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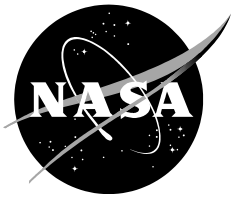

TESS Data Release Notes:
Sectors 14 – 60, Multi-sector Search, DR87

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February 24, 2023

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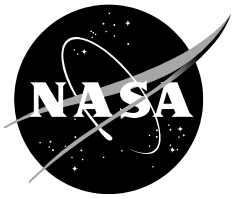

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Acknowledgements

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, 2020)[2]. 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.

The TESS Mission is funded by NASA's Science Mission Directorate.

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-Rev-F.pdf
[2] https://archive.stsci.edu/kepler/manuals/KSCI-19081-003-KDPH.pdf

1 Data

TESS Data Release DR87 consists of results from a transiting planet search conducted with the combined data from Sectors 14 through 26 (TESS Year 2 – northern ecliptic pointings), Sectors 40 and 41 (Beginning of TESS Year 4 – northern ecliptic pointings), Sectors 42 through 46 (TESS Year 4 – ecliptic pointings), Sectors 47 through 55 (TESS Year 4 – northern ecliptic pointings), and Sectors 56 through 60 (TESS Year 5 – northern ecliptic pointings). 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 any of Sectors 56 through 60 that were observed in at least one other previous sector were subjected to a multi-sector planet search (see Data Releases 23, 28, 34, 40, 61, 63, 68, 69, 75, and 81 for Sectors 14–55 multi-sector planet searches). For Sectors 14–19, the data correspond to the 2-minute reprocessed data from DR30, while for Sectors 20–26 and Sectors 40–60, 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 numbers for the observations of each sector. The observations span a 1279 day period with 352 day coverage (Year 2; Sectors 14–26), a 356 day gap in coverage (Year 3), and 572 day coverage (Year 4–5; Sectors 40–60).

Table 2 summarizes the total number of targets with multi-sector data for this data release. A supplemental table[3] lists the targets searched, including a string indicating which sectors the target was observed in, whether or not the target produced a TCE, and whether or not the target completed DV analysis.

The multi-sector planet search is performed using a binned data mode. The binned data mode combines data from five two-minute cadences into a single super-cadence with a ∼10 minute duration. The binning permits reduced pipeline runtime and memory usage, while maintaining sensitivity to planet detection and characterization. The archival DV reports and time series provide figures and data that are binned at the ∼10 minute super-cadence. Super-cadence boundaries are not the same for all targets; that is, individual targets will have different super-cadence start/stop times depending on the sectors in which they were first observed (start time of the first super-cadence for a given target is start time of the first sector in which the target was observed).

2 Transit Search and Data Validation

The light curves of 22037 targets observed in Sectors 14 through 60 were subjected to the transit search in TPS. Figure 2 shows the 1-hour CDPP for the combined light curves of these targets. Threshold Crossing Events (TCEs) at the 7.1 σ level were generated for 4622 of these targets. A search for additional TCEs in potential multiple planet systems was conducted in DV through calls to TPS. A total of 8961 TCEs were identified in the SPOC pipeline on 4622 unique target stars that completed analysis in DV. 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.

[3] https://archive.stsci.edu/missions/tess/catalogs/targetinfo/tess_multisector_14_60_drn87_targetinfo_v01.txt

