What else can we learn with coherent scatter radars?

J. L. Chau et al.

Radio Observatorio de Jicamarca, Instituto Geofísico del Perú, Lima

Acknowledgments

Christos Haldoupis

Dave Hysell

Mike Rouhoniemi

Paul Bernhardt

ISEA12, Crete, Greece – May 24, 2008

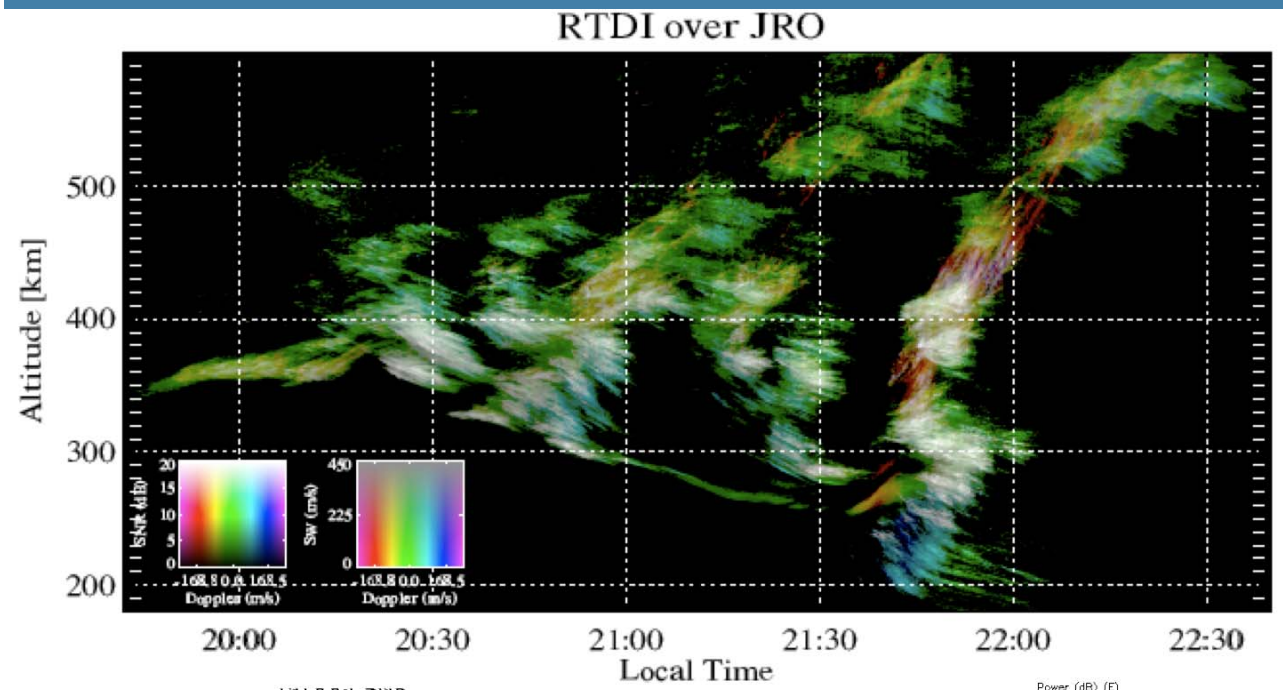
Outline

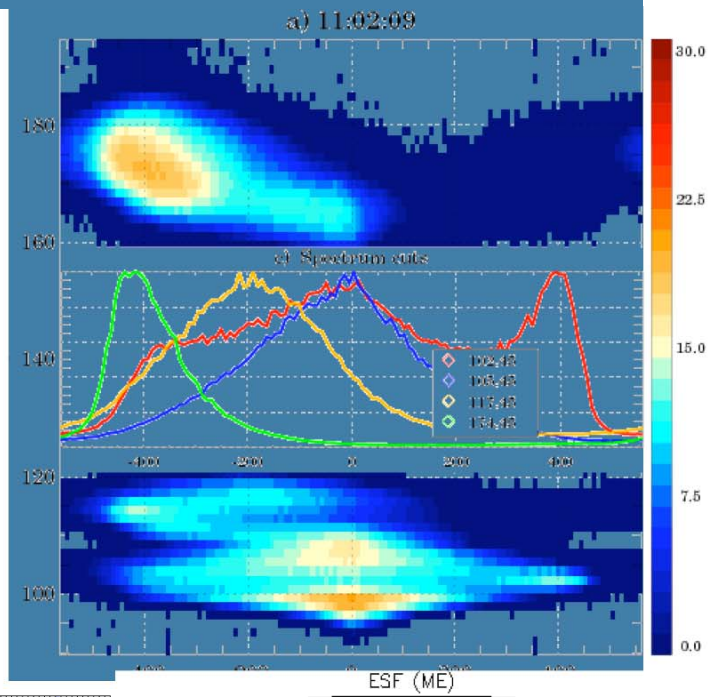
- ?
- Targets/Techniques/Plasma research vs. Diagnostics (Declare victory?)
- 150-km echo challenge
- Mother Nature vs. Man Made
- Conclusions

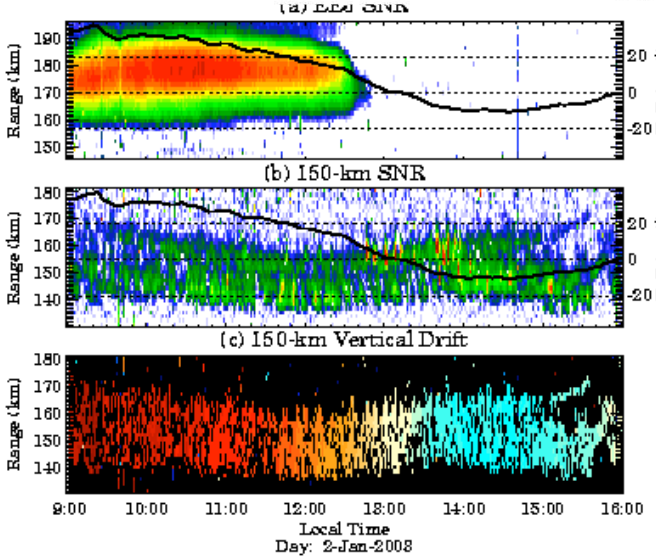
Main "Equatorial" Questions

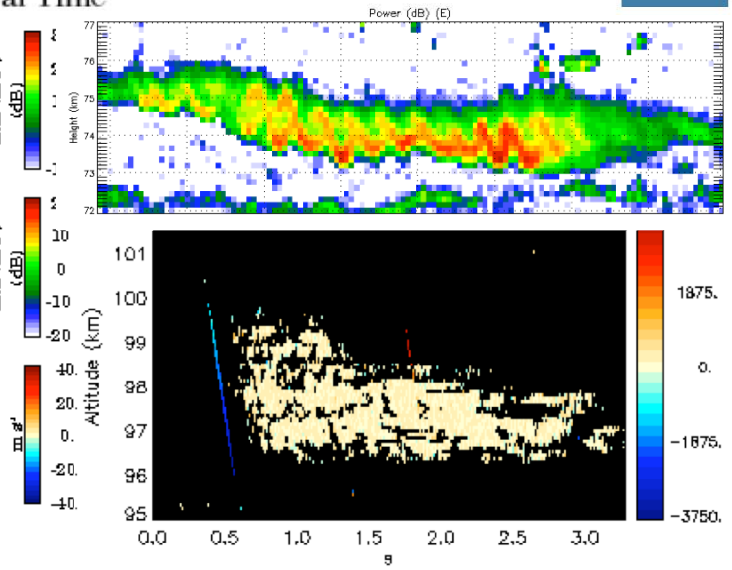
- *F* region: What are the fundamental plasma processes, including nonlinear processes, that govern the generation of plasma plumes? What are the precursor phenomena in the late afternoon F region that control whether or not an F-region plume will be generated after sunset?
- Daytime Valley echoes (or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

