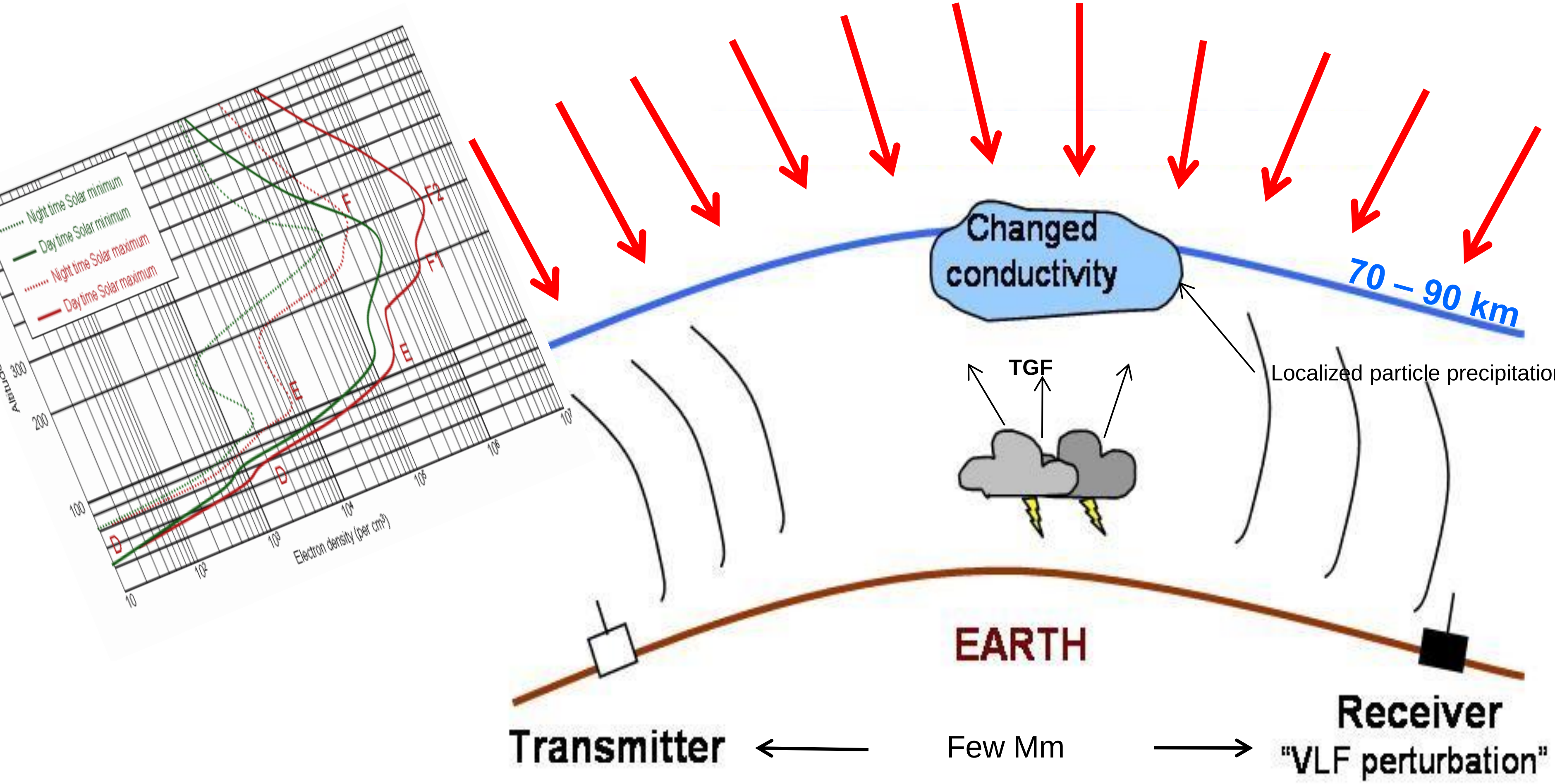
VLF remote sensing technique

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

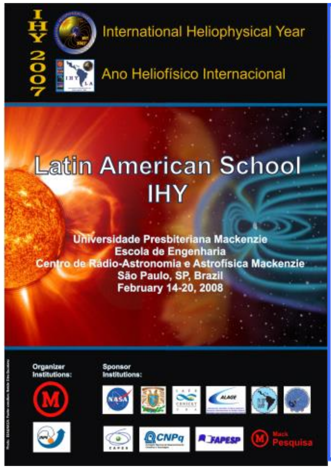
- D-region absorption model – D-RAP (Claudio Machado)

