Geospace System Response at Mid, High Latitudes

Conveners:
Simon Shepherd (Dartmouth)
Phil Erickson (MIT Haystack Observatory)

GSR 1: Monday 1330-1530 LT
GSR 2: Tuesday 1000-1200 LT
Anasazi South

Key features of this session:

- Geospace is a system and should be treated as such
- Disturbance response at subauroral, auroral latitudes allows system study of:
  - Adaptive feedback and memory
  - Nonlinear response
  - Instabilities
  - Sensitivity to initial conditions
- Vastly improved mesoscale diagnostics make these topics compelling for this solar cycle

The above should look like a familiar list..

2011

Charge (Challenge?) to Speakers

Short, to-the-point presentations (no AGU!) that ideally illuminate a process which might be an important part of overall geospace system response, especially in light of recent upticks in activity. As the title says, we're trying to focus on mid to high latitude system response.

We would like a WORKSHOP which has discussion and dynamic flow depending on the topics being illustrated. Make 1 or 2 good/deep/interesting points.

We can adjust schedules and order on the fly. Nominal time = 5 (present) + 5 (discuss).

A good model: CEDAR Storm Studies led by M. Buonsanto: let's cultivate multidisciplinary, system focused studies of geospace response at mid to high latitudes.

NOTE: This workshop is paired with:

Middle Latitude Ionosphere-Atmosphere-Magnetosphere Coupling
(Naomi Maruyama and Tony Manucci, conveners; **Midlat IAM Coupling**)
Monday 1600 - 1800 LT
HERE (Anasazi South)

Nominal Schedule: GSR 1, GSR 2

Monday 1330 - 1530 (GSR 1):

Intro/Systems Overview	Phil Erickson
SuperDARN perspective	Mike Ruohoniemi
Flow channels	Larry Lyons
August 11 Storm	Cheryl Huang
Storm-time substorms	Toshi Nishimura
Energetic e- in night-time F-region	Asti Bhatt
ISR derived PBL questions	Phil Erickson
General Discussion	

Tuesday 1000 - 1200 (GSR 2):

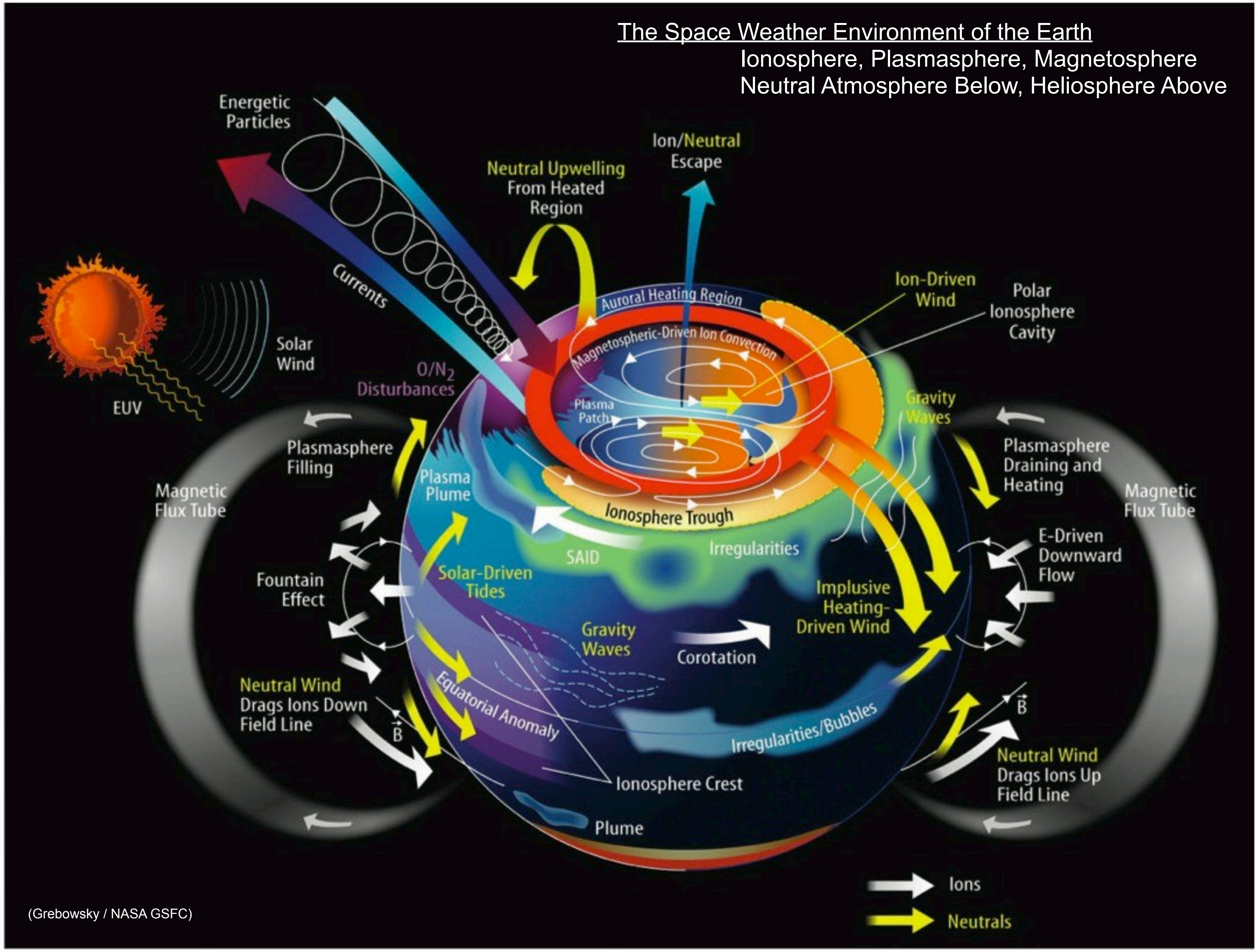
Ground Optics	Eric Donovan
AMPERE	Lars Dyrud
GPS TEC	Gary Bust
Significance of the altitudinal distribution of magnetospheric energy inputs to the upper atmosphere	Yue Deng
Multi-scale view of system drivers	Josh Semeter
Energy deposition at the smallest scales	Hanna Dahlgren
General Discussion	

Nominal Schedule: MidLat IAM Coupling

Monday 1600 - 1800:

Author last name	first name	subject/title	talk length (min)	
Mannucci/Maruyama		introduction	5	16:00-16:05
Reeves	Geoff	RBSP collaboration--RBSP mission objectives and RB modeling	10	16:05-16:15
Spence	Harlan	RBSP collaboration--coordinated observations between ground and space	10	16:15-16:25
Lyons	Larry	flow channels to substorm current wedge signatures and particle injections	9	16:25-16:34
Zou	Shasha	TEC response during substorms	9	16:34-16:43
Liu	Guiping	THEMIS-PFISR comparison	9	16:43-16:52
Nishimura	Toshi	storm time SAPS and neutral wind	9	16:52-17:01
Huba	Joe	SAMI3 modeling	9	17:01-17:10
Wang	Wenbin	SAPS/ ion precipitation effect on the T-I system	9	17:10-17:19
Sazykin	Stan	RCM modeling on MI coupling	9	17:19-17:28
Ridley	Aaron	modeling impact of conductivity and neutral wind on MI coupling	9	17:28-17:37
Holt	Laura	modeling energetic particle precipitation and transport	9	17:37-17:46
Datta-Barua	Seebany	SAPS and plumes during superstorms using GPS density imaging	7	17:46-17:53
Shephard	Simon	SuperDARN coordination with RBSP	**3**	17:53-17:56
		wrap-up discussions	4	17:46-18:00

The System



(Grebowsky / NASA GSFC)

Are there gorillas running around in here?

Mid Latitude Concepts and Acronyms

- **SAPS** = SubAuroral Polarization Stream; fast moving westward flows (poleward electric fields) seen equatorwards of the electron precipitation boundary. Originally labeled PJ = Polarization Jet. Also seen in literature as SARAS: Substorm Associated Radar Auroral Surges.

- **SAID** = SubAuroral Ion Drift; very localized, structured, very intense westward flow (poleward electric field). AWFC = Auroral Westward Flow Channel also reported (with weaker magnitude); might be poleward manifestation of SAIDs.

- **SED** = Storm Enhanced Density; spatially localized, large scale electron density enhancements, often associated with sectors where SAPS flows are evident (but sometimes not). Seen often in Total Electron Content (**TEC**).

- Region 2 field aligned currents (ring current associated); seen downwards associated with SAPS / SAID events. Closure of currents across subauroral latitudes, then through upward flowing Region 1 currents. Driver of Region 2 downward FAC may be pressure differentials in asymmetric ring current.

The Plasmasphere Boundary Layer (PBL)

Annales Geophysicae (2004) 22: 4291–4298
SRef-ID: 1432-0576/ag/2004-22-4291

Annales Geophysicae

The Plasmasphere Boundary Layer

D. L. Carpenter[1] **and J. Lemaire**[2,3]

[1]STAR laboratory, Stanford University, Stanford, CA 94 305, USA
[2]CSR-UCL, Louvain, Belgium
[3]IASB, Brussels, Belgium

Received: 18 August 2004 – Revised: 29 September 2004 – Accepted: 3 October 2004 – Published: 22 December 2004

"Curiously, the plasmapause region has not been described as a boundary layer, in spite of being observed at locations where the cool (≈1 eV) dense (≈400 el/cc) plasmasphere overlaps with, or is otherwise in close proximity to, the hot (≈100 eV–100 keV) tenuous (≈1 el/cc) plasmas of the plasmatrough or the plasmasheet and ring current.."

PBL processes and dynamics are hallmarks of M-I coupling and geospace system response. Their complexity means we need as many simultaneous diagnostics as possible.

