PHYSICS AND ENGINEERING PHYSICS

Validation of Rankin Inlet electron density measurements with the RISR-C incoherent scatter radar

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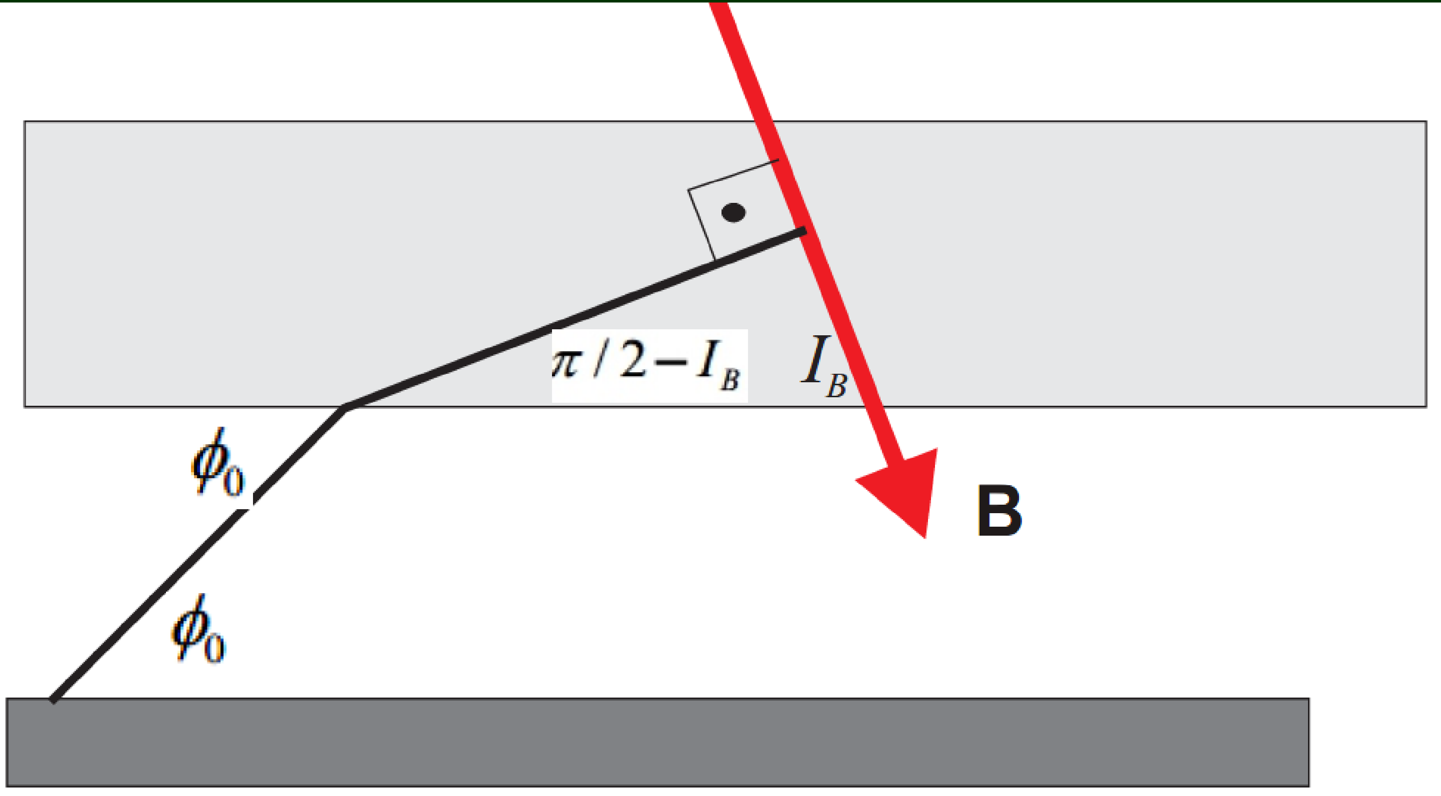
Reasoning

Although convection maps are indeed VERY useful, the radar coverage in recent years is not good. Data usage is on a decline (?)

Density measurements would invigorate the project as a whole!

Having density measurements implemented for all SuperDARN radars would provide data in areas not accessible to other ground-based instruments, for example over oceans.

Ponomarenko et al. [2011] proposed a method of estimating the F-layer peak electron density from the elevation angle measurements of SuperDARN radars



