A Large Catalog of Homogeneous Ultra-Violet/Optical GRB Afterglows: Temporal and Spectral Evolution

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Abstract

We present the second Swift Ultra-Violet/Optical Telescope (UVOT) gamma-ray burst (GRB) afterglow catalog, greatly expanding on the first Swift UVOT GRB afterglow catalog. The second catalog is constructed from a database containing over 120,000 independent UVOT observations of 538 GRBs first detected by Swift, the High Energy Transient Explorer 2 (HETE2), the INTErnational Gamma-Ray Astrophysics Laboratory (INTEGRAL), the Interplanetary Network (IPN), Fermi, and Astro-rivelatore Gamma a Immagini Leggero (AGILE). The catalog covers GRBs discovered from 2005 January 17 to 2010 December 25. Using photometric information in three UV bands, three optical bands, and a “white” or open filter, the data are optimally coadded to maximize the number of detections and normalized to one band to provide a detailed light curve. The catalog provides positional, temporal, and photometric information for each burst, as well as Swift Burst Alert Telescope and X-ray Telescope (XRT) GRB parameters. Temporal slopes are provided for each UVOT filter. The temporal slope per filter of almost half the GRBs are fit with a single power law, but one to three breaks are required in the remaining bursts. Morphological comparisons with the X-ray reveal that ~75% of the UVOT light curves are similar to one of the four morphologies identified by Evans et al. (2009). The remaining ~25% have a newly identified morphology. For many bursts, redshift- and extinction-corrected UV/optical spectral slopes are also provided at 2 × 103, 2 × 104, and 2 × 105 s.

Key words: catalogs – gamma-ray burst: general

Supporting material: tar.gz files

1. Introduction

The Ultra-Violet/Optical Telescope (UVOT; Roming et al. 2000, 2004, 2005) on board the Swift observatory (Gehrels et al. 2004) is designed to rapidly follow-up gamma-ray burst (GRB) afterglows in the 170–800 nm range. UVOT observations of GRB afterglows were first cataloged by Roming et al. (2009, hereafter Paper1) and include 229 bursts discovered between 2005 January 17 and 2007 June 16. These bursts were primarily discovered by Swift but also include GRBs discovered by the High Energy Transient Explorer 2 (HETE2; Ricker 1997), INTERnational Gamma-Ray Astrophysics Laboratory (INTEGRAL), and Interplanetary Network (IPN; Hurley et al. 2005). In Paper1, positional, temporal, and photometric information is provided for each GRB afterglow, as well as filter-dependent light curves, which are fit with a single power law.

In this paper, we describe the second Swift/UVOT GRB afterglow catalog and corresponding databases, which contain information on bursts observed during the first six years of UVOT operations (2005–2010). This catalog more than doubles the number of observed GRBs and also includes UVOT observations of Fermi/Large Area Telescope (LAT; Atwood et al. 2009) and Astro-rivelatore Gamma a Immagini Leggero (AGILE; Tavani et al. 2009) discovered GRBs. The catalog and databases include much of the same type of information provided in Paper1 but also include important additions: data is optimally coadded (Morgan et al. 2008, hereafter M08) to increase the number of detections, optimally coadded data is normalized to a given bandpass, and normalized data are fit with single and broken power laws. Additionally, redshift- and extinction-corrected spectral slopes and filter-dependent temporal slopes are provided.

In Section 2, we present the observations made by the UVOT. In Section 3, we describe the construction of the image/event and normalized optimally coadded databases and the resulting GRB catalog. In Section 4, we describe the databases and catalog. In Section 5, we provide a summary of the catalog and, in Section 6, discuss future work. The databases and catalogs are provided in electronic format as part of this paper and are also available at the Barbara A. Mikulski Archive for Space Telescopes (MAST)10 and Swift11 websites.

10 http://archive.stsci.edu/prepds/uvotgrb/
11 http://swift.gsfc.nasa.gov/results/uvot_grbcat2/
Figure 1. Example of optimally coadded light curves in each UVOT filter (as marked in the lower left of each panel) for a given GRB. The lowest right panel is the normalized light curve (normalized to the filter over the temporal range of $T_0$ to $T_1$ as specified in the lower left of the panel) with the given temporal slopes and break times provided in the upper left of the panel.

Table 1

| OBJECT   | TSTART    | EXPOSURE | FILTER | RAW_TOT_CNTS | MAG  |
|----------|-----------|----------|--------|--------------|------|
| GRB 050525 | 138672355.3 | 9.62     | UVM2   | 94.1         | 14.13|
| GRB 050525 | 138672369.5 | 9.60     | UVW1   | 188.2        | 13.99|
| GRB 050525 | 138672383.1 | 9.61     | U      | 309.7        | 14.21|
| GRB 050525 | 138672397.2 | 9.61     | B      | 271.0        | 15.19|
| GRB 050525 | 138672412.4 | 9.61     | UVW2   | 79.0         | 14.84|
| GRB 050525 | 138672426.1 | 9.60     | V      | 116.1        | 15.02|

Note. This table and the corresponding 570 Swift/UVOT Image/Event Database is available in its entirety in FITS format in the online journal, MAST, and the Swift website. A portion is shown here for guidance regarding its form and content. (This table is available in its entirety in FITS format.)
The UVOT utilizes seven broadband filters during the observation of GRBs: \(uvw2\) (\(\lambda_c = 193\) nm), \(uvm2\) (\(\lambda_c = 225\) nm), \(uvw1\) (\(\lambda_c = 260\) nm), \(u\) (\(\lambda_c = 346\) nm), \(b\) (\(\lambda_c = 439\) nm), \(v\) (\(\lambda_c = 547\) nm), and a clear-filter (Roming et al. 2005; Poole et al. 2008). Data in each filter are collected in either image or event mode. In image mode, individual photons are collected, aspect corrected, and added to an onboard image buffer. At the conclusion of an exposure, images are packaged and sent to the spacecraft awaiting transfer to the ground. In event mode, individual photons are collected, time tagged, and sent to the ground to which correspond event lists and aspect corrected sky images. The event data is used to create high time resolution photon flux density as a function of time, where \(\nu\) is the frequency of the observed flux density, \(t\) is the time post trigger, \(\beta\) is the spectral index, which is related to the photon index \(\Gamma\) (\(\beta = \Gamma - 1\)), and \(\alpha\) is the temporal decay slope.

### 2. Observations

To provide context for understanding the work described herein, we define the following: image pipeline, event pipeline, databases, and catalog. The image pipeline is an IDL-based program that incorporates the UVOT tool, \texttt{uvotsource} \(^{12}\), and is used to perform photometry on Level-1 images. The event pipeline is a collection of tools used to perform fine aspect corrections on UVOT event data and photometric measurements on the resulting event lists; photometry is performed with \texttt{uvotvtlc}. The event pipeline software is described in detail elsewhere (Oates et al. 2009). The databases are a repository for all photometric measurements made by the photometry pipeline. There are two databases: the image/event database that is the result of processing the raw UVOT data, and the normalized optimally coadded (NOC) database that is the final product used to produce the NOC light curves. The catalog is a compilation of the top-level data derived from the image/event and NOC databases and other sources, such as the BAT catalog (Sakamoto et al. 2008, 2011), the \textit{Swift} GRB archive \(^{13}\) (SGA), and the GRB Coordinate Network (GCN; Barthelmy et al. 1995, 1998) circulars. As such, this catalog provides the primary characteristics for each burst.

### 3. Construction of the Data Products

#### 3.1. Image/Event Database Construction

The image/event database was constructed using the image and event pipelines, which are essentially the same as those described in Sections 3.1 and 3.2 of Paper 1. Differences are noted below.

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| OBJECT  | FILTER | TSTART | EXPOSURE | MAG | SIGMA | ALPHA |
|---------|--------|--------|----------|-----|-------|-------|
| GRB 050525 | V       | 684.45 | 9.60     | 15.47 | 4.6   | −1.0000 |
| GRB 050525 | Uvm2   | 702.64 | 9.60     | 15.69 | 7.3   | −1.0000 |
| GRB 050525 | Uvw1   | 716.25 | 9.60     | 16.02 | 10.6  | −1.0000 |
| GRB 050525 | U      | 730.44 | 9.60     | 15.82 | 10.4  | −1.0000 |
| GRB 050525 | B      | 745.58 | 9.60     | 15.51 | 6.0   | −1.0000 |
| GRB 050525 | Uvw2   | 759.22 | 9.60     | 16.44 | 5.7   | −1.0000 |

(This table is available in its entirety in FITS format.)

| OBJECT | R.A. | Decl. | POS_ERR | POS_REF | DISC_BY |
|--------|------|-------|---------|---------|---------|
| GRB 050318 | 49.712529 | −46.395496 | 0.60 | SGA | 0 |
| GRB 050319 | 154.199625 | 43.548290 | 0.50 | SGA | 0 |
| GRB 050326 | 6.946208 | −71.370583 | 2.40 | SGA | 0 |
| GRB 050401 | 247.870083 | 2.187453 | 0.50 | GCN3187 | 0 |
| GRB 050406 | 34.467500 | −50.187725 | 0.60 | SGA | 0 |
| GRB 050408 | 180.572167 | 10.852778 | 1.00 | GCN3192 | 1 |
| GRB 050410 | 89.808792 | 79.603444 | 1.70 | SGA | 0 |
| GRB 050412 | 181.104417 | −1.201000 | 0.50 | GCN3255 | 0 |
| GRB 050416A | 188.47500 | 21.057415 | 1.00 | SGA | 0 |

(This table is available in its entirety in FITS format.)

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\(^{12}\) http://heasarc.nasa.gov/ftools/caldb/help/uvotsource.html

\(^{13}\) http://swift.gsfc.nasa.gov/archive/grb_table/
Table 4
Description of Swift/UVOT Image and Event Databases