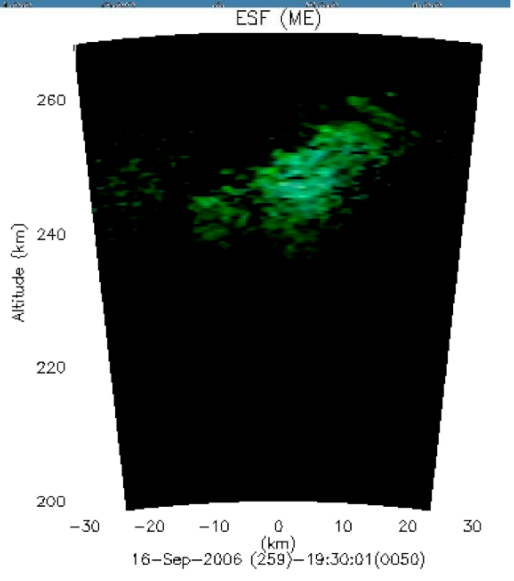
Atmospheric/Ionospheric Irregularities



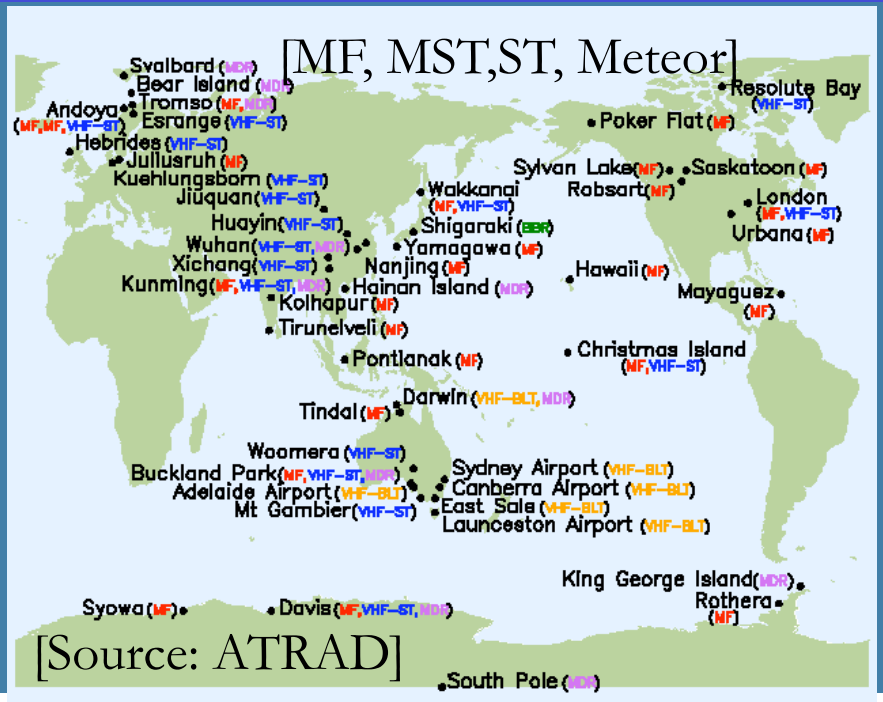








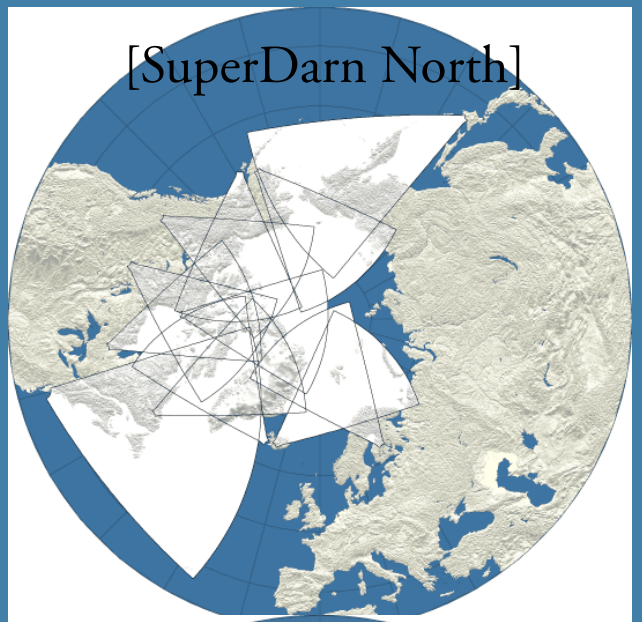
Coherent Radar Networks



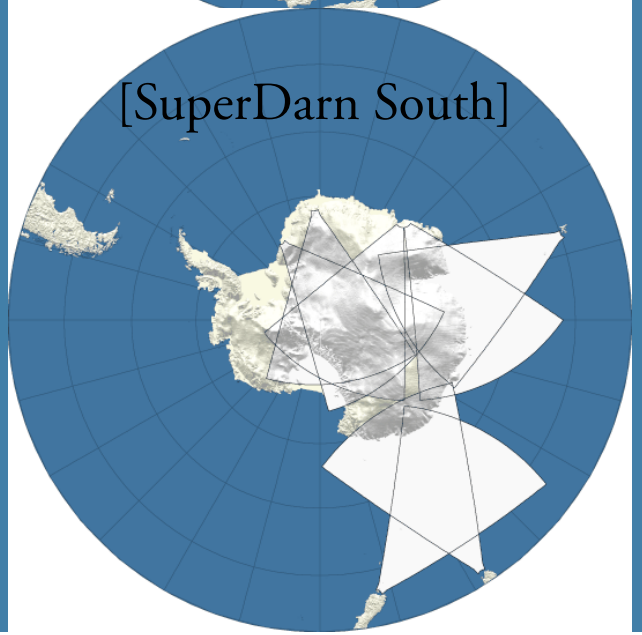
[MF, MST,ST, Meteor]

[Source: ATRAD]

[Digisonde Network]



[SuperDarn North]



[SuperDarn South]

Coherent Radars Summary

Radar Frequency

- MF
- HF
- VHF
- UHF

Configurations/ Techniques

- Monostatic/Multi-Static
- Multi-beam
- CW/Pulsed
- Multi-station
- Interferometry
- Imaging
- Multi Frequency
- Passive

Coherent Targets

- PEME/PMSE
- Specular Meteors
- Other meteors
- E region
- 150-km/Valley
- F region

