PHYSICS AND ENGINEERING PHYSICS

Electron density as a factor affecting SuperDARN echo occurrence rates in the polar cap

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Objectives:

1) We want to systematically assess the echo occurrence rates for the polar cap SuperDARN radars in both hemispheres over the same period of observations

2) We want to further investigate the extent to which the echo occurrence rate is controlled by the electron density variations at these latitudes

3) If possible, investigate the role of E field

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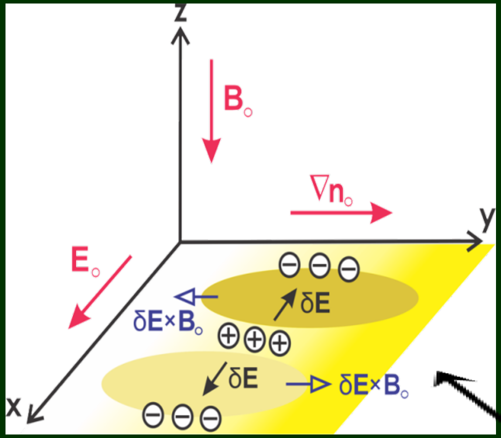
Factors affecting F-region echo occurrence

1. Irregularity production

Gradient Drift instability

$$\gamma_{GD} = \frac{E_\circ}{B_\circ} \frac{\nabla n_\circ}{n_\circ}$$



2. Propagation conditions

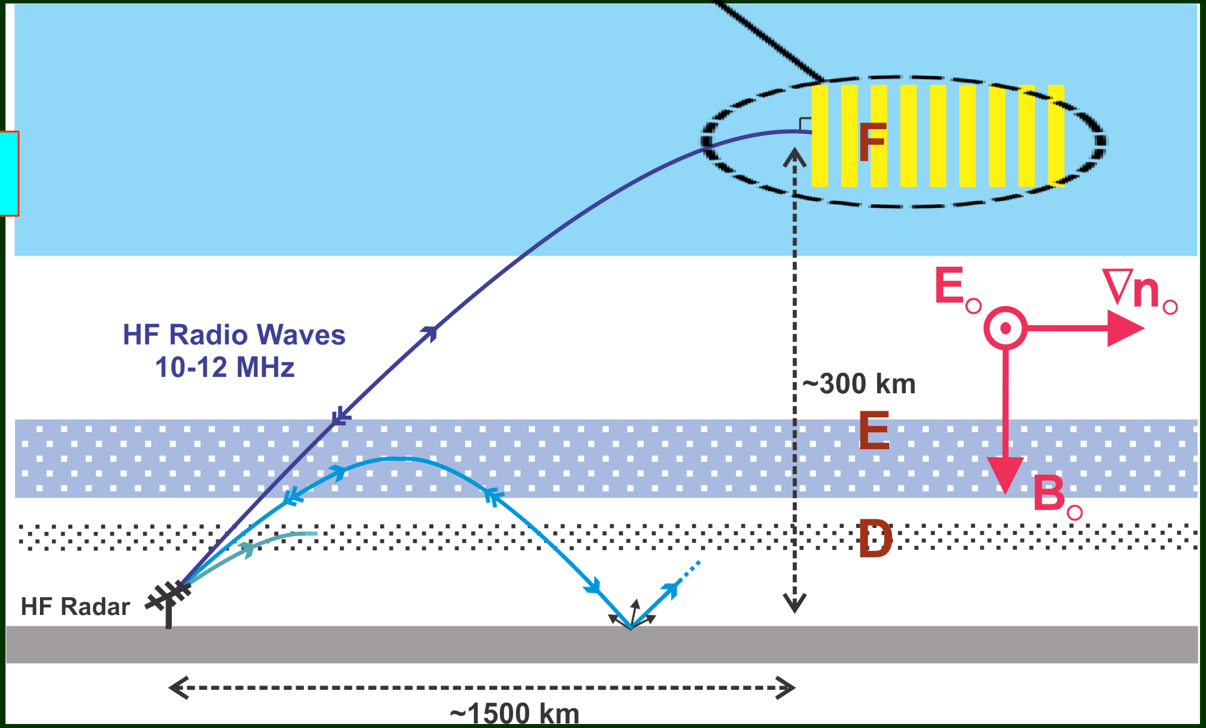
Function of E field?