Mesoscale Ionospheric Redistributions

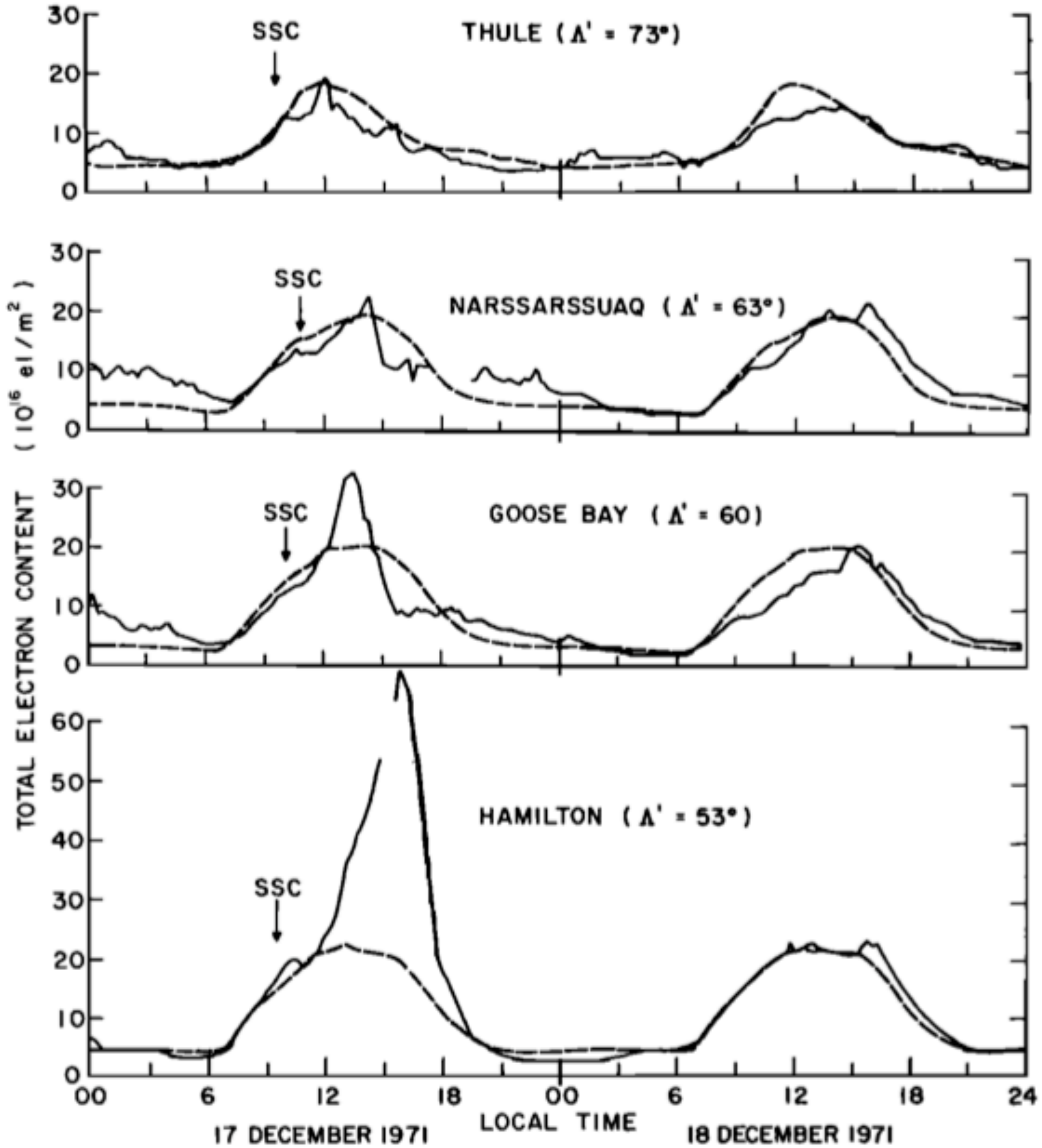


Fig. 5. TEC data from AFRCL facilities at Thule, Narssarssuaq, Goose Bay, and Hamilton for December 17–18, 1971. The dashed curves give the monthly median behavior at each station, and the small arrows mark the local times of the ssc at 1418 UT.

AFCRL network observing ATS series geosynchronous VHF beacons

Differential Doppler estimate of TEC

17 December 1971

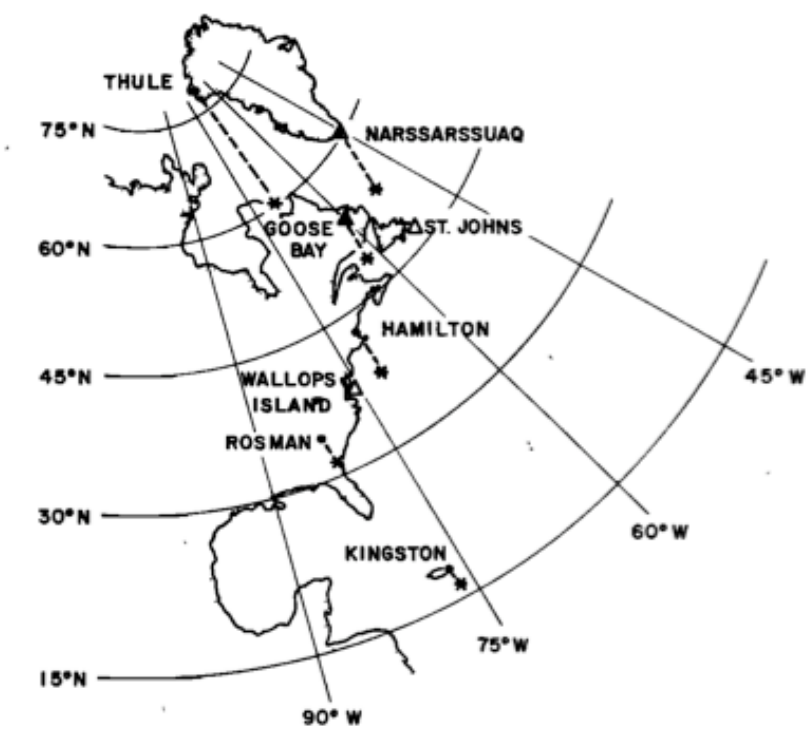
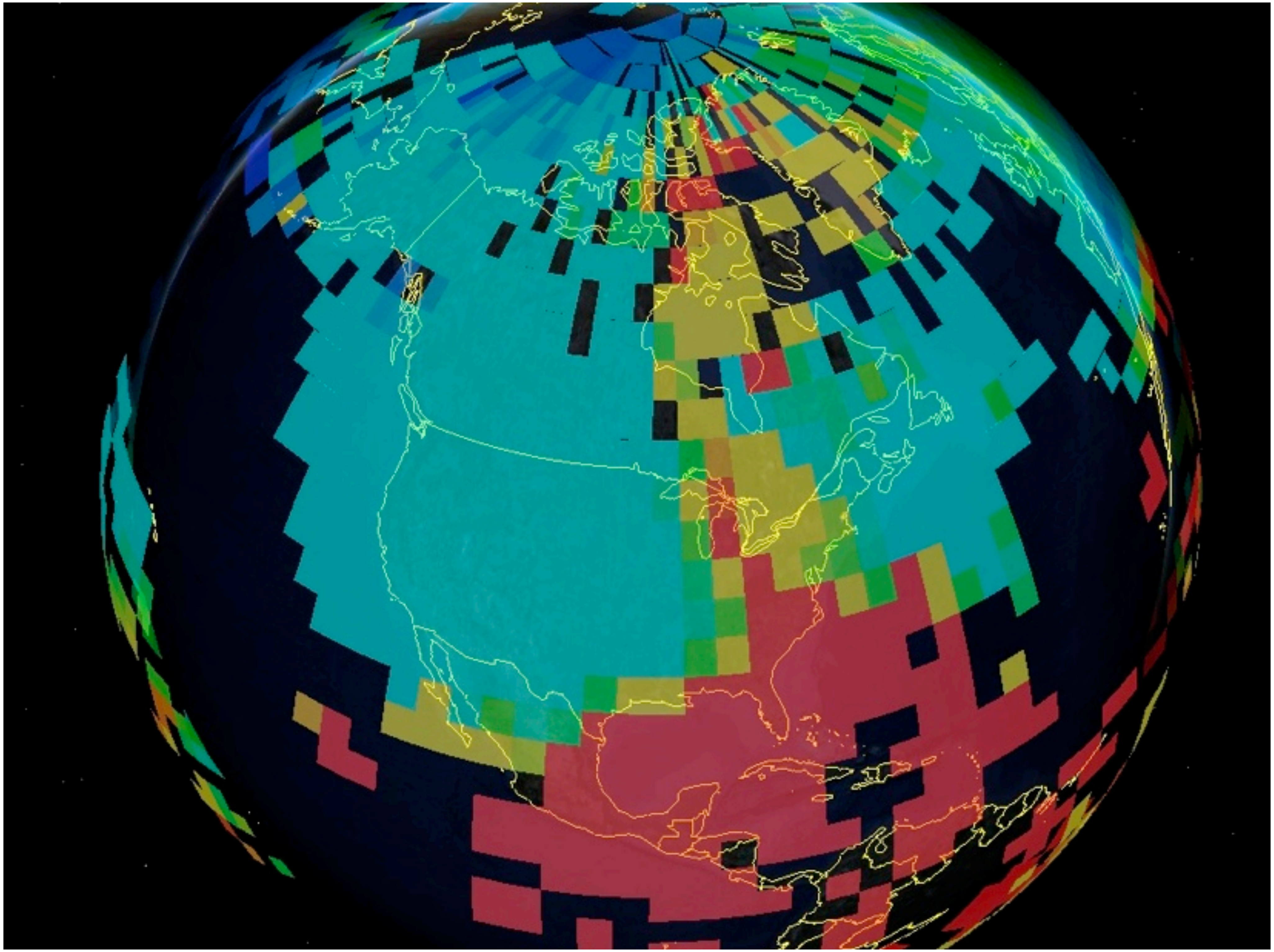


Fig. 1. Locations of TEC observing stations (solid dots), their 420-km subionospheric points (asterisks) for ATS 3 at 70°W, and the nearby ionosonde stations (open triangles).

