K2 Data Release Notes 14:
Campaign 1 First Reprocessing

KSCI-19130-002

K2 Data Analysis Working Group

September 14, 2020

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These data release notes were originally prepared by members of the Data Analysis Working Group, and made available as webpages in December, 2016, 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.

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# DOCUMENT CHANGE LOG

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| September 14, 2020| 002      | Section 3      | Previous release notes erroneously reported CDPP measurements were based on 6.5-hr duration; corrected to 6.0-hr duration CDPP


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1 At a Glance

1.1 Pointing
- RA: 173.939610 degrees
- Dec: 1.4172989 degrees
- Roll: 157.641206 degrees

1.2 Targets with Data at MAST
- 21,647 EPIC IDs in long cadence (LC)
- 56 EPIC IDs in short cadence (SC)
- 1 custom target: TNO 2002 GV31 (EPIC 200001049; see §2.4)

1.3 Full-Frame Images (FFI)
- ktwo2014157010055-c1_ffi-cal.fits
- ktwo2014203150825-c1_ffi-cal.fits

1.4 First and Last Cadences
  - Long Cadence Number: 91332
  - Short Cadence Number: 2728420
- End Time: 2014-08-20 20:19:37 UTC
  - Long Cadence Number: 95353
  - Short Cadence Number: 2849079

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

Figure 2: Left: Schematic of the C1 field-of-view with high-profile objects shown. Right: A full-frame image (FFI) taken during C1, with a flux scaling designed to highlight features of interest.
1.5 Pipeline

This data release was a re-delivery of C1, including the first delivery of C1 long cadence light curve files. This data release (14) included long cadence light curves for C1 targets and updated the exported data products to include pipeline derived target coordinates and thruster firing flags. The C1 FITS target pixel files were also updated to Type-2 files. See §2.4 of [the K2 Handbook] for details on Type-1 vs Type-2 TPFs.

This release also corrected the short cadence collateral bug described in the Global Erratum for Kepler Q0-Q17 & K2 C0-C5 Short-Cadence Data, KSCI-19080. This release replaced the short cadence data previously delivered to the archive in Data Release 3. Specific targets known to have their SC calibration improved by Data Release 14 are identified in the attached file below.

No other features of the data processing have changed since Data Release 13.

Attached file: K2_scrambled_short_cadence_collateral_target_list.csv
2 Features and Events

2.1 Operational Considerations

Campaign 1 (C1) was the first full length observing campaign for K2 where the targets were selected by peer review. The project was uncertain of the pointing precision and compression efficiency that could be achieved in early K2 operations and took steps to minimize the risk of losing science data. In order to allow for the potential of coarse point operations, all target apertures included six halo rings. The oversized apertures and uncertain compression performance led the project to include a mid-campaign break lasting 2.9 days (long cadences 93281–93420) in order to downlink data.

2.2 Pointing and Roll Performance

The C1 pointing and roll behavior (see Figure 3) 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 C1 is less than 2 pixels, well under the 3-pixel limit accommodated by the aperture halos. There were far fewer anomalous thruster firing events in C1 than were seen in other campaigns.

![Figure 3: The roll-error (left) and maximum distance (right) between the photometrically derived attitude (PAD) and the nominal position plotted against time for C1. Note that these plots are reproduced from Data Release 32, as they were not available for this data release.](image)

2.3 Attitude Tweak

As seen in Figure 3, the attitude of the spacecraft was tweaked by 3.3 pixels at cadence 91433 (about 2 days after the start of the campaign) to better position the targets in the centers of their apertures. All cadences in the first 2 days of C1 prior to this event (long cadences 91332—91433) have the first bit in the QUALITY column set (integer value = 1) to indicate that they were taken prior to the tweak.

