

Auroral Boundaries:

Finding Them in Data and Models



Gang Lu

High Altitude Observatory

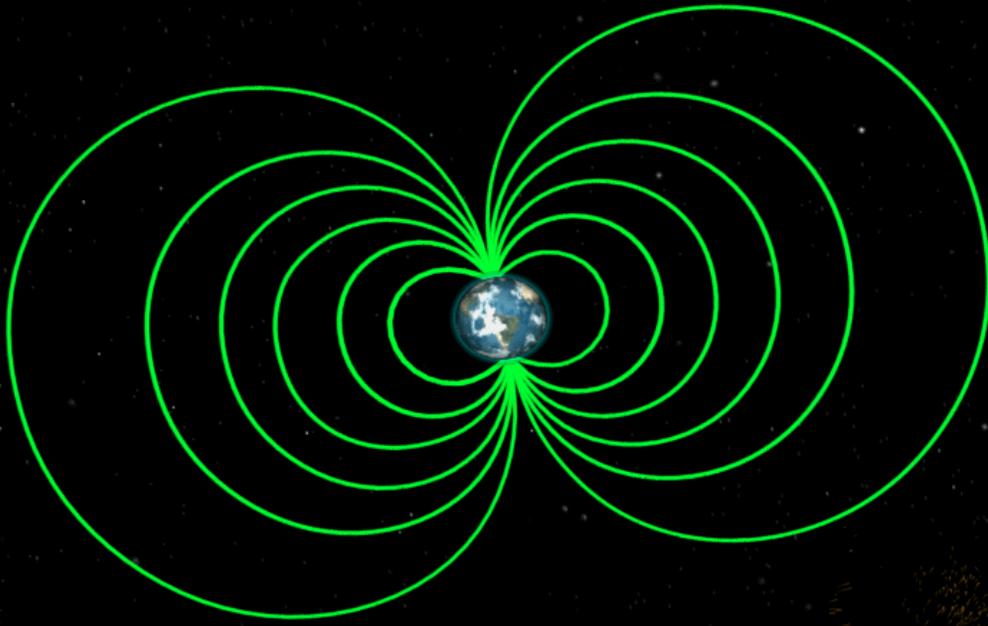
National Center for Atmospheric Research



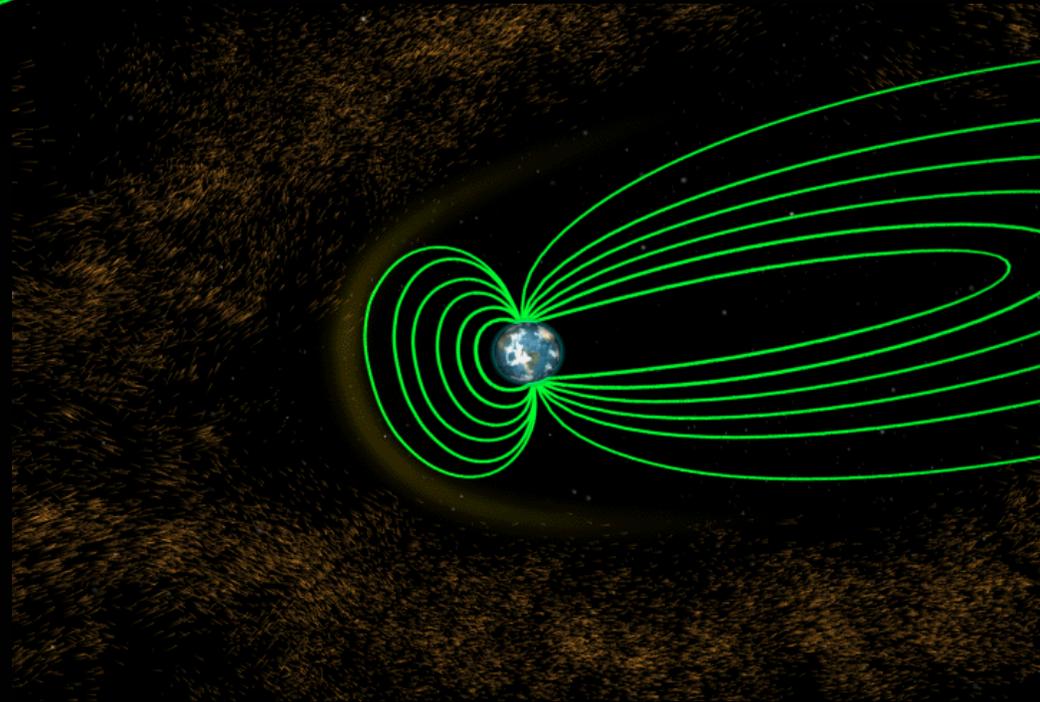
Outline

- Plasma Convection & Convection Reversal Boundary (CRB)
- Plasma Boundary Layers & Auroral Boundaries
- Auroral Boundaries from High Frequency (HF) Radar Measurements
- Auroral Boundaries from Incoherent Scatter (IS) Radar Measurements
- Auroral Boundaries in Global MHD Models
- Advanced Modular Incoherent Scatter Radar (AMISR)

