Toward Scatter Classification at Middle Latitudes

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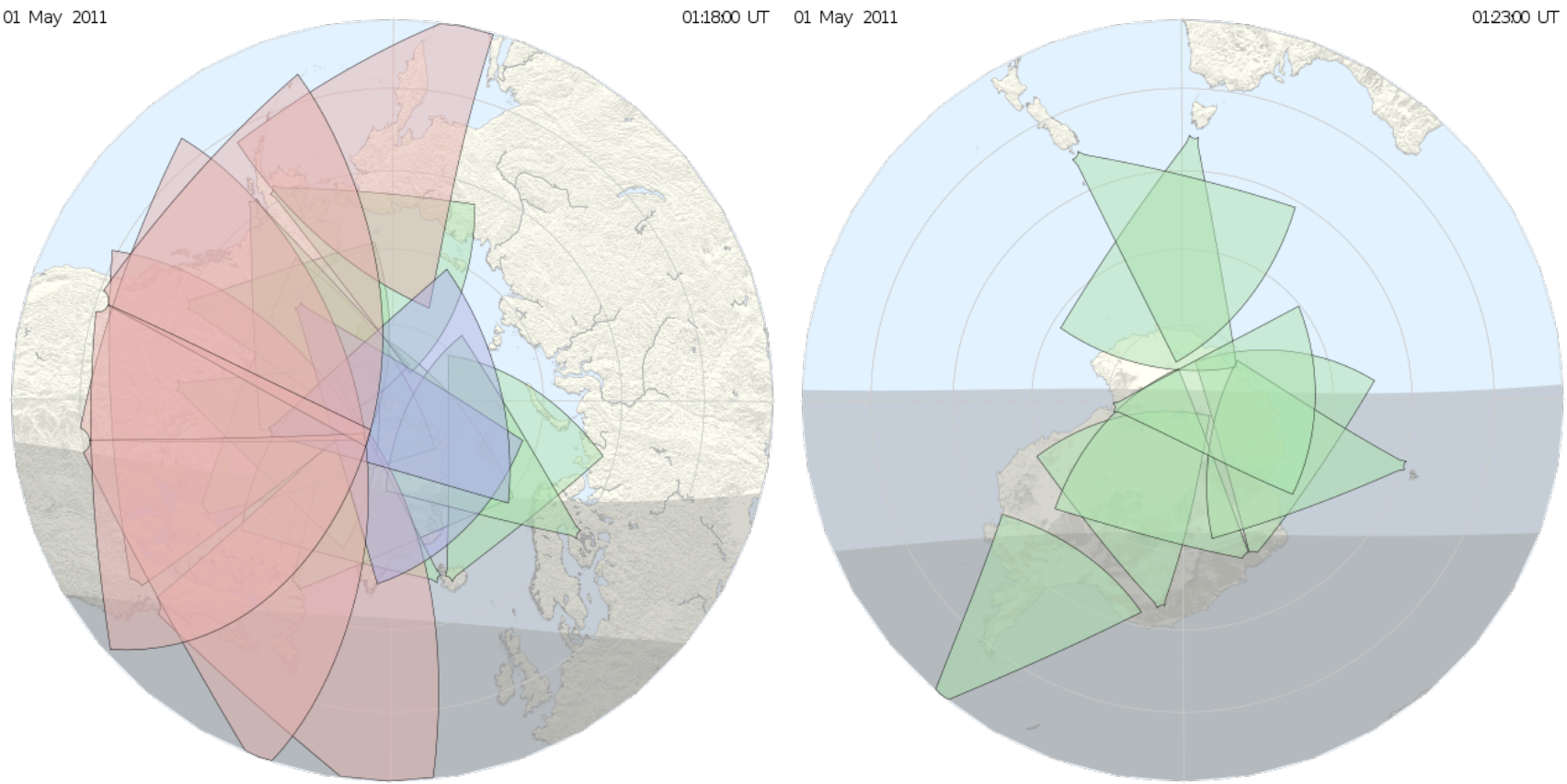
SuperDARN Network



