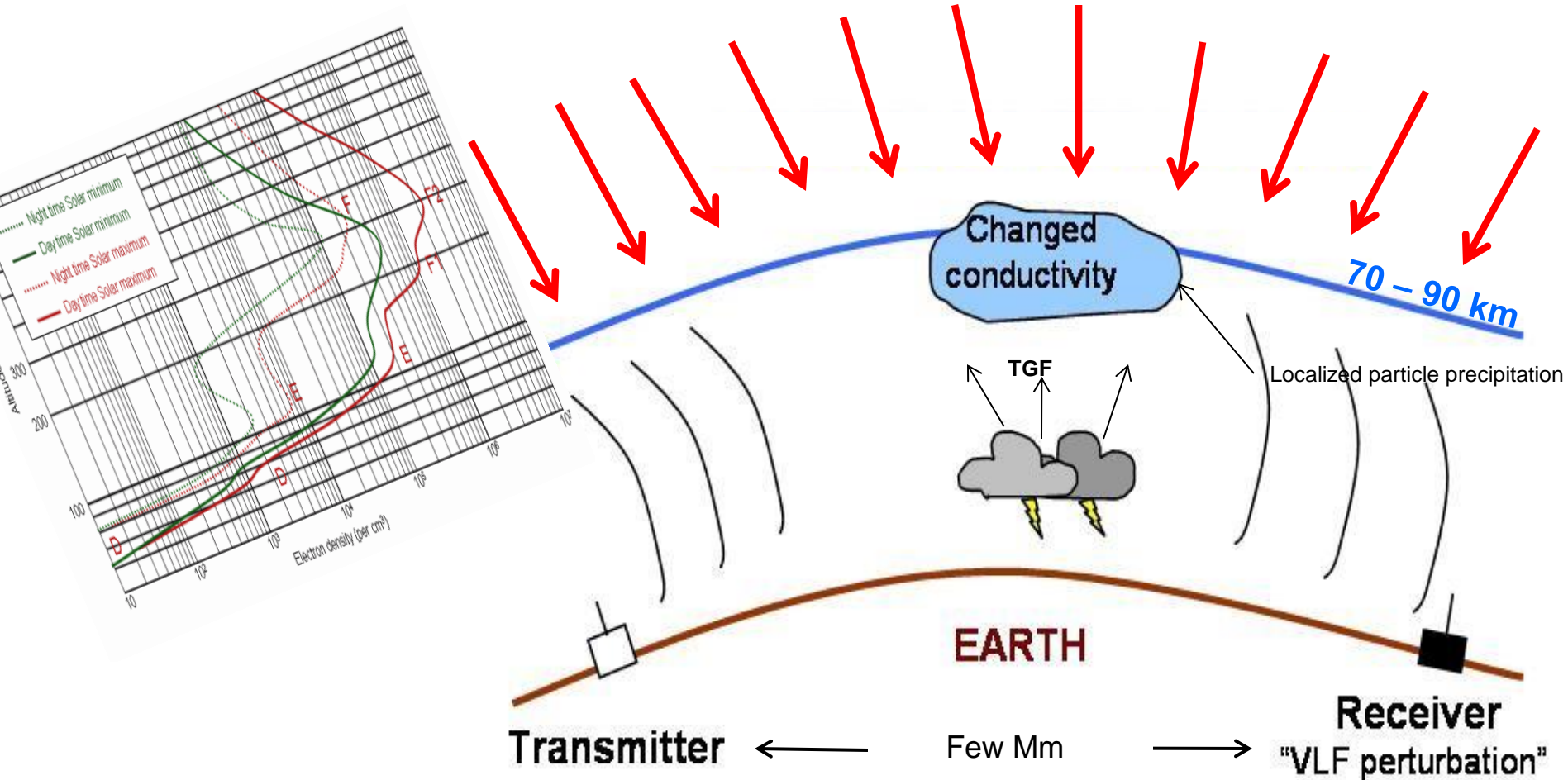


VLF remote sensing technique

Photons and/or energetic particles → ionization excesses → changes of the electrical conductivity

→ VLF propagation anomalies → VLF phase and amplitude changes

Solar: quiescent, Ly- α , X-rays (flares), particles (SEPs); **Non-Solar:** X-rays, GRB, flares from SGR



- ULTRA-MSK + (as of mid-2016) thesavnet724.wordpress.com/
- Modelling ionospheric response to SGR, and energetic protons (future)
 - GEANT 4 + LWPC (PD: Sourav Palit)
- daytime ionospheric sensitivity versus solar activity cycle (see Macotela et al.)
 - F_{\min} (> 6 keV) compared to solar Lyman- α photon flux
- D-region absorption model – D-RAP (Claudio Machado)
 - improvement
- The South Atlantic Anomaly – SAA (Antonio Magalhães, Liliana Macotela)
 - First evidence of the effects of SAA on the quiescent reference height
- Seismic – EM effects prior to Earthquakes