Orthogonality condition

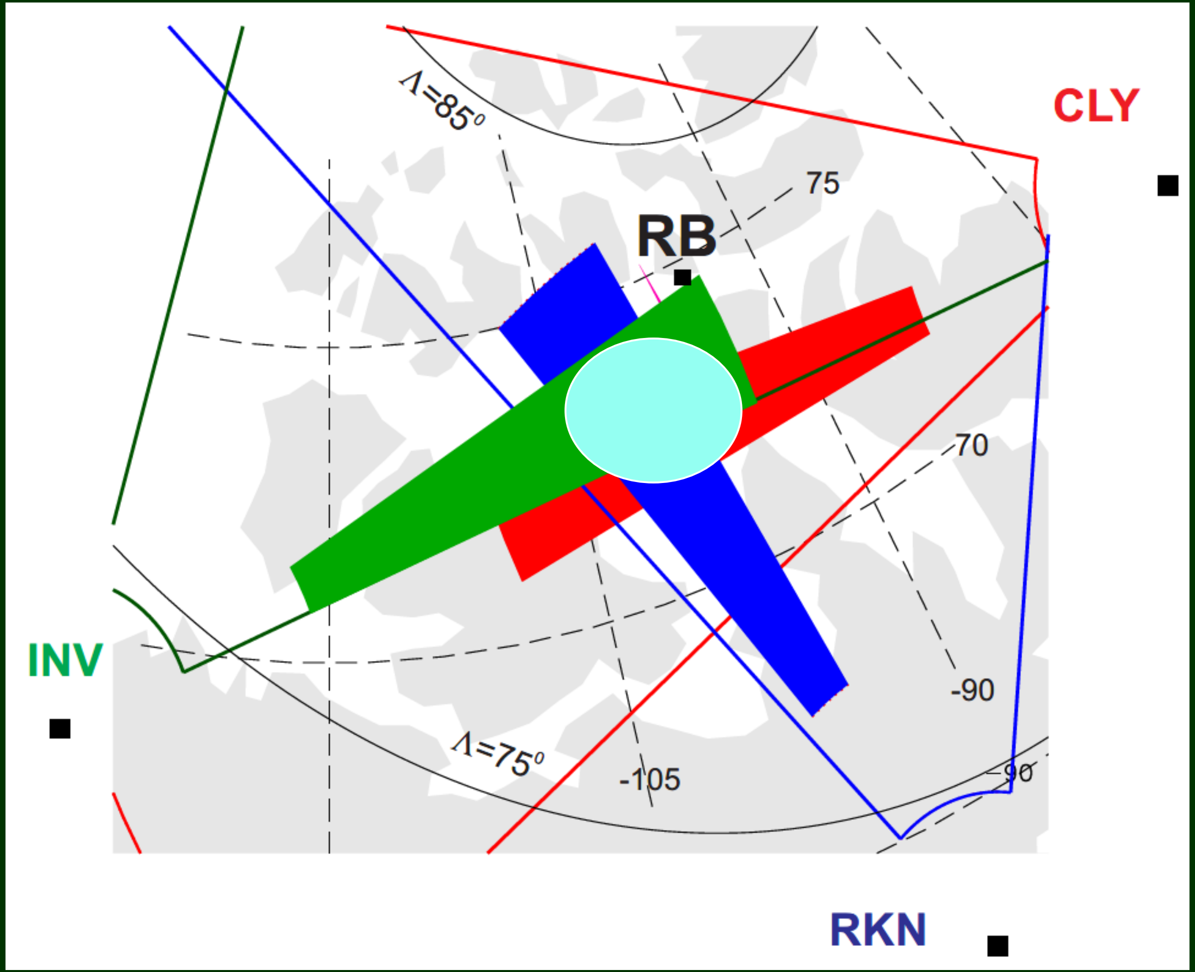
Threshold electron density

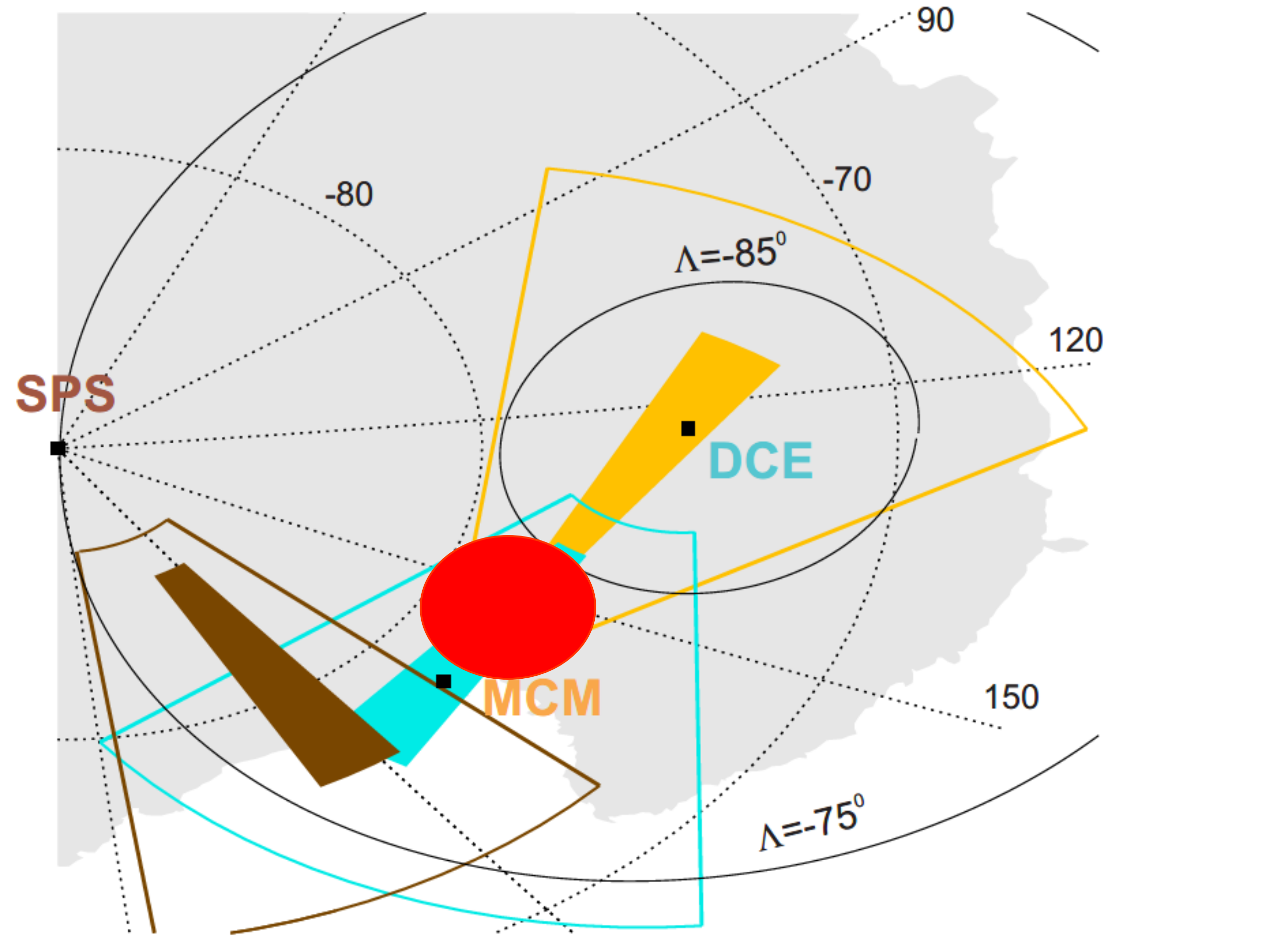
$$P_{rad} \propto n_\circ^2 \left\langle \left(\frac{\nabla n_\circ}{n_\circ} \right)^2 \right\rangle$$

Constant value?



Northern hemisphere Southern hemisphere





RKN radar measures N_e^{max}

Will process DCE to get N_e^{max}

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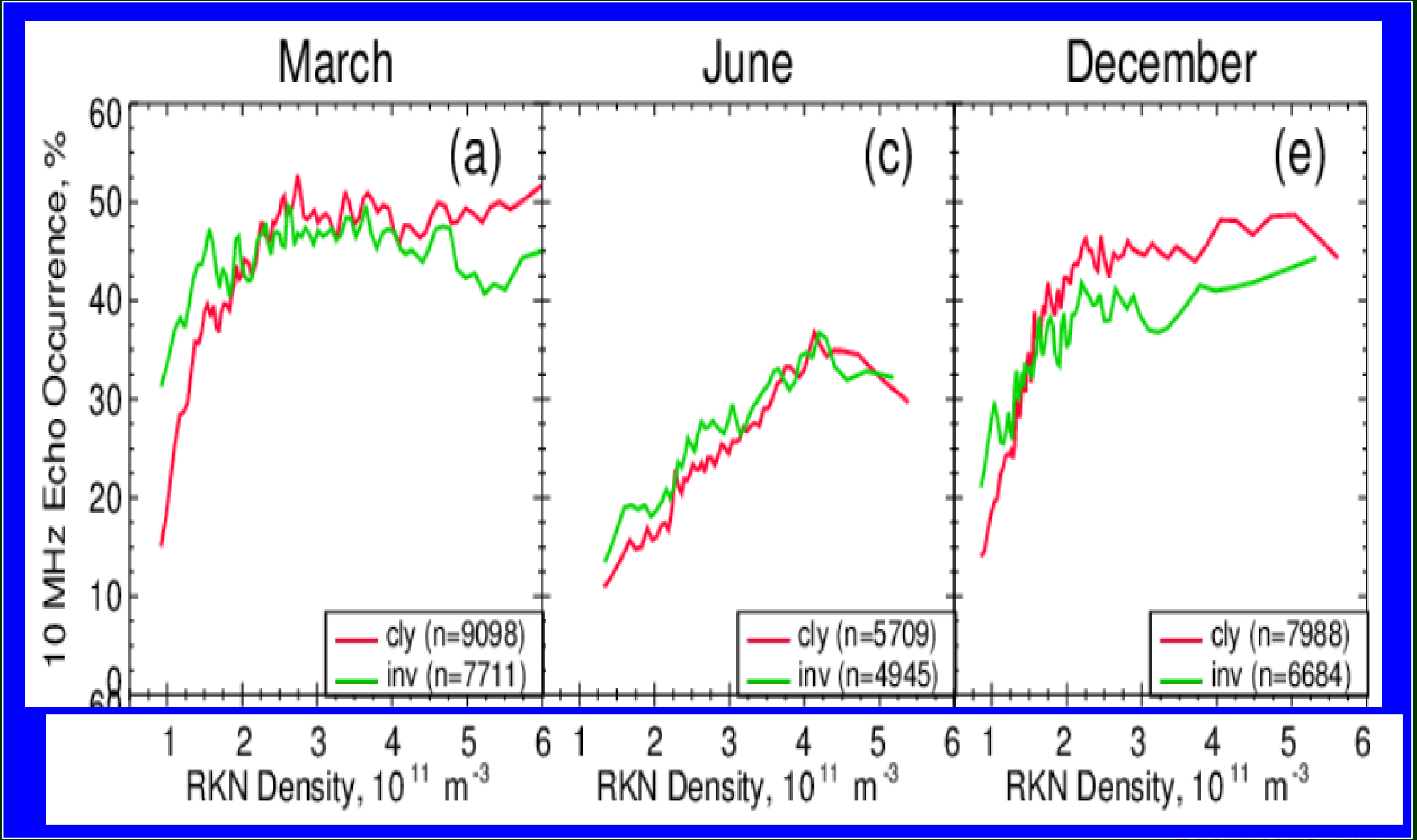
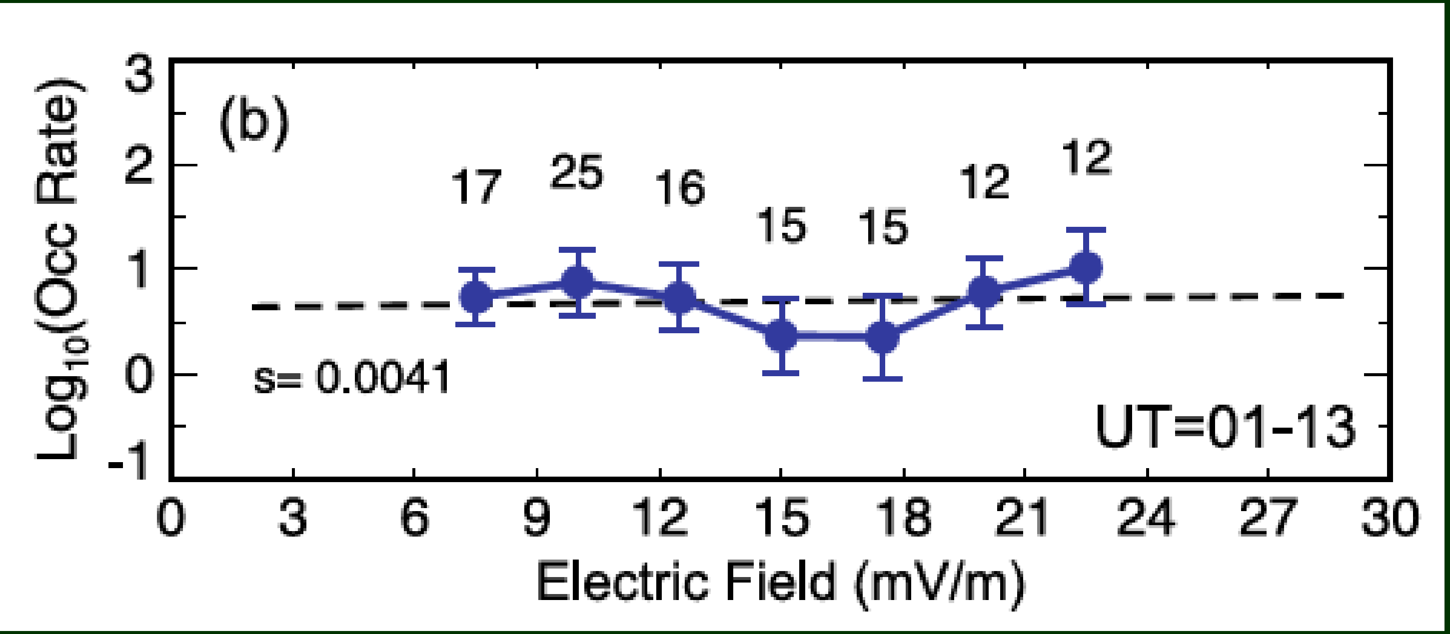
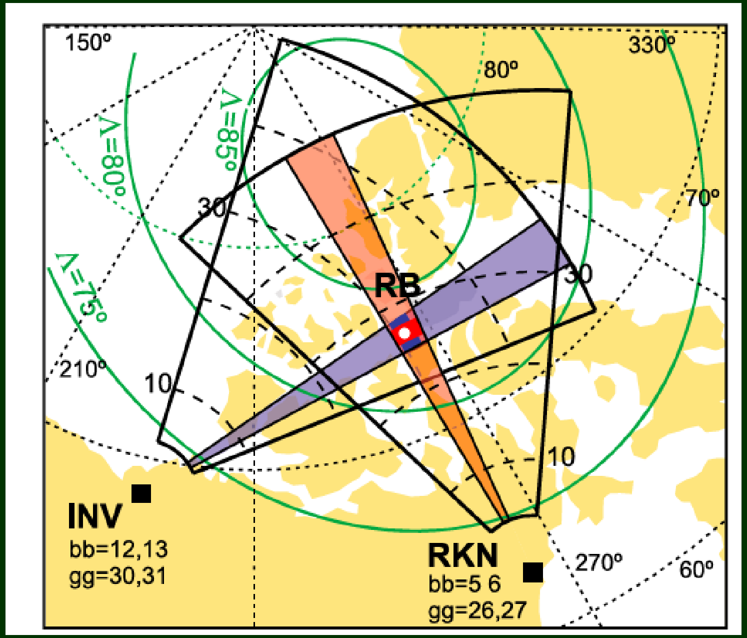
Occurrence response to the electron density increase



