

CEDAR Workshop Tutorial 1991

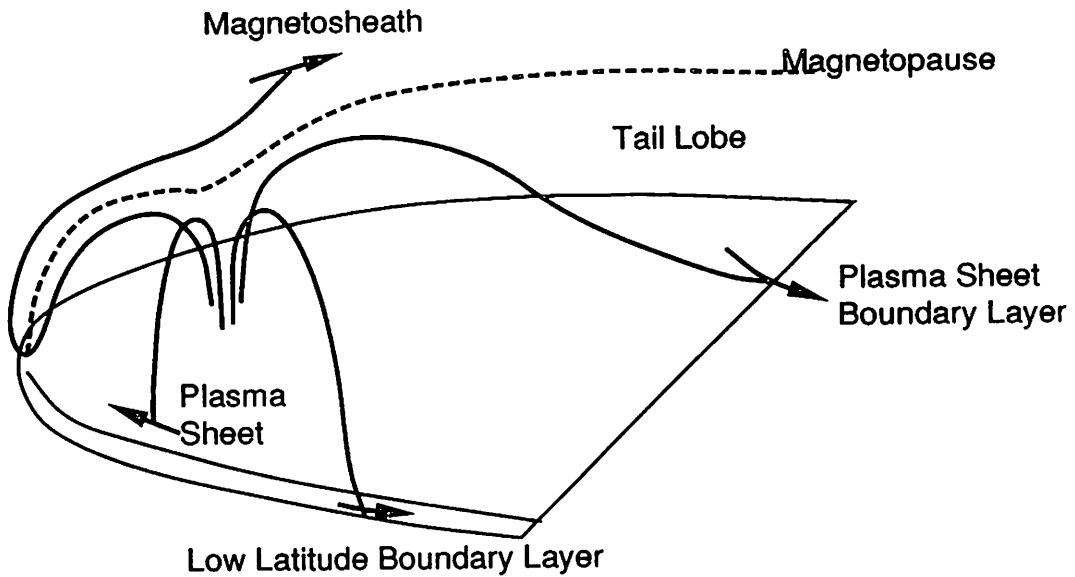
NIST Auditorium, Boulder, CO

Thursday, June 20, 1991

High Latitude Convection

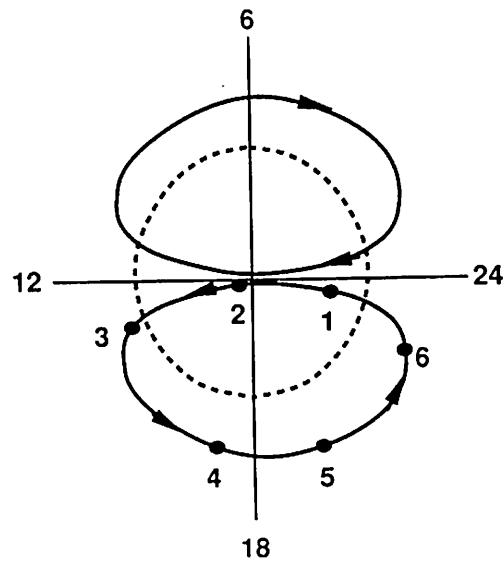
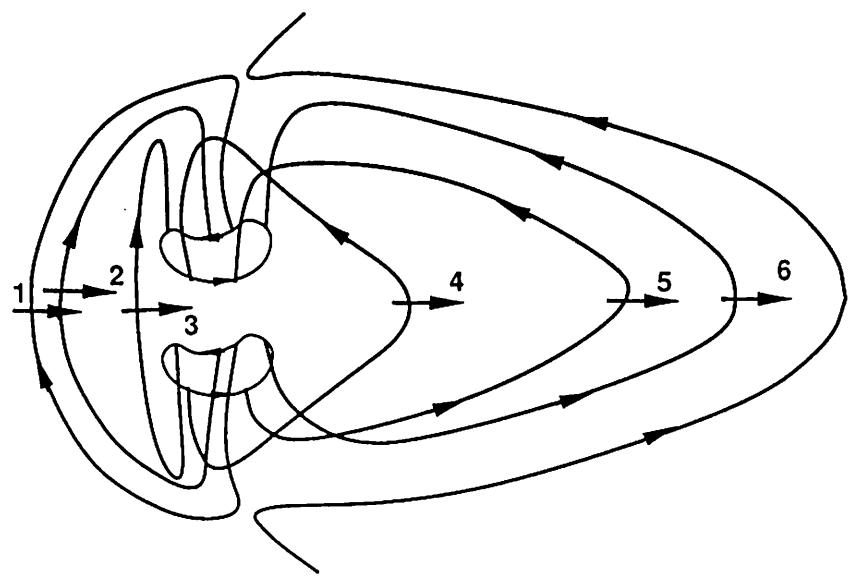
Rod Heelis

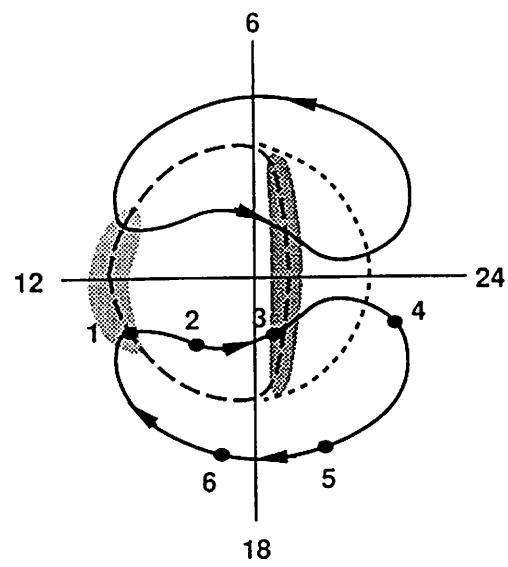
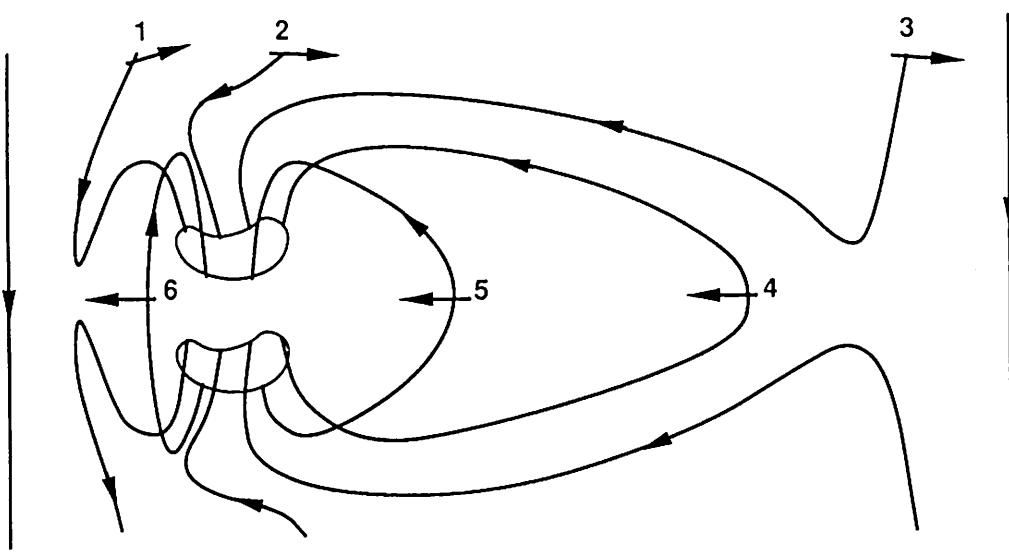
University of Texas at Dallas

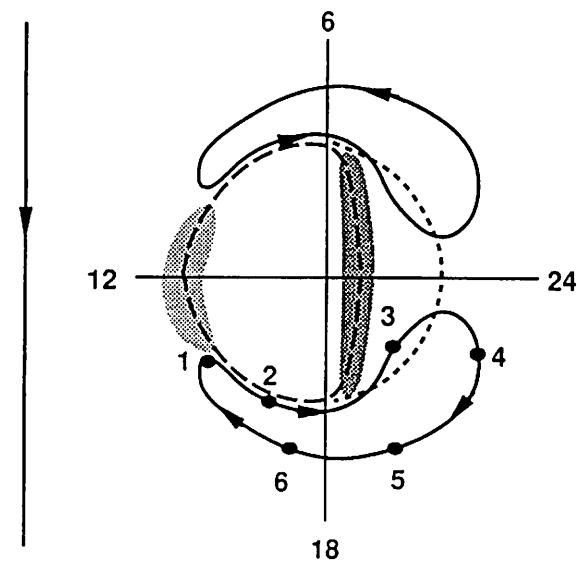
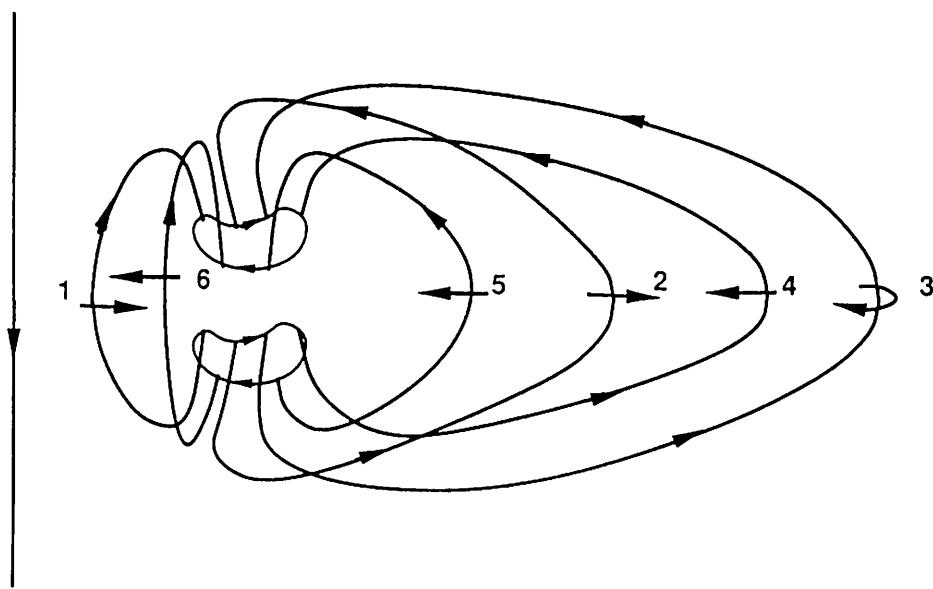


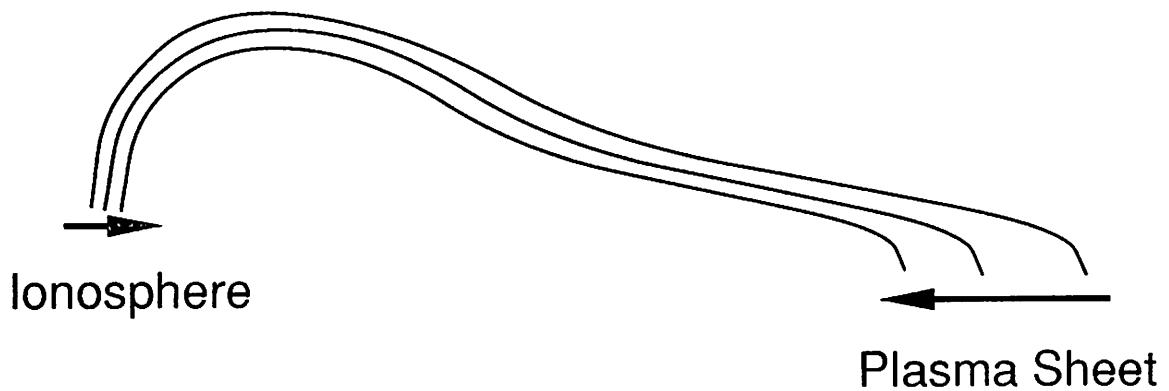
Magnetic Field Lines at High Latitudes Connect to

**The dayside Magnetosheath
The nightside Tail Lobes and Plasma Sheet Boundary Layer
The Low Latitude Boundary Layer
The Plasma Sheet**

