What else can we learn with coherent scatter radars?

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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]

[SuperDarn North]

[SuperDarn South]

[Digisonde Network]
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
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- E region
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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

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
ESF RTDI + Imaging

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Coherent Radars: 150-km Echoes

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
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Main Derived Parameters
- Irregularity Power, Drifts, and spectra shape
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150-km Experiments: Oblique vs. Perpendicular
150-km Spectra: Oblique vs. Perpendicular

(a) Expected 150-km ISR Spectrum

(b) Normalized Radial Velocity [m/s]

900K, mu = 1, 50% [O²], 50% [Molec]
150-km Perpendicular Parameters

SNR Perp. [DC bins] dB

Doppler Perp. [DC bins] [m/s]

Width Perp. [DC bins] [m/s]
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

[Image of a diagram showing the March Equinox conditions, F10.7 = 150, 1845 LT, with color-coded electron density and temperature contours.]

[Courtesy of P. Bernhardtl]
Heated Field Line at 7.9 MHz (7.8 \(10^5\) cm\(^{-3}\)) \(283^\circ\) Longitude Equatorial Ionosphere

March Equinox, \(F10.7 = 150\), 1845 LT

[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.