



TESS Data Release Notes: Sectors 1 & 2, Multi-sector Search, DR3

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Acknowledgements

These Data Release Notes provide information on the processing and export of data from the Transiting Exoplanet Survey Satellite (TESS). This data release is a combined, multi-sector search only. The underlying data products from individual observing sectors have been previously released. The data products included in this data release are the Data Validation (DV) reports, time series, and associated xml files for the threshold crossing events (TCEs) found by searching a combined data set including data from multiple observing sectors.

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 Product Description Document \(SDPDD\)](#)¹. 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, 2017](#)).² The Data Validation algorithms are documented in [Twicken et al. \(2018\)](#) and [Li et al. \(2019\)](#). The TESS Instrument Handbook³ ([Vanderspek et al., 2018](#)) contains more information about the TESS instrument design, detector layout, data properties, and mission operations.

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This report is available in electronic form at
<https://archive.stsci.edu/tess/>

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

²<https://archive.stsci.edu/kepler/manuals/KSCI-19081-002-KDPH.pdf>

³https://archive.stsci.edu/missions/tess/doc/TESS_Instrument_Handbook_v0.1.pdf

1 Data

TESS Data Release 3 consists of results from a transiting planet search conducted in the combined data from Sectors 1 and 2. Figure 1 shows the Right Ascension (RA) and Declination (Dec) of all two-minute targets, color-coded by the number of sectors for which each target was observed. Targets with new data in Sector 2 were subject to a multi-sector planet search, using the same 2-minute cotrended data presented in previous single sector data releases. Table 1 provides basic information and data release note URL entries for the observations of each sector. The observations span a 56.2 day interval.

Table 2 summarizes the total number of targets with multi-sector data. A supplemental table is available⁴ that lists the targets searched in this data release, including a string indicating which sectors the target was observed in, whether the target produced a TCE or not, and whether the target completed DV analysis or not.

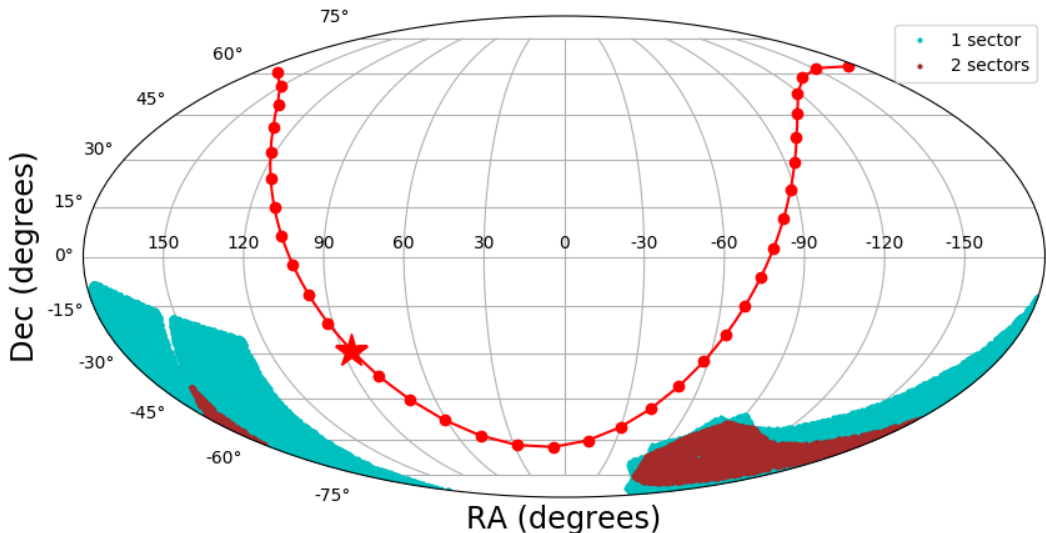


Figure 1: Right Ascension and Declination for all TESS two-minute targets, color-coded by the number of sectors in which that target was observed.