SuperDARN Network

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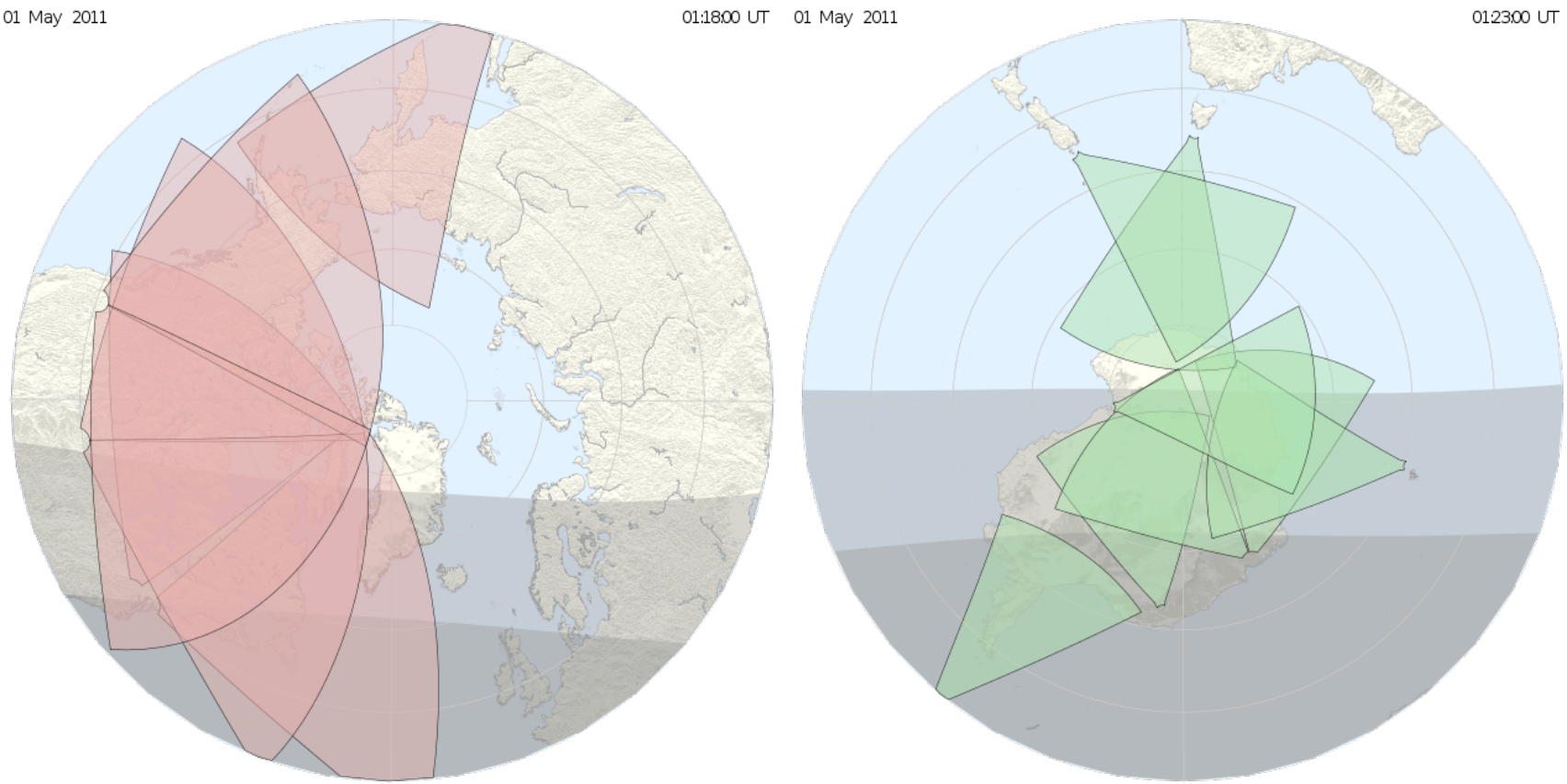
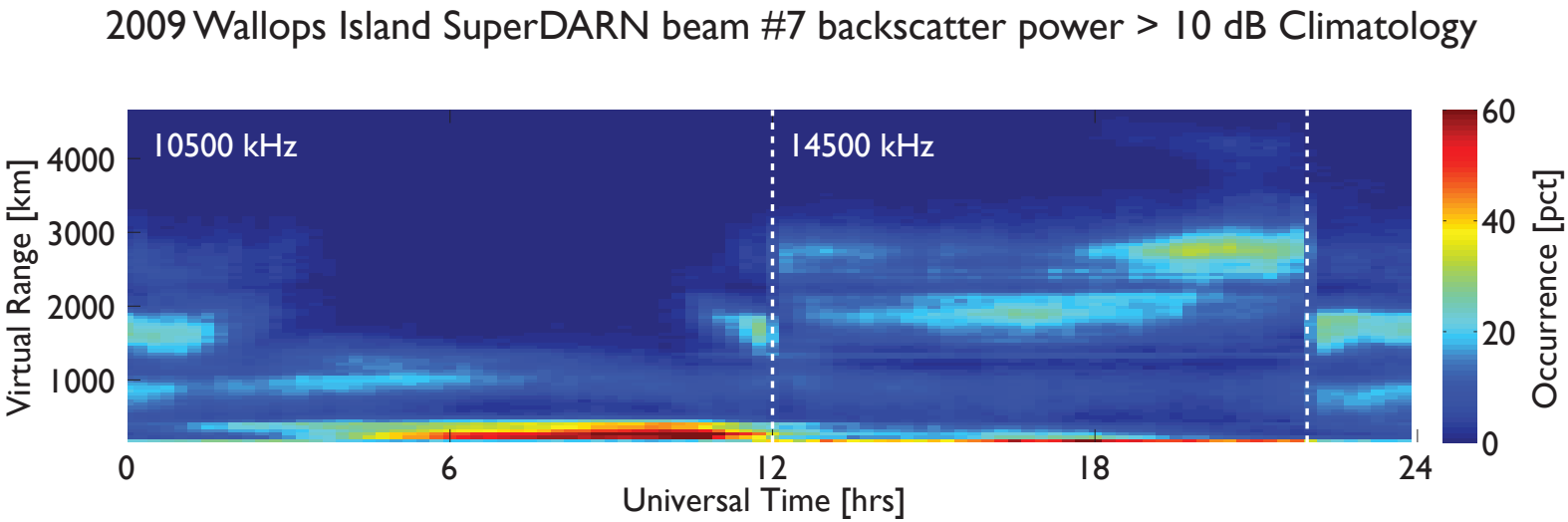


