Calibration of NEXRAD Differential Reflectivity with Metal Spheres

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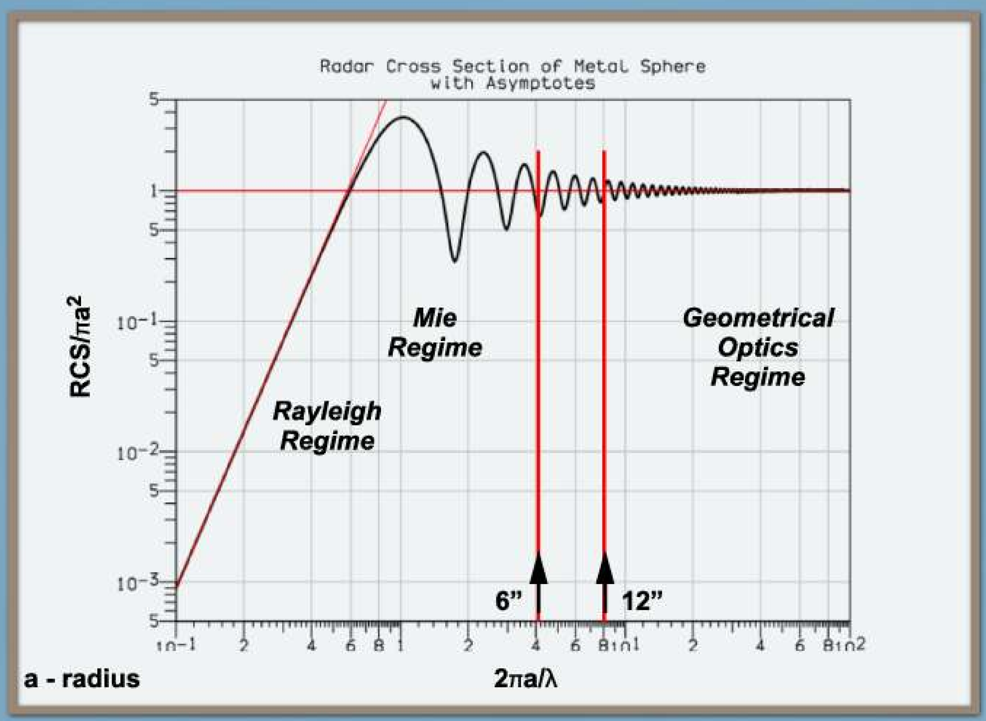
Calibration Methods

Objective: Verify the calibration of differential reflectivity on the WSR-88D relative to the "Holy Grail" of 0.1 dB using a metal sphere lofted into the air via a neoprene weather balloon. Definition of "true method": Z_{DR} of target known to 0.1 dB.

True Calibration Methods	Pseudo Calibration Methods
Metal spheres	Hydrometeor calibration
Vertically pointing "bird bath"	Z-Z_{DR} asymptote method
Sun pointing (receiver check only)	Natural ground clutter (metal towers)
Crosspolar power method	Clear-air targets (Bragg scatter)
Engineering approach	Baron approach
Drizzle	

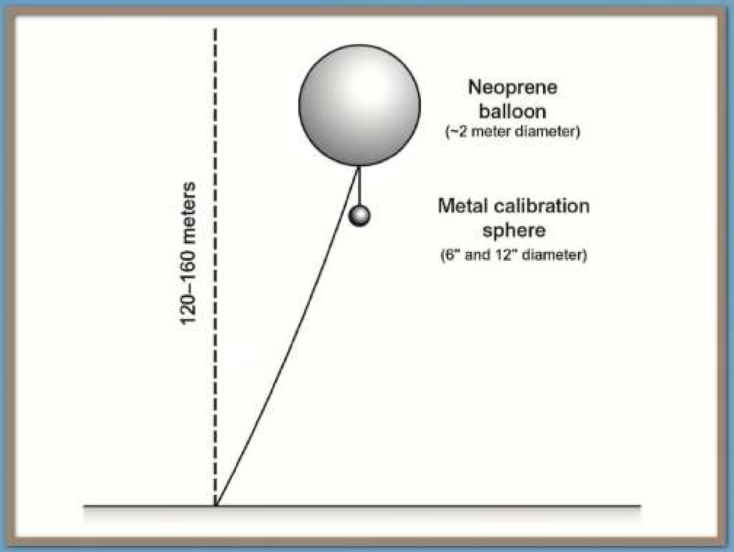
6" seamless aluminum sphere used for the experiment with a sphericity tolerance of 0.005". Theoretical Z: 42.7 dBZ Theoretical Z_{DR}: 0 dB

