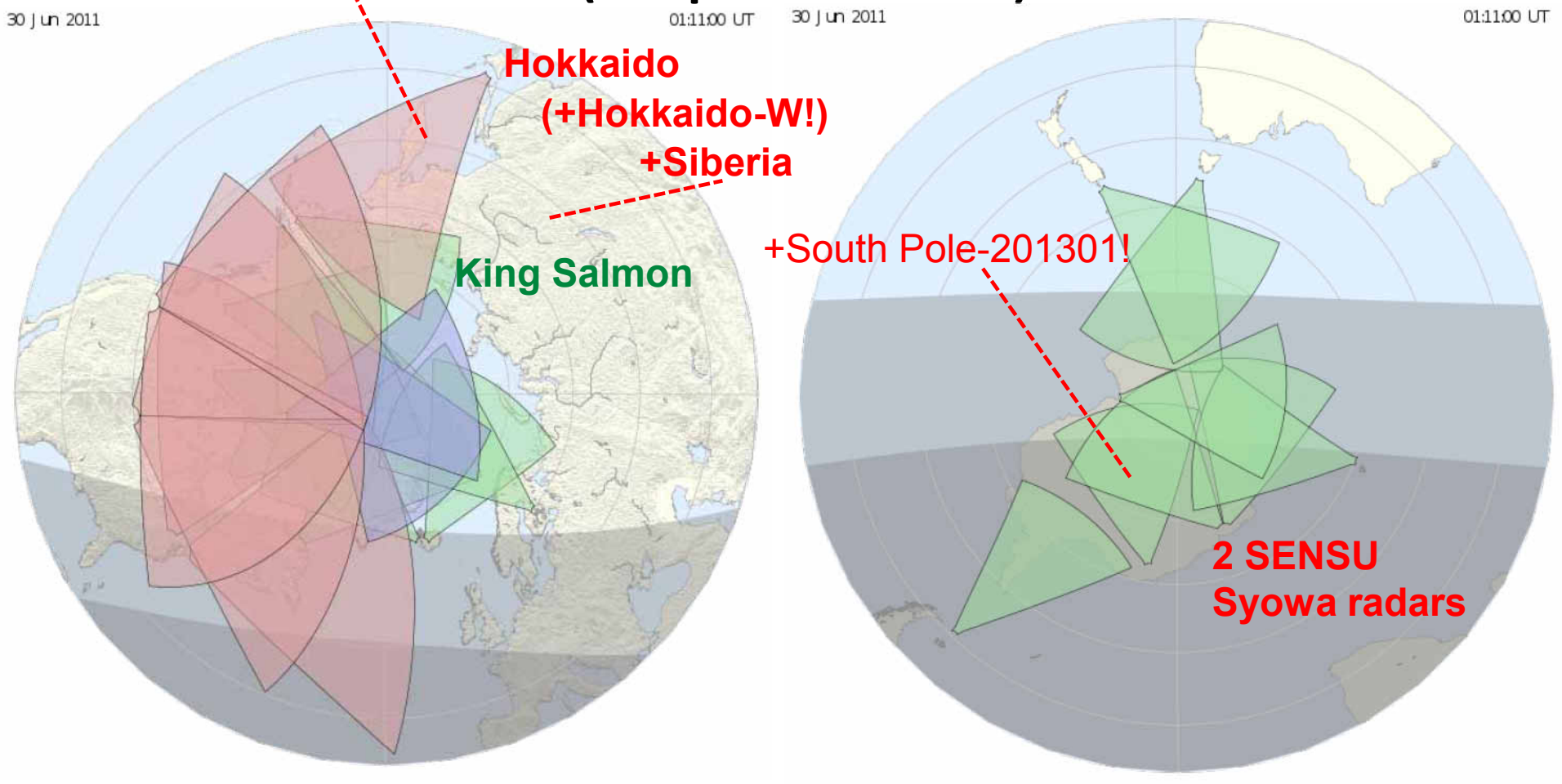
SuperDARNのRBSP(VAP)/ERGモードの運用について
SuperDARN RBSP(VAP)/ERG collaboration and operation modes

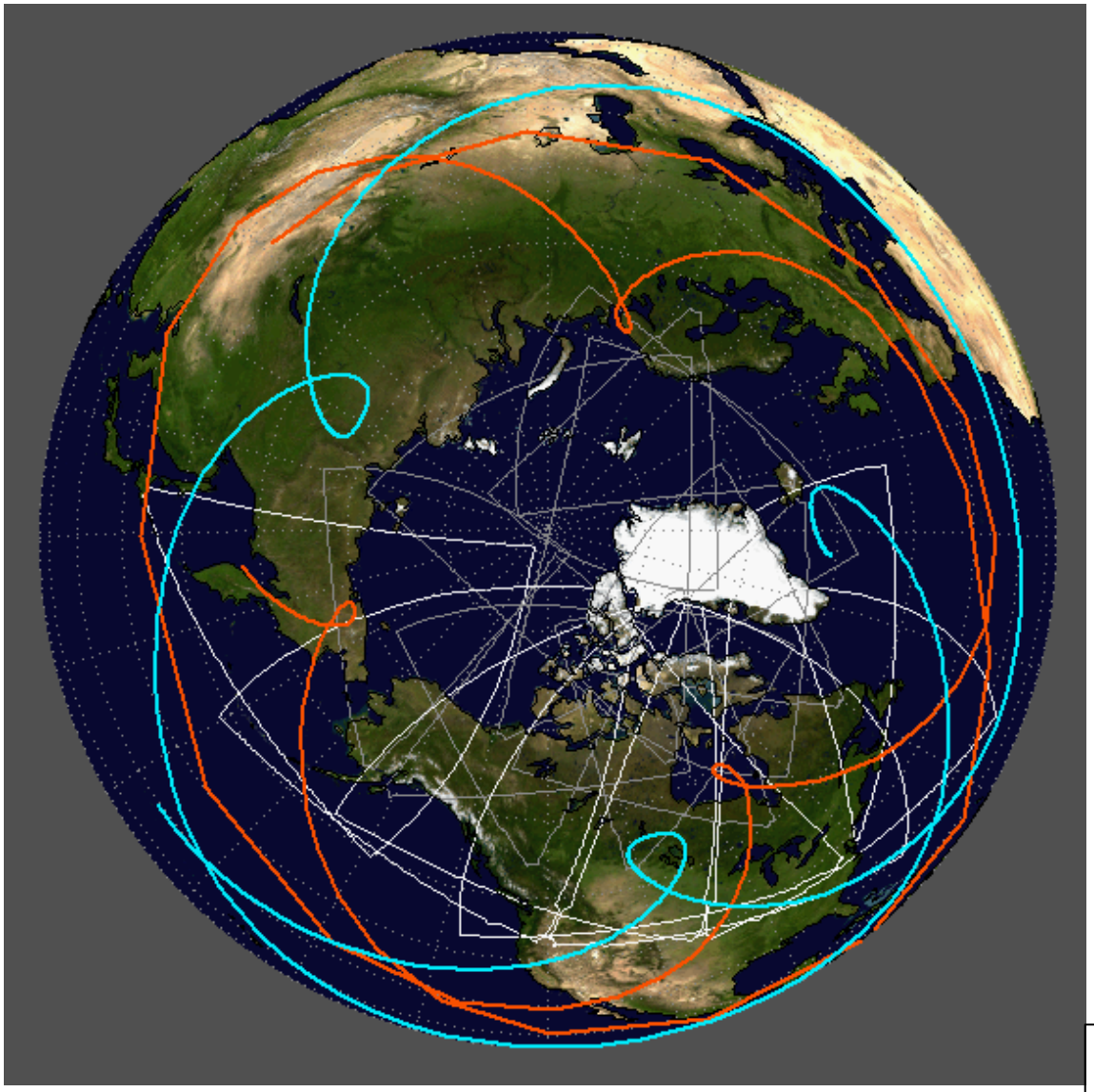
A. S. Yukimatu (NIPR),
N. Nishitani (STEL, Nagoya-U),
T. Nagatsuma (NICT)

Super Dual Auroral Radar Network (SuperDARN)



Number of operating HF radars: 28 (18 in the northern and 10 in the southern hemispheres) as of **June 30, 2011**

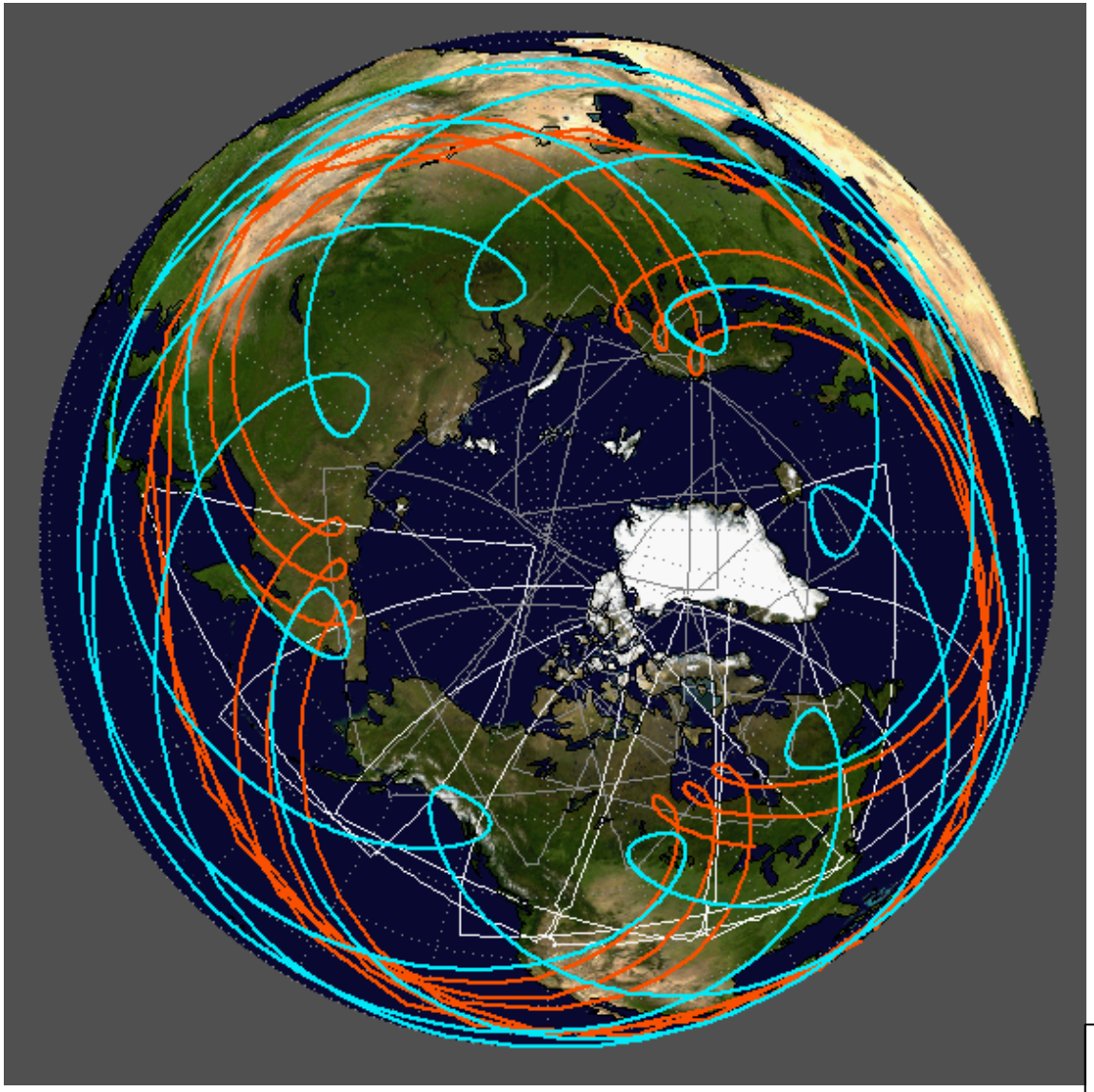
ERG and RBSP(VAP) footprints and SD FOVs