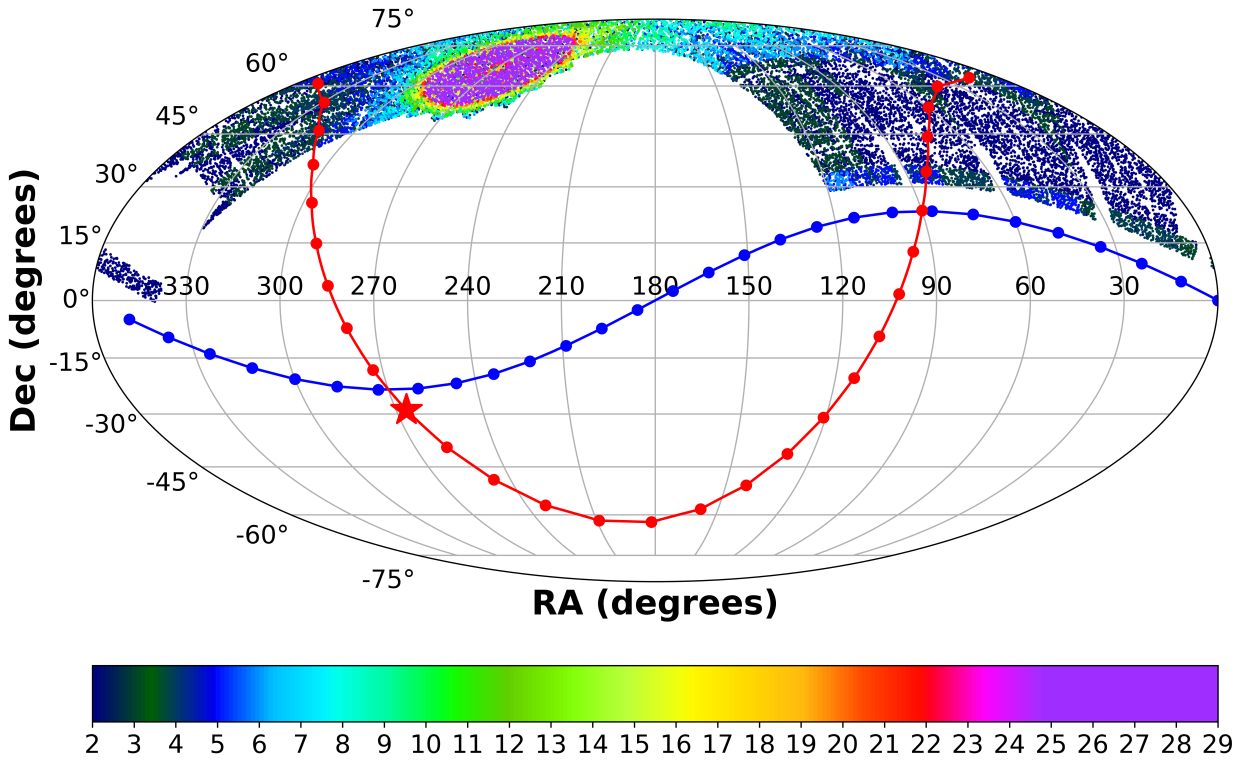

Figure 1: Right Ascension and Declination for TESS two-minute targets included in this multi-sector search, color-coded by the number of sectors in which that target was observed. The galactic and ecliptic planes are indicated by the red and blue lines, respectively.

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 declining for periods out to 30 days, the distribution shows several preferred orbital periods towards the longest period allowed ($\lesssim$1300 day) while requiring at least two transit events.

The true orbital periods of TCEs reported here are ambiguous for single transits[4] observed in TESS Year 2 and 4, due to gaps in observations of northern ecliptic targets. TPS requires two transits to trigger a TCE, but does not require that all transits implied by the estimated period correspond to observed data. The excess of TCEs at various periods in Figure 3 are partially caused by the ambiguities of the data gaps. Large systematic noise signals that occur in TESS Years 2, 4 and 5 contribute to the bulk of these TCE excesses.

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 10 ppm, but the bulk of the transit depths are considerably larger.

[4]Single transits can generate TCEs when folded at a period that matches a glitch or other anomaly elsewhere in the light curve. It is also possible for two glitches to trigger TCEs.