Occurrence response to the E field increase

No answer except of a comparison of RKN and INV with CADI ionosonde data:





~ 110 points only

To be investigated further….. after discussions with Nishitani-san

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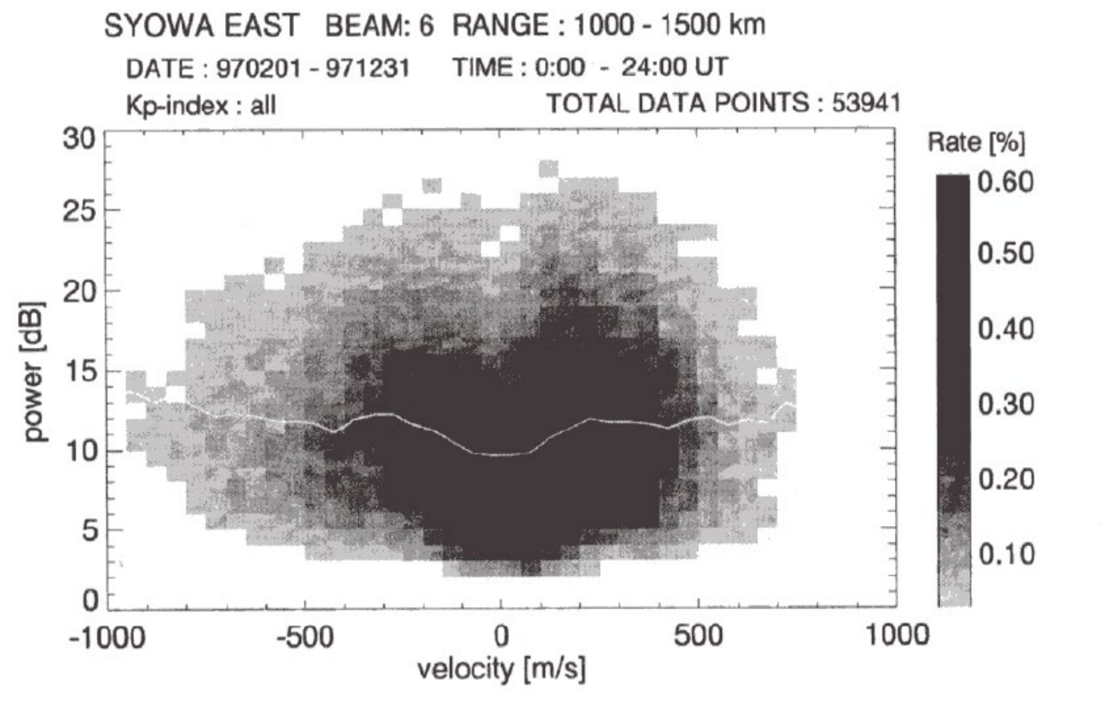
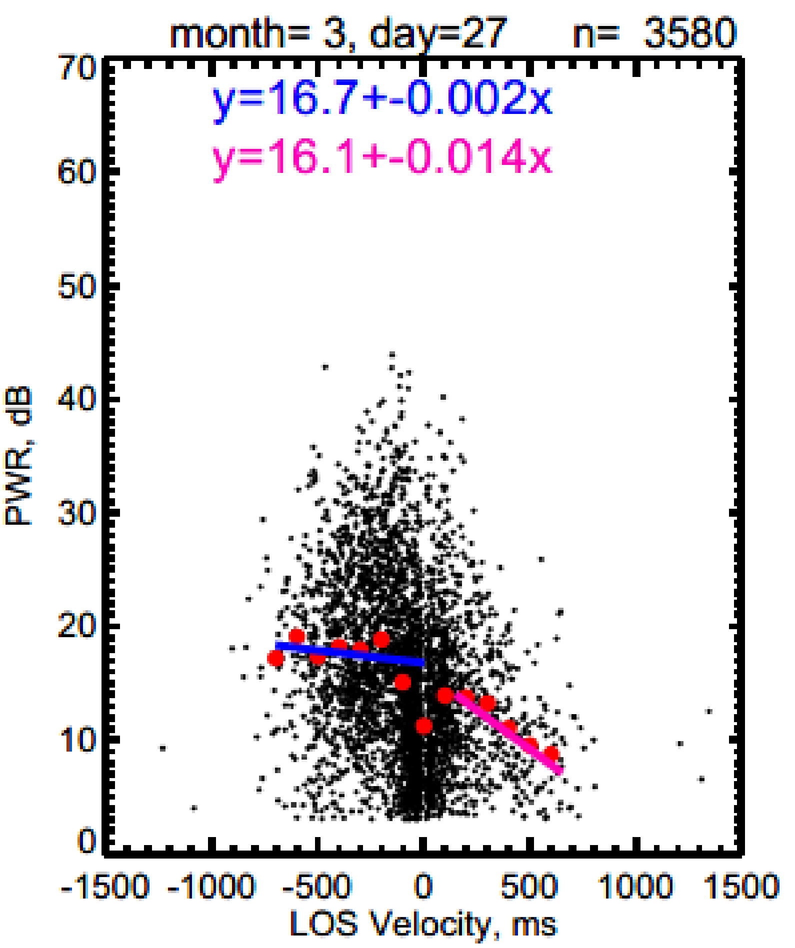
Occurrence response to the E field increase

Fukumoto et al., 2000



2. *Relationship between echo power and Doppler velocity for all data points. The color of each pixel corresponds to the ratio of data points contained in that pixel to the total number of data points. The solid curve represents the median value of the echo power in each Doppler velocity bin.*

RKN data, 2016



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Occurrence response to the E field increase

