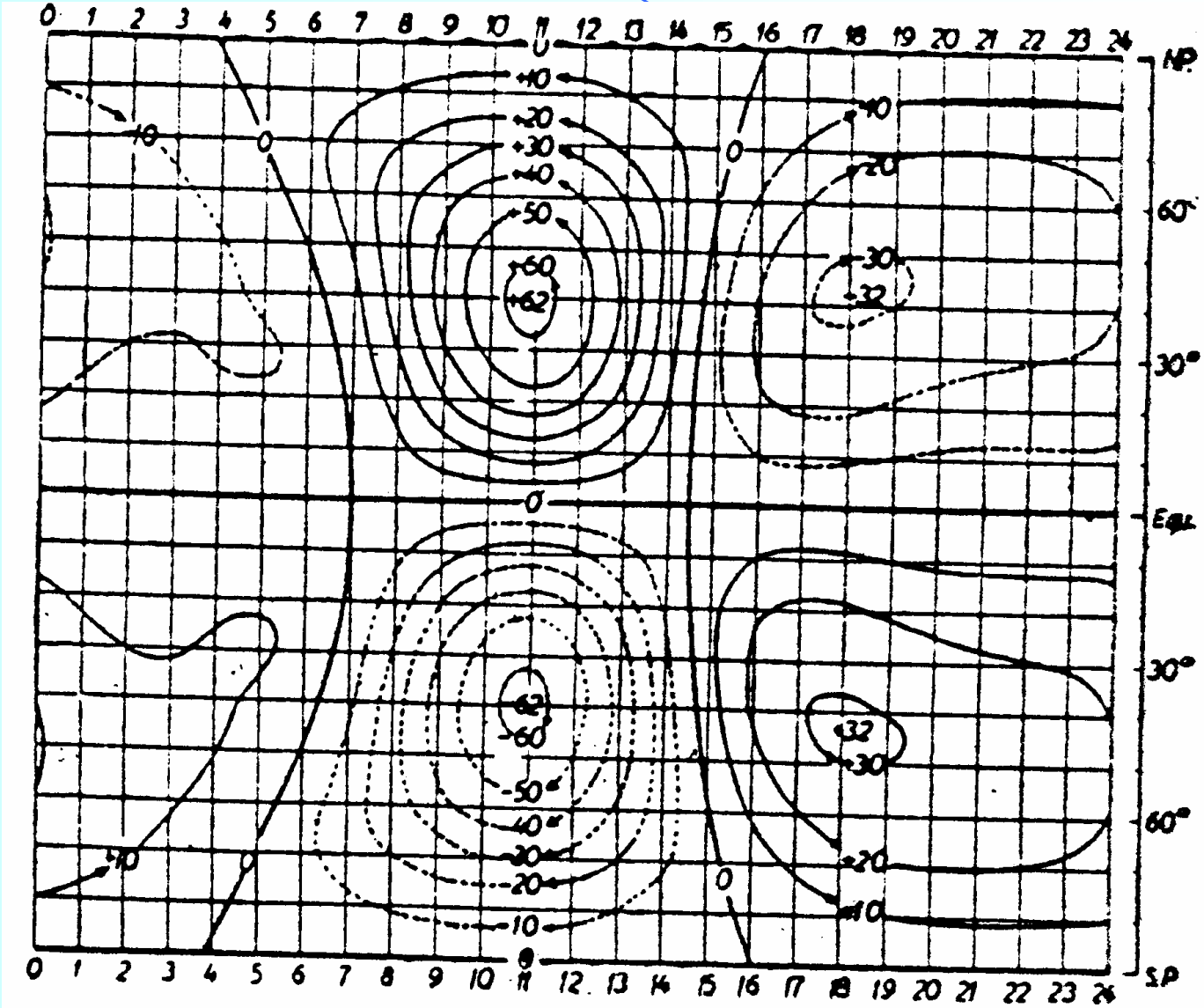
20 Research Institutes

- Address: Hanoi – VIETNAM
- Staff: ≈ 3500 members

Figure 3.9. Solar prominence and filament appearance compared to the size of the Earth (small circle).

SOLAR PROMINENCE

S_q currents


0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
NP
60°
30°
EQL
30°
60°
SP
0
+10
+20
+30
+40
+50
+60
+62
-10
-20
-30
-40
-50
-60
-62
+32
-32