NICT National Institute of Information and Communications Technology

Comparison Of Ionospheric Azimuthal Pc5 Plasma Oscillations With Geomagnetic Pulsations On The Ground And In Geostationary Orbit

Kaori Sakaguchi*, T. Nagatsuma, T. Ogawa
NICT, Japan,

T. Obara
JAXA, Japan

O. Troshichev
AARI, Russia

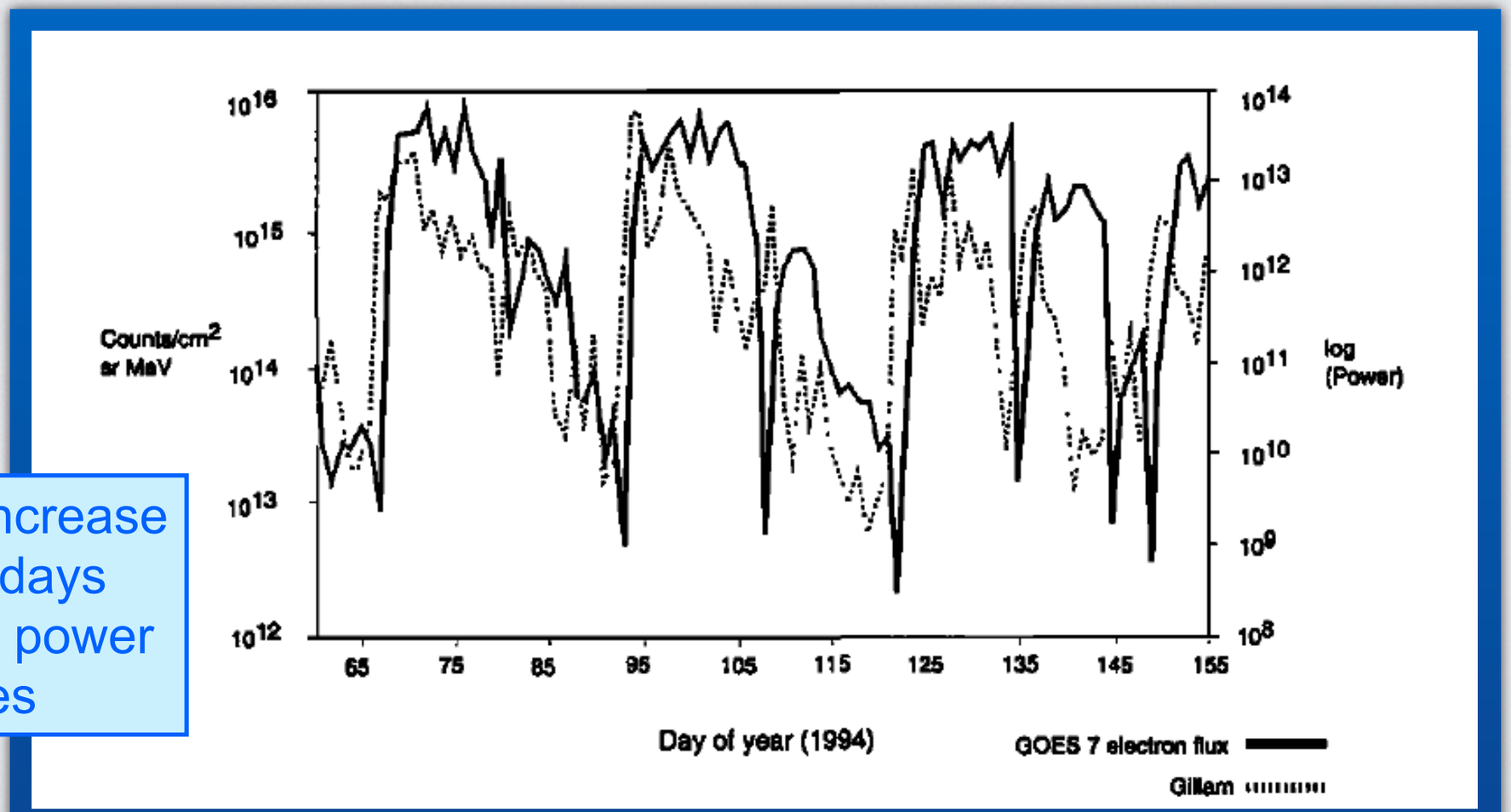
SuperDARN workshop @Hanover, NH, USA, May 31 - June 4, 2011

ULF/Pc5 Wave

Pc5 pulsation [Jacob et al., 1963]

regular and continuous magnetic field variations with periods of 150-600 s

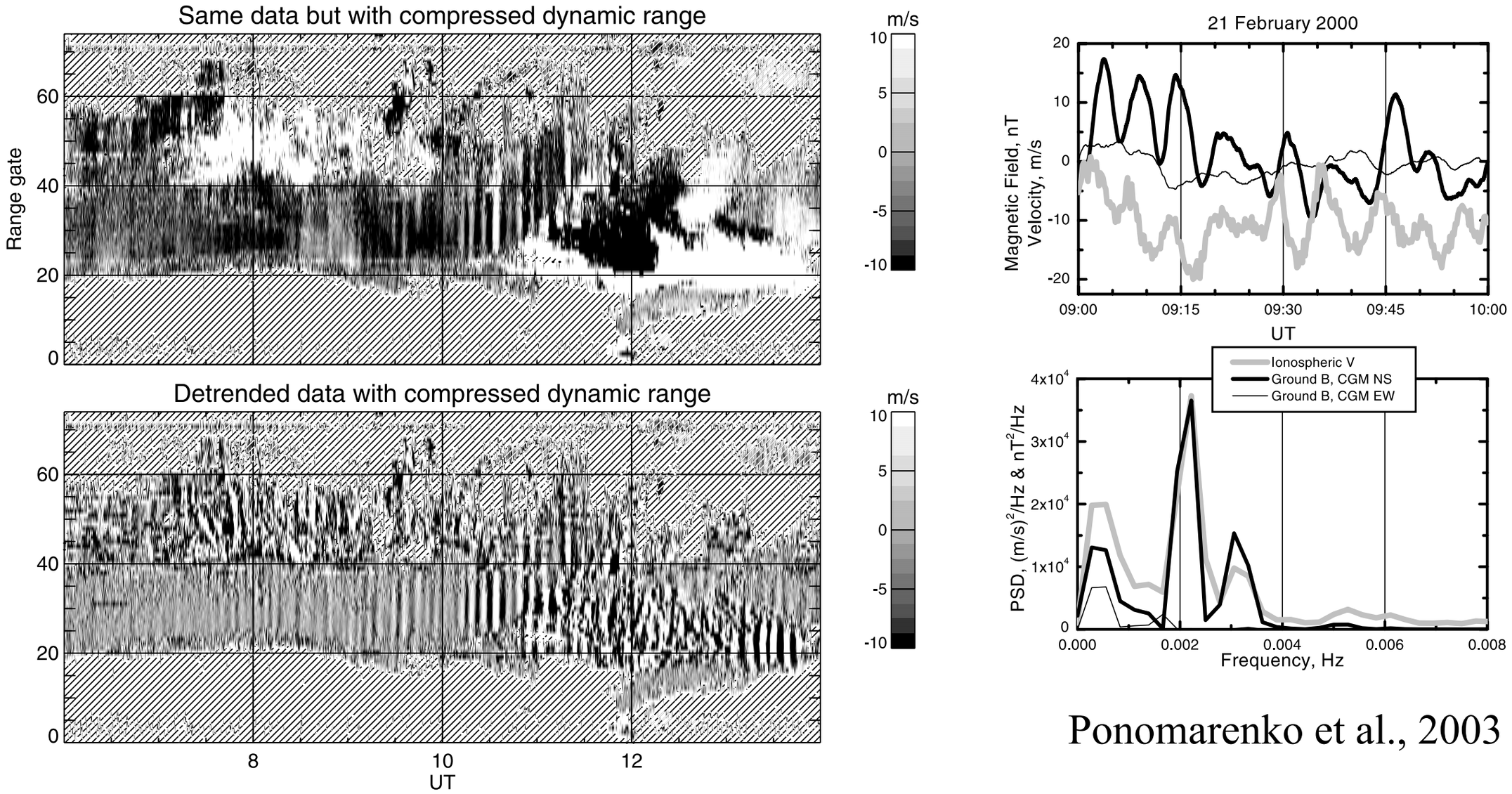
playing an important role in transport and acceleration of energetic electrons in the Earth's outer radiation belt via drift resonance interaction [Elkington et al., 2003]