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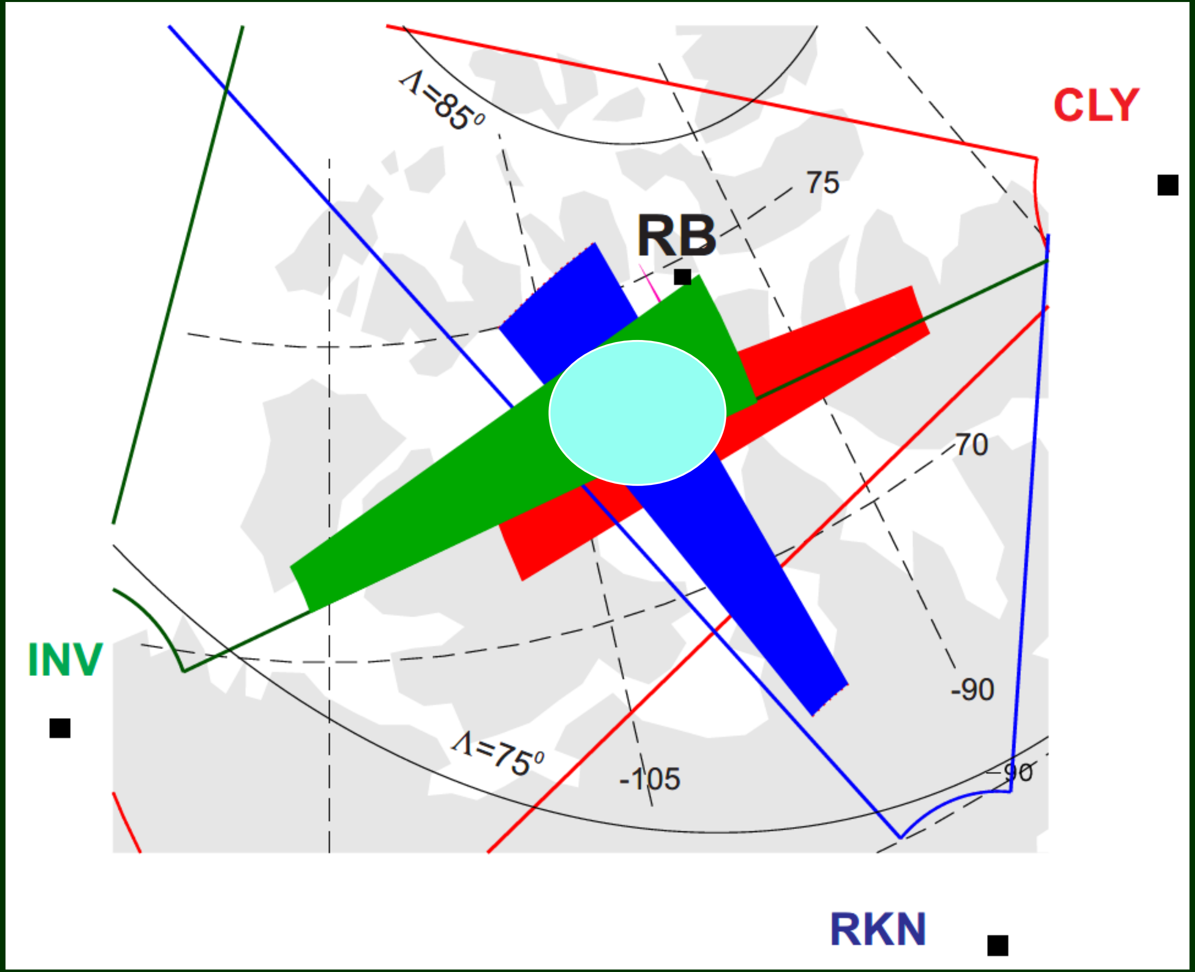
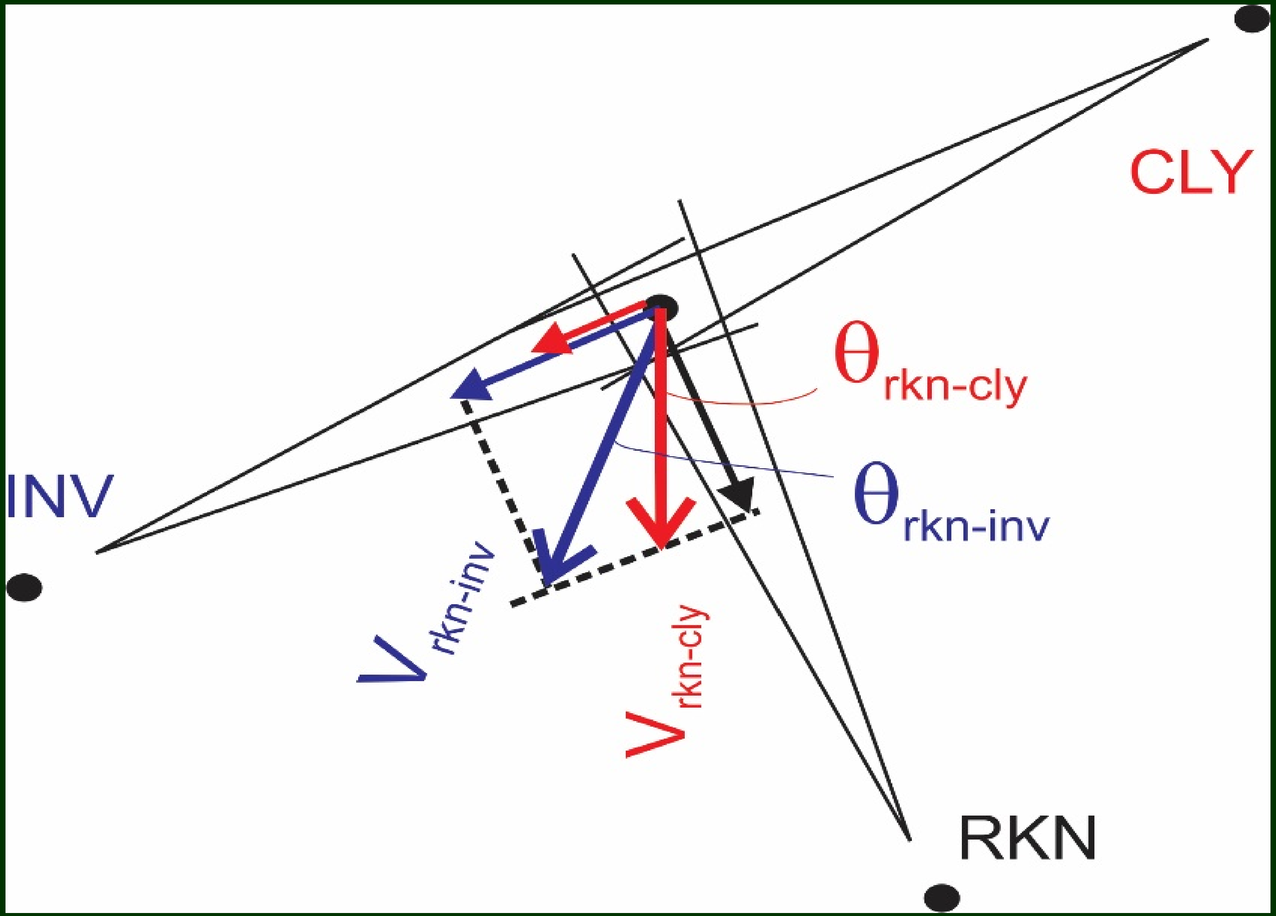