Mendillo and Klobuchar, 1975

Mesoscale Ionospheric Redistributions

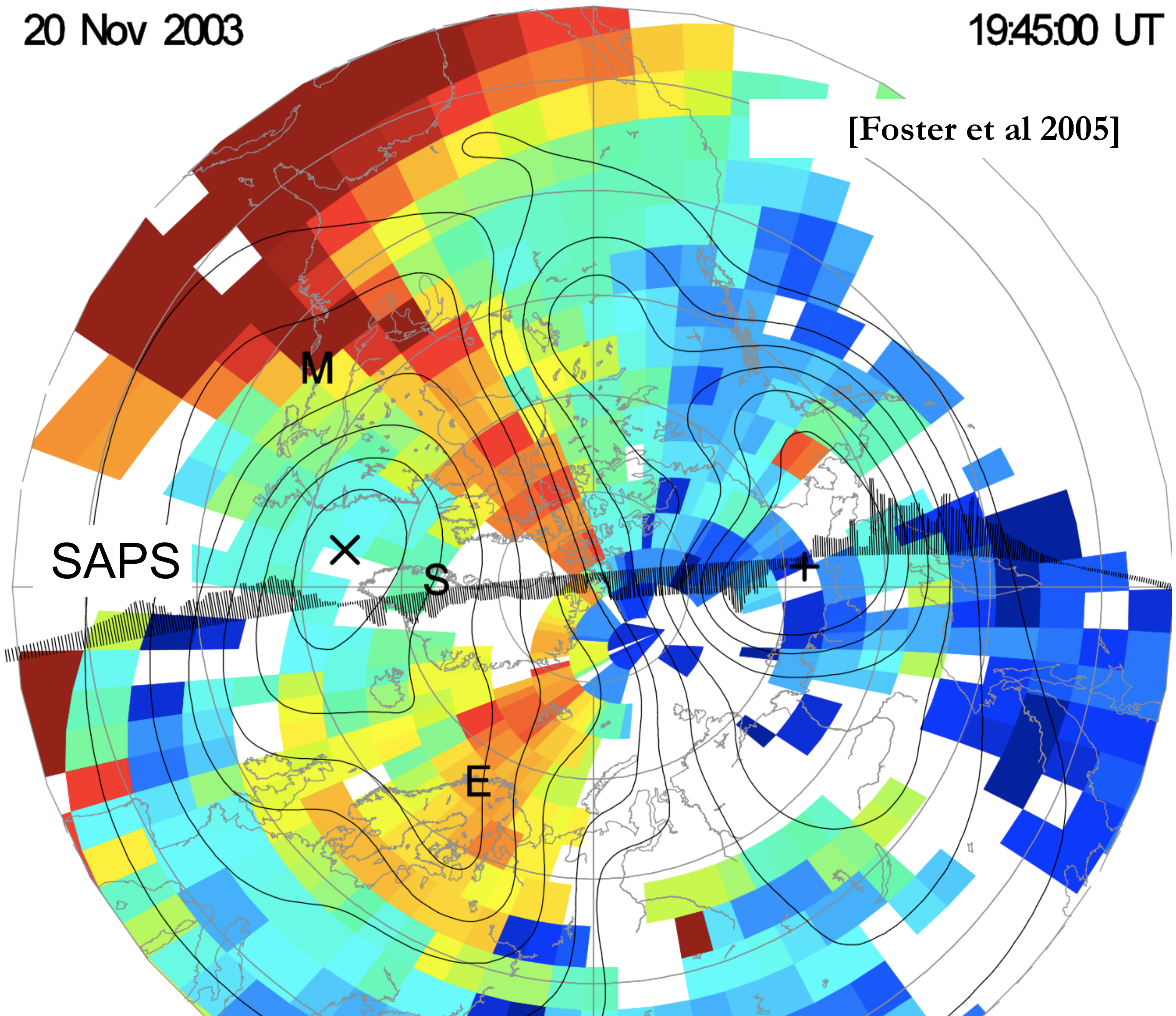


Storm
Enhanced
Density
(SED)

GPS TEC
[0, 60] TECu

Nov 20, 2003
1840 - 1900 UTC

System-Level Redistribution Paths

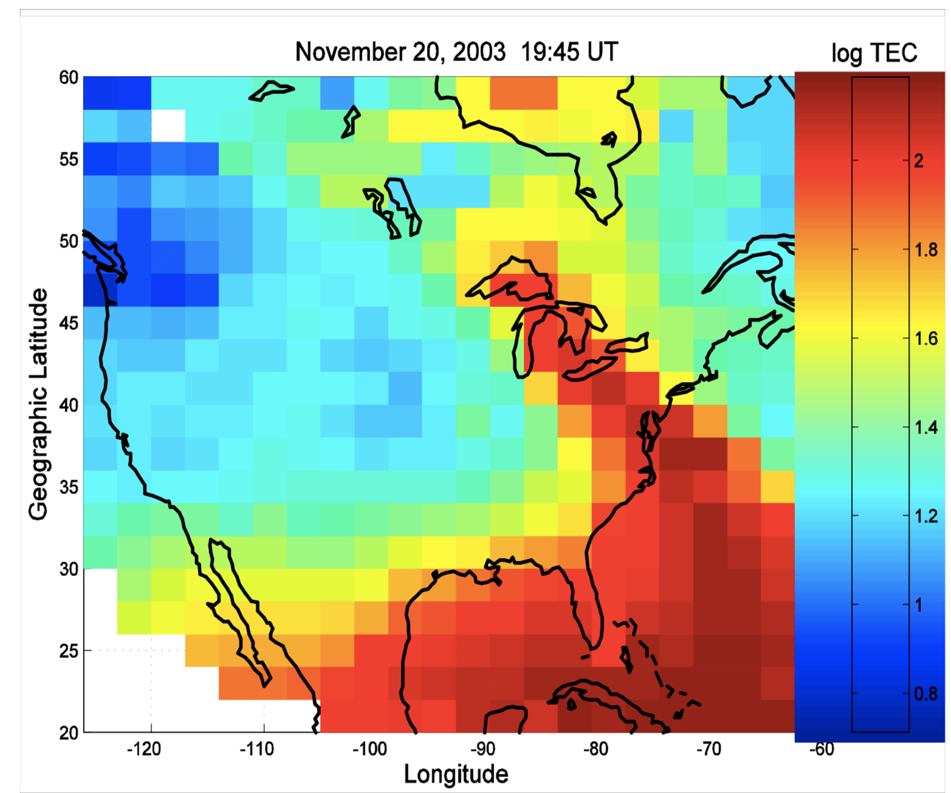


Merged SuperDARN/DMSP Convection
Common projection: maglat/MLT @ 350 km alt

Active plasma redistribution couples equatorial and polar latitudes through mid-latitudes

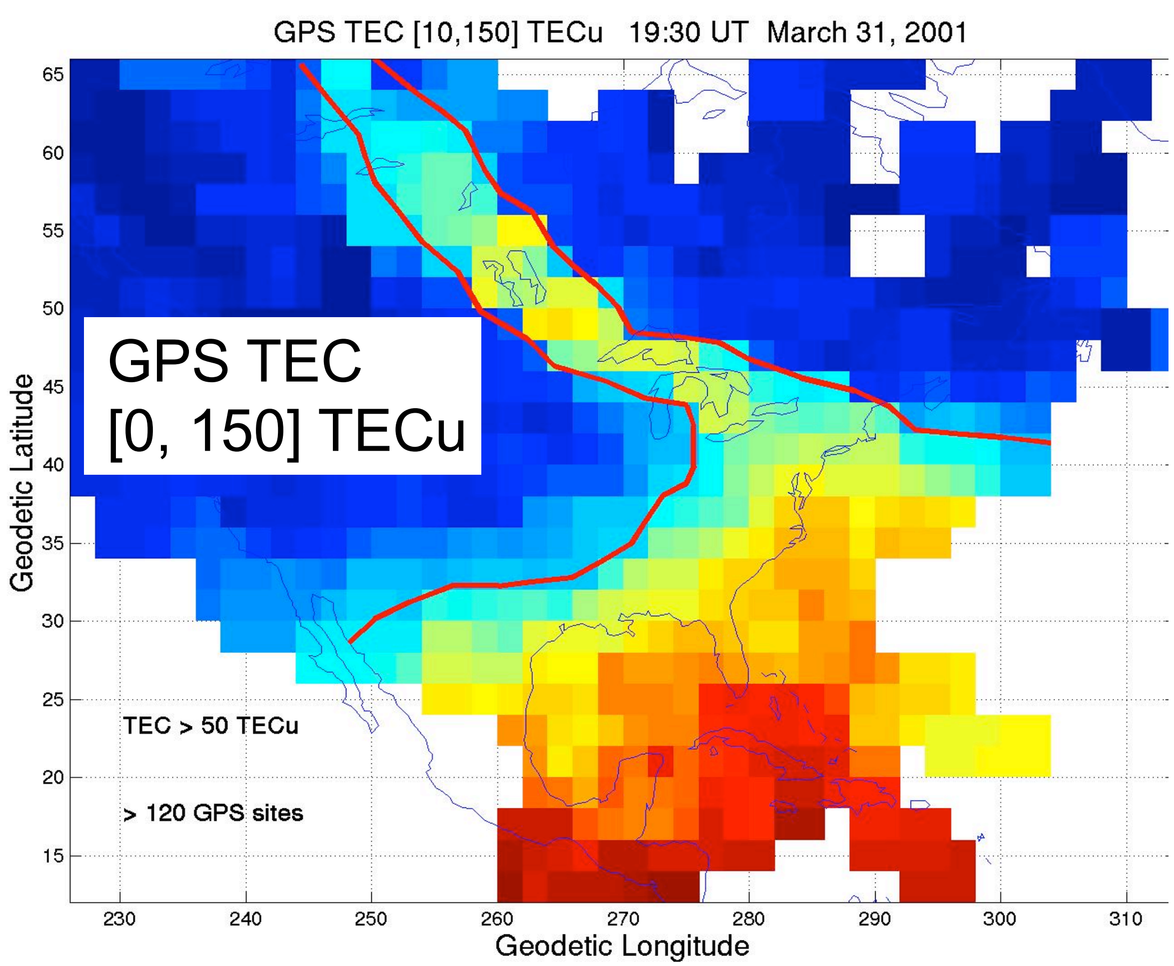
SED, polar tongue of ionization created through actions of region 2 linked SAPS electric fields (M-I coupling)

