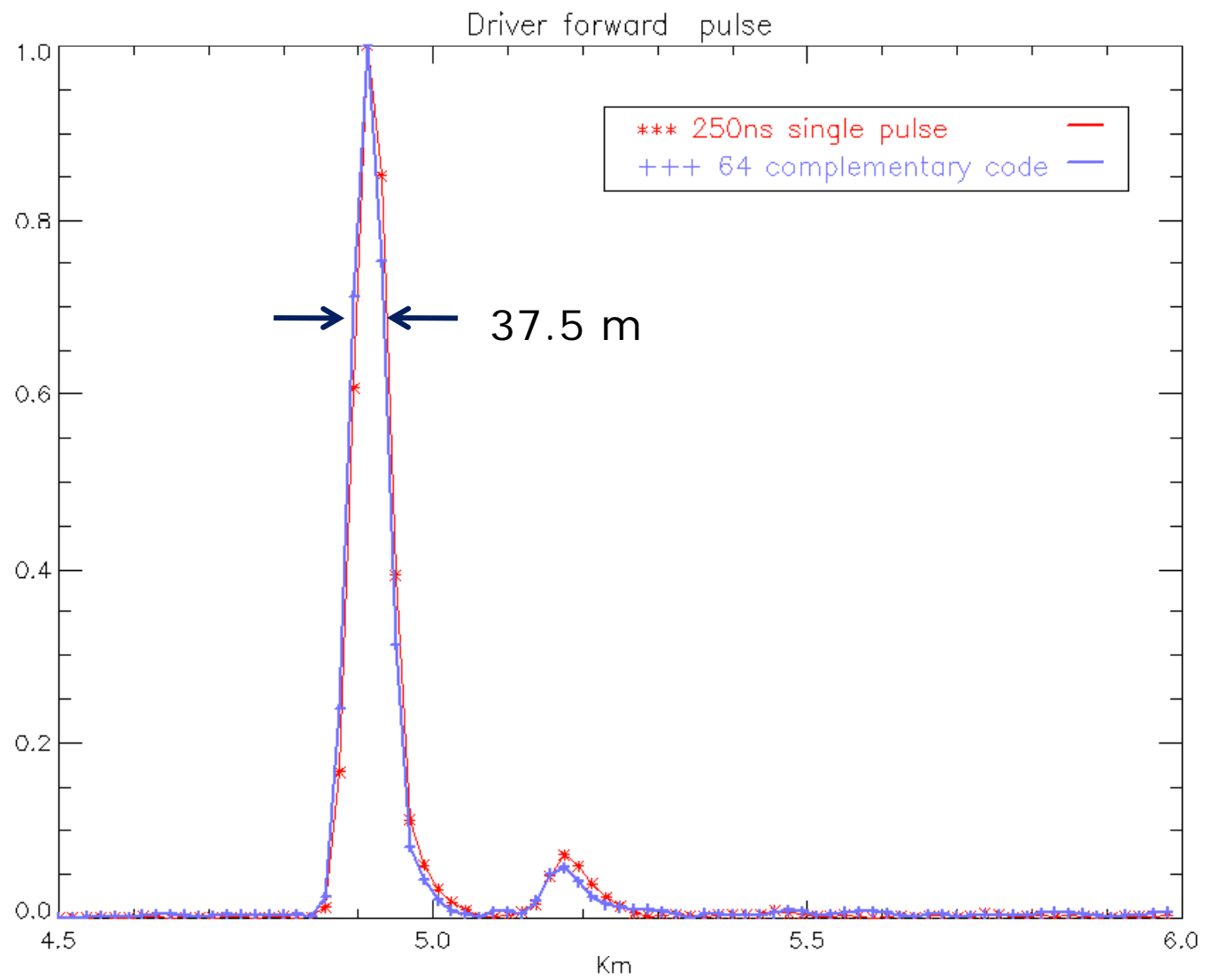


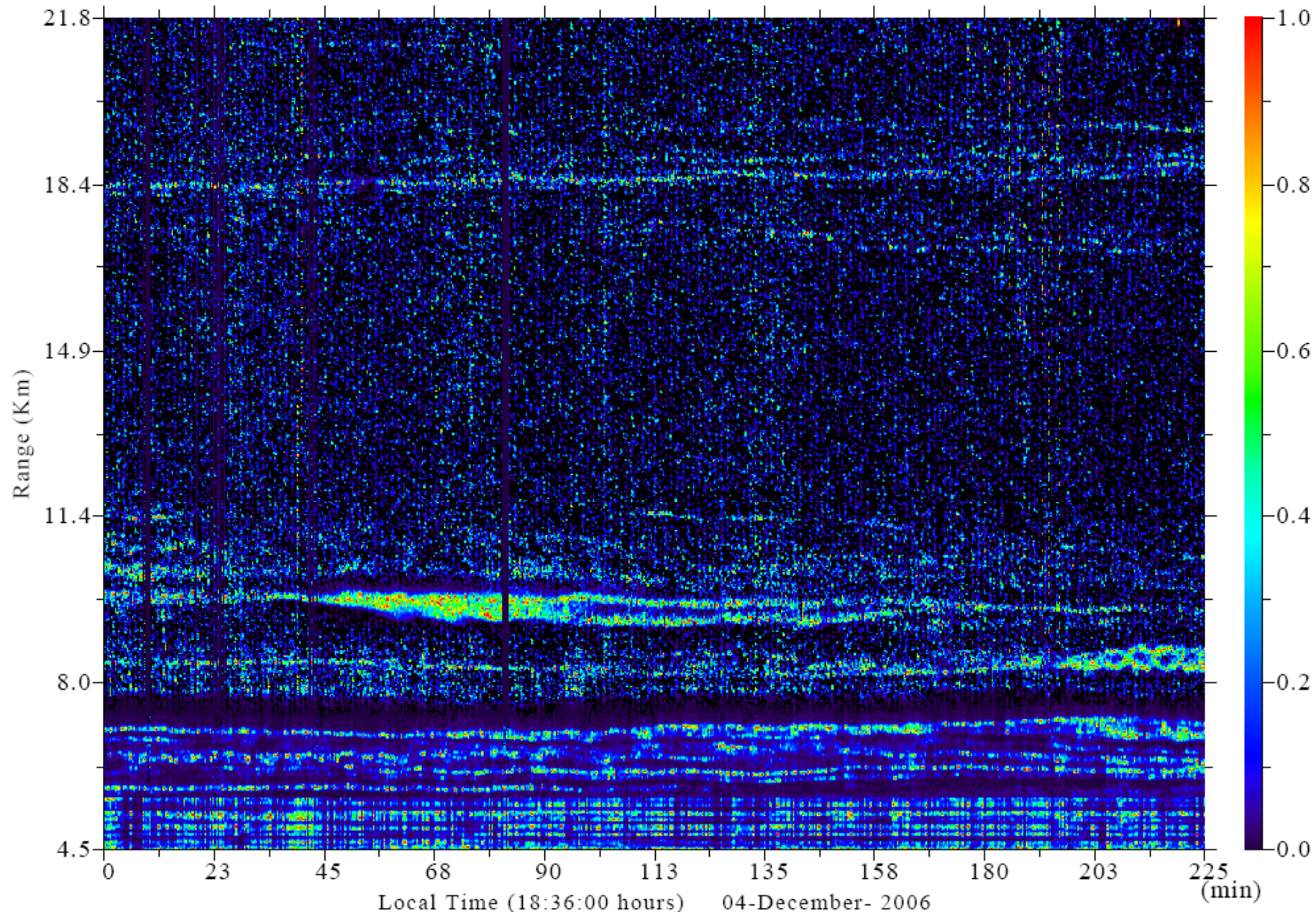
Hi-resolution radar observations of KH billows at upper tropospheric heights

R.F. Woodman and F. Villanueva R.
Jicamarca Radio Observatory
Instituto Geofisico del Peru