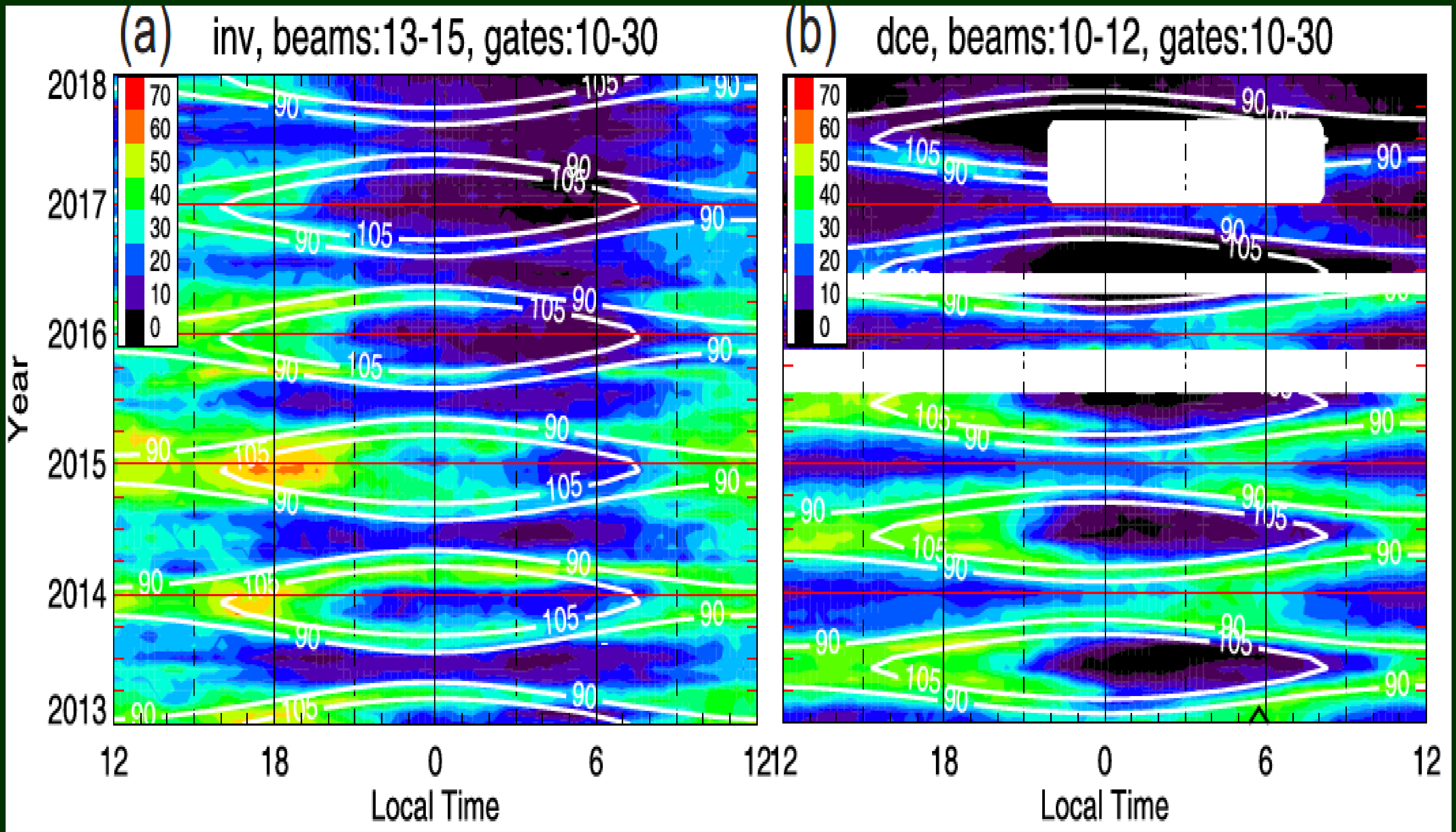


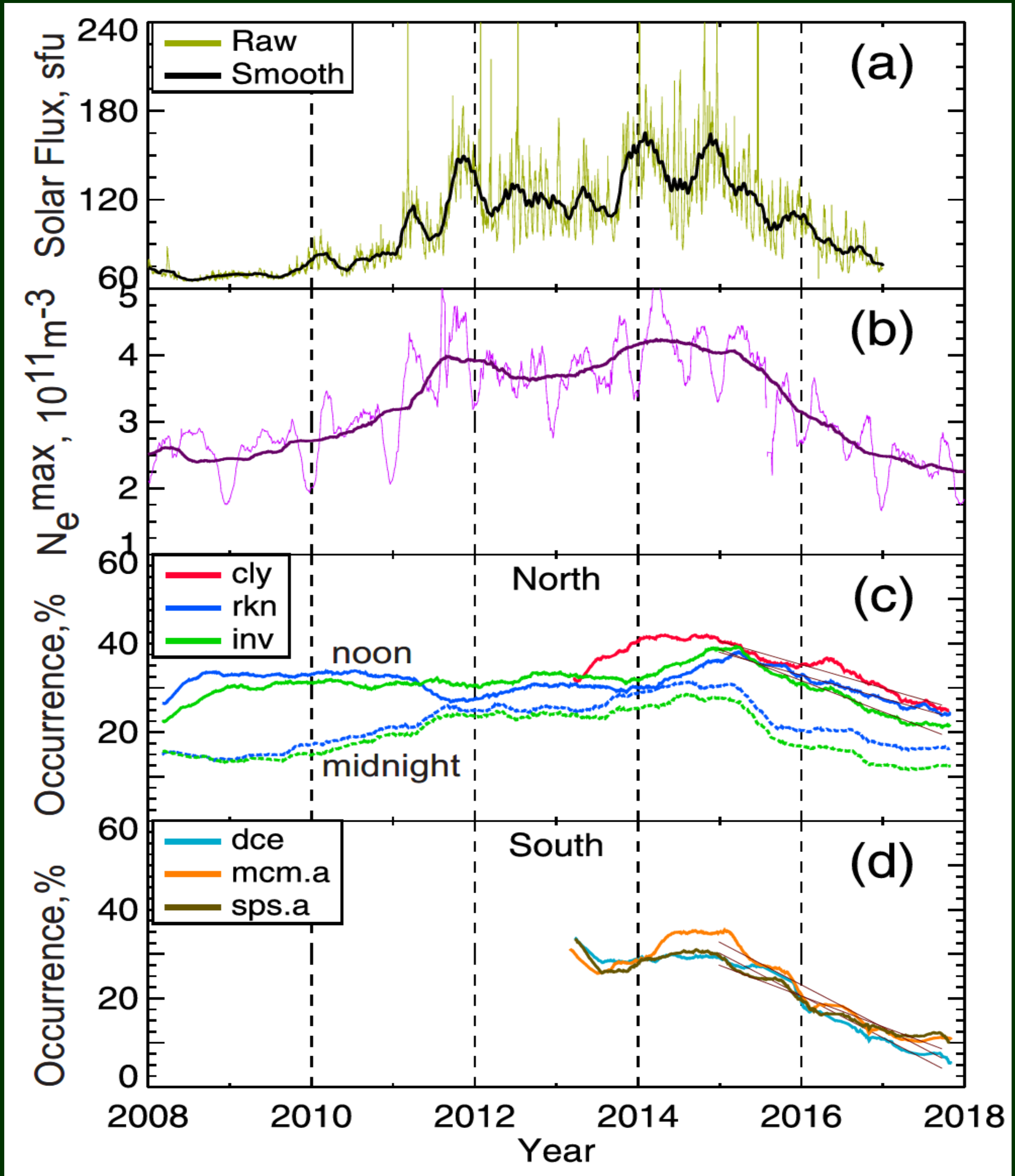
We are planning to get merge velocities and plot Occurrence in % versus velocity magnitude.
We will consider 10 years worth of data.

Coming back to the topic of the ongoing investigation, assigned to Sydney Ullrich (MSc student)

What are solar cycle, seasonal and diurnal variations of the echo occurrence rate for the polar cap radars?

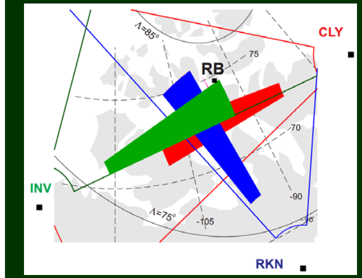
Any hemispheric differences?

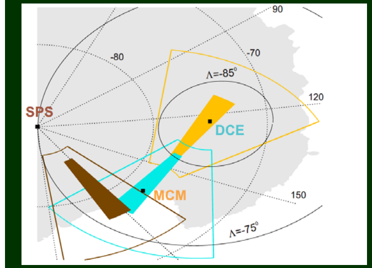

(a) inv, beams:13-15, gates:10-30
(b) dce, beams:10-12, gates:10-30
Year
2018
2017
2016
2015
2014
2013
70
60
50
40
30
20
10
0
90
105
12
18
0
6
12
Local Time



Solar cycle trends

More echoes at solar MAX
Stronger effect on nightside





Monthly averaged occurrences

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Table 2. Liner fit line slopes of the echo occurrence decline in 2015-2017 (Figures 5c and 5d) for various time sectors of observations and radars. The time sectors were selected according to the local solar time. The bottom line shows the average value of the slopes.

	Echo Decrease Per Year (Bands)						
	CLY	RKN	INV	DCE	MCM	SPS	AVG
night	-8.19%	-5.30%	-6.16%	-6.69%	-5.59%	-4.76%	-6.11%
dawn	-5.91%	-2.52%	-5.17%	-8.16%	-5.86%	-6.04%	-5.61%
day	-5.65%	-5.55%	-7.50%	-10.32%	-10.39%	-6.58%	-7.67%
dusk	-7.63%	-5.13%	-5.53%	-9.85%	-11.16%	-8.11%	-7.90%
AVG	-6.84%	-4.63%	-6.09%	-8.75%	-8.25%	-6.37%	-6.82%

