The Jicamarca Radio Observatory

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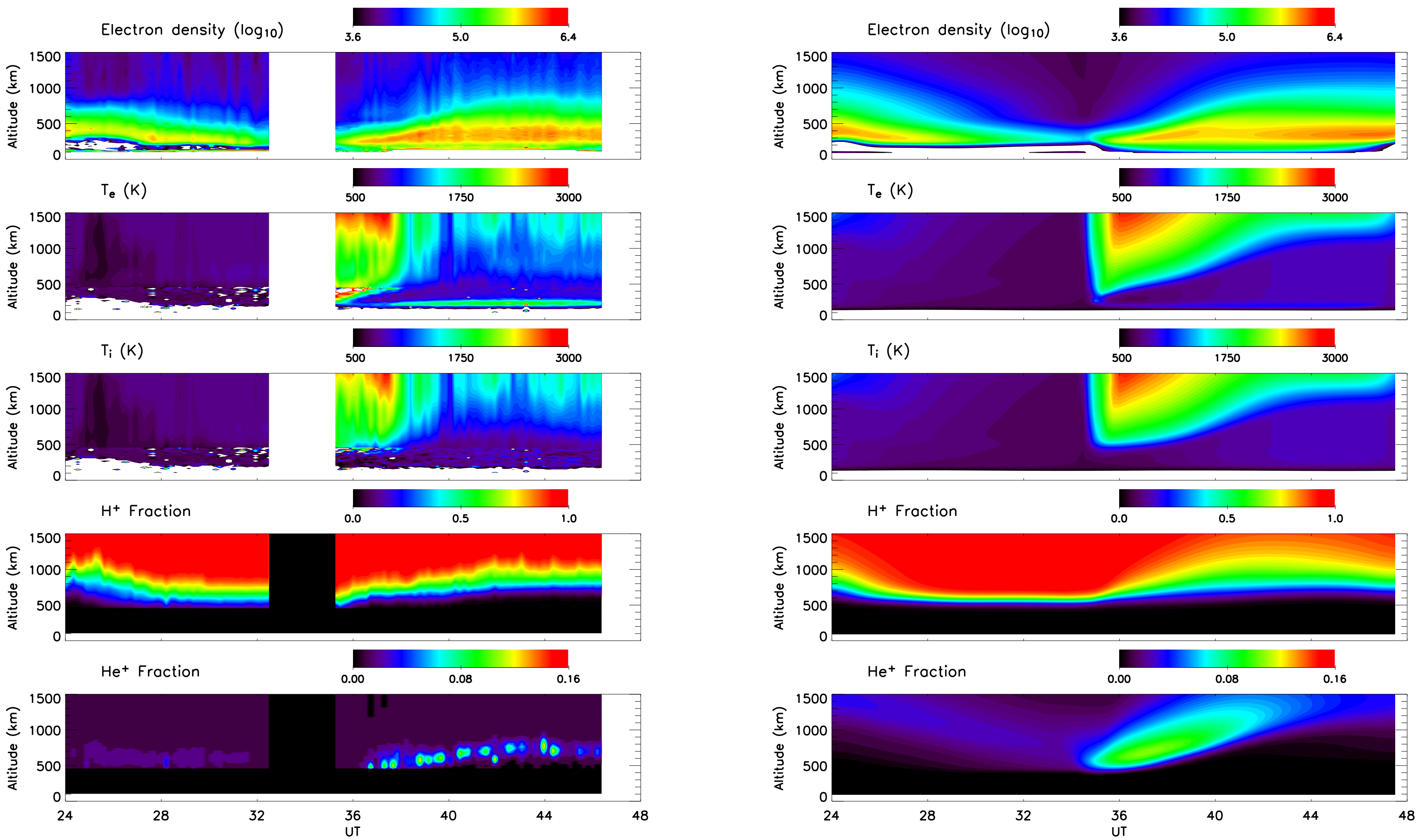
Cornell University, Ithaca, NY

mission

The Jicamarca Radio Observatory was constructed over four decades ago to study the ionosphere using emerging theories of the incoherent scattering of radiation by plasmas. It exists today with the mission of

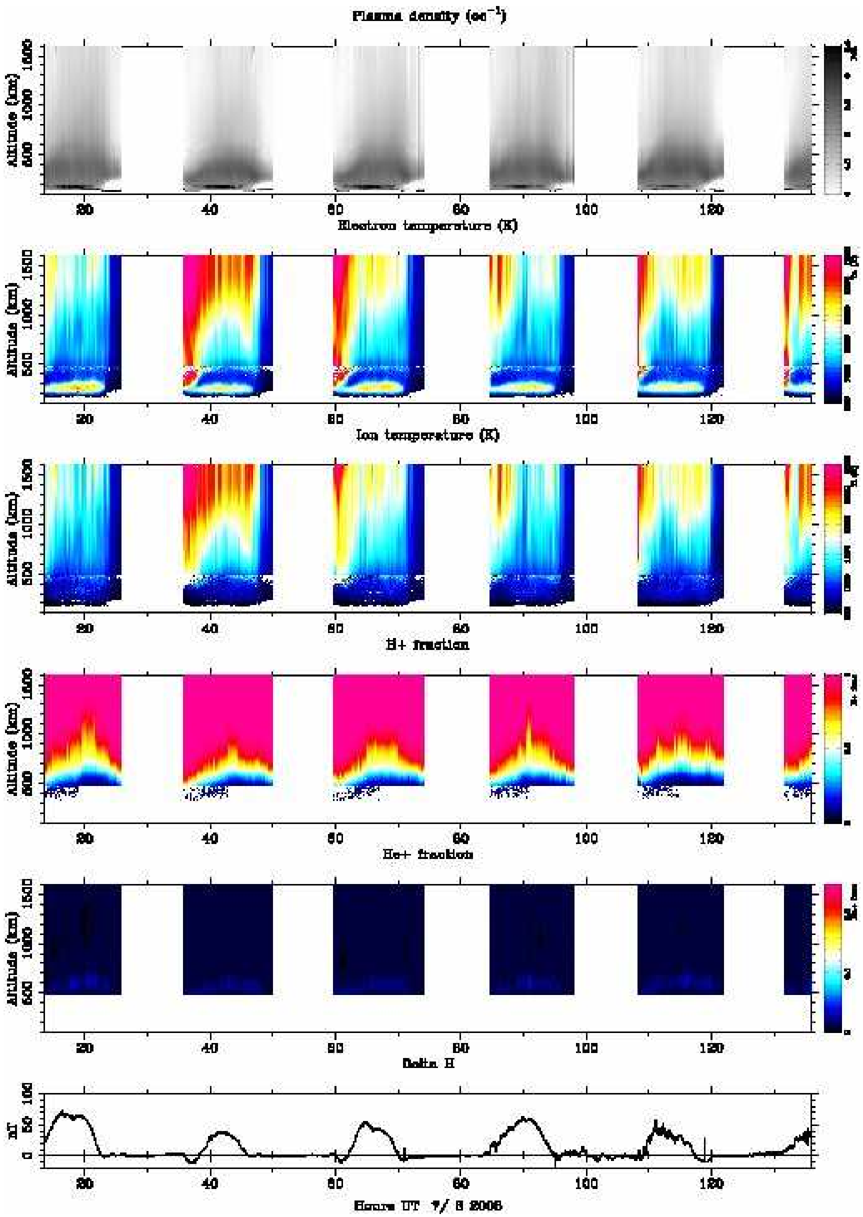
- deepening our understanding of the equatorial and low-latitude atmosphere and ionosphere and the systems to which they are coupled
- fostering the creation of avant-garde radar and radio remote sensing techniques
- training and educating new generations of space physicists and radio scientists and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