[*Rostoker et al.*, 1998]

electron flux increase after a few days following Pc5 power enhances

SuperDARN Observations Of Pc5 Waves

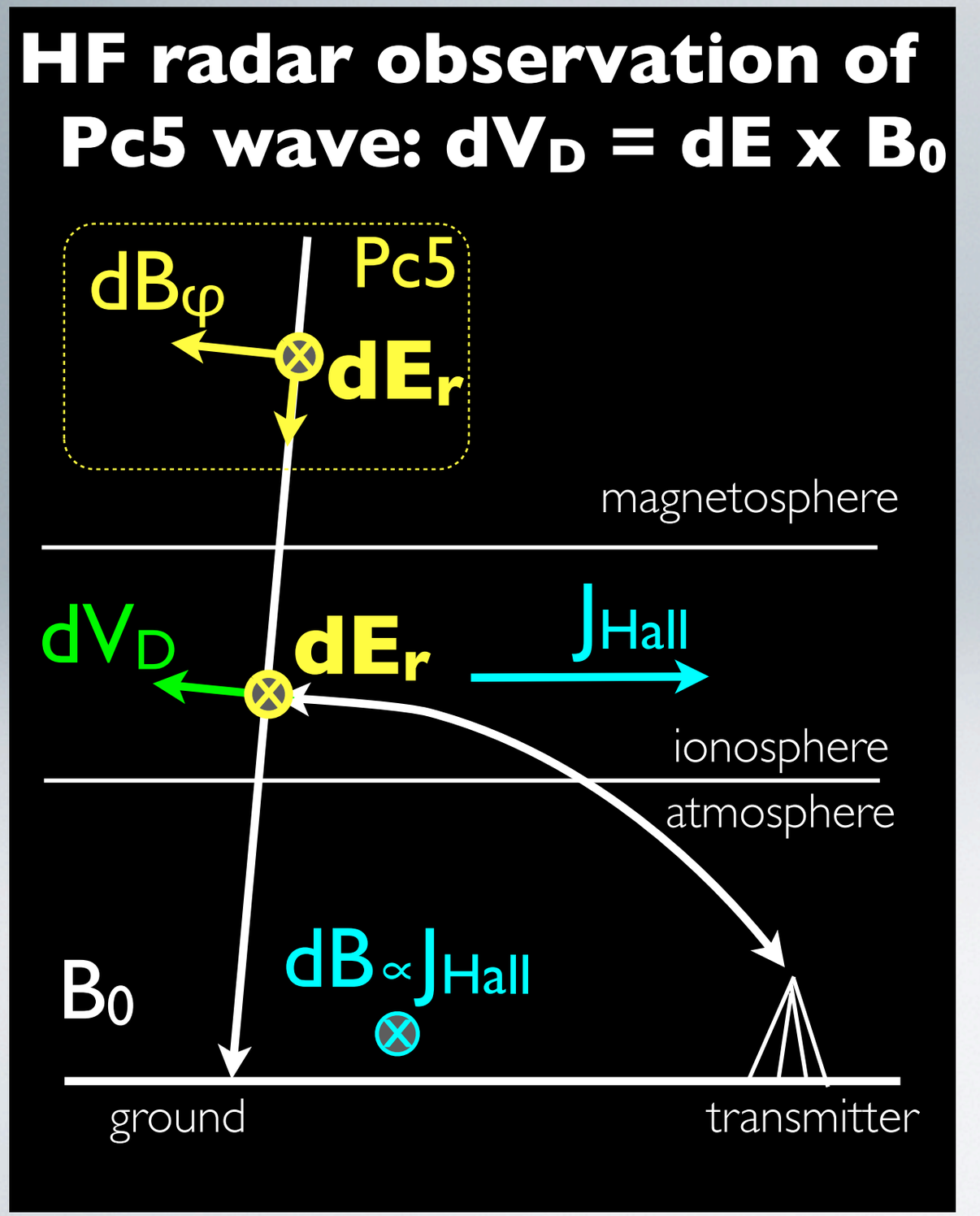


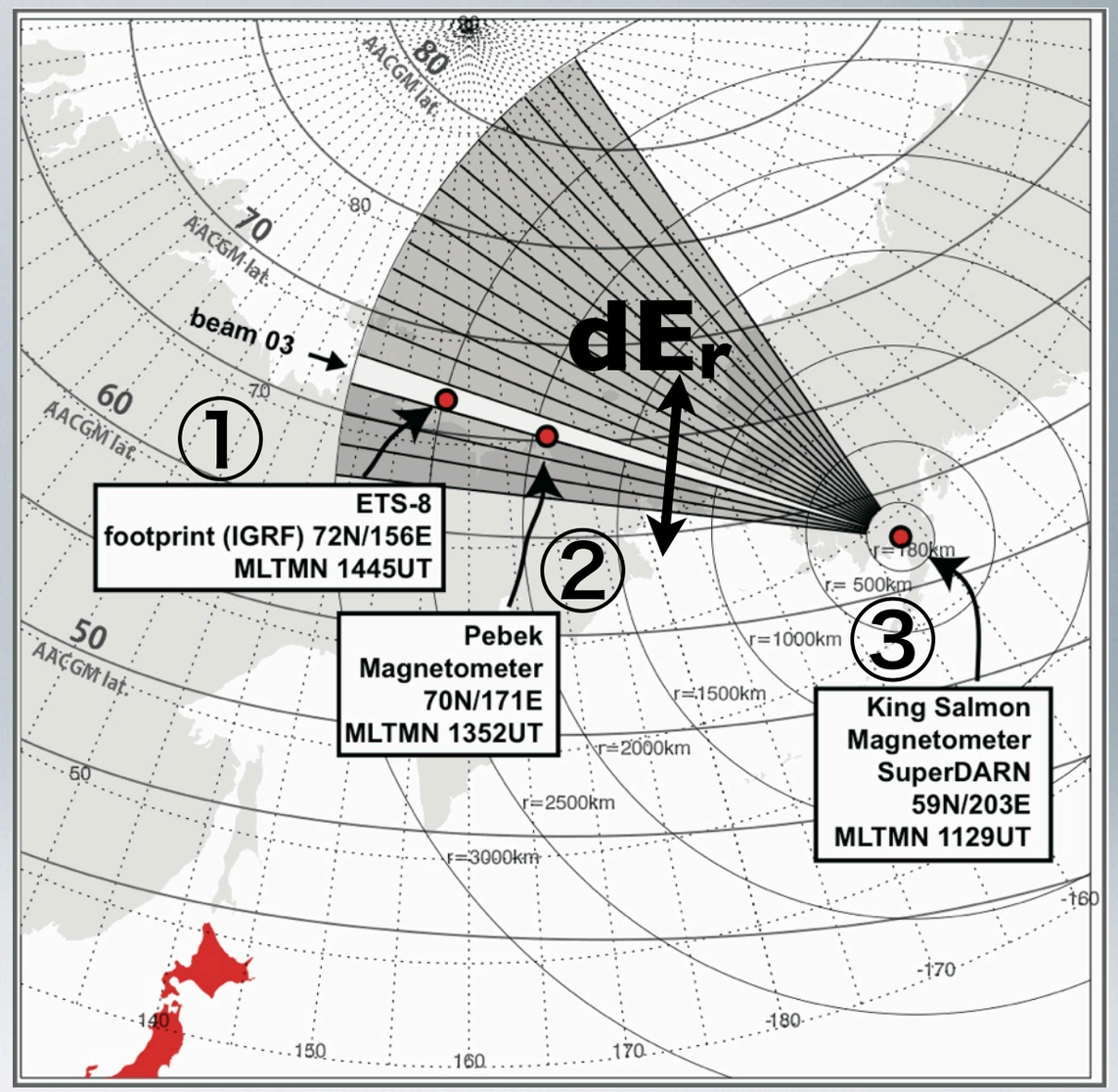
Ponomarenko et al., 2003

54% of the TIGAR radar oscillations were accompanied by similar spectral maxima in the MQI magnetometer data.

The King Salmon HF radar observation of Pc5 wave with an azimuthal beam 3

HF radar observation of Pc5 wave: $dV_D = dE \times B_0$





※ MAGNETOMETERS

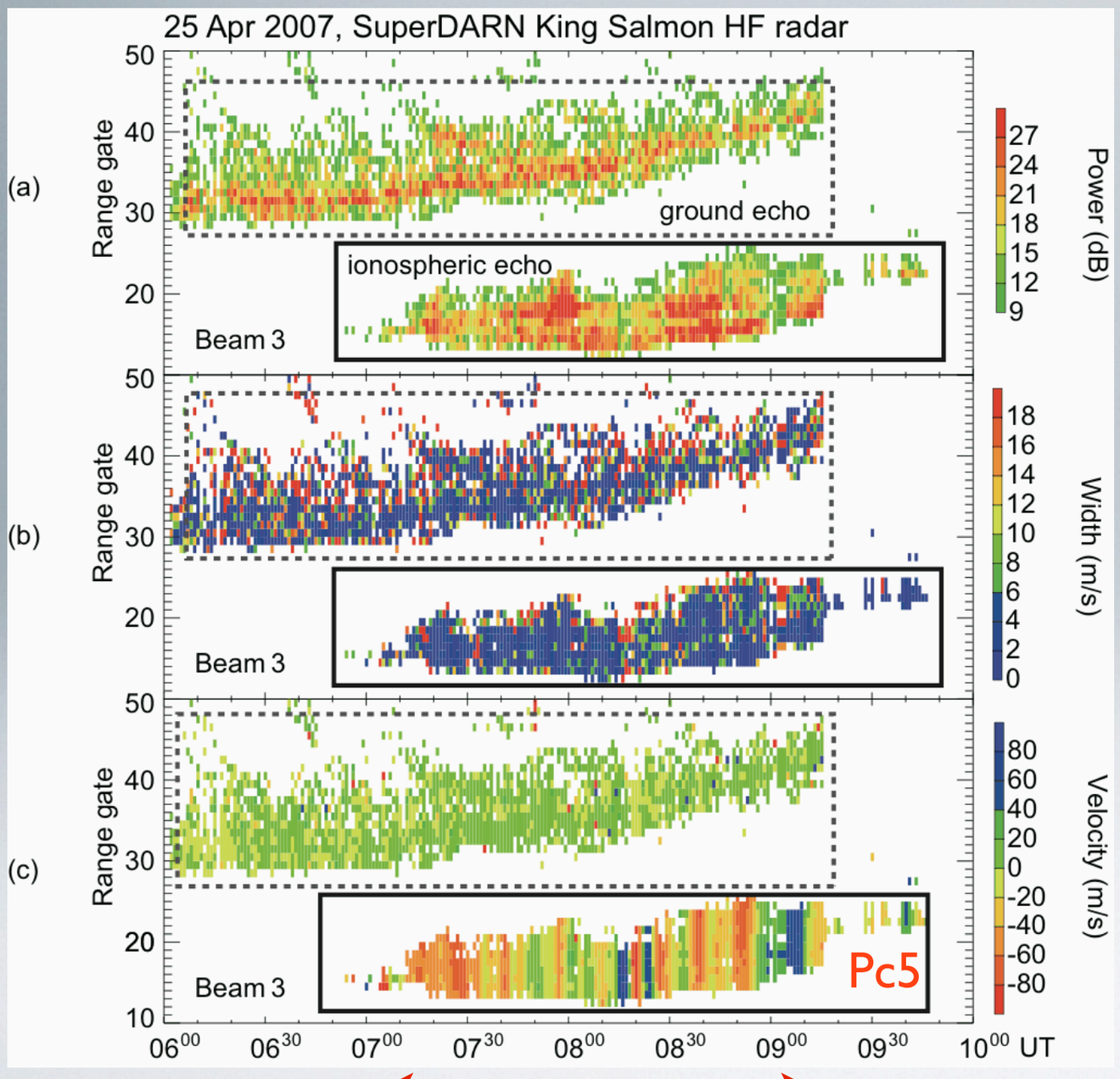
① footprint of ETS8 geostationary satellite