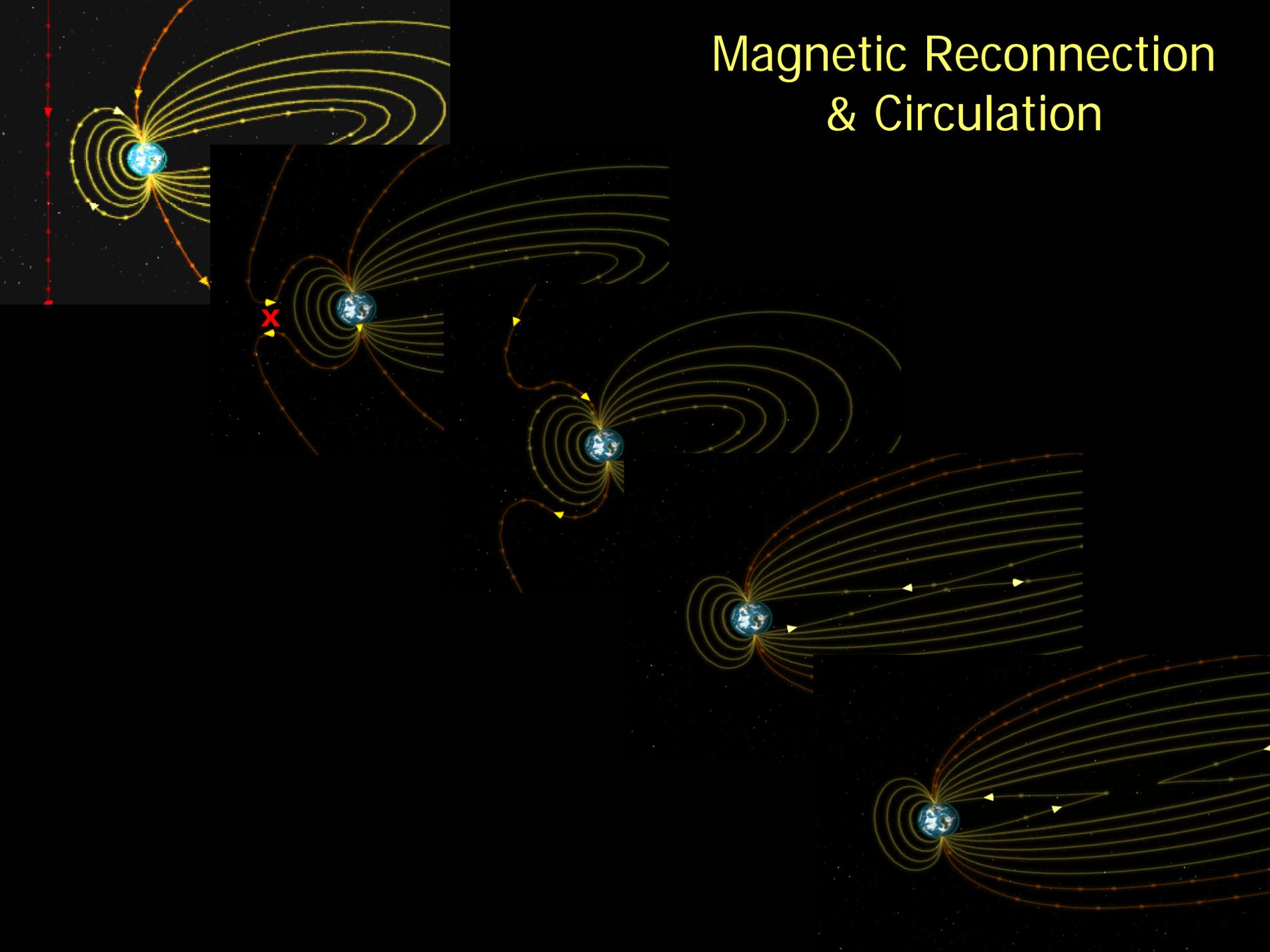
Dipole Magnetic Field



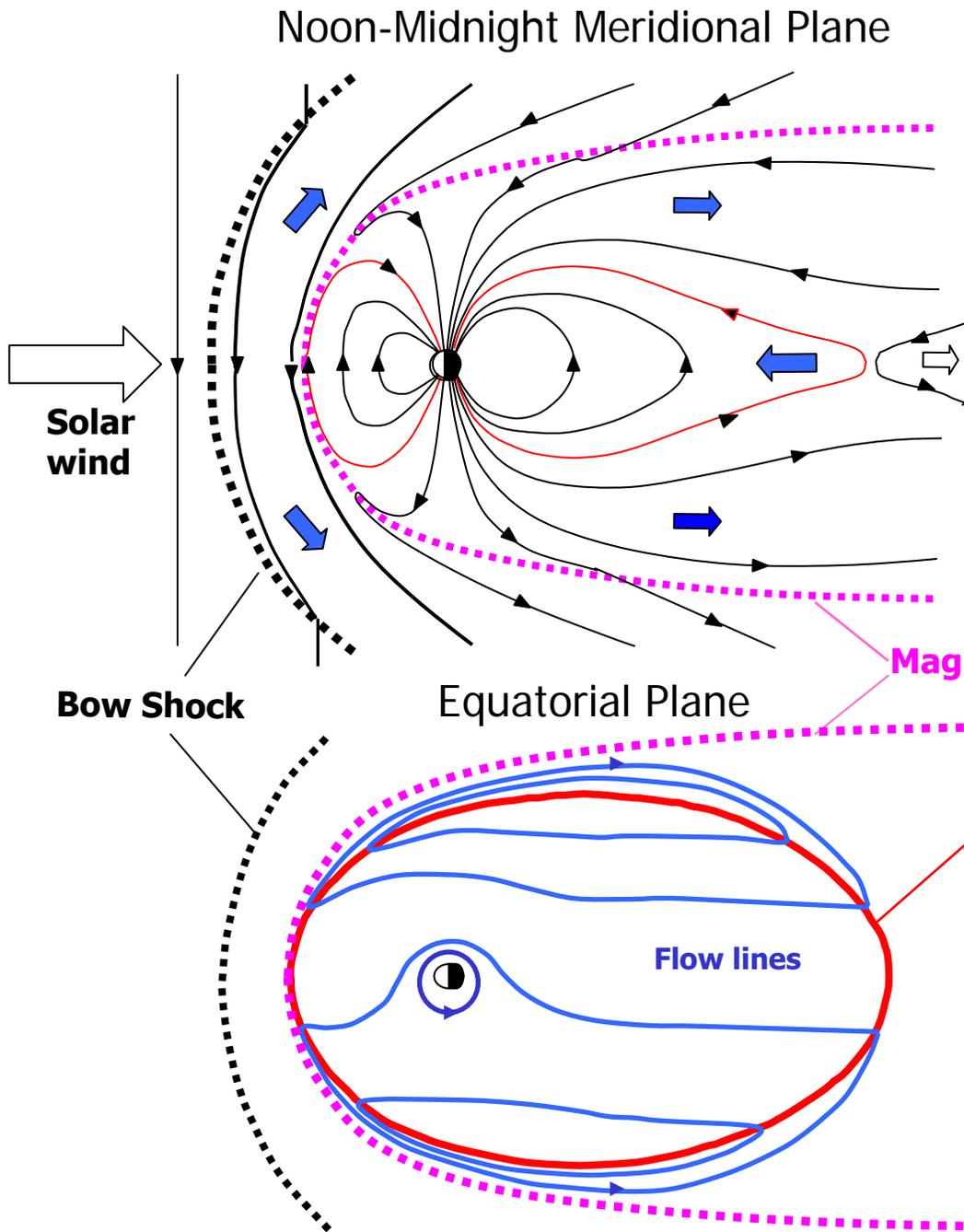
Distorted Magnetic Field



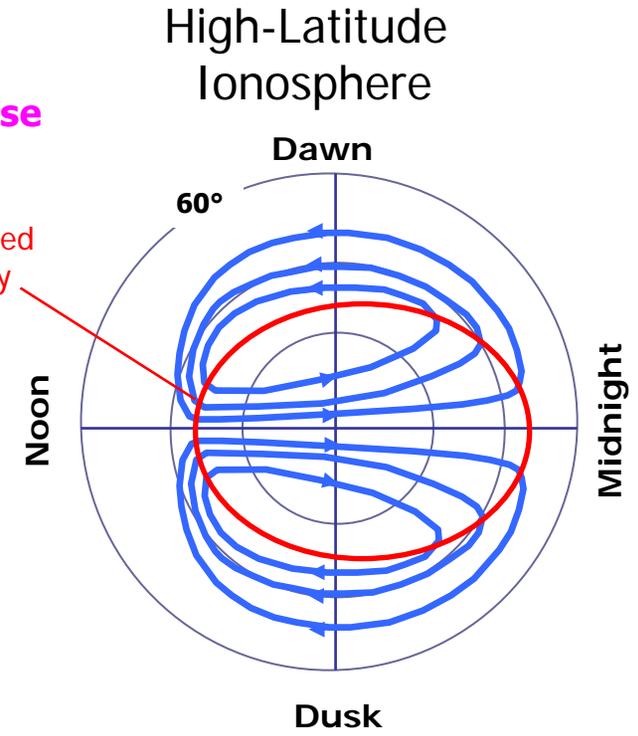
Magnetic Reconnection & Circulation



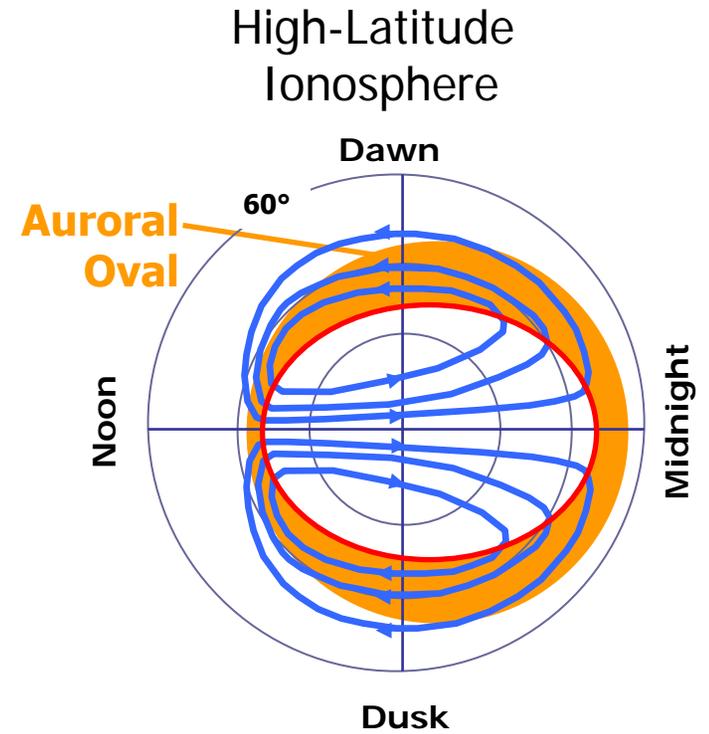
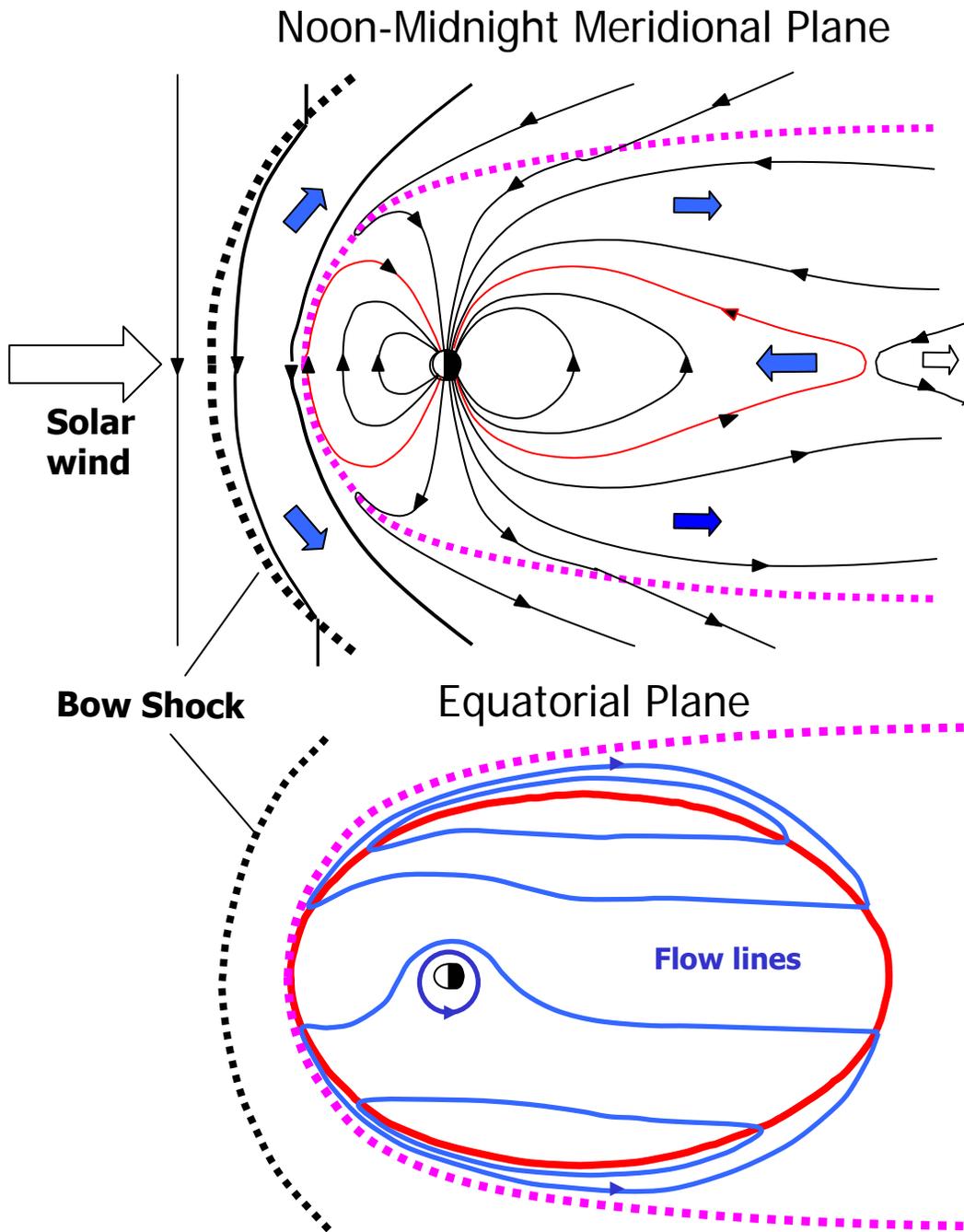
Magnetospheric Topology & Plasma Convection