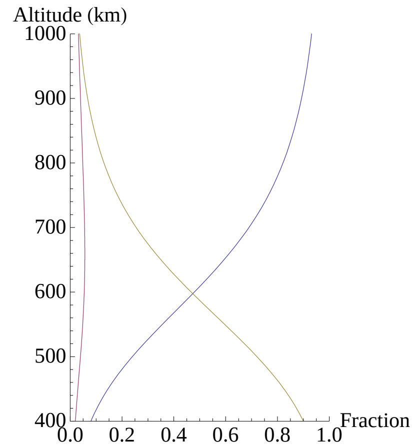
highlight I

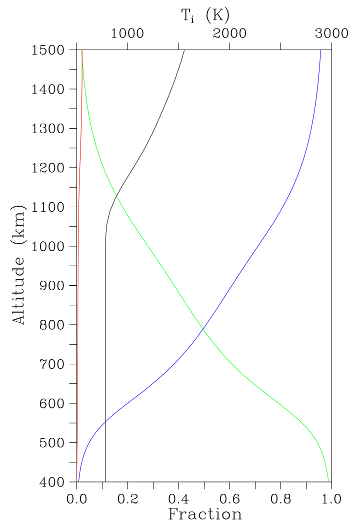


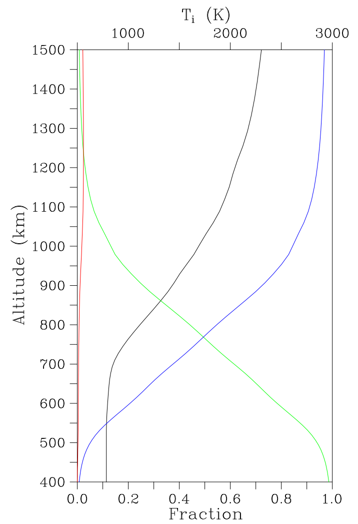
— Hysell et al., 2008

highlight I.I

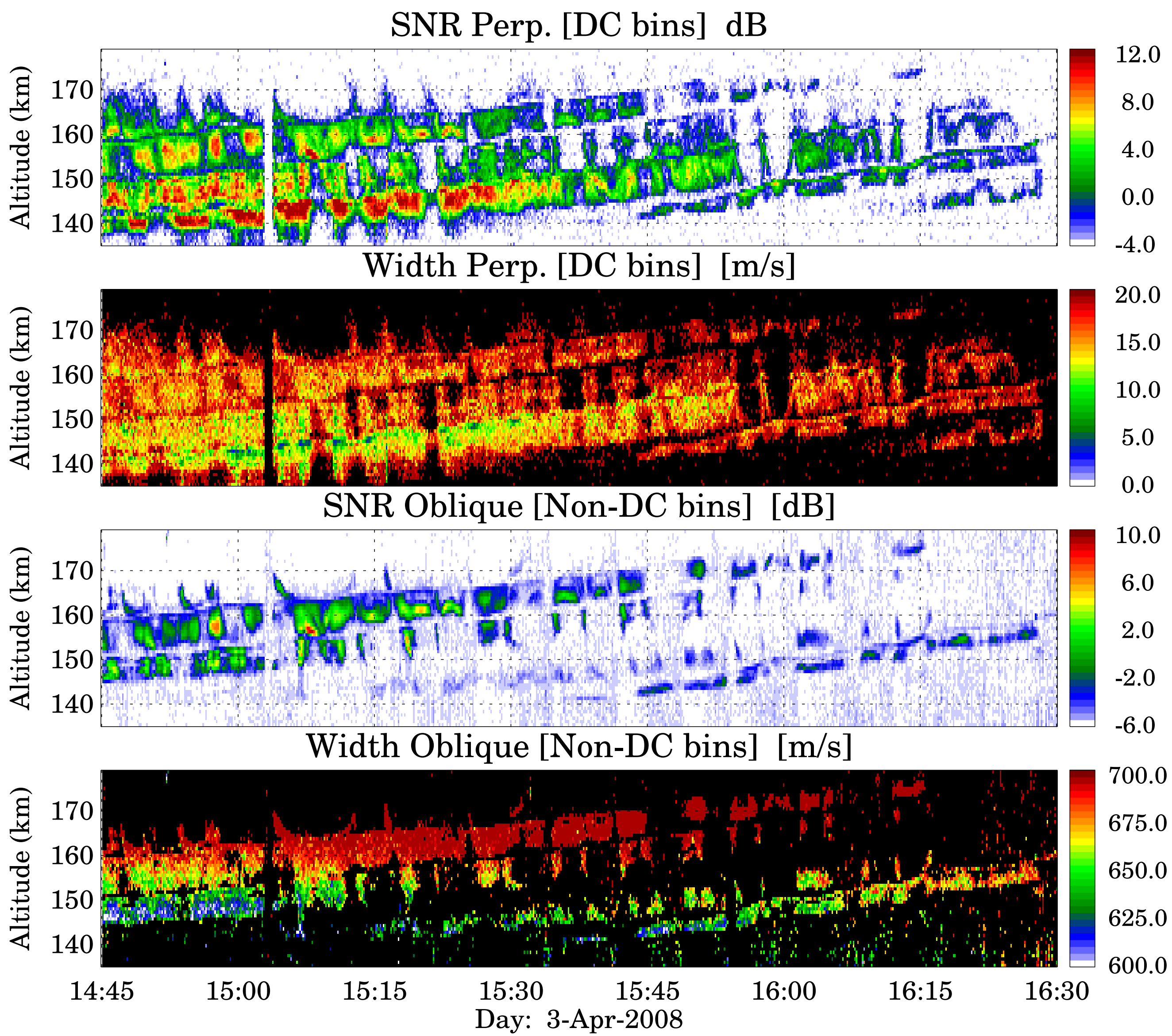




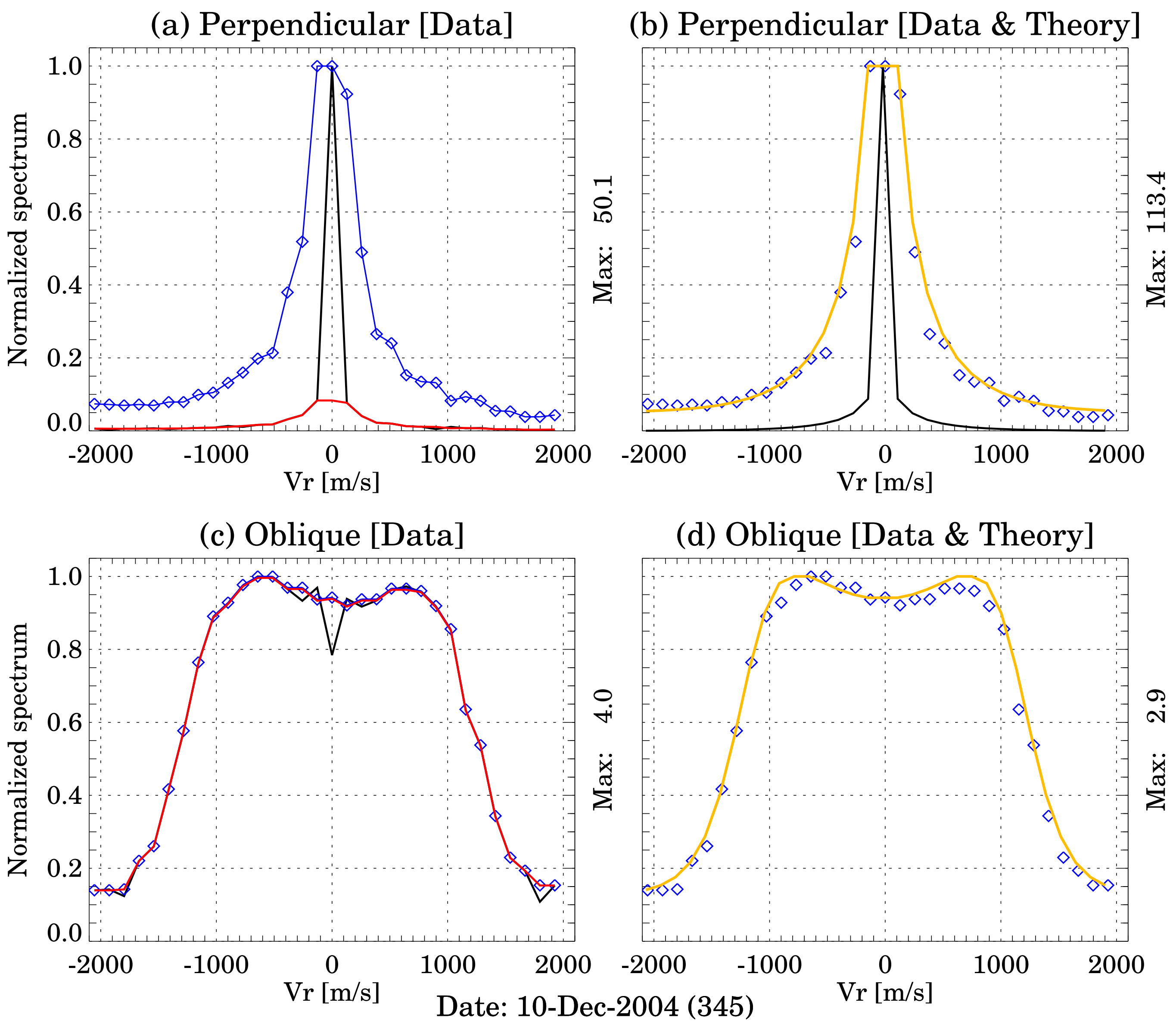




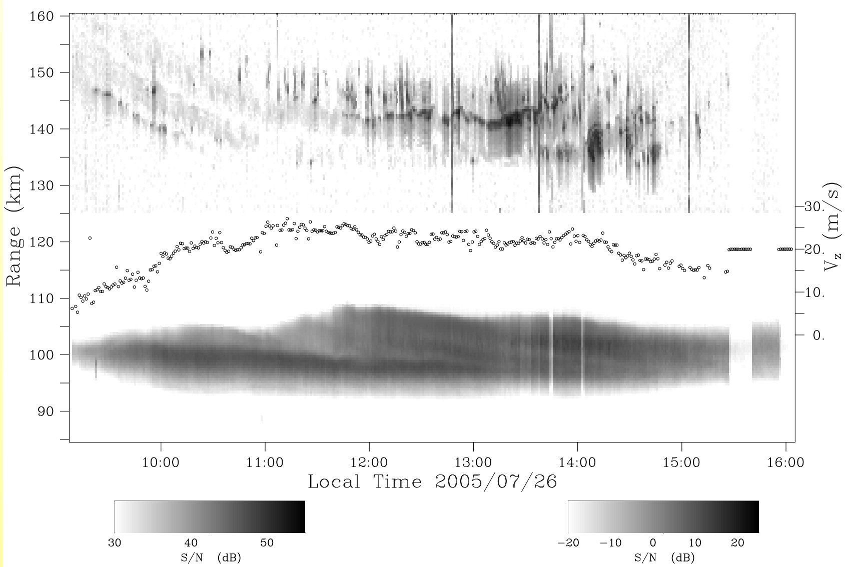
highlight II

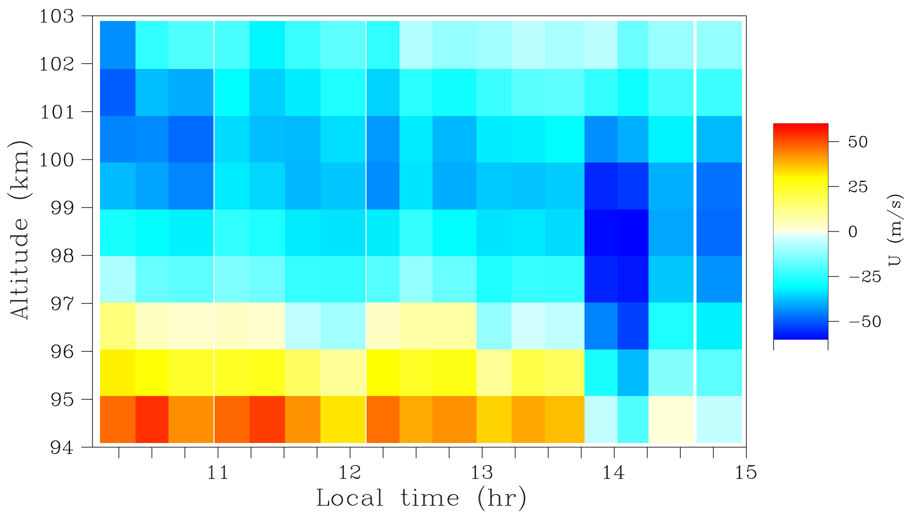


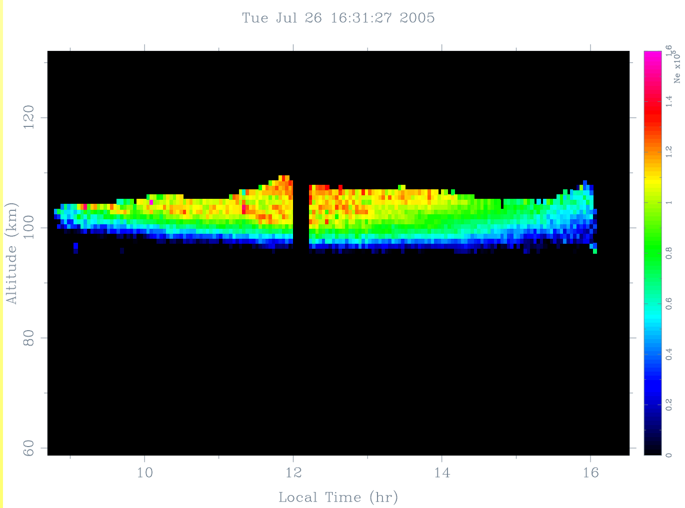
highlight II.I

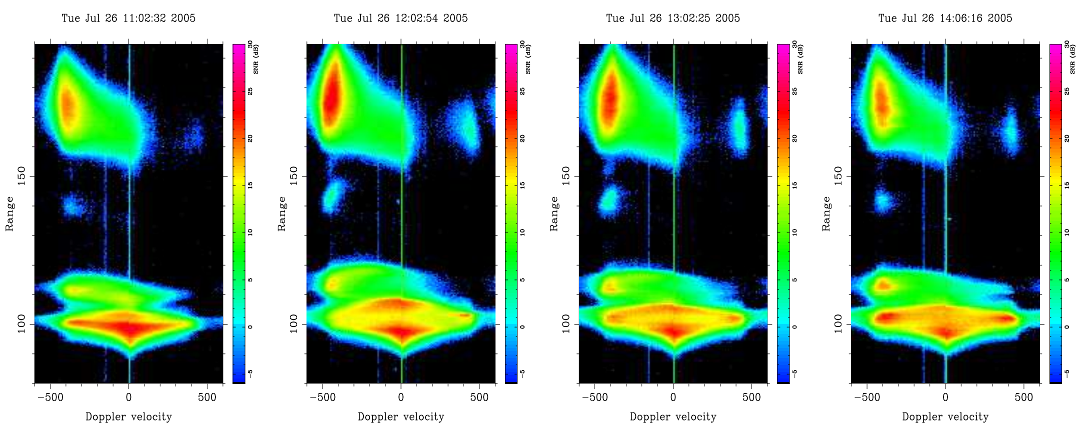


highlight III

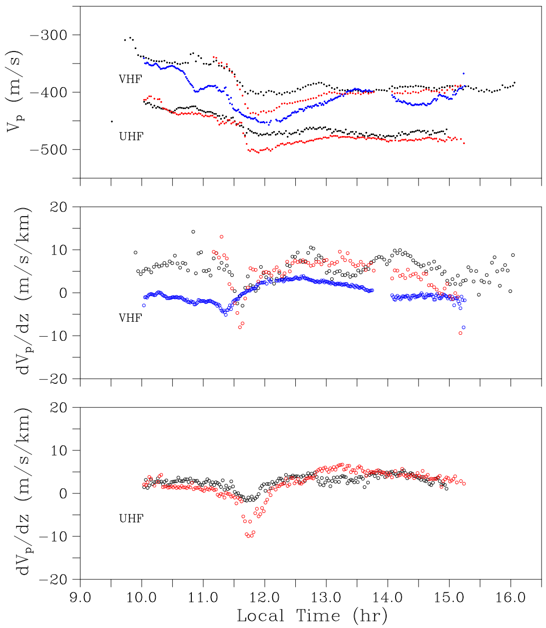


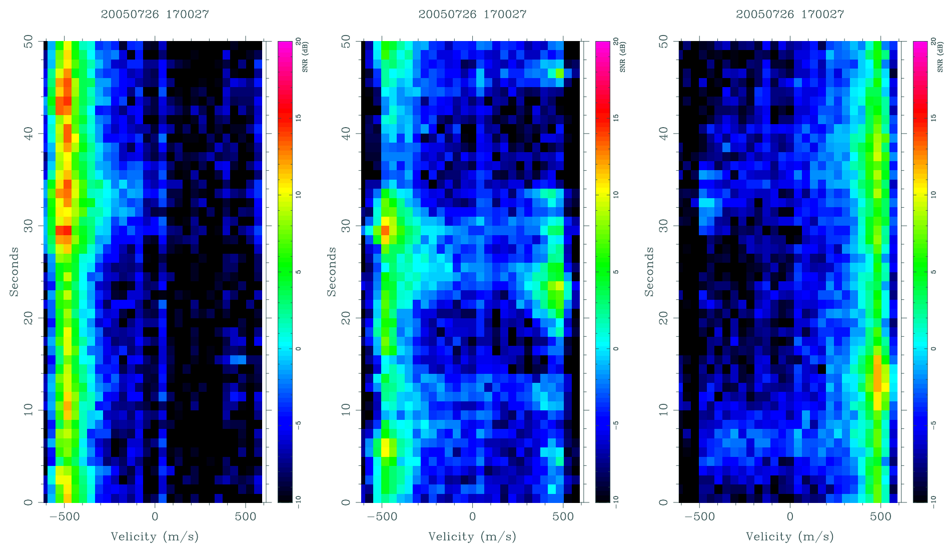




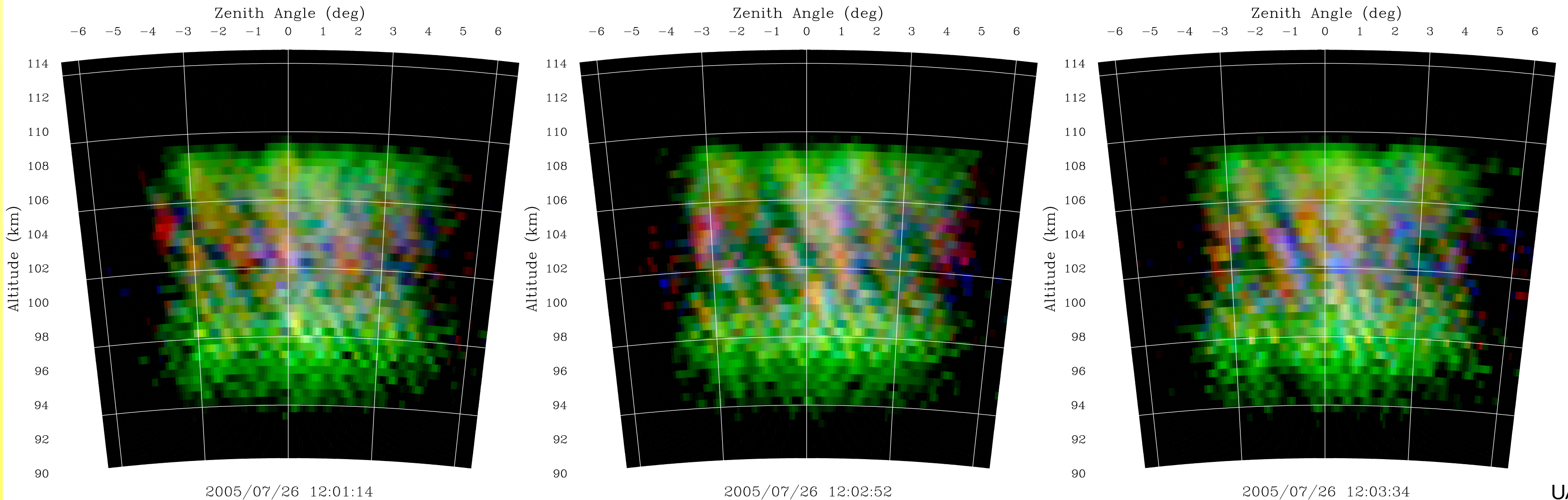


highlight III.I



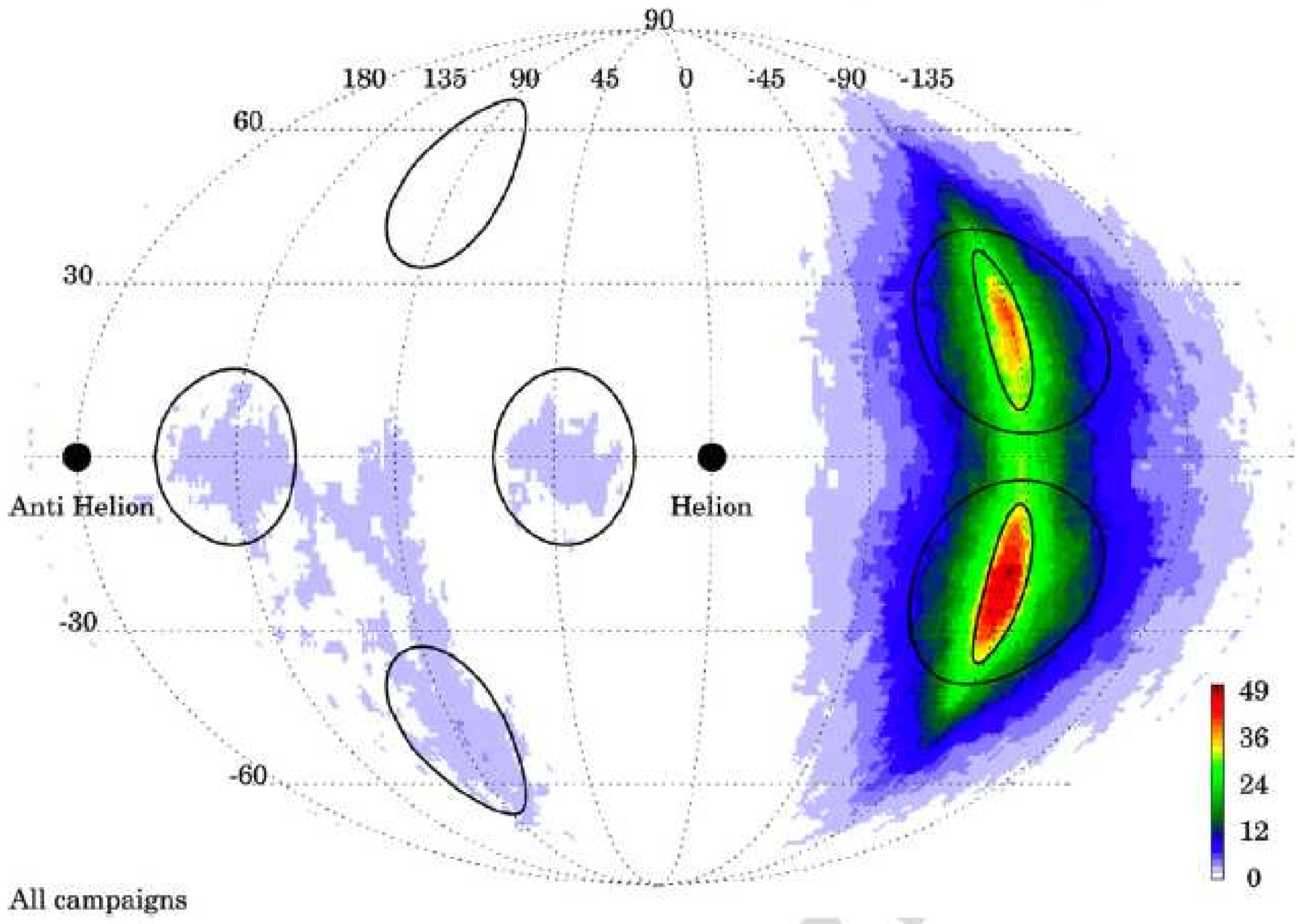


— Hysell et al., 2007



highlight IV

Meteors: Where do they come from?