② Pebek ground station

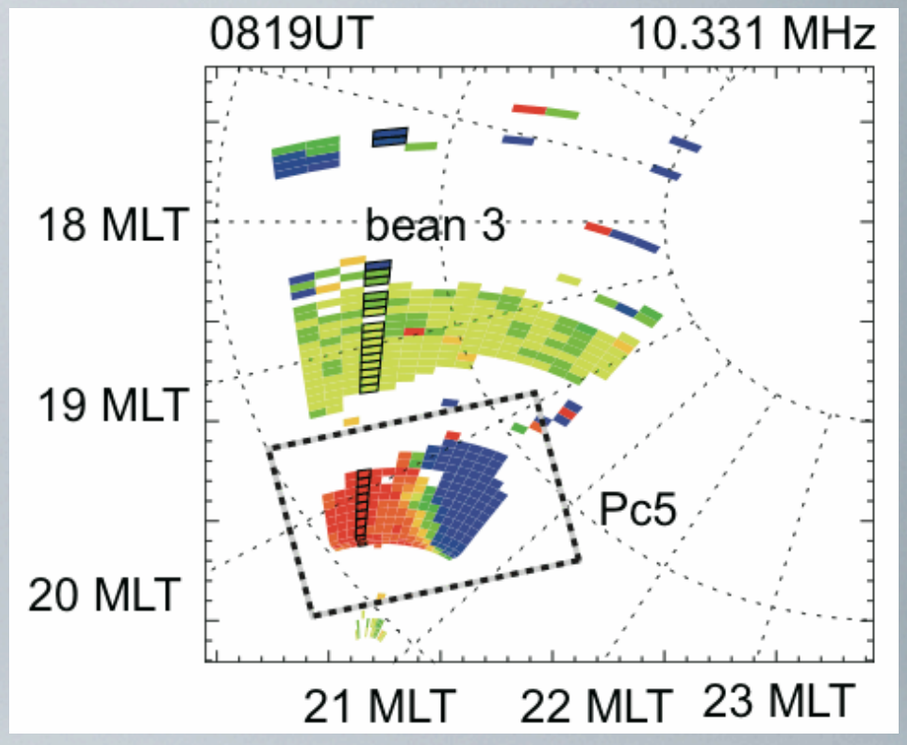
③ King Salmon ground station

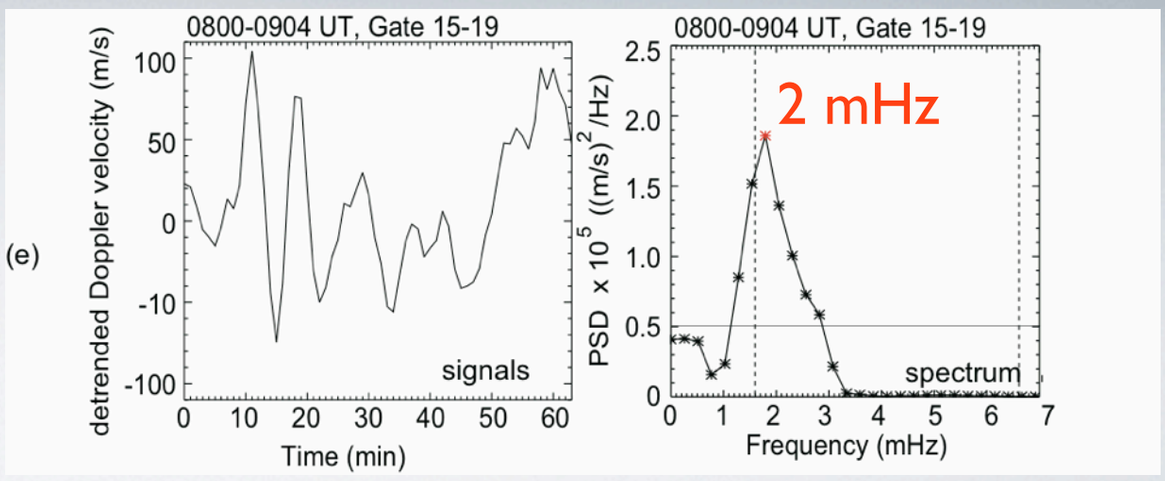
Ionospheric Pc5 Oscillation

beam 3



2 hours, ~19-22 MLT





SUPERDARN PARAMETER PLOT

King Salmon: vel

25 Apr 2007 [114]

[illegible] scan mode (-16?)

0824 00s (115)

10.202 MHz

18 MLT

magnetic north pole

80° AACGM

Pc5

20 MLT

70° AACGM

22 MLT

λ=4000 km

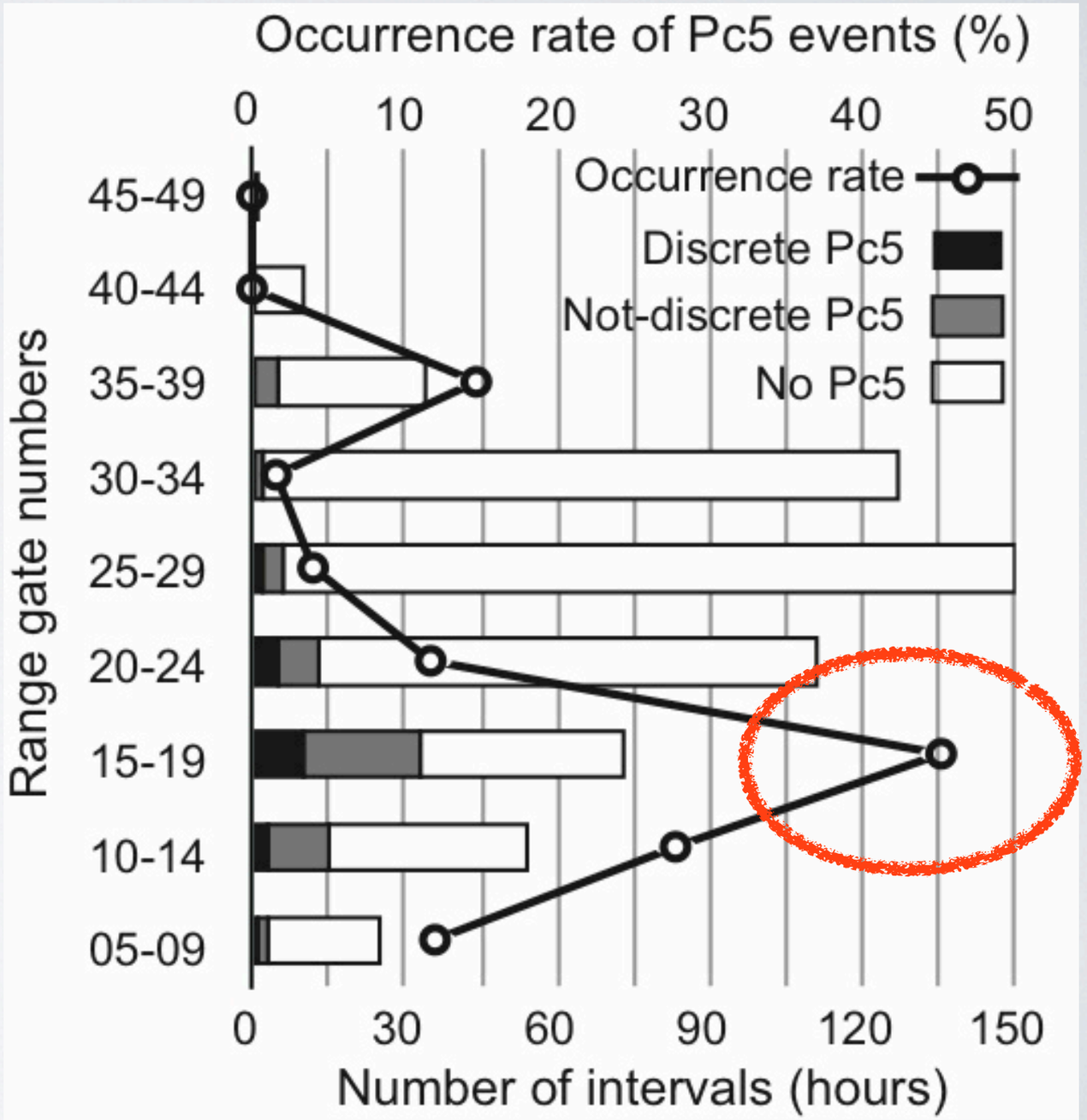
Velocity (m s-1)