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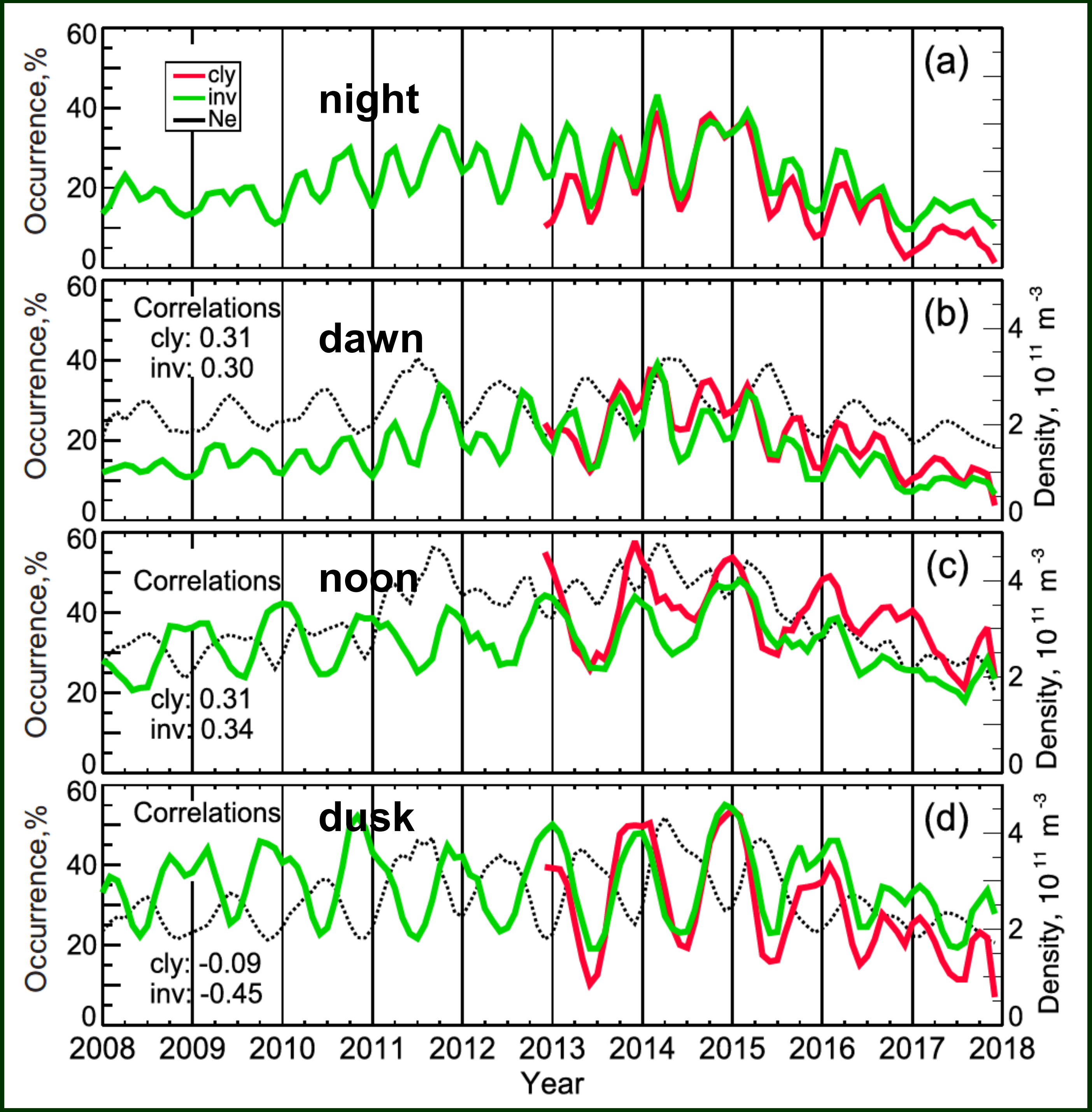
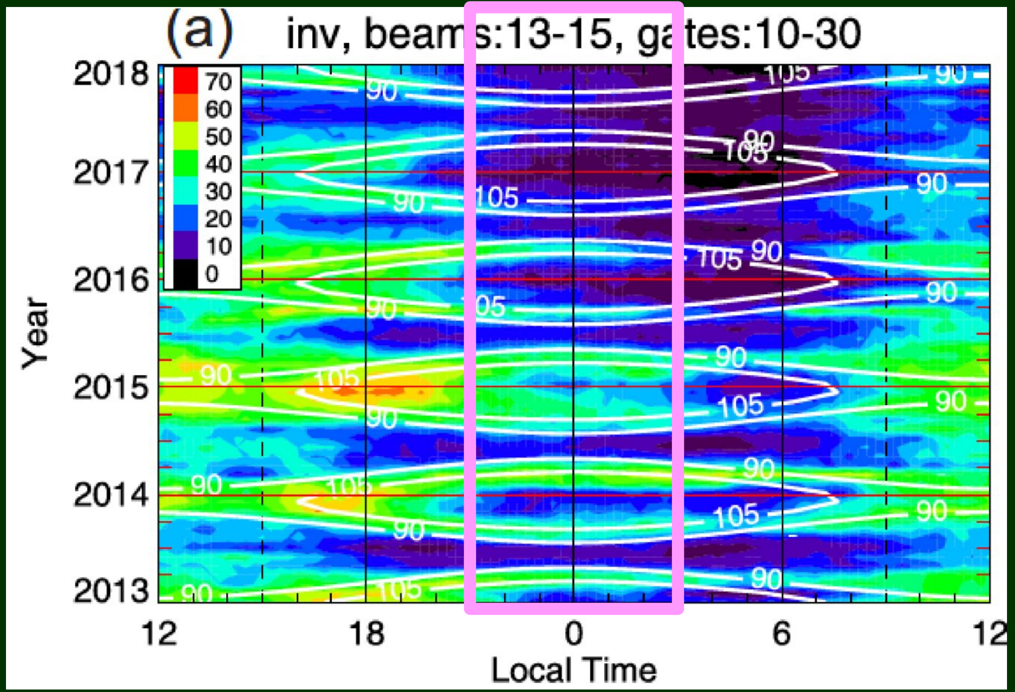
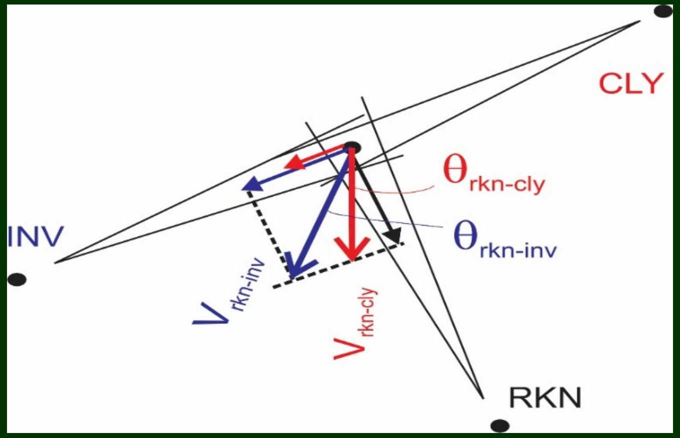
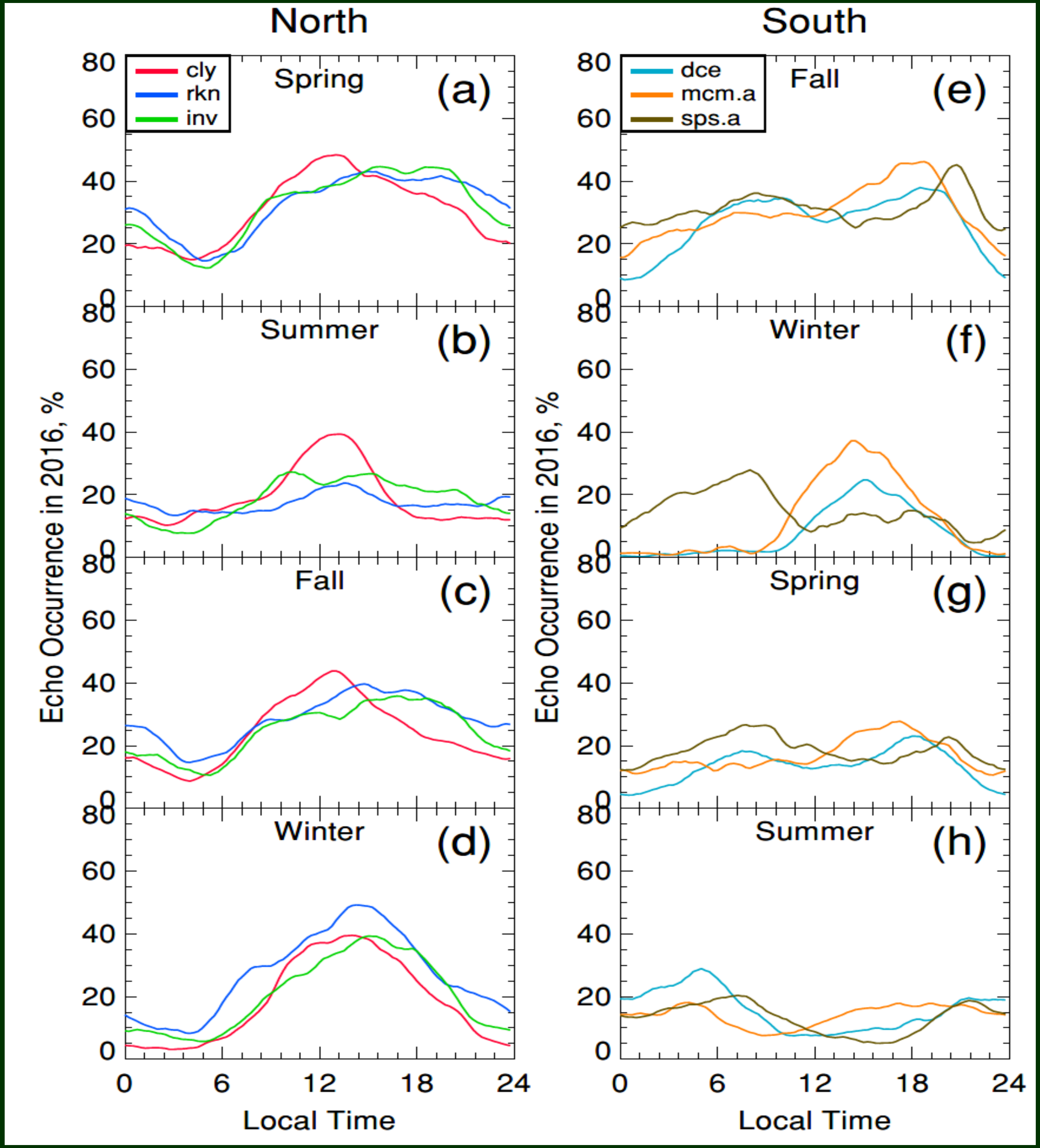


