MECHANICS OF THE MAGNETOSPHERIC SYSTEM AND EFFECTS ON THE POLAR REGION

STUDY OF THE VARIATION OF THE Pc-5 INTENSITY, DURING THE GEOMAGNETIC STORM OF MAY 15, 2005, USING CARISMA, SAMBA, AND MAGDAS MAGNETOMETER ARRAYS DATA.

Marin[1], J., Stepanova[2], M., Vega[1], P.

1 Departamento de Física, Universidad de La Serena
2 Departamento de Física, Universidad de Santiago de Chile

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1 Brief Review:

This magnetic storm, was caused by an interplanetary magnetic cloud.
Kozyreva and Kleimenova (2007), report the develoment of the magnetic bay associated with geomagnetics pulsations, more intense in polar cap.
The Fourier spectrum of the geomagnetics pulsations, and IMF B_y was similar during the magnetic bay growth phase, and then could be penetrate from the solar wind into the open cap, during the initial phase.
In the recovery phase, they detected the tipical dawn Pc5 pulsations, and very intense (200 nT) daytime quasi-monocromatic geomagnetic pulsations with a period around 600 s., in the beginning of the recovery phase. They used data of Image Greenland, Carisma, network of magnotemeters along 210º meridian, and Intermagnet global network.

2 The U.L.F. Wave Propagation Model (Walker, A. D.M., 2004, Alperovich, L. S., Fedorov, E.N., 2007). This model considered:

- Cold plasma and Alfvén mode waves MHD propagating in a medium, on the ionosphere.
- Matrix description of reflection, and conversion coefficients between cutting modes Alfvén, and fast magnetosonic to interact with the system Ionosphere-Atmosphere-Earth.
- Matrix depends on the background magnetic field, the horizontal wave vector, and the ionospheric conductivity.

-Depending on the orientation of the background magnetic field, the wavenumber k_y is the critical parameter, that determines the characteristics of the reflection and mode conversion.

Lineal aproximation and disturbence of first order, on:

- Magnetic Field.
- Plasma Pressure.
- Plasma Density.

2.0.1. Geomagnetic Data Processing (Baker et al.,(2005), Pilipenko (1985)) of Carisma, Magdas and Samba Array. Brief description:

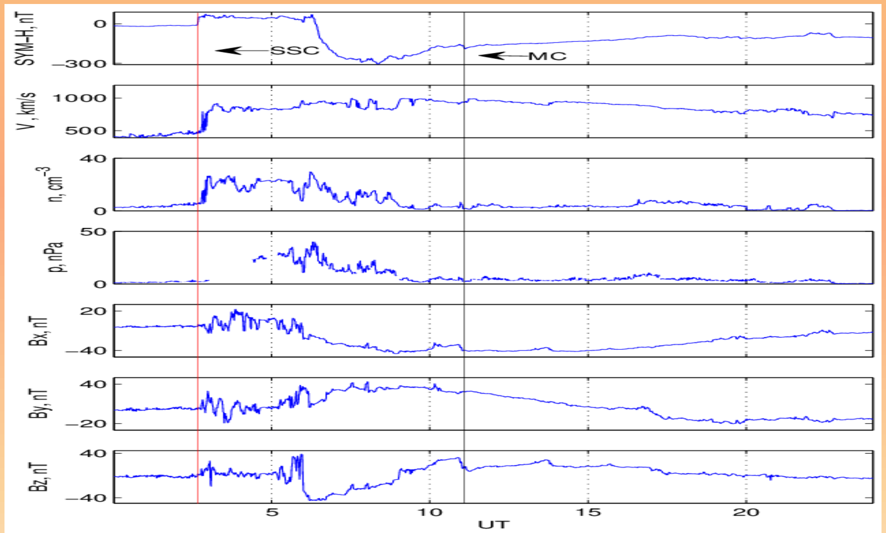
- Cleaning NaN (Not a Number), Samba data: ~2% of data base
- Cubic interpolation.
- Detrend constant: $X_{data} - X_{mean}$
- Hanning window.

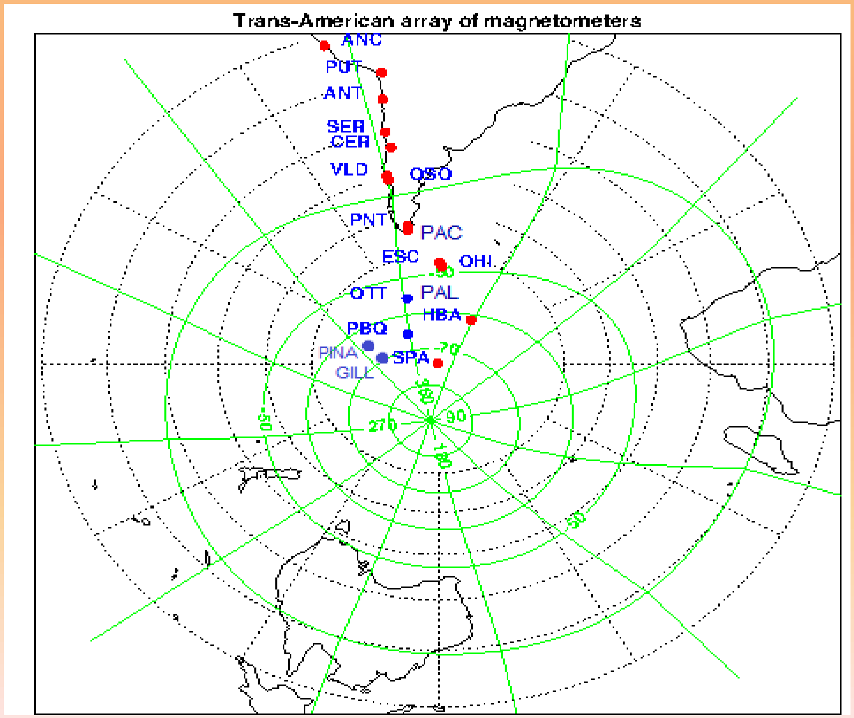
2.02. Fourier transform (SFFT) over unfiltered data.