ERG
RBSP-A
for 24 hour

Courtesy of T. Hori

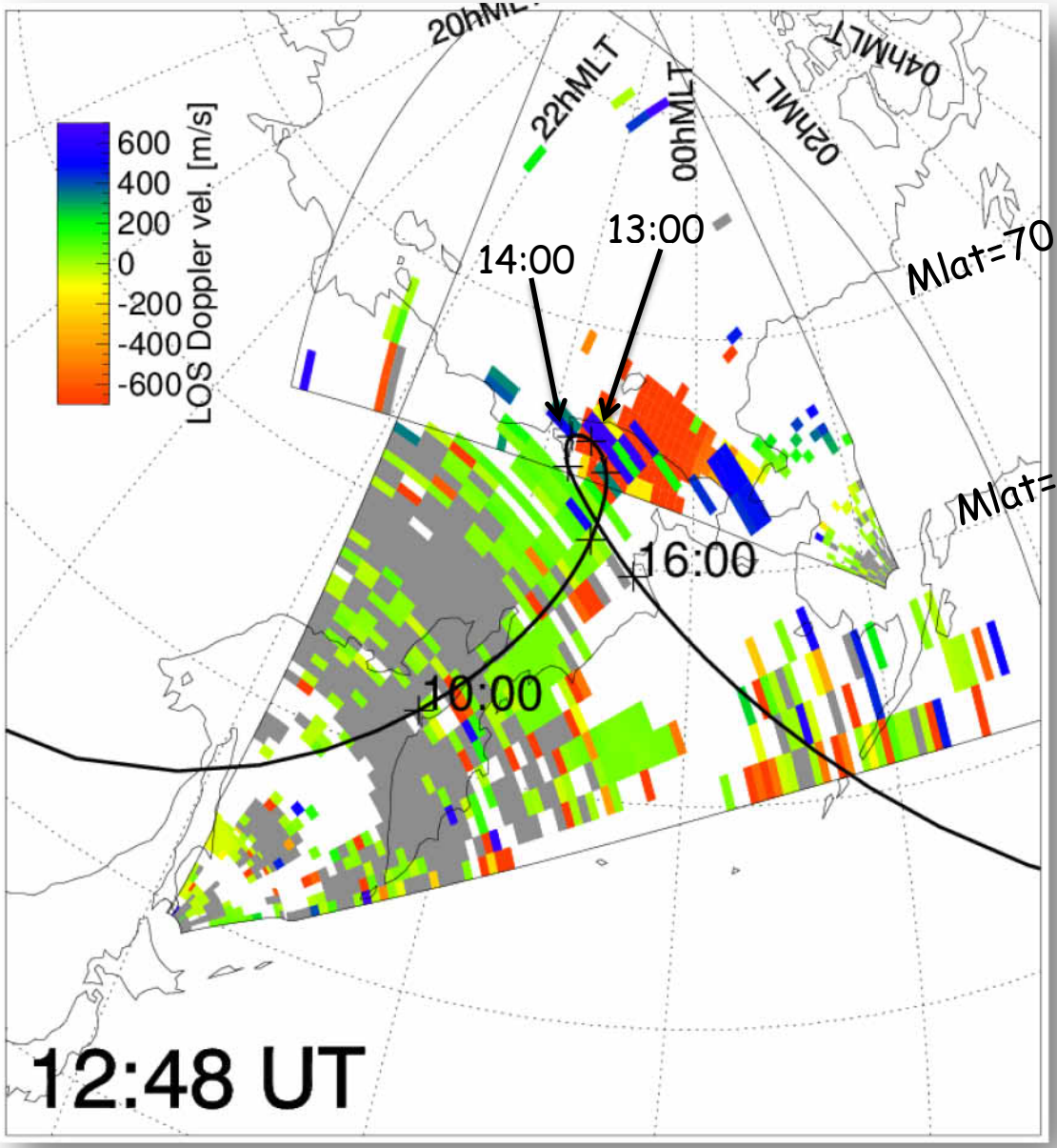
ERG and RBSP(VAP) footprints and SD FOVs



ERG
RBSP-A
for 72 hour

Courtesy of T. Hori

Courtesy of T. Hori



SuperDARN
Hokkaido &
King Salmon
for Jul. 17, 2007
12:48 UT

ERG satellite
footprint
for Jul. 17, 2016
10:00-16:00 UT

ERGのfootprintがSD radarの視野中の定点(near apogee)に長期間(約5時間)滞在するケース – 弱いsubstorm中のSAPS(西向高速flow)観測例

SD Satellite collaborations

- As an important ground-based tool covering considerable portions of high to mid- latitude ionospheres at both hemispheres, SuperDARN has extensively collaborated with satellite missions like Geotail, CLUSTER, IMAGE, THEMIS etc.
- RBSP was launched to investigate IM recently (Aug. 2012).
- SD has been expanding its FOVs to sub-auroral and mid latitudes (StormDARN) as well as very high latitude (PolarDARN).
- SD PI group has decided to collaborate with **RBSP** mission.
- SuperDARN did also express the collaboration with **ERG** mission.
- Since last summer, discussions about **how to operate SD in conjunction with RBSP** have started and test operation started since last autumn.
- PI agreement has been updated so that CT data are now immediately open to the public. (also, CDF data for TDAS…)

SD new PI agreement

- **More clearly stated about "Open data policy"**
- **5.3 Data Usage**
- The SuperDARN Executive Council aims to operate **a completely open data use policy for all data and will actively encourage the wider usage of the data by the scientific community.** The "Rules of the Road" as outlined in Appendix 9 describe the policy in detail. Provision may be limited by available resources and subject to reasonable specific requests and variable lead times for the release of data depending on the operating time category (see Section 4) as follows:
- (i) **Common Time data**
- **Common Time data are immediately available to all once data have been made available to all Principal Investigators.**
- Level 2 data products based on level 1 Common Time data can also be made available to all on the same time scale provided these data are produced by software approved by the SuperDARN Executive Council. A current example of a level 2 data product is the SuperDARN Map Potential. All Level 2 data products currently approved by the SuperDARN Executive Council are listed in Appendix 6. All plots and numerical data produced must be accompanied by a "Rules of the Road" notification outlined in Appendix 9.
- (ii) Special Time data.
- Access to Special Time data is restricted for a period of **one year** following the distribution of the data. During this time the data are for the exclusive use of the SuperDARN Principal Investigators whose radars operated in the Special time mode and Co-Investigators, Guest Investigators and Users designated by these Principal Investigators. **After one year access rights are the same as for Common Time data.** Exclusivity may be waived by the relevant Special Time investigator before this.
- (iii) Discretionary Time data
- (iv) Higher level Data Products

SD new PI agreement

- **Appendix 9**
- **SuperDARN "Rules of the Road" for Data Usage**
- **SuperDARN has an open data use policy – prior permission to access and analyse the data is not required.** However, the data user is strongly encouraged to establish early contact with any Principal Investigator whose data are involved in the project to discuss the intended usage. Data are often subject to limitations which are not immediately evident to new users. In addition, some data is embargoed for use by designated Investigators for a period of one year. SuperDARN and the organizations that contributed data must be acknowledged in all reports and publications (see Appendix 10). The SuperDARN Executive Council must be notified before data is redistributed through another data base. If you have any questions about appropriate use of these data, contact any SuperDARN Principal Investigator.

SD RBSP mode

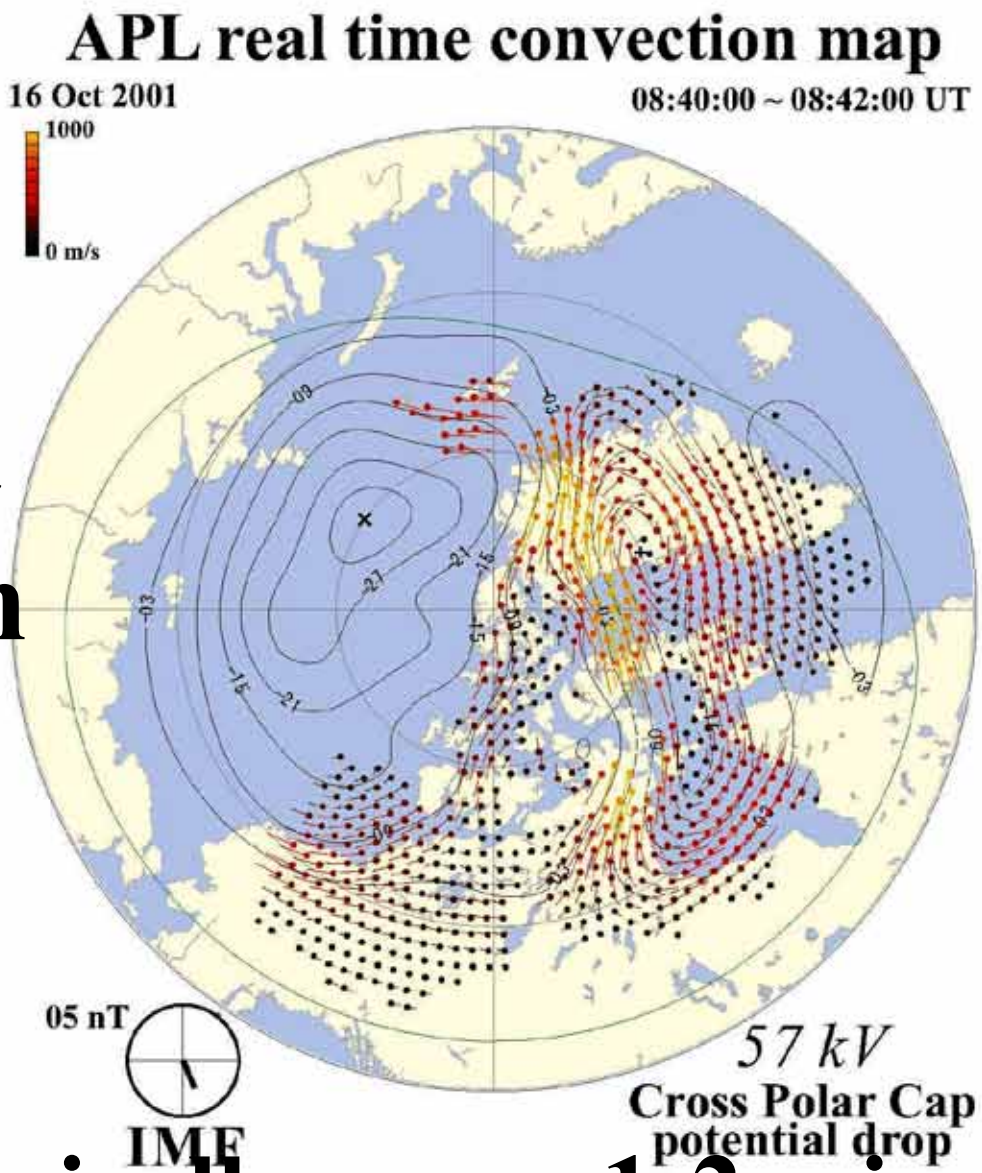
- SD may provide
  - **global convection maps** in quasi real time
    including mid- to high latitude (both hemi.)
    with typically 1-2 min temporal resolution
  - **ULF wave activities**
    over large MLT coverage
    from mid- to high latitude (both hemi.)
  - possibly higher spatial/temporal resolution
    data around satellite footprints
  - **any other requests/requirement?!**

SuperDARN

originally designed to obtain ...

global polar ionospheric plasma convection

(...Ray's dream...)



