A new South America instrumental network for monitoring of the atmospheric electric field

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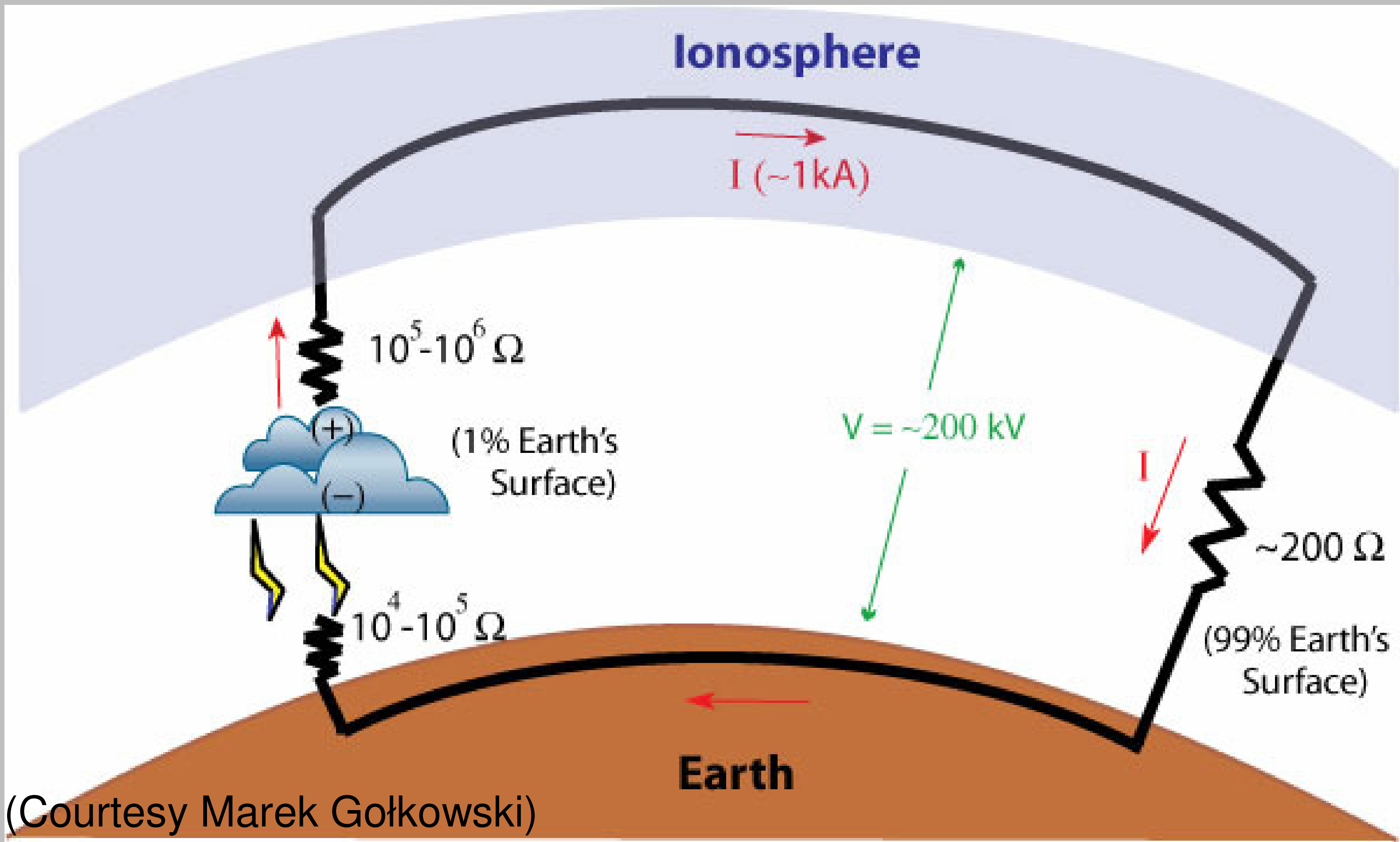
3rd ISWI Workshop – 8-12/10/2012 - Quito - Ecuador

The Global Atmospheric Electric Circuit

The global atmospheric electrical circuit links charge separation in disturbed weather regions with current flow in fair weather regions



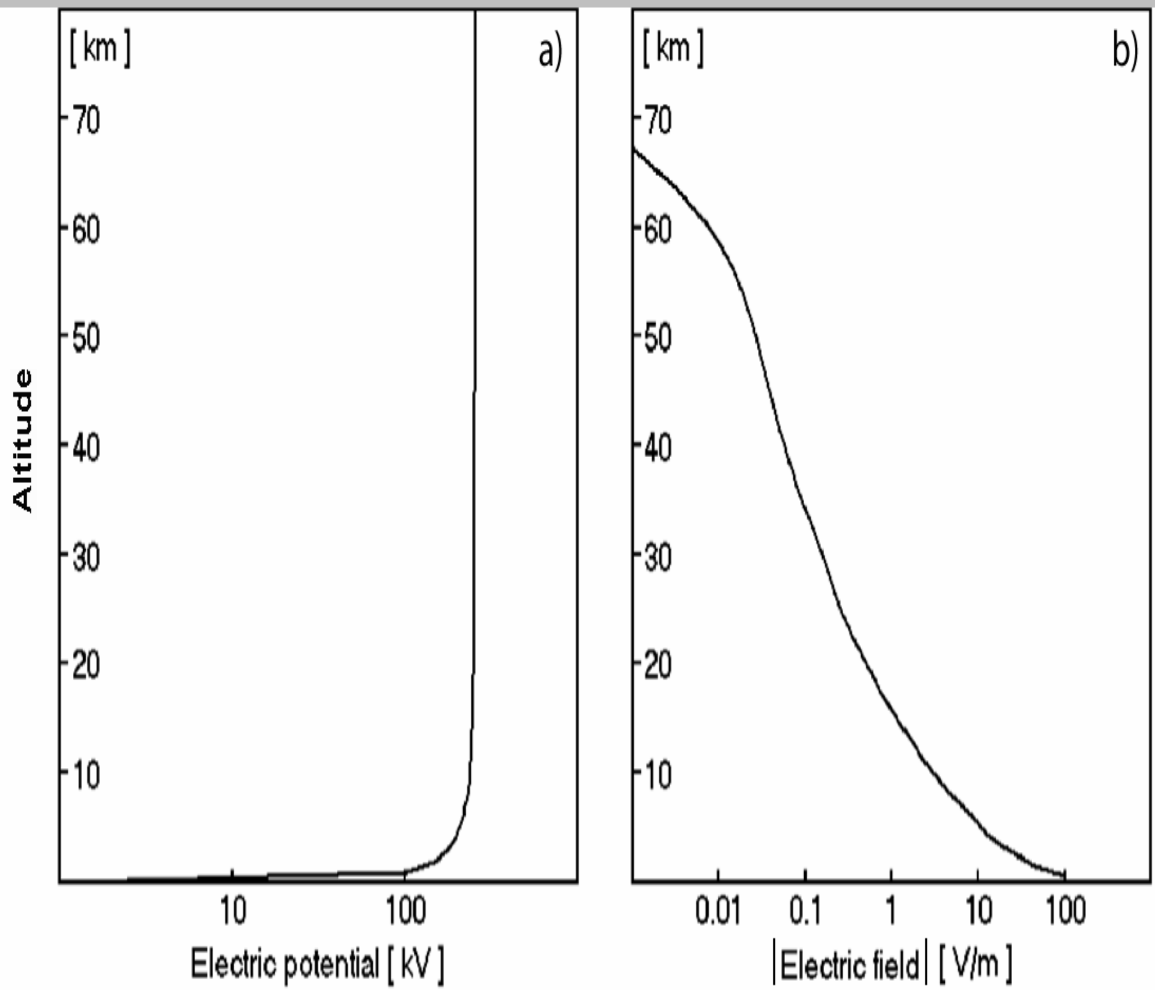
(Courtesy Marek Gołkowski)

