Jicamarca current contributions to South America Aeronomy

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Outline

• Ionospheric/Atmospheric Observing Capabilities
  – ISR modes
  – Coherent scatter modes
  – Other instruments

• Ionospheric/atmospheric Instrumentation
  – Coherent scatter radars
  – Rocket-borne Radio beacon Experiments
  – Magnetometers
The 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 1°).
¿What do we study at Jicamarca?

- Coherent Scatter Radar
- EEJ: Equatorial Electrojet
- ESF: Spread F
- PEME: Neutral turbulence
- Meteors

Diagram showing the altitude and temperature of the Earth's atmosphere with marked regions such as Thermosphere, Mesosphere, Stratosphere, Troposphere, Protonosphere, F Region, D Region, and 150-km echoes. The diagram also indicates the presence of Neutral turbulence and Meteors.
Jicamarca Themes (Stable Ionosphere)

- **Understanding the stable ionosphere**
  - **Topside:** What controls the light ion distribution? Why are the equatorial profiles so different from those at Arecibo? What is the storm time response of the topside?
  - **F region:** Do current theories fully explain electron and ion thermal balance? Do we understand the electron collision effects on ISR theory now? What is the effect of F-region dynamics near sunset on the generation of ESF plumes? What are the effects of N-S winds on inter-hemispheric transport?
  - **E region:** What are the basic background parameters in the equatorial E region? What is the morphology of the density profiles in this difficult to probe region? How does this morphology affect the E-region dynamo?
  - **D region:** What effects do meteor ablation and mesospheric mixing have on the composition in this region?
Oblique ISR Examples

• This mode combines the Faraday Double Pulse mode with a long pulse mode, allowing the use of the available duty cycle.
• It provides:
  - Absolute electron density (from Faraday rotation) and temperatures below 500 km.
  - Density, temperatures and composition above 500 km.
• Preliminary results [Hysell et al. 2008].
  - Good for Topside work and sunrise observations.
Perpendicular ISR Examples

• Simultaneous measurements of vertical and zonal drifts, with 15 km and 5 min resolutions.
• JRO provides the most precise electric field measurements in the ionosphere.

[from Kudeki and Batthacharyya, 1999]
Plasma irregularities: What do we know from traditional radar studies?

- Coherent echoes are typically 2-6 orders of magnitude stronger than ISR echoes.
- Range-time distributions (Intensity=RTI, Velocities)
  - Day-to-day and seasonal variability
  - Time periodicities (Gravity waves, tides)
- Spectral characteristics
  - Spectral shape (Gaussian, Lorentzian, more than one Gaussian)
  - Mean Doppler and Spectral width
- Multi-beam observations
  - Spatial Characteristics
  - 3D velocity vector
- Interferometry
  - Zonal velocity
  - Aspect Sensitivity (scale lengths)
- Imaging
  - Resolve space-time ambiguities
Atmospheric/Ionospheric Irregularities
Main “Equatorial” Questions (Unstable Ionosphere)

– *F* region: What are the fundamental plasma processes, including nonlinear processes, that govern the generation of plasma plumes? What are the precursor phenomena in the late afternoon F region that control whether or not an F-region plume will be generated after sunset?

– Daytime Valley echoes (or so-called 150-km echoes). What are the physical mechanisms causing them?

– *E* region: What are the nonlinear plasma physics processes that control the final state of the electrojet instabilities? To what extent do these instabilities affect the conductivity of the E region.
  
  • What are the basic background parameters in the equatorial E region? What is the morphology of the density profiles in this difficult to probe region? How does this morphology affect the E-region dynamo?

– *D* region: What effects do meteor ablation and mesospheric mixing have on the composition in this region?

– *E* and *F* (valley) region coupling. Does the F region respond to an *Es* layer instability? Are 150-km echoes related to *Es* layers?
Coherent echoes over Jicamarca (1)
RTIs above 100 km

ESF: Equatorial Spread F (nighttime)
EEJ: Equatorial Electrojet (all day)

150-km echoes: Daytime
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Institution</th>
<th>Site</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scintillation Rxs</td>
<td>AFRL</td>
<td>Ancon</td>
<td>S4, Irregularity drifts</td>
</tr>
<tr>
<td>Digisonde</td>
<td>JRO</td>
<td>Jicamarca</td>
<td>Densities</td>
</tr>
<tr>
<td>Magnetometers</td>
<td>JRO</td>
<td>Jicamarca, Piura</td>
<td>ΔH</td>
</tr>
<tr>
<td>ST Radars</td>
<td>IGP, UDEP</td>
<td>Northern Peru</td>
<td>Winds and turbulence</td>
</tr>
<tr>
<td>FPI</td>
<td>UNSA, JRO</td>
<td>Arequipa</td>
<td>Nighttime thermospheric winds and temp.</td>
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<tr>
<td>FPI SOFDI</td>
<td>Clemson, UNJ, IGP</td>
<td>Huancayo</td>
<td>All day therm. winds and temp.</td>
</tr>
<tr>
<td>SOUSY Radar</td>
<td>JRO</td>
<td>Jicamarca</td>
<td>High resolution low. alt. winds</td>
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<tr>
<td>AMISR Prototype</td>
<td>SRI, JRO</td>
<td>Jicamarca</td>
<td>EEJ, ESF and meteor observations at UHF</td>
</tr>
<tr>
<td>GPS rxs</td>
<td>BC, IGP</td>
<td>See LISN</td>
<td>TEC, S4, irregularity drifts</td>
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</tbody>
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JRO as Video RF Camera
Radar Technology: Radar Imaging

