These data release notes were originally prepared by members of the Data Analysis Working Group, and made available as webpages in July, 2015, 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>Section 3</td>
<td>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>
Contents

1 At a Glance ......................................................... 6
  1.1 Pointing ...................................................... 6
  1.2 Targets with Data at MAST .................................. 6
  1.3 Full-Frame Images (FFI) .................................... 6
  1.4 First and Last Cadences .................................... 6
  1.5 Pipeline ..................................................... 6

2 Features and Events ................................................ 7
  2.1 Premature End ................................................ 7
  2.2 Aperture Halos .............................................. 7
  2.3 Pointing and Roll Performance ............................. 8
  2.4 Targets ..................................................... 9
    2.4.1 Neptune ............................................ 9
    2.4.2 Trans-Neptunian Object ............................... 9

3 Data Quality and Processing Notes ............................... 10
  3.1 Highlights of Pipeline Improvements ...................... 10
    3.1.1 PA .................................................. 10
    3.1.2 PDC ............................................... 10
    3.1.3 Exporter [AR] ....................................... 10
  3.2 Light Curve Quality ......................................... 11
  3.3 Reduced Noise from Change in Bandwidth ................. 11
1 At a Glance

1.1 Pointing
- RA: 336.66534641439 degrees
- Dec: -11.09663792177 degrees
- Roll: -158.494818065985 degrees

1.2 Targets with Data at MAST
- 16,833 EPIC IDs in long cadence (LC)
- 216 EPIC IDs in short cadence (SC)
- Many custom targets (see §2.4)

1.3 Full-Frame Images (FFI)
- ktwo2014331202630-c3_fi-cal.fits
- ktwo2015008010551-c3_fi-cal.fits

1.4 First and Last Cadences
- Start Time: 2014-11-15 14:06:05.515 UTC
  - Long Cadence Number: 99599
  - Short Cadence Number: 2976430
- End Time: 2015-01-23 18:37:04.488 UTC
  - Long Cadence Number: 102984
  - Short Cadence Number: 3078009

1.5 Pipeline

Campaign 3 (Data Release 5) data were the first K2 data processed with the SOC 9.3 pipeline. With this data release comes new and improved data products, including quality flags to indicate cadences with thruster firings, background correction for target pixel files, production of lightcurves, and WCSs for FFIs. See §3.1 for details.

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

Figure 2: Left: Schematic of the C3 field-of-view with high-profile objects shown. Right: A full-frame image (FFI) taken during C3, with a flux scaling designed to highlight features of interest.
2 Features and Events

2.1 Premature End

Campaign 3 had a nominal duration of 80 days, but an actual duration of 69.2 days. The campaign ended earlier than expected because the on-board storage filled up faster than anticipated due to poorer than expected data compression.

2.2 Aperture Halos

In order to ensure that the flux from each target is adequately captured in the presence of the K2 roll motion, for C3, 3-pixel halos were included around each target in the center half of the field of view, and 4-pixel halos around each target in the outer half of the field of view, as shown in Figure 3. In comparison, many later campaigns were flown with only 2- and 3-pixel halos.

Figure 3: The number of halo pixels that were placed around each target in campaign 3 to account for K2 roll motion. Targets farther from the center of the focal plane have more halos due to experiencing greater motion due to the spacecraft roll.
2.3 Pointing and Roll Performance

The C3 pointing and roll behavior (see Figure 4) are well within the limits of that seen in other K2 campaigns for the majority of the campaign. The pipeline calculated maximum distance between the derived and nominal positions for any target (the “maximum attitude residual”, or MAR) for C3 is less than 2.1 pixels, well under the 3-pixel limit accommodated by the aperture halos. There were far fewer anomalous thruster firing events in C3 than were seen in other campaigns.

Figure 4: The roll-error (left) and maximum distance (right) between the photometrically derived attitude (PAD) and the nominal position plotted against time for C3. Note that these plots are from Data Release 26.
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 Neptune

Neptune moved across the field of view during C3 and K2 observed it in both long and short cadence. Short cadence data were obtained approximately 20 days on each side of the stationary point of Neptune. The animated GIF in Figure 5, also available as an attached file, shows Neptune and its moons, Triton and Nereid, as they move across the detector over approximately 50 days. Note that Neptune saturates the detector, which results in the observed spikes in the column direction as Neptune moves across the detector. The custom aperture numbers associated with Neptune are 200004468–200004923.

Attached file: k2-neptune-c3.gif

Figure 5: Neptune and its moons, Triton and Nereid, as they move across the detector over approximately 50 days.

