Poster 3118

Background Noise Suppression for Increased Data Acceptance

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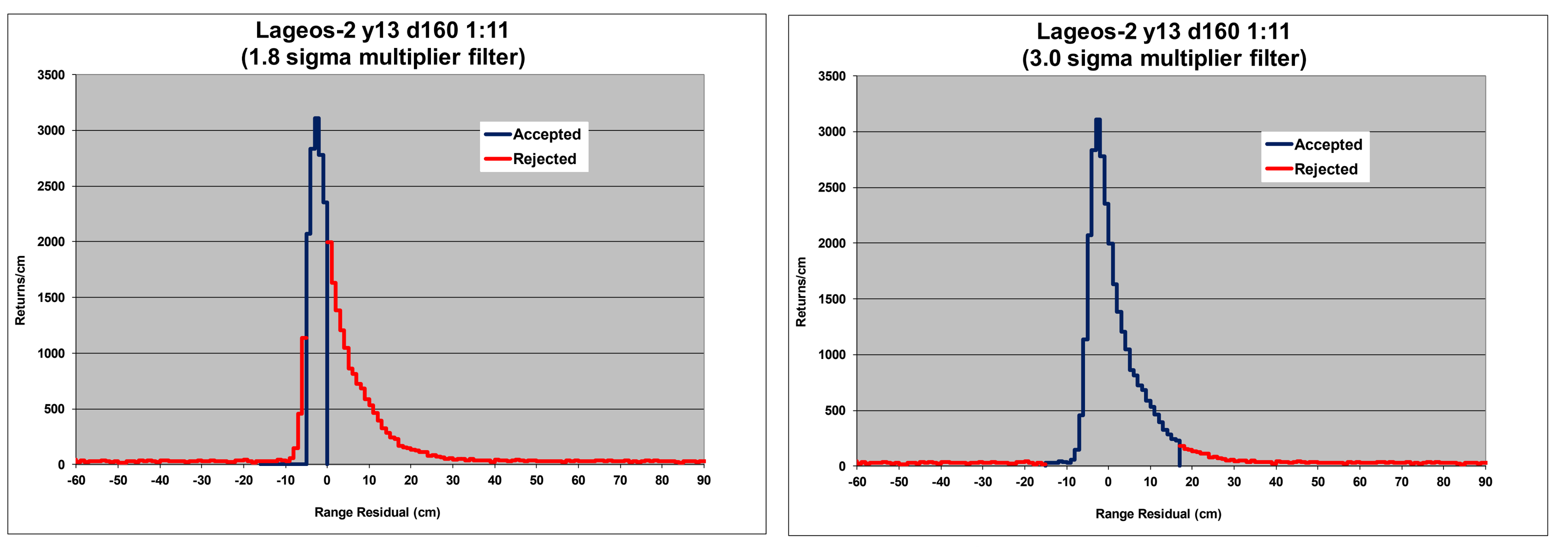
ABSTRACT: During the collocation of the Next Generation Satellite Laser System (NGSLR) with current NASA Standard System, MOBLAS-7, it was found that a centroid estimation of the return distribution using a 3 sigma RMS filter provided for a more accurate estimate of the target range than using peak estimates of the return distribution (~1.8 sigma RMS filter). One observed consequence of utilizing the 3 sigma RMS filter was the loss of valid passes with weaker signal due to the inclusion of background noise within and outside the signal distribution. A background noise suppression technique was developed and used prior to the centroid estimation such that these weaker signal passes were again viable and produced valid normal points. This paper will discuss the algorithm that was developed and present the effect of the algorithm on the quantity of valid normal points and the range determination of the normal points.