| Column | Label         | Description                                                                 |
|-------|---------------|-----------------------------------------------------------------------------|
| 1     | OBJECT        | Object identification. The format is GRByyymmddX, where yy is the last two  |
|       |               | digits of the year of the burst, mm is the month, dd is the day (in UTC),    |
|       |               | and X is used to represent the first, second, third, etc., burst occurring   |
|       |               | on a given day by the letters “A,” “B,” “C,” etc. In some cases the “A” is  |
|       |               | not displayed.                                                              |
| 2     | RA            | J2000.0 R.A. in decimal degrees.                                             |
| 3     | DEC           | J2000.0 decl. in decimal degrees.                                            |
| 4     | POS_ERR       | Positional uncertainty in arcseconds.                                        |
| 5     | TRIGTIME      | Time of burst trigger as measured in Swift mission elapsed time (MET). MET   |
|       |               | is measured in seconds and starts on 2001 January 1, 00:00:00.000 (UTC).     |
|       |               | Swift launch MET is 122668545.865 (2004 November 20, 18:35:45.865 UTC).     |
| 6     | TRIG_UT       | Time of burst trigger as measured in UTC (e.g., 2005-017-12:52:36). Due to   |
|       |               | an error in the processing code some UTC times (TRIG_UT) have not been       |
|       |               | corrected for clock drift, therefore, these values should be treated with   |
|       |               | caution. MET (TRIGTIME) is not affected by clock drift.                     |
| 7     | TSTART        | MET start time of the exposure.                                              |
| 8     | TSTOP         | MET stop time of the exposure.                                               |
| 9     | TELAPSE       | TSTOP–TSTART in seconds.                                                    |
| 10    | TIME          | TSTART + TELAPSE/2 (see columns 7 and 9).                                   |
| 11    | TSINCE_BUR    | Time since burst trigger in seconds (TSTART–TRIGTIME).                      |
| 12    | EXPOSURE      | Corrected exposure time in seconds. Corrections include: detector dead time, |
|       |               | time lost when the spacecraft drift is large enough that event data is lost, |
|       |               | time lost when the UVOT Digital Processing Unit buffers fill due to high     |
|       |               | count rates, and time lost due to exposures in the UVOT blocked filter.     |
| 13    | FILTER        | UVOT filter used for exposure (uvw2, uvm2, uvw1, u, b, v, and white).      |
| 14    | BINNING       | Binning factor (\(1 = 1 \times 1\) and \(2 = 2 \times 2\) sq-pixel binning) |
|       |               | for 0° 5 pixels.                                                            |
| 15    | APERTURE      | Photometric aperture radius in arcseconds.                                   |
| 16    | SRC_AREA      | Area of source aperture in square arcseconds, computed by multiplying the   |
|       |               | number of pixels found by XIMAGE within the source radius by the area of     |
|       |               | each pixel. This value can differ from the specified area \(\pi r^2\) by up   |
|       |               | to 2% because XIMAGE selects whole pixels within the source radius. This     |
|       |               | approach produces an area slightly larger or smaller than \(\pi r^2\).       |
|       |               | Simulations reveal that the 1σ difference between the exact and XIMAGE areas  |
|       |               | is 1.0% and 1.5% for a 10 and 6 pixel radius, respectively. The error in     |
|       |               | photometry is much less than these area fluctuations because source counts   |
|       |               | are concentrated in the center of the aperture and the aperture correction    |
|       |               | uses the radius corresponding to the XIMAGE area.                           |
| 17    | BKG_AREA      | Area, in square arcseconds, of the background region. It is calculated by    |
|       |               | taking the number of pixels in the background annulus and multiplying by the |
|       |               | area of each pixel. Masked regions are excluded therefore only net pixels    |
|       |               | are included. This differs slightly from the exact area \(\pi (r_o - r_i)^2\), |
|       |               | but we are only interested in the background surface brightness, so the       |
|       |               | difference is not significant.                                              |
| 18    | PLATE_SCALE   | Image plate scale in arcseconds per pixel. Error in the mean plate scale is  |
|       |               | \(\pm 0.0005\) pixel\(^{-1}\).                                             |
| 19    | RAW_TOT_CNTS  | Total number of counts measured within the source region.                   |
| 20    | RAW_TOT_CNTS_ERR | Binomial error in RAW_TOT_CNTS. The binomial error is given by \((\text{RAW}_T\text{OT}_\text{CNTS})^1/2 \times \left(\frac{\text{NFRAME} - \text{RAW}_T\text{OT}_\text{CNTS}}{\text{NFRAME}}\right)^1/2\) where NFRAME = TELAPSE/FRAMTIME and FRAMTIME = 0.011032 s for the full FoV. NFRAME is the number of CCD frames (typically one every \(~11\) ms). A discussion of the measurement errors in the UVOT can be found in Kuin & Rosen (2008). |
| 21    | RAW_BKG_CNTS  | Total number of counts measured in the background annulus.                  |
| 22    | RAW_BKG_CNTS_ERR | Binomial error in RAW_BKG_CNTS. The binomial error is given by \((\text{RAW}_B\text{KG}_\text{CNTS})^1/2 \times \left(\frac{\text{EFF}_B\text{KG}_\text{CNTS} - \text{RAW}_B\text{KG}_\text{CNTS}}{80/\text{BKG}_\text{AREA}}\right)^1/2\) where EFF_BKG_CNTS = RAW_BKG_CNTS * 80/BKG_AREA. The effective counts in the background (EFF_BKG_CNTS) is calculated because the background area is larger than the coincidence region. The value 80 is the area (in square arcseconds) of our circular aperture with a radius of \(5^\circ\). |
| 23    | RAW_STD_CNTS  | Total number of counts measured within the standard \(5^\circ\) aperture.    |
|       |               | This constant value is based on the size of the current calibration aperture. |
| Column | Label | Description |
|--------|-------|-------------|
| 24 | RAW_STD_CNTS_ERR | Binomial error associated with RAW_STD_CNTS. |
| 25 | RAW_TOT_RATE | Total measured count rate, in counts per second, in the source region. Calculated using RAW_TOT_CNTS/EXPOSURE. |
| 26 | RAW_TOT_RATE_ERR | RAW_TOT_CNTS_ERR/EXPOSURE. |
| 27 | RAW_BKG_RATE | Total measured count rate, in counts per second, in the background region. Calculated using RAW_BKG_CNTS/EXPOSURE/BKG_AREA. |
| 28 | RAW_BKG_RATE_ERR | RAW_BKG_CNTS_ERR/EXPOSURE/BKG_AREA. |
| 29 | RAW_STD_RATE | Total measured count rate, in counts per second per square arcsecond, in the coincidence loss region. Calculated using RAW_STD_CNTS/EXPOSURE. |
| 30 | RAW_STD_RATE_ERR | RAW_STD_CNTS_ERR/EXPOSURE. |
| 31 | COI_STD_FACTOR | Coincidence-loss correction factor for the coincidence-loss region. This is calculated as follows. First, the COI_STD_RATE (which is not recorded) is calculated using the theoretical coincidence-loss formula and the polynomial correction to RAW_STD_RATE (see Equations (1)–(3) in Poole et al. 2008). The value COI_STD_FACTOR is then the ratio COI_STD_RATE/RAW_STD_RATE. |
| 32 | COI_STD_FACTOR_ERR | Uncertainty in the coincidence correction (see Equation (4) in Poole et al. 2008). |
| 33 | COI_BKG_FACTOR | Coincidence-loss correction factor for the background region. |
| 34 | COI_BKG_FACTOR_ERR | Uncertainty in the coincidence correction of the background counts within the source aperture. |
| 35 | COI_TOT_RATE | Coincidence-loss corrected raw count rate, in counts per second, in the source region. Calculated using RAW_TOT_RATE * COI_STD_FACTOR. |
| 36 | COI_TOT_RATE_ERR | Error in the COI_TOT_RATE. RAW_TOT_RATE_ERR * COI_STD_FACTOR. |
| 37 | COI_BKG_RATE | Coincidence-loss corrected background surface count rate, in counts per second per square arcsecond. Calculated using RAW_BKG_RATE * COI_BKG_FACTOR. |
| 38 | COI_BKG_RATE_ERR | Error in coincidence corrected background surface brightness. Calculated using RAW_BKG_RATE * COI_BKG_FACTOR * SRC_AREA. |
| 39 | COI_SRC_RATE | Coincidence corrected net count rate, in counts per second. Calculated using COI_TOT_RATE-COI_BKG_RATE * SRC_AREA. |
| 40 | COI_SRC_RATE_ERR | Error in the coincidence corrected net count rate. Errors in the source rate and the background rate are added in quadrature: 

\[(COI_TOT_RATE_ERR^2 + (COI_BKG_RATE_ERR * SRC_AREA)^2)^{1/2} \]

Aperture correction for going from a 3" radius to a 5" radius aperture for the v filter. This is computed using the PSF stored in the CALDB by u votapercorr. This is always set to 1.0 unless the CURVEOFGROWTH method is used. The source radius is defined to be \((SRC\_AREA)^{1/2}\), so that one uses an effective source radius to the actual pixel area used by XIMAGE. |
| 41 | AP_FACTOR | The \(1\sigma\) error in AP_FACTOR. AP_FACTOR_ERR = AP_COI_SRC_RATE_ERR / COI_SRC_RATE_ERR. |
| 42 | AP_FACTOR_ERR | Aperture and coincidence-loss corrected count rate used to derive the flux and magnitudes for the NOC database. Calculated using AP_FACTOR * COI_SRC_RATE. |
| 43 | AP_COI_SRC_RATE | Error on the count rate. Calculated using 

\[(COI_COI_SRC_RATE_ERR^2 + (fwhmsig * COI_SRC_RATE)^2)^{1/2}\]

where the “fwhmsig” parameter is the fractional rms variation of the PSF which is set to 3°. This variation is propagated through the uncertainty calculation, and is added in quadrature to the corrected measurement uncertainty. |
| 44 | LSS_FACTOR | Large-scale sensitivity factor to be applied to AP_COI_SRC_RATE. CalDB maps are used. |
| 45 | LSS_RATE | Source count rate with coincidence-loss, aperture, and large-scale sensitivity corrections applied. |
| 46 | LSS_RATE_ERR | The \(1\sigma\) error in LSS_RATE. This is computed by dividing AP_COI_SRC_RATE_ERR by LSS_FACTOR. |
| 47 | SENSCORR_FACTOR | Correction for the \(~1\%\) sensitivity loss per year to be applied to SENSCORR_RATE. |
| 48 | SENSCORR_RATE | Count rate with all corrections applied. LSS_RATE * SENSCORR_FACTOR. |
| 49 | SENSCORR_RATE_ERR | Errors on SENSCORR_RATE. |
| 50 | MAG | Magnitude of source in the UVOT system computed from SENSCORR_RATE. Value is set to 99.00 for upper limits. |
error in FLUX_AA.

error in FLUX_HZ.

corrected for SENSCORR_FACTOR and LSS_FACTOR. If COI_BKG_RATE is set to 99.00 if MAG was an upper limit.

The 1σ error in MAG_BKG.

The "N"-sigma limiting magnitude in the UVOT system.

"N" for MAG_LIM, where "N" is a chosen parameter. The database uses a value of 2.0 for N.

MAG_COI_LIM

Magnitude at which the count rate is one count per CCD frame.

FLUX_AA

Flux density based on an average GRB spectrum, in erg cm⁻² s⁻¹ Å⁻¹.

FLUX_HZ

Flux density in mJy.

COI_RATE_LIMIT

Rate at which the coincidence loss becomes nonlinear and can no longer be corrected.

NSIGMA

Significance of the detection.

FRAMTIME

Readout time for detector frame which includes dead-time correction.

SETTLE_FLAG

Settling images sometimes have a poor aspect solution which creates doublets out of field stars. Settling images also suffer from detector gain issues because the high voltages may still be ramping up part way into the exposure. Such images have an undefined photometric calibration and should be used cautiously. Images fitting all of the following are flagged as settling exposures, i.e., this flag is true (T): first exposure of Segment 0, image taken in Event mode, and EXPOSURE < 11 s.

ASPECT_FLAG

Swift spacecraft pointing accuracy is ≈5°. The astrometric error is improved to about 0.3° by comparing source positions to the USNO-B catalog. For a small number of images the automated procedure did not produce an aspect solution. Such images are flagged as true (T).

TRAIL_FLAG

A number of images suffer from exposure of the CCD during readout clocking (cf. Page et al. 2013). Visible bright streaks along CCD columns (RAWY) sometimes complicate photometric measurements. These images are flagged true (T).

CROWDED_FLAG

If field appears crowded upon visual inspection image is flagged true (T).

SPIKE_FLAG

If a diffraction spike impinges upon the source region then the image is flagged true (T).

EDGE_FLAG

If source is sufficiently close to the edge of the image such that the exposure across the background region is variable then the image is flagged true (T).

HALO_FLAG

A few bursts lie within the halo of bright stars, which can produce inaccurate photometric measurements. Such situations are flagged by comparing the local background to the global background. These images are flagged true (T).

QUALITY_FLAG

Cumulative quality flag. This flag is set to true (T) when any of the following quality flags are true (T): SETTLE_FLAG, ASPECT_FLAG, TRAIL_FLAG, CROWDED_FLAG, SPIKE_FLAG, EDGE_FLAG, or HALO_FLAG.

IMAGE

Input name and FITS extension (e.g., sw00020004001ubb_sk.img.gz[3]).

Names for images and event lists end with ".img.gz" and ".evt.gz" respectively.

