PHYSICS AND ENGINEERING PHYSICS

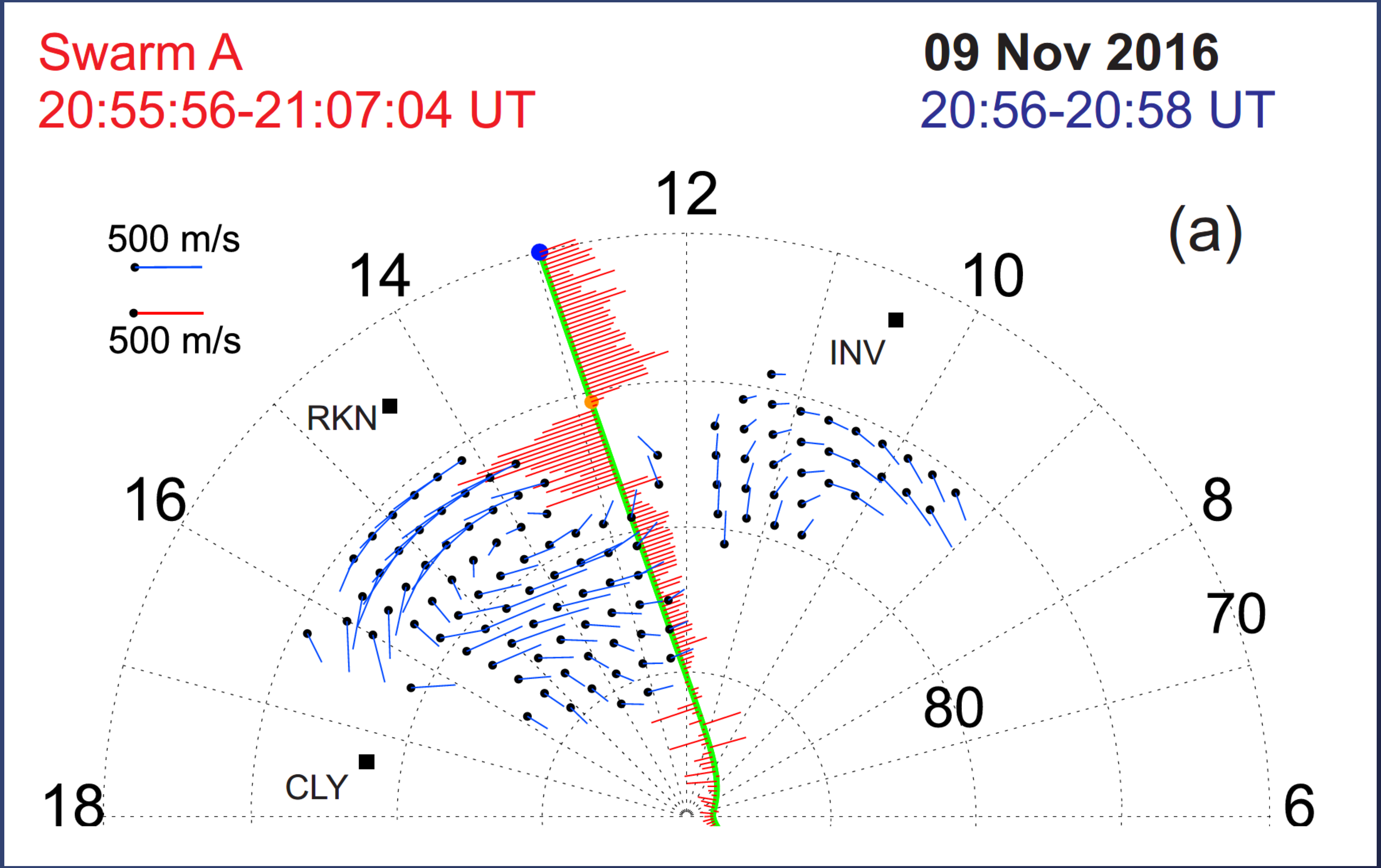
SuperDARN Doppler velocity correction for half-hop echoes

A. Koustov and P. Ponomarenko

Dept of Physics and Eng Physics +ISAS
U of Saskatchewan

Institute of Space and Atmospheric Studies

What are we wondering about? Why?



Objectives of the work

Objectives of the work

General objective:

Revisit the relationship “HF Doppler velocity - ExB drift” for echoes received through 1/2 hop (direct) propagation mode

Objectives of the work

General objective:

Revisit the relationship “HF Doppler velocity - ExB drift” for echoes received through 1/2 hop (direct) propagation mode

Implement geolocation determination through HF elevation.
Assess the differences in geolocation “standard-elevation based”

Objectives of the work

General objective:

Revisit the relationship "HF Doppler velocity - ExB drift" for echoes received through 1/2 hop (direct) propagation mode

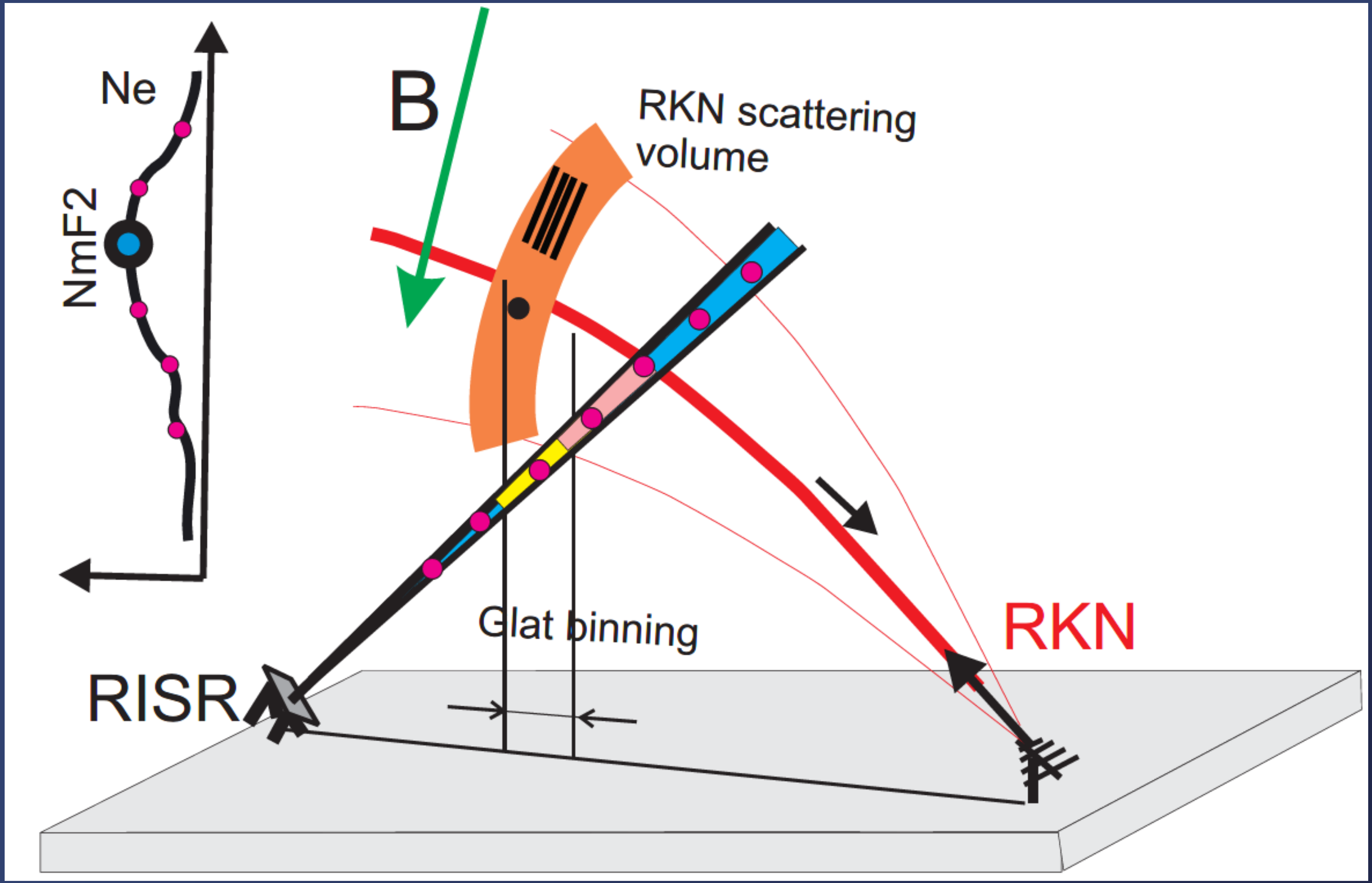
Implement geolocation determination through HF elevation. Assess the differences in geolocation "standard-elevation based"

