The CALOR project at Jicamarca: Initial steps

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Controlled upper Atmosphere experiments with a LOwband Radar

Arecibo, March 30, 2010

Motivation

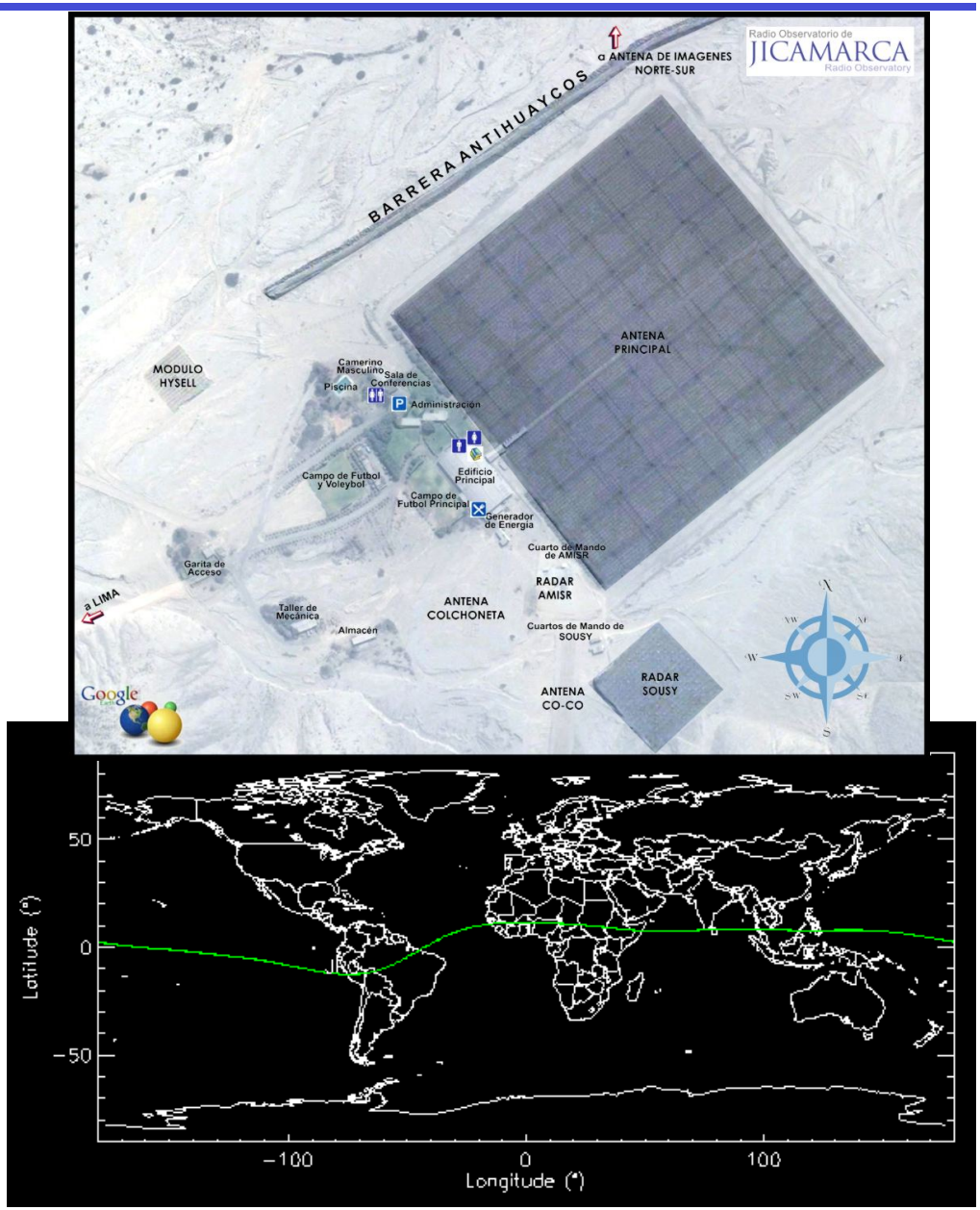
Radio Observatorio de JICAMARCA Radio Observatory

- General advantages of the magnetic equator
  - Relatively stable background conditions
  - Less absorption, more ionization
  - Equatorial electrojet more reliable than auroral electrojet
  - …
- Specific features
  - VLE/ELF generation
  - Artificial periodic inhomogeneities and spread F
  - Electrojet thermal parametric instabilities
  - Langmuir turbulence
  - Mesosphere irregularities

The Jicamarca Radio Observatory

Radio Observatorio de JICAMARCA Radio Observatory

- Built in 1961 by the US NBS and then donated to IGP in 1969.
- Operating frequency: 50 MHz
- Antenna type: array of 18,432 dipoles, organized in 8x8 cross-polarized modules.
- Pointing directions: within 3 degrees from on-axis. Phase changes are currently done manually.
- Transmitters: 3 x 1.5 MW peak-power with 5% duty cycle.
- Located "under" the magnetic equator (dip 1º).



