MMTO Internal Technical Memorandum #11-01

Azimuth Tracking for the 3rd Trimester of 2009 (September – December, 2009)

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Introduction

The MMTO MySQL database was queried for routine tracking and weather data for the final trimester of 2009 (Sept-Dec). These data are presented as a companion to the previously released reports on the MMT main-axis tracking performance.

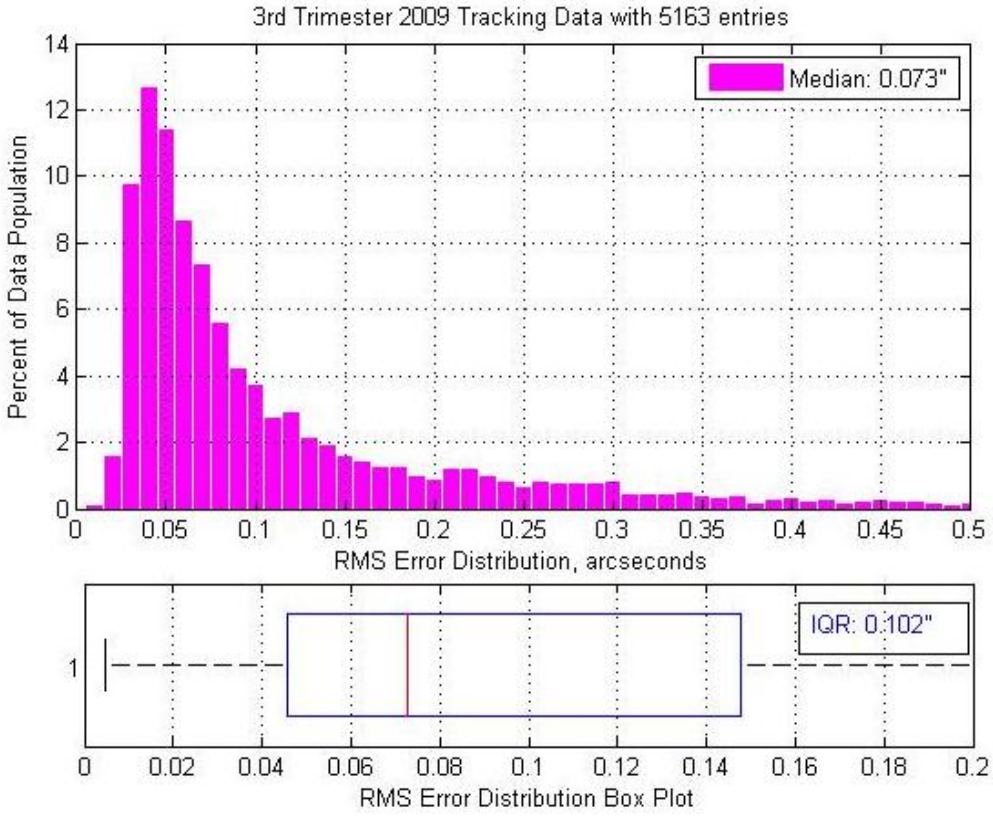
For this report, the database query returned 5163 entries from the tracking performance MySQL table. The tracking performance table contains fields for the timestamp, and source filename from the mount tracking logging software, position, RMS error, peak-to-peak error, and tracking rate. A separate Python application is used to gather wind data from the MySQL database at the same timestamps as in the tracking data so the wind information is coherent with the tracking data.

