AMFR/King City Radar Intercomparison
Timothy J. Lang
Colorado State University
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Here are some results from a preliminary intercomparison between the AMFR and King City Radar. This is an exploratory analysis, basically a sanity check to see if AMFR obtains reflectivity and differential reflectivity values similar to the King Radar. It should also uncover how much attenuation is a factor in the AMFR measurements. However, at this point we will not make any quantitative conclusions, only qualitative ones.

Here we compare just one set of RHIs taken at 0644 UTC on 22 Jan 2007, thru a synoptically forced snowstorm with light to moderate rates. AMFR is 34.27 km from King Radar along the 331° radial. Both radars scanned their RHI within 1 minute of each other, and both along the 331° radial. Thus, they are looking the same direction at about the same time, but due to inherent resolution differences between the two radars, and the longer distance from King Radar, AMFR will have better spatial resolution. This time is after AMFR's apparent H-channel calibration shift during this day (see last report; we do not have collocated RHIs prior to the shift, unfortunately).

We did not filter ground clutter and other spurious echo except to use the filtered King reflectivity field, and to not pay too much attention to extremely low-altitude data (e.g., 0-0.5 km MSL).

What we have done is break down the native polar coodinate data into 2-km blocks along the great circle (S), and 0.5-km blocks in altitude MSL (H). Individual gates of data from each radar were grouped into these blocks using calculations based on radar position (lat, lon, and alt), elevation angle, and slant range. The ray path calculations used the standard 4/3 Earth radius assumption. In each block we calculate mean, median, and standard deviation of reflectivity (ZHH) and differential reflectivity (ZDR) of all respective gates for each radar. We did the calculations in decibel units to minimize the effect of a small number of high reflectivity gates. One could consult the median values over the means, which would be mostly unaffected by this simplification, if one doesn't like linearly averaging logarithmic units.

The next few pages show results. We show values for select blocks for King, AMFR Ku, and AMFR Ka. Note that due to spatial resolution differences AMFR has many more points per block than King. The header in each cell contains two lines listing ΔS and ΔH for that block of data. A lot of blocks are skipped just to keep things from getting unwieldy, but these select results reveal the general trends seen in the full results. The rest of each cell is 4 lines with 3 columns. The top of the page gives the key for interpreting these numbers, but basically it goes like:

King	AMFR Ku	AMFR Ka
# pts	# pts	#pts
mean	mean	mean
median	median	median
stddev	stddev	stddev

ZHH is the left major column, and ZDR the right major column on each page. We show results for various height intervals for S=6-8 km (just beyond where AMFR receivers are saturated), 10-12 km, 16-18 km, and 20-22 km (approaching max AMFR range). S is calculated relative to AMFR.

The tabular results from the intercomparison reveal some interesting trends. In general, at low altitudes (e.g., 0.5-1.0 km MSL) King reflectivities runs several dB hotter than AMFR Ku, which in turn runs hotter than AMFR Ka. However, this discrepancy becomes much less at higher altitudes (e.g., 4.5-5.0 km MSL) where reflectivities are lower. Sometimes AMFR Ku and King are within 1-3 dB here, and at the highest altitudes (e.g., 5.5-6.0 km MSL) AMFR Ku can run somewhat hotter than King. AMFR Ka almost always is much less than either of the other two, but again this discrepancy is less at higher altitudes and in weaker reflectivities. At longer ranges the low-altitude discrepancies just get worse between King and AMFR.

AMFR Ku ZDR values tend to run ~1 dB hotter than King, regardless of range or height. However, AMFR Ka ZDR values are extremely negative.

Due to resolution differences, and the simplistic methodology, we can draw only some preliminary qualitative conclusions right now.