Consider HF velocity correction by

1) NmF2 from ISR concurrent measurements (traditional)

2) Ne from HF elevation angle measurements (news)

Geometry of Rankin Inlet SuperDARN and RISR-C, cartoon

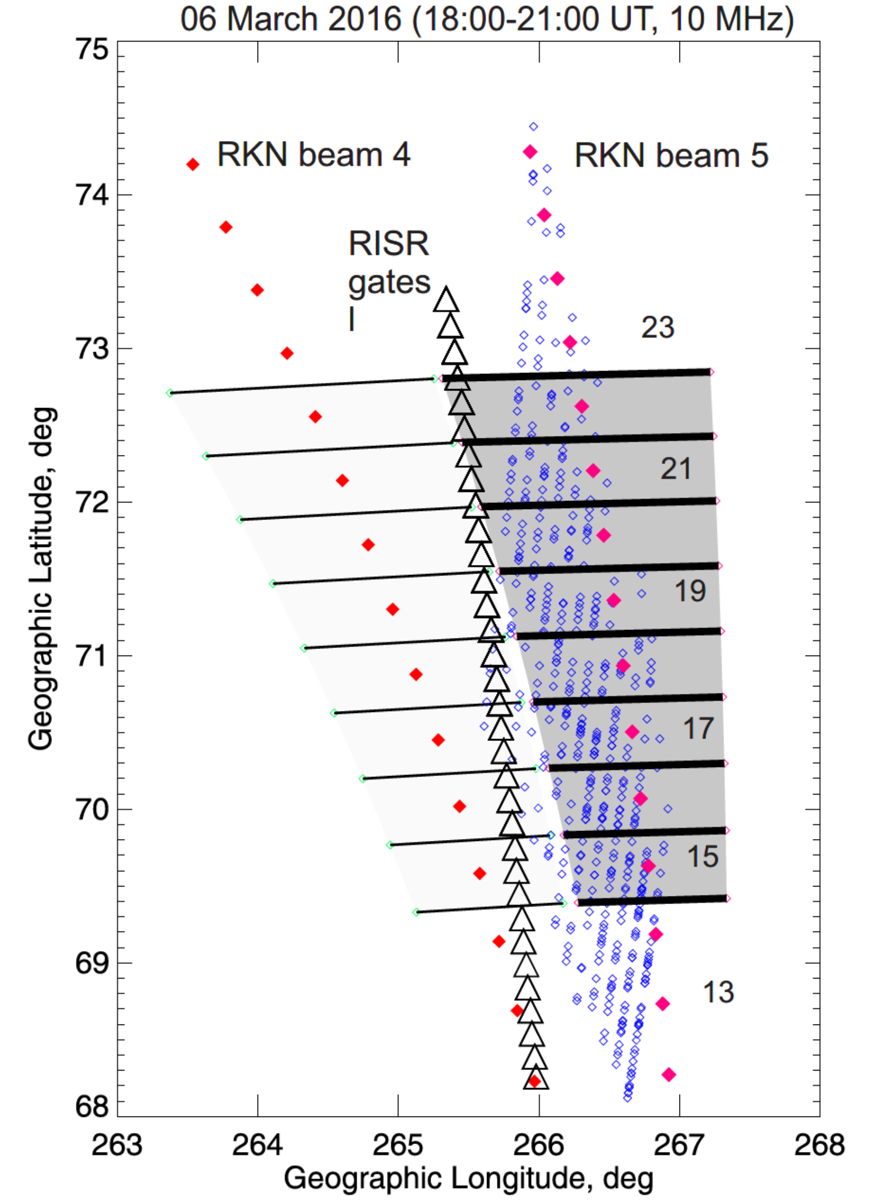


Two issues are paid attention to

1. Echo geolocation

2. Velocity correction by refractive index

Geometry of Rankin Inlet SuperDARN and RISR-C, details on a map

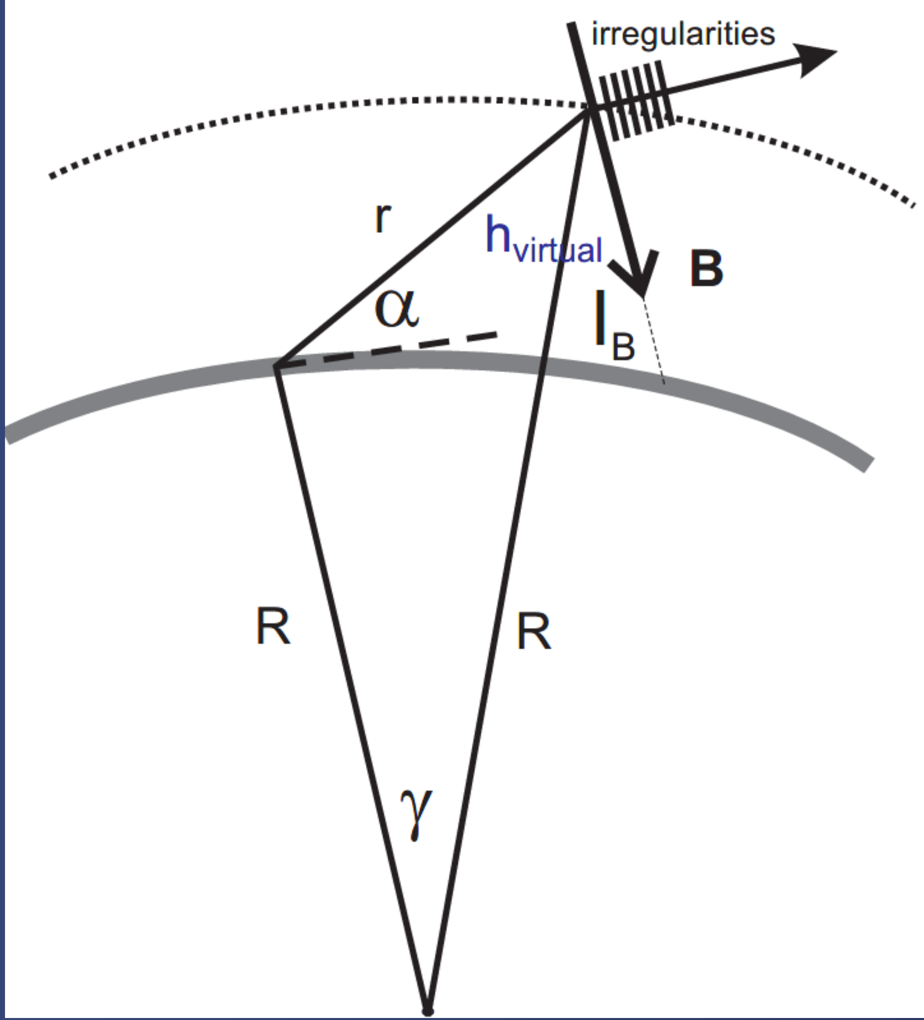


Pink dots – geolocation of RKN gate centers, standard SuperDARN model

Blue diamonds – expected echo geolocations for beam 5 echoes in a short event

Triangles – centers of RISR-C gates

Assessing geolocation of HF echoes received via ½-hop propagation mode



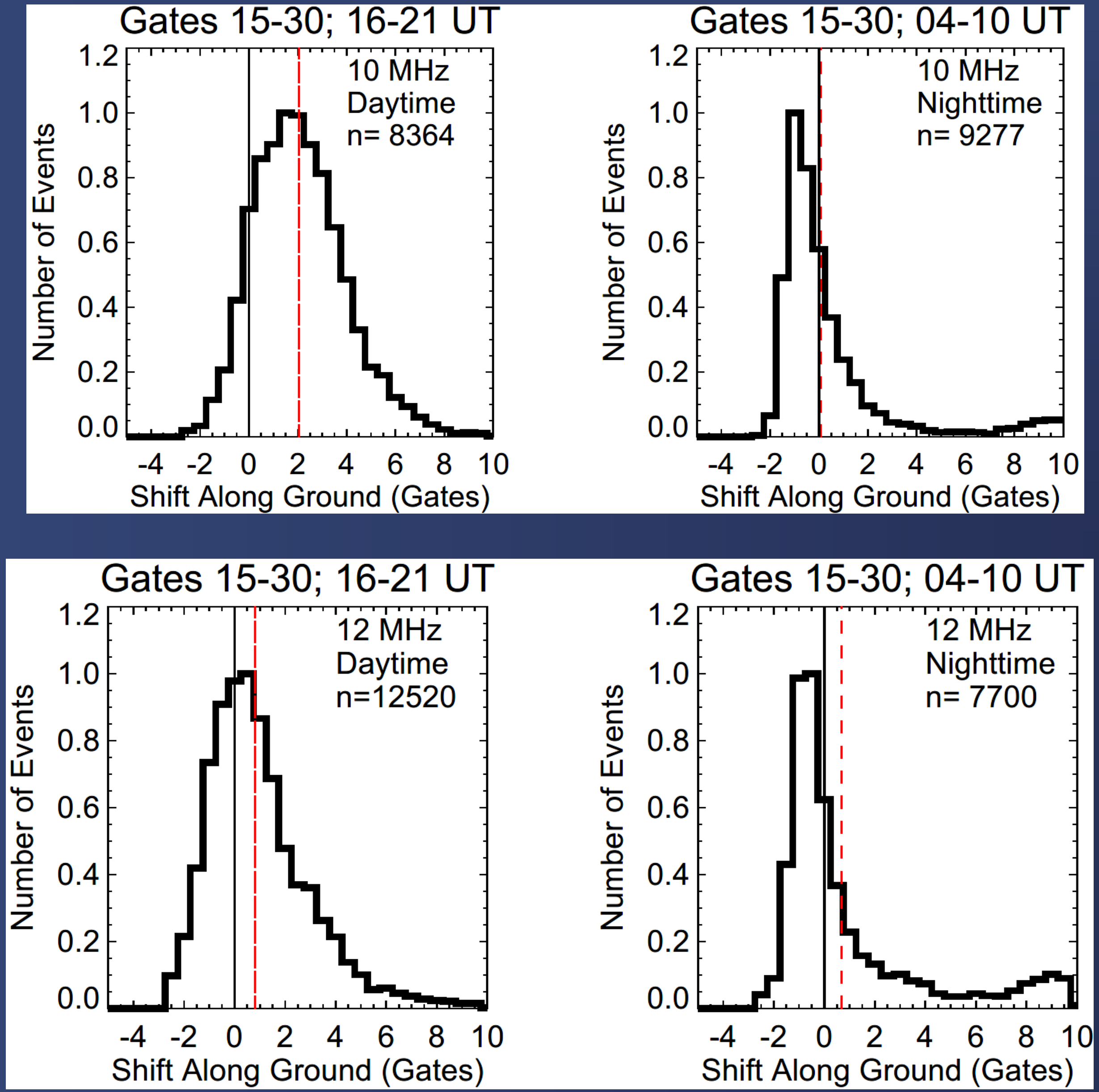
$$h_{virtual} = [R^2 + r^2 + 2rR\sin\alpha]^{\frac{1}{2}} - R$$

$$ground\ range = R \cdot \sin^{-1}\left[\frac{r \cdot \cos\alpha}{R + h_{virt}}\right]$$

Do we need to "correct" RKN gate geolocation?