CRB and OCB do not always coincide

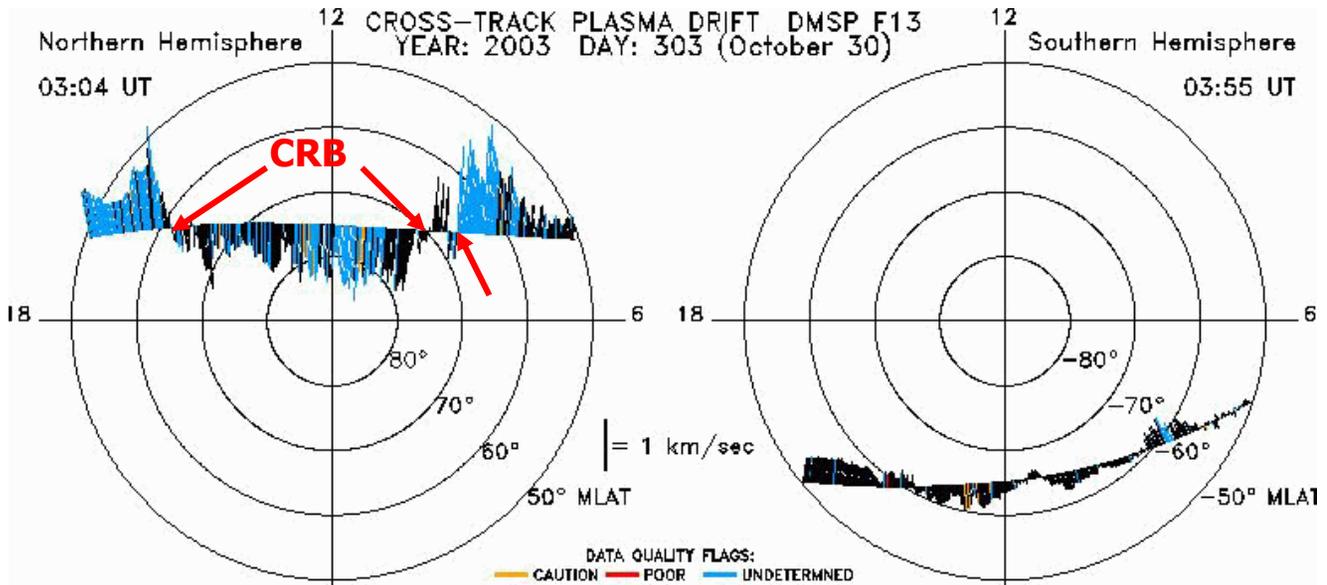


Magnetospheric Topology & Plasma Convection

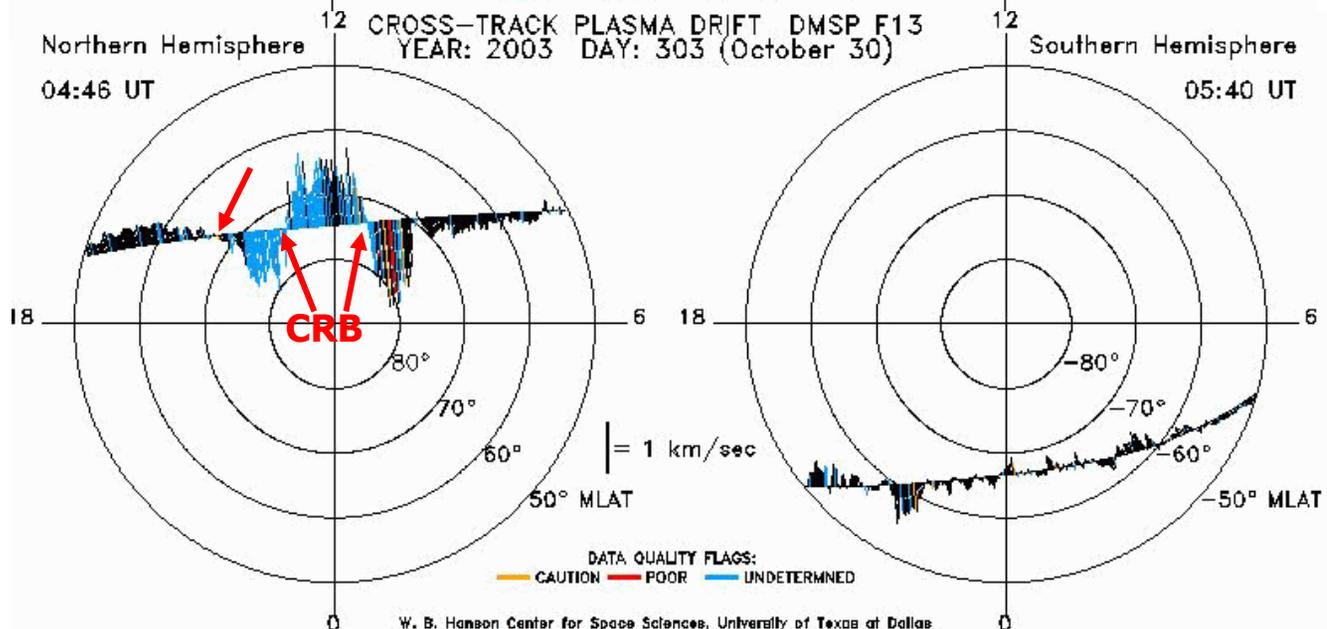


Ion Drifts Measured by DMSP Satellites

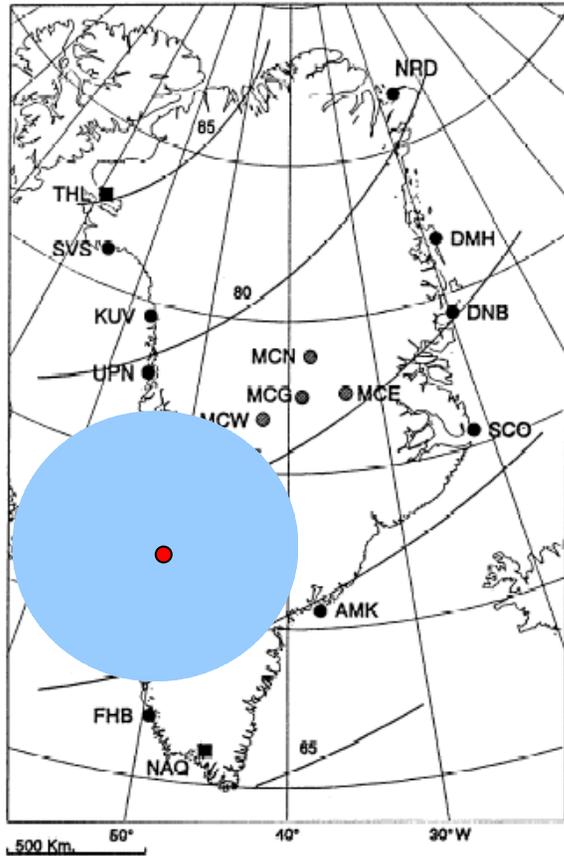
Southward
IMF Bz



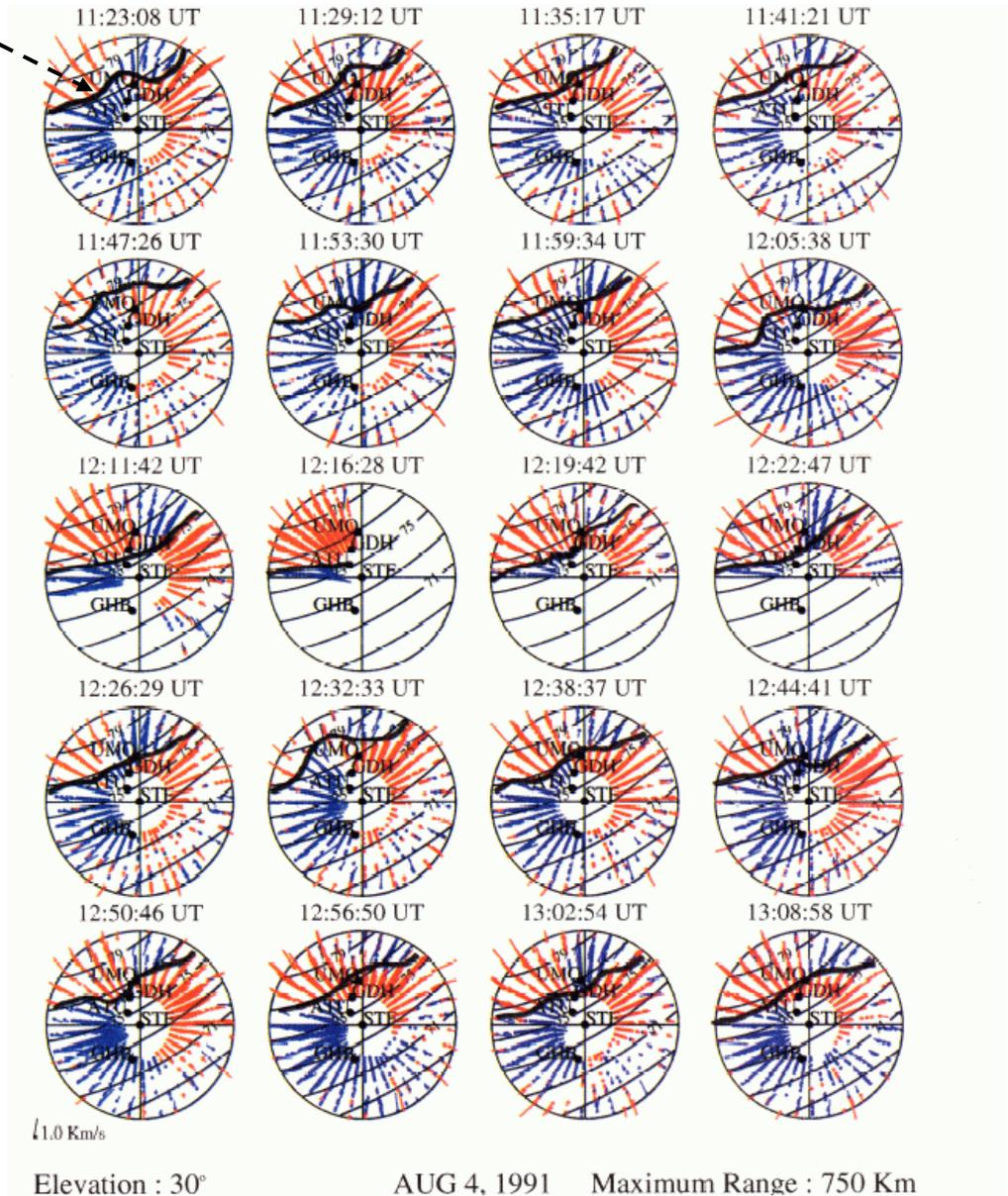
Northward
IMF Bz



Ion Drifts Measured by Sondrestrom IS Radar

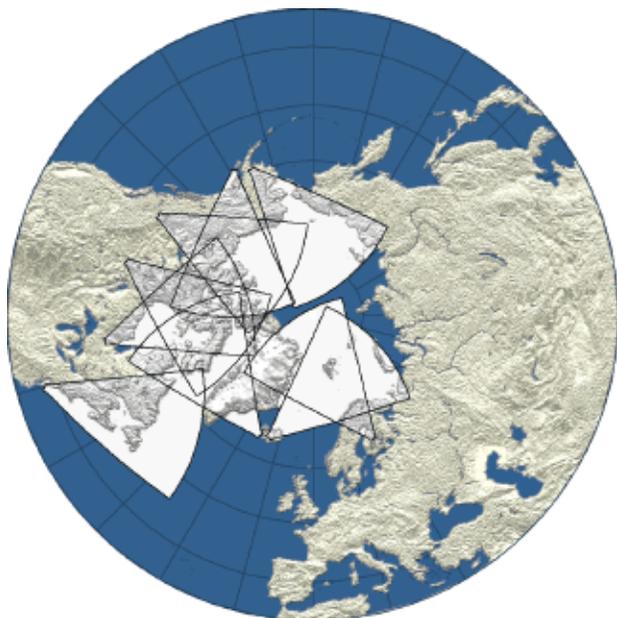


CRB



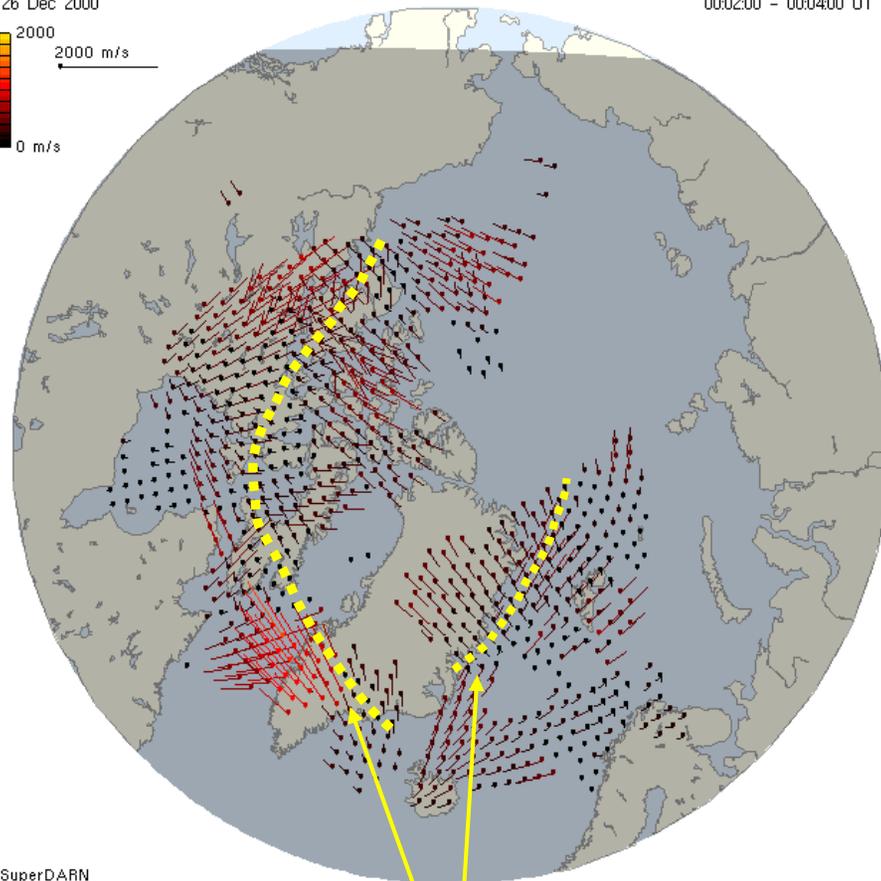
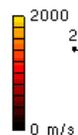
(Clauer & Ridley, JGR, 1995)

