

# TESS Data Release Notes: Reprocessing of Sectors 1–13, DR42 & DR46

*Michael M. Fausnaugh, Christopher J. Burke  
Kavli Institute for Astrophysics and Space Science, Massachusetts Institute of Technology,  
Cambridge, Massachusetts*

*Douglas A. Caldwell  
SETI Institute, Mountain View, California*

*Jon M. Jenkins  
NASA Ames Research Center, Moffett Field, California*

*Jeffrey C. Smith, Joseph D. Twicken  
SETI Institute, Mountain View, California*

*Roland Vanderspek  
Kavli Institute for Astrophysics and Space Science, Massachusetts Institute of Technology,  
Cambridge, Massachusetts*

*John P. Doty  
Noqsi Aerospace Ltd, Billerica, Massachusetts*

*Eric B. Ting  
Ames Research Center, Moffett Field, California*

*Joel S. Villaseñor  
Kavli Institute for Astrophysics and Space Science, Massachusetts Institute of Technology,  
Cambridge, Massachusetts*

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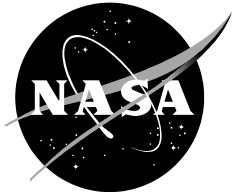
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Ames Research Center, Moffett Field, California*

*Joel S. Villasenor  
Kavli Institute for Astrophysics and Space Science, Massachusetts Institute of Technology,  
Cambridge, Massachusetts*

## Acknowledgements

These Data Release Notes provide information on the processing and export of data from the Transiting Exoplanet Survey Satellite (TESS). The data products included in this data release are full frame images (FFIs), target pixel files, light curve files, collateral pixel files, cotrending basis vectors (CBVs), and Data Validation (DV) reports, time series, and associated xml files.

These data products were generated by the TESS Science Processing Operations Center (SPOC, [Jenkins et al., 2016](#)) at NASA Ames Research Center from data collected by the TESS instrument, which is managed by the TESS Payload Operations Center (POC) at Massachusetts Institute of Technology (MIT). The format and content of these data products are documented in the [Science Data Products Description Document \(SDPDD\)](#)<sup>1</sup>. The SPOC science algorithms are based heavily on those of the Kepler Mission science pipeline, and are described in the Kepler Data Processing Handbook ([Jenkins, 2019](#)).<sup>2</sup> The Data Validation algorithms are documented in [Twicken et al. \(2018\)](#) and [Li et al. \(2019\)](#). The [TESS Instrument Handbook](#) ([Vanderspek et al., 2018](#)) contains more information about the TESS instrument design, detector layout, data properties, and mission operations.

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<sup>1</sup><https://archive.stsci.edu/missions/tess/doc/EXP-TESS-ARC-ICD-TM-0014-Rev-F.pdf>

<sup>2</sup><https://archive.stsci.edu/kepler/manuals/KSCI-19081-003-KDPH.pdf>

# 1 Reprocessing of TESS Sectors 1–13

TESS Data Release 42 (DR42) provides reprocessed data products of Sectors 1 to 6. The updated data products were generated using version 5.0 of the science processing pipeline and conform to the final set of data anomaly flags defined over the last two years of TESS operations. Data release 46 (DR46) corresponds to reprocessed data products for Sector 7–13.

The key changes for the reprocessed data are 1) consistent instrument models, algorithms, and parameters employed by all pipeline modules and 2) consistent time stamps, anomaly flags, and catalog parameters exported in all data products. A description of the main changes are given below, along with the Data Release Note (DRN) numbers that document the details of each change.

- Over the first year of TESS observations, updates were made to several instrument models. All data from Sectors 1–13 are reprocessed with the most up-to-date models in DR42 and DR46.
  - In Sector 2, the instrument electronics model Reference Flux was updated. The update is documented in the Sector 1 release notes ([DRN1](#)).
  - In Sector 8 ([DRN10](#)), the instrument PRF model was updated. The updated PRF model corresponds to improved performance in the spacecraft’s Attitude Control System starting in Sector 4. Note that Sectors 1–3 were also reprocessed with this model.
  - In Sector 10 ([DRN14](#)) the instrument linearity model was updated.
- Algorithms in the pipeline modules were refined during the two-year TESS primary mission. Reprocessed data have been consistently reduced with the updated versions of these algorithms.
  - In Sector 5 ([DRN7](#)), the algorithm in the CAL module that removes the 1D bias from raw pixel data was changed. The 1D bias estimate is now split into two components, a time-dependent scalar correction and a static row-dependent correction.
  - In Sector 14 ([DRN19](#)), the algorithm in the TPS module for searching for transiting planets was changed. An initial run of TPS is now used to identify problematic epochs that are assigned “deemphasis weights” in a second and final run of TPS.
  - In Sector 27 ([DRN38](#)), the algorithm in the CAL module that propagates uncertainty from the 2D bias model was changed. This uncertainty is a static term and is no longer applied to the pixel data or subsequent processing in the pipeline. Note that this change was not applied to Sectors 14–26, which were processed with version 4.0 of the science processing pipeline.
  - In Sector 27 ([DRN38](#)), the algorithm in the PA module that estimates the sky background was changed. A scalar offset is now applied that forces the dimmest background-corrected pixels to values near zero, if those pixels were significantly

negative. Note that this change was not applied to Sectors 14–26, which were processed with version 4.0 of the science processing pipeline. .