$$1\cdot\cos\phi_0 = n\cdot\cos(\pi/2-I_B)$$

$$n=\cos\phi_0\,\frac{R_E}{R_E+h_s}\,\frac{1}{\cos(90^\circ-I_B)}$$

$$f_p=f_0\sqrt{1-n^2}$$

$$f_p^2=\frac{e^2N}{4\pi^2 m\varepsilon_0}$$

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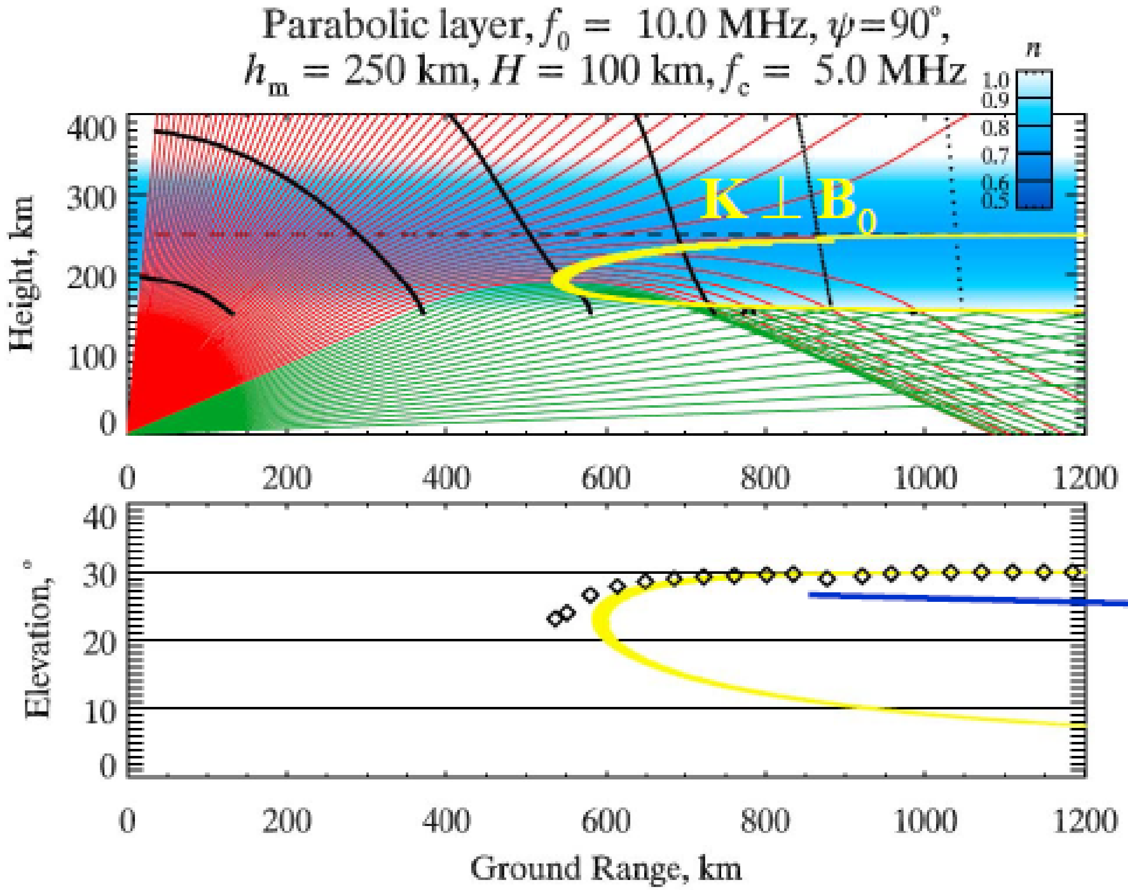
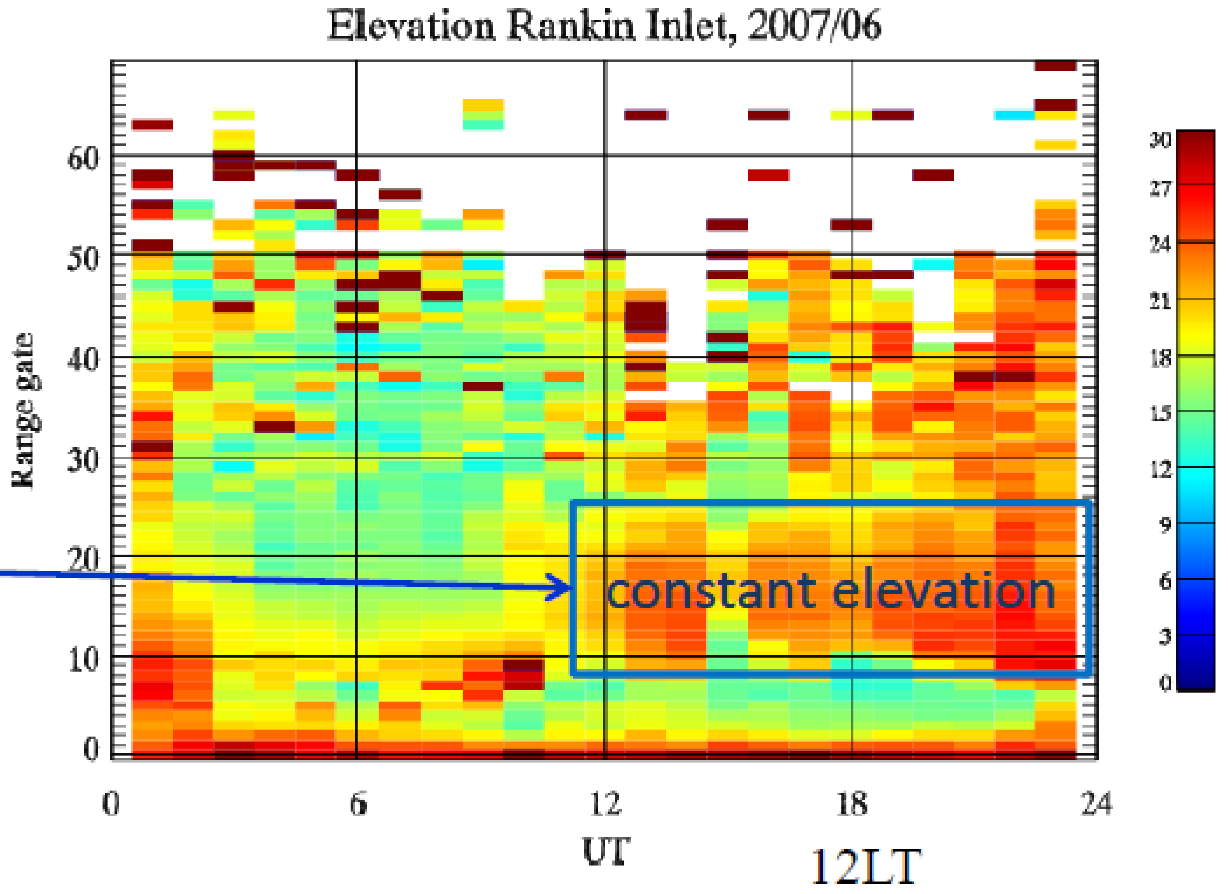
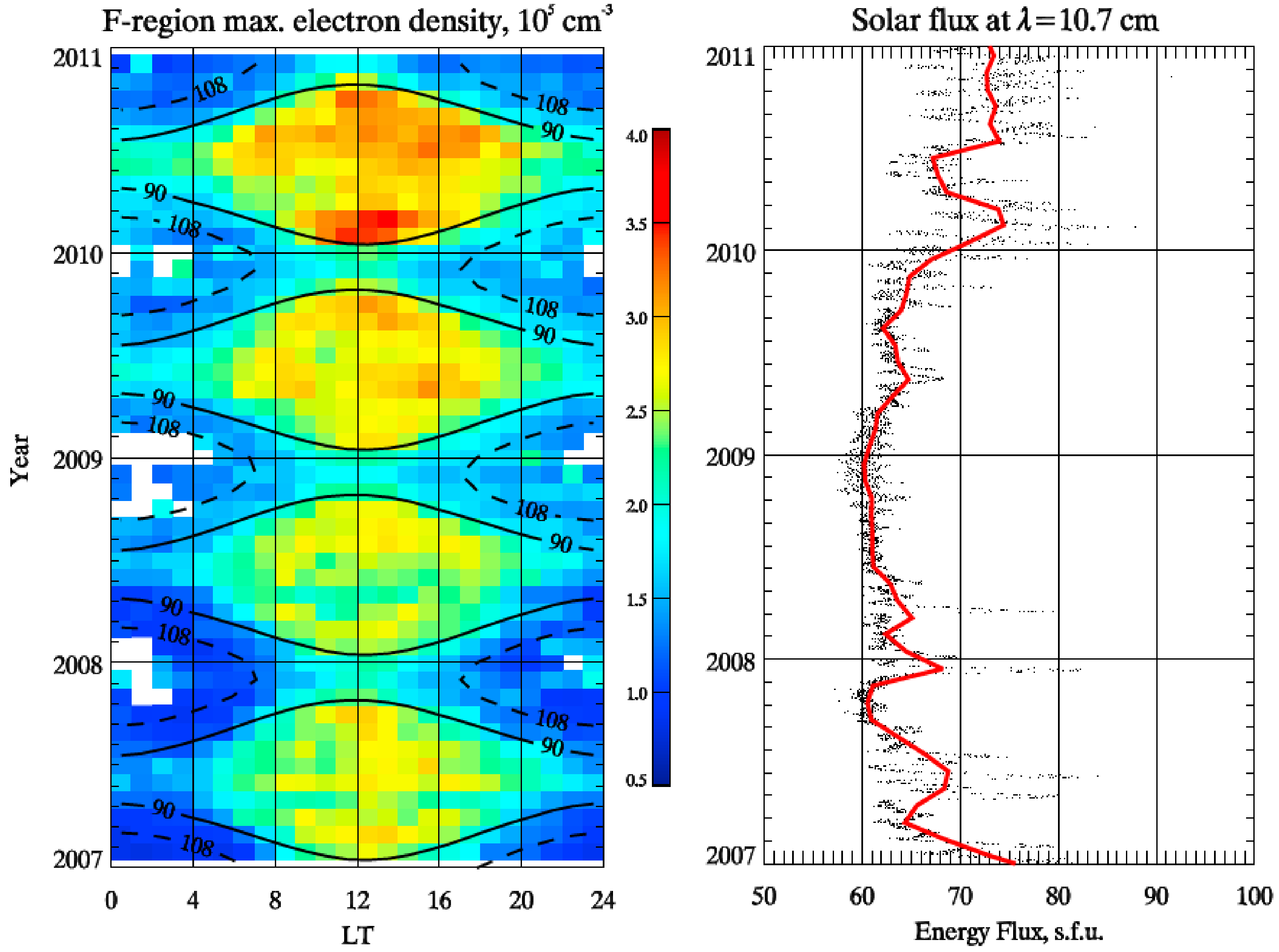
A caveat: Pedersen mode requirement

Pedersen (gliding) propagation







igure 4. (left) Diurnal-seasonal variations of the maximum electron density in the F-layer estimated from elevation data easured by RKN beam #6 during 2007–2010. Horizontal axis: local geographic time (LT). Contour lines: solar zenith ngle at the average geographic location of the analyzed data set. (right) 10.7 cm solar flux variations for the same period easured in solar flux units (s.f.u, 10^{-22} W m^{-2} Hz^{-1}). The black dots represent "raw" data (2–3 values/day) and the red line hows monthly averages. Solar flux data downloaded from ftp://ftp.geolab.nrcan.gc.ca/./../data/solar_flux/, Department of atural Resources Canada.

