Kepler Data and Tools

Kepler Science Conference II
November 5, 2013
Agenda

- Current and legacy data products (S. Thompson)
- Kepler Science Center tools (M. Still)
- MAST Kepler Archive (S. Fleming)
- NASA Exoplanet Archive (R. Akeson)
- Community Follow-up Observing Program - CFOP (D. Ciardi)
- Questions and discussion
Current and legacy data products

Susan Thompson
SETI/Kepler Science Office
Archive Overview

Kepler Project Products

- Target Pixel Files
- Light Curve Files
- Ancillary Files (CBVs, Background, Collateral)
- Data Release Notes
- FFIs
- TCE Tables (transit looking events)
- KOI Tables (planet candidates and false positives)
- (Stellar Table)
Quarterly Deliveries

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The data archive is not complete.
Which light curve are you using?

- Light Curve Options:
  - SAP_FLUX
  - PDCSAP_FLUX
  - SAP_FLUX + CBVs
  - Go to the Pixels (TPFs)
    - Customized Simple Aperture Photometry
    - PRF photometry
Header Keywords:
- **PDCMTHD**: Which MAP algorithm was used (multiScaleMAP, regularMAP)
- **FITTYPEj**: Describe how the jth band is treated (robust, prior, none)
PDC msMAP

- 4 Goodness metrics given as absolute values (0—1) and percentiles compared to other targets
  - Variability (was variability removed?)
  - Noise (was noise added?)
  - Earth Point (was earth point recoveries corrected well?)
  - Correlation (are correlated systematics remaining?)

Full Header Keywords are currently only available in Q15—Q17.
Quality Flags

- Quality Flags, which actually mean the data is bad?

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Quality Flag bit & 10010110100010111
Delivering Transits to the Exoplanet Archive

The Making of Kepler Planet Candidates

1. Triage (quick assessment)
   - 18,406 TCEs found in Q1 - Q12 search
   - 3,486 TCEs are previously known KOIs

2. Fit Transits and Make KOIs (moderate assessment)
   - 3,616 TCEs are potentially transit-like
   - ~1,600 TCEs have poor transit fits (ignore)
   - 1,924 KOIs have good fits
   - ~100 KOIs have troublesome fits

3. Disposition (in-depth assessment)
   - KOIs that are False Positives (archive)
   - KOIs that are Planet Candidates (archive)
Exoplanet Archive: Status Report

- **Q1-Q8 KOI Table**
  - Data is *almost* DONE. Paper submitted. Values can change until table is closed.

- **Q1-Q12 KOI Table**
  - First pass at Giving Dispositions (PC/FP) is done.
  - We will improve the fits to the transits
  - Provide fits for those KOIs not found by the Q1-Q12 TPS/DV planet search.

- **Q1-Q16 Activity**
  - TCEs have been delivered.
  - We will deliver a Q1-Q16 KOI table, including new KOIs found from the TCEs and provide dispositions as the work is done.
  - Deliver Stellar Table from the Stellar WG. Table gives parameters used by the Q1-Q16 planet search for all targets searched.

- **Cumulative Table**
  - Pulls together information from the other KOI Activity Tables. Gives most recent disposition and best fit.
PyKE
keplerscience.arc.nasa.gov/PyKE.shtml
play with your pixels – reap the rewards
play with your pixels – reap the rewards

Tools used: kepmask, kepxtract, kepprfphot, kepflatten, kepfold, kepdraw
play with your pixels – reap the rewards

keplerscience.arc.nasa.gov/PyKEprimer.shtml

or

Kinemuchi et al. (2012) PASP 124 963

Tools used: kepfield
play with your pixels – reap the rewards

Tools used: kepprf
play with your pixels – reap the rewards

Tools used: kepprf, kepflatten, kepstddev
Confused sources can be disentangled by fitting a PSF model to calibrated pixel data. Transits can be localized to a single component within a confused source and false positive and planet likelihoods determined.

Tools used: kepprf, kepprfphot, kepflatten, kepfold, kepdraw
Aperture photometry of confused transiting or eclipsing sources will yield transit or eclipse depths biased by contaminating flux within the aperture.

The Kepler Project infers the fractional contamination by modeling the local field as defined within the Kepler Input Catalog. Archived PDC photometry contains these inferred corrections.