190,000 meteors in 90 hours! Chau et al., 2007

highlight IV.I

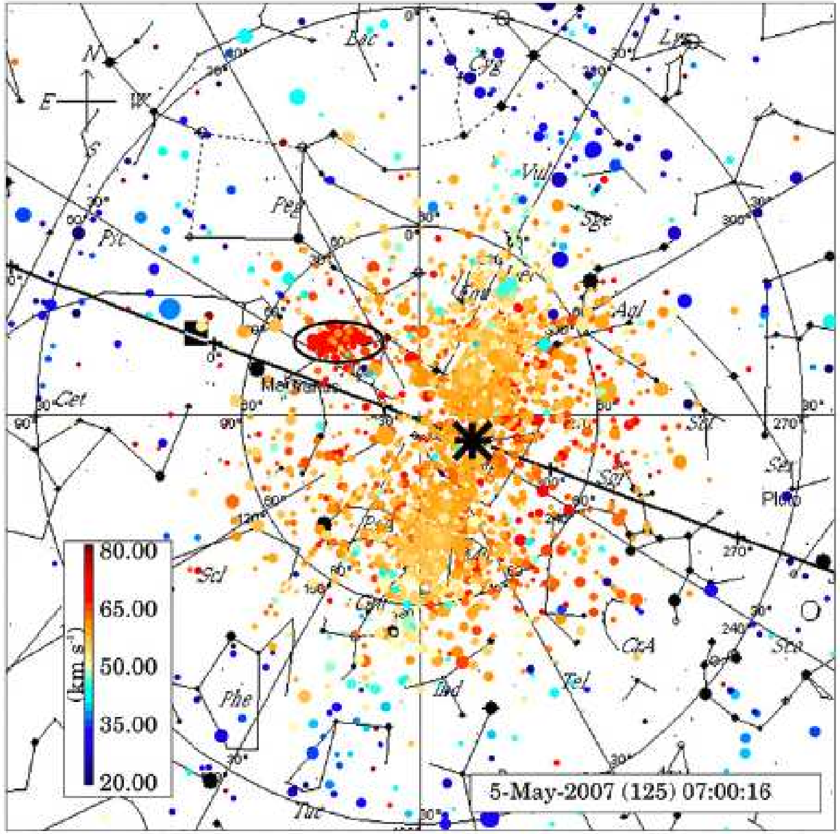
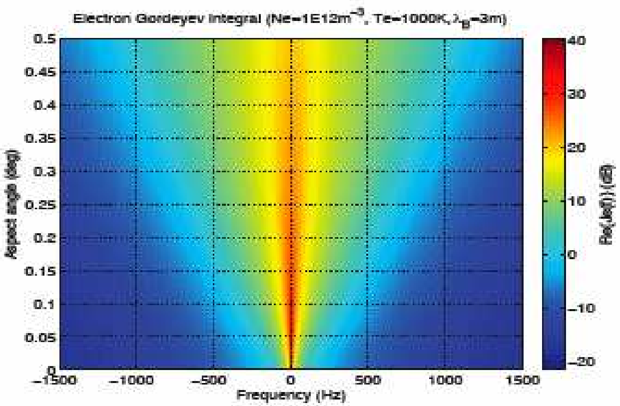


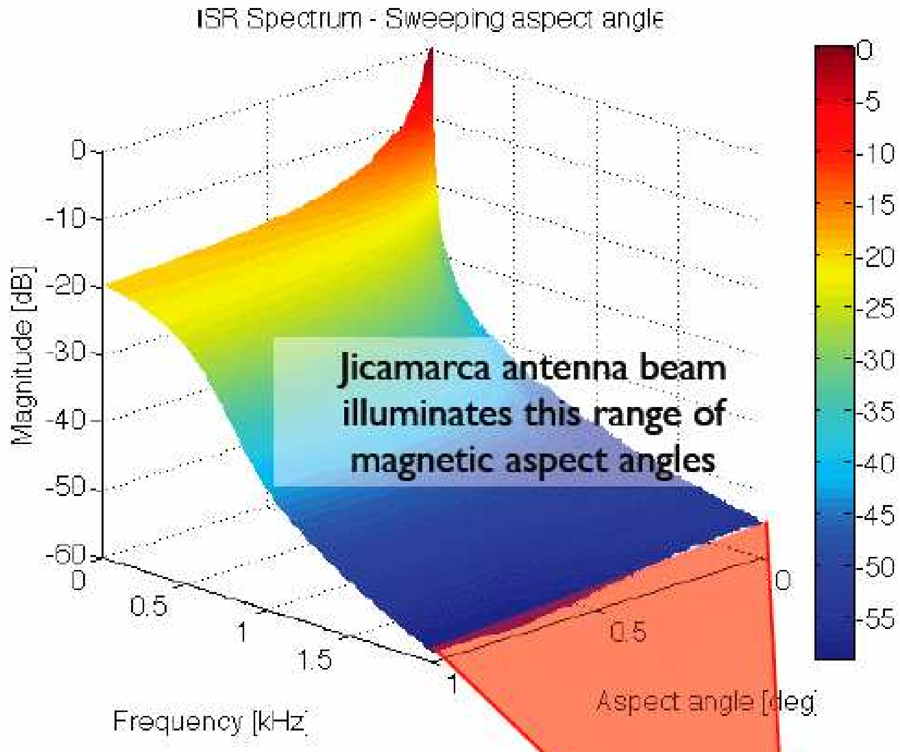
Fig. 1. Skymap distribution of meteor radiants around 1200 UT (±15 min) on May 05, 2007. The absolute velocity is color-coded, while the SNR is represented by the size of the circles. The Ecliptic plane projected into the celestial sphere is shown with a black curve, and the Earth's Apex with a thick asterisk. The ellipse shows the location of the η-Aquariids meteors.

- First observation of showers from meteor-head echoes
- Location and velocity in good agreement with radar estimates
- We are observing the smaller size population not observed by any other technique: Chau and Galindo, 2008

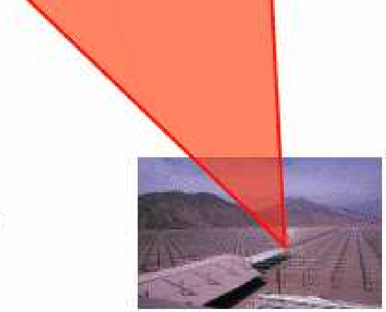
highlight V

Based on the Fokker-Planck collision model, we have developed a Monte-Carlo procedure to compute the electron Gordeyev integral for all magnetic aspect angles (including the perpendicular to B direction).



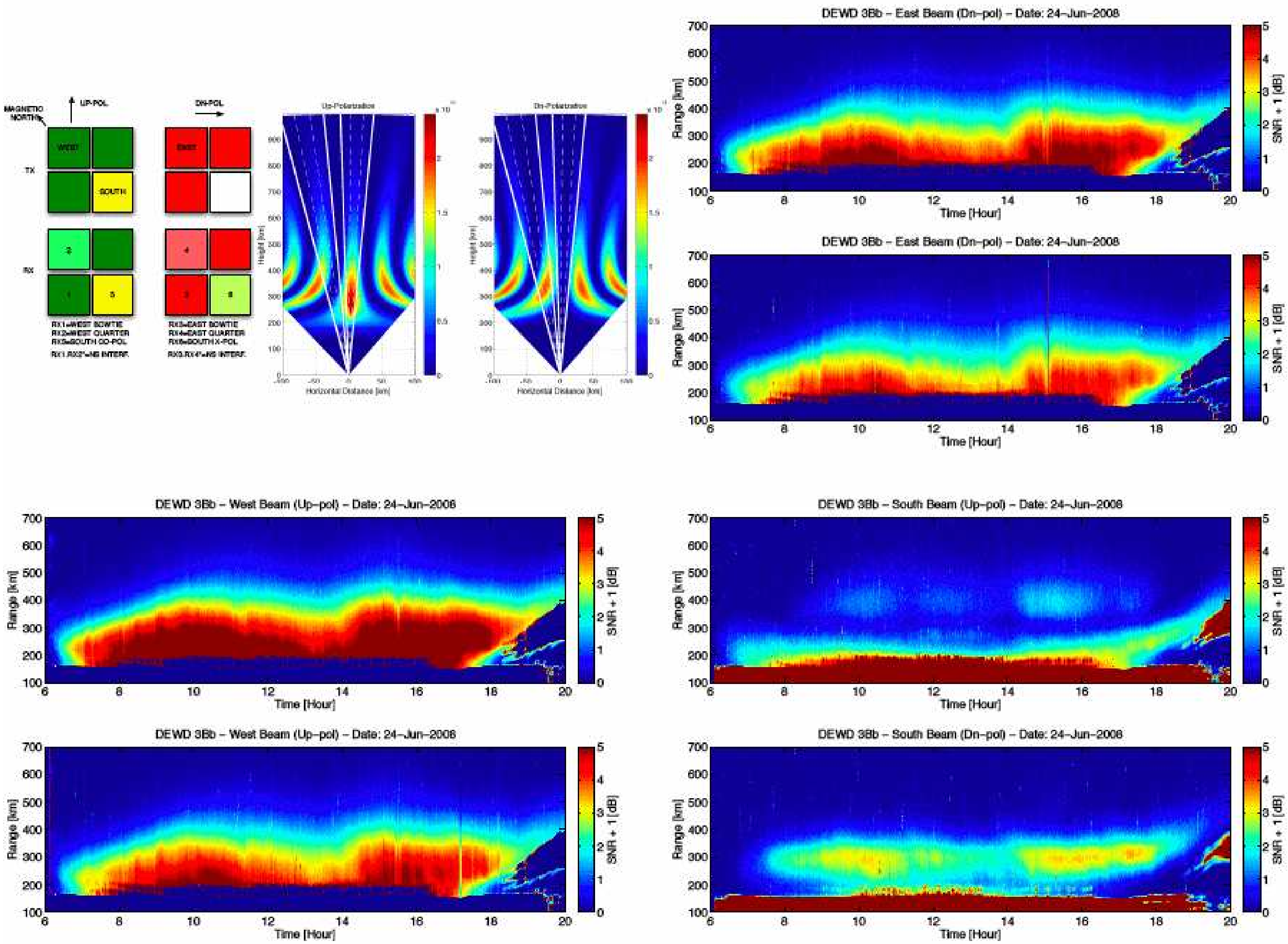


Using this collisional IS spectrum theory and including magnetoioinic propagation effects we can model the beam-weighted spectrum measured at Jicamarca. Using this model, we can fit the data and obtain Te. Of course, we can use these estimates to improve our estimates of Ne and Te/Ti.



