



# **The LISN distributed observatory: The Deployment Phase**



**Cesar E. Valladares, Boston College**

**Jorge L. Chau, JRO**

**Vince Eccles, Space Environment Corp.**

**Erhan Kudeki, Univ. Illinois**

**Ronald F. Woodman, IGP**

**Bill Wright & Nick Zabotin, DSL**



# Objectives

- **To build and install the first Distributed Observatory across the western half of South America. Provide real-time display of observables.**

**By using assimilation:**

- **To study the electrodynamics of the low-latitude ionosphere during magnetic quiet and disturbed conditions.**
- **To develop tools to forecast the initiation of equatorial spread-F (ESF) in a regional basis.**

**A distributed observatory to address aeronomy and space weather problems that will have a standard mode of operation, but at the same time special and campaign modes.**

# GPS selected for the LISN network

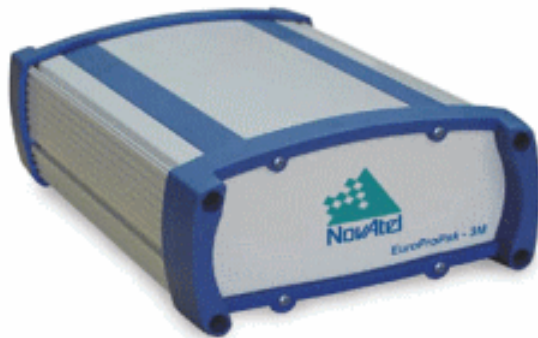
- SBAS capable (amplitude and phase).
- Tracks 10 GPS satellites and 3 SBAS.
- 50 Hz amplitude and phase measurement for scintillations.
- Stable ovenized crystal oscillator.

GPS

IONOSPHERIC

SCINTILLATION AND TEC

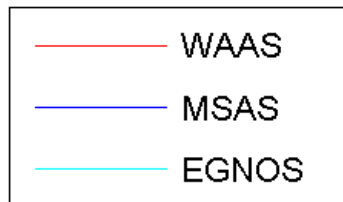
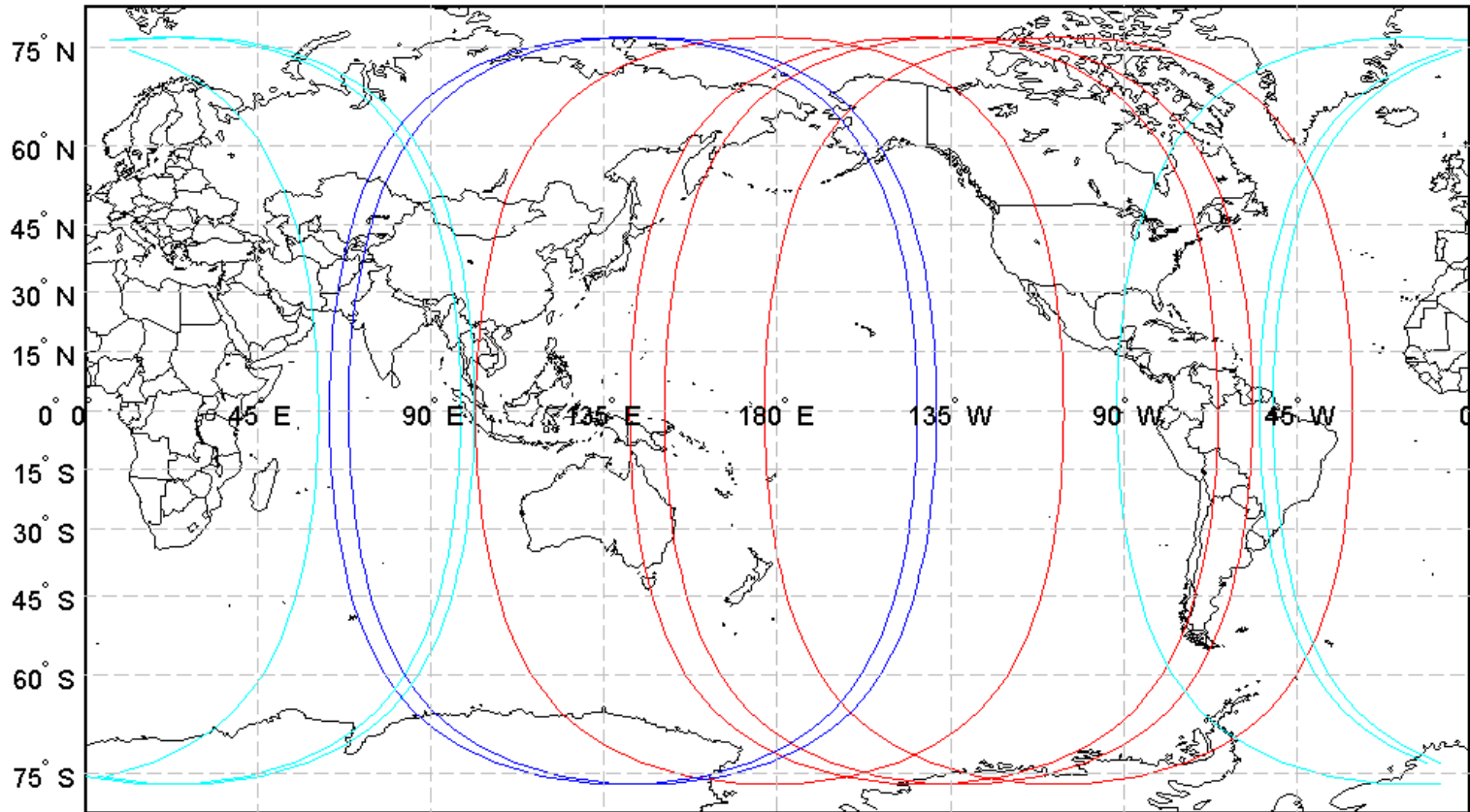
MONITOR GSV4004B



GSV4004B GPS IONOSPHERIC SCINTILLATION AND TEC MONITOR WITH

# Worldwide SBAS GEO Coverage

GEO Footprints @ 5 deg Elevation Angle Mask

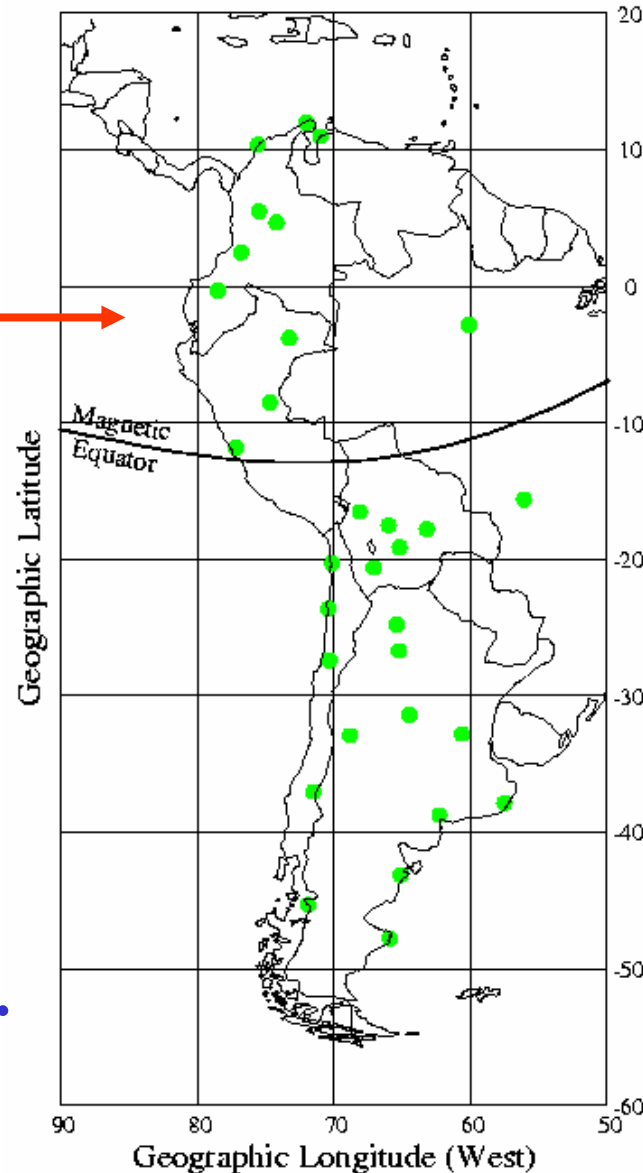




# Existent GPS receivers in SA

Operating GPS receivers in SA that will become part of the LISN network. Their infrastructure is being upgraded.

All these receivers (30) will give TEC in real-time basis. In addition, 17 of them will give scintillations.



Receivers belong to BC(6), Mike Bevis OSU (9), Claudio Brunini UNLP (7), Victor Rios UT, Bob Smalley (2) UM, K. Groves AF (2), Hector Mora INGEOMINAS (2), NGA (1), Yogesh Sahai UNIVAP (1).

# LISN GPS receivers to be installed

Installation to be conducted under the collaboration of (agreements signed with):