Equatorial Irregularities (1)
RTIs above 100 km

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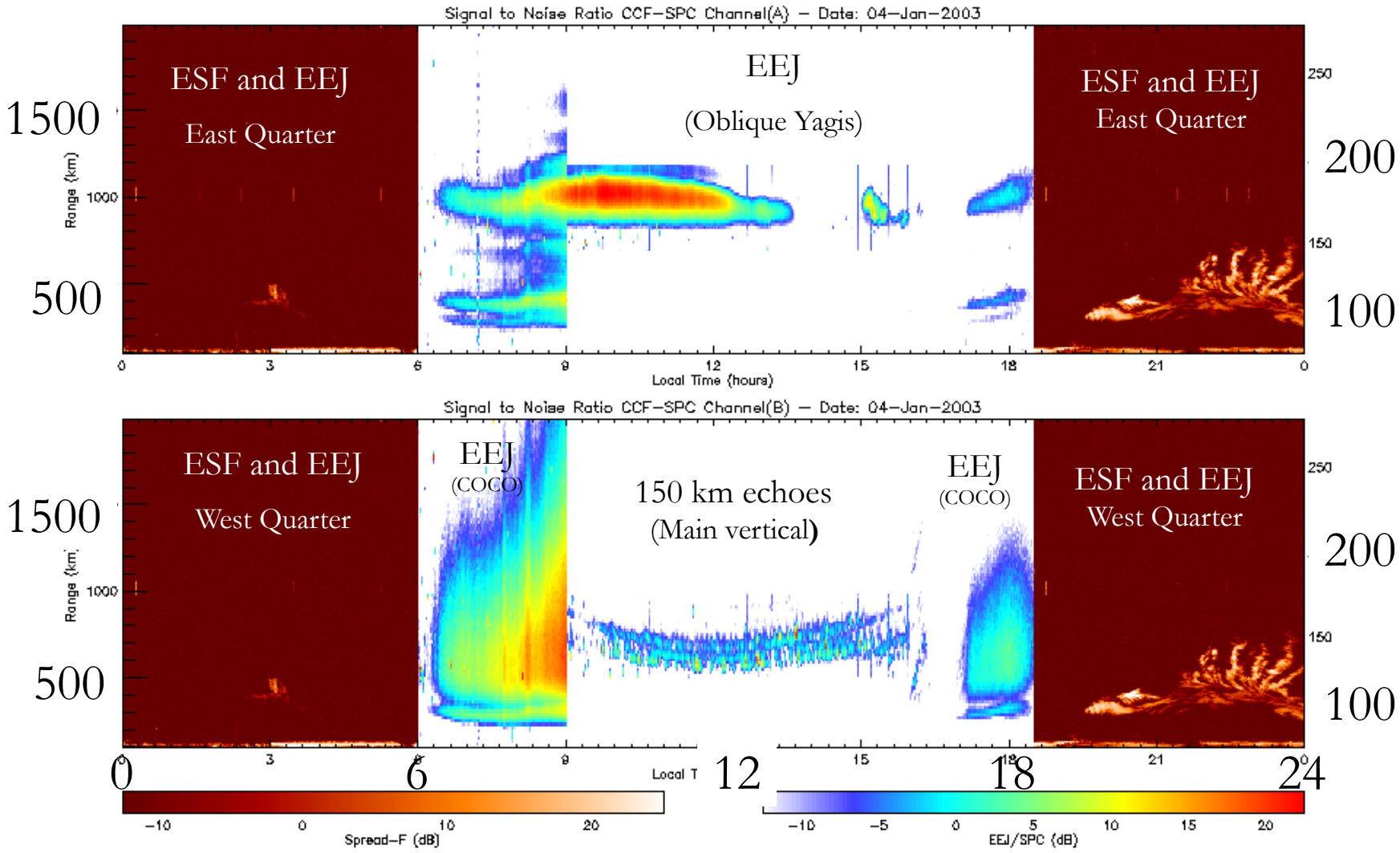

ESF: Equatorial Spread F (nightime)

150-km echoes: Daytime

EEJ: Equatorial Electrojet (all day)