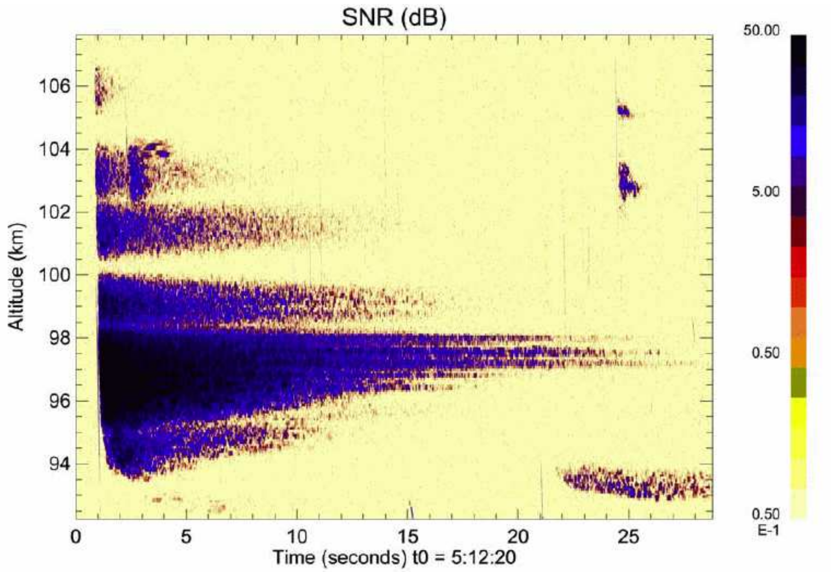
Kudeki and students, 2008

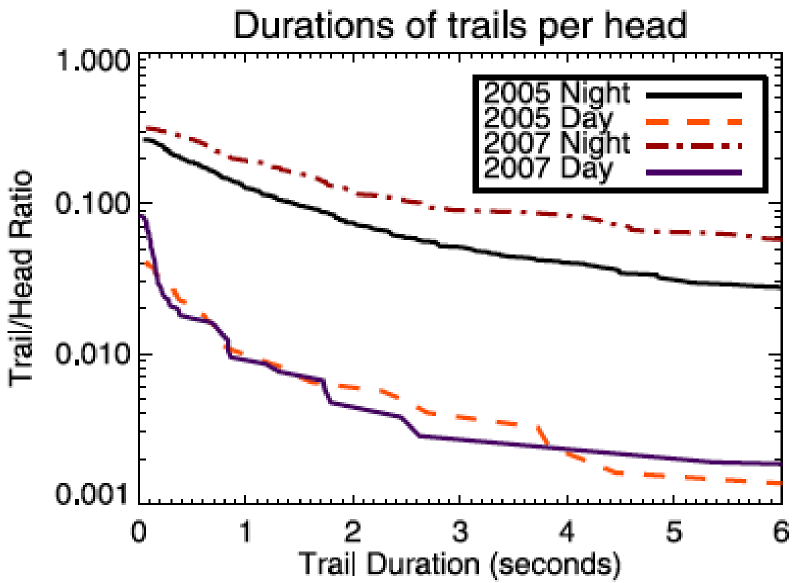
highlight V.I



Kudeki and students, 2008

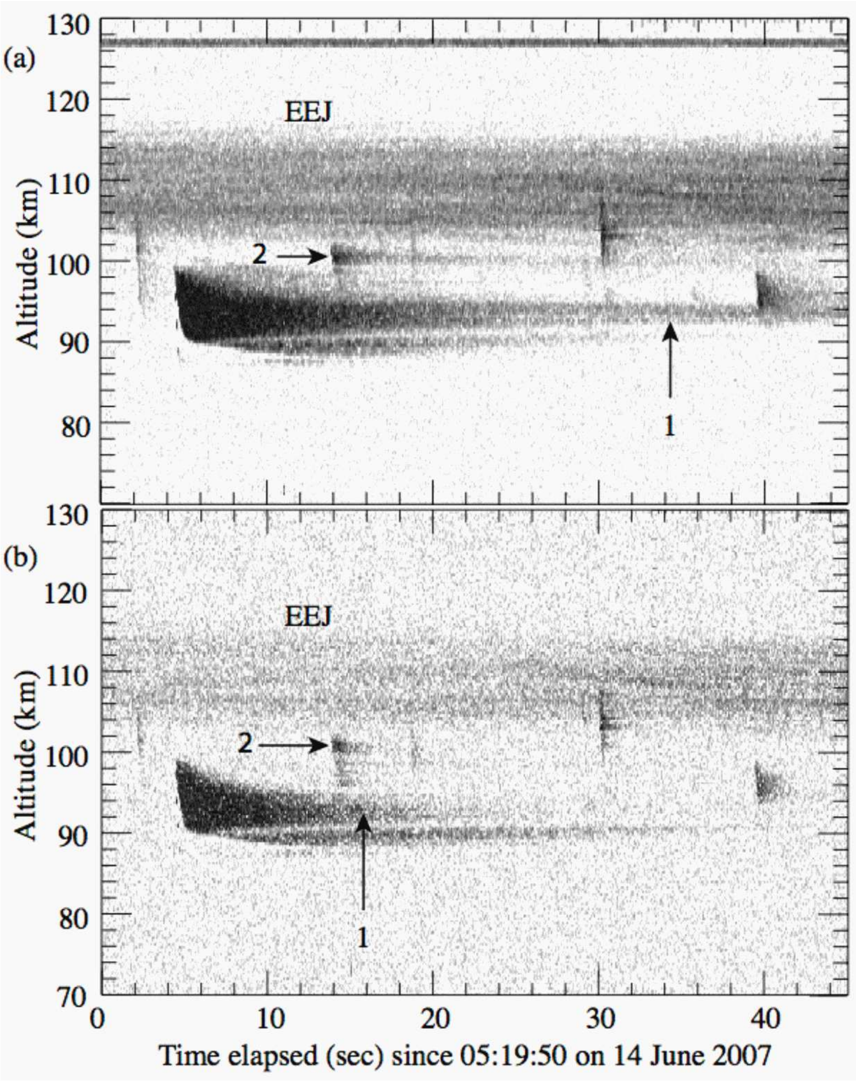
highlight VI





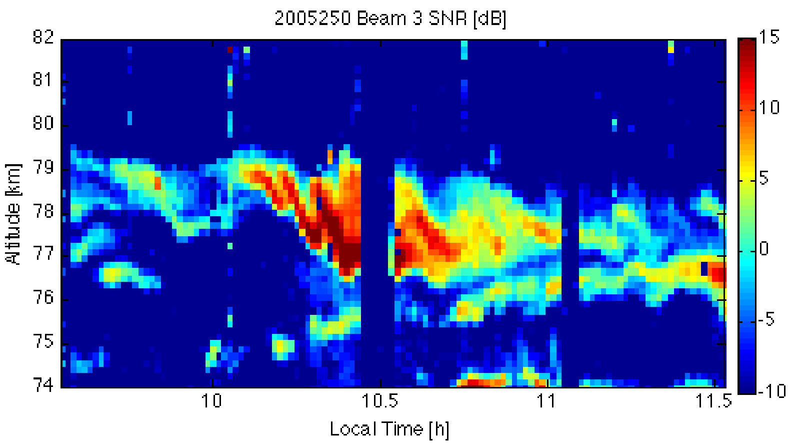
- The results of high range and temporal resolution experiments at Jicamarca show the expected differences
- Recent theoretical development predicted day and night differences on the duration of non-specular meteor trails: Oppenheim et al., 2007

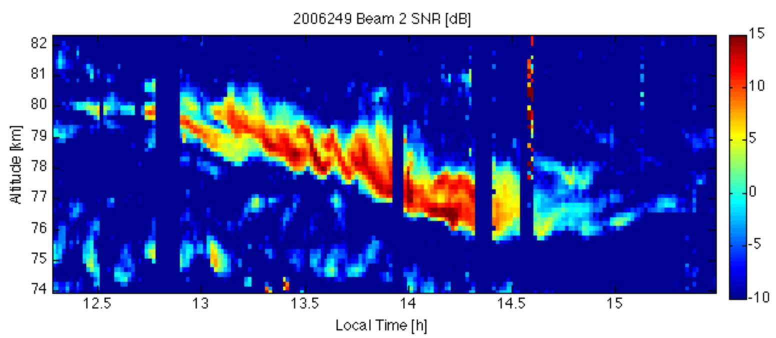
highlight VI.I



- Malhotra et al. [2007a] hypothesized that the duration of the trail echoes dependent on the angle with respect to B (longer coming perp B)
- A receiving site (CAR) was installed 5 km South of JRO. -Bistatic and monostatic observations of concurrent events show longer duration trails at Jicamarca than Carapongo, supporting the hypothesis above
- Trainee, 2006

highlight VII

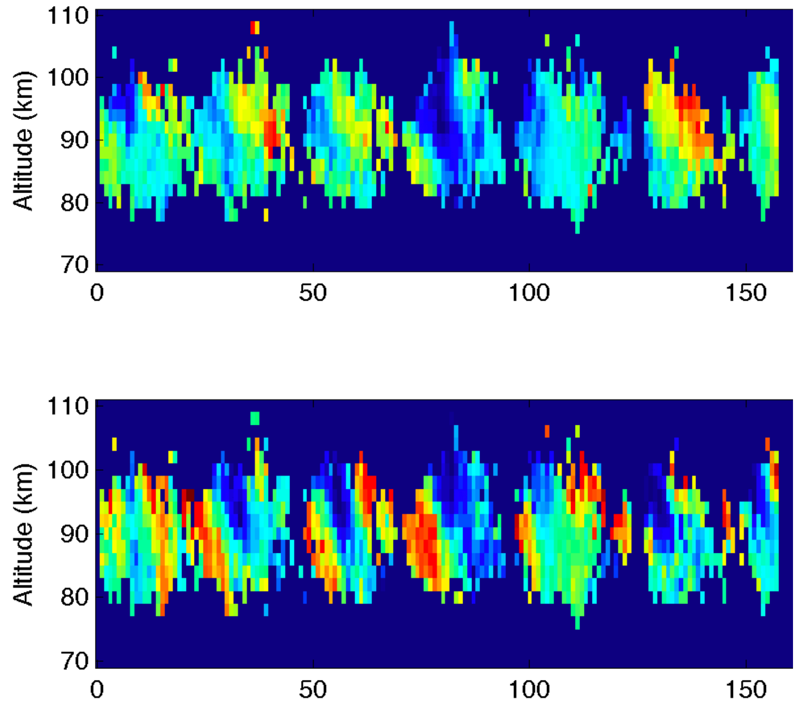




- Kelvin-Helmholtz instabilities excited by wind shears in the mesosphere lead to strong gradients in temperature and electron densities
- Bragg scale (3 m) irregularities cause enhanced echoes. When turbulence mixes the layers, the sharp edges broaden and fade: Lehmacher et al., 2007

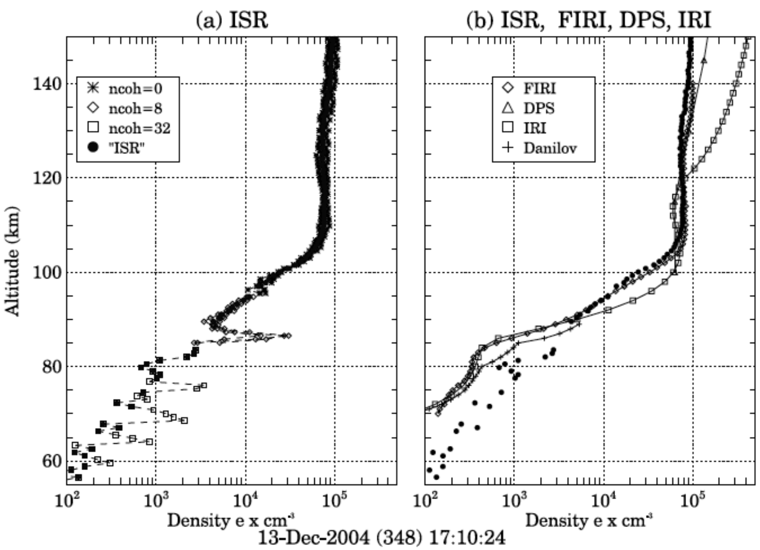
highlight VII.I

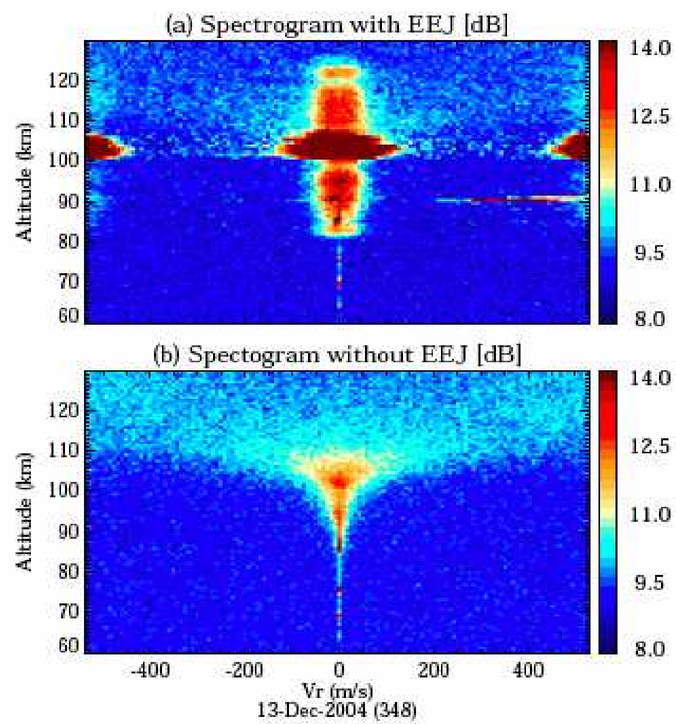
- JASMET measures MLT wind with strong tidal features, especially for meridional component
- Diurnal amplitudes are the strongest in equinox months, and much weaker in solstice months. Semidiurnal amplitudes do not show such pattern
- Diurnal amplitudes are smaller than GSWM prediction



- JASMET amplitude profiles shift 5-10km from TIDI
- Symmetric pattern in monthly zonal and meridional diurnal amplitudes, agree with GSWM prediction and the maxima occur at the same altitude (95km and 100km): L. Guo, Trainee, 2007

highlight VIII

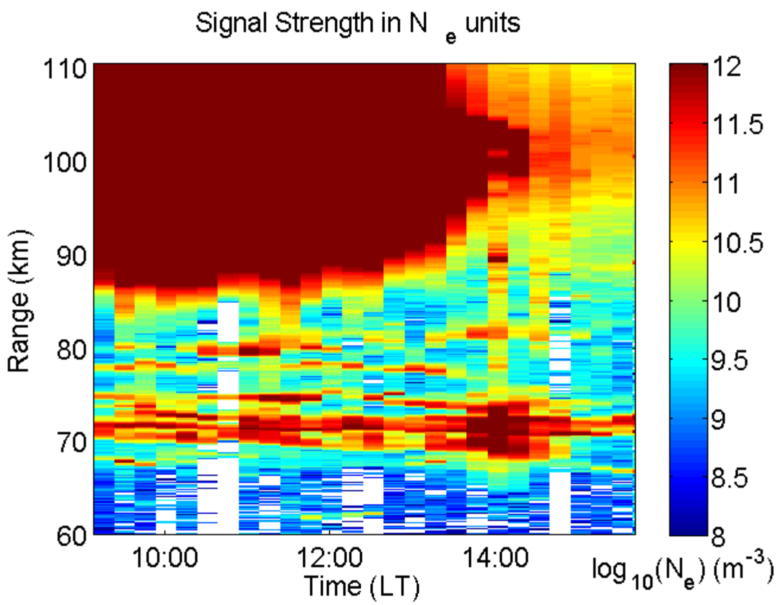


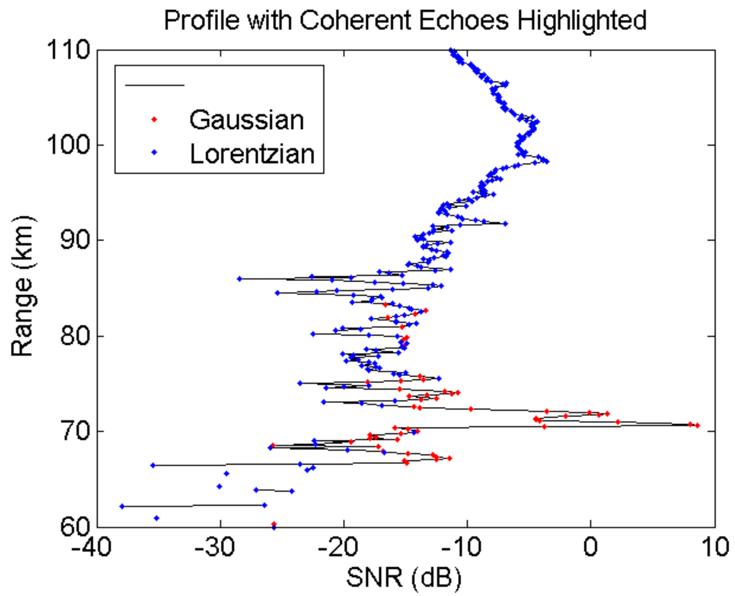


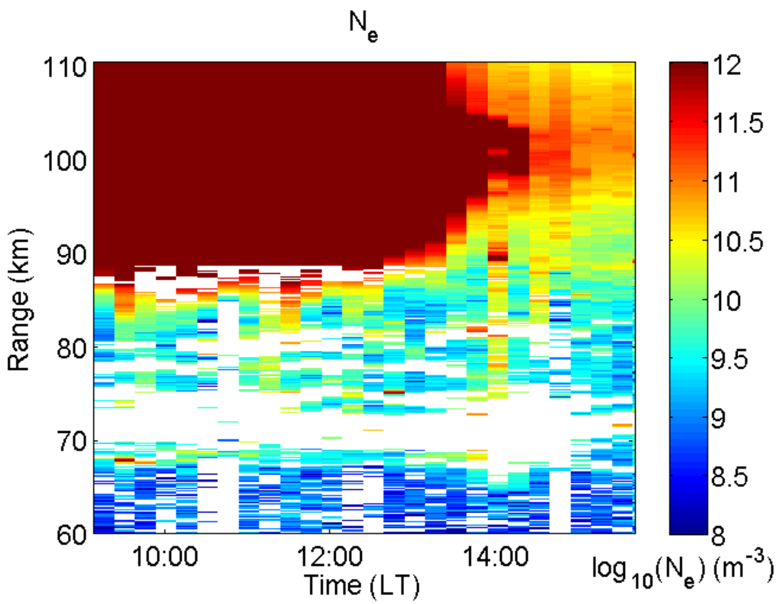
— Chau and Woodman, 2005
— Chau and Kudeki, 2006