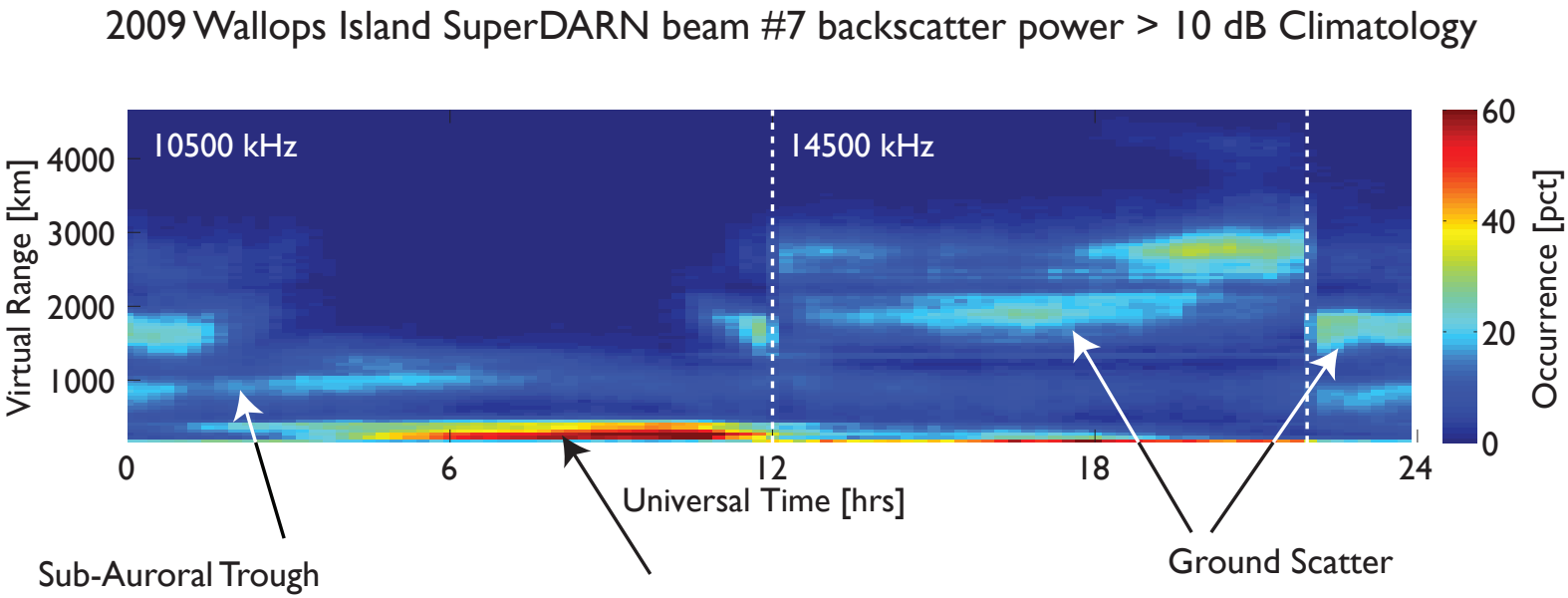
Mid-Latitude SuperDARN

- Installed to observe expansion of convection pattern equatorward of traditional SuperDARN boundaries.
  - This happens with some regularity, but quiet conditions prevail.
- What is observed during quiet time?
- Signal to one is noise to another.
  - $scatter \in \{ionospheric, ground\}$ does not describe mid-latitude variability accurately.
  - $scatter \in \{ionospheric, ground\}$ *algorithm* does not describe mid-latitude *physics* accurately.
- Consider first climatological behavior.

Wallops Island Climatology



Wallops Island Climatology



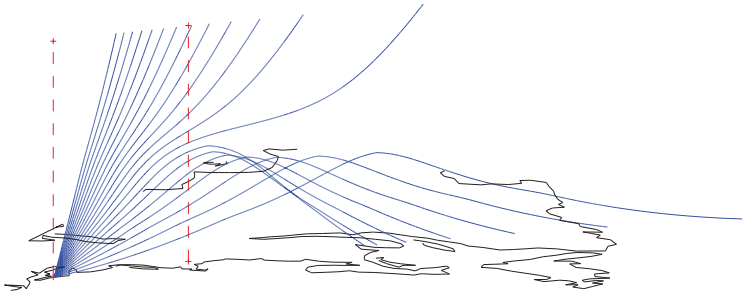
Irregularities in the sub-auroral trough produce significant backscatter on many nights. (See *Talaat, et al,* poster.)

Ablating meteors deposit trails of metallic ions in the *E* region. Sporadic-*E* layers also contribute to this prevalence.

Echoes returned off of the land or sea.

Propagation Mechanisms

Refraction



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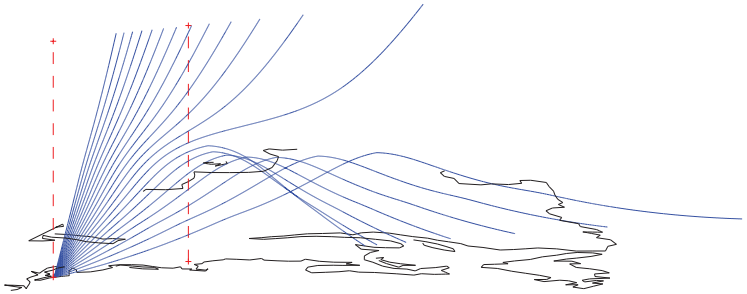
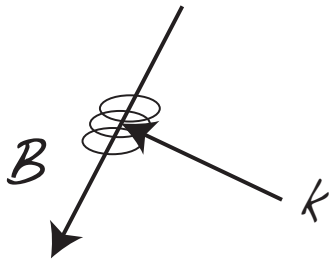
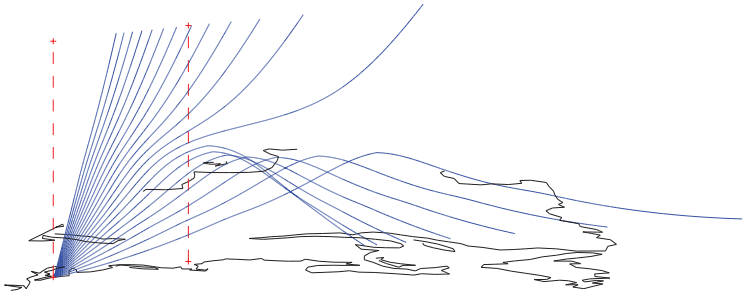


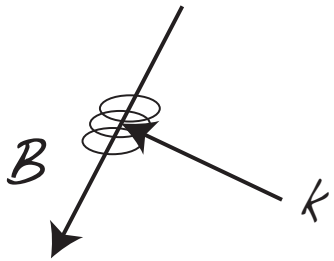


Field-Aligned Irregularities (FAI)

Propagation Mechanisms

Refraction





Field-Aligned Irregularities (FAI)