80
60
40
20
0
-20
-40
-60
-80

Statistical study in 2007

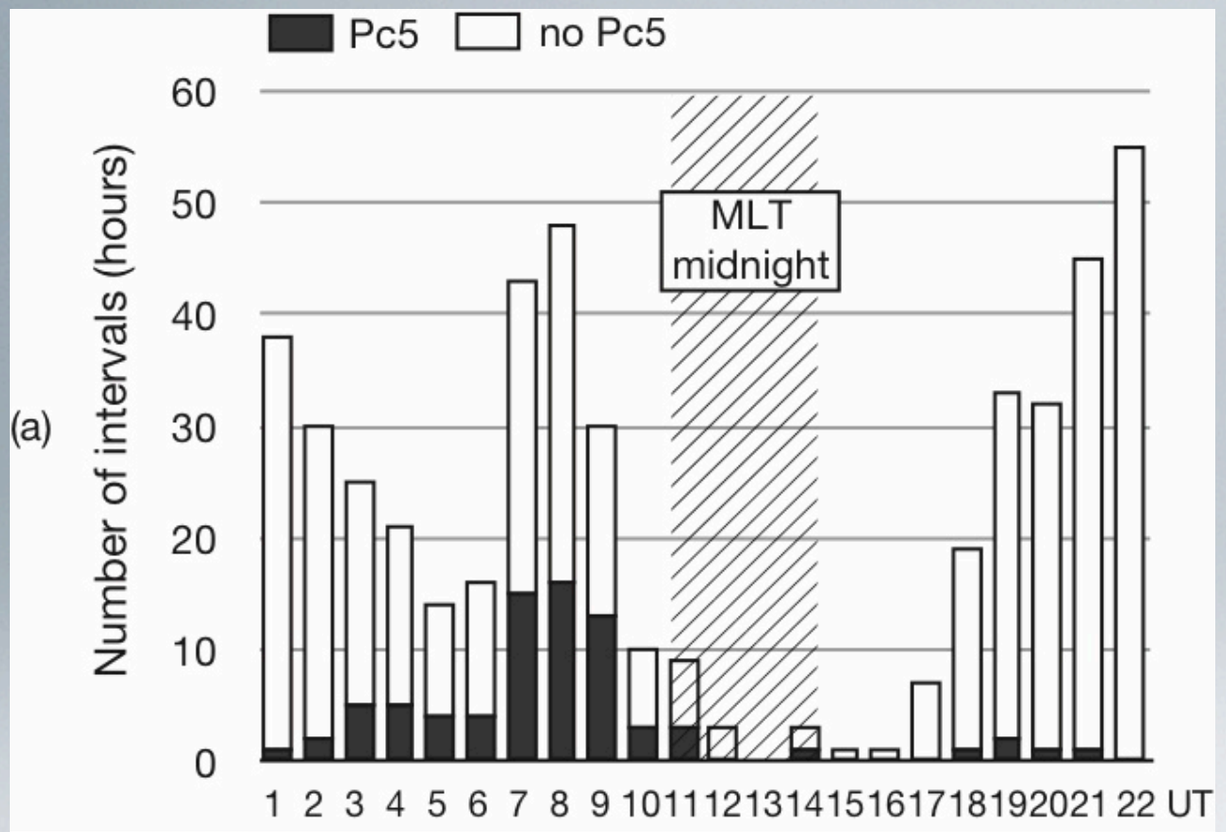
Gate Distribution

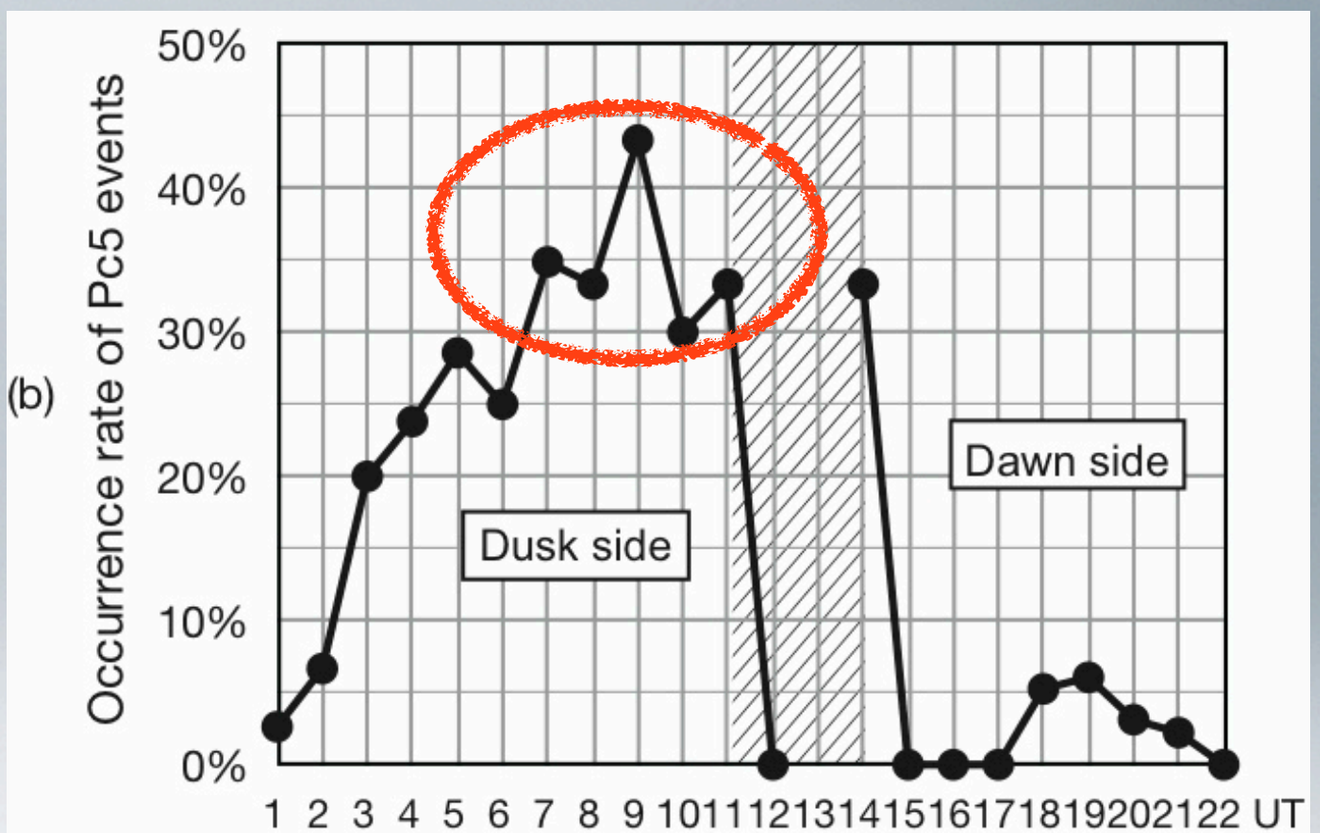
- total observation time with 1-min sampling in 2007: 2896 hours/year ~ 30%
- Fourier analysis every 64 min based on 5-gate averaged time-series
- analyzed interval: maximum at gates 25-29
- Pc5 occurrence rate: maximum at gates 15-19 (600 -1300 km)



Statistical study in 2007

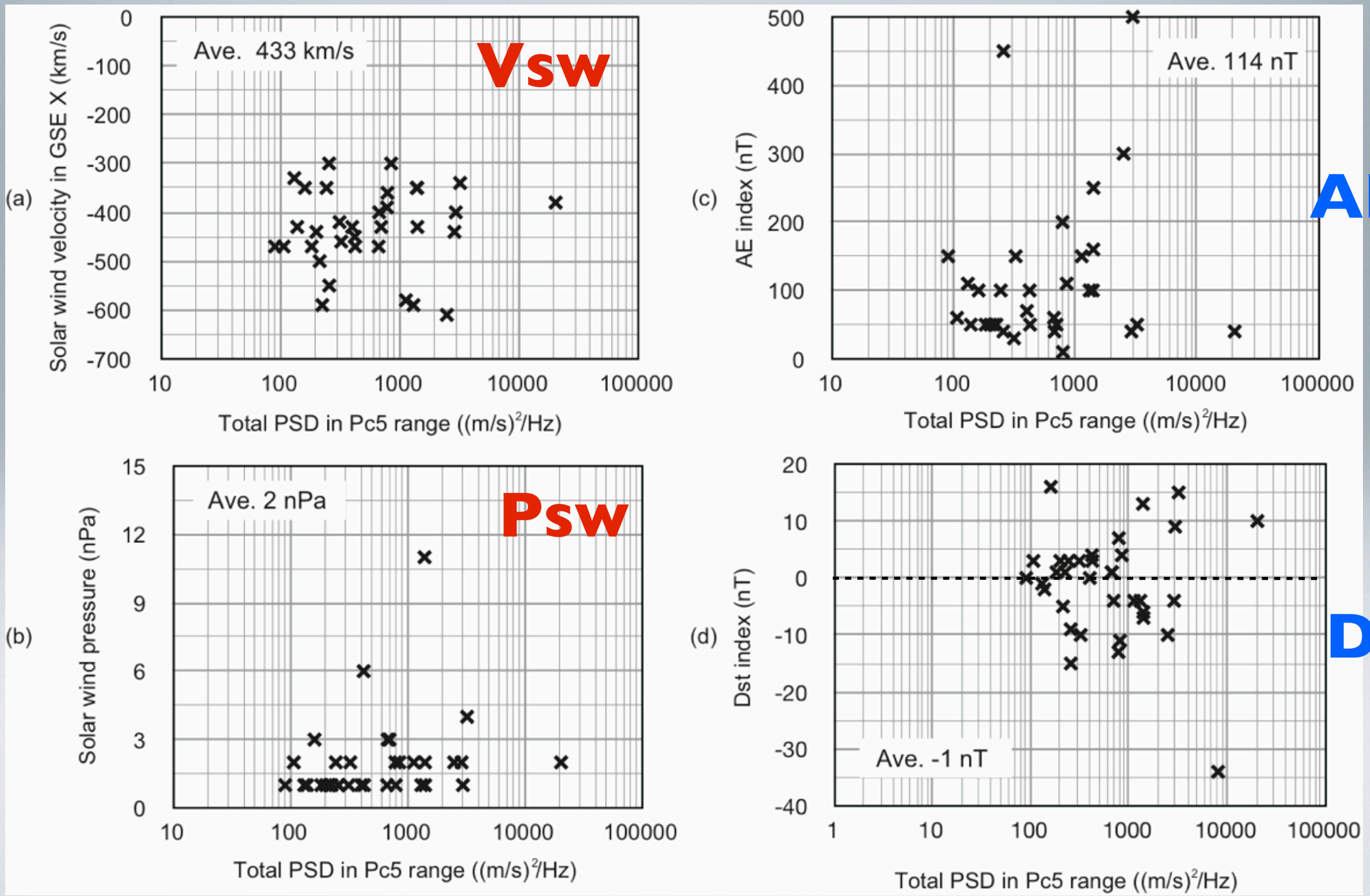
Local Time Distribution Of Ionospheric Pc5 Occurrence Rate