- Challenging measurements: (a) presence of EEJ (E and upper D), mesospheric echoes (D), and meteor echoes (D and E); (b) poor recovery of T/R switches
- First successful measurements during a weak EEJ event using improved acquisition system (digital rxs, 1 us sampling/tx, high data throughputs)

highlight VIII.I

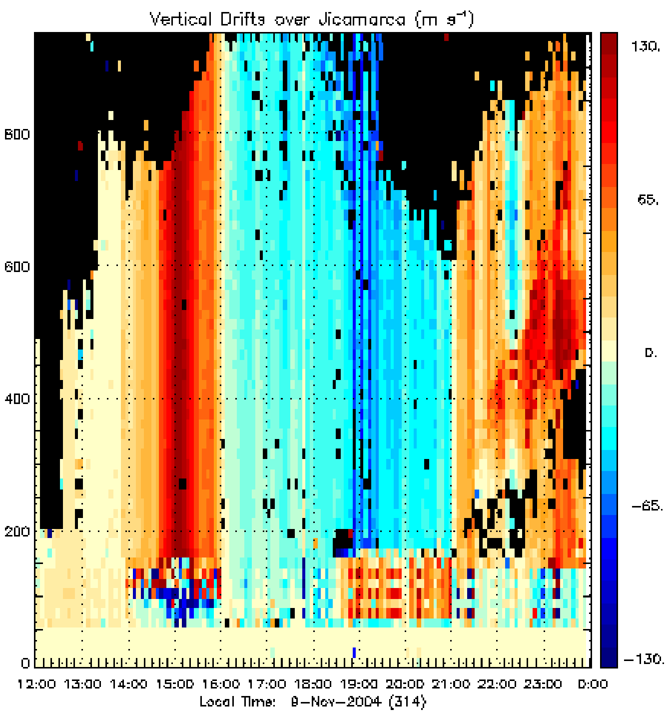


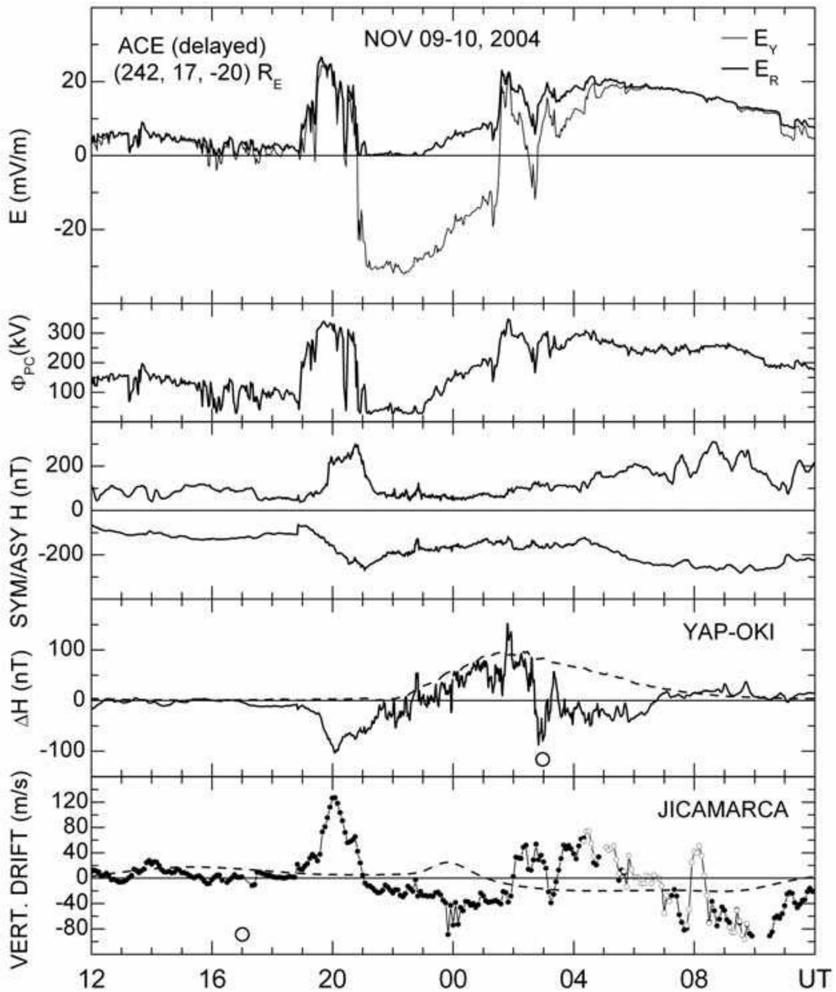




- Profiles for other times
- Meteors and satellites are cleaned using order statistics
- In the D-region, ISR and CSR echoes are identified using Gaussian (CSR) and Lorentzian (ISR): R. Varney, Trainee, 2008

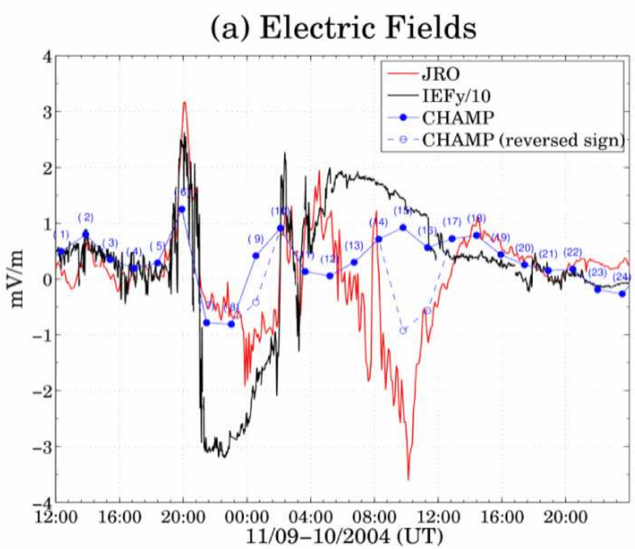
highlight IX





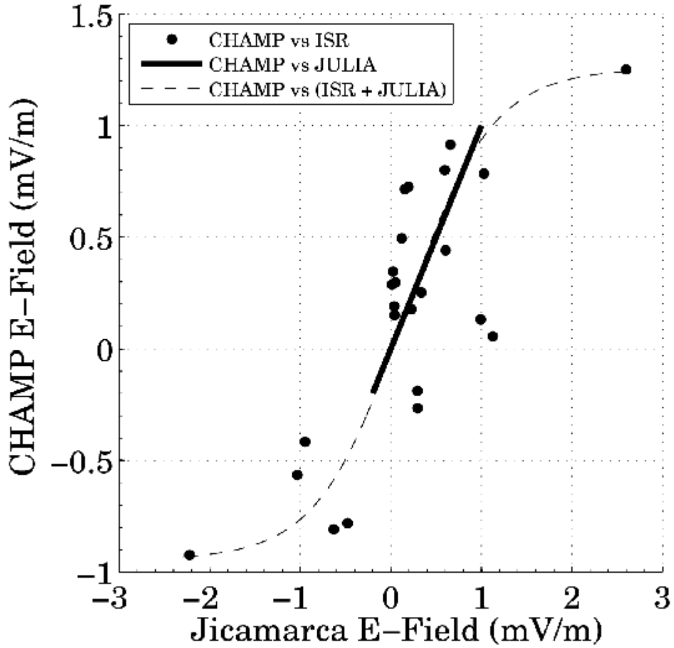
- The LARGEST daytime prompt penetration electric fields (about 3 mV/m) ever observed over Jicamarca occurred during the Nov 9 storm main phase, when large EEJ current and drift perturbations were also present in the Pacific and Brazilian equatorial regions: Fejer et al., 2007

highlight X



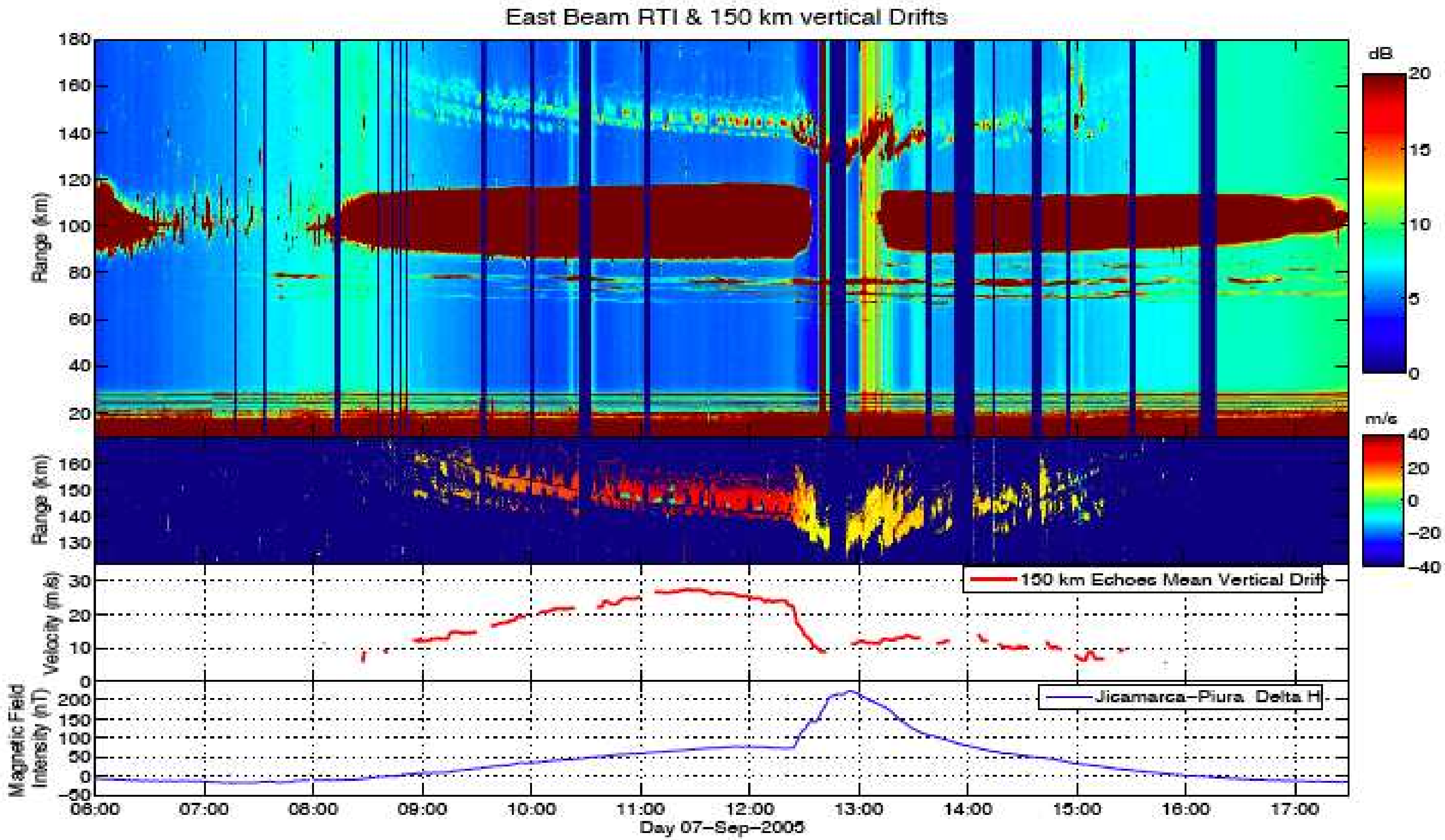
(b) CHAMP Satellite Pass Info

Number	LT	Longitude
(1)	14:33:10	31.60
(2)	14:33:22	8.49
(3)	14:33:47	-14.59
(4)	14:33:40	-37.56
(5)	14:33:19	-60.44
(6)	14:33:02	-83.49
(7)	14:32:30	-106.65
(8)	14:32:20	-129.78
(9)	14:32:26	-152.91
(10)	14:32:15	-176.04
(11)	14:31:12	160.81
(12)	14:28:27	137.70
(13)	14:26:35	114.62
(14)	14:26:55	91.53
(15)	14:27:23	68.45
(16)	14:27:36	45.36
(17)	14:27:41	22.24
(18)	14:28:04	-0.85
(19)	14:28:18	-23.91
(20)	14:28:00	-46.81
(21)	14:27:45	-69.75
(22)	14:27:20	-92.86
(23)	14:26:52	-116.01
(24)	14:26:55	-139.14

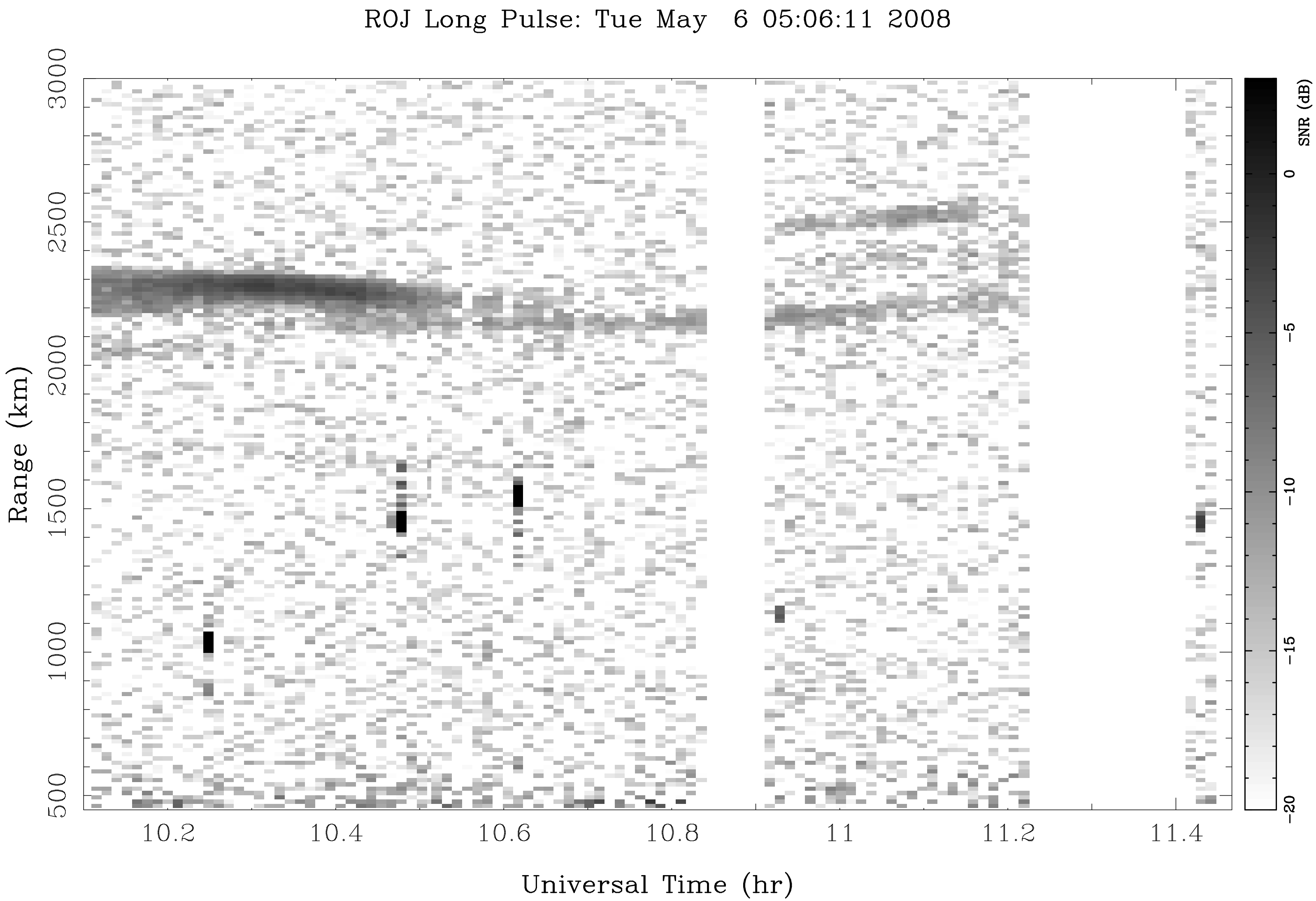


- For zonal electric fields greater than about 1 mV/m the linear relationship between CHAMP-deduced electric fields and Jicamarca measured electric fields breaks down
- The observed magnetic field on CHAMP is a factor of two smaller than expected for the largest zonal electric field (3.2 mV/m) observed at Jicamarca simultaneously in time and nearby spatially
- Our results indicate that the Farley-Buneman waves must be the source of the physical mechanism for the reduced current: Ilma et al., 2007