Assuming King is well calibrated, it appears that AMFR Ku ZHH is strongly affected by attenuation even in light-to-moderate snowfall given that the discrepancies are largest in the stronger echoes and this worsens with range. The differences between AMFR Ku and King, ~5-10 dB depending on range, seem higher than predicted, tho they are not completely out of the range of simulation results by D. Long (2004; CSU Master's Thesis), who simulated an intense snowstorm at different frequencies, including S, Ku, and Ka bands (we assume C band to be largely unattenuated like S band for snowfall). The inference of attenuation being a major factor is further supported by the lower discrepancies at higher altitudes, where higher elevation ray paths have passed thru less precip. In fact, AMFR Ku and King often are within 1-3 dB of one another at these altitudes, which is probably within the inherent uncertainty of this analysis. This implies that AMFR Ku ZHH calibration may not be too bad, at least after the calibration drift prior to this time. As mentioned before, unfortunately we do not have matched RHIs prior to the drift on this day.

AMFR Ku ZDR values are consistently higher than King, which is not predicted for Ku band (D. Long 2004). If anything, they should be slightly lower due to attenuation. This, together with the H and V channel discrepancies mentioned in the previous report, implies that ZDR is not well calibrated for AMFR Ku.

Ka ZHH values often are 15-20 dB less than even Ku at low altitudes. This is much more than predicted by the snowstorm simulations of D. Long (2004). However, this discrepancy actually improves with range, with Ka ZHH increasing at longer ranges, which is not consistent with attenuation, and implies that this storm's Ka echoes are near the noise limit of the AMFR receivers. In addition, the ZDR values are extremely negative at Ka, which again seems unphysical. We tentatively conclude that AMFR Ka band has serious calibration issues on this day, much worse than any that may exist at Ku band. Also, the noise limit of the Ka band hurts its sensitivity relative to Ku.

Note that this is one RHI on one day. We plan to intercompare more RHIs on this and other days in the near future.

S = 6-8 km
H= Variable

KING - AMFR Ku - AMFR Ka
pts
Mean
Median
Standard Deviation

ZHH

****
dr= 6.00000 8.00000
dh= 0.500000 1.00000

48 1236 1236
18.2271 11.8024 -9.97956
18.2900 12.0500 -9.94000
2.58638 2.38497 0.895992
****
dr= 6.00000 8.00000
dh= 1.50000 2.00000

48 1257 1257
8.64646 5.51413 -11.5558
9.25000 5.68000 -11.5100
2.24988 2.31162 0.957873
****
dr= 6.00000 8.00000
dh= 2.50000 3.00000

54 1207 1207
7.91815 2.70337 -12.3619
8.12000 2.70000 -12.3300
1.92242 1.92936 0.845865
****
dr= 6.00000 8.00000
dh= 3.50000 4.00000

42 1129 1129
3.15190 0.697387 -12.1839
2.84000 0.720000 -12.2600
1.41146 2.14886 0.982749
****
dr= 6.00000 8.00000
dh= 4.50000 5.00000

55 993 993
-3.08473 0.219274 -11.3712
-2.67000 0.320000 -11.3500
2.73953 2.57600 0.653400
****
dr= 6.00000 8.00000
dh= 5.50000 6.00000

28 222 222
-9.15393 -6.97815 -10.5168
-9.65000 -6.93000 -10.5300
2.26171 1.85092 0.557909
****

ZDR

****
dr= 6.00000 8.00000
dh= 0.500000 1.00000

48 1236 1236
0.724583 1.46712 -14.0575
0.710000 1.51000 -14.1100
0.187117 2.52632 1.41486
****
dr= 6.00000 8.00000
dh= 1.50000 2.00000

48 1257 1257
1.17167 1.36605 -12.4732
1.18000 1.46000 -12.3700
0.373593 3.05997 1.73245
****
dr= 6.00000 8.00000
dh= 2.50000 3.00000

54 1207 1207
0.986482 2.08781 -10.7249
1.01000 2.04000 -10.5300
0.323251 2.33587 1.42242
****
dr= 6.00000 8.00000
dh= 3.50000 4.00000

42 1129 1129
0.643571 1.72140 -9.76281
0.660000 1.73000 -9.71000
0.240759 2.45146 1.09367
****
dr= 6.00000 8.00000
dh= 4.50000 5.00000

55 993 993
0.590364 1.73329 -9.43809
0.700000 1.66000 -9.33000
0.734383 2.59258 1.51291
****
dr= 6.00000 8.00000
dh= 5.50000 6.00000

28 222 222
1.04071 1.24959 -6.46887
0.920000 1.21000 -6.48000
1.19553 1.91151 0.740832
****