Equatorial Irregularities (2)
Below 200 km

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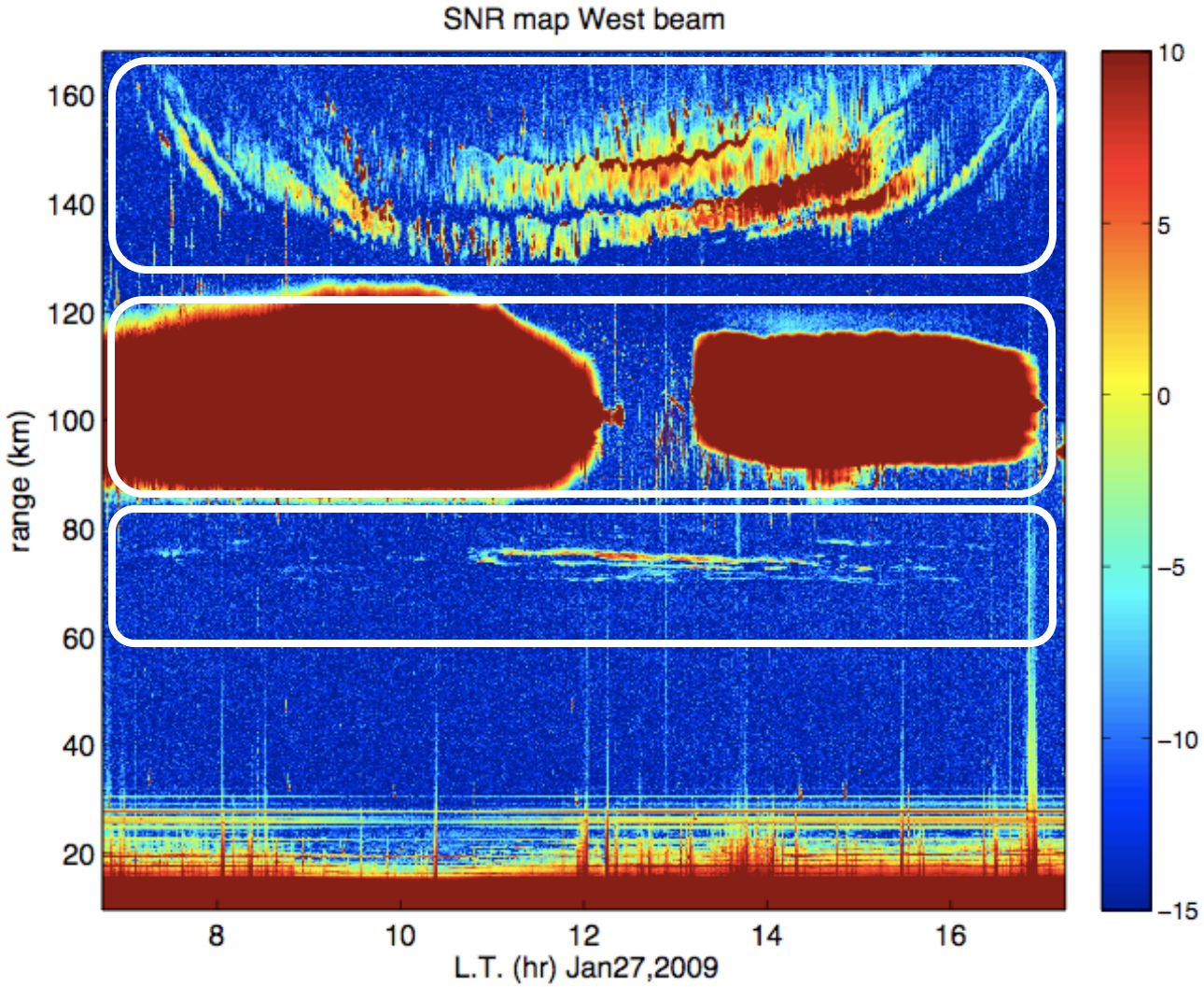

- 150-km echoes from ???
- Equatorial electrojet irregularities
- Meteor echoes
- Mesospheric atmospheric/ ionospheric irregularities

VLF/ELF Generation via EEJ

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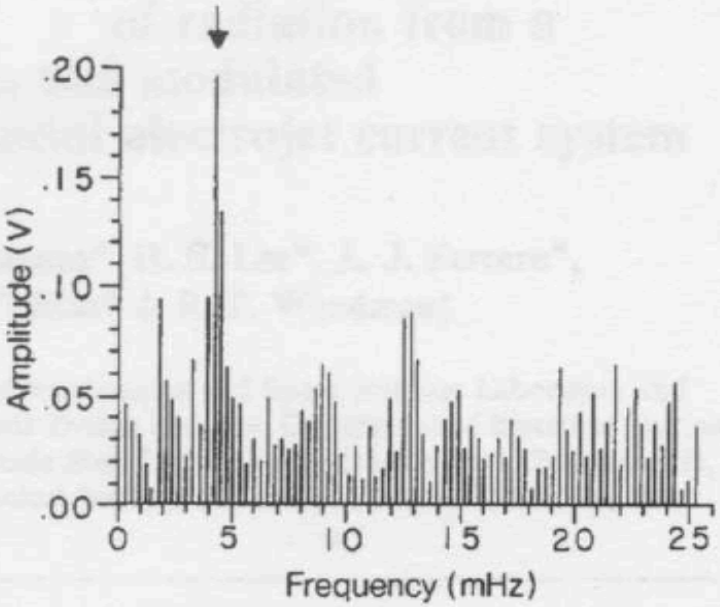

Fig. 1 Long-path amplitude spectrum, 2,500 Hz, Jicamarca, Pe to Salinas, Puerto Rico, 1600–1700 UT, September 1982.