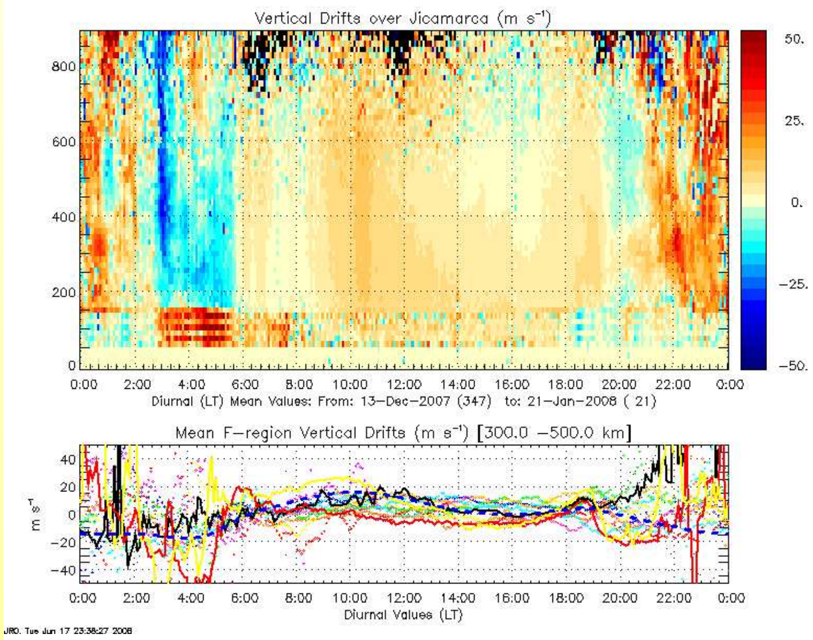
discovery I

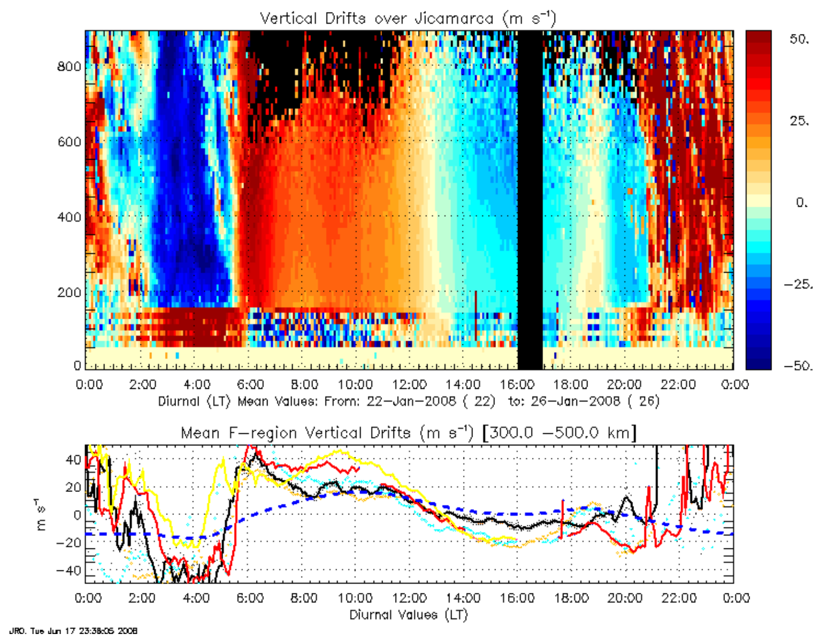

East Beam RTI & 150 km vertical Drifts
Range (km)
dB
m/s
150 km Echoes Mean Vertical Drift
Velocity (m/s)
Magnetic Field Intensity (nT)
Jicamarca−Piura Delta H
Day 07−Sep−2005
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00

discovery II



discovery III

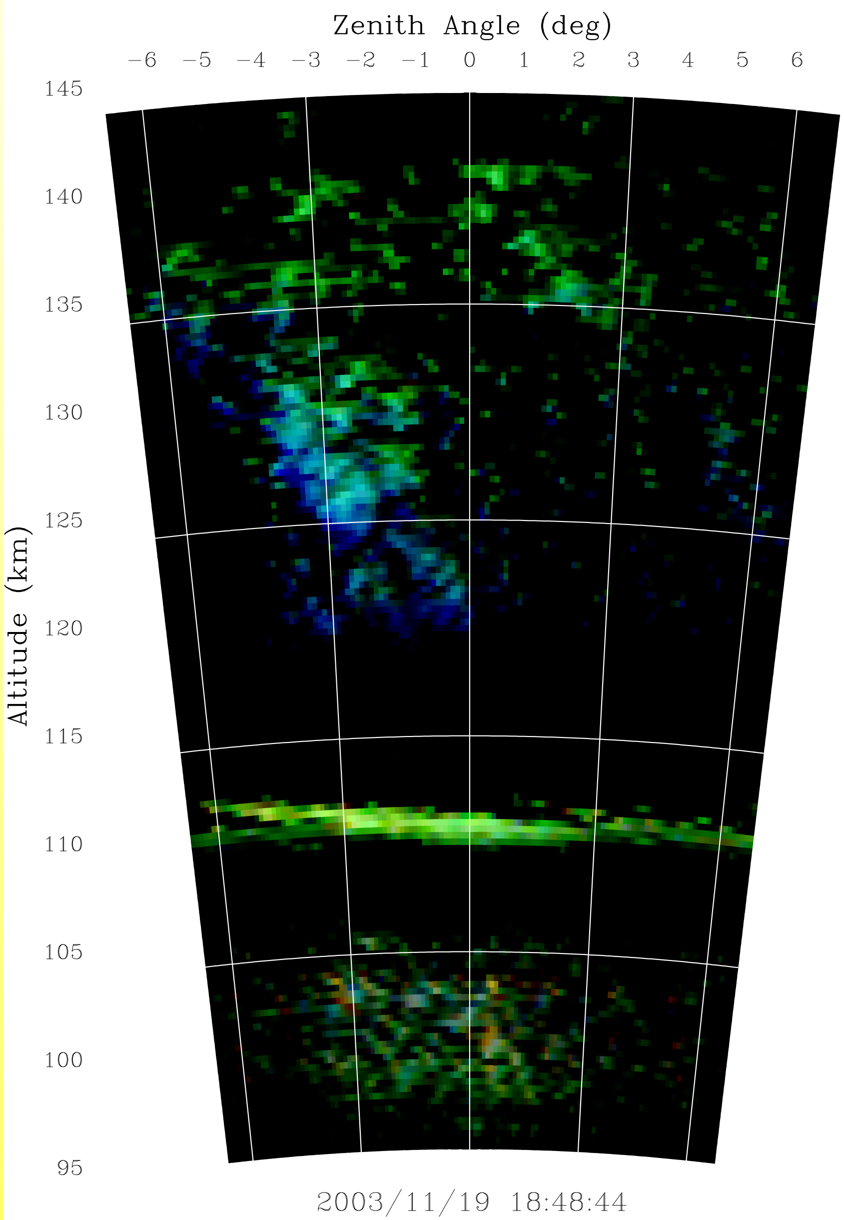




— Dec 2007 – Jan 2008 (no SSW) — Jan 22-26 2008 (SSW)

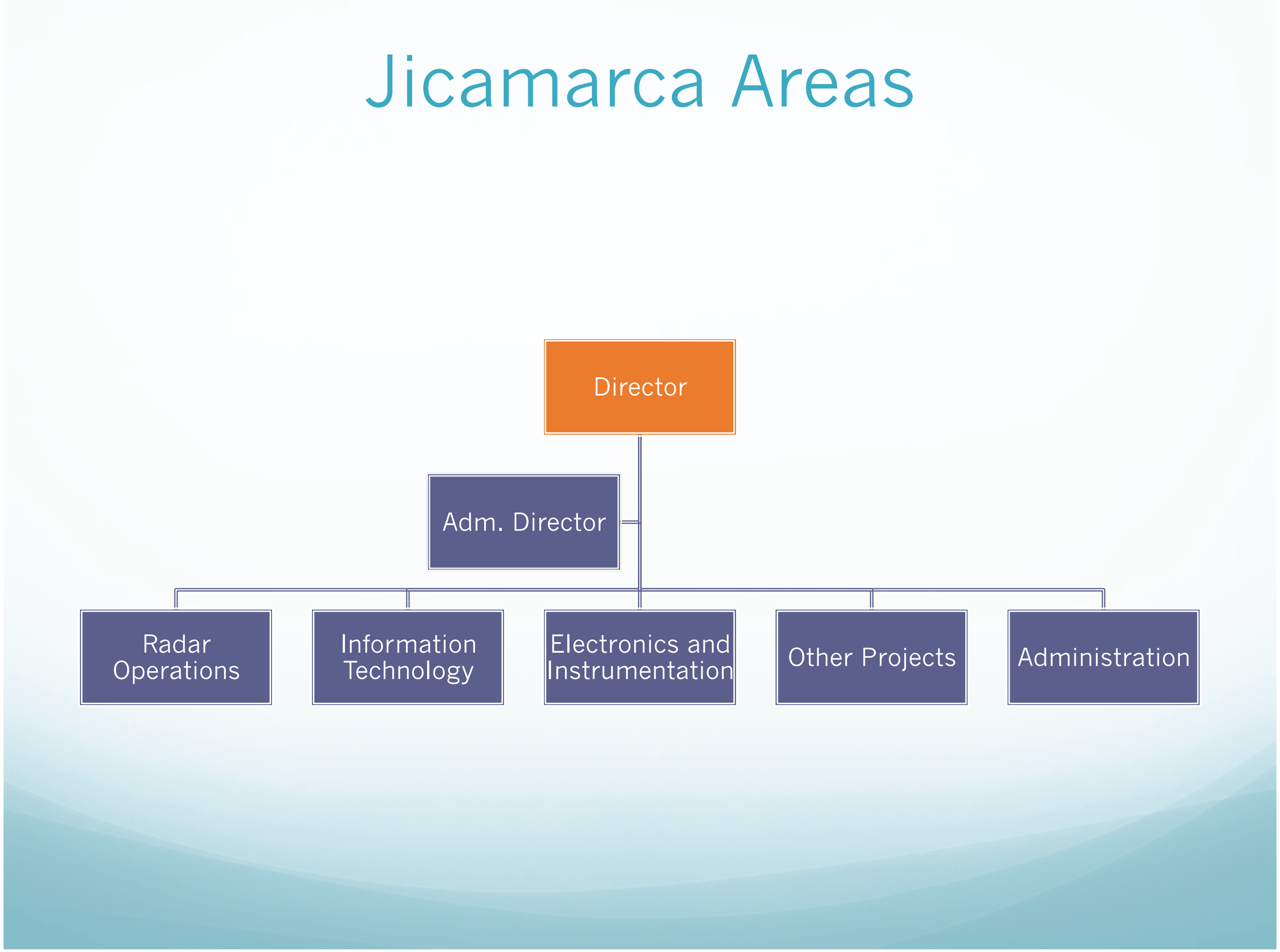
- Strong semidiurnal pattern, particularly during the day, is observed in the EQ F region vertical drift during Jan 2008 ISR SSW campaign. Nighttime measurements are contaminated by strong ESF clutter
- Same vertical drift signature is observed during the Dec 2000 ISR campaign (high solar conditions) and in Jan 2003. The latter is shown in 150-km drifts and also on magnetometer ΔH (Chau et al., 2008)