Main Derived Parameters

- Irregularity Power, Drifts, and spectra shape
- Neutral winds
- Electric fields
- Electron Density
- Neutral Temperatures
- GWs/Tides/PWs

Coherent Radars: SuperDarn

Radar Frequency

- MF
- HF
- VHF
- UHF

Configurations/ Techniques

- Monostatic/Multi-Static
- Multi-beam
- CW/Pulsed
- Multi-station
- Interferometry
- Imaging
- Multi Frequency
- Passive

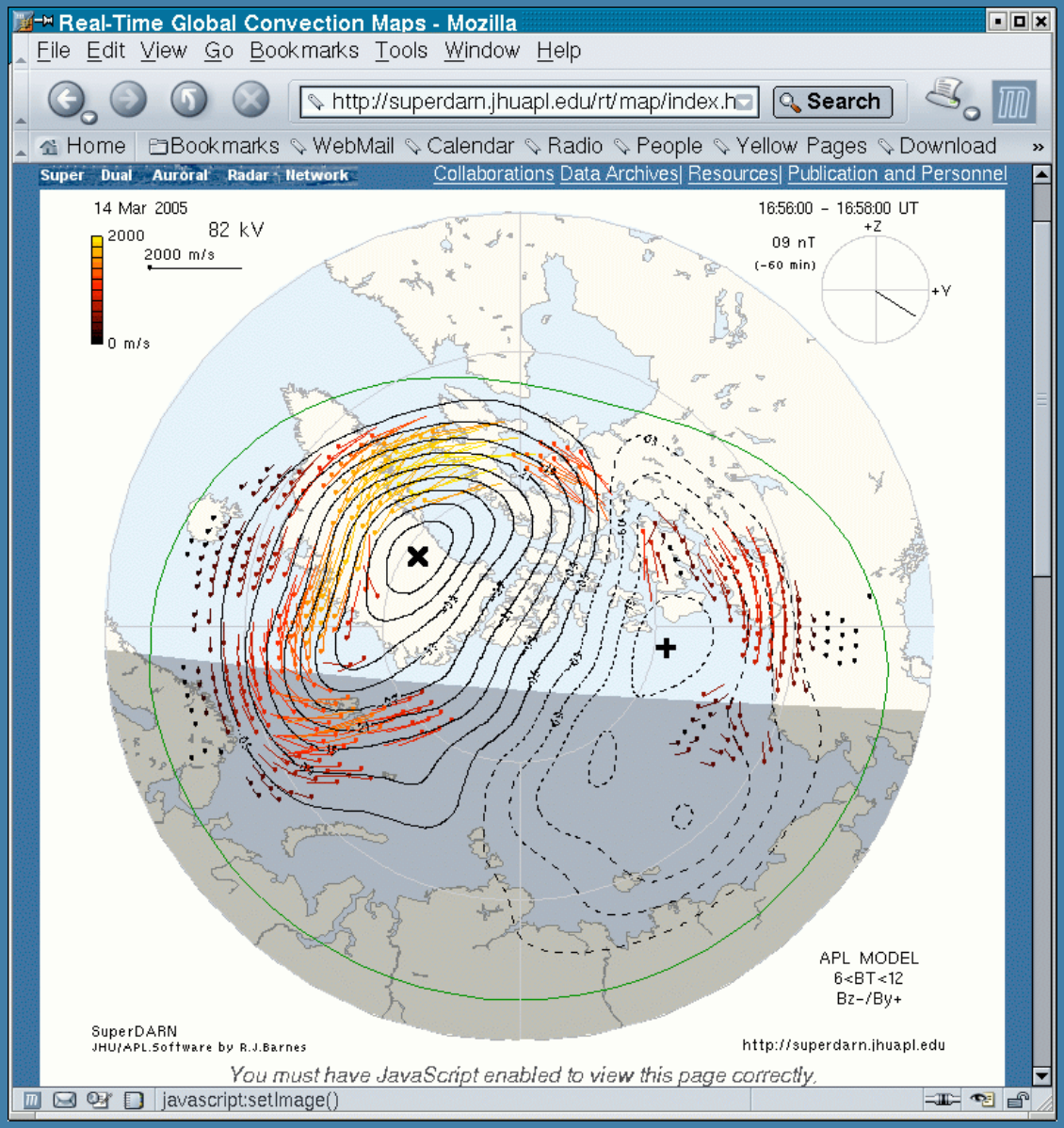
Coherent Targets

- PEME/PMSE
- Specular Meteors
- Other meteors
- E region
- 150-km/Valley
- F region

Main Derived Parameters

- Irregularity Power, Drifts, and spectra shape
- Neutral winds
- Electric fields
- Electron Density
- Neutral Temperatures
- GWs/Tides/PWs

