The STEREO-HI photometric status (Jan 2025).

James Tappin and the RAL Space STEREO-HI team

2025/04/22

1 Introduction

Monitoring the variations of gain in the STEREO-HI cameras is an ongoing process. The most recent change to the characterization was described by Tappin *et al.* (2022) covering the first few years after superior conjunction. That paper also described the limitations of using the single-exposure calibration images rather than the science images for calibration.

As with that analysis this redetermination only attempts to look at the degradation rate as the single-exposure data do not provide enough signal to noise to improve the absolute calibration.

We have used the same base star lists as were used in Tappin *et al.* (2022).

After measurement, slightly different acceptance criteria were applied, in particular, more measurements were required of each star in the post conjunction interval as it is longer. For HI-2 it was also found that a more stringent requirement on background rates could be applied. The acceptance criteria are summarized in Table 1.

Individual measurements more than 2 pixels away from the calculated position, or differing from the predicted rate by more than a factor 2 were also rejected.

2 Results

For HI-1 (Figure 1) while there appears to be a slight flattening of the degradation over the last couple of years, the fitted parameters are little changed, and there are not enough data to adequately characterize the flattening if it is indeed real.

Table 1: Sample selection criteria for HI samples. Figures in **bold** have been changed from the last analysis of Tappin *et al.* (2022).

HI-1			
Parameter	Unit	Pre-conjunction	Post-conjunction
Min. observations		15	**20**
Min. ratio		0.75	
Max. ratio		1.5	
Max. IQ range	fractional	0.1	0.1
Max. position error	CCD pixels	0.6	
Max. background	$\mathrm{DN\,s^{-1}}$	0.2	
Max. count rate	$\mathrm{DN\,s^{-1}}$	1000.0	
Faintest magnitude		9.0	
Closest neighbour	$^\circ$	0.2	
Min. galactic lat.	$^\circ$	15.0	
HI-2			
Min. Observations		**30**	**30**
Min. ratio		0.75	
Max. ratio		1.5	
Max. IQ range	fractional	0.1	
Max. position error	CCD pixel	1.0	
Max. background	$\mathrm{DN\,s^{-1}}$	**10.0**	**10.0**
Max. count rate	$\mathrm{DN\,s^{-1}}$	2500.0	
Faintest magnitude		7.5	
Closest neighbour	$^\circ$	0.5	
Min. Galactic Lat.	$^\circ$	15.0	

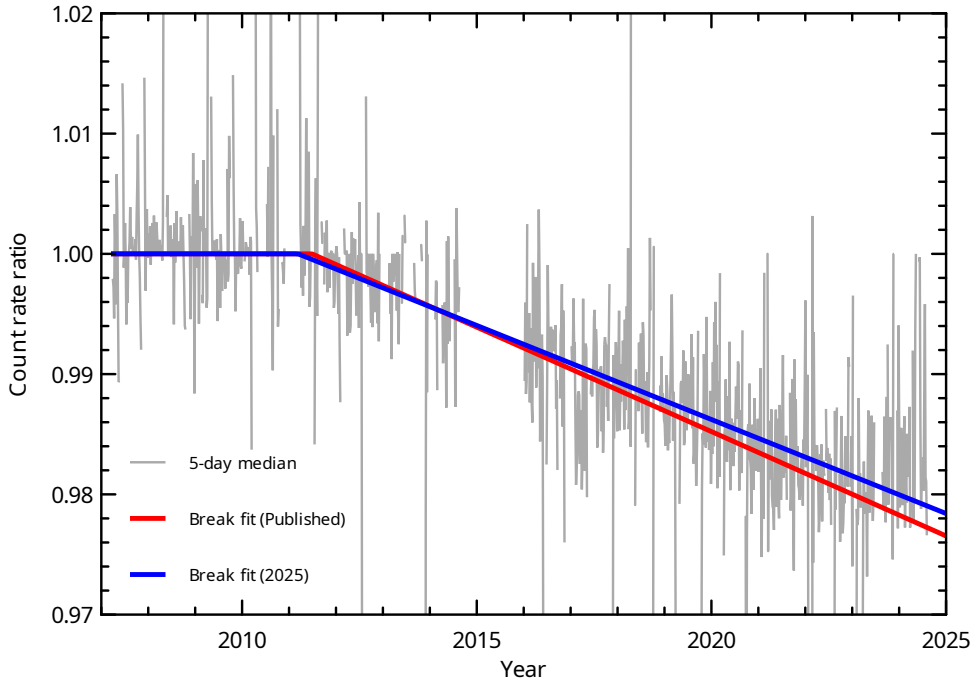

Figure 1: HI-1 normalized rates updated to end of 2024. The median is a 5-day median of all valid data points. The broken fits from the previous published update and to the current data are shown.