2.4.2 Trans-Neptunian Object

The Trans-Neptunian Object (225088) 2007 OR10 was observed with 2 masks and given custom aperture numbers 200004466 and 200004467.
3 Data Quality and Processing Notes

3.1 Highlights of Pipeline Improvements

In addition to the FFIs and the target pixel files that were delivered in previous data releases, for this data release (5) for campaign 3, the project has delivered long cadence light curves, background pixels and collateral data. Detailed updates to each module of the K2 pipeline are listed in the following subsections.

3.1.1 PA

The method used to generate optimal apertures was improved for the SOC 9.3 pipeline. It now includes a data driven approach that uses the actual mask scene data to calculate the pixel noise in the SNR calculation. It also optimizes apertures based on CDPP. A significant improvement in CDPP is found for many targets. As with Kepler, the pixels used to create the light curve seen in the SAP_FLUX data column are shown in the APERTURE extension of the exported light curve and target pixel files.

PA fits motion polynomials (2D polynomial models mapping celestial coordinates to pixel coordinates) to PRF-fitted centroids of bright, well-isolated targets on each channel. The PRF-centroids have been found to be reliable for both Kepler and K2, so the residual errors in the models provide a measure of quality. The median model residual over all targets and cadences across the entire FOV was 0.047 pixels for Kepler Q14 (processed with SOC 9.3) and 0.070 pixels for C3. The relative motion of the star, evaluated for each star and cadence, is available in the POS_CORR columns of the light curve and target pixel files.

3.1.2 PDC

The method used to remove systematic trends in the K2 light curves is very similar to that used for Kepler data. However, some distinct differences are noted:

- Generally, 12 basis vectors are used instead of 8. The roll motion results in a very strong “sawtooth” trend in the simple aperture photometry light curves. It has been found that 12 basis vectors effectively remove this strong trend and yet the number of basis vectors is sufficiently small to avoid overfitting.

- Three corrected light curves are generated: a) a Bayesian MAP fit, b) a Robust Least Squares fit and c) no correction. PDC then selects the fit that results in the best photometric precision. The least squares fit is chosen a majority of the time. However, for more variable targets the MAP prior is used. For exceedingly variable targets and other corner cases, no correction is chosen. For targets with stronger roll sawtooth, the least squares fit is generally better.

- Photometric precision is measured using a 6 hour CDPP measurement. The roll tweak correction occurs up to every 6 hours (every 12th long cadence). The sawtooth therefore has a periodicity of 6 hours and so a 6 hour transit test signal is ideal for measuring residual sawtooth in the corrected light curves.

3.1.3 Exporter (AR)

- Thruster Firing flags have been added to the QUALITY column.
  - Possible Thruster Firing (bit 20) indicates that one or more thrusters may have fired during the indicated cadence. Because the thruster firings are only reported every 16 seconds, if one occurs near a cadence boundary, which cadence contains the thruster firing is unknown. As a result, this flag is most commonly set in short cadence.
  - Definite Thruster Firing (bit 21) indicates that at least one of the thrusters is known to have fired during that cadence.
• WCS coordinates, calculated with the Kepler motion polynomials, are available in the FFI headers.

• The modeled background level has been subtracted from the calibrated pixels available in the target pixel files. The per pixel background that was removed is available in the FLUX_BKG column of the target pixel files. To create non-background subtracted pixels, simply add the FLUX_BKG column to the FLUX column.

• Motion Polynomials have been calculated per cadence. The measured motion relative to the location near the middle of the campaign is recorded in the two POS_CORR columns.

• All Kepler data products are now available, except for short-cadence light curve files. This includes the Target Pixel, Light Curve, FFI, Collateral, Background, Artifact Removal Pixel and Cotrending Basis Vector files.

3.2 Light Curve Quality

The dominant systematic present in K2 simple aperture photometry light curves is a sawtooth shape that is due to the roll of the spacecraft approximately every 6 hours. The PDC module of the Kepler Pipeline uses Principle Component Analysis to remove this signal in addition to other systematics.

The magnitude dependence of CDPP and its distribution over the focal plane are shown in Figure 6 and Figure 7. Figure 8 shows results of a lightcurve injection test to measure how well signals were preserved by the PDC detrending module. In general, signals are degraded less than 10% for periods less than 20 days, and only 1% for periods of a few days or less. Note that the short-cadence light curves produced by the Kepler pipeline were deemed inadequate for scientific research at the time of this data release and so were not released at this time.

3.3 Reduced Noise from Change in Bandwidth

The change in bandwidth for pointing control (from 50 to 20 seconds) for C3 resulted in an increase in SNR for short cadence by a factor of roughly 4–9, with the larger improvement seen at the higher frequency end. Note, the bandwidth pointing control parameter was set to 10 seconds for the original Kepler Mission.
Figure 6: 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 7: 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.
Figure 8: Tests show that stellar signals are well preserved out to a period of about 20 days. However sometimes the stellar signals are partially masked by residual sawtooth.