Los Radares MST

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Radar Observations of Winds and Turbulence in the Stratosphere and Mesosphere

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ABSTRACT

A technique for the observation of radar echoes from stratospheric and mesospheric heights has been developed at the Jicamarca Radio Observatory. Signals are detected at the altitude ranges between 10–35 km and from 55–85 km with powers from many to several tens of decibels above noise level. The three most important frequency spectrum characteristics—power, Doppler shift and spectrum width—are observed in real time. The power levels as well as the spectral width are explained in terms of turbulent layers, with a thickness of the order of 100 m, in regions with a positive potential temperature or electron density vertical gradients. Continuous wind velocity records are obtained with a precision of the order of 0.02–0.2 m sec^{-1} for the vertical component and 0.20–2 m sec^{-1} for the horizontal, with a time resolution of the order of 1 min. The highest precisions are obtained at stratospheric heights. Fluctuations in velocity in the mesosphere are observed at the shortest gravity wave periods with amplitudes of the order of 1 m sec^{-1} for the vertical component and of 10 m sec^{-1} for the horizontal. Tidal components at these altitudes are not as large as predicted by theory. A technique to obtain the power, the Doppler shift, and the width of the frequency spectrum of the echo signals from only two points of the correlation function is described.

•Ecos de tierra enmascaraban ecos estratosférico

•Filtrado de contaminación de ecos de tierra

•Integración coherente: incremento en sensibilidad

•Análisis de características espectrales estimando momentos directamente: gran rapidez en el procesamiento

•Medición de vientos y ancho espectral

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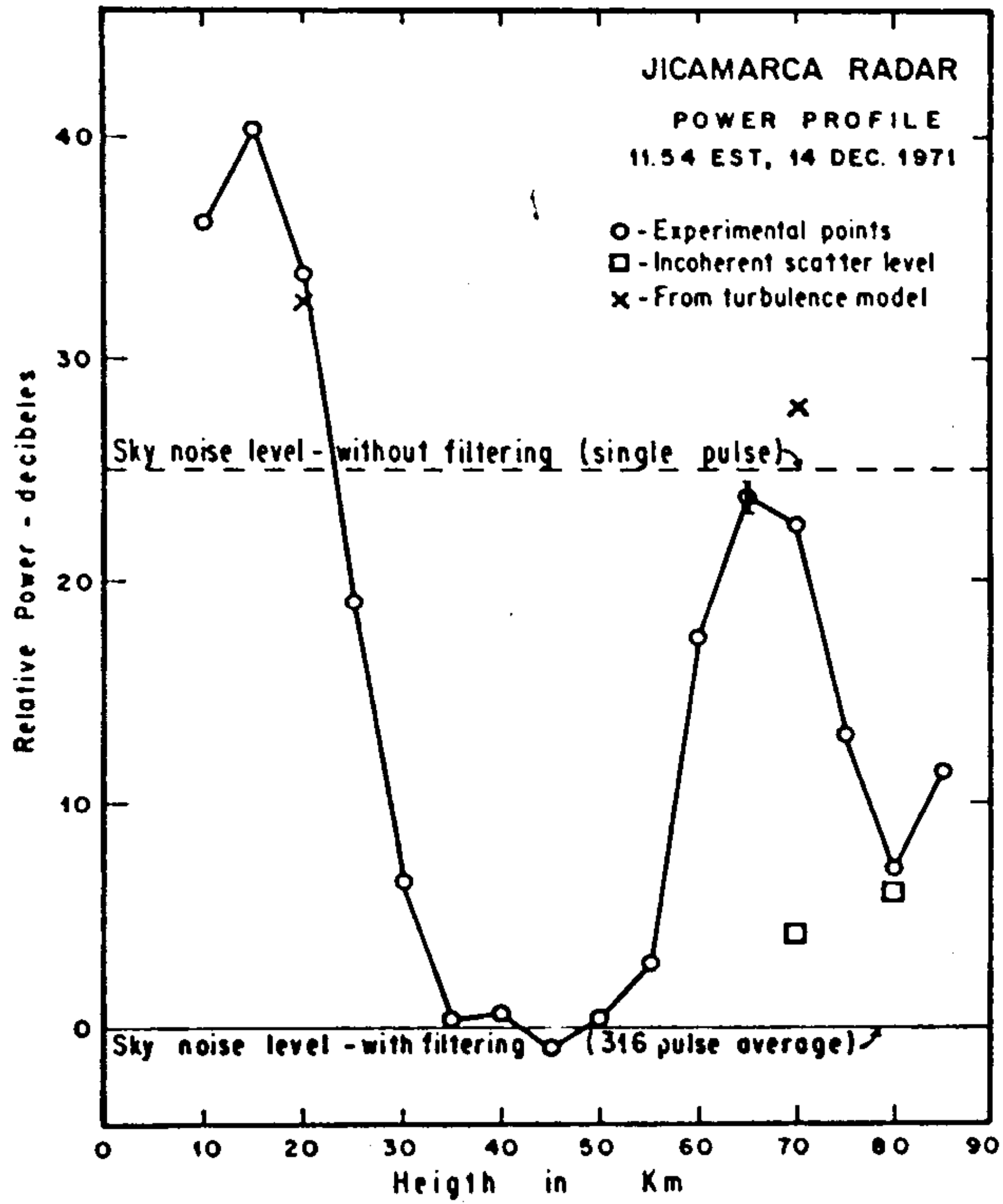


FIG. 2. Backscatter power profile obtained from fluctuations in index of refraction in the upper atmosphere with the 50-MHz Jicamarca radar. The incoherent scatter levels correspond to 0.5×10^9 and 10^9 electrons m^{-3} at 70 and 80 km, respectively. The turbulence models assume $L_0 = 100$ m.

Por primera vez:

- Perfil de vientos con una resolución de 1 minuto (ondas de gravedad)
- Vientos verticales con una precisión de mm/seg en la estratósfera.

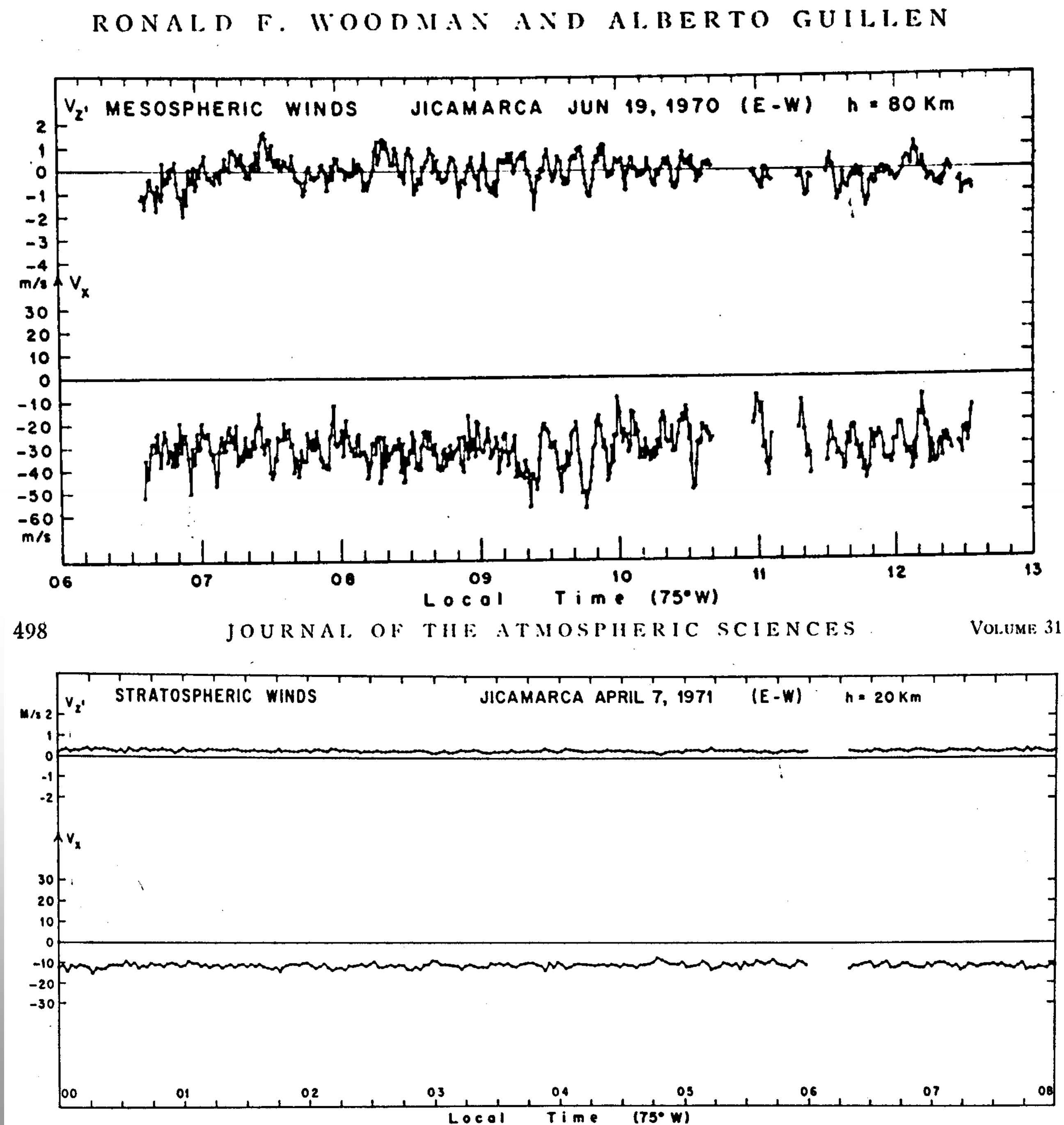


FIG. 3. Record of easterly (V_x) and vertical velocities (V_z) at 20 km obtained from the Doppler shift of radar backscatter echoes.