PSF photometry bypasses the need to calculate and apply a contamination correction.

Tools used: kepprf, kepprfphot, kepflatten, kepdraw
play with your pixels – reap the rewards

Sources move within their pixel apertures on short and long timescales. Archived aperture photometry contains the consequences of that motion. Accurate PSF fitting carries motion systematics within PSF centroids, not within photometry.

Tools used: kepdraw, kepprfphot
MAST Kepler Archive

Scott Fleming
Space Telescope Science Institute
MAST Discovery Portal
Arriving Winter 2013; archive.stsci.edu
### MAST Discovery Portal

Arriving Winter 2013; archive.stsci.edu

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Kepler CasJobs / Previews
http://mastweb.stsci.edu/kplrcasjobs/

MAST Query / CasJobs

Kepler Data Search Results

Object name Kepler16 resolved by Simbad (via SANTA cache) to NAME Kepler-16 (A) (B*Algol)


number of rows returned = 38
note: reload page if no results are shown

Click on top column headers to sort the table on the column contents.
Click on bottom column headers for more information about the data in that column.
Click on Condition Flag entries for more information on flag definitions.
Click on Dataset Name entries to preview information on data set.

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Variability Stats
Available In CasJobs / Previews Soon
Follow / Like Us To Get Latest Updates

facebook.com/MASTArchive

@MAST_News

Kepler Front Page: archive.stsci.edu/kepler

Please take our survey: http://archive.stsci.edu/survey2013.html

Visit my poster 2-314 for more details, new data planned for release.

Also, ask Dorothy or myself for a personal demonstration of how the Discovery Portal can be used for your specific research needs.
NASA Exoplanet Archive

Rachel Akeson
NASA Exoplanet Science Institute
NASA Exoplanet Archive

- The NASA Exoplanet Archive collects and serves public data to support the search for and characterization of exoplanets and their host stars.

- Team members here: Rachel Akeson, Jessie Christiansen, David Ciardi, Peter Plavchan, Solange Ramirez
Overview

Data
- Confirmed planet and stellar host properties
- Kepler pipeline data
  - TCE lists
  - KOI activity tables
  - Data validation files
  - Stellar properties of targets stars
  - Kepler/KOI/KepID names cross-matching
- Time series/light curves
  - Kepler
  - CoRoT
  - SuperWASP
  - XO, HATNet, TrES, etc

Tools
- Interactive tables with sorting, filtering and plotting capabilities
- Interactive visualization for Kepler and SuperWASP light curves
- Periodogram tool
- Transit prediction tool
- API interface to data

http://exoplanetarchive.ipac.caltech.edu
Kepler pipeline data:
TCEs, data validation, stellar properties

- Interactive table with each TCE table available in a separate tab
- Plotting available from table
- Data validation reports and summaries (Q1-12 and Q1-16)
- Links between objects, DV reports and light curves
- Stellar properties for target stars: Q1-12 (Q1-16 coming soon)

Q1-16 TCEs with SNR/MES > 0.6 and $T_{\text{stellar}} < 5000$ K
KOIs and confirmed Kepler planets

- Interactive table for KOI activity tables: Q1-6, Q1-8, Q1-12, cumulative
- Kepler names: cross match between Kepler, KOI, KepID and published names for confirmed planets
- Also links to policy for assignments of Kepler names
- Links between objects, DV reports and light curves
NEW! SuperWASP data

- The WASP consortium has made data from the first WASP data release (2004-2008) available
- 18 million objects covering most of the sky
- Users can
  - Search light curve metadata
  - Download metadata or light curves directly
  - See magnitude and spatial distributions of targets
Light curves and periodograms

- Interactive light curve viewer
  - Combine and normalize Kepler quarters

- Periodogram tool
  - For light curves in the archive or uploaded
  - Three algorithms available: BLS, Lomb-Scargle, Plavchan

- Folded light curves
Transit services

- Predictions of transits based on planet/stellar parameters in archive or user supplied
  - For confirmed planet and KOIs
  - By object
  - By location
Keck Observatory Archive

- **Overview**
  - Currently contains public data from HIRES, NIRSPEC, NIRC2, LRIS
  - All instruments will be included by early 2014
  - Operated by NExScI and WM Keck Observatory