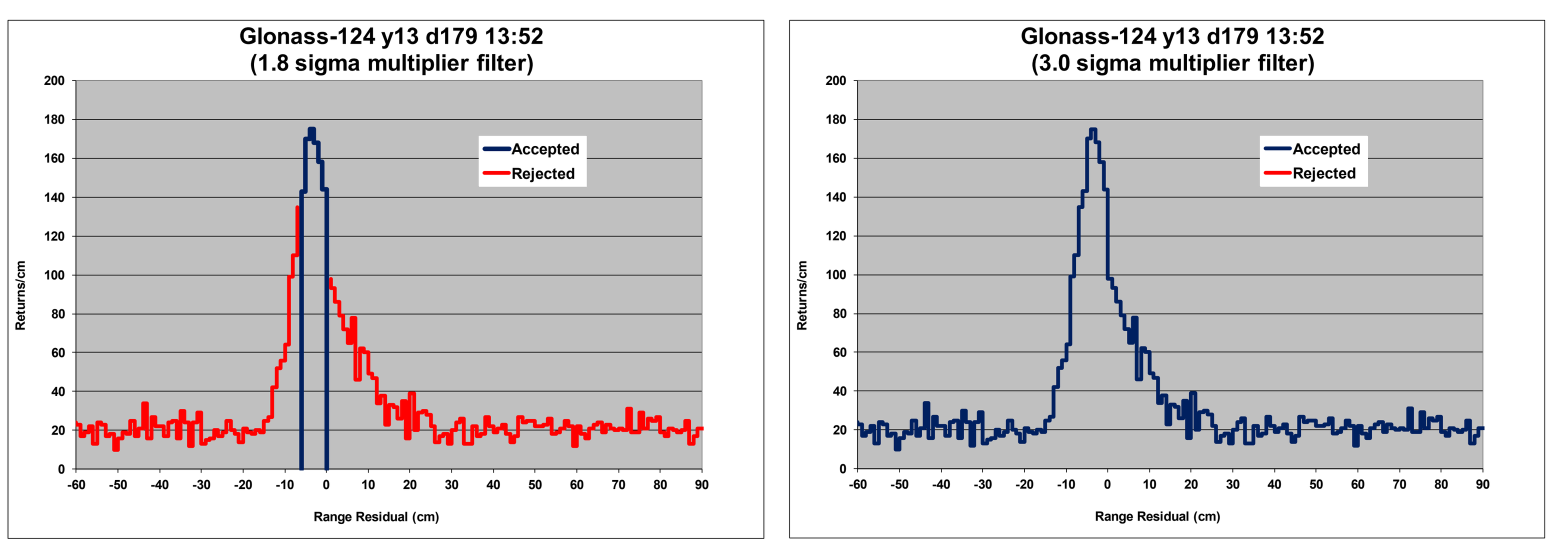
Introduction

- During the collocation of NASA's Next Generation Satellite Laser Ranging (NGSLR) system with current NASA Standard, MOBLAS-7, at NASA Goddard Space Flight Center, it was found that centroid estimation of the return distribution provide a more accurate estimate of the target range estimate than a peak estimate *[Clarke et al. 2013]*.
- Peak estimate is determined by using an iterative 1.8 sigma multiplier filter.
- Cenroid estimate is determined by using an iterative 3.0 sigma multiplier filter.



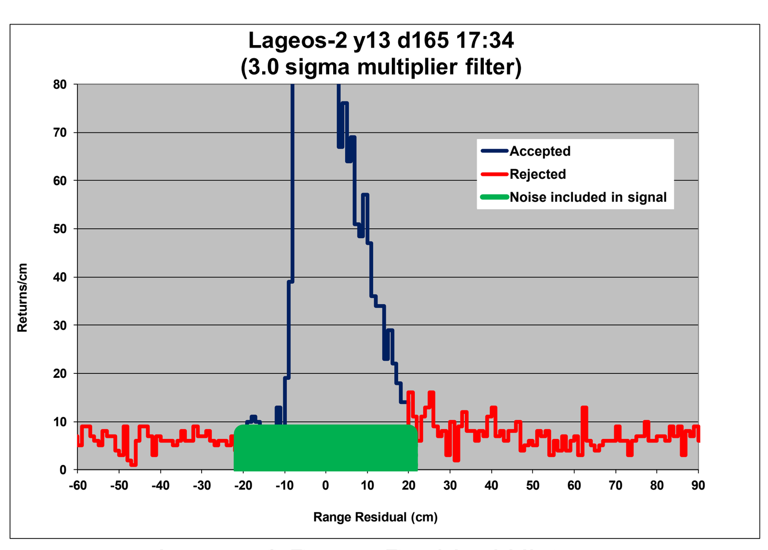
Lageos-2 Range Residual Histogram using 1.8 and 3.0 Sigma Multiplier Filters

- The technique worked well when the signal was strong relative to the background noise.
- The 3.0 sigma filter did not reliably differentiate signal from the background noise in some weaker passes.



Glonass-124 Range Residual Histogram using 1.8 and 3.0 Sigma Multiplier Filters

- Uniformly distributed background noise is included in the centroid calculation of skewed target return.
- The green box is an estimate of noise included in signal centroid calculation.
- "True" target return is on "top" of background noise.