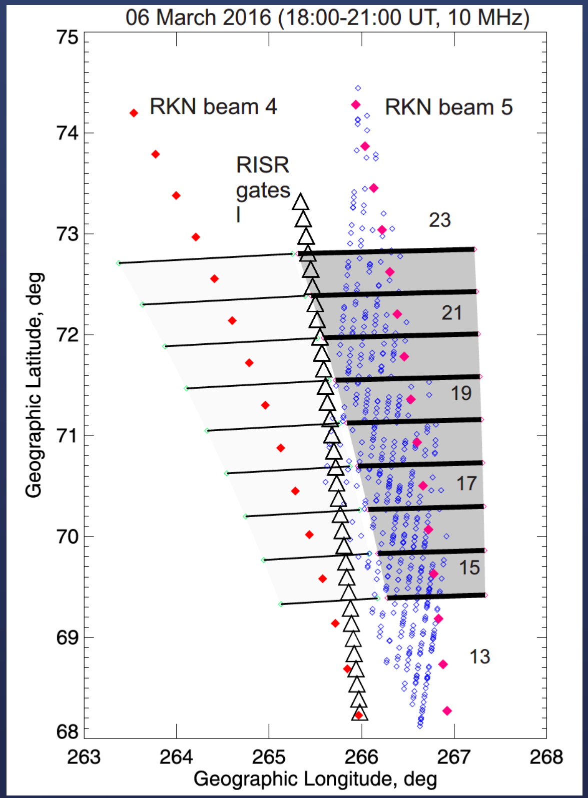
daytime

nighttime



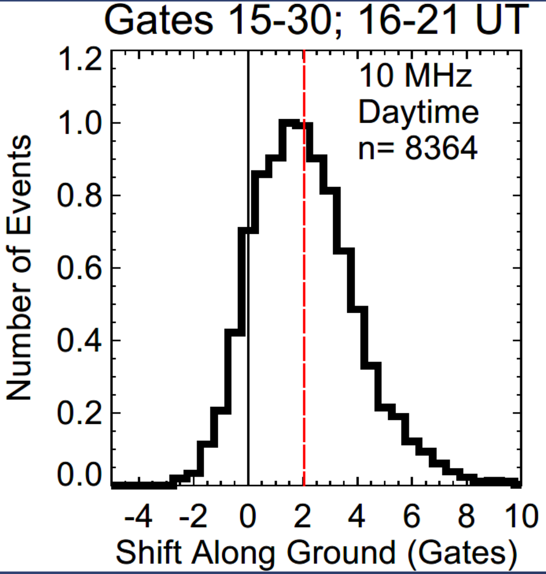
daytime

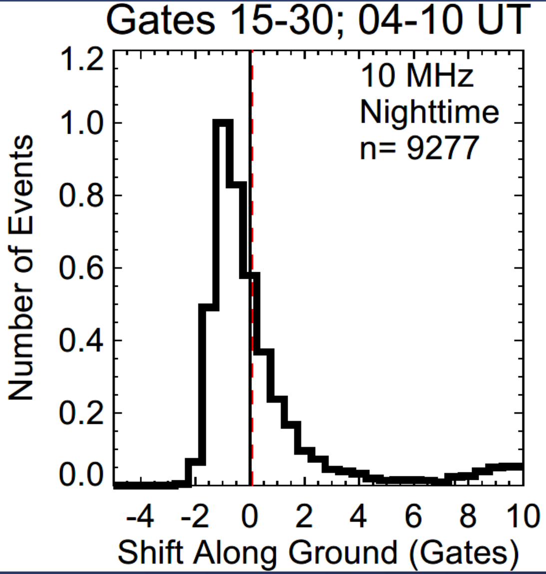
nighttime



Do we need to “correct” RKN gate geolocation?

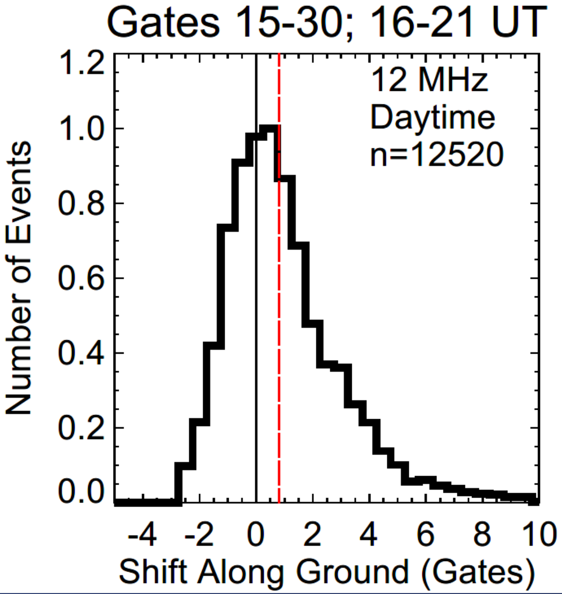
daytime

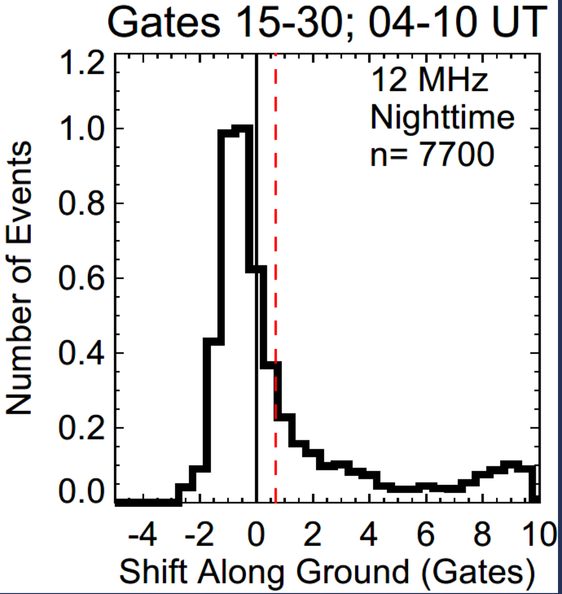




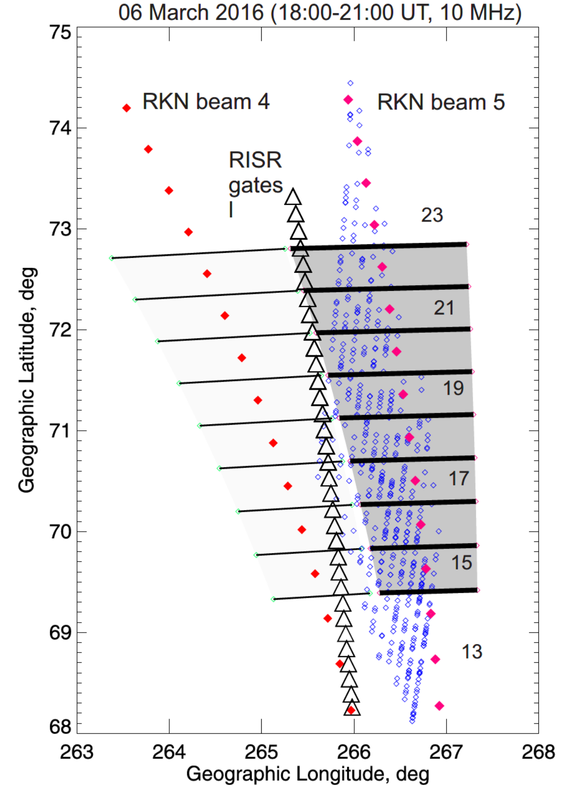
nighttime

daytime





nighttime



On average, the differences are not huge, but all depends on time sector. Improved geolocation determination is highly desired.

SuperDARN velocity "correction" with NmF2 ("traditional")

$$Vel_{ExB}(along\ HF\ beam) = Vel_{HF}(measured) \cdot \frac{1}{n_r}$$

$$n_r = \sqrt{1 - \frac{f_p^2}{f_r^2}}; \quad f_p^2 = \frac{e^2 N_m F_2}{4\pi^2 m_e \varepsilon_0}$$