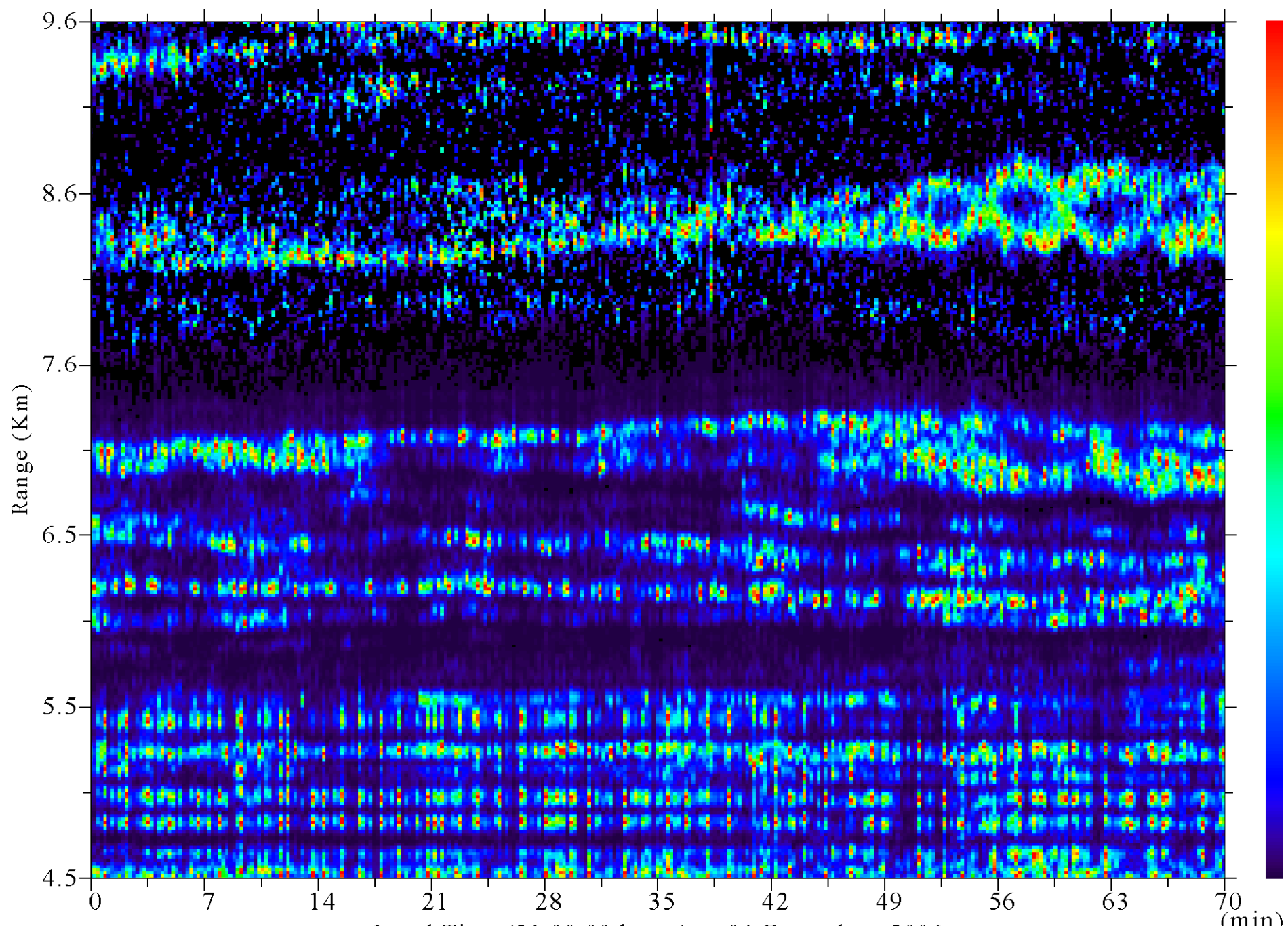




Range Time Intensity (RTI) - Channel A



Range Time Intensity (RTI) - Channel A



Atlas and Metcalf, 1970

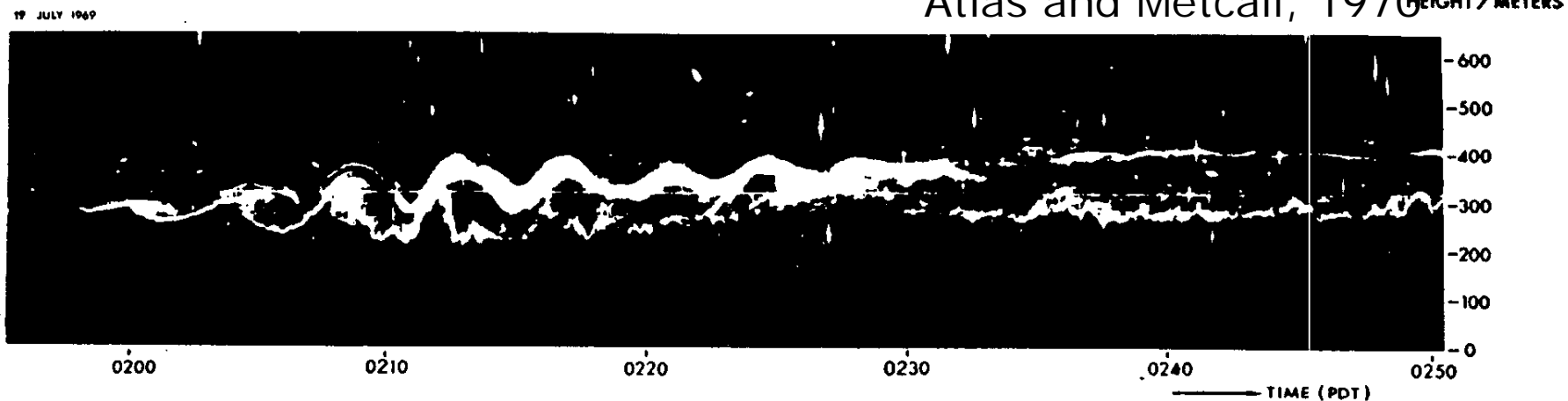
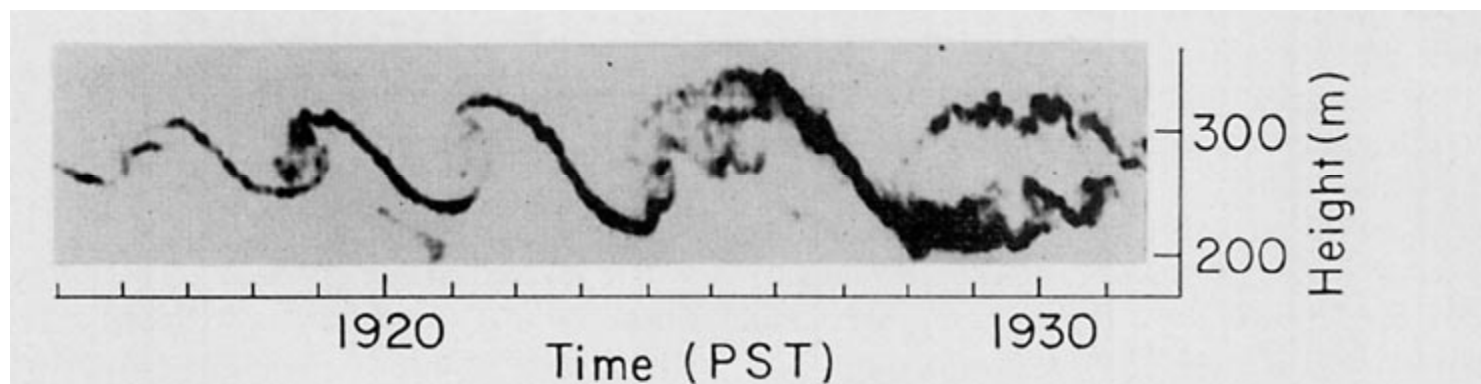
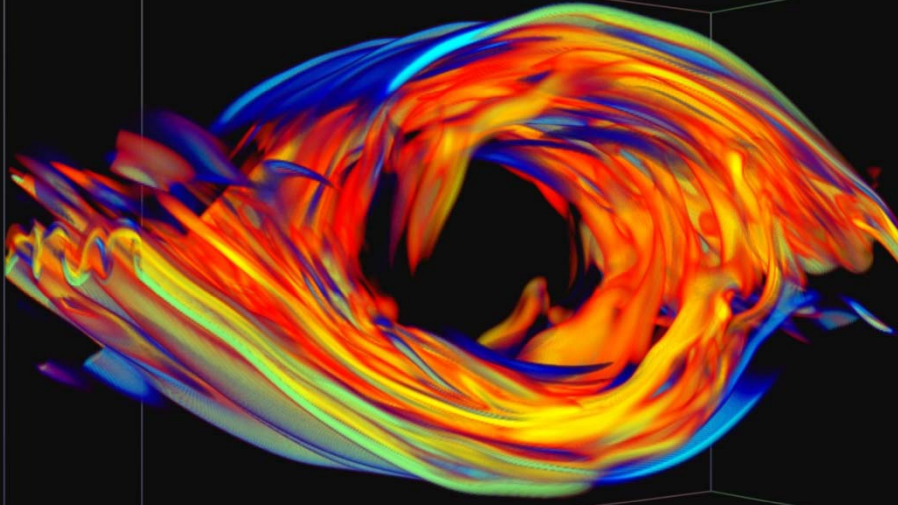


