

# HATSouth Exoplanet Survey Observations of the K2 Campaign 7 Field

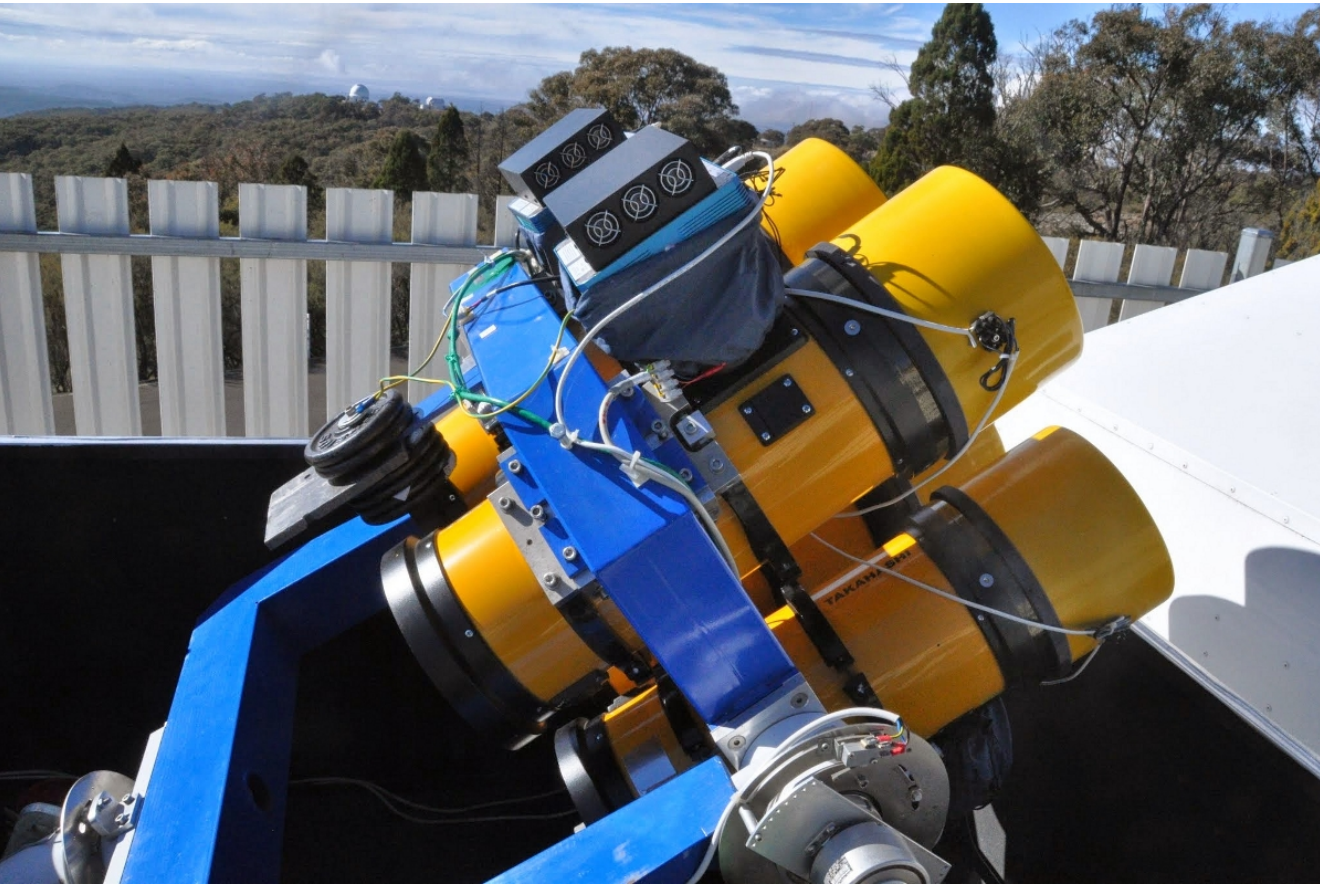
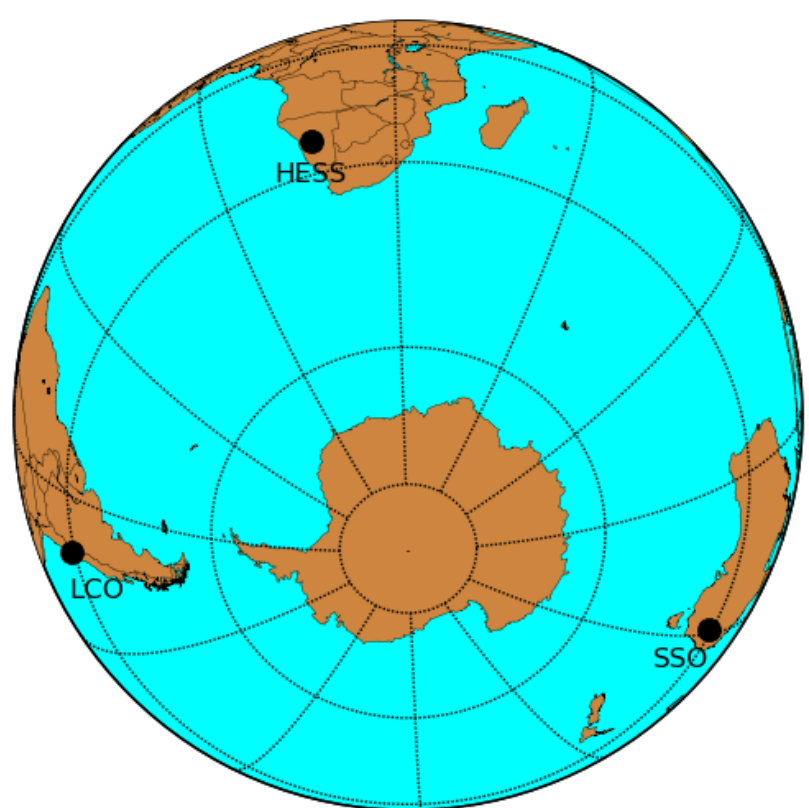
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## Summary