The only support in 2011– Seasonal and solar cycle trends

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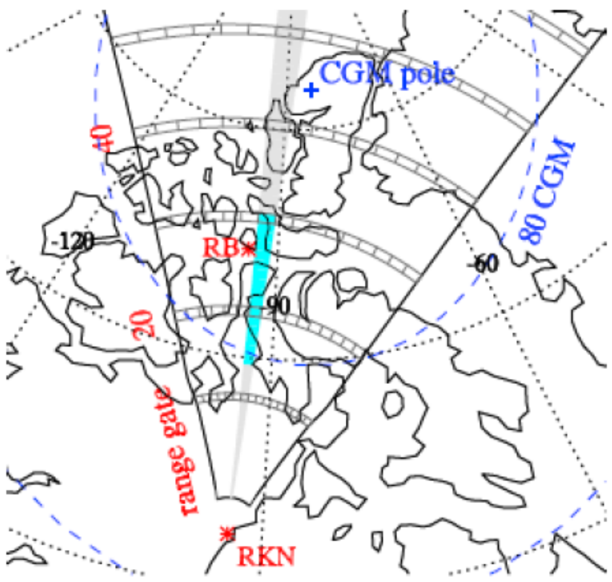
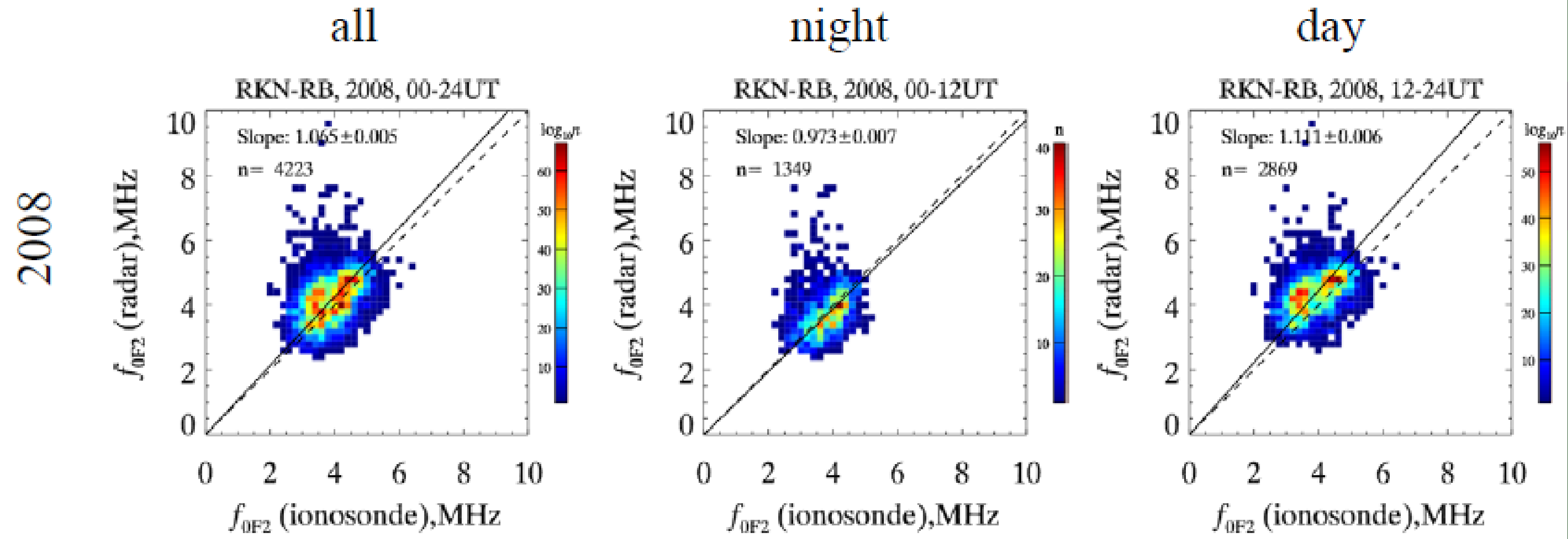
Validation work in 2013: Resolute CADI – SuperDARN (RKN)

Experimental setup & data processing



- RKN beam 6
- RB ionosonde – gate 28
- gates 15-30 – to avoid E-region contamination
- at least 5 gates with valid elevation estimates
- Sampling rate:
  - radar (average): several min
  - ionosonde: 5 min

Overlap of RKN and CADI is not perfect



RKN > CADI daytime
RKN<CADI nighttime

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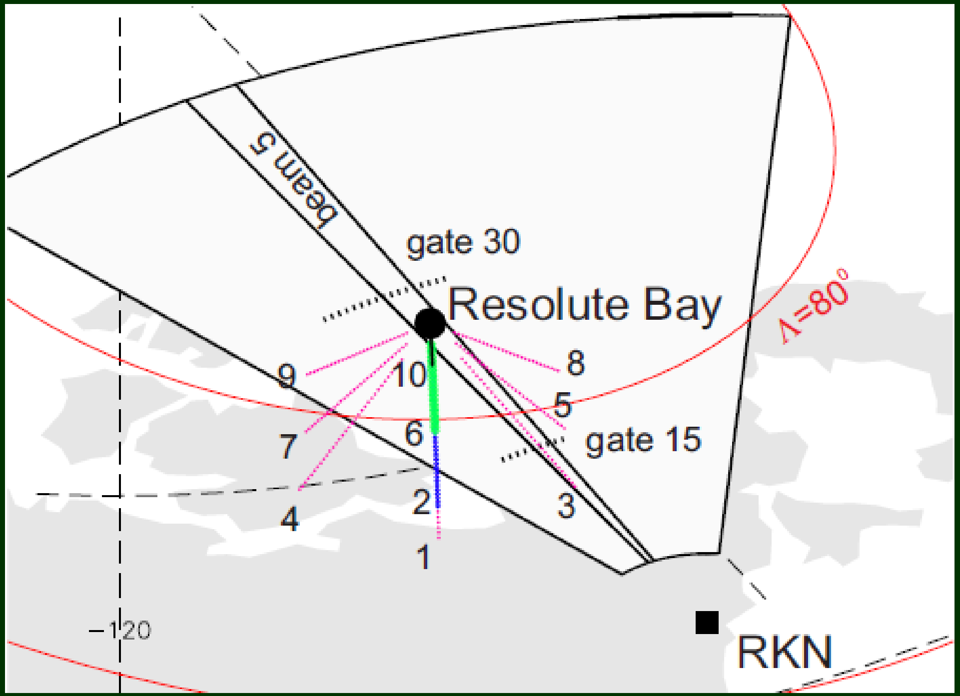
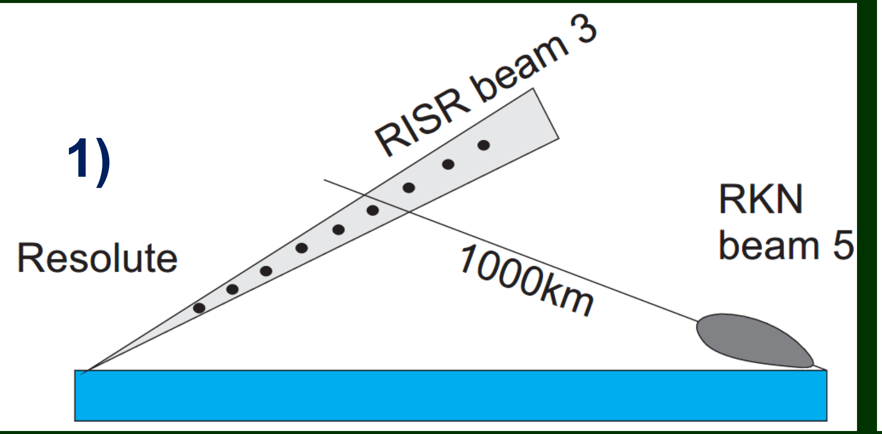
New effort: SuperDARN vs RISR-C