SuperDarn Convection Maps



Coherent Radars: ESF Imaging

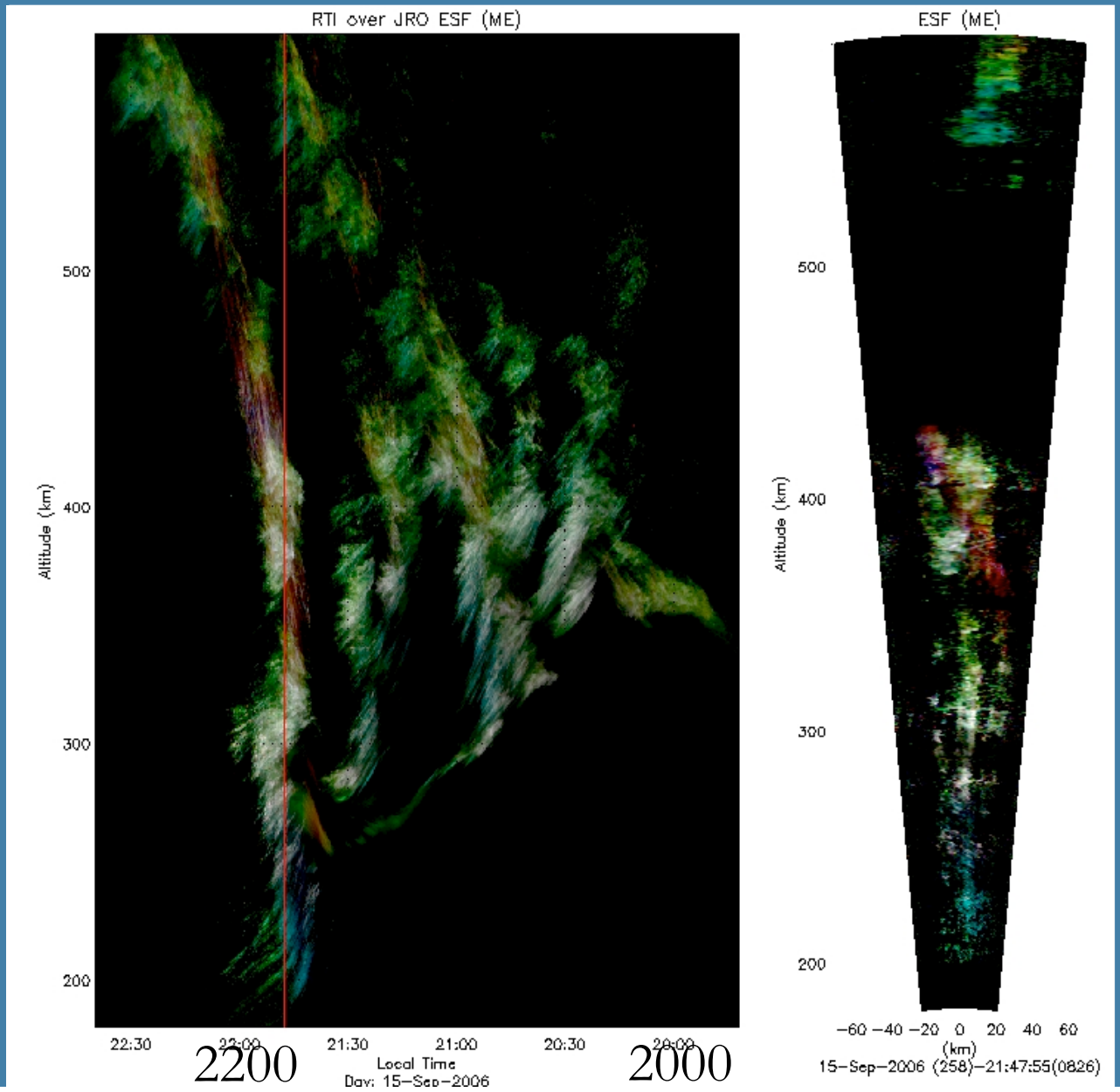
ESF RTDI + Imaging

500