$$C(\tau) \equiv A(\tau) e^{j\phi(\tau)},$$

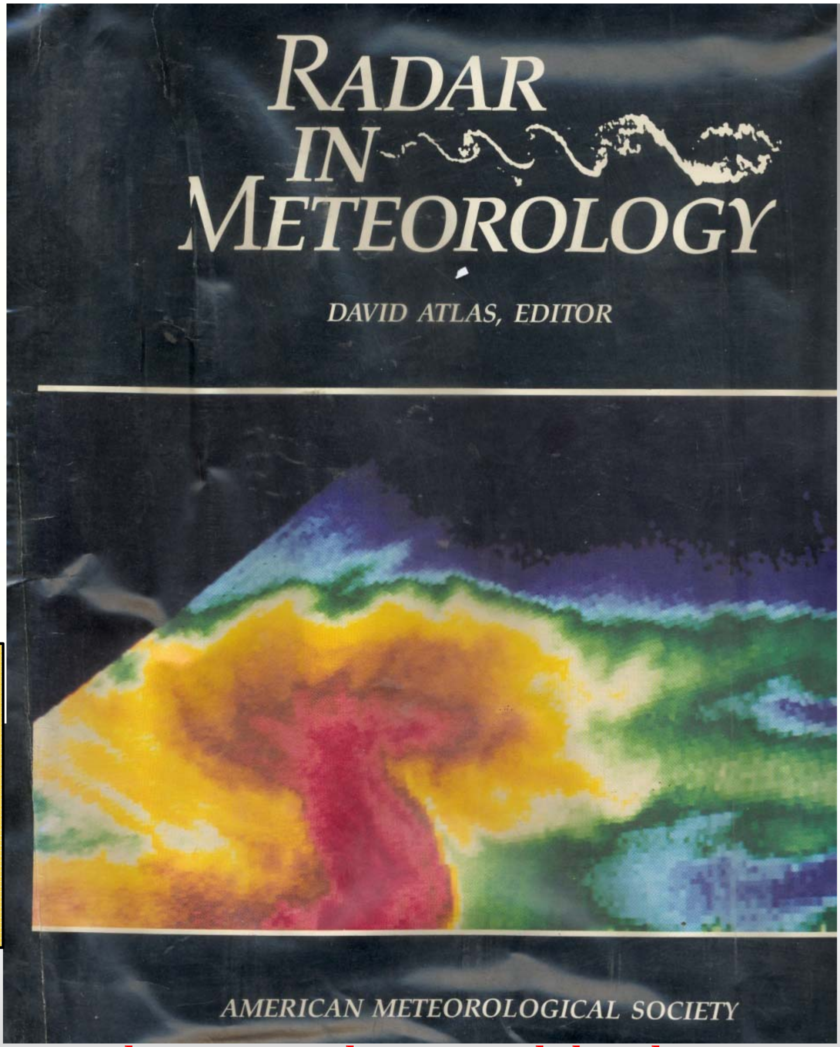
If $C(\tau)$ is evaluated at a single, but sufficiently small delay, and at the origin, we can use (A13) and (A14) to estimate $\phi'(0)$ and $A''(0)$ to obtain Ω and σ as given by (A11) and (A12). The result is

$$\Omega = \frac{\phi(\tau_1)}{\tau_1}, \qquad \text{(A15)}$$

$$\sigma^2 = \frac{2[1 - A(\tau_1)/C(0)]}{{\tau_1}^2}. \qquad \text{(A16)}$$

spheric radar observations. The basic antenna array design and the special signal processing techniques for the modern UHF / VHF radar systems and the operational wind profiler systems have come directly from the large ionospheric scatter radar facility at Jicamarca, Peru. In the late 1960s, the 50-MHz radar in Peru was found to produce echoes from the lower atmosphere, although no particular attention was paid to them initially. Woodman and Guillen (1974) adapted the data acquisition and analysis procedures that had been used for ionospheric studies to evaluate the radar echoes from the mesosphere, the stratosphere and the upper troposphere. The first power profile obtained by backscatter from fluctuations in the refractive index in the clear air between 10 and 90 km is presented in Figure 2.1. The observations were made with the Jicamarca radar operating at 50 MHz, with 1 MW peak power, 5-km range resolution, and a vertical-beam antenna with an aperture of 84 000 m^2.

Woodman and Guillen's (1974) contribution included improvements in the technique for measuring velocities as well as the first application of coherent preintegration, as described in section 6. They recognized the great potential of the technique for remote sounding of the lower and middle atmosphere, and their studies triggered the evolution of a new generation of UHF / VHF radars for atmospheric research. The first of the new radars was built

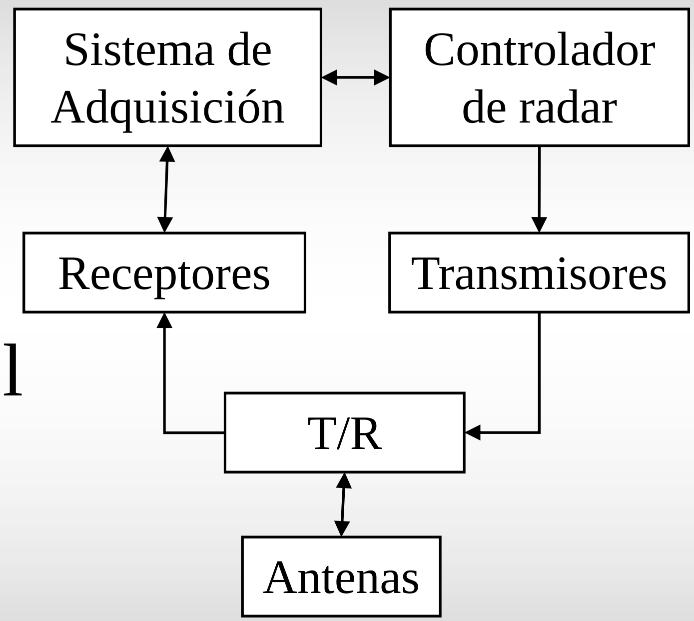


However, covariance processing for velocity measurements apparently was first used in March 1968 for ionospheric velocity measurements (Woodman and Hagfors, 1969). Woodman and Guillén (1974) also reported covariance-based velocity measurements in the mesosphere at the Jicamarca MST radar in 1970. This algorithm development in the MST community was independent of Rummler´s work. The pulse pair algorithm led to an exciting growth in the use of Doppler radar by the scientific community (Groginsky et al., 1972; Lhermitte, 1972; Sirmans, 1975; Lhermitte and Serafin, 1974)

Woodman actively pursued the clear-air research and obtained Doppler wind velocities in both the lower atmosphere and the mesosphere (Woodman and Guillén, 1974). This paper is widely regarded as the seminal work that led to the active research using VHF radar n the decade that followed.