- Pipeline parameters were refined in all pipeline modules during the TESS primary mission. The data in this release have been reprocessed with the most up-to-date set of pipeline parameters. The most important changes are:
  - In Sector 2 ([DRN2](#)), the first two overclock rows were removed from the calculation of the 1D bias correction in the CAL module.
  - In Sector 5 ([DRN7](#)), parameters to calibrate PDC goodness metrics were finalized in the PDC module.
  - In Sector 20 ([DRN27](#)), the photometric apertures for stars with  $T_{\text{mag}} < 11$  were slightly increased in the COA module.
  - The layout and annotations of DV reports was refined through the TESS primary mission, and were finalized in Sector 20 ([DRN27](#)).
- Targets from Sectors 1–13 were reprocessed with version 8 of the TESS Input Catalog (TIC), consistent with Sectors 14–26. TIC 8 is based on Gaia DR2 rather than 2MASS, and includes significantly more stars and improved stellar parameters. The change in TIC version affects the apertures assigned to individual targets, the calculations of crowding and flux fraction reported in the CROWDSAP and FLUXFRAC keywords, and the physical properties of TCEs derived from stellar parameters.
- Timestamps for data from Sectors 1–13 were updated in two ways.
  - A drift term in the spacecraft clock kernels was present in Sectors 1–6 of the original data releases. The accumulated error in the timestamps caused by this drift was about 2 seconds by the end of Sector 6. The data have been reprocessed with an improved clock kernel, removing this error in DR42 and DR46.
  - Adjustments to timestamps for electronic effects were applied to DR42 and DR46. These adjustments are about 2 seconds or less in all cases, and are described in detail in [DRN30](#). All data from Sector 1–36 are now registered to a consistent time system.
- New data quality flags were applied to Sectors 1–13, consistent with those described in [DRN30](#). These flags are primarily used to mitigate the effects of scattered light. The flags are applied per target, rather than per CCD, and improve the cotrending and planet search for the reprocessed data.

In Sectors 1–3, “Manual Exclude” flags (bit 8) were set based on results from the transiting planet search in an ad hoc fashion. In Sector 3, we began setting this flag based on observed pointing excursions. All “Manual Exclude” flags are set in a consistent way for the reprocessed data, using a pointing excursion threshold of 7 arcseconds measured from the spacecraft’s fine pointing system ([DRN5](#)).

- For one target in Sector 12 (448302254), no background pixels were assigned after updates to the background estimation algorithm. In this data release, a target pixel file for this target with original and calibrated pixel data is provided, but no light curve was produced.
- The planet search of the reprocessed light curves produced a different set of TCEs from the original processed data. Although there is a high degree of overlap between the original and reprocessed data, new TCEs were produced in DR42 and DR46, and not every TCE from previous data releases was recovered.

In order to differentiate Data Validation products from DR42/DR46 and the initial data releases, the “pipeline instance number” (`pin`) is included in the filenames of the `dv-timeseries`, `dv-reports`, and `dv-result` xml files. A larger number for the `pin` always indicates more recently processed data. The DR number is also included as a keyword in the export product headers (`DATA_REL`). The `SDPDD` contains additional information about file names and associated fields for DV products.

## References

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# Acronyms and Abbreviation List

|             |   |
|-------------|---|
| <b>BTJD</b> | Barycentric-corrected TESS Julian Date      |
| <b>CAL</b>  | Calibration Pipeline Module                 |
| <b>CBV</b>  | Cotrending Basis Vector                     |
| <b>CCD</b>  | Charge Coupled Device                       |
| <b>CDPP</b> | Combined Differential Photometric Precision |
| <b>COA</b>  | Compute Optimal Aperture Pipeline Module    |
| <b>CSCI</b> | Computer Software Configuration Item        |
| <b>CTE</b>  | Charge Transfer Efficiency                  |
| <b>Dec</b>  | Declination                                 |
| <b>DR</b>   | Data Release                                |
| <b>DV</b>   | Data Validation Pipeline Module             |
| <b>DVA</b>  | Differential Velocity Aberration            |
| <b>FFI</b>  | Full Frame Image                            |
| <b>FIN</b>  | FFI Index Number                            |
| <b>FITS</b> | Flexible Image Transport System             |
| <b>FOV</b>  | Field of View                               |
| <b>FPG</b>  | Focal Plane Geometry model                  |
| <b>KDPH</b> | Kepler Data Processing Handbook             |
| <b>KIH</b>  | Kepler Instrument Handbook                  |
| <b>KOI</b>  | Kepler Object of Interest                   |
| <b>MAD</b>  | Median Absolute Deviation                   |
| <b>MAP</b>  | Maximum A Posteriori                        |
| <b>MAST</b> | Mikulski Archive for Space Telescopes       |
| <b>MES</b>  | Multiple Event Statistic                    |
| <b>NAS</b>  | NASA Advanced Supercomputing Division       |
| <b>PA</b>   | Photometric Analysis Pipeline Module        |



**PDC** Pre-Search Data Conditioning Pipeline Module

**PDC-MAP** Pre-Search Data Conditioning Maximum A Posteriori algorithm

**PDC-msMAP** Pre-Search Data Conditioning Multiscale Maximum A Posteriori algorithm

**PDF** Portable Document Format

**POC** Payload Operations Center

**POU** Propagation of Uncertainties

**ppm** Parts-per-million

**PRF** Pixel Response Function

**RA** Right Ascension

**RMS** Root Mean Square

**SAP** Simple Aperture Photometry

**SDPDD** Science Data Products Description Document

**SNR** Signal-to-Noise Ratio

**SPOC** Science Processing Operations Center

**SVD** Singular Value Decomposition

**TCE** Threshold Crossing Event

**TESS** Transiting Exoplanet Survey Satellite

**TIC** TESS Input Catalog

**TIH** TESS Instrument Handbook

**TJD** TESS Julian Date

**TOI** TESS Object of Interest

**TPS** Transiting Planet Search Pipeline Module

**UTC** Coordinated Universal Time

**WCS** World Coordinate System

**XML** Extensible Markup Language