To ensure that all images and exposure maps benefited from consistent and up-to-date calibrations, the Swift Data Center reprocessed images taken before GRB 070621. This reprocessing was necessary due to the fact that earlier versions of the processing pipeline did not take advantage of essential lessons learned from the first years of operations. Images for
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Table 5

| Column | Label       | Description                                                                 |
|--------|-------------|-----------------------------------------------------------------------------|
| 1      | OBJECT      | Same description as for column 1 of the image/event database.                |
| 2      | FILTER      | Same description as for column 13 of the image/event database.               |
| 3      | TIME        | Weighted time of the detection as described in M08.                         |
| 4      | TSTART      | MET start time of the data used in the optimal coaddition.                  |
| 5      | TSTOP       | MET stop time of the data used in the optimal coaddition.                   |
| 6      | EXPOSURE    | Total exposure time in seconds for the optimally coadded data. Exposure time includes all corrections described in column 12 of the image/event database. |
| 7      | CSRC        | Computed source counts in a coadded image as described in M08.              |
| 8      | CERR        | Uncertainty in the source counts of a coadded image as described in M08.    |
| 9      | RATE        | Computed coadded source rate calculated using (CSRC * SCALE_FACT)/EXPOSURE. |
| 10     | RATE_ERR    | Source rate error calculated using (CERR * SCALE_FACT)/EXPOSURE.            |
| 11     | MAG         | Magnitude of the source in the UVOT system computed from RATE.              |
| 12     | MAG_ERR     | Same description as for column 52 of the image/event database.              |
| 13     | FLUX        | Same description as for column 58 of the image/event database.              |
| 14     | FLUX_ERR    | Same description as for column 59 of the image/event database.              |
| 15     | SIGMA       | Signal-to-noise of the coadded weighted image as described in M08.          |
| 16     | FIT_START   | Start time of the segment of the light curve used for normalization.        |
| 17     | FIT_STOP    | Stop time of the segment of the light curve used for normalization.         |
| 18     | ALPHA       | Temporal slope between FIT_START and FIT_STOP used for normalization.       |
| 19     | SCALE_FACT  | Normalization value used to scale the data taken in FILTER to NORM_TO.      |
| 20     | NORM_TO     | UVOT filter to which all filters have been normalized (uvw2, avm2, uvw1, a, b, v, or white). |

subsequent bursts were taken directly from the Swift archive. The FTOOL uvotskycorr was manually run on a small number of archive images to improve the aspect solution. In Paper 1, we reported the position of potentially contaminating sources. This has been dropped from the current version of the database since its primary purpose is already accounted for in a quality flag.

For event lists, all available event data (including settling exposures) from the first observation segment, which can span more than one orbit, was extracted; in Paper 1, we only considered event data taken in the v- and white-filters in the first orbit. We note that for the earliest settling exposures (\(\leq 4\) s) the cathode is still warming up, therefore these exposures can produce erroneous values. All settling exposures in these databases are marked with a quality flag.

Both image and event pipelines utilized HEADAS Version 6.10 and the 2011 January 31 UVOT CALDB. In Paper 1, we provided only 3\(^{\prime}\)0 radius apertures that were used for aperture photometry. In this version, we provide both 3\(^{\prime}\)0 and 5\(^{\prime}\)0 radius photometry apertures in the image and event pipelines. Upper limits were reported for sources \(<2\sigma\). Here we use \(2\sigma\) instead of \(3\sigma\) (as in Paper 1) since the position of the burst is often known to the arcsecond-level.

To determine the fraction of false positives \((f_{FP})\), we use Equation (1), where \(N_{ND}\) is the number of non-detections \((<2\sigma)\) in the catalog (98,601 and 98,689 for the 3\(^{\prime}\)0 and 5\(^{\prime}\)0 databases, respectively), \(Q(2)\) is the Q-function at two standard deviations, and \(M\) is the number of observations (119,598 and 120,217).

\[
f_{FP} = \frac{N_{ND}Q(2)(1 - Q(2))^{-1}M^{-1}}{Q(2)}.
\]

We conservatively estimate that the fraction of false positives is 1.92% and 1.91% for the 3\(^{\prime}\)0 and 5\(^{\prime}\)0 databases, respectively.

3.2. Normalized Optimally Coadded Database Construction

The NOC Database was created through a five step process: initial optimal coaddition of the data, preliminary fits to the light curves, rerunning of the optimal coaddition, refitting of the light curves, and normalization of the color light curves to a single filter. Optimal coaddition is one of the fundamental differences between this work and that presented in Paper 1. The first step was to perform optimal coaddition on each burst in the 5\(^{\prime}\)0 image/event database for each filter. Optimal coaddition uses the \(\alpha\) of a GRB to “optimally weight each exposure during image summation to maximize the signal-to-noise of the final coadded image” (M08). This initial step recovers a greater number of individual detections in each filter with which to generate light curves. Our method differs slightly from the one provided by the FTOOL uvotoptsum since uvotoptsum is optimized for individual detections whereas our code is optimized for producing detailed light curves. M08 have shown that using an \(\alpha\) within \(+0.5\) of the actual GRB \(\alpha\) during optimal coaddition provides for a more significant detection than an unweighted coaddition technique; therefore, during the initial optimal coaddition process, we used a “canonical” \(\alpha\) of 0.88, an average decay value determined from a sample of light curves for >500 s after the trigger (Oates et al. 2009). From the optimally coadded data, we produced detailed light curves for each burst in each filter.

We then fit each segment, or data points between break times, of the light curve with a single power law, varying the temporal slope each time. Our fitting routine is centered around the IDL-based program mpfit (Markwardt 2009). For each \(\alpha\), a model fit is produced, compared to the data, and an overall \(\chi^2_{\text{red}}\) for the entire light curve is calculated. For the purposes of this catalog, we assume that the cooling frequency \(\nu_{\text{c}}\) has not, or

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\(^{14}\) See http://cnx.org/contents/hDU5uzaA@2/The-Q-function for a description of the Q-function.
Table 6
Description of Swift/UVOT Burst Catalog

