

The STEREO-HI photometric status (Apr 2026).

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1 Introduction

Monitoring the variations of gain in the STEREO-HI cameras is an ongoing process. The most recent published 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.

Since that redetermination, there have been three further re-examinations.

1. January 2024: Covering data up to the inferior conjunction.
2. April 2025: Covering data up to the end of 2024.
3. October 2025: Covering data up to 20 October 2025.

As with the analysis of Tappin *et al.* (2022) these redeterminations only attempt to look at the degradation rate as:

- Since shortly before superior conjunction the gyros have been disabled, this results in somewhat degraded pointing stability. The interaction of this with the particle hit removal algorithm mean that the stars in the science data can no-longer be used for photometric calibrations.
- the daily single-exposure image 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 now has more data. 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

2.1 Early 2024 measurements.

The results from the data up to the inferior conjunction, show a continuation of the trends found by Tappin *et al.* (2022). These are summarized in Figures 1 and 2.

On the basis of these measurements, it was decided that there was no immediate need to update the calibration parameters.

2.2 Early 2025 measurements

For HI-1 (Figure 3) 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, the existence of this flattening was confirmed by the most recent determination (Section 2.3).

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:

$$G = 1.0077928 - 0.0017362039 * \max((Y - 2007), 4.4864277). \quad (1)$$

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

$$G = 1.0065579 - 0.0015639533 * \max((Y - 2007), 4.1931655). \quad (2)$$

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.

Table 1: Sample selection criteria for HI samples. Figures in **bold** have been changed from the last published analysis of Tappin *et al.* (2022). Where two numbers are given in the final column the second applies to the late 2025 check (Section 2.3) and the first to the early 2025 determinations.

HI-1				
Parameter	Unit	Tappin <i>et al.</i> 2022	2024	2025-2026
Min. observations		12	15	20, 25
Min. ratio		0.75	0.75	0.75
Max. ratio		1.5	1.5	1.5
Max. IQ range	fractional	0.1	0.1	0.1
Max. position error	CCD pixels	0.6	0.6	0.6
Max. background	DN s ⁻¹	0.2	0.2	0.2
Max. count rate	DN s ⁻¹	1000.0	1000.0	1000.0
Faintest magnitude		9.0	9.0	9.0
Closest neighbour	°	0.2	0.2	0.2
Min. galactic lat.	°	15.0	15.0	15.0
HI-2				
Min. Observations		20	30	30, 35
Min. ratio		0.75	0.75	0.75
Max. ratio		1.5	1.5	1.5
Max. IQ range	fractional	0.1	0.1	0.1
Max. position error	CCD pixel	1.0	1.0	1.0
Max. background	DN s ⁻¹	100.0	10.0	10.0
Max. count rate	DN s ⁻¹	2500.0	2500.0	2500.0
Faintest magnitude		7.5	7.5	7.5
Closest neighbour	°	0.5	0.5	0.5
Min. Galactic Lat.	°	15.0	15.0	15.0

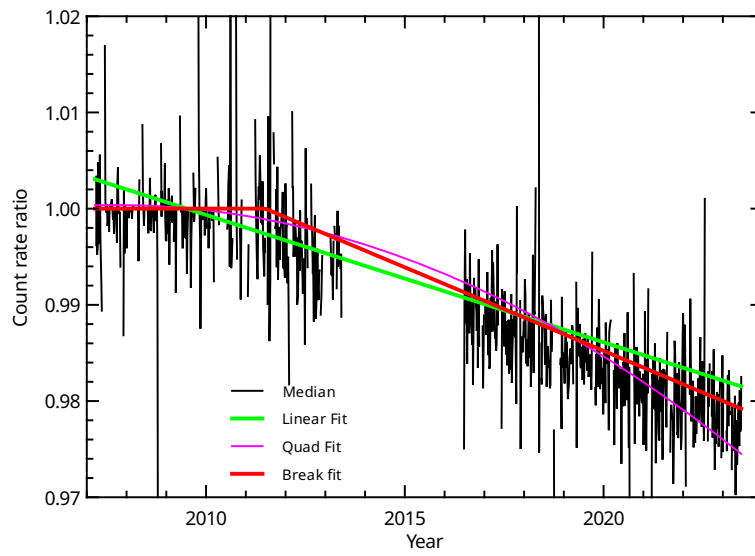


Figure 1: Five-day medians of the normalized count rates for HI-1A from start of mission to the start of the roll for inferior conjunction. Overlaid are the fits obtained by Tappin *et al.* (2022).