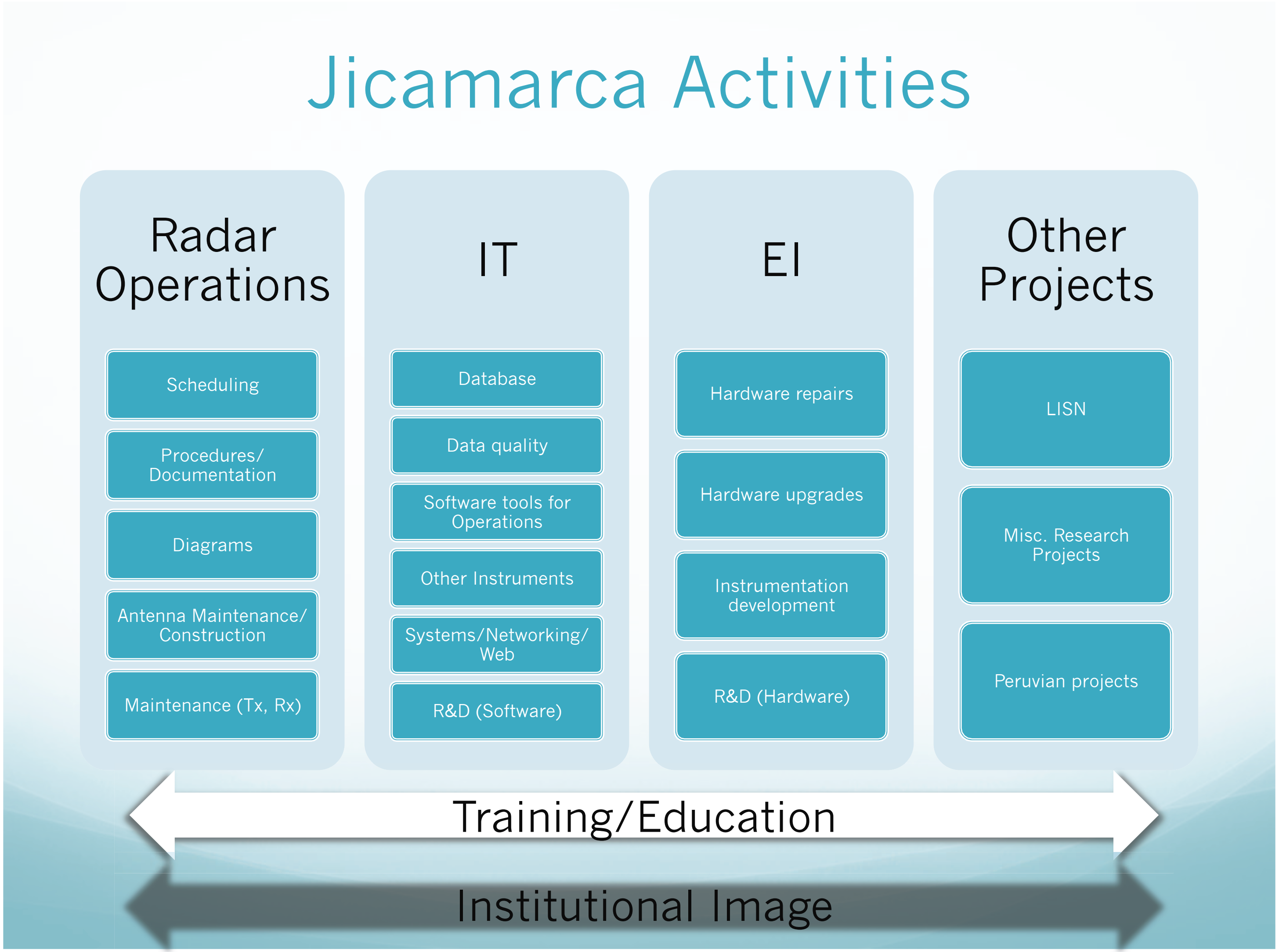
discovery IV

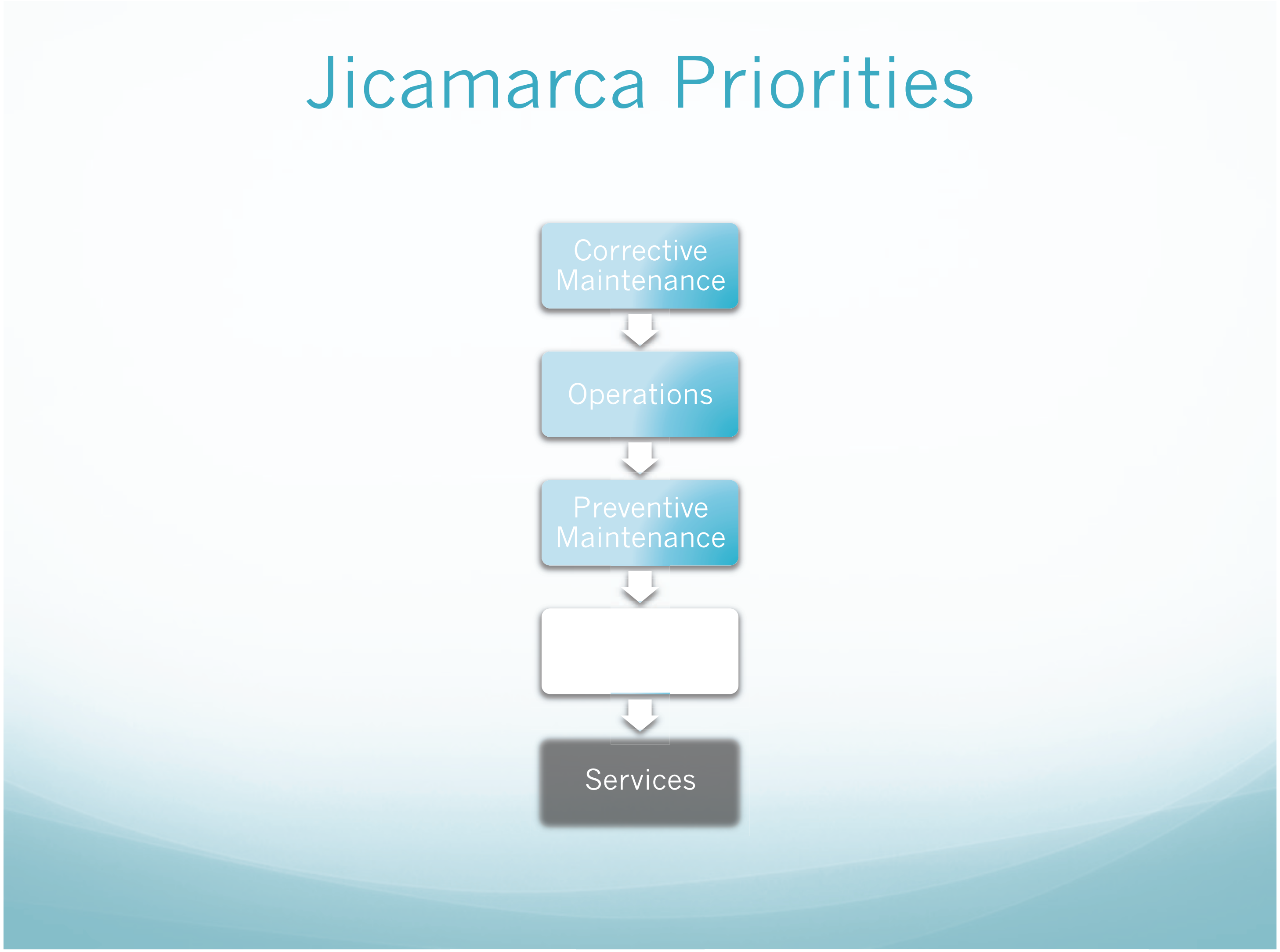


animation

organization




Jicamarca Activities
Radar Operations
Scheduling
Procedures/ Documentation
Diagrams
Antenna Maintenance/ Construction
Maintenance (Tx, Rx)
IT
Database
Data quality
Software tools for Operations
Other Instruments
Systems/Networking/ Web
R&D (Software)
EI
Hardware repairs
Hardware upgrades
Instrumentation development
R&D (Hardware)
Other Projects
LISN
Misc. Research Projects
Peruvian projects
Training/Education
Institutional Image

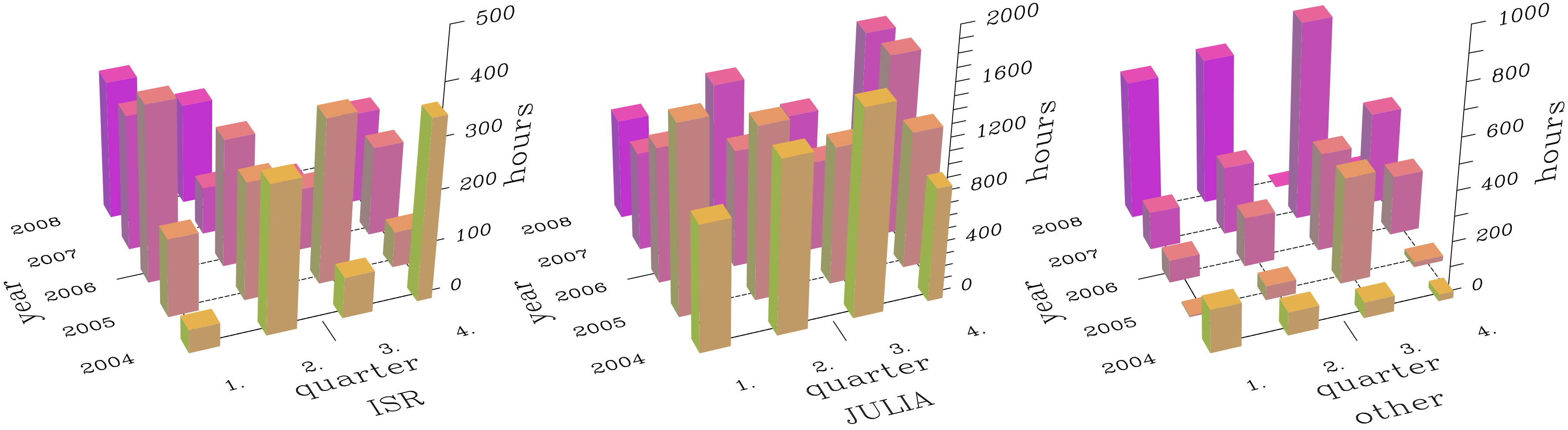

Jicamarca Priorities
Corrective Maintenance
Operations
Preventive Maintenance
Services

Jicamarca Radio Observatory

instrument cluster

Instrument	Institution	Site	Misc.
JULIA	JRO	Jicamarca	many antenna arrays
scintillation Rx	AFRL	Ancon	S4, irregularity drifts
digisonde	AFRL	Jicamarca	Ne
magnetometers	JRO	Jicamarca, Piura	ΔH
ST radars	IGP, UDEP	Northern Peru	winds and turbulence
FPI	Clemson	Arequipa	nighttime winds and temps.
FPI SOFDI	Clemson, UNJ, IGP	Huancayo	24-hr winds and temps.
SOUSY radar	JRO	Jicamarca	high res., low alt. winds
AMISR proto.	SRI, JRO	Jicamarca	EEJ, ESF, meteor echoes at UHF
LISN	BC, IGP	South America	TEC, S4, irregularity drifts, ΔH
JASMET	JRO, ATRAD	Jicamarca	specular meteor radar (50 MHz)
bistatic	JRO	JRO/Paracas	Daytime E-region Ne

operations

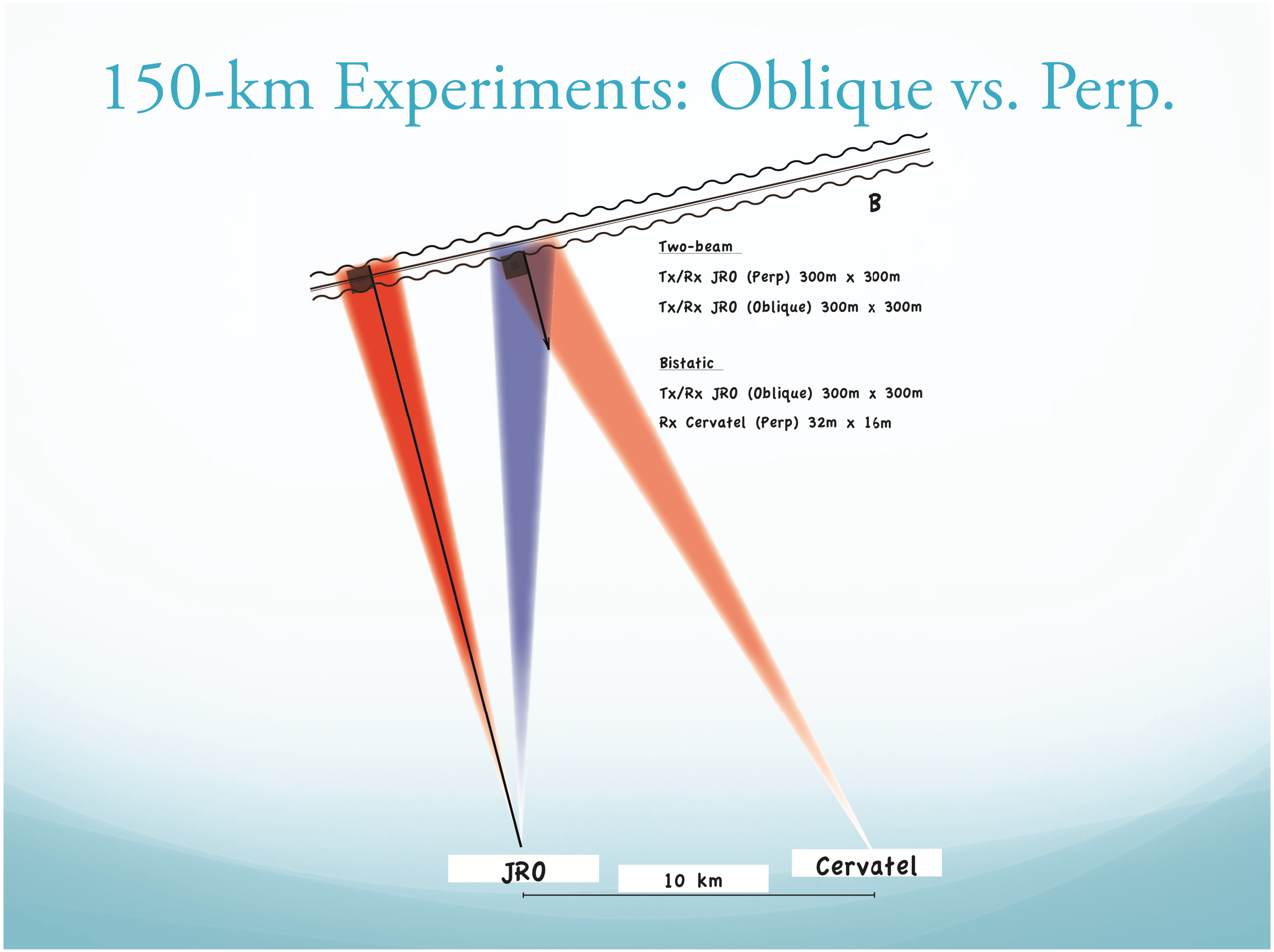


- On track for 6300 hours in 2008!
- "Other" includes aspect sensitivity and imaging, meteor heads, multistatic meteors, JASMET, solar echoes, passive modes, tests, skymaps.

upgrades and maintenance

component	description	comment
main antennas	quarterly maintenance	dipoles, feed points
other antennas	new Yagi modules	150-km tristatic, meteor bistatic
T/R switches	medium power passive	replacing old spark gaps
Txs	solid-state low power driver	improved bandwidth (1 μs)
Tx power supply	from 17 to 20 kV	improved avg. power, shape
Rxs	6 echotek + 2 homebrew	improved dynamic range, throughput, I/Q
radar controller	FPGA based	8/16 line version with GPS sync, ext. clock
DDS	AD based + μController	multifrequency pulse-to-pulse

multistatic system



JRO improvements 2007-8

- Averaged transmitter power for two transmitters improved from $\sim$65 kW to $\sim$100 kW (improvement in Power supply from 17 kV to 20 kV) [O. Castillo et al.]
- Development and construction of magnetometers [O. Veliz et al.]
- Multi-static capabilities using digital receivers [K. Kuyeng et al.]
- Development of 100 kW passive T/R switches [F. Villanueva et al.]
- Development of a 16-line radar controller [J. Muñoz]
- Development of Strategic plan for Management and Operations (help from consultants)
- Electronic beam steering

technique development

- Hybrid ISR modes + full-profile analysis
- Radar Imaging improvements: full-covariance, different receiving antennas, automatic calibration, code simplification and optimization
- Satellite (outlier) removal improvement using order statistics
- Improved noise estimation
- Meteor-head detection.
- JASMET
- Zonal drifts from 150-km echoes
- FPI analysis using 2D approach

publications

- about 120 JRO publications since start of 2005, 160 since 2004
- about 25 of these theses
- over 50 distinct first authors, not counting theses
- Special issue of JASTP November 2004

2007–8 student support

Student	Advisor	Degree/Inst	Topic
M. Milla	E. Kudeki	Ph.D./UIUC	perpendicular ISR parameters
F. Rodrigues	D. Hysell	Ph.D./Cornell	oblique ISR parameters
P. Reyes	E. Kudeki	Ph.D./UIUC	mesosphere/150-km/perp B
E. Bass	M. Oppenheim	Ph.D./BU	meteoroid mass from heads
A. Malhorta(*)	J. Mathews	Ph.D./PSU	meteor heads, trails, spE
L. Guo(*)	G. Lehmacher	Ph.D./Clemson	"ignorosphere" parameters
R. Ilma	M. Kelley	Ph.D./Cornell	EEJ anomalous resistivity
G. Sugar	M. Oppenheim	B.S./BU	day/night trail differences
S. Flores	J. Chau	M.S./PUCP	FPI 2D anal.
N. Yoza	J. Chau	B.S./PUCP	EEJ communications
H. Pinedo	J. Chau	M.S./PUCP	high-resolution spectral techniques

- +observatory visits
- +9 additional Peruvian students

Jicamarca experiment support

To improve operations and ensure data quality, starting in 2008, each experiment has an assigned local user, responsible for:

- interacting with the end user and/or the Jicamarca Director to define experiment parameters, programs, and schedule
- coordinating with the Chief of Operations the experiment parameters and on-line tools
- approving the experiment configuration and performing test runs
- inspecting the first-look data quality
- processing the data and verifying data quality (routine experiments)
- uploading processed data to databases (routine experiments)
- developing tools for on- and off-line processing

experiment support

Mode	Local User	Area	End User
ISR oblique	L. Condori	IT	D. Hysell, J. Meriwether, C/NOFS, CITRIS
ISR perp	F. Galindo	IT	E. Kudeki et al., C/NOFS
JULIA	H. Pinedo	IT	many
bistatic	H. Pinedo	IT	D. Hysell, M. Nicolls, P. Strauss
150-km drifts	H. Pinedo	IT	D. Anderson, B. Fejer, others
BLR	L. Flores	IT	IGP
MST-ISR	K. Kuyeng	IT	E. Kudeki, G. Lehmacher, et al.
LISN ionosonde	C. De. la Jara	EL	T. Bullet, B. Livingston, C. Valladares, J. Chau
AMISR	F. Galindo	IT	D. Hysell, R. Cuevas, D. Scipion
JASMET	L. Condori	IT	L. Guo, D. Holdsworth, G. Lehmacher
meteor heads	F. Galindo	IT	J. Chau, M. Oppenheim, J. Mathews et al.