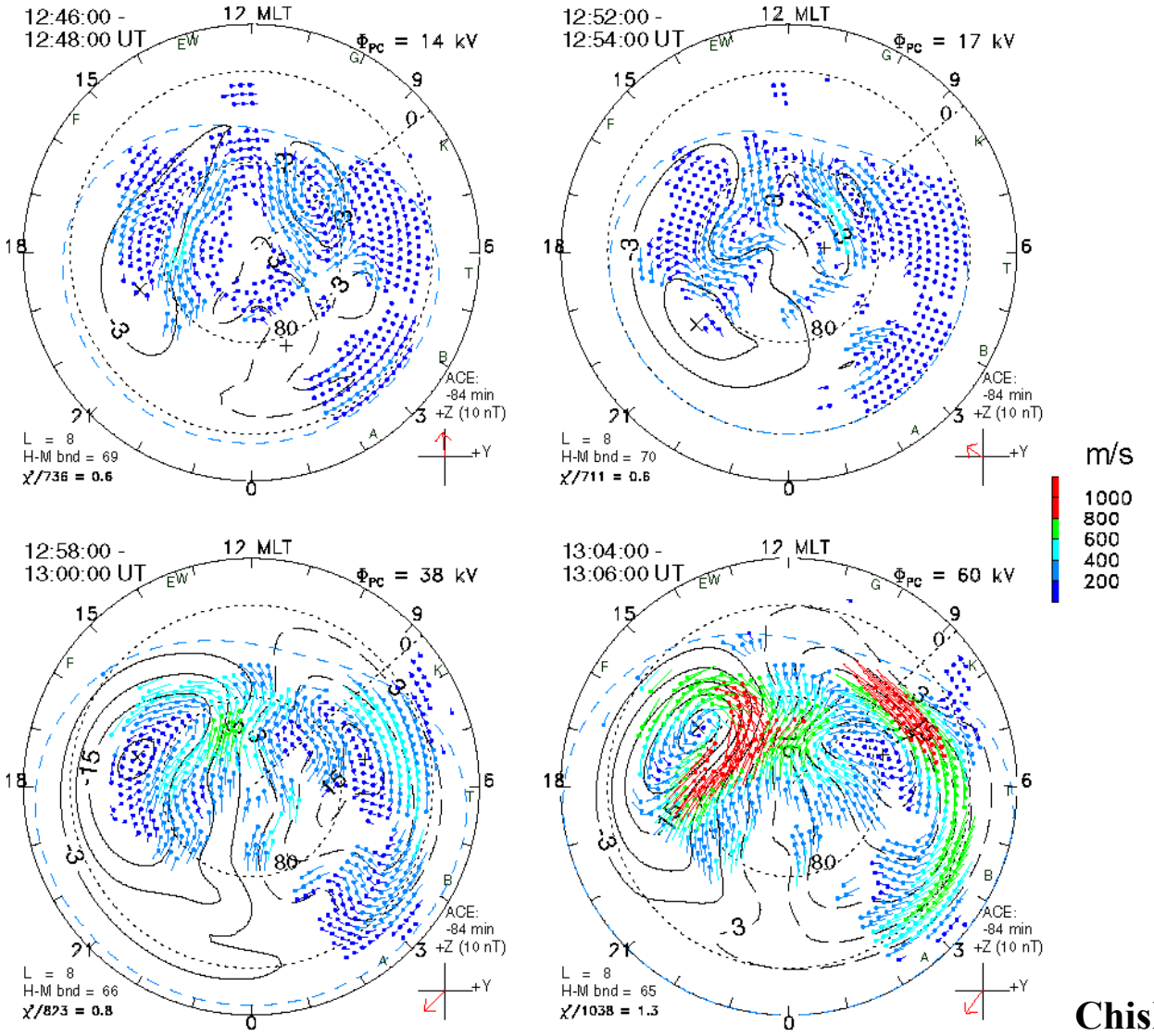
but as time goes by and SD grows, it has been realized that SD can address many more issues/scientific questions

typically every 1-2 min

dynamics of global convection

especially when IMF Bz, By drastically changes

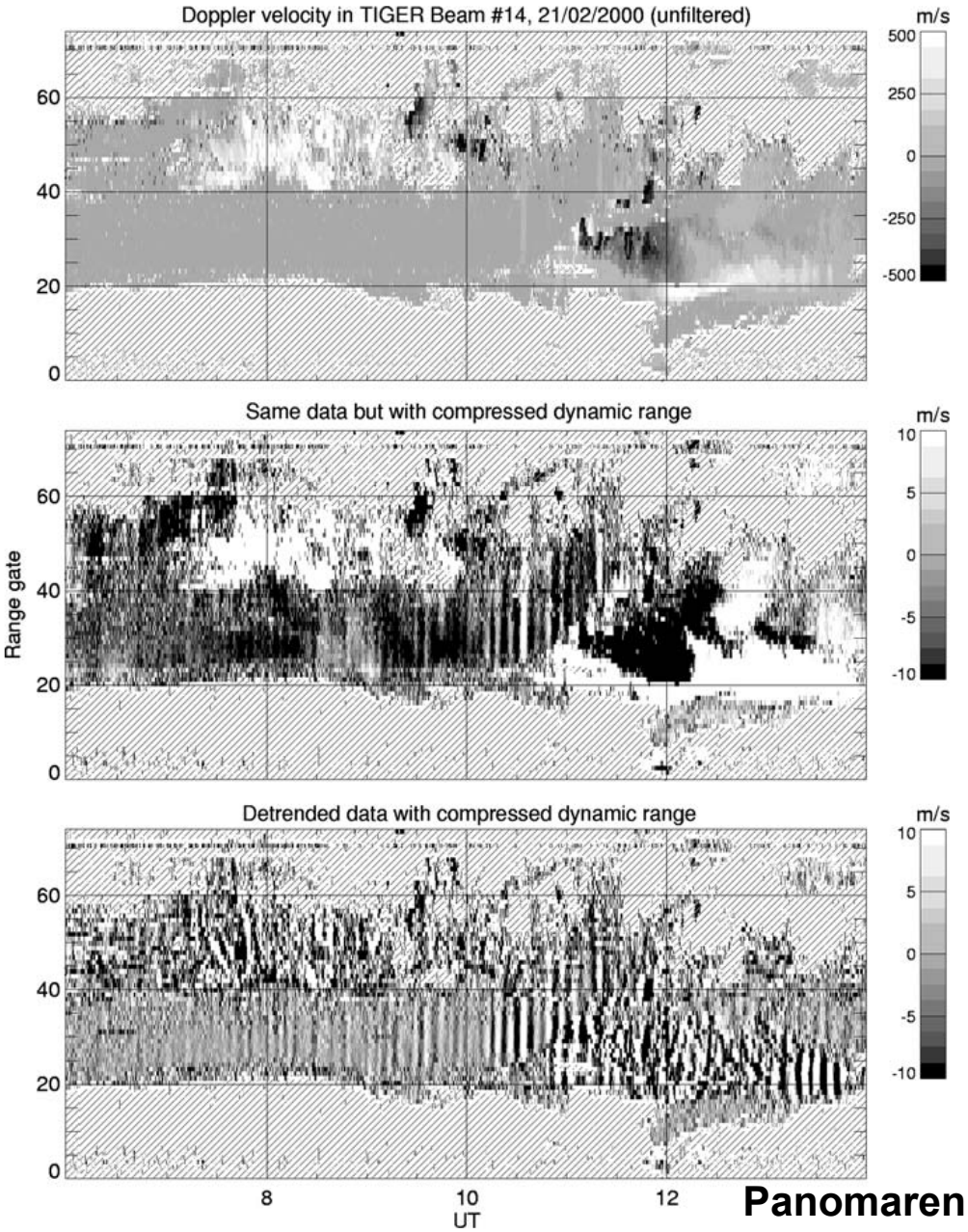
12/03/2001



- ~12:56 : IMF Bz>0
  stable condition
  4 cell pattern @ 12:46
  3 cell pattern @ 12:52
- 12:56 : abrupt Bz<0 change happened!
- ~2min later aft Bz change : reconfiguration from Bz>0 pattern to Bz<0 pattern within 2-4 min.
- ~10 min later : enhance & strengthen Bz<0 pattern

Chisham, et al., Surv. in Geophys., 2007

SD MHD waves monitoring

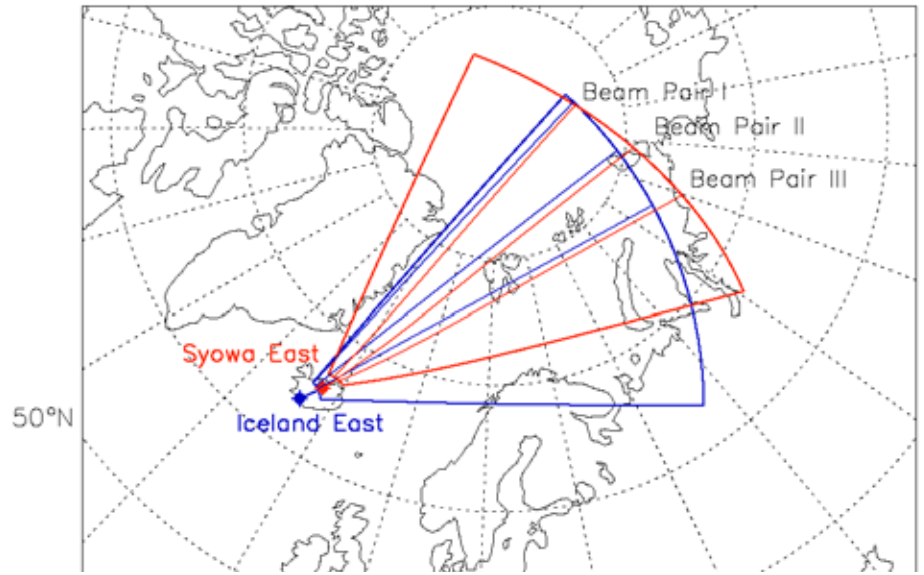


- Pc3~Pc5 ULF waves detectable w/ SD
- ULF waves also found in ground scatter echoes
- High-m ULF detectable
- 2-D and large MLT-Latitudinal distribution of ULF activities can be monitored

