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Studying Ionospheric Solar-Cycle Variations with SuperDARN

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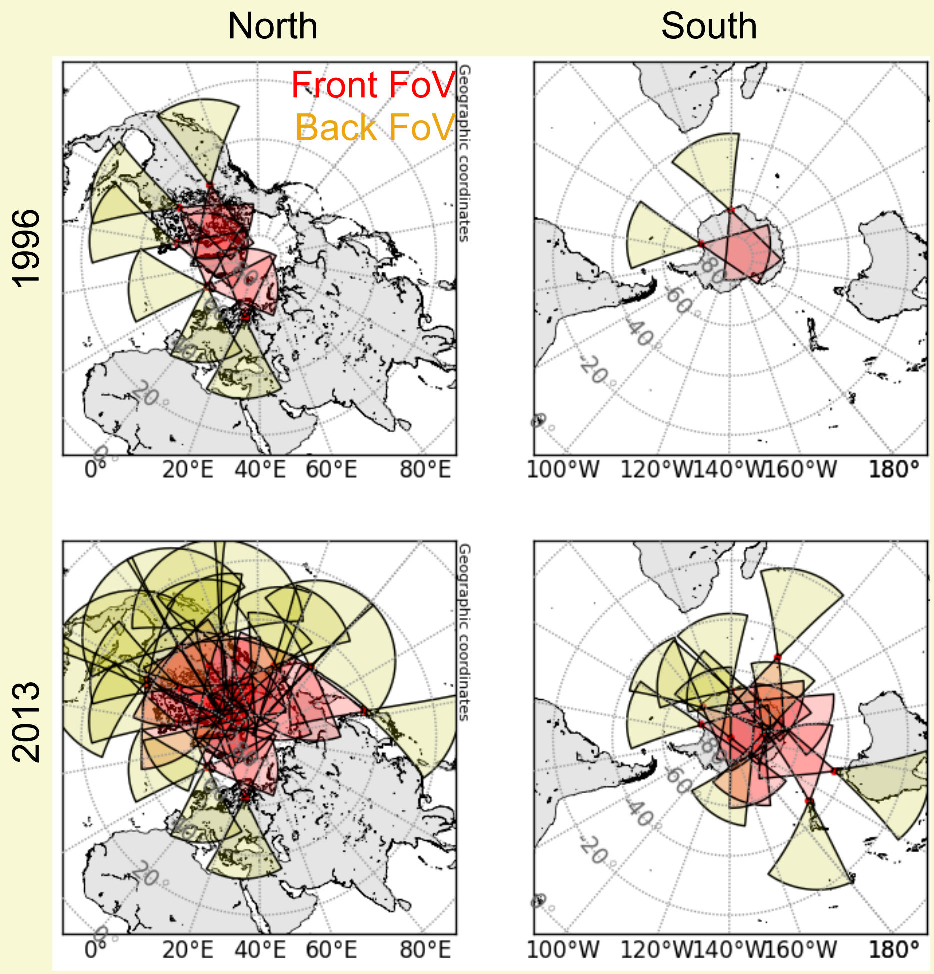
Super Dual Auroral Radar Network

- SuperDARN consists of over 30 HF radars operated continuously by institutions in 10 countries
- About 1.5 solar cycles of data are currently available
- Operates between 8-22 MHz
  - Identifies field-aligned irregularities with wavelengths between about 10-100 m
- Designed to observe F-region ionospheric scatter from the front (red) field-of-view