| Column | Label                  | Description |
|--------|------------------------|-------------|
| 1      | OBJECT                 | Same description as for column 1 of the image/event database. |
| 2      | RA                     | Best available J2000 right ascension in decimal degrees. |
| 3      | DEC                    | Best available J2000 declination in decimal degrees. |
| 4      | POS_ERR                | Positional uncertainty in arcseconds. If no positional uncertainty is available, value is set to −1.00. |
| 5      | POS_REF                | Position reference for columns 2–4. References are from the SGA, GCN Circulars, Goad et al. (2007, 2008), or Butler (2007). |
| 6      | DISC_BY                | The “discovery flag” indicating which spacecraft discovered the GRB. The flag is an integer from 0 to 7 representing: 0 = Swift, 1 = HETE2, 2 = INTEGRAL, 3 = IPN, 4 = Fermi, 5 = BAT Slew Survey (BATSS), 6 = AGILE, and 7 = Swift ground analysis. |
| 7      | TRIGTIME               | Same description as for column 5 of the image/event database. |
| 8      | TRIG_UT                | Same description as for column 6 of the image/event database. |
| 9      | Z                      | Redshift of the GRB from the SGA or Fynbo et al. (2009). If no redshift is available, value is set to −1.00. |
| 10     | E(B-V)_MW              | Mean Milky Way E(B − V) from Schlafly & Finkbeiner (2011) found at IRSA. |
| 11     | E(B-V)_HOST            | GRB host galaxy E(B − V) from Schady et al. (2010, 2012). If no value is available, value is set to −99.00. |
| 12     | T90                    | $T_{90}$ in seconds. |
| 13     | T90_REF                | $T_{90}$ is from the SGA, or GCN Circulars when not available in the SGA. |
| 14     | BAT_FL                 | BAT fluence in the 15150 keV range in erg cm$^{-2}$. If not observed by BAT or data is not available in the SGA, value is set to −1.0000E−07. |
| 15     | BAT_FL_ERR             | BAT fluence 90% error in the 15–150 keV range in erg cm$^{-2}$. If not observed by BAT or data is not available in the SGA, value is set to −1.0000E−07. |
| 16     | BAT_PPF                | BAT 1 s peak photon flux in the 15–150 keV range in ph cm$^{-2}$ s$^{-1}$. If not observed by BAT or data is not available in the SGA, value is set to −1.00. |
| 17     | BAT_PPF_ERR            | BAT 1 s peak photon flux 90% error in the 15–150 keV range in ph cm$^{-2}$ s$^{-1}$. If not observed by BAT or data is not available in the SGA, value is set to −1.00. |
| 18     | BAT_PI                 | BAT photon index in the 15–150 keV range. If not observed by BAT or data is not available in the SGA, value is set to −1.00. |
| 19     | BAT_PIT                | BAT photon index type. PL = a simple power law; CPL = cutoff power law. If not observed by BAT or data is not available in the SGA, value is set to NULL. |
| 20     | BAT_PIT_ERR            | BAT photon index 90% error in the 15–150 keV range. If not observed by BAT or data is not available in the SGA, value is set to −1.00. |
| 21     | XRT_FRST_OBS           | Start time of the first XRT observation measured in seconds from the burst trigger. If not observed by XRT or data is not available in the SGA, value is set to −1.00. |
| 22     | XRT_FLUX               | Early XRT flux in the 0.3–10 keV range in erg cm$^{-2}$ s$^{-1}$. If not observed by XRT or data is not available in the SGA, value is set to −1.0000E−11. |
| 23     | XRT_11FLUX             | Same as for XRT_FLUX but at 11 hr. |
| 24     | XRT_24FLUX             | Same as for XRT_FLUX but at 24 hr. |
| 25     | XRT_TI                 | Initial XRT temporal index. If not observed by XRT or data is not available in the SGA, value is set to 99.0000. |
| 26     | XRT_SI                 | XRT spectral index. If not observed by XRT or data is not available in the SGA, value is set to 99.0000. |
| 27     | XRT_NH                 | XRT column density in cm$^{-2}$. If not observed by XRT or data is not available in the SGA, value is set to −1.0000E+21. |
| 28     | FRST_TSTART            | Start time of first UVOT observation measured in seconds from the burst trigger. If not observed by UVOT, value is set to −1.0. |
| 29     | FRST_FILT              | UVOT filter used for the FRST_TSTART exposure (uw2, uvw2, uvw1, u, b, v, and white). If not observed by UVOT, value is set to NULL. |
| 30     | FRST_MAG               | Magnitude of the FRST_TSTART observation. If no detections are reported, or not observed, value is set to 99.00. |
| 31     | FRST_MAG_ERR           | The 1σ error on FRST_MAG. If no detections are reported for FRST_MAG, value is set to 99.00. |
| 32     | FRST_FLUX              | Flux density of the FRST_TSTART observation in erg cm$^{-2}$ s$^{-1}$ Å$^{-1}$. If no detections are reported for FRST_MAG, value is set to 0.000000E+00. |
| 33     | FRST_FLUX_ERR          | The 1σ error in FRST_FLUX. If no detections are reported for FRST_MAG, value is set to 0.000000E+00. |
| 34     | FRST_SIGMA             | Significance of the FRST_MAG detection. If no detection is reported for FRST_MAG, value is set to 0.00. |
| 35     | PEAK_TSTART            | Same description for column 28 immediately above, but for the peak values. |
| 36     | PEAK_FILT              | Same description for column 29 immediately above, but for the peak values. |
| 37     | PEAK_MAG               | Same description for column 30 immediately above, but for the peak values. |
| 38     | PEAK_MAG_ERR           | Same description for column 31 immediately above, but for the peak values. |
| Column | Label         | Description                                                                 |
|--------|---------------|-----------------------------------------------------------------------------|
| 39     | PEAK_FLUX     | Same description for column 32 immediately above, but for the peak values.   |
| 40     | PEAK_FLUX_ERR | Same description for column 33 immediately above, but for the peak values.   |
| 41     | PEAK_SIGMA    | Same description for column 34 immediately above, but for the peak values.   |
| 42     | ALP1_W2       | Temporal slope ($\alpha_{uvw2}$) for the first segment of the light curve in the $uvw2$-filter. In the case of two or more afterglow detections in the pre-normalized $uvw2$ light curve, a temporal slope is calculated. Otherwise the value is set to $-99.99$. The value is calculated using $F(t) = A t^n$, where $F(t)$ is the flux density, $A$ is the amplitude, and $t$ is the time since burst. If ALP1_W2 is $-99.99$, then ALP1N_W2 is set to $-99.99$. |
| 43     | ALP1N_W2      | Negative $1\sigma$ error in ALP1_W2. If ALP1_W2 = $-99.99$, then ALP1N_W2 is set to $-99.99$. |
| 44     | ALP1P_W2      | Positive $1\sigma$ error in ALP1_W2. If ALP1_W2 = $-99.99$, then ALP1P_W2 is set to $-99.99$. |
| 45     | TB1_W2        | Break time between segment one and two of the $uvw2$ light curve. If there is no second segment, value is set to $-1.000000E+00$. |
| 46     | TB1N_W2       | TB1_W2 negative $1\sigma$ error. If TB1_W2 = $-1.000000E+00$, then TB1N_W2 is set to $0.000000E+00$. |
| 47     | TB1P_W2       | TB1_W2 positive $1\sigma$ error. If TB1_W2 = $-1.000000E+00$, then TB1P_W2 is set to $0.000000E+00$. |
| 48     | ALP2_W2       | In the event that a second segment of the light curve exists, a temporal slope is calculated for the segment. Otherwise the value is set to $-99.99$. |
| 49     | ALP2N_W2      | Same description for column 43 immediately above, but for ALP2_W2. |
| 50     | ALP2P_W2      | Same description for column 44 immediately above, but for ALP2_W2. |
| 51     | TB2_W2        | Break time between segment two and three of the $uvw2$ light curve. If there is no third segment, value is set to $-1.000000E+00$. |
| 52     | TB2N_W2       | Same description for column 46 immediately above, but for TB2_W2. |
| 53     | TB2P_W2       | Same description for column 47 immediately above, but for TB2_W2. |
| 54     | ALP3_W2       | In the event that a third segment of the light curve exists, a temporal slope is calculated for the segment. Otherwise the value is set to $-99.99$. |
| 55     | ALP3N_W2      | Same description for column 43 immediately above, but for ALP3_W2. |
| 56     | ALP3P_W2      | Same description for column 44 immediately above, but for ALP3_W2. |
| 57     | TB3_W2        | Break time between segment three and four of the $uvw2$ light curve. If there is no fourth segment, value is set to $-1.000000E+00$. |
| 58     | TB3N_W2       | Same description for column 46 immediately above, but for TB3_W2. |
| 59     | TB3P_W2       | Same description for column 47 immediately above, but for TB3_W2. |
| 60     | ALP4_W2       | In the event that a fourth segment of the light curve exists, a temporal slope is calculated for the segment. Otherwise the value is set to $-99.99$. |
| 61     | ALP4N_W2      | Same description for column 43 immediately above, but for ALP4_W2. |
| 62     | ALP4P_W2      | Same description for column 44 immediately above, but for ALP4_W2. |
| 63     | NORM_W2       | Normalization factor (or $A$) for the first segment. This value is set to $-1.000000E+00$ if ALP1_W2 is $-99.99$. |
| 64     | NORMN_W2      | Negative $1\sigma$ error in NORM_W2. If NORM_W2 = $-1.000000E+00$, then NORMN_W2 is set to $0.000000E+00$. |
| 65     | NORMP_W2      | Positive $1\sigma$ error in NORM_W2. If NORM_W2 = $-1.000000E+00$, then NORMP_W2 is set to $0.000000E+00$. |
| 66     | CHISQ_W2      | The $\chi^2$ value determined from the fit to the $uvw2$ light curve. If there is no fit, value is set to $-1.0000$. |
| 67     | DOF_W2        | Degrees-of-freedom associated with CHISQ_W2. If there is no fit, value is set to $-1$. |
| 68     | ALP1_M2       | Same description for column 42 immediately above, but for the $uvw2$-filter. |
| 69     | ALP1N_M2      | Same description for column 43 immediately above, but for the $uvw2$-filter. |
| 70     | ALP1P_M2      | Same description for column 44 immediately above, but for the $uvw2$-filter. |
| 71     | TB1_M2        | Same description for column 45 immediately above, but for the $uvw2$-filter. |
| 72     | TB1N_M2       | Same description for column 46 immediately above, but for the $uvw2$-filter. |
| 73     | TB1P_M2       | Same description for column 47 immediately above, but for the $uvw2$-filter. |
| 74     | ALP2_M2       | Same description for column 48 immediately above, but for the $uvw2$-filter. |
| 75     | ALP2N_M2      | Same description for column 49 immediately above, but for the $uvw2$-filter. |
| 76     | ALP2P_M2      | Same description for column 50 immediately above, but for the $uvw2$-filter. |
| 77     | TB2_M2        | Same description for column 51 immediately above, but for the $uvw2$-filter. |
| 78     | TB2N_M2       | Same description for column 52 immediately above, but for the $uvw2$-filter. |
| 79     | TB2P_M2       | Same description for column 53 immediately above, but for the $uvw2$-filter. |
| 80     | ALP3_M2       | Same description for column 54 immediately above, but for the $uvw2$-filter. |
| 81     | ALP3N_M2      | Same description for column 55 immediately above, but for the $uvw2$-filter. |
| 82     | ALP3P_M2      | Same description for column 56 immediately above, but for the $uvw2$-filter. |
| 83     | TB3_M2        | Same description for column 57 immediately above, but for the $uvw2$-filter. |
| 84     | TB3N_M2       | Same description for column 58 immediately above, but for the $uvw2$-filter. |
| 85     | TB3P_M2       | Same description for column 59 immediately above, but for the $uvw2$-filter. |
| Column | Label   | Description                                                                 |
|--------|---------|-----------------------------------------------------------------------------|
| 86     | ALP4_M2 | Same description for column 60 immediately above, but for the *uvu*2-filter. |
| 87     | ALP4N_M2| Same description for column 61 immediately above, but for the *uvu*2-filter.   |
| 88     | ALP4P_M2| Same description for column 62 immediately above, but for the *uvu*2-filter.   |
| 89     | NORM_M2 | Same description for column 63 immediately above, but for the *uvu*2-filter.   |
| 90     | NORMN_M2| Same description for column 64 immediately above, but for the *uvu*2-filter.   |
| 91     | NORMP_M2| Same description for column 65 immediately above, but for the *uvu*2-filter.   |
| 92     | CHISQ_M2| Same description for column 66 immediately above, but for the *uvu*2-filter.   |
| 93     | DOF_M2  | Same description for column 67 immediately above, but for the *uvu*2-filter.   |
| 94     | ALP1_W1 | Same description for column 42 immediately above, but for the *uvu*2-filter.   |
| 95     | ALP1N_W1| Same description for column 43 immediately above, but for the *uvu*2-filter.   |
| 96     | ALP1P_W1| Same description for column 44 immediately above, but for the *uvu*2-filter.   |
| 97     | TB1_W1  | Same description for column 45 immediately above, but for the *uvu*2-filter.   |
| 98     | TB1N_W1 | Same description for column 46 immediately above, but for the *uvu*2-filter.   |
| 99     | TB1P_W1 | Same description for column 47 immediately above, but for the *uvu*2-filter.   |
| 100    | ALP2_W1 | Same description for column 48 immediately above, but for the *uvu*2-filter.   |
| 101    | ALP2N_W1| Same description for column 49 immediately above, but for the *uvu*2-filter.   |
| 102    | ALP2P_W1| Same description for column 50 immediately above, but for the *uvu*2-filter.   |
| 103    | TB2_W1  | Same description for column 51 immediately above, but for the *uvu*2-filter.   |
| 104    | TB2N_W1 | Same description for column 52 immediately above, but for the *uvu*2-filter.   |
| 105    | TB2P_W1 | Same description for column 53 immediately above, but for the *uvu*2-filter.   |
| 106    | ALP3_W1 | Same description for column 54 immediately above, but for the *uvu*2-filter.   |
| 107    | ALP3N_W1| Same description for column 55 immediately above, but for the *uvu*2-filter.   |
| 108    | ALP3P_W1| Same description for column 56 immediately above, but for the *uvu*2-filter.   |
| 109    | TB3_W1  | Same description for column 57 immediately above, but for the *uvu*2-filter.   |
| 110    | TB3N_W1 | Same description for column 58 immediately above, but for the *uvu*2-filter.   |
| 111    | TB3P_W1 | Same description for column 59 immediately above, but for the *uvu*2-filter.   |
| 112    | ALP4_W1 | Same description for column 60 immediately above, but for the *uvu*2-filter.   |
| 113    | ALP4N_W1| Same description for column 61 immediately above, but for the *uvu*2-filter.   |
| 114    | ALP4P_W1| Same description for column 62 immediately above, but for the *uvu*2-filter.   |
| 115    | NORM_W1 | Same description for column 63 immediately above, but for the *uvu*2-filter.   |
| 116    | NORMN_W1| Same description for column 64 immediately above, but for the *uvu*2-filter.   |
| 117    | NORMP_W1| Same description for column 65 immediately above, but for the *uvu*2-filter.   |
| 118    | CHISQ_W1| Same description for column 66 immediately above, but for the *uvu*2-filter.   |
| 119    | DOF_W1  | Same description for column 67 immediately above, but for the *uvu*2-filter.   |
| 120    | ALP1_UU | Same description for column 42 immediately above, but for the *u*2-filter.     |
| 121    | ALP1N_UU| Same description for column 43 immediately above, but for the *u*2-filter.     |
| 122    | ALP1P_UU| Same description for column 44 immediately above, but for the *u*2-filter.     |
| 123    | TB1_UU  | Same description for column 45 immediately above, but for the *u*2-filter.     |
| 124    | TB1N_UU | Same description for column 46 immediately above, but for the *u*2-filter.     |
| 125    | TB1P_UU | Same description for column 47 immediately above, but for the *u*2-filter.     |
| 126    | ALP2_UU | Same description for column 48 immediately above, but for the *u*2-filter.     |
| 127    | ALP2N_UU| Same description for column 49 immediately above, but for the *u*2-filter.     |
| 128    | ALP2P_UU| Same description for column 50 immediately above, but for the *u*2-filter.     |
| 129    | TB2_UU  | Same description for column 51 immediately above, but for the *u*2-filter.     |
| 130    | TB2N_UU | Same description for column 52 immediately above, but for the *u*2-filter.     |
| 131    | TB2P_UU | Same description for column 53 immediately above, but for the *u*2-filter.     |
| 132    | ALP3_UU | Same description for column 54 immediately above, but for the *u*2-filter.     |
| 133    | ALP3N_UU| Same description for column 55 immediately above, but for the *u*2-filter.     |
| 134    | ALP3P_UU| Same description for column 56 immediately above, but for the *u*2-filter.     |
| 135    | TB3_UU  | Same description for column 57 immediately above, but for the *u*2-filter.     |
| 136    | TB3N_UU | Same description for column 58 immediately above, but for the *u*2-filter.     |
| 137    | TB3P_UU | Same description for column 59 immediately above, but for the *u*2-filter.     |
| 138    | ALP4_UU | Same description for column 60 immediately above, but for the *u*2-filter.     |
| 139    | ALP4N_UU| Same description for column 61 immediately above, but for the *u*2-filter.     |
| 140    | ALP4P_UU| Same description for column 62 immediately above, but for the *u*2-filter.     |
| 141    | NORM_UU | Same description for column 63 immediately above, but for the *u*2-filter.     |
| 142    | NORMN_UU| Same description for column 64 immediately above, but for the *u*2-filter.     |
| 143    | NORMP_UU| Same description for column 65 immediately above, but for the *u*2-filter.     |
| 144    | CHISQ_UU| Same description for column 66 immediately above, but for the *u*2-filter.     |
| 145    | DOF_UU  | Same description for column 67 immediately above, but for the *u*2-filter.     |
| 146    | ALP1_BB | Same description for column 42 immediately above, but for the *b*2-filter.     |
| 147    | ALP1N_BB| Same description for column 43 immediately above, but for the *b*2-filter.     |
| 148    | ALP1P_BB| Same description for column 44 immediately above, but for the *b*2-filter.     |
| Column | Label     | Description                                                                 |
|--------|-----------|-----------------------------------------------------------------------------|
| 149    | TB1_BB    | Same description for column 45 immediately above, but for the b-filter.     |
| 150    | TB1N_BB   | Same description for column 46 immediately above, but for the b-filter.     |
| 151    | TB1P_BB   | Same description for column 47 immediately above, but for the b-filter.     |
| 152    | ALP2_BB   | Same description for column 48 immediately above, but for the b-filter.     |
| 153    | ALP2N_BB  | Same description for column 49 immediately above, but for the b-filter.     |
| 154    | ALP2P_BB  | Same description for column 50 immediately above, but for the b-filter.     |
| 155    | TB2_BB    | Same description for column 51 immediately above, but for the b-filter.     |
| 156    | TB2N_BB   | Same description for column 52 immediately above, but for the b-filter.     |
| 157    | TB2P_BB   | Same description for column 53 immediately above, but for the b-filter.     |
| 158    | ALP3_BB   | Same description for column 54 immediately above, but for the b-filter.     |
| 159    | ALP3N_BB  | Same description for column 55 immediately above, but for the b-filter.     |
| 160    | ALP3P_BB  | Same description for column 56 immediately above, but for the b-filter.     |
| 161    | TB3_BB    | Same description for column 57 immediately above, but for the b-filter.     |
| 162    | TB3N_BB   | Same description for column 58 immediately above, but for the b-filter.     |