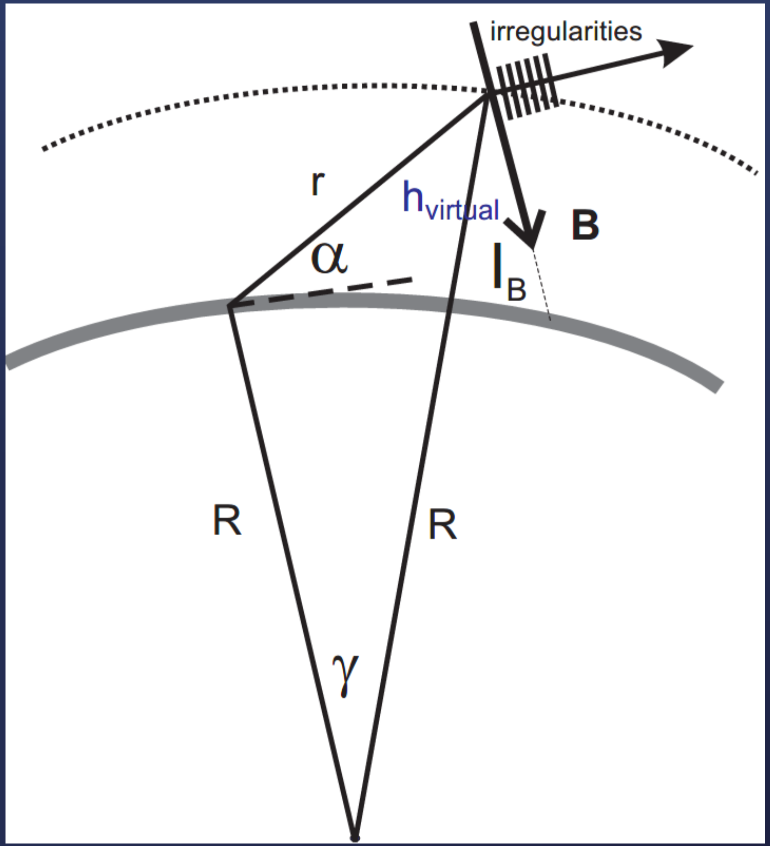
$N_m F_2$ To be taken from ISR data or ionosonde data or ionospheric model

SuperDARN velocity "correction" with elevation angle data (newly proposed)

