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Data Columns in the Kepler TCE Table

The following tables list all of the data columns in the Kepler TCE tables that can be returned through the Exoplanet Archive's Application Programming Interface (API) and used in the TCE interactive table. A Threshold-Crossing Event (TCE) is a sequence of transit-like features in the flux time series of a given target that resembles the signature of a transiting planet to a sufficient degree that the target is passed on for further analysis. For more information, see the TCE release notes.

There are similar documents for other archive tables. See the API User Guide for a comprehensive list.

Additional Links:

- Kepler Extended Mission Archive Philosophy
- Exoplanet Archive Kepler Mission Resources

Questions about the structure and use of this table in the archive format should be submitted through the Exoplanet Archive's Helpdesk. Questions about the content descriptions should be sent to the Kepler Science Center.

Skip to a section:

1. Target Labels and Flags

Database Column Name	Table Label	Description
kepid†	KepID or Kepler Identification	Target identification number, as listed in the Kepler Input Catalog (KIC). The KIC was derived from a ground-based imaging survey of the Kepler field conducted prior to launch. The survey's purpose was to identify stars for the Kepler exoplanet survey by magnitude and color. The full catalog of 13 million sources can be searched at the MAST archive. The subset of 4 million targets found upon the Kepler CCDs can be searched via the Kepler Target Search form. The Kepler ID is unique to a target and there is only one Kepler ID per target.
tce_plnt_num†	Planet Number	Planet Number
tce_rogue_flag†	Rogue Flag	This flag addresses a bug in DR25 and earlier versions of TPS, which inadvertently allowed a subset of signals that fail the "three-transit weight check" (see Section 2 of the DR25 window function documentation, KSCI-19101) to become TCEs. The intent of the TPS algorithm was to fail signals that fail the "three-transit weight check." In order to enforce this intended criterion and create valid TCEs in a uniform manner, we have flagged 1498 of the 34032 TCEs identified in the DR25 pipeline run (Twicken et al. 2016) as "rogue" (or unintended) detections (i.e., tce_rogue_flag=1). These rogue TCEs are excluded from all subsequent analyses, so only the TCEs uniformly meeting the intended detection criteria (i.e., tce_rogue_flag = 0) are considered for inclusion in the DR25 KOI activity table and reflected in the DR25 occurrence rate products.
tce_delivname	Delivery Name	The TCE delivery name from the Kepler project. Possible values are: q1_q12_tce, q1_q16_tce, q1_q17_dr24_tce, and q1_q17_dr25_tce

rowupdate	Date of Last Update	Date of last update for this TCE
tce_datalink_dvs	Link to DV Summary	This is the relative path for the data validation summary; use it when retrieving individual reports through the archive's application programming interface with wget. You must append the following URL to the file name in your wget query: `https://exoplanetarchive.ipac.caltech.edu/data/KeplerData/`
tce_datalink_dvr	Link to DV Report	This is the relative path for the data validation report; use it when retrieving individual reports through the archive's application programming interface with wget. You must append the following URL to the file name in your wget query: `https://exoplanetarchive.ipac.caltech.edu/data/KeplerData/`

2. Transit Fit Parameters

Transit parameters delivered by the Kepler Project are typically best-fit parameters produced by a Mandel-Agol (2002) fit to a multi-quarter Kepler light curve, assuming a linear orbital ephemeris. Some of the parameters listed below are fit directly, other are derived from the best-fit parameters. Limb darkening coefficients are fixed and pre-calculated from host star properties. Orbital Period, Transit Epoch, Planet-Star Radius Ratio, Planet-Star Separation and mpact Parameter are the free parameters in the fit. Matrix covariances are adopted as errors to the fit parameters, they therefore ignore the effects of correlation between the fit parameters and are likely to be underestimates.

Database Column Name	Uncertainties Column (positive +) (negative -)	Displayed String Name	Table Label	Description
tce_period†	tce_period_err	tce_period_str	Orbital Period (days)	The interval between consecutive planetary transits.
tce_time0bk†	tce_time0bk_err	tce_time0bk_str	Transit Epoch (BJD - 2,454,833.0)	The time corresponding to the center of the first detected transit in Barycentric Julian Day (BJD) minus a constant offset of 2,454,833.0 days. The offset corresponds to 12:00 on Jan 1, 2009 UTC.
tce_time0	tce_time0_err	tce_time0_str	Transit Epoch in BJD	The time corresponding to the center of the first detected transit in Barycentric Julian Day (BJD).
tce_ror	tce_ror_err	tce_ror_str	Planet-Star Radius Ratio	The planet radius divided by the stellar radius.
tce_dor	tce_dor_err	tce_dor_str	Planet-Star Separation	The distance between the planet and the star at mid-transit divided by the stellar radius. For the case of zero orbital eccentricity, the distance at mid-transit is the semi-major axis of the planetary orbit.
tce_incl	tce_incl_err	tce_incl_str	Inclination (deg)	The angle between the plane of the sky (perpendicular to the line of sight) and the orbital plane of the planet candidate.
tce_impact†	tce_impact_err	tce_impact_str	Impact Parameter	The sky-projected distance between the center of the stellar disc and the center of the planet disc at conjunction, normalized by the stellar radius.
tce_duration†	tce_duration_err	tce_duration_str	Transit Duration (hrs)	The duration of the observed transits. Duration is measured from first contact between the planet and star until last contact. Contact times are typically computed from a best-fit model produced by a Mandel-Agol (2002) model fit to a multi-quarter Kepler light curve, assuming a linear orbital ephemeris.
tce_ingress	tce_ingress_err	tce_ingress_str	Ingress Duration (hrs)	The time between first and second contact of the planetary transit. Contact times are typically computed from a best-fit model produced by a Mandel-Agol (2002) model fit to a multi-quarter Kepler light curve, assuming a linear orbital ephemeris.
tce_depth†	tce_depth_err	tce_depth_str	Transit Depth (ppm)	The fraction of stellar flux lost at the minimum of the planetary transit. Transit depths are typically computed from a best-fit model produced by a Mandel-Agol (2002) model fit to a multi-quarter Kepler light curve, assuming a linear orbital ephemeris.
tce_eccen	tce_eccen_err	tce_eccen_str	Eccentricity	Eccentricity Value
tce_longp	tce_longp_err	tce_longp_str	Long. of Periastron (deg)	Longitude of Periastron
tce_limbdark_mod			Limb	A reference to the limb darkening model used to calculate stellar