The HATSouth Exoplanet Survey has carried out an extensive observing campaign on a 8.2 degree x 8.2 degree field overlapping with the K2 Campaign 7 field of view. A total of 10,000 four minute *r*-band exposures were collected between Sep. 2009 and Aug. 2011 and were used to derive light curves for ~250,000 stars in this field with  $8 < r < 16$ . These light curves have been used to identify 63 candidate transiting planet systems, four of which have so far been fully confirmed. Here, we make public HATSouth light curves for these transit candidates, as well as all sources that are close neighbors to K2.7 targets, including stars outside of the K2 stamps, through a web-based search and data exploration interface.

## The HATSouth Exoplanet Survey



Left: the observing sites for the HATSouth global network; at the Las Campanas Observatory (LCO) in Chile, the High Energy Stereoscopic System (HESS) site in Namibia, and the Siding Spring Observatory (SSO) in Australia. Right: view of a HATSouth observing system with four telescopes and cameras each; each HATSouth site has two such systems.

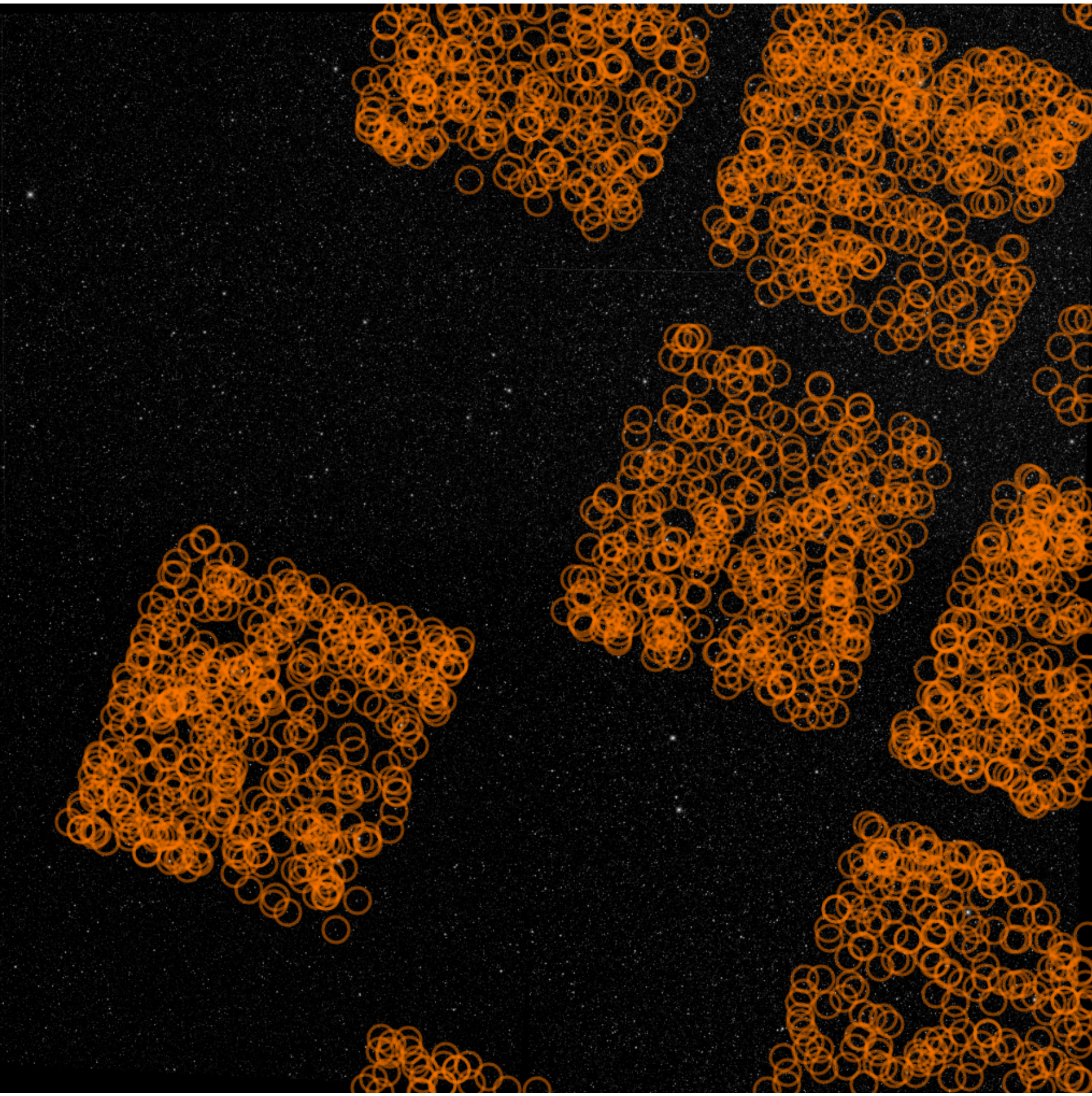
The HATSouth Exoplanet Survey (Bakos, et al. 2013) is a network of six robotic telescope systems distributed over three sites in the Southern Hemisphere: LCO in Chile, the HESS site in Namibia, and SSO in Australia. Each site has two HATSouth systems; each system has four 180-mm aperture f/2.8 astrographs attached to large-format CCDs, with a system field-of-view of 8.2 deg x 8.2 deg at ~4 