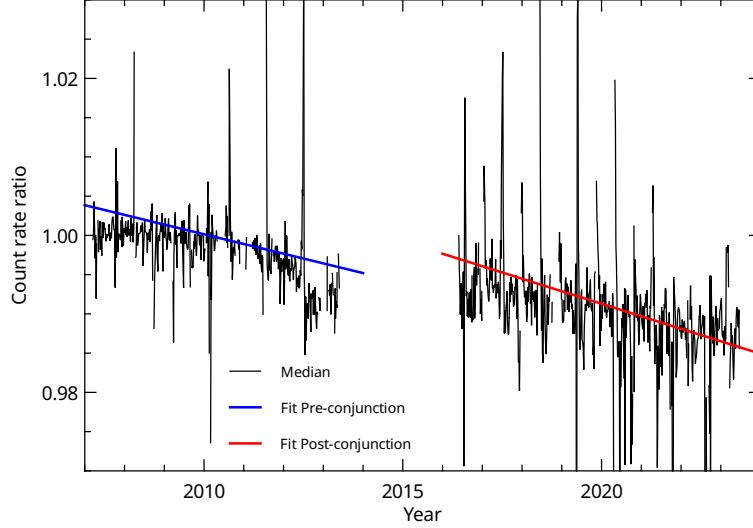


Figure 2: Five-day medians of the HI-2A normalized count rates. The two superposed traces show the fits from Tappin *et al.* (2022).

In the case of HI-2, the flattening in the recent data is more obvious (Figure 4). 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 and after superior conjunction:

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

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

$$\begin{aligned} G(Y) &= 1.005 \times (1.0040745 - 0.00091671512 \times (Y - 2007)), \\ &= 1.0091 - 0.000921 \times (Y - 2007), \end{aligned} \tag{3}$$

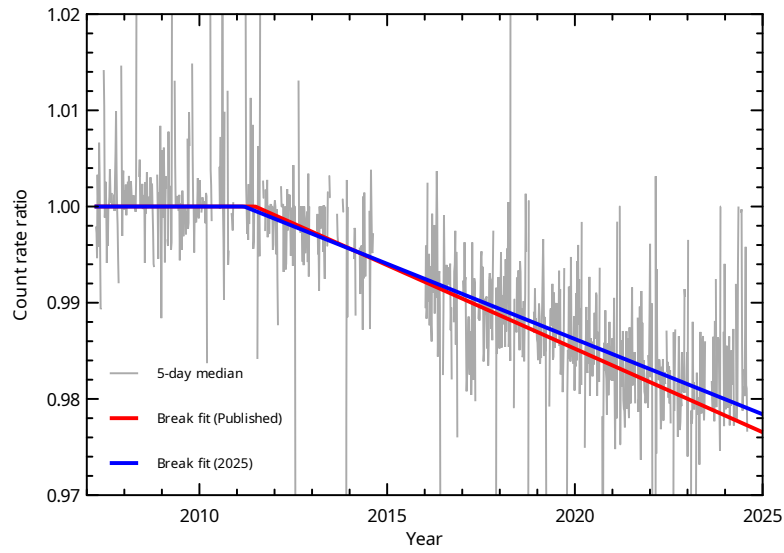


Figure 3: HI-1 normalized rates updated to end of 2024. The median is a 5-day median of all valid data points. The broken fits from the previous published update and to the current data are shown.

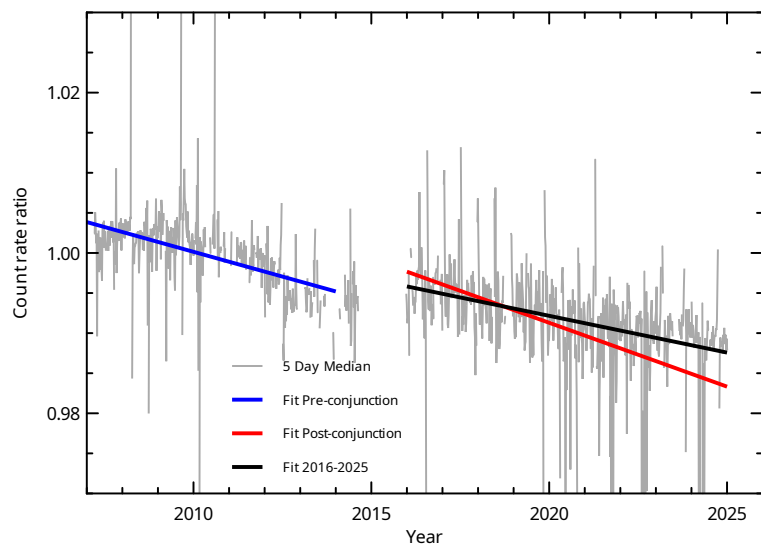


Figure 4: HI-2 normalized rates updated to the end of 2024.

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

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

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 (as of April 2025).

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

$$G(Y) = 1.0171 - 0.001602 \times (Y - 2007). \quad (4)$$

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

2.3 Late 2025 update

Analysis updated to 2025, day 293.

For HI-2A (Figure 5), the trend continues in agreement with the revised trend. Thus it appears no revision is needed.

For HI-1A (Figure 6, the hint of a flattening does appear to continue. Therefore it is suggested to revise the fit for HI-1A, to the current “linear with break” fit:

$$G = 1.0064791 - 0.0015579409 \times (\max(y, 2011.1587651) - 2007), \quad (5)$$

(though this is almost indistinguishable from the relation in Equation 2).