			Darkening Model Name	limb darkening coefficients.
tce_ldm_coeff1, tce_ldm_coeff2, tce_ldm_coeff3, tce_ldm_coeff4			Limb Darkening Coefficients	Up to four coefficients (a_1, a_2, a_3, a_4) that define stellar limb darkening (e.g., Claret 2000). Limb darkening is the variation of specific intensity of the star as a function of $\mu = \cos(\theta)$. θ is the angle between the line-of-sight of an observer and a line perpendicular to the stellar surface at an observed point. Coefficients are dependent upon stellar temperature, surface gravity and metallicity. Adopted coefficients are required input for Mandel-Agol (2002) fits and are extracted from archived tables (e.g., Claret and Bloemen 2011). Limb darkening coefficients remain fixed during fit minimization. Note that the dependence of limb darkening coefficients upon stellar parameters implies that planet radius does not scale linearly with stellar radius. If new stellar parameters are adopted, the most-correct approach is to re-fit the transit with new limb-darkening coefficients in order to re-measure planet size.
tce_num_transits			Number of Transits	The number of expected transits or partially-observed transits associated with the planet candidate occurring within the searched light curve. This does not include transits that fall completely within data gaps.
tce_trans_mod			Transit Model	A reference to the transit model used to fit the data (e.g., Mandel-Agol 2002).
tce_full_conv			Full Convergence Flag	True or false. The model convergence indicates whether the fit converged to a solution. True indicates the fit was successful.
tce_model_snr†			Transit Signal-to-Noise (SNR)	Transit depth normalized by the mean uncertainty in the flux during the transits.
tce_model_chisq			Chi-Square	The goodness of the transit fit to the data. Within the TCE table this quantity is the χ^2 statistic. Within the KOI table this quantity is the reduced-χ^2 statistic, e.g., divided by the number of degrees of freedom in the fit.
tce_model_dof			Degrees of Freedom	The number of degrees of freedom used when fitting the transit model to the data.
tce_robstat			Robust Statistic	This statistic measures the significance of transit depth variations among the events that contribute to the potential TCE. In cases where the transit depths are consistent across all events, the robust statistic will equal the multiple event statistic (MES). The robust statistic will be less than the MES when the potential TCE consists of an inconsistent set of transit depths. As a result, the robust statistic is used by the pipeline to remove potential TCEs with significant transit depth variations, such as a single deep systematic event combined with numerous shallow events. A value significantly below the value of the MES indicates the TCE is made of inconsistent transit depths. The exact formulation of the robust statistic is found in Appendix A of Tenenbaum et al. (2013, ApJS, 206, 5).
tce_dof1			Degrees of Freedom 1	The degrees of freedom associated with the first chi-square discriminator. It is used along with Chi Square 1 to remove likely false-positives from the TCE list. For more information on how this value is used to remove false-positives, see Appendix B of Tenenbaum et al. (2013, ApJS, 206, 5), and in more detail in Seader et al. (2013, ApJS, 206, 25).
tce_dof2			Degrees of Freedom 2	The degrees of freedom associated with the second chi-square discriminator. It is used along with Chi Square 2 to remove likely false-positives from the TCE list. For more information on how this value is used to remove false-positives, see Appendix B of Tenenbaum et al. (2013, ApJS, 206, 5), and in more detail in Seader et al. (2013, ApJS, 206, 25).
tce_chisq1			Chi Square 1	The first chi-square discriminator is used along with the associated degrees of freedom and MES to remove likely false-positives from the TCE list. This statistic compares the single event statistic in the wavelet domain to what is expected given the noise. If the data match the model and the noise behaves as expected, this statistic should equal the degrees of freedom. Larger values indicate a poor match to the model given the

				estimate of the noise. The exact formulation of this statistic is described in Appendix B, equation B8, of Tenenbaum et al. (2013, ApJS, 206, 5) and in more detail in Seader et al. (2013, ApJS, 206, 25).
tce_chisq2			Chi Square 2	The second chi-square discriminator used along with the associated degrees of freedom and MES to remove likely false-positives from the TCE list. This statistic compares the measured temporal contributions to the multiple event statistic to what is expected. If the data matches the model and the noise behaves as expected, this statistic should equal the degrees of freedom. Larger values indicate a poor match to the model given the estimate of the noise. The exact formulation of this statistic is described in Appendix B, equation B13, of Tenenbaum et al. (2013, ApJS, 206, 5)) and in more detail in Seader et al. (2013, ApJS, 206, 25).
tce_chisqgofdof			Chi-Square GOF DOF	The degrees of freedom for the chi-square goodness of fit measurement (see Seader et al. 2015, Appendix B).
tce_chisqgof			Chi-Square GOF	The chi-square goodness of fit measures the difference between the amplitude of the detected signal in TPS and the signal-to-noise ratio of the transit fit in DV (see Seader et al. 2015, Appendix B).