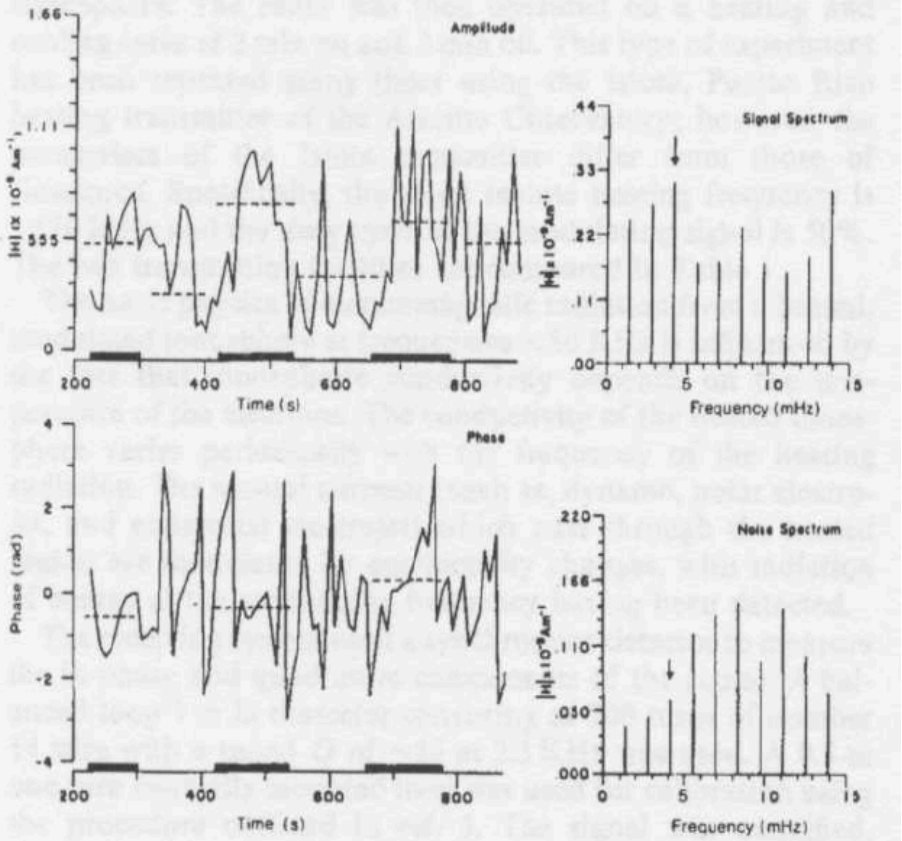

Fig. 3 Amplitude, phase and spectrum of a local Jicamarca, Peru signal at 2,500 Hz, 1345–1400 UT, 9 May 1983, compared with noise spectrum.

- Lunnen et al., *Nature, 311*(13), 134, 1984
- N. Lehtinen, URSI GA, Chicago, Aug. 11–16, 2008
- 2006 BAE Systems patent

SAMI2 Model
283°E Equatorial Ionosphere

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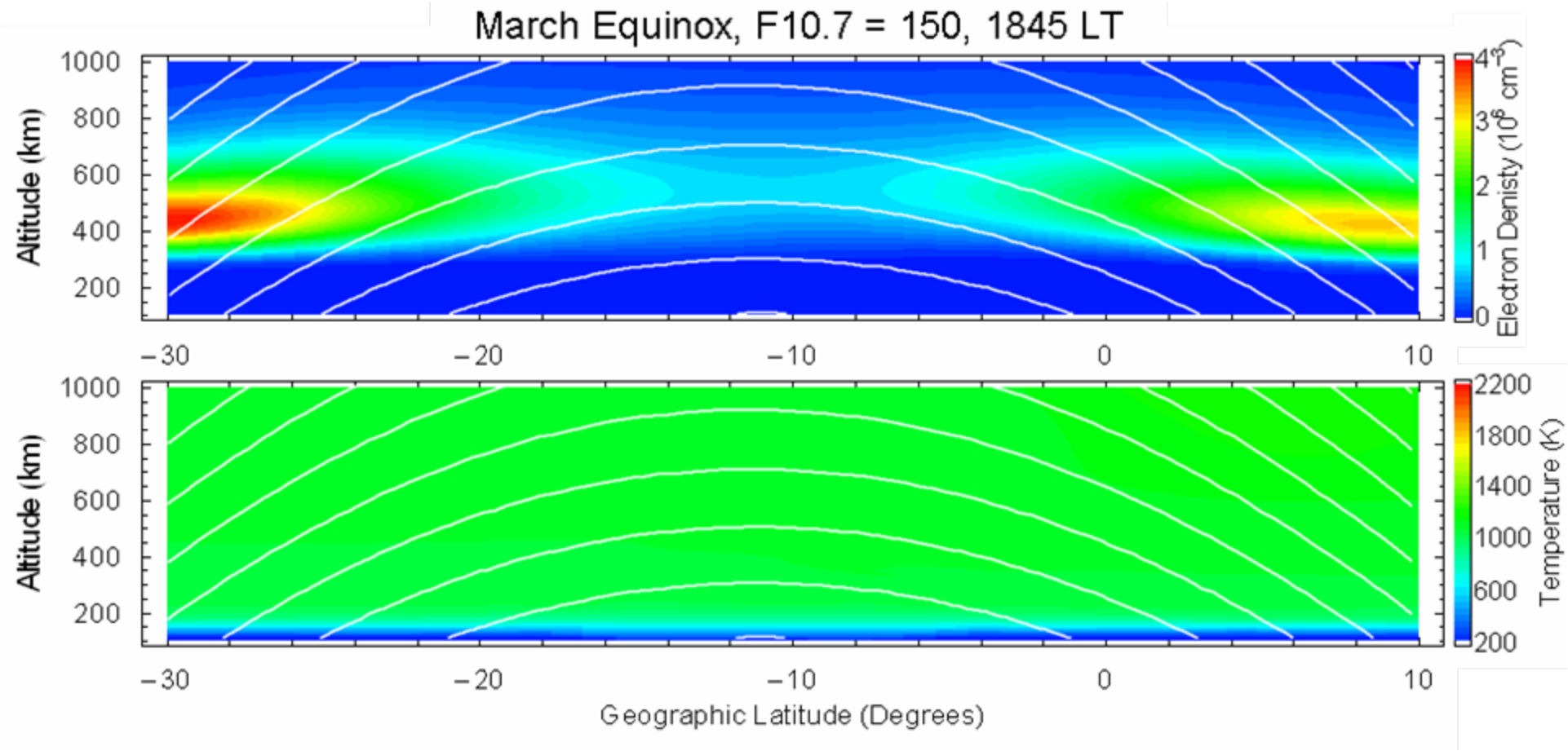