**Dr. J. Chau, JRO, Peru**

**Dr. C. Brunini UNLP, Argentina**

**Dr. E. DePaula, INPE, Brazil**

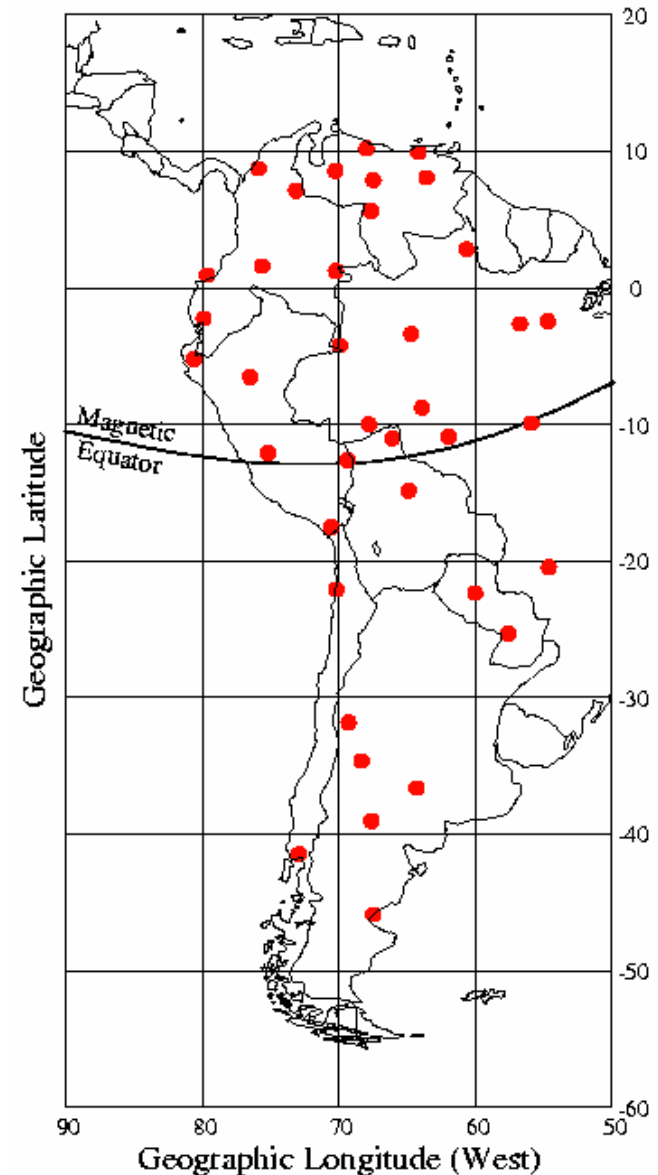
**Dr. J. Villalobos, UNC, Colombia**

**Dr. H. Mora, INGEOMINAS, Colombia.**

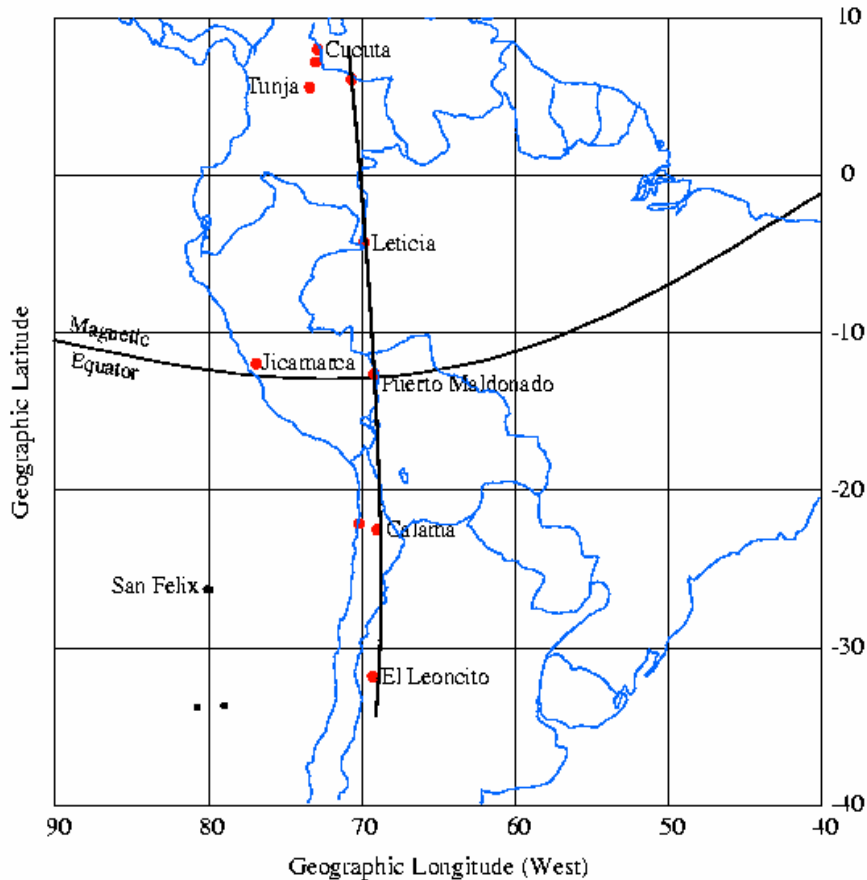
**Dr. J. Araya, UCN, Chile.**

**Dr. A. Tierra, EPE, Ecuador.**

**Dr. M. Bevis will help with the installation in Bolivia.**



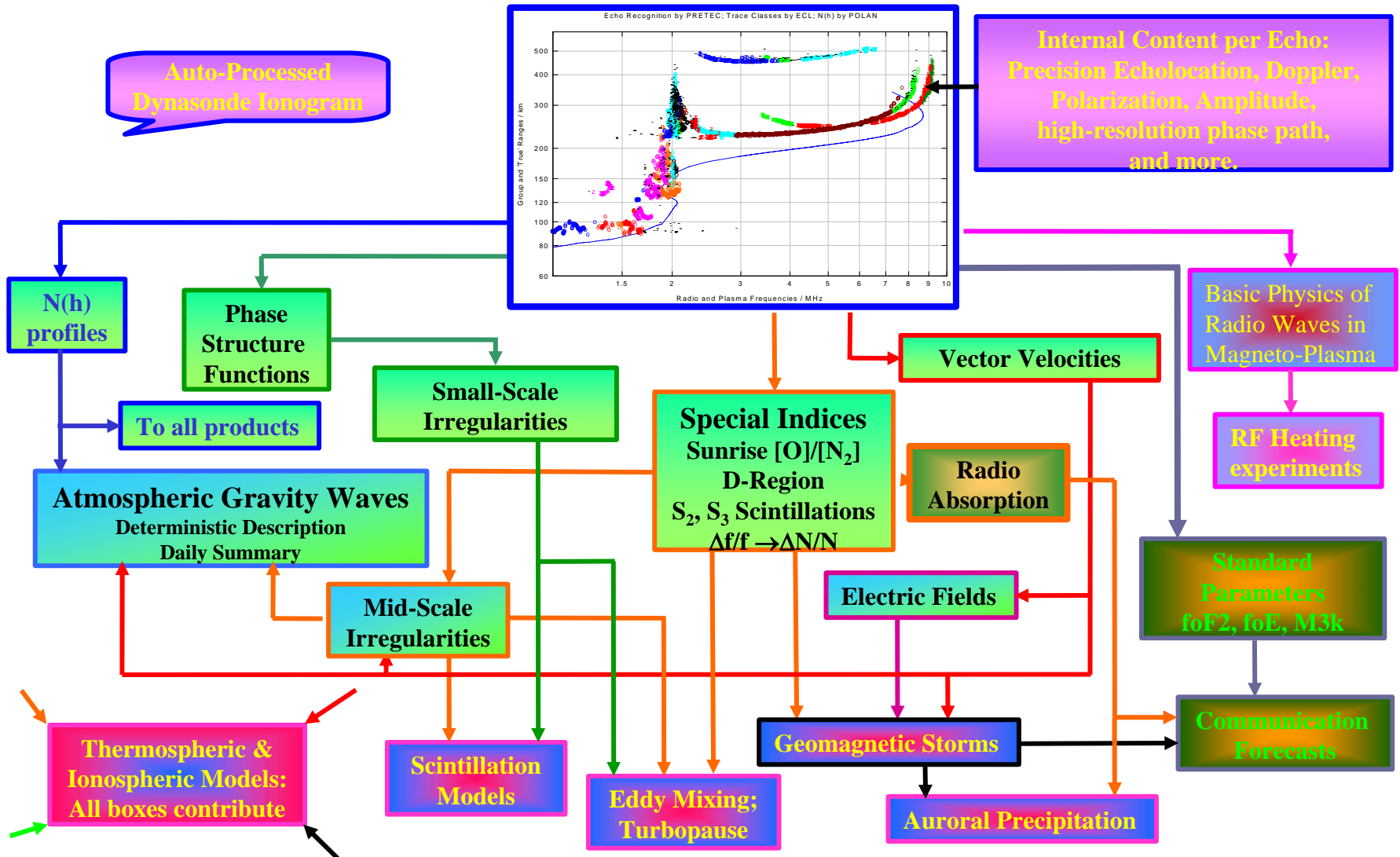
# 5 dynasondes to be paced at El Leoncito, Carmen Alto, Puerto Maldonado, Leticia & northern Colombia



**5 Dynasondes designed by Terry Bullett, Bob Livingstone (hardware) and Bill Wright (software).**

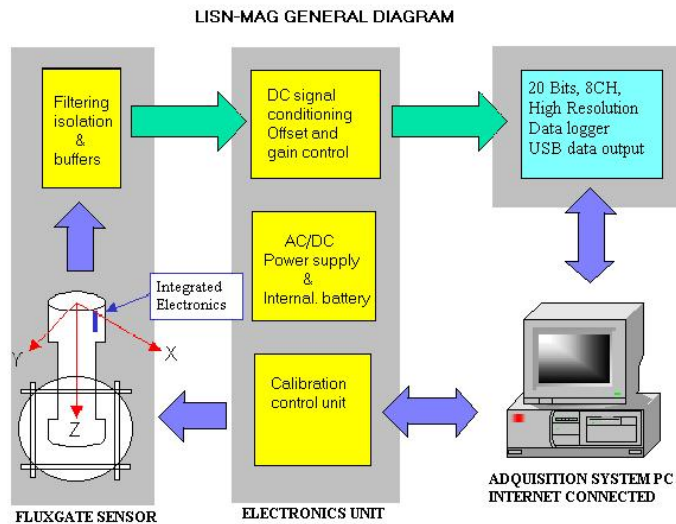
- 1. High-frequency radar hardware system.  
Eight receiver channels.  
Eight active antenna preamplifiers.  
Real-time control/data acquisition PC.  
GPS timing module for bistatic operation.  
Linux O/S with radar control interface.**
- 2. Transmitter power amplifier, Tomco.  
Four KW**
- 3. Receiver dipole array with eight non-resonant dipole antennas.**

# Dynasonde design done by: Terry Bullett, Livingston, Wright, and Zabotin



# Development of a prototype magnetometer

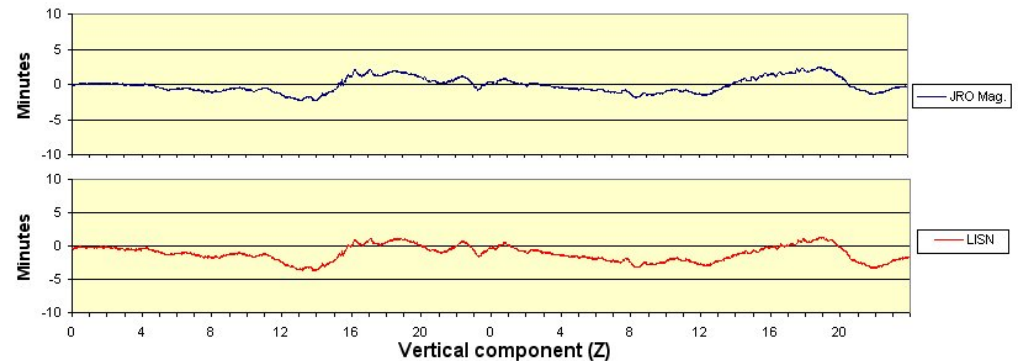
Comparison of UCLA magnetometer and new Jicamarca (LISN) prototype.