arcsec/pixel scale. HATSouth is designed to detect transiting exoplanets in orbit around stars with  $8.0 < r < 14.0$  with 4-minute cadence. The wide separation in longitude allows near-continuous monitoring of selected fields during the Southern summer months, greatly improving phase coverage for targets, and reducing our susceptibility to false-positive transit signals.

Since first light in 2009, HATSouth has discovered 13 exoplanets so far, with many more candidates in the process of confirmation and follow-up observations. Highlights include a Saturn-mass planet around an M-dwarf (HATS-6b; Hartman, et al. 2015), and the longest orbital period transiting planet discovered from the ground (HATS-17b; Brahm, et al. 2015).

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The HATSouth network is operated by a collaboration consisting of Princeton University, the Max-Planck-Institut für Astronomie (MPIA), and the Australian National University (ANU). The station at Las Campanas Observatory of the Carnegie Institute, is operated by Princeton University in conjunction with collaborators at the Pontificia Universidad Católica de Chile. The station at the High Energy Spectroscopic Survey (HESS) site is operated in conjunction with MPIA. Finally, the station at Siding Spring Observatory is operated jointly with ANU. HATSouth development was supported by NSF MRI grant AST-0723074. HATSouth operations are supported by NASA grant NNX09AB29G. HATSouth follow-up campaigns are partially supported by NSF grant AST-1108686.