When creating light curves, the pipeline uses PA-COA to determine the optimal photometric aperture that maximizes the signal-to-noise ratio for each target over the full campaign. This static optimal aperture is determined from a robust average of the achieved pointing, so relatively short segments of off-nominal pointing tend to be excluded from the aperture calculation. In the case of C1, the optimal apertures generally do not contain the target star in the pre-attitude tweak cadences. Accordingly, the SAP-Flux and PDC-Flux values found in the light curve files are gapped for the pre-tweak cadences (long cadences 91332—91433,
where the QUALITY flag=1). In addition, neither background flux (FLUX_BKG, FLUX_BKG_ERR) nor motion polynomial values (POS_CORR1, POS_CORR2) were computed for the pre-tweak cadences.

Because of the large C1 apertures (with six halos) the TPFs do fully contain the target in the pre-attitude tweak cadences. However, due to the offset, incorrect background flux values are subtracted from the TPF pixel fluxes given in the FLUX column of the TPF. Users wishing to recover photometry from these cadences should add the per-cadence pixel background values (TPF column FLUX_BKG) back into the pixel flux values and then compute their own background levels. The position offset columns (POS_CORR1, POS_CORR2) should likewise be ignored for these pre-tweak cadences.

Finally, in the pre-tweak cadences a small number of targets may have incorrect smear calibrations due to bright saturating stars spilling charge into the detector smear regions. Such effects are flagged and excluded from smear calibration for the post-tweak cadences, but the pre-tweak positions of the bright stars were not used to flag bad smear corrections. Only about 0.2% of the focal plane columns were affected in this way, so the number of potentially affected targets is very small.

2.4 Targets

For this Campaign, a number of targets were proposed without EPIC IDs. If a target was observed, it was either 1) given an EPIC ID from the regular catalog if that target matched a target in the catalog, or 2) assigned a new EPIC ID. EPIC IDs were created for 28 targets, ranging from 210282464 to 210282491. The remaining C1 targets have EPIC IDs ranging from 20100000001 to 202059065.

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 Trans-Neptunian Object

A long-cadence custom aperture was constructed in order to collect data on trans-Neptunian Object 2002 GV31. Note, this target is very faint (V=22) and falls in its 23x22 pixel custom aperture for only about 10 days. This custom aperture can be found by searching the MAST for EPIC ID 200001049.
3 Data Quality and Processing Notes

3.1 Light Curve Quality

C1 long cadence light curves have been delivered with this data release (14). The dominant noise contributors in the C1 data are the saw-tooth roll signal inherent in K2 data and an increased (over Kepler and later K2 campaigns) cross-bore sight pointing motion due to the lower bandwidth for the attitude determination and control system (ADCS) used in K2 campaigns C0, C1, and C2. The low ADCS bandwidth was particularly problematic for short cadence data, as it meant that the spacecraft pointing errors are on the same time scale as the SC exposure, so that the pointing induced noise is correlated from cadence to cadence. See [K2 Data Release Note 28](#) for details.

Analysis of the light curve quality reveals that long cadence CDPP values for dwarf stars are in family with the values from subsequent campaigns. 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: K2-C1_CDPP_Summary_16102111.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 log g >=4
File Name: K2-C1_CDPP_Summary_16102111.txt
Star list: /home/jevancle/matfiles/files/k2StellarPropertiesStruct.mat
This file created: 21-Oct-2016 11:43:45
MJD 57682.48872
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

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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 FFI Interpolation Bug

This data release was affected by a minor bug in the pipeline, which was then corrected for subsequent data releases. When a K2 campaign has more than one Full-Frame Image, the Kepler pipeline interpolates data between those FFIs, and extrapolates before and after each, to account for variations over time when calibrating the pixel-level data. A bug was discovered where FFIs from later campaigns were used to interpolate for calibration of the current campaign. This bug affected the pixel-level data, and thus lightcurves as well. Since there are usually two FFIs per campaign, taken 1/3 and 2/3 the way through a given campaign, for the last 1/3 of a campaign the interpolation was between the last FFI of the current campaign and the first FFI of the next campaign (which has, by definition, a different field-of-view). Thus, the latest cadences of the campaign are affected the most by this bug. The exact impact of the effect is not known, but is thought to be small given that the FFI data are only used to supplement the undershoot correction (see §6.6 of the Kepler Instrument Handbook) in calibration and the interpolation will weight the FFI values towards the correct campaign.