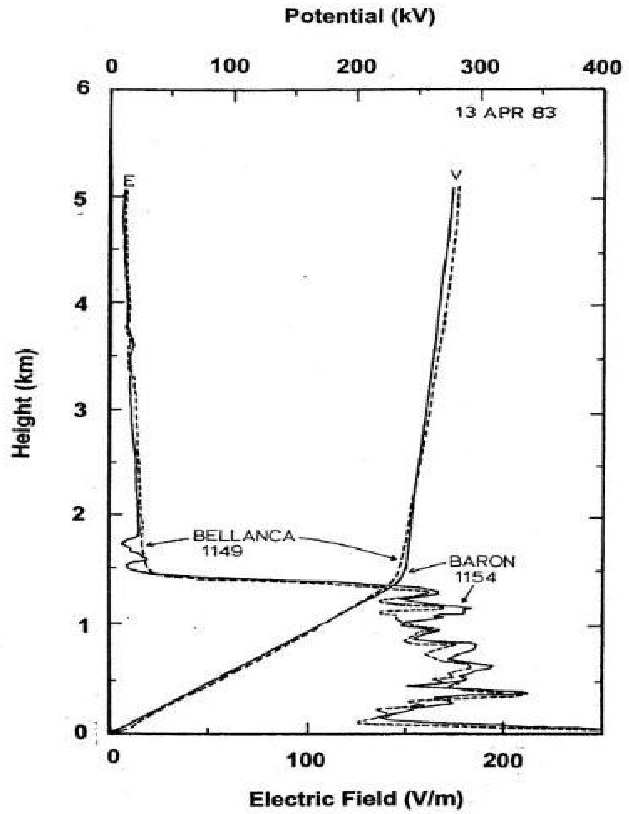
10^{-4} s

4 s

5-40 min

Atmospheric electric parameters, fair weather
Model results of Rycroft et al., JASTP, **62**, 2485, 2007

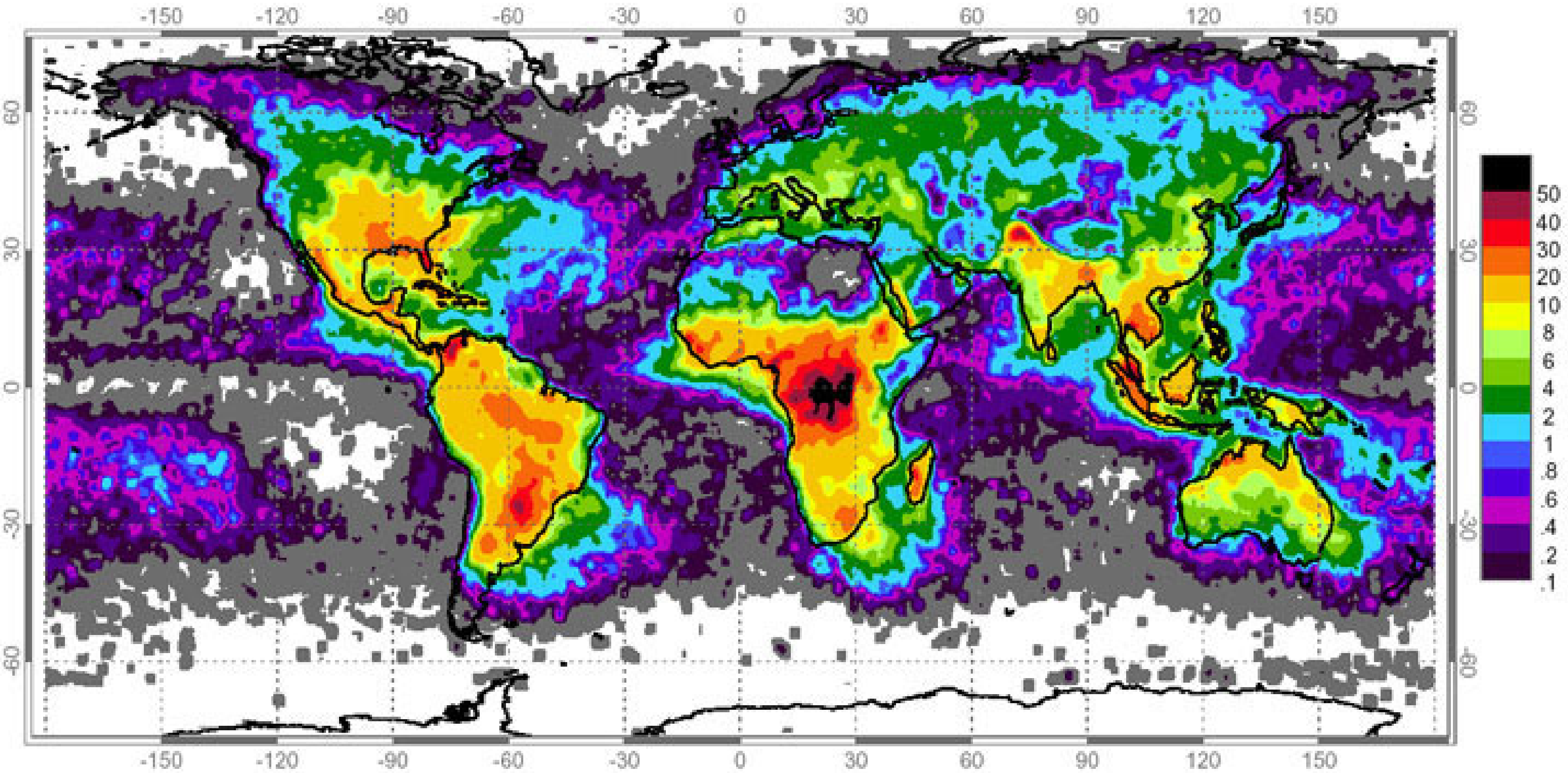




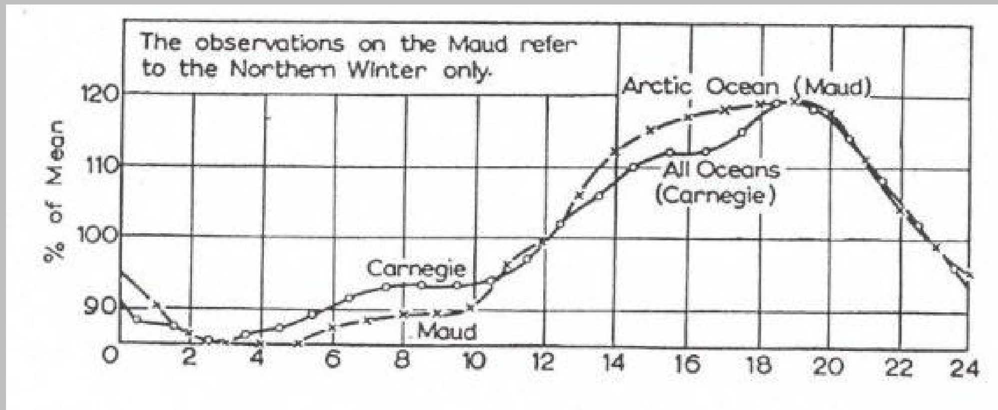
(Courtesy Earl Williams)

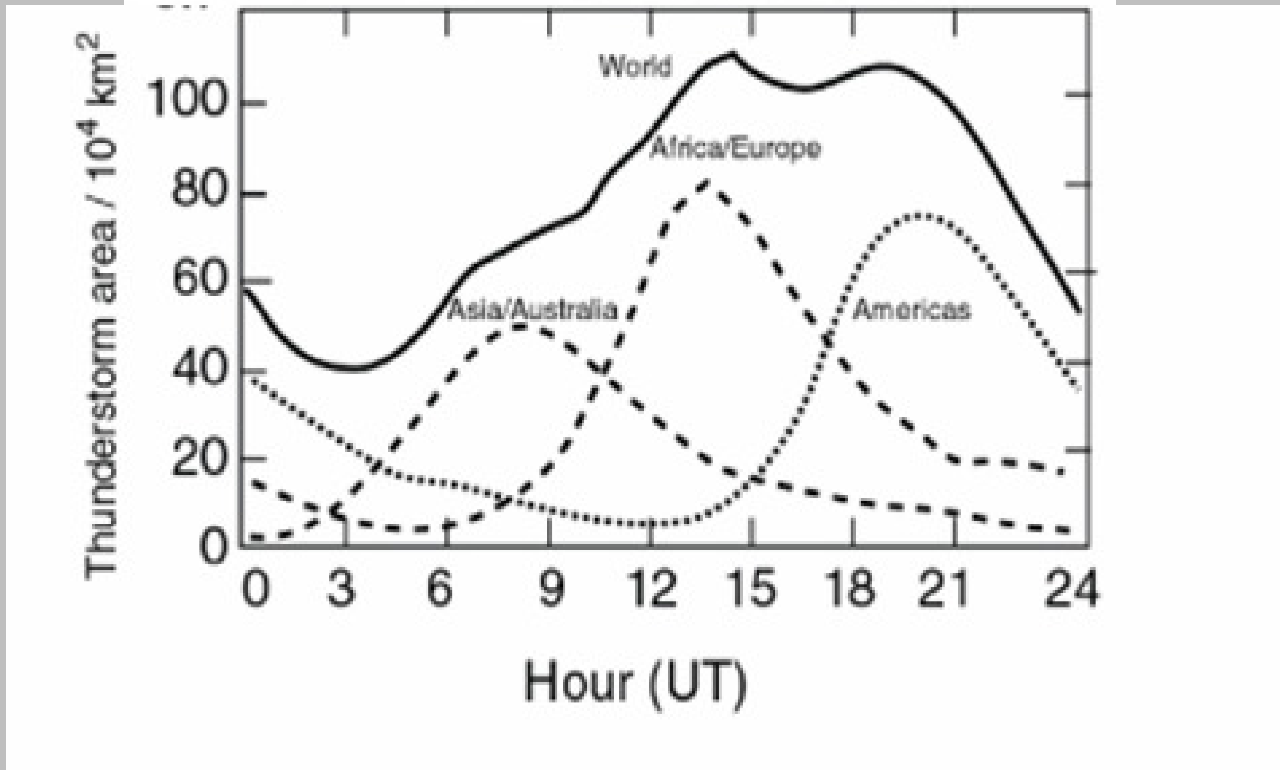
Fig. 2 Two almost simultaneous electric field soundings (E) from aircraft 100 km apart over the ocean off Virginia illustrating the electrode layer close to the ocean, the inversion at 1.4 km and the low-noise exponential region above the inversion. The integrated potential (V) variation with height is shown. The close match of the two profiles indicates the reliability of the measuring procedure.