-Pc5 unfiltered: Pc5 Latitudinal Profile, Pc5 Profile and L, Phase difference between stations.

2.1.- Magnetometers paramater, Wind satellite data, and Transamerican Array.

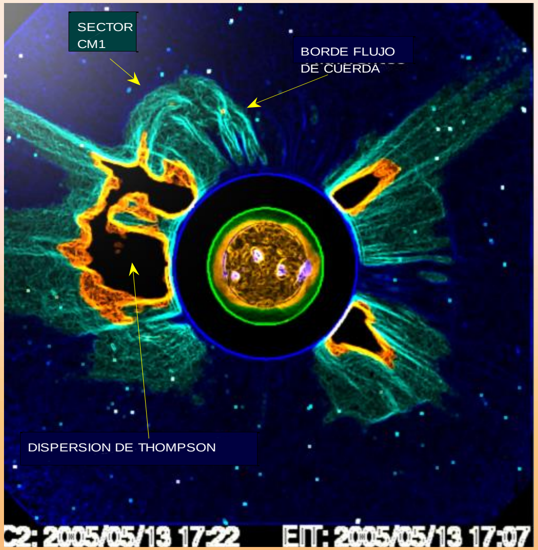
Magnetometer Fluxgate	UT midnight of MLT	L value	Geographic Latitude	Geographic Longitude	CGM Latitude	CGM Longitude
Gilliam(GILL)	6:00	6.15	56.40	265.4	66.03	333.0
Pinawa(PINA)	6:00	4.10	50.19	263.9	59.98	331.8
Ottawa(OTT)	6:00	3.10	70.49	277.8	55.86	355.9
Palmer(PAL)	4:00	2.39	-64.77	64.05	-49.74	9.20
Escudero(ESC)	3:48	2.18	-62.18	58.92	-47.17	11.45
Magallanes(PAC)	4:22	1.63	-53.20	-70.90	-38.27	2.87
Valdivia(VLD)	4:32	1.23	-39.48	-73.14	-25.58	359.60
Los Cerrillos(CER)	4:26	1.13	-33.45	-70.60	-19.80	0.75
Antofagasta(ANT)	4:26	1.03	-23.39	-70.24	-10.31	0.72
Ancón(ANC)	5:10	1.00	-11.77	282.9	0.77	354.3

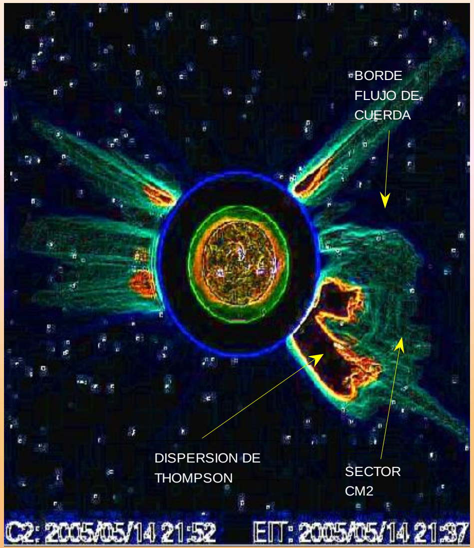




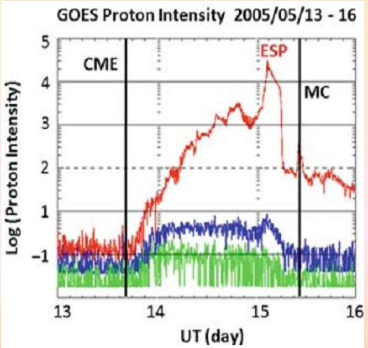
The sheath region of this cloud was associated with a high particle density (25-30 particles/cm^{-3}), with solar wind speed between 800-1000 Km s^{-1}, and strong variations in the magnetic field (IMF).

2.2, 2.3.- Events Associates, D_{ST} and SYM-H Indexes.



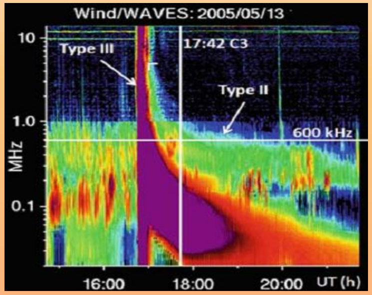


Coronal mass ejections; May 13, May 14



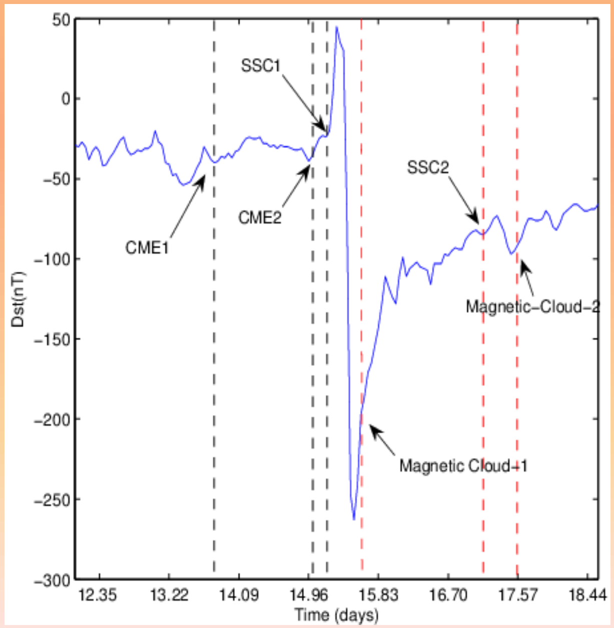
Intensity; flux of particles= proton (cm^{-2} s^{-1} sr^{-1})
Red Line: 10 MeV
Blue line:50 MeV
Green line:100 MeV

