Determining the low signal threshold for ICON MIGHTI analysis

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When the signal observed by MIGHTI is very dim, the resulting interferogram may be too noisy for the analysis to succeed. In these cases, the error in the analysis is large and not well characterized by the statistical error bars. This can be caused by:

1. The inability to isolate the peak corresponding to the emission line in the Fourier transform of the fringe
2. Mis-identifying 2π jumps in the phase unwrapping
3. Errors in fitting a line to the unwrapped phase

It is desirable to identify, flag, and ignore these low-amplitude rows before analysis, because otherwise they could propagate to other rows (i.e., altitudes) during the onion-peeling. We believe that the true errors are so large for these rows that they are practically unusable, even if we were able to better characterize the uncertainty.

The question is what to use for the threshold to identify these rows. This document will describe our choice of thresholds for the Red and Green channels, which are included in v0.09 of the MIGHTI L2 winds code.

We simulate an inteferogram using the University of Illinois version of the NRL MIGHTI instrument model. For a given atmospheric brightness, we simulate an interferogram using the instrument model and apply a simplified version of the Level 1 (L1) processing. We then analyze this (complex-valued) interferogram to extract a single scalar amplitude and phase. The amplitude is defined as the sum of the magnitude of the interferogram over each pixel (i.e., each optical path difference). The scalar phase is determined by fitting a line to the unwrapped phase vs. optical path difference. It can be converted to velocity with a color-dependent factor and the known zero wind phase. This is identical to how interferograms are analyzed in practice on real data.

We repeat this process 50 times, with different noise realizations, to determine the precision. We then repeat this for many different initial signal brightnesses to create the plot in Figure 1.

Instead of using the input brightness in Rayleigh as the independent variable, we use the observed interferogram L1 brightness (as described above), since that is easier to threshold in practice. Figure 1 shows that in the high-signal regime, the errors behave as expected for Poisson noise; that is, the slope of the line is 0.5. The red dot on the plot indicates the manually chosen point where this assumption breaks down and errors blow up. Figure 2 shows the same analysis for the green channel. Table 1 shows the thresholds chosen. An extra factor of 1.5 was applied for margin.

	L1 Amplitude	Brightness
Red	5100 counts	86 R
Green	5800 counts	120 R

Table 1: Chosen minimum-amplitude thresholds

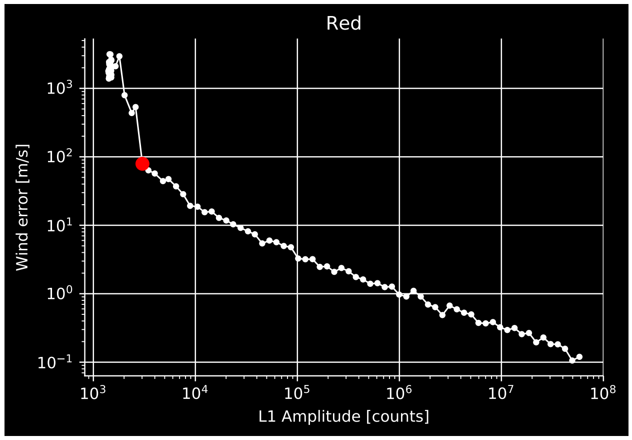

Figure 1: Wind precision as a function of observed brightness for the red channel. The red dot indicates the chosen threshold where the Poisson noise assumption evidently breaks down.

We note that in practice this thresholding is done at the beginning of the Level 2 processing. In priniciple it is possible that on the bottomside of the emission profile, the onion-peeling might result in an altitude where the onion-peeled amplitude is dim, and the same problems would apply. However, since the onion-peeling changes the units, this situation is harder to identify, and we expect that error propagation in Level 2 should result in accurate error bars in any case. However, this will be something we will watch on-orbit.

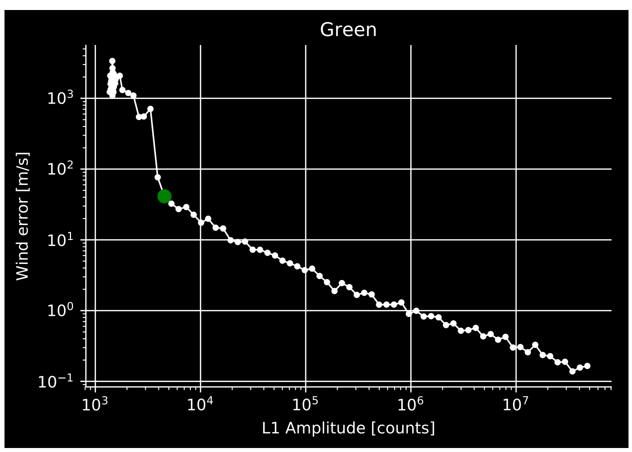

Figure 2: Wind precision as a function of observed brightness for the green channel. The green dot indicates the chosen threshold where the Poisson noise assumption evidently breaks down.