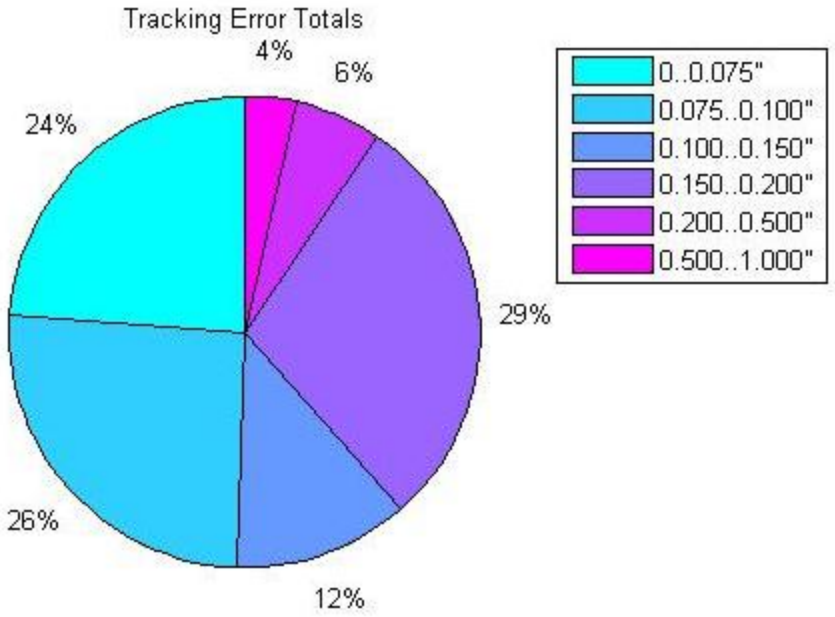
Tracking Error Statistics

The RMS error statistics in arc seconds for the whole data population are:

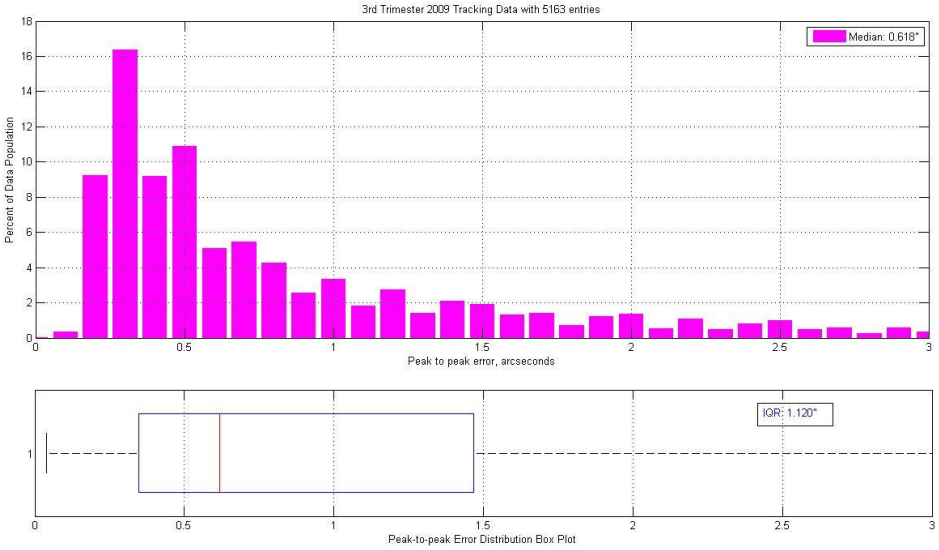
Min	Max	Median	Inter-quartile Range
0.005”	**1.984”**	**0.073”**	**0.102”**

The inter-quartile range (IQR) measures the width of the 50% of the data that lies between the 25th and 75th percentiles, and gives a better estimate of the spread of the data than the standard deviation (std), which can be sensitive to outliers. Below are a histogram and pie chart of the RMS error distribution for the data population.