Global distribution of the number of lightning flashes per square km per year, measured from space (NASA): thunderstorms, an important generator in the global circuit

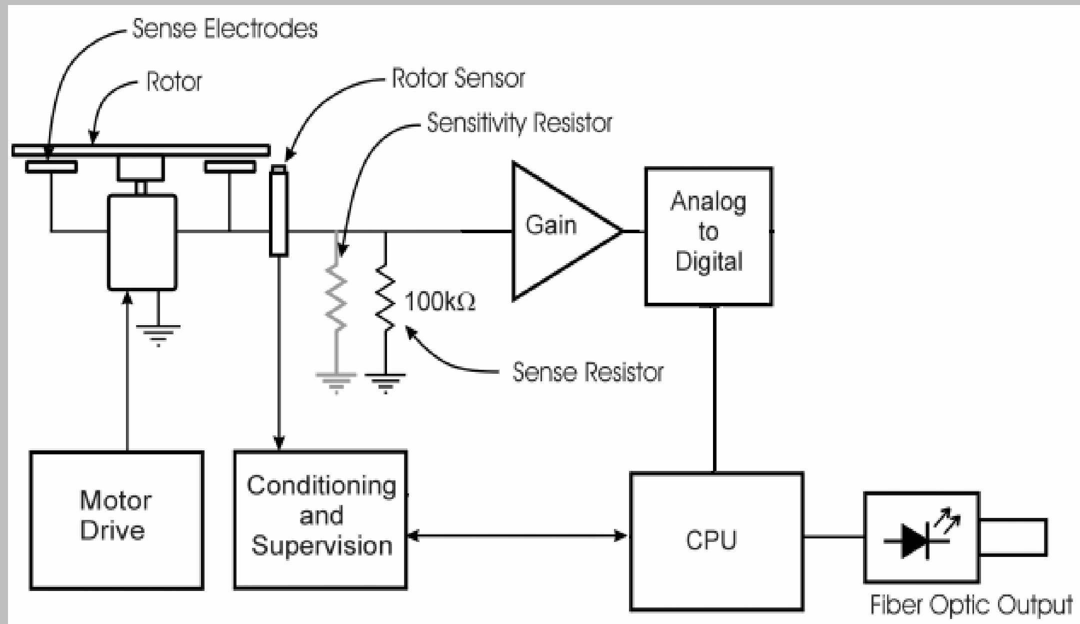


The Carnegie Curve





EFM Measurements



EFM Installation at PLO

IMAGEN 6

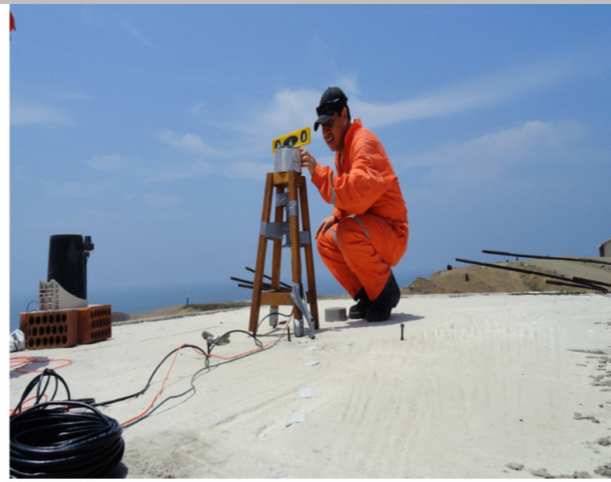


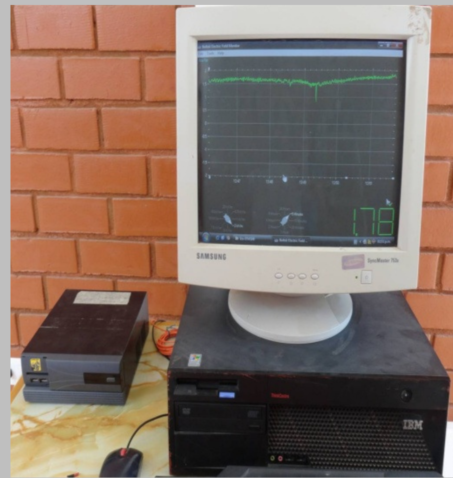
IMAGEN 3

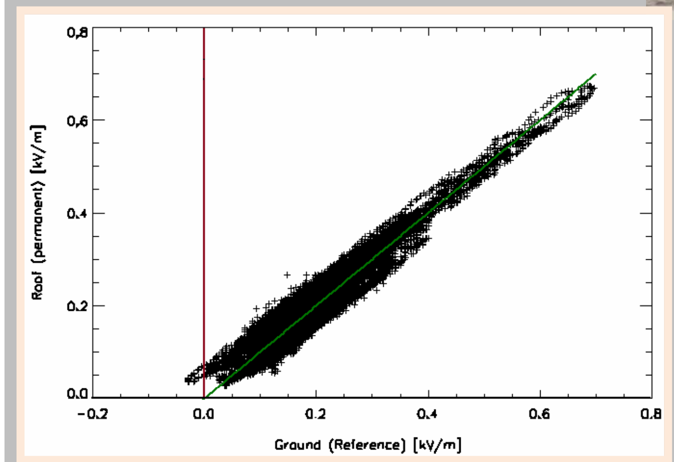
EFM Installation at ICA

Fair weather measurements

Final location

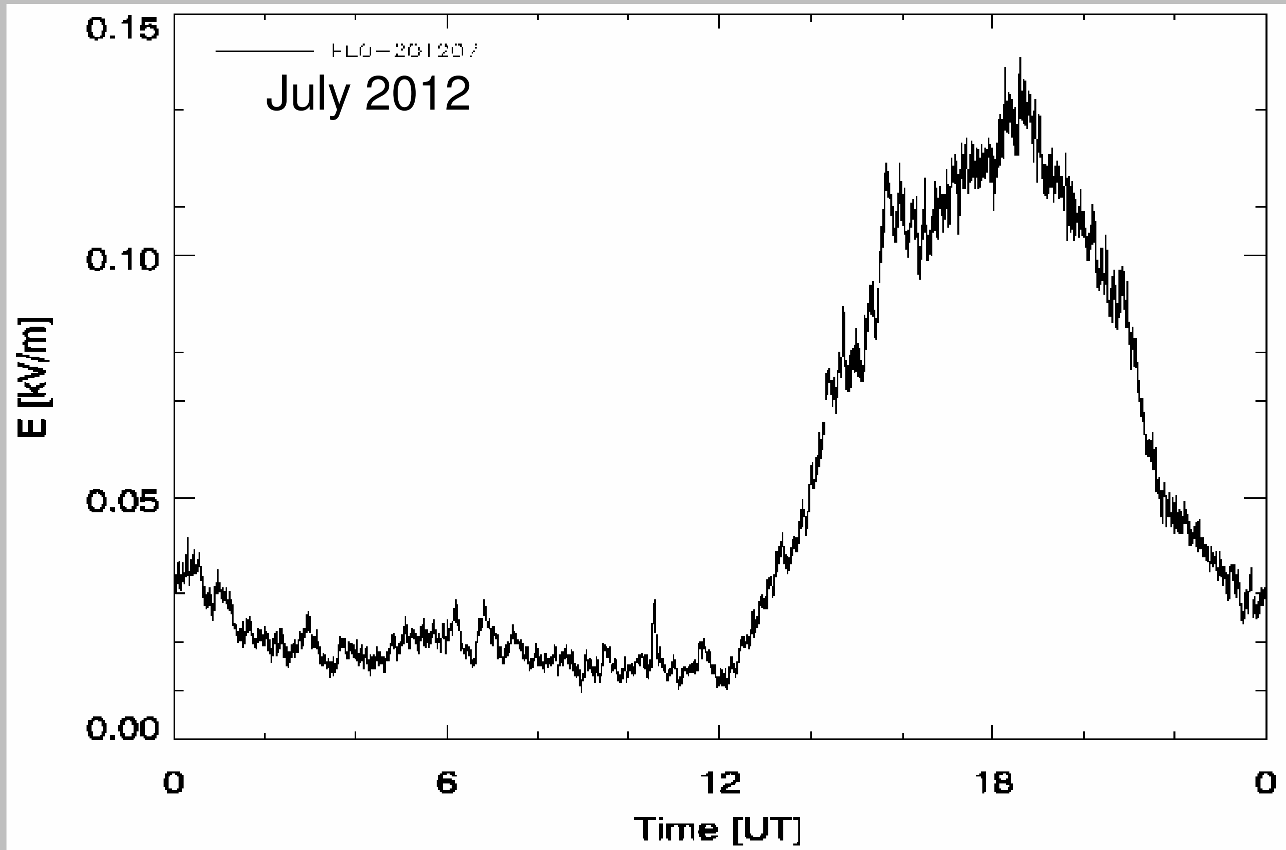
EF signal acquisition





Calibration procedure

EFM Measurements at PLO



Good local conditions to observe the fair weather atmospheric electric field
→ 80-90% usable days within a single month of observation