[Courtesy of P. Bernhardt, J. Huba]

Heated Field Line at 7.9 MHz (7.8 105 cm^{-3}) 283°E Equatorial Ionosphere

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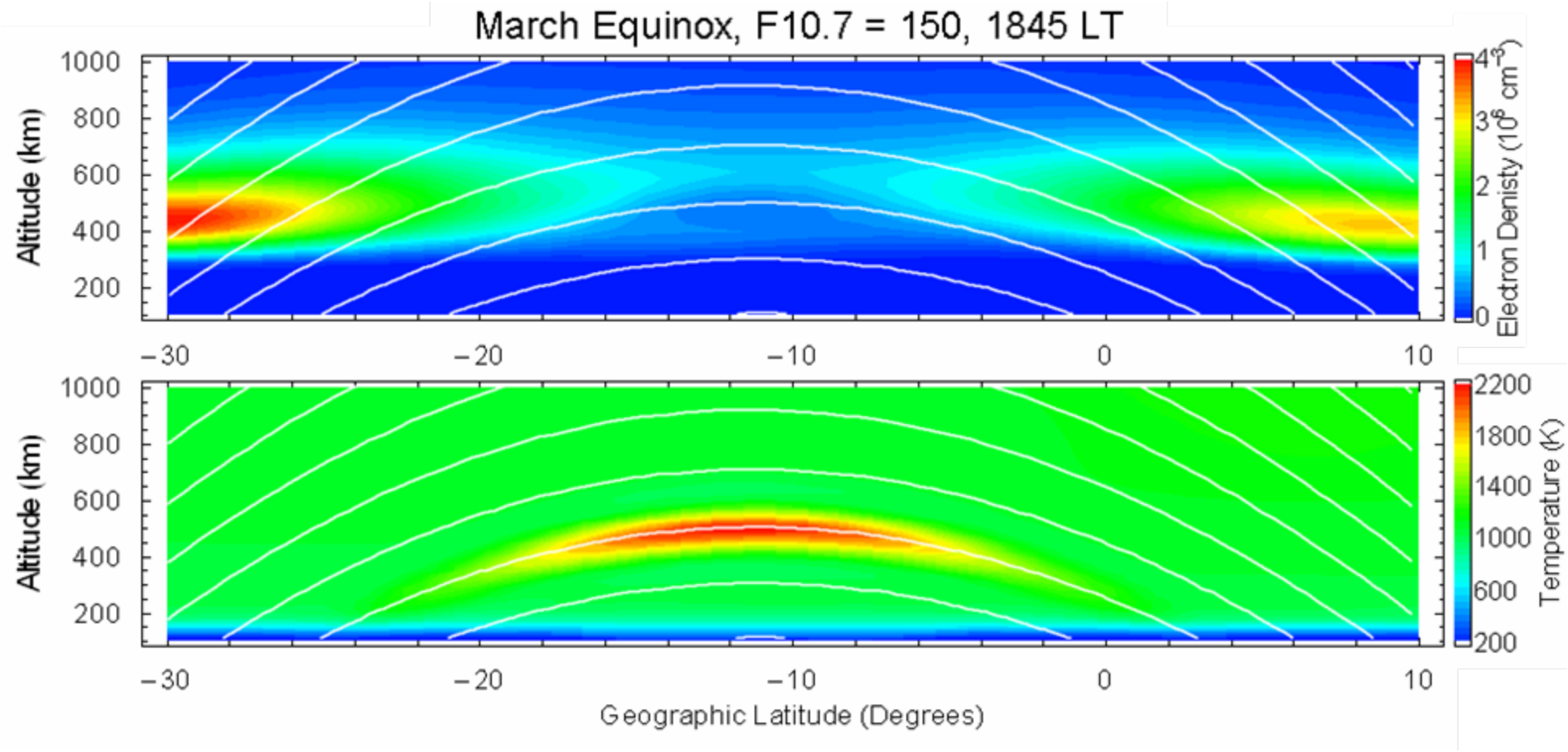

[Courtesy of P. Bernhardt, J. Huba]

Electrojet thermal parametric instabilities (1)