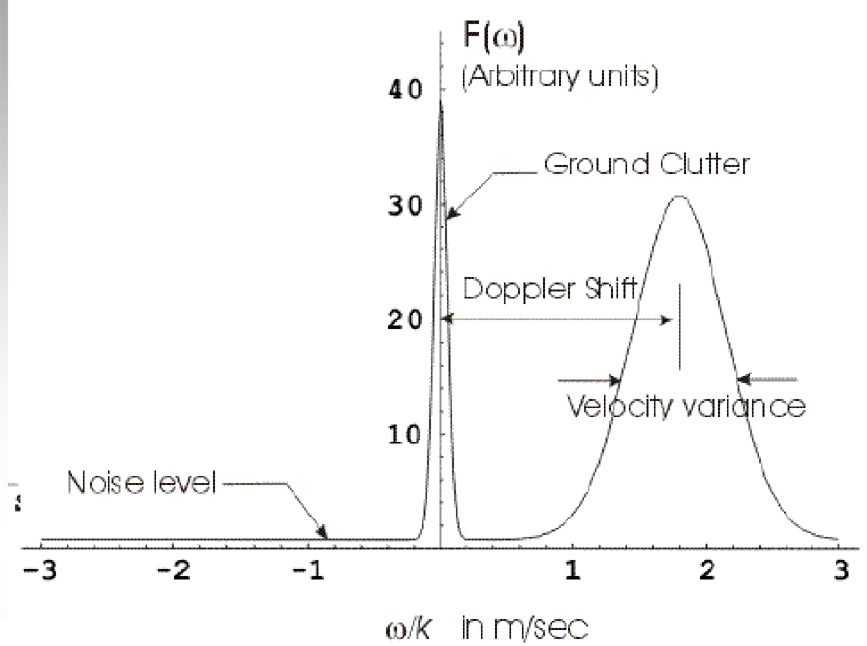
Principios Básicos de Funcionamiento (1)

- Funcionan como cualquier radar
- Blanco: “Aire claro” (via fluctuaciones en su índice de refracción)
- Medidas a diferentes rangos con el uso de pulsos
- La señal recibida representa un proceso aleatorio complejo. Sus parámetros estadísticos están relacionados con parámetros atmosféricos



Principios Básicos de Funcionamiento (2)

- Momentos espectrales:
  - 0: Turbulence intensity
  - 1: Velocidad radial media
  - 2: rms de las velocidades radiales

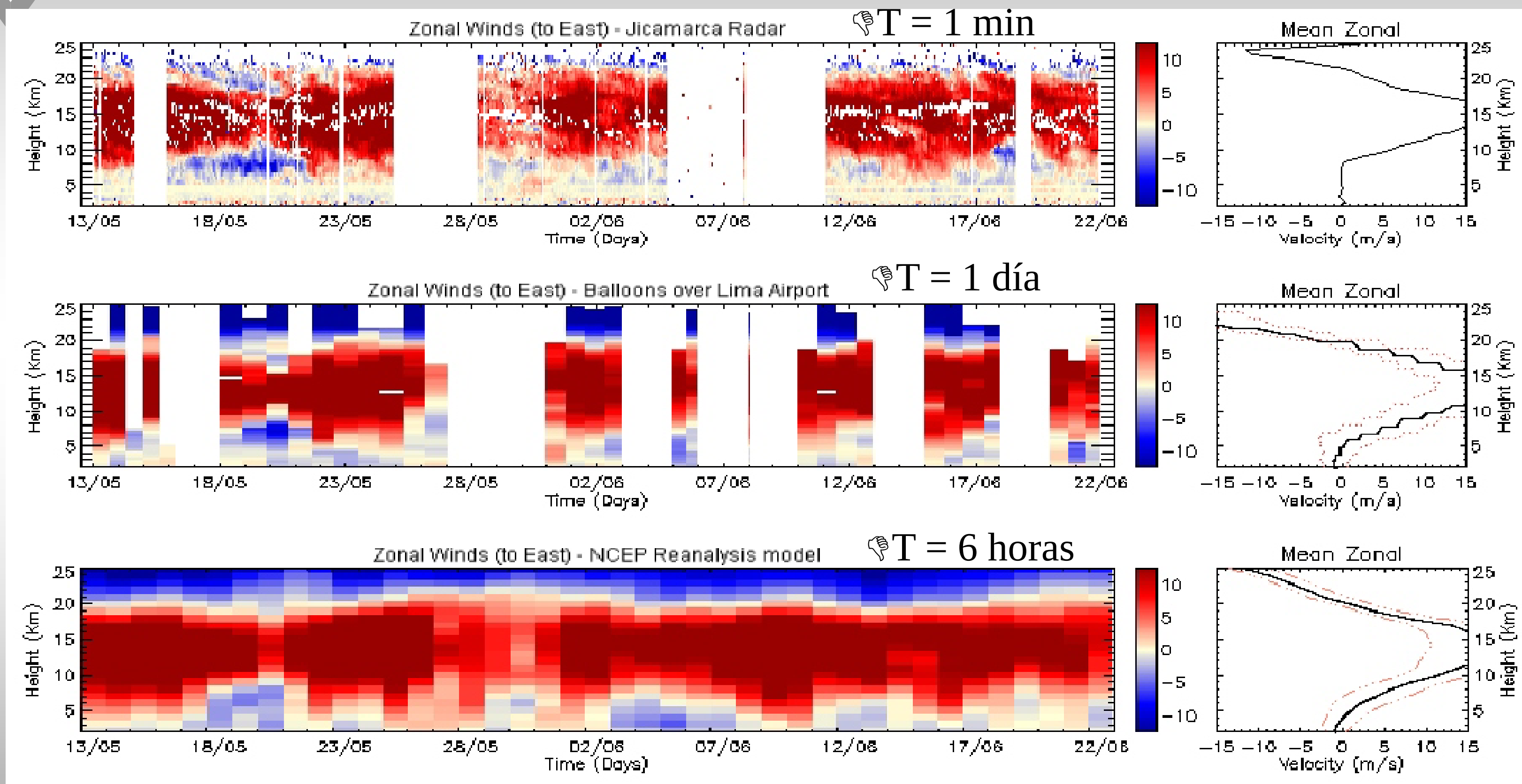


$$F(\omega) \leftrightarrow C(\tau)$$

$$\Omega = \frac{\phi(\tau_1)}{\tau_1},$$

$$\sigma^2 = \frac{2[1 - A(\tau_1)/C(0)]}{{\tau_1}^2}.$$

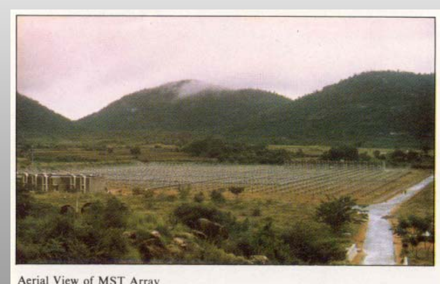
Jicamarca MST (1)
Radar vs otras técnicas



(de *Woodman et al.* [2000])

Historia

- Técnica inventada en Jicamarca.
- Luego “exportada”
  - Poker Flat, Alaska
  - SOUSY, Alemania
  - MU, Japón
  - Gadanki, India



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Historia (2)