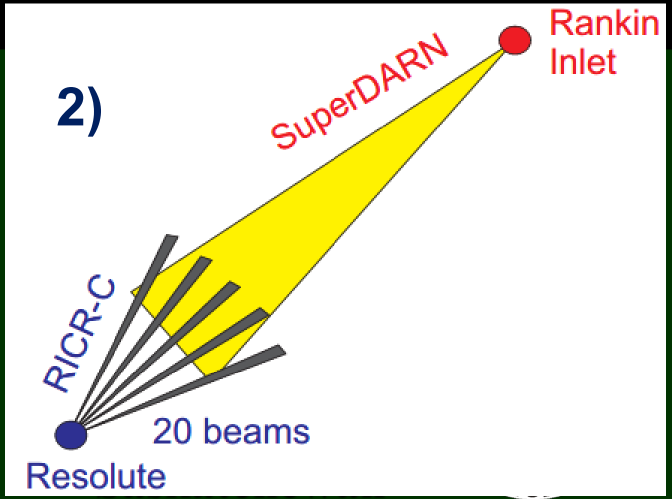
RISR-C provides 5-min Ne profiles. 2 modes:

1) World-day mode with 11 beams
2) Imaging mode with 51 beams

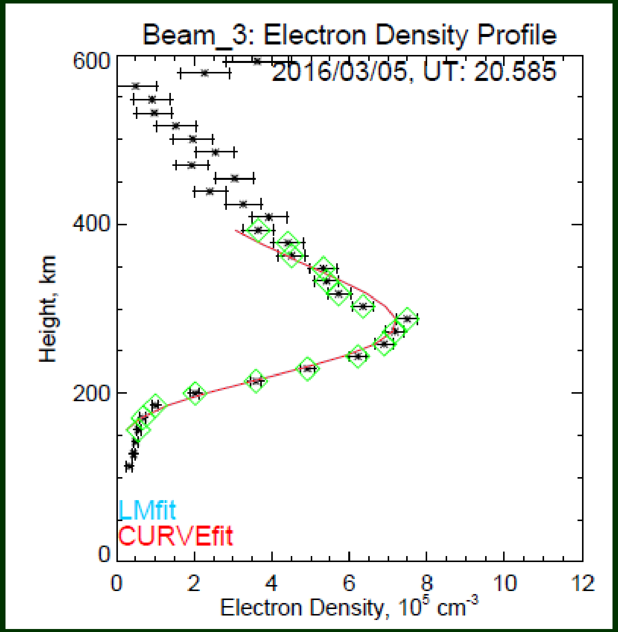
Overlap of RKN beam 5 and RISR-C beam 3 is good. Overlap with 20 RISR beams operating in Imaging mode is good for comparison of average values