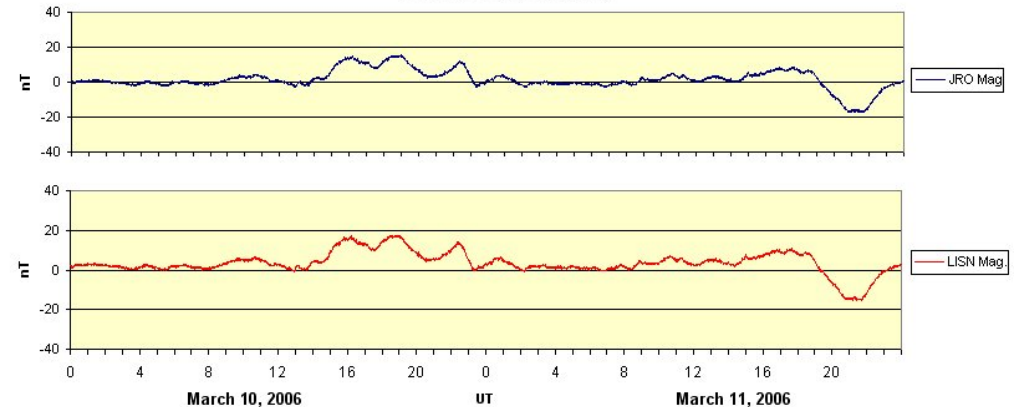
**Horizontal Component (H).**



**Declination Component (D)**



**Vertical component (Z)**



Magnetometer Design  
by Oscar Veliz

# LISN Web Page

## <http://jro.igp.gob.pe/subwebs/lisn/>

### LOW-LATITUDE IONOSPHERIC SENSOR NETWORK

<a href="#">Home</a>	<a href="#">About LISN</a>	<a href="#">Equipment</a>	<a href="#">Stations</a>	<a href="#">Other</a>
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Telecommunications play an important role in science and technology world-wide. This field has its own phenomena that need to be explained, and that is the challenge for LISN.

LISN, as a permanent array of the newest geophysical instruments in South America, closely coordinate as a "distributed observatory". Our main focus is on complex and extreme state of disturbance that take place in the magnetical-equatorial ionosphere nearly every day after sunset, and on the ionosphere-thermosphere-electrodynamics (ITE) system than constantly controls the dynamics of the plasma density, creating the proper conditions to initiate plasma turbulence.

Known and studied for seven decades, the equatorial Spread F (ESF) phenomena are now held responsible for causing high-technology (GPS) navigation and communication failures that depend on inter-hemispheric link. Enough is known and understood about this region and its process to show conclusively that nothing less than a meteorological approach to detailed and comprehensive observations, integrated closely with assimilative modeling, can lead to physical understanding and the imperatives of practical forecasting and nowcasting.

#### Stations



[All Stations](#)



[Peru](#)



[Brazil](#)



[Ecuador](#)



[Argentina](#)



[Chile](#)



[Paraguay](#)



[Bolivia](#)



[Colombia](#)



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*Science Uniting the Americas*

Username: userlisn

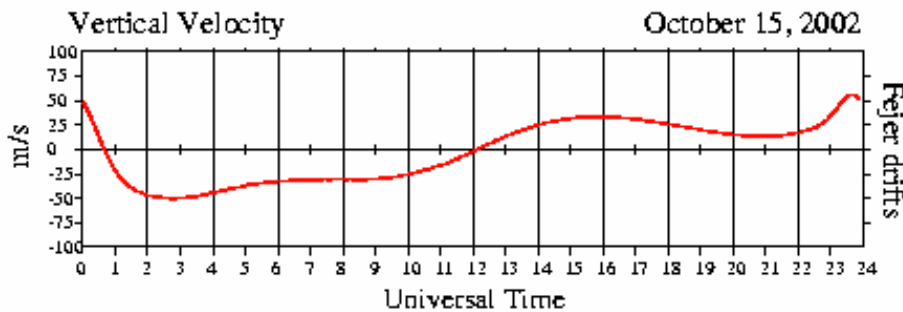


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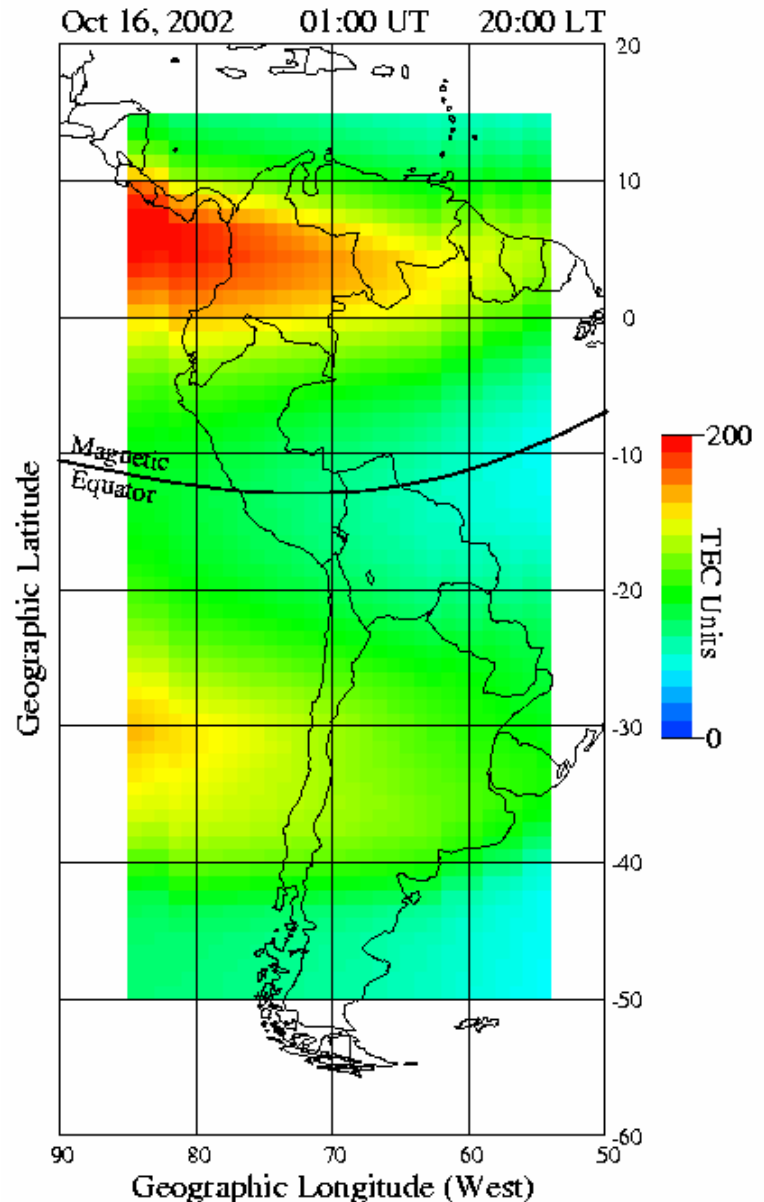


# Simulation of the LISN TEC display

Fejer's drifts multiplied by a factor dependent on longitude. 1.3 at  $85^{\circ}\text{W}$  and 0.7 at  $55^{\circ}\text{W}$ .

