



TESS Data Release Notes: Sectors 1 – 9, Multi-sector Search, DR15

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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 transit 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 Products 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 15 consists of results from a transiting planet search conducted with the combined data from Sectors 1 through 9. 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 7, 8, or 9 that were observed in at least one other earlier sector were subjected to a multi-sector planet search (see Data Release 3, Data Release 6, and Data Release 11, for Sector 1–2, Sector 1–3, and Sector 1–6 multi-sector planet searches, respectively). The data are the same 2-minute cotrended light curves 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 243 day interval.

Table 2 summarizes the total number of targets with multi-sector data. A supplemental table⁴ 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.

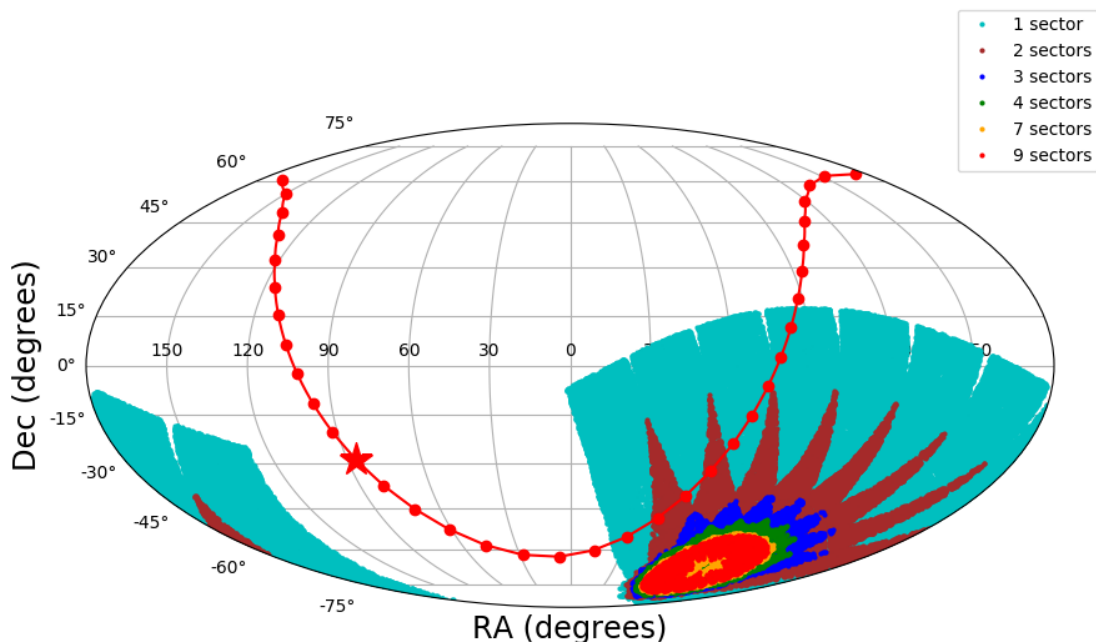


Figure 1: Right Ascension and Declination for all TESS two-minute targets, color-coded by the number of sectors in which that target was observed.

⁴https://archive.stsci.edu/missions/tess/catalogs/targetinfo/tess_multisector_01_09_drn15_targetinfo_v01.txt

Table 1: Sectors Searched

Sector #	Physical Orbits	Start TJD ^a	End TJD	Data Release #
1	9,10	1325.293	1353.178	1
2	11,12	1354.101	1381.515	2
3	13,14	1385.897	1406.292	4
4	15,16	1410.900	1436.849	5
5	17,18	1437.826	1464.400	7
6	19,20	1468.270	1490.044	8
7	21,22	1491.626	1516.085	9
8	23,24	1517.342	1542.000	10
9	25,26	1543.216	1568.475	11

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

Table 2: Targets With Number of Sectors Observed

Number of Sectors	Target Count
2	5772
3	1602
4	950
5	1203
6	1228
7	816
8	2746
9	2166

2 Transit Search and Data Validation

The light curves of 16483 targets observed in Sectors 1 through 9 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 2091 of these targets. A search for additional TCEs in potential multiple planet systems was conducted in DV through calls to TPS. A total of 3889 TCEs were identified in the SPOC pipeline on 2090 unique target stars. There was 1 target (419425547) that caused a run-time error in DV due to an invalid entry for a stellar parameter in the TIC catalog, and the TCE associated with that target is not available in the archived data products. Targets with errors are flagged in the supplemental target information table. 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.