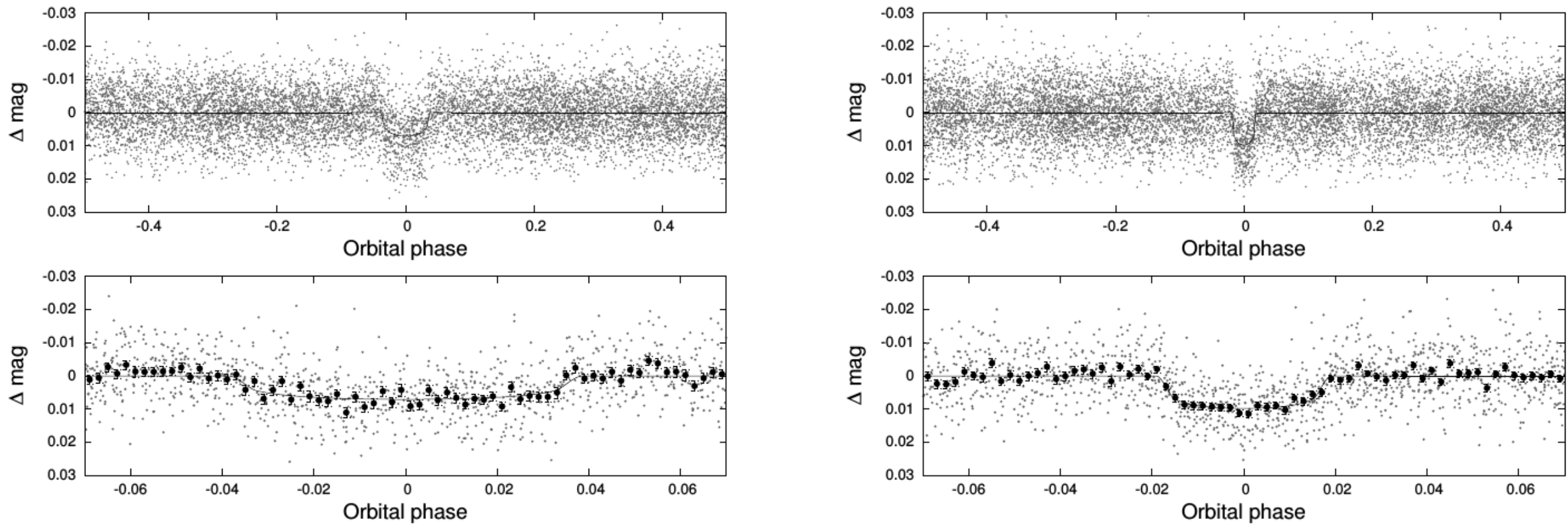
## HATSouth and K2.7



Mosaic of the HATSouth combined four CCD field-of-view of HAT field G579 covering about 8 deg x 8 deg. The Kepler K2 Campaign 7 targets that fall within the field of view of the HATSouth instruments are represented by circles.

The Kepler K2 mission (Howell, et al. 2014) has been observing fields along the ecliptic since Jun 2014 after the loss of two reaction wheels ended its primary mission. The K2 Campaign 7 field (K2.7; centered at 19:18:18 -23:21:36) will be observed from Oct 4, 2015 to Dec 26, 2015. The HATSouth Exoplanet Survey observed a partially overlapping field (HS G579 centered at 19:30 -22:30) from Sep 2009 to Aug 2011 at 4-minute cadence, using the HS1 (LCO), HS3 (HESS), and HS5 (SSO) systems. We extracted light curves for 326,247 stars in this field, with a median of 10,109 *r*-band light curve points per object. These light curves were trend-filtered using the EPD and TFA algorithms, resulting in high quality light curves for ~250,000 stars with a nominal TFA unbinned light curve precision of 6 mmag at *r* ~ 12.0 mag.

63 exoplanet transit candidates were identified, including 4 confirmed planets, two of which (HAT-9b and HATS-10b) are shown below. These HATSouth light curves extend the time base-line for the K2.7 observations of overlapping objects and allow identification of variable objects in and near the K2 object stamps, which may cause false-positive exoplanet transit signals in the K2 light curves.