400

300

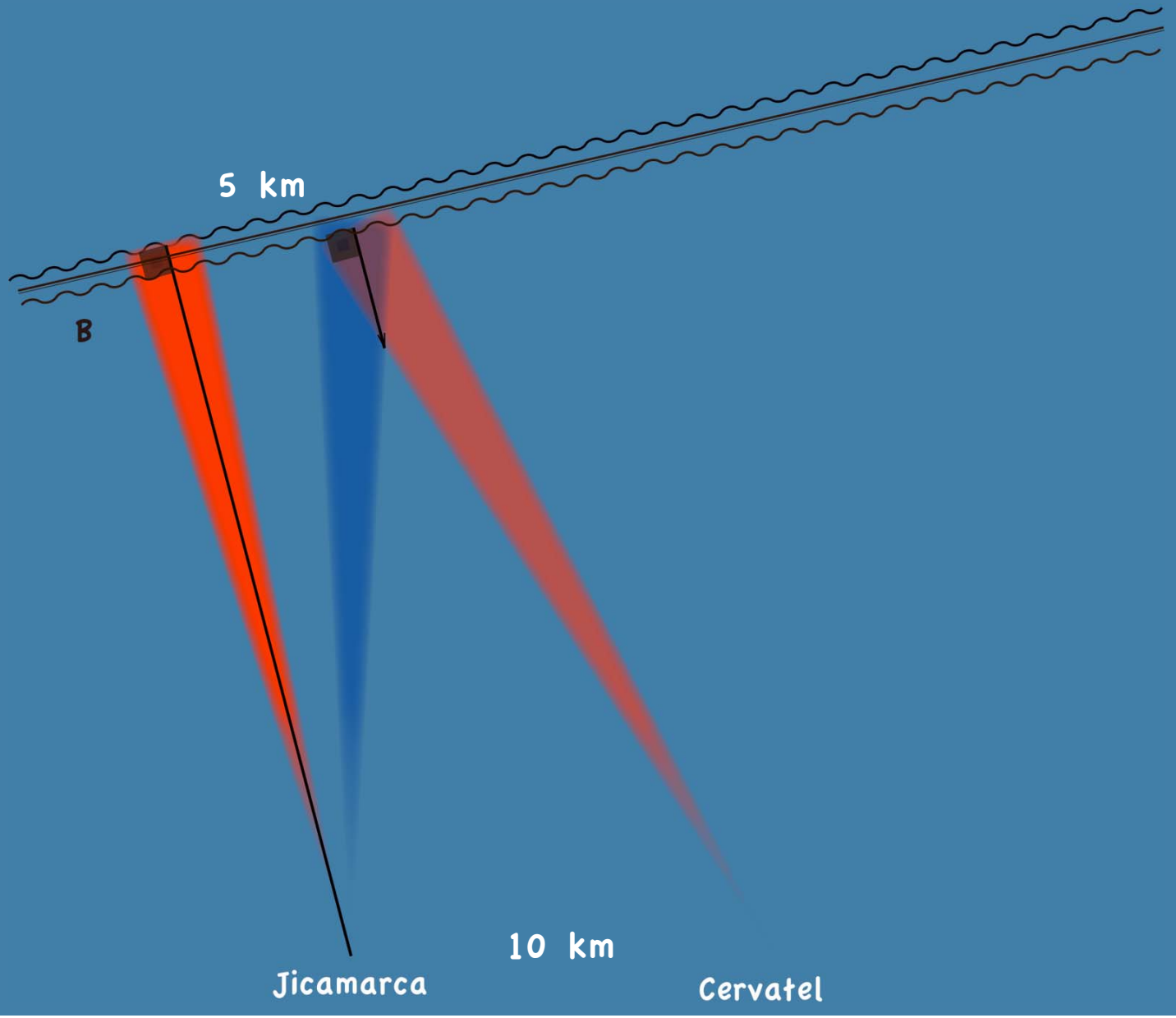
200



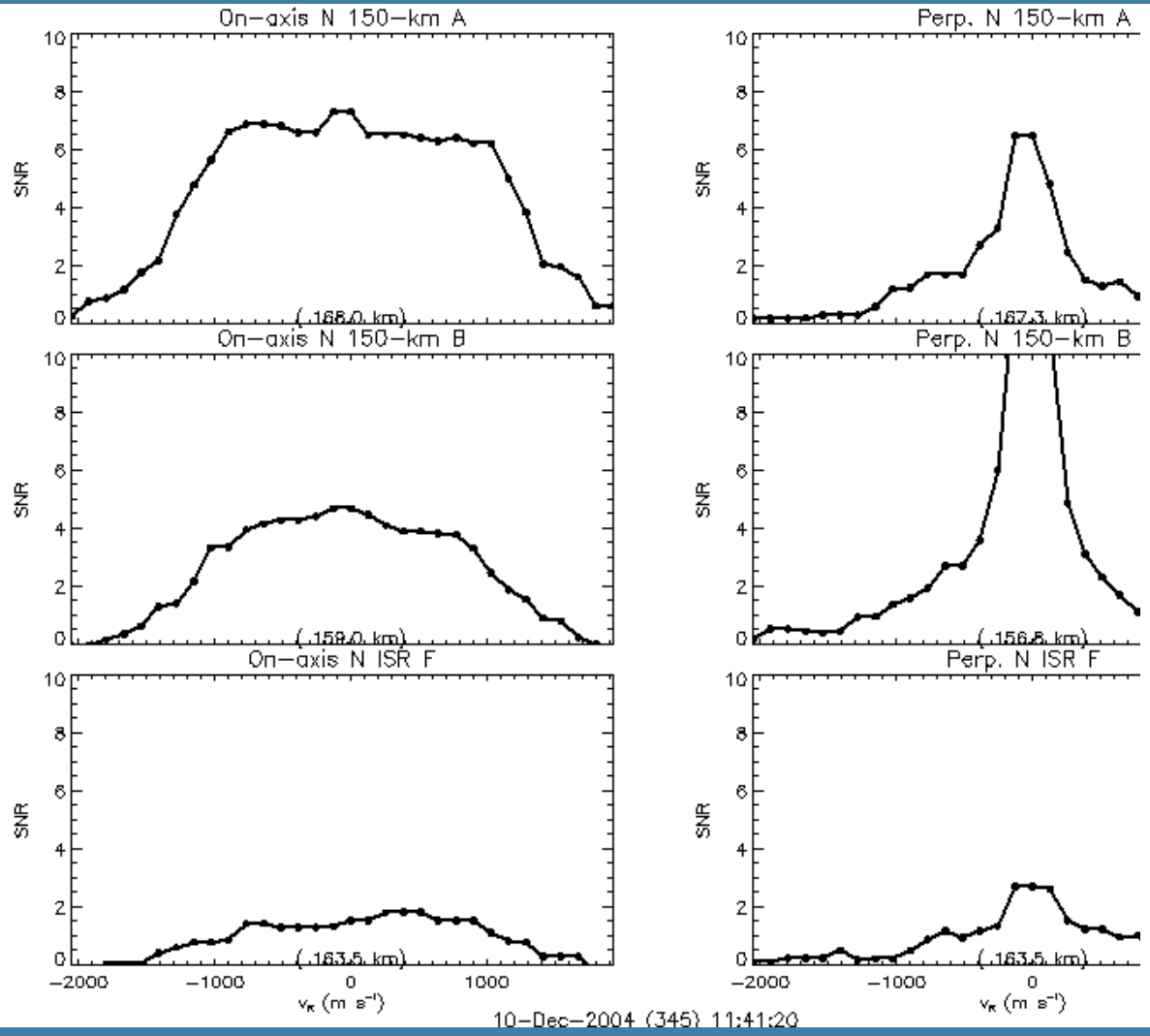
[*Chau et al.*, 2008]