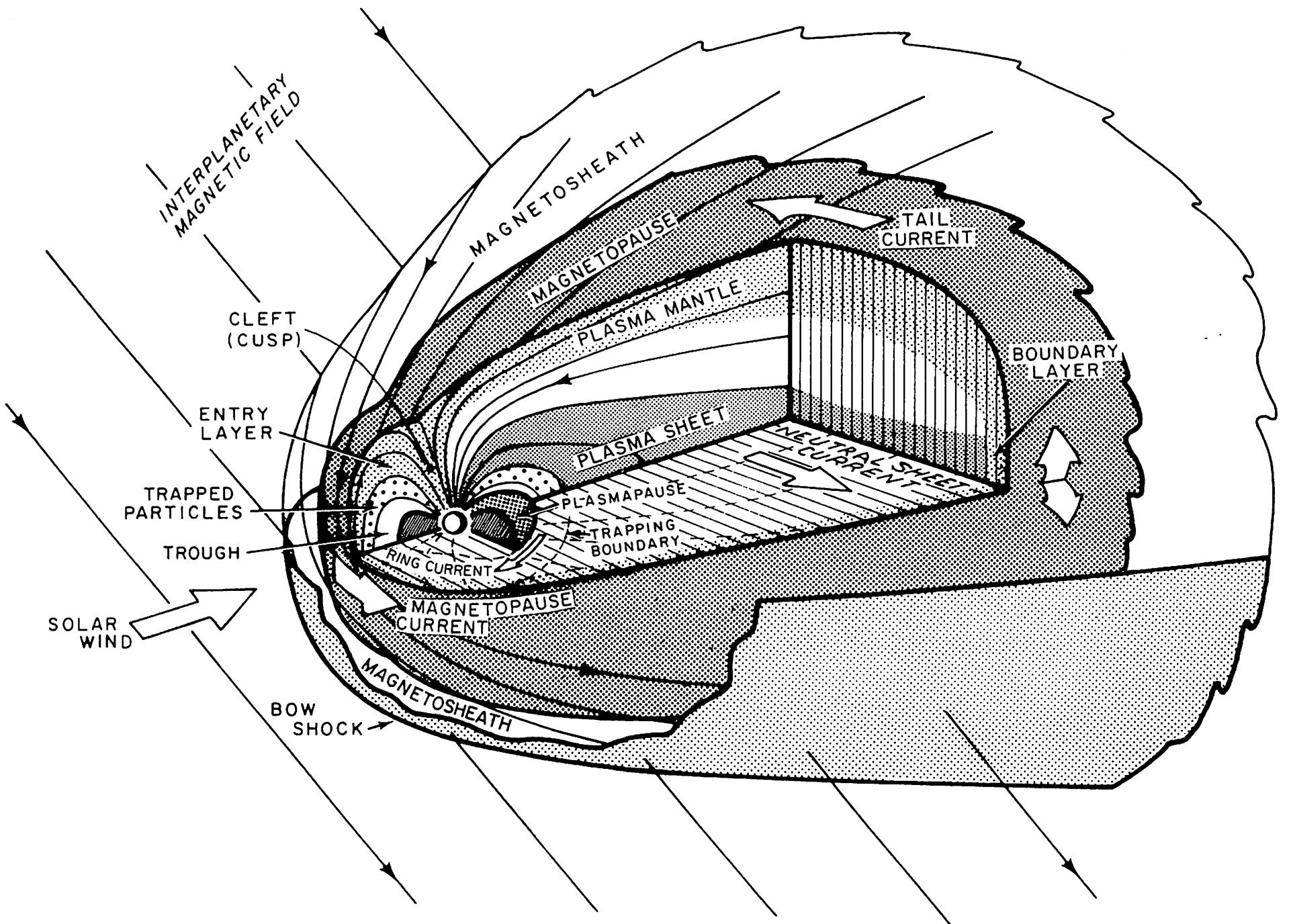








On Closed Field Lines Near the noon-midnight Meridian
Anti-sunward Flow in the Ionosphere
Maps to Sunward Flow in the Plasma Sheet



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

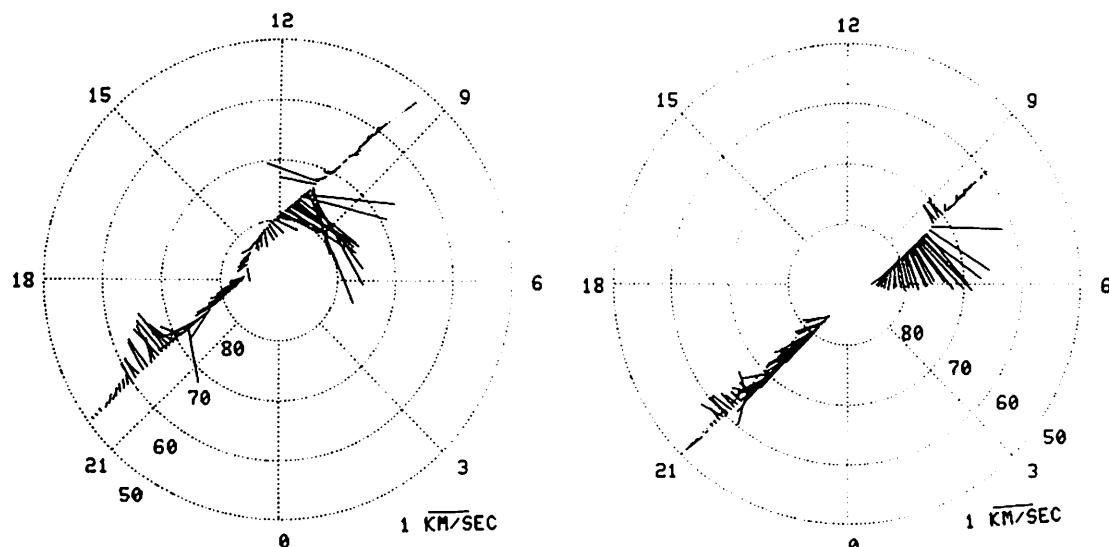
Doppler Measurements of Optical Emissions

Spaced Receiver Measurements of Beacon Signals

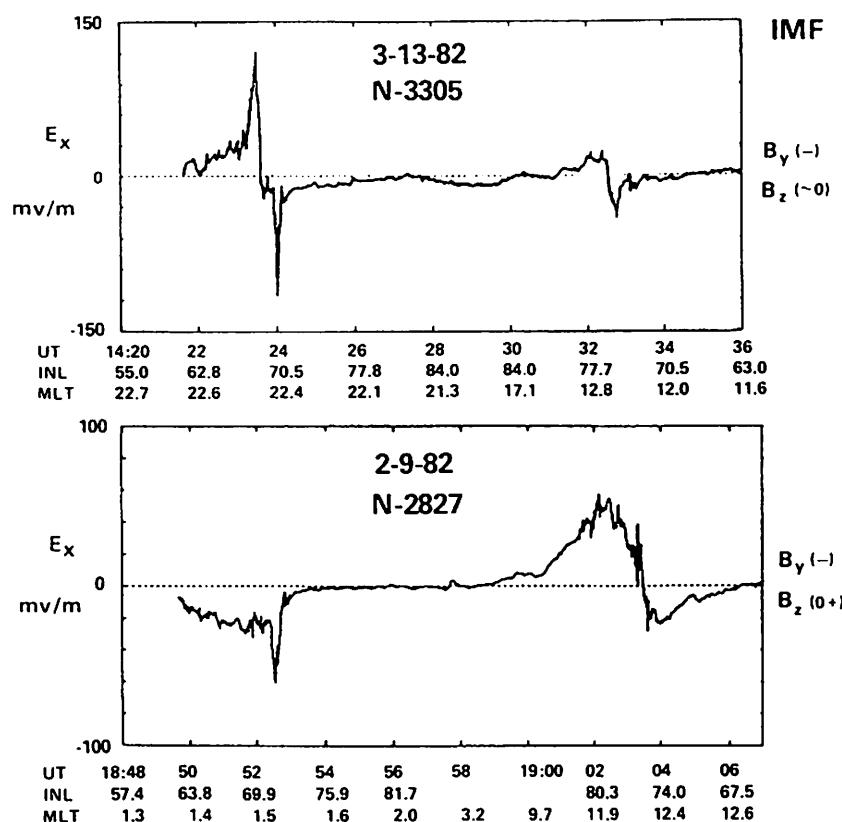
Measurements of Current Systems

Assimilative Mapping of Electrodynamic Parameters

10:50 UT 25 OCT 1981 14:00 UT



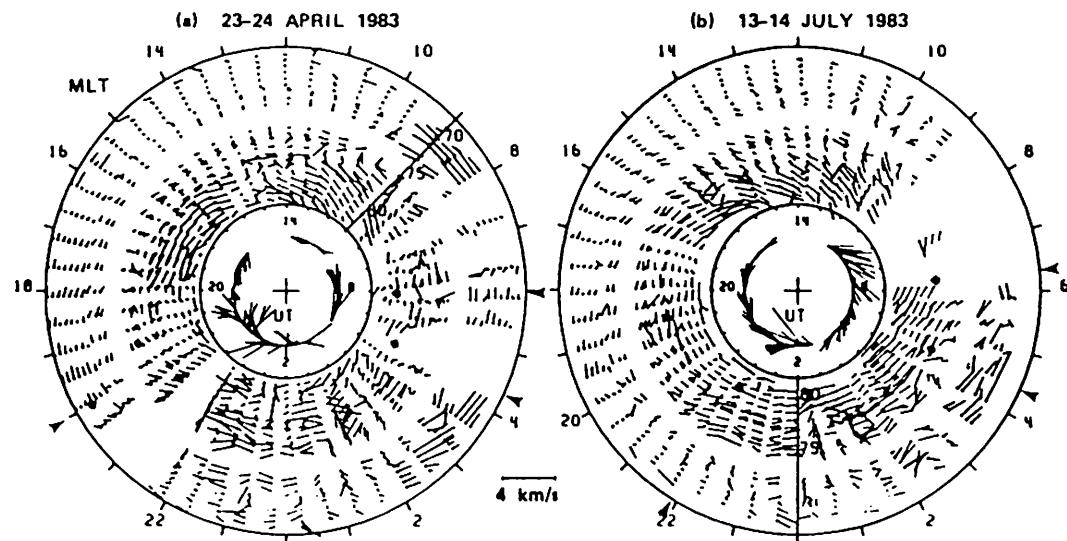
HEPPNER AND MAYNARD: EMPIRICAL ELECTRIC FIELD MODELS



Satellite Measurements of Electric Fields and Ion Drifts

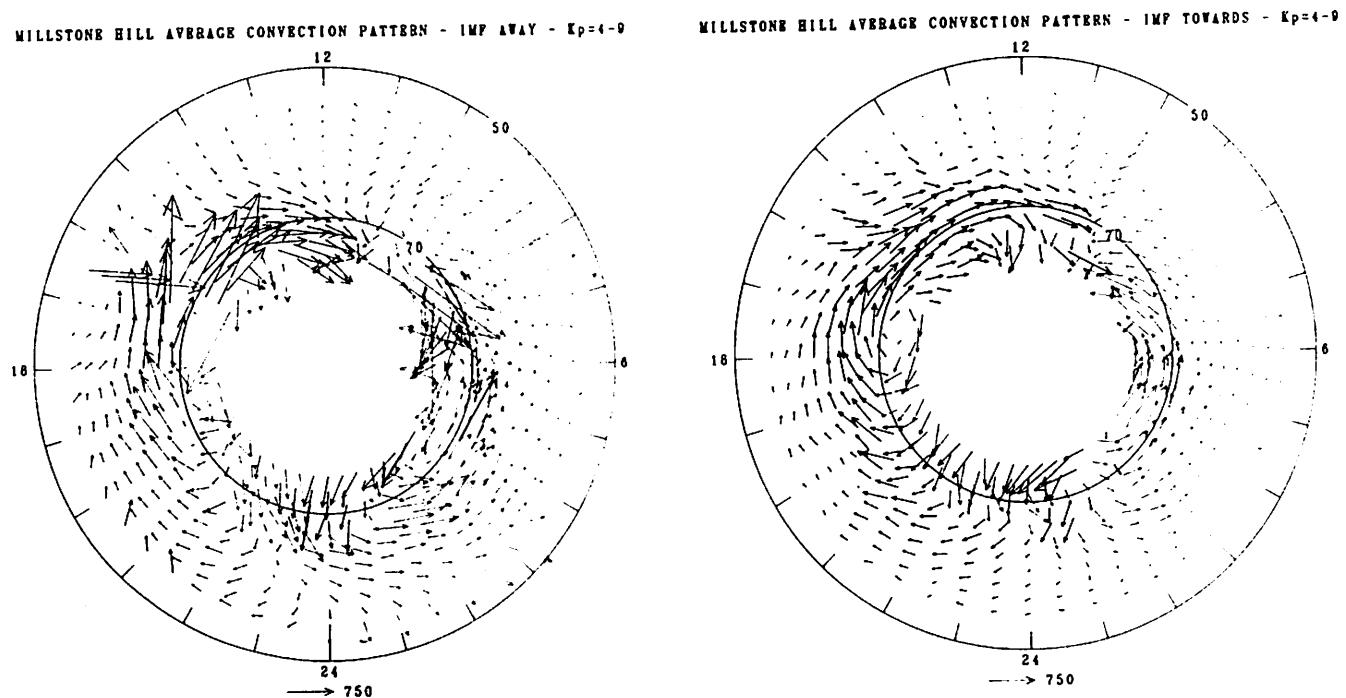
Heelis et al., J. Geophys. Res., 88, 10111, 1983

