

TESS Data Release Notes:

Sectors 1 – 36, Multi-sector Search, DR53

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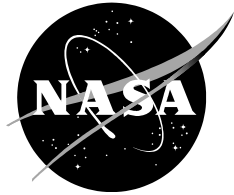
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Acknowledgements

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 DR53 consists of results from a transiting planet search conducted with the combined data from Sectors 1 through 13 (TESS Year 1 – southern ecliptic pointings) and Sectors 27 through 36 (Partial TESS Year 3 – southern 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 27–36 that were observed in multiple sectors were subjected to a multi-sector planet search (see Data Releases 3, 6, 12, 15, and 20 for Sectors 1–13 multi-sector planet searches). For Sectors 1–13, the data correspond to the 2-minute reprocessed data from DR42 and DR46, while for Sectors 27–36 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 980.7 day period with 357 day coverage (Year 1; Sectors 1–13), a 353 day gap in coverage (Year 2), and 269.2 day coverage (Partial Year 3; Sectors 27–36).

Table 2 summarizes the total number of targets with multi-sector data for this data release. A supplemental table³ 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.

2 Transit Search and Data Validation

The light curves of 57515 targets observed in Sectors 1 through 36 were subjected to the transit search in TPS.⁴ 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 6791 of these targets. A search for additional TCEs in potential multiple planet systems was conducted in DV through calls to TPS. A total of 12466 TCEs were identified in the SPOC pipeline on 6789 unique target stars. There were 2 targets (30312722 & 149351776) which did not complete analysis in DV, and the TCEs associated with those targets are not available in the archived data products. 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 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 out to 50 days, the distribution shows a broad tail towards the longest period allowed ($\lesssim 1000$ day) while requiring at least two transit events.

The true orbital periods of TCEs reported here are ambiguous for single transits⁵ observed in TESS Year 1 and 3, due to the gap in observations of southern ecliptic targets during Sectors 14–26 (TESS Year 2 – northern ecliptic pointings). TPS requires two transits to trigger a TCE, but does not require that all transits implied by the estimated period

³https://archive.stsci.edu/missions/tess/catalogs/targetinfo/tess_multisector_01_36_drn53_targetinfo_v01.txt

⁴Two additional targets (382630542 & 425064757) did not successfully complete analysis in TPS.

⁵Single 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.

