K2 Data Release Notes 27: Campaign 18

KSCI-19143-002

K2 Data Analysis Working Group

September 14, 2020

NASA Ames Research Center
Moffett Field, CA 94035
These data release notes were originally prepared by members of the Data Analysis Working Group, and made available as webpages in October, 2018, when the data were originally delivered to the Milksulski Archive for Space Telescopes. They are reproduced here for permanent archiving, with edits for clarity and consistency.

Approved by: ____________________________ Date: 2020-09-14
Douglas Caldwell, Data Analysis Working Group Lead

Approved by: ____________________________ Date: 2020-09-14
Jeffrey L. Coughlin, Science Office Director
Document Control

Ownership

This document is part of the Kepler Project Documentation that is controlled by the Kepler Project Office, NASA/Ames Research Center, Moffett Field, California.

Control Level

This document will be controlled under KPO @ Ames Configuration Management system. Changes to this document shall be controlled.

Physical Location

The physical location of this document will be in the KPO @ Ames Data Center.

Distribution Requests

To be placed on the distribution list for additional revisions of this document, please address your request to the Kepler Science Office:

Jeffrey L. Coughlin
Kepler Science Office Director
MS 244-30
NASA Ames Research Center
Moffett Field, CA 94035-1000
kepler-scienceoffice@lists.nasa.gov
# DOCUMENT CHANGE LOG

<table>
<thead>
<tr>
<th>CHANGE DATE</th>
<th>REVISION</th>
<th>PAGES AFFECTED</th>
<th>CHANGES/NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 29, 2020</td>
<td>001</td>
<td>All</td>
<td>Original release</td>
</tr>
<tr>
<td>September 14, 2020</td>
<td>002</td>
<td>Sections 2 and 3</td>
<td>Clarified that asteroid Aphophis was not actually observed due to observations ending before it entered the field of view. Updated section 3.2 to reflect updated FITS headers and time values for EPIC 200233235’s TPF. Removed the section “Missing CDPP Values for 50% of Non-Custom Targets” as MAST has updated these FITS files to now include the (previously missing) CDPP values. Also, previous release notes erroneously reported CDPP measurements were based on 6.5-hr duration; corrected to 6.0-hr duration CDPP.</td>
</tr>
</tbody>
</table>
1 At a Glance

1.1 Pointing
- RA: 130.1610170 degrees
- Dec: 16.8278629 degrees
- Roll: 165.8977388 degrees

1.2 Targets with Data at MAST
- 36,909 EPIC IDs in long cadence (LC)
- 237 EPIC IDs in short cadence (SC)
- Many custom targets (see §2.4)

1.3 Full-Frame Images (FFI)
- ktwo2018143080022-c18_ffi-cal.fits

1.4 First and Last Cadences
- Start Time: 2018-05-13 00:44:43 UTC
  - Long Cadence Number: 161969
  - Short Cadence Number: 4847530
- End Time: 2018-07-02 21:51:26 UTC
  - Long Cadence Number: 164458
  - Short Cadence Number: 4922229

1.5 Pipeline
No features of the pipeline or data files have changed from Data Release 26.

Figure 1: Distribution of the Kepler magnitudes of observed LC targets.

Figure 2: Left: Schematic of the C18 field-of-view with high-profile objects shown. Right: A full-frame image (FFI) taken during C18, with a flux scaling designed to highlight features of interest.
2 Features and Events

2.1 Overlap with C5 and C16

The C18 field is almost identical to that observed during Campaign 5, and overlaps substantially with Campaign 16. Many targets observed in C18 were also observed in C5 and C16, establishing a 3 year temporal baseline with an 8 month duty cycle that provides unique science opportunities.

2.2 Early End to Campaign 18

Due to indications that the spacecraft fuel tank was running very low ∼50 days into Campaign 18, collection of science data was terminated on July 2, 2018 and the spacecraft was put in a hibernation-like state until the data was downloaded at the regularly scheduled time in early August. As a result, only one FFI was collected.

2.3 Pointing and Roll Performance

The C18 pointing and roll behavior are well within the limits of other K2 campaigns, with no degradation seen due to potentially low fuel levels. The pipeline-calculated maximum distance between the derived and nominal positions for any target (the “maximum attitude residual”, or MAR) for C18 is less than 1.9 pixels for nearly the entire campaign, well under the 3-pixel limit accommodated by the aperture halos.

The exception is about a dozen long cadences just prior to BKJD 3432 / MJD 58264.5, where the pointing temporarily exceeded 4 pixels, as clearly seen in Figure 3. Users are encouraged to discard long cadences 162613 – 162627 (short cadences 4866897 – 4867246) due to this pointing excursion. These cadences are flagged using QUALITY flag bit #3. Similarly, while not visible in the plots below, the very last long cadence of the campaign, 164458 (short cadences 4922216 – 4922230) had a very large pointing excursion and are also flagged using QUALITY flag bit #3.