† Default column: these columns display in the interactive table when the table is first loaded, and when **Reset Filters** is clicked.

3. Scaled Planetary Parameters

Scaled planetary parameters combine the dimensionless fit parameters with physical stellar parameters to produce planet characteristics in physical units.

Database Column Name	Uncertainties Column (positive +) (negative -)	Displayed String Name	Table Label	Description
tce_prad†	tce_prad_err	tce_prad_str	Planetary Radius (Earth radii)	The radius of the planet. Planetary radius is the product of the planet star radius ratio and the stellar radius.
tce_sma	tce_sma_err	tce_sma_str	Orbit Semi-Major Axis (au)	Half of the long axis of the ellipse defining a planet's orbit. For a circular orbit this is the planet-star separation. The semi-major axis is derived based on Kepler's third law, i.e., utilizing the orbital period and stellar mass, not scaling the planet-star separation by the stellar radius.
tce_eqt†	tce_eqt_err	tce_eqt_str	Equilibrium Temperature (K)	Approximation for the temperature of the planet. The calculation of equilibrium temperature assumes i) thermodynamic equilibrium between the incident stellar flux and the radiated heat from the planet, ii) a Bond albedo (the fraction of total power incident upon the planet scattered back into space) of 0.3, iii)that the planet and star are blackbodies, and iv) that the heat is evenly distributed between the day and night sides of the planet.
tce_insol†	tce_insol_err	tce_insol_str	Insolation Flux	The insolation flux derived from the transiting planet model fit for the TCE relative to the Solar flux received at the top of Earth's atmosphere. The theoretical habitable zone of a star is commonly given as a range of insolation fluxes.

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4. Stellar Parameters

Best-fit planetary transit parameters are typically normalized to the size of the host star. Physical planet parameters may be derived by scaling to the star's size and temperature. Transit parameters also depend weakly upon the limb darkening coefficients which are derived from the stellar parameters (e.g., Claret and Bloemen 2011). Stellar effective temperature, surface gravity, metallicity, radius, mass, and age should comprise a consistent set. Associated error estimates are 1-σ uncertainties.

Database Column Name	Uncertainties Column (positive +) (negative -)	Displayed String Name	Table Label	Description
tce_nkoi			Number of	The total number of TCEs detected on this target by DV during the

<table>
<tr><td></td><td></td><td></td><td>Associated KOIs</td><td>specified run. This should not be confused with the planet number, which is used to denote different TCEs on the same target.</td></tr>
<tr><td>tce_ioflag</td><td></td><td></td><td>Interesting Object Flag</td><td>This flag indicates the object is on the "list of interesting objects" posted by the Kepler project for the Q1-17 DR24 transit search.</td></tr>
<tr><td>tce_quarters</td><td></td><td></td><td>Quarters Passed</td><td>A string of seventeen zeroes and ones indicating which quarters contain data that were passed to Transit Planet Search (TPS). The left-most bit represents quarter 1 and the quarters increase to the right. A target with data in quarters 1, 3, 5, 7, 8, 13, 15, 17 will have the following string: <code>10101011000010101</code>.</td></tr>
<tr><td>tce_steff†</td><td>tce_steff_err</td><td>tce_steff_str</td><td>Stellar Effective Temperature (K)</td><td>The photospheric temperature of the star.</td></tr>
<tr><td>tce_slogg†</td><td>tce_slogg_err</td><td>tce_slogg_str</td><td>Stellar Surface Gravity ($\log_{10}$(cm s^{-2})</td><td>The base-10 logarithm of the acceleration due to gravity at the surface of the star.</td></tr>
<tr><td>tce_smet</td><td>tce_smet_err</td><td>tce_smet_str</td><td>Stellar Metallicity (dex)</td><td>The base-10 logarithm of the Fe to H ratio at the surface of the star, normalized by the solar Fe to H ratio.</td></tr>
<tr><td>tce_sradius†</td><td>tce_sradius_err</td><td>tce_sradius_str</td><td>Stellar Radius (Solar radii)</td><td>The photospheric radius of the star.</td></tr>
<tr><td>tce_steff_prov</td><td></td><td></td><td>Stellar Effective Temperature Provenance</td><td rowspan="3">A flag describing the source of the stellar effective temperature, surface gravity and metallicity.
• KIC = the parameters are extracted from the Kepler Input Catalog (Brown et al. 2011). Uncertainties of Teff = 200 K, log(g) = 0.3 dex and [Fe/H] = 0.4.
• J-K = the star is unclassified in the KIC, J-K has been used to estimate temperature. The host star is assumed to be on the ZAMS with corresponding log(g) based on the Schmidt-Kaler relation.
• Pinsonneault = uses a revised T_{eff} scale from Pinsonneault et al. (2012) with [Fe/H] fixed at -0.2. The quantity log(g) is taken from the KIC. Values are then revised by fitting to Yonsei-Yale stellar evolution models (Yi et al. 2001).
• SPE = Spectroscopy
• PHO = Photometry
• TRA = Transits or Eclipsing Binaries
• AST = Asteroseismology
• Solar = No physical parameters are known for this object and so the pipeline used Solar values. These values were used directly without fitting.