2 Transit Search and Data Validation

The light curves of 7081 targets observed in sectors 1 and 2 were subjected to the transit search in TPS. Figure 2 shows the 1-hour CDPF for the combined light curves of these targets. Threshold Crossing Events (TCEs) at the 7.1σ level were generated for 582 of these targets. A search for additional TCEs in potential multiple planet systems was conducted in DV through calls to TPS. A total of 1019 TCEs were identified in the SPOC pipeline on

⁴https://archive.stsci.edu/missions/tess/catalogs/targetinfo/tess_multisector_01_02_drn03_targetinfo_v01.txt

Table 1: Sectors Searched

Sector #	Physical Orbits	Start TJD ^a	End TJD	Data Release #
1	9,10	1325.29278	1353.17778	1
2	11,12	1354.10102	1381.51460	2

^a TJD = TESS JD = JD - 2,457,000.0

Table 2: Targets With Number of Sectors Observed

Number of Sectors	Target Count
2	7081

574 unique target stars. There were 8 targets that caused a run-time error in DV, and the TCEs associated with those targets are not available in the archived data products. Targets with errors are flagged in the supplemental target information table, and visual inspection of these cases did not yield signals with viable planet candidates. Table 3 provides a breakdown of the number of TCEs by target. Note that targets with large numbers of TCEs are likely to include false positives.

Table 3: Sector 2 TCE Numbers

Number of TCEs	Number of Targets	Total TCEs
1	309	309
2	161	322
3	62	186
4	21	84
5	8	40
6	13	78
–	504	1019

Figure 3 gives the distribution in period–transit depth space of the TCEs found in the multi-sector search. The top panel shows the distribution of orbital periods for the TCEs. After rapidly declining for periods between 1 and 5 days, the distribution shows an excess of TCEs between about 15 and 32 days, including narrow peaks in the histogram at about 15, 23, and 27 days. These features are likely associated with time-isolated pointing excursions that occur approximately every 2.5 days, and scattered light variations that can repeat over an orbital period or sector (13.7 and 27 days). These artifacts are largely a result of setting the minimum required number of transits to 2 in the transiting planet search.

The vertical histogram in the right panel of Figure 3 shows the distribution of transit depths derived from limb-darkened transiting planet model fits for TCEs. The model

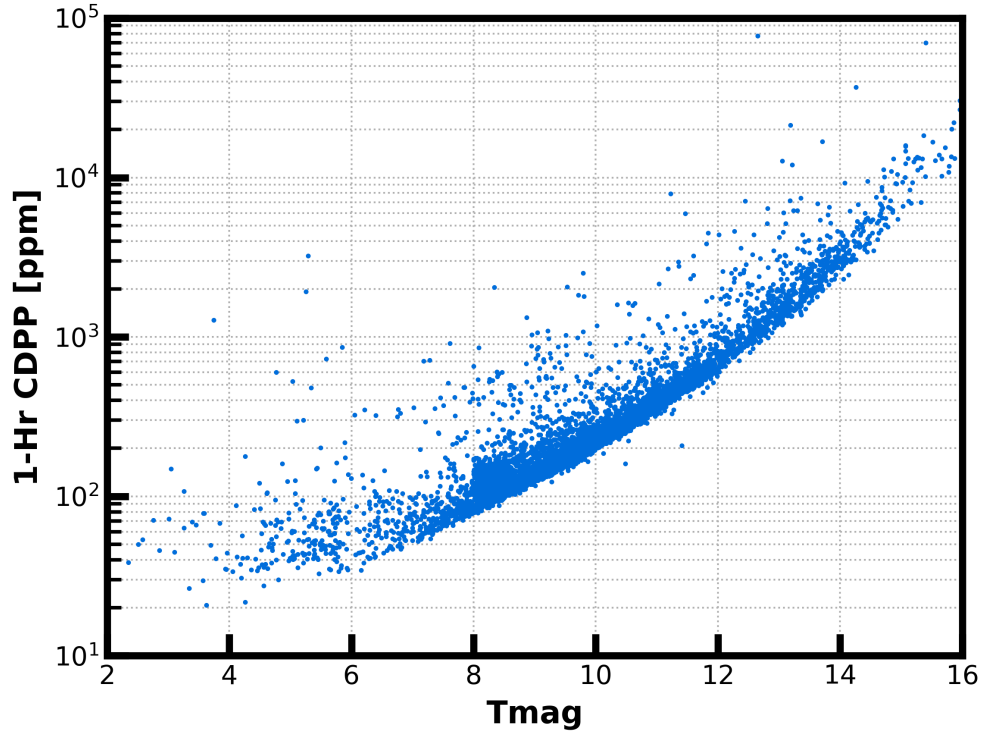


Figure 2: 1-hour CDPP. The points are RMS CDPP measurements for the 7081 light curves from the Sectors 1 & 2 multi-sector search plotted as a function of TESS magnitude.

transit depths range down to the order of 100 ppm, but the bulk of the transit depths are considerably larger.