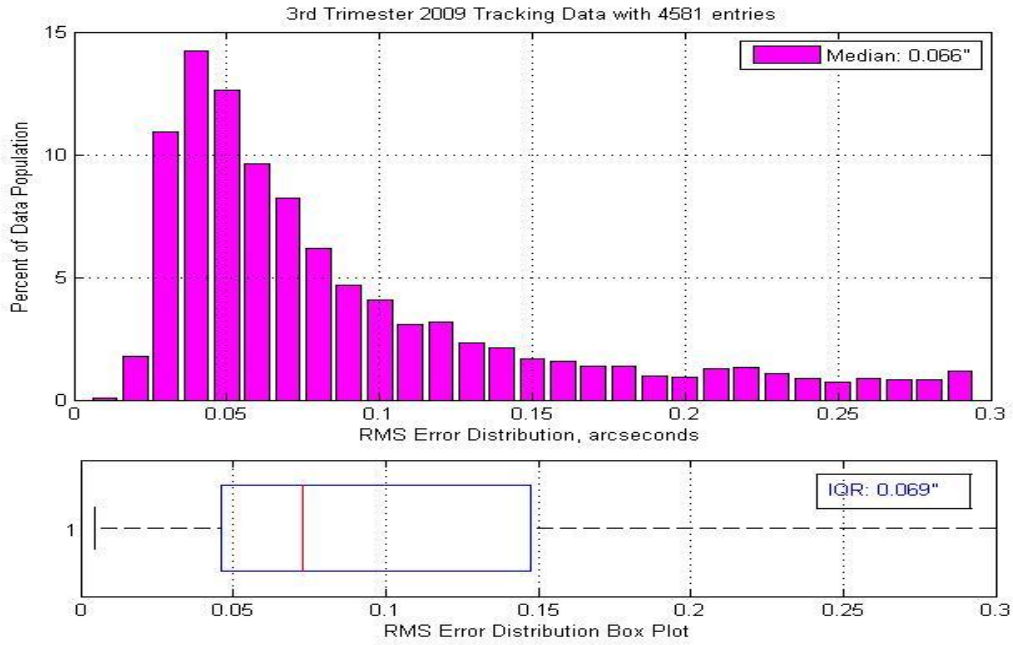


The peak-to-peak error for the data is below:

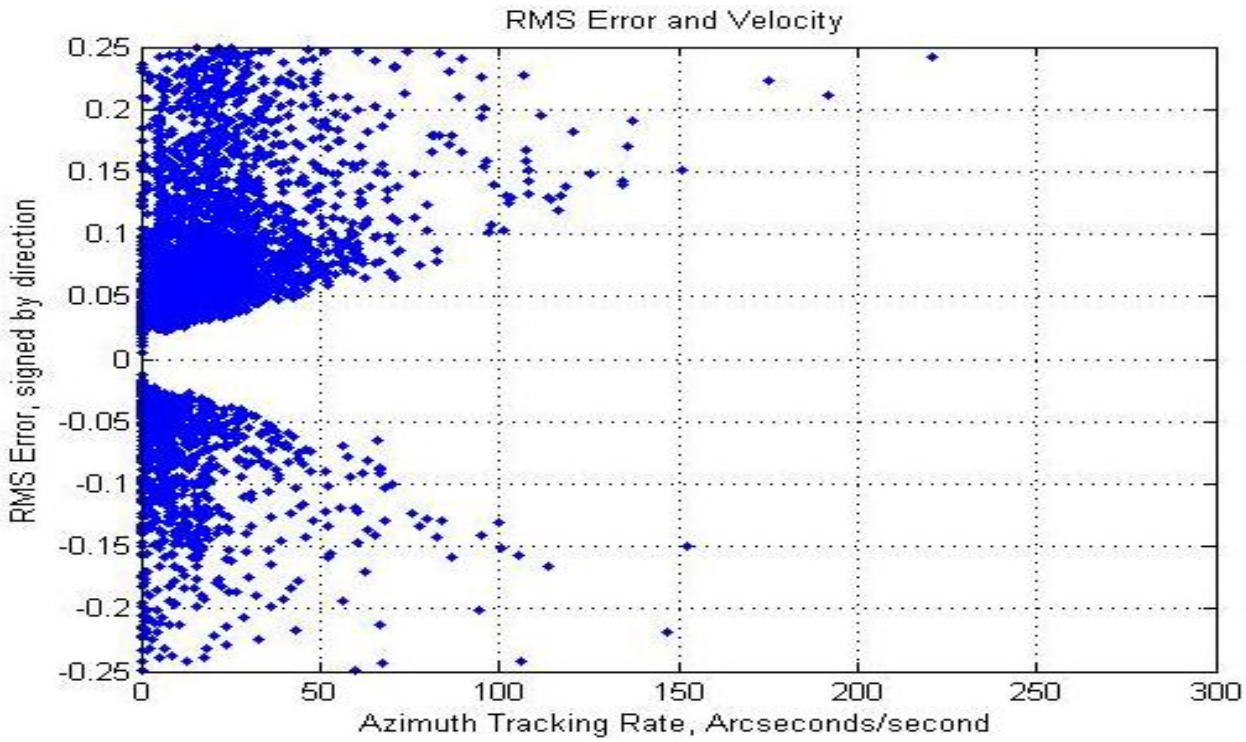


The `boxplot` routine records the outlier value for the RMS data as ~0.3”, so guarding the data by exclusion of those entries removes 582 members from the data set. We do this exclusion due to unwanted capturing of guider offsets and other step changes in the logged data that tend to contaminate the error statistics. This changes the RMS error distribution somewhat; the median RMS error then becomes 0.066”, with an IQR of 0.029”.