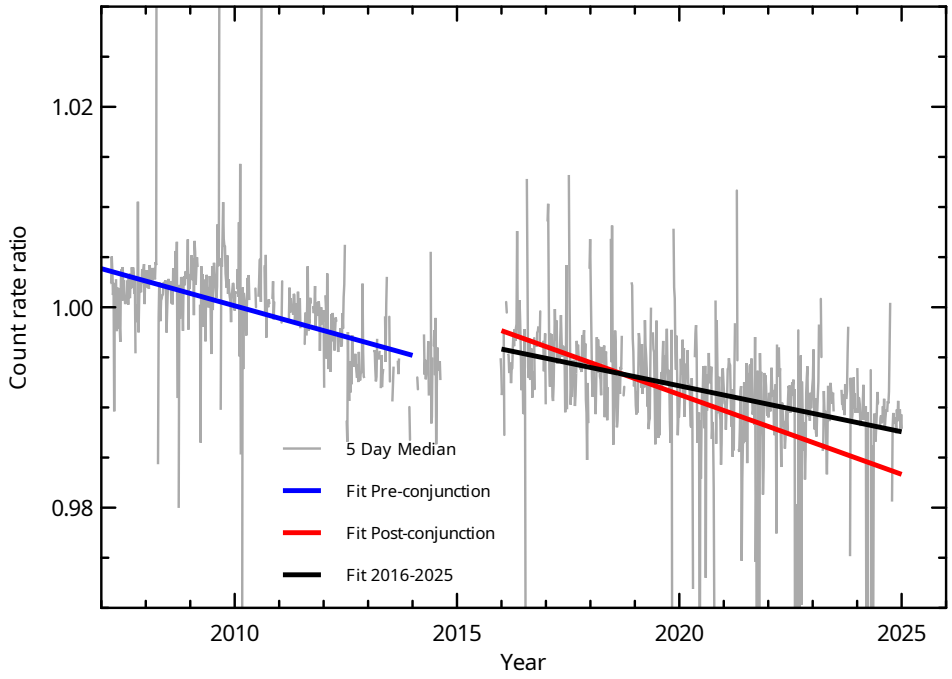

Figure 2: HI-2 normalized rates updated to the end of 2024.

The current model used for HI-1 is a constant gain for the first part of the dataset and then a linear decay from then:

$$G = 1.0077928 - 0.0017362039 * \max((Y - 2007), 4.4864277).$$

This form is still consistent with the data with a best fit of:

$$G = 1.0065579 - 0.0015639533 * \max((Y - 2007), 4.1931655).$$

Given the small differences between the two fits, we consider it is not yet necessary to update the fitting parameters, we will however continue to monitor the situation.

In the case of HI-2, the flattening in the recent data is more obvious (Figure 2). With the post-conjunction fit being markedly flatter and a single slope appearing to be possible.

For HI-2 the current model is a two part fit with separate linear fits to data before

HI-2A after 2015.0		
Unit	Constant	Linear
$B_\odot$	4.4765E-14	-4.0859E-17
S10	99.51	-0.0908
$\mathrm{W\,m^{-2}\,sr^{-1}}(0-\infty)$	8.9530E-07	-8.1694E-10
$\mathrm{W\,m^{-2}\,sr^{-1}}(360-1800\,\mathrm{nm})$	6.2187E-07	-5.6761E-10
$\mathrm{W\,m^{-2}\,sr^{-1}}(\mathrm{Passband})$	3.3187E-07	-3.0292E-10

Table 2: Updated physical parameters for HI-2A post conjunction.

and after superior conjunction:

$$\begin{aligned} G &= 1.00385 - 0.00123590 \times (Y - 2007) \quad \text{Before conjunction} \\ G &= 1.01201 - 0.00159364 \times (Y - 2007) \quad \text{After conjunction.} \end{aligned}$$

The difference to the new Post-conjunction fit of:

$$G = 1.0040745 - 0.00091671512 \times (Y - 2007)$$

is sufficiently large and clear to require the updating of the HI-2 variation.

Since the pre-conjunction interval for the normalization is unchanged the correction from the relative to the absolute calibration is unchanged since the analysis of Tappin *et al.* (2022) at 1.005 (equations 13 and 14 thereof). Hence we have modified the HI-2A calibration use an adjustment factor of

$$\begin{aligned} G(Y) &= 1.005 \times (1.0040745 - 0.00091671512 \times (Y - 2007)), \\ &= 1.0091 - 0.000921 \times (Y - 2007), \end{aligned} \tag{1}$$

where Y is the year, and the precision is adjusted to sensible ranges. These changes have been committed to the relevant routines in SolarSoft, and applied to the data served from UKSSDC.

It should be noted that this is a slower rate of degradation than the previous estimate, as the current parameters are:

$$G(Y) = 1.0171 - 0.001602 \times (Y - 2007). \tag{2}$$

In physical units, (c.f. Table 9 of Tappin *et al.* (2022)) we get the values in Table 2.

References

Tappin, S. J., Eyles, C. J., & Davies, J. A. 2022. A Post-Conjunction Re-Evaluation of the Calibration and Long-term Evolution of the STEREO-A Heliospheric Imagers. *Solar Phys.*, **297**(3), 37.