If the letter code is trailed by a number, the number corresponds to a specific paper. That list is available here.</td></tr>
<tr><td>tce_slogg_prov</td><td></td><td></td><td>Stellar Surface Gravity Provenance</td></tr>
<tr><td>tce_smet_prov</td><td></td><td></td><td>Stellar Metallicity Provenance</td></tr>
<tr><td>tce_sradius_prov</td><td></td><td></td><td>Stellar Radius Provenance</td><td>The internal parameters (R, M, rho) codes:
• DSEP = Based on Dartmouth Stellar Evolution Program. DSEP given without a reference number corresponds to values derived with the model grid presented in Huber et al. 2013.
• MULT = Based on multiple evolutionary tracks/isochrones, including DSEP

If the letter code is trailed by a number, the number corresponds to a specific paper. That list is available here.</td></tr>
</table>

† Default column: these columns display in the interactive table when the table is first loaded, and when **Reset Filters** is clicked.

5. Trapezoidal Fit Parameters

A trapezoidal model is fit to a quarter-stitched, harmonics removed, detrended light curve at the TCE's period. Cadences during transit are given zero weight during the detrending. The fitted parameters for the trapezoidal fit are epoch (BKJD), transit duration (hours), ingress time (hours), and transit depth (ppm). The full convergence parameter is set to true when the fit is successful (see Garcia, D., Computational Statistics & Data Analysis, 2010, 54, 1167 for further details).

Database Column Name	Uncertainties Column (positive +) (negative -)	Displayed String Name	Table Label	Description
tcet_period	tcet_period_err	tcet_period_str	Orbital Period	Orbital period in days for the trapezoidal model fit to the detrended flux time series associated with the TCE. The orbital period is fixed to the value found by the transiting planet search for the given TCE.
tcet_time0bk	tcet_time0bk_err	tcet_time0bk_str	Transit Epoch [BKJD]	Zero-point for the trapezoidal model fit to the detrended flux time series in Kepler BJD (BJD – 2,454,833.0) for the given TCE.
tcet_time0	tcet_time0_err	tcet_time0_str	Transit Epoch [BJD]	Zero-point for the trapezoidal model fit to the detrended flux time series in BJD for the given TCE.
tcet_duration	tcet_duration_err	tcet_duration_str	Transit Duration	Transit duration in hours for the trapezoidal model fit to the detrended flux time series for the given TCE.
tcet_ingress	tcet_ingress_err	tcet_ingress_str	Transit Ingress Duration	Transit ingress time in hours for the trapezoidal model fit to the detrended flux time series for the given TCE.
tcet_depth	tcet_depth_err	tcet_depth_str	Transit Depth	Transit depth in ppm for the trapezoidal model fit to the detrended flux time series for the given TCE.
tcet_full_conv			Trap Fit Convergence	The model convergence indicates whether the trapezoidal fit converged to a solution. True indicates the fit was successful.
tcet_model_dof			Trap Fit Degrees of Freedom	The number of degrees of freedom used when fitting the trapezoidal model to the data.
tcet_model_chisq			Trap Fit model Chi-Square	The goodness of the trapezoidal fit to the data. This quantity is the chi-squared statistic.

6. Weak Secondary Test

Afer finding a transit signature (or threshold-crossing event, TCE), the pipeline searches for a secondary eclipse and provides statistics to determine ig the identified event is real. This is done by removing the primary transit signature from the light curve and recalculating the multiple-event statistic (MES) for the same period and duration. The phase where the resulting MES time series reaches maximum is regarded as the "significant secondary" event and used to evaluate the results of this test. Occasionally, the largest MES event is associated with a feature in the light curve that is not a secondary event, such as the edge of the primary or another planet in the system.

Database Column Name	Table Label	Description
wst_robstat	Weak Secondary Robust Statistic	The robust statistic computed for the possible secondary event identified at the maxMES Phase. This statistic measures the significance of the transit signal after suppressing the contribution of statistical outlying observations. If its value is small, the detected secondary signal may not be an astrophysical eclipse.
wst_depth	Weak Secondary Depth	The fitted depth, in parts per million, of the most significant secondary transit signature.
tce_mesmedian	Weak Secondary Median MES	Median value over all phases of all MES values computed at the

		period and pulse duration of the TCE in the absence of the primary transit event. If significantly different than zero, it may indicate that there are systematic features in the light curve at the TCE's period and duration.
tce_mesmad	Weak Secondary MAD-MES	Median absolute deviation over all phases of the multiple event statistic computed at the period and pulse duration of the TCE in the absence of the primary transit event. If the MAD-MES is comparable to the identified secondary's maxMES, then the secondary may not be a significant detection.
tce_maxmes	Weak Secondary max MES	Statistic (MES), similar to SNR, of the most significant secondary at the same period and duration as the primary.
tce_minmes	Weak Secondary min MES	Minimum multiple-event statistic over all phases computed at the period and pulse duration of the TCE in the absence of the primary transit events. The minimum MES is the significance of the largest positive excursion associated with the TCE, which, if significant, may indicate there are systematic features in the light curve at the TCE's period and duration.
tce_maxmesd	Weak Secondary max MES Phase	Phase, in barycentric days offset by 2454833, associated with the largest detected secondary event. The phase zero-point is the center of the original TCE's primary transit.
tce_minmesd	Weak Secondary min MES Phase	Phase in days associated with the minimum multiple-event statistic for the largest positive excursion associated with the TCE. The phase zero-point is the center of the original TCE's primary transit.