Figure 4 shows the number of TCEs at a given cadence that exhibit a transit signal and highlights observing epochs with pointing and scattered light variations. Problematic epochs can be identified with the large ($>3\sigma$) peaks. In particular, there is a peak in the second half of Sector 1 that is associated with anomalously high pointing jitter, which likely drives many of the TCEs in the 15–32 day period range.

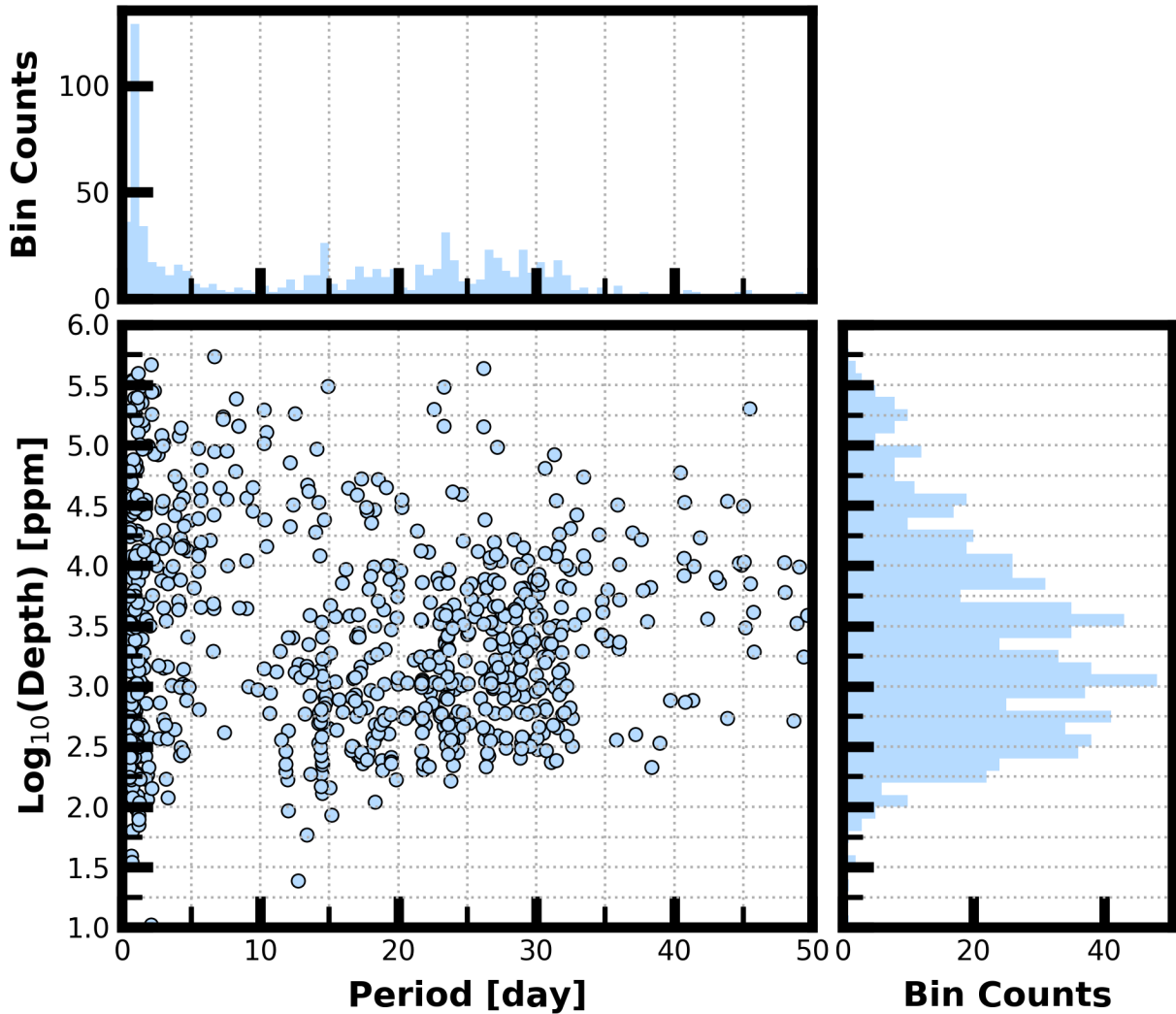


Figure 3: Lower Left Panel: Transit depth as a function of orbital period for the 1019 TCEs identified for the Sectors 1 & 2 multi-sector search. For enhanced visibility of long period detections, TCEs with orbital period < 0.5 days are not shown. Reported