Ion Drifts Measured by SuperDARN HF Radars



26 Dec 2000

00:02:00 - 00:04:00 UT

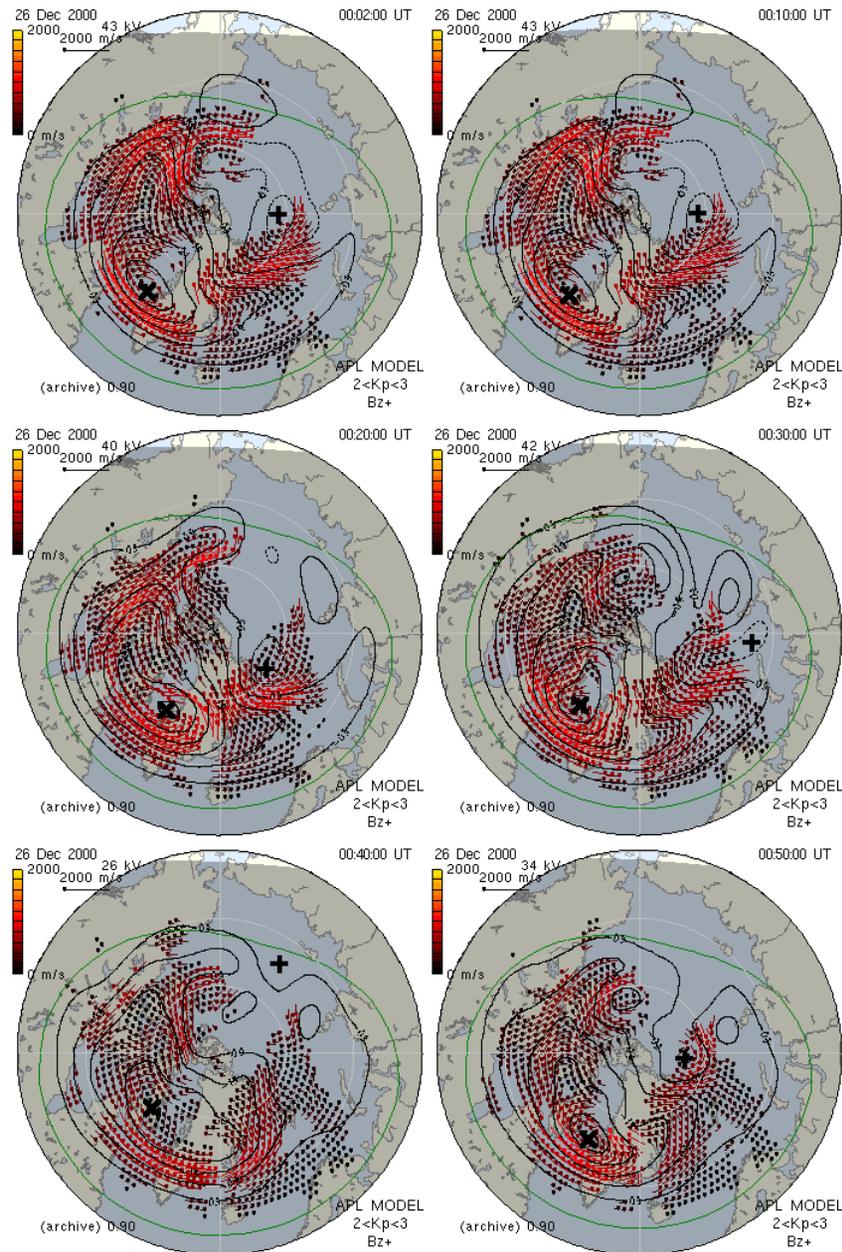


SuperDARN
JHU/APL Software by R.J.Barnes

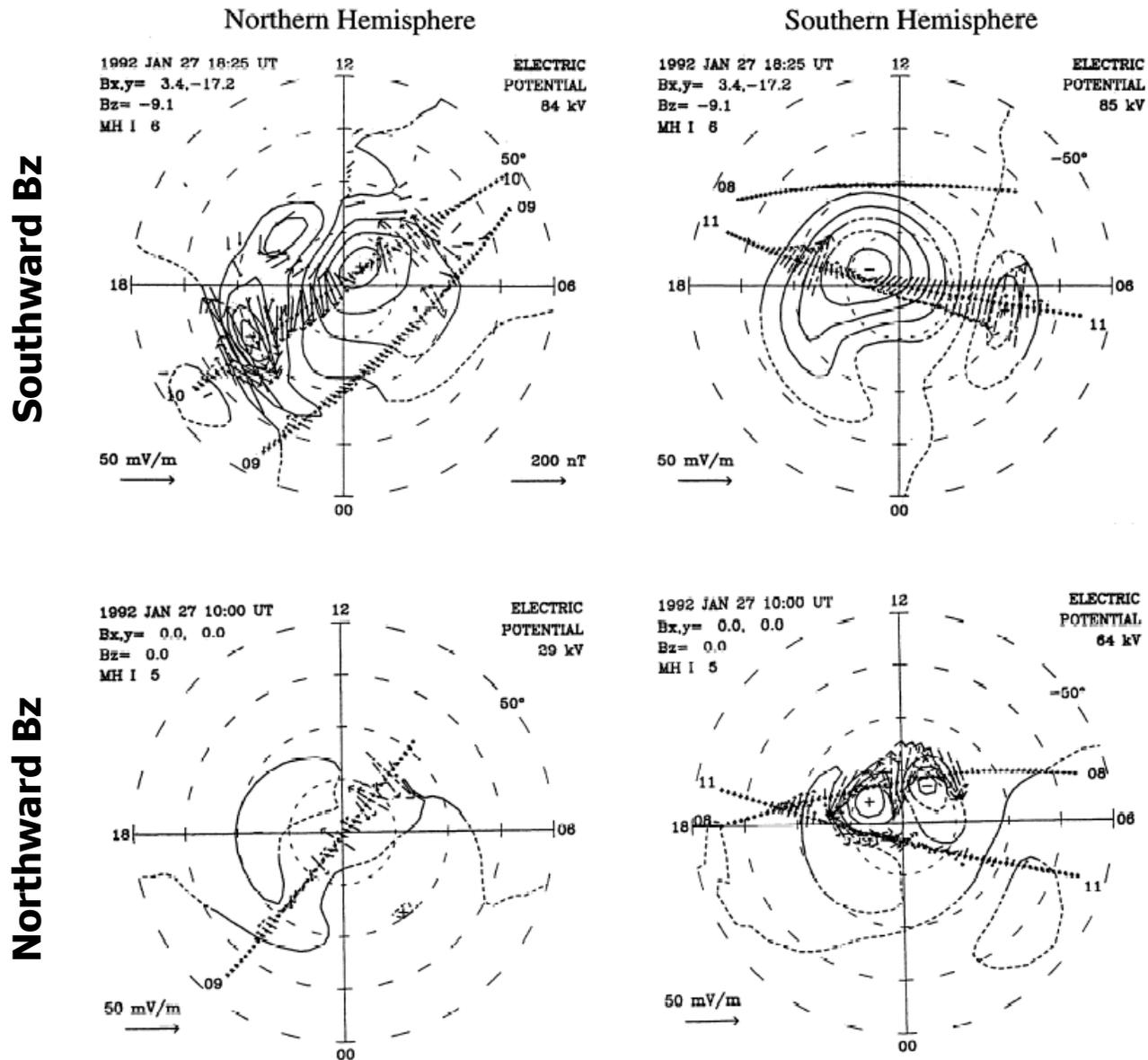
<http://superdarn.jhuapl.edu>

CRB

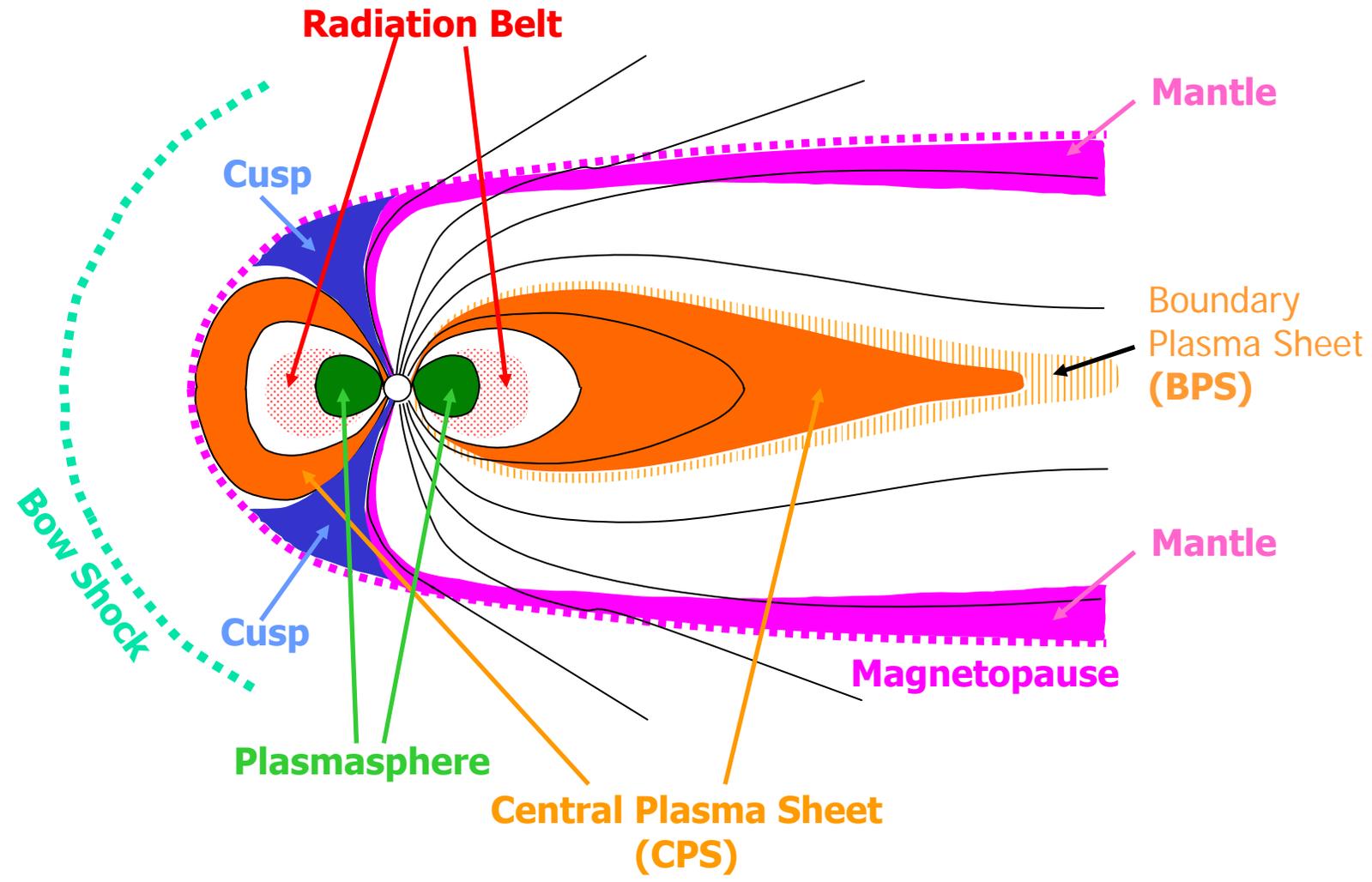
Convection Patterns Derived from SuperDARN



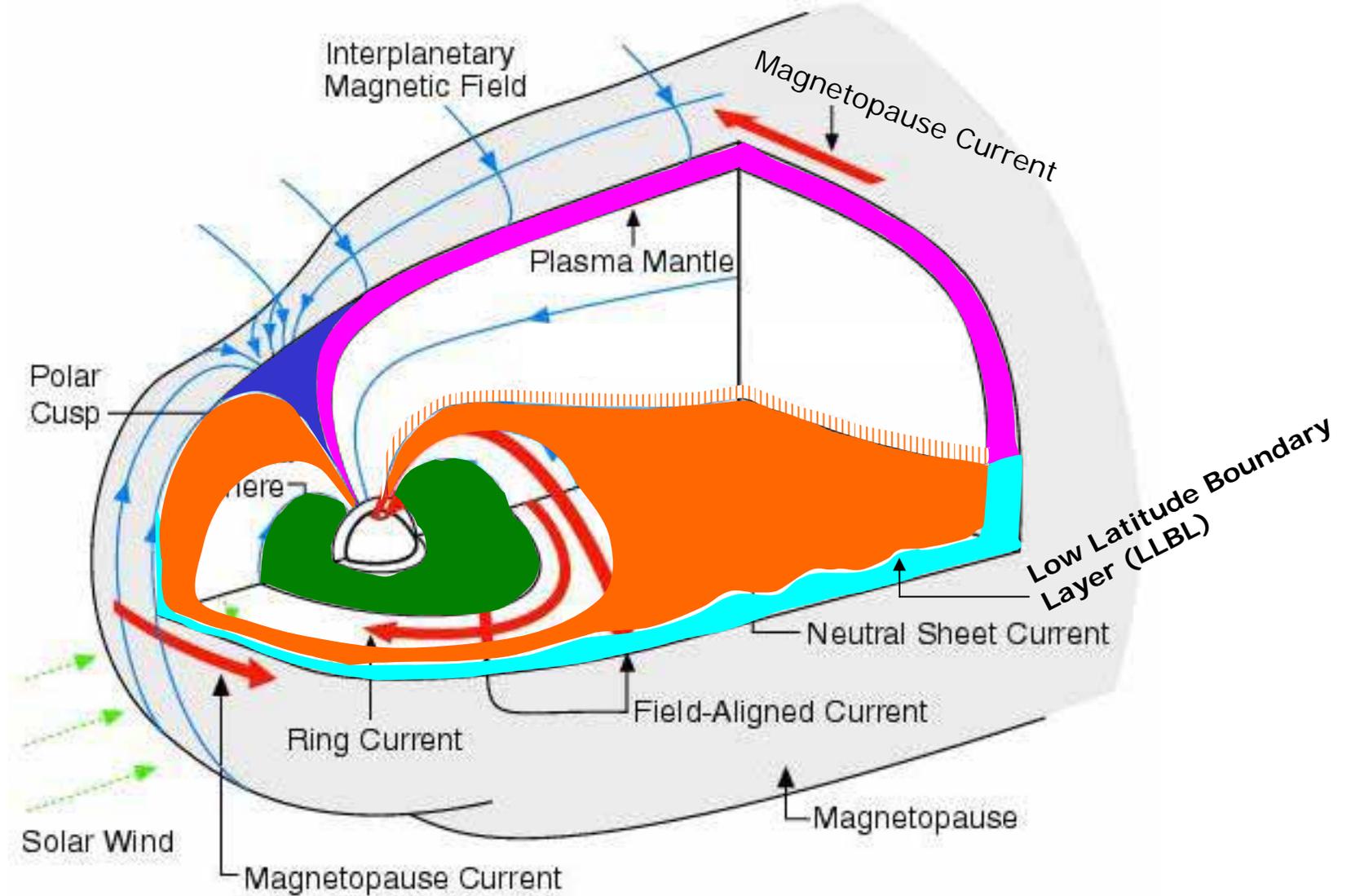
Convection Patterns Derived from AMIE



Morphology of Plasma Boundary Layers

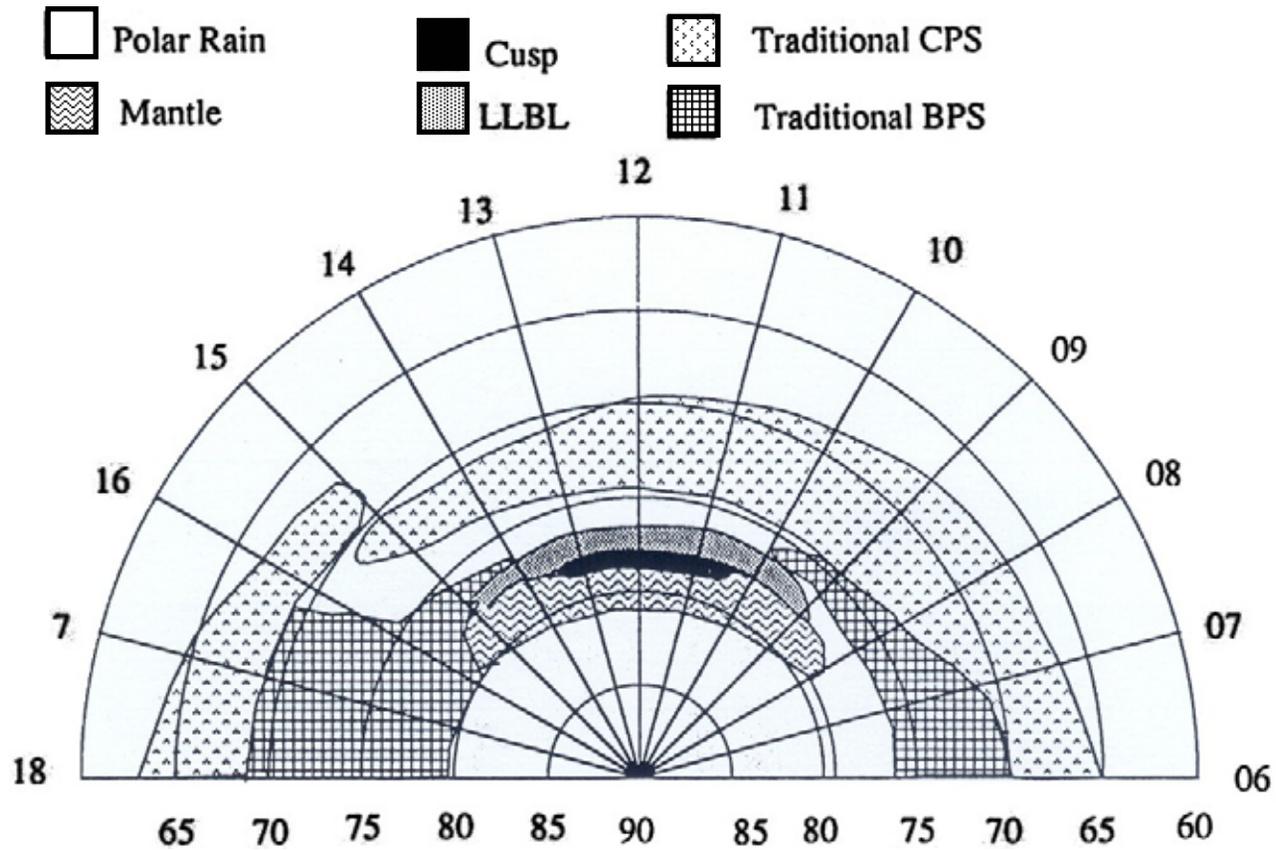


Morphology of Plasma Boundary Layers in 3D



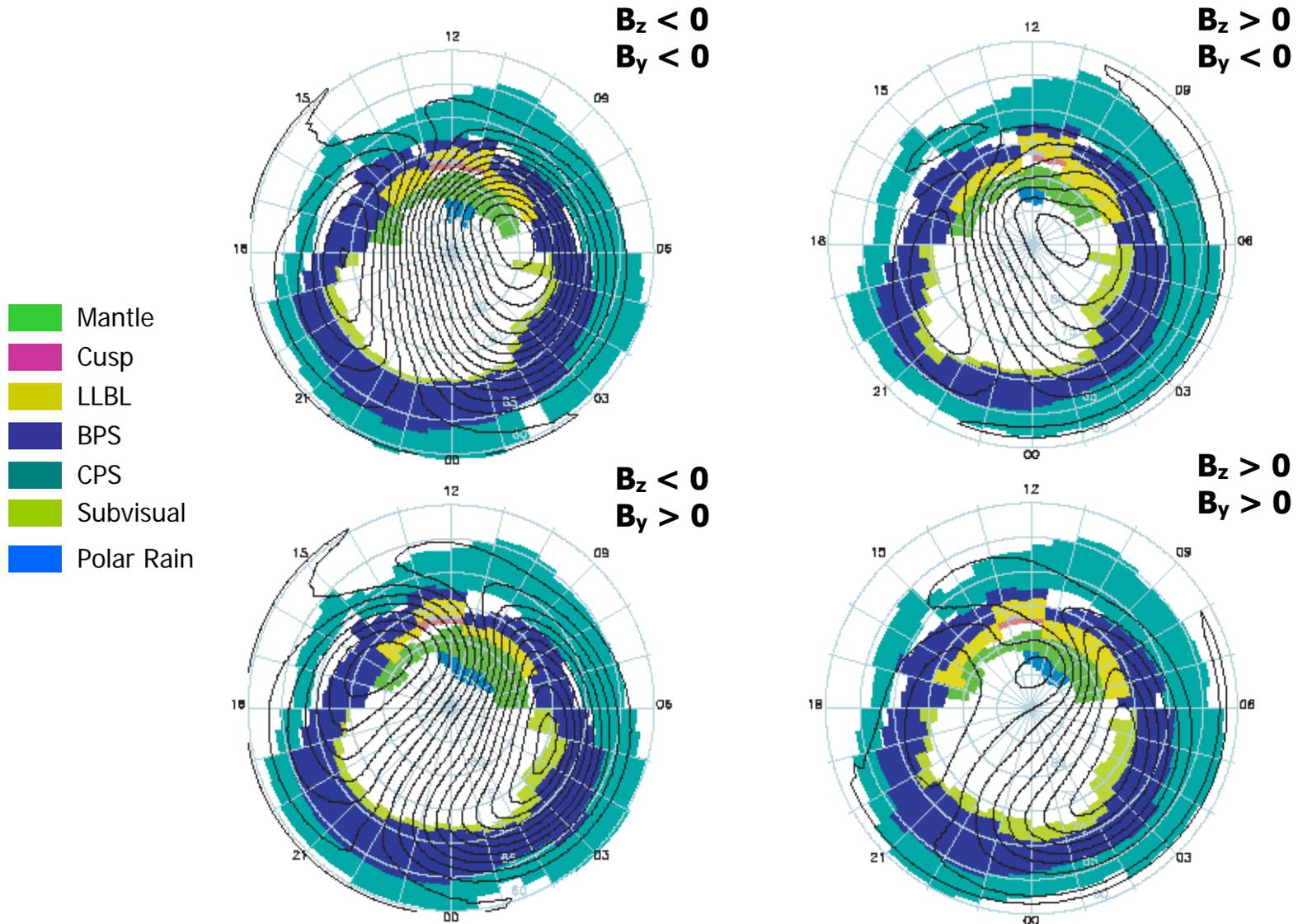
(after Kivelson & Russell, 1995)