FIG. 1. Intensity-modulated display of time-height record of 19 July 1969 with 2 m vertical resolution. Note inset (dot) echoes, mostly above 300 m, many of which appear to follow the wave motion. Unstable waves and subsequent turbulence in lower layer contrast with smooth structure of the upper layer. The double layer structure observed after 0230 is characteristic of many clear air echoes.

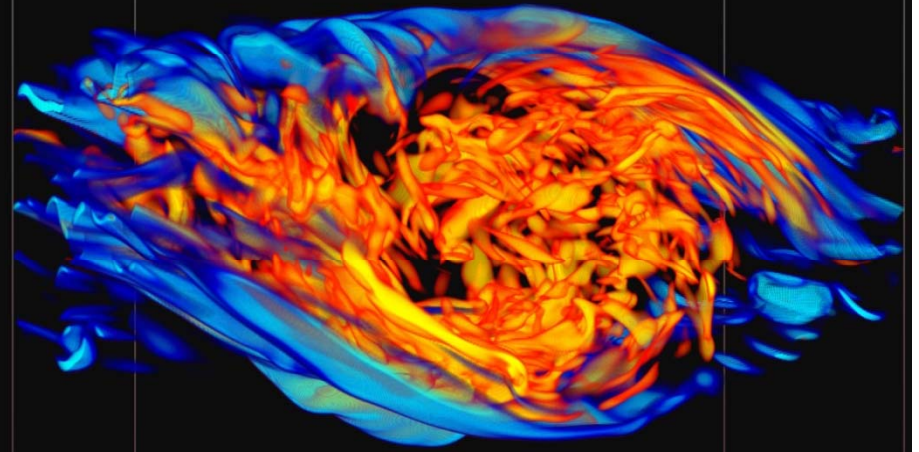


Metcalf, 1975

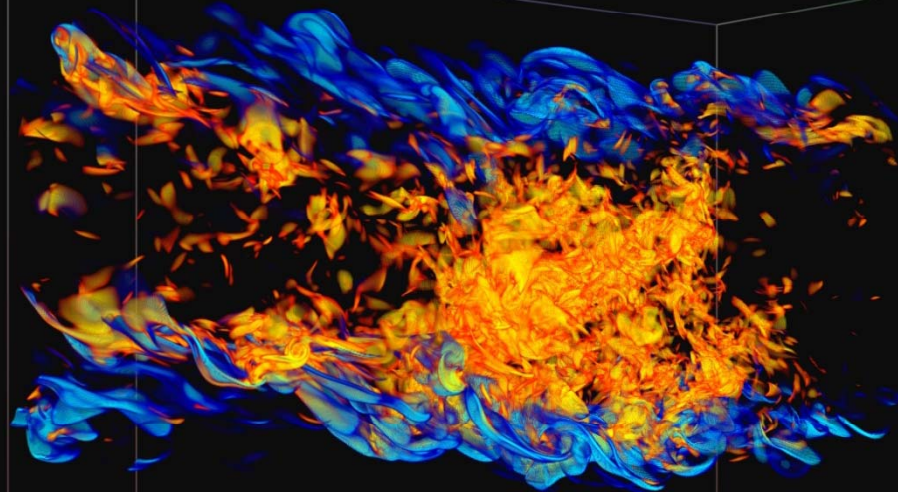
$t \sim 2$



$t \sim 3$

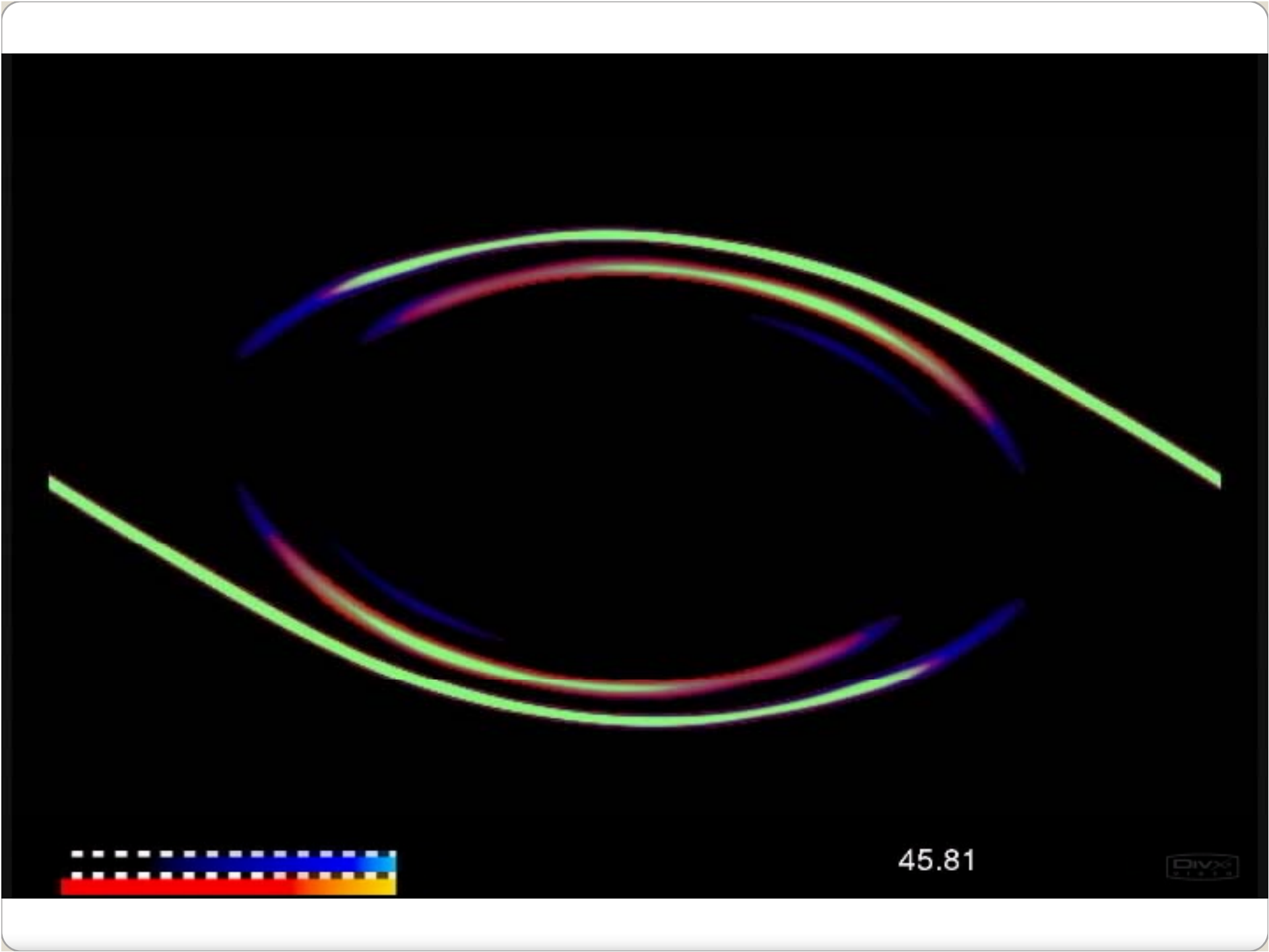


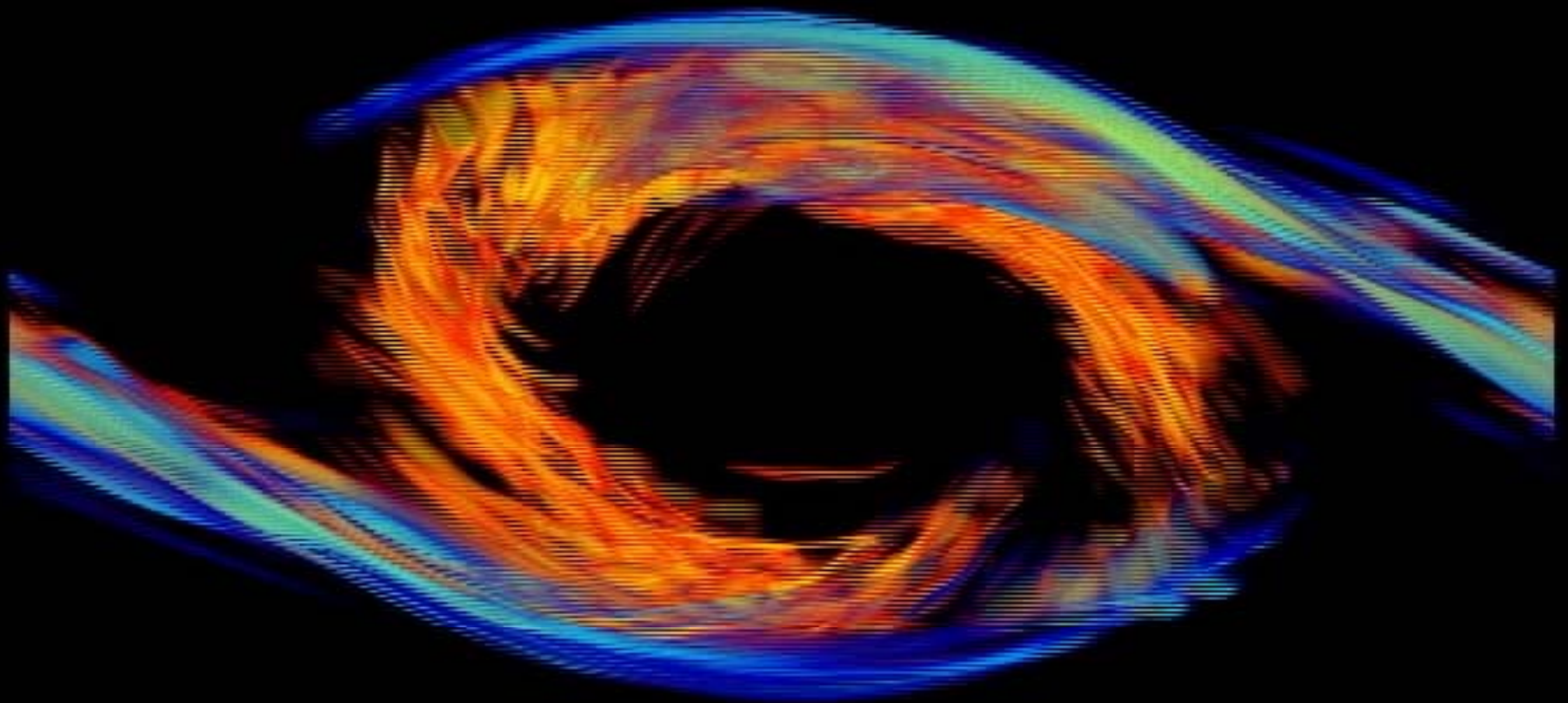