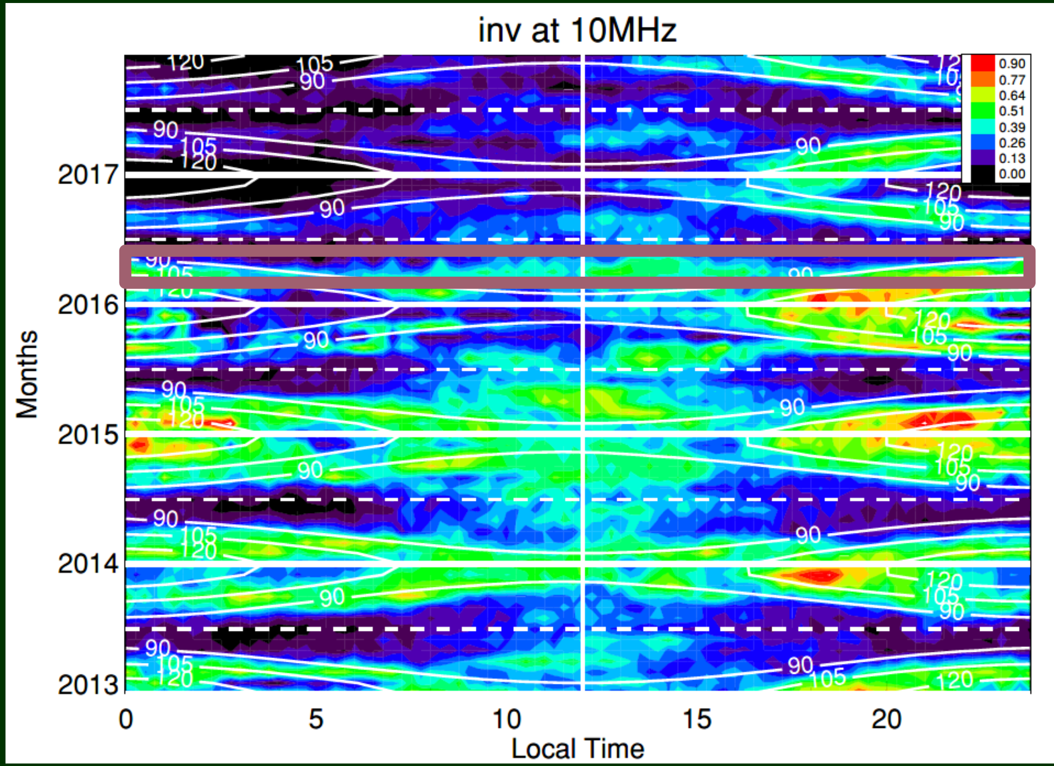


Seasonal trends



Diurnal trends



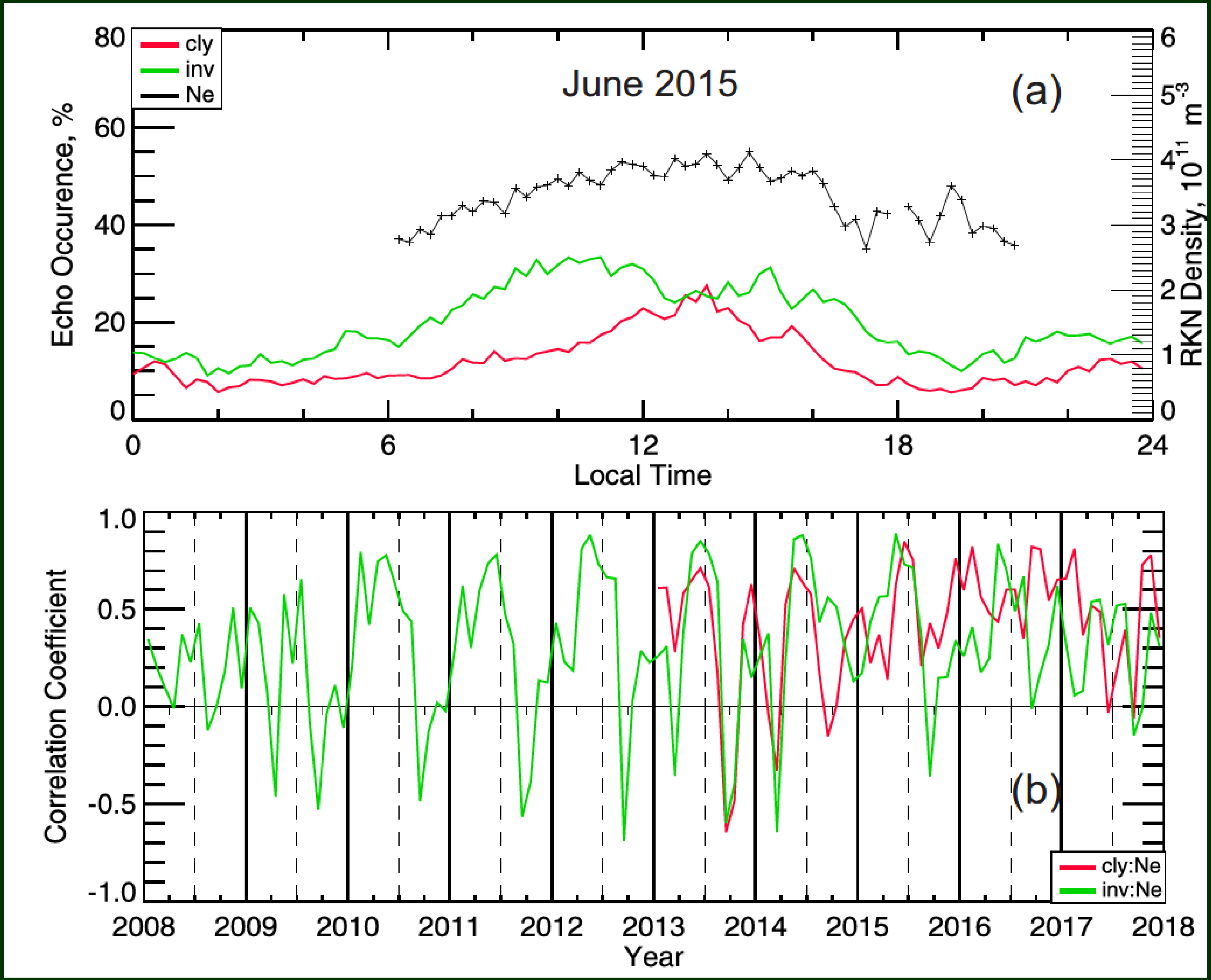


Diurnal trends for North and South are the same. Minor differences:

1) weaker equinoctial trends

2) no near noon maxima in SH

Correlation in diurnal trends of echo occurrence and Ne



Diurnal trends of occurrence and Ne correlate in summer, a bit worse in winter and NO correlation in equinoxes

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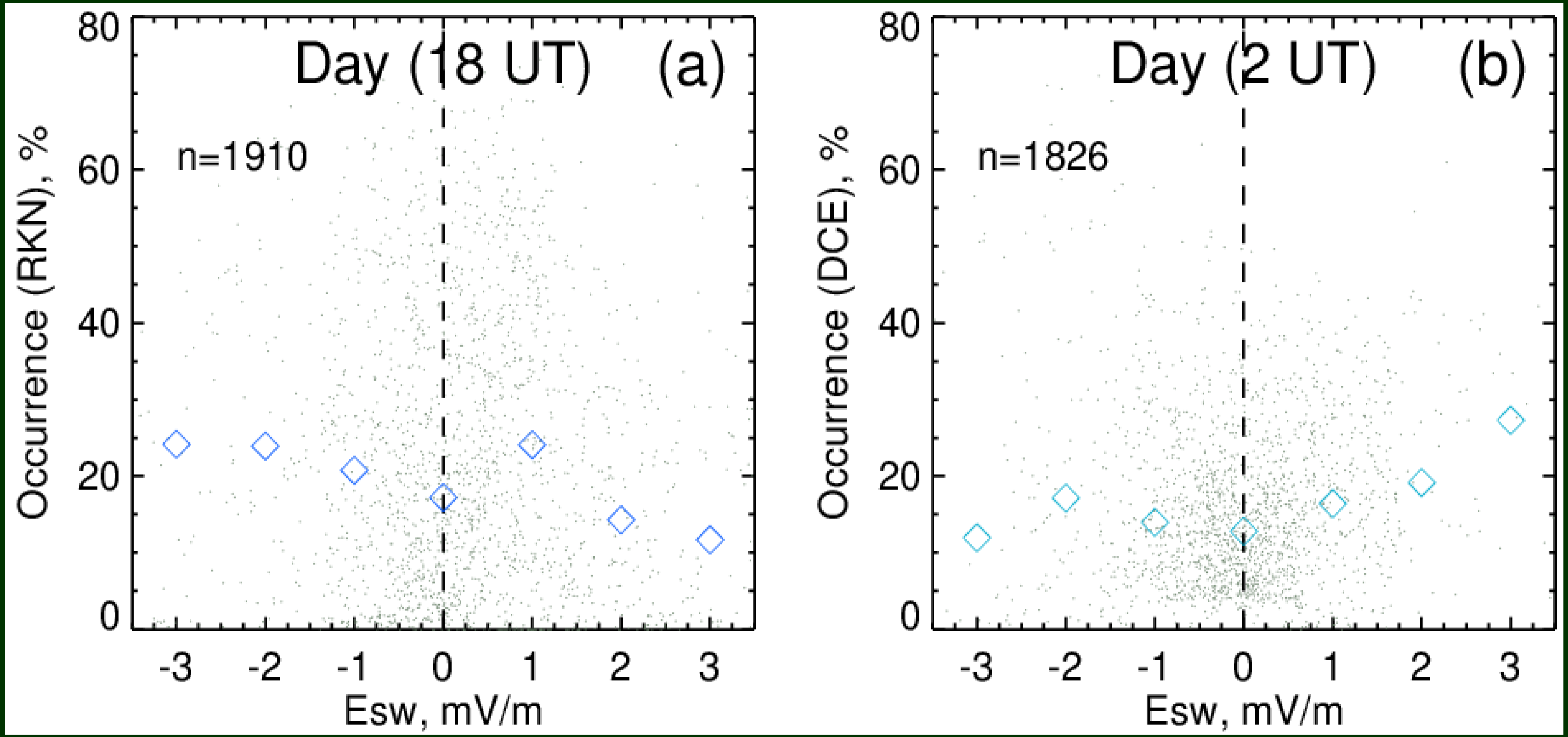
(In)dependence of echo occurrence upon solar wind driver



The reason for solar maximum enhancement of the echo occurrence rate is not so much due to stronger E fields as due to the density increase!