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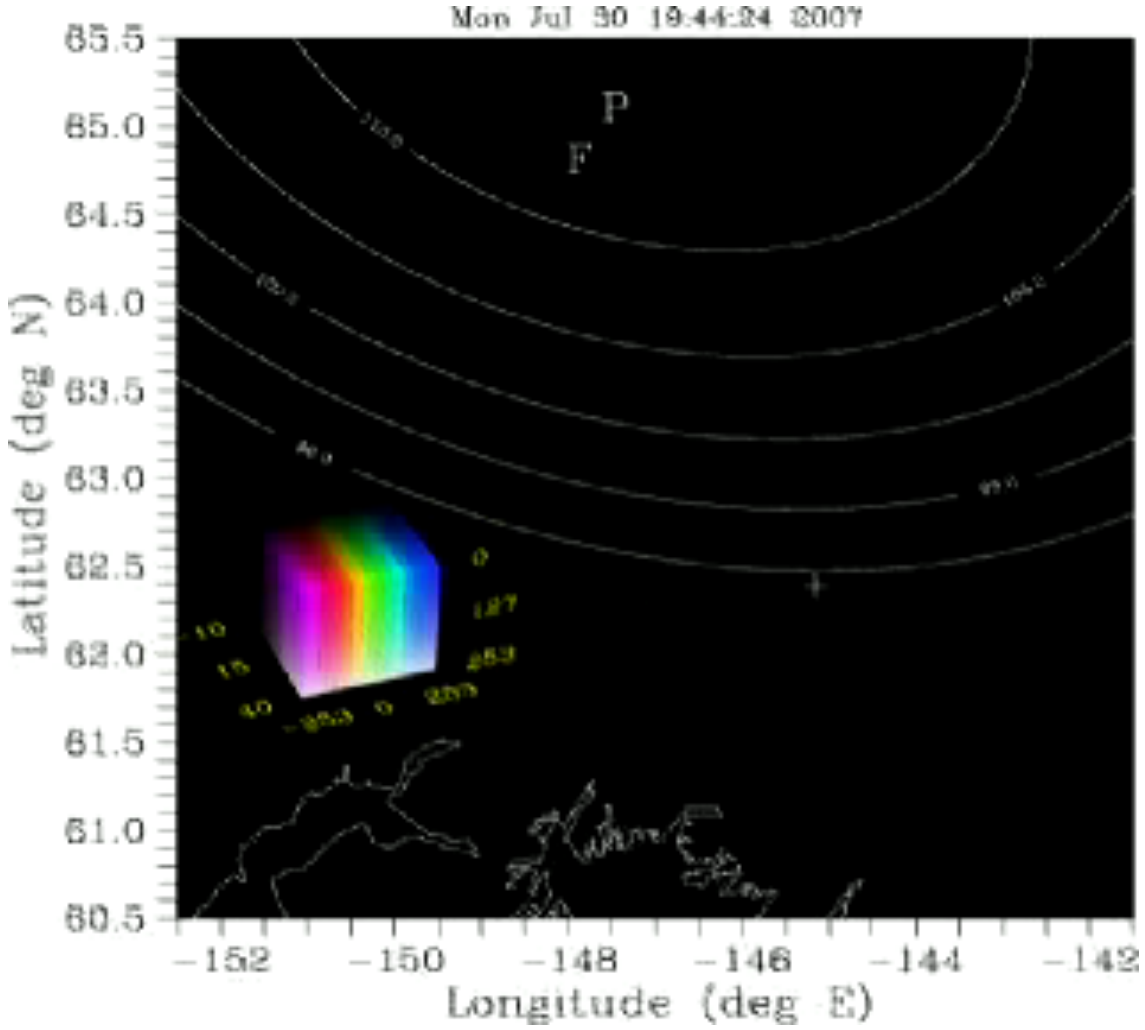

[Courtesy of D. Hysell]

Electrojet thermal parametric instabilities (2)

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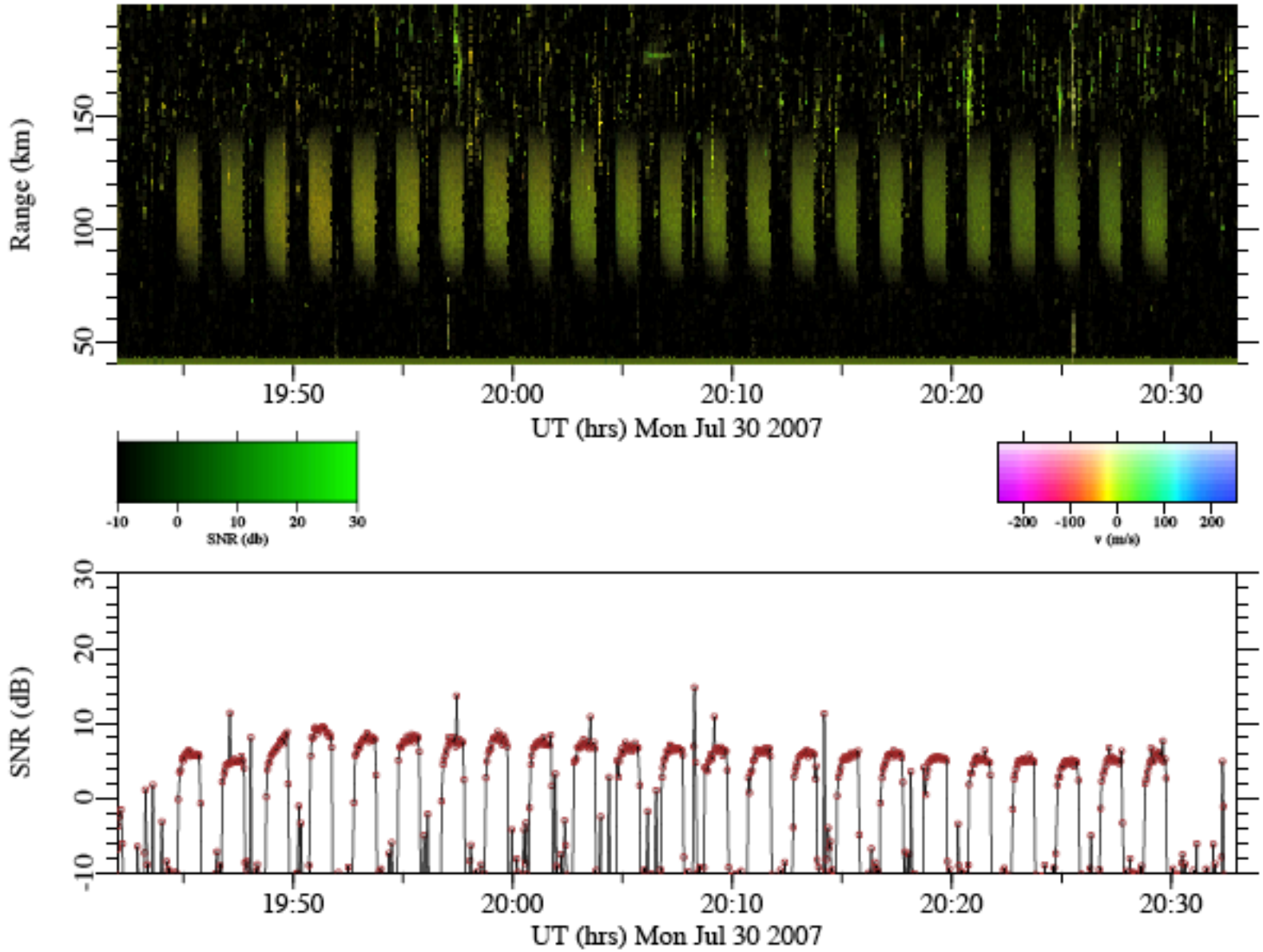