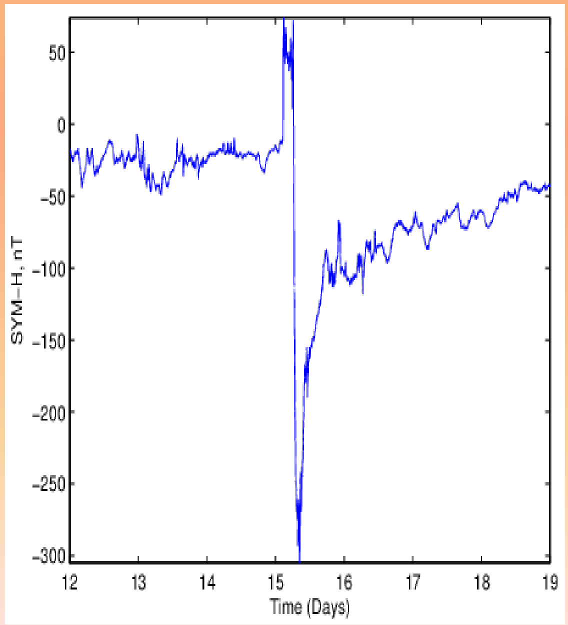
(Gopalswamy et al., 2010)



Electrons Beam; from eruption solar place (III), accelerated in Shock wave(II)

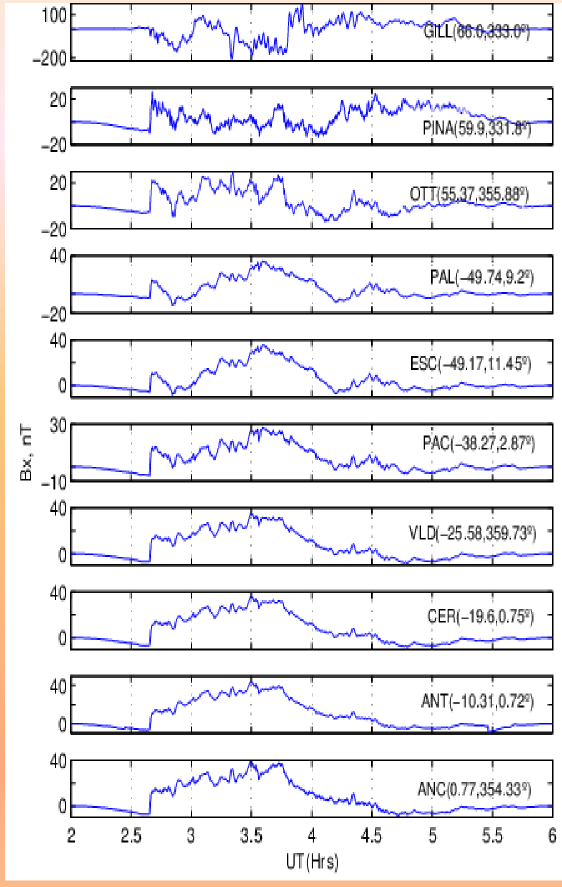
D_{ST} and SYM-H indexes, shows the fall of the Geomagnetic Field, and define the phases of magnetic storm. Minimum D_{ST} - 263 nT and the minimum SYM-H - 303 nT. SSC_1, Storm sudden commencement associated with CME_1.



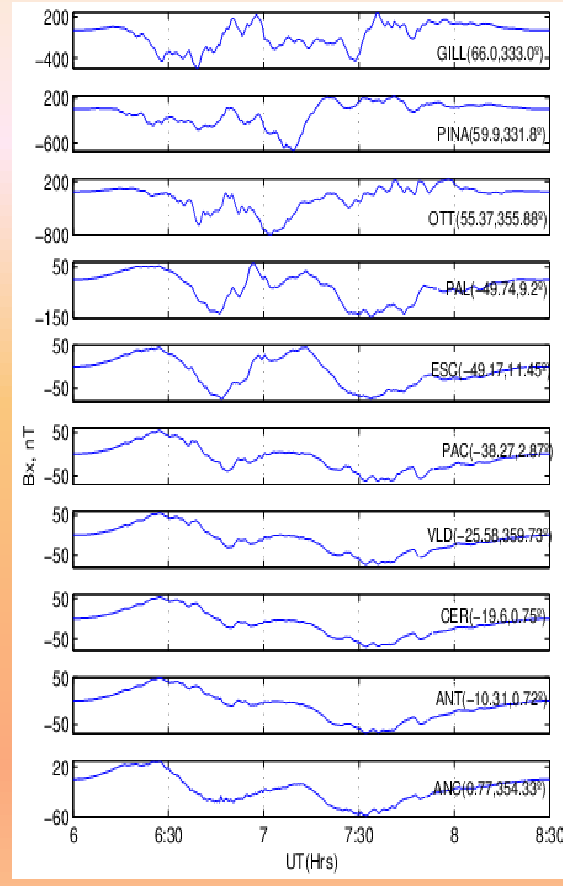


2.4.- Geomagnetic Disturbances, time-scale 1 s. Except OTT, 5 s.