2007–8 campaigns

User	Institution	Time	Topic
C. Siefring, P. Bernhardt	NRL	Jul 2007	CITRIS cal.
M. Oppenheim, E. Bass	BU	Jul 2007	meteor heads (6 rx, 2 pol)
C. La Hoz/ V. Belyey	U. Tromsø	Jul 2007	150-km 3D imaging
J. Chau/ M. Oppenheim	JRO/BU	Sep 2007	Aurigids shower
J. Chau/ M. Oppenheim	JRO/BU	Sep 2007	biststic meteors (heads & trails)
M. Milla/ E. Kudeki	UIUC	Apr 2008	bistatic 150-km (oblique vs. perp)
D. Hysell	Cornell	May 2008	oblique ISR
C/NOFS EWG	AFRL et al.	June 2008	vertical & zonal drifts
E. Kudeki/ P.. Reyes	UIUC	June 2008	3-beam ISR
L. Guo/ G. Lehmacher	Clemson	monthly	JASMET (mesospheric winds)

- excludes World Days, low-power, passive, etc.

Visitors 2007–8

- July 2007: M. Oppenheim. Boston University
- August 2007: J.-P. St. Maurice. University of Saskatchewan
- January 2008: A. J. Gerrard. New Jersey Institute of Technology
- February 2008: J. Estela. German Spacial Agency
- March 2008: V. Belyey, C. La Hoz. University of Tromsø
- March 2008: M. Milla. University of Illinois
- April 2008: D. Hysell. Cornell University
- June 2008: B. Livingston, T. Bullet, C. Valladares, R. Grubb. LISN
- June 2008: E. Kudeki. University of Illinois

LISN: Jicamarca role

- Overall management of instrument deployment, operations, database [E. Silvestre, J. Chau]
- Development of affordable magnetometers [O. Veliz et al.]
- Feasibility study of *E* region density measurements around twilight with LISN ionosondes [R. Woodman, C. de la Jara]

satellite support

- COSMIC O. de la Beaujardiere et al., G. Bust et al.
- DMSP (SSUSI, SSULI) J. Makela, P. Strauss, R. Heelis.
- CITRIS C. Siefring, P. Bernhardt
- C/NOFS (CalVal, science) AFRL, EWG
  – electron density profiles
  – electric fields and drifts
  – temperature and composition
  – GPS radio occultation
  – radio beacon scintillation, tomography
  – ESF occurrence, behavior

database(s)

Mode	CEDAR	Madrigal	JRO web	JRO internal	other
ISR oblique	Ne Te Ti %	Ne Te Ti %	Ne Te Ti %	raw data	Cornell
ISR perp	drifts	drifts	drifts	raw data	Illinois
JULIA			SNR, drifts	spectra	Cornell
bistatic	E Ne	E Ne	E Ne	spectra	
150-km	drifts		drifts	spectra	Cornell
BLR			winds	ACFs	
Digisonde			ionograms	ionograms	Lowell
mags			ΔH	1-min	

- GPS, other
- useful online programs (sky noise, antenna patterns, indices)
- `http://jro.igp.gob.pe/english/database_en.html`

Jicamarca real time

- Depending on the mode:
  – averaged spectra and cross-spectra for selected pairs of channels
  – range-time plots of selected parameters: SNR, coherence, phase difference
  – range-time and averaged plots of derived parameters: vertical and zonal drifts
  – multi-radar plots, e.g., JULIA and bistatic
- electronic log-book for Jicamarca staff or external user

`http://jro.igp.gob.pe/english/radar/operation/real-time_en.php` http://jro.igp.gob.pe/DB_Admin/JRO_Schedule/Sc...

July 2008
Today

M. Jan Y. 2008
Go

Sun	Mon	Tue	Wed	Thu	Fri	Sat
29 (181) <-> JULIA.	30 (182) <-> JULIA.	1 (183) <-> JULIA.	2 (184) <-> JULIA.	3 (185) <-> JULIA.	4 (186) <-> JULIA.	5 (187) <-> JULIA.
6 (188) <-> JULIA.	7 (189) <-8 JULIA.	8 (190) 8-> ISCOD.	9 (191) <-> ISCOD.	10 (192) <-> ISCOD.	11 (193) <-> ISCOD.	12 (194) <-> ISCOD.
13 (195) <-8 ISCOD.	14 (196) 10-15 D & F.	15 (197) 10-15 D & F.	16 (198) 10-15 D & F.	17 (199)	18 (200)	19 (201) 0-> C-NOF.
20 (202) <-> C-NOF.	21 (203) <-24 C-NOF.	22 (204) 8-> JULIA	23 (205) <-> JULIA	24 (206) <-> JULIA	25 (207) <-> JULIA	26 (208) <-> JULIA
27 (209) <-> JULIA	28 (210) <-> JULIA	29 (211) <-> JULIA	30 (212) <-> JULIA	31 (213) <-> JULIA	1 (214) <-> JULIA	2 (215) <-> JULIA
3 (216) <-> JULIA	4 (217) <-> JULIA	5 (218) <-> JULIA	6 (219) <-> JULIA	7 (220) <-> JULIA	8 (221) <-> JULIA	9 (222) <-> JULIA

Welcome to the JRO Schedule

Click on a day or particular task for a detailed description.

Types of tasks

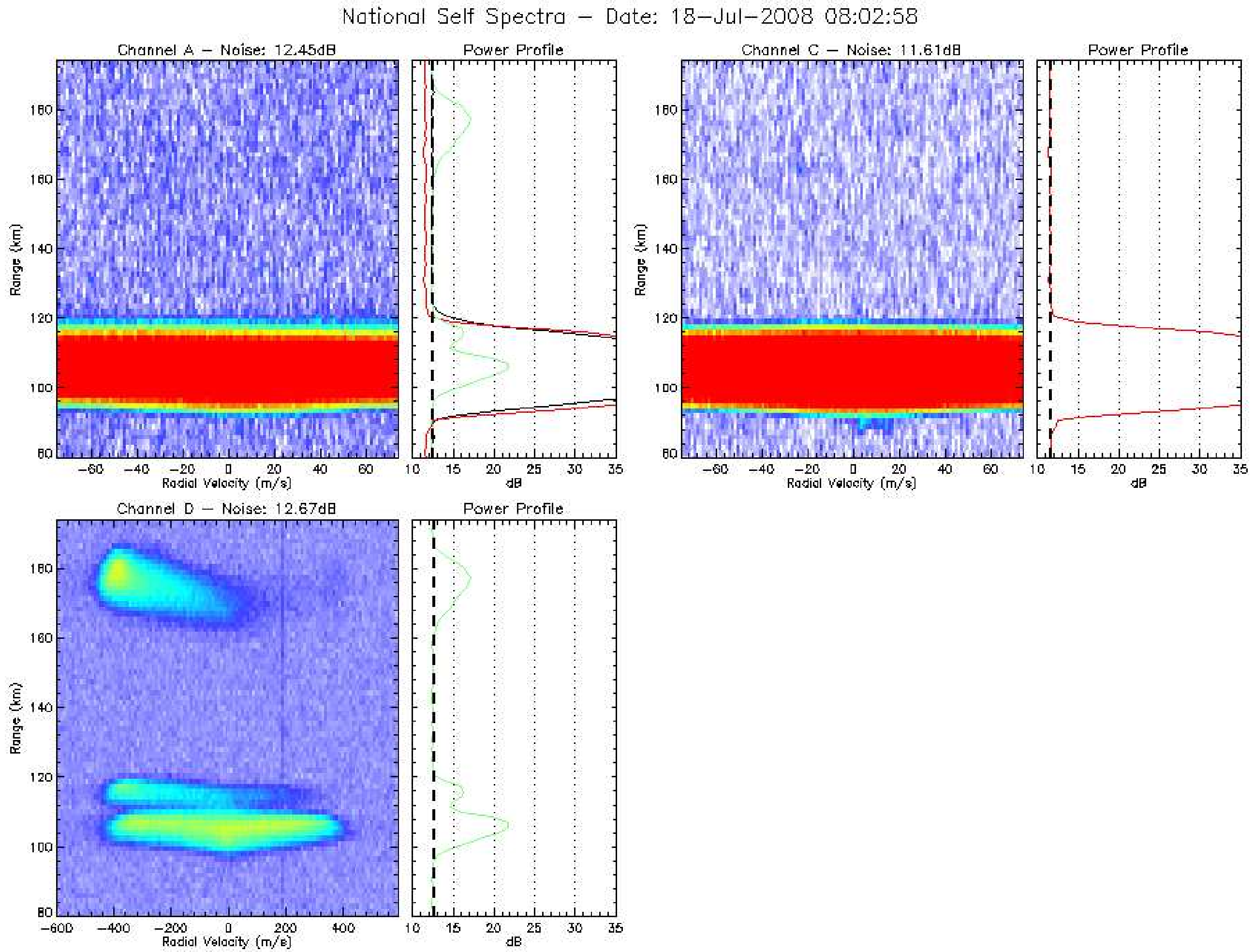
- Jicamarca
- JULIA
- Maintenance
- SOUSY
- AMISR
- Bistatic System
- Antennas
- JASMET
- Other

The first 3 symbols or numbers show the starting and ending hour of a task on a particular day. Examples:

6 - 8	the task starts at 6 am. and ends at 8 am.
7 - 14	the task starts at 7 am. and ends at 2 pm.
5 - >	the task starts at 5 am. and continues through the next day.
< - 20	the task has been executed since the day before and will end at 8

displays

Instantaneous Display http://jro.igp.gob.pe/english/radar/operation/instan...



Instantaneous display will reload in 23 seconds.

Jiacmarca Newsletter

Newsletter

http://jro.igp.gob.pe/newsletter

Boletín Informativo | Año 2 - Nº1 [Marzo del 2008] | ENGLISH VERSION

Inside JICAMARCA

[Presentación] [Noticias] [Publicaciones y Ponencias] [Eventos] [Personal] [Otros]

PRESENTACIÓN

Hola a todos, les doy la bienvenida a una nueva presentación de Inside Jicamarca. Como han observado hemos cambiado de diseño y de diagramación y aprovecharemos este cambio para proponernos que nuestro boletín electrónico cruce los ámbitos del Radio Observatorio y llegue a los hogares de cada una de nuestras familias y amistades. Queda en cada uno de los integrantes de esta comunidad hacer conocer un poco más la labor y la misión que tiene el ROJ en nuestra sociedad y en el mundo.

Para esta primera edición del año 2008, en la Sección de Noticias contamos con la colaboración del Ingeniero Darwin Córdoba del Área de Mantenimiento, quien ha escrito sobre el proyecto "Componentes RF en el radar . TR hecho con componentes de estado sólido"; este artículo es una introducción al tema de circuitos de commutación y sus aplicaciones en radiofrecuencia. En posteriores ediciones, Darwin nos mostrará más componentes que son vitales para el

NOTICIAS

Conozcamos como funciona el radar principal del ROJ (1era Parte)

El radar del Radio Observatorio de Jicamarca está compuesto por subsistemas que manejan diferentes tipos de señales y realizan diferentes

ENTREVISTA

publications

- about 120 JRO publications since start of 2005, 160 since 2004
- about 25 of these theses
- over 50 distinct first authors, not counting theses
- Special issue of JASTP November 2004

2007–8 student support

Student	Advisor	Degree/Inst	Topic
M. Milla	E. Kudeki	Ph.D./UIUC	perpendicular ISR parameters
F. Rodrigues	D. Hysell	Ph.D./Cornell	oblique ISR parameters
P. Reyes	E. Kudeki	Ph.D./UIUC	mesosphere/150-km/perp B
E. Bass	M. Oppenheim	Ph.D./BU	meteoroid mass from heads
A. Malhorta(*)	J. Mathews	Ph.D./PSU	meteor heads, trails, spE
L. Guo(*)	G. Lehmacher	Ph.D./Clemson	“ignorosphere” parameters
R. Ilma	M. Kelley	Ph.D./Cornell	EEJ anomalous resistivity
G. Sugar	M. Oppenheim	B.S./BU	day/night trail differences
S. Flores	J. Chau	M.S./PUCP	FPI 2D anal.
N. Yoza	J. Chau	B.S./PUCP	EEJ communications
H. Pinedo	J. Chau	M.S./PUCP	high-resolution spectral techniques

- +observatory visits
- +9 additional Peruvian students

International Research Experience Program

Student	"Summer"	Degree/Inst	Topic
A. Malhorta (*)	2006	Ph.D./PSU	meteor heads, trails, and spE
L. Tracy	2006	B.S./U. W.	multifrequency DDS, passive radar
M. Mercado	2007	M.S./Polytechnic U. (PR)	WWW display tools for imaging
L. Guo (*)	2007	Ph.D./Clemson	"ignorosphere" parameters
R. Varney	2008	B.S./Cornell	*D* region experiments: ISR and CSR
B. Etzlinger	2008	B.S./Johannes Kepler	GPS disciplined clock,
			up-converter, filter

training/ career development

- Peruvian trainee program (2004-2008)
  – 5 trainees at the time for 3-6 months
  – 6 Engineering thesis
  – 3 M.S. students in Peruvian Universities
  – 6 Ph.D. students in U.S. universities: Cornell (2), U. Illinois (2), U. T. Dallas (1), Oklahoma Univ. (1)
- Jicamarca International Research Experience
  – 2 Ph.D. students with Jicamarca research topics (4 papers)
  – 1 M.S.
  – 3 B.S
- Jicamarca staff and trainees present at international meetings
- Postdoc studying equatorial aeronomy at Cornell with support from Japan

Cornell curriculum

- ECE 303 — electricity and magnetism
- EAS 484 — inverse methods
- ECE 486 — electricity and magnetism II
- EAS 487 — antennas and radar
- ECE 488 — rf design
- ECE 588 — incoherent scatter
- EAS 711 — upper atmospheric physics
- various special topics classes
- + Radar and Antennas class, U. Catolica, Lima

meetings hosted

Second Jicamarca School of Radars

- Dates: March 20-31, 2006
- Venue: JRO
- Organizers: J. Roettger, M. Sarango, J. Chau
- Lecturers: D. Farley, W. Swartz, J. Roettger, R. Woodman, J. Chau and M. Sarango
- Participants: 18 Peruvians + 1 Brazilian

First LISN Workshop and School

- Dates: August 1-9, 2007
- Venue: JRO
- Organizers: E. Silvestre, C. Valladares, J. Chau
- Participants: > 20 from different SA countries and USA.

`http://jro.igp.gob.pe/subwebs/jsr2/`
`http://jro.igp.gob.pe/lisn/workshop1/home.htm`

Jicamarca to host next ISEA