| 163    | TB3P_BB   | Same description for column 59 immediately above, but for the b-filter.     |
| 164    | ALP4_BB   | Same description for column 60 immediately above, but for the b-filter.     |
| 165    | ALP4N_BB  | Same description for column 61 immediately above, but for the b-filter.     |
| 166    | ALP4P_BB  | Same description for column 62 immediately above, but for the b-filter.     |
| 167    | NORM_BB   | Same description for column 63 immediately above, but for the b-filter.     |
| 168    | NORMN_BB  | Same description for column 64 immediately above, but for the b-filter.     |
| 169    | NORMP_BB  | Same description for column 65 immediately above, but for the b-filter.     |
| 170    | CHISQ_BB  | Same description for column 66 immediately above, but for the b-filter.     |
| 171    | DOF_BB    | Same description for column 67 immediately above, but for the b-filter.     |
| 172    | ALP1_VV   | Same description for column 42 immediately above, but for the v-filter.     |
| 173    | ALP1N_VV  | Same description for column 43 immediately above, but for the v-filter.     |
| 174    | ALP1P_VV  | Same description for column 44 immediately above, but for the v-filter.     |
| 175    | TB1_VV    | Same description for column 45 immediately above, but for the v-filter.     |
| 176    | TB1N_VV   | Same description for column 46 immediately above, but for the v-filter.     |
| 177    | TB1P_VV   | Same description for column 47 immediately above, but for the v-filter.     |
| 178    | ALP2_VV   | Same description for column 48 immediately above, but for the v-filter.     |
| 179    | ALP2N_VV  | Same description for column 49 immediately above, but for the v-filter.     |
| 180    | ALP2P_VV  | Same description for column 50 immediately above, but for the v-filter.     |
| 181    | TB2_VV    | Same description for column 51 immediately above, but for the v-filter.     |
| 182    | TB2N_VV   | Same description for column 52 immediately above, but for the v-filter.     |
| 183    | TB2P_VV   | Same description for column 53 immediately above, but for the v-filter.     |
| 184    | ALP3_VV   | Same description for column 54 immediately above, but for the v-filter.     |
| 185    | ALP3N_VV  | Same description for column 55 immediately above, but for the v-filter.     |
| 186    | ALP3P_VV  | Same description for column 56 immediately above, but for the v-filter.     |
| 187    | TB3_VV    | Same description for column 57 immediately above, but for the v-filter.     |
| 188    | TB3N_VV   | Same description for column 58 immediately above, but for the v-filter.     |
| 189    | TB3P_VV   | Same description for column 59 immediately above, but for the v-filter.     |
| 190    | ALP4_VV   | Same description for column 60 immediately above, but for the v-filter.     |
| 191    | ALP4N_VV  | Same description for column 61 immediately above, but for the v-filter.     |
| 192    | ALP4P_VV  | Same description for column 62 immediately above, but for the v-filter.     |
| 193    | NORM_VV   | Same description for column 63 immediately above, but for the v-filter.     |
| 194    | NORMN_VV  | Same description for column 64 immediately above, but for the v-filter.     |
| 195    | NORMP_VV  | Same description for column 65 immediately above, but for the v-filter.     |
| 196    | CHISQ_VV  | Same description for column 66 immediately above, but for the v-filter.     |
| 197    | DOF_VV    | Same description for column 67 immediately above, but for the v-filter.     |
| 198    | ALP1_WH   | Same description for column 42 immediately above, but for the white-filter. |
| 199    | ALP1N_WH  | Same description for column 43 immediately above, but for the white-filter. |
| 200    | ALP1P_WH  | Same description for column 44 immediately above, but for the white-filter. |
| 201    | TB1_WH    | Same description for column 45 immediately above, but for the white-filter. |
| 202    | TB1N_WH   | Same description for column 46 immediately above, but for the white-filter. |
| 203    | TB1P_WH   | Same description for column 47 immediately above, but for the white-filter. |
| 204    | ALP2_WH   | Same description for column 48 immediately above, but for the white-filter. |
| 205    | ALP2N_WH  | Same description for column 49 immediately above, but for the white-filter. |
| 206    | ALP2P_WH  | Same description for column 50 immediately above, but for the white-filter. |
| 207    | TB2_WH    | Same description for column 51 immediately above, but for the white-filter. |
| 208    | TB2N_WH   | Same description for column 52 immediately above, but for the white-filter. |
| 209    | TB2P_WH   | Same description for column 53 immediately above, but for the white-filter. |
| 210    | ALP3_WH   | Same description for column 54 immediately above, but for the white-filter. |
| Column | Label          | Description                                                                 |
|--------|----------------|-----------------------------------------------------------------------------|
| 211    | ALP3N_WH       | Same description for column 55 immediately above, but for the white-filter. |
| 212    | ALP3P_WH       | Same description for column 56 immediately above, but for the white-filter. |
| 213    | TB3_WH         | Same description for column 57 immediately above, but for the white-filter.  |
| 214    | TB3N_WH        | Same description for column 58 immediately above, but for the white-filter. |
| 215    | TB3P_WH        | Same description for column 59 immediately above, but for the white-filter.  |
| 216    | ALP4_WH        | Same description for column 60 immediately above, but for the white-filter.  |
| 217    | ALP4N_WH       | Same description for column 61 immediately above, but for the white-filter.  |
| 218    | ALP4P_WH       | Same description for column 62 immediately above, but for the white-filter.  |
| 219    | NORM_WH        | Same description for column 63 immediately above, but for the white-filter.  |
| 220    | NORMN_WH       | Same description for column 64 immediately above, but for the white-filter.  |
| 221    | NORMWP_WH      | Same description for column 65 immediately above, but for the white-filter.  |
| 222    | CHISQ_WH       | Same description for column 66 immediately above, but for the white-filter.  |
| 223    | DOF_WH         | Same description for column 67 immediately above, but for the white-filter.  |
| 224    | R2_2E3_W2      | Count rate calculated at $2 \times 10^3$ s from the respective uvw2 temporal slope. Value is set to $-1.00000E+00$ if no temporal slope is available. |
| 225    | R2_ERN_2E3_W2  | R2_2E3_W2 negative error. If R2_2E3_W2 = $-1.00000E+00$, value set to $-1.00000E+00$. |
| 226    | R2_ERP_2E3_W2  | R2_2E3_W2 positive error. If R2_2E3_W2 = $-1.00000E+00$, value set to $-1.00000E+00$. |
| 227    | F2_2E3_W2      | R2_2E3_W2 converted into flux density in erg s$^{-1}$ cm$^{-2}$ Å$^{-1}$. This value is corrected for Milky Way extinction using the methods described by Cardelli et al. (1989) and Gordon et al. (2009, 2014), and is further corrected for redshifted host extinction using the method described in Pei (1992). We assume a SMC dust for the host based on results from Schady et al. (2010). If E(B-V)_HOST = $-99.0000$, the value is set to 0.1, which is the average host extinction found by Schady et al. (2012). If no redshift is available, the value is set to 1.2517, the mean value of our UVOT detected sample. If R2_2E3_W2 = $-1.00000E+00$, then F2_2E3_W2 = $-1.00000E+00$. For calculation purposes, if this value is 0.0000E+00, it is set to 1.0000E−23. |
| 228    | F2_ERN_2E3_W2  | F2_2E3_W2 negative error. If F2_2E3_W2 = $-1.00000E+00$, value set to $-1.00000E+00$. For calculation purposes, if F2_2E3_W2 = $0.00000E+00$, it is set to 1.0000E−23. |
| 229    | F2_ERP_2E3_W2  | F2_2E3_W2 positive error. If F2_2E3_W2 = $-1.00000E+00$, value set to $-1.00000E+00$. For calculation purposes, if F2_2E3_W2 = $0.00000E+00$, it is set to 1.0000E−23. |
| 230    | R2_2E3_M2      | Same description for column 224 immediately above, but for the uvw2-filter. |
| 231    | R2_ERN_2E3_M2  | Same description for column 225 immediately above, but for the uvw2-filter. |
| 232    | R2_ERP_2E3_M2  | Same description for column 226 immediately above, but for the uvw2-filter. |
| 233    | F2_2E3_M2      | Same description for column 227 immediately above, but for the uvw2-filter. |
| 234    | F2_ERN_2E3_M2  | Same description for column 228 immediately above, but for the uvw2-filter. |
| 235    | F2_ERP_2E3_M2  | Same description for column 229 immediately above, but for the uvw2-filter. |
| 236    | R2_2E3_W1      | Same description for column 224 immediately above, but for the uvw1-filter. |
| 237    | R2_ERN_2E3_W1  | Same description for column 225 immediately above, but for the uvw1-filter. |
| 238    | R2_ERP_2E3_W1  | Same description for column 226 immediately above, but for the uvw1-filter. |
| 239    | F2_2E3_W1      | Same description for column 227 immediately above, but for the uvw1-filter. |
| 240    | F2_ERN_2E3_W1  | Same description for column 228 immediately above, but for the uvw1-filter. |
| 241    | F2_ERP_2E3_W1  | Same description for column 229 immediately above, but for the uvw1-filter. |
| 242    | R2_2E3_UU      | Same description for column 224 immediately above, but for the u-filter. |
| 243    | R2_ERN_2E3_UU  | Same description for column 225 immediately above, but for the u-filter. |
| 244    | R2_ERP_2E3_UU  | Same description for column 226 immediately above, but for the u-filter. |
| 245    | F2_2E3_UU      | Same description for column 227 immediately above, but for the u-filter. |
| 246    | F2_ERN_2E3_UU  | Same description for column 228 immediately above, but for the u-filter. |
| 247    | F2_ERP_2E3_UU  | Same description for column 229 immediately above, but for the u-filter. |
| 248    | R2_2E3_BB      | Same description for column 224 immediately above, but for the b-filter. |
| 249    | R2_ERN_2E3_BB  | Same description for column 225 immediately above, but for the b-filter. |
| 250    | R2_ERP_2E3_BB  | Same description for column 226 immediately above, but for the b-filter. |
| 251    | F2_2E3_BB      | Same description for column 227 immediately above, but for the b-filter. |
| 252    | F2_ERN_2E3_BB  | Same description for column 228 immediately above, but for the b-filter. |
| 253    | F2_ERP_2E3_BB  | Same description for column 229 immediately above, but for the b-filter. |
| 254    | R2_2E3_VV      | Same description for column 224 immediately above, but for the v-filter. |
| 255    | R2_ERN_2E3_VV  | Same description for column 225 immediately above, but for the v-filter. |
| 256    | R2_ERP_2E3_VV  | Same description for column 226 immediately above, but for the v-filter. |
| 257    | F2_2E3_VV      | Same description for column 227 immediately above, but for the v-filter. |
| 258    | F2_ERN_2E3_VV  | Same description for column 228 immediately above, but for the v-filter. |
| 259    | F2_ERP_2E3_VV  | Same description for column 229 immediately above, but for the v-filter. |
| 260    | R2_2E4_W2      | Same description for column 224 immediately above, but calculated at $2 \times 10^3$ s. |
| 261    | R2_ERN_2E4_W2  | Same description for column 225 immediately above, but calculated at $2 \times 10^3$ s. |
| Column | Label                      | Description                                                                 |
|--------|----------------------------|-----------------------------------------------------------------------------|
| 262    | R2_ERP_2E4_W2              | Same description for column 226 immediately above, but calculated at $2 \times 10^5$ s. |
| 263    | F2_2E4_W2                  | Same description for column 227 immediately above, but calculated at $2 \times 10^5$ s. |
| 264    | F2_ERN_2E4_W2              | Same description for column 228 immediately above, but calculated at $2 \times 10^5$ s. |
| 265    | F2_ERP_2E4_W2              | Same description for column 229 immediately above, but calculated at $2 \times 10^5$ s. |
| 266    | R2_2E4_M2                  | Same description for column 230 immediately above, but calculated at $2 \times 10^5$ s. |
| 267    | R2_ERN_2E4_M2              | Same description for column 231 immediately above, but calculated at $2 \times 10^5$ s. |
| 268    | R2_ERP_2E4_M2              | Same description for column 232 immediately above, but calculated at $2 \times 10^5$ s. |
| 269    | F2_2E4_M2                  | Same description for column 233 immediately above, but calculated at $2 \times 10^5$ s. |
| 270    | R2_ERN_2E4_M2              | Same description for column 234 immediately above, but calculated at $2 \times 10^5$ s. |
| 271    | F2_ERP_2E4_M2              | Same description for column 235 immediately above, but calculated at $2 \times 10^5$ s. |
| 272    | R2_2E4_W1                  | Same description for column 236 immediately above, but calculated at $2 \times 10^5$ s. |
| 273    | R2_ERN_2E4_W1              | Same description for column 237 immediately above, but calculated at $2 \times 10^5$ s. |
| 274    | R2_ERP_2E4_W1              | Same description for column 238 immediately above, but calculated at $2 \times 10^5$ s. |
| 275    | F2_2E4_W1                  | Same description for column 239 immediately above, but calculated at $2 \times 10^5$ s. |
| 276    | F2_ERN_2E4_W1              | Same description for column 240 immediately above, but calculated at $2 \times 10^5$ s. |
| 277    | F2_ERP_2E4_W1              | Same description for column 241 immediately above, but calculated at $2 \times 10^5$ s. |
| 278    | R2_2E4_UU                  | Same description for column 242 immediately above, but calculated at $2 \times 10^5$ s. |
| 279    | R2_ERN_2E4_UU              | Same description for column 243 immediately above, but calculated at $2 \times 10^5$ s. |
| 280    | R2_ERP_2E4_UU              | Same description for column 244 immediately above, but calculated at $2 \times 10^5$ s. |
| 281    | F2_2E4_UU                  | Same description for column 245 immediately above, but calculated at $2 \times 10^5$ s. |
| 282    | F2_ERN_2E4_UU              | Same description for column 246 immediately above, but calculated at $2 \times 10^5$ s. |
| 283    | F2_ERP_2E4_UU              | Same description for column 247 immediately above, but calculated at $2 \times 10^5$ s. |
| 284    | R2_2E4_BB                  | Same description for column 248 immediately above, but calculated at $2 \times 10^5$ s. |
| 285    | R2_ERN_2E4_BB              | Same description for column 249 immediately above, but calculated at $2 \times 10^5$ s. |
| 286    | R2_ERP_2E4_BB              | Same description for column 250 immediately above, but calculated at $2 \times 10^5$ s. |
| 287    | F2_2E4_BB                  | Same description for column 251 immediately above, but calculated at $2 \times 10^5$ s. |
| 288    | R2_ERN_2E4_BB              | Same description for column 252 immediately above, but calculated at $2 \times 10^5$ s. |
| 289    | F2_ERP_2E4_BB              | Same description for column 253 immediately above, but calculated at $2 \times 10^5$ s. |
| 290    | R2_2E4_VV                  | Same description for column 254 immediately above, but calculated at $2 \times 10^5$ s. |
| 291    | R2_ERN_2E4_VV              | Same description for column 255 immediately above, but calculated at $2 \times 10^5$ s. |
| 292    | R2_ERP_2E4_VV              | Same description for column 256 immediately above, but calculated at $2 \times 10^5$ s. |
| 293    | F2_2E4_VV                  | Same description for column 257 immediately above, but calculated at $2 \times 10^5$ s. |
| 294    | F2_ERN_2E4_VV              | Same description for column 258 immediately above, but calculated at $2 \times 10^5$ s. |
| 295    | F2_ERP_2E4_VV              | Same description for column 259 immediately above, but calculated at $2 \times 10^5$ s. |
| 296    | R2_2E5_W2                  | Same description for column 262 immediately above, but calculated at $2 \times 10^5$ s. |
| 297    | R2_ERN_2E5_W2              | Same description for column 265 immediately above, but calculated at $2 \times 10^5$ s. |
| 298    | R2_ERP_2E5_W2              | Same description for column 266 immediately above, but calculated at $2 \times 10^5$ s. |
| 299    | F2_2E5_W2                  | Same description for column 267 immediately above, but calculated at $2 \times 10^5$ s. |
| 300    | F2_ERN_2E5_W2              | Same description for column 268 immediately above, but calculated at $2 \times 10^5$ s. |
| 301    | R2_2E5_M2                  | Same description for column 269 immediately above, but calculated at $2 \times 10^5$ s. |
| 302    | R2_ERN_2E5_M2              | Same description for column 270 immediately above, but calculated at $2 \times 10^5$ s. |
| 303    | R2_ERP_2E5_M2              | Same description for column 271 immediately above, but calculated at $2 \times 10^5$ s. |
| 304    | F2_2E5_M2                  | Same description for column 272 immediately above, but calculated at $2 \times 10^5$ s. |
| 305    | F2_ERN_2E5_M2              | Same description for column 273 immediately above, but calculated at $2 \times 10^5$ s. |
| 306    | F2_ERP_2E5_M2              | Same description for column 274 immediately above, but calculated at $2 \times 10^5$ s. |
| 307    | R2_2E5_W1                  | Same description for column 275 immediately above, but calculated at $2 \times 10^5$ s. |
| 308    | R2_ERN_2E5_W1              | Same description for column 276 immediately above, but calculated at $2 \times 10^5$ s. |
| 309    | R2_ERP_2E5_W1              | Same description for column 277 immediately above, but calculated at $2 \times 10^5$ s. |
| 310    | F2_2E5_W1                  | Same description for column 278 immediately above, but calculated at $2 \times 10^5$ s. |
| 311    | R2_ERN_2E5_W1              | Same description for column 279 immediately above, but calculated at $2 \times 10^5$ s. |
| 312    | R2_2E5_M2                  | Same description for column 280 immediately above, but calculated at $2 \times 10^5$ s. |
| 313    | F2_ERN_2E5_M2              | Same description for column 281 immediately above, but calculated at $2 \times 10^5$ s. |
| 314    | R2_2E5_UU                  | Same description for column 282 immediately above, but calculated at $2 \times 10^5$ s. |
| 315    | R2_ERN_2E5_UU              | Same description for column 283 immediately above, but calculated at $2 \times 10^5$ s. |
| 316    | R2_ERP_2E5_UU              | Same description for column 284 immediately above, but calculated at $2 \times 10^5$ s. |
| 317    | F2_2E5_UU                  | Same description for column 285 immediately above, but calculated at $2 \times 10^5$ s. |
| 318    | F2_ERN_2E5_UU              | Same description for column 286 immediately above, but calculated at $2 \times 10^5$ s. |
| 319    | F2_ERP_2E5_UU              | Same description for column 287 immediately above, but calculated at $2 \times 10^5$ s. |
| 320    | R2_2E5_BB                  | Same description for column 288 immediately above, but calculated at $2 \times 10^5$ s. |
| 321    | R2_ERN_2E5_BB              | Same description for column 289 immediately above, but calculated at $2 \times 10^5$ s. |
| 322    | R2_ERP_2E5_BB              | Same description for column 290 immediately above, but calculated at $2 \times 10^5$ s. |
| 323    | F2_2E5_BB                  | Same description for column 291 immediately above, but calculated at $2 \times 10^5$ s. |
| 324    | F2_ERN_2E5_BB              | Same description for column 292 immediately above, but calculated at $2 \times 10^5$ s. |
Table 6
(Continued)