Lageos-2 Range Residual Histogram

- Passes were rejected when they had a larger than expected RMS due to the inclusion of background noise.
- 18% of Lageos and 34% of GNSS normal points were lost due to the inclusion of background noise when using centroid calculation.

	1.8 Sigma Filter	3.0 Sigma Filter	% Decrease
Lageos Passes	**51**	**35**	**31.4**
Lageos Normal Points	**554**	**455**	**17.9**
GNSS Passes	**30**	**16**	**46.7**
GNSS Normal Points	**94**	**62**	**34.0**

Effects of Applying a 3.0 versus a 1.8 Sigma Filter to the Collocation Data Set

Noise Suppression Technique

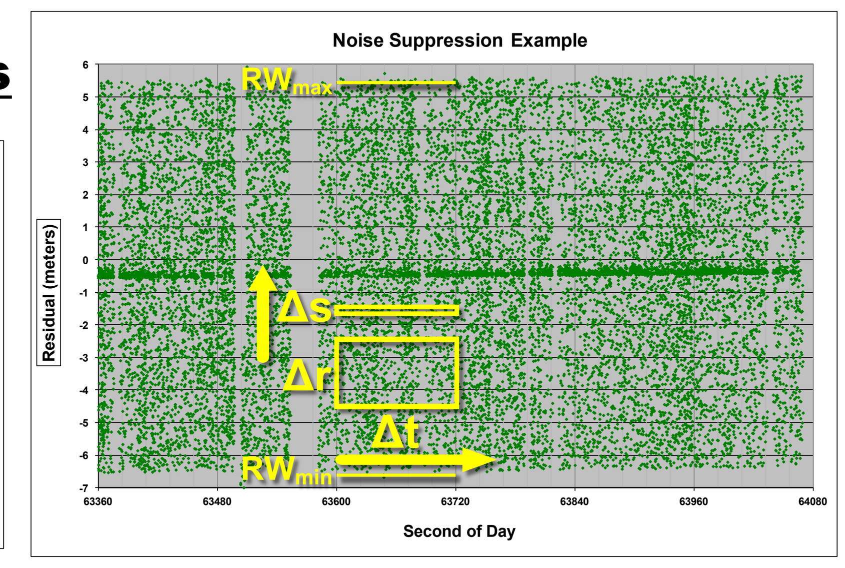
- A noise suppression technique was developed so that weaker passes would not have to be eliminated from the data set.
- The technique consisted of determining the background noise rate by sampling the noise outside the signal window and then randomly editing observations at the noise rate + 1σ.
- This "noise rate + 1σ" editing was chosen because it appeared to do the best job of eliminating noise while not significantly eliminating signal.

Noise Suppression Algorithm

- The algorithm processes data in time bins of Δt size starting a the beginning of the pass.
- For each time bin the following steps are performed:
  - Reject all data outside of a range residual window from RW_{min} to RW_{max} (signal is centered in window)
  - Estimate background noise rate using counts in a smaller range window outside the signal (counts in the Δr by Δt box).
  - Perform noise suppression to residual steps of Δs, starting at RW_{min} and ending at RW_{max}. For each step the noise suppression is performed using the following decisions:
    - If the number returns in the step (counts in the Δs by Δt box) is less than the expected noise returns, E_{bn}, then all the returns are rejected.
    - If the number returns are greater than E_{bn}, then E_{bn} of the total returns in the step are rejected. The rejected returns are chosen using a random number generator.