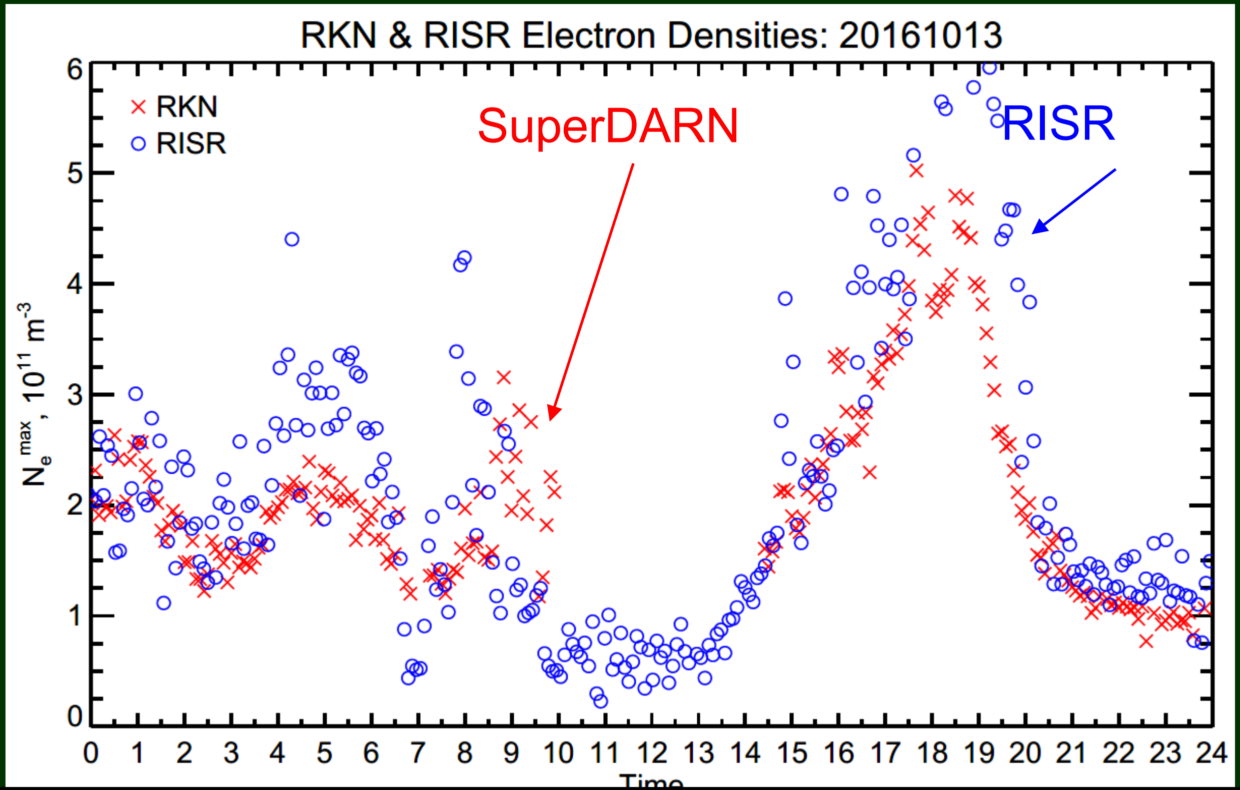




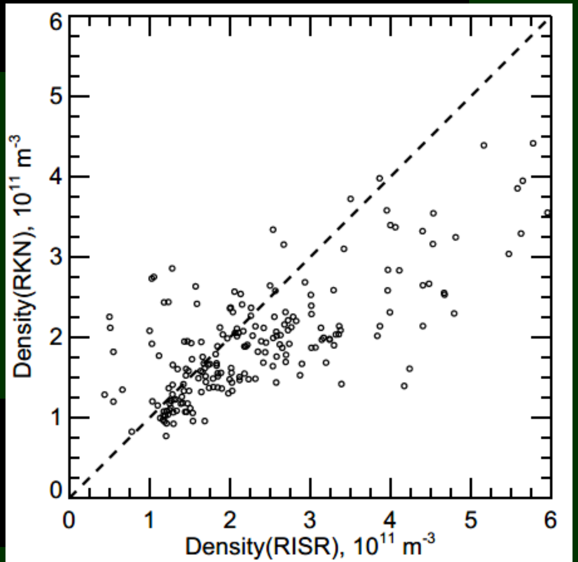
5 March 2016



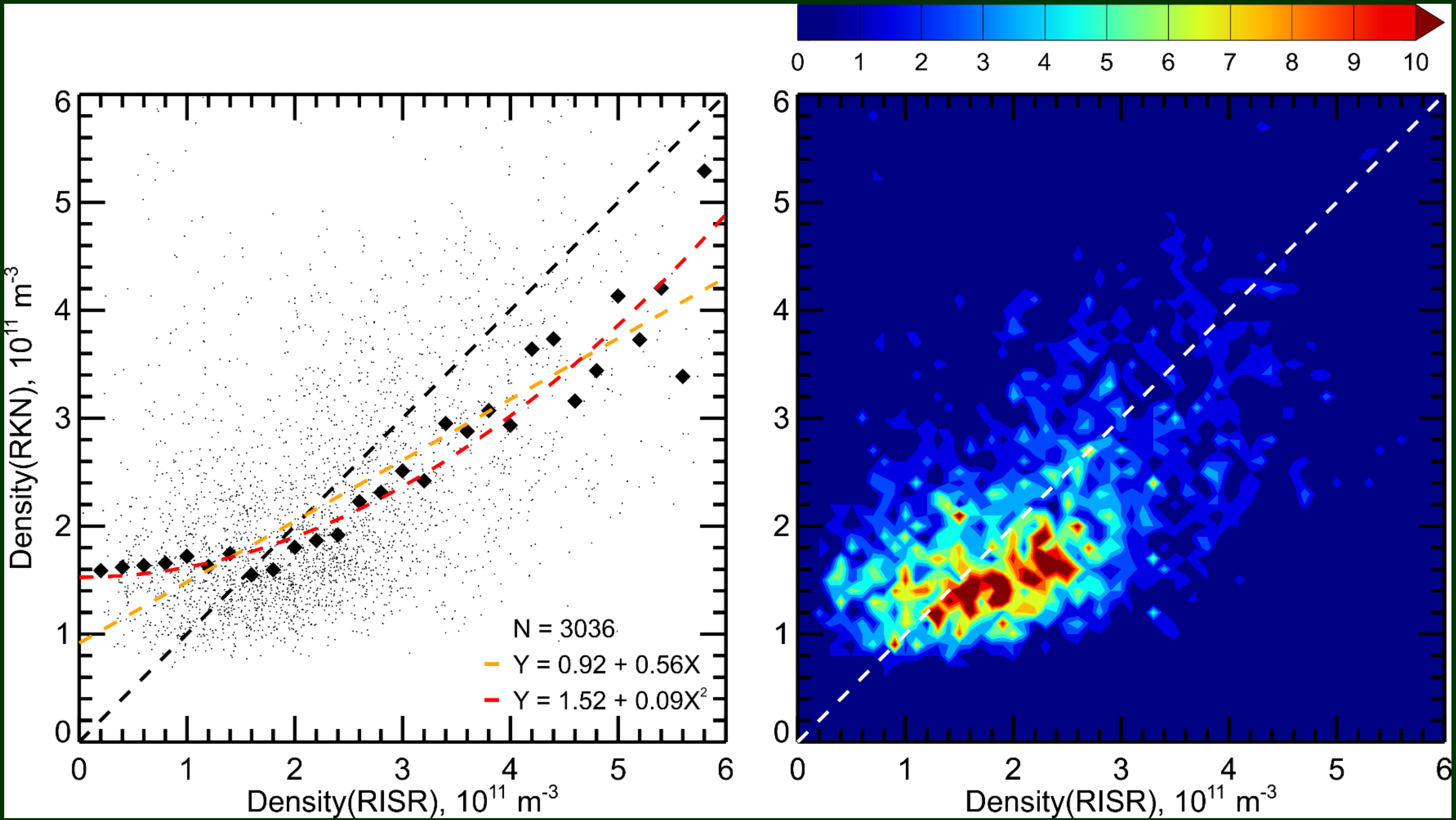
N_e^{max} is determined either by fitting or simply by taking the raw max value. Considered 5-min data



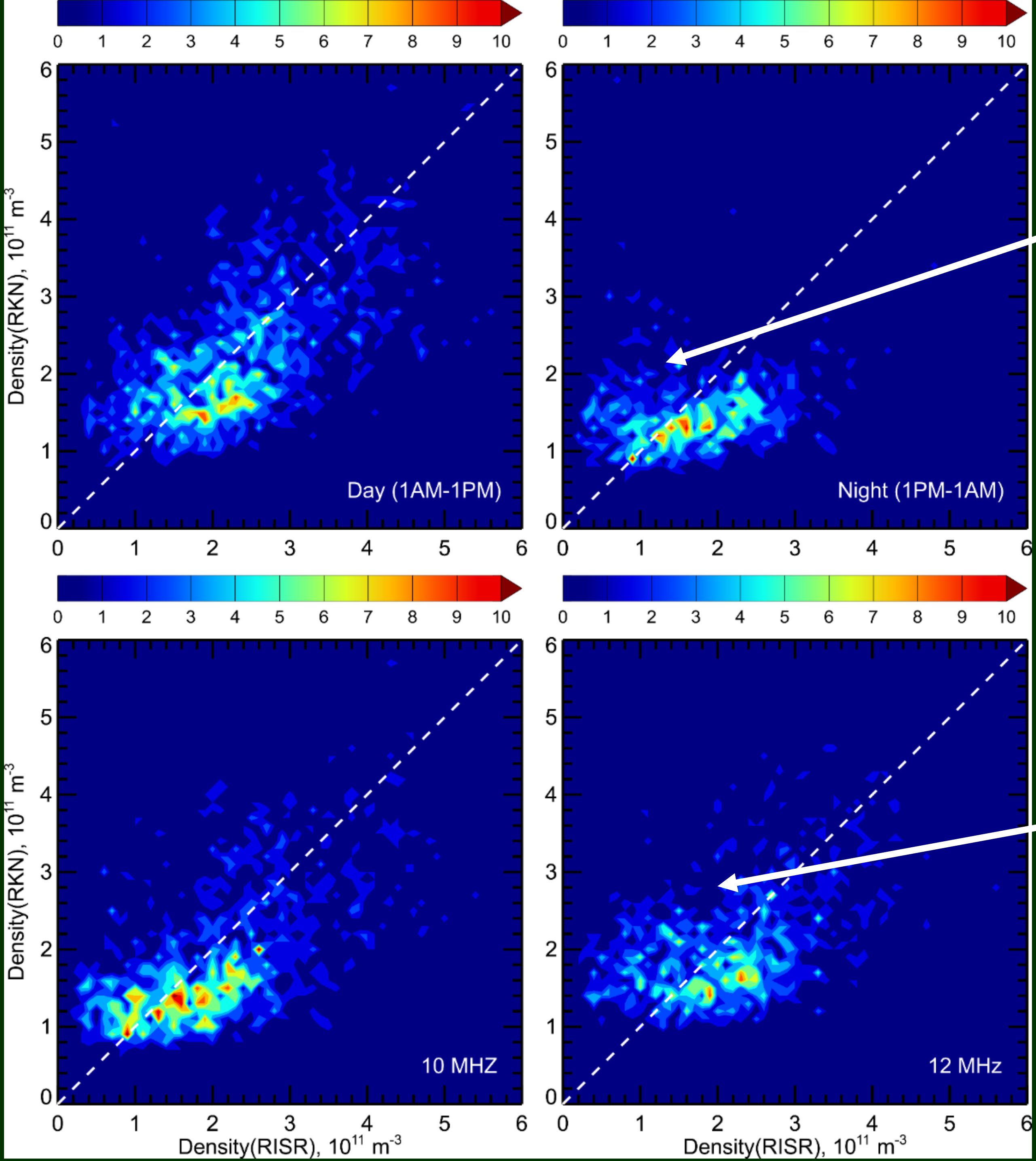
RKN-based densities follow the diurnal variation observed by RISR-C



Although some disagreements are obviously present, data clustering is around the bisector



A scatter plot of all SuperDARN vs RISR-C electron densities, with linear (in orange) and parabolic (in red) fits to medians in 0.2 10^{11} m^{-3} bins and a contour plot showing the point density in the corresponding scatter plot.



