

## ***Interactive comment on “Validation of Clyde River SuperDARN radar velocity measurements with the RISR-C incoherent scatter radar” by Alexander Koustov et al.***

### **Anonymous Referee #1**

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The article ‘Validation of Clyde River SuperDARN radar velocity measurements with the RISR-C incoherent scatter radar’ presents a study that validates SuperDARN velocities measured from the Clyde River radar using the RISR-C incoherent scatter radar as a ‘truth’ data set. To my knowledge, this radar has not previously been validated, making this study a valuable contribution to the literature. The validation methods used are mostly appropriate, but could benefit from further clarification. The presentation and language are mostly clear, but have room for improvement (especially with respect to the use of articles). The length of the paper is adequate. The authors give proper credit to related work and relate how the study they present builds upon past validations. I believe this study will make an important scientific contribution once revisions have

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been made.

**Title and abstract:** The title is clear and appropriate. The abstract needs some clarification on line 14 “...SuperDARN convection maps (constructed for the area of joint measurements) shows the effect of smaller HF velocities even at smaller velocities”. The first part of this phrase begs the question: “Which other radars were used?”. While it may not be necessary to name the other radars in the abstract, this phrase could be reworded to emphasize how this combined data is useful in a validation of a single radar. The second part of this phrase is difficult to read (is it saying that HF velocities are notably smaller than ISR velocities at times when the ion drifts are both large and small?), and should be reworded.

### **Major Questions:**

1. Which background model was used to produce the mapped SuperDARN velocities?
2. The discussion regarding the linear fit would be improved by providing the R-squared value instead of just the slope of the fitted line (discussion on Line 167, 208 and elsewhere).
3. Why not used the cleaned data set, with groundscatter contamination removed, to produce the SuperDARN maps? This would improve the significance of the mapped study results.
4. Why is a 2 min convection map shown in Figure 6b? It would be more appropriate and informative to use the 5 min map used in this study.
5. In the paragraph starting on line 335, the detection of the convection reversal boundary (CRB) is mentioned. How is the CRB identified in the SuperDARN data and the RISR data? How accurate is each detection method?

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6. How much data goes into each point in Figure 7?

**Minor Questions and Clarifications:**

1. What is meant by “above the  $E \times B$  component” on line 39?
2. Since the beam centres are shown in Figure 1, shouldn't the shaded region be wider (encompassing the full width of all three beams)?
3. Paragraph on lines 131-135 does not make it clear how many median values of SuperDARN velocities are calculated. Is just one velocity median produced for each 5 minute  $\times$  3 beam  $\times$  4 gate bin? Or are up to 12 medians calculated in each 5 minute period?
4. Due to use of local time in discussion Figures 2, 4, 5, and 7 should plot local time on the x-axis instead of (or as well as) UT. This could be added on the upper x-axis.
5. Figure 2 captions says the figure plots the number of joint observations for all events. Does this include or exclude times with mixed ground scatter? Wording in discussion made this unclear.
6. The discussion of Figure 3 states that the black-white dots are close to the line of perfect agreement, and this seems to be true when there are more points. It would be useful to know, quantitatively, when the agreement degrades with respect to both the velocity magnitude and the number of velocity pairs.
7. “...data are spread across the local times, and so the R medians are dominated by low velocity data in (which bins?) of Figure 4.” on Line 253.
8. On line 290, what do the data agree with? Each other?

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9. Line 345: What types of errors are likely to be encountered? Is the limited RISR FoV important?
10. Point 2 of the summary: expand on the last sentence, spelling out the import of the results presented in the last sentence.
11. On line 390, what is meant by “strong IMF  $B_Z > 0$ ”? Does it mean any IMF with  $B_Z > 0$ ? Or a positive  $B_Z$  with a large magnitude? If so, what magnitude is considered large?
12. Quantify what is meant by “reasonable agreement” on line 393.
13. Point 6 of the summary should be discussed better in the article's main text.

**Figure legibility:**

1. The pink asterisks and black bars in Figure 3 are not legible. I recommend outlining the black bars in white (as was done with the points). The same could be done for the pink asterisks, or they could be made larger or removed if the plot is too busy.
2. Label needed for colour bar on Figure 3.
3. Suggest changing velocity scale to  $\pm 1000 \text{ m.s}^{-1}$  in Figure 5
4. Colour bar needed for electric potential in Figure 6b, or remove colour contour.
5. In Figure 6, specify LOS and mapped velocity in colour bars.