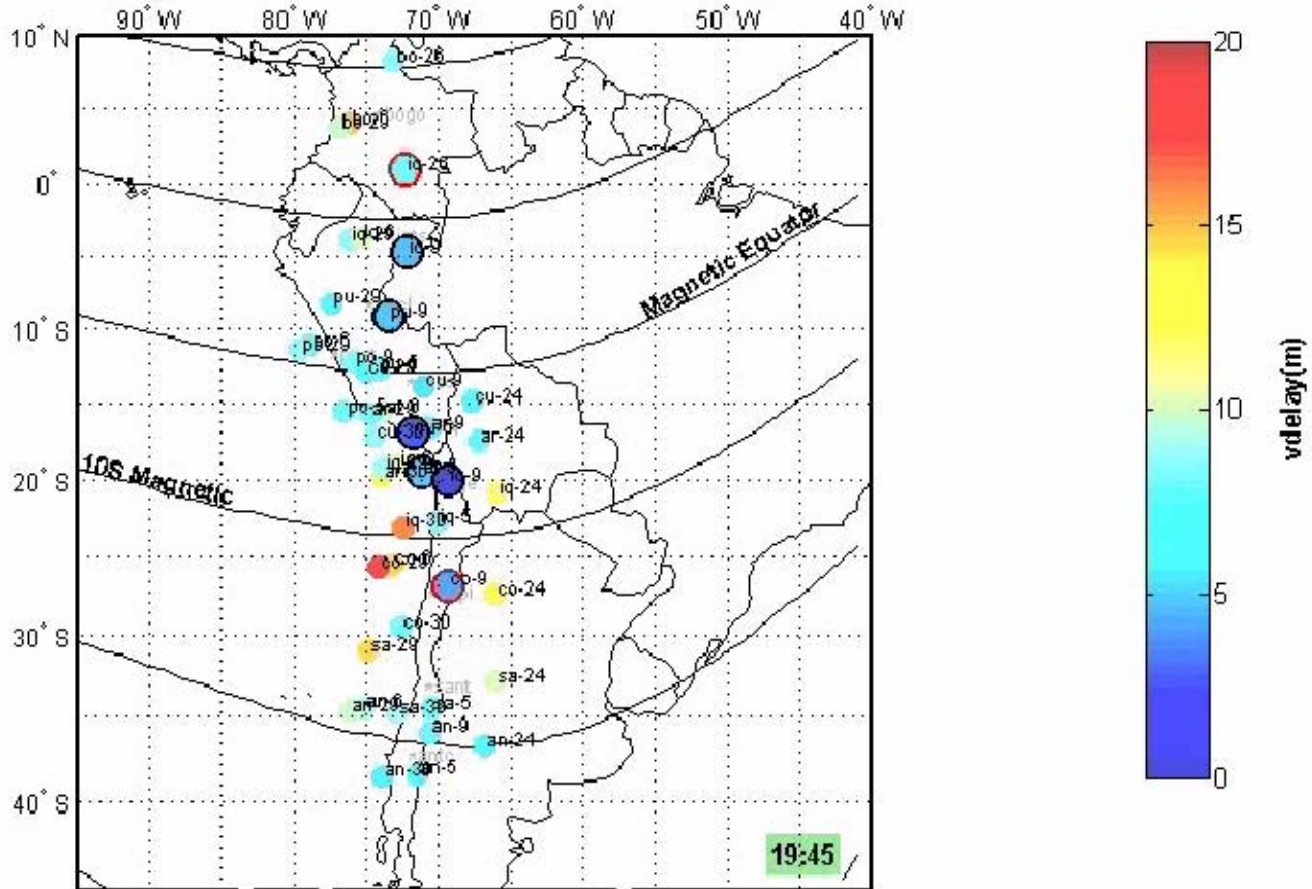


**Constant meridional  
wind equal to +60 m/s  
(northward)**





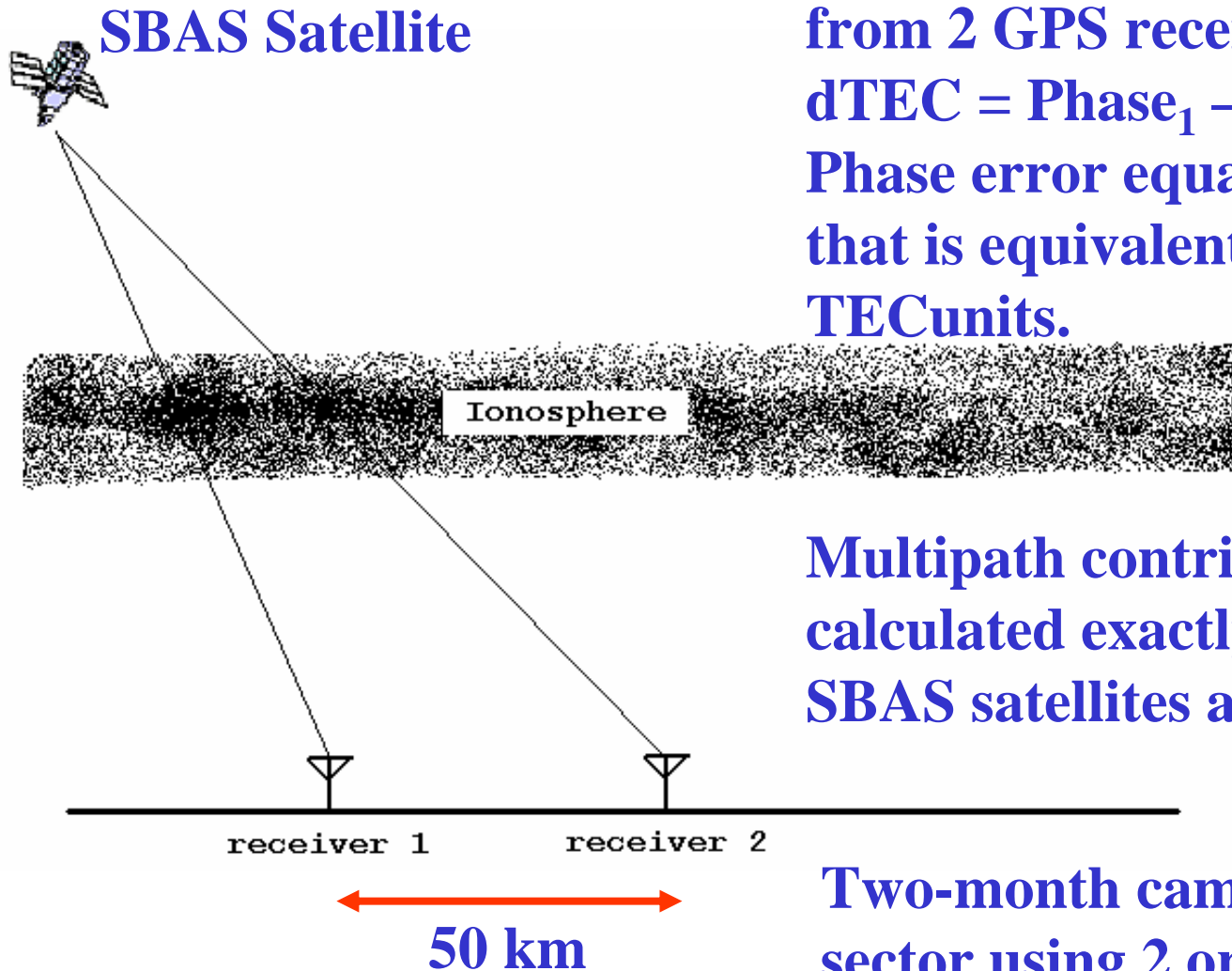
# TEC-Depletion detection from 10 Sites in the Western Side of South America, March 19, 2002



Circles indicate the presence of TEC depletions.



# Measurement of differential TEC using 2 GPS receivers

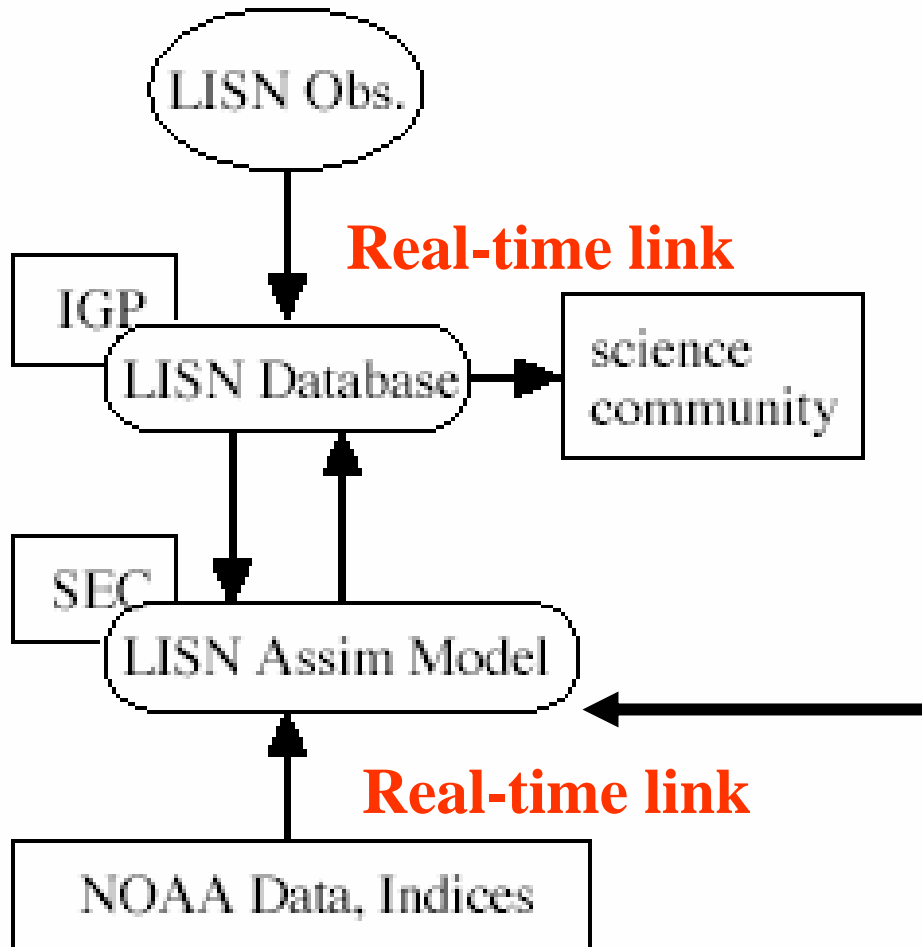


We plan to use the SBAS phase from 2 GPS receivers to obtain  $dTEC = Phase_1 - Phase_2 + bias$   
Phase error equal to 0.1 radian, that is equivalent to 0.02 TECunits.

Multipath contribution can be calculated exactly given that the SBAS satellites are geo-stationary.

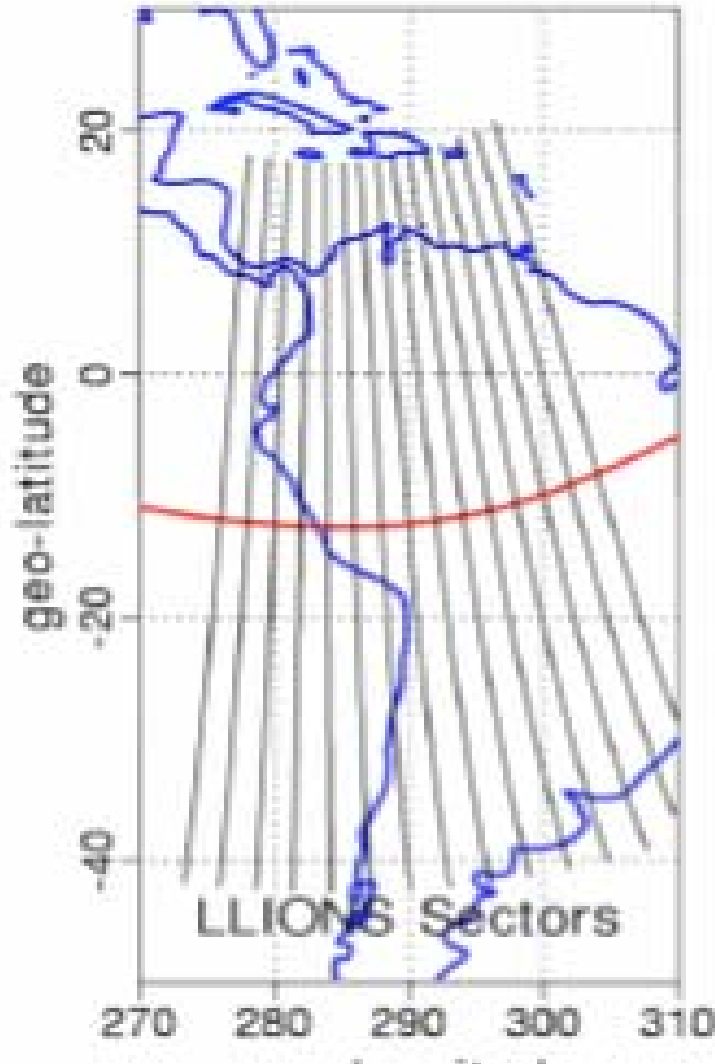
Two-month campaign in the Peru sector using 2 or 4 receivers.

# Real-time data flows of LISN data and assimilation



- (1) Low-latitude Ionospheric model, (2) low-latitude electrodynamics model, (3) model of ground-based magnetic perturbations for a 3-D current system (4) Kalman filter program.

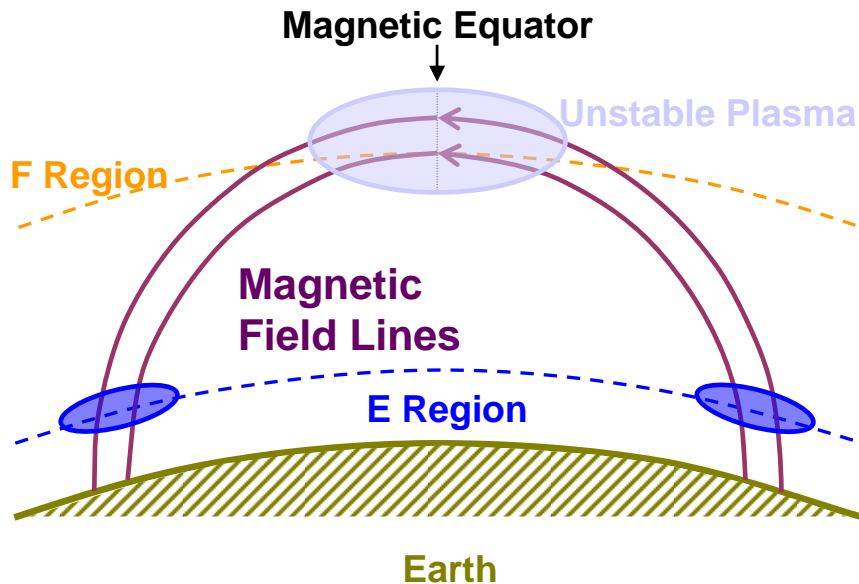
# A Complementary Aspect of LISN



The LISN project includes an assimilative physics-based model designed to “nowcast” the ionosphere above the same geographic region. The model will use a Kalman filtering technique to assimilate the data and the LLIONS model developed by SEC.