| Column | Label | Description |
|--------|-------|-------------|
| 325    | F2_ERP_2E5_BB | Same description for column 253 immediately above, but calculated at $2 \times 10^4$ s. |
| 326    | R2_2E5_VV | Same description for column 254 immediately above, but calculated at $2 \times 10^4$ s. |
| 327    | R2_ERN_2E5_VV | Same description for column 255 immediately above, but calculated at $2 \times 10^4$ s. |
| 328    | R2_ERP_2E5_VV | Same description for column 256 immediately above, but calculated at $2 \times 10^4$ s. |
| 329    | F2_2E5_VV | Same description for column 257 immediately above, but calculated at $2 \times 10^4$ s. |
| 330    | F2_ERN_2E5_VV | Same description for column 258 immediately above, but calculated at $2 \times 10^4$ s. |
| 331    | F2_ERP_2E5_VV | Same description for column 259 immediately above, but calculated at $2 \times 10^4$ s. |
| 332    | BETA_2E3 | Spectral slope at $2 \times 10^3$ s ($\beta_{2E3}$) as determined from F2_2E3_W1, F2_2E3_UU, F2_2E3_BB, and F2_2E3_VV after conversion to mJy. In the case of a detection in two or more filters, a spectral slope is calculated. The value is calculated using $F(\nu) = B\nu^{\beta}$, where $F(\nu)$ is the flux density in mJy, $B$ is the normalization factor, and $\nu$ is the filter redshifted central frequency. To calculate $\beta$, we fit a straight line in log-log space to the data using LINEFIT in IDL. We then calculate the $\chi^2$ fit of this line to the data points. The data have unequal plus and minus errors, therefore we conservatively use the greater of these errors in our calculation. If there are less than two data points this value is set to $-99.00$. |
| 333    | BETA_2E3_ERR | The $1\sigma$ error on BETA_2E3. If BETA_2E3 = $-99.00$, this value is set to $-1.00$. |
| 334    | NORM_2E3 | Normalization factor ($B$) for spectral slope calculation. Value set to $-1.0000E+00$ if BETA_2E3 is $-99.00$. The maximum value is capped at 9.9900E+00. |
| 335    | NORM_2E3_ERR | Error on NORM_2E3. If NORM_2E3 = $-1.0000E+00$, this value is set to $-1.0000E+00$. |
| 336    | CHISQ_B3 | The $\chi^2$ value determined from the fit to the spectral slope at an epoch of $2 \times 10^4$ s. If there is no fit, value is set to $-1.0000E+00$. |
| 337    | DOF_B3 | Degrees-of-freedom associated with CHISQ_B3. If there is no fit, value is set to $-1.00$. |
| 338    | BETA_2E4 | Same description for column 332 immediately above, but calculated at $2 \times 10^5$ s. |
| 339    | BETA_2E4_ERR | Same description for column 333 immediately above, but calculated at $2 \times 10^5$ s. |
| 340    | NORM_2E4 | Same description for column 334 immediately above, but calculated at $2 \times 10^5$ s. |
| 341    | NORM_2E4_ERR | Same description for column 335 immediately above, but calculated at $2 \times 10^5$ s. |
| 342    | CHISQ_B4 | Same description for column 336 immediately above, but calculated at $2 \times 10^5$ s. |
| 343    | DOF_B4 | Same description for column 337 immediately above, but calculated at $2 \times 10^5$ s. |
| 344    | BETA_2E5 | Same description for column 338 immediately above, but calculated at $2 \times 10^5$ s. |
| 345    | BETA_2E5_ERR | Same description for column 339 immediately above, but calculated at $2 \times 10^5$ s. |
| 346    | NORM_2E5 | Same description for column 340 immediately above, but calculated at $2 \times 10^5$ s. |
| 347    | NORM_2E5_ERR | Same description for column 341 immediately above, but calculated at $2 \times 10^5$ s. |
| 348    | CHISQ_B5 | Same description for column 342 immediately above, but calculated at $2 \times 10^5$ s. |
| 349    | DOF_B5 | Same description for column 343 immediately above, but calculated at $2 \times 10^5$ s. |