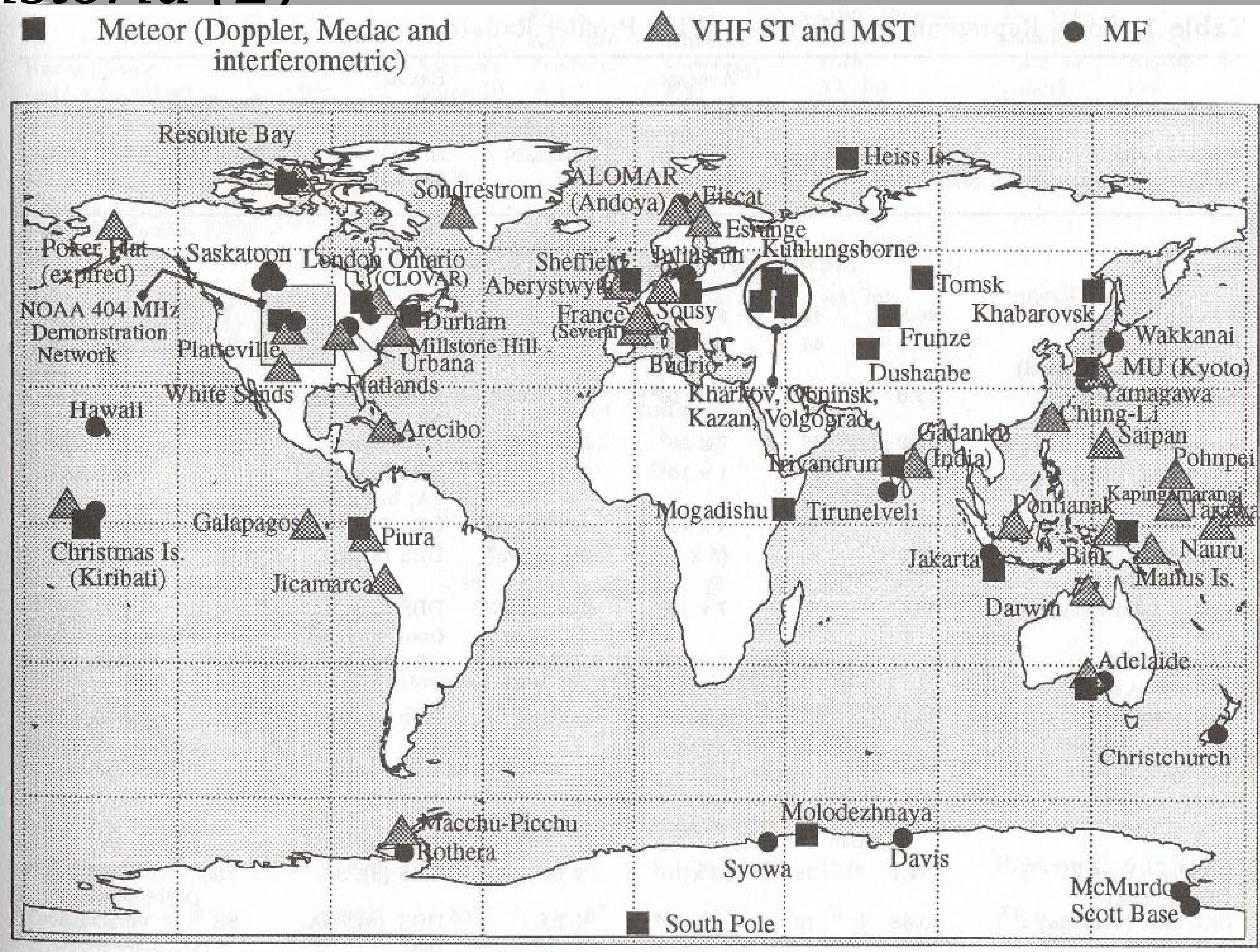
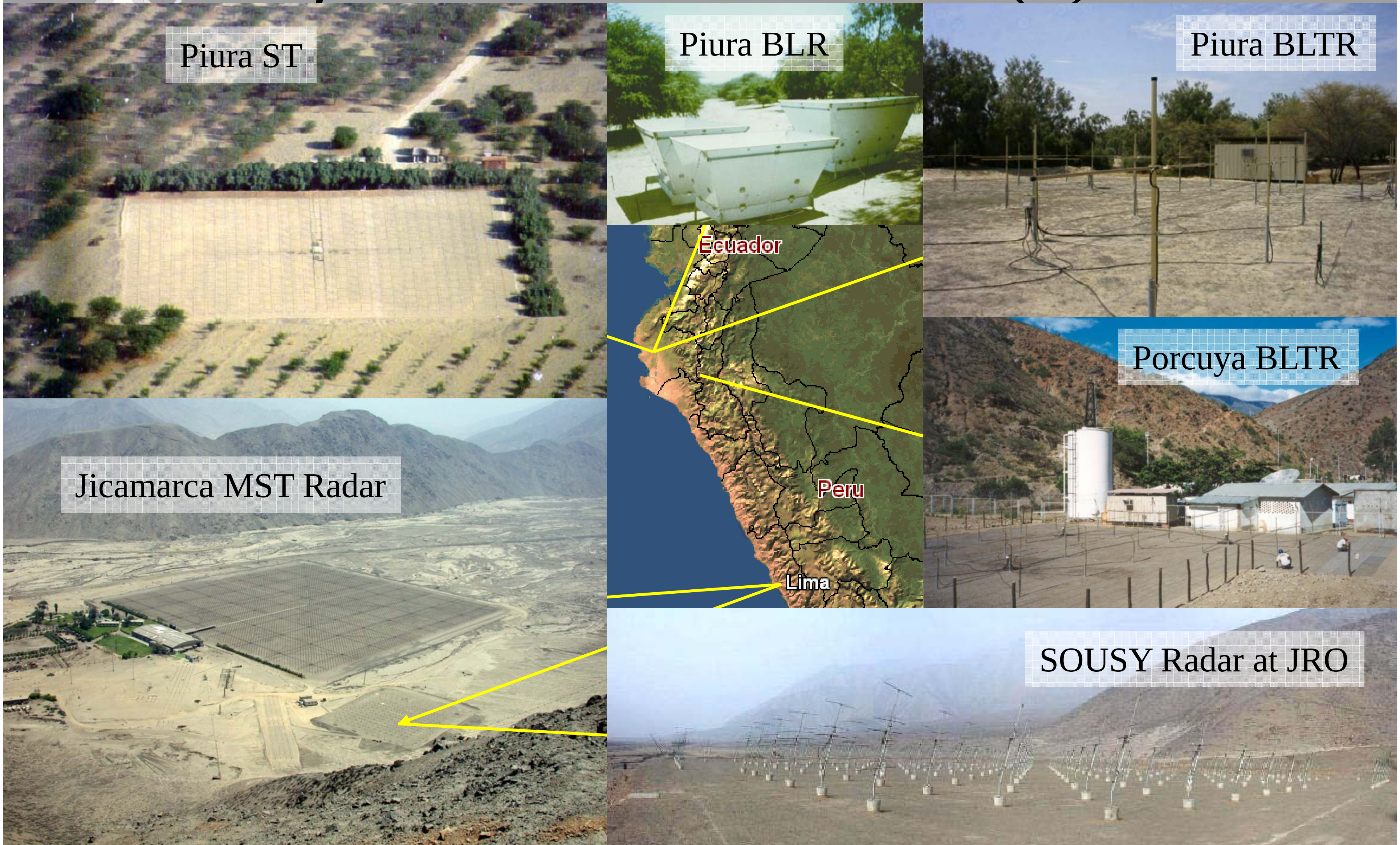


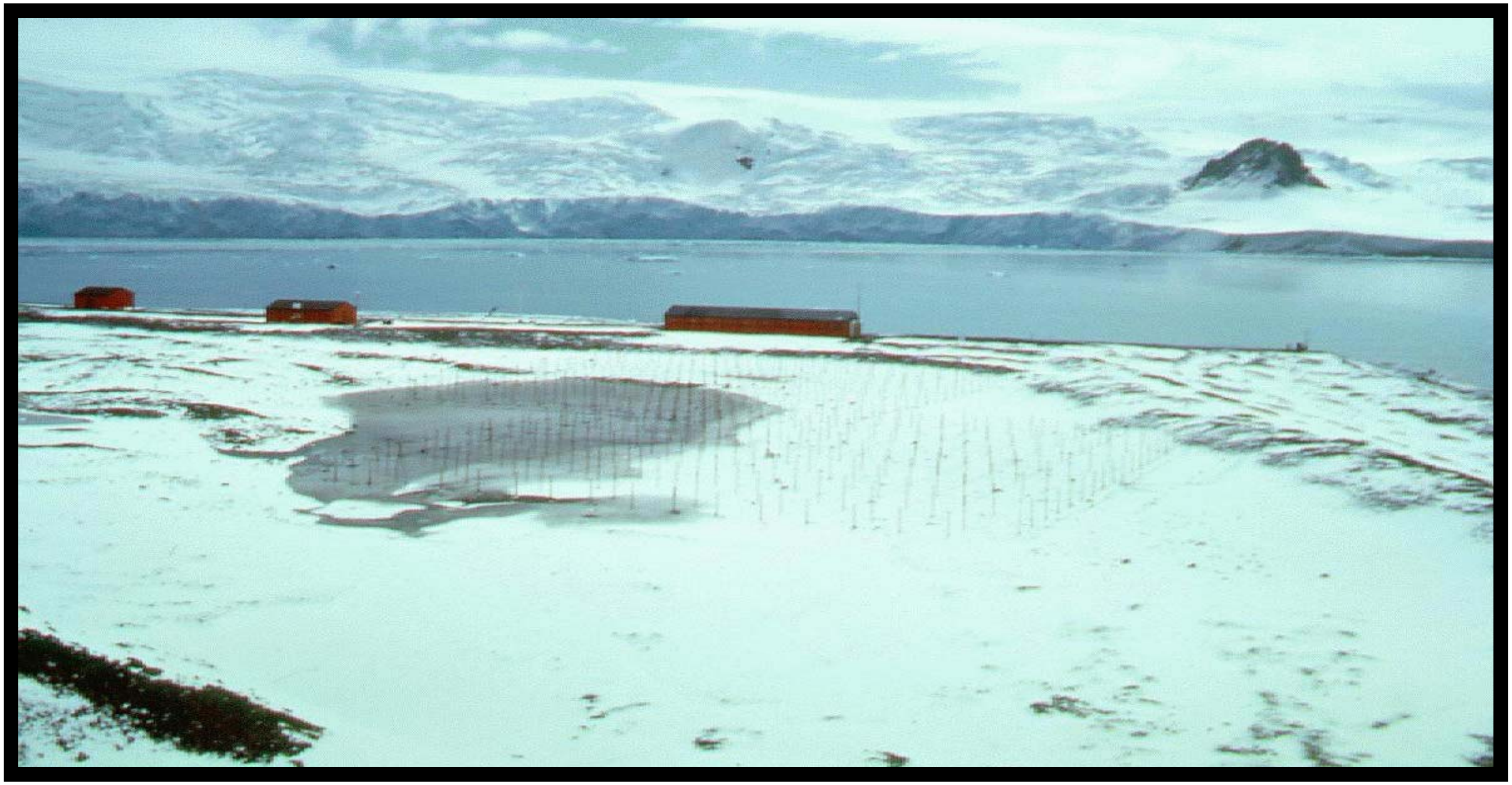
Figure 1. Distribution of VHF, MF, and meteor radars on a world-wide basis.