depth comes from the DV limb darkened transit fit depth when available, and when not available, the DV trapezoid model fit depth. Top Panel: Orbital period distribution of the TCEs shown in the lower left panel. Right Panel: Transit depth distribution for the TCEs shown in the lower left panel.

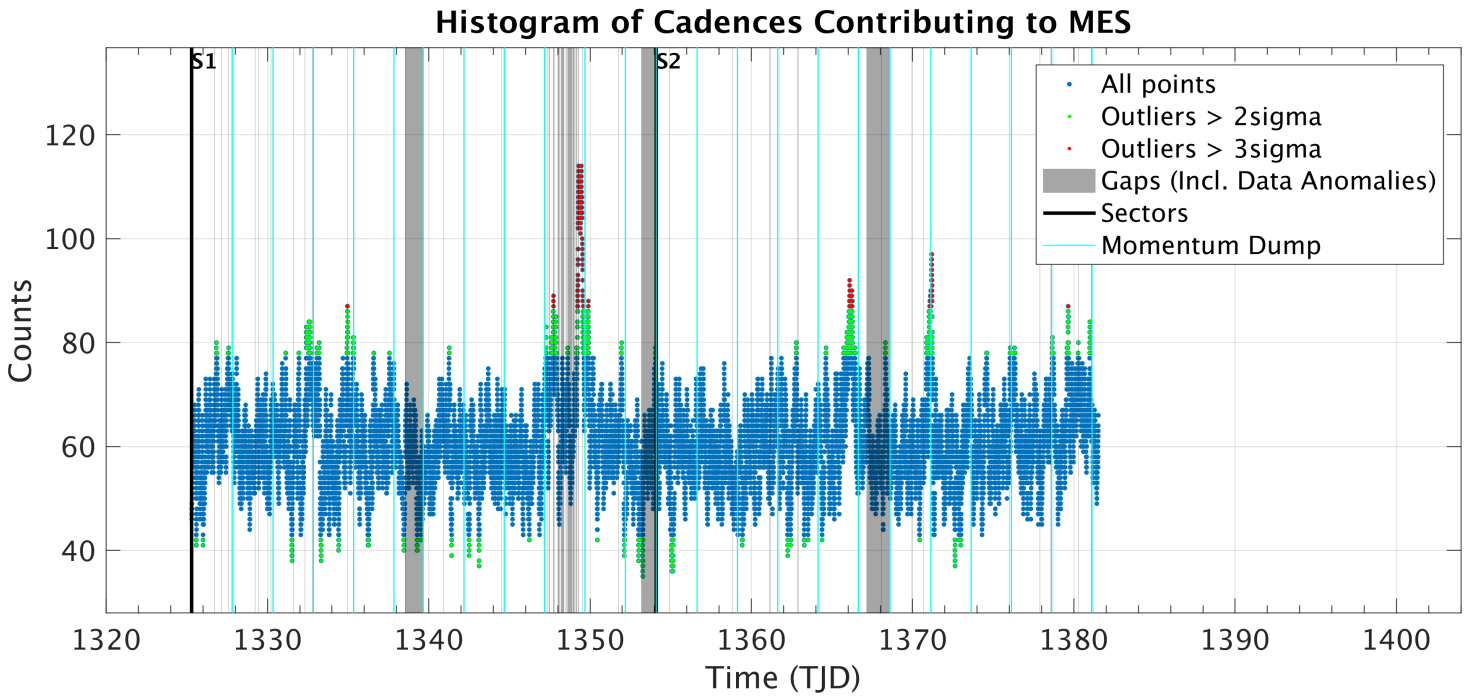


Figure 4: Number of TCEs at a given cadence exhibiting a transit signal. Isolated peaks are caused by a single event and result in spurious TCEs. The peaks typically align with pointing instabilities and strong background variations.

References

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Acronyms and Abbreviation List

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