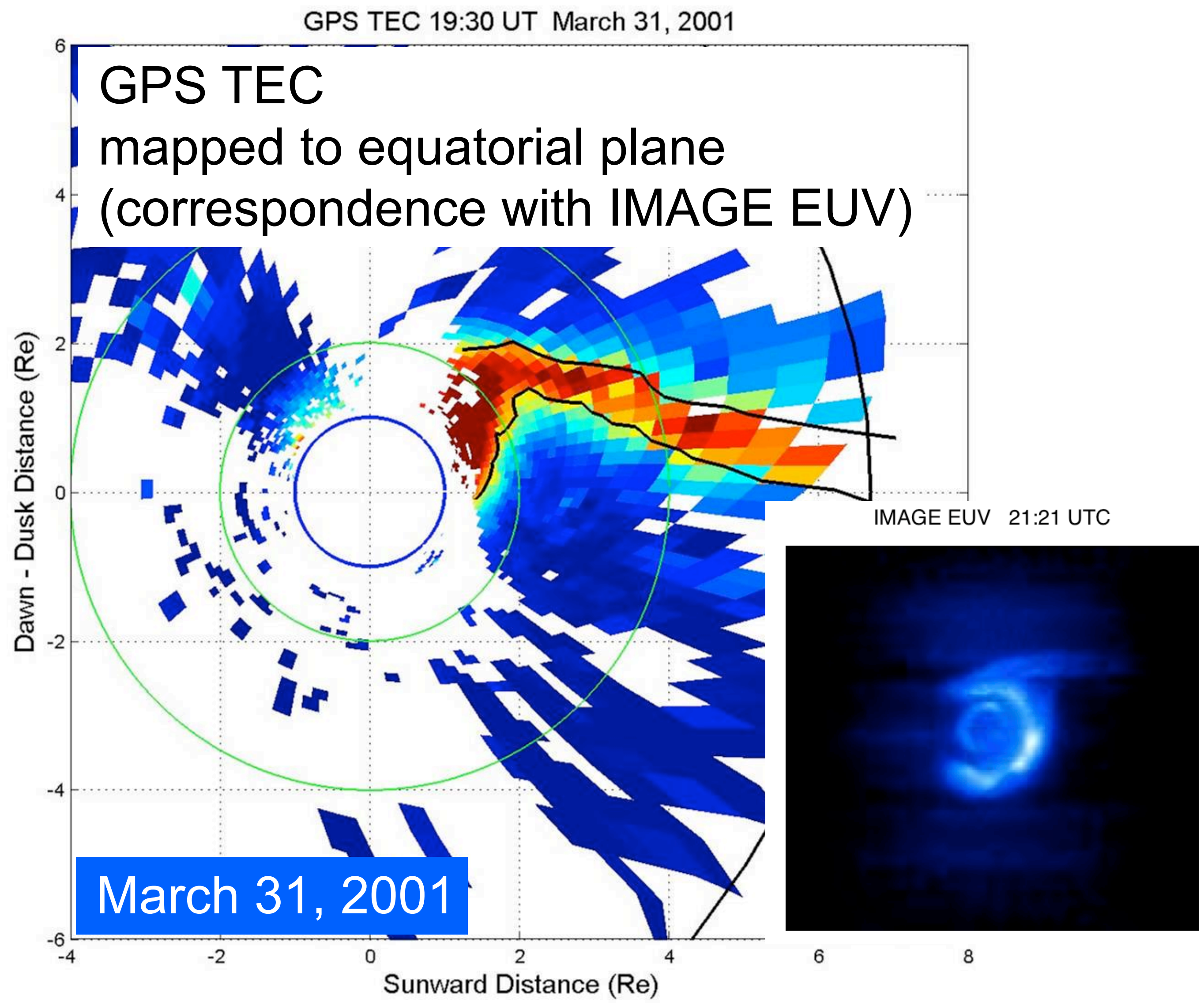
GPS TEC Map



The Coupled Geospace Observational View

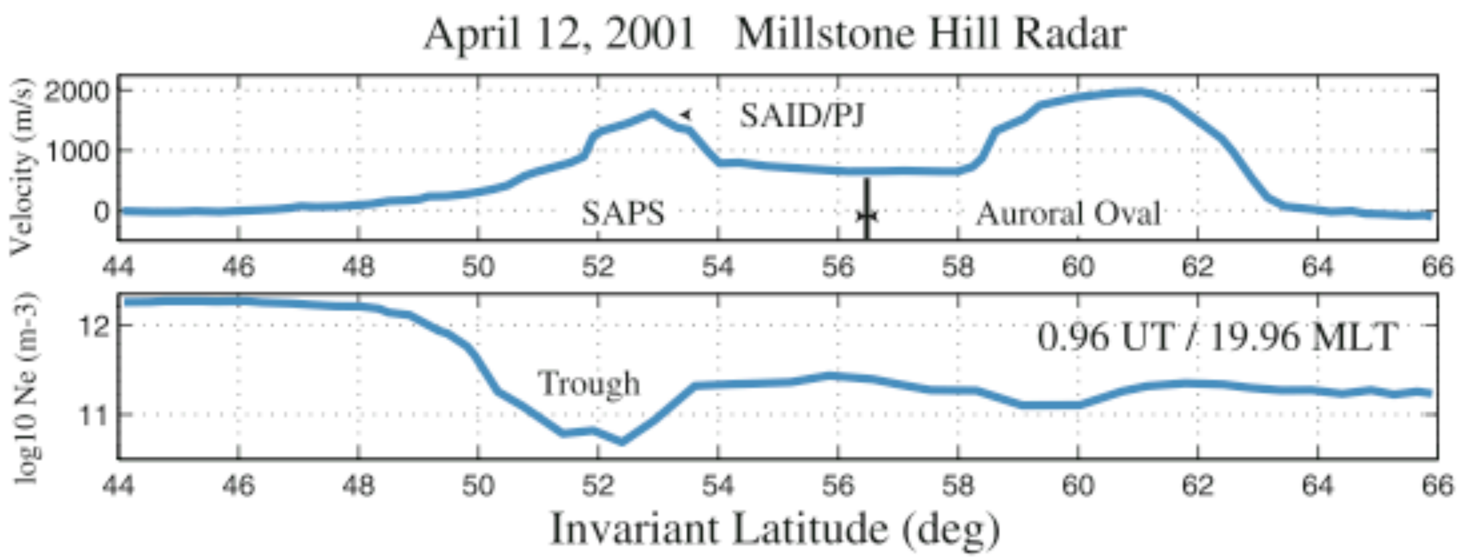
What are the *statistical and system* characteristics of this mesoscale redistribution in the ionosphere?

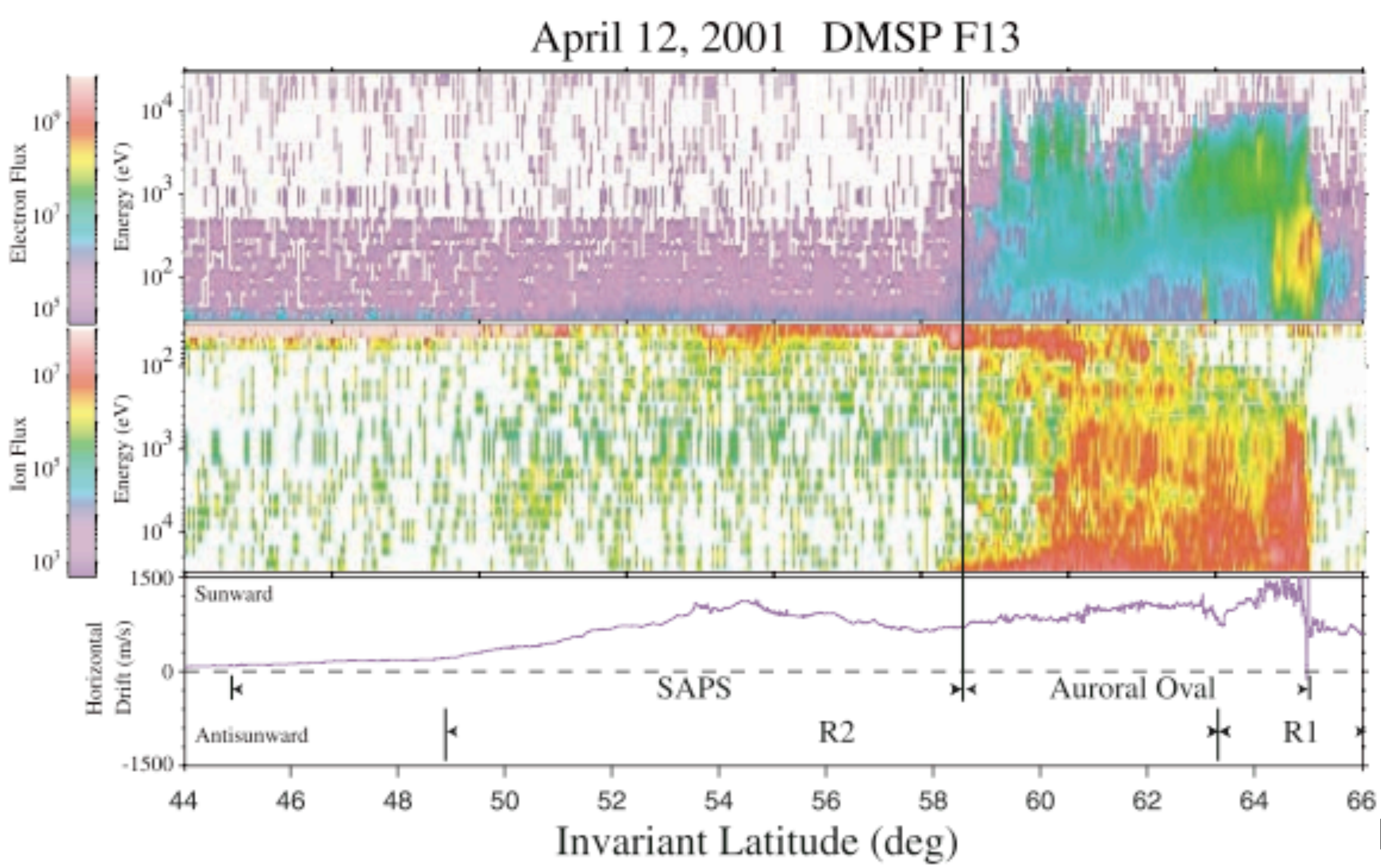




(e.g. Foster et al 2004)

Sub-Auroral Polarization Stream (SAPS)