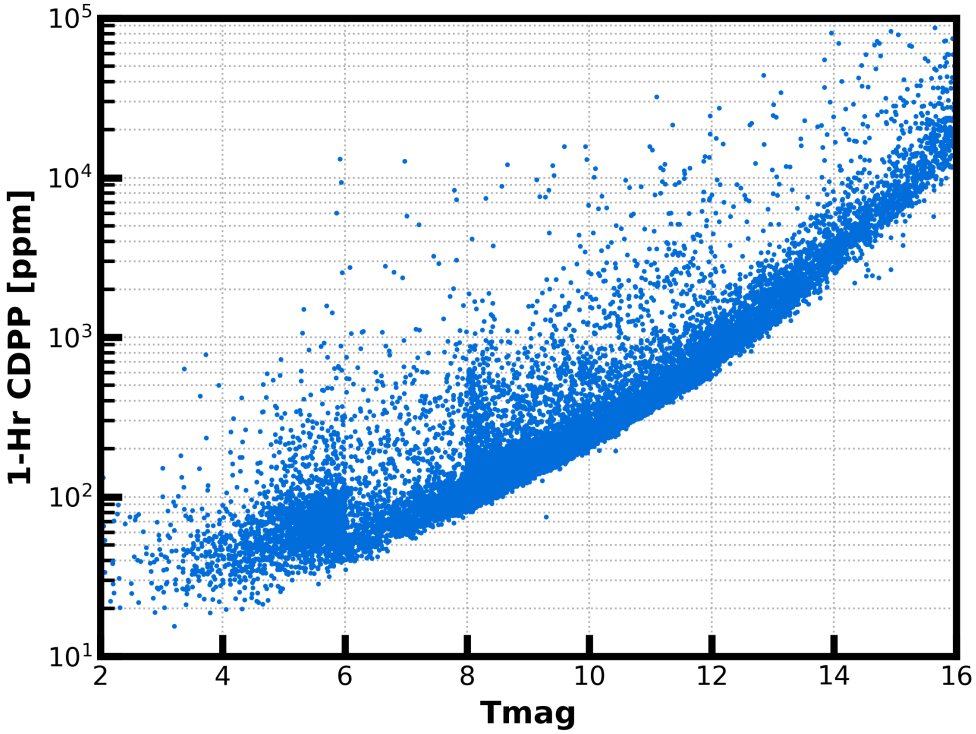

Figure 2: 1-hour CDPP. The points are RMS CDPP measurements for the 22037 light curves from the Sectors 14 – 60 multi-sector search plotted as a function of TESS magnitude.

Table 1: Sectors Searched

Sector #	Physical Orbits	Start TJD[a]	End TJD	Data Release #
14	35,36	1683.348	1710.204	30
15	37,38	1711.359	1737.409	30
16	39,40	1738.647	1763.319	30
17	41,42	1764.679	1789.694	30
18	43,44	1790.651	1815.030	30
19	45,46	1816.077	1841.148	30
20	47,48	1842.498	1868.822	27
21	49,50	1870.429	1897.780	29
22	51,52	1899.301	1926.493	31
23	53,54	1928.100	1954.875	32
24	55,56	1955.790	1982.280	35
25	57,58	1983.627	2009.305	36
26	59,60	2010.262	2035.134	37
40	87,88	2390.648	2418.853	57
41	89,90	2419.984	2446.578	59
42	91,92	2447.685	2473.159	60
43	93,94	2474.162	2498.888	62
44	95,96	2500.183	2524.440	64
45	97,98	2525.502	2550.624	65
46	99,100	2551.560	2578.701	66
47	101,102	2579.796	2606.940	67
48	103,104	2607.928	2635.985	70
49	105,106	2637.467	2664.314	71
50	107,108	2665.266	2691.509	72
51	109,110	2692.942	2717.534	74
52	111,112	2718.630	2743.076	76
53	113,114	2743.991	2768.978	77
54	115,116	2769.894	2796.128	78
55	117,118	2797.095	2824.263	79
56	119,120	2825.252	2853.138	80
57	121,122	2853.138	2882.114	82
58	123,124	2882.324	2910.048	83
59	125,126	2910.259	2936.687	84
60	127,128	2936.898	2962.583	85

[a] TJD = TESS JD = JD - 2,457,000.0

Table 2: Targets in this Data Release With Number of Sectors Observed

Number of Sectors	Target Count
2	8224
3	3397
4	2228
5	1666
6	965
7	762
8	500
9	418
10	258
11	248
12	258
13	246
14	226
15	239
16	216
17	161
18	132
19	99
20	91
21	65
22	82
23	104
24	130
25	182
26	318
27	396
28	299
29	127