$T \sim 6$



thermal dissipation, χ

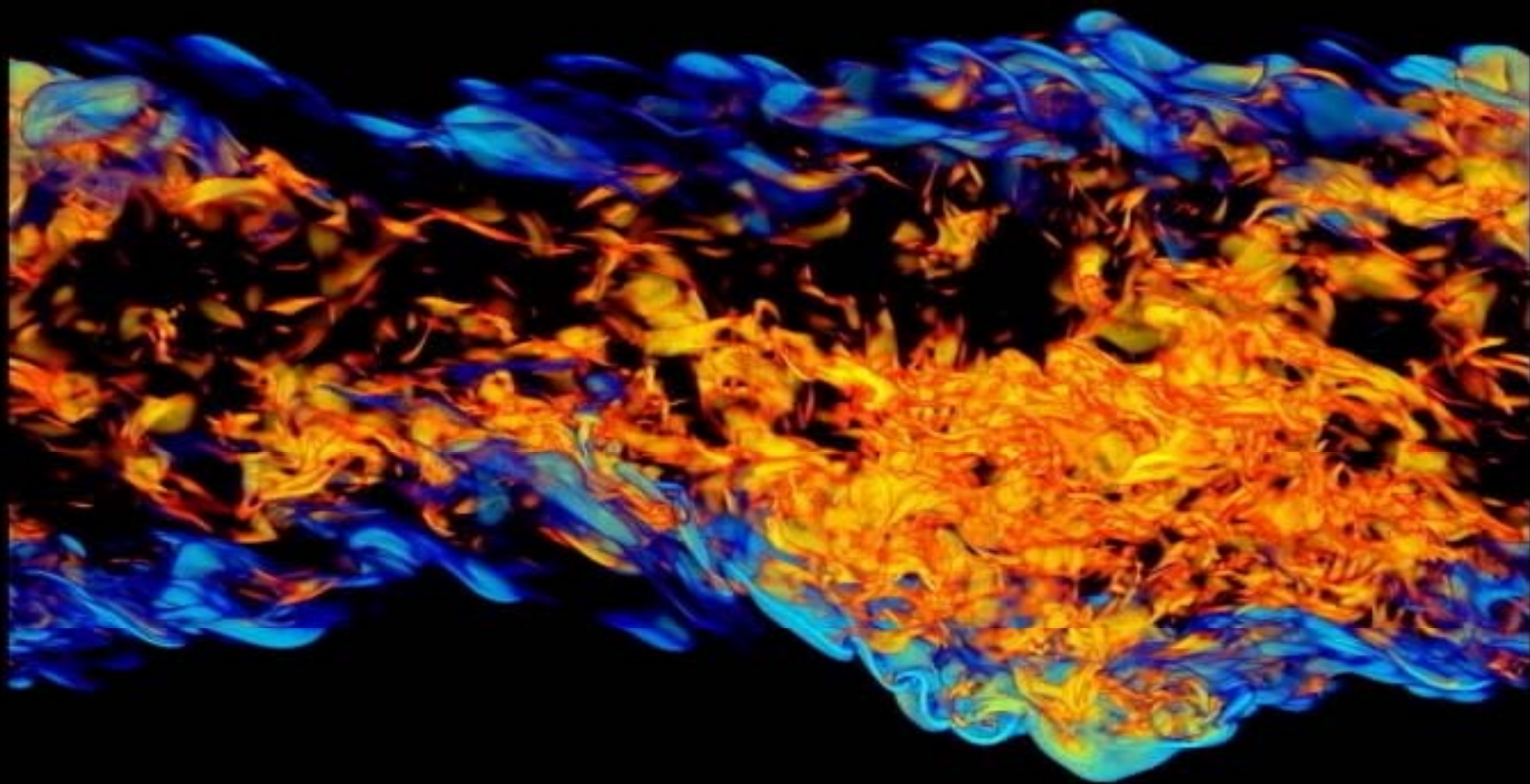
viscous dissipation, ε





93.22





171.12



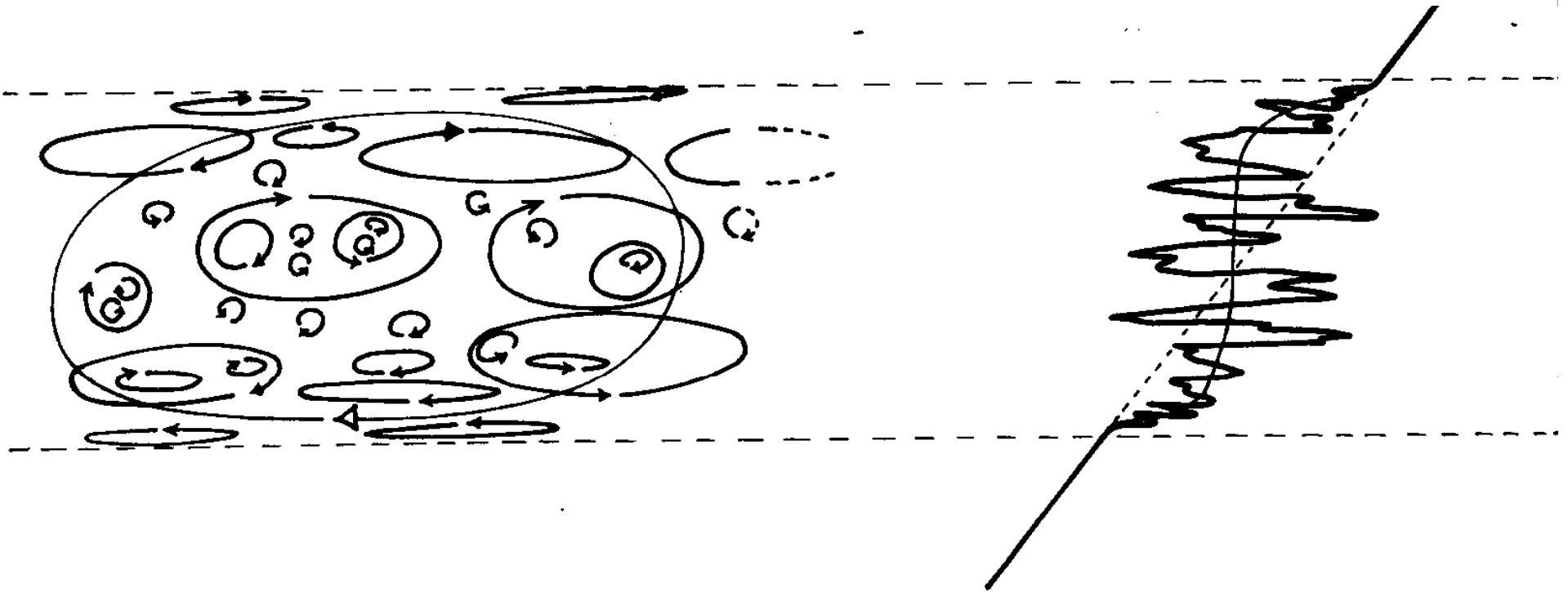
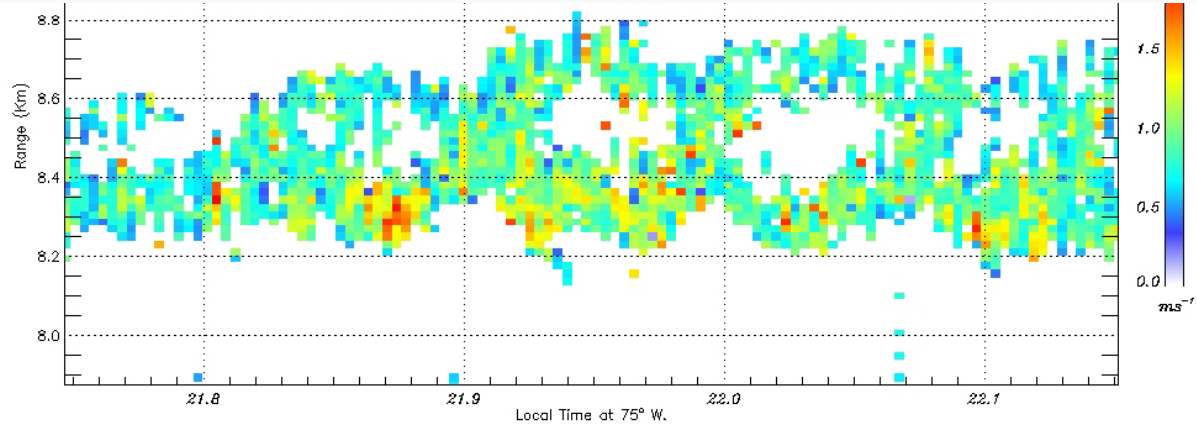
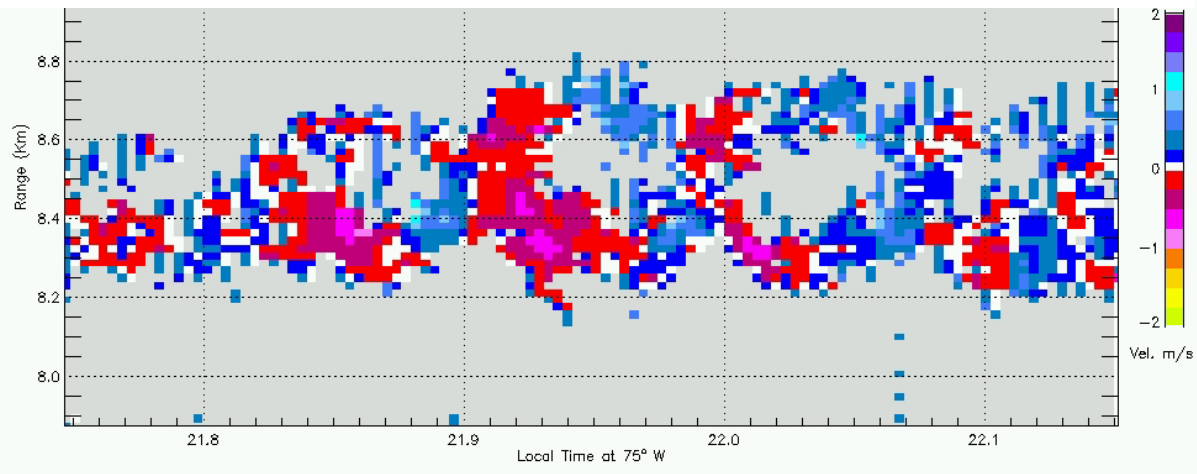
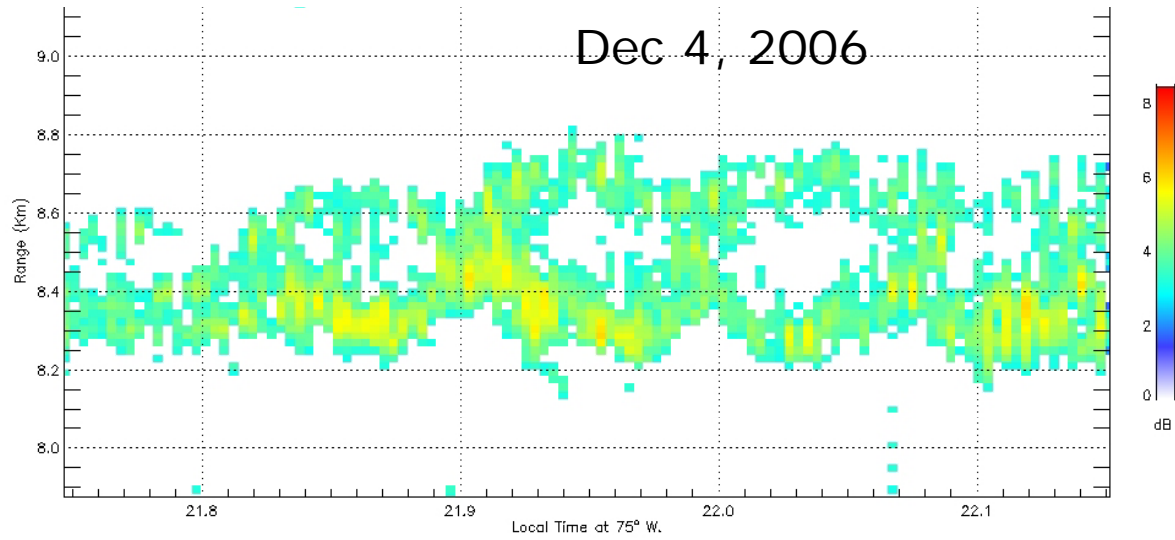