Noise Suppression Parameters

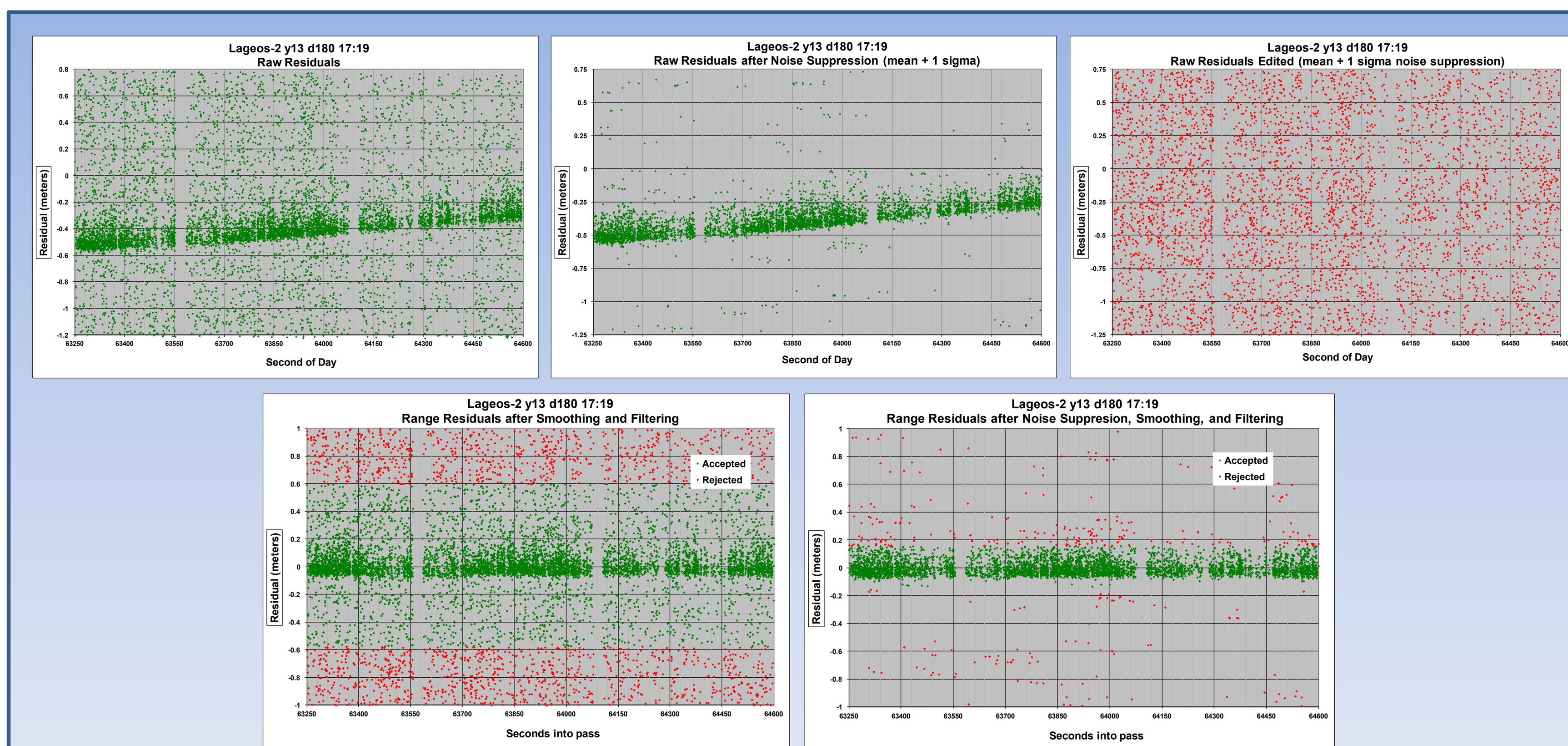
Δt	Length to time bin / step
Δs	Size of range residual bin / step
Δr	Range window used to sample background noise
Rw_{min}	Minimum of range residual window *(range residual less than value are rejected)*
Rw_{max}	Maximum of range residual (range residuals greater than value are rejected
E_{bn}	Expected number of background noise returns *(given noise rate + 1σ)*