Panomarenko et al., GRL, 2003

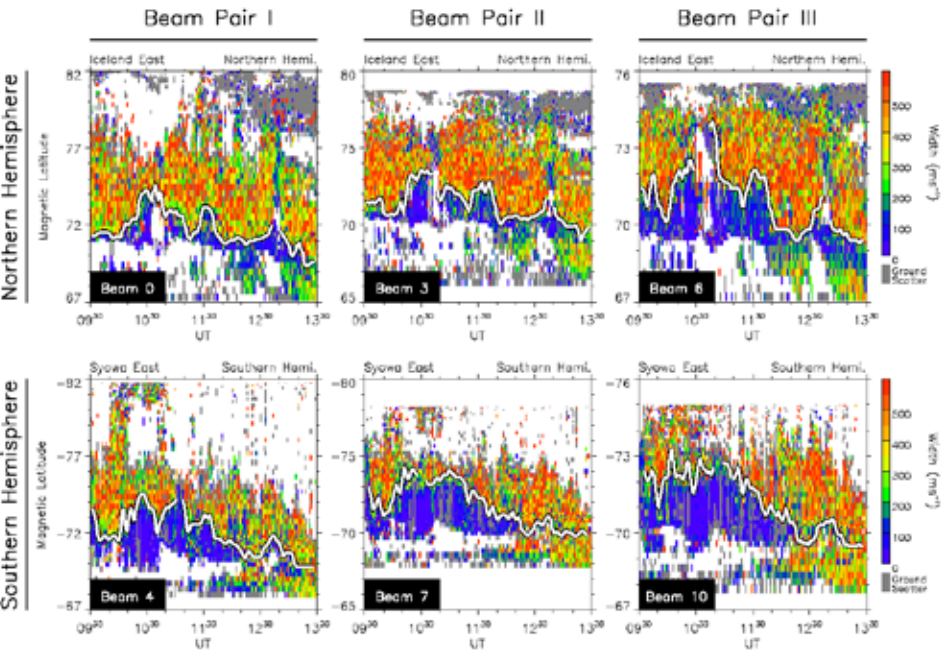
SWB/OCB/FTE/Reconnection

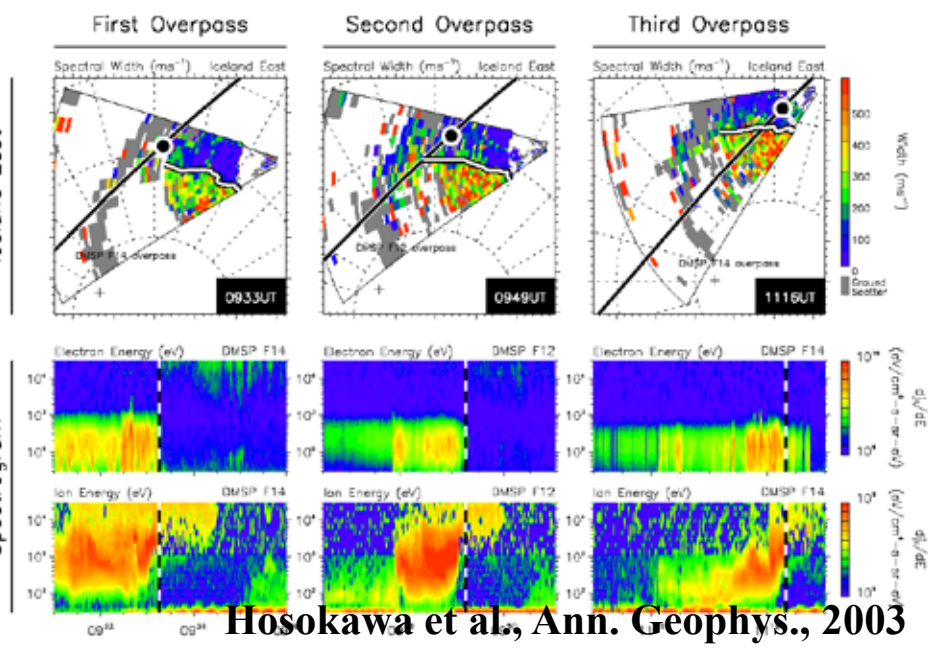
Spectral Width Boundary(SWB) as proxy of OCB?



- Doppler Spectral Width sharply changes around Convection Flow Reversal (polar: higher width)
- Can Spectral Width Boundary (SWB) be a proxy of OCB (open/closed field line boundary)?

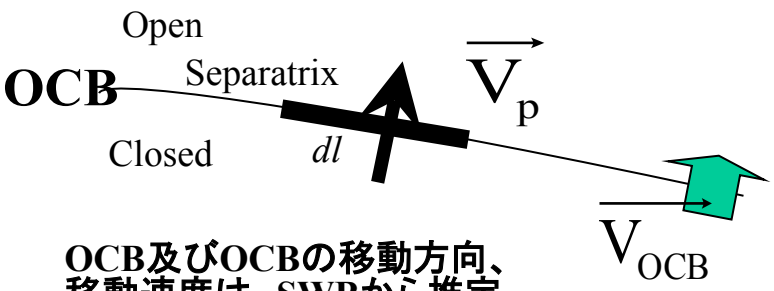
Hosokawa et al., Ann. Geophys., 2003



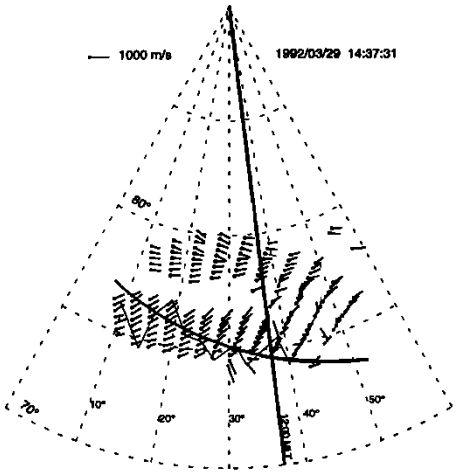


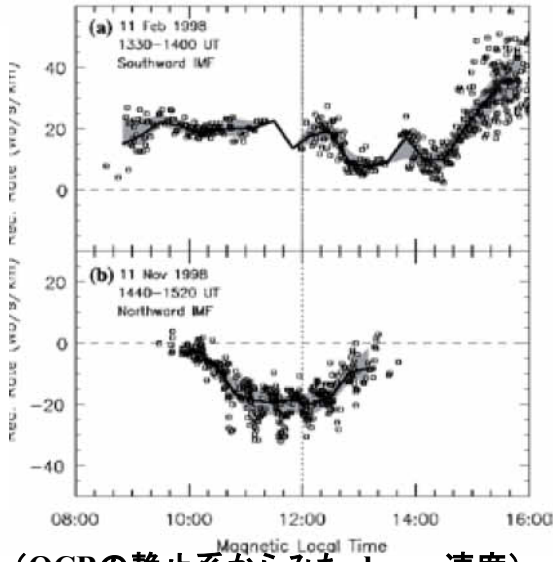
Hosokawa et al., Ann. Geophys., 2003

estimate of Reconnection Rate



OCB及びOCBの移動方向、
移動速度は、SWBから推定。





（OCBの静止系からみたplasma速度）

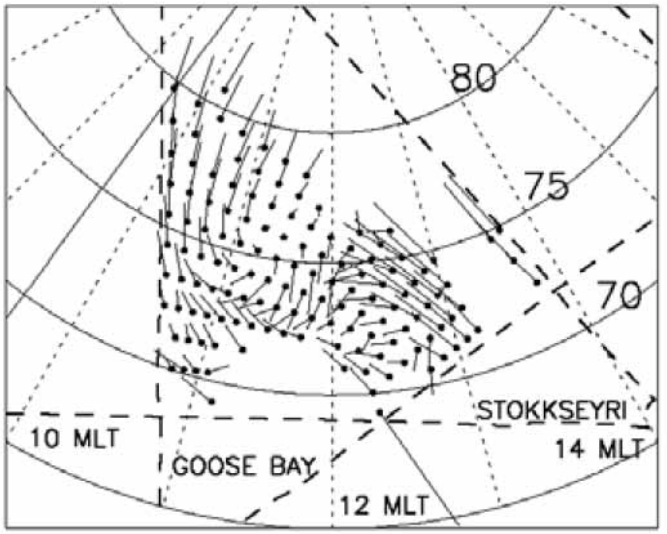
OCB上長さdlの境界線を超えて
単位時間あたりに輸送される磁束Fは、、

$$dF/dt = \vec{B} \times \vec{V} \cdot \vec{dl}$$

$$\vec{V} = \vec{V}_p - \vec{V}_{OCB}$$

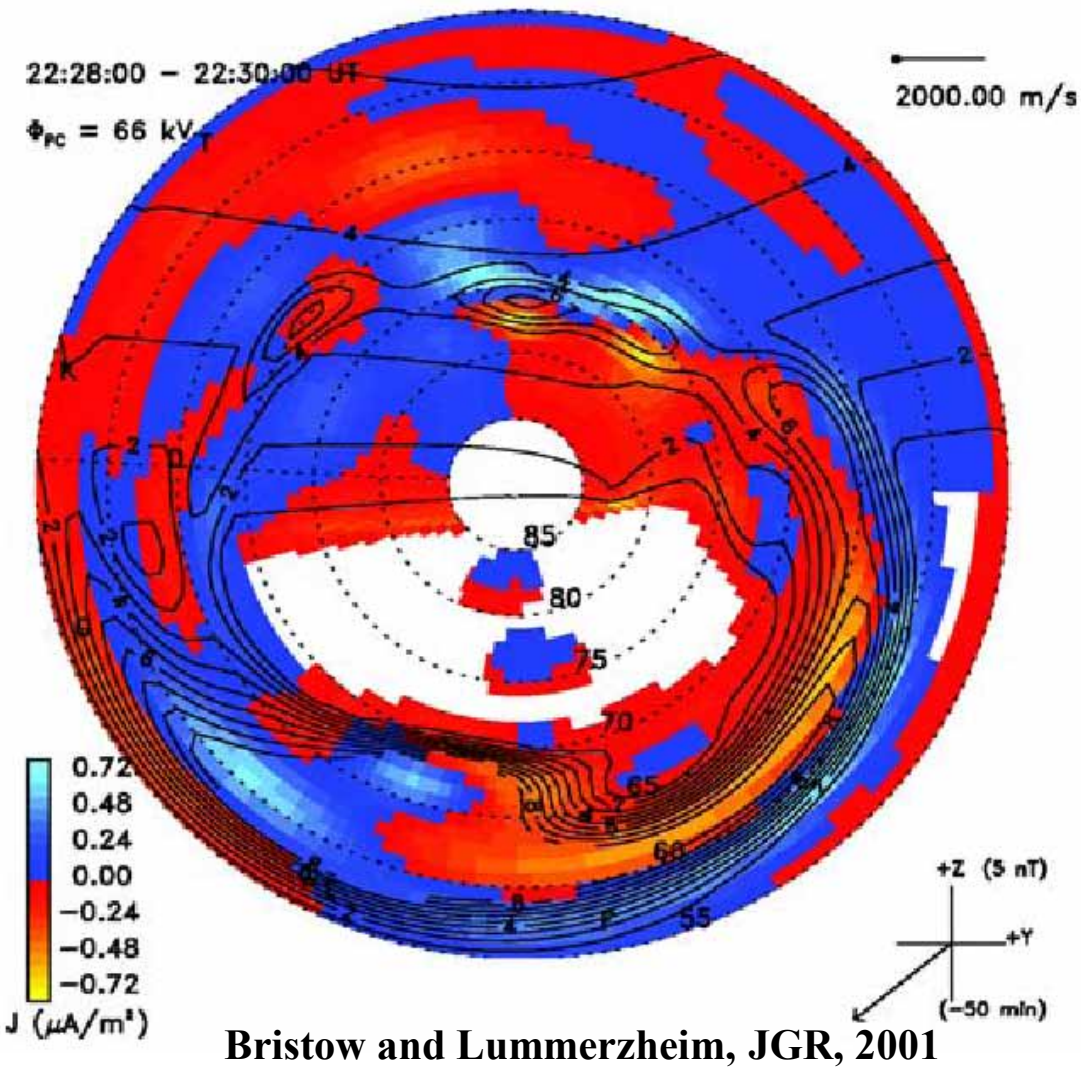
Testing Reconnection theories

- antiparallel reconnection hypothesis
  - places where antiparallel happen
- component reconnection hypothesis
  - subsolar point
  - high sheath B strength & sheath flow stagnate