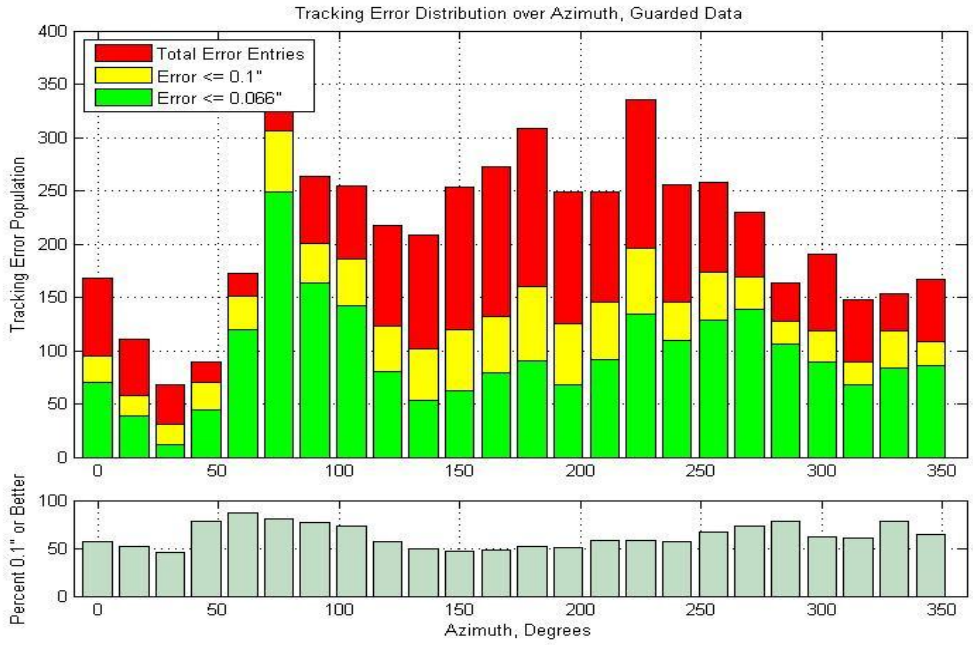
For brevity, all plots below are of guarded data, except for the error over velocity plot.