S = 10-12 km
H= Variable

KING - AMFR Ku - AMFR Ka
pts
Mean
Median
Standard Deviation

ZHH

****
dr= 10.0000 12.0000
dh= 0.500000 1.00000

48	801	801
18.1490	10.8699	-7.31833
18.3900	11.1000	-7.32000
2.34420	2.16623	0.634655

****
dr= 10.0000 12.0000
dh= 1.50000 2.00000

48	791	791
11.2663	5.10098	-8.04284
11.7100	4.51000	-8.07000
1.58610	2.06484	0.686289

****
dr= 10.0000 12.0000
dh= 2.50000 3.00000

56	797	797
10.0537	1.69686	-8.29902
9.85000	1.80000	-8.28000
1.76436	1.92084	0.701663

****
dr= 10.0000 12.0000
dh= 3.50000 4.00000

38	759	759
6.23474	1.36516	-8.01639
6.73000	1.38000	-8.04000
1.93125	1.41381	0.676058

****
dr= 10.0000 12.0000
dh= 4.50000 5.00000

53	743	743
-1.72849	-2.33982	-7.91251
-1.85000	-2.44000	-7.91000
2.62843	1.70590	0.683087

****
dr= 10.0000 12.0000
dh= 5.50000 6.00000

39	717	717
-5.94897	-6.33470	-7.61000
-6.59000	-6.46000	-7.61000
3.20815	1.53025	0.708871

****

ZDR

****
dr= 10.0000 12.0000
dh= 0.500000 1.00000

48	801	801
0.740208	1.55186	-11.3219
0.720000	1.50000	-11.3500
0.241225	1.92289	1.13311

****
dr= 10.0000 12.0000
dh= 1.50000 2.00000

48	791	791
0.866250	1.75716	-9.09010
0.900000	1.87000	-8.81000
0.343156	1.93218	1.28699

****
dr= 10.0000 12.0000
dh= 2.50000 3.00000

56	797	797
0.756429	1.95051	-7.43337
0.730000	1.92000	-7.43000
0.304197	1.93621	0.774925

****
dr= 10.0000 12.0000
dh= 3.50000 4.00000

38	759	759
0.637632	1.89684	-7.72849
0.620000	1.91000	-7.72000
0.291811	1.83903	0.801836

****
dr= 10.0000 12.0000
dh= 4.50000 5.00000

53	743	743
0.391887	1.38031	-6.81727
0.520000	1.37000	-6.80000
0.613643	2.03529	0.662915

****
dr= 10.0000 12.0000
dh= 5.50000 6.00000

39	717	717
0.331795	1.13665	-6.13399
0.350000	1.16000	-6.13000
0.760930	1.79081	0.620138

****

S = 14-16 km
H= Variable

KING - AMFR Ku - AMFR Ka
pts
Mean
Median
Standard Deviation

ZHH

****
dr= 14.0000 16.0000
dh= 0.500000 1.00000

32	502	502
21.1419	10.2800	-4.86926
21.3100	10.4200	-4.86000
1.42217	1.35392	0.525702

****
dr= 14.0000 16.0000
dh= 1.50000 2.00000

48	582	582
12.9377	5.40342	-5.15189
13.1100	5.42000	-5.14000
1.60768	1.28860	0.640375

****
dr= 14.0000 16.0000
dh= 2.50000 3.00000

49	587	587
9.51979	5.04876	-5.12465
9.46000	5.12000	-5.13000
1.29266	2.35522	0.643118

****
dr= 14.0000 16.0000
dh= 3.50000 4.00000

48	585	585
5.87708	2.52147	-5.04268
5.74000	2.60000	-5.05000
1.35888	1.36861	0.608354

****
dr= 14.0000 16.0000
dh= 4.50000 5.00000

46	550	550
-2.16109	-2.58184	-5.01725
-1.99000	-2.66000	-5.04000
2.01792	1.39183	0.563551

****
dr= 14.0000 16.0000
dh= 5.50000 6.00000

22	559	559
-9.10727	-6.09576	-4.84006
-9.29000	-6.18000	-4.85000
1.16201	0.839322	0.595723

