DYNAMO Self-consistency Reflectivity Calibration Verification

To verify the reflectivity calibration of the S-PolKa S-band radar, the self-consistency calibration technique of Vivekanandan et al. (2003) was performed on 3 time periods during DYNAMO. The computed reflectivity bias numbers are listed below.

Date	Time (UTC)	Estimated bias (dB)
Oct 12, 2011	1400 to 1500	0.43
Nov 17, 2011	2000 to 2100	0.21
Dec 23, 2011	1745 to 1800	0.01

The expected accuracy of this technique is $\pm$ 0.5 dB, so these results indicate well calibrated S-band reflectivity measurements throughout DYNAMO. The variance is most likely due to variations in drop size distribution and drop shape.

The Vivikanandan et al. (2003) technique utilizes the relationship the specific differential phase change (Kdp) has to reflectivity (Z) and differential reflectivity (Z_{dr}) in the form

$$Kdp = aZ^b Z_{dr}^c \tag{1}$$

where the coefficients a, b and c are determined by fitting modeled data using a given drop shape assumption and a range of drop size distributions (DSD). The attenuation and differential attenuation must also be taken into account when applying equation 1. Vivekanandan et al. (2003) showed that if the same DSD and drop shape assumptions are used for attenuation and differential attenuation relations as used in equation 1, the impact on Z bias estimates due to variations in DSD are mitigated. This results in about $\pm$ 0.5 dB accuracy.

The technique assumes a well calibrated Z_{dr}. The Z_{dr} calibration was confirmed via vertical pointing data collected on numerous days throughout the project. Using the calibrated Z_{dr} and Z, the Kdp is computed using equation 1 along ray segments that are carefully selected to avoid contaminants from ice, ground clutter. The lowest elevation angle of 0.5 degrees is not used to avoid ground clutter and the particle ID (Vivekanandan et al. 1999) and hail detection ratio (HDR; Aydin et al. 1986) are used to detect and reject ice contaminated ray segments. Ray segments are chosen with substantial measured total differential phase (Φ_{dp}), i.e. about 20 degrees or more, to reduce the variance of the method (Vivekanandan et al. 2003).

Once the data ray segments are collected, the Kdp are computed from the Z and Zdr and then integrated in range to obtain the computed Φ_{dp}. The computed Φ_{dp} for numerous rays are compared to the measured Φ_{dp} change. The mean bias in Z can be estimated from the difference in the measured and computed Φ_{dp}. This is possible because Z_{dr} is calibrated independently and the Kdp is a phase measurement and is therefore independent of the Z calibration.

Figures 1, 2 and 3 show scatter plots of the computed versus the measured Φ_{dp} for the 3 analysis periods. Each point in the plots represents one ray segment. An offset from the one-to-one line in the slope of the scatter points is indicative of a Z bias.

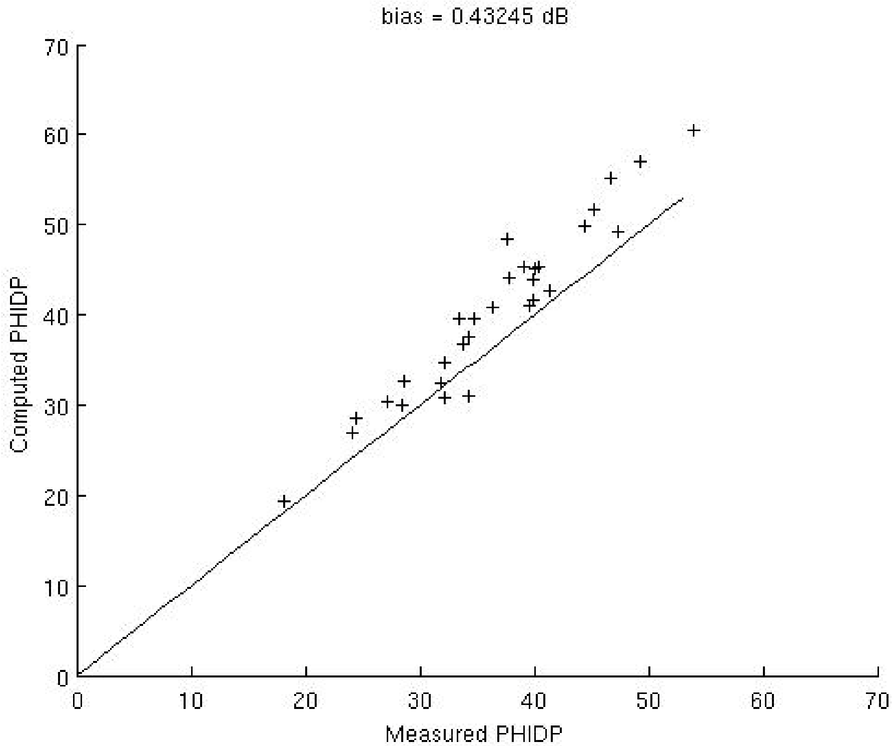

Figure 1. Scatter plot of computed versus measured Φ_{dp} for the data collected on October 12, 2011.