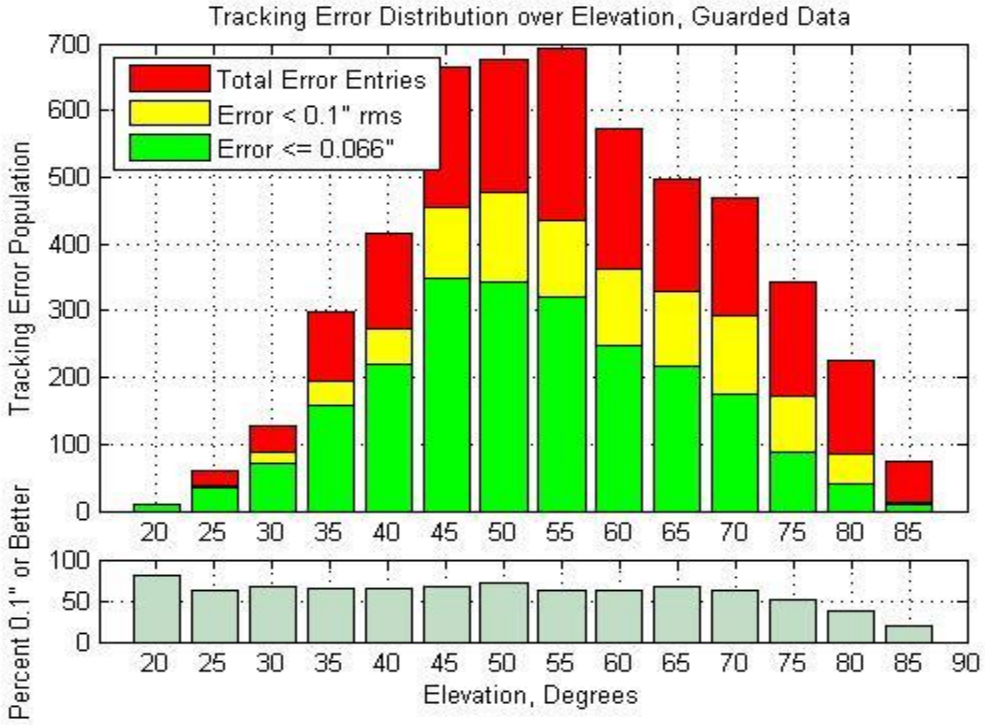


As earlier reported, there is also a lower limit to the tracking error that is related to velocity down to the absolute encoder quantization limit of 0.038":



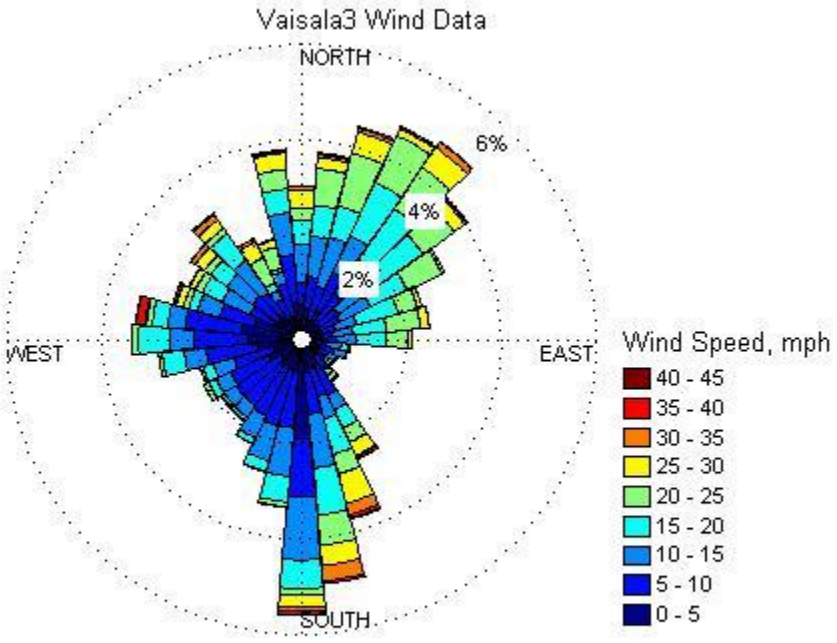
The RMS tracking error population over azimuth position and elevation are plotted below:





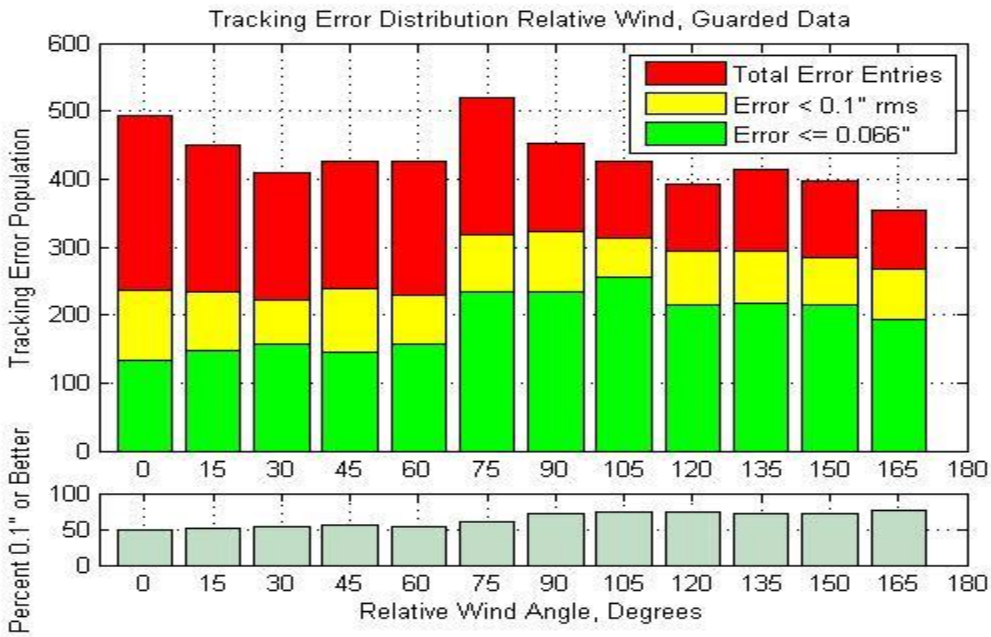
Wind Influence on Tracking

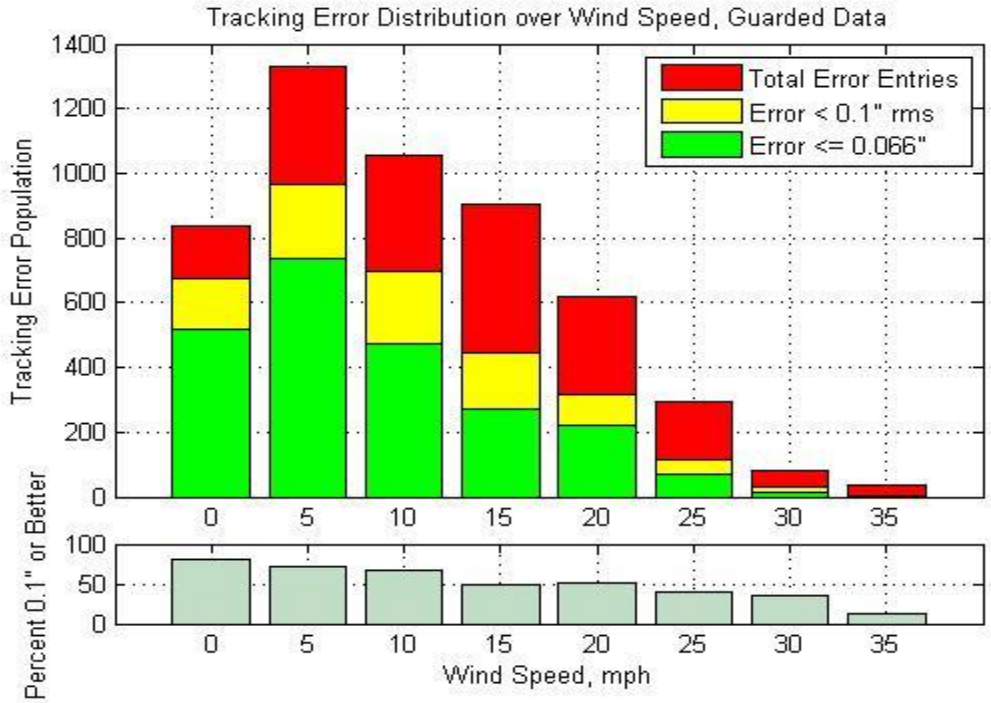
Perhaps the strongest contributor to tracking error degradation is wind. Below, we have relevant plots illustrating the wind at the summit and the tracking error.