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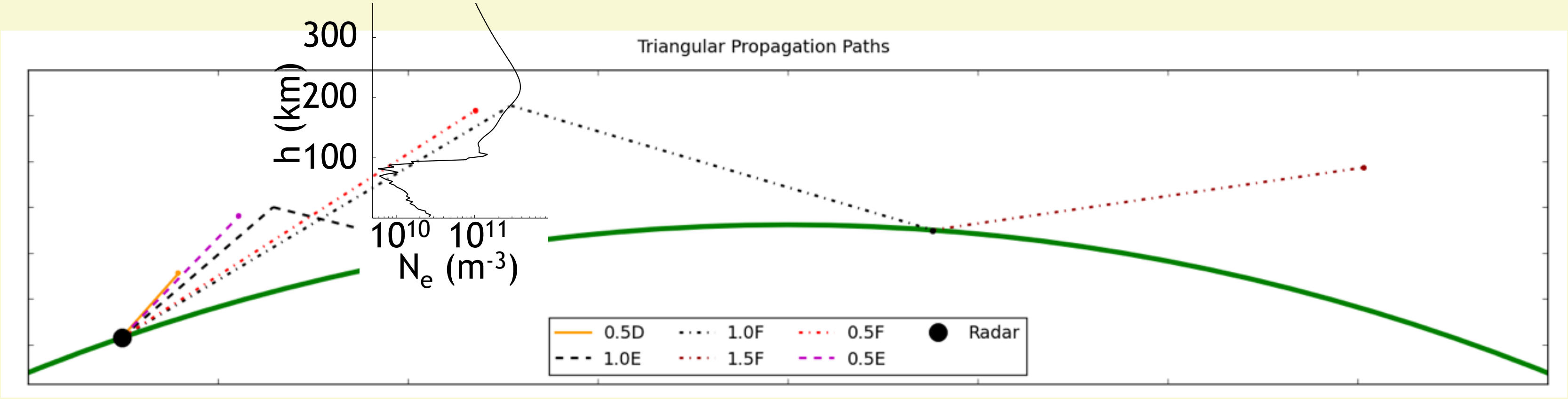
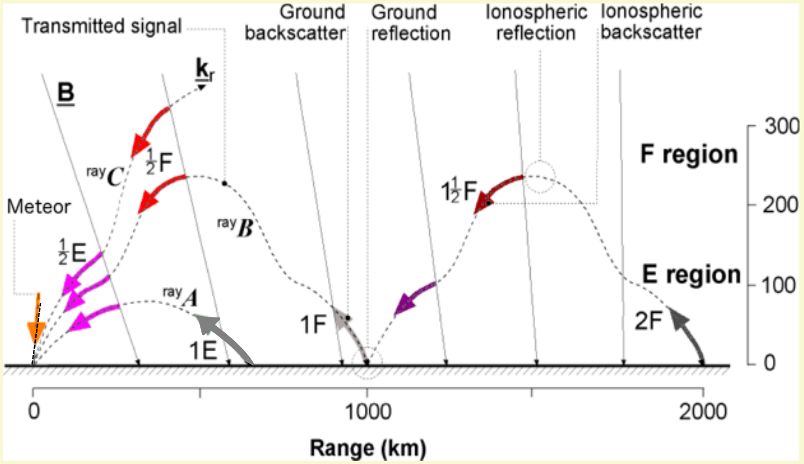
SuperDARN



- Scatter may be observed from several different propagation paths
  - Ground backscatter is selected based on the Doppler velocity, spectral width, and power
  - D, E, and F region paths can be separated based on their virtual height (*h'*)
- For any backscatter point, a virtual height and electron density (proportional to transmission frequency) can be calculated



$$h' = \sqrt{d^2 + R_\oplus^2 + 2dR_\oplus \sin\Delta} - R_\oplus$$

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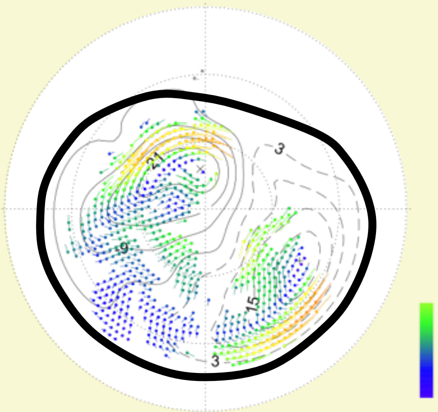
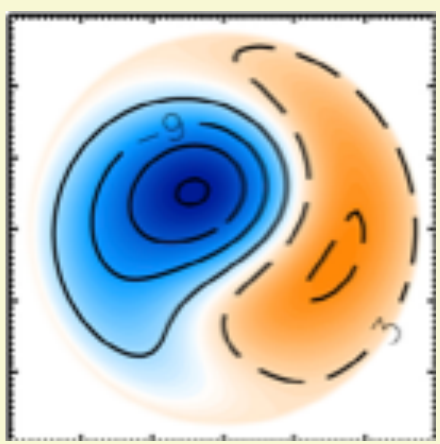
SuperDARN over a Solar Cycle