SAVNET



International Heliophysical Year
Ano Heliológico Internacional

Latin American School
IHY

Universidade Presbiteriana Mackenzie
Escola de Engenharia
Centro de Rádio-Astronomia e Astrofísica Mackenzie
São Paulo, SP, Brazil
February 14-20, 2008

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Agência Espacial do Pará
Atividade de Astronomia
1902-0204
Direção de Cooperação

CURSO-TALLER
Conexión Sol-Tierra
Del 17 al 22 de Abril del 2006

Dr. Jean Pierre Raulin
Investigador del Observatorio de Toulouse-Blagnac
Formador del Observatorio de São Paulo, Brasil
Cooperador del Observatorio de São Paulo, Brasil

Dirigido a estudiantes universitarios de Ciencias (pre y post grado), investigadores y público en general con conocimientos de física.

CONTENIDO

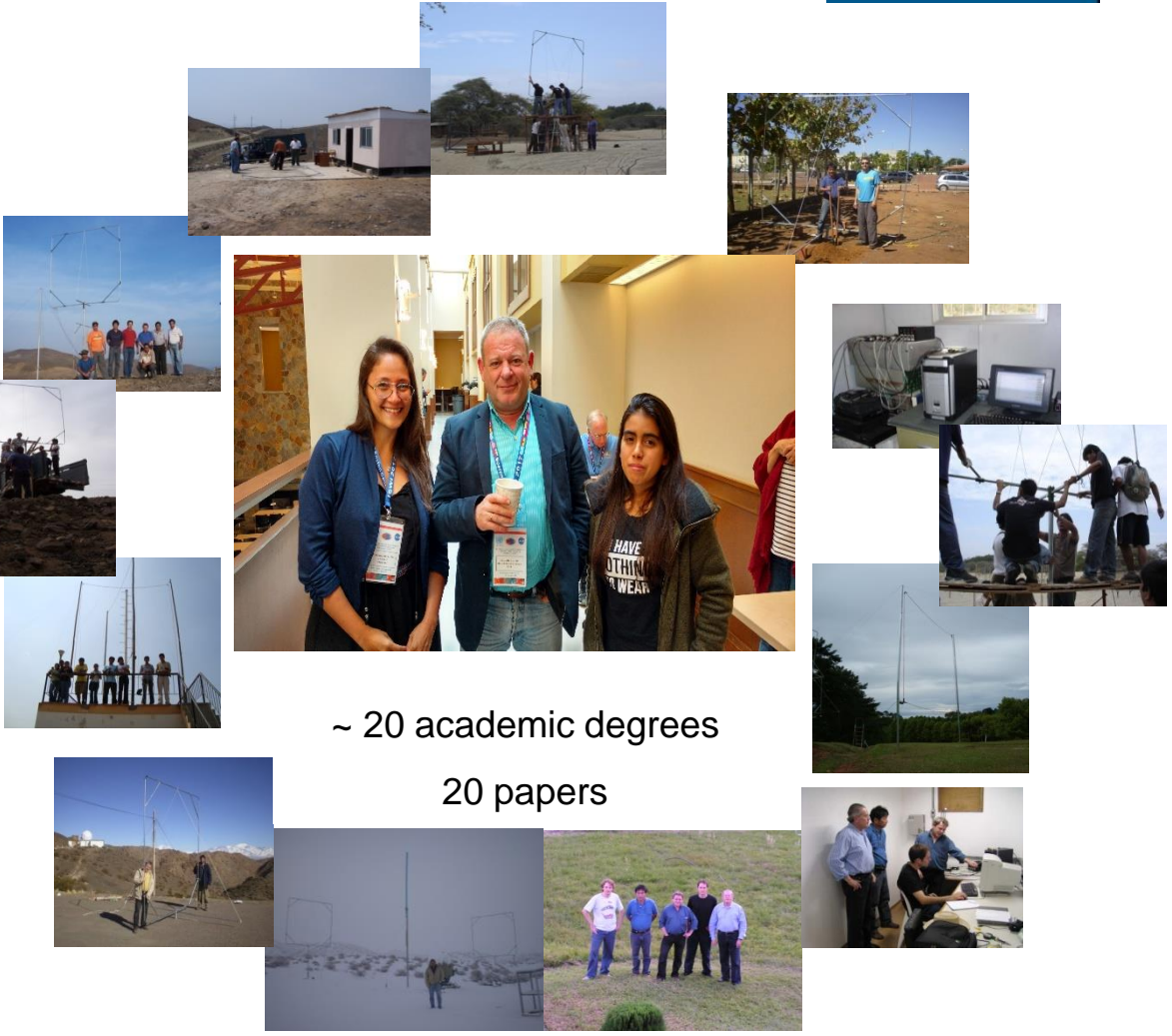
- El Sol y su ciclo de actividad
- La conexión Sol-Tierra
- Impactos de la dinámica del Clima Espacial sobre la Atmósfera Terrestre y Sistemas Tecnológicos
- La ionosfera terrestre como un enorme sensor de señales solares

HORARIO: Lunes a Viernes de 3 a 6 p.m.
Sábado de 8 a 11 a.m.