Baker et al., JGR, 1997
Pinnock et al., Ann. Geophys., 2003,
Chisham et al., Ann. Geophys., 2004b
Coleman et al., JGR, 2001

deduction of global FAC system

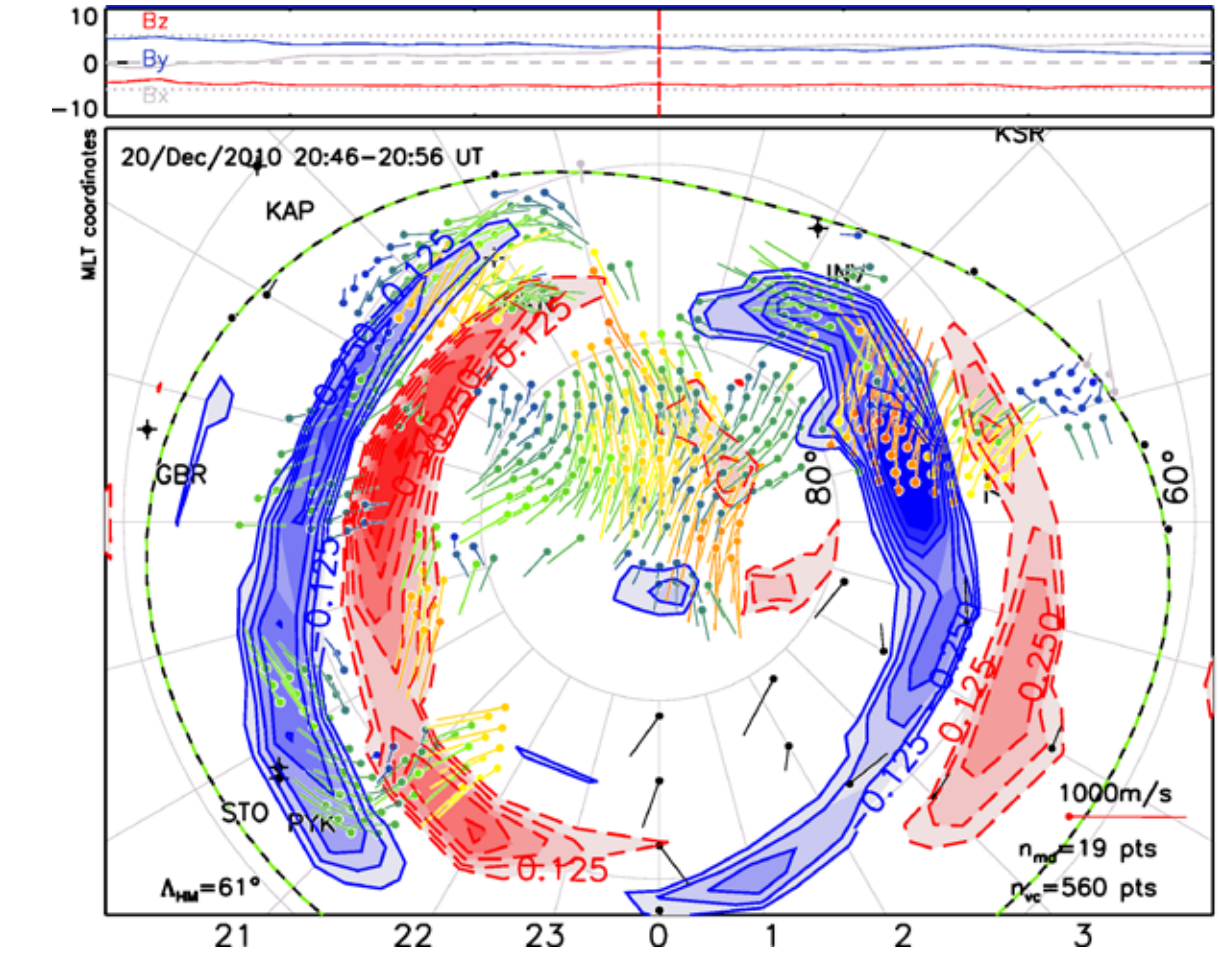


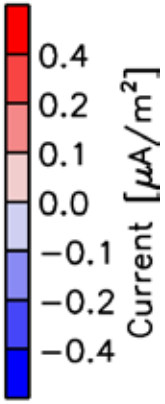
Bristow and Lummerzheim, JGR, 2001

- From Polar UVI image auroral luminosity, particles precipitation into ionosphere can be inferred, which can then be combined with model for photo-ionization etc and Pedersen、Hall conductivity（Σ_P, Σ_H）at whole polar region can be deduced. (possible problems on reliability at low luminosity regions)
- By combining the deduced Σ_P, Σ_H & SD 2-D global E fileds, $J_\perp$ can be obtained and FAC, $J_{//}$ can then be inferred (by $\nabla \cdot J_\perp$).
- up(red)/down(blue) ward FAC、& Σ_P (contour)
- extensive validation with satellite magnetometer data etc requied

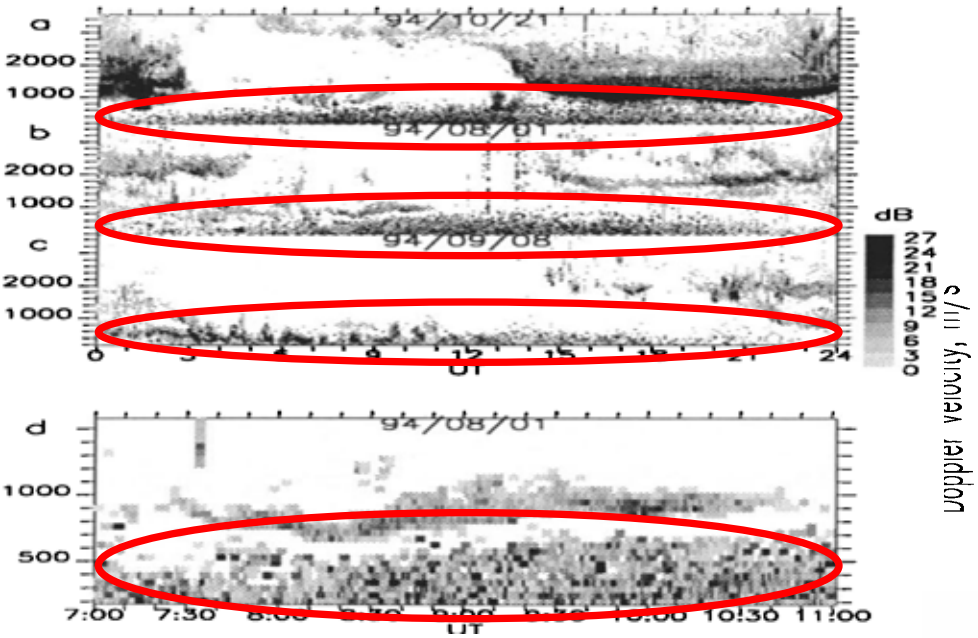
●昼間側は太陽紫外線の影響がdominantで∇∑は小さく、∇xVによるFACの評価でもよいが、夜側は、aurora活動による∇∑が大きく、∇xVからFACの評価は困難であることもわかる。

SuperDARN & AMPERE

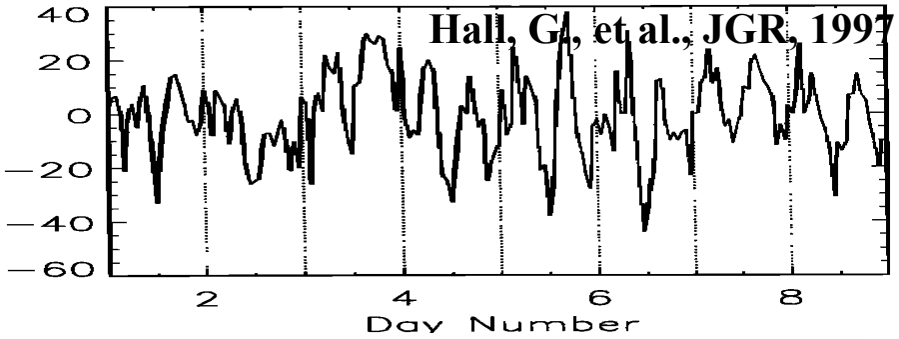


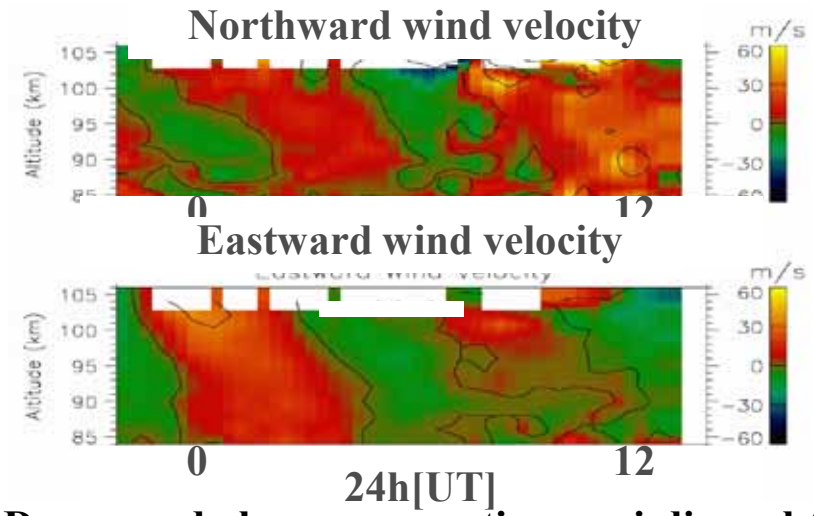


neutral winds by SD meteor echoes

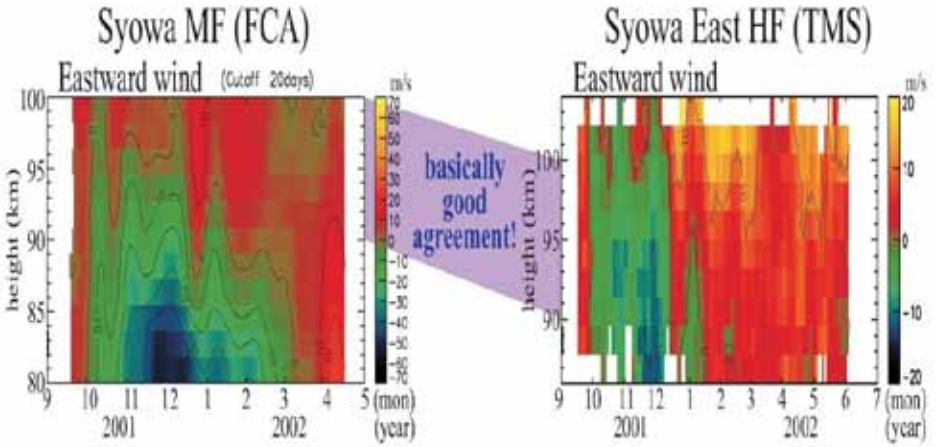


- GNREs(Grainy Near-Range Echoes)
  - mostly found @ r<400km
  - random echo power distrib.
  - both in ranage & in time
- not depend on geomagnetic activity
  - periodic appearance mostly every day