Night data show density over-estimates (all MHz)

12-MHz data show density over-estimates more frequently

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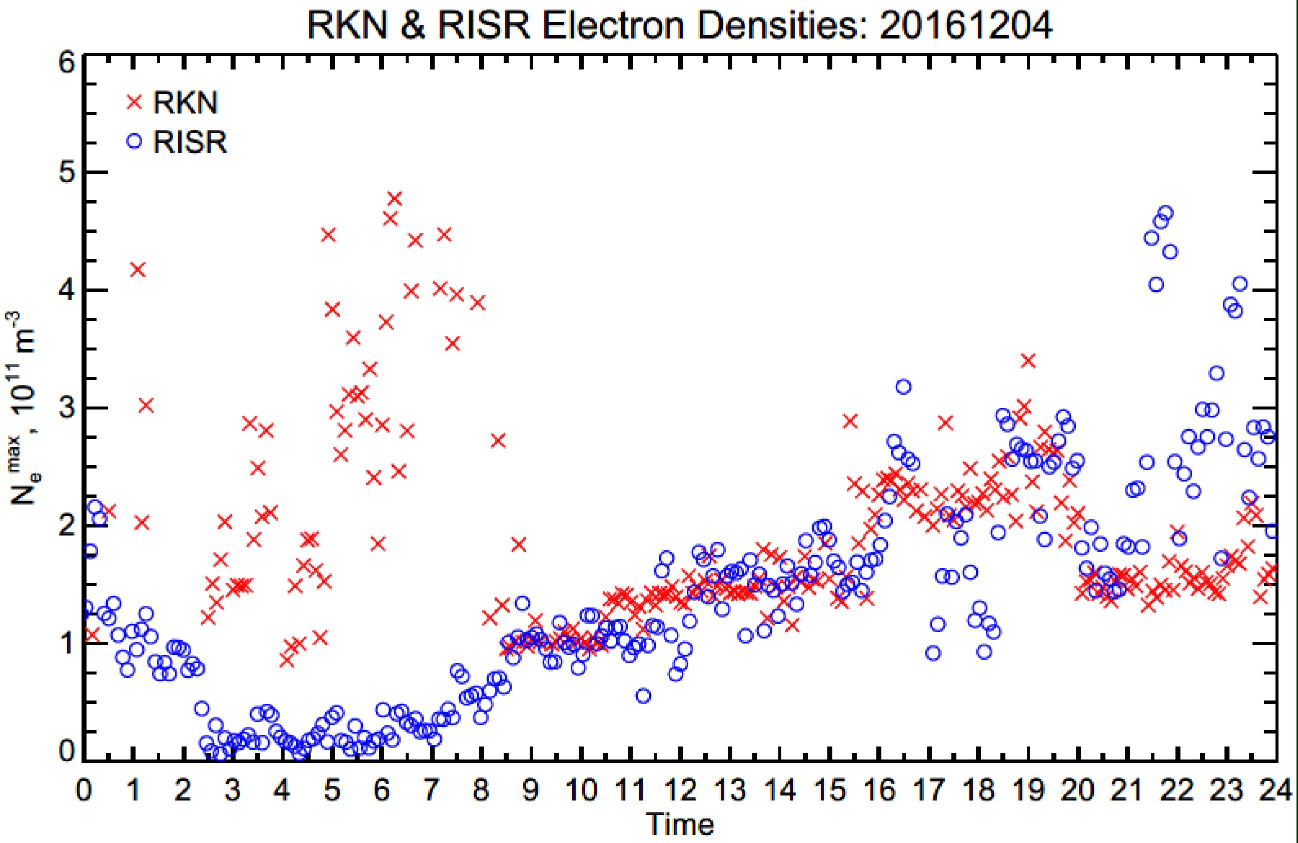
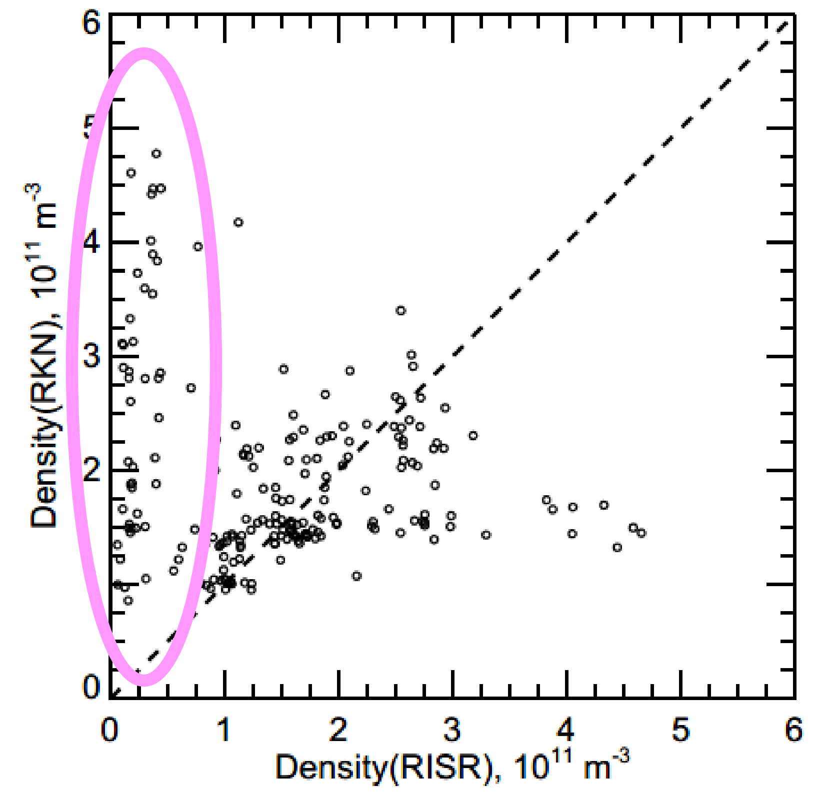
Data Set	Linear Correlation	Rank Correlation
All	0.266	0.401
Day	0.457	0.536
Night	-0.110	0.064
10 MHz	0.430	0.498
12 MHz	0.142	0.312
11 Beam	0.319	0.432
51 Beam	0.230	0.368

Data Set	Linear Fit (A + B*X)		Parabolic Fit(C + D*X^2)	
	A	B	C	D
All	0.92	0.56	1.52	0.09
Day	1.56	0.43	1.79	0.09
Night	1.15	0.24	1.32	0.06
10 MHz	0.88	0.54	1.45	0.09
12 MHz	1.70	0.26	1.97	0.04
11 Beam	0.65	0.60	1.47	0.09
51 Beam	1.09	0.55	1.62	0.10