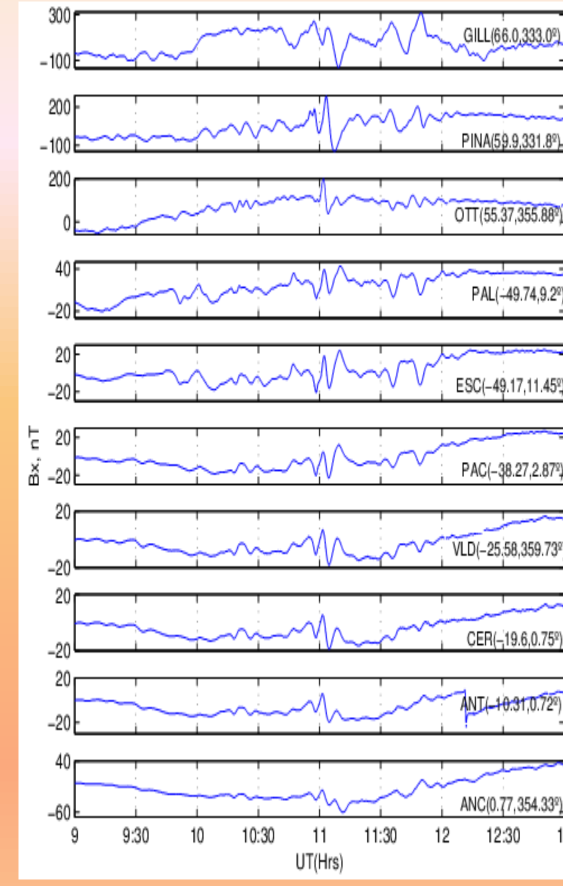
Initial Phase



Main phase



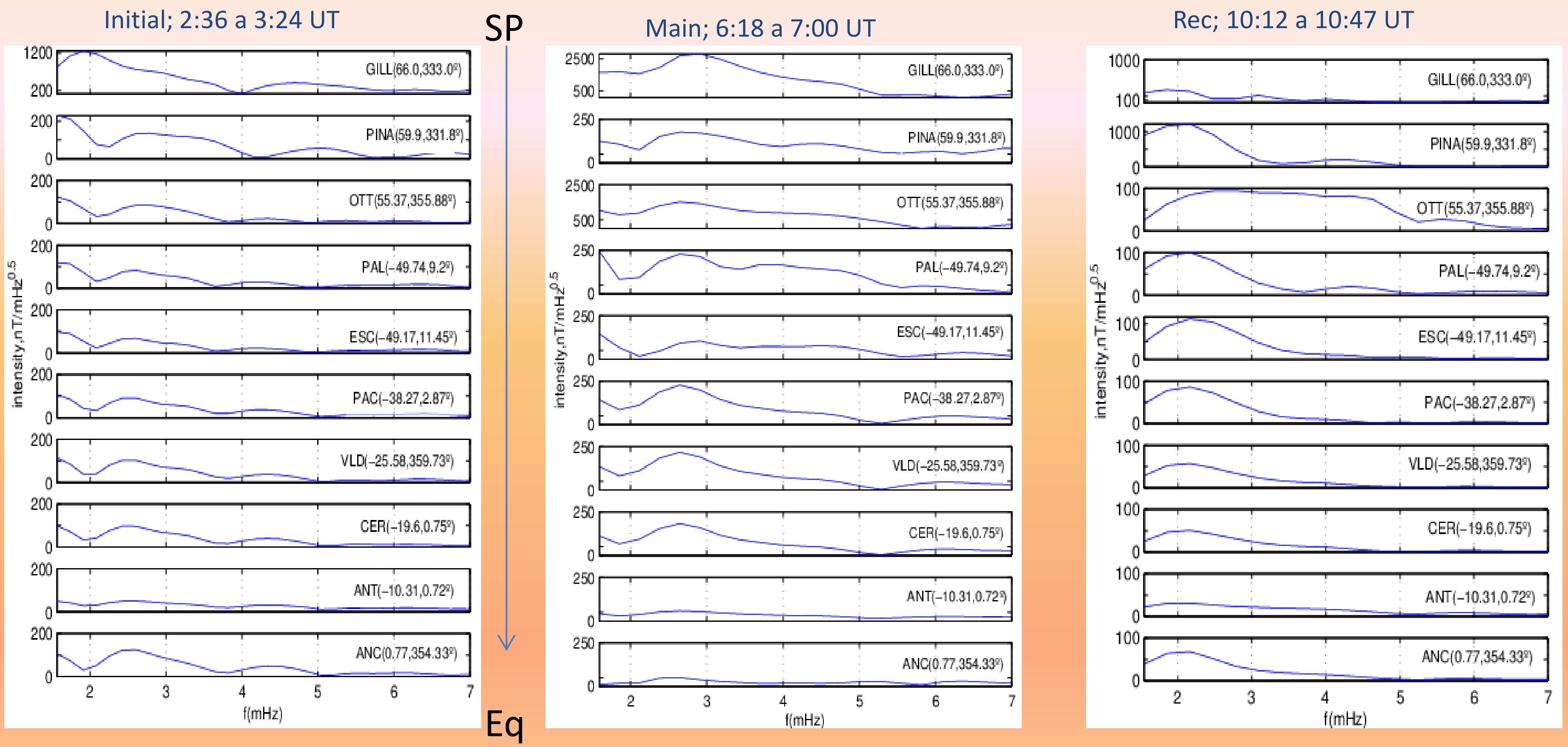
Recovery Phase



The magnetic pulsations are observed in all latitudes, during initial phase.
The main phase, shows in Samba stations, a significant decrease in the magnetic pulsations.
The recovery phase shows around the 11 UT, an important peak similar to report Kozyreva and Kleimenova (2007).