high occurrence rate
~40% at pre midnight

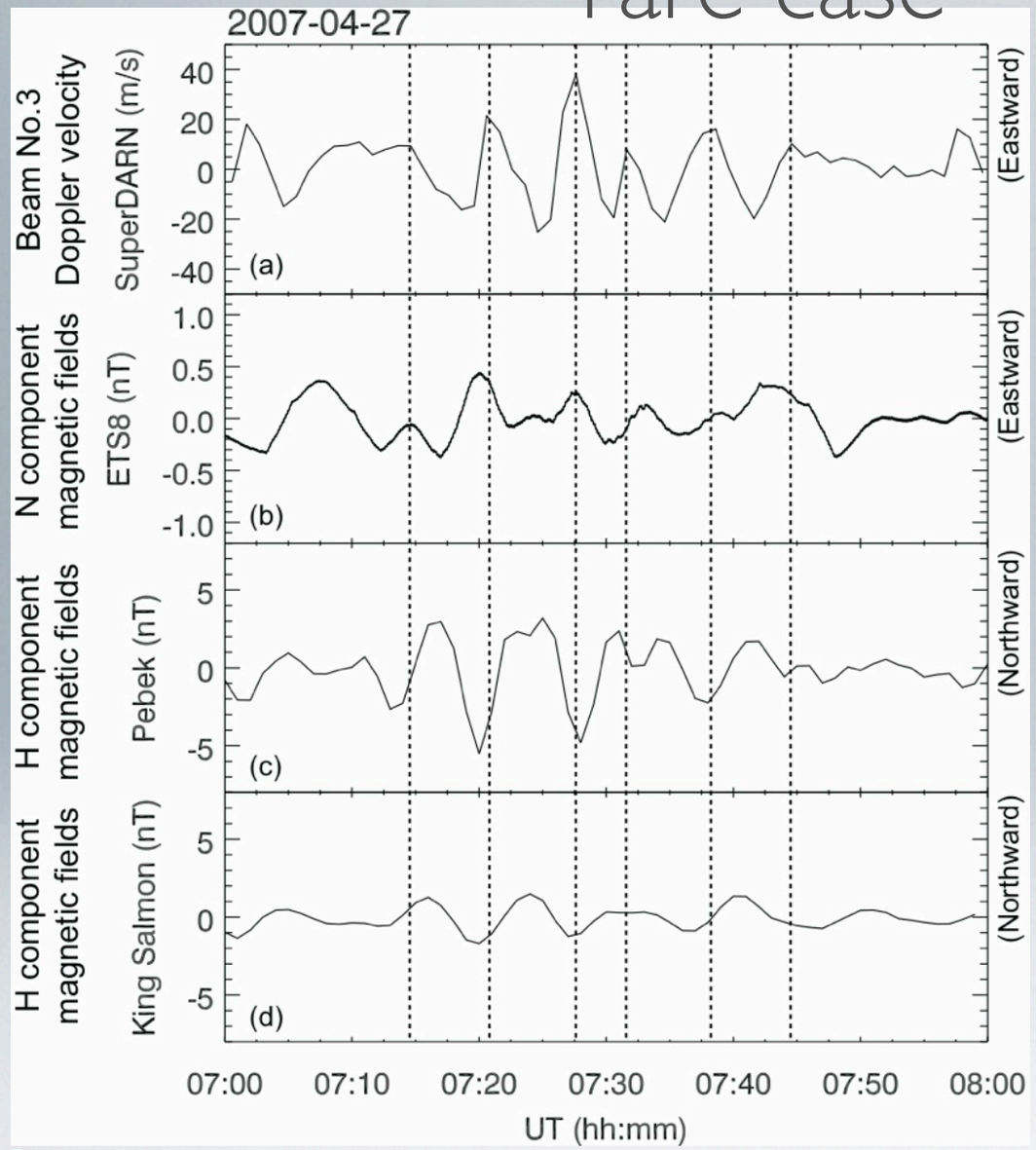
Ionospheric Pc5 Power And Solar Wind Parameters Etc