EFM Network

-PLO and ICA (2011) - CONIDA

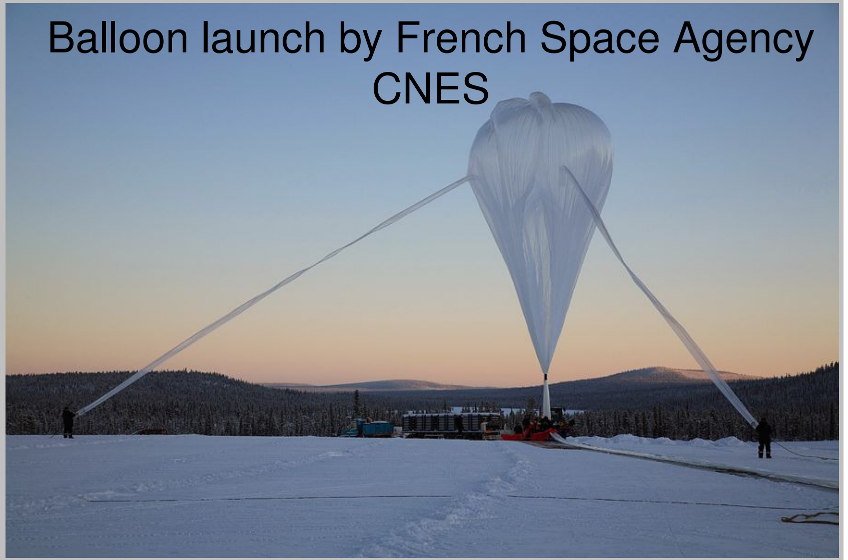
- Lima and Ancon (10/2012) - IGP

- Argentina/CASLEO (since 06/2008)

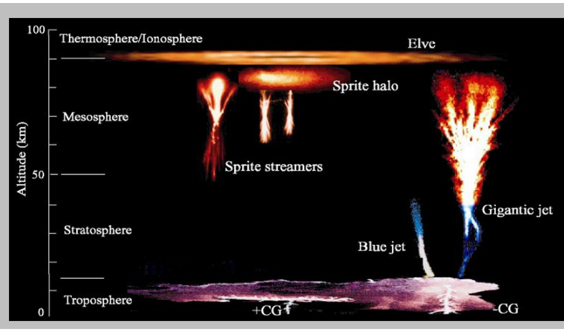
- 4 more EF sensors in 2013

COBRAT PROJECT
(PI: J.-B. Renard, CNRS-LPC2E, France)
1st Phase approved (06/2012)

- “Long and short duration balloon flights for the study of high energy phenomena and their consequence for stratospheric chemistry”.
- Consortium of 34 scientists from 9 countries. ACATMOS and LEONA for Brazilian participation.
- Brazilian experiments: Lightning and TLE imaging, Electric Field Measurements, on-board High-Energy (Solar and Cosmic) particles, Ground-based support.
- Instruments for TGF and TLE detection, imaging, electric and magnetic field measurements, NOx and aerosols concentration measurements.
- Ground-based support by imaging and radio systems
- TARANIS and the ISS European instrument ASIM (TLE, TGF): 2016



TLEs and High-Enery particles: up to Date



***ACATMOS* Team**

The *Atmospheric Electrodynamical Coupling – ACATMOS* team

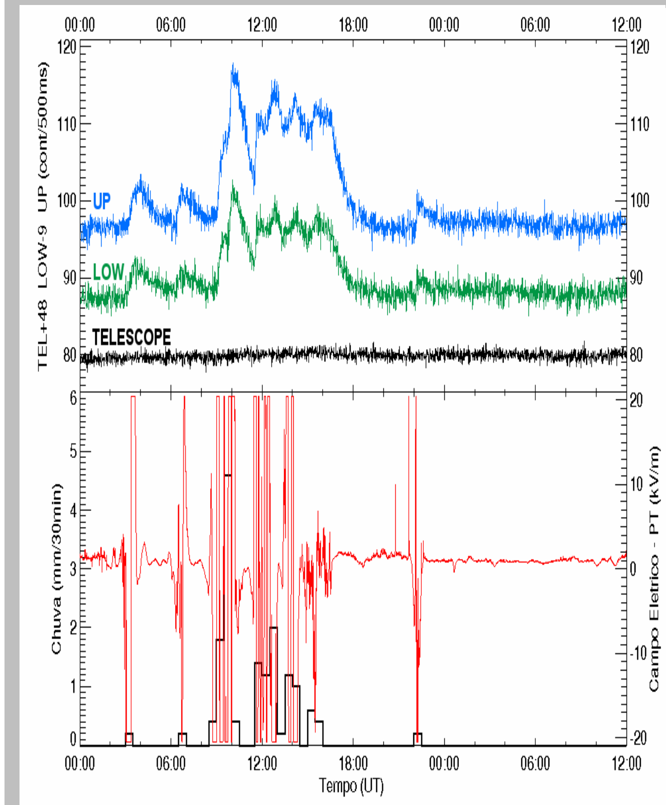
- Brazil:
- National Institute for Space Research – INPE
- Instituto Tecnológico SIMEPAR
- Center for Radioastronomy and Astrophysics Mackenzie – CRAAM
- Lebedev Physical Institute – LPI/Russia via CRAAM collaboration
- Federal University of Mato Grosso do Sul – UFMS
- University of São Paulo – USP

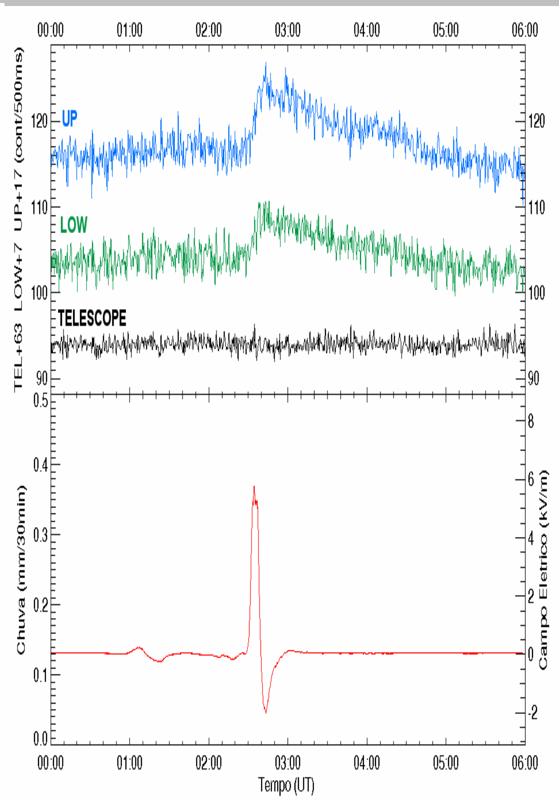
-Argentina:
- Observatorio Astronómico, Universidad Nacional de Córdoba – UNC
- Consejo de Investigaciones Científicas y Técnicas – CONICET