Langmuir turbulence: 150-km echoes

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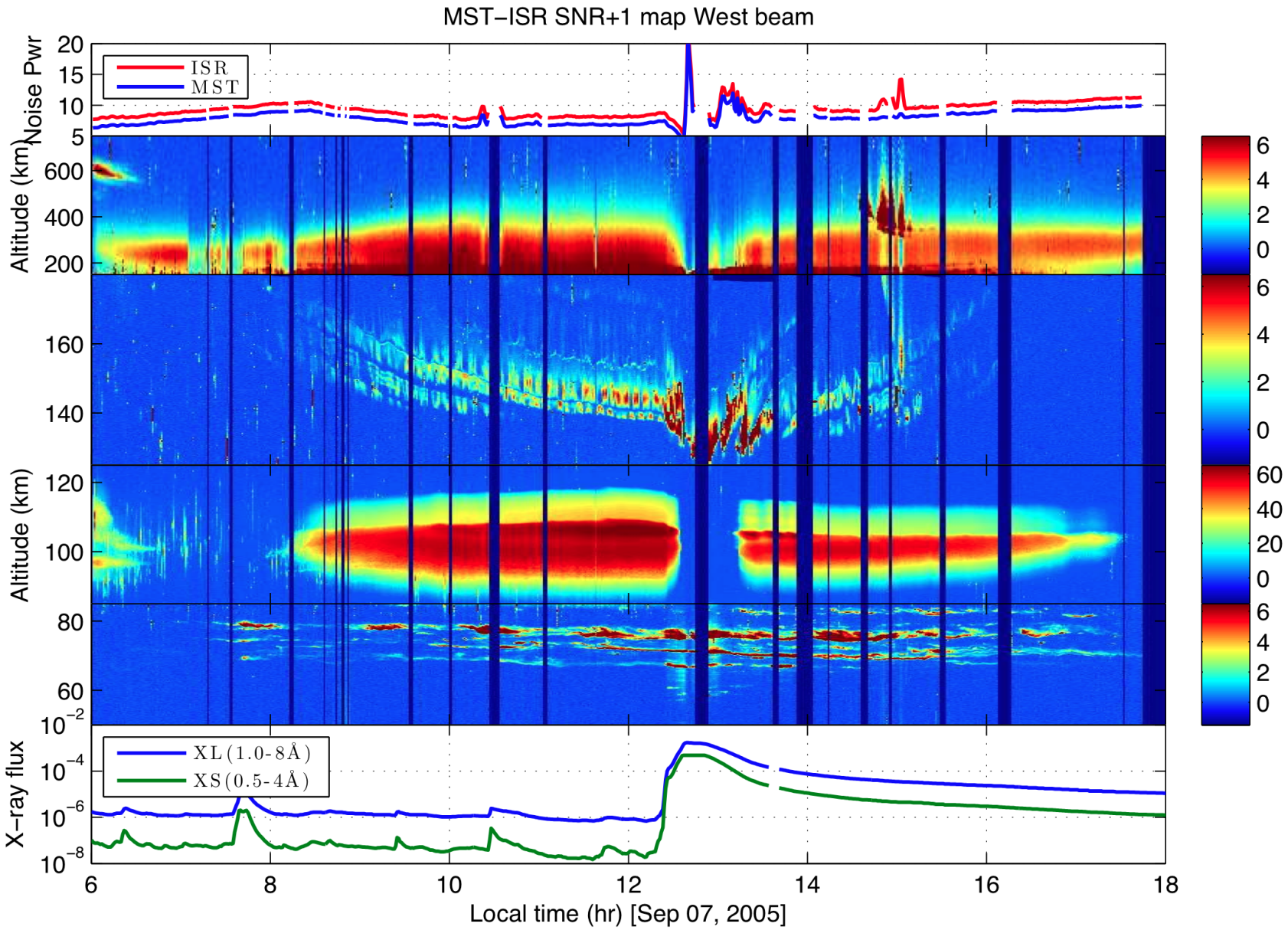