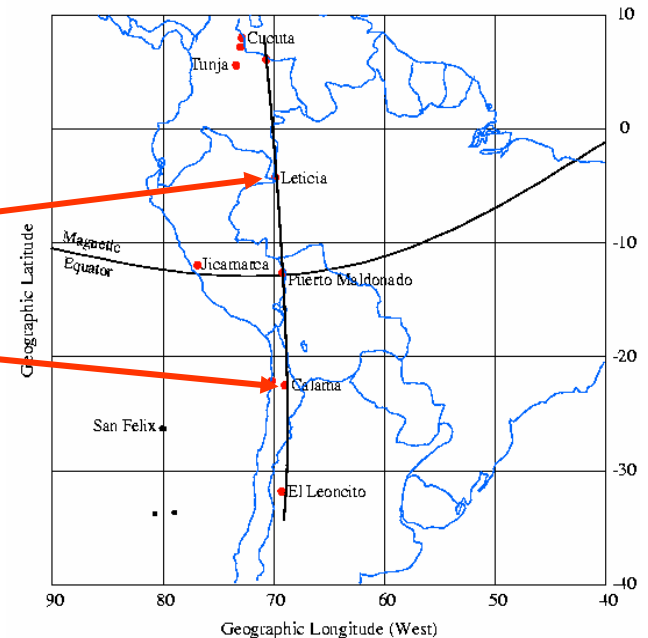
Jicamarca will be used to validate results, but also its data will be later assimilated into the assimilation string. We can use the high altitude resolution of the Jicamarca meas. to extend this resolution along a meridian. Ingest Jicamarca temperatures.

# Measure nighttime E-region density



**5 dynasondes will be placed along the field line that crosses the magnetic equator at  $69^\circ$  W. They will measure E-region densities during the onset of ESF.**

**The field lines that intersect the E region over the cities of Leticia and Carmen Alto map to 300 km at the magnetic equator. We will be able to observe: (1) times when E-region densities (sporadic E) “short out” electrodynamic instabilities. (2) role of equatorial and off-equatorial E region to balance pre-reversal currents.**



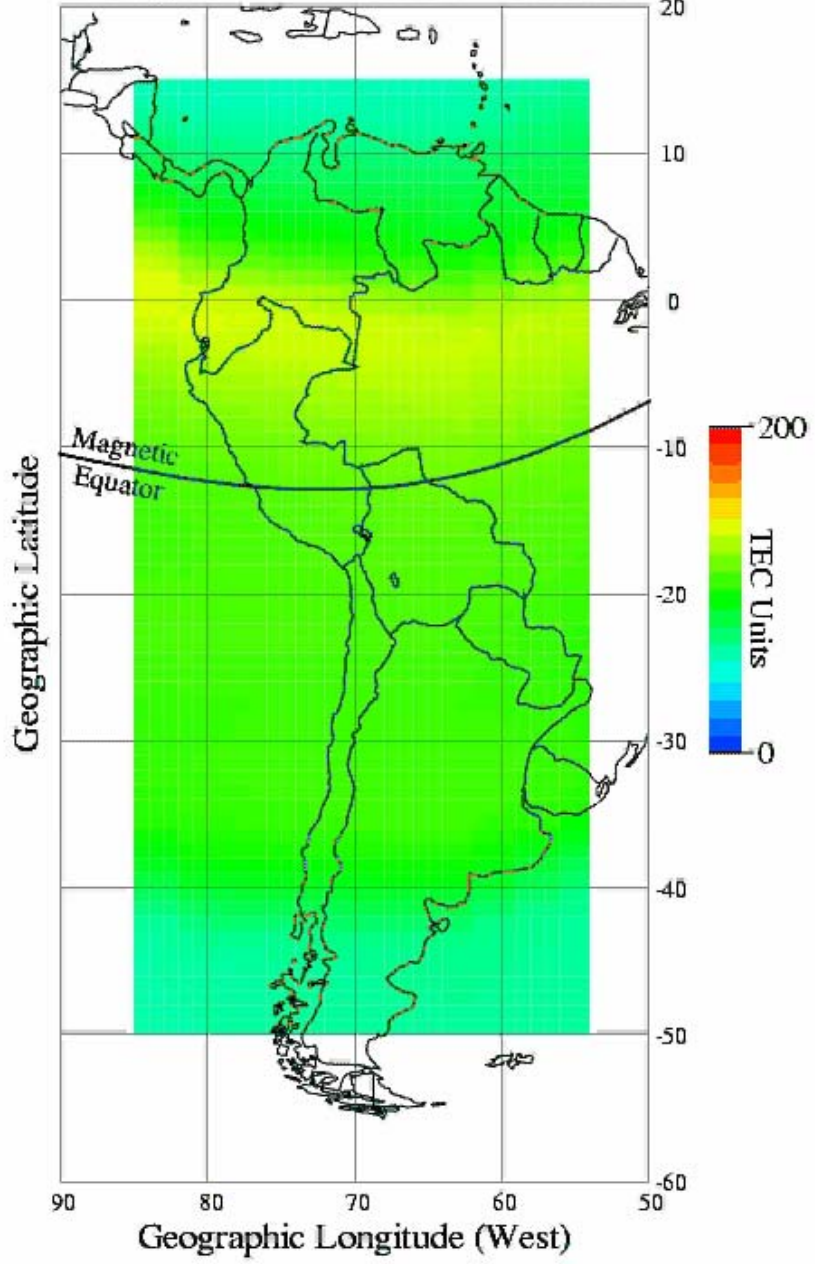
# Concluding Remarks

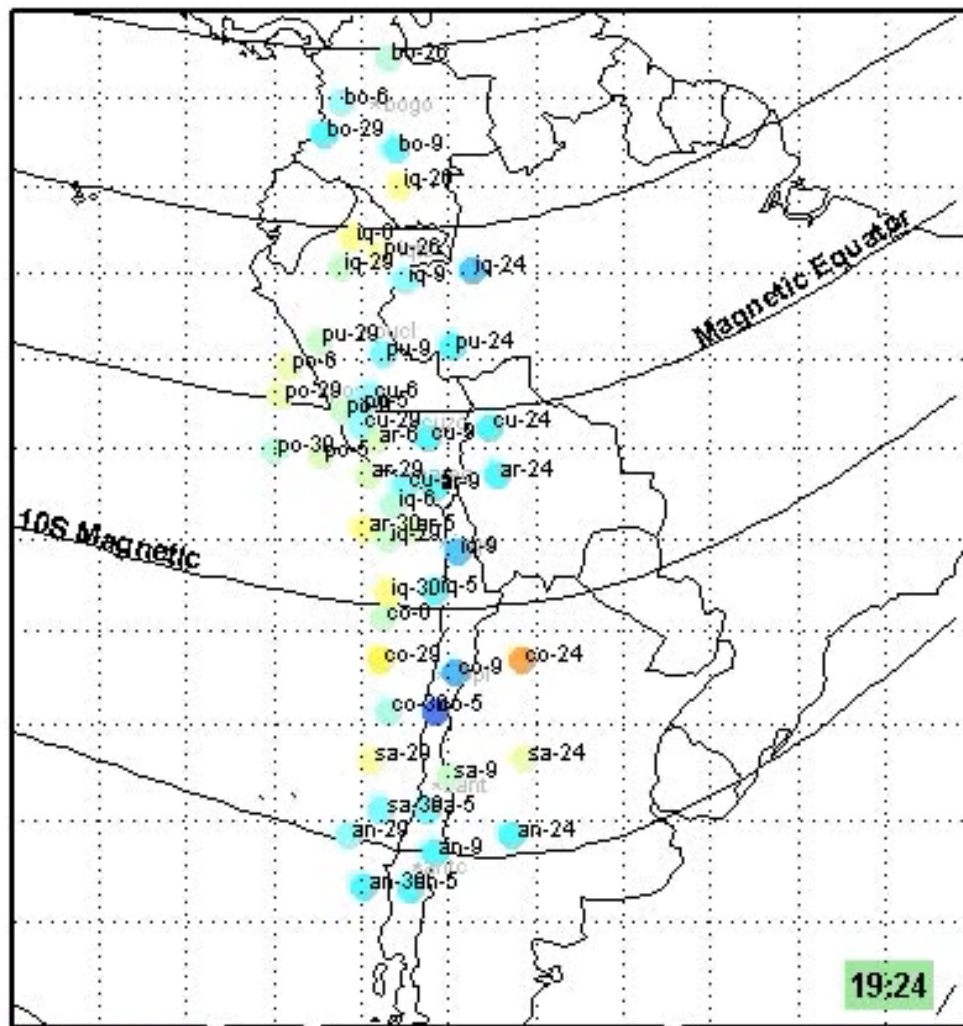
- **I want to invite other members of the CEDAR community, who have instruments in South America to be part of LISN. A SuperLISN?**
- **This program is supported by the National Science Foundation and AFOSR to initiate collaboration with universities and research institutes from South America.**