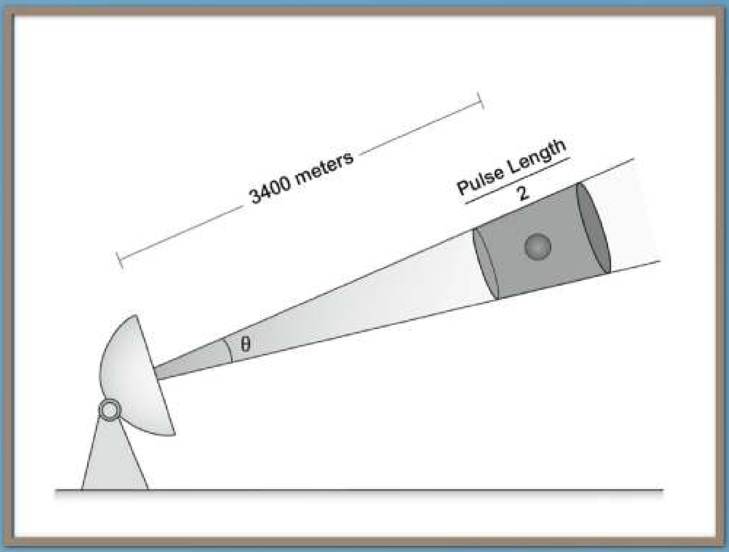


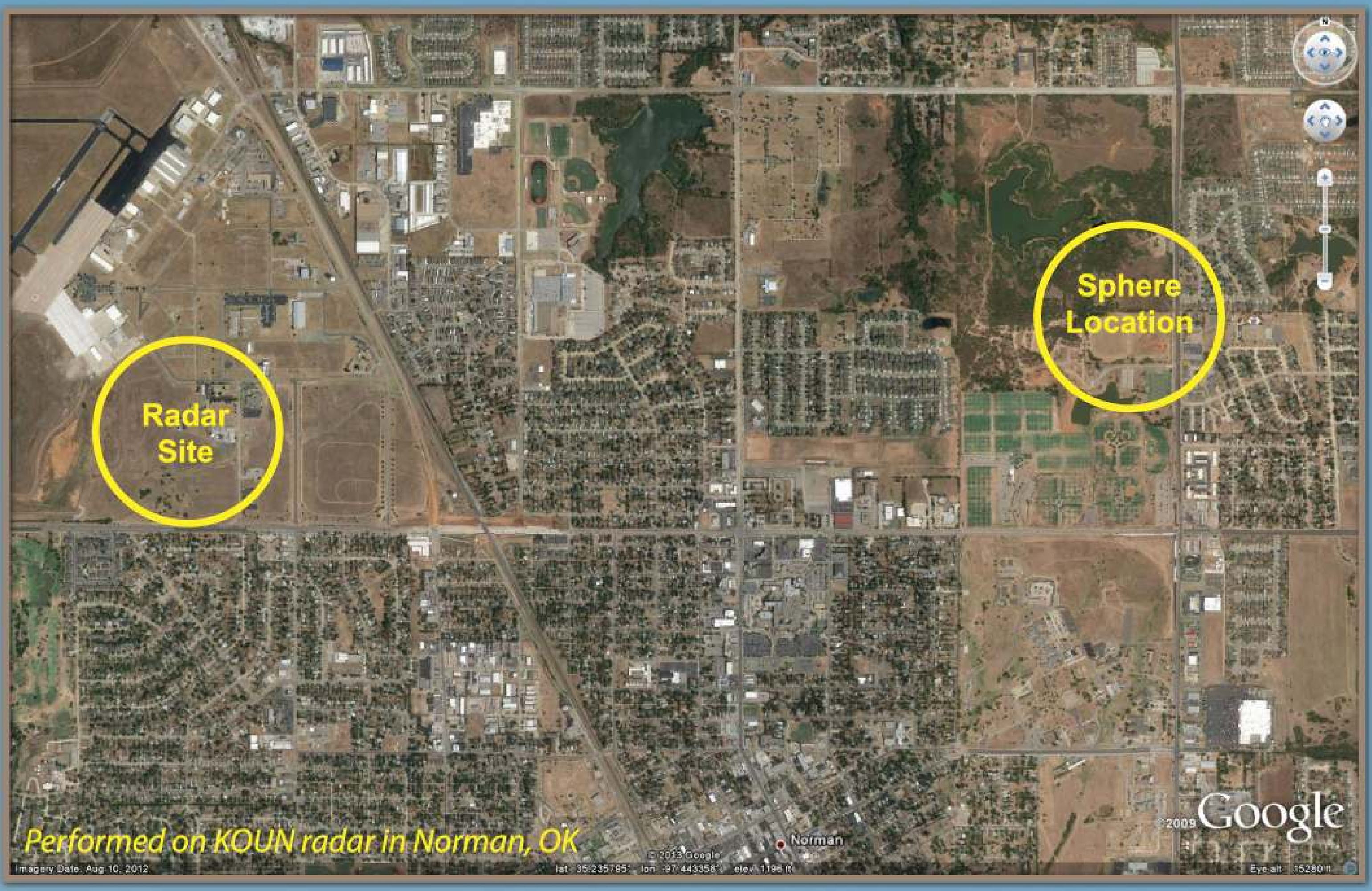
Theoretical radar cross section of metal spheres in three scattering regimes