$$Vel_{ExB}(along\ HF\ beam) = Vel_{HF}(measured) \cdot \frac{1}{n_r}$$

$$n_r = \frac{R}{R+h} \frac{\cos\alpha}{\sin I_B}$$

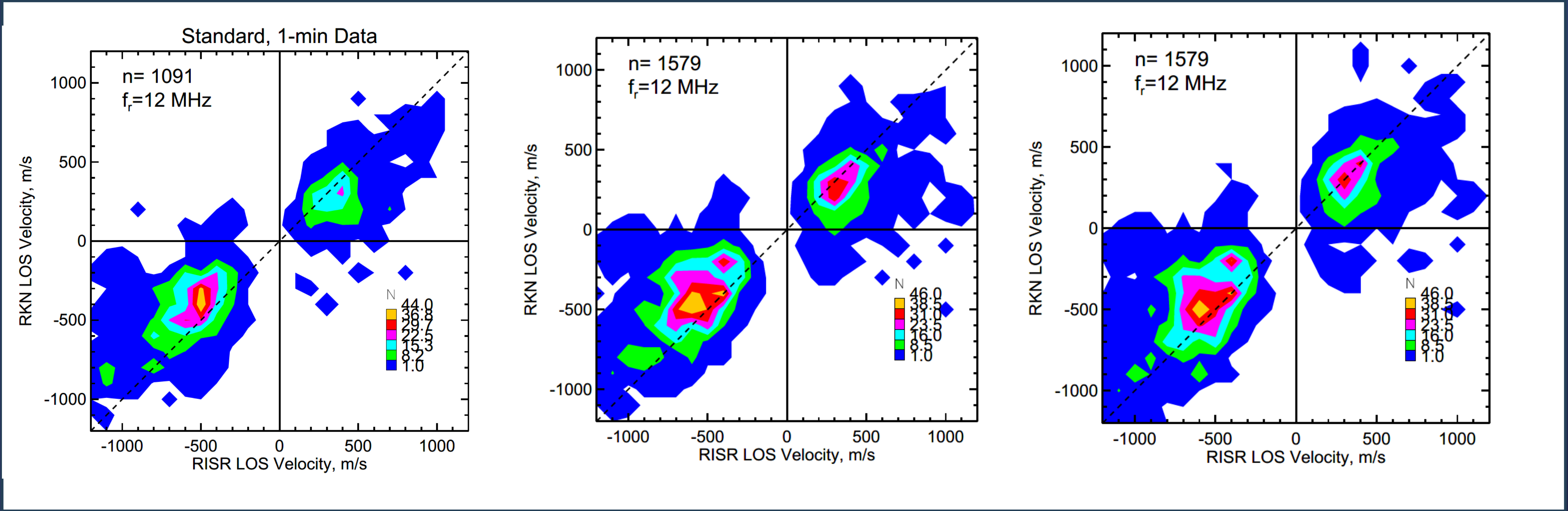
Assumed h=250 km. I_B=10deg



“Improvements” of agreement, 1-min 12-MHz data for RKN

geolocation corrected

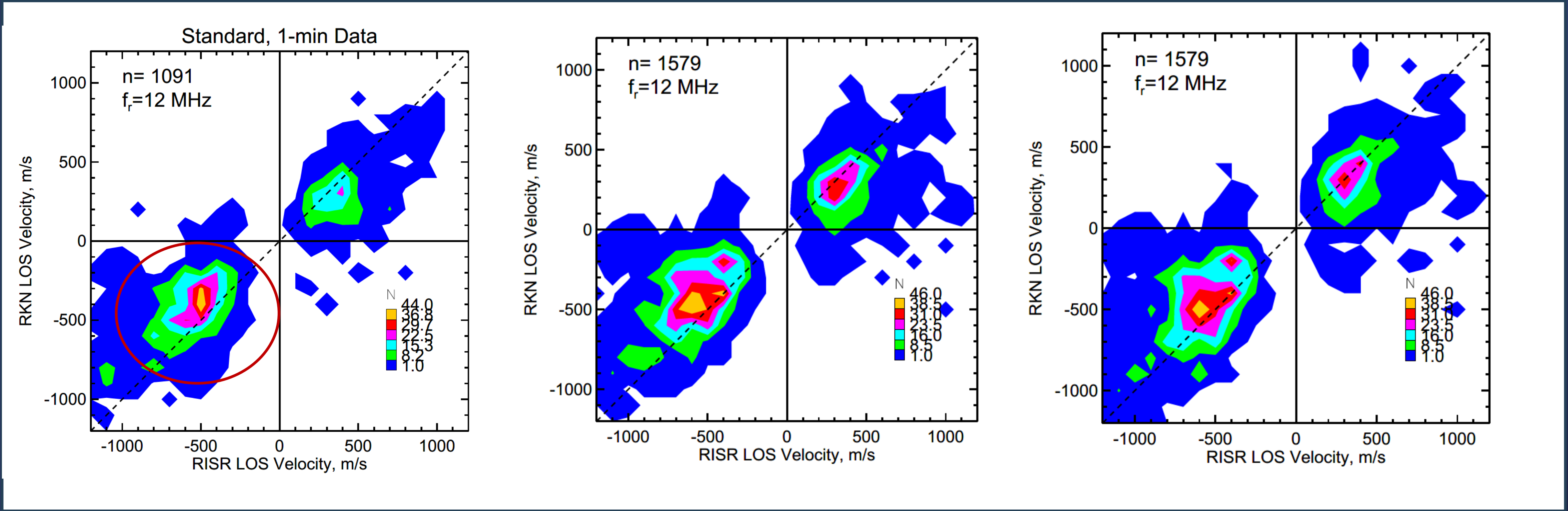
Geoloc corr+index refraction corr