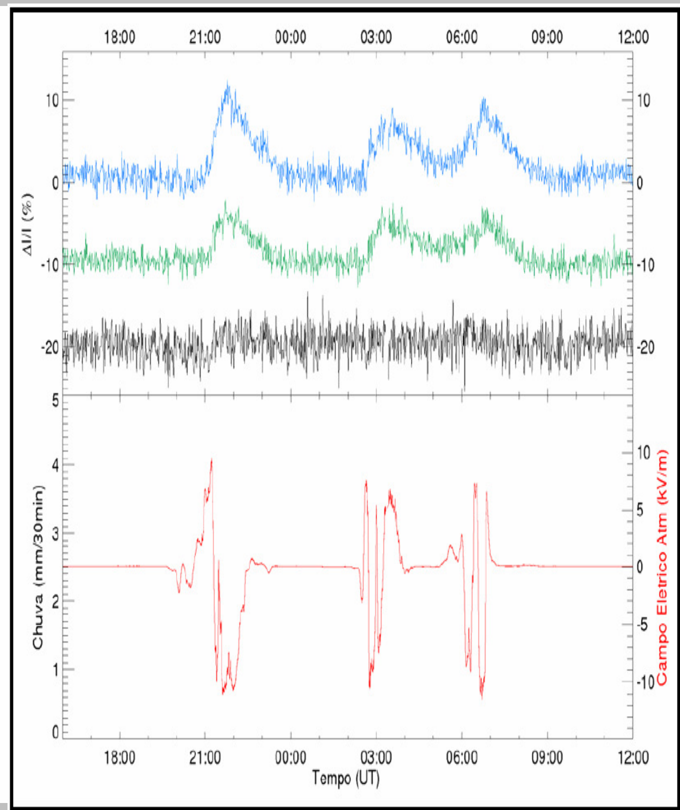
-Peru:
- Jicamarca Radio Observatory – JRO, CONIDA

Short-term modulation of 2nd CR - Atmospheric Phenomena

Flux of secondaries CR is corrected for atmopsheric pressure and temperature



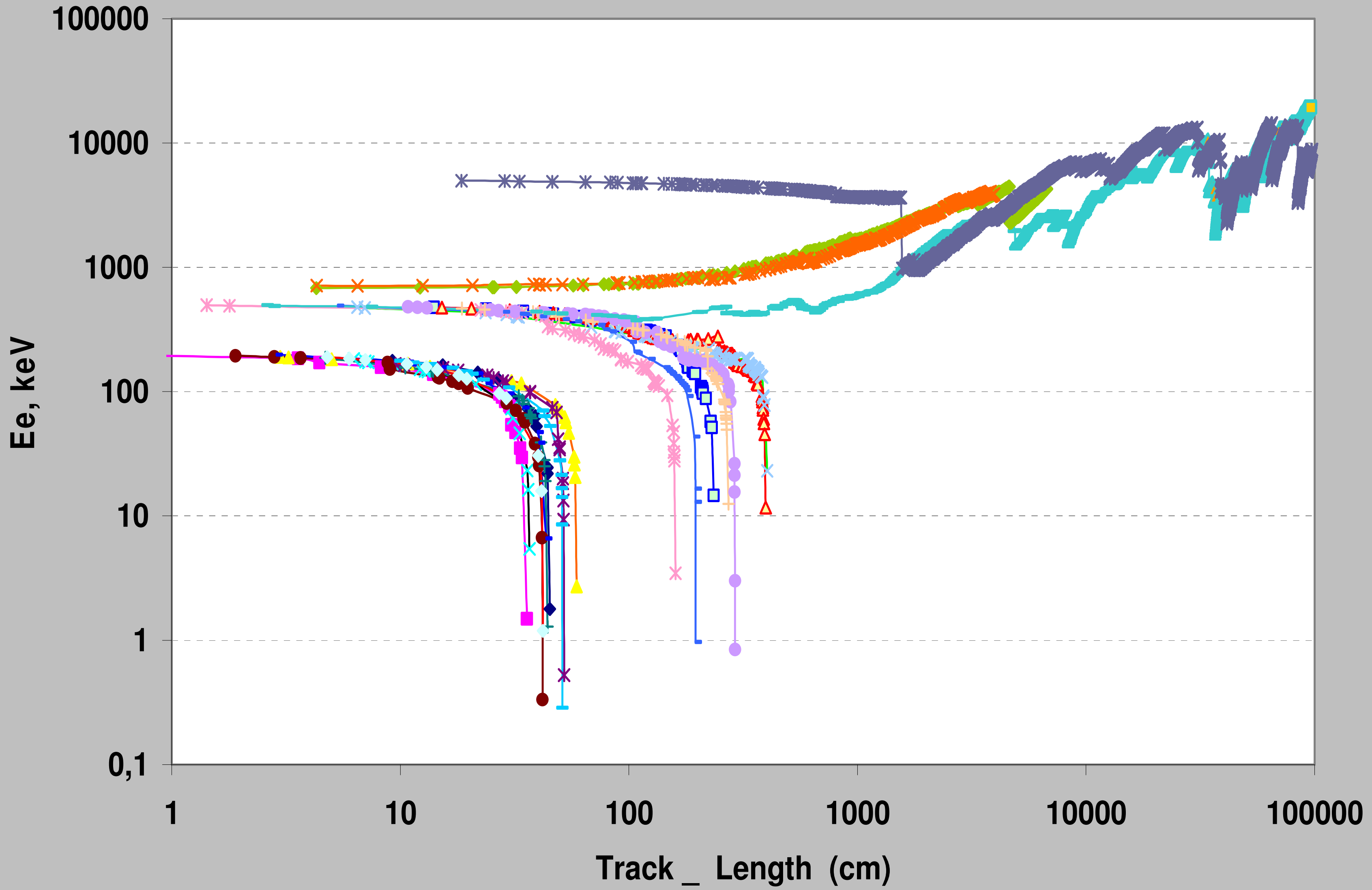




RC increase events (LOW, UP) can be observed in association with rain precipitation.

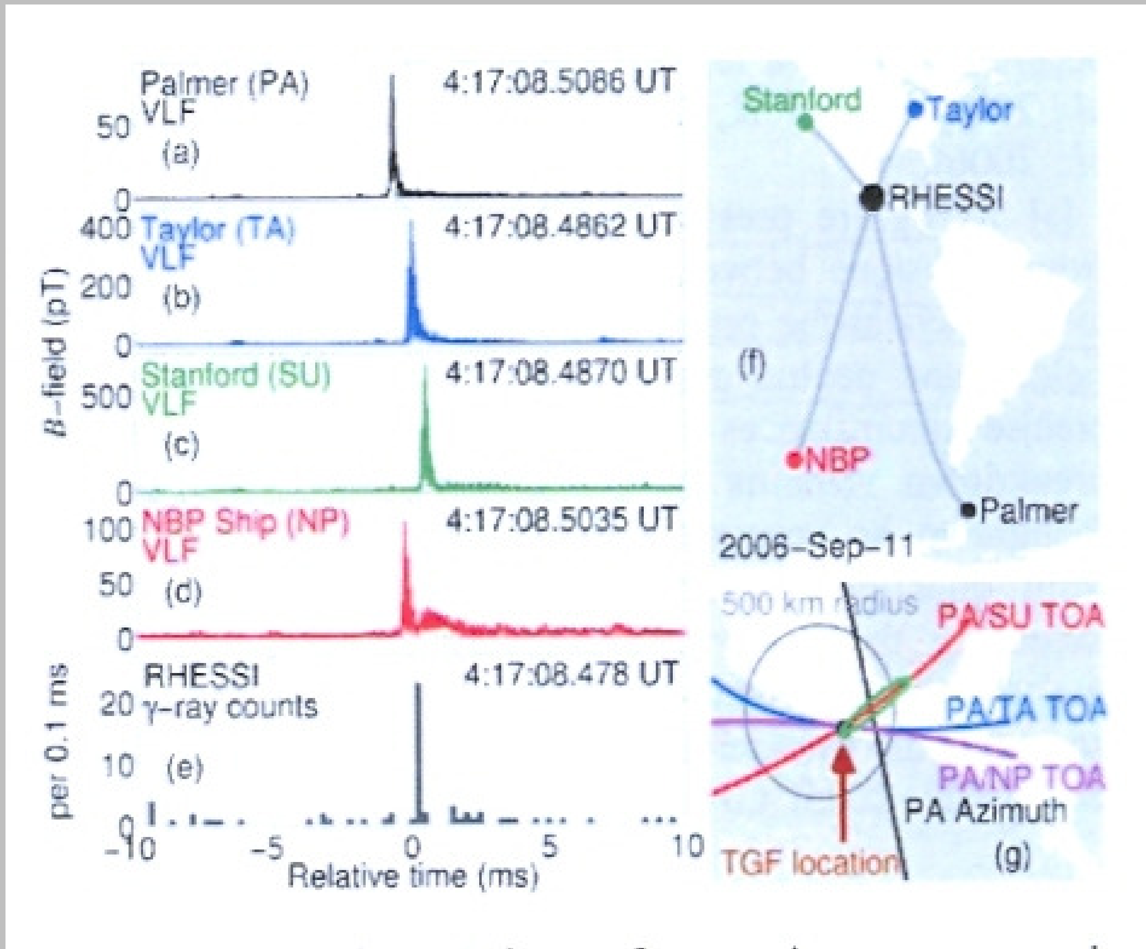
All RC increase events (LOW, UP and TEL) are associated with atmospheric electric field variations.