Downward phase propagating semi-diurnal tide



Comparison with MF radar obs. - Good Agreement

●SD⇒meteor radar network!

more topics related to mid-lat SD

- SC/Storm – Pc5 etc.
- Overshielding effect
- Disturbance dynamo theory – corotation lag…
- Region identification?
- …

SD scheduling and RBSP

- 3 categories
  CT (Common Time) >=50% of each month
  getting 1-min global convection pattern
  (THEMIS mode – terminated this year)
  DT (Discretionary Time) <=30%
  ST (Special Time) <=20%
- Proposed 2 months before each target month, final version fixed 1 month before the month
- Difficult to allocate **storm time special mode**
- **Newly introduce "Trigger-mode" for RBSP**

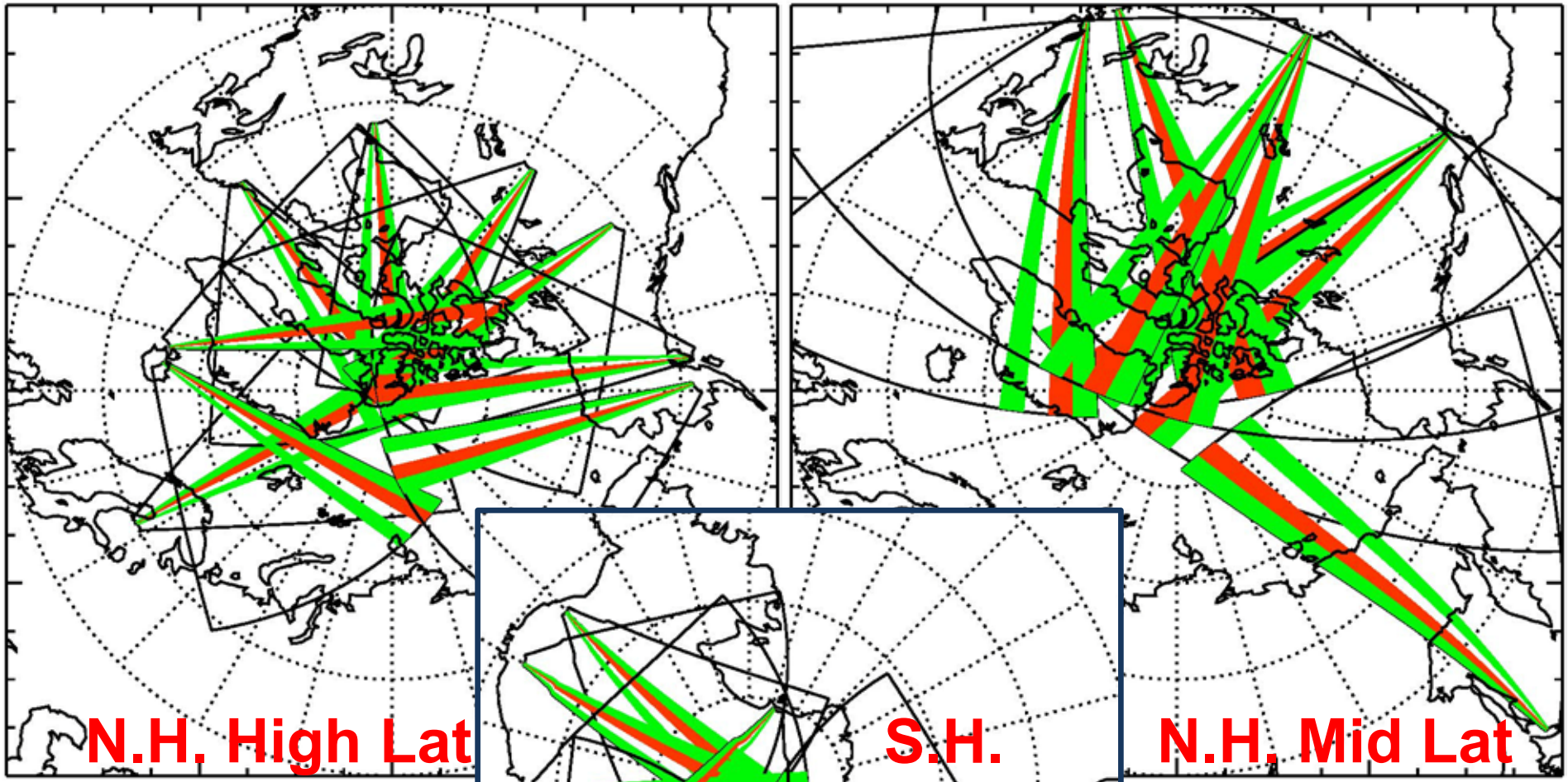
SD RBSP mode (test)

- **CT-TRIG** mode introduced
  When a storm happens, SD changes from the normal CT mode to RBSP special mode during CT
  - CT-TRIG data will be open like CT data
- **ST-APOG** mode introduced
  ST-APOG mode is scheduled in advance for period when RBSP is near apogee whose footprint is in one of SD FOVs
  – ST program but CT CPID will be assigned so ST-APOG data will be open like CT data
- Override
  CT-TRIG overrides ST-APOG
  Priority btw CT-TRIG and DT decided by each PI
  Priority btw ST and CT-TRIG decided by each PI
- Tested Oct – Dec, 2012, will be reviewed Jan 2013

SD RBSP mode – CT-TRIG (plan)

- Currently proposed and agreed mode:
- Global scan with 3-beams mini-scan interleaved **for global convection patterns and ULF activities**
- Integration time for each beam: 3 sec
  Range resolution: 45km (or less?)
- **Global convection patterns** every **2 min**
  high temporal resol. 3-beam data every **18 sec**.
- **Beam sequence:**
  0, S1, 1, S2, 2, S3, 3, S1, 4, S2, 5, S3, 6, S1, …
- 3 beam selection: N-1, N, N+2(or 3)
  where N: poleward beam if possible
- **Trigger algorithm** - many debate….

SD RBSP mode – CT-TRIG (plan)



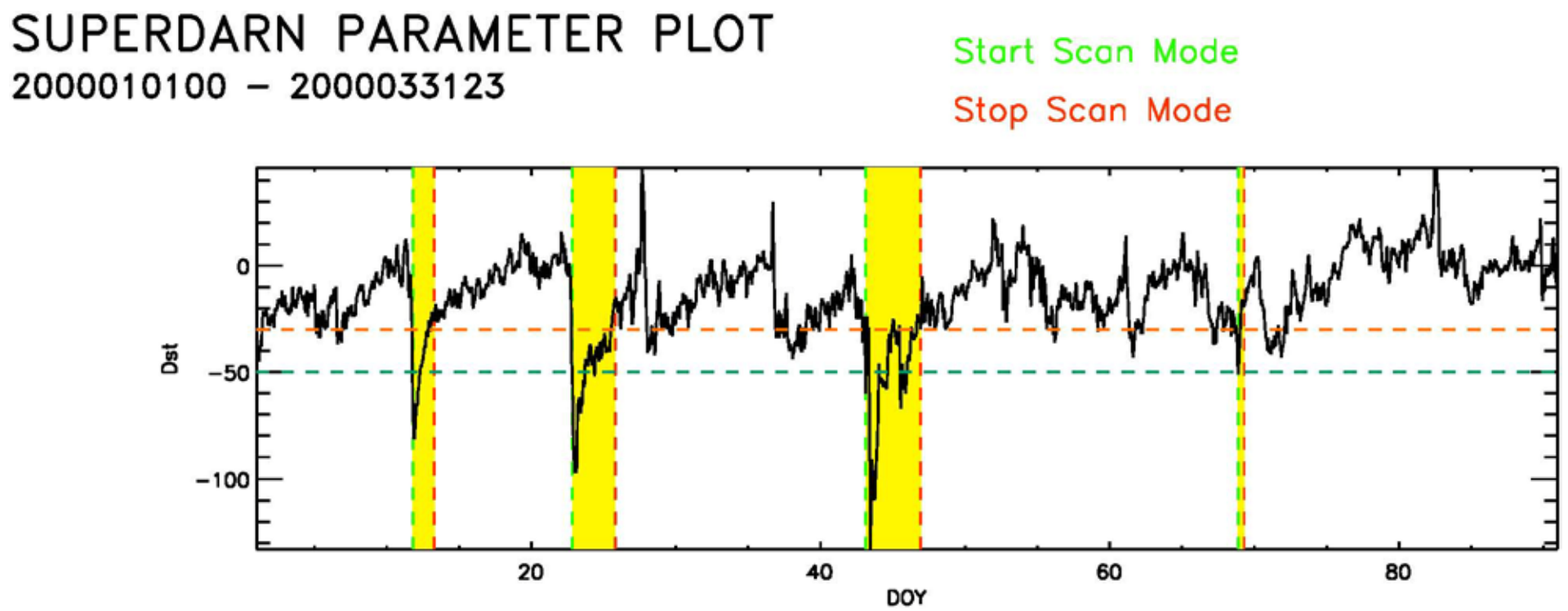
Global Scan +
3 camp. beams
(n-1, n, n+2)