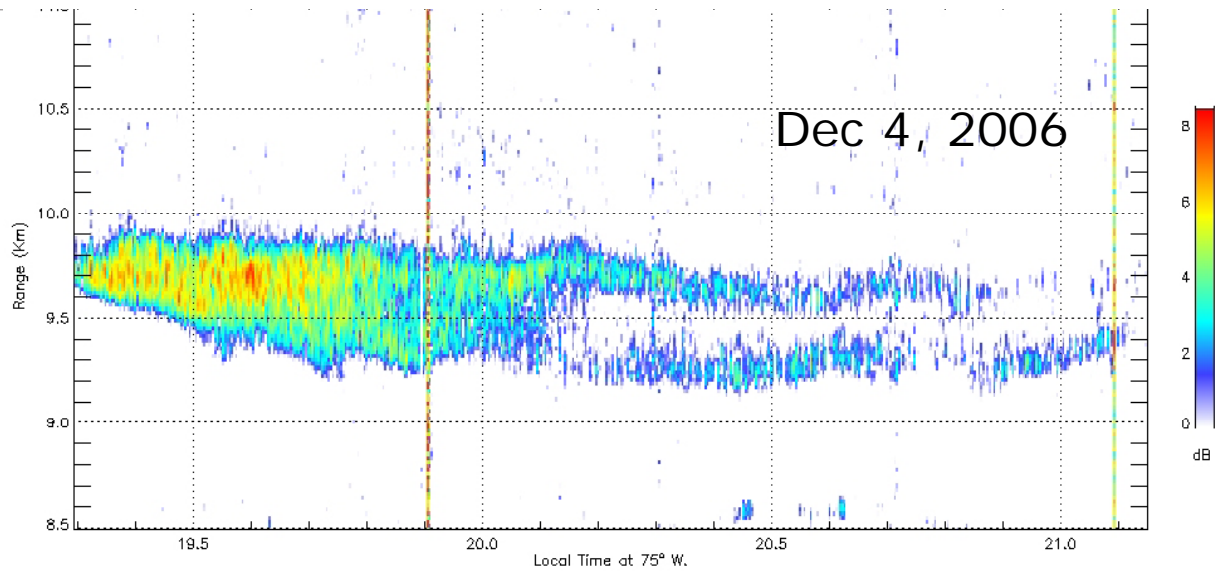
Fig. 4. Schematic diagram of an anisotropic turbulent model proposed in the text. The left figure shows schematically the “shape” of the eddies throughout the volume. Note that the eddies at the edges have been purposely elongated in the horizontal dimension. The horizontal dimensions at the edges are driven by the larger central eddies, while the small vertical dimensions are confined by the steep stable gradients in potential temperature. The right-hand diagram in the figure shows the mean and disturbed profile of potential temperature.