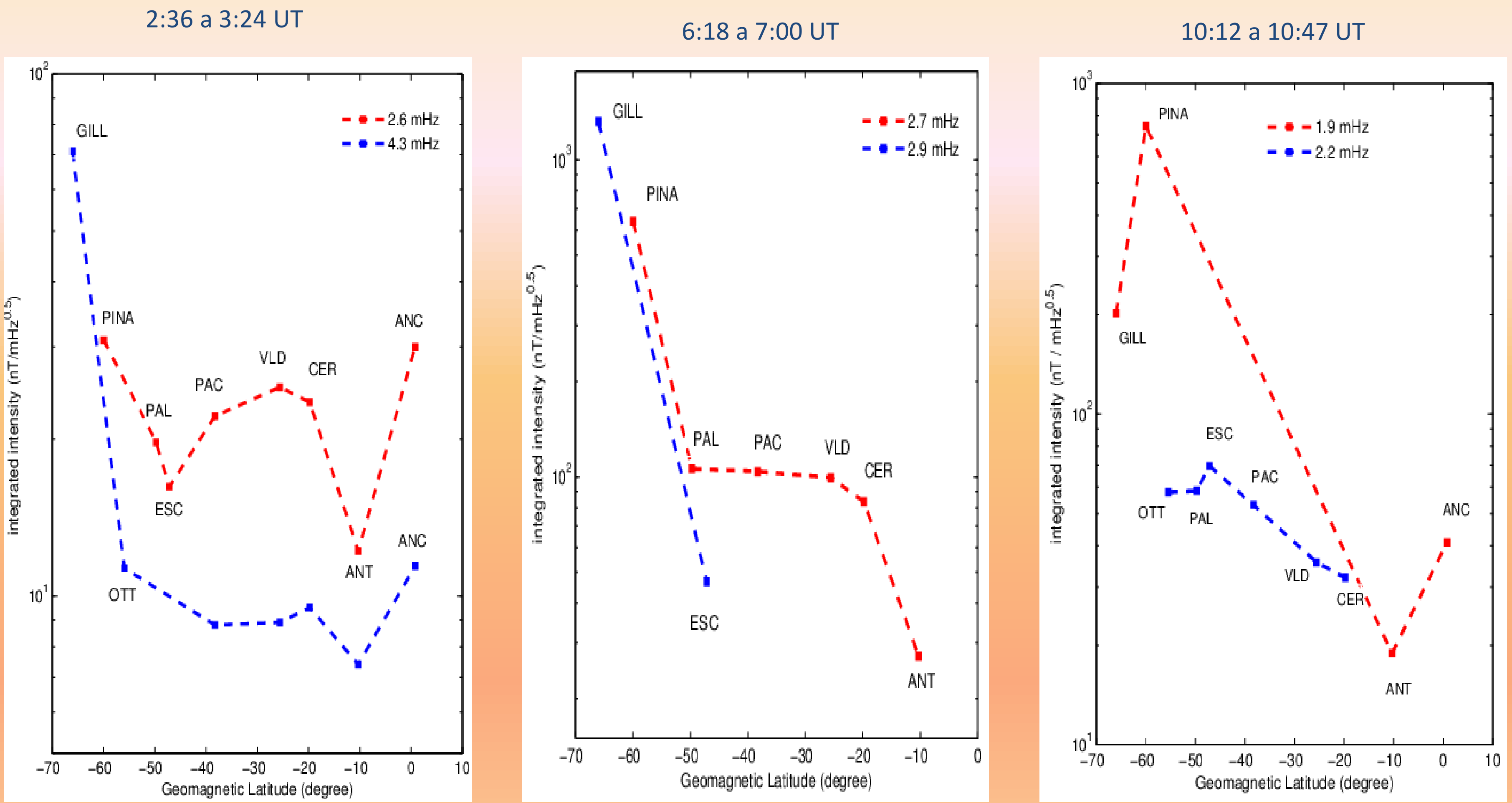
Other contributions in the search for Pc5 : initial phase, Ziesolleck and Chamalaun (1993) AWAGS Array, main phase, Lee et al., (2007), L~4. recovery phase; Sakurai et al., (2005), L=1.06.

2.5.- Spectral Analysis; Fourier Fast Transform, Percival, D.B., and Walden, A.T., 1993. Turbulence, (Kozyreva et al., 2007, Coult et al., 2007), plasma fluctuations and field.



At the initial phase, Pc5 intensity decreases from south pole to ANT station, and increases toward magnetic equator.
The main phase shows an increase in the bandwidth of the Pc5 intensity, because the turbulence enhancement shifts the harmonics and shrinks the signal .
Recovery phase shows an initial increase then decreases and again increases in the magnetic equator

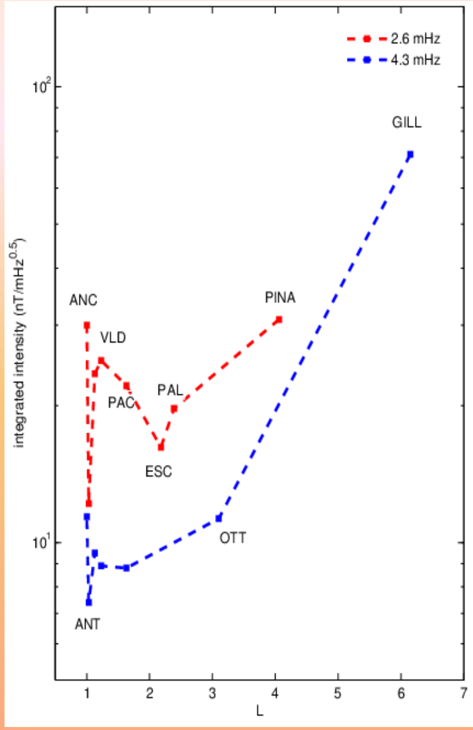
2.6.- Latitudinal Profile of the Pc5 intensity, (Potapov et al., 2005, 2006).