Procedure

- Aluminum sphere is tied at the base of a weather balloon
- Low wind conditions are essential to successful calibration
- Balloon lifts sphere to an approximate height of 120 meters and centered in a pulse resolution volume
- Theodolite user identifies elevation and azimuth for radar
- Radar elevation and azimuth adjusted until a power maximum is observed







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Relevant equations

$$\eta = \frac{\sigma}{PRV}\left(\frac{m^2}{m^3}\right) \quad PRV = \frac{\pi\theta\varphi h R^2}{8}(m^3)$$

— Theoretically computed values of Z have Probert-Jones correction applied

$$Z = \frac{8\lambda^4}{\theta\varphi h \pi^5 |k|^5}\frac{r^2}{R^2}\left(\frac{mm^6}{m^3}\right)$$

$$Z_{H,V}(dBZ) = 10\log_{10}\left(\frac{(P_{H,V} - N_{H,V})}{N_{H,V}}\right) + 20\log_{10} r + l + dBZ_0$$

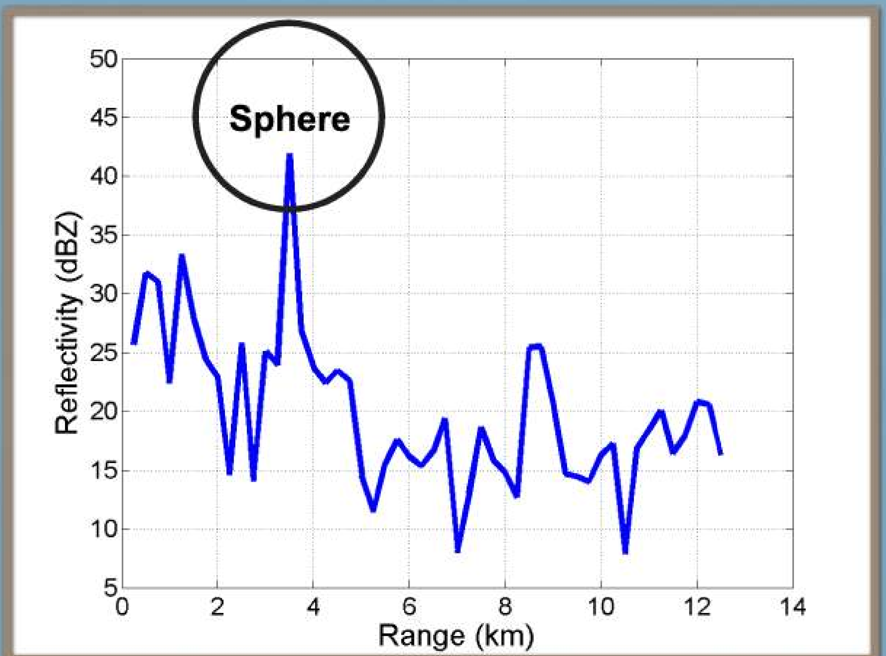
— Reflectivity

$$Z_{DR}(dB) = 10\log_{10}\left(\frac{P_H - N_H}{P_V - N_V}\right)$$