(de *Hocking* [1997])

Atmospheric radars in Peru (1)



RADAR ANTARTICO "MST"



IX EXPEDICION CIENTIFICA

Estación Científica "MACHU PICCHU"

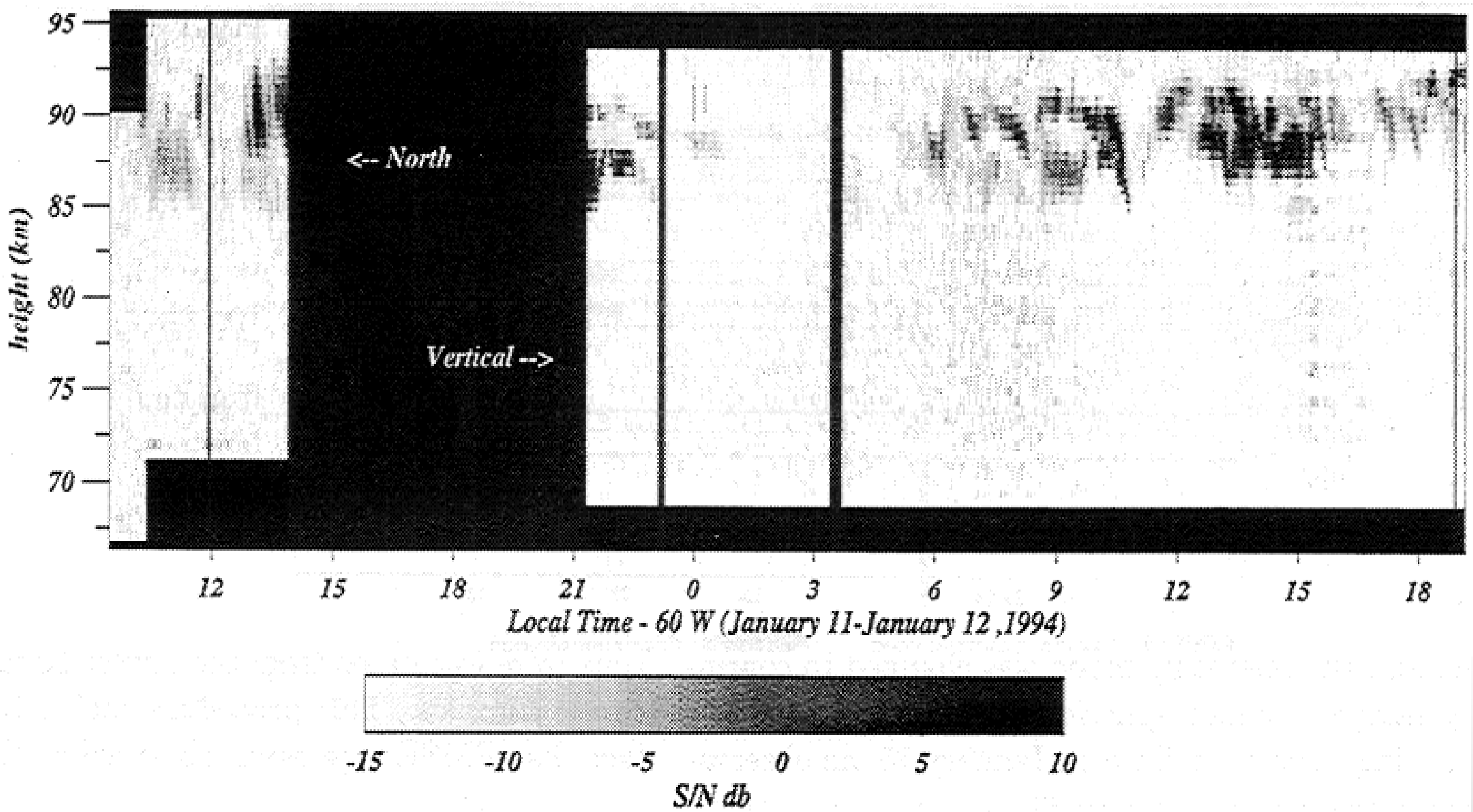


Figure 2. Range-time-intensity plot covering the period between late January 11 to midday January 15, 1994, when continuous observations at mesospheric heights were made and polar mesospheric summer echoes (PMSEs) were observed.

Perfiladores Peruanos

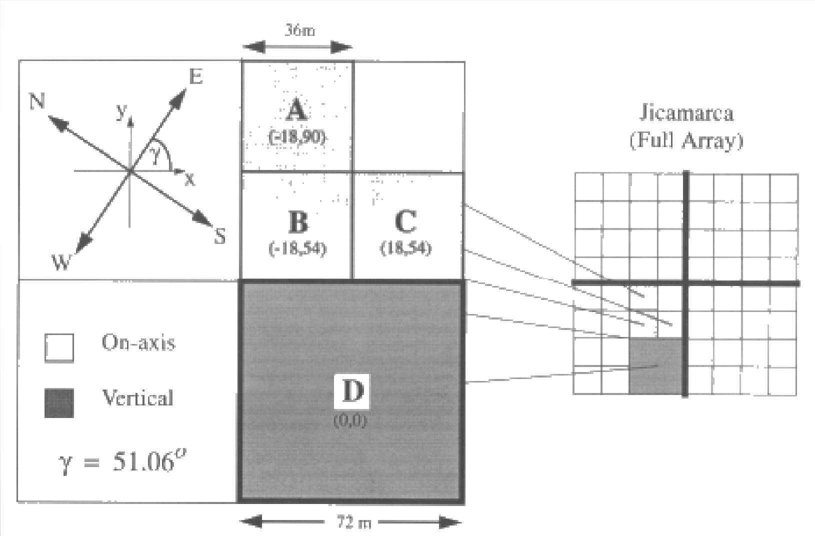
Ubicación	Tipo	Banda	Tamaño	Potencia	Método	Período
Jicamarca	MST	VHF	< 300m x 300m > 36m x 36m	100 kW o 4 MW	DBS/SA	1972-
Piura	ST	VHF	100m x 100m	30 kW	DBS	1989-
Antártida	MST	VHF	50m x 50m	30 kW	DBS	1998-1999?
Piura	BLR	UHF	3m x 3m	4 kW	DBS	1998-1999?
Piura (Isla Lobos?)	BLT	VHF	30m x30m	12 kW	SA	2001-2003?
Porcuya (Huancayo)	BLT	VHF	30m x 30m	12 kW	SA	2002-
Jicamarca SOUSY	MST	VHF	64m x 64m	500 kW	DBS	2003?-

Principales estudios

- Vientos:
  - Varias ventajas sobre medidas realizadas por aviones o globos:
    - Medidas de volumen en lugar de puntuales
    - Medidas contínuas, esenciales para los estudios de variación a mesoescala.
    - Vientos verticales, otras técnicas los infieren y sólo obtienen valores sinópticos.
- Ondas atmosféricas:
  - Con períodos desde minutos a días (ondas de gravedad, planetarias, mareas, ...)
- Turbulencia
- Estabilidad atmosférica
- …

Métodos de Funcionamiento

- A través de proyecciones múltiples (Doppler beam swinging)
  - Usan una misma antena de tx y de rx.
  - Antenas apuntan en diferentes direcciones.
  - Asumen homogeneidad en un espacio de ±15º respecto a la vertical, y obtienen el viento de 3D.
  - Usan análisis espectral de frecuencia.
- A través de “sombras” y el uso de múltiples antenas (Spaced Antenna)
  - Usan por lo menos tres antenas de rx y una de tx.
  - Miden el patrón de difracción en tierra (en las antenas de rx)
  - Mediante análisis de correlaciones cruzadas en los señales recibidas se obtienen los parámetros atmosféricos.