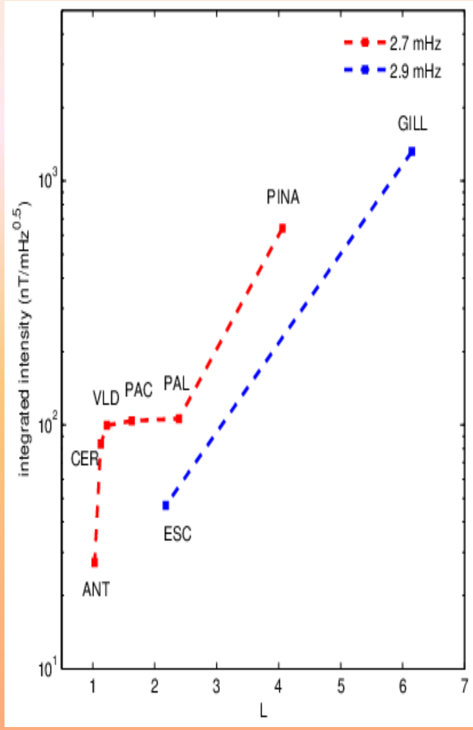
In the Initial phase there are fluctuations in both harmonics, but the 2.6 mHz, the integrated intensity over the frecuency, increases toward magnetic equator, and is higher than 4.3 mHz. Main phase doesn`t show an enhancement toward magnetic equator, in both harmonics. Recovery phase shows an enhancement from GILL to PINA, and from ANT to magnetic equator. The enhancement toward to magnetic equator are associated to the global oscillations.

2.7.- Pc5 Intensity Profile, as a function of L, (Crosby et al., 2005).

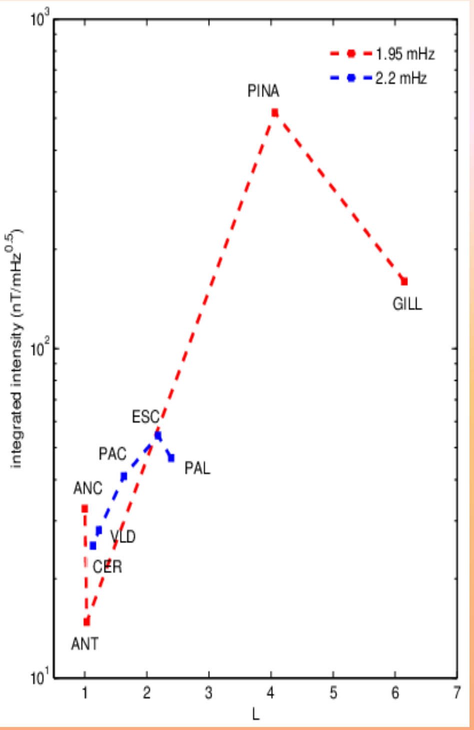
2:36 a 3:24 UT



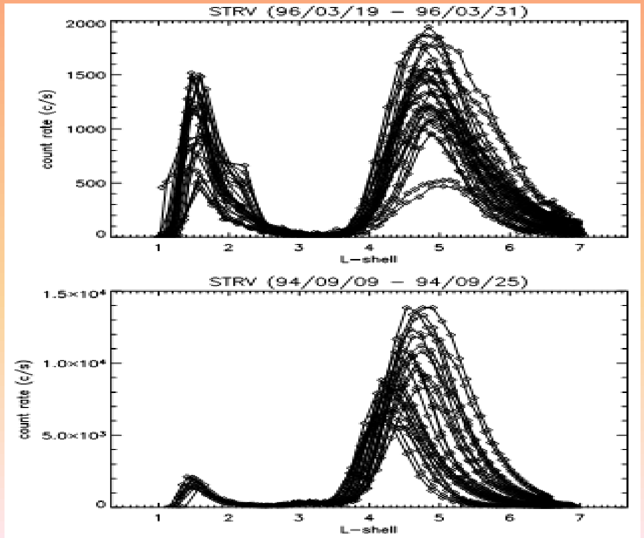
6:18 a 7:00 UT



10:12 a 10:47 UT



Counting rate of electrons in radiation belts CID / STRV function of L, for two observation periods. (Fig. 1 in Crosby et al., (2005)).



Initial phase decreases from PINA toward ESC then increases up to VLD. This could be related to particle - wave interaction, accord to Crosby et al., the compression is correlated to increase of 2.6 mHz harmonic.
Similar situation occurs in the recovery phase in the increase from GILL to PINA, for 1.95 mHz harmonic. In the main phase we don`t observe behavior as in the initial and recovery phase.