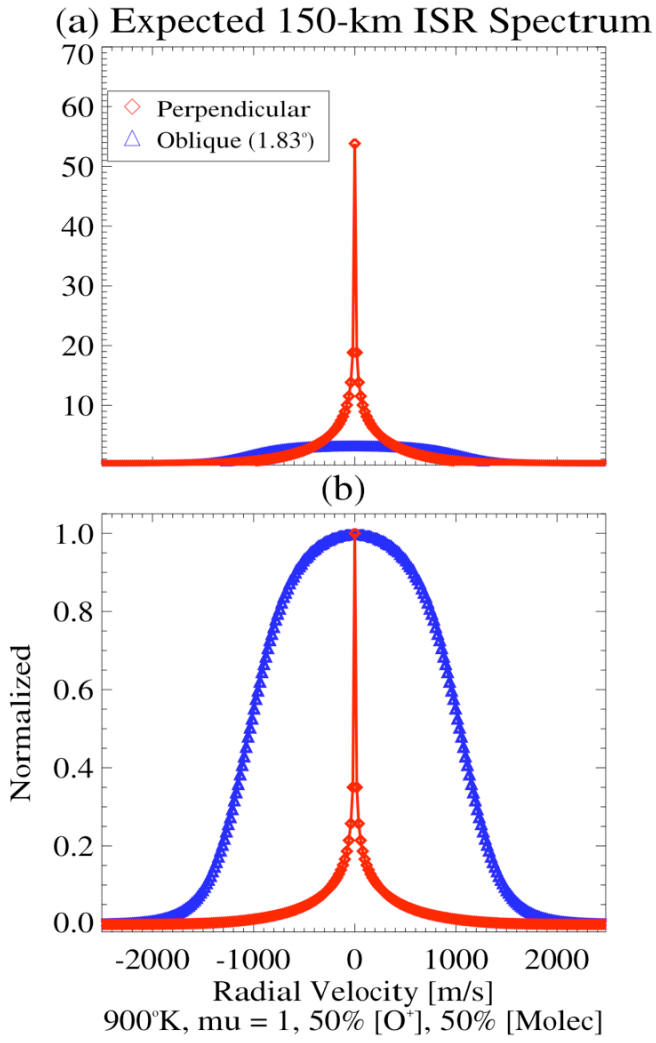
Coherent Radars: 150-km Echoes

150-km Experiments: Oblique vs. Perpendicular

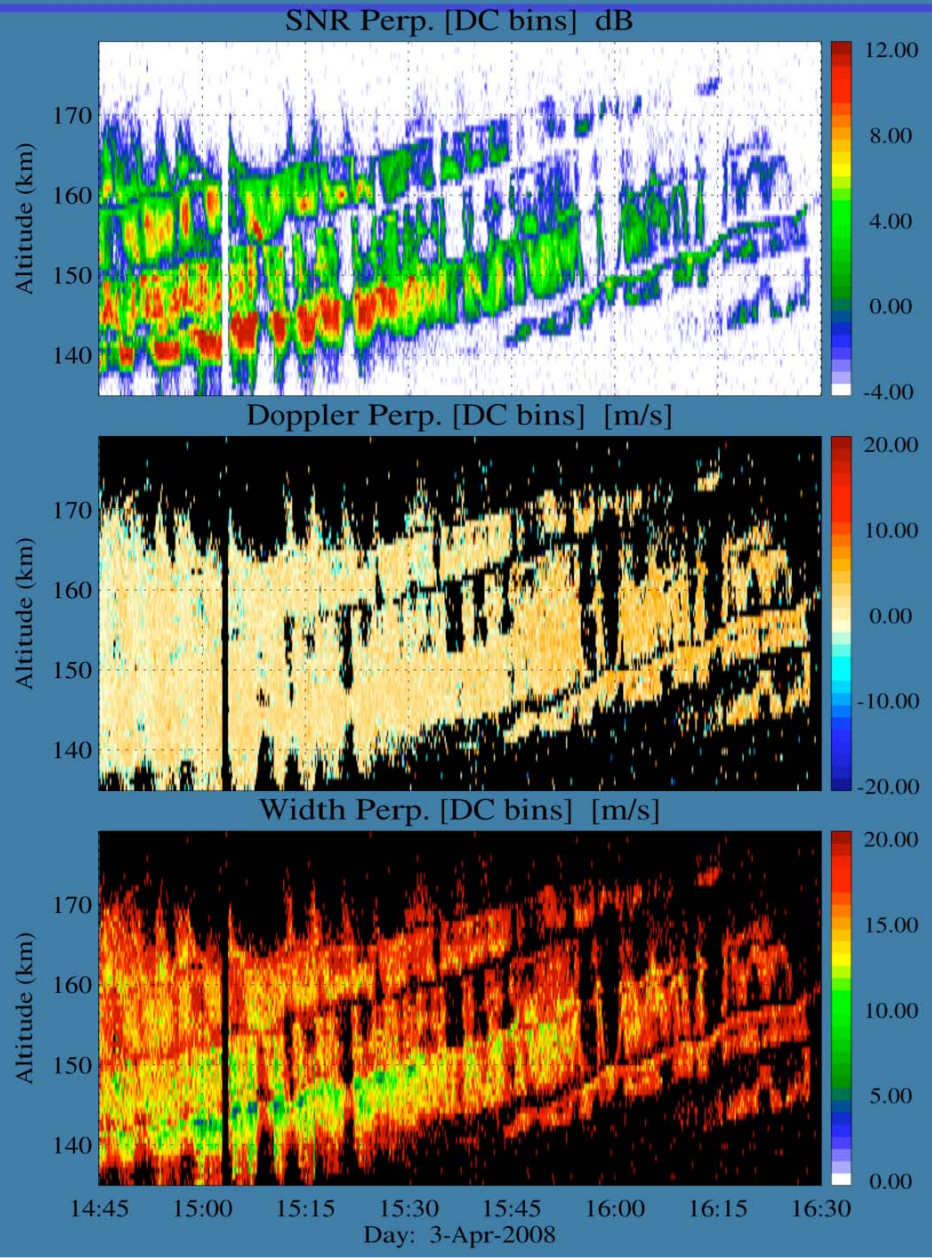


150-km Spectra: Oblique vs. Perpendicular