Notes.

a This research has made use of the NASA/IPAC Infrared Science Archive, which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

b We caution that, for convenience, we have extrapolated into the UV the Pei (1992) SMC empirical extinction curve beyond that published.

Table 7
Swift/UVOT GRB Catalog Parameter Means

| Parameter | Mean | $\sigma$ |
|-----------|------|---------|
| $z$       | 2.04 | 1.39    |
| $E(B-V)_{\text{Gal}}$ | 0.20 | 1.43    |
| $E(B-V)_{\text{Host}}$ | 0.09 | 0.08    |
| $T_{90}$ | 75.4 s | 135.0 s |
| $T_{90} > 2$ | 82.7 s | 139.4 s |
| $T_{90} \leq 2$ | 0.6 s | 0.6 s |
| $S_\nu$ | $3.17 \times 10^{-6}$ erg cm$^{-2}$ s$^{-1}$ | $7.38 \times 10^{-6}$ erg cm$^{-2}$ s$^{-1}$ |
| $F_{\nu, XR}$ | $1.03 \times 10^{-8}$ erg cm$^{-2}$ s$^{-1}$ | $3.90 \times 10^{-8}$ erg cm$^{-2}$ s$^{-1}$ |
| $N_{\text{H}}$ | $4.86 \times 10^{21}$ cm$^{-2}$ | $6.69 \times 10^{21}$ cm$^{-2}$ |

Note. The mean is calculated only for those GRBs with measured parameters; therefore, each parameter mean will be represented by a different number of GRBs. The parameters are redshift ($z$), Milky Way reddening ($E(B-V)_{\text{Gal}}$), host reddening ($E(B-V)_{\text{Host}}$), all $T_{90}$, $T_{90}$ for long bursts ($T_{90} > 2$ s), $T_{90}$ for short bursts ($T_{90} \leq 2$ s), BAT fluence ($S_\nu$), early XRT flux ($F_{\nu, XR}$), and gas column density ($N_{\text{H}}$).

Table 8
Mean Temporal Slopes Per Segment Per UVOT Filter

| Filter | $\tau_T$ ($\sigma$) | $\tau_T$ ($\sigma$) | $\tau_T$ ($\sigma$) | $\tau_T$ ($\sigma$) |
|--------|-------------------|-------------------|-------------------|-------------------|
| uvw2   | $-0.24 (0.83)$    | $-0.98 (1.06)$    | $-2.19 (0.35)$    | $-0.27 (\cdots)$ |
| uvm2   | $-0.34 (0.73)$    | $-0.87 (1.02)$    | $-1.55 (1.27)$    | $-0.28 (\cdots)$ |
| uvm1   | $-0.55 (2.22)$    | $-0.85 (1.42)$    | $-0.52 (0.65)$    | $-0.28 (\cdots)$ |
| $u$    | $-0.56 (1.03)$    | $-0.71 (1.02)$    | $-0.47 (0.81)$    | $-1.77 (0.22)$    |
| $b$    | $-0.56 (1.28)$    | $-1.06 (1.85)$    | $0.22 (1.23)$     | $-1.56 (\cdots)$ |
| $v$    | $-0.41 (0.82)$    | $-0.66 (1.15)$    | $-0.71 (0.65)$    | $-1.23 (\cdots)$ |
| white  | $-0.35 (1.50)$    | $-0.47 (1.37)$    | $-0.74 (0.74)$    | $-0.28 (\cdots)$ |
| all    | $-0.45 (1.30)$    | $-0.70 (1.31)$    | $-0.68 (0.90)$    | $-1.15 (0.71)$    |

Note. If no temporal slopes exist for a given filter (or $\sigma$ cannot be calculated), the value is represented by a $\cdots$.

has already, passed through the UVOT bandpass for all bursts. Confirmation of this assumption will be provided in a forthcoming publication. Based on this assumption, for each
segment of the burst and a given $\alpha$, the average $\chi^2_{\text{Red}}$ for all filters is calculated. The $\alpha$ with an average $\chi^2_{\text{Red}}$ that most closely approaches unity is the temporal slope used for the given segment in the remaining steps.

With newly determined temporal slopes for each burst, optimal coaddition was rerun on each burst in the image/event database. The newly produced light curves were then refitted as described previously (e.g., Figure 1). All color light curves for each burst were then normalized to a given band (typically $\nu$-band) and then fit with a single, broken, or multiply broken power law (e.g., Figure 1), as described in Racusin et al. (2009).

### 3.3. Quality Control

As in Paper 1, we compare a sample of the resultant light curves with those published in the literature to check for consistency: GRBs 050525A (Blustin et al. 2006), 050603 (Grupe et al. 2006), 050730 (Perri et al. 2007), 050801 (De Pasquale et al. 2007), 050802 (Oates et al. 2007), 060124 (Romano et al. 2006), 060313 (Roming et al. 2006a), 060729 (Grupe et al. 2007), 061007 (Schady et al. 2007), 070125 (Updike et al. 2008), 080319B (Racusin et al. 2008), 080810 (Page et al. 2009), 081008 (Yuan et al. 2010), 081203A (Kuin et al. 2009), 090426 (Xin et al. 2011), 090510 (De Pasquale...
For each of these bursts, we look for at least three events with comparable exposure times at similar epochs, while keeping the normalized and published filters the same whenever possible. Based on these criteria, we compare the magnitudes, fluxes, or count rates to determine if they are consistent with each other, within the errors. We note that some values are visually extracted from the literature for comparison as there are no tabular values available. Our resultant light curves are found to be consistent with the published values.

Figure 3. Histogram of the temporal slopes ($\alpha$) for the first segment of the light curves in each UVOT color filter. Any extreme outliers are not shown in the histogram.
**Table 9**
Mean, Minimum, and Maximum Break Times ($\times 10^4$ s) Per UVOT Filter

| UVOT Filter | $t_{b1}$ ($\sigma$) | $t_{b2}$ ($\sigma$) | $t_{b3}$ ($\sigma$) | $t_{b\text{-min}}$ | $t_{b\text{-max}}$ |
|-------------|----------------------|----------------------|----------------------|-------------------|-------------------|
| uvw2        | 5.14 (5.87)          | 9.85 (4.21)          | 32.43 (—)            | 0.04              | 32.43             |
| uvw2        | 5.70 (6.19)          | 13.07 (13.41)        | 31.77 (—)            | 0.81              | 31.77             |
| uvw1        | 11.94 (22.16)        | 52.92 (73.83)        | (—)                  | 0.15              | 162.13            |
| u           | 7.60 (23.03)         | 27.17 (45.04)        | 47.67 (47.93)        | 0.02              | 81.56             |
| b           | 2.15 (3.00)          | 15.09 (11.94)        | 83.57 (—)            | 0.08              | 83.57             |
| v           | 2.89 (6.20)          | 5.47 (7.75)          | 93.37 (—)            | 0.02              | 93.37             |
| white       | 2.87 (9.41)          | 14.58 (27.18)        | (—)                  | 0.01              | 83.56             |
| all         | 4.69 (13.21)         | 17.43 (32.46)        | 56.08 (33.87)        | 0.01              | 162.13            |

**Note.** If no break time exists for a given filter (or $\sigma$ cannot be calculated), the value is represented by a —.

**Figure 4.** Schematics of GRB light-curve morphologies adapted from Evans et al. (2009). Morphologies a–d are unchanged from Evans et al. (2009), but morphologies e–f are new. These additional morphologies are representative of some UVOT observed GRBs. Dotted lines represent those portions of the light curves that are not always seen in these morphologies.
3.4. GRB Catalog Construction

The UVOT GRB Catalog was constructed by combining information from various databases and catalogs. The filter, magnitude, and flux\textsuperscript{15} of the first and peak detections, along with the start times of these events, were taken from the image/event database for each burst. Temporal slopes in each filter for each burst were derived from the NOC light curves. From these temporal slopes, dust extinction and redshift corrected fluxes in each filter were computed at $2 \times 10^3$ s, $2 \times 10^4$ s, and $2 \times 10^5$ s and spectral slopes were determined. These times were chosen so as to be after the period of greatest afterglow \textsuperscript{variation (500 s; Oates et al. 2009) and to span two decades in time. Details of the spectral slope fitting are provided in Table 6 Column 332.}

Additional information for the catalog was gleaned from the UVOT data, SGA, or the literature. A reference to the best reported burst position is provided. Also included is a flag indicating which observatory discovered each burst. The burst trigger time, $T_{90}$, BAT fluence, BAT peak photon flux, BAT photon index, \textit{Swift}/X-Ray Telescope (XRT; Burrows et al. 2005) flux at various epochs, XRT temporal and spectral indices, and the H\textsc{i} column density along the line of sight are from the SGA and are provided in the catalog for each burst.

\textsuperscript{15} We use the standard flux conversion factors from the CALDB for a GRB.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure5.png}
\caption{Histogram of the spectral slopes for $2 \times 10^3$ s ($\beta_{2E3}$), $2 \times 10^4$ s ($\beta_{2E4}$), and $2 \times 10^5$ s ($\beta_{2E5}$) for the platinum, gold, silver, and bronze samples.}
\end{figure}
4. Database and Catalog Formats

The image/event databases, the NOC database, and the Swift UVOT GRB Catalog can be found in their entirety in the electronic version of this paper and at the MAST and Swift websites. Sample columns and rows are provided in Tables 1–3, respectively. The databases and catalog are available in binary FITS format and are 46.6 MB, 46.8 MB, 1.4 MB, and 1.0 MB in size for the $3^\circ$0 image/event, $5^\circ$0 image/event, and NOC databases, and the catalog, respectively. The $3^\circ$0 image/event database contains 81 columns and 119,598 rows, the $5^\circ$0 image/event database contains 81 columns and 120,217 rows, the NOC database contains 20 columns and 13,597 rows, and the GRB catalog contains 349 columns and 626 rows. A description of each column in the image/event databases, NOC database, and the Swift UVOT burst catalog can be found in Tables 4–6, respectively.

5. Catalog Summary

We present some of the general features from the UVOT GRB databases and catalog. Of the 538 UVOT observed GRBs, 62% (43%) are detected by the UVOT at the $2\sigma$ ($3\sigma$) level in optimally coadded exposures. This is comparable to the ~50% detection rate by ground-based observations (see Fynbo et al. 2009) and an increase of ~2 (for the $3\sigma$ value) from Paper 1. The increased detection rate, as compared to Paper 1, is attributed to the use of optimal coaddition. If the sample is subdivided into long ($T_{90} > 2$ s) and short ($T_{90} < 2$ s) bursts (Kouveliotou et al. 1993), then the detection rate for optimally
Table 11
Fits to Correlated Data

| Data (Figure #) | Equation   | x-range    | y-range    | \( R^2 \) |
|-----------------|------------|------------|------------|----------|
| \( \beta_{2E3} \) versus \( \beta_{2E4} \) (6) | \( y = 0.53x - 0.02 \) | \(-2.75\)–\(1.93\) | \(-2.67\)–\(2.66\) | 0.285 |
| \( \beta_{2E4} \) versus \( \beta_{2E5} \) (7) | \( y = 0.63x + 0.09 \) | \(-2.75\)–\(1.28\) | \(-2.93\)–\(2.78\) | 0.000 |
| \( \beta_{2E3} \) versus \( \beta_{2E5} \) (8) | \( y = -0.01x - 0.59 \) | \(-2.90\)–\(2.75\) | \(-2.93\)–\(2.81\) | 0.300 |
| \( \beta_{BAT} \) versus \( \beta_{2E3} \) (9-Top) | \( y = 1.05x - 3.00 \) | \(1.33\)–\(3.52\) | \(-2.75\)–\(2.76\) | 0.093 |
| \( \beta_{BAT} \) versus \( \beta_{2E4} \) (9-Middle) | \( y = 0.83x - 2.24 \) | \(1.68\)–\(3.52\) | \(-2.67\)–\(2.57\) | 0.044 |
| \( \beta_{BAT} \) versus \( \beta_{2E5} \) (9-Bottom) | \( y = 0.40x - 1.41 \) | \(1.33\)–\(3.52\) | \(-2.93\)–\(2.81\) | 0.004 |
| \( \Gamma_{BAT} \) versus \( \beta_{2E3} \) (10-Top) | \( y = -0.36x - 0.33 \) | \(0.70\)–\(3.08\) | \(-2.75\)–\(2.76\) | 0.018 |
| \( \Gamma_{BAT} \) versus \( \beta_{2E4} \) (10-Middle) | \( y = 0.38x - 1.21 \) | \(0.43\)–\(3.08\) | \(-2.67\)–\(2.75\) | 0.018 |
| \( \Gamma_{BAT} \) versus \( \beta_{2E5} \) (10-Bottom) | \( y = 0.44x - 1.57 \) | \(0.31\)–\(3.08\) | \(-2.93\)–\(1.61\) | 0.029 |
| \( T_{90} \) versus \( S_5 \) (11) | \( y = 2.00E-07x^{0.58} \) | \(0.04\)–\(2.100\) | \(6.00E-09\)–\(1.05E-04\) | 0.474 |
| \( F_{v,uv} \) versus \( S_5 \) (12) | \( y = 1.00E-04x^{0.22} \) | \(2.30E-14\)–\(6.12E+02\) | \(6.00E-09\)–\(1.05E-04\) | 0.241 |
| \( F_{v,uvm} \) versus \( F_{u,1} \) (13) | \( y = 4.00E-15x^{0.16} \) | \(2.80E-14\)–\(6.12E+02\) | \(6.71E-19\)–\(1.02E-13\) | 0.060 |
| \( F_{v,1} \) versus \( S_6 \) (14) | \( y = 0.01x^{0.24} \) | \(2.78E-20\)–\(1.02E-13\) | \(9.00E-09\)–\(1.05E-04\) | 0.102 |

Figure 8. Relationship between the platinum spectral slopes at \(2 \times 10^3 \) s (\(\beta_{2E3}\)) and \(2 \times 10^5 \) s (\(\beta_{2E5}\)). Using the Spearman rank correlation (\(\rho = 0.01\)), the data are weakly correlated (\(P = 0.97\)).

coadded exposures is 63% (43%) and 49% (40%) for long and short bursts, respectively. The mean redshift (\(z\)), galactic reddening (\(E(B-V)_{Gal}\)), host reddening (\(E(B-V)_{Host}\)), \(T_{90}\), \(T_{90} > 2\) s, \(T_{90} \leq 2\) s, BAT fluence (\(S_5\)), early XRT flux (\(F_{v,uv}\)), and the gas column density (\(N_H\)) for our sample are found in Table 7.