**Grammar and organisation:**

1. HF needs to be defined on line 20

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2. "...measure the Doppler velocity..." on line 22
3. Reword sentence ending on line 24 with "...plasma  $E \times B$  drift."
4. "...(LOS) velocities and the  $E \times B$  drift..." on line 30.
5. Remove commas flanking "published so far" on line 32.
6. Swap "accepted" and "now" on line 33.
7. "One factor found to lead to this result is an assumption made during SuperDARN velocity calculations, which sets the index of refraction for the ionosphere to unity." On lines 34-35, or reword in another fashion.
8. "...velocity magnitudes are substantially smaller..." Line 37.
9. replace "of >" with "exceeding" on line 38.
10. remove "often" on line 38.
11. "...are often above..." on line 39.
12. recommend replacing "Some" with "Other" on line 41.
13. "Despite obvious progress in measurement interpretations, HF-based..." on line 44
14. "...investigation to continue improving the quality..." on line 45.
15. "...unit is necessary to be confident in the reliability..." on line 47.
16. recommend replacing "work" with "study" on line 49.
17. "...this effort complements the previous validation..." on line 50.

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18. "Since the CLY radar currently provides a significant contribution to the..." on line 53.
19. "We take advantage of the availability of  $E \times B$  drift measurements made by the recently installed ISR RISR-C..." on lines 54-55.
20. RISR needs to be defined on line 55.
21. comma needed after "e.g." everywhere in text (e.g., line 56)
22. recommend placing the "e.g., Gillies et al. (2016)" reference in parenthesis on line 56.
23. Need to reword last sentence of paragraph ending on line 57, and move this sentence to the beginning of the following paragraph. Suggest something like: "In the present work we compare CLY and ISR-based velocities in a different way than previous studies."
24. "...systems that make measurements..." on line 58.
25. "...same direction are performed (e.g., Gillies et al., 2018)."
26. "...geometry due to the distance between the radars' beams" on line 60.
27. Recommend referring to Figure 1 in paragraph encompassing Line 60 instead of Figure 1 from Gillies et al. (2018). If more information is needed that is not included in this paper's Figure 1, I recommend adding it.
28. "...compare them with CLY data averaged over 3 beams and 4 gates." on line 64.
29. "...the average and median velocities..." on line 65.
30. "A validation using highly-averaged data is appropriate since the SuperDARN global-scale..." on line 66.

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31. "...LOS velocities (the so-called gridded velocities)." on line 68.
32. "...up to 27 LOS velocity values in bins consisting of data within  $\pm$  one radar..." on line 69.
33. "...implies that the input to the Potential..." on line 71.
34. "...space domain. Thus, a validation of the CLY contribution to SuperDARN convection maps can be performed using 2D RISR-C data and HF velocity..." on lines 72-73.
35. "...value in this CLY-RISR comparison." on line 76.
36. "...estimations also has some limitations (HN, 2008) that need testing. A couple of the limitations we will consider are a lack..." on lines 76-78.
37. "...SuperDARN is expected, but the degree of this agreement is not yet known." on lines 81-82.
38. "The approximate points where..." on line 92.
39. "...assigned are show in Figure 1 for the height of 300 km." on line 93.
40. Figure 1 caption: recommend using ISR instead of "incoherent scatter radar"
41. "...CLY beams 4, 5, and 6 (their centers) and the area where data were considered. The shaded region flanked by beams 4..." on Lines 105-106.
42. "...that within these range gates the CLY beams 4-6 are..." on line 108.
43. "...geographic latitude, as shown in Fig. 1." on Line 109.
44. "...CLY LOS velocities with the..." on Line 110.

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45. recommend cutting "as given by RISR" on line 111.
46. "RKN and INV radars, so that..." on line 112.
47. "...comprising of about 1,000 h of RISER observations made over the entire year of 2016. The radar..." on lines 116-117.
48. Reword sentence on line 119.
49. "...available for winter and both equinoxes, with no measurements made in the summer. We consider 5 min RISR data, because they have much smaller measurement errors than the 1 min resolution data." on lines 121-123.
50. "...radar measurements, times when RISR and CLY both made measurements in the blue and shaded region shown in Figure 1, for various UT." on line 125.
51. "...because of the preferential..." on line 126.
52. "...interest during the daytime..." on line 127.
53. "...comparison. Periods when CLY data were contaminated by ground scatter were dropped from further consideration due to their profound affect on the velocity comparison (Gillies et al., 2018)." on Lines 128-130.
54. Recommend moving paragraph starting on 131 to be the second paragraph in Section 3.
55. "...select a 5 min period..." on line 131.
56. recommend placing "see blue circles in Figure 1" in parenthesis on line 132.
57. "...compute a median..." on line 133.
58. "...velocity over a matching 5 minute interval in 3 beams..." on line 134.