Conclusions in general terms

1. Echo occurrence rates of the PolarDARN radars depends on Ne with initial growth @ small Ne up to a certain threshold after which a saturation occurs.

2. Echo occurrence is maximized at the solar cycle maximum and this is due to general enhancement of Ne.

3. Seasonal variations are stronger in SH where radars monitor echoes at higher geographic (and geomagnetic latitudes). Probably due to Ne as well.

4. Diurnal variations of echo occurrence are consistent with Ne changes except of equinox.

5. In equinoxes, Ne is high all day long, above threshold for the saturation, and other factors control diurnal trends, such as terminator-related large-scale inhomogeneity providing better propagation/orthogonality conditions.

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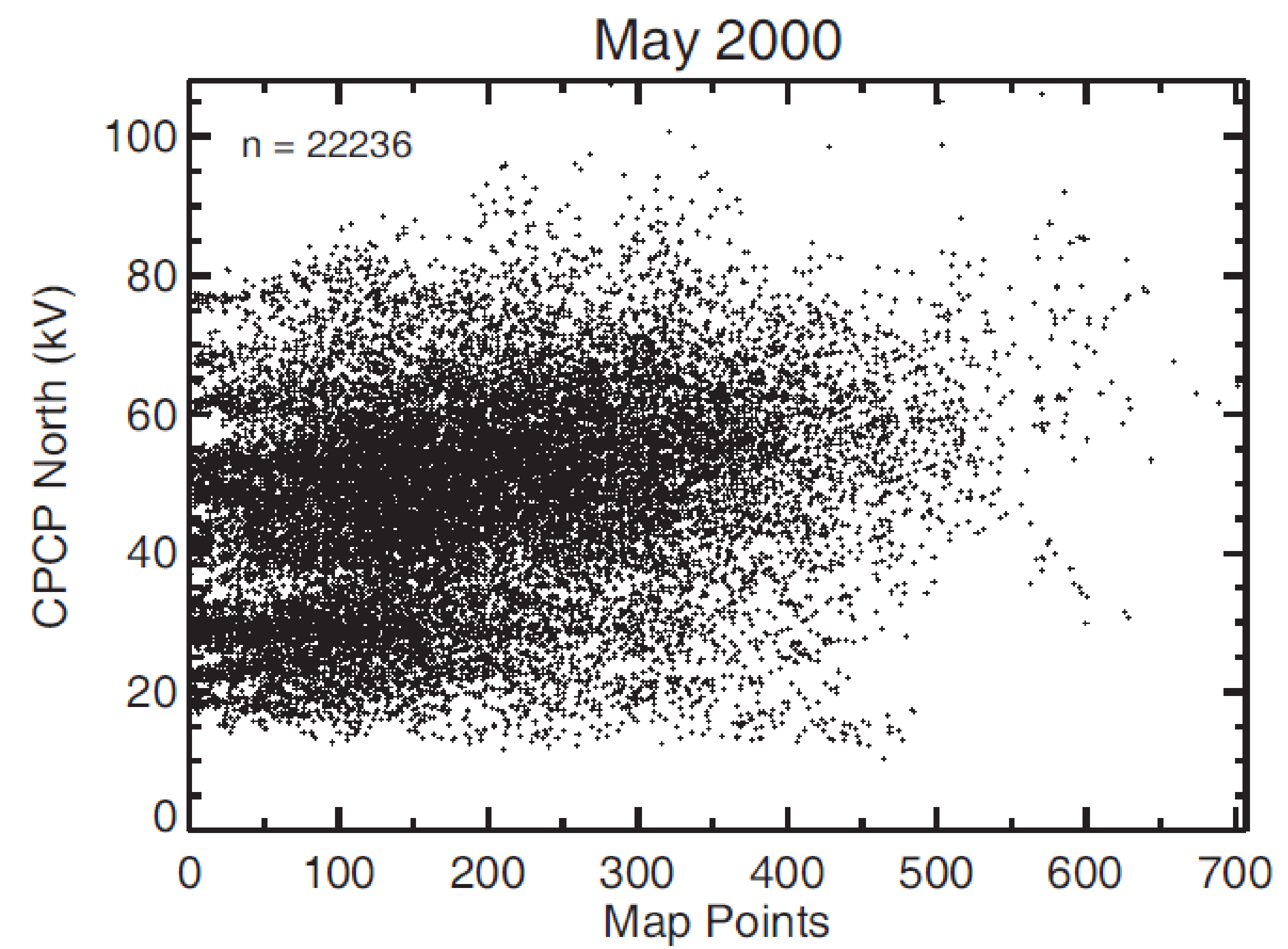
Thank you for attention

SD CPCP quantization effect



Quantization is obvious for < 200 points on a convection map. Here is the reason for Mori's choice of at least 300 points on every convection map considered

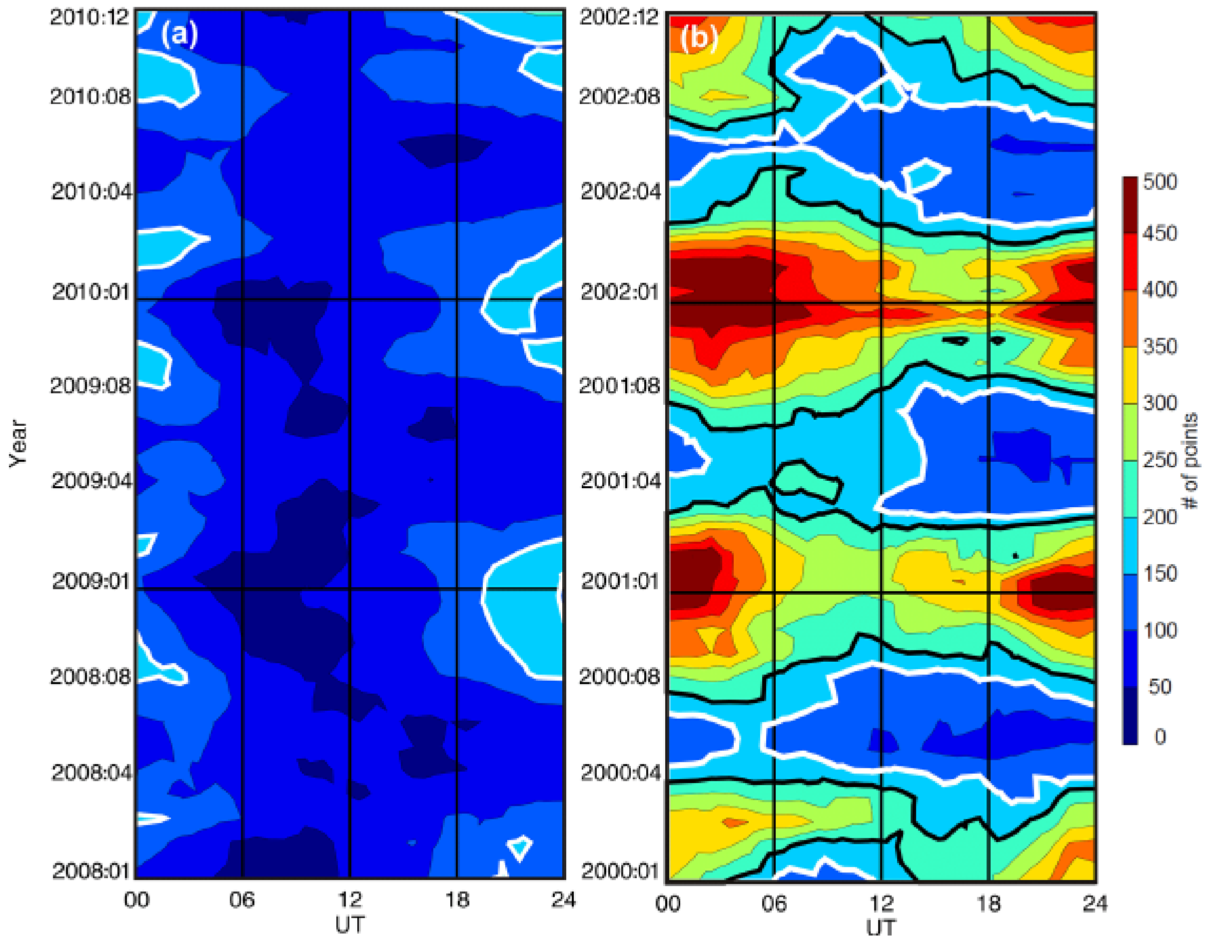


Fig. 7. Contour plot for the hourly-averaged number of grid points on individual 2 min SuperDARN convection maps for periods of **(a)** minimum solar activity (2008–2010) and **(b)** maximum solar activity (2000–2002) as a function of UT time. The white line is the contour with the number of points at 150 (both panels) and 200 (panel **b**); in regions with a lower number of points a SuperDARN convection map based on the data is expected to be globally unreliable.

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