Heppner and Maynard, J. Geophys. Res., 92, 4467, 1987



HOLT ET AL.: MODELS FOR PLASMA CONVECTION

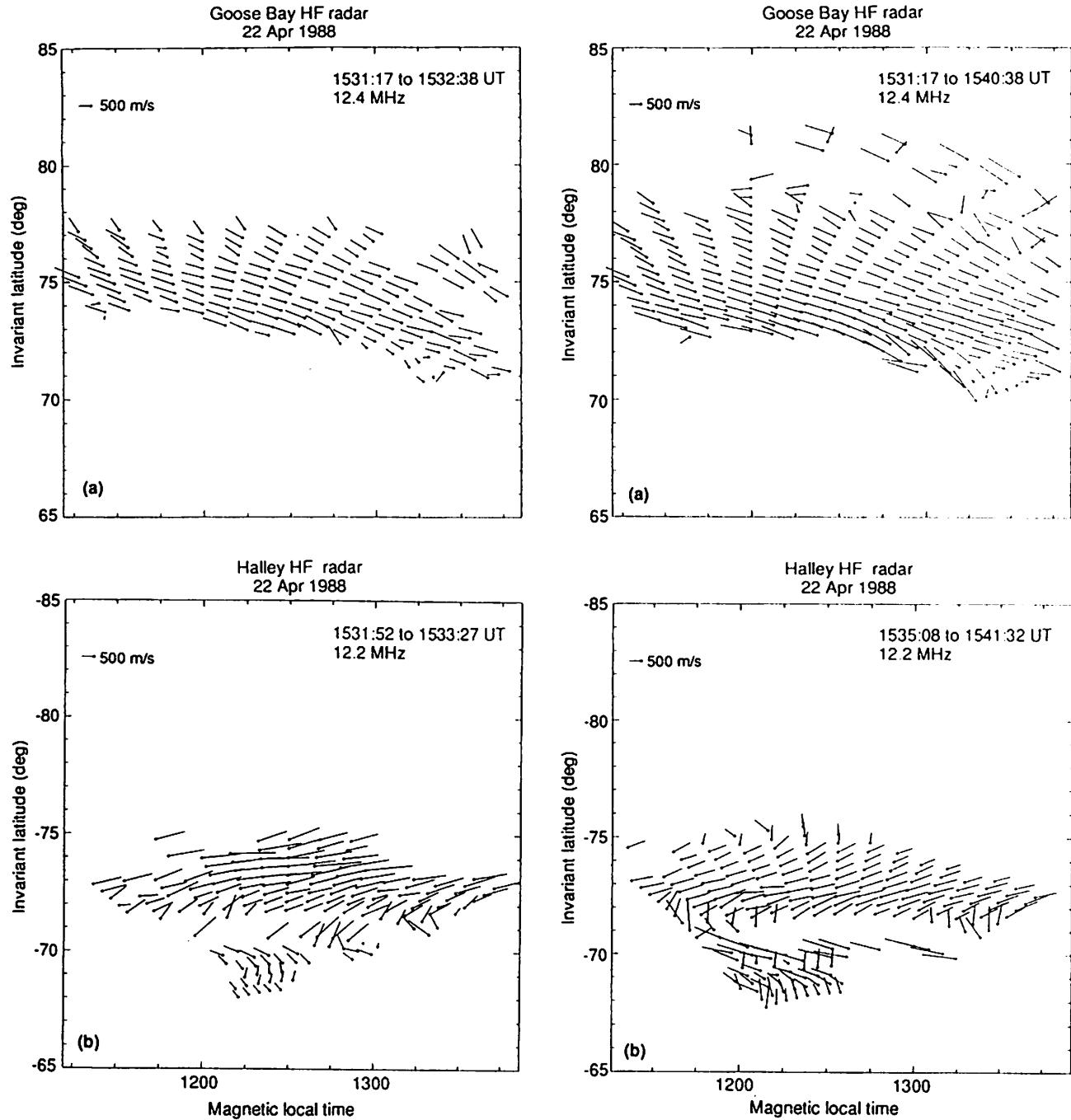
207



Incoherent Scatter Radar Measurements of Ion Drifts

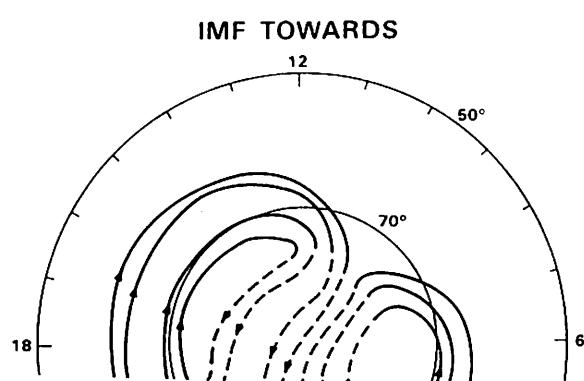
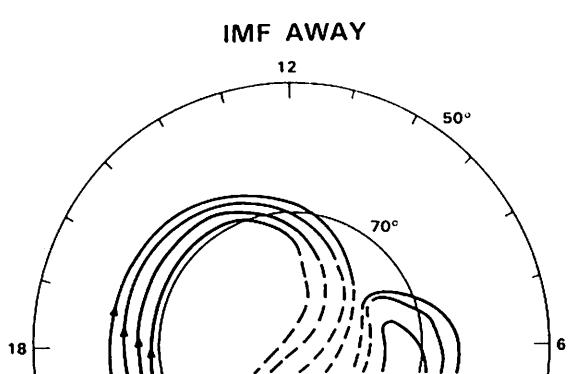
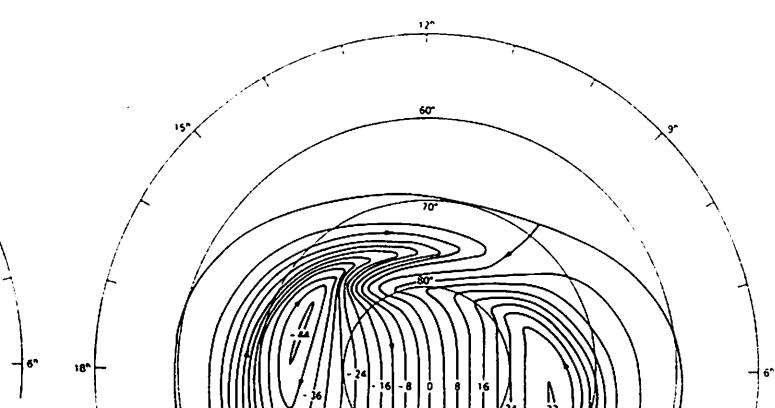
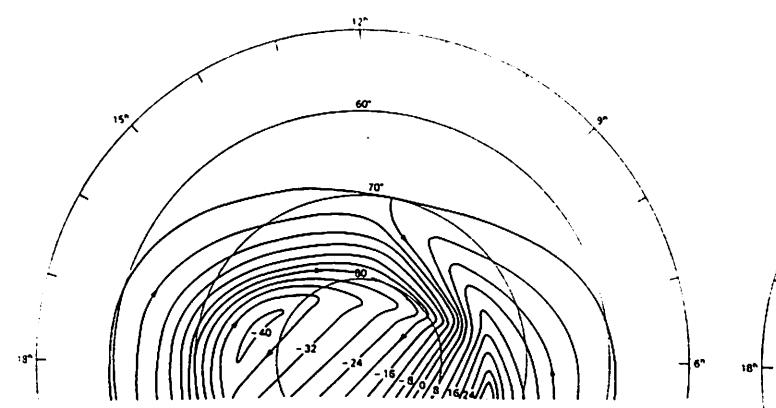
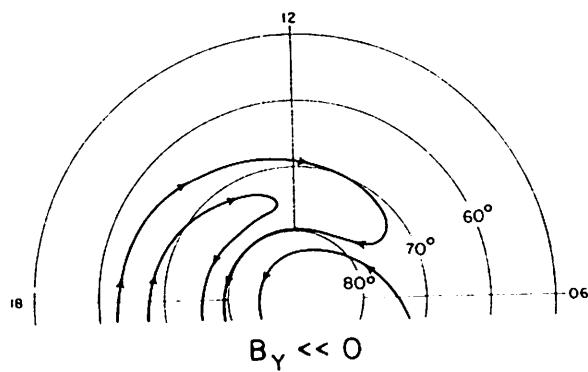
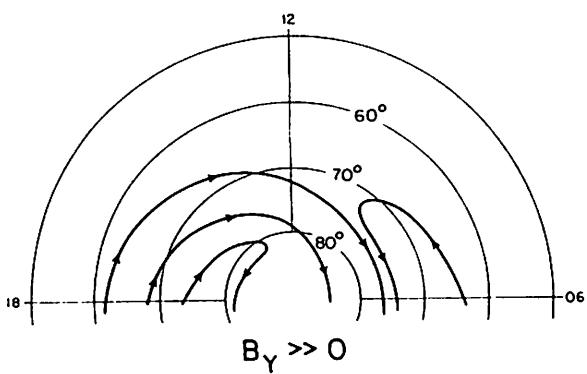
de la Beaujardiere et al., Geophys. Res. Lett., 12, 461,
1987

Holt et al., J. Geophys. Res., 92, 203, 1987



HF Radar Measurements of Structure Drifts

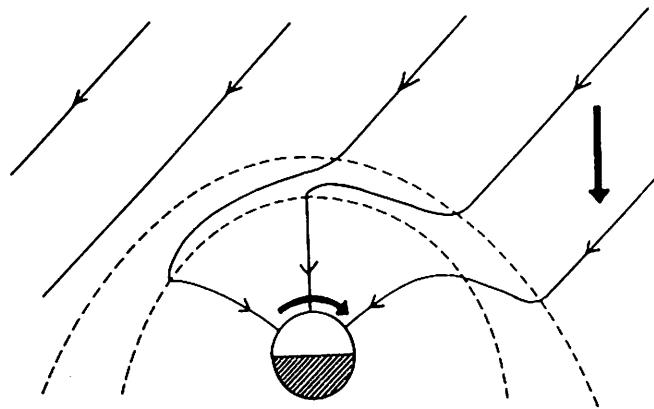
Greenwald et al., J. Geophys. Res., 95, 8057, 1990



Southward IMF Dependence of Convection Pattern on B_Y

Heelis et al., J. Geophys. Res., 89, 2873, 1984.
Heppner and Maynard, J. Geophys Res. 92, 4467, 1987.
Holt et al., J. Geophys. Res., 92, 203, 1987.

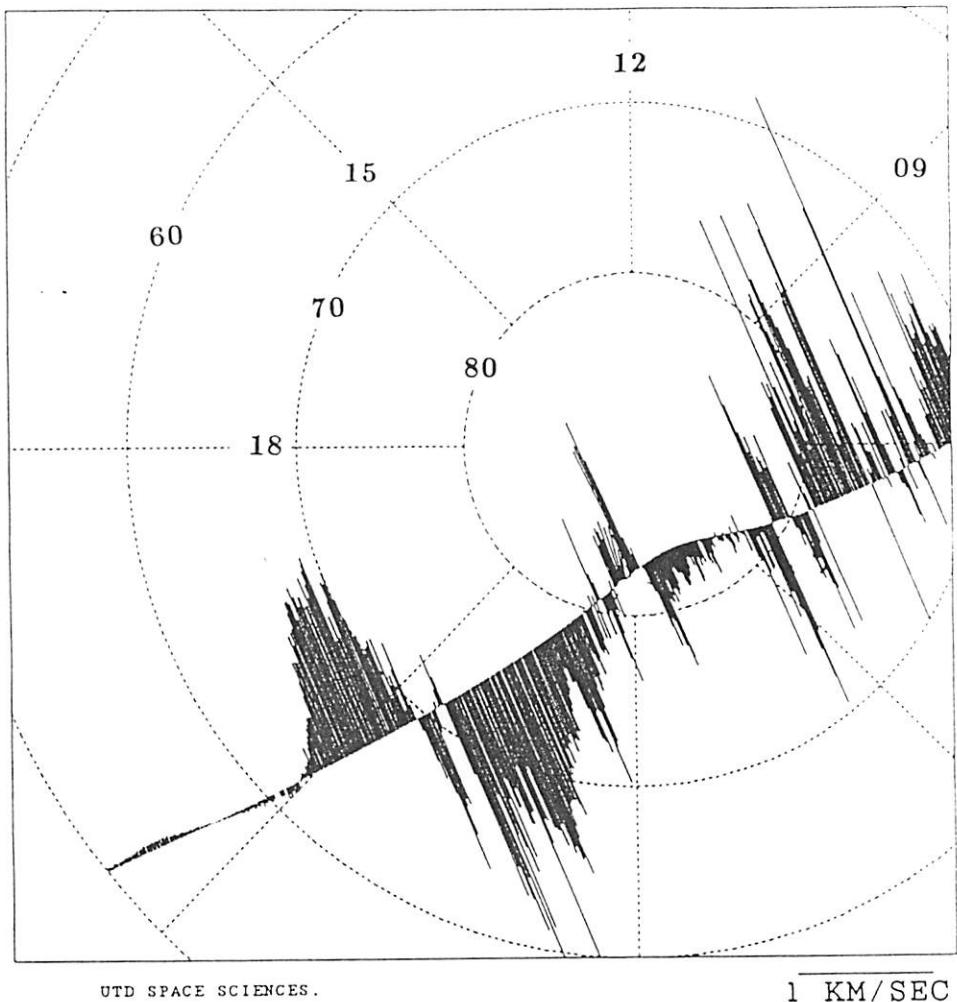
15 min?