GEANT4 simulation E=0.4 kV/cm (40 kV/m)

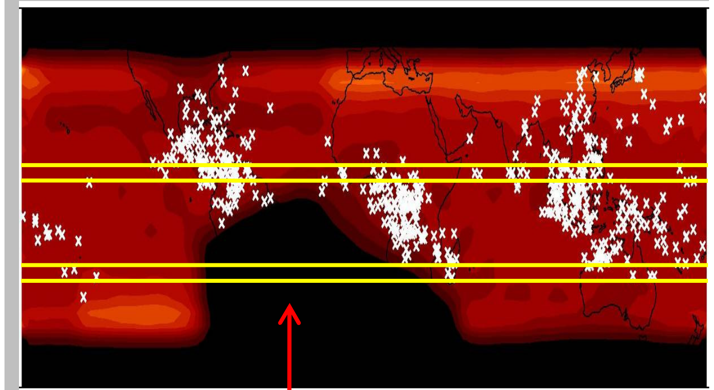


TERRESTRIAL GAMMA-RAY FLASHES - TGF

Combining with VLF instrumentation



So far ~ 1000 TGFs were detected
1 ms or less
Photons up to 20 MeV
Electrons up 30 MeV
Spectra → OTB
Np ~ 10^{16}
Ne ~10^{17}
Altitude ~ 15 – 20 km



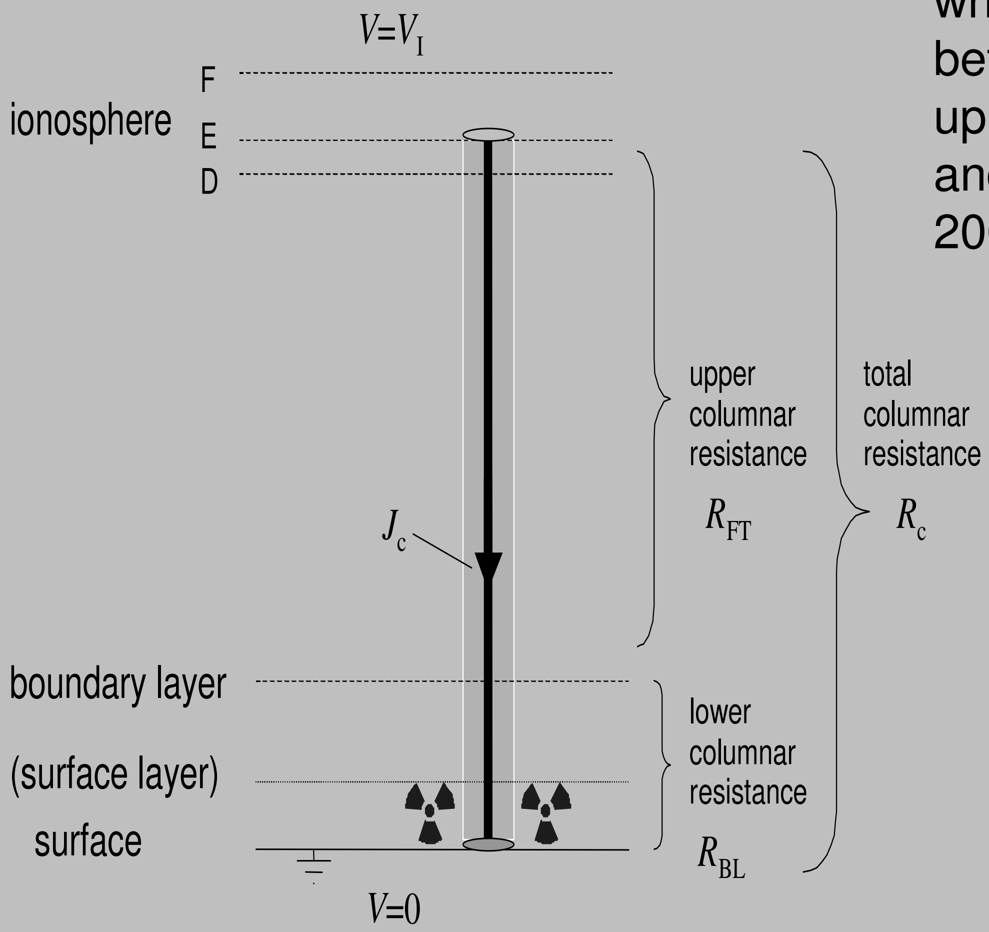
RHESSI - TGFs

No observation because of SAMA

Cohen, M.B., et al. 2010

TGF are associated with lightning activity

Global circuit changes before land earthquake
Concept of Harrison, Aplin, Rycroft, JASTP, **72**, 376, 2010



Radon emissions from the ground, which cause air ionisation, increased before the 1995 Kobe earthquake, by up to an order of magnitude (Yasuoka and Shinogi, 1997; Yasuoka et al., 2006).

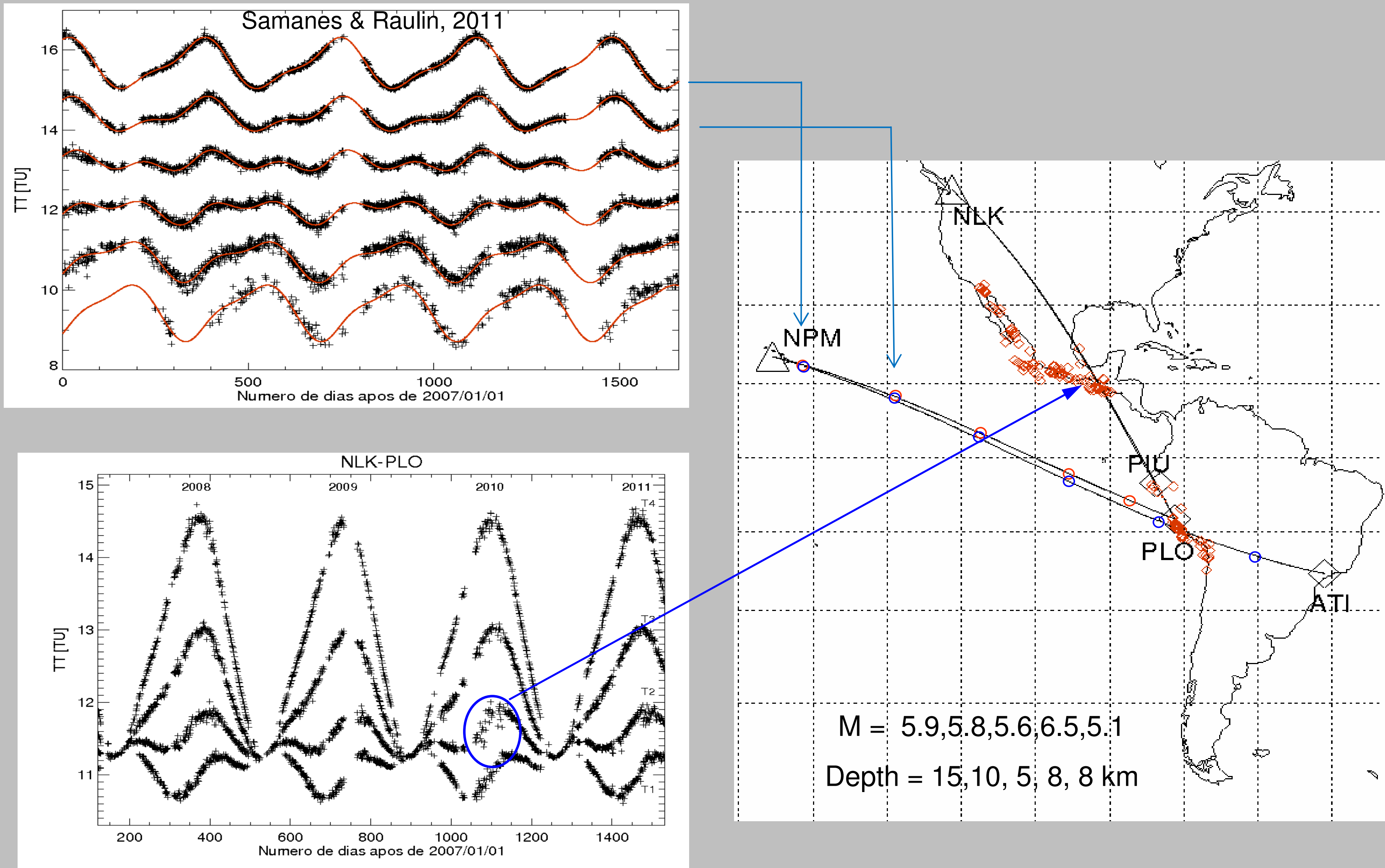
↓

Increase of surface layer conductivity – Measurable electrical properties of surface layer ?