“Improvements” of agreement, 1-min 12-MHz data for RKN

geolocation corrected

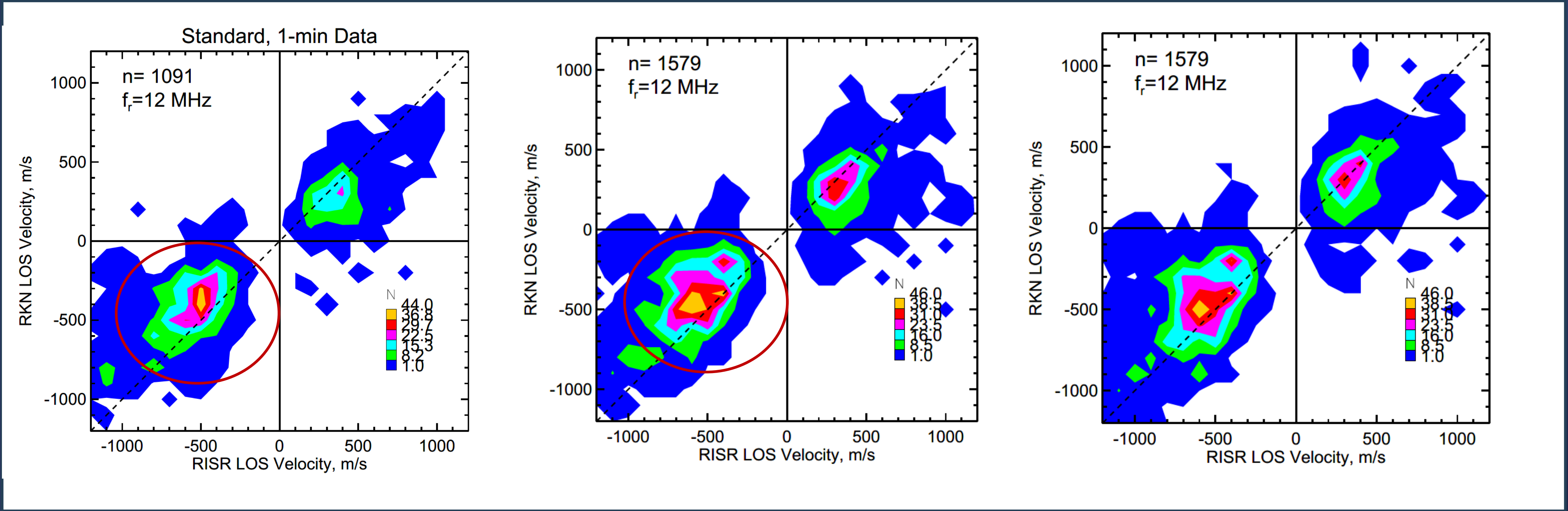
Geoloc corr+index refraction corr



“Improvements” of agreement, 1-min 12-MHz data for RKN

geolocation corrected

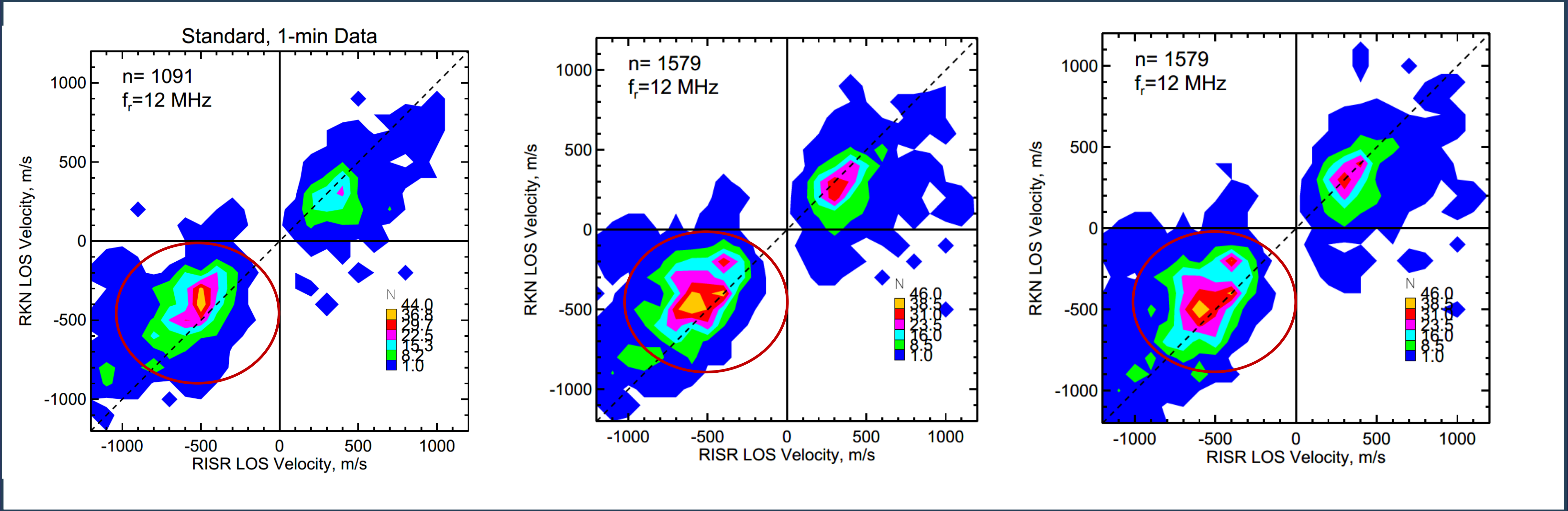
Geoloc corr+index refraction corr



“Improvements” of agreement, 1-min 12-MHz data for RKN