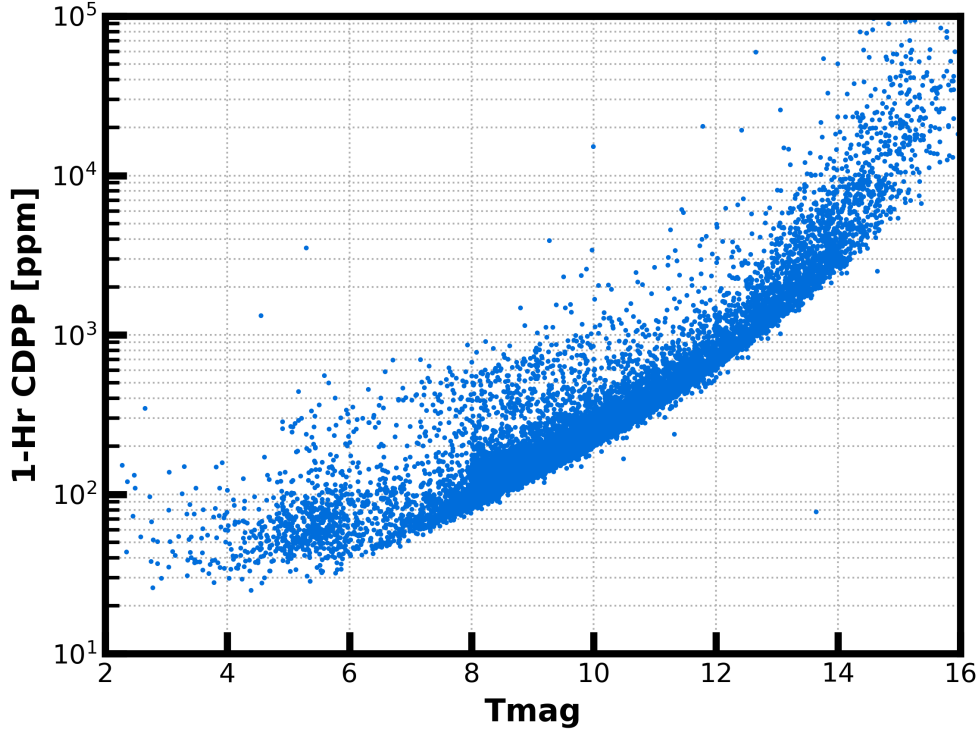


Figure 2: 1-hour CDPP. The points are RMS CDPP measurements for the 16483 light curves from the Sectors 1 – 9 multi-sector search plotted as a function of TESS magnitude.

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 a broad tail towards the longest period allowed ($\lesssim 220$ day) while requiring at least two transit events. Small excesses of TCEs at a given period can primarily be associated with scattered light and momentum dump features (see below).

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 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. The largest peak is associated with thermal changes after the instrument anomaly in Sector 8 (see Data Release 10).

Table 3: Sector 1 – 9 TCE Numbers

Number of TCEs	Number of Targets	Total TCEs
1	1069	1069
2	588	1176
3	209	627
4	132	528
5	63	315
6	29	174
–	2090	3889