Auroral Precipitation Boundaries from DMSP Satellites

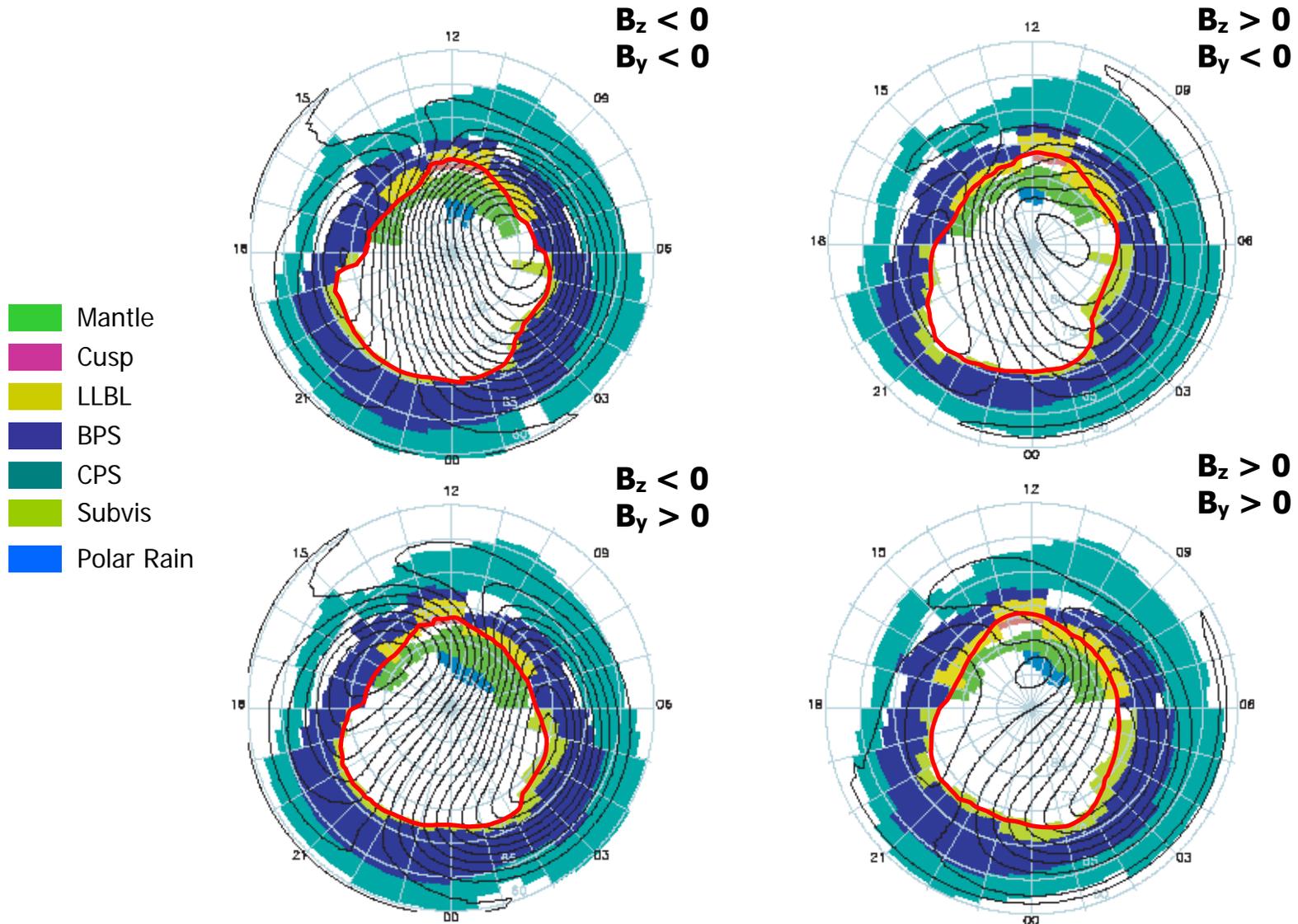


(Newell & Meng, GRL, 1988)

Relationship Between Auroral Precipitation & Convection

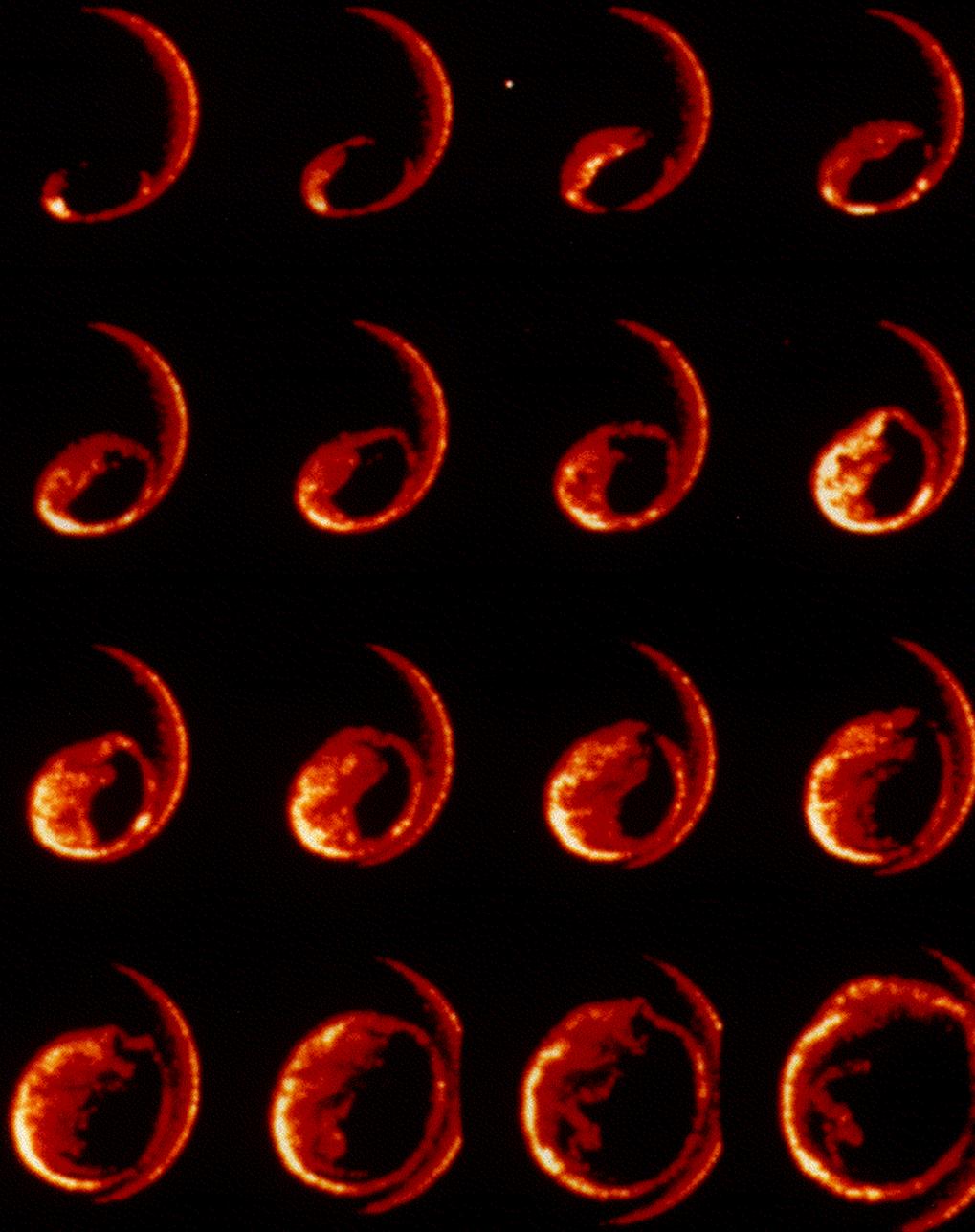


Relationship Between Auroral Precipitation & Convection



(Newell et al, JGR, 2004)

Auroral Boundaries – A Global View

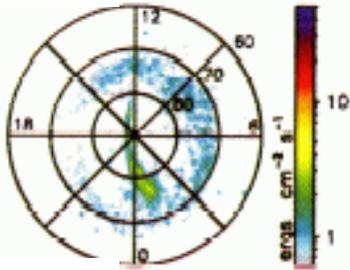


Polar UVI

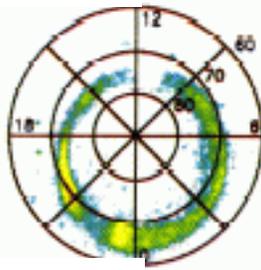
Jan. 9, 1997 (LBHL)

(Brittnacher et al, JGR, 1999)

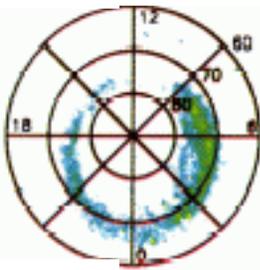
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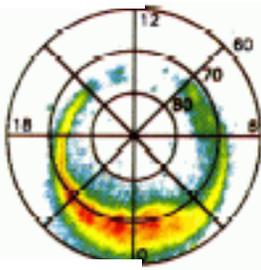
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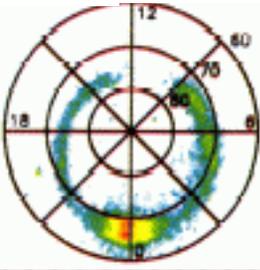
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0759:32



0719:40



0839:24

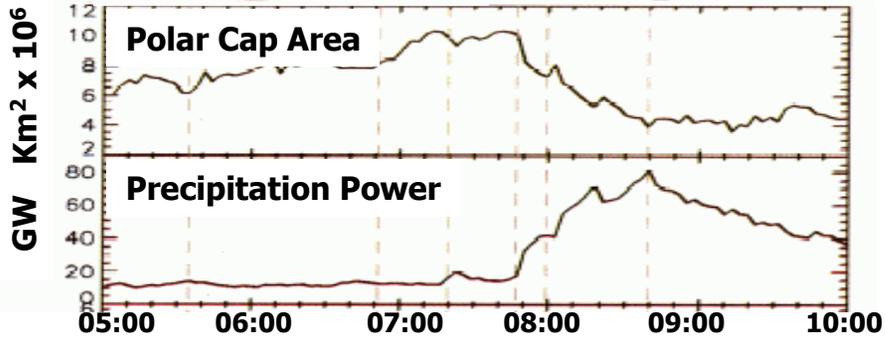
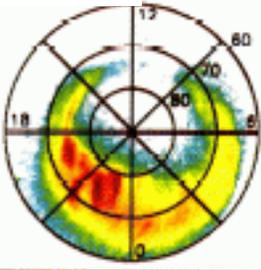
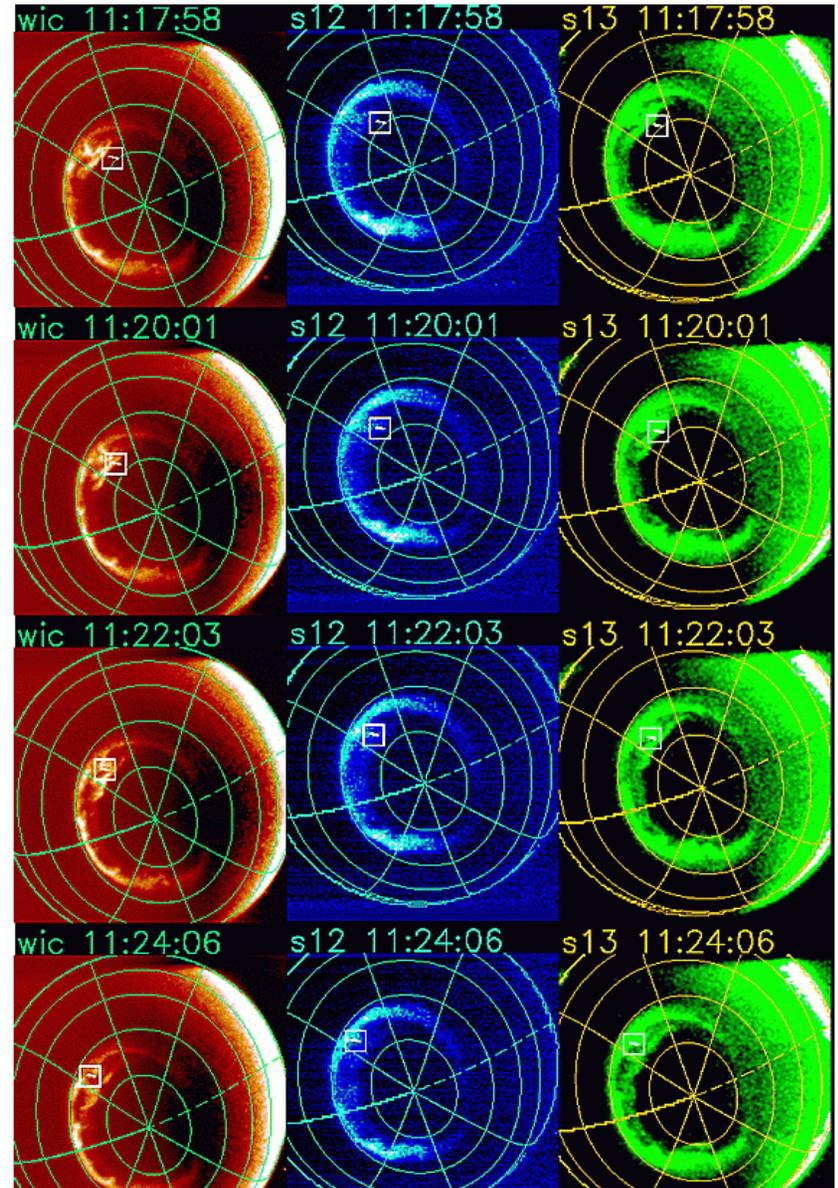