Implementation (1)

Radio Observatorio de JICAMARCA Radio Observatory

- Use surplus OTH transmitters (8-10), feed lines
- Different options under evaluation (HIPAS, Tromso, Islote, colocated/independent).
- Construct exciter/ control hardware locally (FPGA/ DDS units)
- Likewise HF receivers (Echotek)
- Power improvement and conditioning (Rent of diesel generators).
- Upgrade diagnostics (AMISR-7, SEE receivers, VLF receivers, optics, magnetometer, ionosonde, ...)

Implementation (2)

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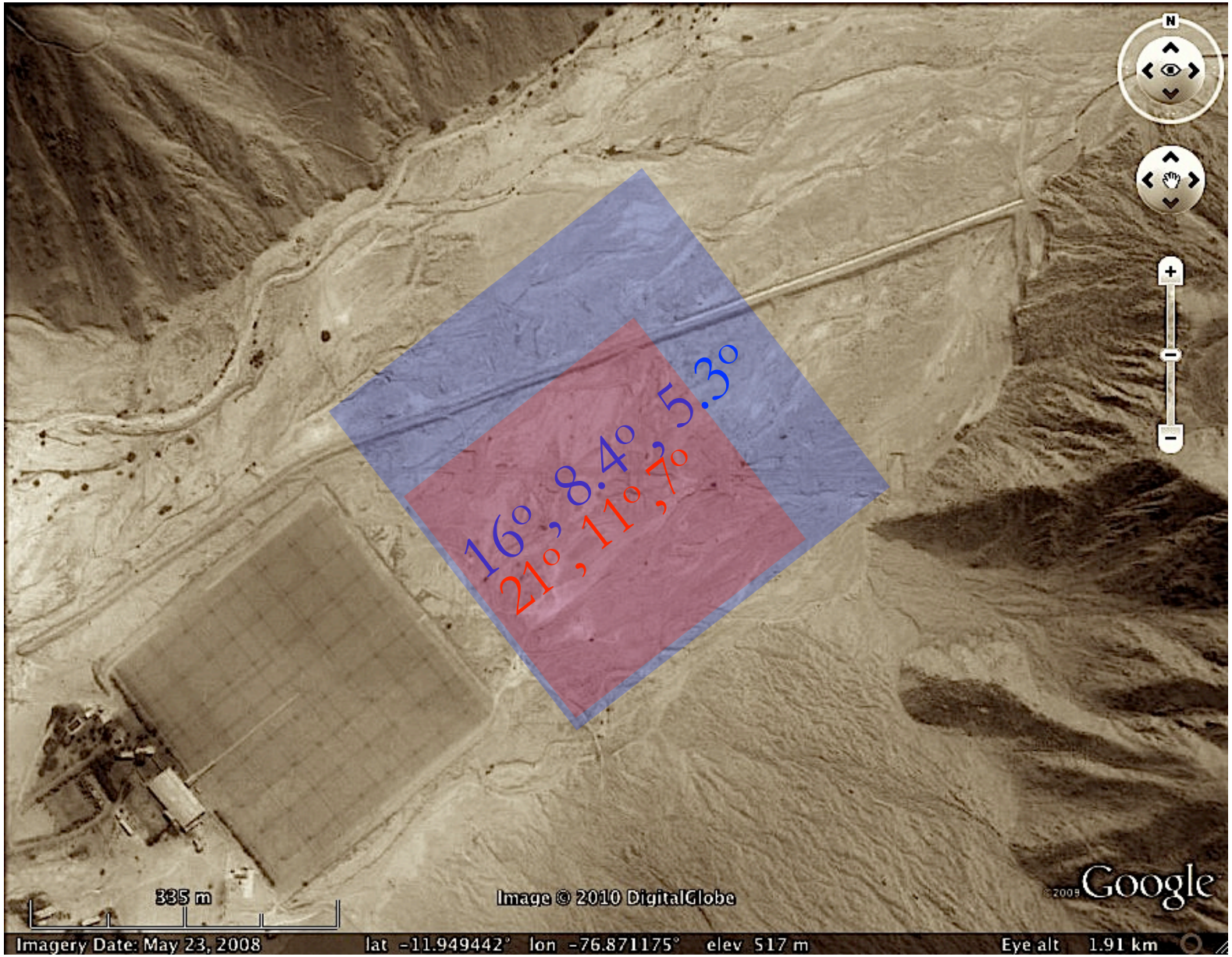

Implementation (3)

Radio Observatorio de JICAMARCA Radio Observatory

- Participate in the installation of the transmitters at Arecibo (2 engineers + 1 technician).
- Study feasibility for:
  - Operations at lower frequency
  - Improve the efficiency (currently 30%).
- We need an independent unit to experiment
  - At Arecibo
  - Or at Jicamarca (need to de-classify the txs)