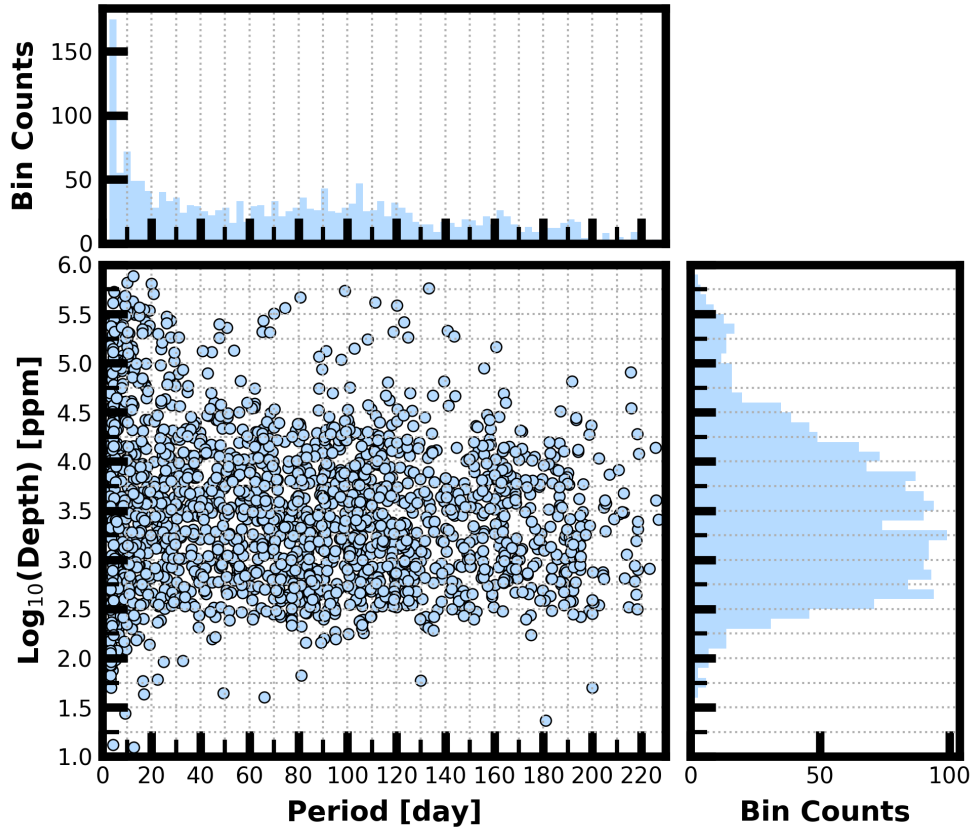


Figure 3: Lower Left Panel: Transit depth as a function of orbital period for the 3889 TCEs identified for the Sectors 1 – 9 multi-sector search. For enhanced visibility of long period detections, TCEs with orbital period < 0.5 days are not shown. Reported depth comes from the DV limb darkened transit fit depth when available (or the DV trapezoid model fit depth if the limb darkened transit fit is not available). 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.

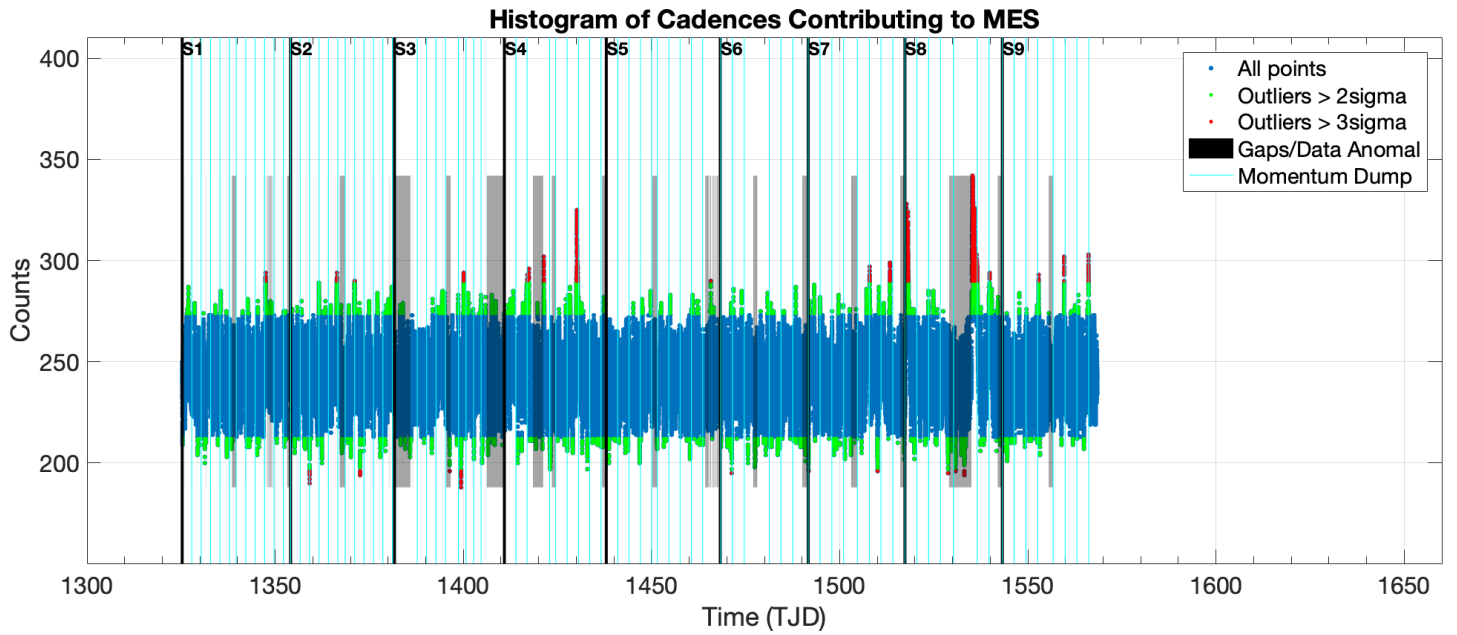


Figure 4: Number of TCEs at a given cadence exhibiting a transit signal. Isolated peaks are caused by a single event and result in spurious TCEs. The peaks typically align with pointing instabilities and strong background variations. TCE ephemerides are projected back to the start of Sector 1 even if the associated targets were not observed that early in the mission.

References

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Acronyms and Abbreviation List

BTJD	Barycentric-corrected TESS Julian Date
CDPP	Combined Differential Photometric Precision
Dec	Declination
DV	Data Validation Pipeline Module
KDPH	Kepler Data Processing Handbook
MAST	Mikulski Archive for Space Telescopes
MES	Multiple Event Statistic
NAN	Numerical Not-A-Number
POC	Payload Operations Center
ppm	Parts-per-million
RA	Right Ascension
RMS	Root Mean Square
SDPDD	Science Data Product Description Document
SNR	Signal-to-Noise Ratio
SPOC	Science Processing Operations Center
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