Investigating the nighttime over-estimation

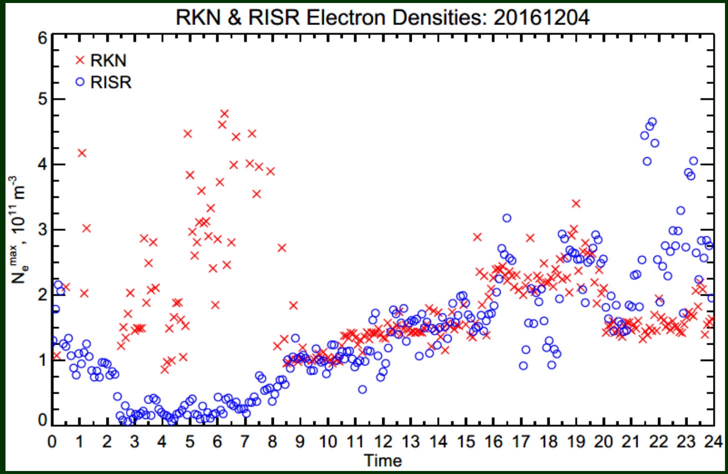




Between 3 and 9 UT (this is the midnight sector) multiple events with wrong RKN density

Investigating the nighttime over-estimation

Low electron densities mean very low elevation angles for SuperDARN. Density derivation procedure has been known to occasionally mistreat the received signal phase in such cases. Need a new procedure, starting from RAW ACF data. Ponomarenko is thinking ……



Conclusions

- **Rankin Inlet SuperDARN measurements of F region electron density peak are generally consistent with measurements by RISR-C ISR**
- **Agreement between SuperDARN and RISR-C is better during solar day**
- **Comparable results for 10 and 12 MHz SuperDARN radar frequencies**
- **Significant differences during solar night when low electron densities are expected**
- **Improvements are needed to treat low elevation angle data**

Thank you for attention

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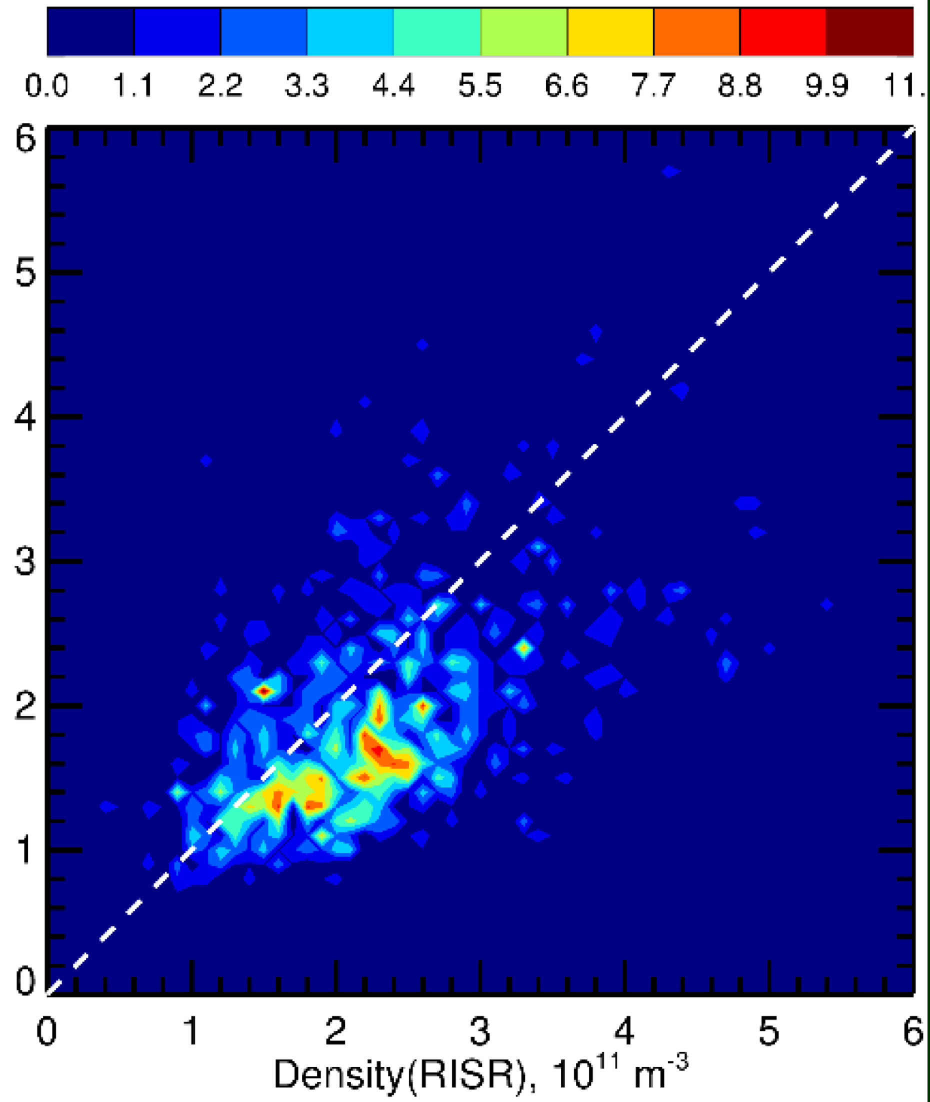
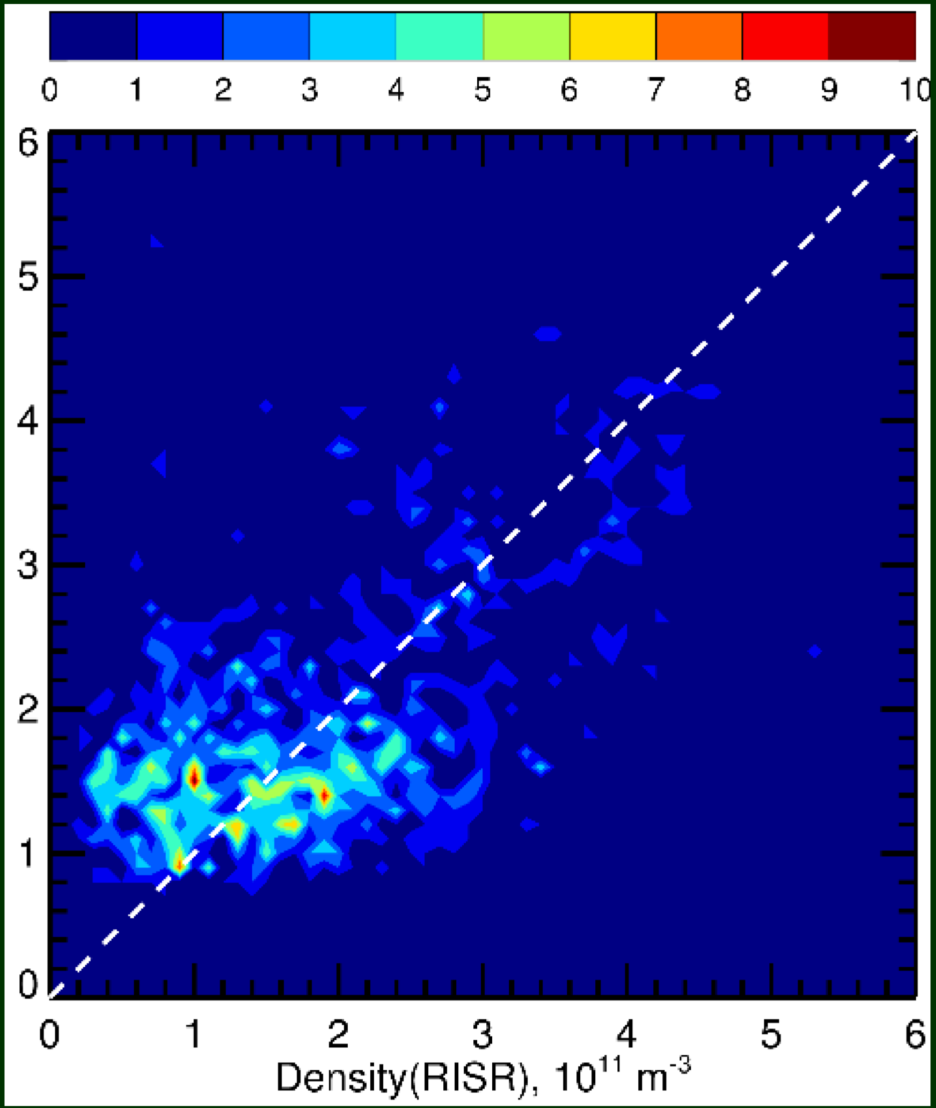
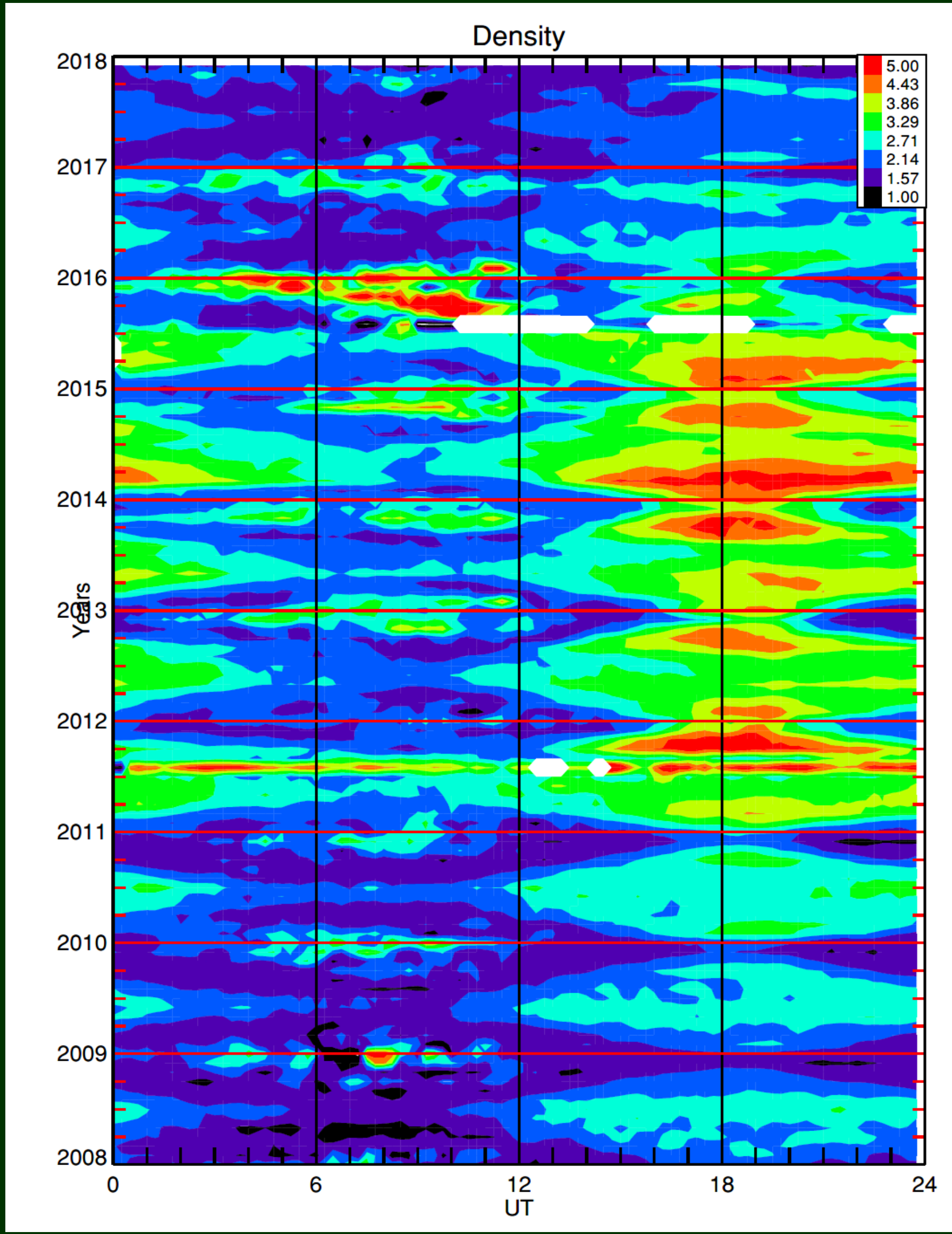
Beam/Mode Split