Jicamarca: Configuración SA

MST•10

TENTH INTERNATIONAL WORKSHOP ON TECHNICAL AND SCIENTIFIC ASPECTS OF MST RADAR

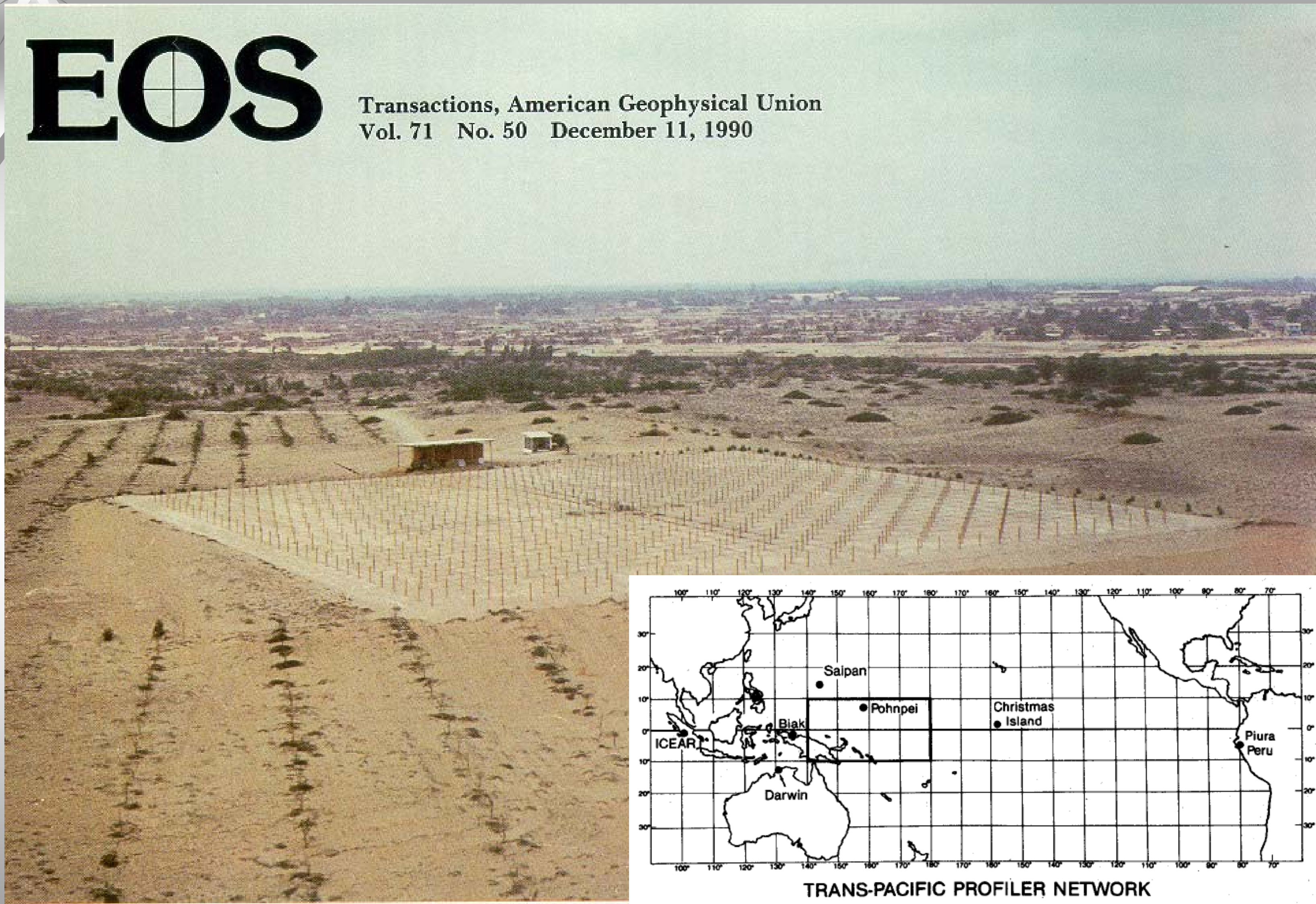
UNIVERSIDAD DE PIURA, PERU

MAY 20-27, 2003 (OR MAY 13-20, 2003, TBD)

IF YOU ARE INTERESTED IN RECEIVING FURTHER INFORMATION ABOUT THE WORKSHOP, PLEASE SEND AN EMAIL TO MST10@JRO.IGP.GOB.PE BY AUGUST 15, 2002, SPECIFYING

1. YOUR NAME AND AFFILIATION
2. FULL MAILING ADDRESS
3. TELEPHONE AND FAX NUMBERS INCLUDING THE INTERNATIONAL CODE
4. E-MAIL ADDRESS
5. AN INDICATION WHETHER YOU ARE PLANNING TO PRESENT PAPER(S)
6. POTENTIAL TOPIC OF YOUR PAPER(S)

Piura ST (1)

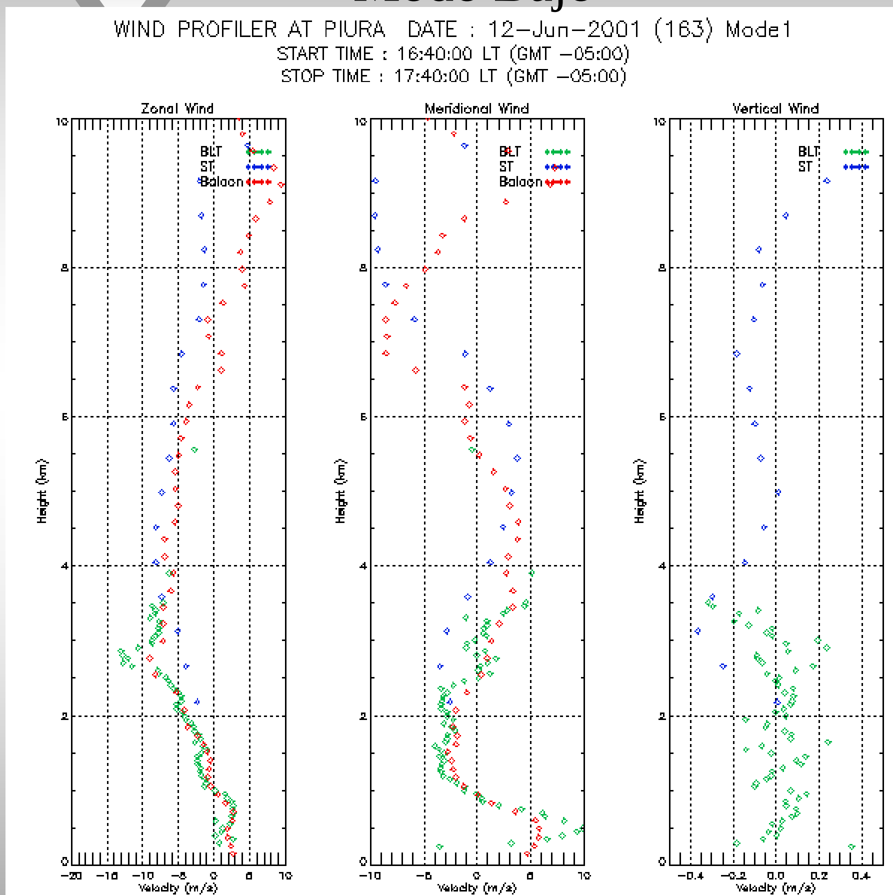

EOS
Transactions, American Geophysical Union
Vol. 71 No. 50 December 11, 1990
Saipan
Pohnpei
Christmas Island
Biak
ICEAR
Darwin
Piura Peru
TRANS-PACIFIC PROFILER NETWORK

Piura BLT (1)

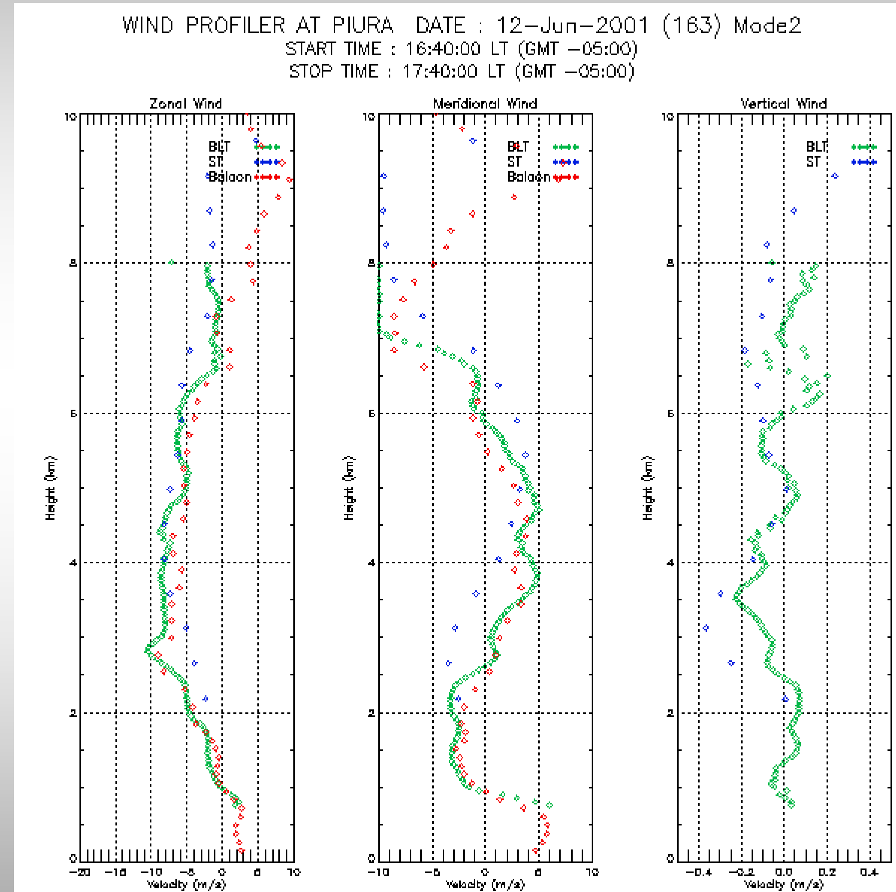
- Radar comprado por el IGP como parte del proyecto multi-institucional para el estudio de El Niño.
- Funciona desde Junio del 2001 y sus datos se encuentran en la página Web del ROJ http://jro.igp.gob.pe/database/winds_blt/html/windsblt.htm
- Datos horarios son publicados en tiempo real en la página web del ROJ.