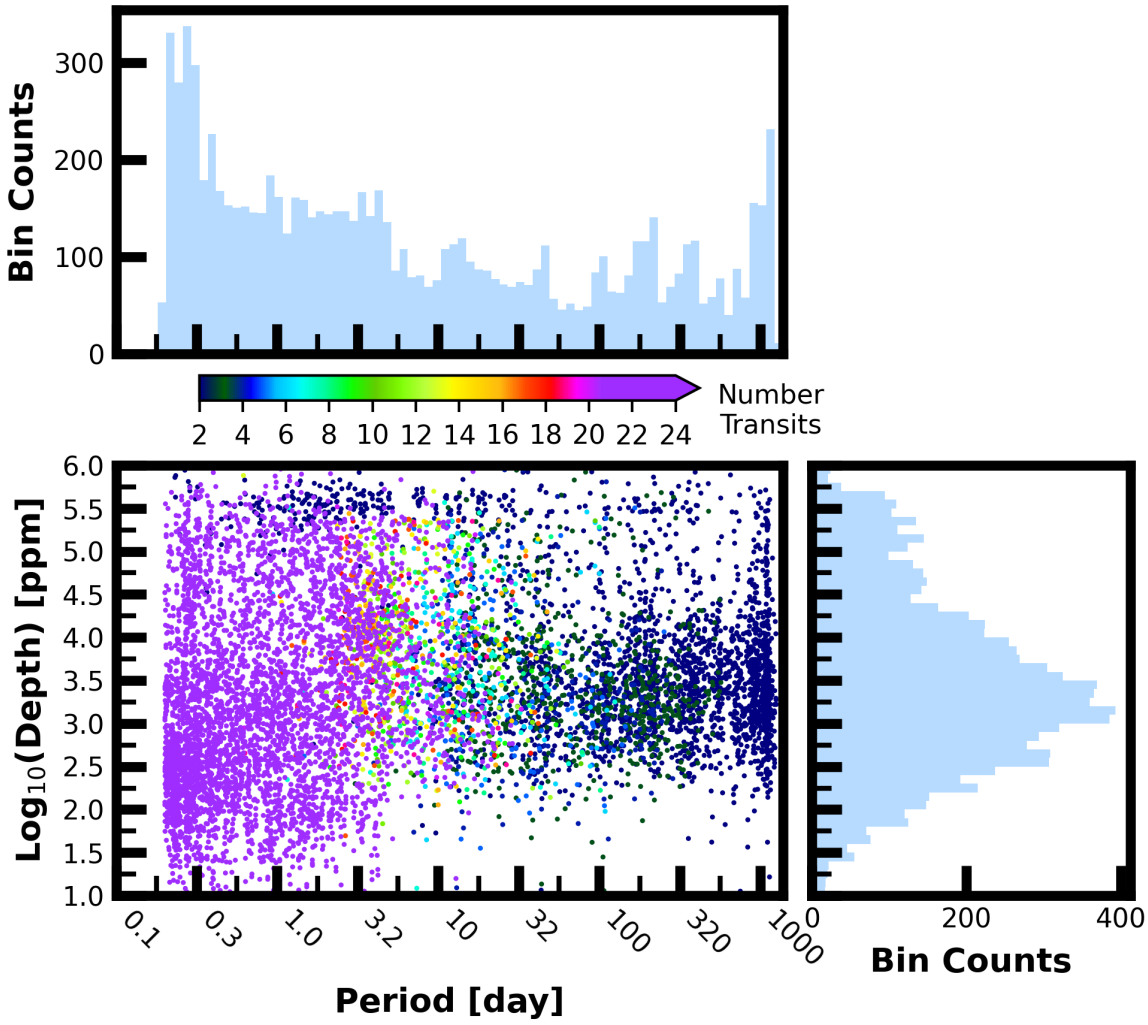

Figure 3: Lower Left Panel: Transit depth as a function of orbital period for the 8961 TCEs identified for the Sectors 14 – 60 multi-sector search. The color of the points indicates the number of transit events that were observed for the TCE. Reported depth comes from the DV limb darkened transit fit 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.

Table 3: Sector 14 – 50 TCE Numbers

Number of TCEs	Number of Targets	Total TCEs
1	2347	2347
2	1210	2420
3	528	1584
4	248	992
5	116	580
6	173	1038
–	4622	8961

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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 Products 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