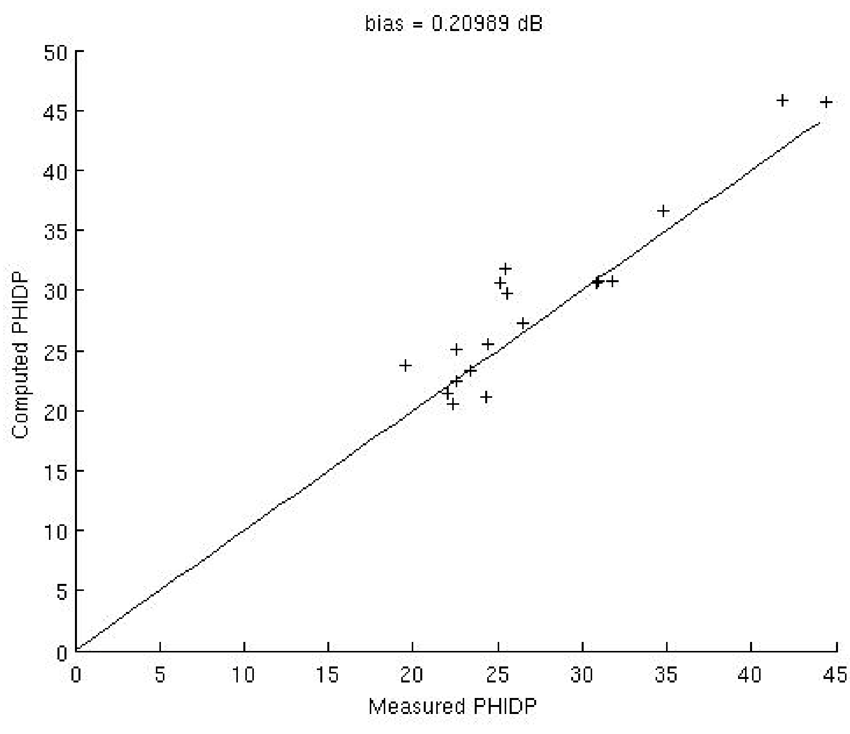

Figure 2. Same as Figure 1 for November 17, 2011.

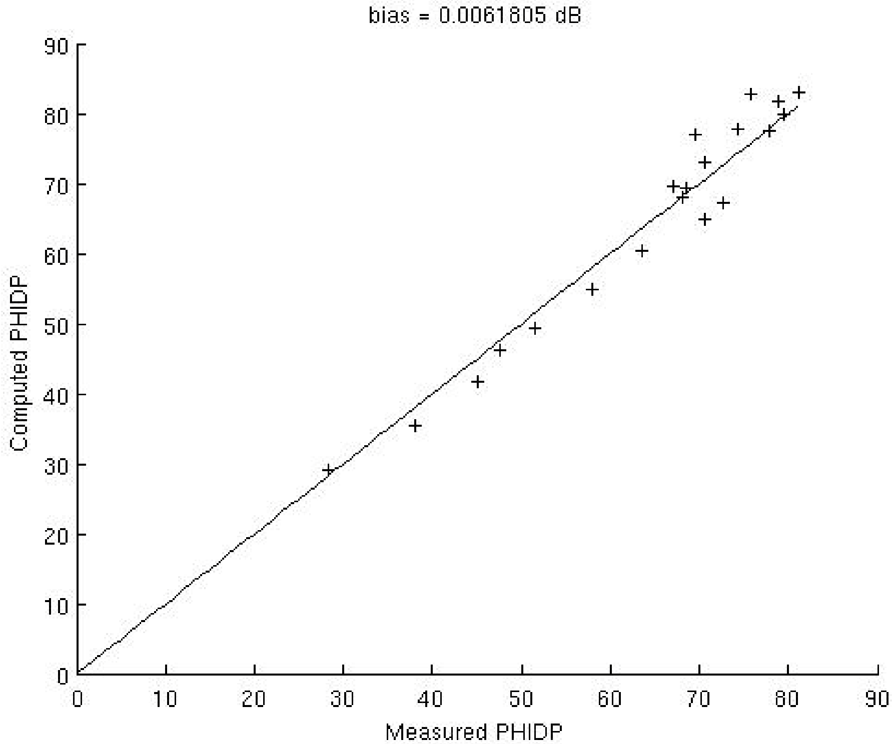

Figure 3. Same as Figure 1 for December 23, 2011.

References:

Aydin, K., T. A. Seliga, and V. Balaji, Remote sensing of hail with a dual-linear polarization radar, *J. Clim. Appl. Meteorol.*, **25**, 1475–1484, 1986.

Vivekanandan, J., G. Zhang, S. M. Ellis, D. Rajopadhyaya, and S. K. Avery, Radar reflectivity calibration using differential propagation phase measurement, *Radio Sci.*, **38(3),** 8049, doi:10.1029/2002RS002676, 2003.

Vivekanandan, J., S.M Ellis, D. S. Zrnic, R. Oye, A. V. Ryzhkov, and J. Straka, 1999: Cloud Microphysics Retrieval Using S-Band Dual-Polarization Radar Measurements. *Bull. Amer. Meteor. Soc.*, **80**, 381-388.