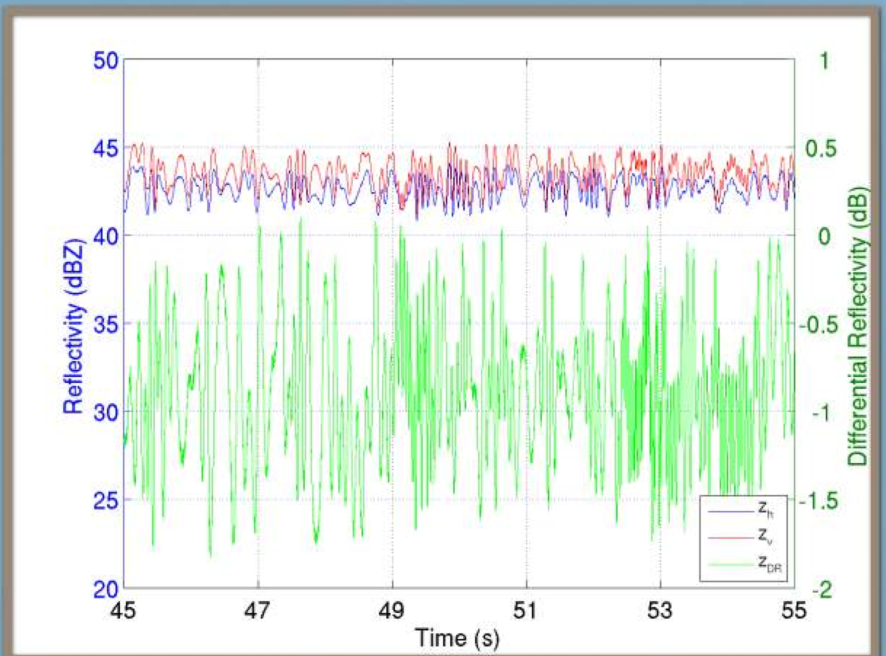
— Differential Reflectivity

Results

A-scope display showing location of sphere return at 3.4 km range



Pulse-to-pulse time-series of Z_H, Z_V, and Z_{DR}



Data from the 6" sphere on 28 October, 2011 at 0947 Z

Conclusions

- Excellent agreement between theory and experiment for reflectivity on the 6" sphere
- Results for both the 6" and 12" spheres indicate that KOUN had a Z_{DR} bias of –0.5 dB
- One hypothesis of Z_{DR} variability involves possible multipath of the radar signal between the sphere and ground
- Another hypothesis is the (uncorrelated) phase jitter on the H and V channels; the variable atmosphere may set the ultimate limit on Z_{DR} stability and accuracy

Sphere Size	Elev. (deg)	Predicted Z (dBZ)	Measured Z (dBZ)	Std. Dev. Z (dB)	Predicted Z_{DR} (dB)	Measured Z_{DR} (dB)	Std. Dev. Z_{DR} (dB)
6"	1.36	42.7	42.5	0.47	0	-0.56	0.25
12"	1.23	50.0	46.7	0.36	0	-0.52	0.20

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