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

Jorgensen et al., J. Geophys. Res., 77, 1976, 1972

DE-B ION DRIFT VELOCITIES
MLT V ILAT NORTHERN HEMISPHERE
DAY 81312 UT 15: 3 ORBIT 1437

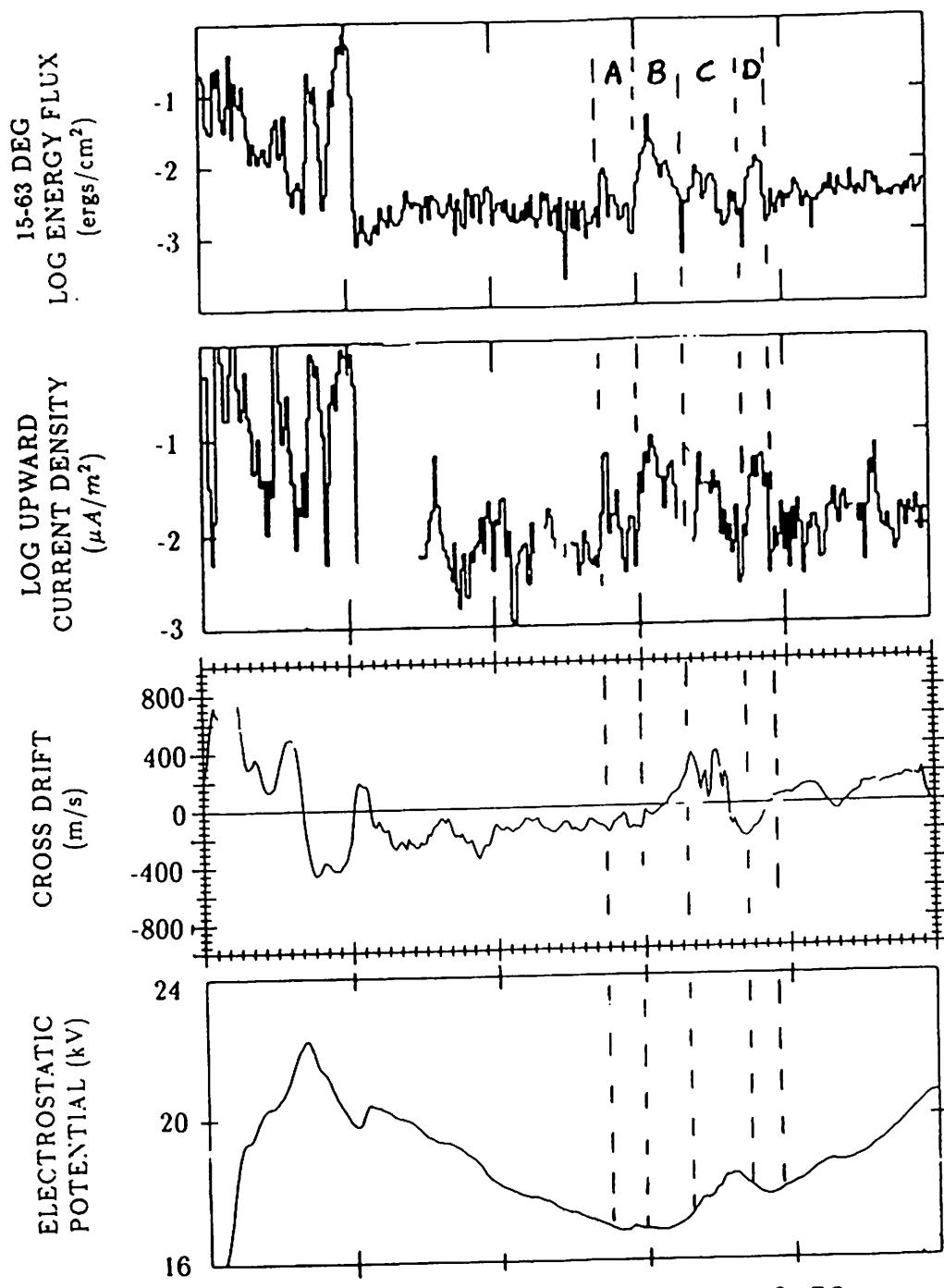


**Nightside convection signature frequently consistent
with extremely strutured two cell pattern**

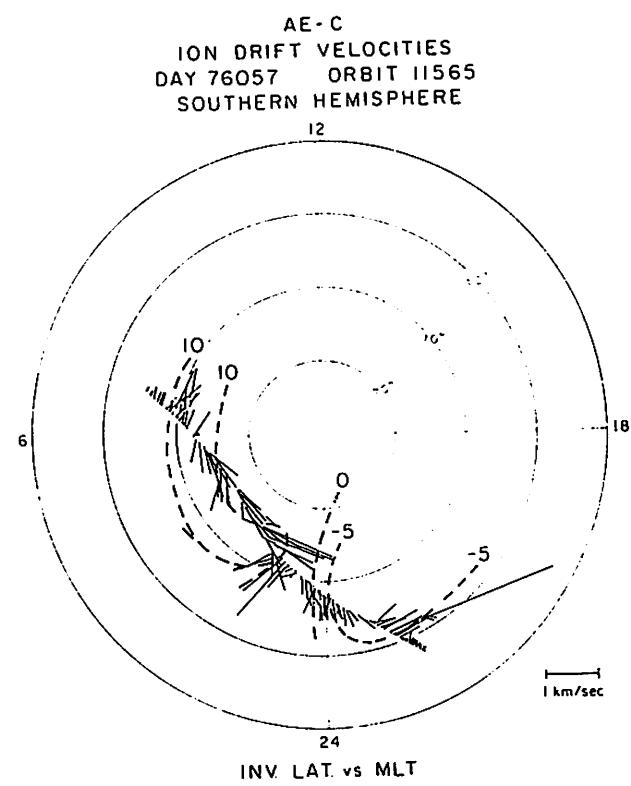
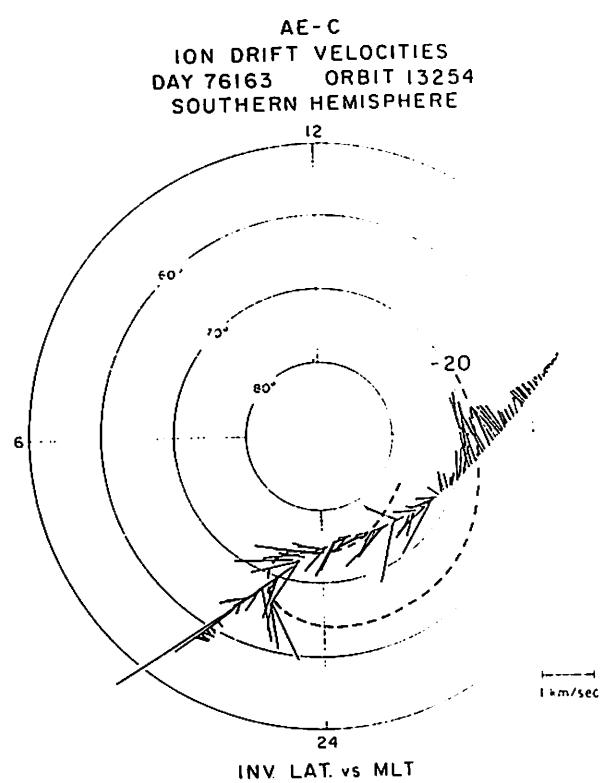
Frank et al., J. Geophys. Res., 91, 3177, 1986
Carlson et al., J. Geophys. Res., 93, 14501, 1988
Nielsen et al., J. Geophys. Res., 95, 21169, 1990

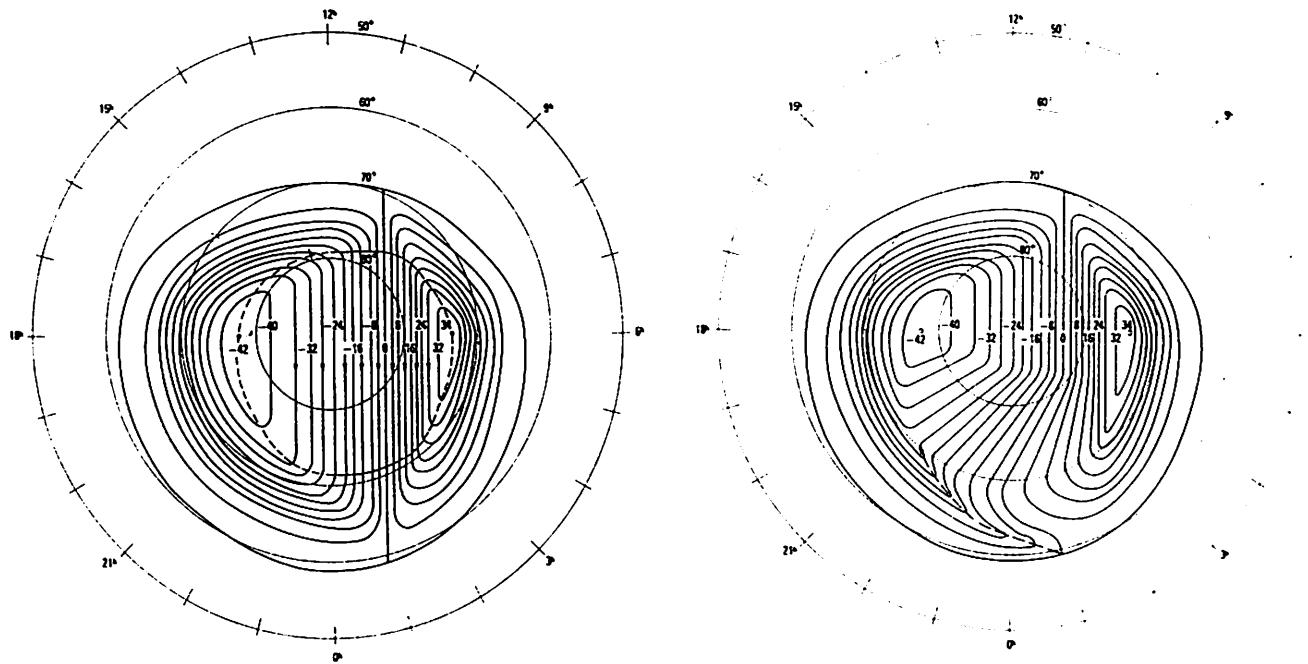
DE-2 ORBIT 2534

DAY 82021



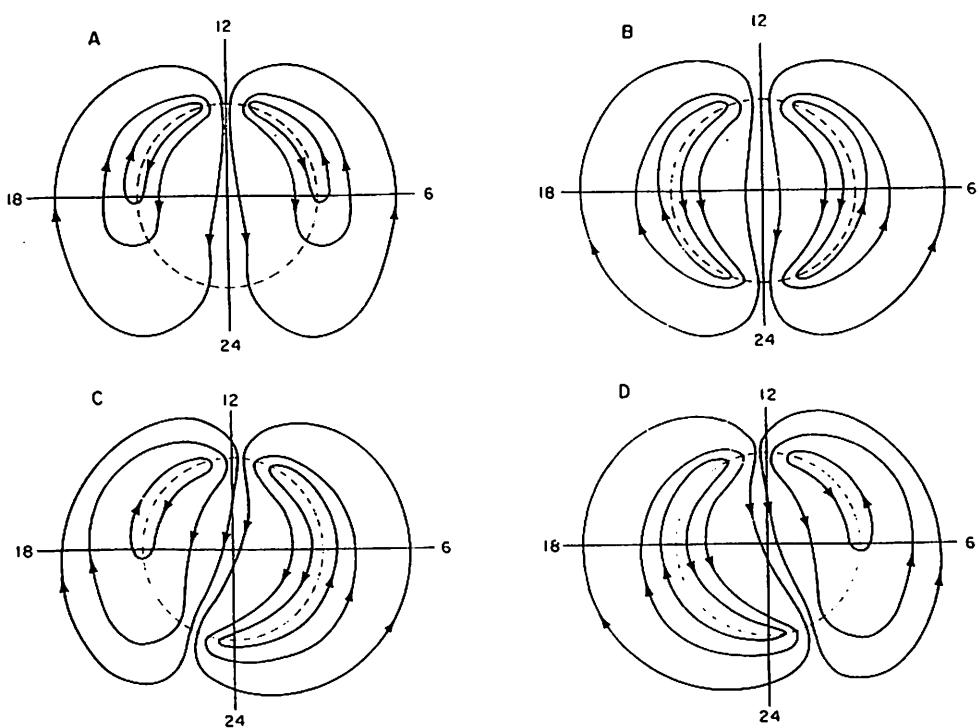
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ALT(KM)	723	739	755	769
GLAT(DEG)	69.43	73.01	76.57	80.11
GLNG(DEG)	-62.1	-62.3	-62.6	-62.8
MLT(HRS)	3.23	3.56	4.85	12.13
ILAT(DEG)	78.86	81.91	84.77	86.95





HEELIS AND HANSON: NIGHTTIME IONOSPHERIC CONVECTION

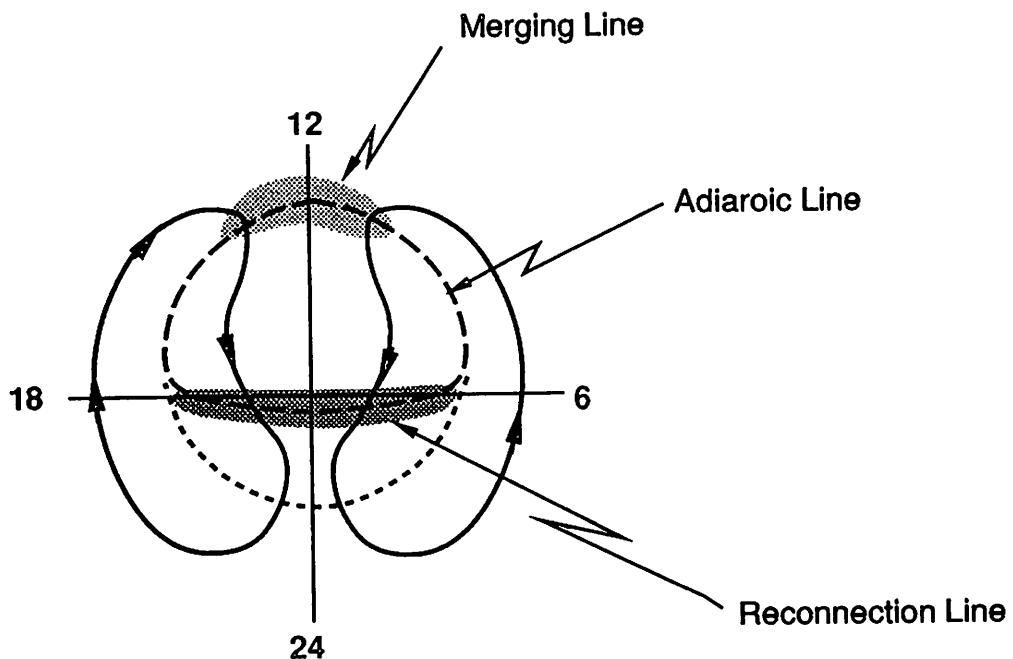
2001



Nightside Convection Pattern may Possess Convection Reversals across which the flow rotates or is sheared

Heppner, J. Geophys. Res., 82, 1115, 1977
 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

Adiabatic 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
Adiabatic lines move outward

If Reconnection Potential exceeds Merging Potential
Adiabatic lines move inward.

Motion of the Merging and Reconnection Lines must be taken into account.