7. Light Curve-Based KOI Vetting Statistics

The Transiting Planet Search (TPS) module of the Kepler data analysis pipeline performs a detection test for planet transits in the multi-quarter, gap-filled flux time series. The TPS module detrends each quarterly PDC light curve to remove edge effects around data gaps and then combines the data segments together, filling gaps with interpolated data so as to condition the flux time series for a matched filter. The module applies an adaptive, wavelet-based matched filter (Jenkins 2002, Jenkins et al. 2010 and Tenenbaum et al. (2012)) to perform a joint characterization of observation noise and detection of transit-like features in the light curve.

The TPS module estimates the Power Spectral Density of the flux time series as a function in time. This provides coefficients for a whitening filter to accommodate non-stationary, non-white noise and yields Single Event Statistic (SES) time series components. These can be interpreted as measurements of the statistical significance of the presence of a transit of trial duration at each point in the time series.

Single Event Statistics are folded at each trial orbital period and the maximum Multiple Event Statistic (MES) is obtained over all trial periods and phases. The MES estimates the signal to noise ratio of the putative transit-like sequence against the measurement noise. The MES threshold for defining the sample of Threshold-Crossing Events (TCEs) is provided within the Release Notes. For reference, a lower MES threshold of 7.1σ limits the number of false positives in the TCE sample due to statistical random noise to less than 1 over the primary mission (Jenkins, Caldwell and Borucki 2002).

Database Column Name	Table Label	Description
tce_max_sngle_ev	Single Event Statistic	The maximum calculated value of the SES. Maximum SES statistics for different TCEs from the same target differ because the most significant TCE is removed from the time series before repeating the test for further, weaker transit signals.
tce_max_mult_ev	Multiple Event Statistic (MES)	The maximum calculated value of the MES. TCEs that meet the maximum MES threshold criterion and other criteria listed in the TCE release notes are delivered to the Data Validation (DV) module of the Kepler data analysis pipeline for transit characterization and the calculation of statistics required for disposition. A TCE exceeding the maximum MES threshold are removed from the time-series data and the SES and MES statistics recalculated. If a second TCE exceeds the maximum MES threshold then it is also propagated through the DV module and the cycle is iterated until no more events exceed the criteria. Candidate multi-planet systems are thus found this way. Users of the TCE table can exploit the maximum MES statistic to help filter and sort samples of TCEs for the purposes of discerning the event quality, determining the likelihood of planet candidacy, or assessing the risks of observational follow-up.
tce_minmes	Minimum MES	
tce_mesmad	Median Absolute Deviation (MAD) MES	

tce_bin_oedp_sig	Odd-Even Depth Comparison Statistic	A transit model is fit independently to the even-numbered transits and the odd-numbered transits. The depth of the fit to even-numbered transits is compared to that of the odd-numbered transits. A statistically significant difference in the transit depths is an indication of a planetary candidate false positive, due either to a background binary contaminant in the light curve or a binary star system displaying a grazing eclipse. The odd-even depth statistic is a number by which the depths of the odd transit and even transit fits deviate. The larger the statistic, the more likely the event is an astrophysical false positive. The odd-even diagnostic is only useful for identifying circular or near-circular binary stars. The TCE table provides the statistic by a percentage likelihood of depth mis-match, whereas the KOI table provides the statistic in terms of the number of σ deviating from equal depth.
tce_rmesmad	Calculated Ratio MES over MAD MES	
tce_rsnrmes	Calculated Ratio SNR over MES	
tce_rminmes	Calculated Ratio Min. MES over MES	

8. Secondary Event Results

Database Column Name	Table Label	Description
tce_albedo	Secondary Geometric Albedo	The geometric albedo of a planet that would produce the observed secondary depth when occulted by the host star, given the planet's radius and semi-major axis, assuming all light from the planet is due to reflection. The geometric albedo is given by D * (a^2) / (Rp^2), where D is secondary eclipse depth (wst_depth), a is semi-major axis, and Rp is planet radius. Values greater than 1 indicate the TCE is caused by a self-luminous companion (i.e., the system is an eclipsing binary).
tce_ptemp	Planet Effective Temperature	The effective temperature of a planet that is consistent with the observed secondary depth when occulted by the host star. This is calculated using the planet's and star's radii and the system's semi-major axis, assuming all light from the planet is due to thermal emission. The planetary effective temperature is given by (D^1/4) * Teff / (Rp/R*)^1/2, where Rp/R* is tce_ror, Teff is tce_steff, and D is wst_depth.
tce_albedo_stat	Albedo Comparison Statistic	The difference between the geometric albedo associated with the most significant secondary event and 1.0. The value is given in units of standard deviations. The TCE is likely to be a false positive if the maximum secondary multiple-event statistic is above the transit detection threshold and the albedo comparison statistic is statistically significant.
tce_ptemp_stat	Effective Temperature Comparison Statistic	The difference between the planet effective temperature associated with the most significant secondary event and the planet equilibrium temperature. The value is given in units of standard deviations. The TCE is likely to be a false positive if the secondary maximum multiple event statistic is above the transit detection threshold and the temperature comparison statistic is statistically significant.