Westward (sunward) subauroral velocity near footprint of region 2 / ring current

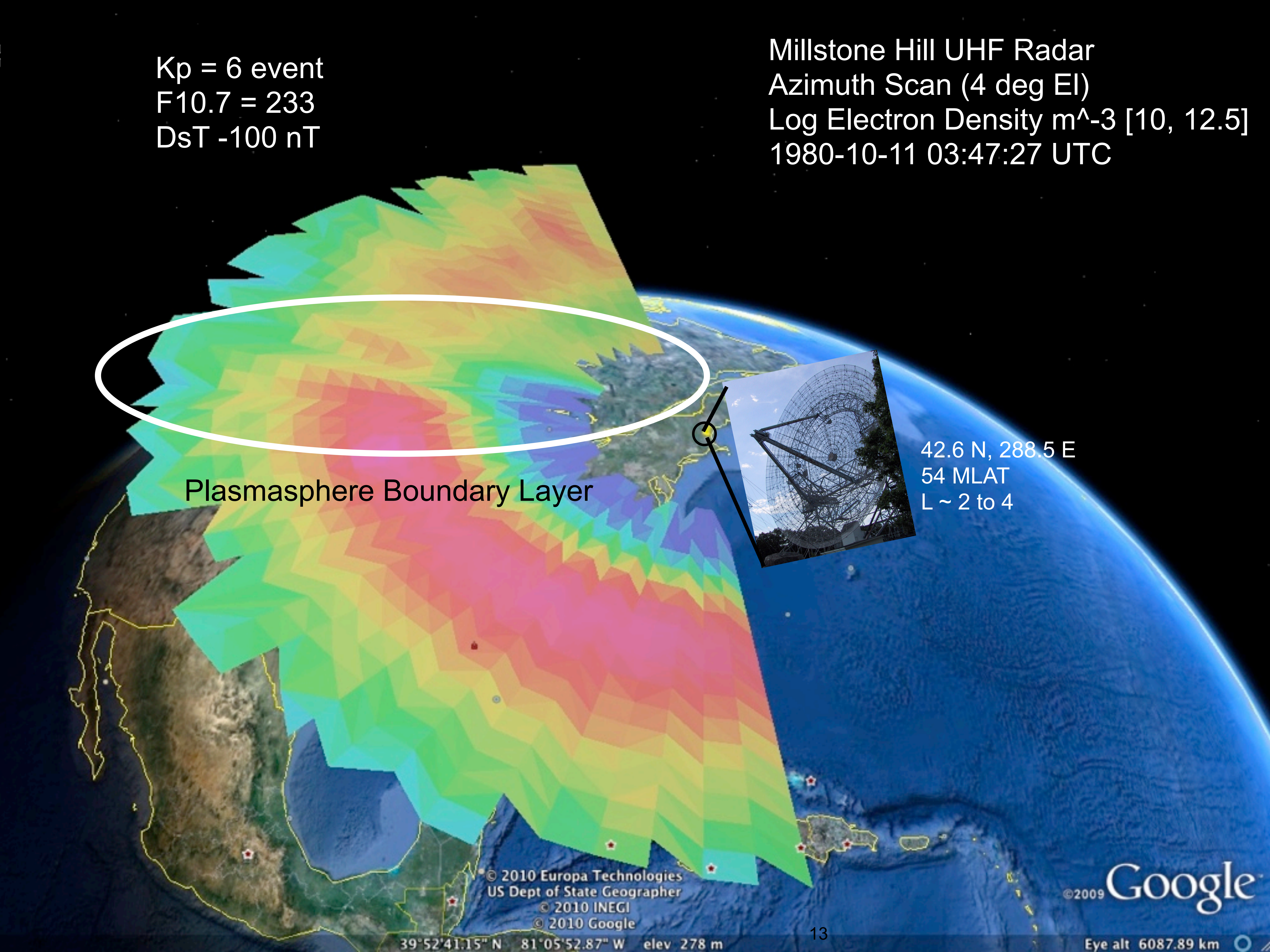
2-5 deg wide

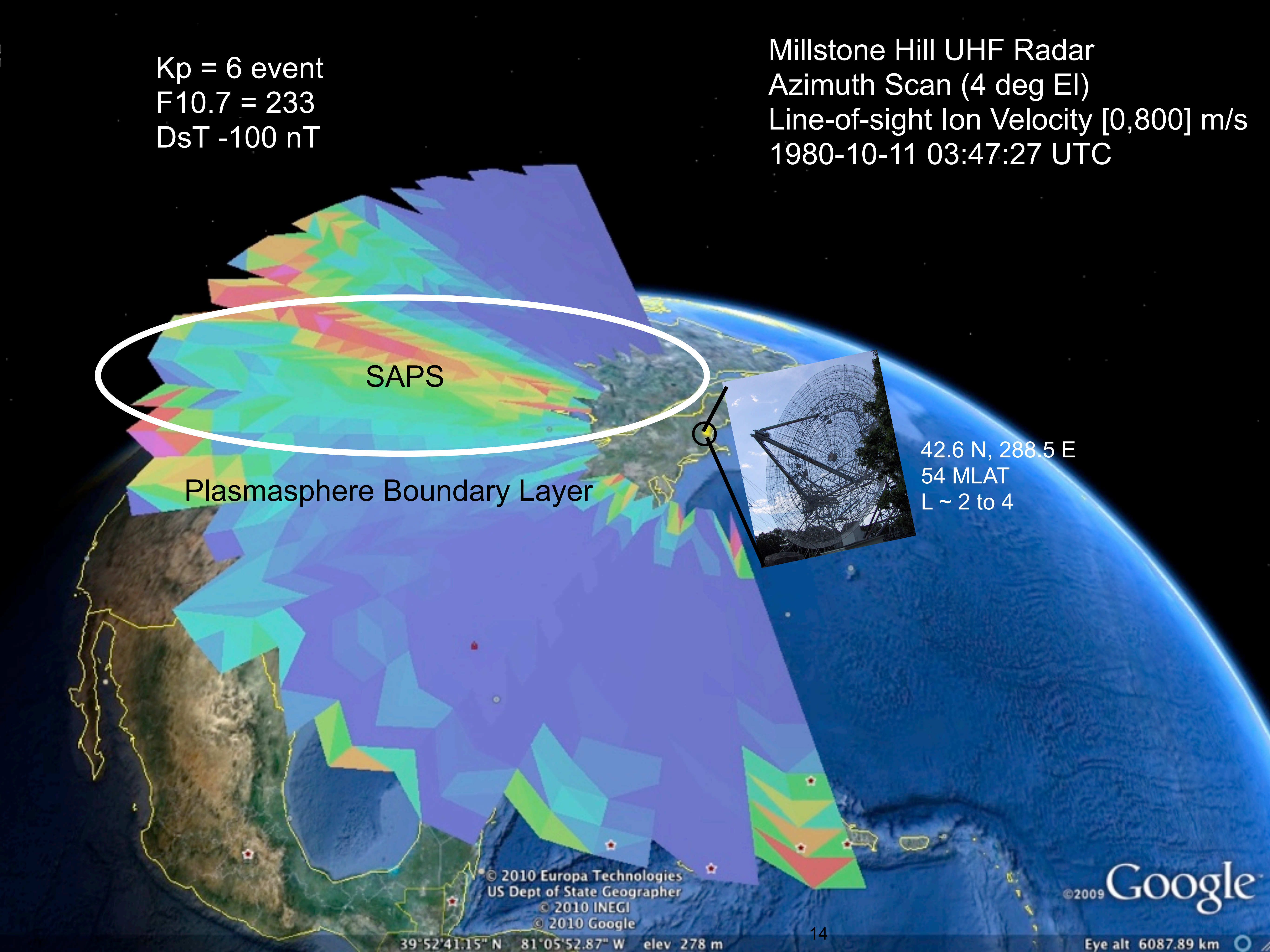
Embedded small and highly variable structures (SAID)

Overlaps edge of storm enhanced density (SED)

Dusk sector transport of material to noontime cusp

Foster and Vo, 2002


Kp = 6 event
F10.7 = 233
DsT -100 nT
Millstone Hill UHF Radar
Azimuth Scan (4 deg El)
Log Electron Density m^-3 [10, 12.5]
1980-10-11 03:47:27 UTC
Plasmasphere Boundary Layer
42.6 N, 288.5 E
54 MLAT
L ~ 2 to 4
© 2010 Europa Technologies
US Dept of State Geographer
© 2010 INEGI
© 2010 Google
©2009 Google
39°52'41.15" N 81°05'52.87" W elev 278 m
Eye alt 6087.89 km



Kp = 6 event
F10.7 = 233
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Millstone Hill UHF Radar
Azimuth Scan (4 deg El)
Line-of-sight Ion Velocity [0,800] m/s
1980-10-11 03:47:27 UTC
SAPS
Plasmasphere Boundary Layer
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39°52'41.15" N 81°05'52.87" W elev 278 m
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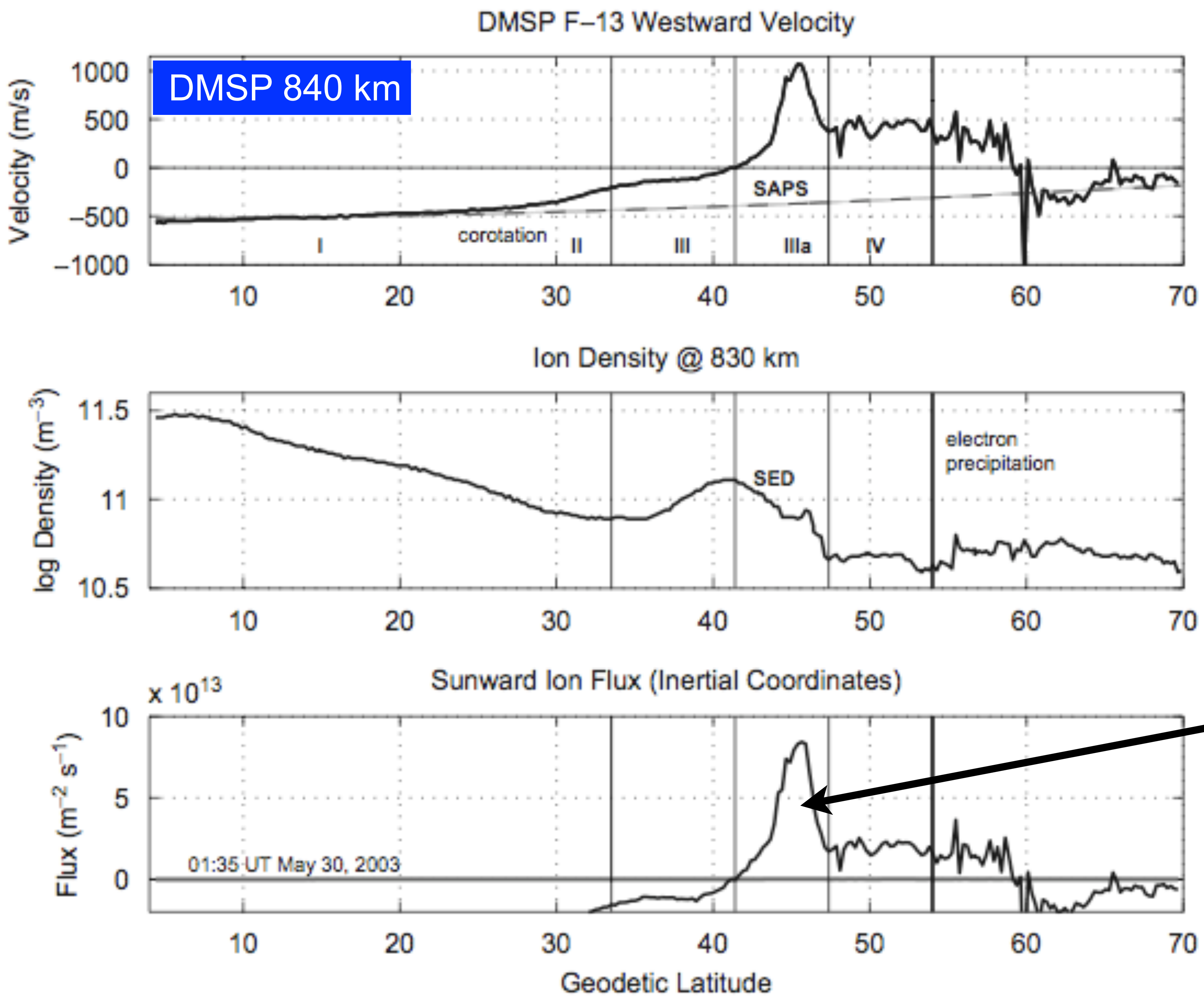
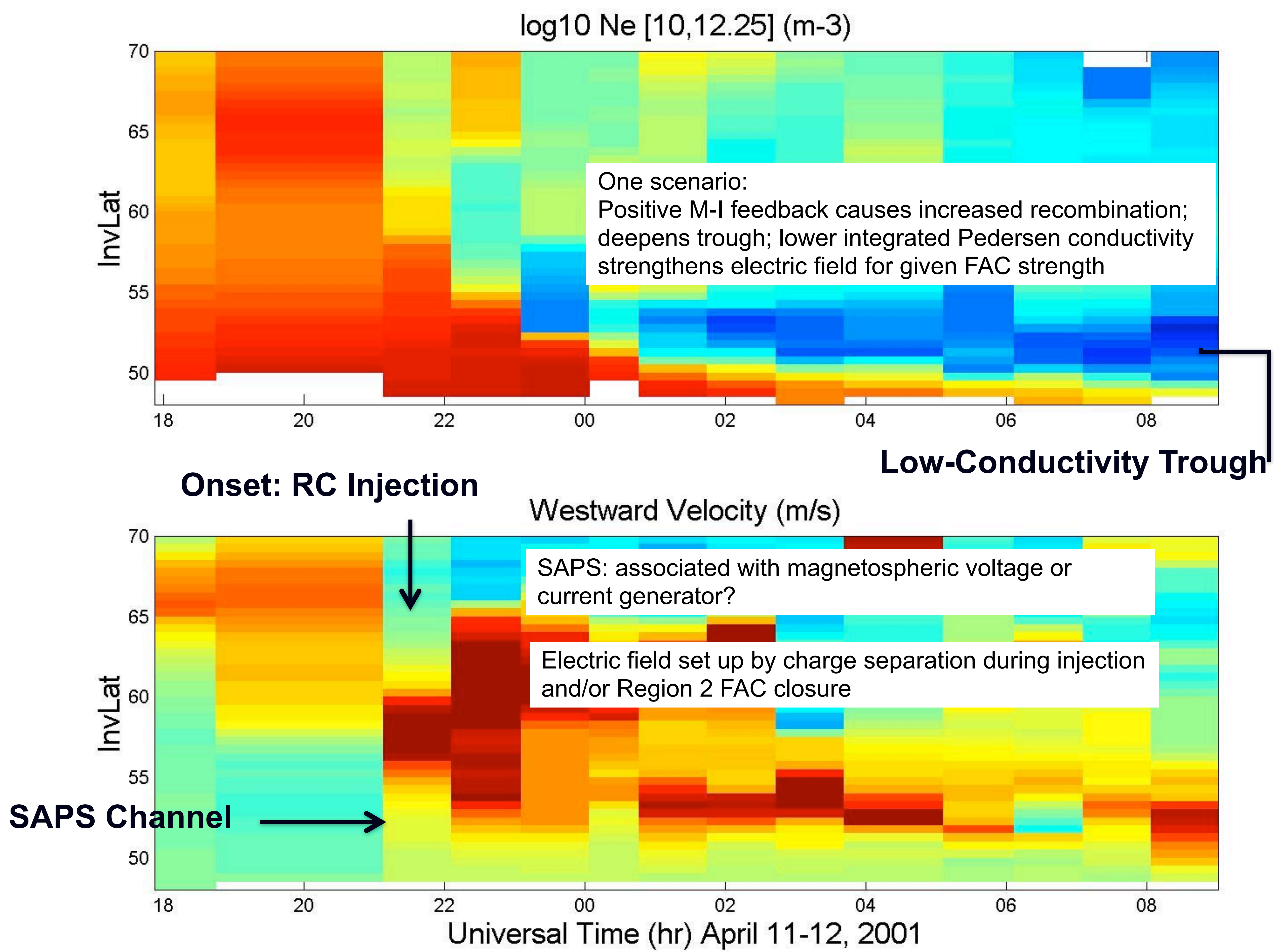
Sunward ion flux driven by SAPS