Piura BLT (2)
Comparaciones con globos piloto y radar ST

Modo Bajo

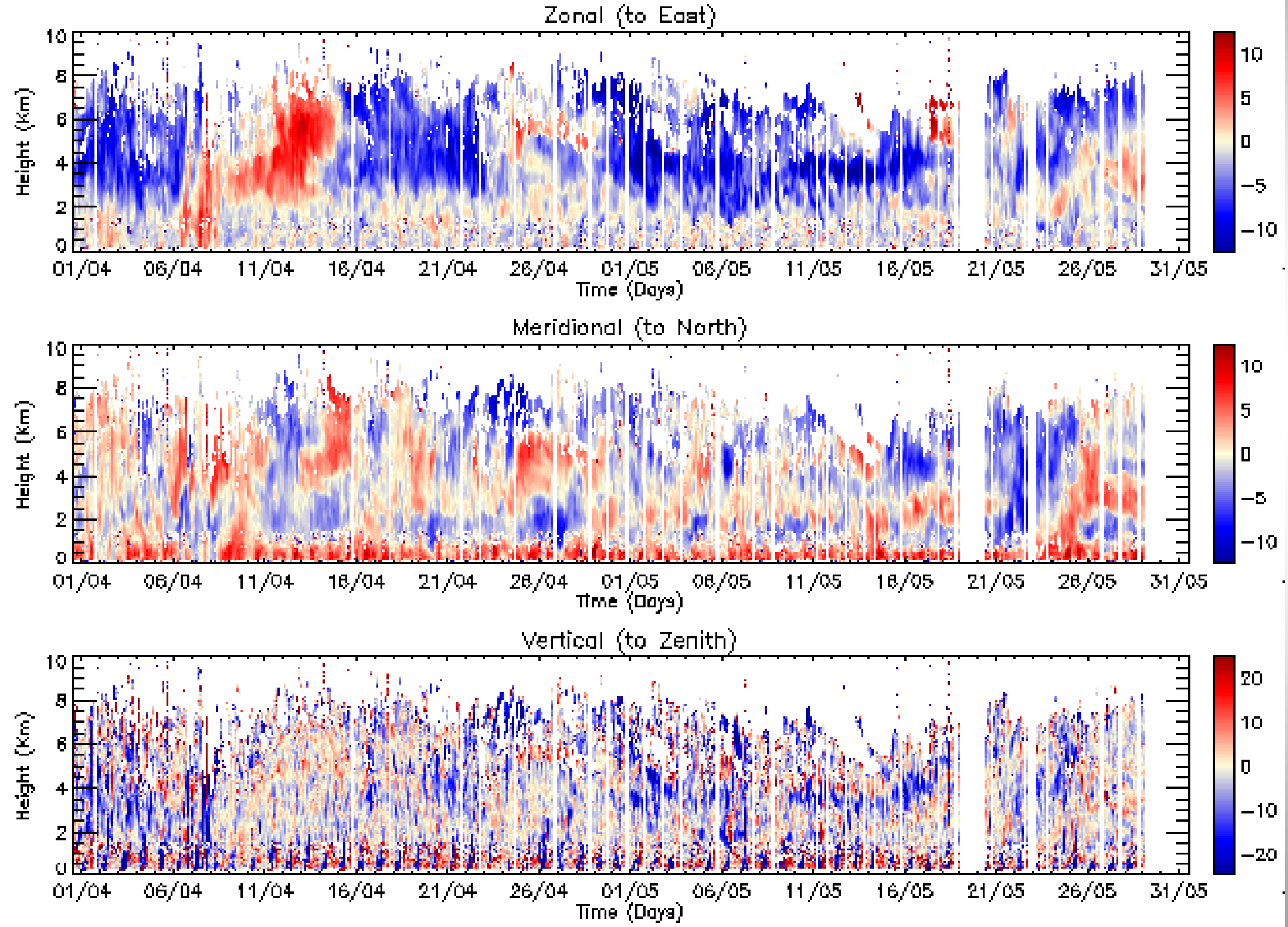


Modo Alto



(Chau et al., C. personal)

Piura BLT (3)
Vientos sobre Piura
(01 de abril al 31 de mayo, 2002)

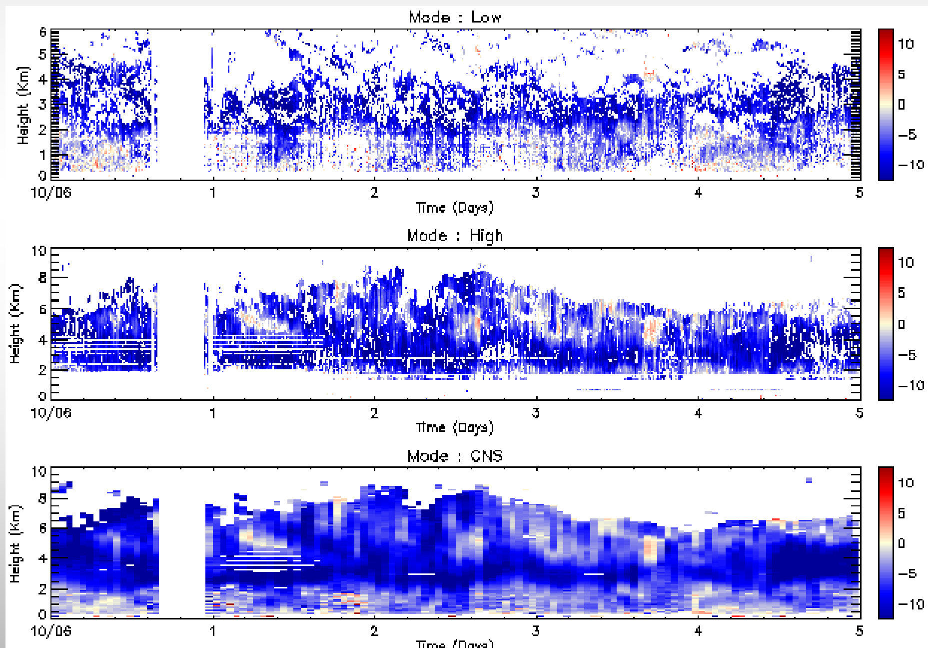


(Chau et al., C. personal)

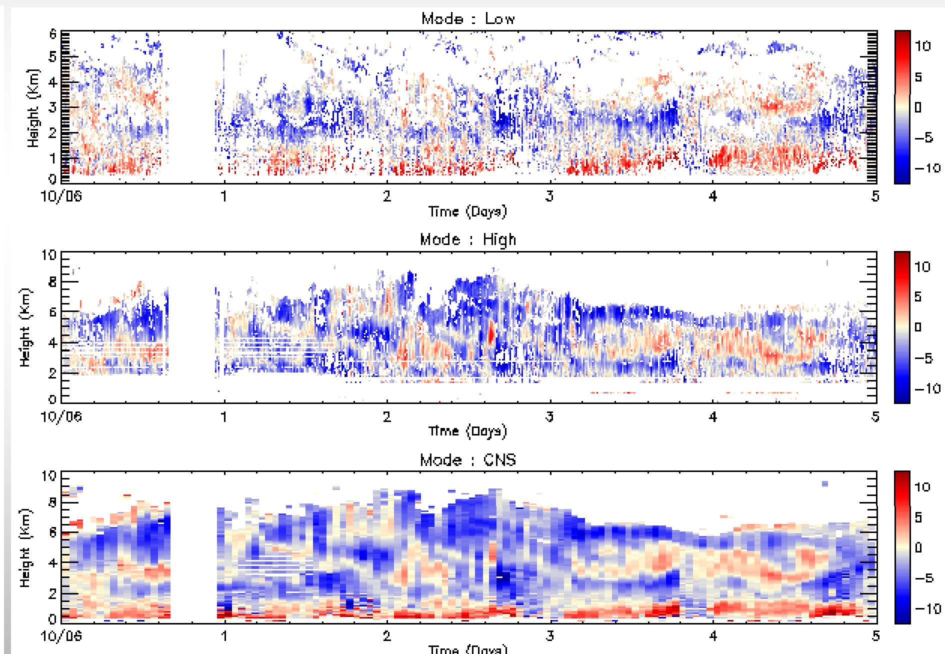
Porcuya BLT (3)
Datos horarios

(10-14 de Junio, 2002)