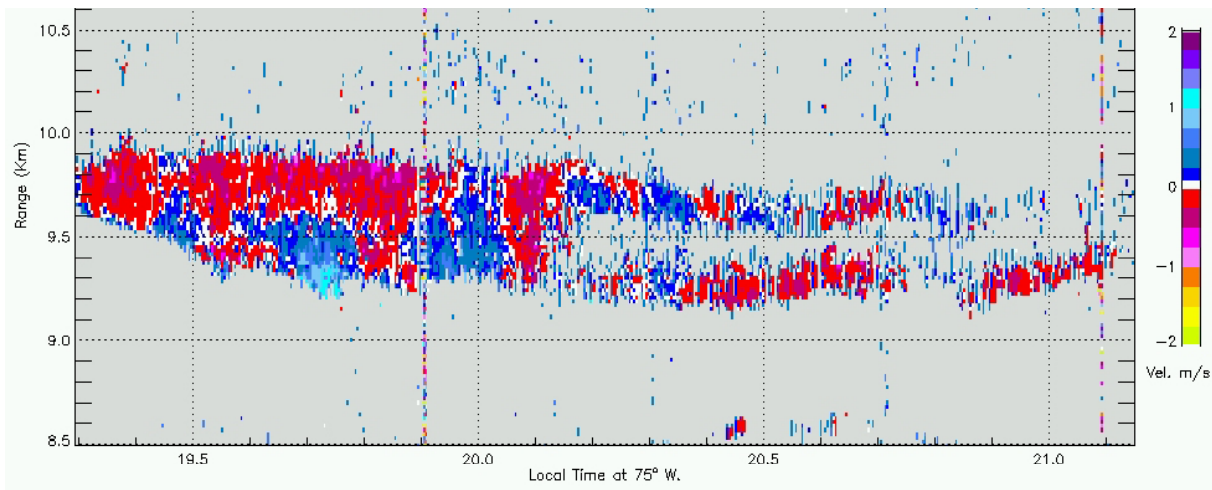
Power

Vertical
velocity

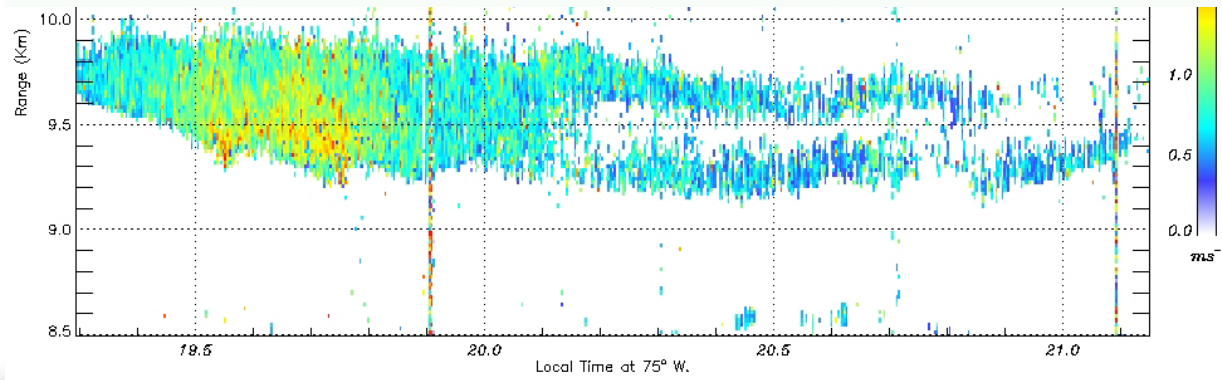
Spectral
width



Power



Vertical
velocity



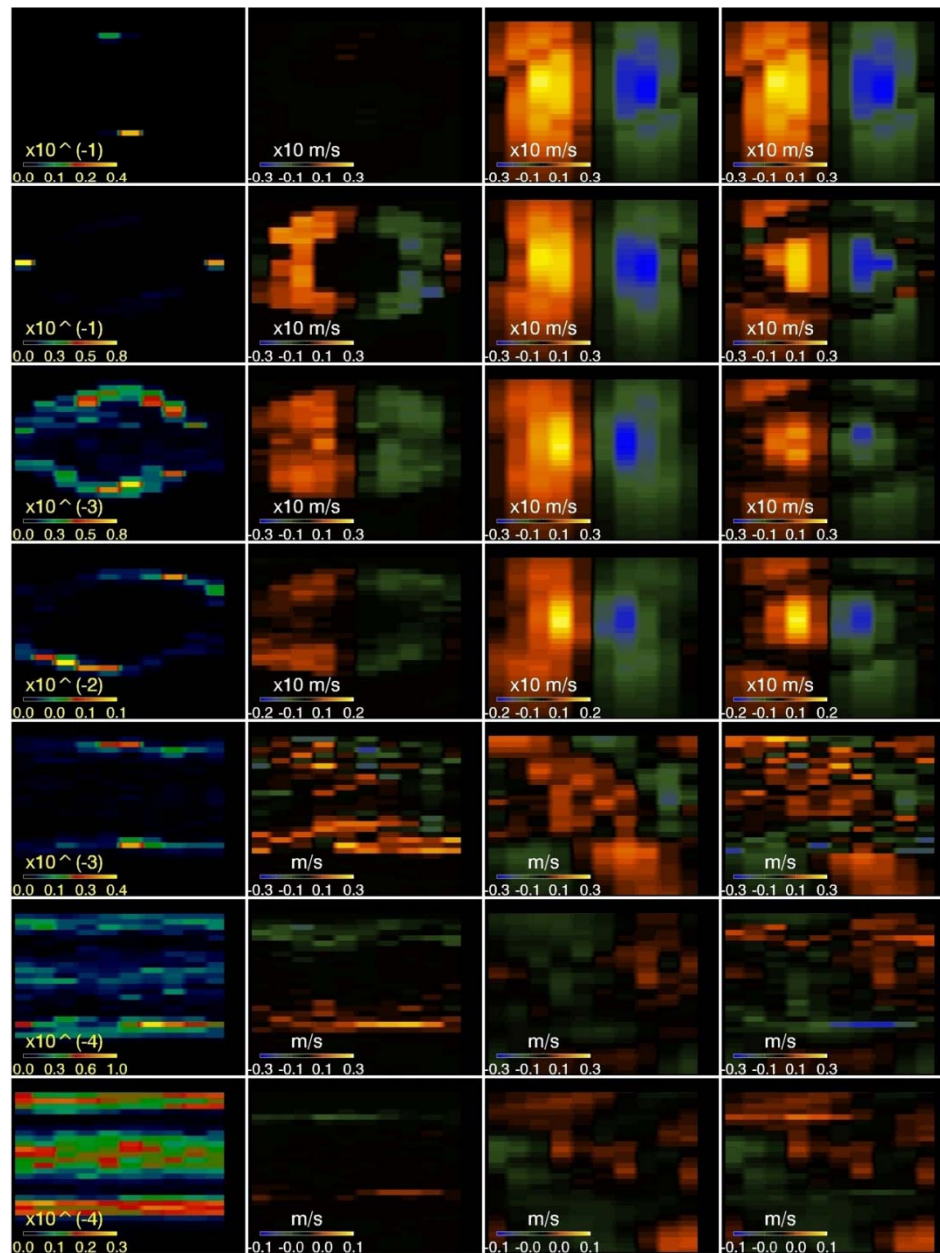
Spectral
width

$$C(\tau, T) \approx \int F(\mathbf{a}, h - T) \hat{\rho}(\mathbf{k}, \tau; \mathbf{a}, h) d^2 \mathbf{a} dh$$

where

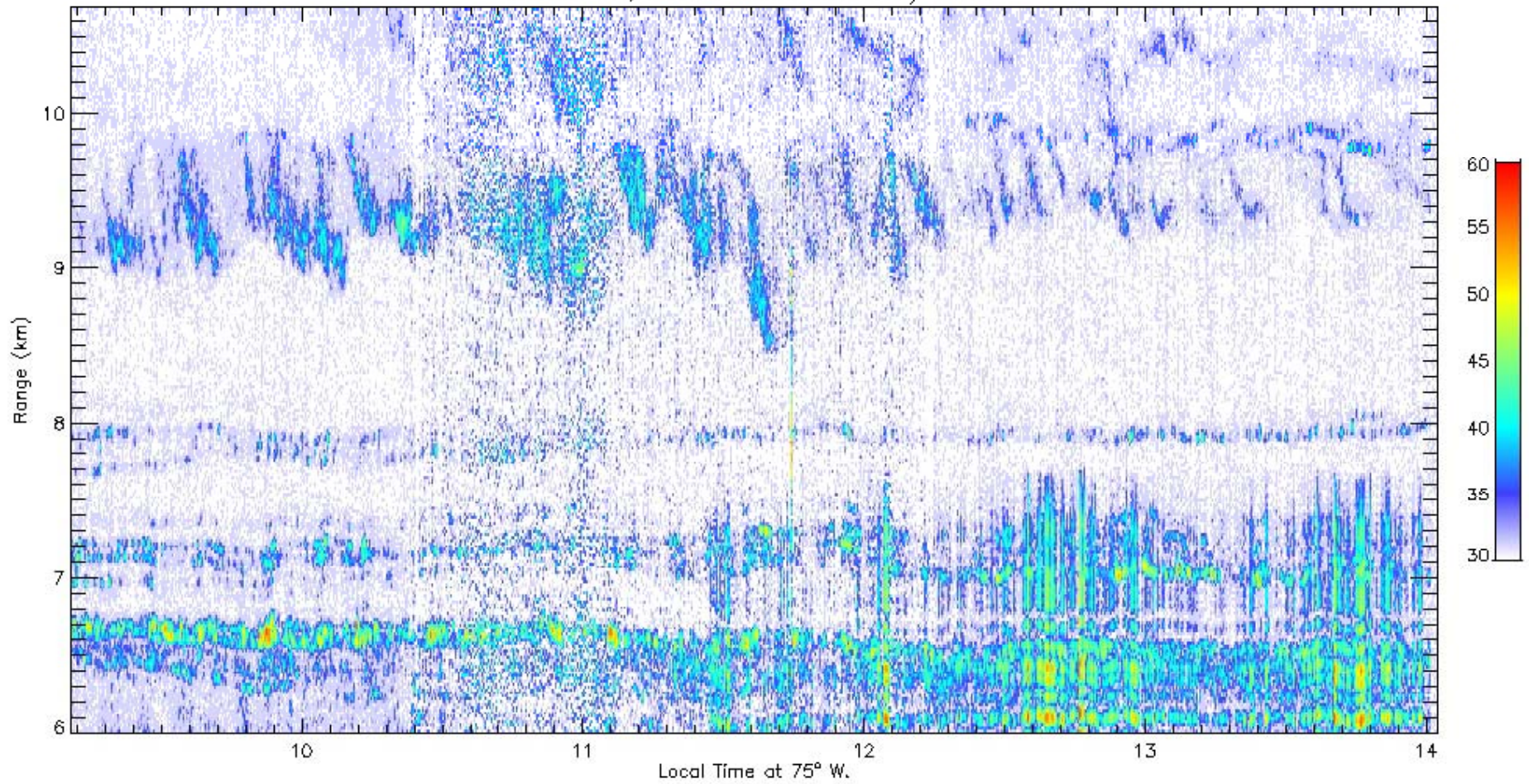
$$\hat{\rho}(\mathbf{k}, \tau; \mathbf{a}, h) = R_o(\mathbf{a}, h) \hat{\rho}'(\mathbf{k}, \tau; \mathbf{a}, h)$$

$$\bar{\mathbf{v}} = \int F(\mathbf{a}, h) \mathbf{v}(\mathbf{a}, h) d^2 \mathbf{a} dh$$