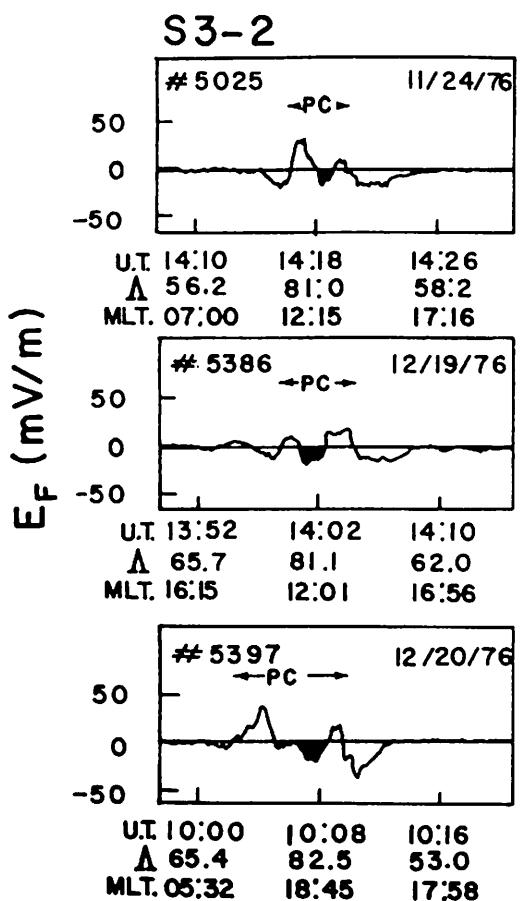
Southward IMF Key Questions

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

What controls the configuration of the nightside convection pattern

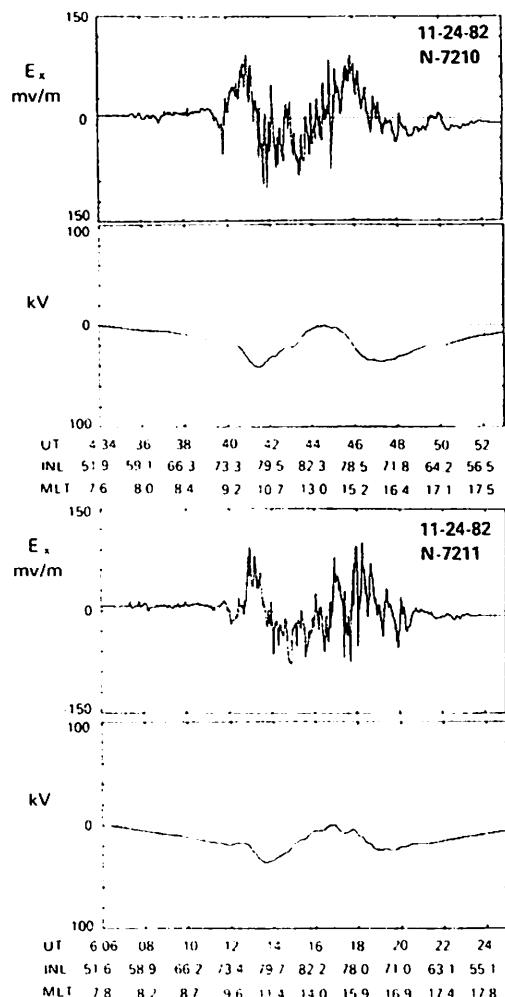
How does the nightside convection pattern depend on magnetic activity

What is the relationship between the dayside and nightside potential distributions along the convection reversal boundary.

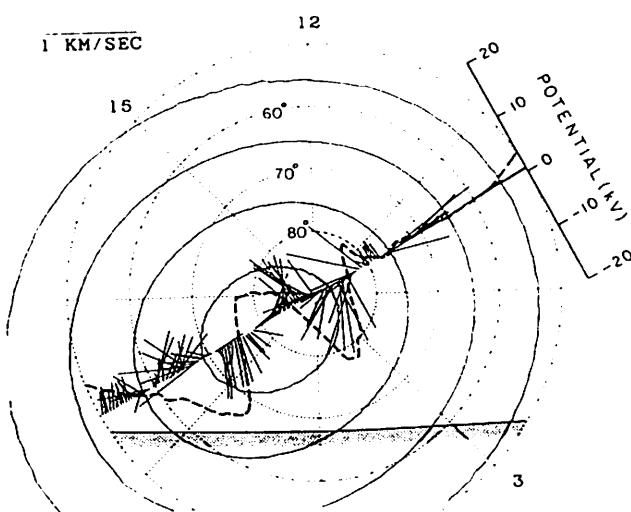


IMF

- 0.2
- 3.2
+ 0.5



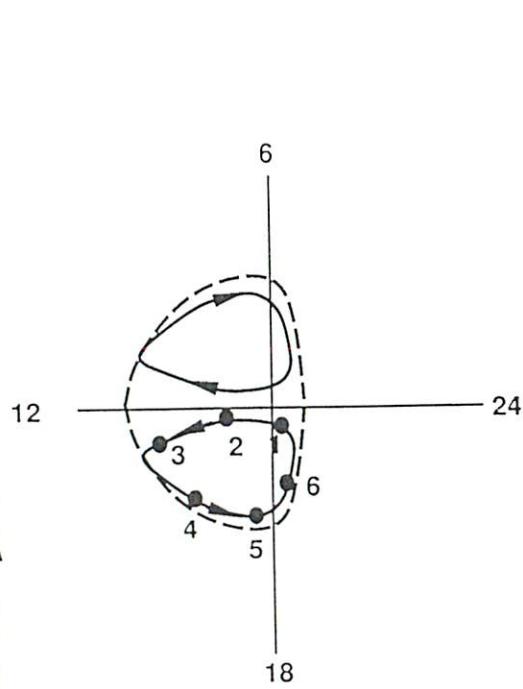
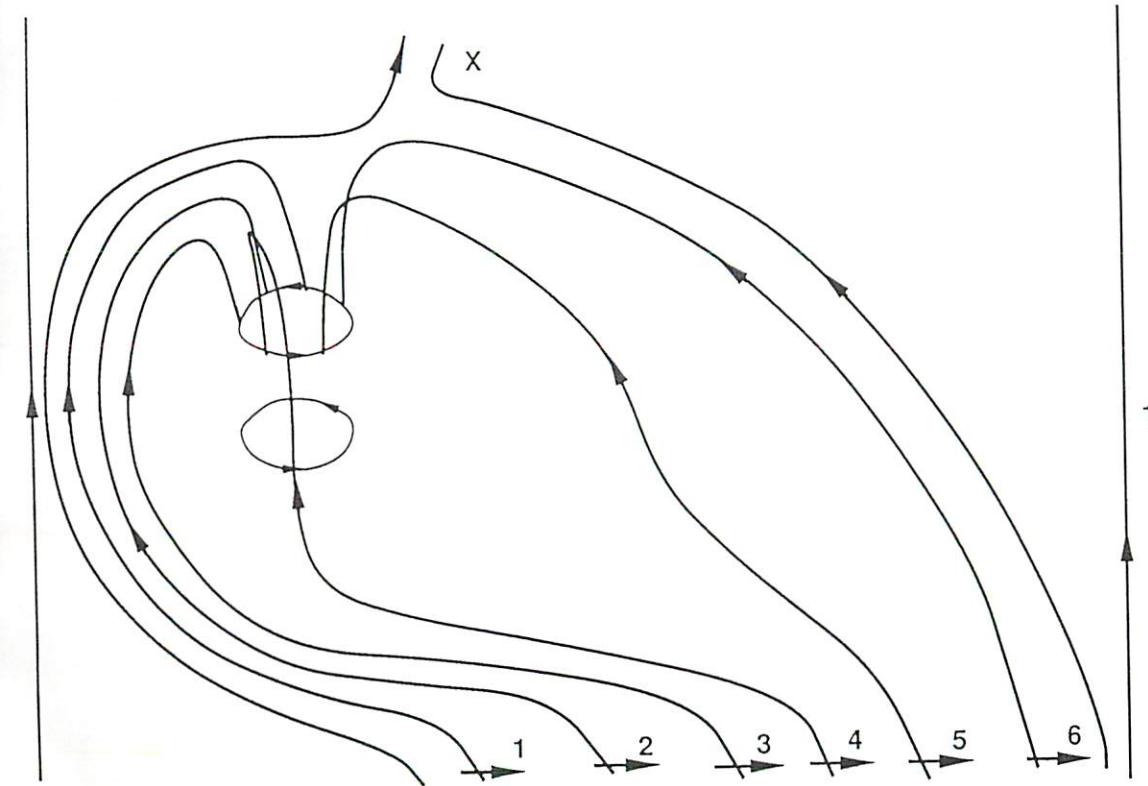
DAY 82124 · UT 01:45 · ORBIT 4083

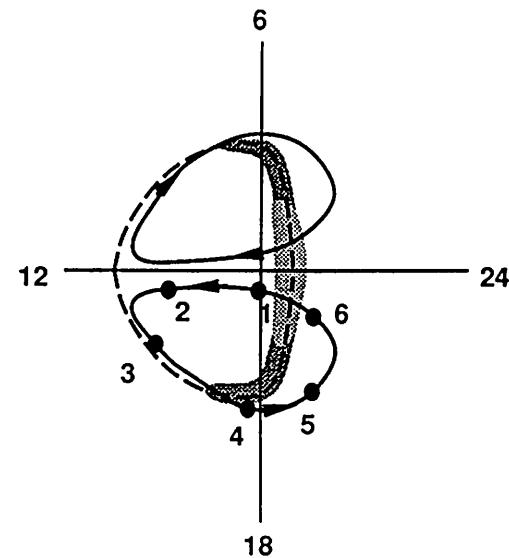
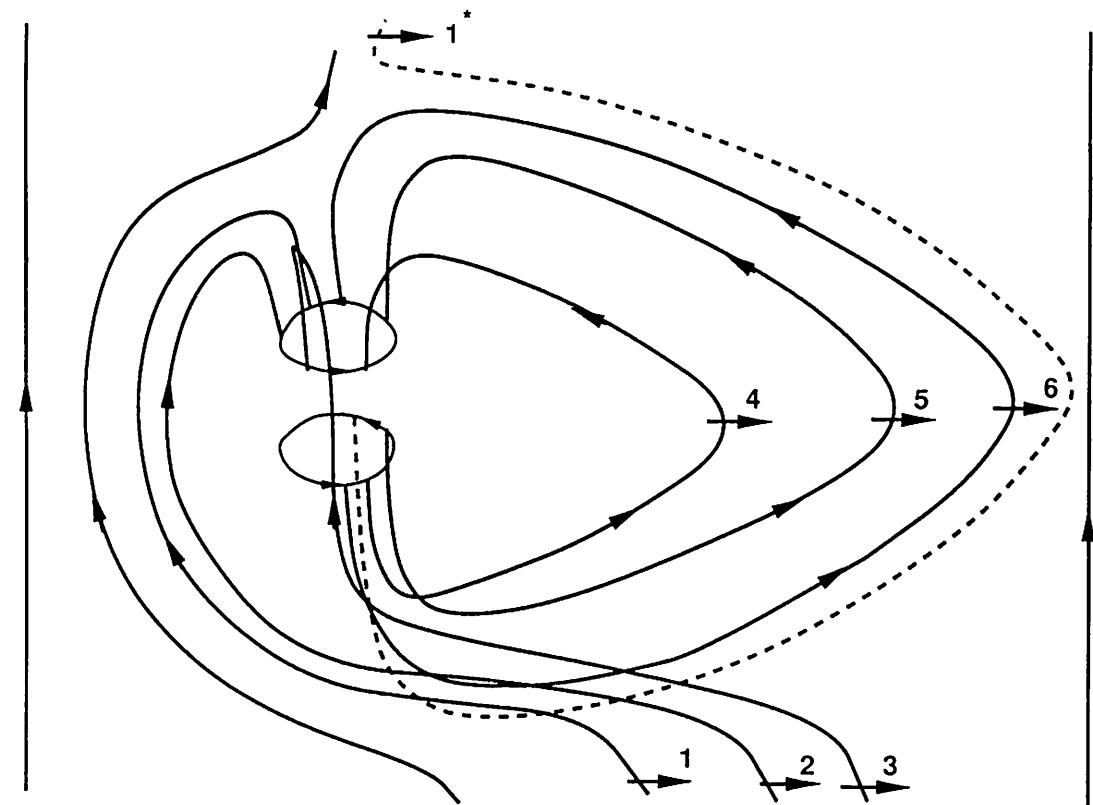