↓

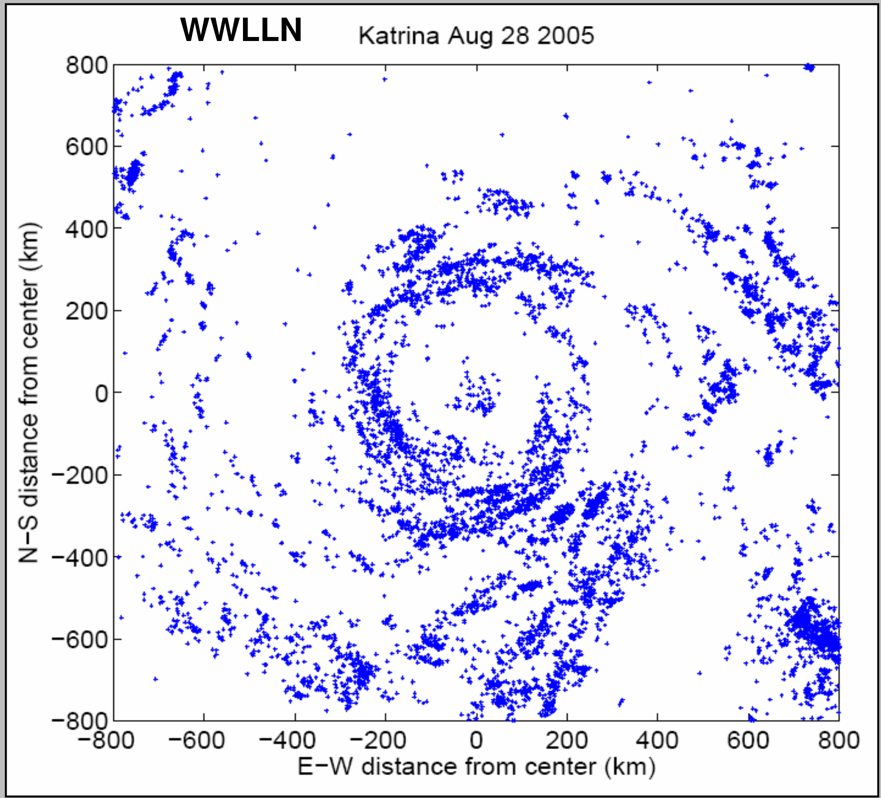
DEMETER – Changes of low frequency cutoff of the EIW

Seismic – EM effects



Other Natural Phenomena with Large Societal Impact

Natural disasters: seismic EM effects (volcano, hurricanes, floods etc …)



(Craig Rodger presentation)

Other Natural Phenomena with Large Societal Impact

Natural disasters: seismic EM effects (volcano, hurricanes, floods etc …)

From: Price et al.,
Nature Geoscience
2, 329 - 332 (2009).

(Craig presentation)

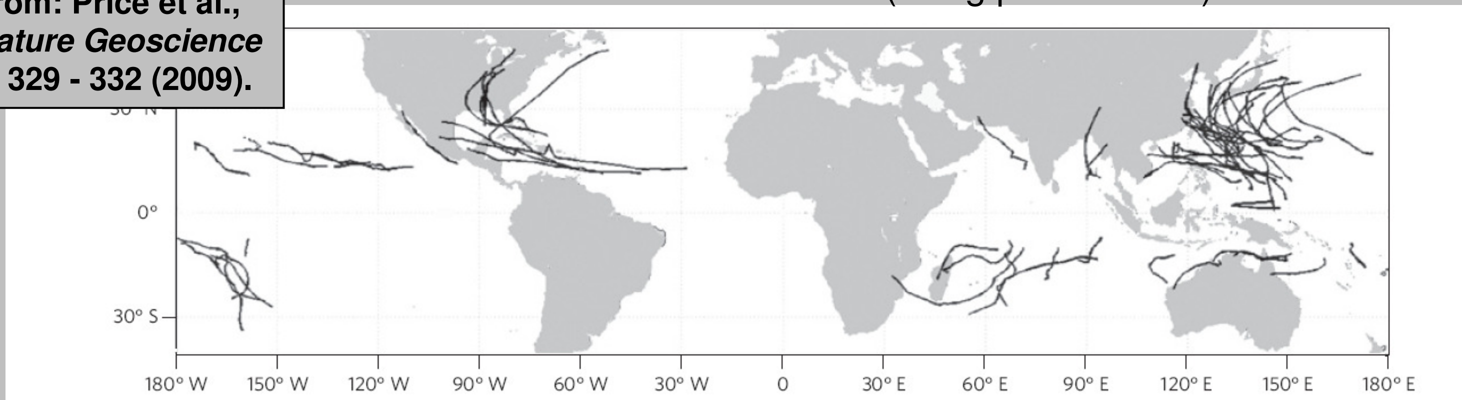


Figure 1 | Global distribution and paths of the 58 hurricanes used in this study. The category-4 and category-5 hurricanes included in this study are: 2005—Adeline, Bertie, Dennis, Emily, Haitang, Ingrid, Katrina, Kenneth, Khanun, Kirogi, Longwang, Mawar, Meena, Nabi, Nancy, Nesat, Olaf, Percy, Rita, Sonca, Talim, Wilma; 2006—Bondo, Carina, Chanchu, Chebi, Cimaron, Daniel, Durian, Ewiniar, Floyd, Glenda, Ioke, John, Larry, Mala, Monica, Saomai, Shanshan, Xangsane, Xavier, Yagi; 2007—Dean, Dora, Favio, Felix, Flossie, Gonu, Indlala, Kajiki, Krosa, Man-yi, Nari, Sepat, Sidr, Usagi, Wipha and Yutu.

Looking at 58 intense hurricanes, cyclones and typhoons, they showed that WWLLN lightning data provided **about 30 hours of prediction time as to the future intensity of the storm system**.

Satellite systems provide a great ability to track and *predict* the storms path, but now we have a possible new route for predicting the changing intensity of these intense storms!

SUMMARY

• Atmospheric Electric Field sensors have been successfully installed in Peru (PLO, ICA, Lima). Local observational conditions are spectacular, and the use of Fair Weather Data can be optimize.

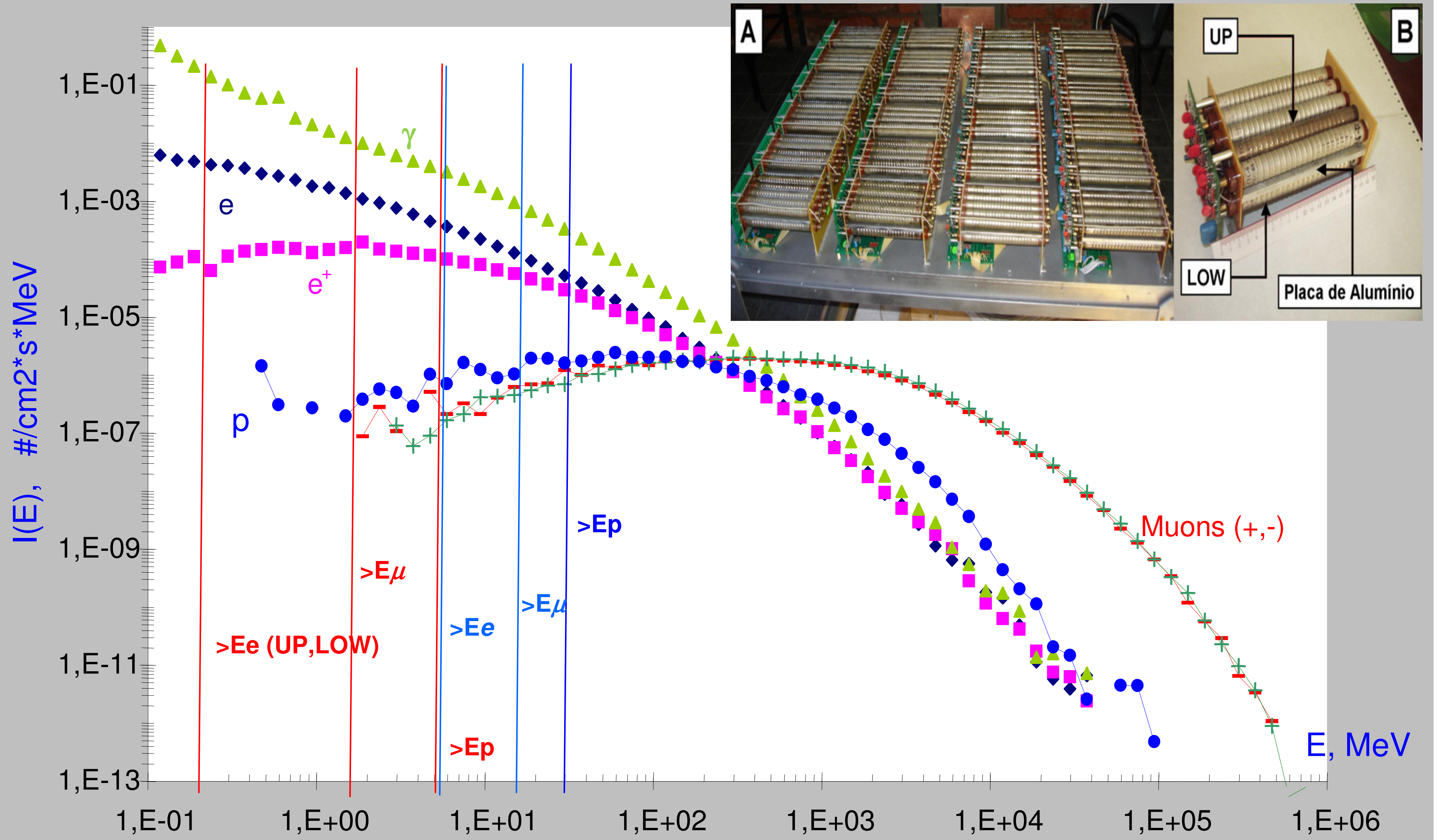
• Atmospheric Electric Field database, combined with VLF data, will allow to study seasonal and local variability, related to SW or other natural phenomena.