Noting that the factor to adjust for the averaging over the pre-conjunction interval is indistinguishable from 1.0 and the scaling factor of HI-1A scaling to pre-launch values of 0.9342 (Tappin *et al.*, 2022, §5.1), the scaling to the pre-launch values becomes:

$$\begin{aligned} G_{\text{HI-1A}}(T) &= 0.9342 (1.0065 - 0.001558 \times \max(Y - 2007, 4.159)) \\ &= 0.9401 - 0.001455 \times \max(Y - 2007, 4.159) \end{aligned} \quad (6)$$

Converting to physical units we obtain the results in Table 3.

These changes have been applied in SolarSoft and also to the data served from UKSSDC since February 2026.

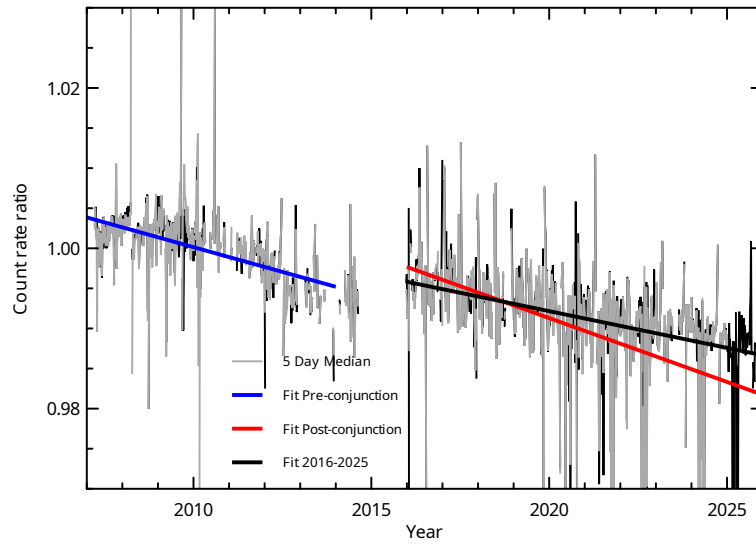


Figure 5: Revised trends for HI-2A.

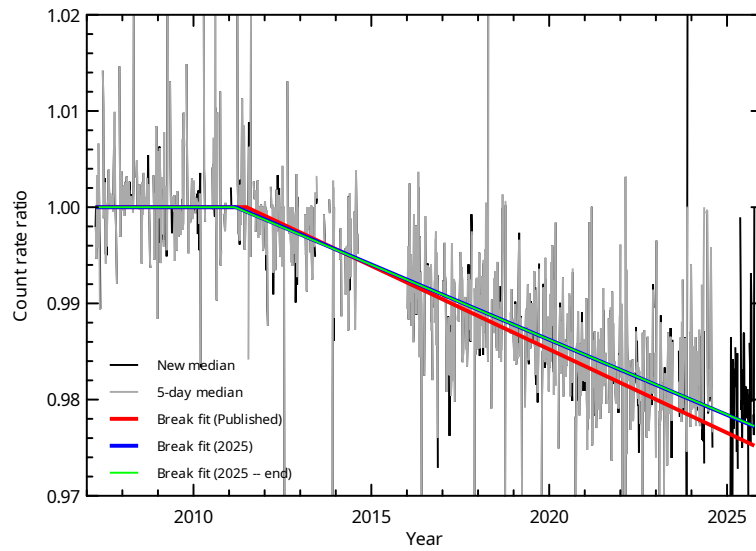


Figure 6: Revised trends for HI-1A.

HI-1A Revision			
Unit	Constant	Linear	Break
B_{\odot}	3.686E-13	5.743E-16	2011.159
S10	8.184E+02	1.275E+00	2011.159
$W \text{ m}^{-2} \text{ sr}^{-1} (0 - \infty)$	7.362E-06	1.147E-08	2011.159
$W \text{ m}^{-2} \text{ sr}^{-1} (360 - 1800 \text{ nm})$	5.250E-06	8.179E-09	2011.159
$W \text{ m}^{-2} \text{ sr}^{-1} (\text{Passband})$	8.337E-07	1.299E-09	2011.159

Table 3: Updated physical parameters for HI-1A post conjunction.

3 Summary

Since the last published calibration results for STEREO-HI-A (Tappin *et al.*, 2022), three checks have been made on the degradation rates of these instruments. These show a continuation of the very slow (by comparison with other instruments) degradation of sensitivity.

On the basis of these, updates have been made to the calibration parameters for both HI-1A and HI-2A, both in the direction of **reducing** the rate of degradation. The changes to HI-1A were implemented into the processing pipe in April 2025, and those to HI-2A in February 2026.

On the basis of these results and the earlier published results it is to be expected that the optics and sensors of STEREO-HI will be able to operate for several more decades.

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.