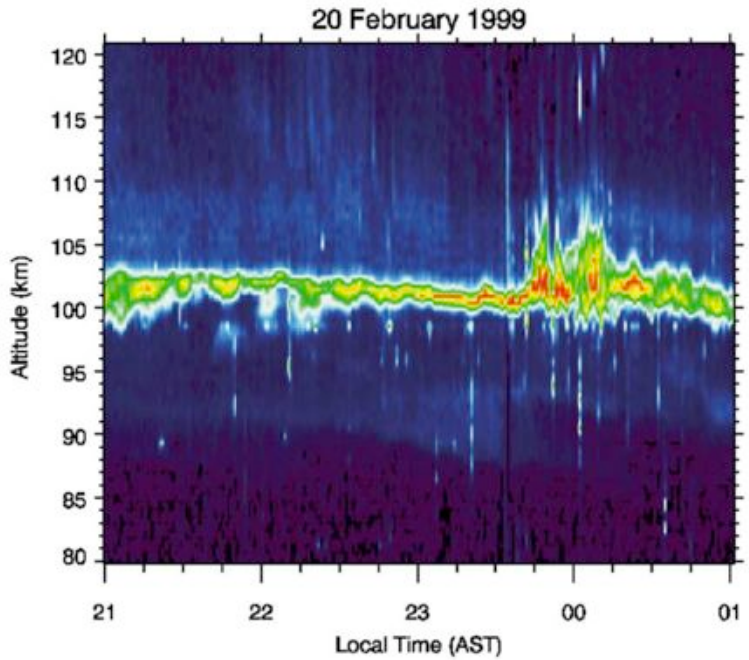
Specular Reflection

Meteor Scatter

- Essentially all SuperDARN meteor scatter is *specular*.
  - FAI typically observed by powerful IS-class radars.
- Meteor trails have short lifetimes ($\sim$ 100 ms).
- Individual trails usually only appear in one range gate in space and time.
- Ensemble of many trails yields "cloud" of scatter at close ranges.

Sporadic-*E*

- Thin, dense, turbulent layer of metallic ions at *E*-region altitudes.
- Specular echoes, FAI, ground scatter, all possibilities.
- Separating specular echoes from FAI?