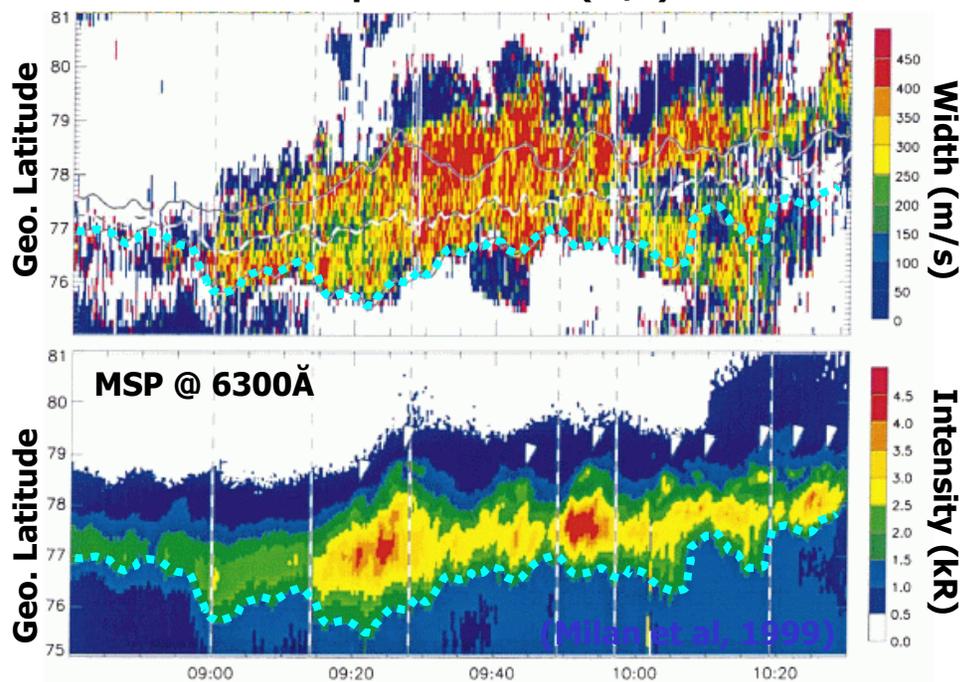
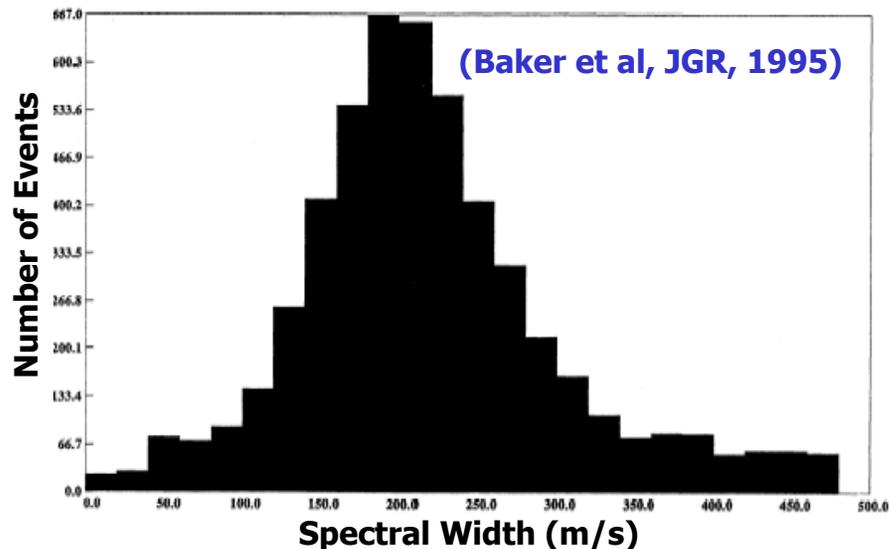
IMAGE FUV



(Mende et al, JGR, 2003)

Auroral Boundaries from HF Radar Measurements

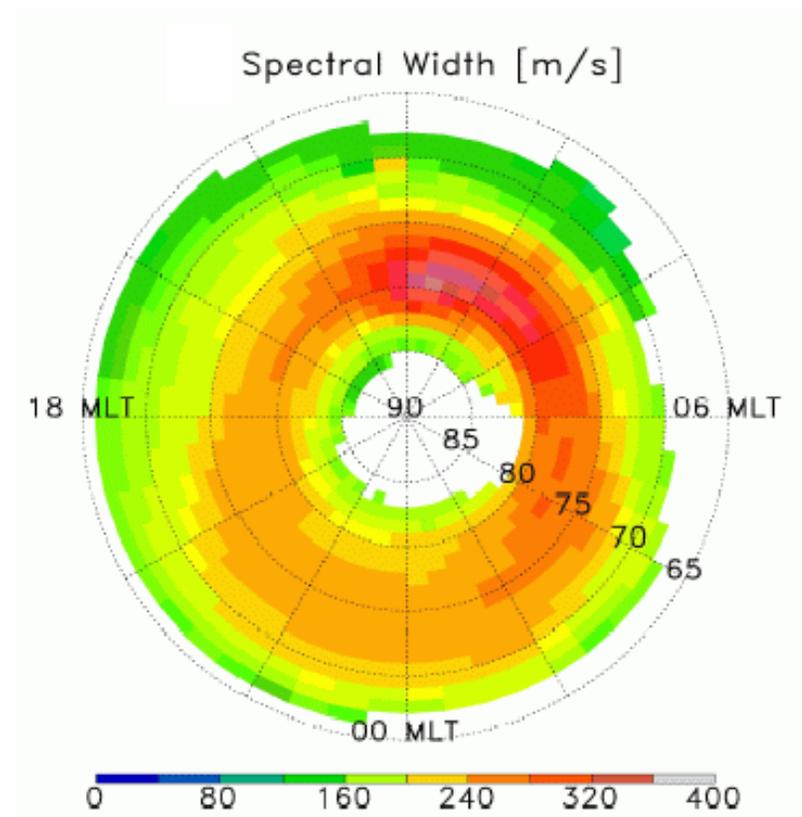
- A sharp latitudinal gradient in the Doppler spectral width has been associated with:
 - the dayside Cusp



(Milan et al, Ann. Geophys.,1999)

Auroral Boundaries from HF Radar Measurements

- A sharp latitudinal gradient in the Doppler spectral width has been associated with:
 - the dayside Cusp
 - the boundary between the CPS and the BPS
 - the LLBL
 - the open-closed boundary



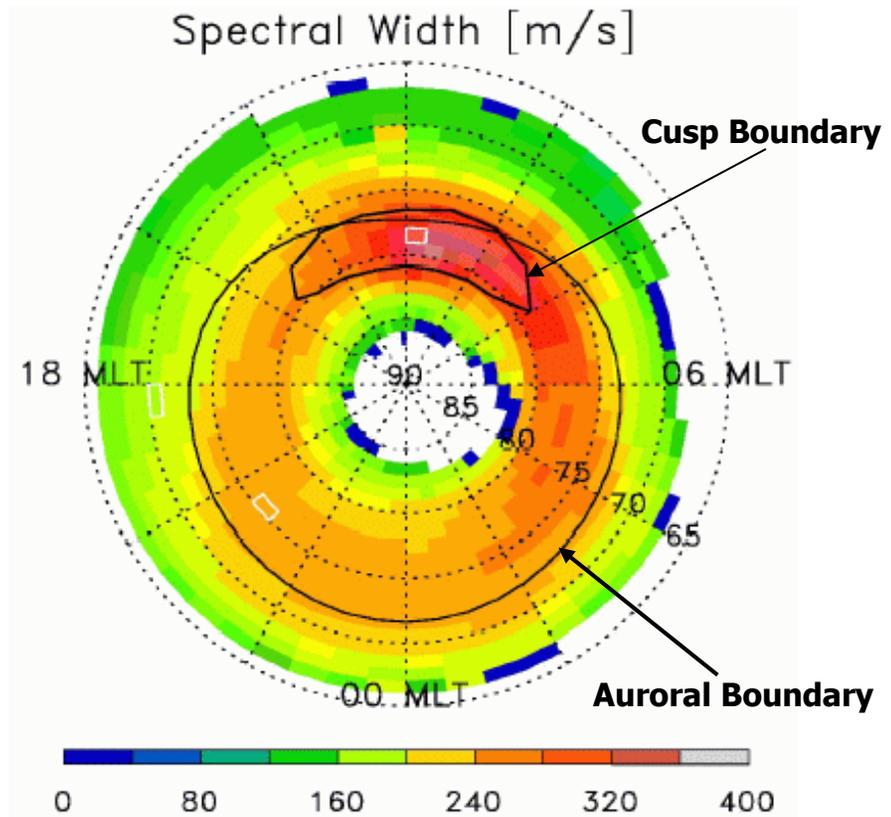
**Based on 6 HF radars between
October 1996 – May 1997**

Auroral Boundaries from HF Radar Measurements

- A sharp latitudinal gradient in the Doppler spectral width has been associated with:
 - the dayside Cusp
 - the boundary between the CPS and the BPS
 - the LLBL
 - the open-closed boundary
- Advantage:

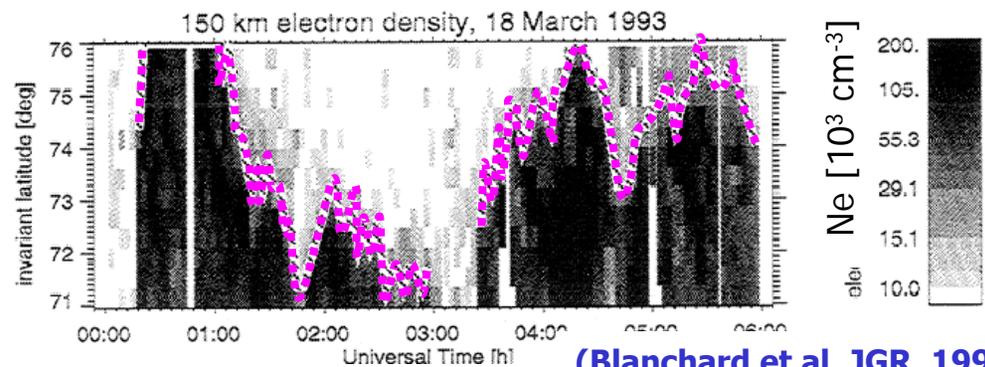
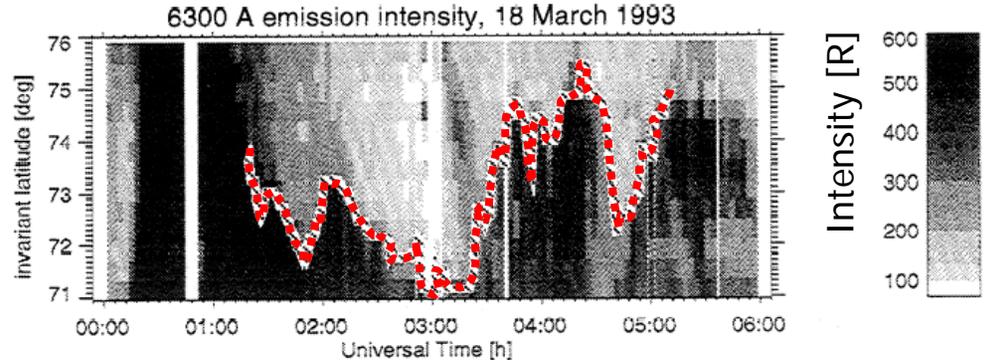
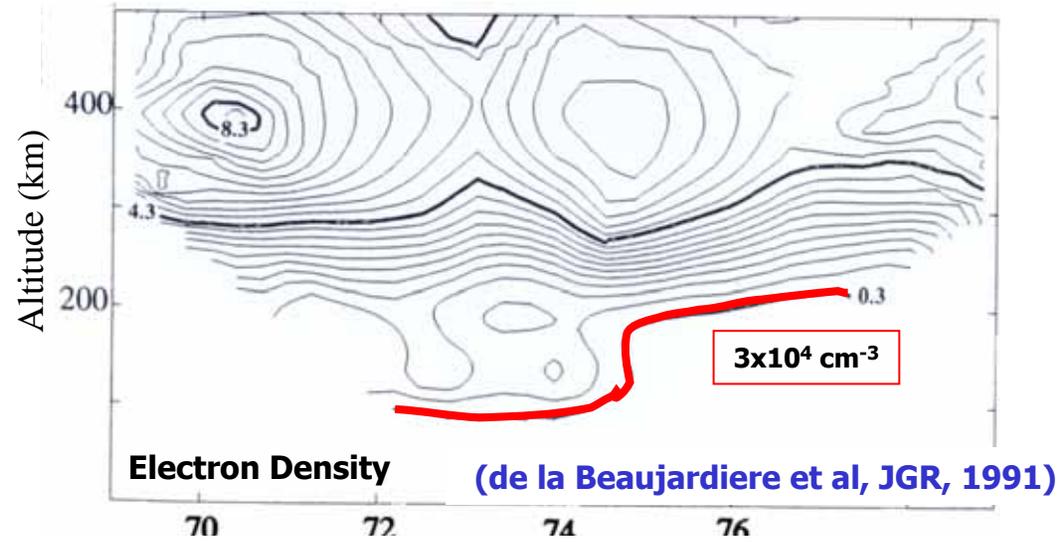
The broad radar coverage allows to image the auroral boundaries continuously and globally
- Limitation:

The high spectral width can be observed both on closed and open regions (e.g., Lester et al., *Ann. Geophys.*, 2001; Woodfield et al., *Ann. Geophys.*, 2002; Andre et al., *Ann. Geophys.*, 2002)