**“Imagination is more important than knowledge”**

**Albert Einstein**

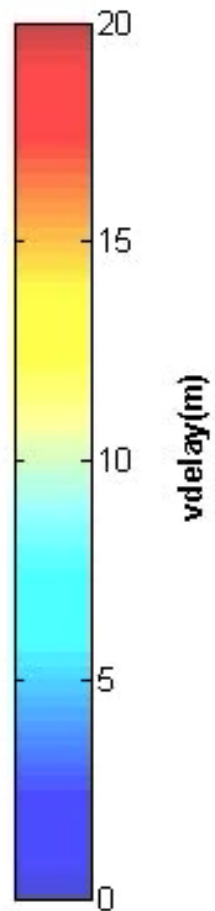
Oct 15, 2002 18:00 UT 13:00 LT



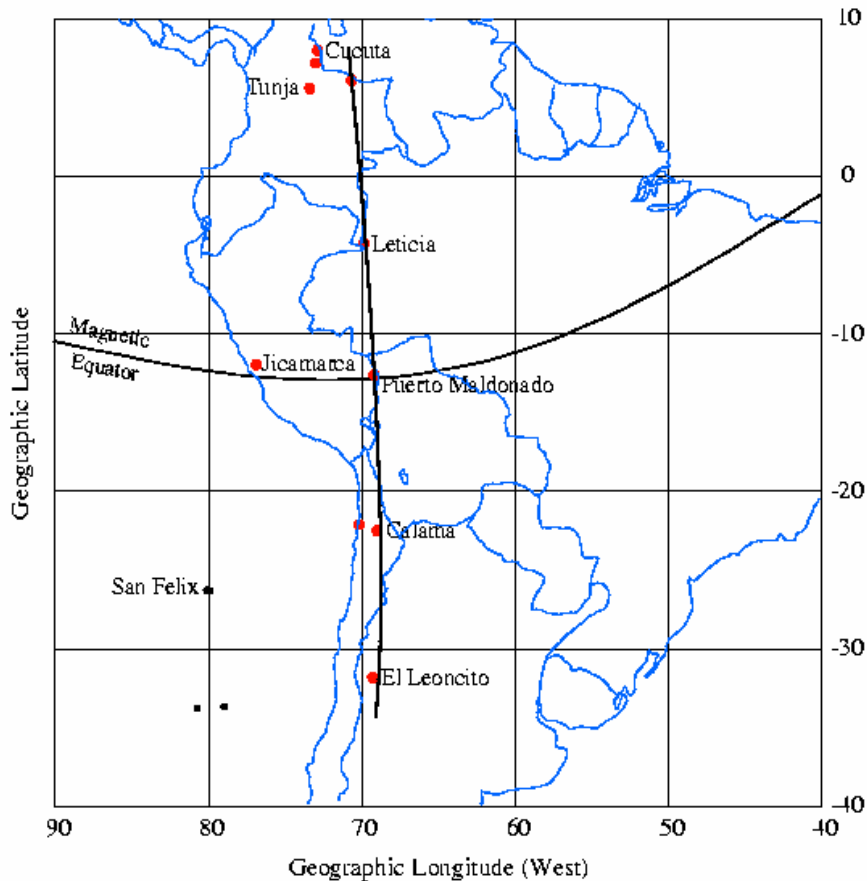


MITRE/CAASD

02/03/19



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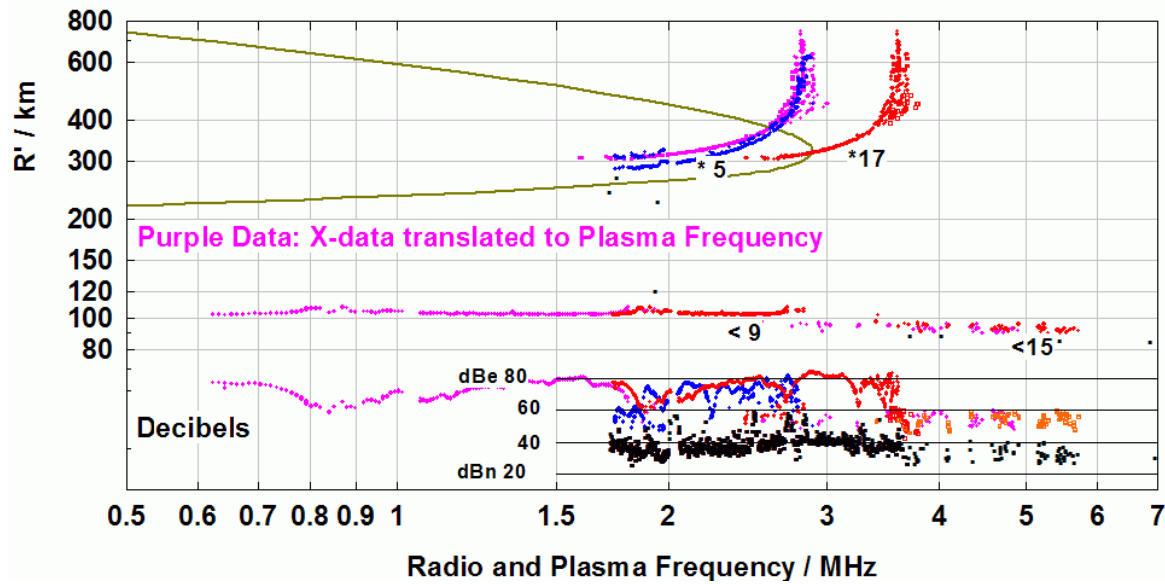
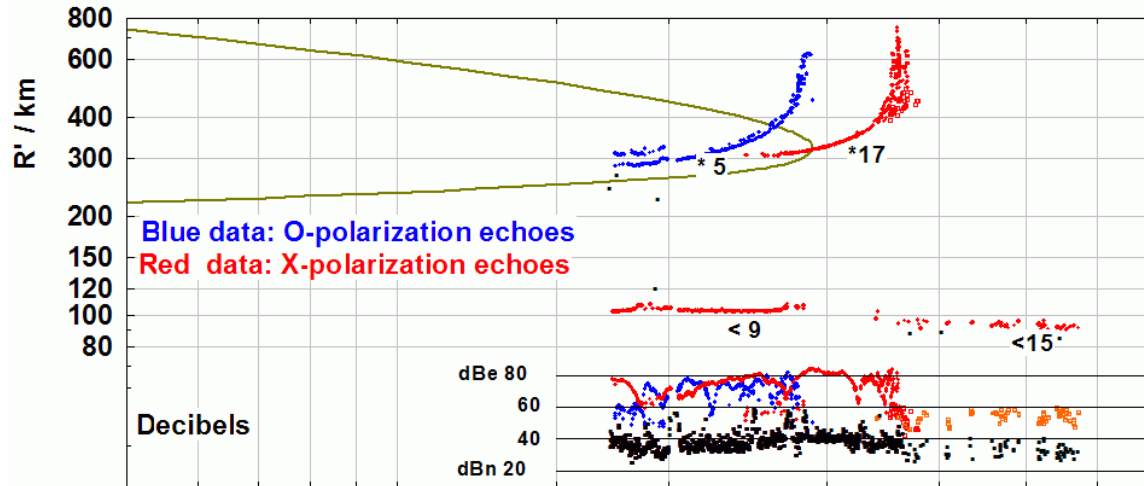
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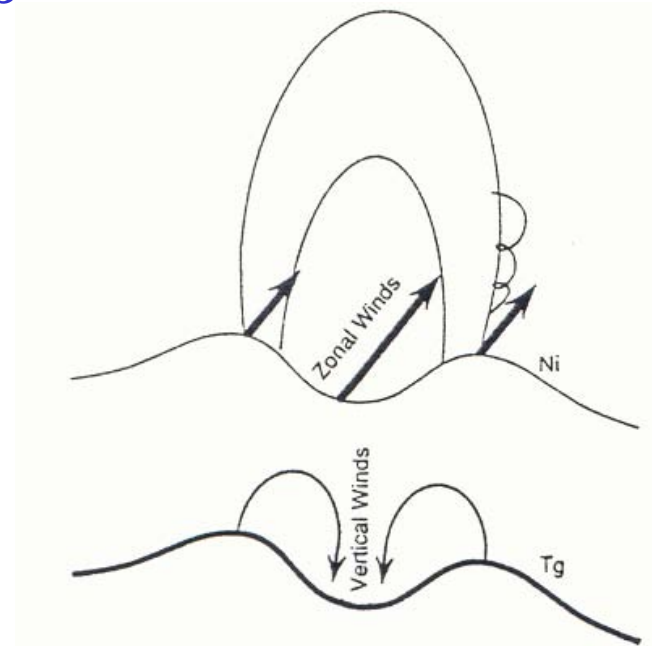
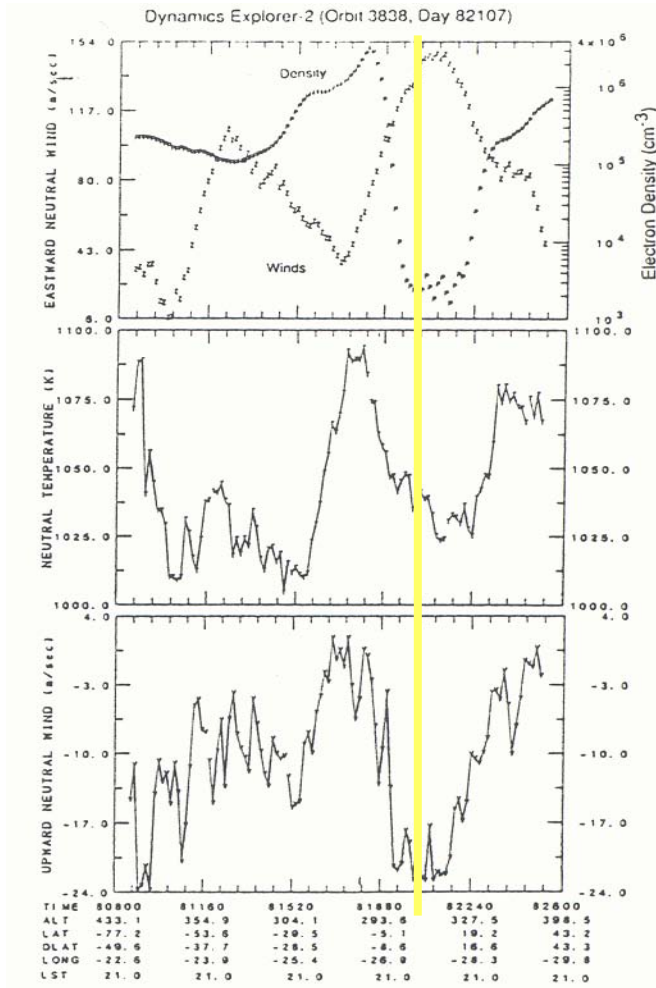
# Conclusions

- **The LISN network and its assimilation effort will be able to provide:**
  - (1) Number density, Conductivities, ExB drifts, neutral wind.**
  - (2) Map of TEC, GPS S4 scintillations, TEC depletions**
- **Data from the Jicamarca radar will help to verify density profiles and later will be ingested into the LISN assimilation program. Measurements of the Fabry-Perot interferometers in Arequipa, Peru and Carmen Alto, Chile will be also assimilated.**

BEAR LAKE UTAH DYNASONDE 05-07-31 1040UT 105W  
4pB 6lt1 DoY=212.44444 File= 07311040.B\_G



# DE-2 electron density, zonal winds and vertical winds



**Schematic of the dynamic coupling process between the ionization anomaly and the thermosphere at low latitudes.**

# Prototype Magnetometer



- Overall Range: +/- 60,000nT.
- Dynamic Range: +/- 2000nT
- Resolution : 0.1nT
- Output: +/-2.5 VDC (analog signal)
- Digital outputs: USB, 5 output channels, X,Y,Z and 2 temperature sensors
- Internet data rate: 5min.