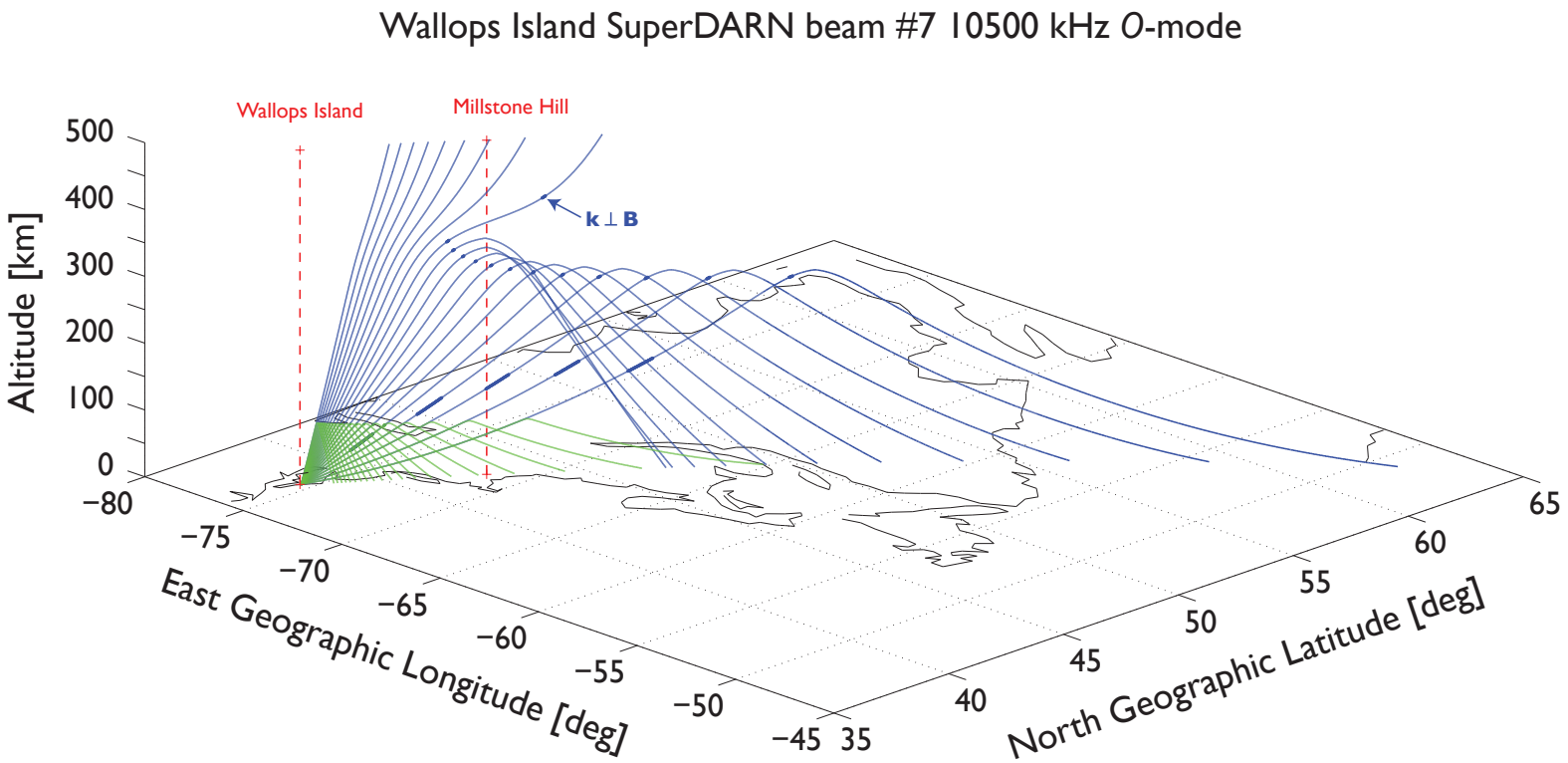


Sporadic-*E* over Arecibo. After *Swartz, et al*, 2002.

Raytracing

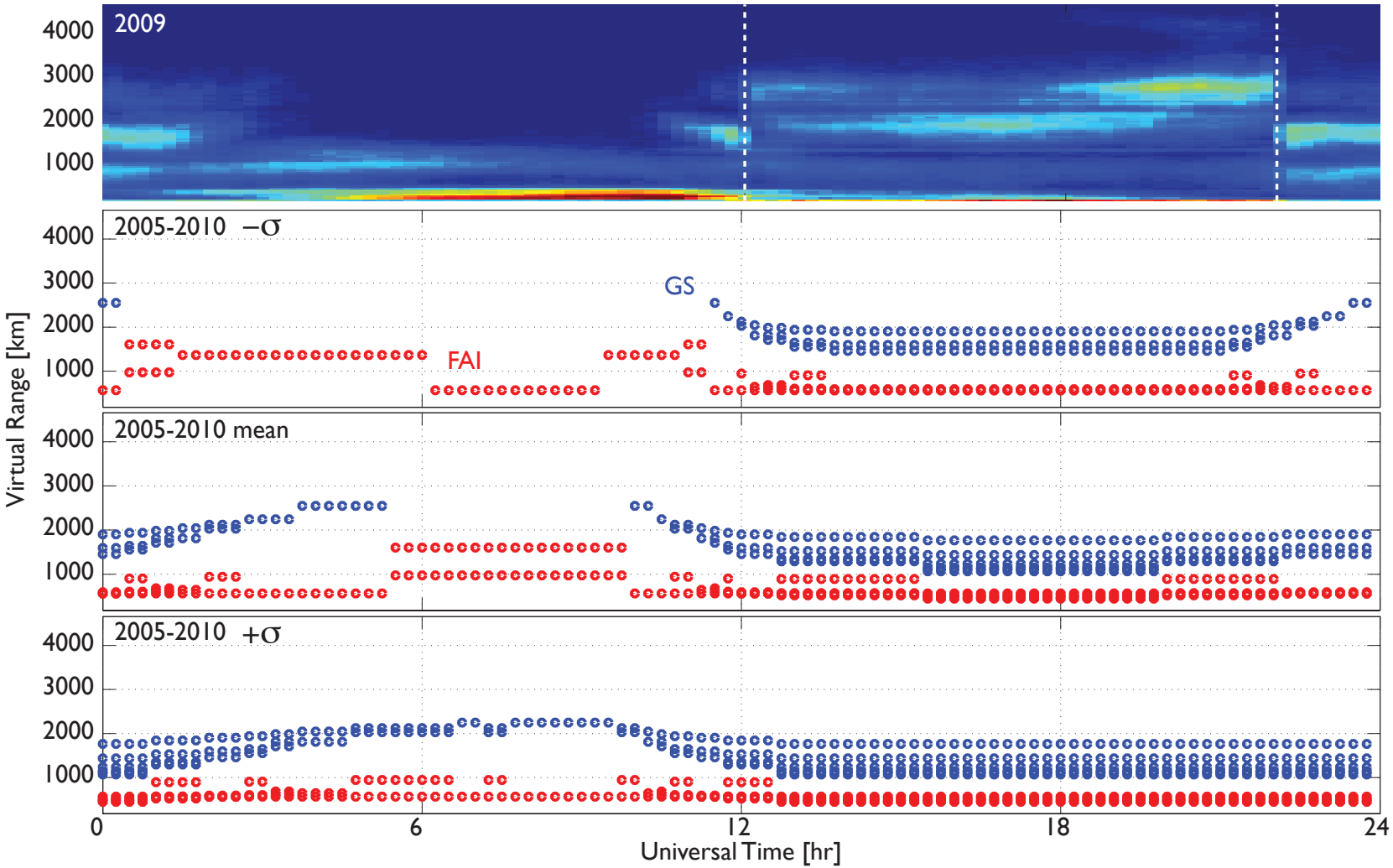
- Need not be complicated to be informative.
  - Parabolic or Chapman profiles driven by standard URSI coefficients. Or interpolate other datasets, use IRI (called directly from MATLAB).
  - Geomagnetic field (IGRF is easy in MATLAB).
  - Basic Appleton-Hartree magneto-ionic effects.
  - Loosely based on Jones-Stephenson code, but only for 2.5D.
- Find ground scatter location.
- Find $\mathbf{k} \perp \mathbf{B} \rightarrow$ possible FAI location.