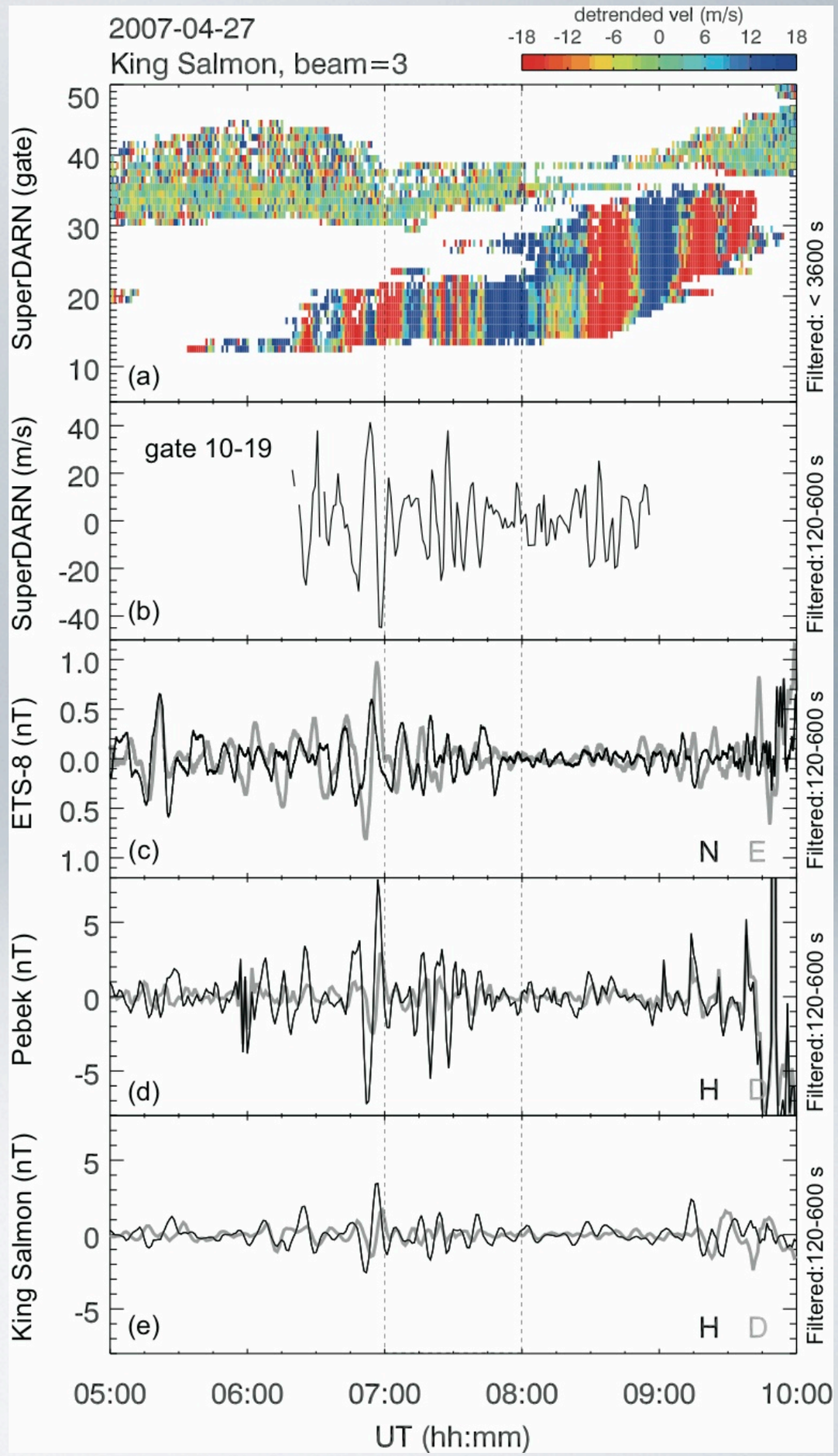


COMPARISON WITH MAGNETIC FIELD VARIATIONS

Pc5 Event ①

rare case

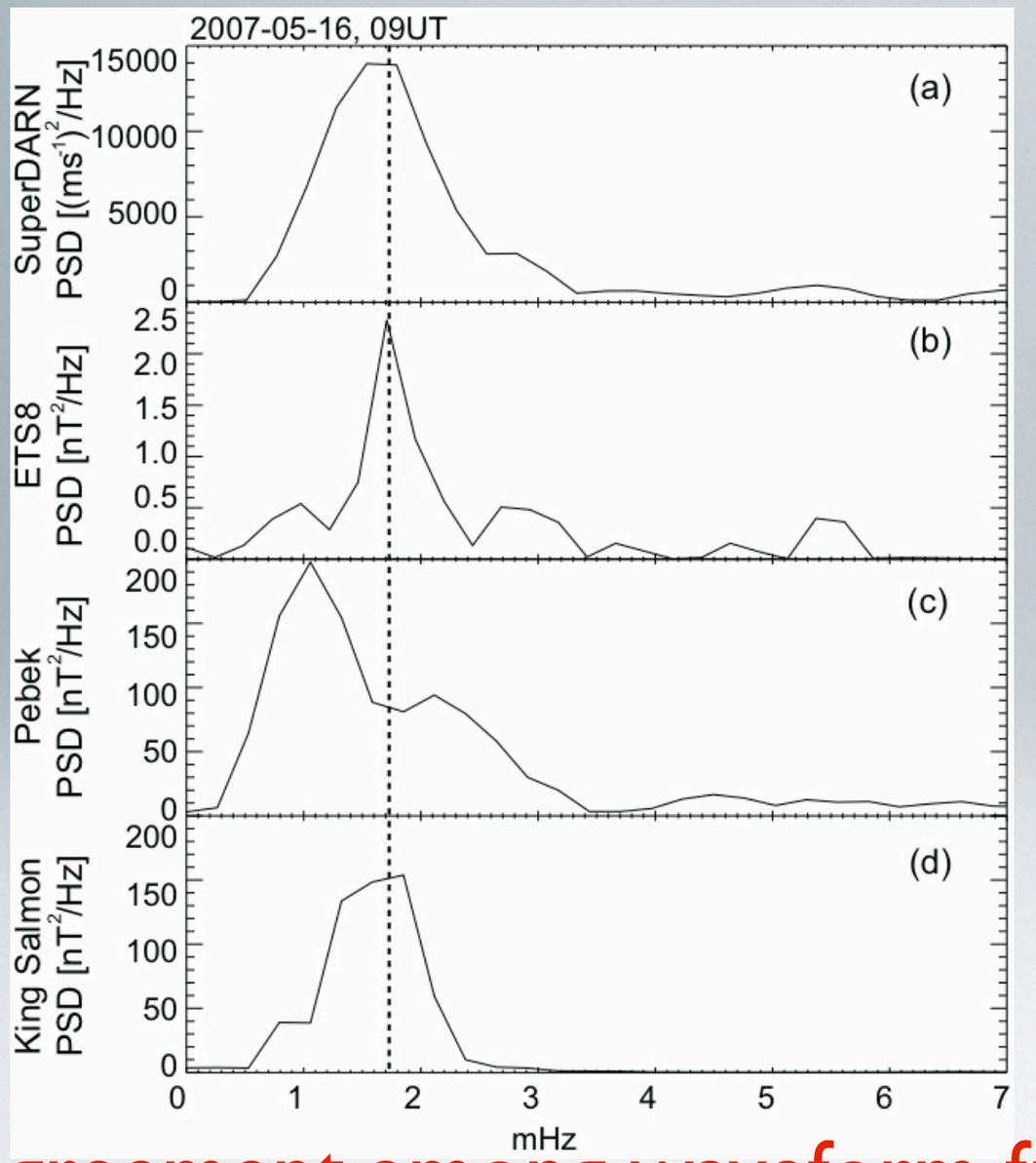


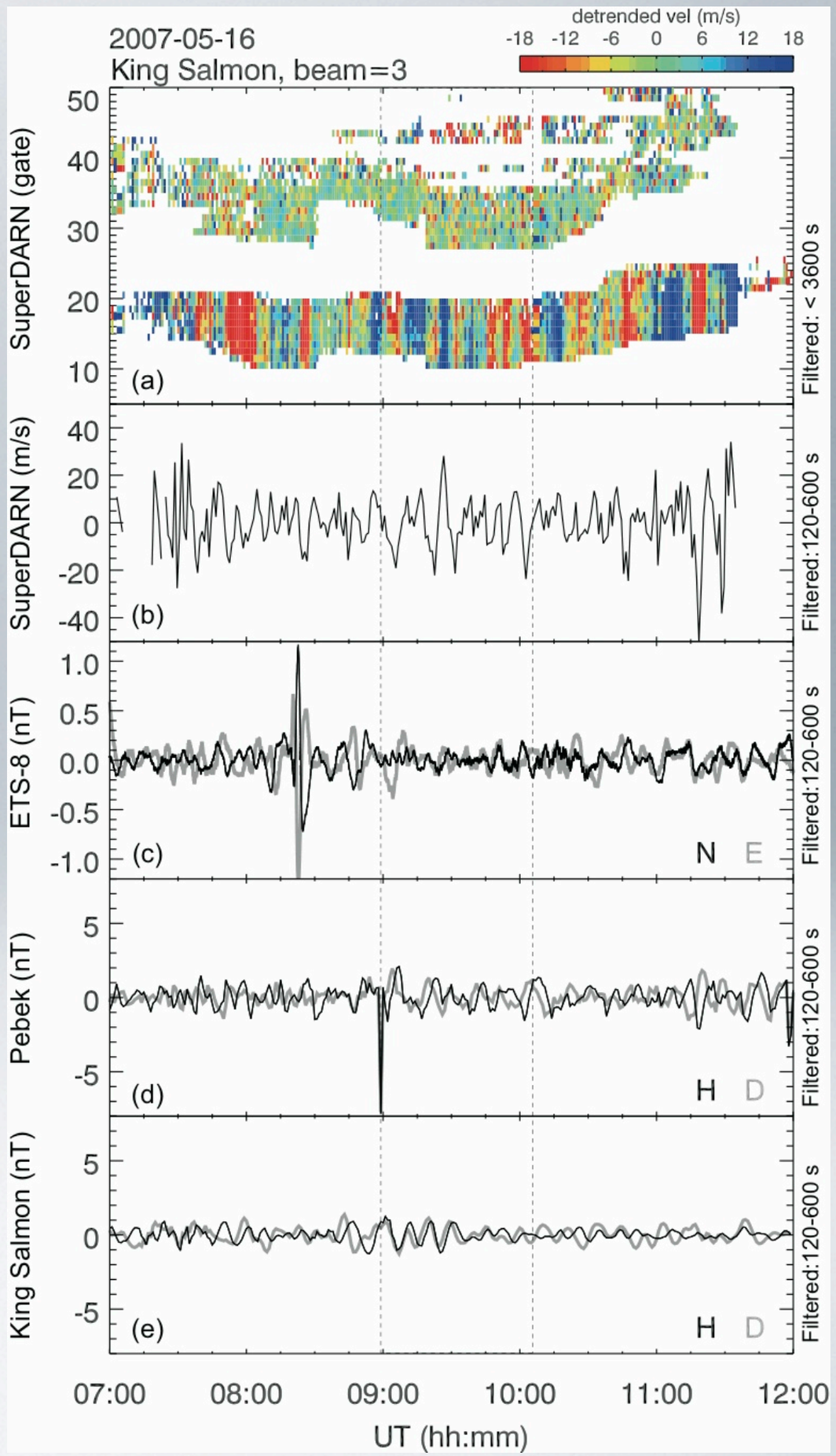


only three ionospheric Pc5 events showed similar waveform variations with concurrent magnetic field pulsations