by Tim Yeoman

Triggers to initiate RBSP mode

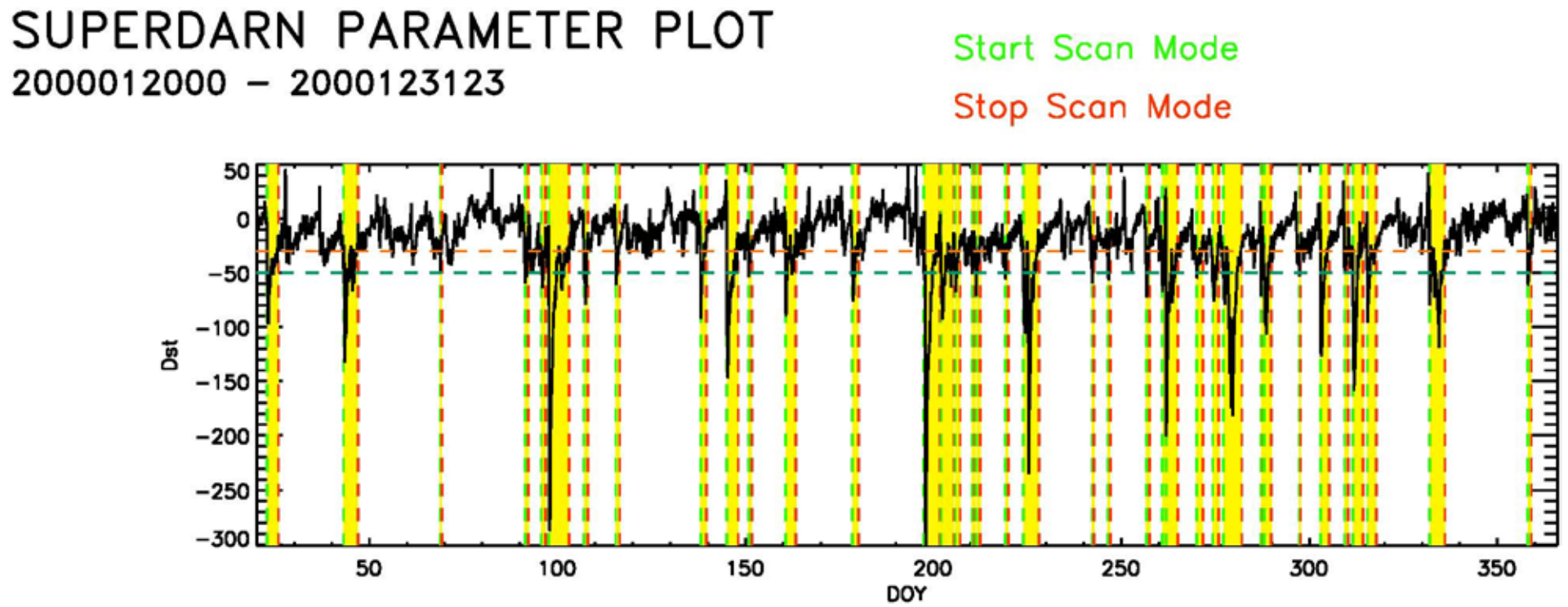
- Many debates…
- Current proposal
- **Simple Dst triggering algorithm**
- Started/triggered by Dst <-50nT
- End countdown started by Dst >-30nT
- Countdown time: 6 hours
  (terminated if Dst stays >-30nT for 6hours)
- Avoid false positive (誤検出)