As mentioned in the C14 release notes, a change in the on-board fine point fault logging threshold results in additional cadences being flagged as “Spacecraft is not in fine point” (QUALITY flag bit #16, decimal=32768). As a reminder, the project recommends that starting with C15, users look to QUALITY flag bit #3 as an accurate indicator of poor spacecraft pointing.

Figure 3: The roll-error (left) and maximum distance (right) between the photometrically derived attitude (PAD) and the nominal position plotted against time for C18.
2.4 Targets

The Mikulski Archive for Space Telescopes (MAST) K2 Data Search and Retrieval Page has an option to select data by Object Type, including sections for the custom targets listed below. The corresponding custom EPIC IDs for the masks can also be found in the custom aperture file hosted at MAST.

2.4.1 Galaxies

There are 2,193 galaxies targeted in the C18 field of view; all but five used standard aperture masks. The five large galaxies were covered with 35-pixel diameter large circular custom masks.

2.4.2 Clusters

The C18 field of view includes the Beehive cluster (M44) and M67. M44 is one of the most nearby open star clusters and is known to contain at least six confirmed planets (K2-95b, K2-100b, K2-101b, K2-102b, K2-103b, K2-104b). Its members were observed using standard masks. M67 is a benchmark star cluster with solar-like age and metallicity. Hundreds of stars in the cluster core were observed using 441 unique 20x20-pixel long cadence aperture masks which create a contiguous 420x420 pixel region. In addition, hundreds of members in the outskirts were observed using standard masks, and more than 40 targets were observed using short cadence masks.

2.4.3 Solar System Objects

The C18 field of view includes 22 comets and Trojan Asteroids, and 9 faint Trans-Neptunian Objects, all observed in long cadence. While the formerly potentially hazardous asteroid 99942 Apophis was assigned apertures for observation, the asteroid did not actually enter the field of view before the end of C18 observations.

2.4.4 Other Notable Targets

- 42 confirmed exoplanets from Campaign 5: K2-34b, 95b, 97b, 98b, 100b, 101b, 102b, 103b, 104b, 105b, 108b, 114b, 115b, 117bc, 118b, 119b, 120b, 121b, 122b, 123b, 124b, 146b, 180b, 181b, 182b, 183bcd, 184b, 185b, 187bcde, 188bc, and HIP 41378 bcd. Most noteworthy, the HIP 41378 system is a bright F-type dwarf (V=9) shown by Campaign 5 to host at least five planets. The majority of these confirmed planet systems were observed in short cadence.

- Dozens of unconfirmed planet candidates from Campaign 5 were re-observed, the majority in long cadence. In addition, the Campaign 16 planet candidate around the bright F dwarf HD 73344 (V=7) was observed in short cadence.

- 60 low-mass flare stars and 59 variable white dwarfs were observed in short cadence.

- 13 very bright stars were observed using custom circular masks, including ζ Cancri and 25 Cancri in short cadence, and η, γ, χ, 21, 29, 49, 50, and 60 Cancri in long cadence.

- OJ 287, a well-studied bright galaxy (V=15) which is thought to show lightcurve variations due to a binary supermassive black hole at its center. It was observed in short cadence.
3 Data Quality and Processing Notes

3.1 Light Curve Quality

As in previous campaigns, the 6-hour spacecraft roll cycle continues to dominate the systematic errors in C18 simple aperture photometry light curves. The pipeline CDPP 12th magnitude noise benchmark for C18 is the second-lowest ever seen (just higher C5) at the time of this processing. The improved precision compared to most other campaigns is likely due to a combination of lower star density, stable pointing (compared to most other campaigns), and the updated pipeline version (in-particular the use of the coarse-point flags; see §2.3 of the K2 Handbook for details).

The magnitude dependence of CDPP and its distribution over the focal plane are shown in Figure 4 and Figure 5. CDPP statistics for various magnitude bins are given in an attached file, also printed below.