  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









~ 20 academic degrees

20 papers

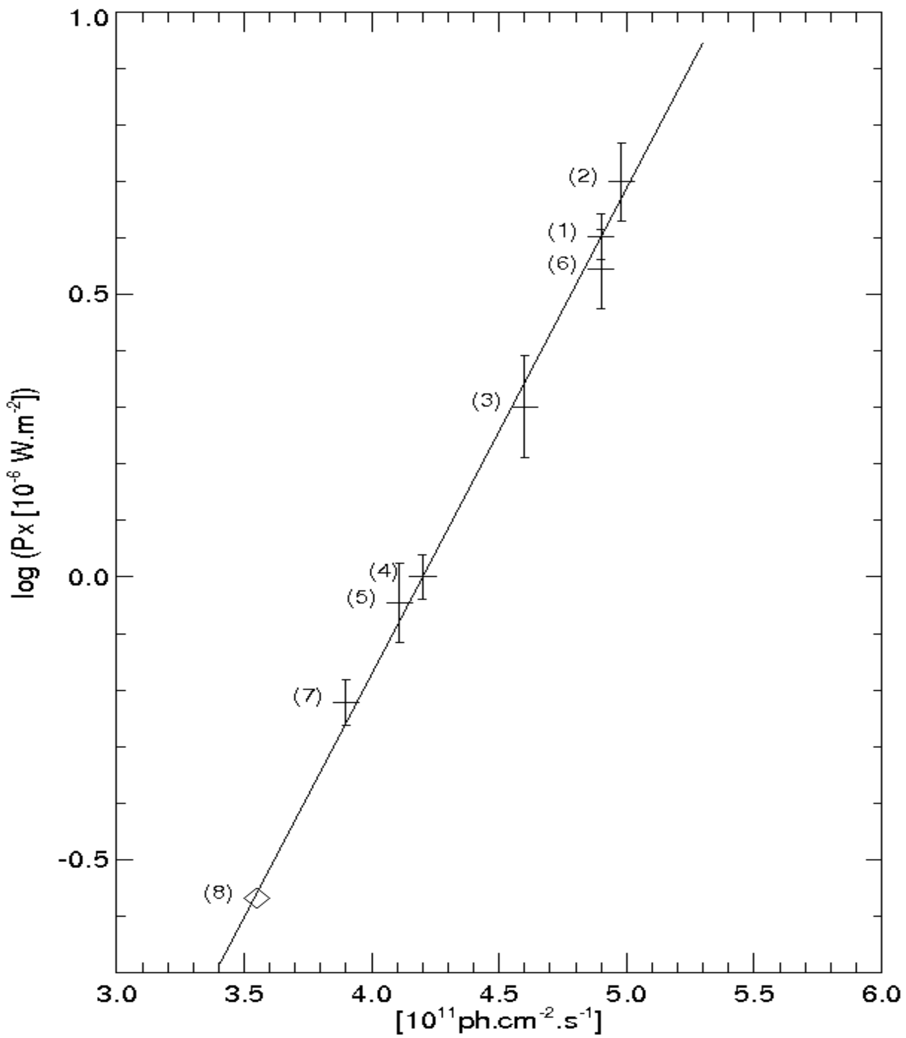




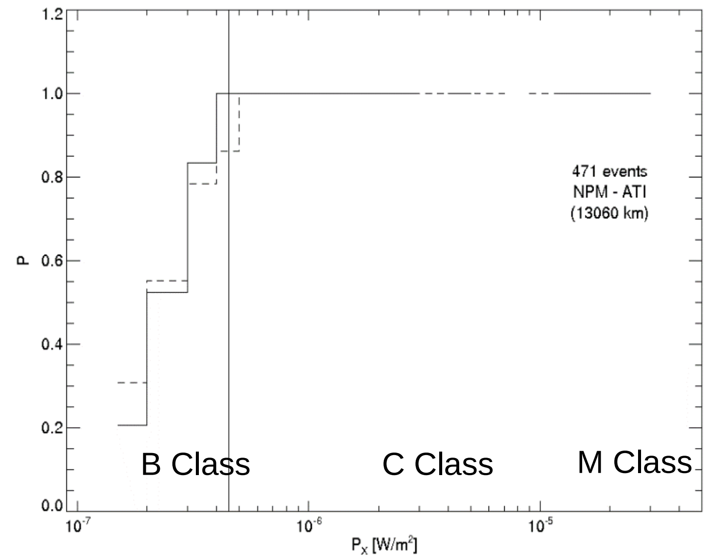
Capacity building

Formation of human ressources

TRANSIENT SOLAR FORCING: FLARES



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



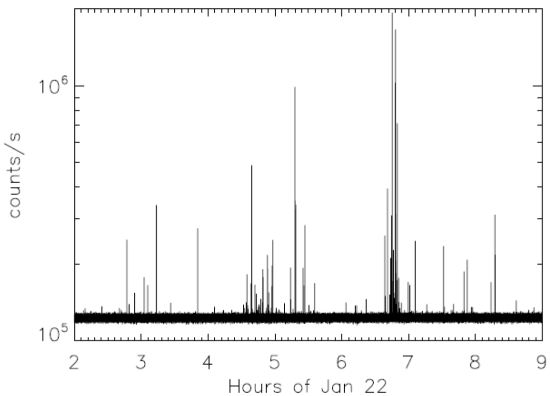
The minimum detectable soft X-ray flux is correlated with the averaged Lyman-α flux : the higher the solar activity the higher Px

↓

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

SGR J1550-5418 on 2009, January 22

ACS/SPI-INTEGRAL (~75 keV)



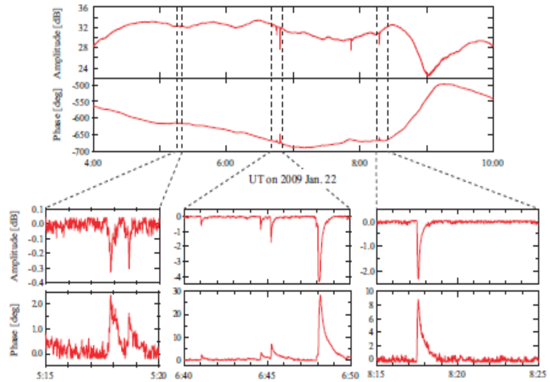