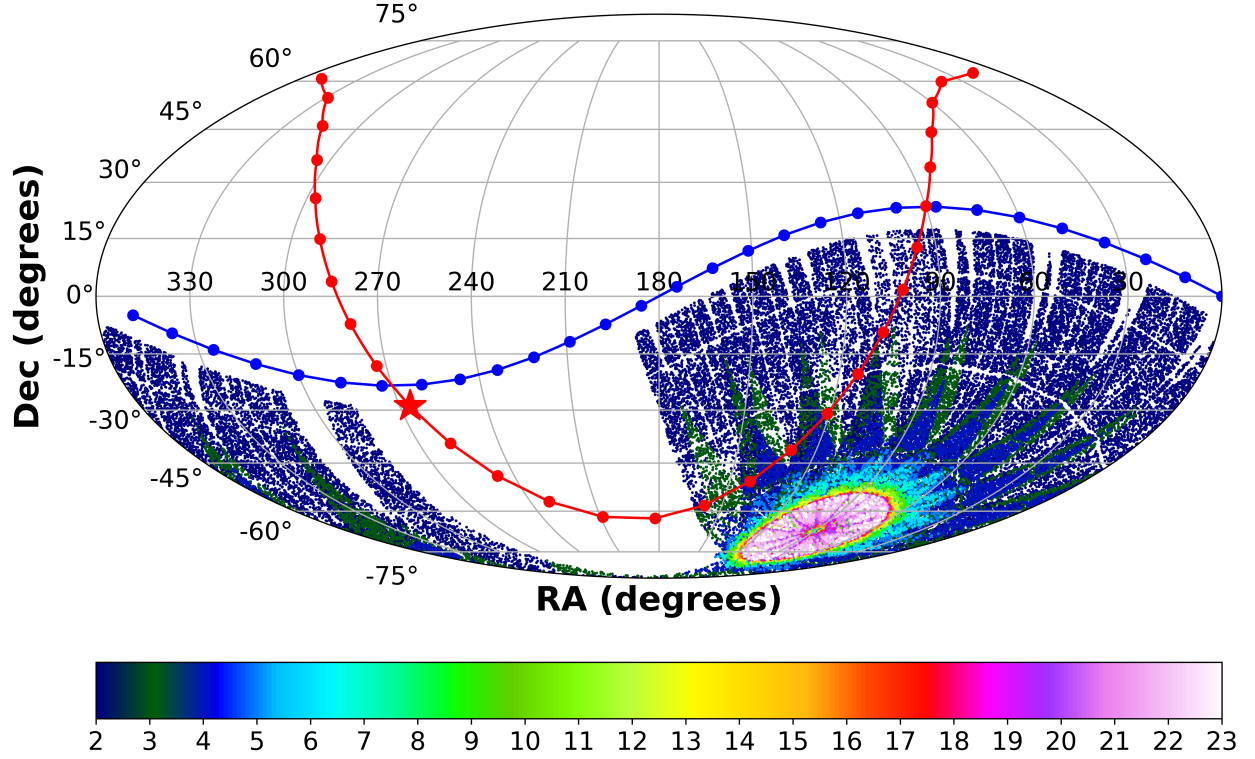


Figure 1: Right Ascension and Declination for TESS two-minute targets included in this multi-sector search, color-coded by the number of sectors in which that target was observed. The galactic and ecliptic planes are indicated by the red and blue lines, respectively.

correspond to observed data. Thus, a TCE may have a reported period between approximately 30 and 730 days even if the target was observed by a separation of ~ 730 days or more between TESS Years 1 and 3. Figure 3 shows an excess of TCEs at 1- and 2-year periods, partially caused by this ambiguity. Large systematic noise signals that repeat in TESS Years 1 and 3 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 100 ppm, but the bulk of the transit depths are considerably larger.

2.1 Systems With Transit Timing Variations

Although a majority of targets benefit with increased SNR and improved ephemerides from additional sectors of observation, systems with strong transit timing variations (TTVs) can result in inaccurate planet parameters in the longer duration multi-sector search. An example case is TOI 216.01 (TIC 55652896), where the correct system periods were not recovered in this multi-year search.

Table 1: Sectors Searched

Sector #	Physical Orbits	Start TJD ^a	End TJD	Data Release #
1	9,10	1325.293	1353.178	42
2	11,12	1354.101	1381.515	42
3	13,14	1385.897	1406.292	42
4	15,16	1410.900	1436.849	42
5	17,18	1437.826	1464.400	42
6	19,20	1468.270	1490.044	42
7	21,22	1491.626	1516.085	46
8	23,24	1517.342	1542.000	46
9	25,26	1543.216	1568.475	46
10	27,28	1569.432	1595.680	46
11	29,30	1596.772	1623.891	46
12	31,32	1624.950	1652.891	46
13	33,34	1653.915	1682.357	46
27	61,62	2036.273	2060.6412	38
28	63,64	2061.845	2087.097	41
29	65,66	2088.234	2114.433	43
30	67,68	2115.880	2143.221	45
31	69,70	2144.509	2169.944	47
32	71,72	2174.218	2200.231	48
33	73,74	2201.727	2227.572	49
34	75,76	2228.745	2254.065	50
35	77,78	2254.984	2279.979	51
36	79,80	2280.898	2305.988	52

^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	35387
3	7630
4	4200
5	1383
6	1060
7	571
8	604
9	1353
10	1107
11	246
12	210
13	203
14	159
15	119
16	135
17	143
18	228
19	282
20	496
21	576
22	1097
23	326