9. Autovetter Parameters

The autovetter is a machine-learning classifier that dispositions TCEs into the three classes: PC (Planet Candidate), AFP (Astrophysical False Positive) and NTP (Non-Transiting Phenomenon). It uses the Random Forest, a decision tree-based machine learning technique, and also provides a Bayesian determination of the posterior probability for the TCE to be in each of the three classes. For TCEs classified as PCs, the posterior probability to be in the class PC is a measure of our confidence in the classification.

The autovetter "learns" heuristics developed by TCERT as well as other diagnostics, then applies them uniformly and consistently to classify the TCEs and produces a catalog of planet candidates.

For more detail about the autovetter and its random forest underpinning, see Automatic Classification of Kepler Planetary Transit Candidates, McCauliff et al. 2015 ApJ 806, 6.

The autovetter requires two inputs:

1. **The attributes matrix:** Attributes are the ~100 scalar values that are computed for each TCE. They range from fitted transit parameters (such as period, transit depth, transit epoch), to diagnostic metrics such as maximum ephemeris correlation with TCEs on other stars. The attributes matrix has a row for each TCE and a column for each attribute.

2. **Training data**: The training data set consists of labels (**PC**=planet candidate, **AFP**=astrophysical false positive, **NTP**=non-transiting phenomena) for a subset of several thousand TCEs. PC labels are derived entirely from TCERT dispositions. AFP and NTP labels come from TCERT dispositions combined with other diagnostics. For the purpose of training the autovetter, these dispositions are considered to be "ground truth." For more detail about how the training set is constructed, see Autovetter Planet Candidate Catalog for Q1-Q17 Data Release 24 (KSCI-19091).

The autovetter was only run on DR 24 and produced the following outputs for each TCE:

- An autovetter-determined classification of PC, AFP or NTP.
- Random forest vote fraction, in percent, for each class (PC, AFP, NTP).
- Uncertainy in random forest vote fraction, in percent, for each class.
- Posterior probabilities for the TCE to be in each of the three classes.
- Training label (PC, AFP, or NTP), if the TCE was in the training set.

Database Column Name	Table Label	Description
av_vf_pc	Autovetter Planet Candidate Vote Fraction [percent]	Vote fraction value for Planet Candidate class
av_vf_pc_err	Autovetter Planet Candidate Vote Fraction Error [percent]	The error in the mean class vote fraction from a set of 10 random forest runs is the standard deviation in the class vote fraction divided by the square root of 10.
av_vf_afp	Autovetter Astrophysical False Positive Vote Fraction [percent]	Vote fraction value for Astrophysical False Positive class
av_vf_afp_err	Autovetter Astrophysical False Vote Fraction Error [percent]	The error in the mean class vote fraction from a set of 10 random forest runs is the standard deviation in the class vote fraction divided by the square root of 10.
av_vf_ntp	Autovetter Non-Transiting Phenomena Vote Fraction [percent]	Vote fraction value for Non-Transiting Phenomena class
av_vf_ntp_err	Non-Transiting Phenomena Vote Fraction Error [percent]	The error in the mean class vote fraction from a set of 10 random forest runs is the standard deviation in the class vote fraction divided by the square root of 10.
av_pp_pc	Autovetter Planet Candidate Posterior Probabilities [percent]	Posterior probabilities for Planet Candidate class.
av_pp_afp	Autovetter Astrophysical False Positive Posterior Probabilities [percent]	Posterior probabilities for Astrophysical False Positive class.
av_pp_ntp	Autovetter Non-Transiting Phenomena Posterior Probabilities [percent]	Posterior probabilities for Non-Transiting Phenomena class.
av_training_set	Autovetter Training Set Label	If the TCE was included in the training set, the training label encodes what is believed to be the "true" classification, and takes a value of either **PC**, **AFP** or **NTP**. The TCEs in the UNKNOWN class sample are marked **UNK**. Training labels are given a value of NULL for TCEs not included in the training set. For more detail about how the training set is constructed, see *Autovetter Planet Candidate Catalog for Q1-Q17 Data Release 24* (KSCI-19091).
av_pred_class	Autovetter Predicted Classification	Predicted classifications, which are the "optimum MAP classifications." Values are either **PC**, **AFP**, or **NTP**.

10. Bootstrap Statistics

Database Column Name	Table Label	Description
boot_fap	Bootstrap False Alarm Probability	The Probability of False Alarm (PFA) is defined to be the integral part of the distribution of the null detection statistic above the value of the detection statistic returned by the search. The probability density function of the null Multiple Event Statistic (MES) is estimated by a bootstrap algorithm. Nominally, the null MES is Gaussian distributed with zero mean and unit variance. In reality, however, due to imperfections in the whitening process, the distribution of the null MES deviates from this nominal distribution form. The PFA is then calculated from the corresponding cumulative distribution function of the null MES using the search threshold of 7.1 sigma.

boot_mesthres	Bootstrap MES Threshold	The threshold required, given the distribution of the MES estimated from the bootstrap algorithm, to achieve the same PFA as using a 7.1 sigma threshold on a Gaussian distribution with zero mean and unit variance (~6.24e-13).
boot_mesmean	Bootstrap Mean of MES Distribution	The mean of the best-fit Gaussian distribution to the null MES distribution estimated by the bootstrap.
boot_messtd	Bootstrap Standard Deviation of MES Distribution	The standard deviation of the best-fit Gaussian distribution to the null MES distribution estimated by the bootstrap.

11. Ghost Diagnostic

The ghost diagnostic determines whether a transit signature is likely the result of an optical ghost. If the core aperture correlation statistic is smaller than the halo aperture correlation statistic, then contamination by an optical ghost is likely.