[Chau et al., 2008]
<table>
<thead>
<tr>
<th>Site</th>
<th>Contacts</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sousy Svalbard,</td>
<td>C. Hall /JRO</td>
<td>Radar receiver/acquisition/control/low power tx systems + Processing programs</td>
</tr>
<tr>
<td>Norway</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antarctica,</td>
<td>R. Woodman/JRO</td>
<td>Except for txs all the radar system has been developed at JRO</td>
</tr>
<tr>
<td>Peru</td>
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<tr>
<td>Sao Luis, Brasil</td>
<td>E. De Paula/D. Hysell</td>
<td>Interferometry and 4 channel radar imager, including solid state txs.</td>
</tr>
<tr>
<td>INPE, Brasil</td>
<td>C. Denardin, A. Acuña, H. Aveiro/</td>
<td>Spent few days/months at JRO learning radar processing and techniques</td>
</tr>
<tr>
<td>JRO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U. Tucuman</td>
<td>V. Rios/JRO</td>
<td>Engineers from Tucuman spent few weeks at JRO.</td>
</tr>
<tr>
<td>MORRO, Norway</td>
<td>C. LaHoz/M. Sarango/JRO</td>
<td>JRO has provided the processing and analysis software</td>
</tr>
<tr>
<td>Gadanki, India</td>
<td>D. N. Rao, A. Patra/ JRO</td>
<td>Advise on future upgrades to their radar systems: antenna compression, imaging, E region Faraday, Incoherent Scatter Radar.</td>
</tr>
</tbody>
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Radar Technology: Example from Sao Luis, Brasil
Radio Beacon Experiments: PERSEUS
Development of magnetometers: LISN Magn. (1)

LISN funded the design of a prototype magnetometer. Tests of 4 additional units has been done. Right Figure shows a comparison with UCLA magnetometer.

Characteristics of Jicamarca’s Triaxial ring core fluxgate magnetometer:
• High Sensitivity and field resolution (0.1nT)
• Long term mechanical and thermal stability
• Highly robust electronics and system reliability (multi-layer circuitry).
• Low power consumption
• Data readily available to Internet uploading (5 min cadence time).
Development of magnetometers: LISN Magn. (2)
Welcome to the International Research Experience Program at the Jicamarca Radio Observatory in Lima, Peru. This program originally called "Summer Program for Students from Non-Peruvian Institutions" started two years ago and is financed by the National Science Foundation. After two successful years, and thanks to the positive feedback from previous students, we are offering an improved program this year.

The Jicamarca Radio Observatory exists today with the mission of deepening our understanding of the equatorial and low-latitude atmosphere and ionosphere and the systems to which they are coupled, fostering the creation of avant-garde radar and radio remote sensing techniques, training and educating new generations of space physicists and radio scientists and technicians, expanding its own capabilities through upgrade and invention, and increasing its influence internationally.

The students will work with staff engineers and scientists on projects related to ongoing research or instrumentation development programs. Research may be conducted in neutral atmospheric and ionospheric science as well as radar/radio instrumentation and software development. Given its location, frequency of operation, and array system, most JRO's research capabilities are unique. For example, this is the best place in the world where radar imaging of atmospheric and ionospheric phenomena can be learned and explored. Besides the unique research capabilities where students are welcomed to propose and run their own experiments, JRO offers a good opportunity to get hands-on experience on different aspects of radar systems, from changing the antenna connections, improving RF components of the system, to develop sophisticated acquisition and processing programs. The students will be also exposed to frequent lectures and seminars given by the staff and by the visiting scientists. In addition, the students are also asked to give lectures at the beginning and at the end of their experience. A side benefit of the program is that students will get to know Peru, heir to ancient cultures and rich colonial tradition.

Who should apply?
<table>
<thead>
<tr>
<th>Roger Varney</th>
<th>Bernhard Etzlinger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical and Computer Engineering</td>
<td>Mechatronics</td>
</tr>
<tr>
<td>Cornell University, USA</td>
<td>Johannes Kepler University</td>
</tr>
<tr>
<td></td>
<td>Linz, Austria</td>
</tr>
</tbody>
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