Pc5 Event ②

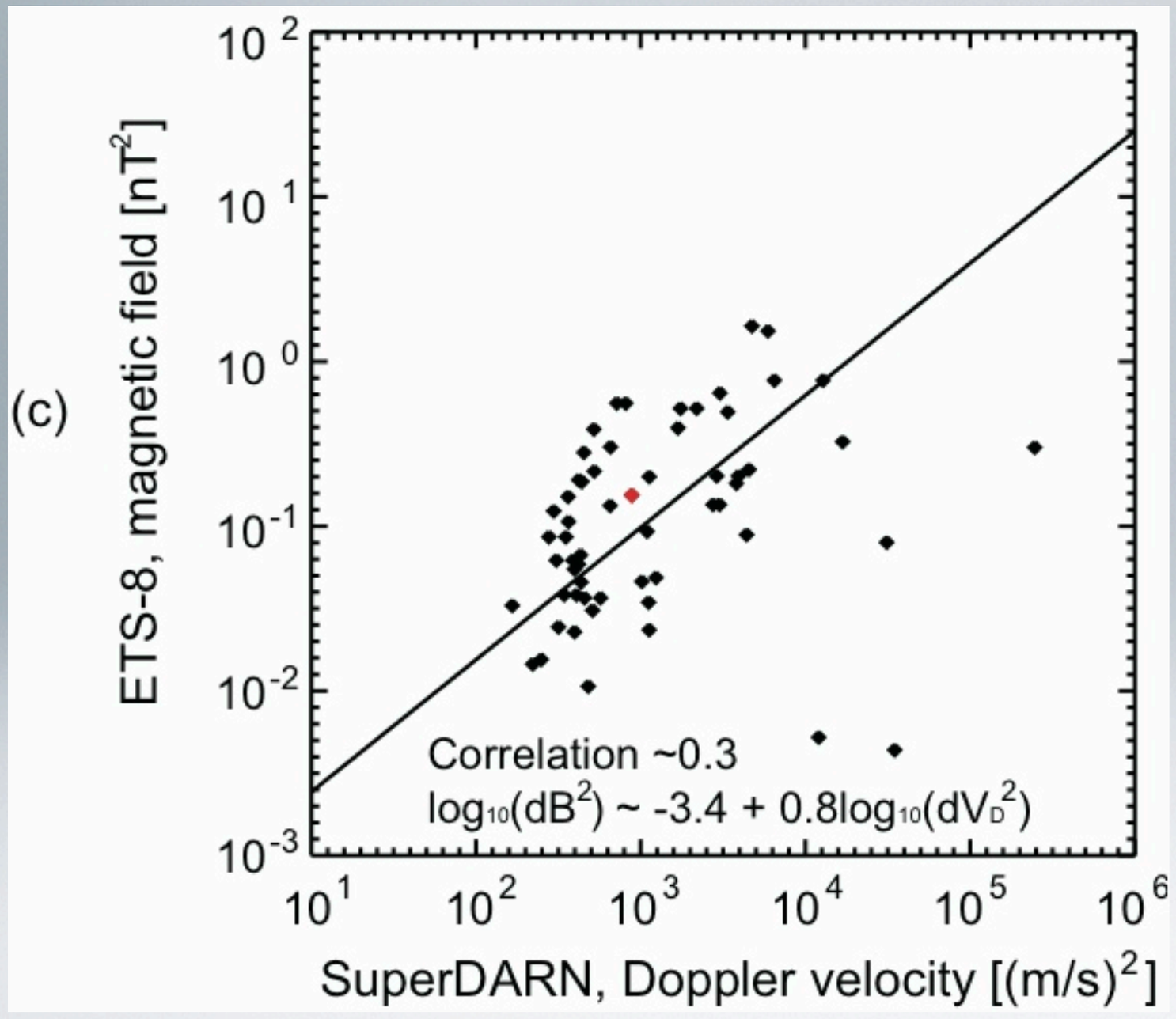
typical case





no agreement among waveform from radar, satellite, and ground, but some show similar spectra each others

geostationary and ionospheric
Pc5 Spectral Power Comparisons



ETS8 vs HF radar

fit line

$$\log_{10}(\delta B^2) \sim -3.4 + 0.8 \log_{10}(\delta V_{\mathrm{D}}^2)$$

dB [nT]
~ 0.01 x dV_D [m/s]

positive Pc5 power correlation between radar and satellite observations

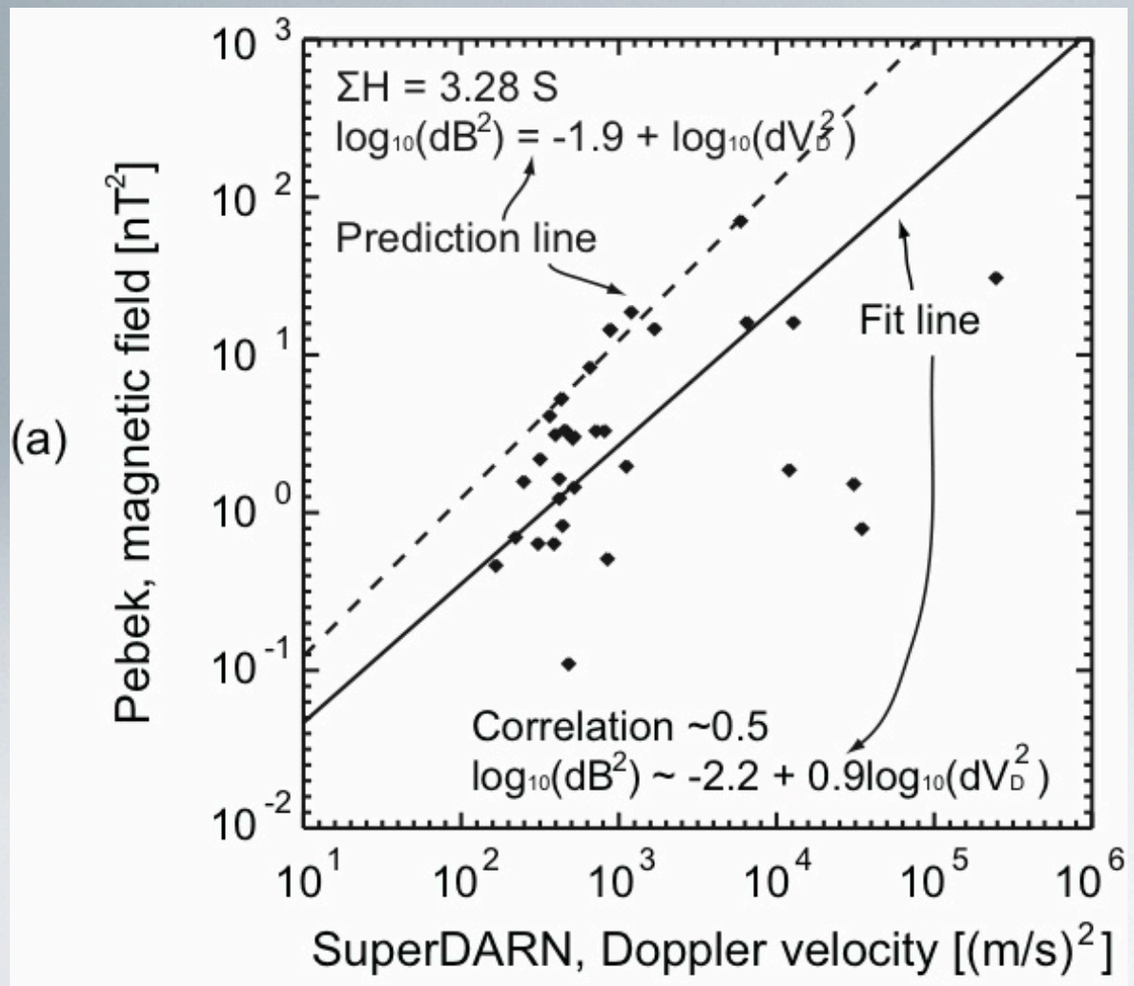
ground and ionospheric
Pc5 Spectral Power Comparisons

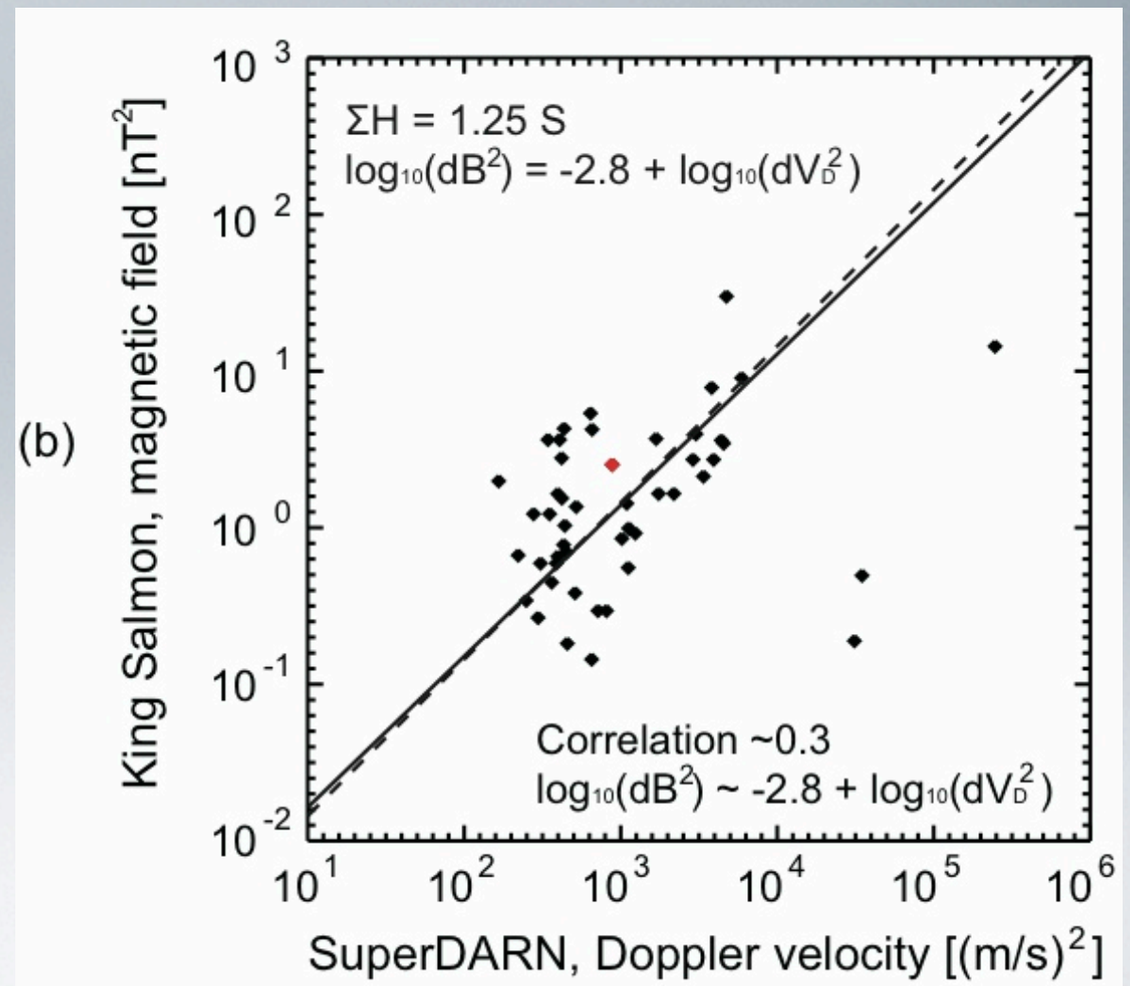
ground magnetic field variation induced by Hall currents due to Pc5 electric fields + several assumptions ☞