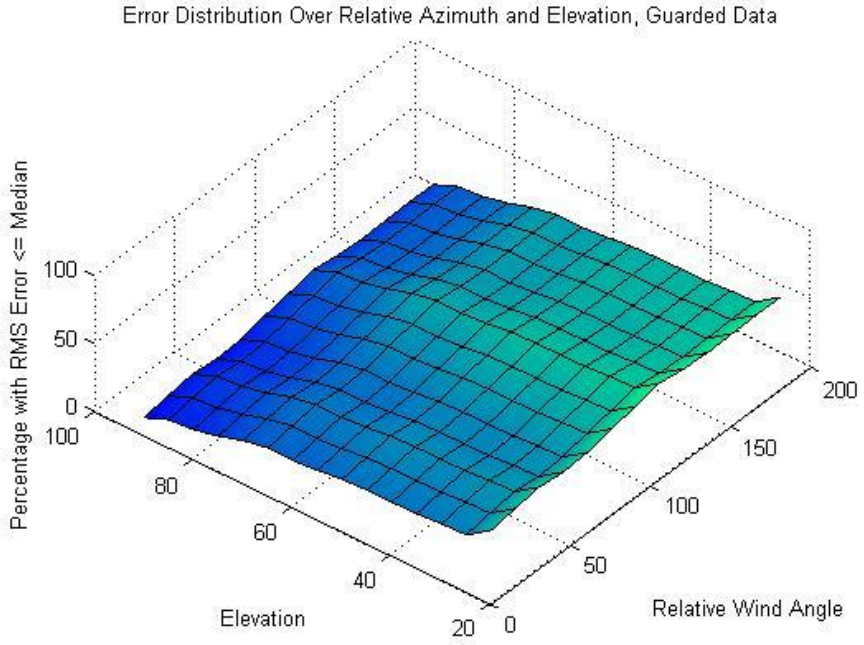
Generally, winds measured by the Vaisala3 sensor see winds to the south and west, and generally below about 20mph, which is historically consistent with weather conditions on Mt. Hopkins.

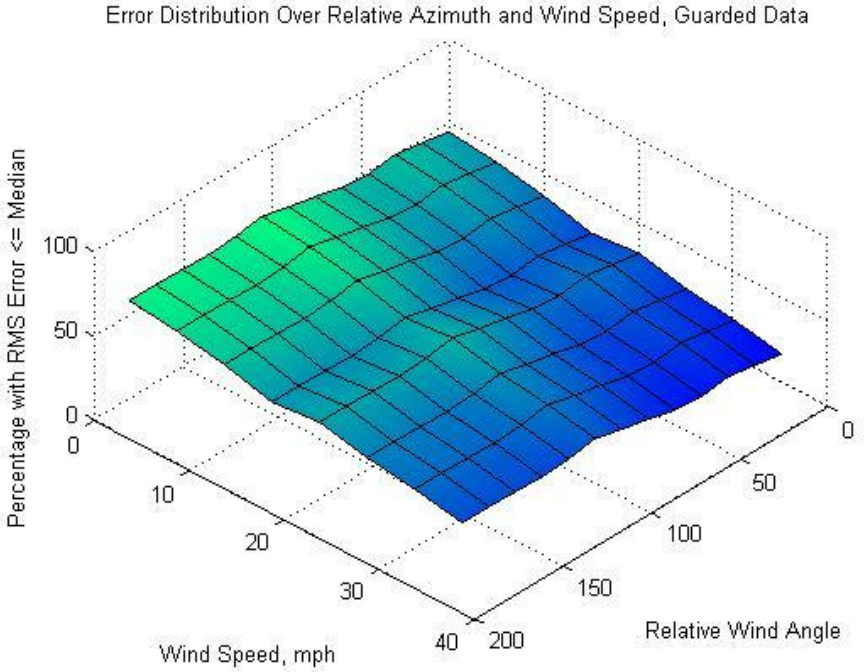
Below, we show the error distribution over relative angle and wind speed. As expected, tracking improves when facing normal to the wind, and when wind velocity is low.


Tracking Error Distribution Relative Wind, Guarded Data
Total Error Entries
Error < 0.1" rms
Error <= 0.066"
Tracking Error Population
Percent 0.1" or Better
Relative Wind Angle, Degrees


Tracking Error Distribution over Wind Speed, Guarded Data
Total Error Entries
Error < 0.1" rms
Error <= 0.066"
Tracking Error Population
Percent 0.1" or Better
Wind Speed, mph

The error distribution can be combined, as shown below. In addition, we can see that low elevations away from the wind are also situations that produce better tracking:





Conclusion

Azimuth tracking quality during this trimester is on a par with that reported previously. There is still a lower limit to tracking error related to velocity that may be mitigated as the azimuth servo upgrades go forward. Tracking is again improved in light winds and at target positions away from the wind; lower elevations are perhaps to be preferred unless airmass is a concern for the given observations.