Auroral Boundaries from IS Radar Measurements

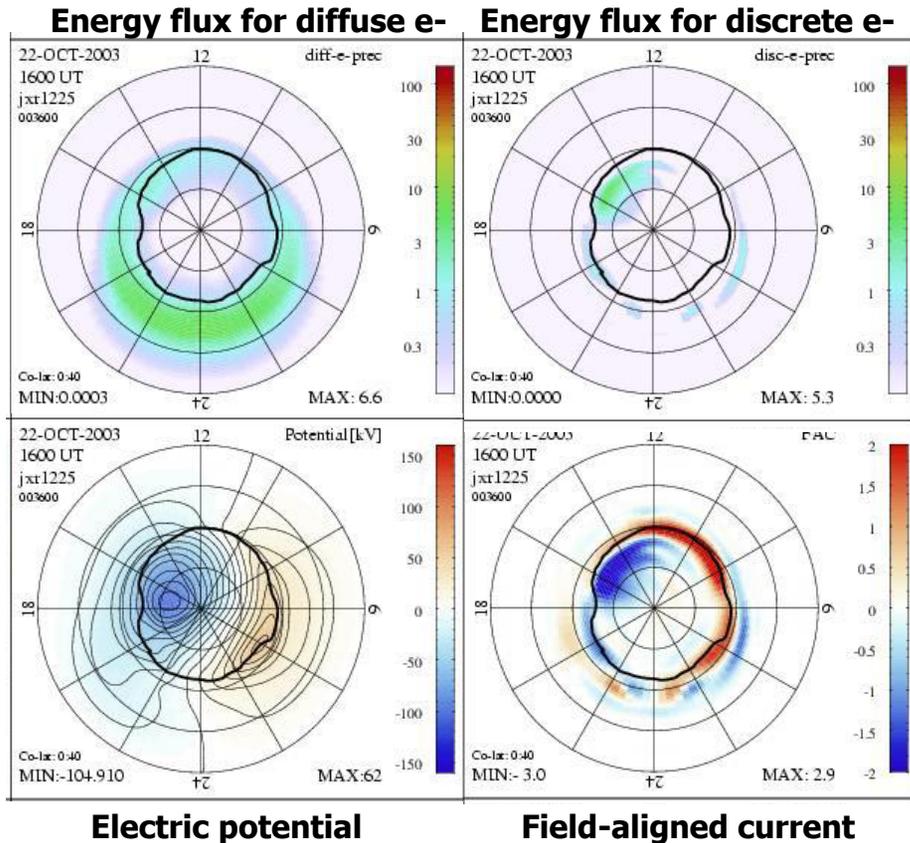
- Ti and/or Te, and the E-region electron density have been used to identify:
 - the dayside Cusp
 - the nightside auroral poleward boundary
- Advantage:
 - not affected by “blackouts”
 - able to observe several important plasma parameters (e.g., Ne, Ti, Te, Vi) simultaneously
- Limitation:
 - limited availability of IS radars
 - expensive to operate



(Blanchard et al, JGR, 1996)

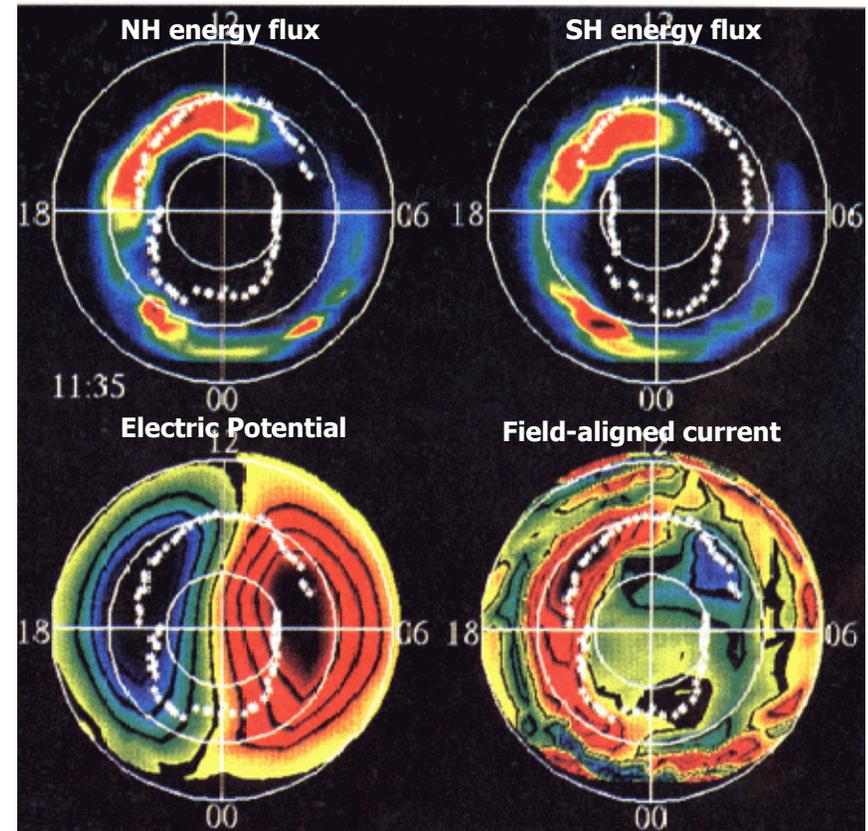
Auroral & Open-closed Boundaries in Global MHD Models

UCLA-GGCM Code



(Courtesy of Jimmy Raeder)

Lyon-Fedder-Mobarry Code



(Fedder et al, JGR, 1995)

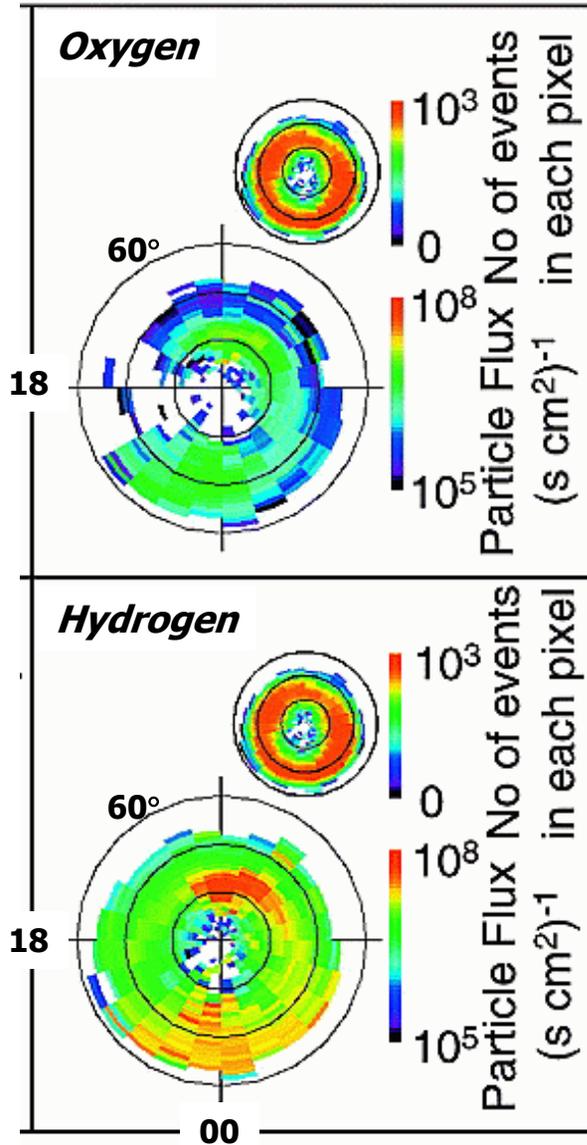


Why should we care about auroral boundaries?

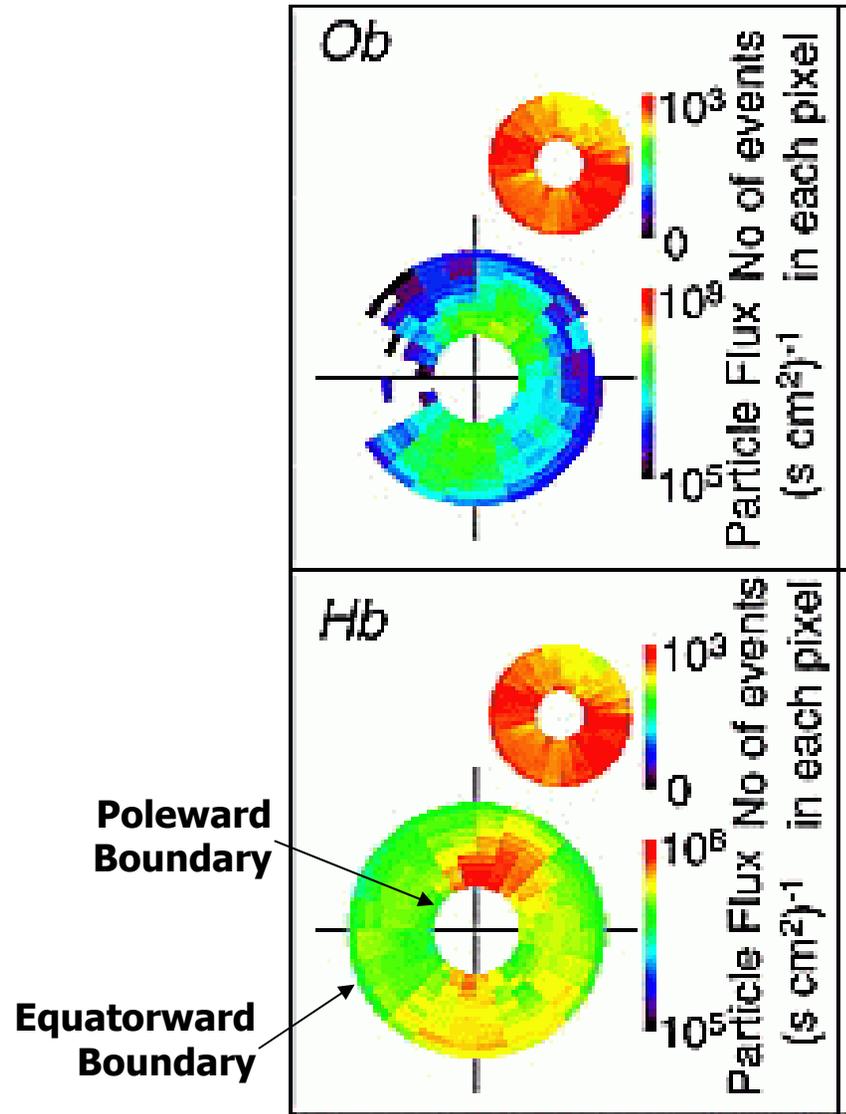
- Observations of auroral boundaries can be used to remotely monitor magnetospheric processes (e.g., reconnection rate), and to validate large-scale magnetospheric models
- Auroral boundaries may be used as a dynamical coordinate system to better organize some physical parameters (e.g., Poynting flux, ion upflow/outflow)

Auroral Boundaries – Dynamic Coordinates

Ion Outflow (ILAT/MLT Coordinates)



Ion Outflow (Dynamic Coordinates)



(Andersson et al, JGR, 2004)



Why should we care about auroral boundaries?

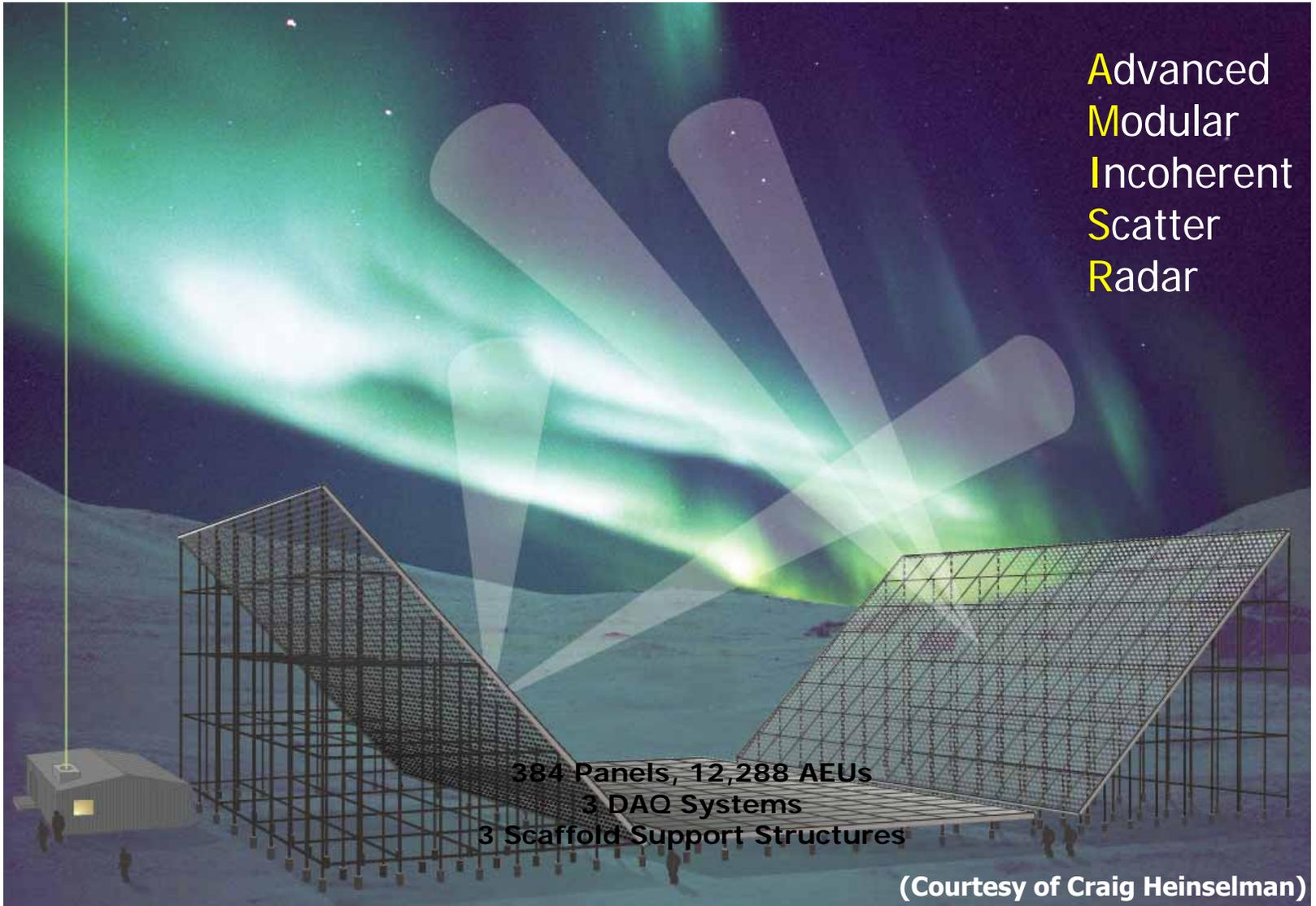
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- Auroral precipitation and ionospheric plasma convection represent two of the major magnetospheric forcings on the ionosphere and thermosphere dynamics and electrodynamics (they are the two primary upper boundary inputs of GCMs)
- Let's not forget about the ionospheric feedback effects