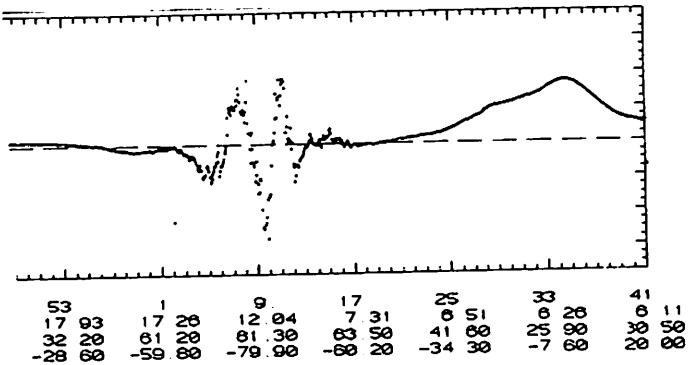
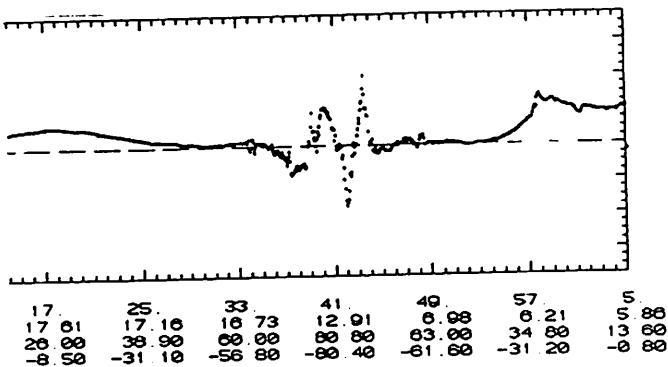
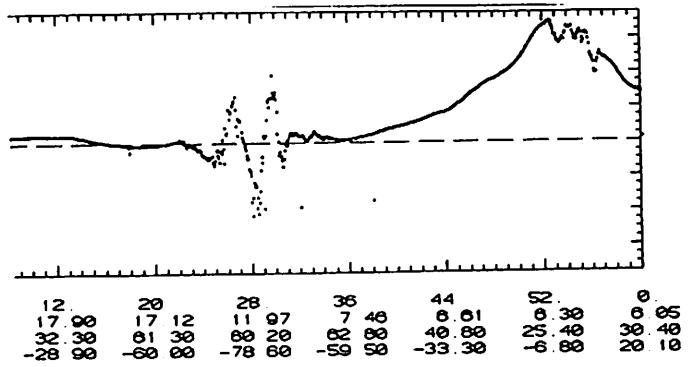
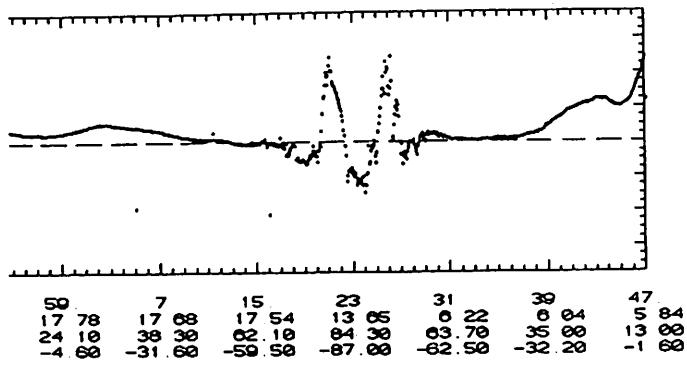
Observations of Sunward Flow at Highest Latitudes during Periods of Northward IMF

Burke et al., Geophys. Res. Lett., 6, 21, 1979.
Heelis et. al., J. Geophys. Res., 91, 5817, 1986.
Heppner and Maynard, J. Geophys. Res., 92, 4467, 1987.

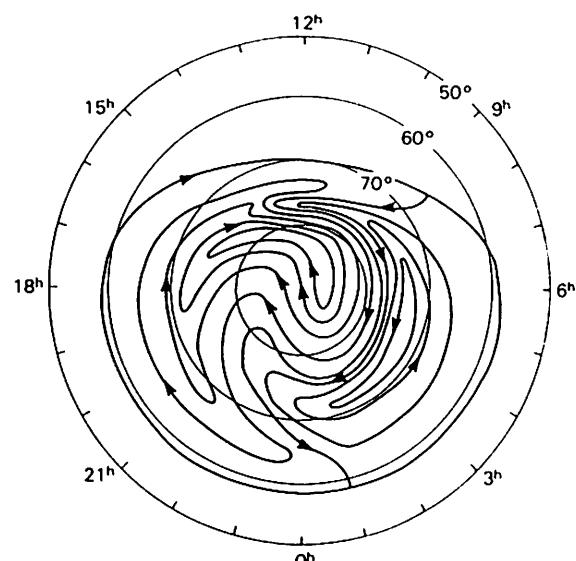
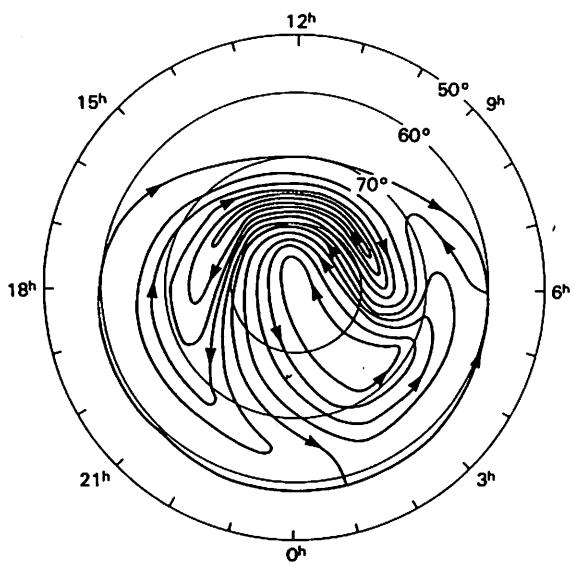
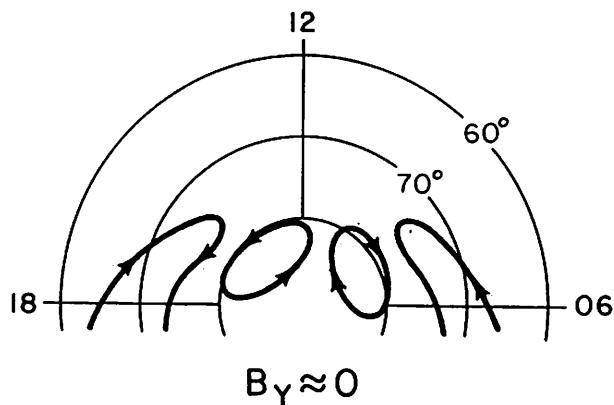
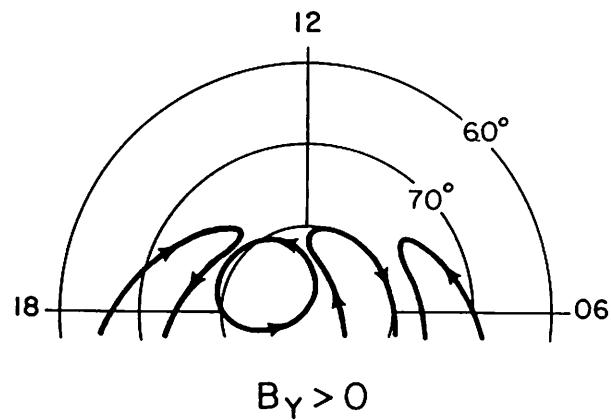
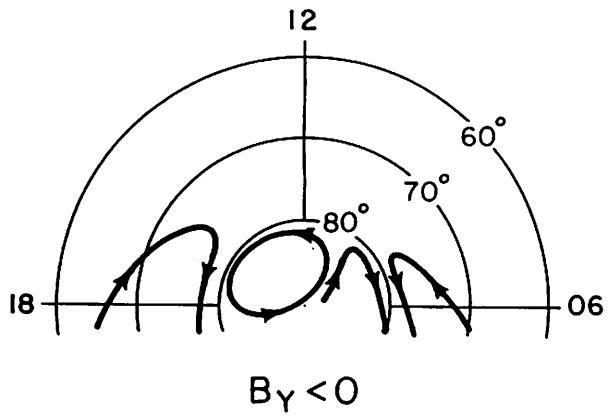
30 min







**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

Heppner and Maynard, J. Geophys. Res., 92, 4467, 1987
Heeley et al., J. Geophys. Res., 91, 5817, 1986

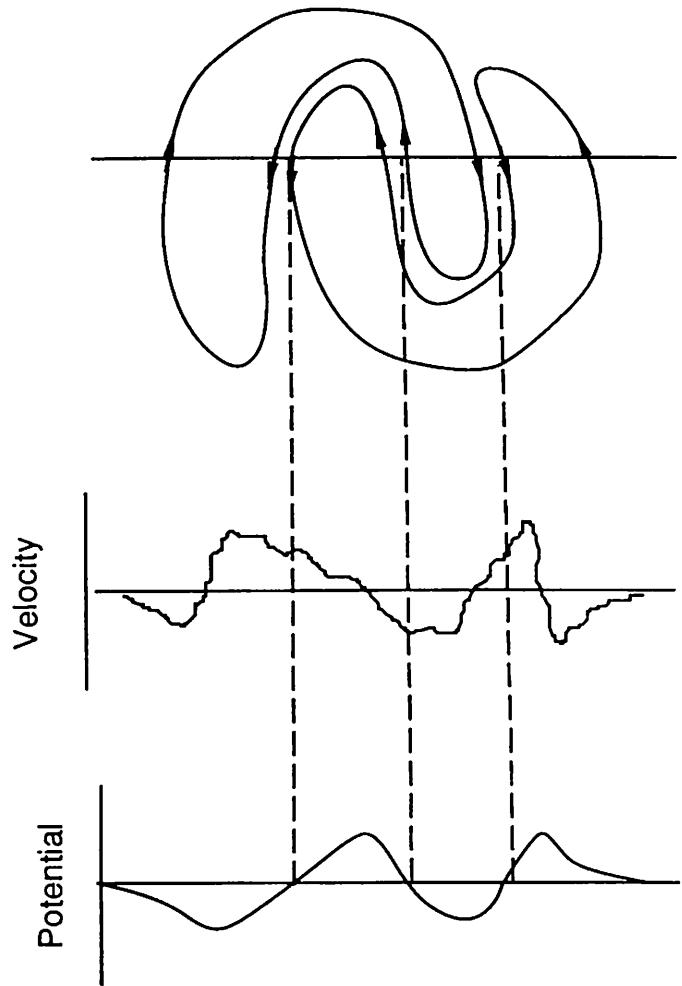
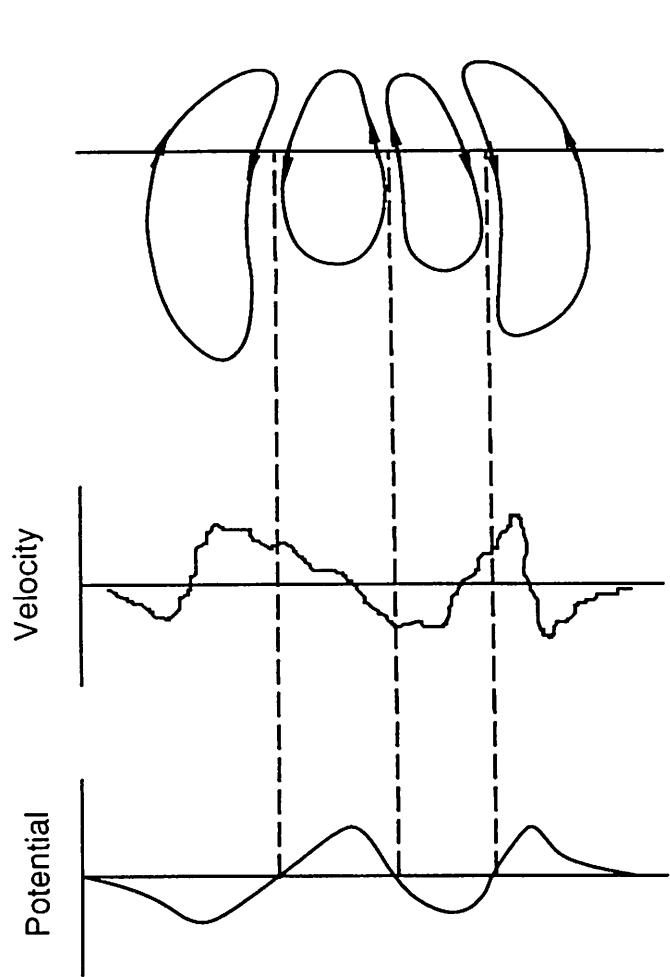
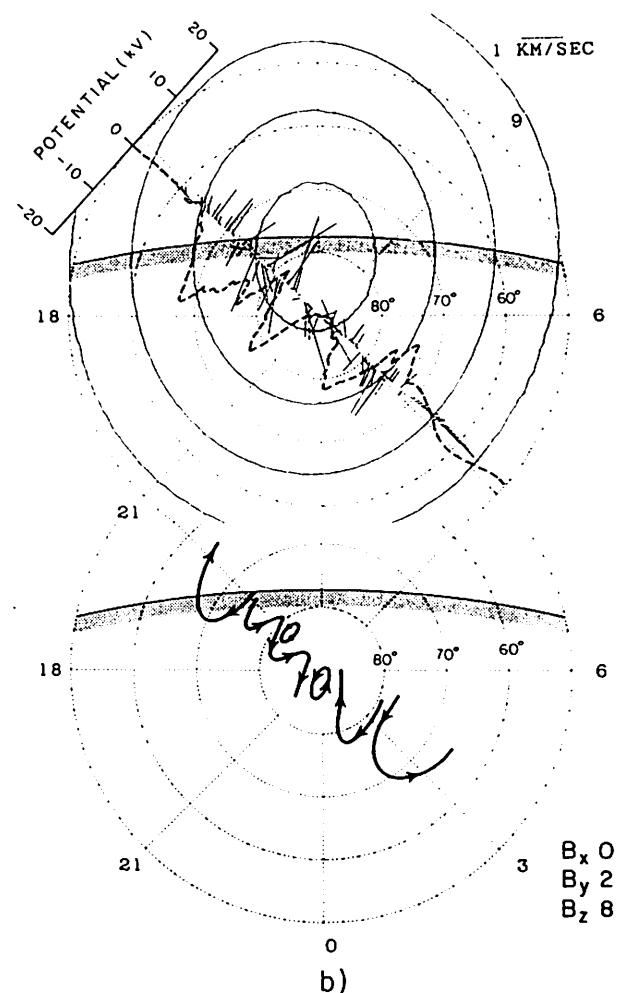