Zonal



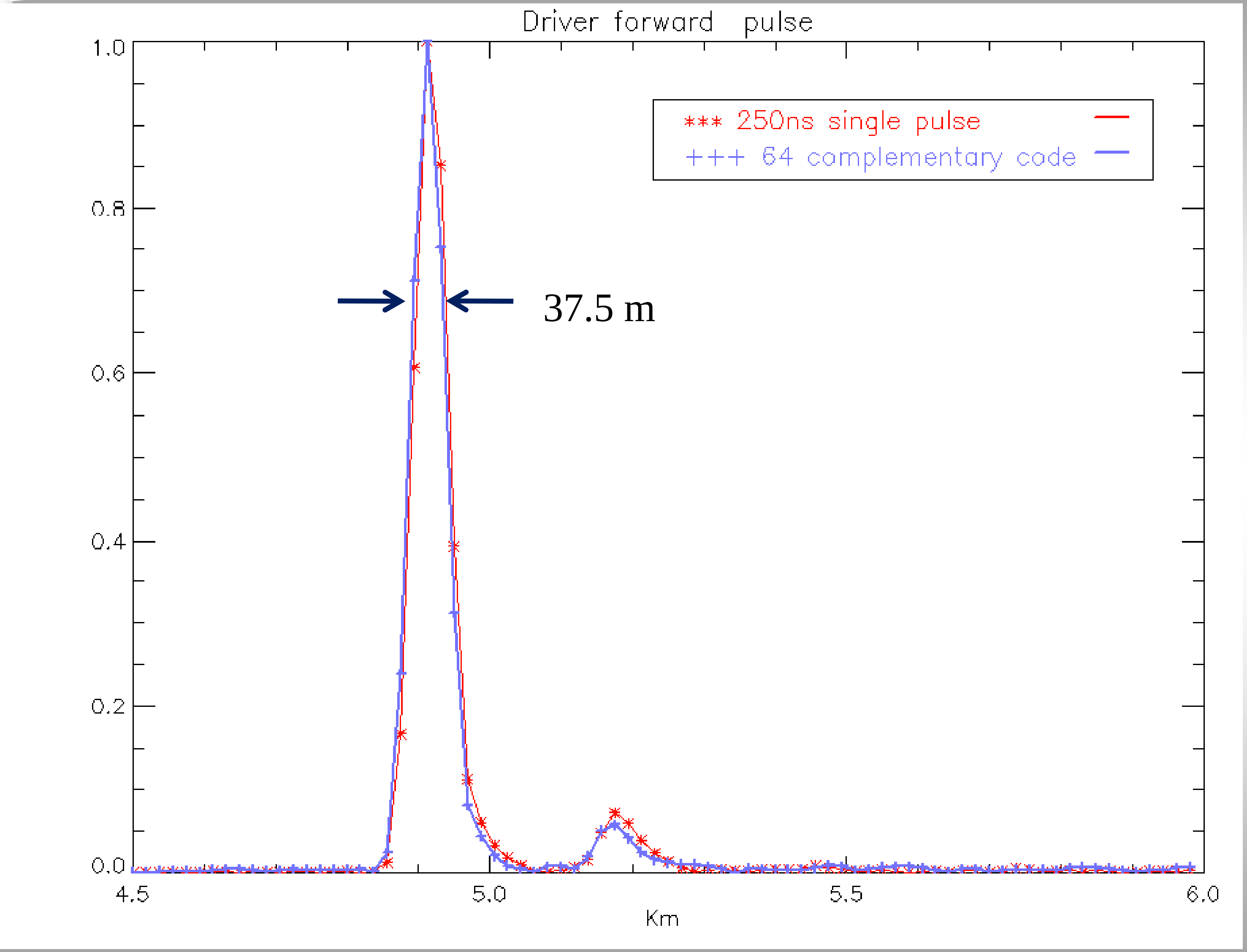
Meridional

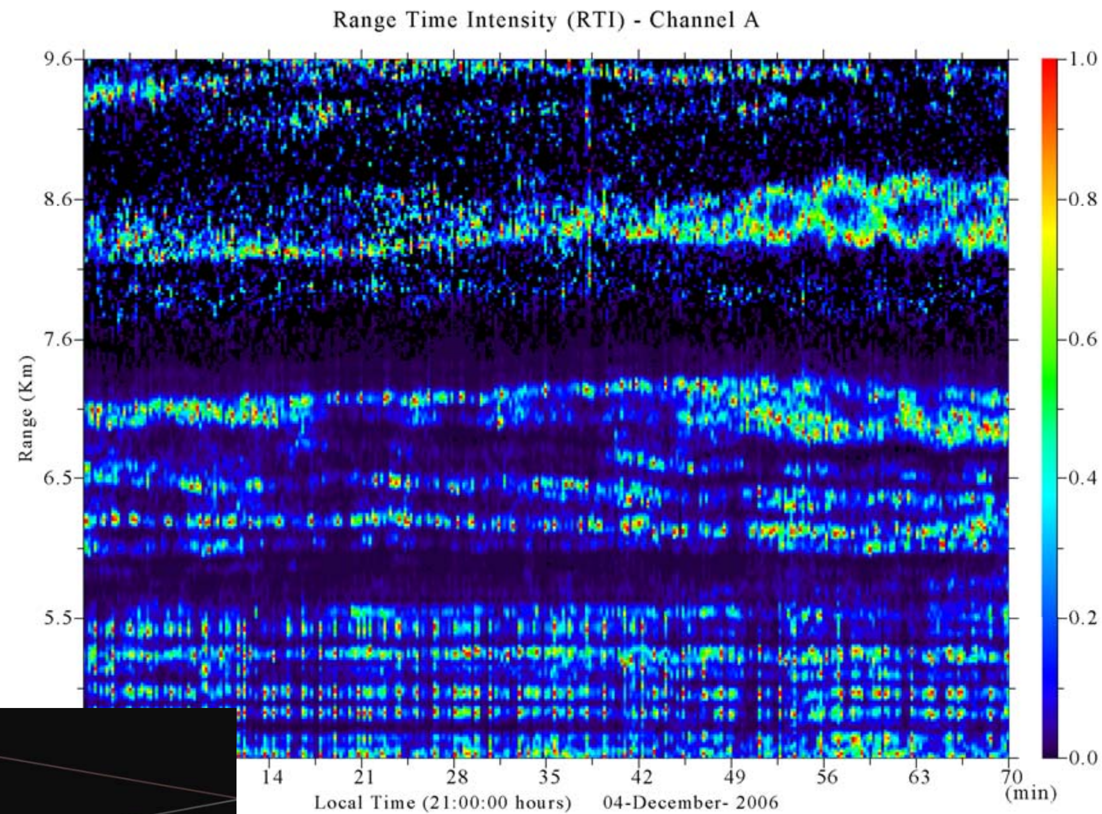


Viento predominante del Este!

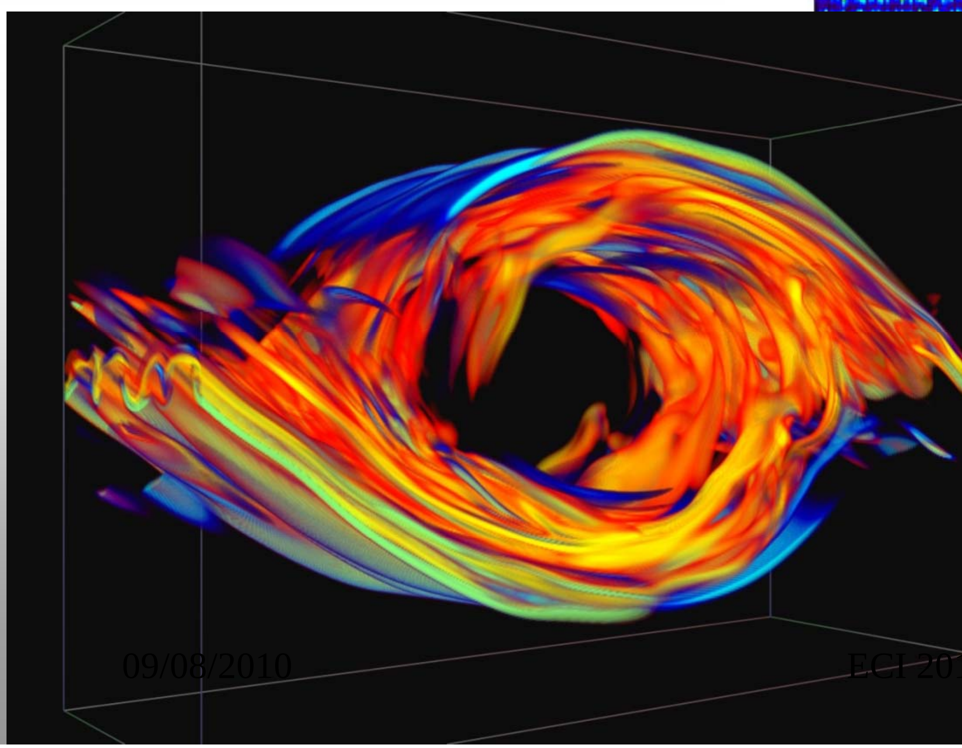
(Chau et al., C. personal)

Radar SOUSY en Jicamarca


Driver forward pulse
*** 250ns single pulse
+++ 64 complementary code
37.5 m
1.0
0.8
0.6
0.4
0.2
0.0
4.5
5.0
5.5
6.0
Km



(Woodman y Villanueva, 2009)



(Fritz et al., 2009)(

CONCLUSIÓN

El Perú puede!

GRACIAS!