• As in the case of SAVNET deployment and operation, capacity building as the participation and formation of local technicians and students is an important aspect of this new initiative.

• A platform as ISWI supported by UN is very important to continue and improve what has been achieved so far. Such interaction is very relevant for local researchers to look for local funding.

Differential Energy spectra of CR secondaries p, e^-, e^+, μ^+, μ^- and γ at atmospheric depth X=800 g·cm^{-2}

UP, LOW : e> 0,2 MeV, p> 5 MeV, γ>0,02 MeV, μ>1,5 MeV TEL: e> 5 Mev, p > 30 MeV, μ> 15.5 MeV



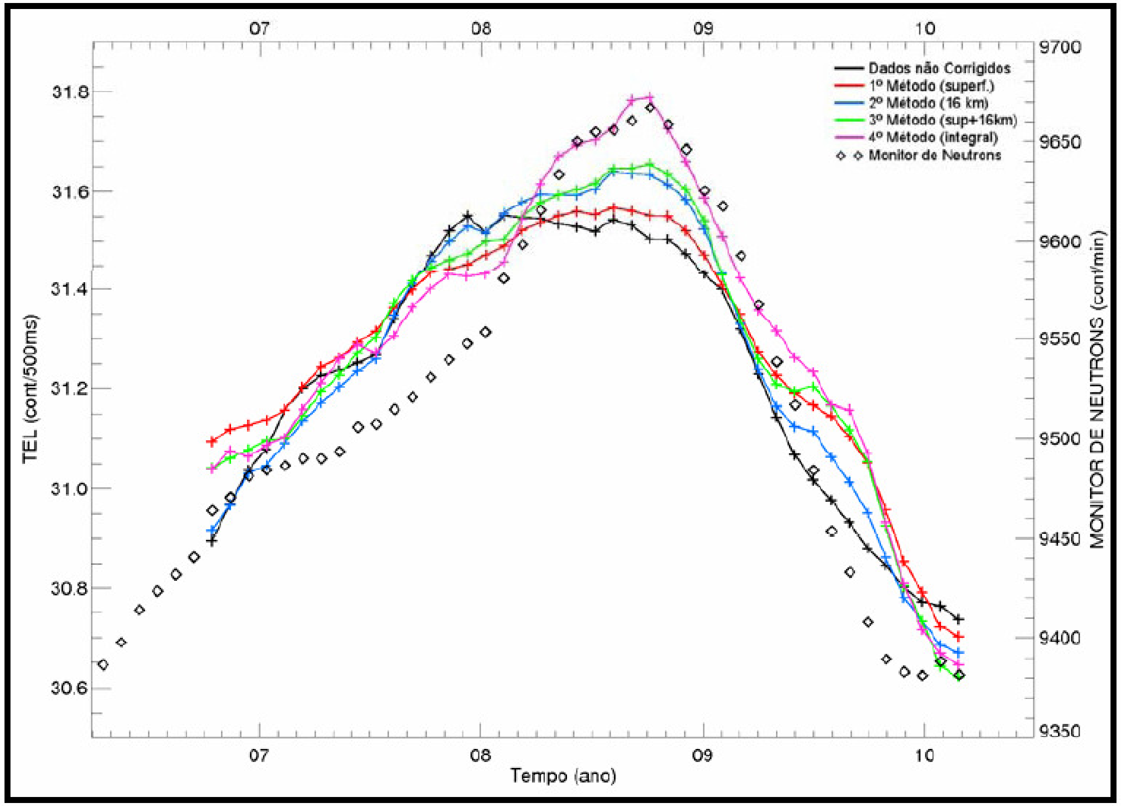


Figura 3.12 – Média corrida de 13 meses das médias mensais da contagem de raios cósmicos sem correção por temperatura (preto), corrigida pela temperatura na superfície (vermelho), pela temperatura na altura de maior produção de partículas secundárias (azul), pela temperatura na superfície e na de maior produção de partículas (verde), e pela integral das temperaturas observadas ao longo da atmosfera (rosa). Os pontos com forma de losangulo representam a média corrida das médias mensais da contagem de raios cósmicos registrada pelo monitor de nêutrons de Moscou. Os dados exibidos entre Abril de 2006 e Julho de 2010.

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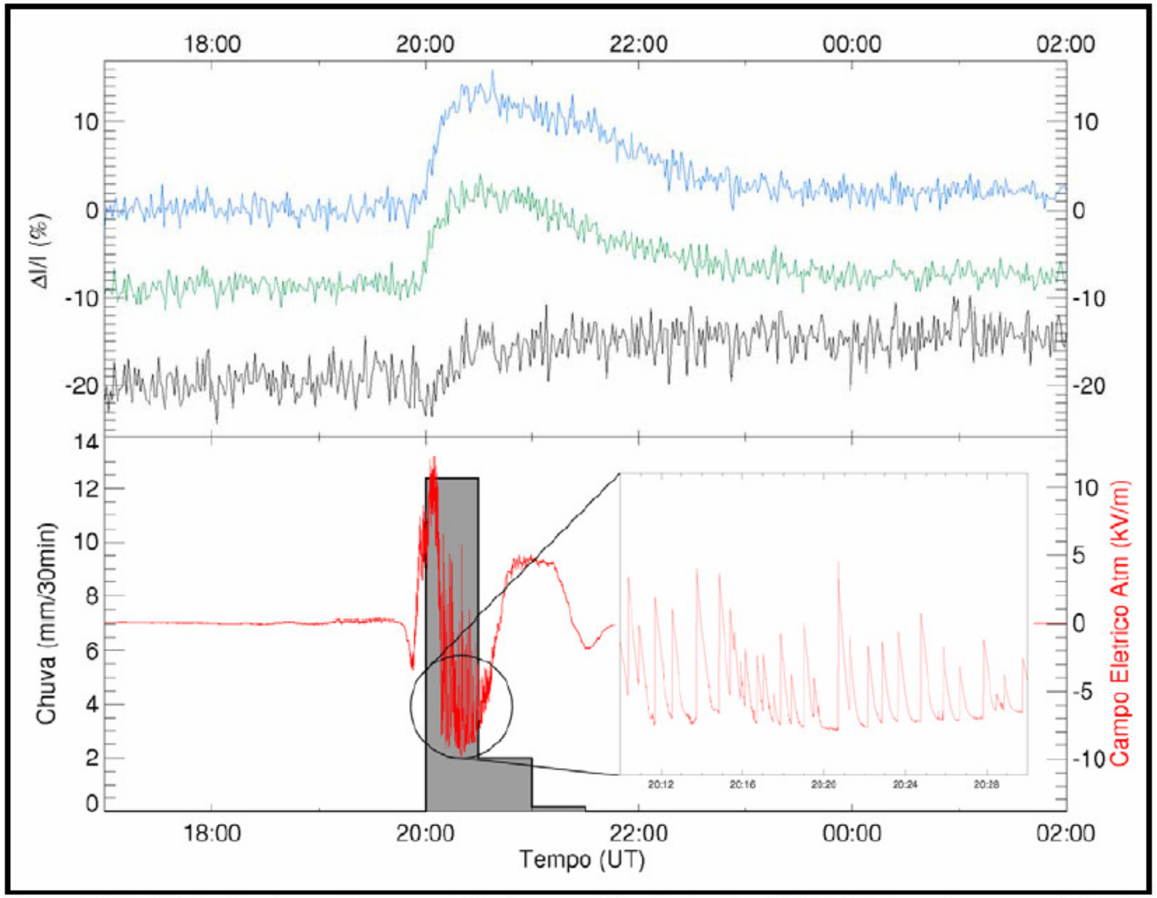

Figura 4.25 – Variação da contagem registrada nos três sinais do CARPET durante um período de ocorrência de chuva (histograma cinza) e de rápidas e intensas variações no campo elétrico atmosférico (curva em vermelho). Dados mostrados entre os dias 10/03/2010 às 17 UT e 24/01/2010 às 02 UT.