Sunward ion flux caused by SAPS/SED overlap

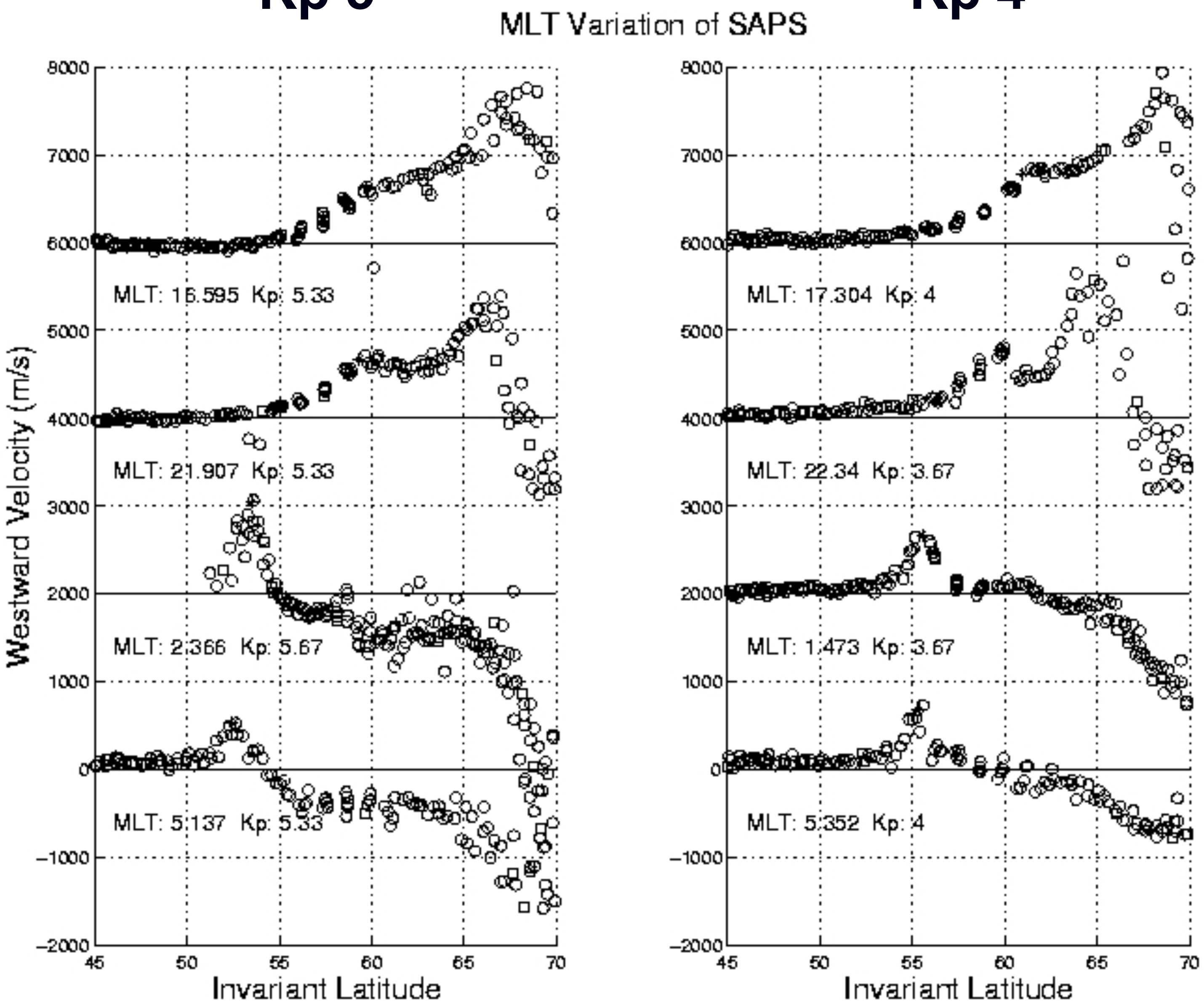
Foster et al, 2007


log10 Ne [10,12.25] (m-3)
InvLat
70
65
60
55
50
18
20
22
00
02
04
06
08
One scenario:
Positive M-I feedback causes increased recombination; deepens trough; lower integrated Pedersen conductivity strengthens electric field for given FAC strength
Low-Conductivity Trough
Onset: RC Injection
Westward Velocity (m/s)
SAPS: associated with magnetospheric voltage or current generator?
Electric field set up by charge separation during injection and/or Region 2 FAC closure
SAPS Channel
Universal Time (hr) April 11-12, 2001