- The Heppner-Maynard Boundary (HMB) encircles the region of ionospheric convection at its lowest latitude
  - HMB latitude decreases during the declining phase of the solar cycle (2003) and peaks during solar minimum (2009)
- Convection pattern morphology can be quantified using Spherical Harmonic Functions





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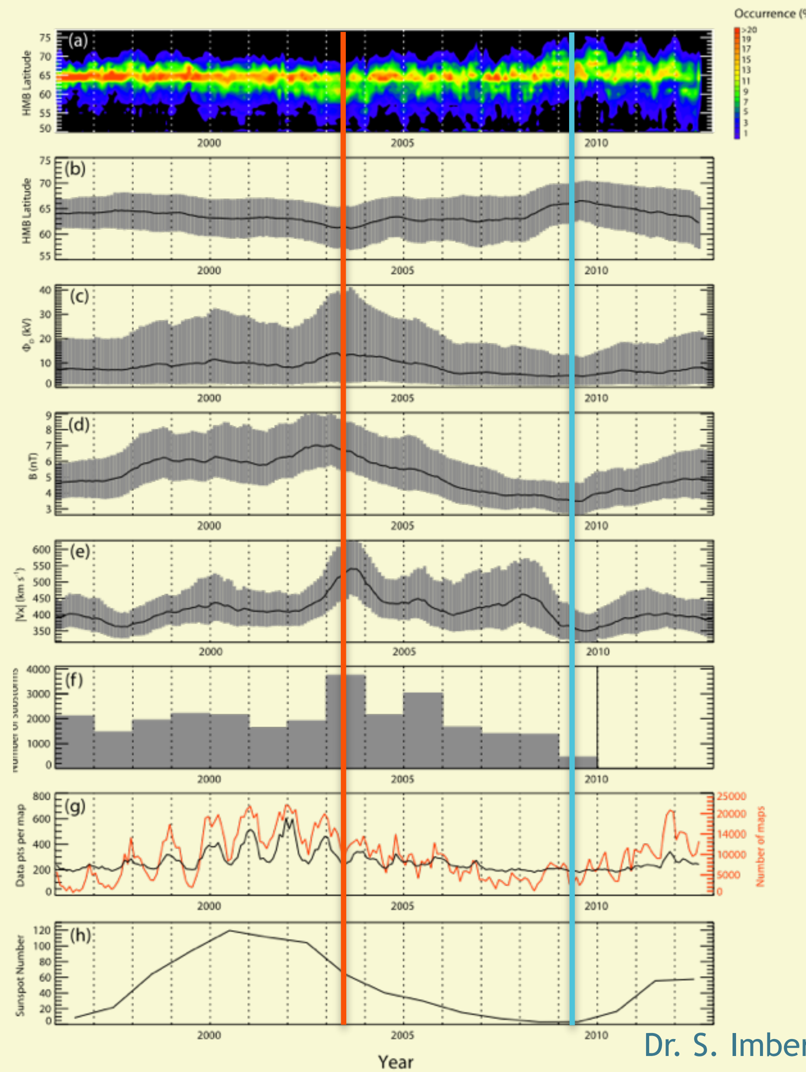