LOCAL : Lunes, Martes, Miércoles - Auditorio Fac. Física U.N.M.S.M. Av. Venezuela Cdra. St. Ciudad Universitaria Jueves, Viernes y Sábado - Auditorio CONIDA Jr. Luis Felipe Villarín 1009, San Isidro

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Red de VLF de América del Sur (SAVNET): estudios de la actividad solar, geofísica y astronómica para aplicaciones científicas y tecnológicas

Jean-Pierre Raulin
CRAAM-EE-Mackenzie

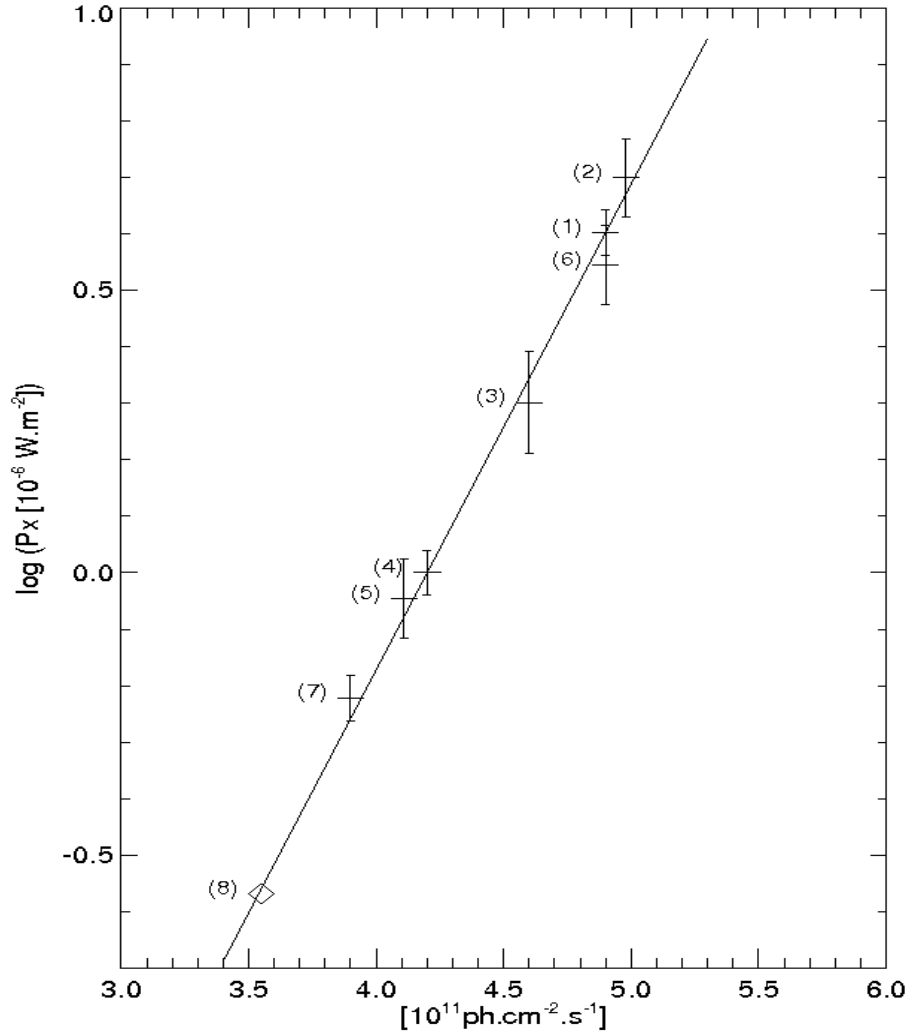
LIMA, ICA, April, 2009

~ 20 academic degrees
20 papers

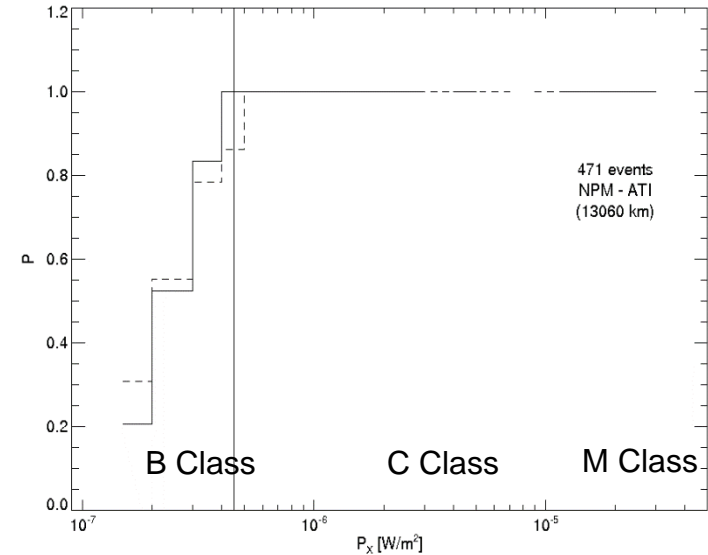
Capacity building
Formation of human resources



TRANSIENT SOLAR FORCING: FLARES



B 4 (and higher) Class events are detected with 100 % probability



The minimum detectable soft X-ray flux is correlated with the averaged Lyman- α flux : the higher the solar activity the higher P_x



Lyman- α solar radiation maintains the quiet ionospheric D-region (Nicolet & Aikin 1960)



SGR J1550-5418 on 2009, January 22

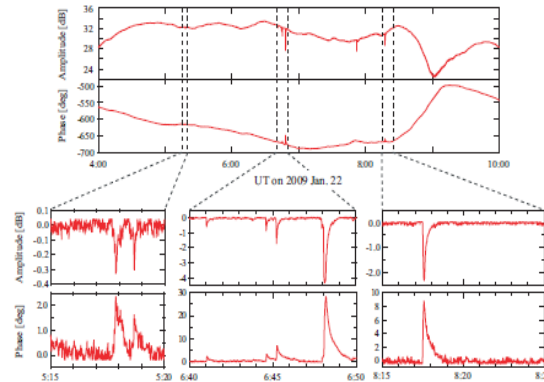
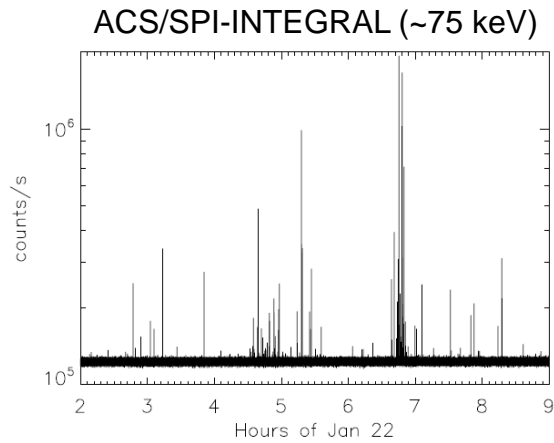


Figure 2. Amplitude and phase variations of a VLF signal from NPM transmitter (21.4 kHz), which were observed at ATI (see Figure 1) from 4:00 UT to 10:00 UT on 2009 January 22. Lower figures are background-subtracted blow-ups at time ranges during which short repeated SGR bursts were detected (see also Table 1).