AMISR

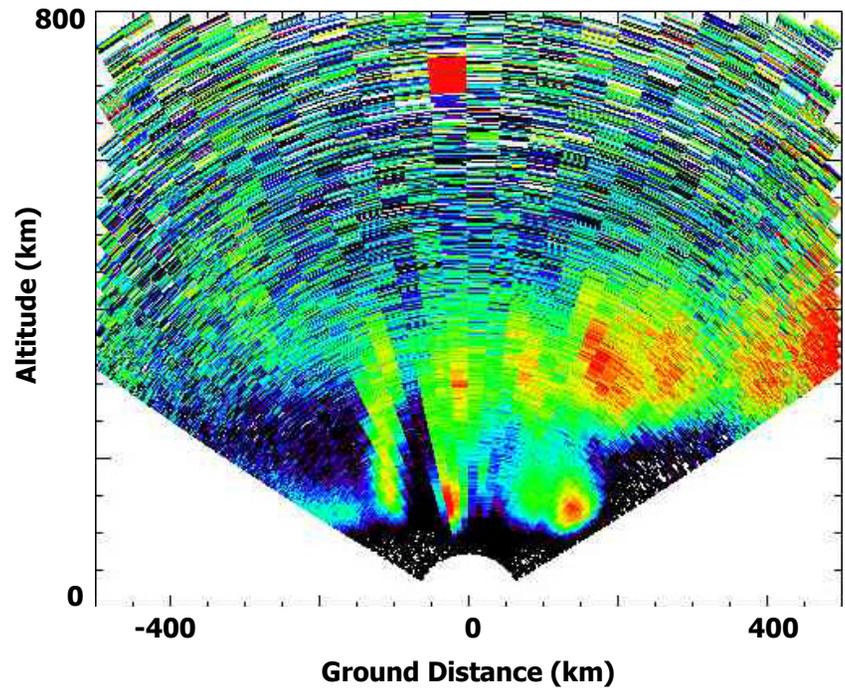
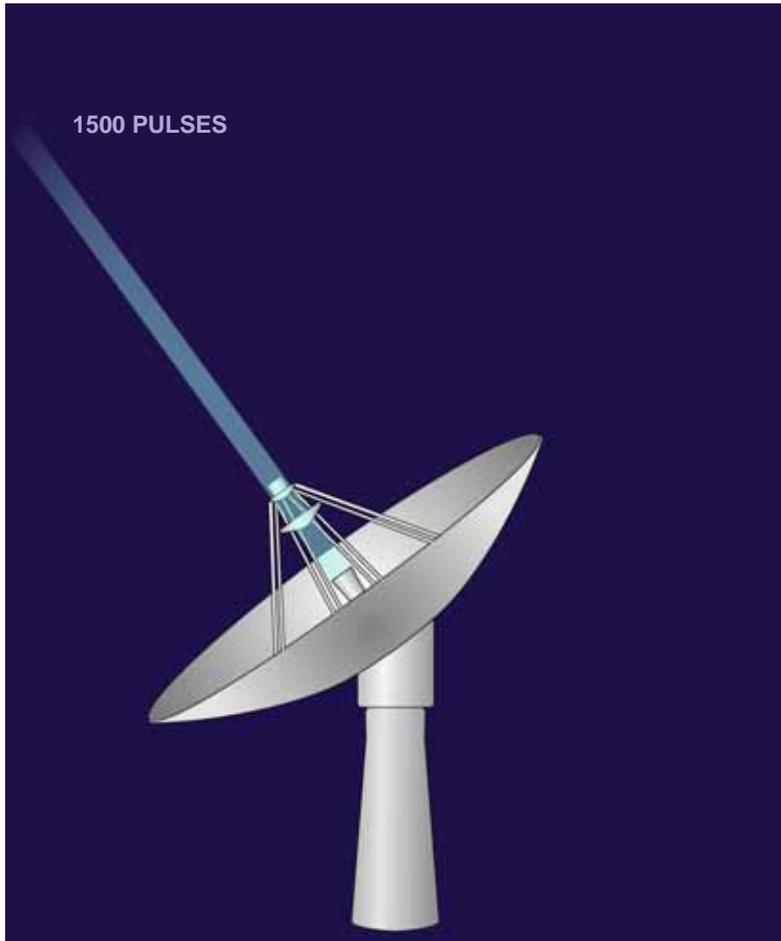
Advanced
Modular
Incoherent
Scatter
Radar

384 Panels, 12,288 AEUs
3 DAQ Systems
3 Scaffold Support Structures

(Courtesy of Craig Heinselmann)

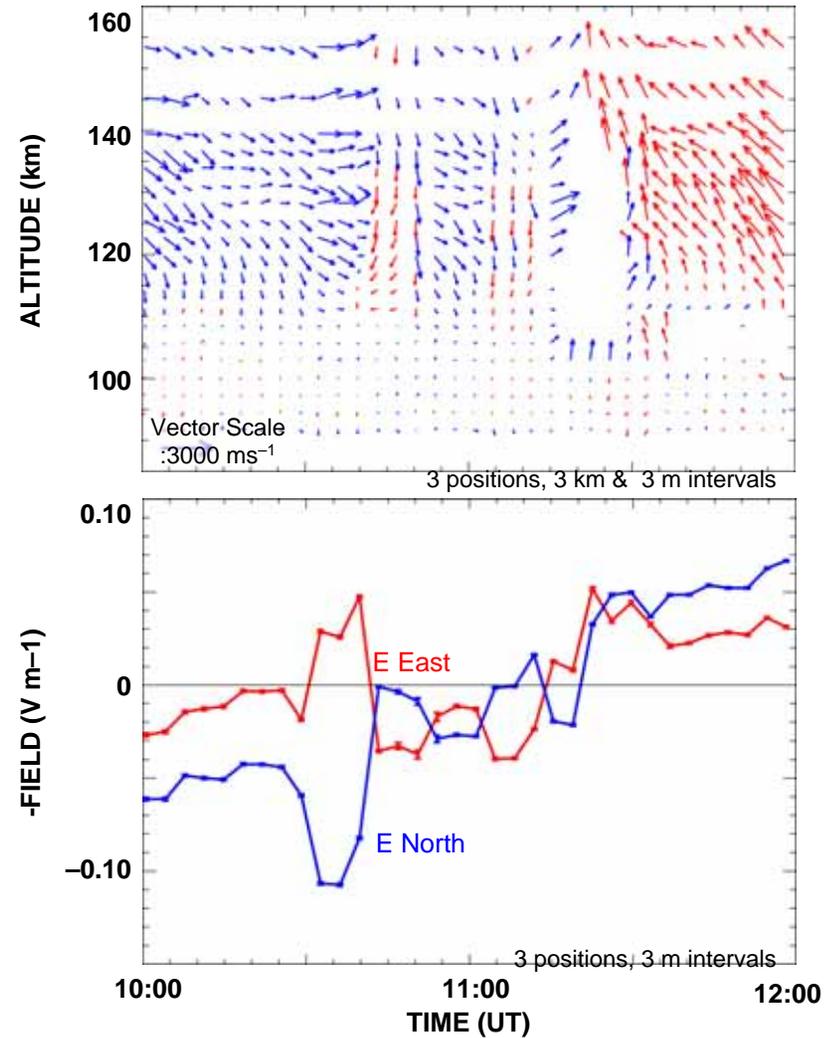
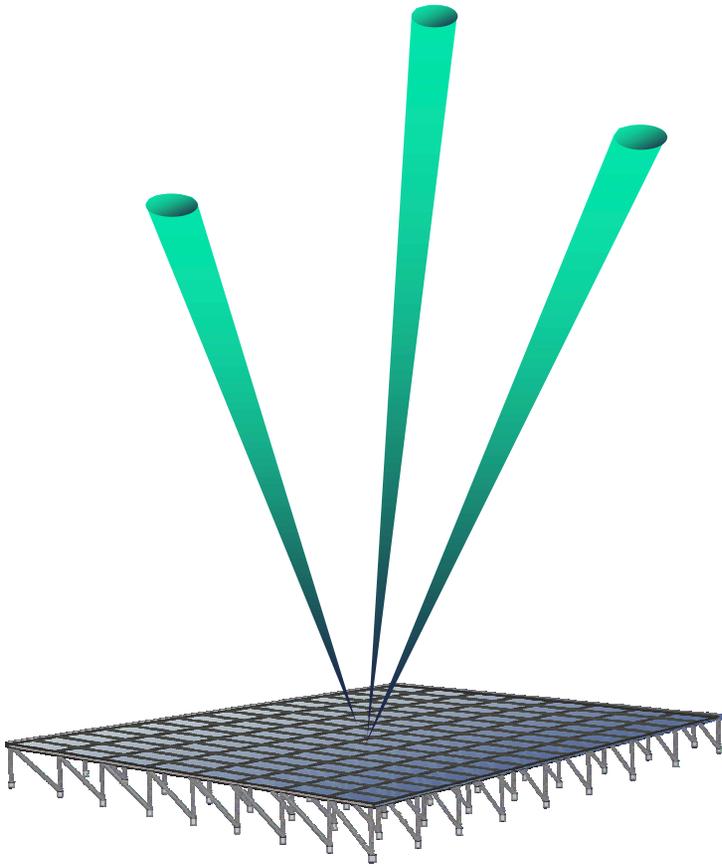


Plasma Parameter Maps



(Courtesy of Craig Heinselman)

AMISR Ion Velocity Estimation

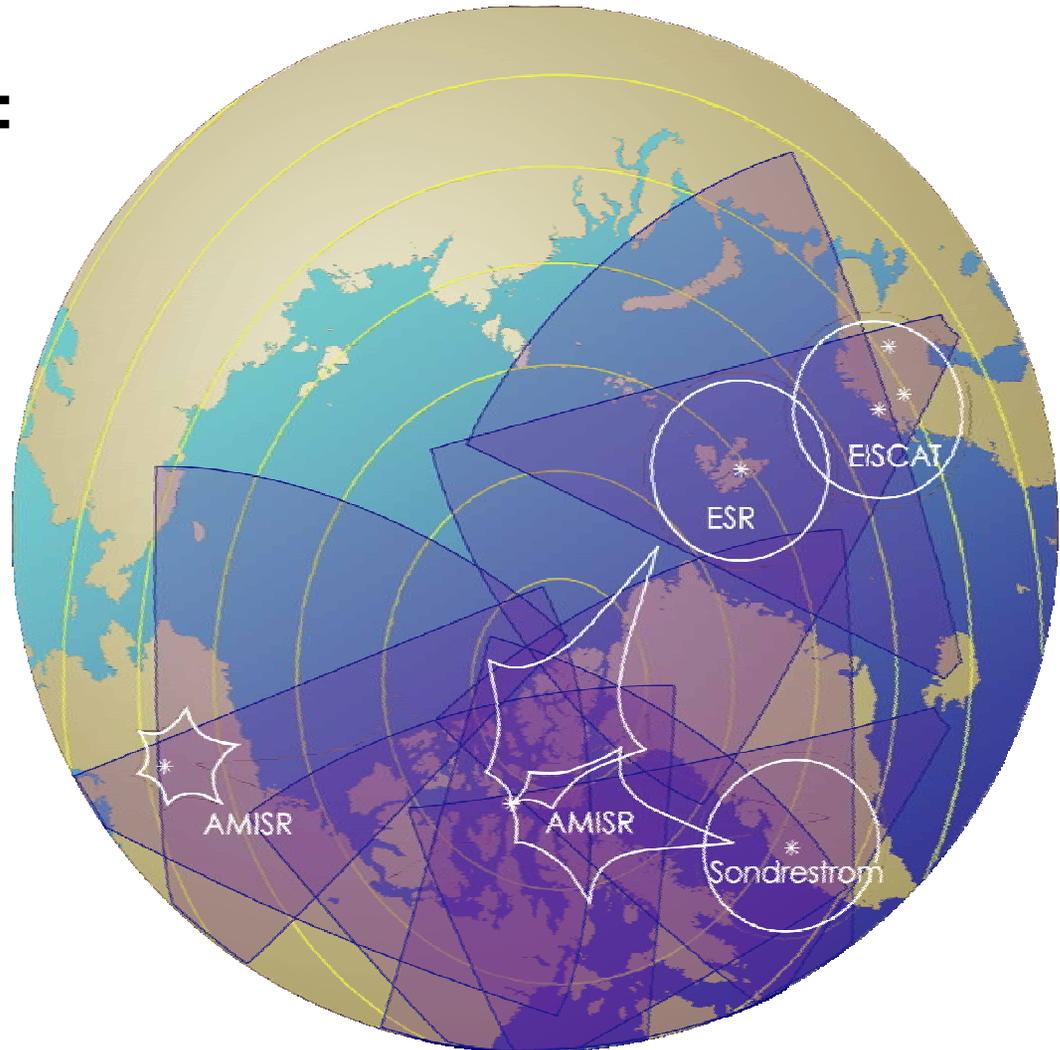


(Courtesy of Craig Heinselman)

AMISR Coverage – Global Context

A Great Observatory:

- ISRs
- SuperDARN
- Optical Instruments (MSPs & All-sky imagers)
- Distributed Arrays of Small Instruments (DASI)
- + Satellites



(Courtesy of Craig Heinselman)