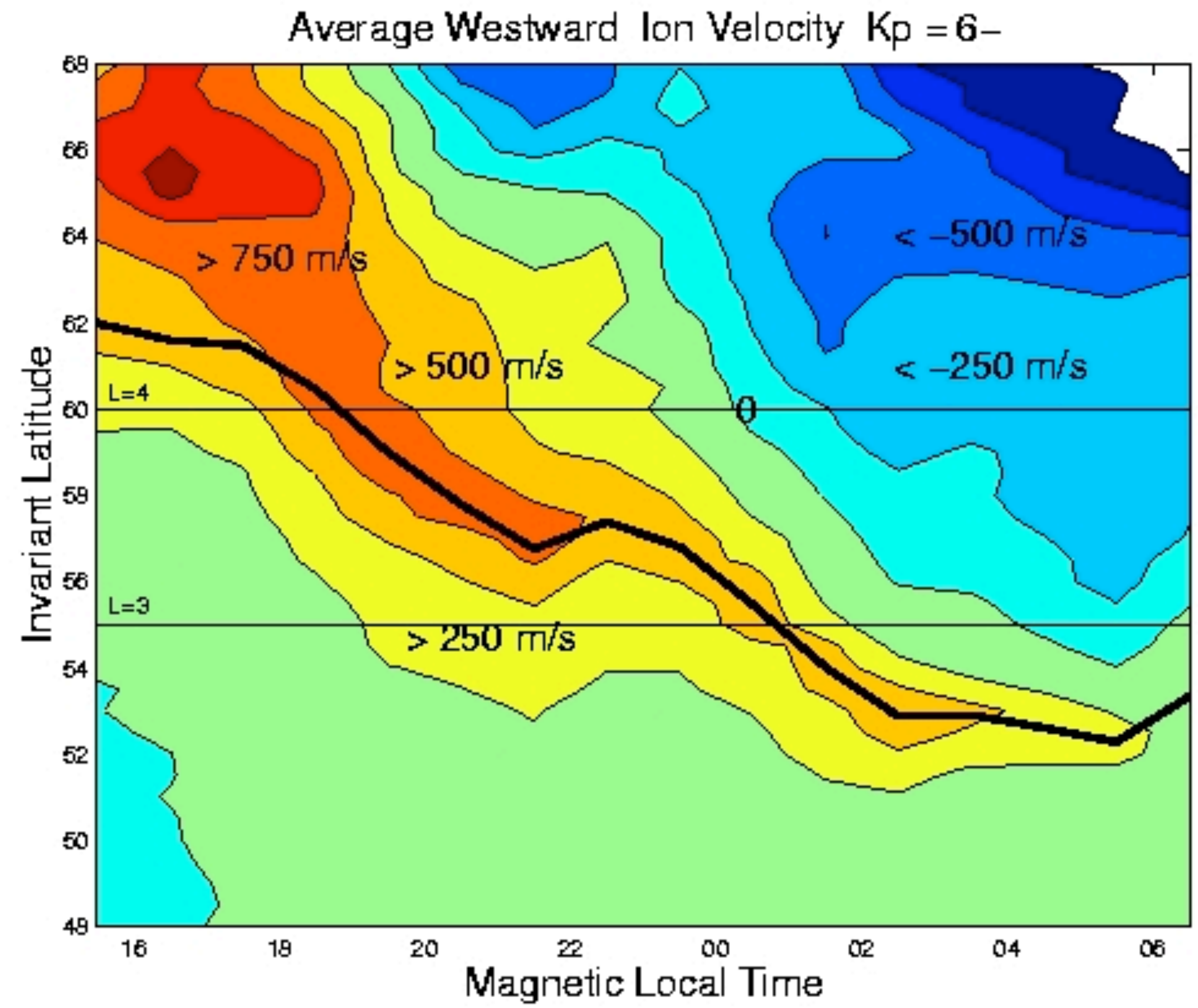
Average SAPS Velocity Characteristics

Foster and Vo 2002

Kp 5 **Kp 4**



Kp 6

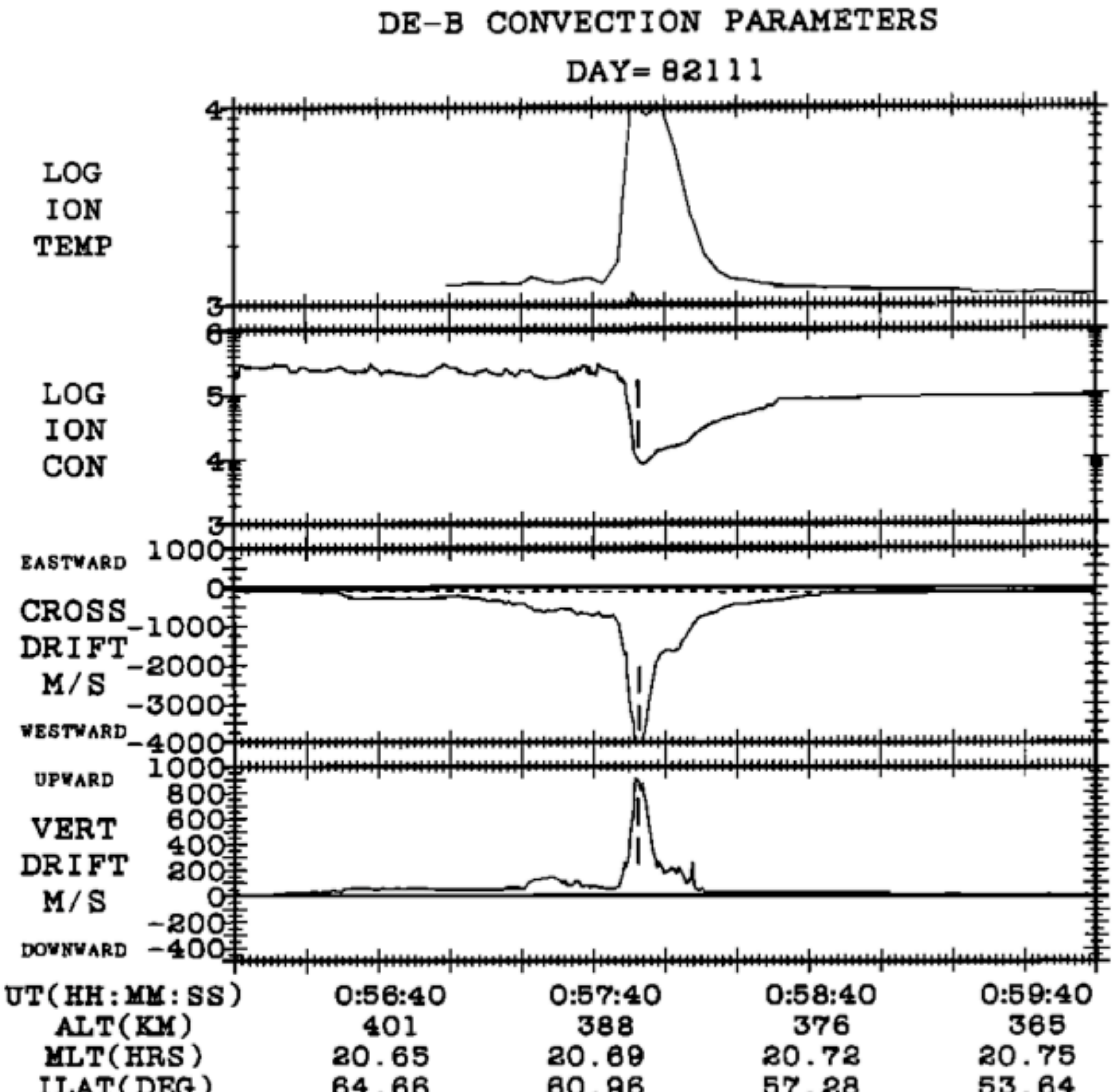


SAID: The Microscale Electric Field View

Structures < 0.1 deg invlat

Riding on top of overall (3-5 deg wide) SAPS envelope

Microscale in both space and time; presumably modulated by impulsive current due to integrated conductivity changes



Anderson et al 1991

Subauroral Electric Field Dynamic Variations

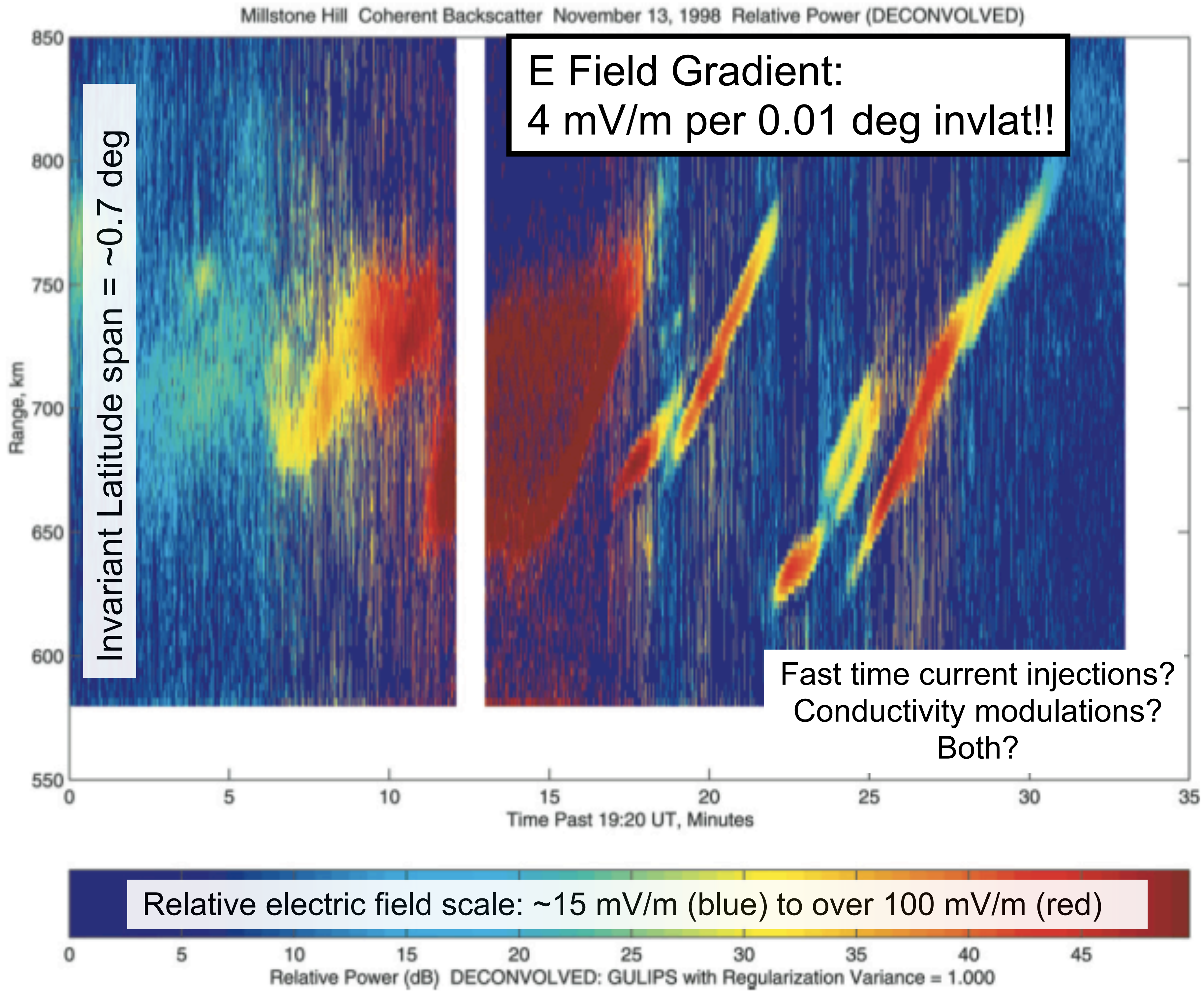
Spatial scales as small as 10-20 km (<= 0.1 deg invlat)

Temporal lifetimes as short as 1 minute

Amplitude variation of driving E field ~80 mV/m over threshold (100 mV/m total?)

E region conductivity modulations: SAID scale structures on top of overall SAPS envelope

What does this look like in the plasmasphere/ magnetosphere?