FIG 1

DAY 83011 · UT 17:32 · ORBIT 7971



HEPPNER: EMPIRICAL MODELS OF ELECTRIC FIELDS

1123

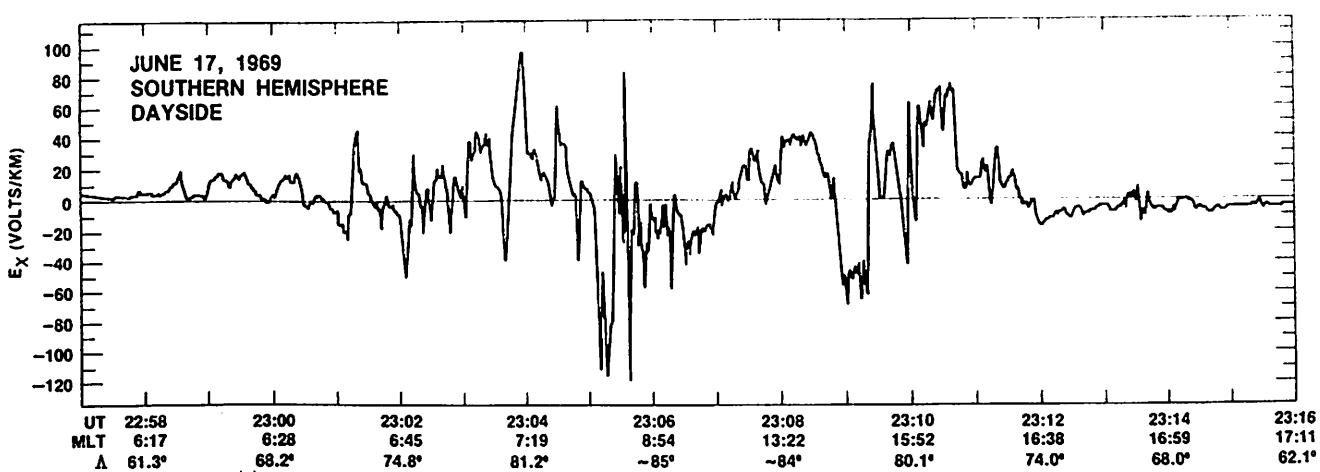
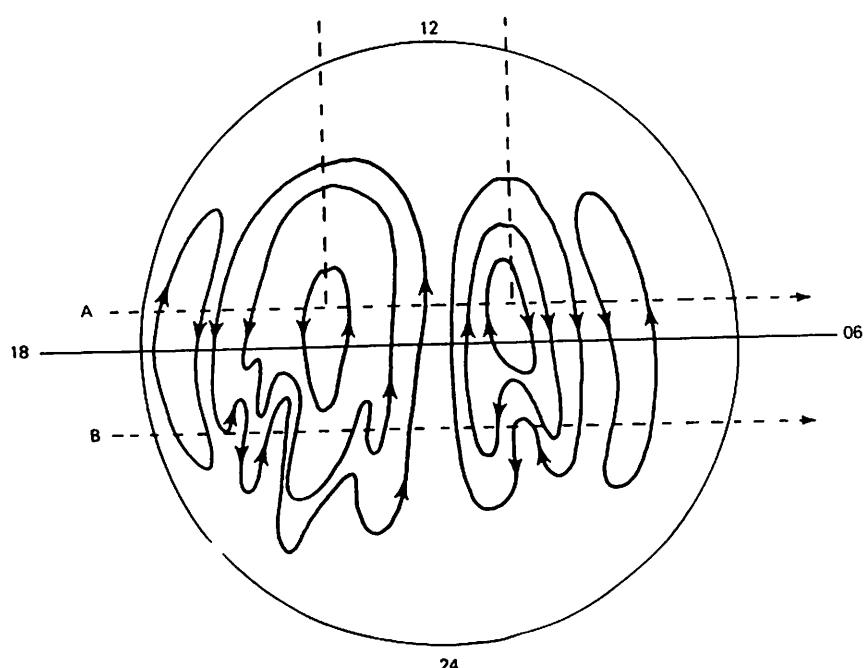
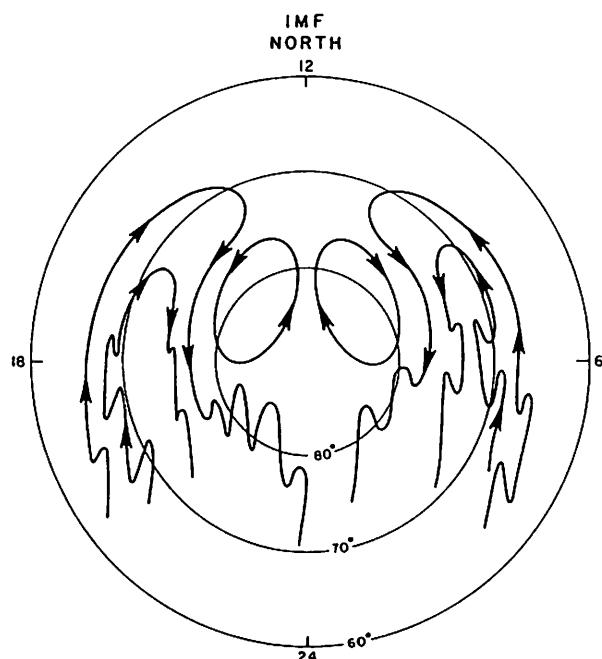


Fig. 11. An example of highly irregular electric fields in the dayside winter hemisphere.



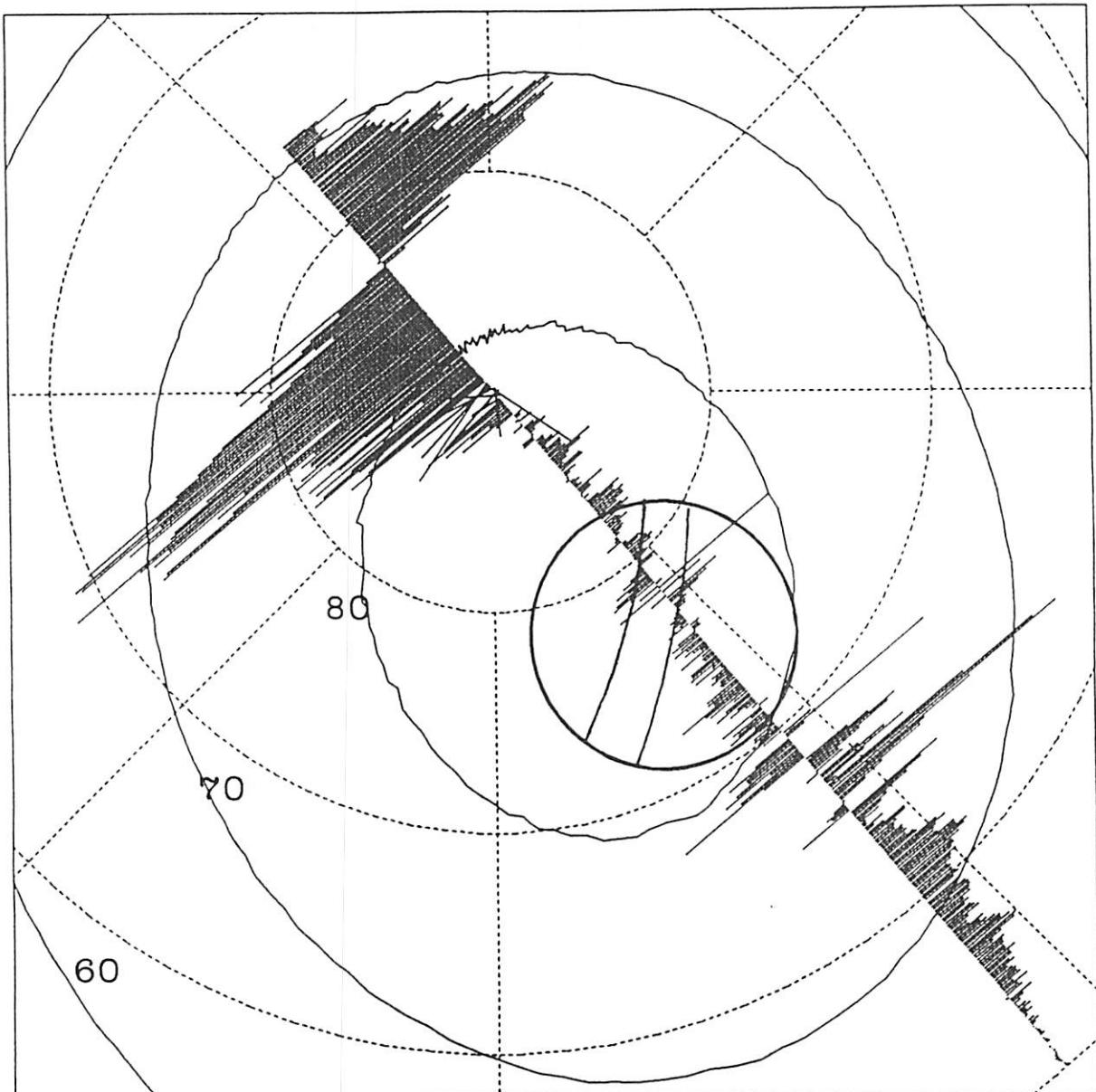
Evidence exists for structured almost turbulent flow in the winter and on the nightside

Heppner, J. Geophys. Res., 82, 1115, 1977

Heelis, Rev. Geophys., 20, 567, 1982

Bythrow et al., 90, 5319, 1985

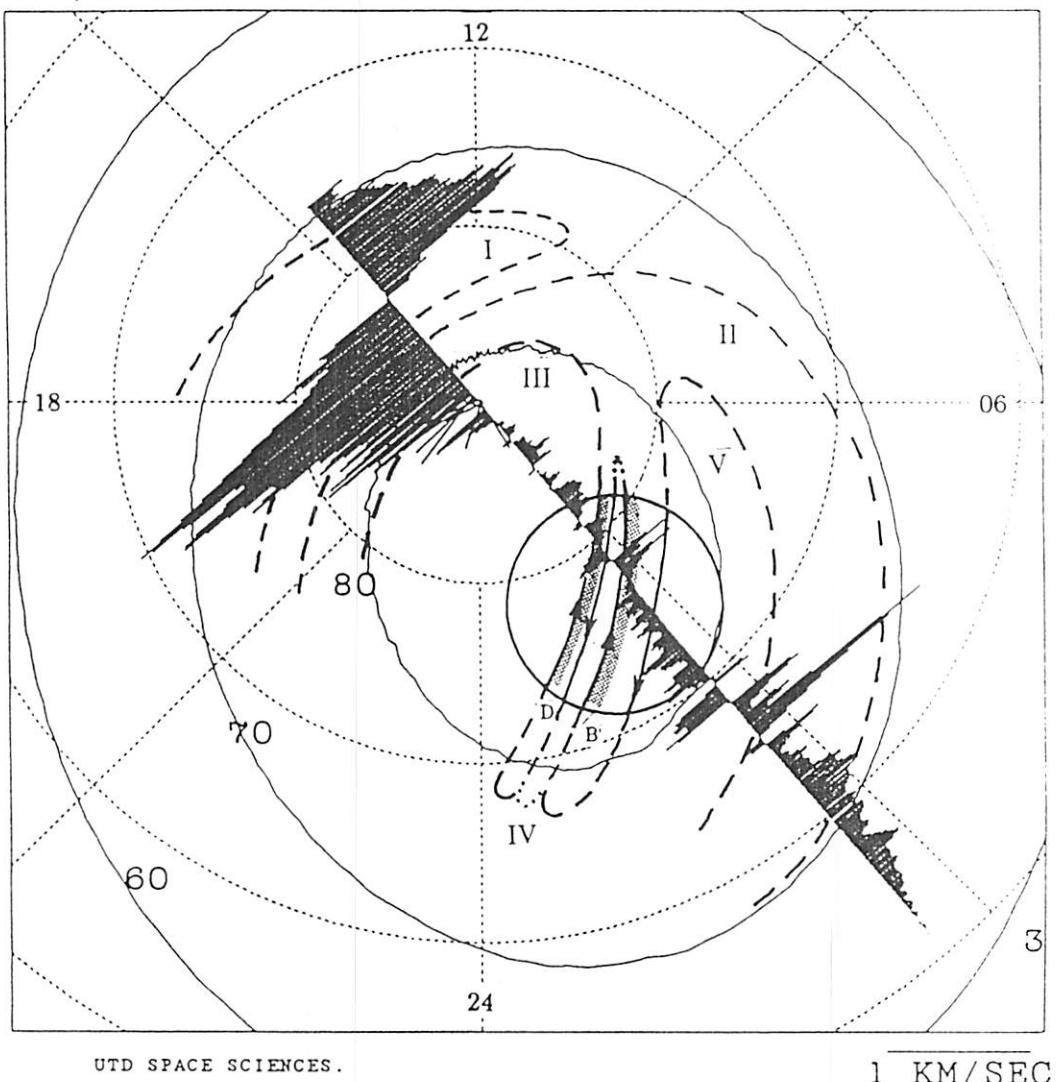
DE-B ION DRIFT VELOCITIES
MLT V ILAT NORTHERN HEMISPHERE
DAY 82 21 UT 6: 0 ORBIT 2534



**Apparently structured ionospheric flow is associated
with discrete stable auroral forms**

Frank et al., J. Geophys. Res., 91, 3177, 1986
Carlson et al., J. Geophys. Res., 93, 14501, 1988
Nielsen et al., J. Geophys. Res., 95, 21169, 1990
Valladares and Carlson, J. Geophys. Res., 96, 1379, 1991
Weber et al., J. Geophys. Res.... be watching !!!