Simple Dst trigger algorithm

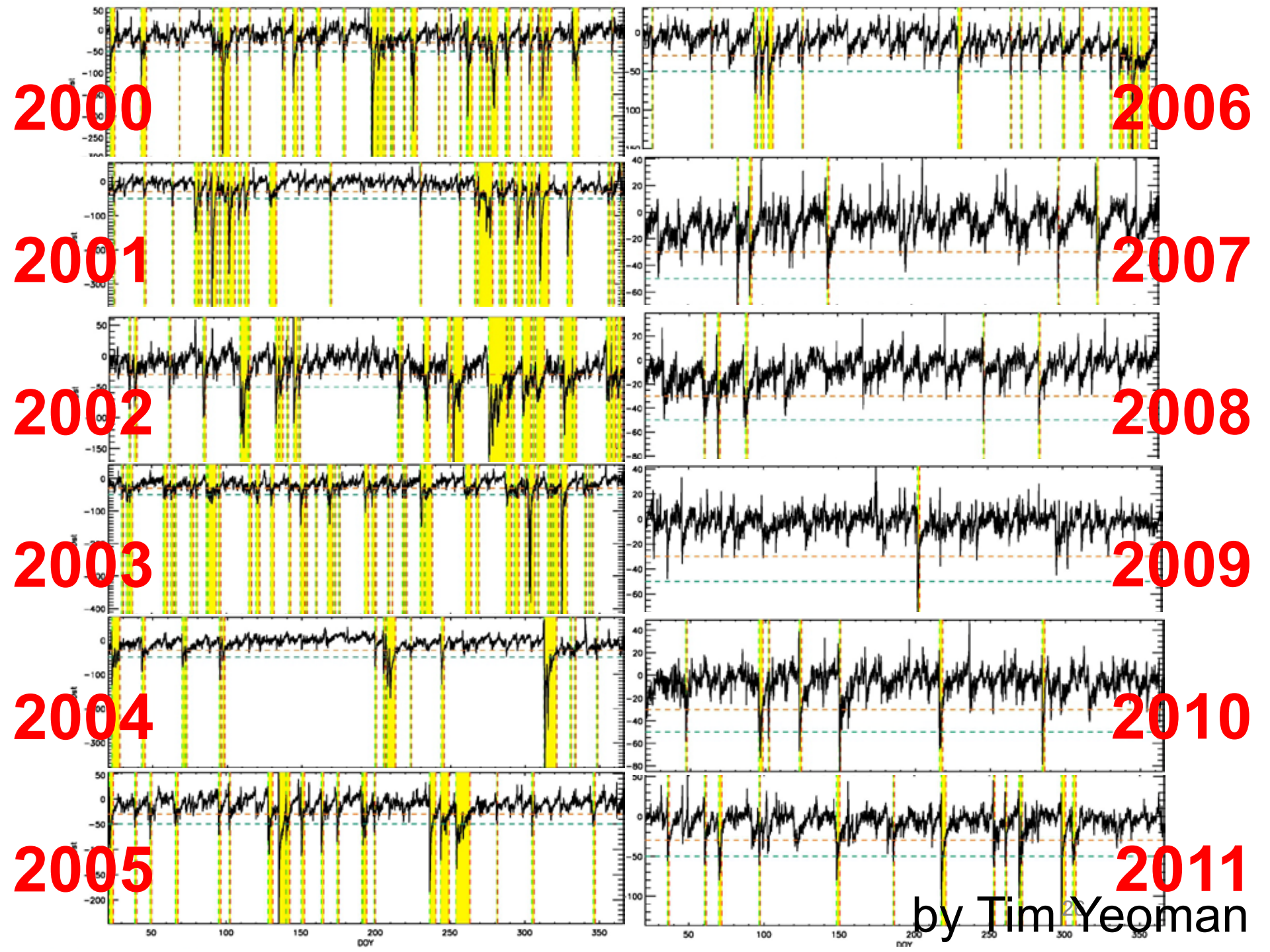


by Tim Yeoman

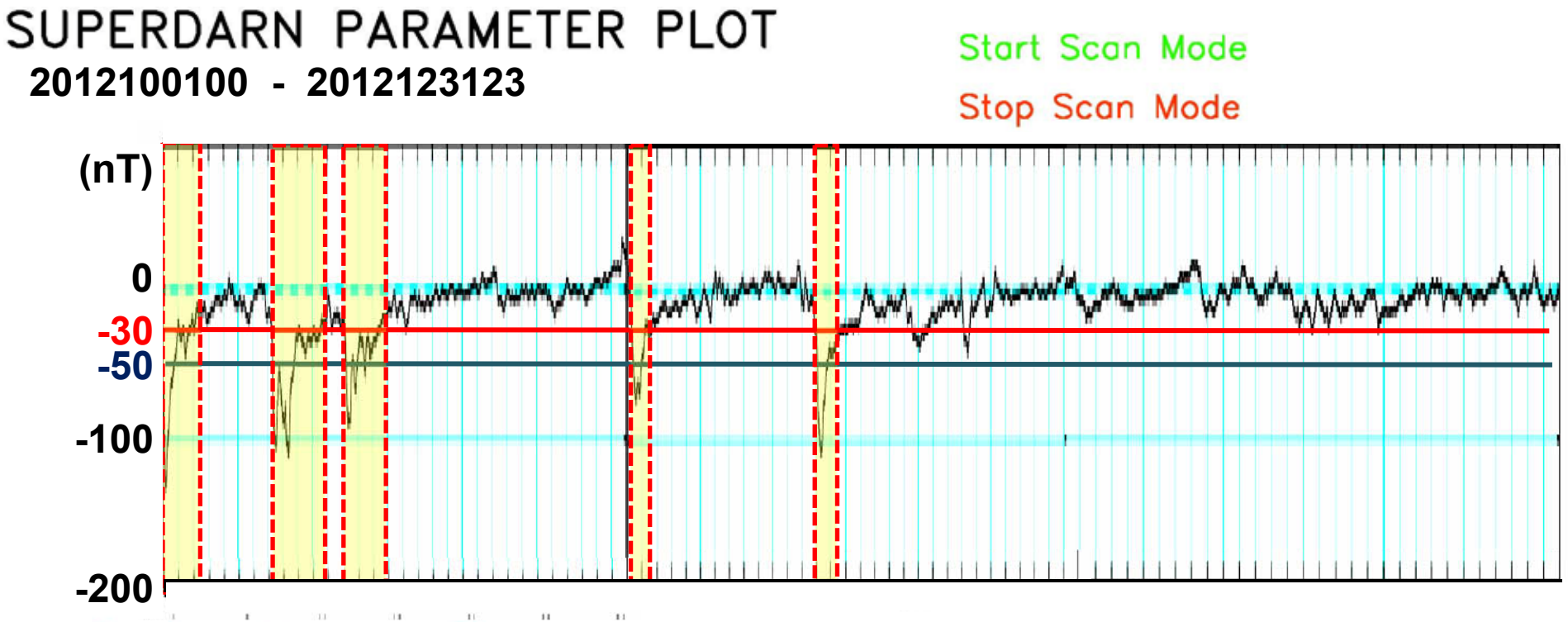
Simple Dst trigger algorithm



by Tim Yeoman


2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
DOY
DOY
by Tim Yeoman

Simple Dst trigger algorithm



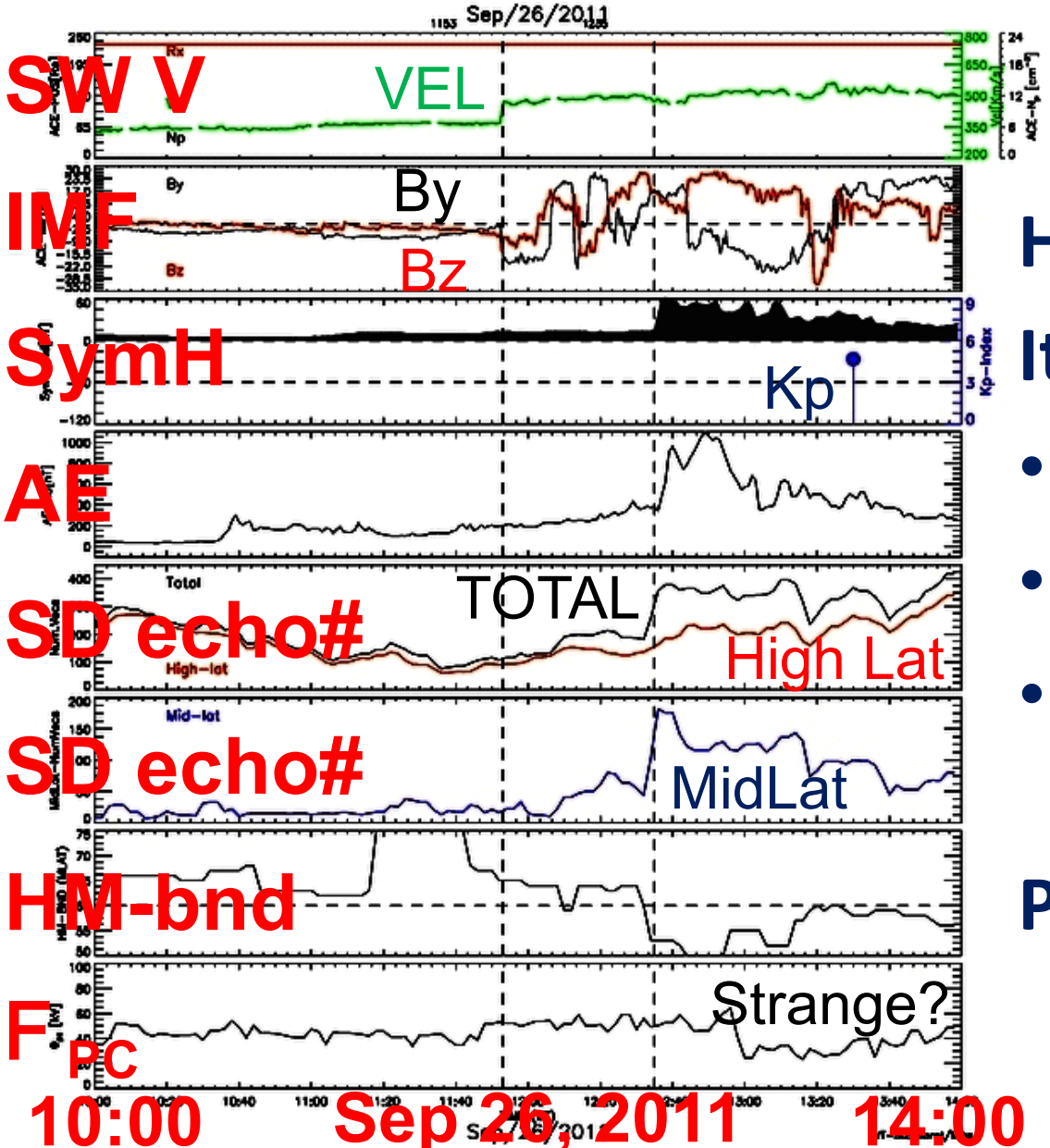
Simple Dst trigger algorithm

Year	SSN	trigger time %	Max duration	Min duration	Mean duration	# of triggers
2000	120	21%	127	47	9	37
2001	110	20%	232	15	58	29
2002	104	24%	293	11	69	29
2003	64	25%	131	8	48	44
2004	40	10%	200	15	55	15
2005	30	15%	228	10	59	21
2006	15	9%	130	12	44	17
2007	8	1%	36	14	25	5
2008	3	2%	35	16	26	5
2009	3	0.4%	35	35	35	1
2010	16	3%	62	14	35	7
2011	56	6%	81	16	36	13
2012	**66**	**9%**	**109**	**15**	**43**	**19**

- Does not miss anything too significant
- Does not run too often
- No false positives (important)
- Reasonable trigger condition to start with
  until something more sophisticated is developed.

by Tim Yeoman(+Sessai)

Dst Trigger mode – problems



However,

It does miss…

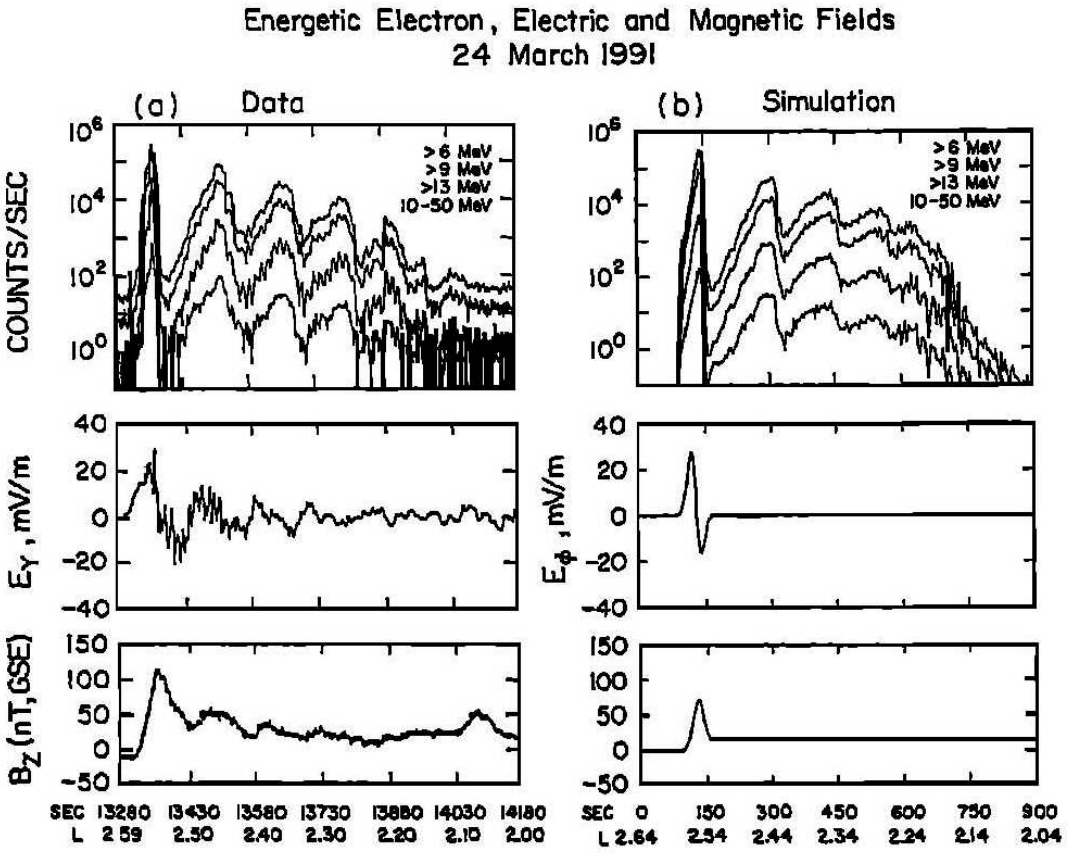
- **Pre-onset**
- **Onset**
- **Early Development of the storm cycle**

Prediction required…

by Mike Ruohoniemi

Triggered by SCs?

- Some storms -no SC
  - depending on CME/CIR storms
- Miss SCs themselves!
  – possible drift echo event with large electric field…



X. Li et al., GRL, 1993
Miyoshi & Kataoka, 2005
Kataoka & Miyoshi, 2007

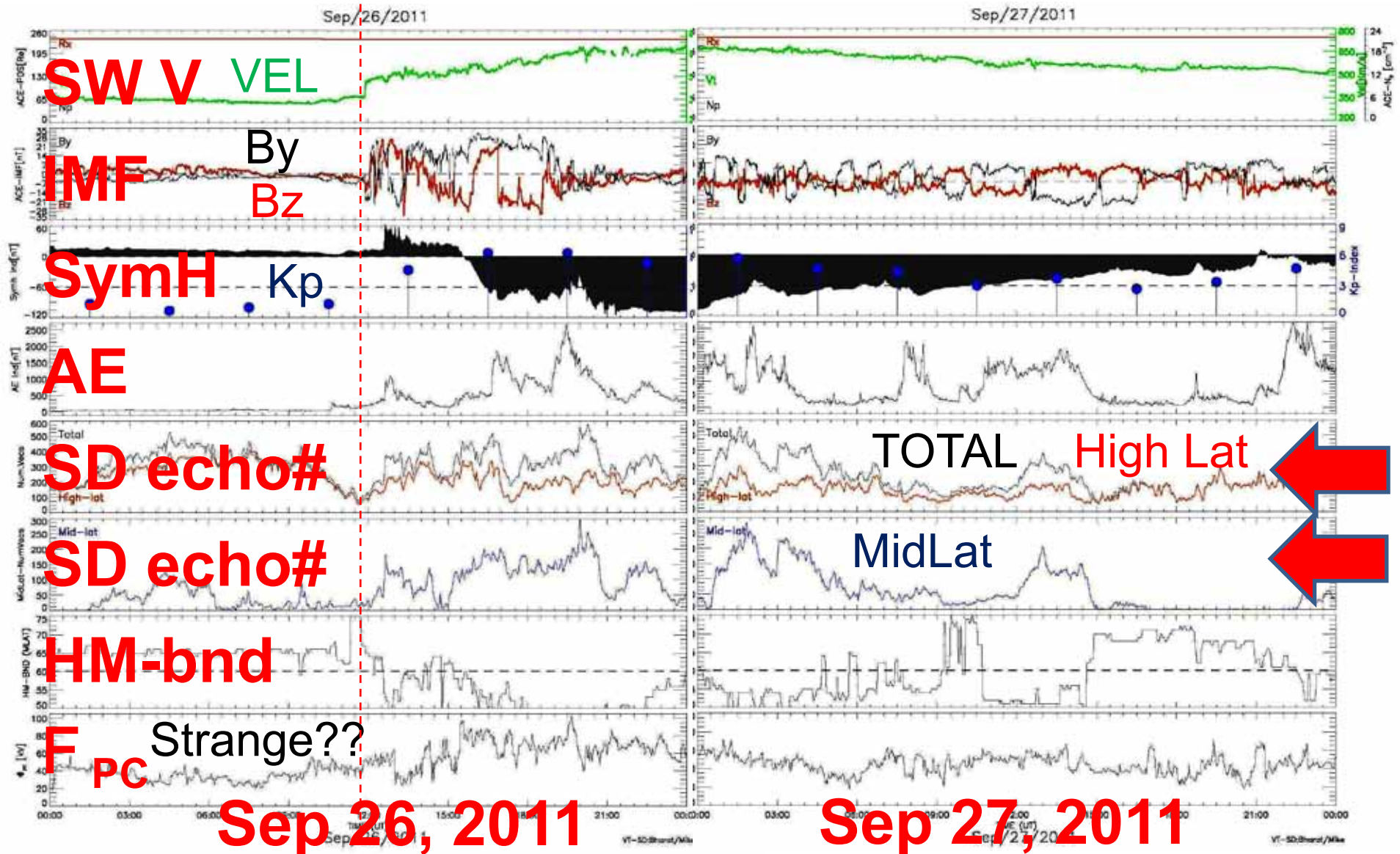
Triggers to initiate RBSP mode

- Many arguments on how to trigger RBSP mode
- Triggered by **SCs**? – no SC CME/CIR, miss SCs!!!
- by **IMF (Bz) and Solar Wind parameters @ L1**?
- by **Simulation predictions**?
- by RBSP special campaign mode trigger if any?
- should always run RBSP during all CT time for longer monitoring including quiet period?!
- Some algorithm for cases of **false positives**
- Important scientific targets esp. space weather, too! Great if SD-Jpn/ERG group to propose for better ideas!

SD ST-APOG mode

- A radar whose FOV has RBSP footprint during apogee periods (for several hours?):
  some sophisticated special mode?
  e.g., high spatial/temporal resolution mode?
- Other radars during ST-APOG period:
  run normal CT mode?
  run RBSP CT-TRIG mode?
- Scientific target?!?
- SD not fixed the details of this mode
  - inputs will be welcome…

SD echoes during a Storm



Summary

- SD-RBSP(VAP) collaboration is about to be started. SD also expressed support for ERG mission.
- Currently, SD's RBSP(VAP) mode is discussed in SD community.
- Triggering mechanism (how to trigger RBSP mode) is one of the important issues – and it is one of the important research targets, too.
- Sci. targets during ST-APOG mode - investigated
- Discussions on SD-RBSP mode will be valuable for planning of the future ERG-SD collaboration.