Erickson et al, 2002

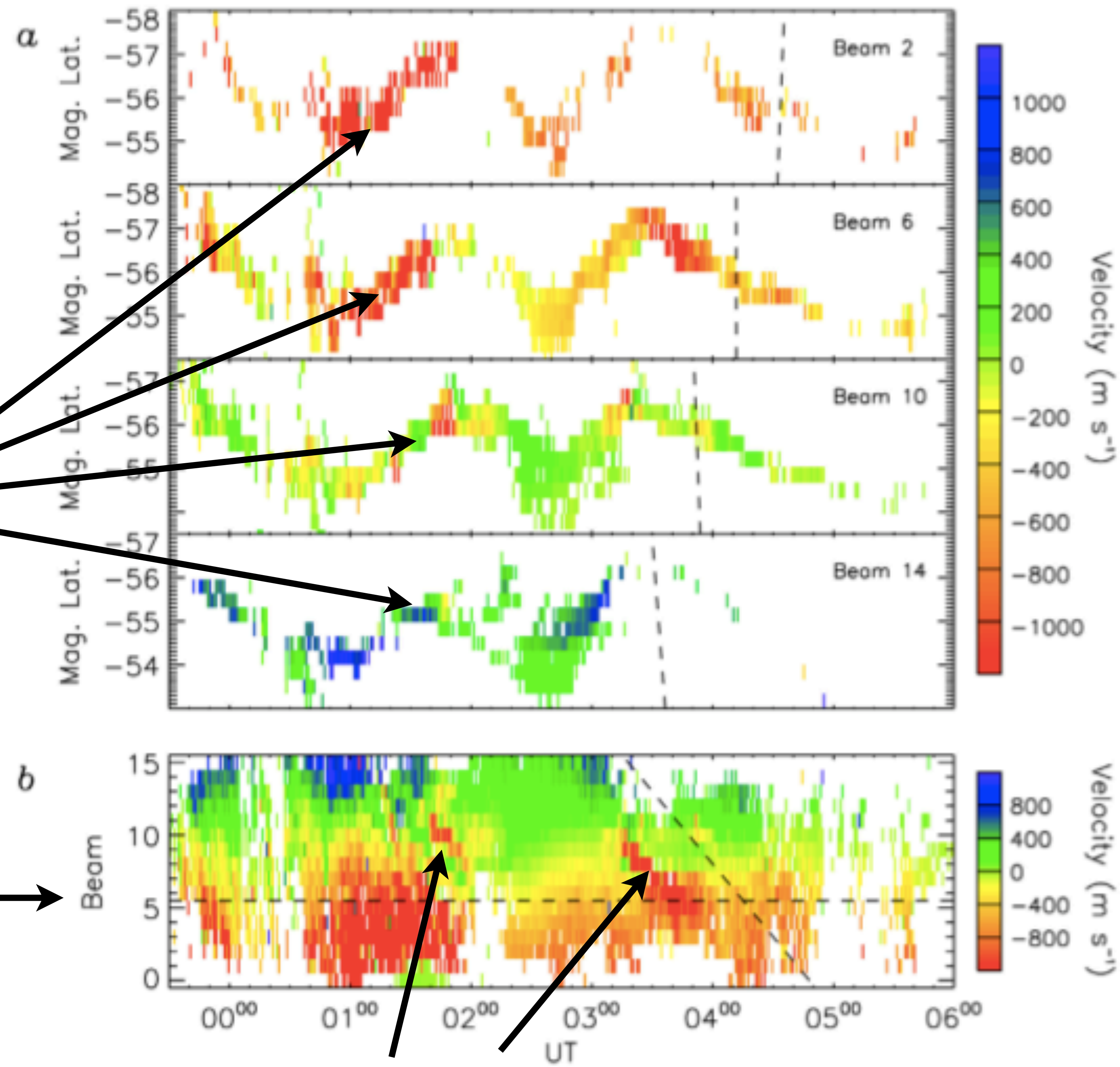
New SuperDARN E Field Variability Diagnostics

Grocott et al 2011:
HF radar backscatter diagnostics of individual SAID channels from SuperDARN network at subauroral latitudes

Storm event (DsT max = -80 nT)

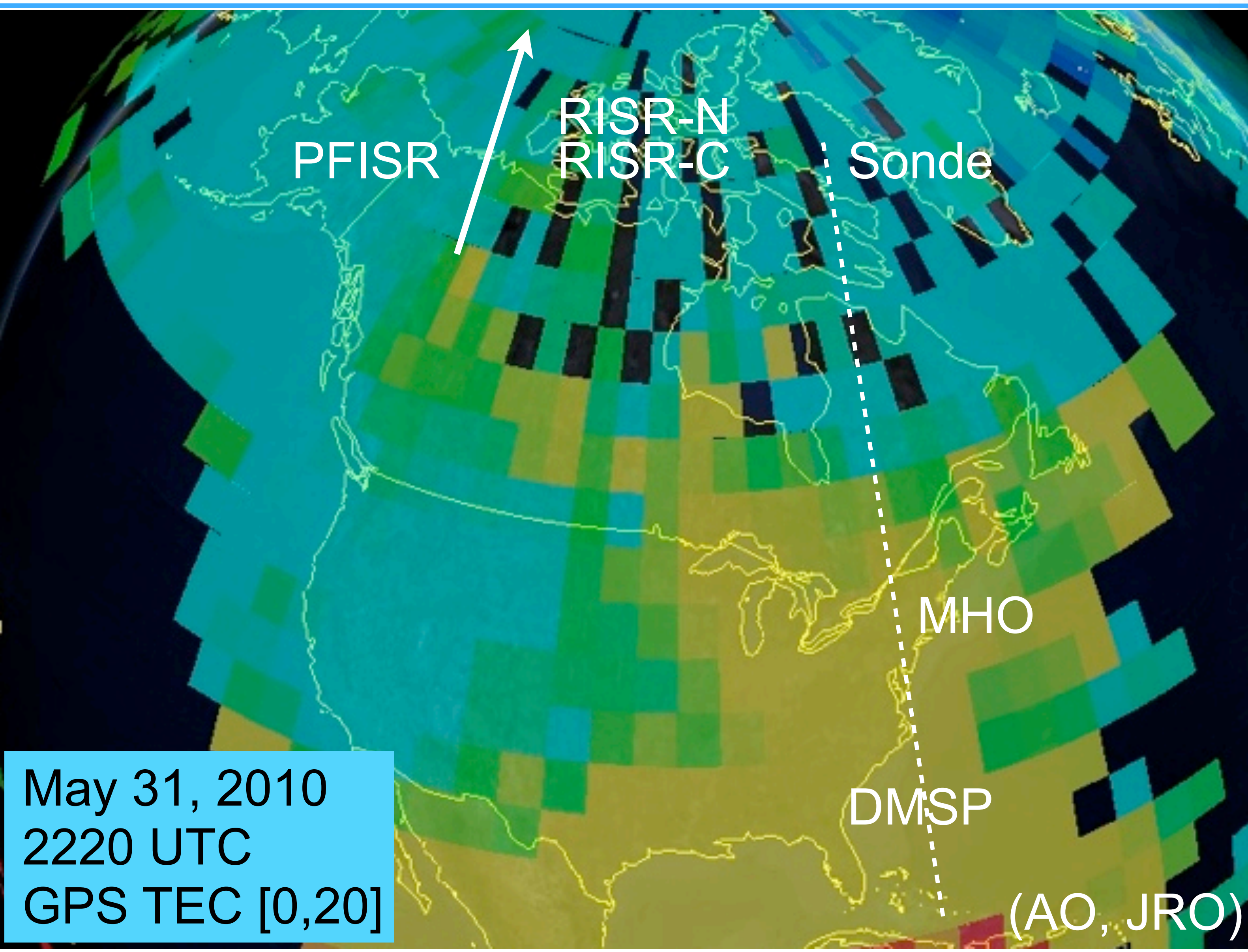
Considerable E field spatial variability (beam to beam): over 40 mV/m variations within 2-3 deg invlat

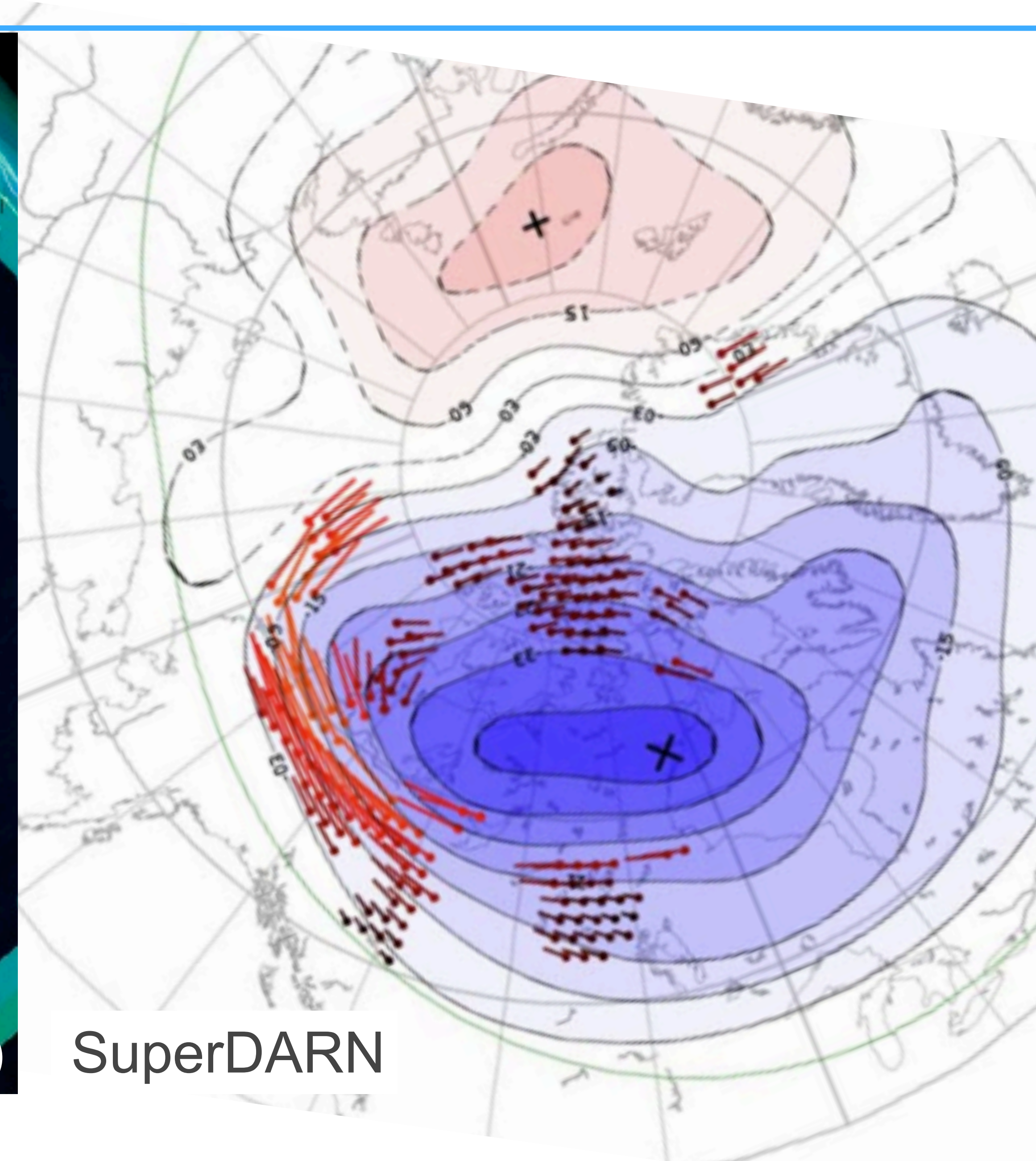
E field temporal variability (Beam-Time-Intensity plot) within overall event as well: 40 mV/m variations within < 30 min



Note very narrow, fast SAID events similar to Erickson et al 2002

Geospace Observations: DASI





System Level Responses Require System Level Observations and Science