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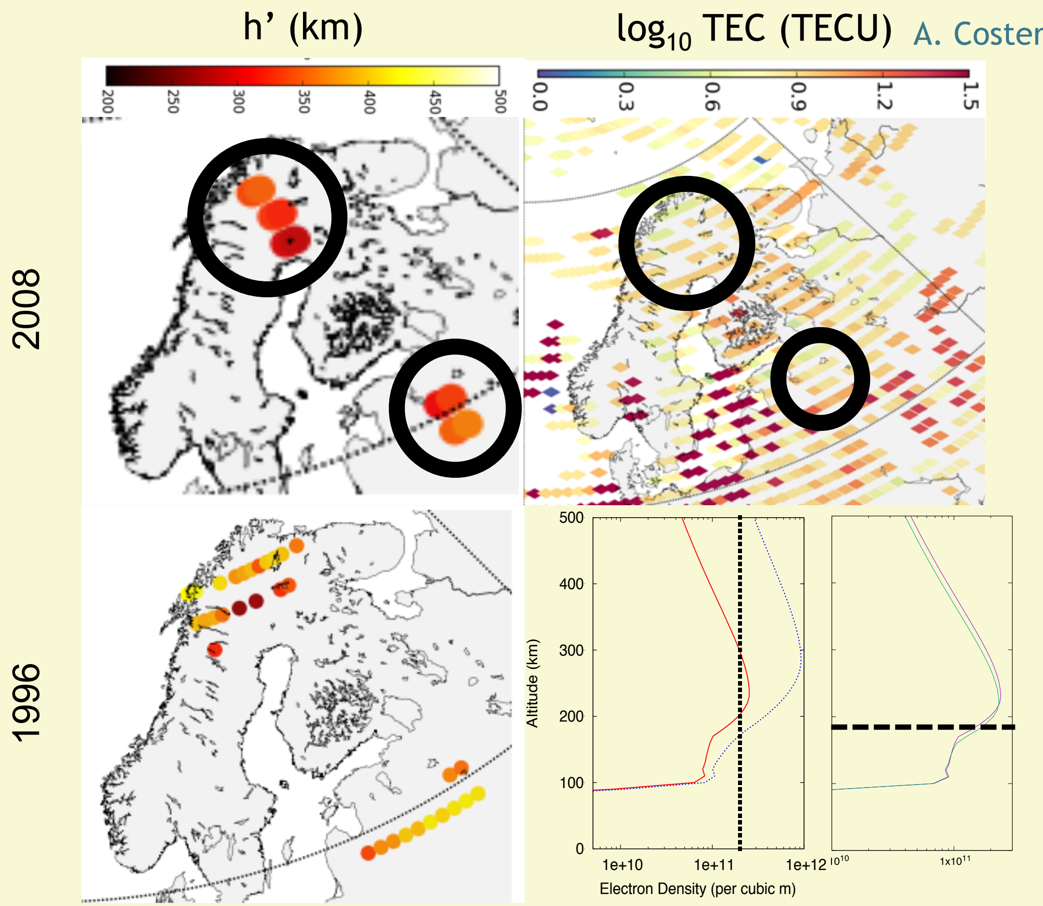
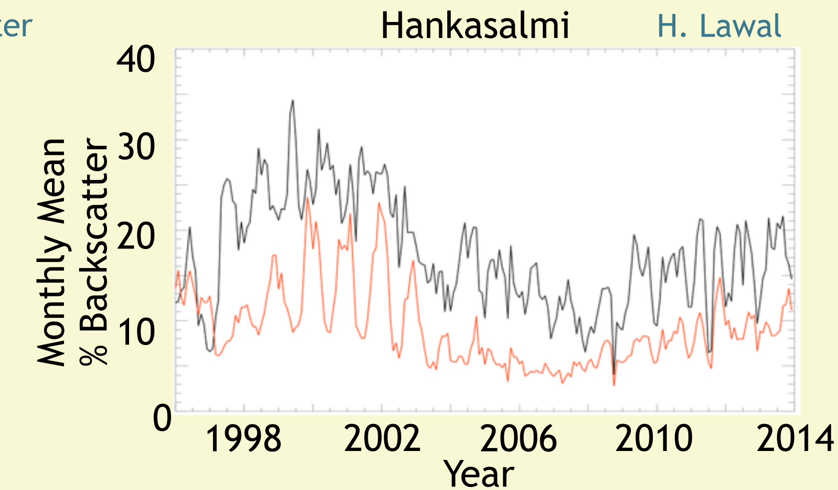
SuperDARN over a Solar Cycle





- Relative occurrence of ground and ionospheric backscatter shows seasonal and solar cycle variations
- Virtual height and density of ground backscatter shows the polar variations in the bottomside ionosphere
  - Combine with TEC or ionosonde data to improve ionospheric characterization
  - Reveals long-term variations in HF propagation due to solar irradiance and climate change

Long-term Trend Question

- How do the influences of magnetosphere-ionosphere coupling, ionosphere-thermosphere coupling, and solar irradiance change in importance over the solar cycle, when considering the behaviour of the polar ionosphere?
  - How do the polar convection patterns vary over the solar cycle?
    - Clearly their latitudinal extent changes, influenced by the presence of substorms and solar irradiance
    - Morphology patterns change with IMF orientation, season; perhaps solar cycle as well?
  - How does the bottomside ionosphere vary?
  - What does the solar cycle climatology of ionospheric irregularities look like?
    - Do larger scale ionospheric irregularities show the same type of trends as GPS scintillation?
    - Are these variations related to the polar cap convection patterns?