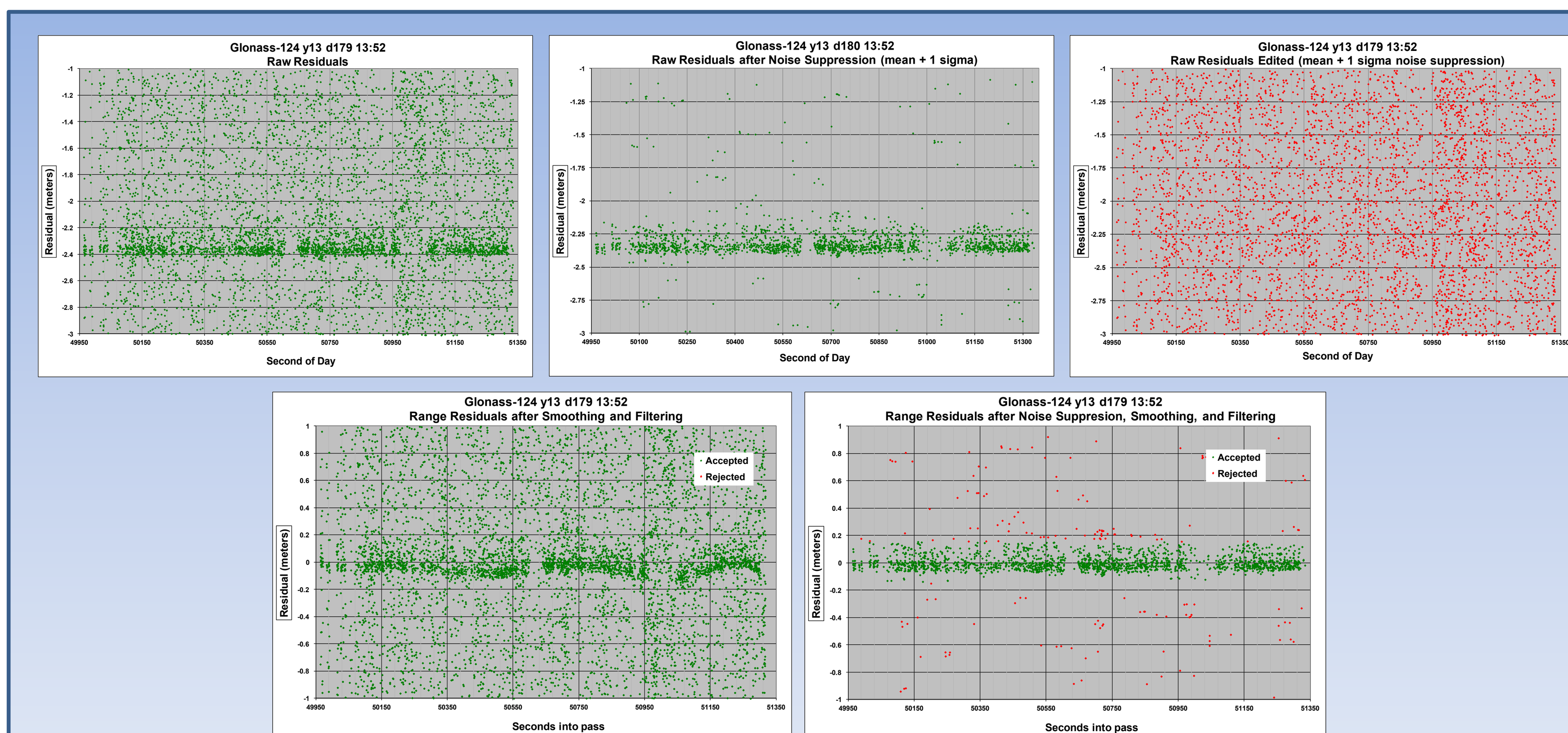
Example of Noise Suppression Parameters on a Range Residual Plot

Results of Noise Suppression

- The plots below display the results of noise suppression on two weaker signal passes.
- The top three plots in each set display the raw residuals before noise suppression, the raw residuals after noise suppression, and the returns that were edited during noise suppression. The noise suppression eliminates most of the background noise and very little of the signal.
- The bottom two plots in each set display the processed data (smoothed and sigma multiplier filtered) with and without noise suppression. The data with noise suppression accepts almost entirely signal, while the data without noise suppression includes large amounts of noise.



Effects of Noise Suppression on a Lageos-2 pass



Effects of Noise Suppression on a Glonass-124 pass

- Processing the collocation data set while applying noise suppression increased the number of Lageos and GNSS normal points significantly. There was ~ 200% increase in GNSS passes and normal points.

	No Noise Suppression	With Noise Suppression	% Increase
Lageos Passes	**35**	**52**	**48.6**
Lageos Normal Points	**455**	**594**	**30.5**
GNSS Passes	**16**	**50**	**212.5**
GNSS Normal Points	**62**	**184**	**196.8**

Effects of Applying Noise Suppression to the Collocation Data Set

- Most of the newly included passes were tracked during the daytime or under poor seeing conditions. Only six of the new normal points had overlapping MOBLAS-7 normal points with enough full rate observations to be used in collocation.
- The mean range difference between NGSLR and MOBLAS-7 decreased ~2.5 mm when the data was processed with noise suppression due to the distribution of the edited background noise in the signal.
- The mean range difference is in good agreement with Lageos theoretical predictions given the different types of receive systems used by NGSLR and MOBLAS-7 [Degnan, 1994; Fan et al, 2001].

Lageos	Mean Range Difference [NGSLR - Moblas-7] (mm)	Number of Normal Points	Standard Deviation (mm)	Standard Deviation of Mean (mm)
Without noise suppression	**12.81**	**270**	**4.98**	**0.30**
With noise suppression	**10.26**	**276**	**4.86**	**0.29**

Effects of Noise Suppression on the Collocation Data Set Summary