geolocation corrected

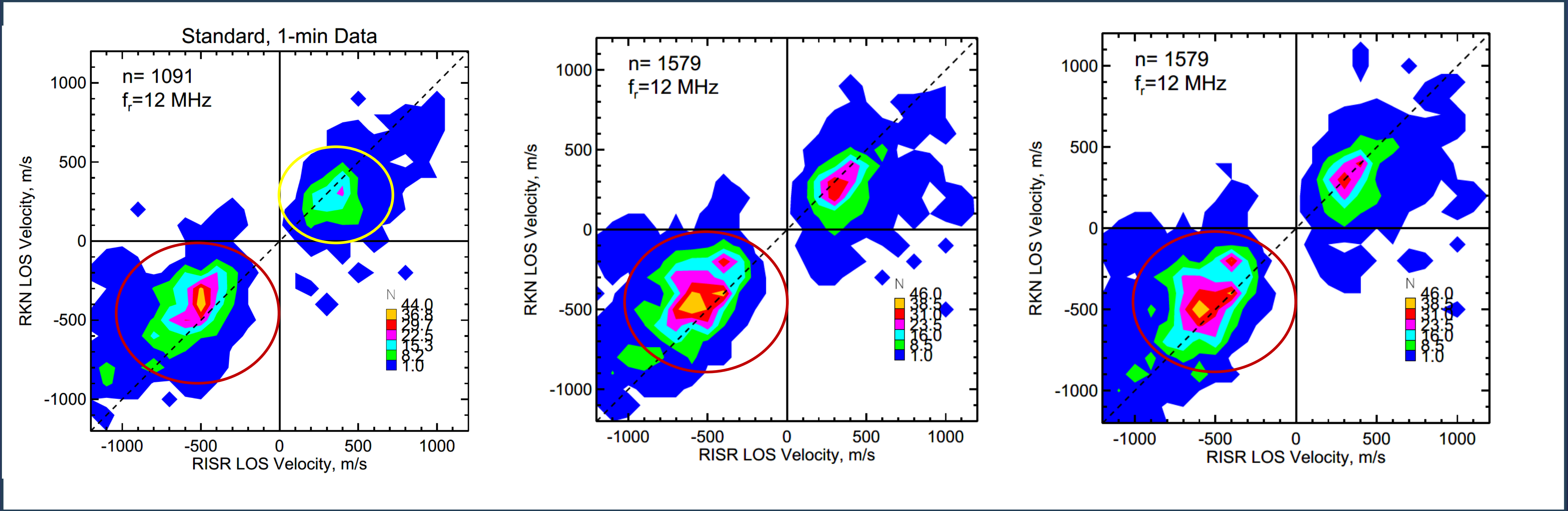
Geoloc corr+index refraction corr



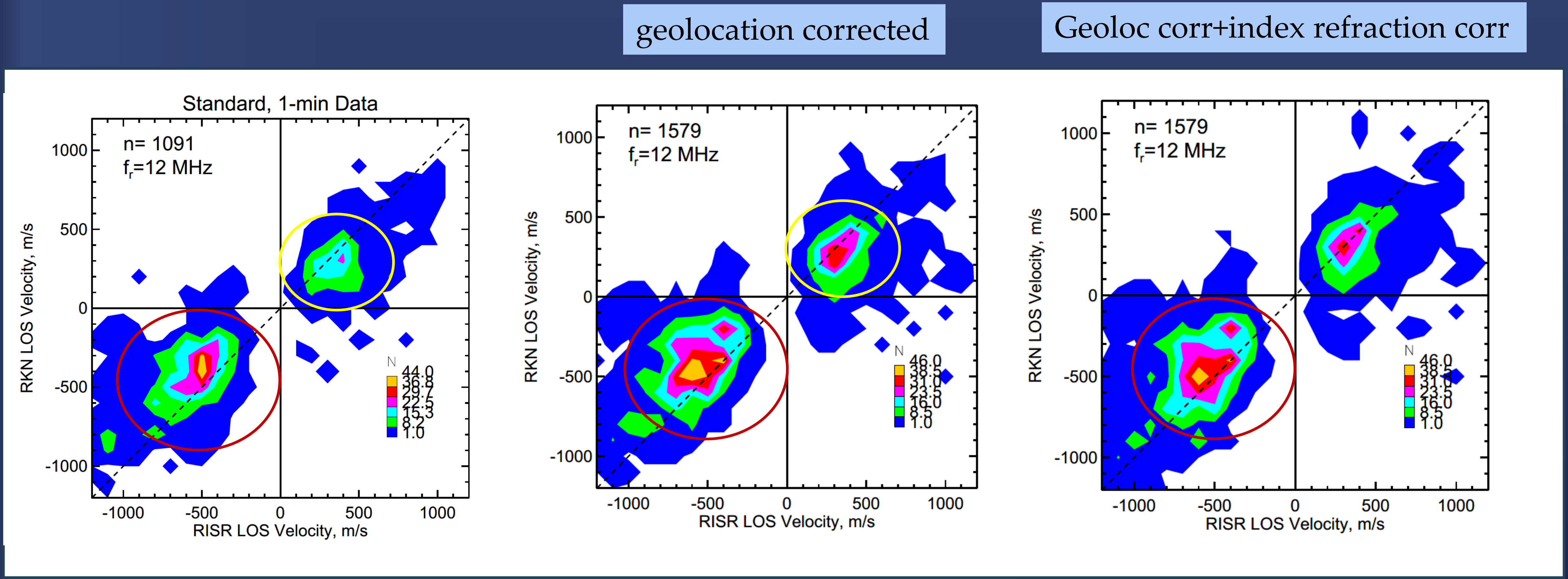
“Improvements” of agreement, 1-min 12-MHz data for RKN

geolocation corrected

Geoloc corr+index refraction corr



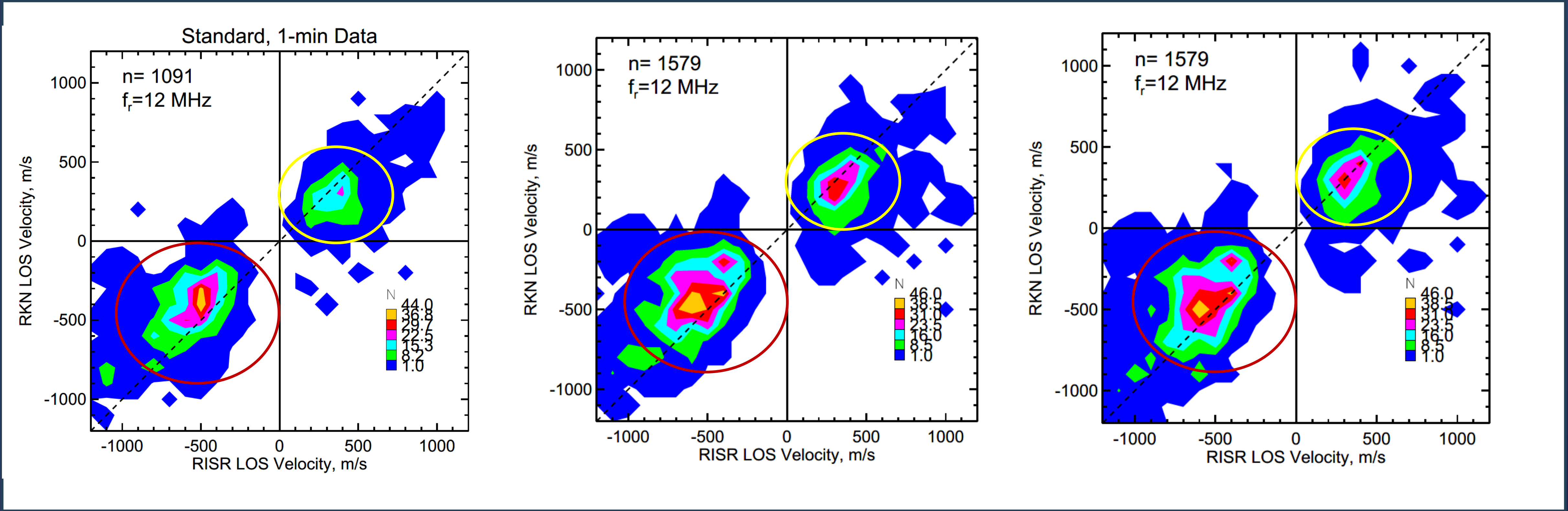
"Improvements" of agreement, 1-min 12-MHz data for RKN