- **Kepler content**
  - Keck has been used extensively for follow-up observations
  - Over 7000 science files from the Kepler field are available in the archive

http://koa.ipac.caltech.edu
The Community Follow-Up Observation Program Website (CFOP)

https://cfop.ipac.caltech.edu

David Ciardi
NASA Exoplanet Science Institute
CFOP Purpose

- Coordinated and Systematic spectroscopic and imaging program of the KOIs
  - To support the determination of the false positive probabilities
  - To determine the stellar properties of the host stars
  - To determine the photometric blending of the host stars

- Need to communicate and organize observing priorities and accomplishments
  - Make best efficient and effective use of the facilities available
  - Avoid duplication of effort
  - Avoid observing of false positives or already confirmed planets (unless, of course, you want to observe them)

- Sharing of data, notes, derived parameters, files, analysis ...
Overall Content

- All KOIs identified by the Kepler Project
  - Candidates/Confirmed: 3602 planets around 2716 stars
  - False Positives: 2183 “planets” around 2140 stars
  - Synced with the Kepler pipeline output and Exoplanet Archive

- Uploaded content
  - Over 55,000 stellar parameters
  - Over 16,000 planetary parameters
  - Over 70,000 files

- For each KOI
  - Summary Page
  - Coordinates, magnitudes, transit parameters, stellar parameters, planet parameters
  - Free form observing notes
  - File upload
  - Observing summary table
Every datum and file connected to owner (and contact information)
Observing Notes

- Free form page for notes for each KOI
- Can link directly to any file that is associated with that KOI

**Observing Notes for KOI #2626**

Optional: Insert link to uploaded file: 2626Pp SH20130729b.epc (everett 2013-09-17)

Enter Notes

---

everett
2013-09-13 15:29:32

Speckle imaging at Gemini on 2013-07-26, 2013-07-27 and 2013-07-29 reveals K012626 to be a triple source. Dates of observation, separations, PA, delta magnitudes in three filters are listed below.

**Secondary Source**

<table>
<thead>
<tr>
<th>Date</th>
<th>Filter</th>
<th>Separation (*)</th>
<th>PA (deg)</th>
<th>Delta m</th>
</tr>
</thead>
<tbody>
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<td>0.2100</td>
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<td>2013-07-29</td>
<td>562nm</td>
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**Tertiary Source**

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<th>Delta m</th>
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<td>562nm</td>
<td>0.1760</td>
<td>177.83</td>
<td>1.95</td>
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</table>

**Note:** The 2013-07-26 observation in the 880nm filter was adversely affected by scattered light (so was noisy).

Because there are limitations to the quality of the data in 662 and 360nm on both nights (10th UT = noisy 880nm images and 27th UT = relatively few frames for a total of 9 minutes integration), a combined reduction of the data from these two nights was performed. These particular reductions were done using a lower resolution filter in the image reconstruction (which is used for the background limit calculation). This means there are relatively fewer points in the background limit plot and limiting magnitudes below 0.04 arcseconds are not reliable. The combined data photometry given below are probably the best numbers for other to use for most applications.

**Secondary Source**

<table>
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<th>Filter Separation (*)</th>
<th>PA (deg)</th>
<th>Delta m</th>
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</thead>
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<td>880nm</td>
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</table>

**Tertiary Source**

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<tbody>
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<tr>
<td>880nm</td>
<td>0.1647</td>
<td>185.69</td>
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</table>

**Note:** K012626 was observed through a 447nm filter on 2013-07-29. The S/N was insufficient in this case to analyze the secondary and tertiary sources at 447nm.
Observation Summaries

- Tables of summary of observations for spectroscopy and imaging
- Intended to help users/observers know what has already been observed and with what quality
Follow Your Favorite KOIs

- Sign up to receive nightly emails about a set of KOIs that you wish to “follow”
Summary

- CFOP is open to the public and is intended to enable collaborative efforts, sharing of data and results, and effective use of the facilities available to the general community.

- All data on CFOP is available to the public - request users to contact the data owners if you wish to utilize the data that has been uploaded.

- Two posters to go see:
  - Summary of CFOP Functionality 1 – 105
  - Summary of CFOP Content 1 – 106

- Questions or issues:
  - cfop@ipac.caltech.edu
  - ciardi@ipac.caltech.edu
Questions, comments and discussion time