High Latitude Convection

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Magnetic Field Lines at High Latitudes Connect to

The dayside Magnetosheath
The nightside Tail Lobes and Plasma Sheet Boundary Layer
The Low Latitude Boundary Layer
The Plasma Sheet
On Closed Field Lines Near the noon-midnight Meridian
Anti-sunward Flow in the Ionosphere
Maps to Sunward Flow in the Plasma Sheet
High Latitude Ionospheric Convection

Sources of Data

Satellite Measurements of Ion Drifts and Electric Fields

Incoherent Scatter Radar Measurements of Ion Drifts

HF Radar Measurements of F-region Structure Drifts

Doppler Ionosondes

Doppler Measurements of Optical Emissions

Spaced Receiver Measurements of Beacon Signals

Measurements of Current Systems

Assimilative Mapping of Electrodynamnic Parameters
Satellite Measurements of Electric Fields and Ion Drifts

Incoherent Scatter Radar Measurements of Ion Drifts

HF Radar Measurements of Structure Drifts

Greenwald et al., J. Geophys. Res., 95, 8057, 1990
Southward IMF Dependence of Convection Pattern on $B_y$

IMF Line Tension is consistent with the By dependence in dayside ion drift directions

Nightside convection signature frequently consistent with extremely structured two cell pattern

Carlson et al., J. Geophys. Res., 93, 14501, 1988
Nielsen et al., J. Geophys. Res., 95, 21169, 1990
15-63° DEG LOG ENERGY FLUX (ergs/cm²)

LOG UPWARD CURRENT DENSITY (μA/m²)

CROSS DRIFT (m/s)

ELECTROSTATIC POTENTIAL (kV)

UT(HR:MIN)  6:49  6:50  6:51  6:52
ALT(KM)     723  739  755  769
GLAT(DEG)   69.43  73.01  76.57  80.11
GLNG(DEG)   -62.1  -62.3  -62.6  -62.8
MLT(HRS)    3.23  3.56  4.85  12.13
ILAT(DEG)   78.86  81.91  84.77  86.95
Heelis and Hanson: Nighttime Ionospheric Convection

AE-C
ION DRIFT VELOCITIES
DAY 76163 ORBIT 13254
SOUTHERN HEMISPHERE

INV LAT vs MLT

1 km/sec

AE-C
ION DRIFT VELOCITIES
DAY 76057 ORBIT 11565
SOUTHERN HEMISPHERE

INV LAT vs MLT

1 km/sec
Nightside Convection Pattern may Possess Convection Reversals across which the flow rotates or is sheared

Heelis and Hanson, J. Geophys. Res., 85, 1995, 1980
Southward IMF Ionospheric Convection
Direct Connection with the IMF

Merging Line: Across which ionospheric plasma flows from closed to open field lines

Reconnection Line: Across which ionospheric plasma flows from open to closed field lines

Adiaroic Line: Across which there is no ionospheric plasma flow since the plasma velocity perpendicular to the line is the same as the velocity of the line

If Merging Potential exceeds Reconnection Potential
Adiaroic lines move outward

If Reconnection Potential exceeds Merging Potential
Adiaroic lines move inward.

Motion of the Merging and Reconnection Lines must be taken into account.
Southward IMF Key Questions

How confined in local time is the region of flow rotation from sunward to antisunward

What controls the configuration of the nightside convection pattern

How does the nightside convection pattern depend on magnetic activity

What is the relationship between the dayside and nightside potential distributions along the convection reversal boundary.
Observations of Sunward Flow at Highest Latitudes during Periods of Northward IMF

Large Scale Regions of Sunward Flow at Highest latitudes appear to be confined to the dayside of the convection pattern.
Identical Single Component Convection Data can be interpreted differently

FIG 1

Potential Velocity

Velocity

Potential
Fig. 11. An example of highly irregular electric fields in the dayside winter hemisphere.
Evidence exists for structured almost turbulent flow in the winter and on the nightside

Heeils, Rev. Geophys., 20, 567, 1982
Bythrow et al., 90, 5319, 1985
Apparentely structured ionospheric flow is associated with discrete stable auroral forms

Carlson et al., J. Geophys. Res., 93, 14501, 1988
Nielsen et al., J. Geophys. Res., 95, 21169, 1990
Weber et al., J. Geophys. Res.... be watching !!!
Local Electrodynamics is consistent with the optical emissions implying a coherence in the convection features along the arc

Carlson et al., J Geophys. Res., 93, 14501, 1988
Nielsen et al., J. Geophys. Res., 95, 21169, 1990
Northward IMF Outstanding Questions

Under what conditions is large scale sunward flow seen on the dayside?

How does this sunward flow evolve from antisunward flow at other times?

How is the dayside sunward flow connected to other large scale flow regions?

How do smaller scale features of the nightside connect to the large scale features?

What is the relationship between large and small scale flow features and plasma circulation in the magnetosphere?
Perspectives and Needs

Convection Patterns provide only an instantaneous picture of the electric field configuration.

Convection Pattern changes on time scales that are short compared to the time taken for plasma to flow around a closed loop.

Magnetic field topology is unknown from the convection pattern alone. It is frequently difficult to determine.

Substantial points of departure between flow at each end of a flux tube can exist when field-aligned potentials exist.

Multiple point simultaneous measurements are essential for further understanding of convection patterns.

Agreement between different techniques needs to be established.

Multiple ground-based and satellite data are only now being utilized

Happy Hunting !!
Extra Figures
VELOCITY SHEAR &
CURRENT CONTINUITY

\[ V_1 < V_2 \]

\[ E_1 \rightleftharpoons E_2 \]

\[ I_{P1} \rightleftharpoons I_{P2} \]

\[ j_{\|} \]

\[ \Sigma_{P1} \rightleftharpoons \Sigma_{P2} = \Sigma_{P1} \]
Fig. 3. Weak stable extended 6300A sun-aligned arcs, persisting over an hour (the bright spots on the edge of the field of view are lights near the horizon).