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59. "Data binned in this way are shown by..." on line 149.
60. "...are almost linearly related, especially..." on line 164.
61. "...the bisector are the RISR velocities with magnitudes greater than..." on line 165.
62. Reword last sentence on paragraph containing line 165.
63. "...LOS comparison, shown in Figure 1." on line 173.
64. "We selected the three grid nodes at 81.5° magnetic latitude that were closest to the area of the CLY LOS velocity assessment and the two closest grid nodes at 80.5° magnetic latitude, marked by red crosses in Figure 1." on lines 174-176.
65. "...location, the geographic Eastward component..." on line 176.
66. "...1 measurement) was calculated to represent the eastward plasma flow component of a 5 min SuperDARN map. This is not a traditional temporal..." on lines 178-181.
67. "...intervals often occurred at irregular times, while the SuperDARN maps were produced at exact..." at Line 184.
68. "10-15 min, and so on. For the comparison, only..." on line 185.
69. "...component was usually available at all locations shown..." on line 189.
70. space missing on line 191 ("of0.25")
71. Replace line 193 with "The selection criteria produced a slightly smaller (but still statistically significant) data set than was obtained for the LOS..." on Lines 193-194, removing the "Obtained data pairs..." sentence.

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72. Consider adding something like ", with the SuperDARN vectors calculated using measurements from CLY, RKN, and INV, as well as the XXX model." to the end of the last paragraph of section 5.
73. "...plasma flow measured by RISR and SuperDARN. The data..." on line 200.
74. "...Figure 3b using the same methods as performed on Figure 3a, see Section 4." on lines 201-202.
75. "...SuperDARN is expected." on line 214.
76. "...of 300-600  $ms^{-1}$ . The inconsistencies are characterized by slower SuperDARN velocities." on Line 216.
77. "...measurements, giving..." on line 220.
78. "One reason frequently given for the systematic 'underestimation' of the SuperDARN velocity measurements is the assumption that the index of refraction is unity (e.g., Gillies et al, 2009; Ponomarenko et al. 2009)." on lines 225-27.
79. "..., previous studies, though it does not entirely account for the differences between the radar measurements. (start new paragraph) . We also investigated the..." on line 234.
80. "...velocity ratio  $R=v_{HF}/v_{RISR}$  as done previously by Gillies et al. (2018) to explore possible influences of the refractive index on velocity using typical local time variations in electron density as a proxy for refractive index. For the winter and equinoctial ionosphere..." on lines 235-238.
81. "...are typically observed near local solar noon and the afternoon..." at line 239.
82. "...smallest at these times, as reported by..." on line 241.

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83. "...not as far below unity as near..." on line 244.
84. "...likely, incorrectly estimated for..." on line 246.
85. "...RB, we expect that this effect will also..." on line 247.
86. "...significantly. It is lower in the daytime...than during dawn/pre-noon hours (12-18 UT), but its values are..." on Lines 249-250.
87. "...This is probably because the infrequent..." on line 252.
88. "...R values are caused by an 'overestimation' of the true..." on line 254.
89. "...LOS velocities. Our data..." on line 257.
90. "...enhancements and decreases affect..." on line 277.
91. "...by ISRs. Such points are occasionally seen in..." on lines 288-289.
92. "... data (e.g., Ruohoniemi et al. 1987; Davies et al., 1999). Our data in Figure 3 also..." on lines 289-290.
93. cut "just for one CLY velocity scan" on Line 314.
94. "...within the CLY FoV, for one velocity scan during the above event." on Line 315.
95. "...originating from the RKN..." on line 319.
96. "The presence of highly-curved flows is evident near noon." on line 320.
97. Figure 6 caption: "...a standard 2 min convection map calculated from..."
98. Remove "highly" on line 327.
99. "Evaluating the extent that SuperDARN and..." on line 330.

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100. "In addition, the agreement between the RISR and SuperDARN map data improves dramatically when only the lower latitude SuperDARN map data is considered." on lines 332-334.
101. "We investigated further by determining the location..." on line 335.
102. "...like that shown in the Figure 6b contours). This is done by considering..." on line 336.
103. "...CLY velocity scan maps, and by..."
104. Use same language in Figure 7 caption as in the discussion.
105. "...we adopted a different approach. We considered..." lines 359-360.
106. "...flow vector, as..." line 360.
107. "...multiple beams, and compared it to the CLY velocities from a number of eastward oriented beams and wit the..." on lines 360-362.
108. "...radar velocities measured in beams 4-6 are statistically..." on line 366.
109. "...below one, implying... on line 377.
110. "...diurnal variations of the ratio..." on line 378.
111. "...velocity show their strongest..." on line 379.
112. "...stronger for plasma drifts faster than about  $750 \text{ m s}^{-1}$ ." on lines 381-382.
113. "One factor that may contribute to slower HF velocities in addition to the refractive index is the nature of HF propagation. Because HF radars receive stronger signals from..." on lines 384-385.

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114. "...radar beams is usually a reliable method. The comparison..." on lines 394-395.

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