Wallops Predictions

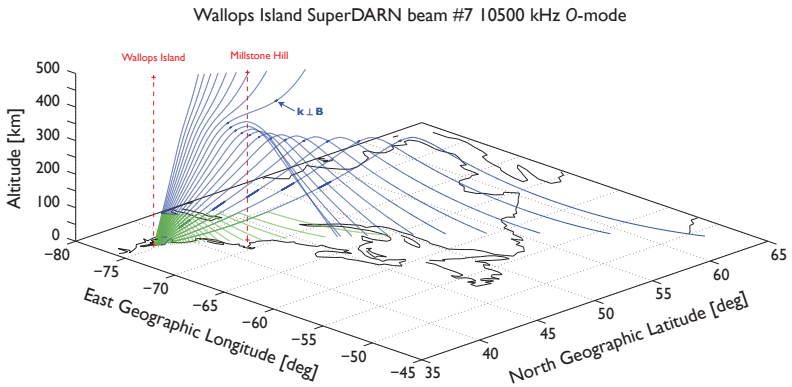


- Drive with Millstone Hill Digisonde.
- Wallops beam #7 passes directly over Millstone.

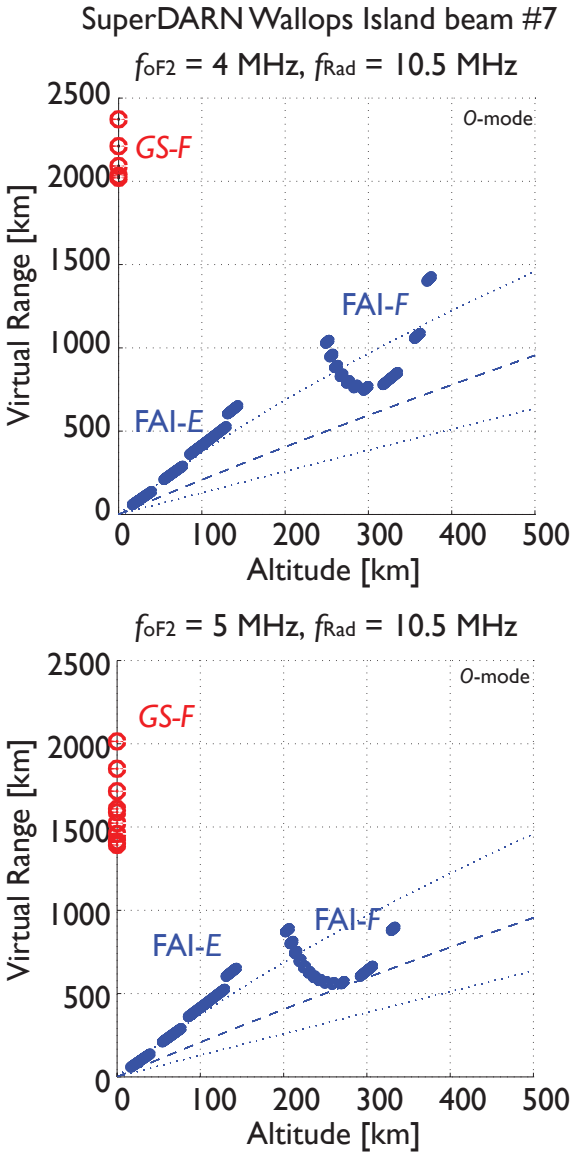
Wallops Predictions



Scatter Geolocation Tool

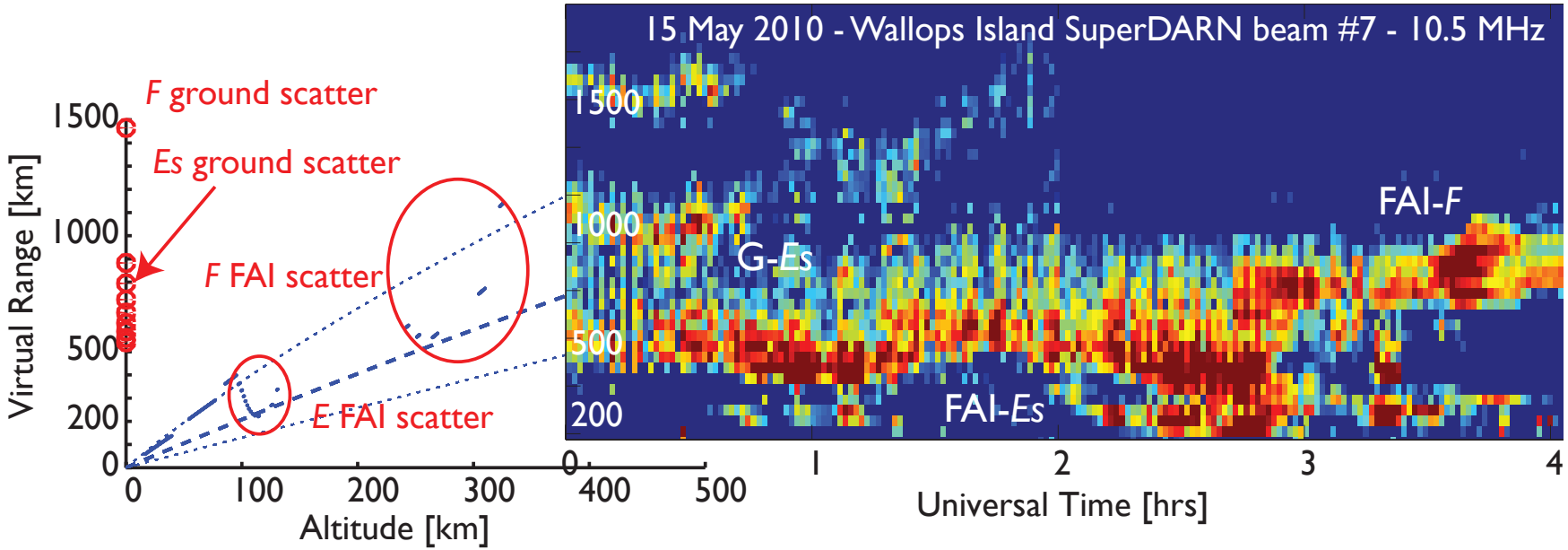


- Convert pretty (but useless) 3D plot to Virtual Range vs altitude.



Scatter Geolocation Tool

- Triple-hop sporadic-E (G-E_s) ground scatter 0000–0045 UT.
- Field-aligned irregularity (FAI) scatter from locations where $\mathbf{k} \perp \mathbf{B}$.
- Differentiate between FAI-F and G-E_s using Doppler velocity.



Discussion

- Mid-latitudes exhibit new and subtle sources of SuperDARN scatter.
  - Non-auroral FAI.
  - Sporadic-E.
- Raytracing and phenomenology provide some guidance.
  - Not operational, but good for case studies.
  - Interferometer elevation can also help (not active at Wallops presently).
  - Raytracing in inhomogeneous ionosphere for irregularity studies.