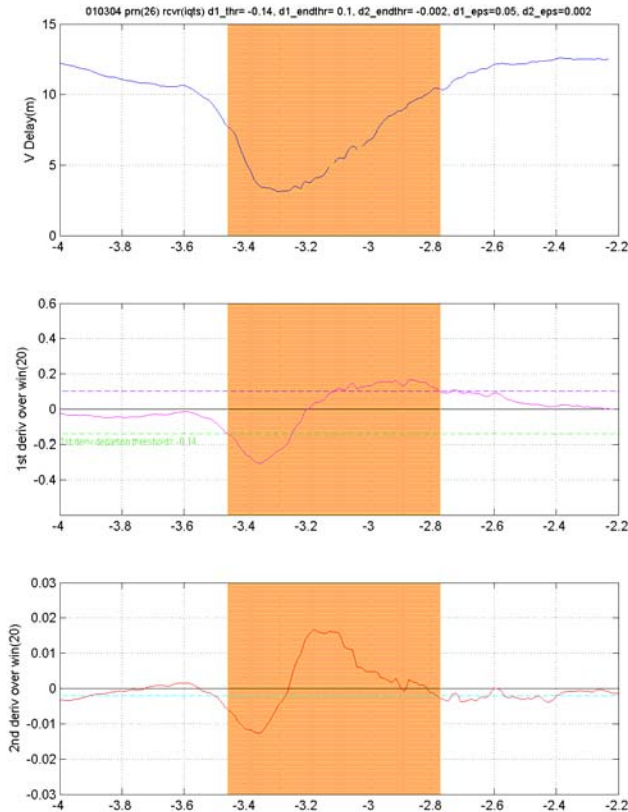
- Sensor : Triaxial ring core fluxgate.

- Sensor Module: PVC cylinder de 4" x 0.80 m, contains internal temperature sensor and 3 Helmholtz coils for periodic calibration.

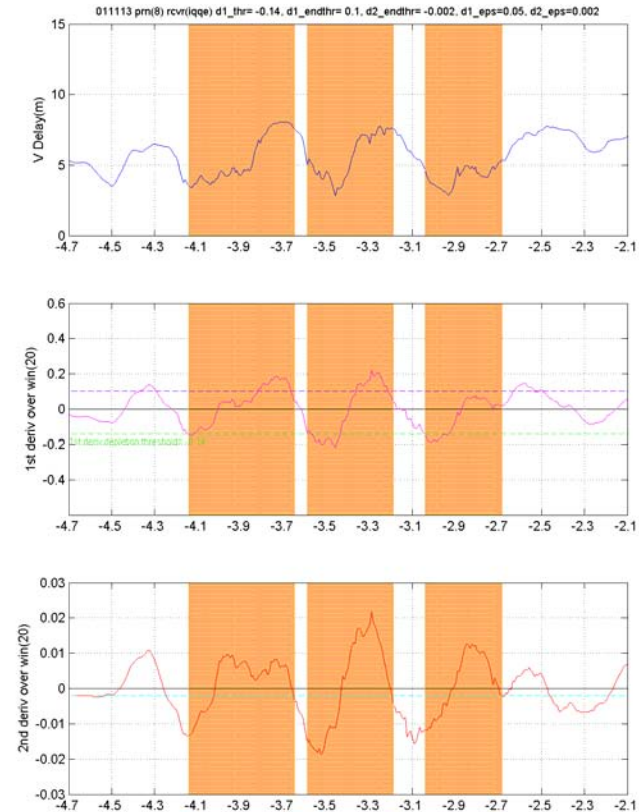
- Electronic unit: AGC, fields cancellation and filters, including a data logger of high resolution : 20



# Examples of Detecting A Single Depletion and 3 Depletions



**PRN26 at Iquitos, Peru,  
March 4, 2001**

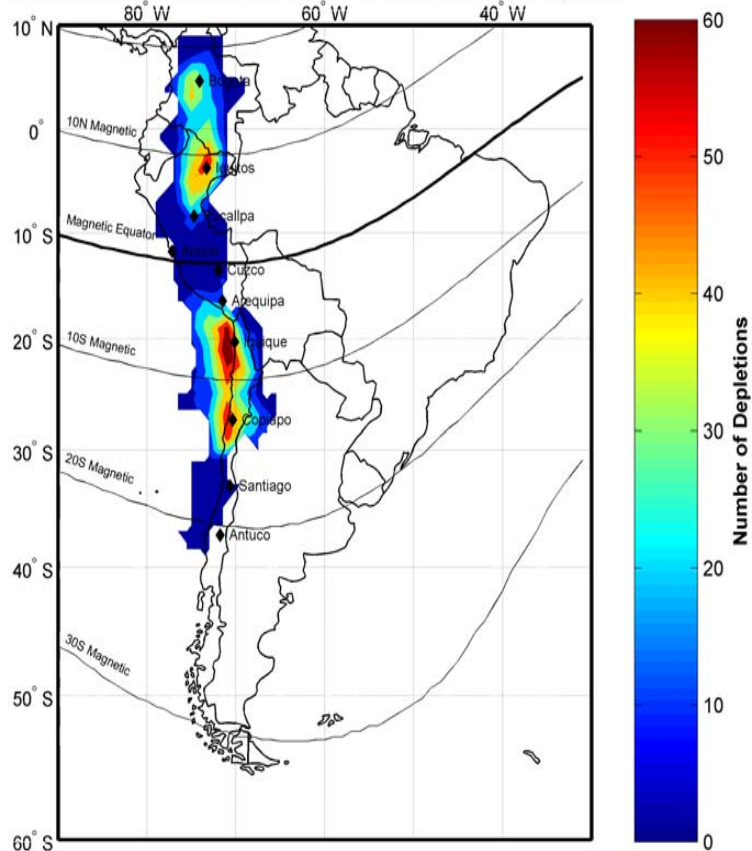


**PRN8 at Iquique, Chile,  
November 13, 2001**

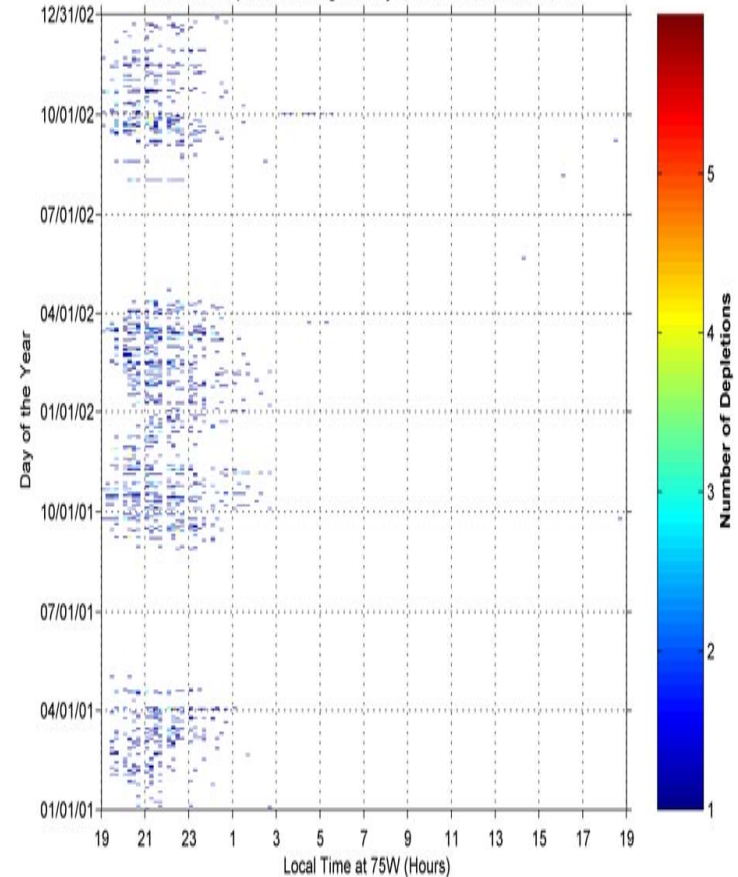


# Location and Frequency of Depletions for Two Years of Data

Number of Depletions during January 1, 2001 to December 31, 2002



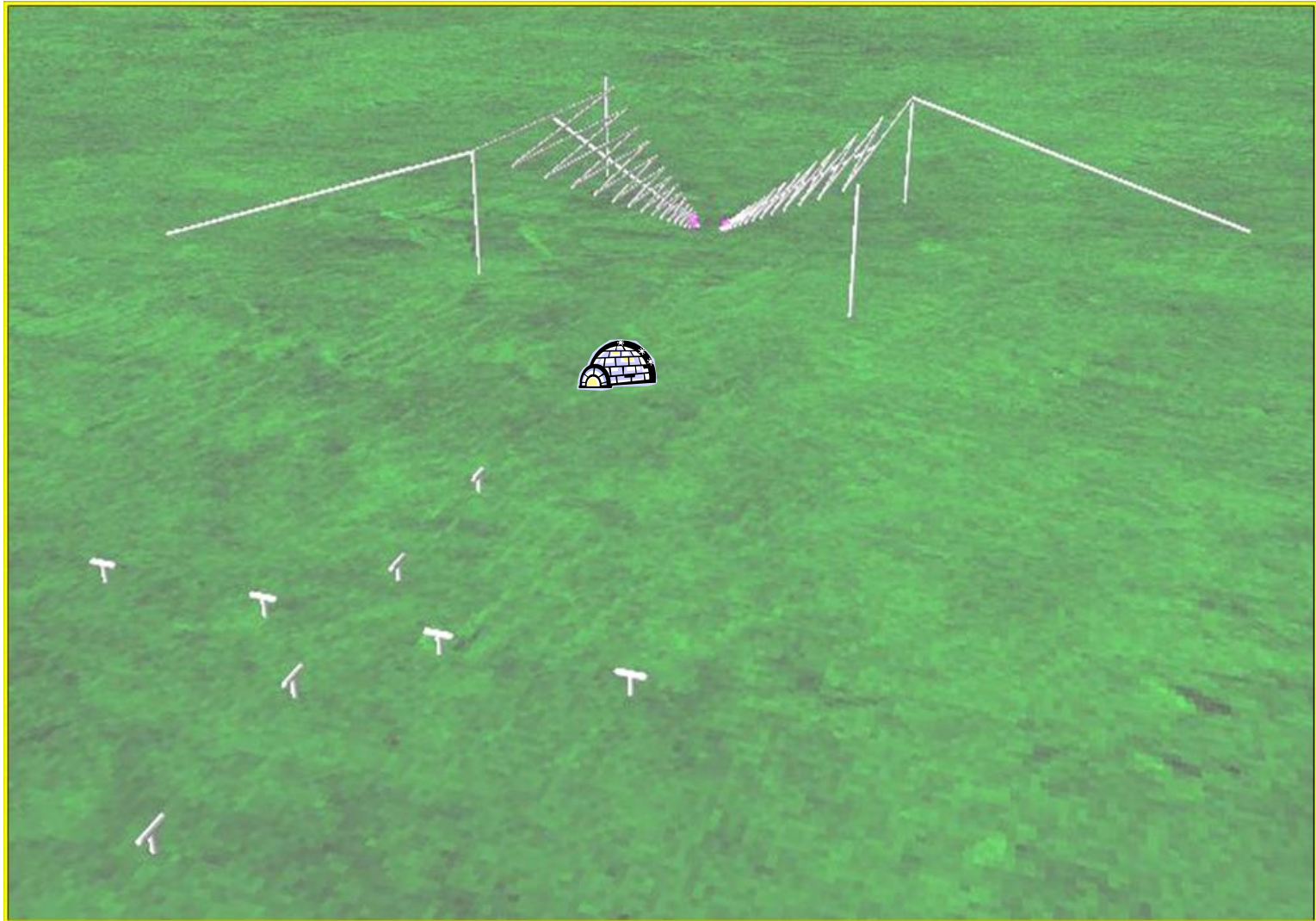
Number of Depletions during January 1, 2001 to December 31, 2002