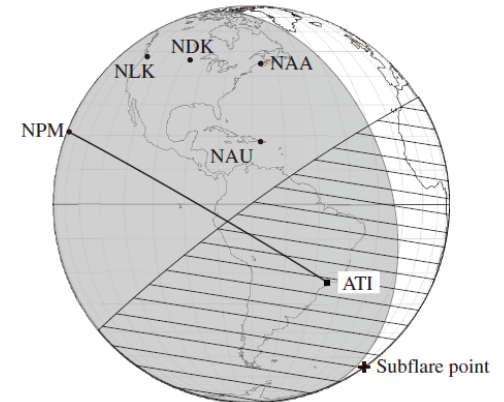


Figure 1. VLF propagation path from NPM transmitter (Hawaii) to ATI observing station (São Paulo, Brazil). Also shown are the locations of other four VLF transmitters (NLK, NDK, NAA, and NAU). Shaded hemisphere indicates the nighttime part of the Earth at 6:48 UT, when the largest burst occurred (see Table 1). The part of the Earth illuminated by gamma rays at 6:48 UT is also drawn by dashed area.

The VLF technique can be used to study remote objects of great astrophysical importance. The fact that the nighttime ionosphere can be disturbed by **intermediate cosmic X-ray bursts**, and not only by **giant ones**, indicates that the **frequency of detection of such events could be improved**. The VLF detection appears as an observational diagnostic that complements their detection in space, in particular when space observations are not available, for example during **Earth's occultation** or above the **South Atlantic Anomaly region**, or suffer from **saturation**. The VLF technique can be used to constrain the **low energy photon spectrum**.