****

ZDR

****
dr= 14.0000 16.0000
dh= 0.500000 1.00000

32	502	502
0.763437	1.72040	-9.21905
0.760000	1.75000	-9.24000
0.158351	1.87900	0.776130

****
dr= 14.0000 16.0000
dh= 1.50000 2.00000

48	582	582
0.549167	1.60043	-7.41902
0.560000	1.65000	-7.39000
0.203844	1.52449	0.732494

****
dr= 14.0000 16.0000
dh= 2.50000 3.00000

49	587	587
0.667143	1.64114	-7.26283
0.660000	1.63000	-7.23000
0.255425	2.00929	0.736035

****
dr= 14.0000 16.0000
dh= 3.50000 4.00000

48	585	585
0.531042	1.43393	-7.15424
0.530000	1.43000	-7.17000
0.273614	1.49239	0.673467

****
dr= 14.0000 16.0000
dh= 4.50000 5.00000

46	550	550
0.382391	1.10944	-6.17433
0.370000	1.13000	-6.16000
0.584044	1.31245	0.609344

****
dr= 14.0000 16.0000
dh= 5.50000 6.00000

22	559	559
0.219545	0.696869	-5.83395
0.360000	0.680000	-5.85000
1.82415	1.01286	0.575223

****

S = 20-22 km
H= Variable

KING - AMFR Ku - AMFR Ka
pts
Mean
Median
Standard Deviation

ZHH

****
dr= 20.0000 22.0000
dh= 0.500000 1.00000

47 267 267
19.1991 10.2869 -1.85195
19.2700 10.4000 -1.82000
2.22094 1.35591 0.526201
****
dr= 20.0000 22.0000
dh= 1.50000 2.00000

47 399 399
13.5468 7.08449 -1.90825
13.3500 7.18000 -1.94000
1.62331 0.801723 0.606563
****
dr= 20.0000 22.0000
dh= 2.50000 3.00000

38 415 415
10.0274 5.62778 -1.84735
10.2300 5.61000 -1.83000
1.18897 1.36492 0.542775
****
dr= 20.0000 22.0000
dh= 3.50000 4.00000

43 421 421
3.55721 0.708338 -1.88389
3.73000 0.720000 -1.91000
2.56535 1.05919 0.543108
****
dr= 20.0000 22.0000
dh= 4.50000 5.00000

24 418 418
-5.36917 -3.21352 -1.84861
-4.98000 -3.28000 -1.82000
2.46012 0.716463 0.544940
****
dr= 20.0000 22.0000
dh= 5.50000 6.00000

10 379 379
-8.10200 -4.44367 -1.77551
-8.00000 -4.46000 -1.76000
1.08684 0.421972 0.586170
****

ZDR

****
dr= 20.0000 22.0000
dh= 0.500000 1.00000

47 267 267
0.732979 1.54809 -7.29689
0.740000 1.64000 -7.32000
0.227576 1.49832 0.633552
****
dr= 20.0000 22.0000
dh= 1.50000 2.00000