# Basic Dynasonde Principles

- Phase differences among several (4-8) pulsed signals of a carefully designed pulse set, received through several (4-8) antenna/receiver channels, define, by a least squares solution, a radio “echo” with physical parameters:
  - “Doppler” or phase-path velocity  $V^*$ , m/s
  - “Stationary-Phase Group Range”  $R'$ , km
  - Eastward XL and northward YL echolocations, km
  - Polarization rotation or “chirality” PP, degrees
  - The pulse set mean phase  $\phi_0$ , degrees
  - A least-squares residual EP, degrees
  - An echo peak amplitude A, decibels, from signal magnitude
  - Possible 2<sup>nd</sup> order parameters with 8 antennas and receivers

## An "Ideal" Dynasonde Antenna Layout



### Key Features:

Flat land

Tx, Rx separated

Underground coax

No competing antennas

Instrument bldg. midway

Non-conducting towers

Underground Power Lines

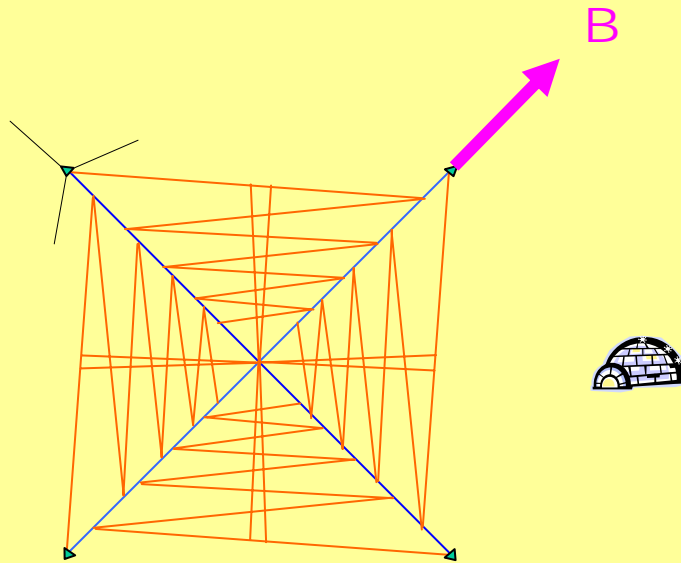
Space for expansion

Rotate Rx array 45°

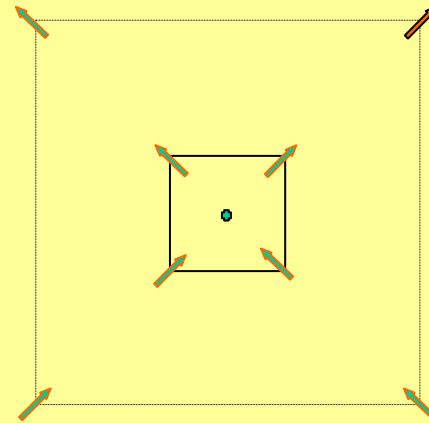


## Plan View of an "Ideal" Dynasonde Antenna Layout

In this example, the Tx Log Periodic is shown with 4 planes. Guys are shown for one of the four supporting towers: it is important that the guys be oriented as shown, to avoid the LPA curtains and for direct backward tension of the diagonal support ropes. Two opposing curtains are sufficient for most dynasonde purposes, but four provide better mechanical stability at little cost.



Tx 4-plane vertex-down LPA



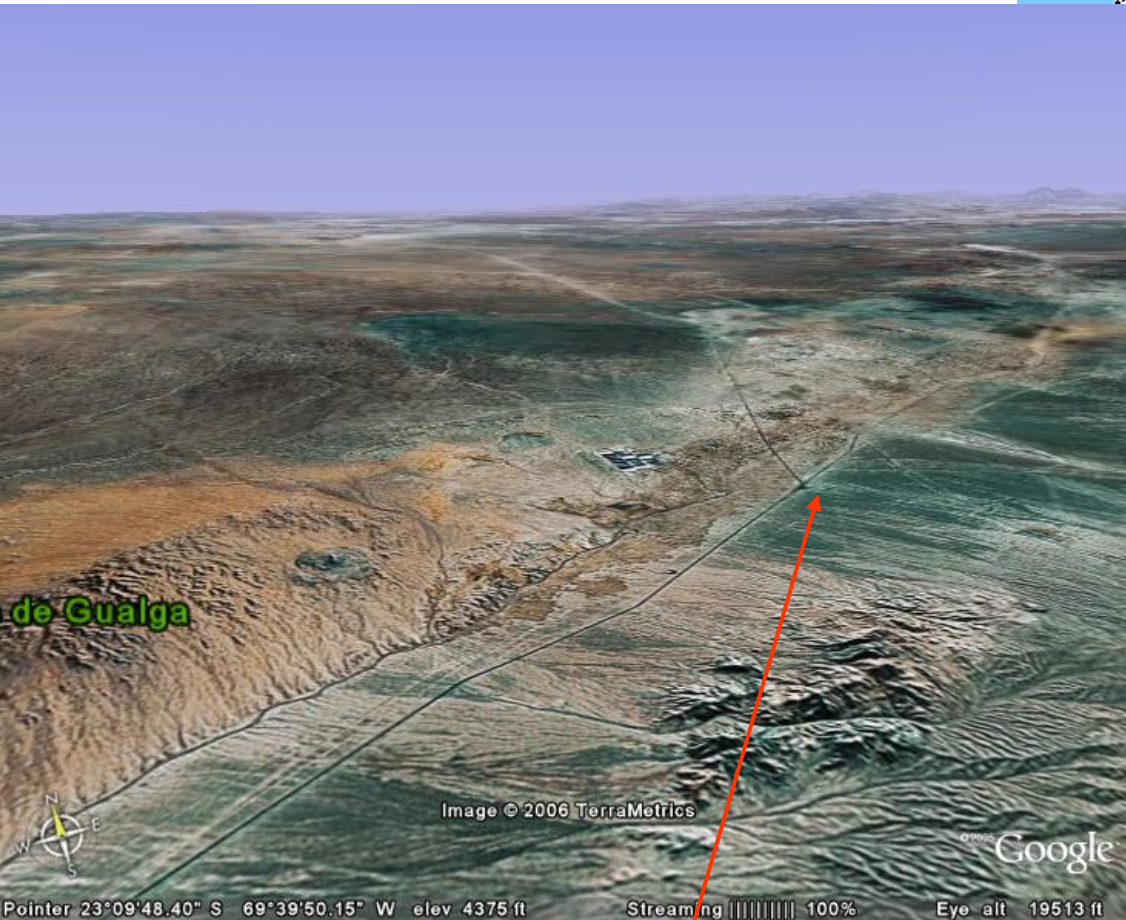
Rx 8-dipole array. Outer-square size controls precision of echolocation; inner square defines aliasing interval.

Placing the Tx and Rx arrays on either side of the instrumentation building maximizes their separation (good for RF isolation) and minimizes transmission-cable length (for economy and least signal loss). The 45 degrees between the Tx wires and the Rx dipoles also reduces radiation coupling between them. Magnetic-equatorial sites require that a diagonal of the Tx and Rx arrays be oriented along the magnetic field B, as shown, to put equal power into the Ordinary and extraordinary magnetoionic modes. Placing coax transmission lines in PVC tubing and underground avoids damage from traffic, animals and other users of the land.

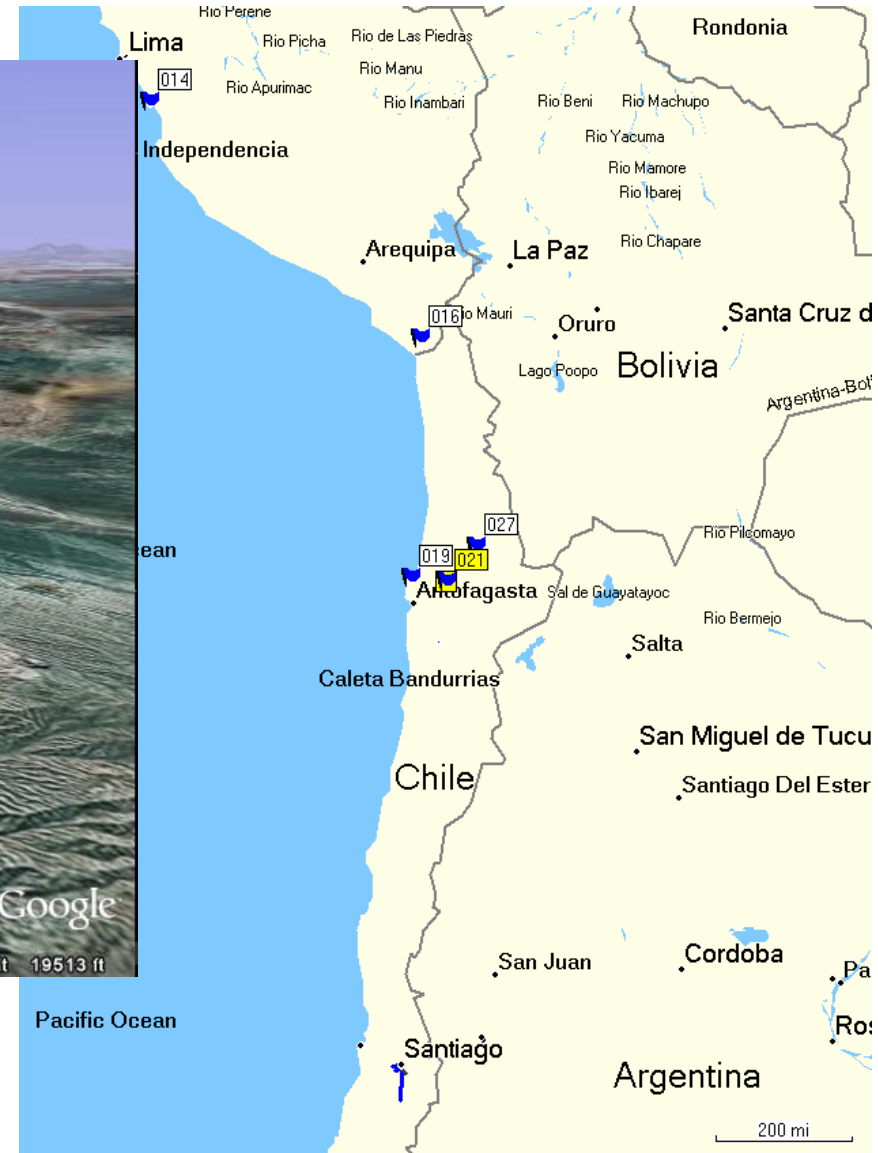
# Leticia Site



# Carmen Alto Site



**Site Location**





# El Leoncito Site