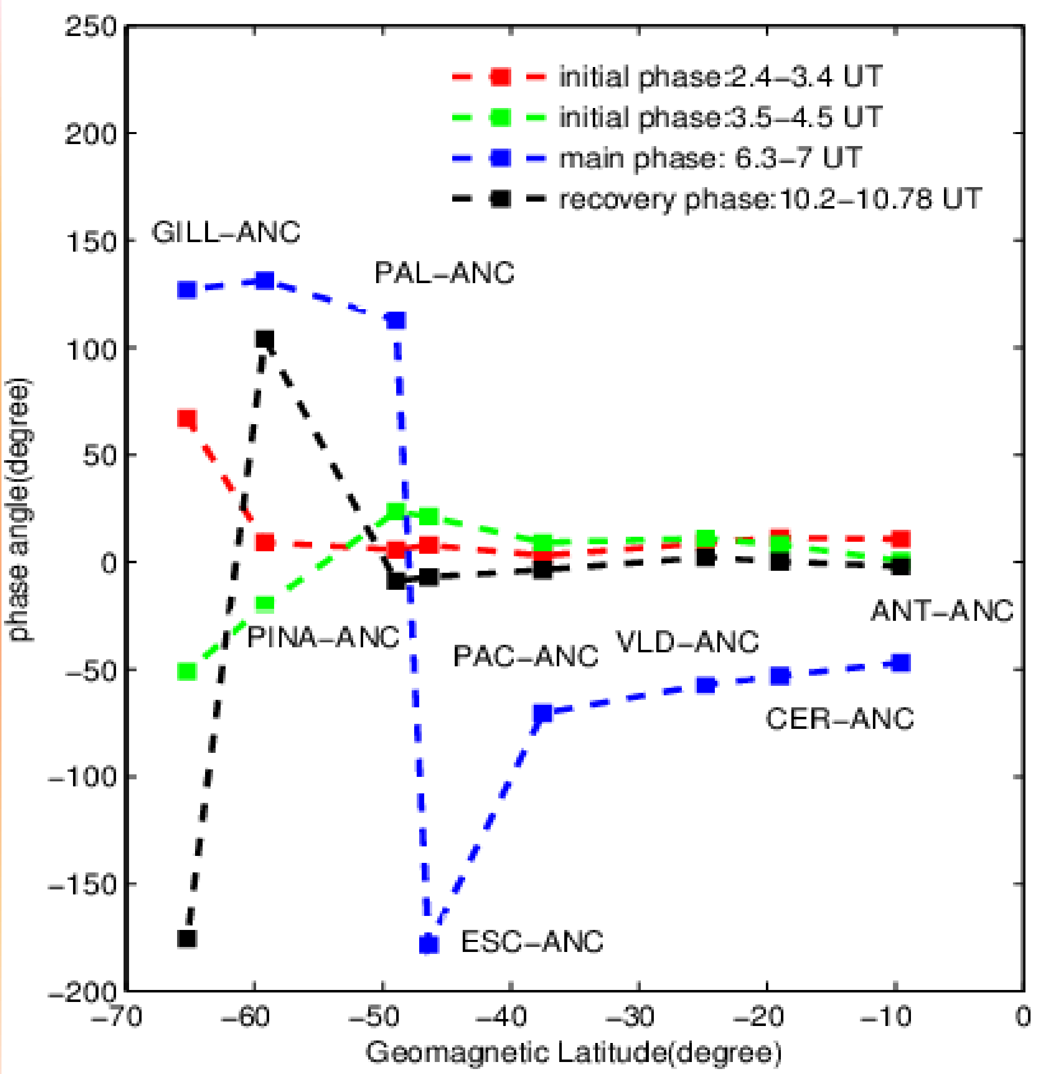
2.8.- Pc5 Phase Difference, between equatorial dip station, and those outside the dip.

Shinoara et al., (1998), Sutcliffe and Lühr, (2010)

Shinoara Model :
The equatorial phase lags can be explained by the induction effect of the equatorial enhanced ionospheric current above the good conductor Earth.

For 5.8º of the magnetic equator, around 20º in phase difference, for Pc-5 with frecuency range lower 5 mHz, in daytime. During night-time the ionospheric conductivity is reduced around 10^{-2} of that in the daytime, and then phase difference is quite small.

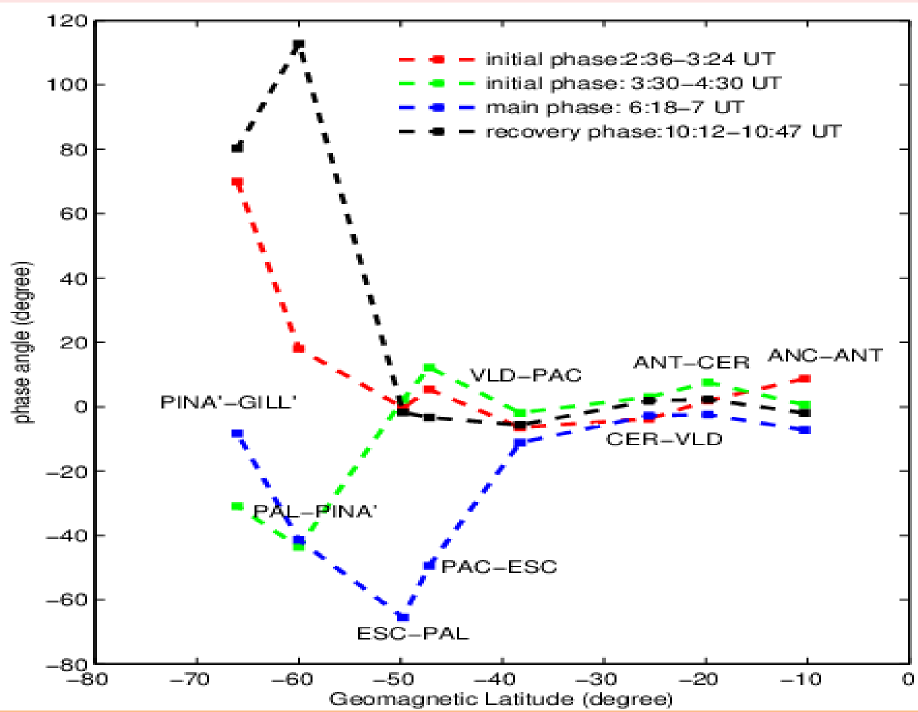
At initial and recovery phase, until ESC-ANC, our values are near a values proposed daytime model, and then are deflections respect to night-time model.