“Improvements” of agreement, 1-min 12-MHz data for RKN

geolocation corrected

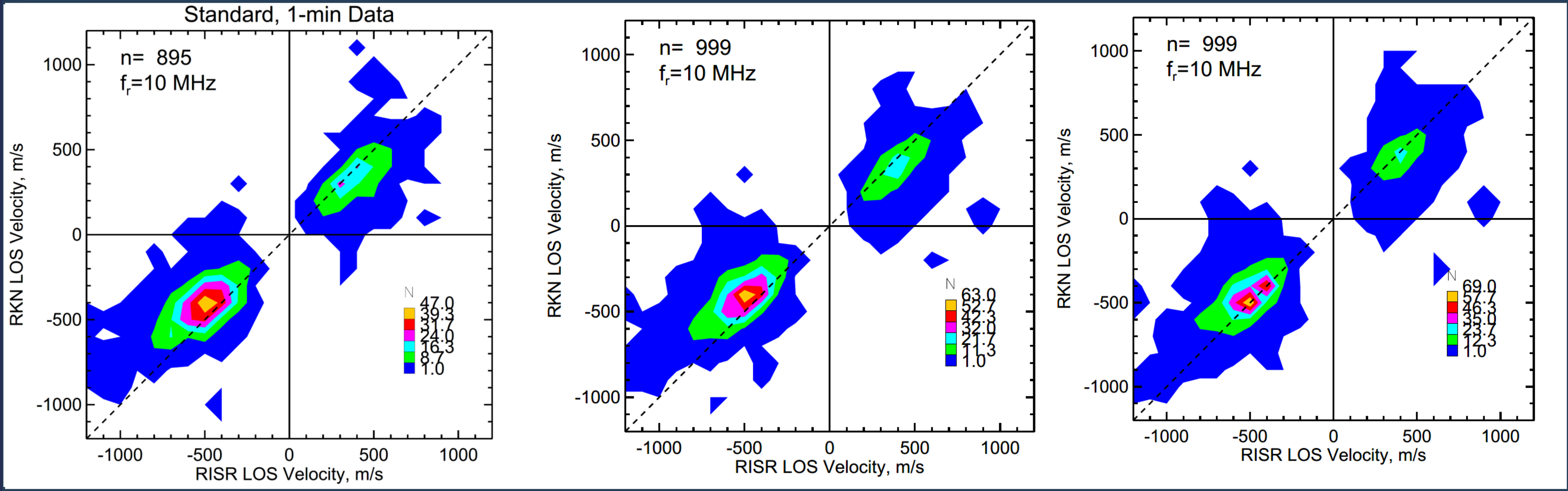
Geoloc corr+index refraction corr



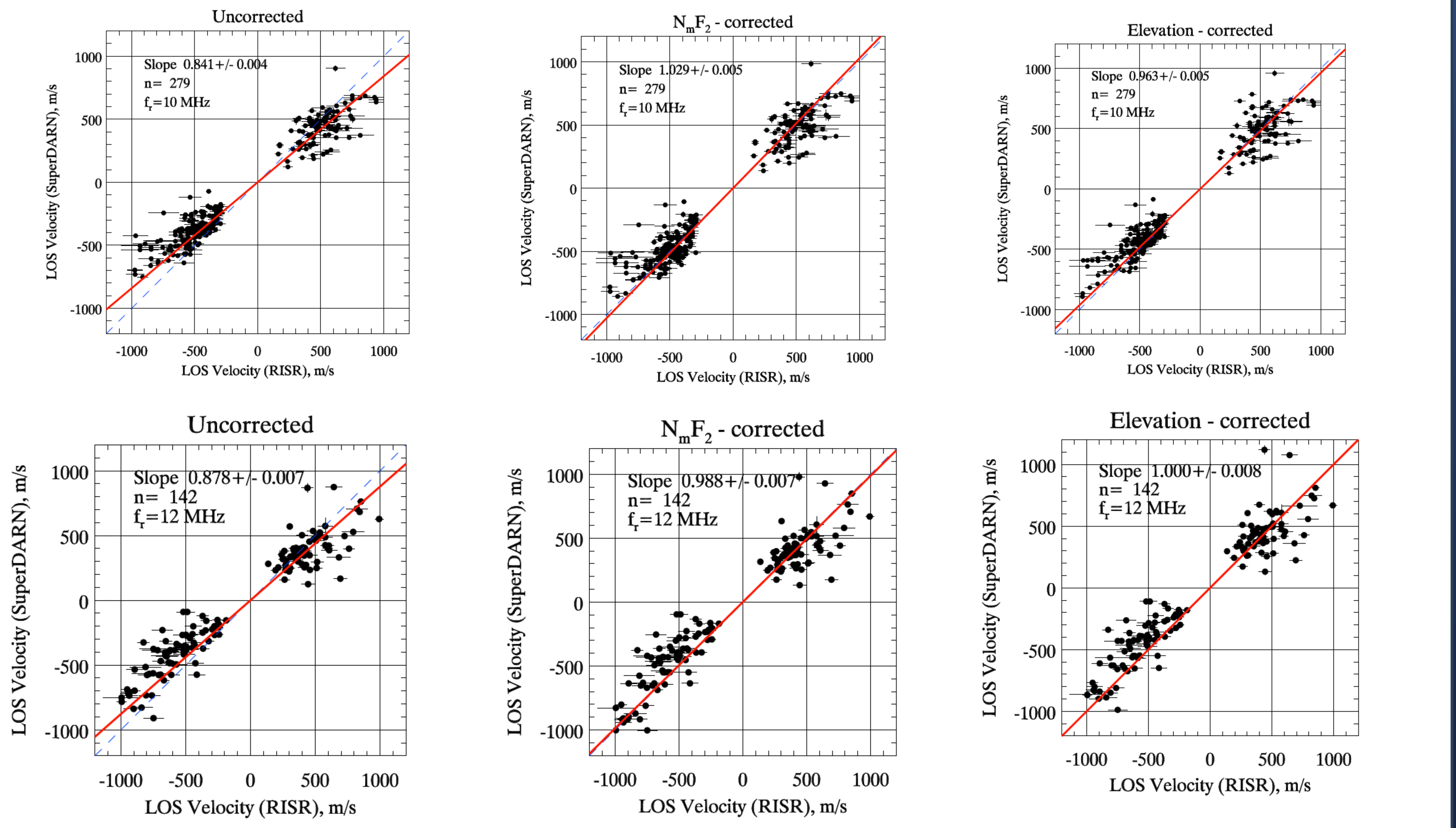
“Improvements” of agreement, 1-min 10-MHz data for RKN

geolocation corrected

Geoloc corr+index refraction corr



6-min averaged data



Slopes of the best fit line
(considering errors in X and Y)

	Uncorrected	NmF2 corrected	Elevation corrected
10 MHz	0.84	1.03	0.96
12 MHz	0.88	0.99	1.00

Conclusions

Conclusions

Statistically, the agreement between HF velocity and ExB drift improves in both cases of considering NmF2 and elevation angle data.

Conclusions

Statistically, the agreement between HF velocity and ExB drift improves in both cases of considering NmF2 and elevation angle data.

Corrections based on NmF2 produce more often values above the reference $\mathbf{E} \times \mathbf{B}$ drift observed by RISR. For these cases, NmF2 is large = dense ionosphere. Echoes are likely detected from heights well below h_mF2.

Conclusions

Statistically, the agreement between HF velocity and ExB drift improves in both cases of considering NmF2 and elevation angle data.

Corrections based on NmF2 produce more often values above the reference $\mathbf{E} \times \mathbf{B}$ drift observed by RISR. For these cases, NmF2 is large = dense ionosphere. Echoes are likely detected from heights well below h_mF2.

Statistically speaking, elevation-angle based HF velocity corrections produce better results compared to those based on NmF2.

Thank you