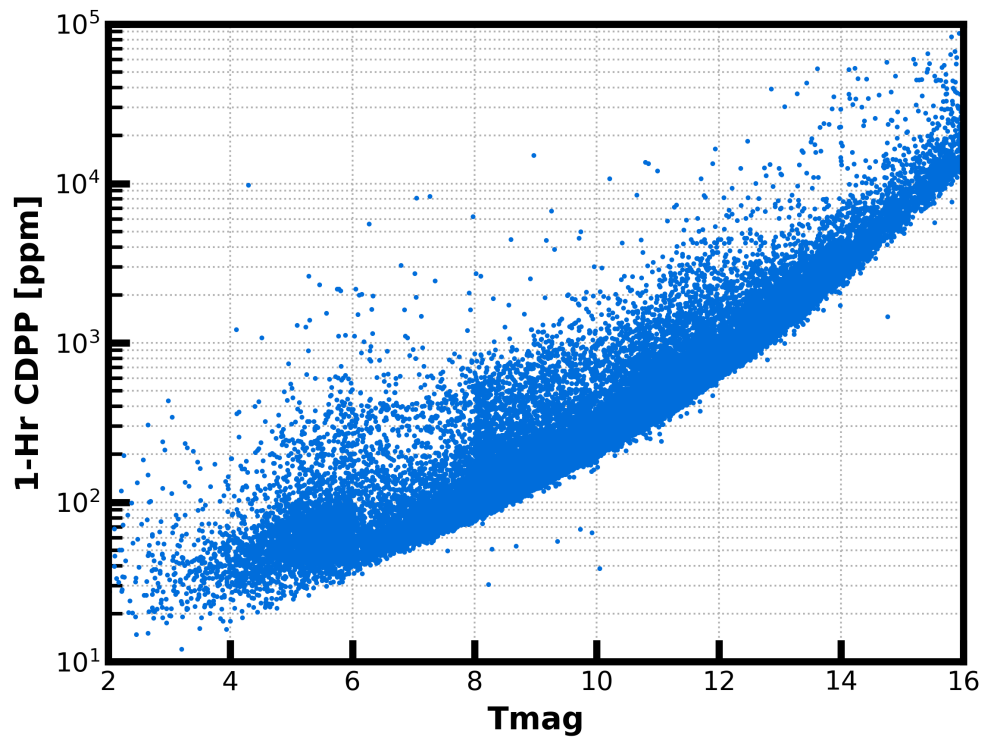


Figure 2: 1-hour CDPP. The points are RMS CDPP measurements for the 57515 light curves from the Sectors 1 – 36 multi-sector search plotted as a function of TESS magnitude.

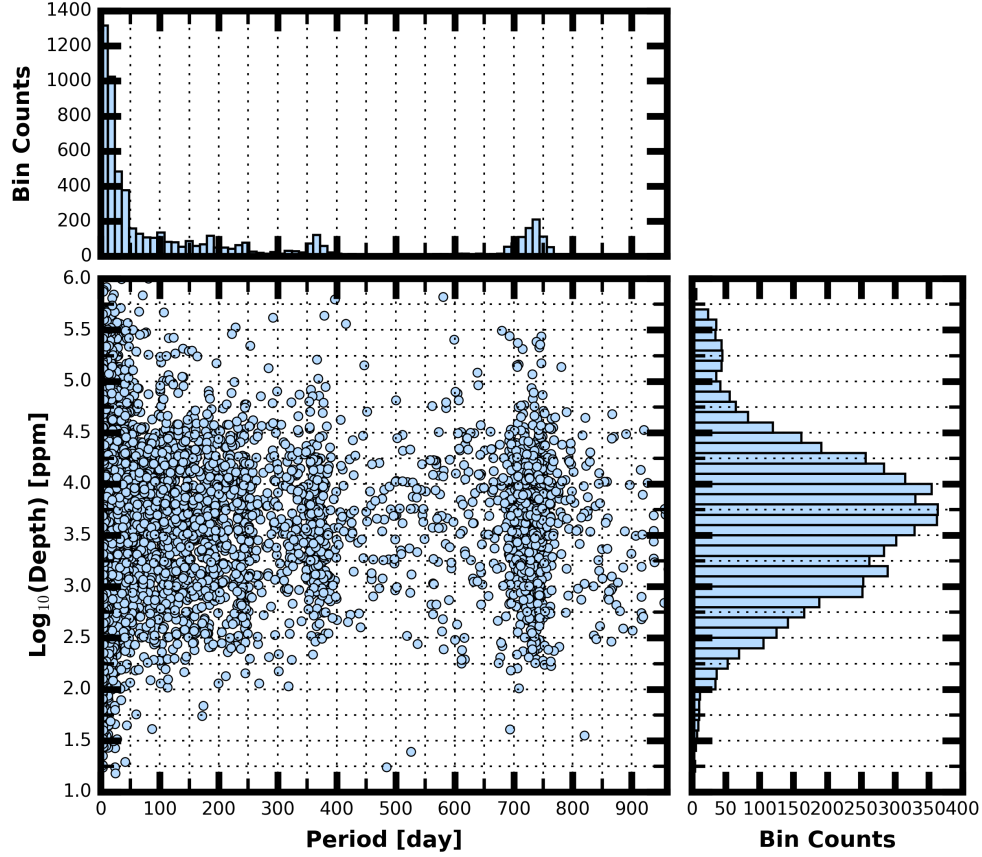


Figure 3: Lower Left Panel: Transit depth as a function of orbital period for the 12466 TCEs identified for the Sectors 1 – 36 multi-sector search. For enhanced visibility of long period detections, TCEs with orbital period < 3.0 day are not shown. Reported depth comes from the DV limb darkened transit 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.

Table 3: Sector 1 – 36 TCE Numbers

Number of TCEs	Number of Targets	Total TCEs
1	3517	3517
2	1805	3610
3	840	2520
4	401	1604
5	153	765
6	75	450
–	6791	12466

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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