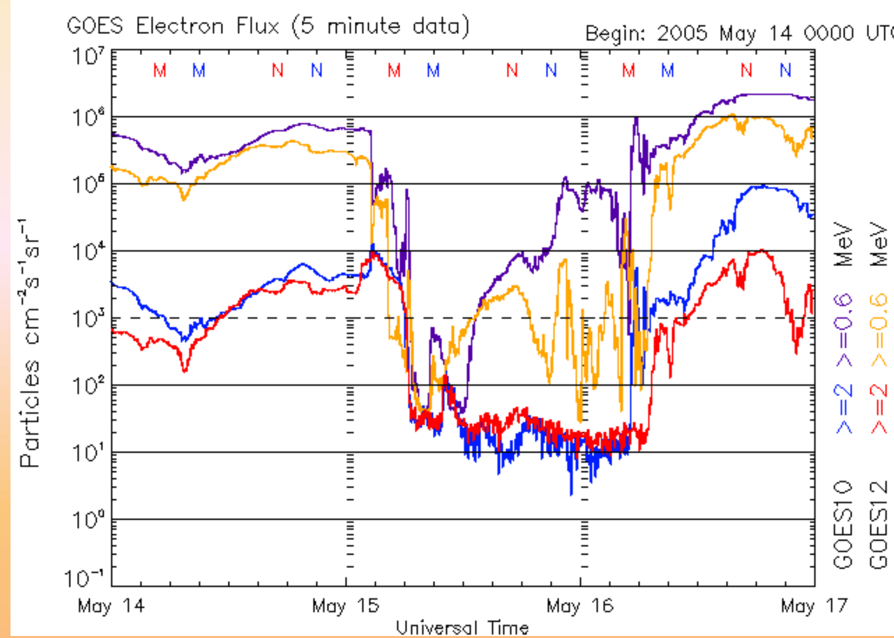


2.9.- Phase difference between nearby stations, relativistic electrons.

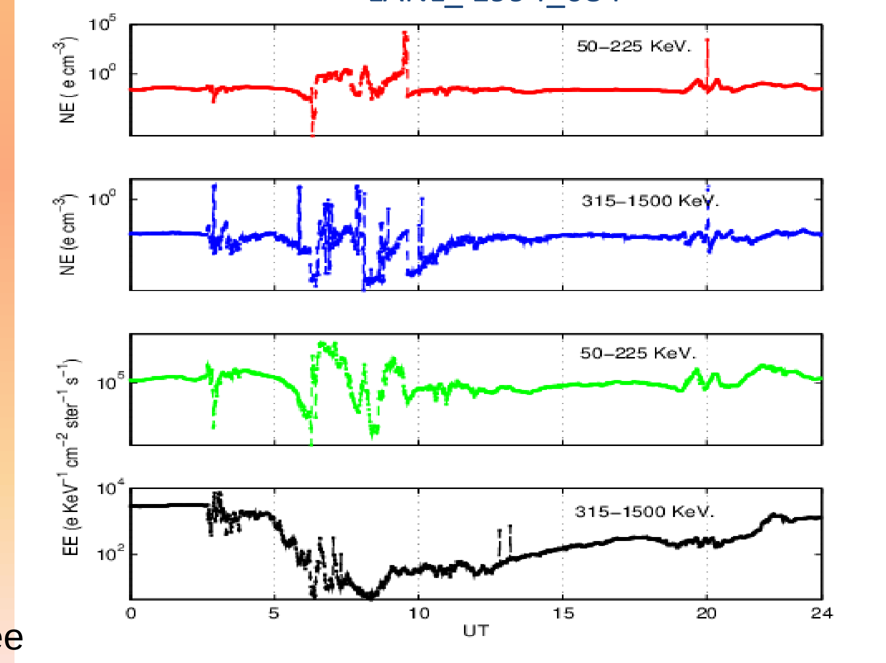
(Kitamura et. al., 2012)

LANL_1994_084
Orbit: geo-synchronous (6.6 Re, equatorial)
Spin period: ~10 seconds
Spacing: roughly 120 degrees apart
Spin Axis: earth pointing





LANL_ 1994_084



The strong fluctuations in the Pc5 phase difference between near stations, could be related to increase in the flow of electrons of high energy.
During t he magnetic storm , we observe strong fluctuations in the main phase, for ESC-PAL, and the recovery phase, for PAL-PINA. GOES 10, 12, show increase up the flow between 15 to 18 UT, May 16, in agree with Kitamura et al.

3 Conclusions:

3.1 The linear techniques on geomagnetic data, are justified by the linearity applied on the ULF waves propagation models.

3.2 Pc5 pulsations are observed from the northern hemisphere to the Antarctic, during the phases of the magnetic storm of May 15, 2005, by using Carisma, Samba and Magdas array, as a deflections to the proposition of F.L.R. theory, (Resonance Line Field).

3.3 In the Pc5 intensity profile, significant fluctuations are observed, but in general showing a decrease spatially.

3.4 The Bx component of the Pc5 intensity increases toward the magnetic equator, in the initial phase and in the recovery phase. This fact shows the presence of the global oscillations.

3.5 The phase difference of the values of Pc5 between the magnetic equator station, and outside until ESC, in the initial phase and recovery phase, are deflected by approximately two orders of magnitude, compared to the values proposed by the nightime inductive model, and are of the order of the values proposed in daytime.

3.6 Other increasing values of the Pc5 intensity as a function of L, in X component could be related to the wave particle interaction, due to the dynamic of the radiation belts and ring current during the storm.

3.7 A dependence of the intensity Pc5, respect to MLT is clearly observed, i. e. higher values of intensity are observed during the main phase in magnetic local time, between midnight and dawn.

3.8 Fluctuations in Pc5 phase difference between neighboring stations would be one aspect to consider in the study of the increases in the electron flow medium and high energy. A significant increase in the flow of electrons higher than 2 MeV occurs ~ 09 UT May 16, around 24 hrs after Pc5 intensity maxima, at the end of the main phase, and at the beginning of the recovery phase.

3.9 The mechanism associated to the ULF wave propagation in Low Latitude, is a open problem yet.

3.10. The mechanism associated between relativistic electrons and Pc5 ULF, is a open problem yet.