Database Column Name	Table Label	Description
tce_cap_stat	Ghost Core Aperture Statistic	This statistic measures the correlation between the transit model and the average flux per pixel in the core aperture minus the average flux per pixel in the halo aperture. The core aperture is the optimal photometric aperture associated with the target in each quarter. It is assumed that null correlation statistics are drawn from a standard normal distribution.
tce_hap_stat	Ghost Halo Aperture Statistic	This statistic measures the correlation between the transit model and the average flux per pixel in the halo aperture. The halo aperture is an annulus surrounding the optimal photometric aperture associated with the target in each quarter. It is assumed that null correlation statistics are drawn from a standard normal distribution.

12. Rolling Band Contamination Histogram

A temperature-sensitive amplifier oscillation at >1 GHz on some channels can super-impose a Moir� pattern on the CCD readout by sampling the high-frequency oscillation at the 3MHz serial-pixel clocking rate. Since the amplifier oscillation frequency drifts with the temperature of the electronic components by as much as 500 kHz/�C, the signal from a given pixel in a series of dark images has a time varying signature. This signature may be highly correlated with neighboring pixels and yet poorly correlated with slightly more distant pixels. When the oscillation frequency is a harmonic of the serial clocking frequency, the sampled high frequency oscillation produces an offset from the mean bias-level in the image 10 to 100 rows wide across all CCD columns. As the high frequency drifts with temperature, the rows on the image where this shift occurs move up or down producing a Rolling Band Artifact (RBA). The signature of a rolling band is a time-varying displacement in trailing black spatial fit residual time series. Convolution of a square wave transit kernel with this time series produces a time series of detected transit depths. Normalizing by the uncertainty in detected transit depth produces a time series of detection statistics in sigma. DV reports significant RBAs that are correlated with the ephemeris of the TCE for the rows that make-up its optimal aperture.

Database Column Name	Table Label	Description
tce_tb_tpdur	Test Pulse Duration	The pulse duration (in units of long cadences) used to report detected RBAs in the black residuals. The chosen transit duration is usually the one that is closest to the transit duration associated with the given TCE.
tce_rb_tcount$i$	Transit Counts i (where i=0,1,2,3,4)	The number of transits for the given TCE coincident with rolling band artifacts at a level indicated by the column name. The number of impacted transits are given for five different levels, they are 0: 0--1, 1: 1--2, 2: 2--3, 3:3-- 4, and 4: >=4. The severity levels are in units of sigma. The maximum severity level over all rows in the optimal aperture is reported as the severity for the target on each cadence. Transits are not counted at any severity level when they occur on cadences where the rolling band flags are undefined. The number of transits shown for a severity level of zero is reported on the one-page DV summaries as the parameter RollingBand-fgt.

13. Pixel-Based KOI Vetting Statisics

Planetary transit false positives are commonly caused by light curve contamination from an eclipsing binary falling partially within the target aperture (i.e., the pixels used to collect and sum target flux). Two pixel analysis methods are used to identify such eclipsing binaries: flux-weighted centroiding, which measures how the center of light in the collected pixels changes during a transit, and PRF-fit difference images, which localize the source of the transit signal. Both methods provide an estimate of the location of the source of the transit signal. When that source location is offset from the target star by more than 3-σ, it is likely that the transit signal is due to a background source (note the caveats due to crowding described below). These analysis techniques use pixel-level data, available in the Target Pixel Files (TPFs). The resulting position measurements are compared with the Kepler Input Catalog (KIC) (Brown et al. 2011).

In flux-weighted centroid analysis, when more than one source is present within a pixel aperture, either fully or partially, then the combined center of light within the collected pixels will occur between the locations of the sources. When the flux from either the target or one of the nearby contaminants varies in a transit or eclipse, then the combined center of light within the aperture will move across the focal plane. This motion is called a centroid shift. The location of the varying source can often be inferred from the centroid shift. The size and direction of the centroid shift is measured using the flux-weighted (FW) mean, (e.g., the first moment of the pixel data). This mean is computed with every flux measurement (30-minute long cadence), creating a time series of flux-weighted means. The centroid shift is measured by comparing portions of the flux-weighted mean time series that are Out-Of-Transit (OOT) with portions that are In-Transit (IT). The flux-weighted shift of the IT mean from the OOT mean is given as Right Ascension and Declination shifts. The offset of the transiting source object from the OOT flux-weighted mean is computed by taking the product of the FW shift and the factor [1 - 1 / (fractional transit depth)]. The Right Ascension, α (J2000), and Declination, δ (J2000), of the transiting object calculated in this way are reported in the table. The α and δ offsets of the resulting source location from the KIC target star position are also reported. The uncertainties and significance of the FW shifts and offsets are provided but do not reflect systematics caused by crowding. The flux-weighted method can be very accurate when the target star is well isolated and the transit source is located (well) within the flux aperture associated with the target star.

The PRF-fit difference image method uses three images: i) an average of Out-Of-Transit (OOT) Target Pixel File images from data that were obtained near but not during transit events, ii) an average of In-Transit (IT) image Target Pixel File images that were collected during transit events, and iii) a Difference Image (DIFF) that is the difference between the Out-Of-Transit and In-Transit average images. The difference image provides an image of the transit source (neglecting variability of field stars). The Pixel Response Function (PRF) is a convolution of the Kepler Point Spread Function model with a model of typical spacecraft pointing jitter, providing a system point spread function (Bryson et al. 2010). The PRF is fit separately to the OOT and DIFF images, providing a measured location of the target star (fit to the OOT image) and a measured location of the transit source (fit to the DIFF image). The offset of the transit source location from the target star is given in the table as Right Ascension and Declination offsets (Δα,Δδ) as well as magnitude (sky offset Δθ).