Figure 2. Amplitude and phase variations of a VLF signal from NPM transmitter (21.4 kHz), which were observed at ATI (see Figure 1) from 4:00 UT to 10:00 UT on 2009 January 22. Lower figures are background-subtracted blown-ups at time ranges during which short repeated SGR bursts were detected (see also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

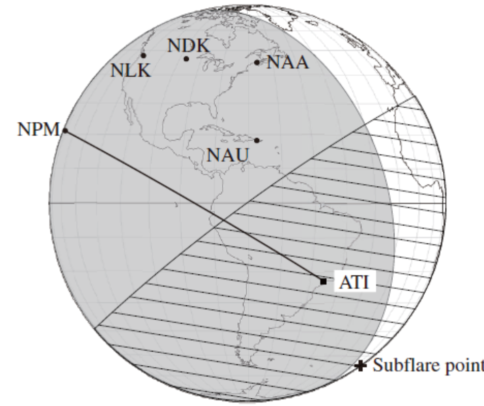


Figure 1. VLF propagation path from NPM transmitter (Hawaii) to ATI observing station (São Paulo, Brazil). Also shown are the locations of other four VLF transmitters (NLK, NDK, NAA, and NAU). Shaded hemisphere indicates the nightside part of the Earth at 6:48 UT, when the largest burst occurred (see 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**.