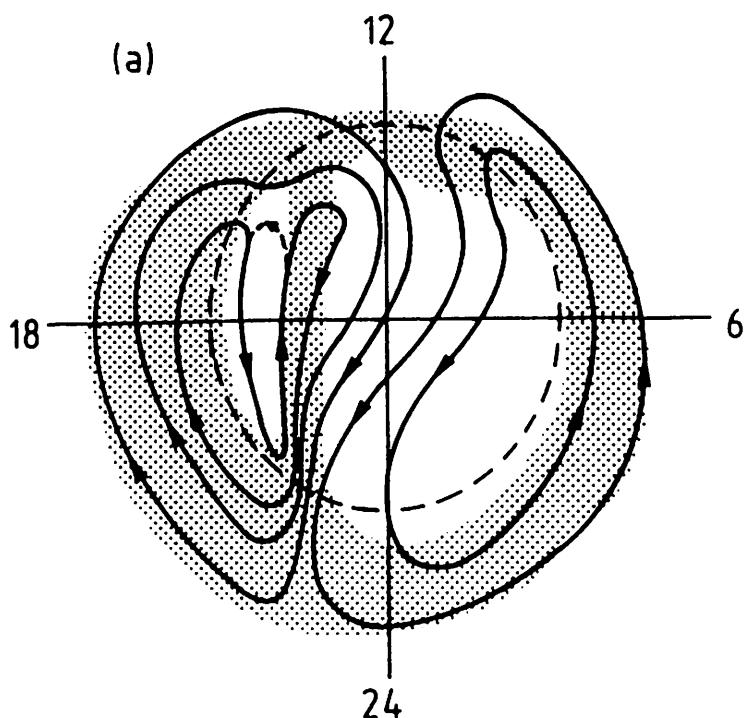
DE-B ION DRIFT VELOCITIES
MLT V ILAT NORTHERN HEMISPHERE
DAY 82 21 UT 6:51 ORBIT 2534



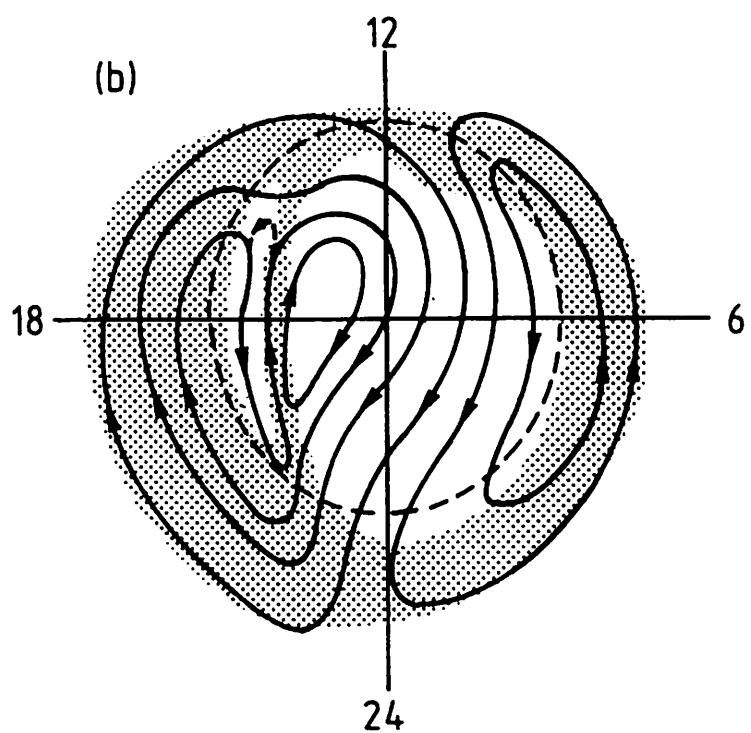
Local Electrodynamics is consistent with the optical emmisions implying a coherence in the convection features along the arc

Carlson et al., J Geophys. Res., 93, 14501, 1988
Nielsen et. al, J. Geophys. Res., 95, 21169, 1990

(a)



(b)



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.

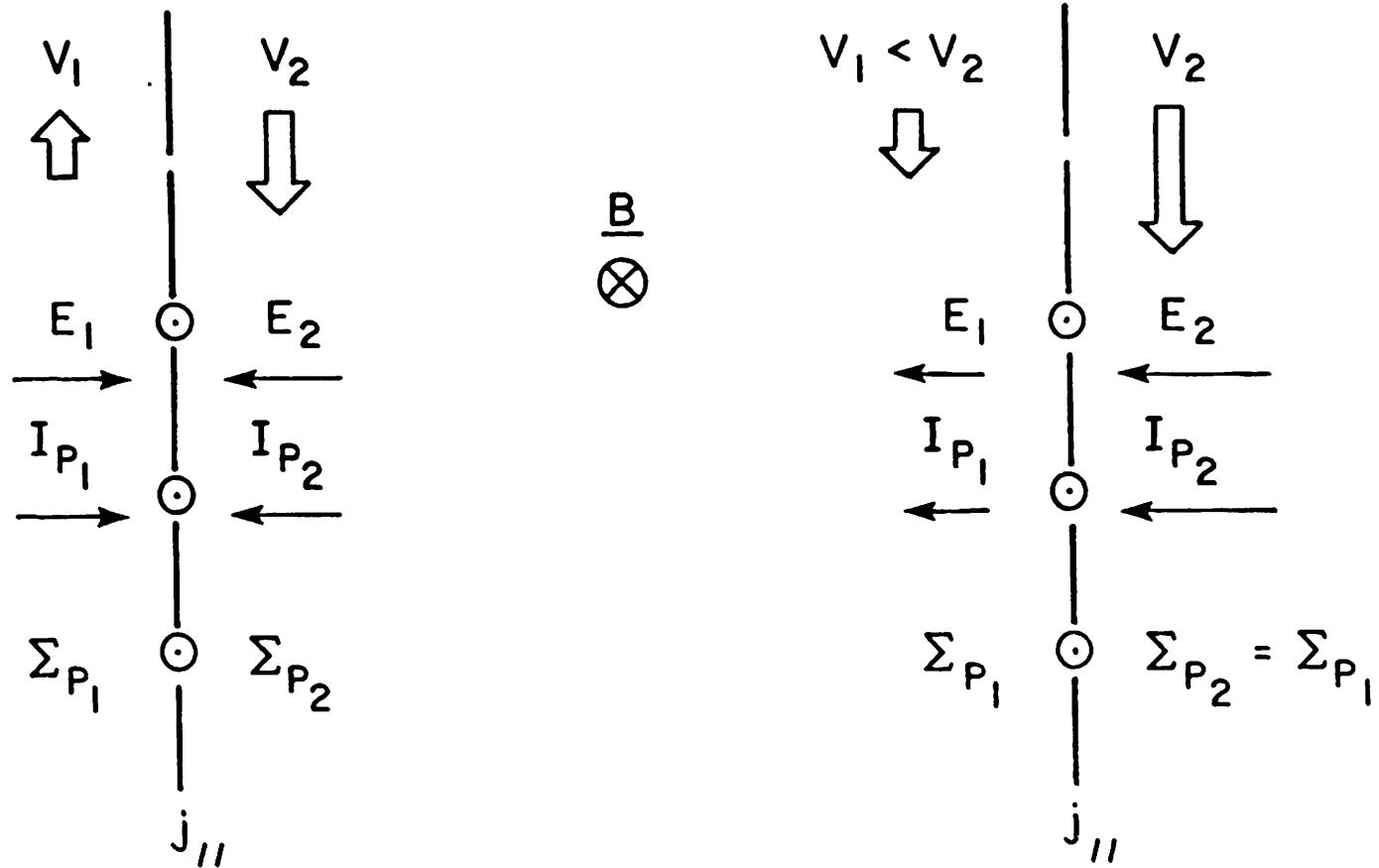
Agreement between different techniques needs to be established.

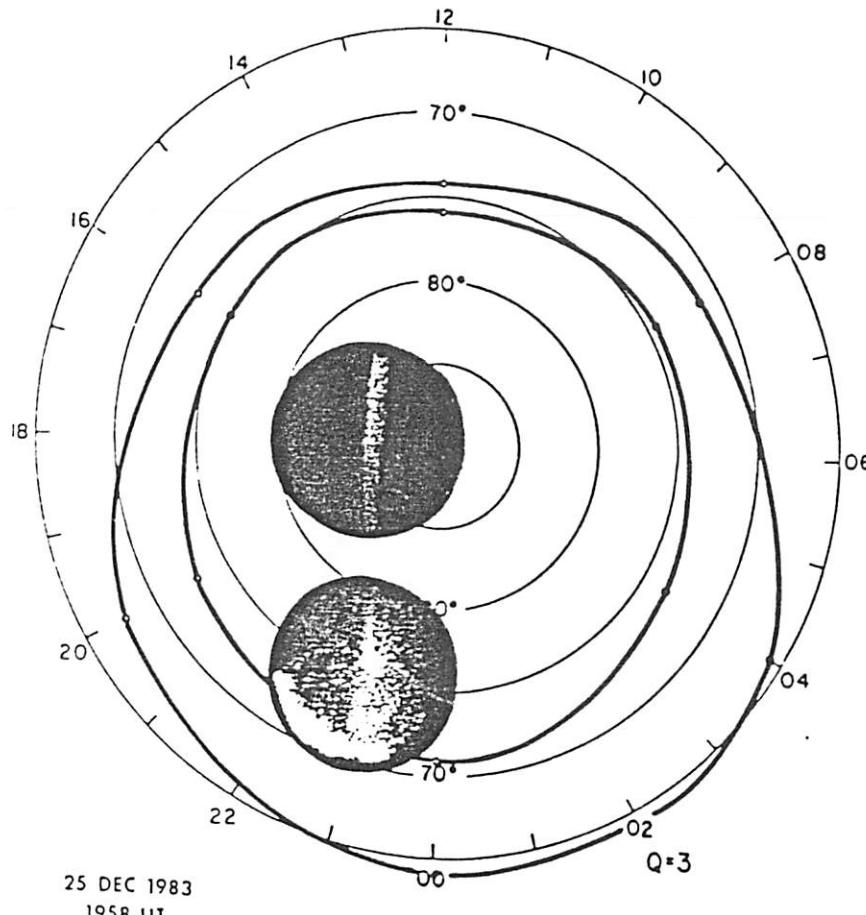
Multiple ground-based and satellite data are only now being utilized

Happy Hunting !!

Extra Figures

VELOCITY SHEAR & CURRENT CONTINUITY





25 DEC 1983
1958 UT

$Q=3$

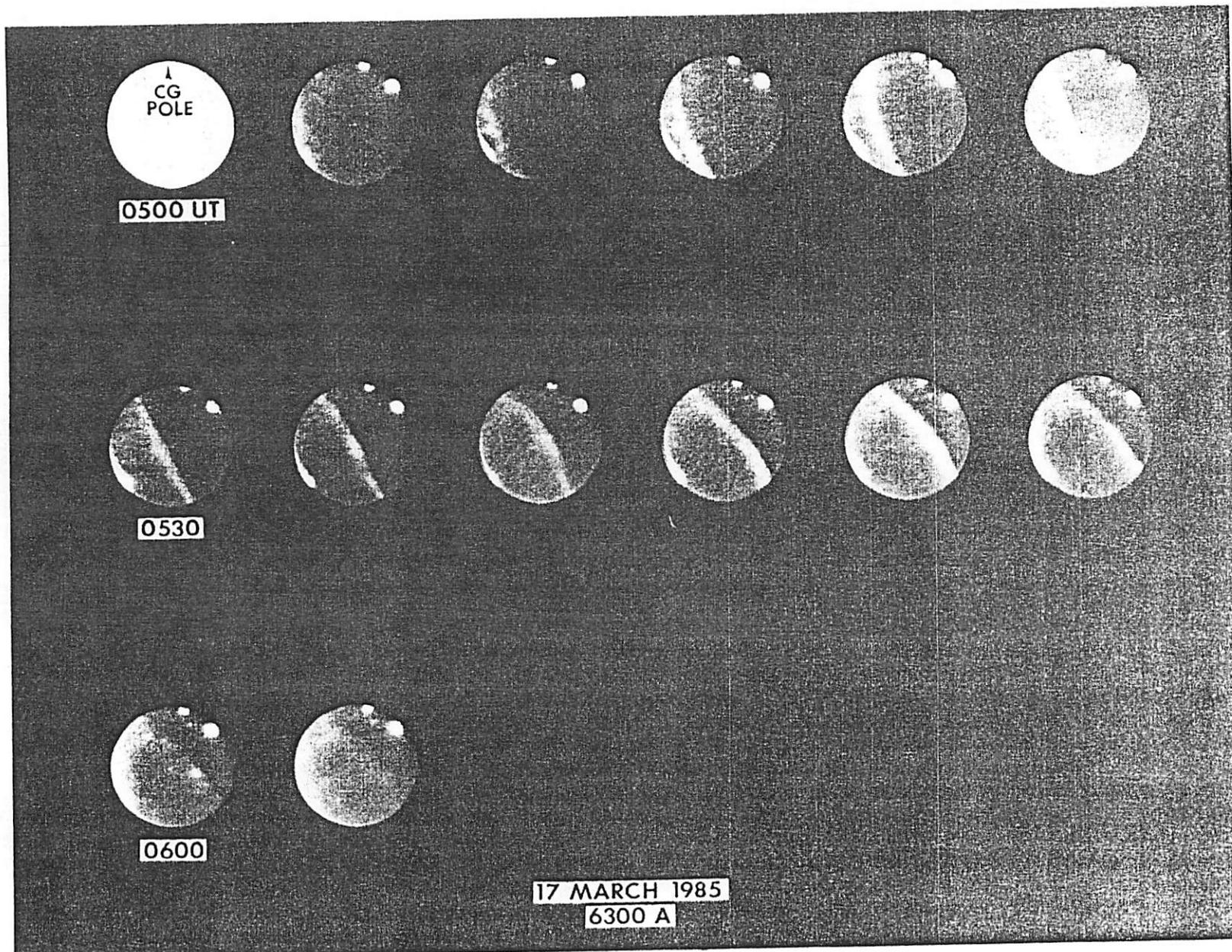


Fig. 3. Weak stable extended 6300A sun-aligned arcs, persisting over an hour (the bright spots on the edge of the field of view are lights near the horizon).