Attached file: c18_bin1.00_sc1.00_CDPP_Summary_18101501.txt

Kepler Data Analysis Handbook Supplement
6.0 hr CDPP Summary
Generated by MATLAB program cdpp_stats_ismember.m using quasiCdpp
    collected by fovPlottingClass.compile_fov_statistics_from_taskDirs
    Bin Width 1 mag, CDPP in ppm, dwarfs identified by logg >=4
File Name: c18_bin1.00_sc1.00_CDPP_Summary_18101501.txt
Star list: /space/data-repo/flight/so/catalogs/K2_stellar_parameters/
             k2StellarPropertiesStruct.mat
This file created: 15-Oct-2018 01:14:59
MJD 58406.05207
Column Definitions
1. KepMag bin
2. Number of dwarfs
3. 10th percentile CDPP for dwarfs
4. Median CDPP for dwarfs
5. Number of stars in list in bin
6. 10th percentile CDPP of all stars
7. Median CDPP for all stars
8. Number of giants
9. 10th percentile CDPP for giants
10. Median CDPP for giants
11. Noise model CDPP
12. Fraction of all stars < noise model, percent

<table>
<thead>
<tr>
<th>Mag</th>
<th>9.0</th>
<th>10.0</th>
<th>11.0</th>
<th>12.0</th>
<th>13.0</th>
<th>14.0</th>
<th>15.0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>124</td>
<td>348</td>
<td>972</td>
<td>2259</td>
<td>5067</td>
<td>3539</td>
<td>982</td>
</tr>
<tr>
<td></td>
<td>35.9</td>
<td>32.6</td>
<td>35.4</td>
<td>41.2</td>
<td>56.7</td>
<td>75.7</td>
<td>207.6</td>
</tr>
<tr>
<td></td>
<td>53.7</td>
<td>56.0</td>
<td>64.1</td>
<td>83.8</td>
<td>118.1</td>
<td>157.8</td>
<td>437.5</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>529</td>
<td>1218</td>
<td>2570</td>
<td>5516</td>
<td>3782</td>
<td>1192</td>
</tr>
<tr>
<td></td>
<td>36.2</td>
<td>35.1</td>
<td>36.5</td>
<td>42.2</td>
<td>57.0</td>
<td>76.3</td>
<td>208.8</td>
</tr>
<tr>
<td></td>
<td>64.6</td>
<td>61.5</td>
<td>69.3</td>
<td>87.4</td>
<td>119.5</td>
<td>159.2</td>
<td>425.1</td>
</tr>
<tr>
<td></td>
<td>126</td>
<td>181</td>
<td>246</td>
<td>311</td>
<td>449</td>
<td>243</td>
<td>210</td>
</tr>
<tr>
<td></td>
<td>36.7</td>
<td>43.5</td>
<td>49.3</td>
<td>60.3</td>
<td>60.9</td>
<td>82.8</td>
<td>214.6</td>
</tr>
<tr>
<td></td>
<td>76.5</td>
<td>76.6</td>
<td>95.7</td>
<td>115.4</td>
<td>133.7</td>
<td>187.5</td>
<td>378.8</td>
</tr>
<tr>
<td></td>
<td>3.8</td>
<td>6.0</td>
<td>9.5</td>
<td>15.2</td>
<td>15.2</td>
<td>40.1</td>
<td>68.8</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Figure 4: 6.0-hr CDPP measurements for all targets as a function of Kepler magnitude. Dim targets have poorer overall photometric precision than bright targets, but can look better because the residual sawtooth falls below the noise floor. Saturated targets tend to have lowest CDPP, but often show a residual sawtooth.
Figure 5: 6.0-hr CDPP measured as a function of position on the focal plane, for 12th and 14th magnitude dwarf stars. The photometric precision is generally better near the center of the focal plane where the variations in roll angle produce less pixel motion. All cadences coincident with a definite thruster firing are gapped.
3.2 Target With Manually-Updated FITS Header: EPIC 200233235

The custom target EPIC 200233235 was missing centroid information and values for the following FITS headers in its target pixel and lightcurve files: RA\_OBJ, DEC\_OBJ, 1CRVL4, 2CRVL4, 1CRVL5, 2CRVL5, 1CRVL6, 2CRVL6, 1CRVL7, 2CRVL7, 1CRVL8, 2CRVL8, 1CRVL9, 2CRVL9, EXPOSURE, TELAPSE, LIVETIME, TSTART, TSTOP, CRVAL1, and CRVAL2. This was a custom target for which the entire 20x20 pixel stamp was selected as the aperture by the pipeline. As a result there were no background pixels available to compute the centroid information, and thus the values for the listed FITS headers and TIME/TIMECORR arrays were blank/NaN. This issue appears unique to this custom target and no other targets were affected. Users wanting to analyze this target are encouraged to create their own lightcurve using software such as the lightkurve Python package, PyKE software tool suite, or other packages.

After initial delivery, a manual correction was performed to this target’s TPF file to make them usable for science analysis. The RA\_OBJ and DEC\_OBJ values were created using the target’s CCD position and the https://github.com/stevepur/Kepler-RaDex2Pix code, with the *CRVL* and *CRVAL* values updated to reasonable values in order to construct a working WCS. The TIME and TIMECORR values were copied from neighboring, nominal TPFs, which should result in negligible inaccuracy regarding timing corrections. The FITS keywords DATE2 and ORIGIN2 have been added to indicate these TPFs were modified after their data release.