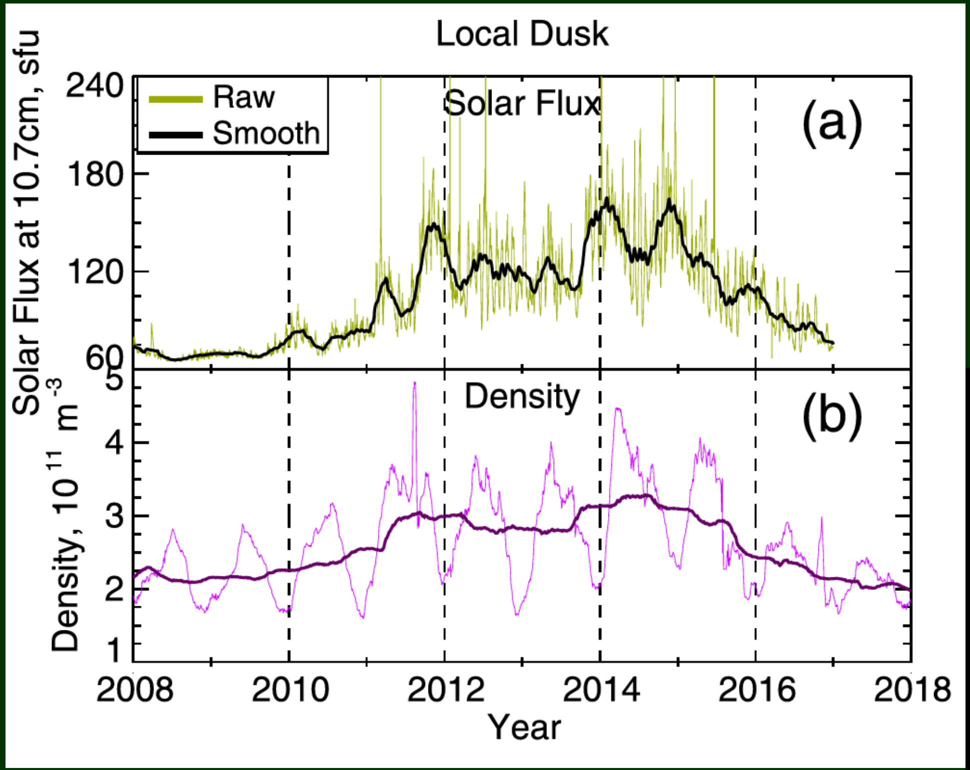




11 beam data **51 beam data**

F-region peak density in the Resolute Bay area inferred from RKN elevation angle measurements





Investigation of the solar cycle and seasonal variations in N_e^{max}