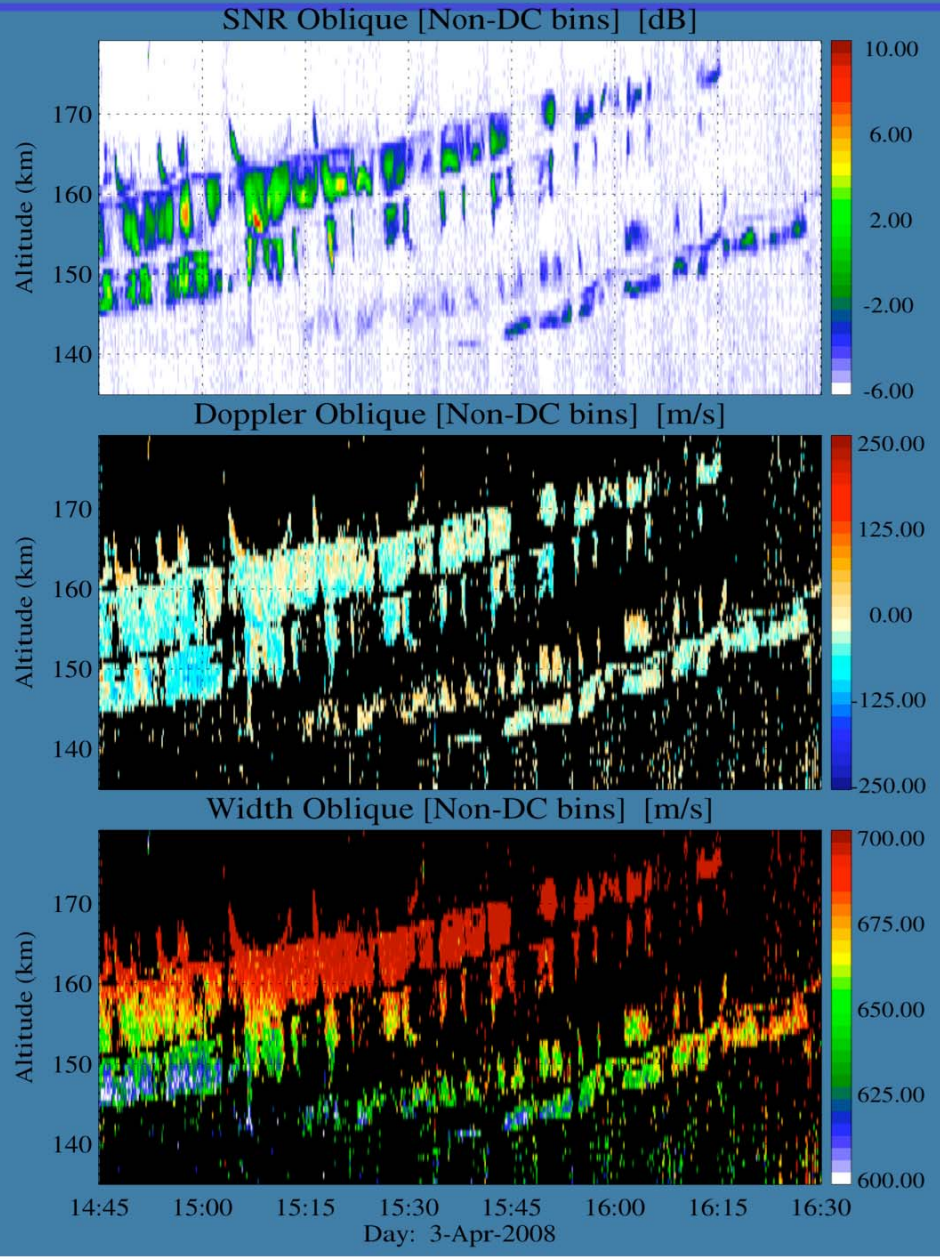




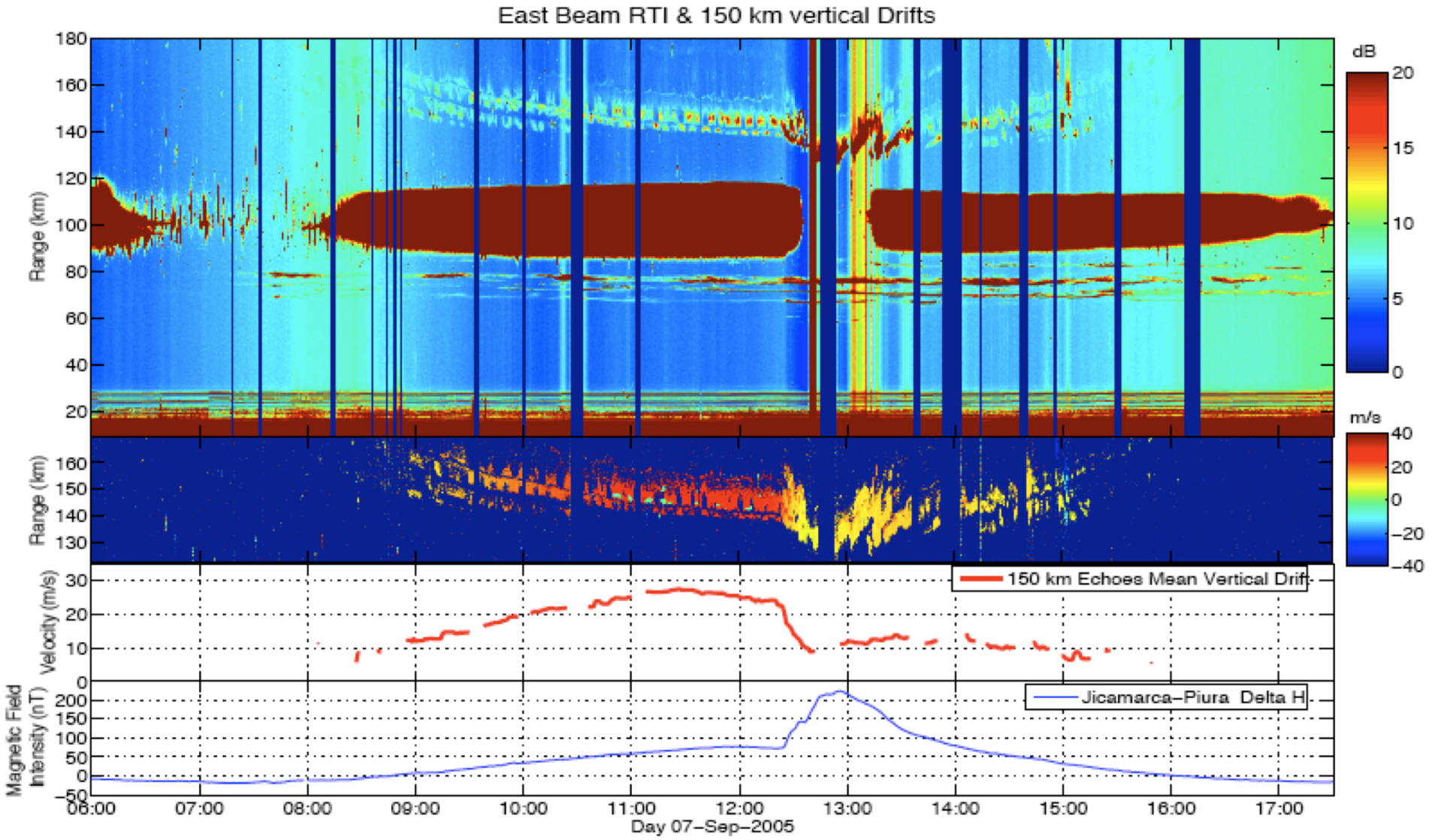
150-km Perpendicular Parameters



150-km Oblique Parameters



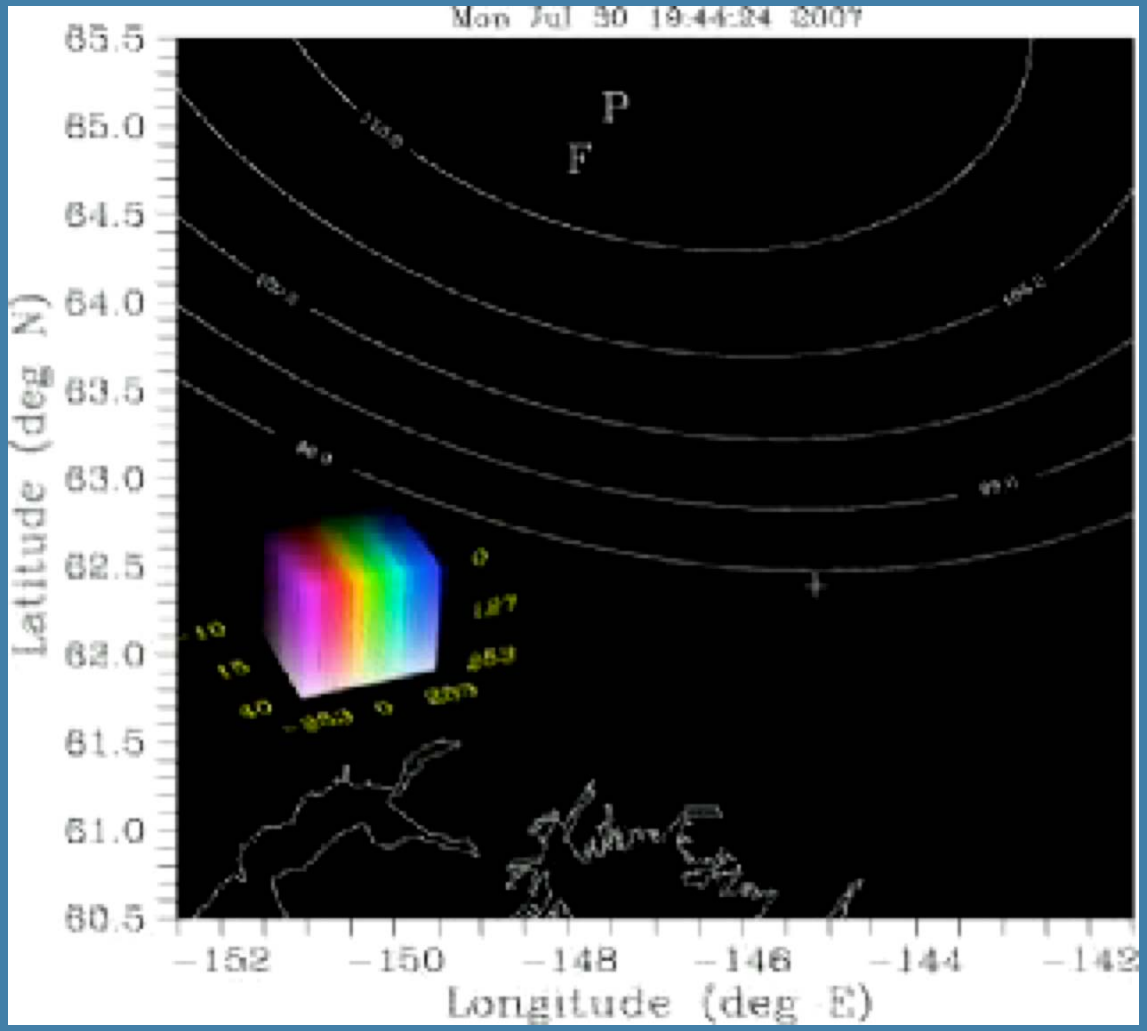
Equatorial Irregularities modified by Solar Flares