PRF offsets can only be computed on a per-quarter basis. The single quarter (SQ) PRF offsets are combined by a weighted mean.

The target position measured by the PRF fit to the OOT images is vulnerable to crowding. Therefore an alternative PRF offset of the transit source (measured by the PRF fit to the DIFF image) from the KIC position of the target star is provided. Both the flux-weighted and PRF-fit methods will have systematic errors due to crowding when other stars appear in the aperture's pixels, though these error are smaller for the PRF-fit method compared to the flux-weighted method.

The associated error estimates are 1-σ uncertainties.

Database Column Name	Uncertainties Column (positive +) (negative -)	Displayed String Name	Table Label	Description
tce_fwm_stat			Flux-Weighted Offset Significance (percent)	Indicates whether there is a statistically significant flux-weighted offset between in-transit and out-of-transit images. 100% indicates there is no offset and there is confidence that the transit is on the target star. The accuracy of this calculation degrades when the transit source has significant flux that falls outside the photometric aperture + a halo of pixels around it.
tce_fwm_sra	tce_fwm_sra_err	tce_fwm_sra_str	FW Source α(OOT) (hours)	The Right Ascension (J2000) of the location of the transiting object calculated from the flux-weighted centroids. This result does not reflect the systematics due to crowding which can introduce significant errors in the calculated position
tce_fwm_sdec	tce_fwm_sdec_err	tce_fwm_sdec_str	FW Source δ(OOT) (degrees)	The Declination (J2000) of the location of the transiting object calculated from the flux-weighted centroids. This result does not reflect the systematics due to crowding which can introduce significant errors in the calculated position.
tce_fwm_srao	tce_fwm_srao_err	tce_fwm_srao_str	FW Δα(OOT)(seconds (not arcseconds))	The RA (J2000) flux-weighted centroid shift. This is the RA of the in-transit flux

				weighted centroid minus the RA of the out-of-transit flux weighted centroid.
tce_fwm_sdeco	tce_fwm_sdeco_err	tce_fwm_sdeco_str	FW Δδ(OOT) (arcseconds)	The Dec (J2000) flux-weighted centroid shift. This is the Dec of the in-transit flux weighted centroid minus the Dec of the out-of-transit flux weighted centroid.
tce_fwm_prao	tce_fwm_prao_err	tce_fwm_prao_str	FW Source Δα(OOT) (seconds (not arcseconds))	The calculated Right Ascension offset of the transiting or eclipsing object from the KIC location of the target star. The accuracy of this calculation degrades when the transit source has significant flux that falls outside the photometric aperture + a halo of pixels around it.
tce_fwm_pdeco	tce_fwm_pdeco_err	tce_fwm_pdeco_str	FW Source Δδ(OOT) (arcseconds)	The calculated Declination offset of the transiting or eclipsing object from the KIC location of the target star. The accuracy of this calculation degrades when the transit source has significant flux that falls outside the photometric aperture + a halo of pixels around it.
tce_dicco_mra	tce_dicco_mra_err		PRF $\Delta\alpha_{SQ}$(OOT) (arcseconds)	The angular offset in the RA (J2000) direction between the best-fit PRF centroids from the Out-Of-Transit image and the Difference Image by averaging the weighted single-quarter measurements. The out-of-transit centroids are subtracted from the difference image centroids.
tce_dicco_mdec	tce_dicco_mdec_err	tce_dicco_mdec_str	PRF $\Delta\delta_{SQ}$(OOT) (arcseconds)	The angular offset in the Dec (J2000) direction between the best-fit PRF centroids from the Out-Of-Transit image and the Difference Image by averaging the weighted single-quarter measurements. The out-of-transit centroids are subtracted from the difference image centroids.
tce_dicco_msky	tce_dicco_msky_err	tce_dicco_msky_str	PRF $\Delta\theta_{SQ}$(OOT) (arcseconds)	The angular offset on the plane of the sky between the best-fit PRF centroids from the Out-Of-Transit image and the Difference Image by averaging the weighted single-quarter measurements. The out-of-transit centroids are subtracted from the difference image centroids.
tce_dikco_mra	tce_dikco_mra_err	tce_dikco_mra_str	PRF $\Delta\alpha_{SQ}$(KIC) (arcseconds)	The angular offset in the RA (J2000) direction between the best-fit PRF centroids from the difference image and the Kepler Input Catalog position by averaging the weighted single-quarter measurements. The KIC position is subtracted from the difference image centroids.
tce_dikco_mdec	tce_dikco_mdec_err	tce_dikco_mdec_str	PRF $\Delta\delta_{SQ}$(KIC) (arcseconds)	The angular offset in the Dec (J2000) direction between the best-fit PRF centroids from the difference image and the Kepler Input Catalog position by averaging the weighted single-quarter measurements. The KIC position is subtracted from the difference image centroids.
tce_dikco_msky	tce_dikco_msky_err	tce_dikco_msky_str	PRF $\Delta\theta_{SQ}$(KIC) (arcseconds)	The angular offset in the plane of the sky between the best-fit PRF centroids from the difference image and the Kepler Input Catalog position by averaging the weighted single-quarter measurements. The KIC position is subtracted from the difference image centroids.

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