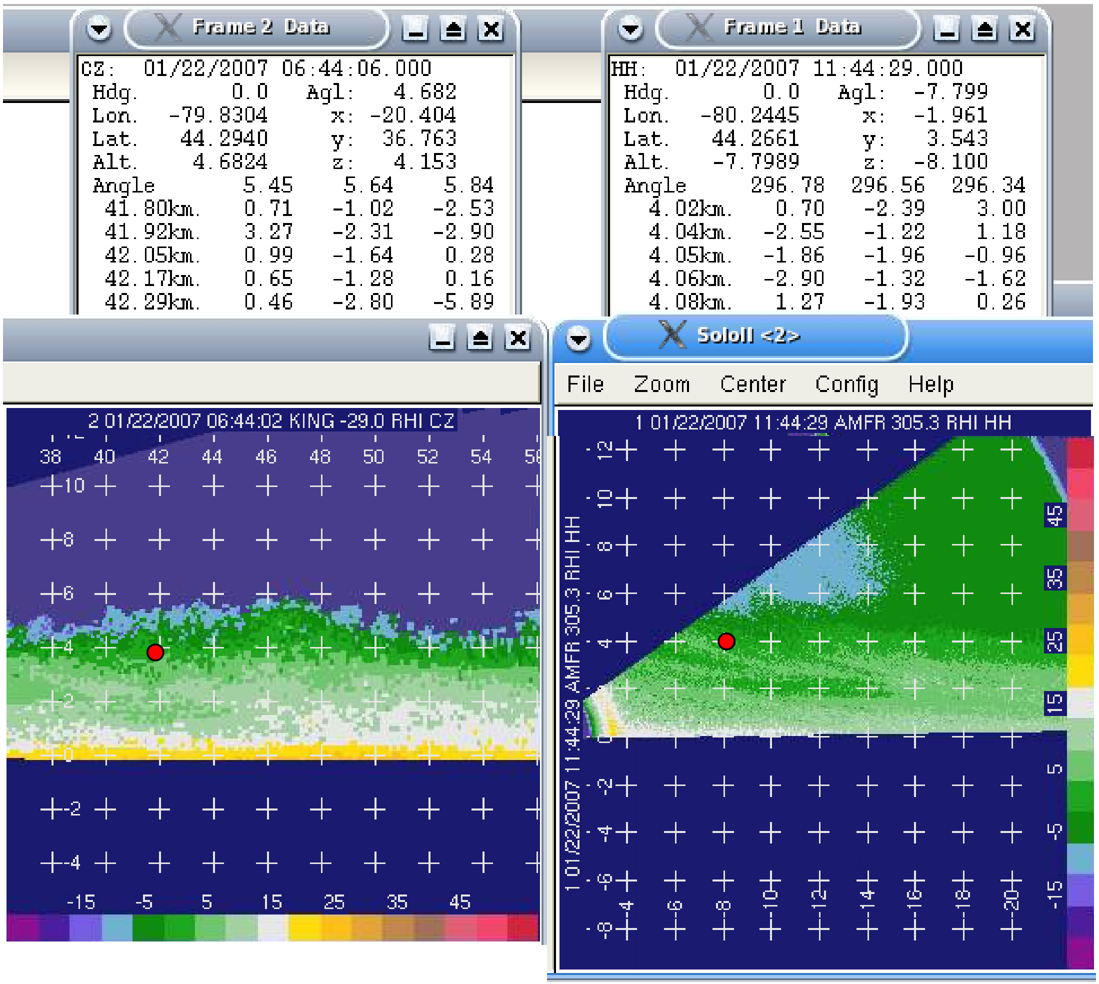
47 399 399
0.527447 1.38406 -6.76208
0.550000 1.40000 -6.79000
0.212700 0.971558 0.606797
****
dr= 20.0000 22.0000
dh= 2.50000 3.00000

38 415 415
0.511579 1.58190 -6.72374
0.520000 1.59000 -6.70000
0.233036 1.85639 0.640166
****
dr= 20.0000 22.0000
dh= 3.50000 4.00000

43 421 421
0.494651 1.21637 -6.08034
0.470000 1.16000 -6.10000
0.404424 1.12256 0.564641
****
dr= 20.0000 22.0000
dh= 4.50000 5.00000

24 418 418
0.529167 0.643828 -5.79182
0.720000 0.640000 -5.82000
1.18559 0.694197 0.562681
****
dr= 20.0000 22.0000
dh= 5.50000 6.00000

10 379 379
-0.0200000 0.437045 -5.71372
0.380000 0.400000 -5.72000
1.01384 0.458500 0.563012
****



Here are SOLO plots for each radar, which confirm our inferences based on the tabular results. Left is King reflectivity, right is AMFR Ku. The red dots are the approximate positions where the text output above each image is coming from. They are both roughly 8 km from AMFR (King is ~34 km away, so 42 km range is 8 km from AMFR) and 4 km AGL (radar altitudes were within 100 m, so these are similar MSL altitudes as well). Ignore the AMFR positioning and timing metadata, as they are messed up.

Low altitude King reflectivities are much larger than AMFR Ku (color scales are same), and this worsens with range, but at higher altitudes with lower reflectivities (e.g., the red dot and text output) the values are more similar, often within 1-3 dB.