Solar flare 07-Sep-2005

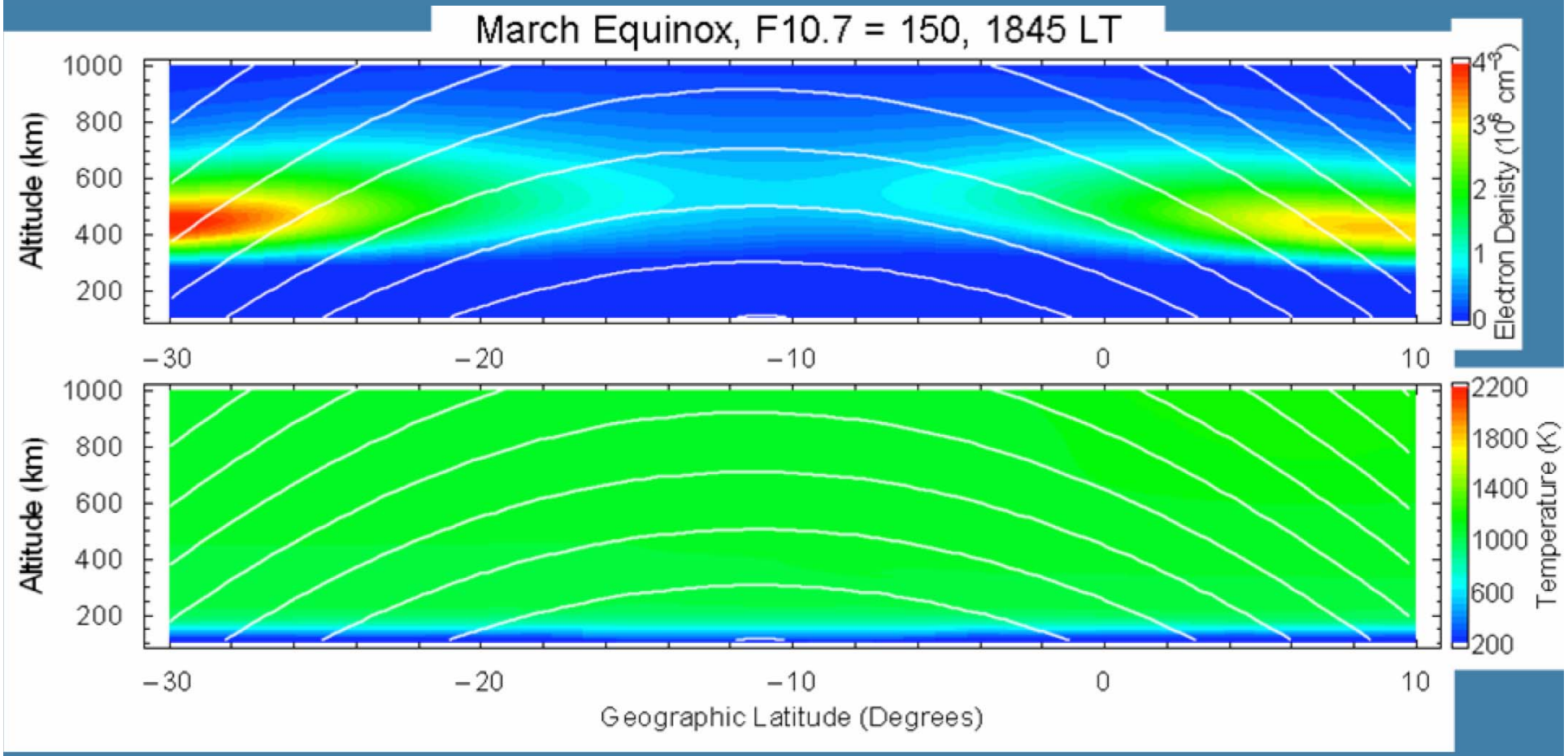
[Courtesy of P. Reyes]

Artificial Ionospheric Irregularities



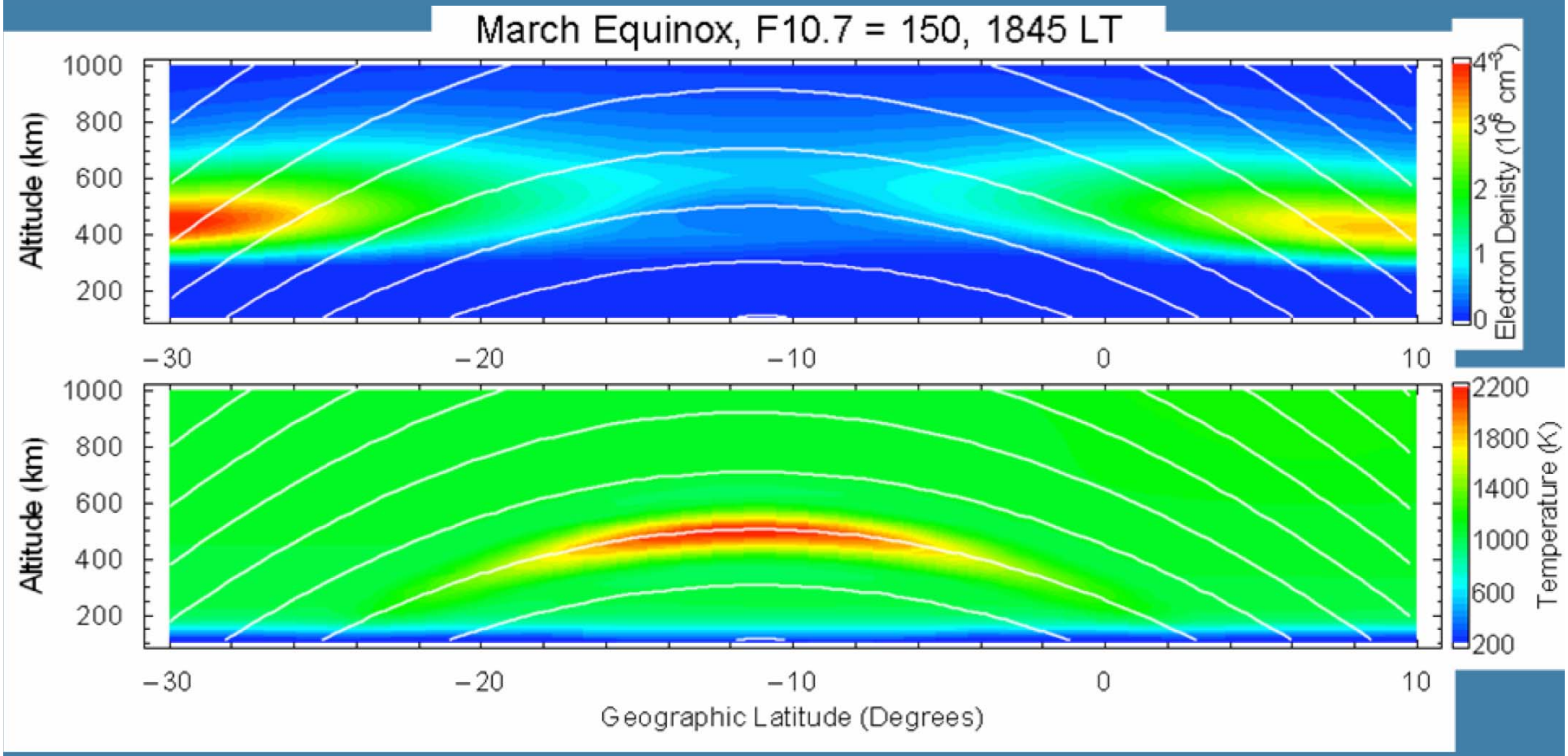
[Courtesy of D. Hysell]

SAMI2 Model
283° Longitude Equatorial Ionosphere



[Courtesy of P. Bernhardtl]

Heated Field Line at 7.9 MHz (7.8 105 cm-3) 283° Longitude Equatorial Ionosphere



[Courtesy of P. Bernhardtl]

Concluding Remarks

- Irregularity drifts vs. electric fields (local and background)
- Radar Imaging.
- Common volume multi-frequency.
- E and F (valley) region coupling.
- 150-km campaigns (multi-instrument?)
- Coherent scatter diagnostics of artificial ionospheric irregularities at equatorial and low latitudes.