The mean magnitude of the first detections is 17.06 (1\(\sigma = \pm 1.94\)), with 11.43 and 21.71 mag for the brightest and faintest first magnitude, respectively (Figure 2-top left). The mean peak magnitude is 17.70 (1\(\sigma = \pm 1.80\)), with 11.41 and 22.43 mag for the brightest and faintest peak magnitude, respectively (Figure 2-top right). For bursts that meet the criteria time-to-observation <500 s and Galactic reddening <0.5 (see Fynbo et al. 2009), an afterglow is detected in an optimally coadded exposure 60% (41%) of the time. For time-to-observation of bursts >500 s and for Galactic reddening <0.5, an afterglow is detected in an optimally coadded exposure 64% (44%) of the time. The remaining “dark” bursts are most likely explained by one or more of the following scenarios: the afterglow is below the detection threshold due to rapid temporal decay (see Roming et al. 2006b), high background due to small Sun-to-field angle (see Fynbo et al. 2009), large Galactic extinction (see Fynbo et al. 2009), high circumburst extinction (see Roming et al. 2006b; D’Elia & Stratta 2012; Jeong et al. 2014), and Ly\(\alpha\) damping due to high-redshift (see Roming et al. 2006b; D’Elia & Stratta 2012).

The median time to burst observation is 110.8 s (Figure 2, bottom left). The fastest time for an observation to begin is 37.8 s for GRB 050509B. The median time to a peak observation is 1600.2 s (Figure 2, bottom right). The fastest time to a peak observation is 39.8 s for GRB 050509A.

The distribution of the temporal slopes in the first segment for each filter are found in Figure 3. The mean temporal slopes (\(\bar{\tau}\)) for each UVOT filter and light-curve segment are provided in Table 8. The mean break times (\(\bar{\tau}_b\)) for the different segments in each filter, as well as the minimum (\(\tau_{b,\text{min}}\)) and maximum (\(\tau_{b,\text{max}}\)) break times per filter, are found in Table 9. An examination of the temporal slopes reveals a general shallow decline in the first segment followed by a steepening in the second segment by a factor of approximately two. For the bluest UV filters (\(uvw2\) and \(uvw3\)), as well as the white filter, the transition from the second segment to the third is again steepened. In contrast, the remaining filters manifest the opposite behavior. Since there are fewer measured temporal slopes in the third and fourth segments, we caution that inferring any general trends using the individual filters in the later segments may provide erroneous conclusions.

If we take all the filters together, the trend starts shallow in the first segment, is more steep in the second, has a shallower slope in the third (although not as shallow as the first segment), and finally has a steep decay. This general description does not behave the same as the “canonical” X-ray light curve...
However, from an examination of the individual normalized UVOT light curves, ~7%, ~7%, ~14%, and ~47% are consistent with the “a,” “b,” “c,” and “d” X-ray morphologies described in Evans et al. (2009) and illustrated in Figure 4. Of the remaining ~25%, ~21% have the new morphology “e” and ~4% have the “f” morphology as illustrated in Figure 4. Morphology “e” echoes a somewhat similar profile to that described above when all filters are taken together. The profile starts with a gentle rise in the first segment, transitioning to a steep decay in the second, then a shallow decay in the third, changing to another steep decay, and finally a more gentle decay. Morphology “f” starts with a rapid and steep decay, then a rise to peak (in some instances, with a break in between the rise), a steep decay, and a final less-steep decay (probably as a result of poor background subtraction due to the background host signal dominating over the GRB signal). We caution that sparsely populated light curves tend to be classified as morphological type “d,” which may or may not be the actual morphology. Therefore, the percentages quoted here should not be considered representative of the global burst population.

We also examined the relationship between peak afterglow brightness and number of breaks. We find that for light curves with one, two, three, or four segments that the magnitude range (number of GRBs) is 13.73–20.62 (165), 11.43–19.10 (65), 11.41–18.78 (17), and 14.94–15.53 (2), respectively; the mean
is 17.93, 16.23, 15.81, and 15.24, respectively. If we take
the dimmest magnitude of the four segment sample (15.53)
to be the discriminator between bright and dim, we find that 3%,
29%, 35%, and 100% of GRBs are bright for one, two, three,
and four segments, respectively. These numbers are not
surprising since brighter bursts will have smaller error bars
and therefore distinguishing breaks will be much easier. This
implies that these values should be taken as lower limits for the
distribution of brightness versus numbers of breaks, i.e., the
number of bursts with breaks is most likely higher than
determined here.

Using the fluxes at $2 \times 10^3$, $2 \times 10^4$, and $2 \times 10^5$ s in each
UVOT filter, the spectral slopes are calculated. The sample is
then culled using only those slopes with $0.01 \leq \chi^2_{\text{Red}} \leq 5$ (e.g.,
values with $\chi^2_{\text{Red}} = 0$, or only two data points, are not
included). The culled sample is then divided into a platinum,
gold, silver, and bronze sample depending on the degrees-of-
freedom (dof) associated with the $\chi^2_{\text{Red}}$ and range of $\beta$ values.
For platinum, dof $\geq 3$ and $-3 < \beta < 3$; gold, dof $\geq 2$ and
$-3.5 < \beta < 3.5$; silver, dof $\geq 1$ and $-4 < \beta < 4$; and bronze,
all dof $\geq 1$. The distribution of the culled spectral slopes are
found in Figure 5 and the mean ($\langle \beta \rangle$), median ($\beta_{\text{Md}}$), standard



Figure 10. Relationship between the BAT photon index ($\Gamma_{\text{BAT}}$) and the UVOT platinum spectral slopes at $2 \times 10^3$ s ($\beta_{\text{pl}}$: top panel), $2 \times 10^4$ s ($\beta_{\text{pl}}$: middle panel), and $2 \times 10^5$ s ($\beta_{\text{pl}}$: bottom panel). Using the Spearman rank correlation ($\rho = 0.13, 0.14,$ and 0.19, respectively), the data are weakly correlated ($P = 0.32, 0.29,$ and 0.11, respectively).
deviation (σ), number in the sample (Num), minimum (β_min), and maximum (β_max) of the spectral slopes at $2 \times 10^3$ s, $2 \times 10^4$ s, and $2 \times 10^5$ s are provided in Table 10.

Figures 6–8 show the relationship between the spectral slopes at $2 \times 10^3$ s ($\beta_{3E3}$), $2 \times 10^4$ s ($\beta_{3E4}$), and $2 \times 10^5$ s ($\beta_{3ES}$) for the platinum sample. Using the Spearman rank correlation (ρ = 0.48, 0.61, and 0.01, respectively, for $\beta_{3E3}$ versus $\beta_{3E4}$, $\beta_{3E4}$ versus $\beta_{3ES}$, and $\beta_{3ES}$ versus $\beta_{3ES}$, respectively), the data are strongly (P = 7.9 × 10^{-5}), strongly (P < 1 × 10^{-5}), and weakly (P = 0.97) correlated, respectively. Linear fits to the data are provided in Table 11.

A comparison of the XRT spectral index ($\beta_{XRT}$) to $\beta_{3E3}$, $\beta_{3E4}$, and $\beta_{3ES}$ are illustrated in Figure 9. Using the Spearman rank correlation (ρ = 0.04, 0.11, and 0.01, respectively), the data are weakly correlated (P = 0.75, 0.38, and 0.94, respectively). Linear fits to the data are provided in Table 11. A comparison of the BAT photon index (Γ_BAT) to $\beta_{3E3}$, $\beta_{3E4}$, and $\beta_{3ES}$ for the platinum sample are illustrated in Figure 10. Again, using the Spearman rank correlation (ρ = 0.13, 0.14, and 0.19, respectively), the data are weakly correlated (P = 0.32, 0.29, and 0.11, respectively). Linear fits to the data are also provided in Table 11.

Other correlations provided in this paper include $T_{90}$ versus $S_{\gamma}$ (Figure 11), $F_{X,e}$ versus $S_{\gamma}$ (Figure 12), $F_{X,e}$ versus the first UVOT flux ($F_{U,1}$; Figure 13), and $F_{U,1}$ versus $S_{\gamma}$ (Figure 14). Using the Spearman rank correlation (ρ = 0.64, 0.57, 0.18, and 0.27, respectively), the data are shown to be strongly correlated (P ≤ 1 × 10^{-5}), with the exception of $F_{X,e}$ to $F_{U,1}$, which is only marginally correlated (P = 0.02). The data reveal that longer bursts tend to be of a higher fluence. $F_{X,e}$ and $F_{U,1}$ trend toward larger values with the increase of $S_{\gamma}$ consistent with the results of Gehrels et al. (2008). We note that the data have not been redshift corrected, nor is the UV/optical data at a common epoch or in a common filter.

6. Conclusions and Future Work

In this paper, we describe the second Swift/UVOT GRB afterglow catalog and its corresponding databases. This catalog significantly expands upon the first Swift/UVOT GRB afterglow catalog (Paper 1) and provides spectral information that was not available in Paper 1. The detection rate in this current catalog has increased due to the use of optimal coaddition (MO8). Due to the significantly larger amount of data available in this version of the catalog, we were able to refine the temporal slopes per UVOT filter for multiple light-curve segments and to include average break times per filter.
From the temporal slopes and break times, we were able to compare our morphological results with that in the X-ray (Evans et al. 2009). We find that ~75% of the UVOT light curves have one of the four morphologies identified by Evans et al. (2009). The remaining ~25% have a newly identified morphology, which we designate as morphology types “e” and “f,” continuing where Evans et al. (2009) left off. Although many of the bursts were classified as morphological type “d,” we did not remove poorly sampled light curves from our database, thus many type-d’s may be misclassified. Future work includes breaking up the database into “gold,” “silver,” and “bronze” light curves in order to more accurately determine the UV/optical morphological distribution of the global burst population.

We also examined the spectral slopes at fixed epochs ($2 \times 10^3$ s, $2 \times 10^4$ s, and $2 \times 10^5$ s). The spectral slopes were divided into a platinum, gold, silver, and bronze sample. Using the platinum sample, we find that there is a strong correlation between the early-mid and mid-late time spectral slopes, while the early-late spectral slopes were only weakly correlated. Future efforts include targeting specific epochs with a larger number of data points in each individual burst, which will further increase the accuracy of the spectral slopes. Coupling time-dependent UV/optical and X-ray spectral slopes would be a powerful tool for probing the environments of massive stars (i.e., windy or ISM) and would help determine the fraction of GRBs with their cooling break ($\nu_c$) between the optical and X-ray. Time-dependent UV/optical and X-ray temporal and spectral slopes would also help validate and further constrain GRB afterglow models (see Zhang & Mészáros 2004; Zhang et al. 2006).

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Facility: Swift(UVOT).

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