$$\delta B_{\mathrm{N}}^{(\mathrm{g})} = \frac{\mu_0}{2}\Sigma_{\mathrm{H}} V_{\mathrm{D}\perp,\mathrm{W}} \,|\mathrm{B}|\sin^2\theta$$

$$\delta B_{\mathrm{N}}^{(\mathrm{PBK})} \sim 0.11 \times V_{\mathrm{D}\perp,\mathrm{W}}$$

$$\delta B_{\mathrm{N}}^{(\mathrm{KSM})} \sim 0.038 \times V_{\mathrm{D}\perp,\mathrm{W}}.$$





good agreements on integrated Pc5 wave powers between ground and ionosphere

Summary And Discussion ①

- Occurrence rate of Pc5 Doppler oscillations (probably toroidal mode) obtained from the King Salmon HF radar is maximum at pre midnight (40%/echos)
- Ionospheric Pc5 power showed no relation with solar wind velocity and dynamic pressure, Dst index, nor AE index.

Source of ionospheric Pc5

- Kelvin-Helmholtz instability: flank regions of magnetosphere, V_{SW}
- Solar wind dynamic pressure: magnetopause, $P_{dyn, SW}$
- drift/drift-bounce instability: ring current region, storm/substorm

Summary And Discussion ②

- Pc5 spectral powers among a radar, a satellite, and ground observations show positive correlations each others, whereas it is rare to observe similar waveform variations among them.

Problem is .... that dayside (especially, morning side) Pc5 geomagnetic pulsations were not detected by the radar observations.

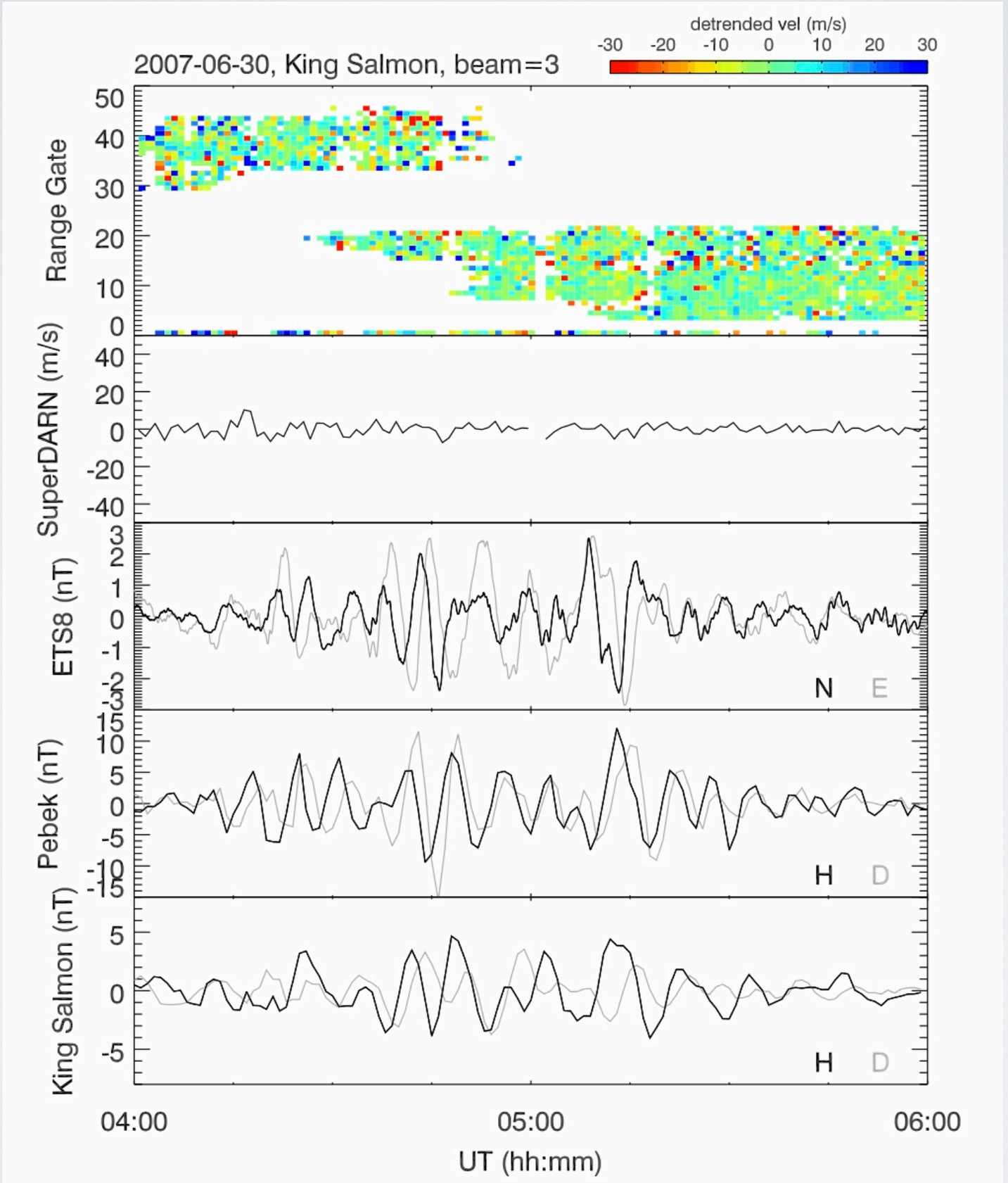
- **Local time distribution of Pc5 power obtained from HF radar show different features from magnetic field observations**

  → **need to investigate m number in future study**

Thank you

ありがとうございました

NO ionospheric oscillation during large Pc5 geomagnetic pulsation



ground scatter?

ionospheric scatter?

VHF radar observations of Pc5

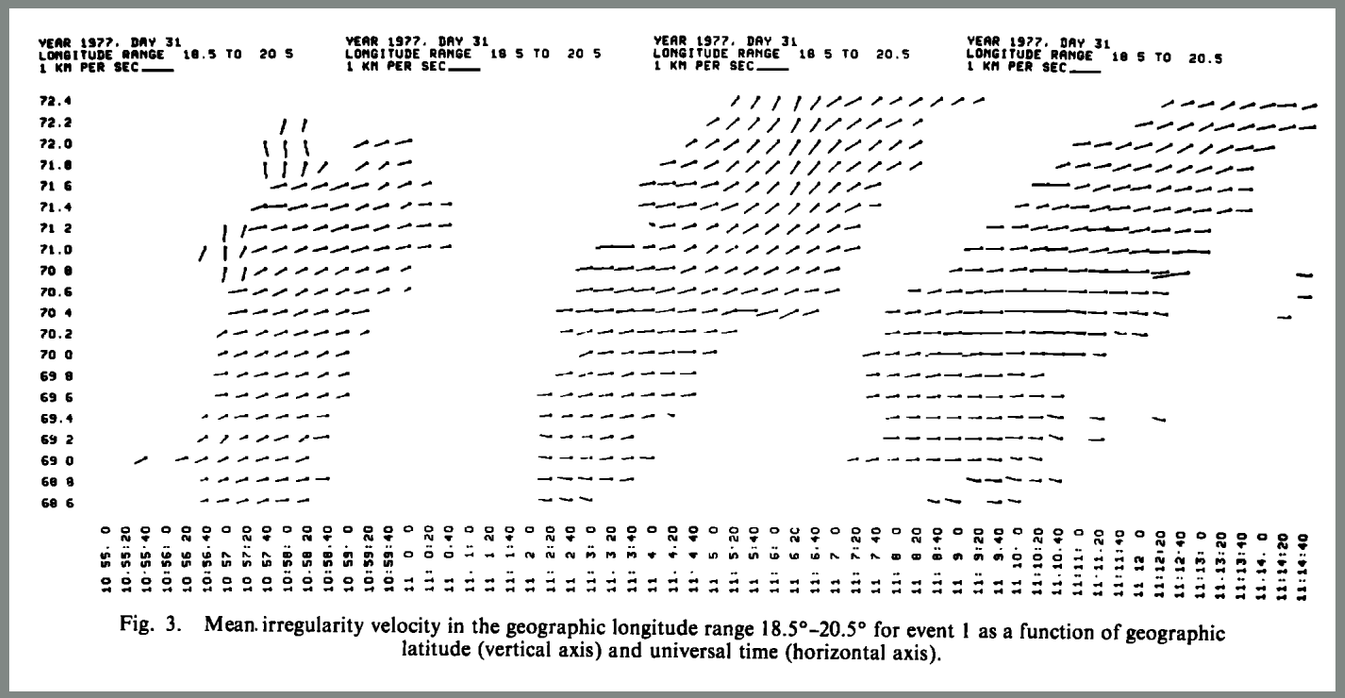


Fig. 3. Mean irregularity velocity in the geographic longitude range 18.5°–20.5° for event 1 as a function of geographic latitude (vertical axis) and universal time (horizontal axis).

Walker et al., 1979