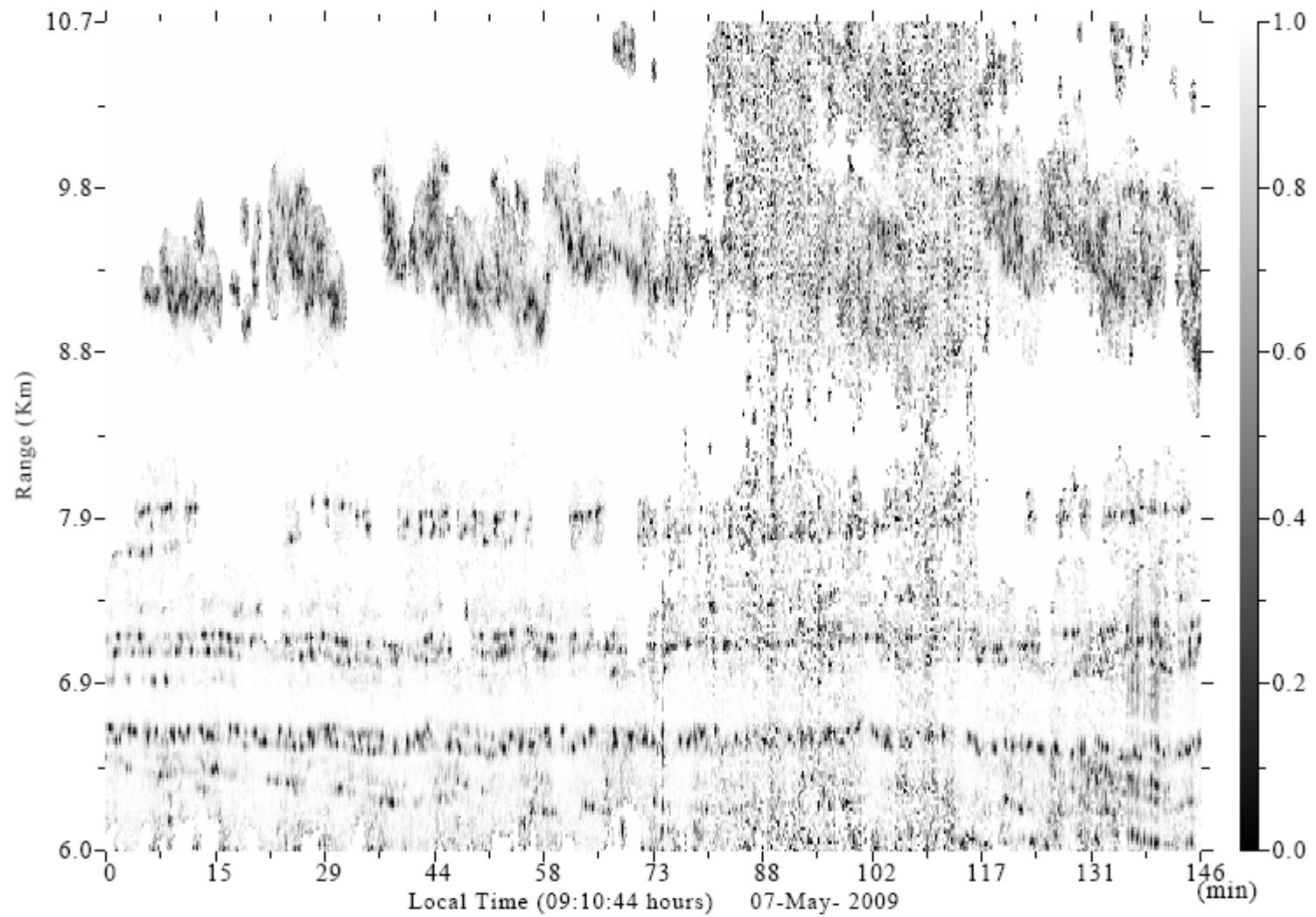


Fritts et al., submitted

Power RTI, SOUSY Radar – 07 May 2009



Range Time Intensity (RTI) - Channel A



Conclusions

- The SOUSY/Jicamarca radar has sufficient resolution to observe the inner structure and dynamics of KH unstable layers
- Its high resolution allows comparisons between numerical models and reality.
- Hi-resolution observations are important to evaluate the capabilities and limitations of lower resolution VHF radars to measure velocities

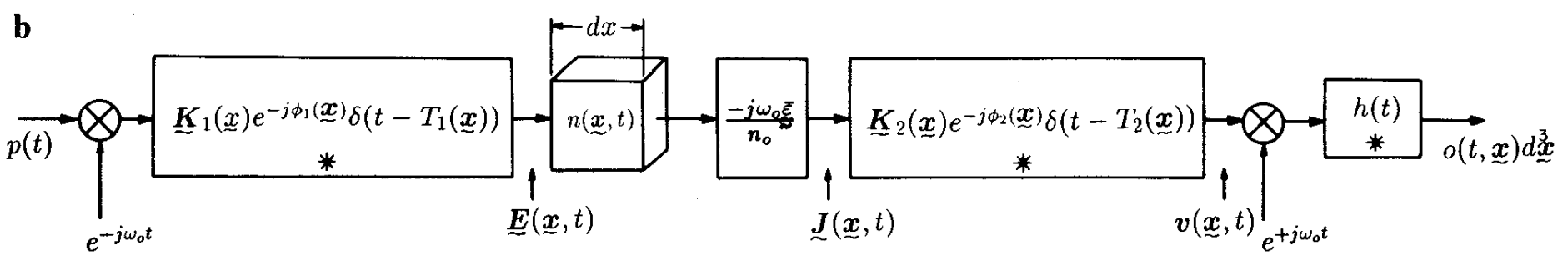
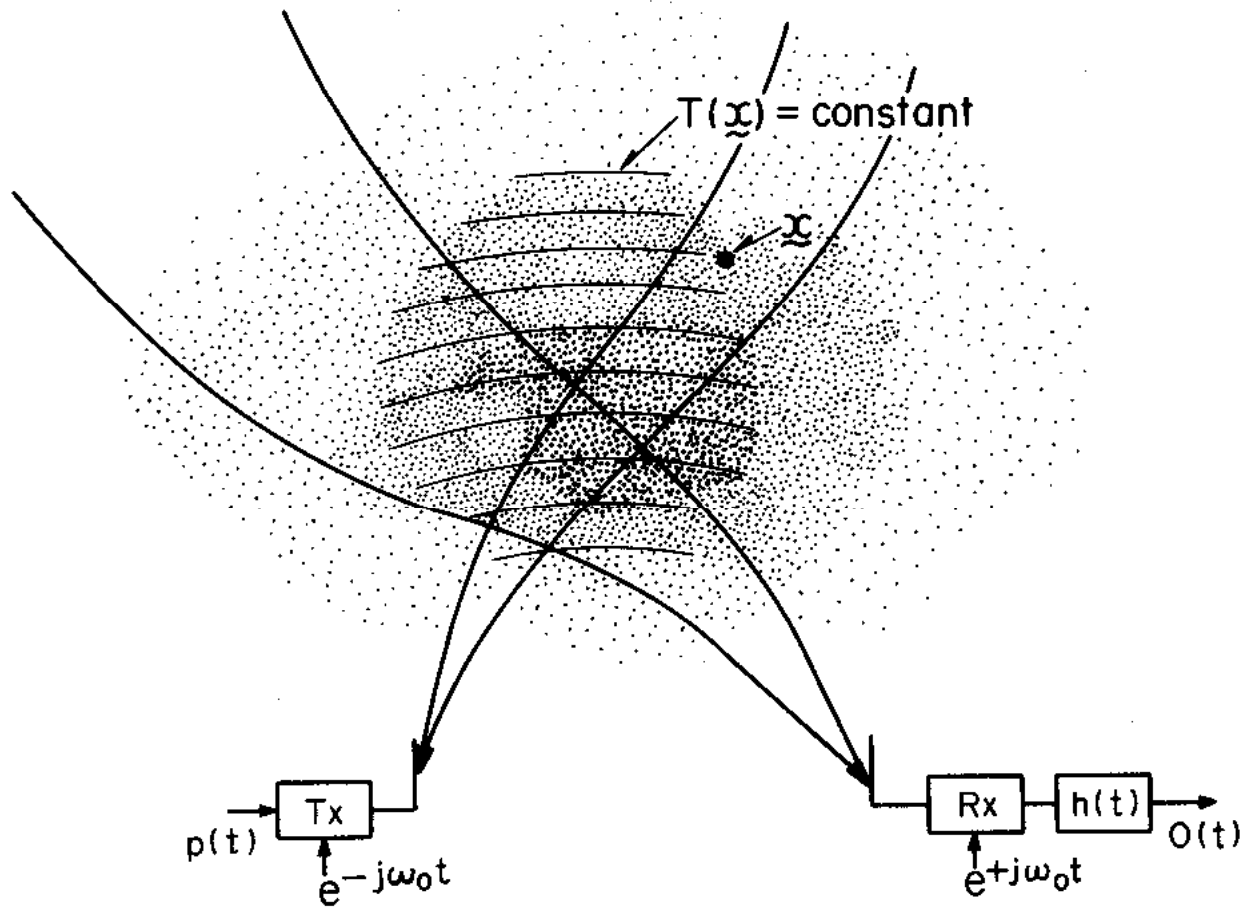
Thank you

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 96, NO. A5, PAGES 7911–7928, MAY 1, 1991

A General Statistical Instrument Theory of Atmospheric and Ionospheric Radars

RONALD F. WOODMAN

Jicamarca Radio Observatory, Instituto Geofísico del Perú, Lima



$$C(\tau, t) = F_0 \int dT d\tau' \cdot P(t - T, \tau - \tau', t - T + \tau') \bar{\rho}_k(\tau', T). \quad (42)$$

where

$$\bar{\rho}_k(\tau, T) = \frac{1}{A} \int d\mathbf{a} \hat{\rho}_w(\mathbf{k}(T, \mathbf{a}), \tau; T, \mathbf{a}), \quad (38)$$

Here, $\hat{\rho}_w(\mathbf{k}(T, \mathbf{a}), \tau; T, \mathbf{a})$:

Has already been weighted by the antenna pattern and the Jacobian of the T, \mathbf{a} coordinates