Phase-folded HATSouth light curves for HATS-9b (left) and HATS-10b (right). The top two panels show the full light curve, while the bottom two panels zoom in on the planet transit. The solid lines are model fits to the light curves, while the dark filled circles in the bottom panels show light curve points binned in phase using a bin size of 0.002. Figure from Brahm, et al. 2015.

## Accessing the Data

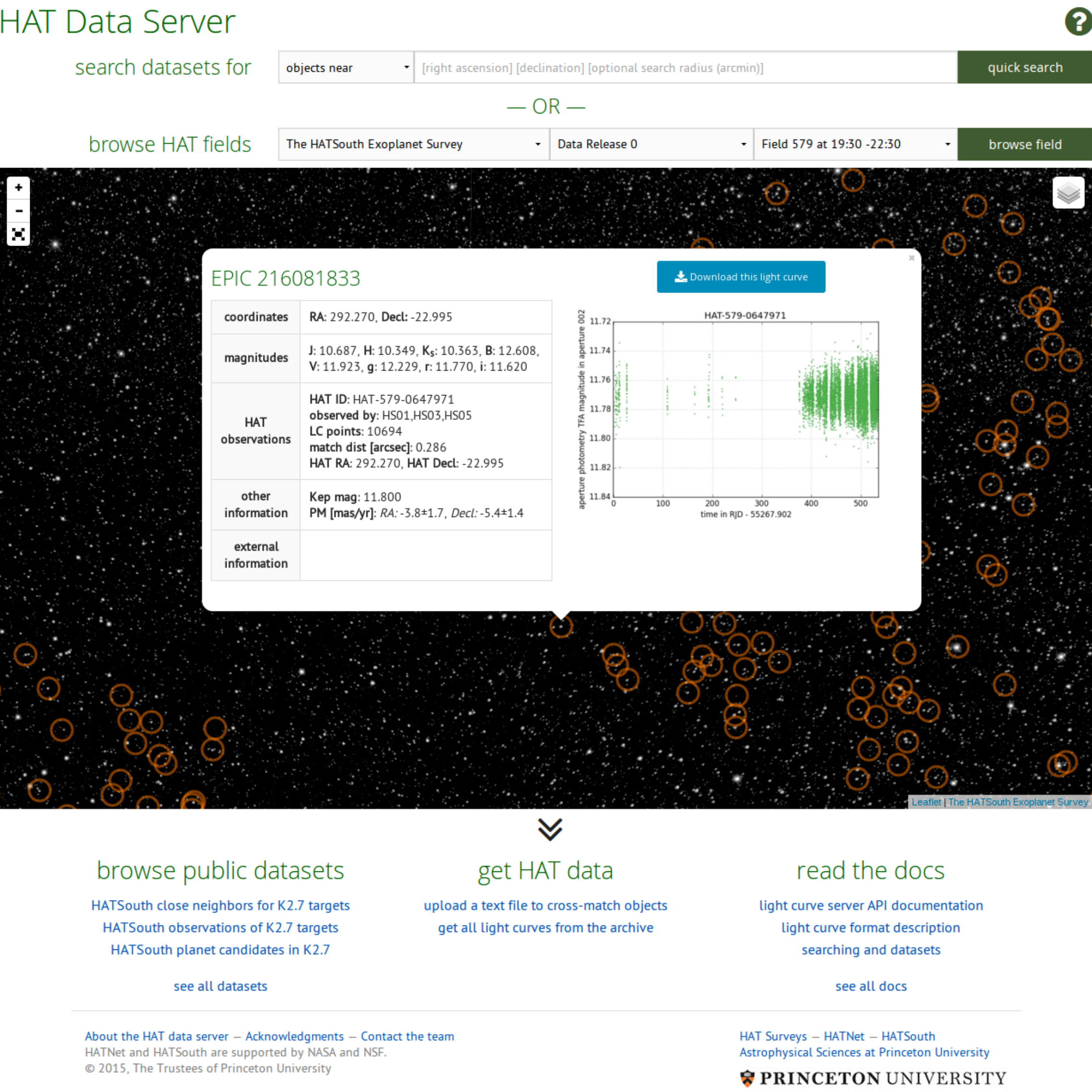
All data from this project will be released through the HAT Data Server:

<http://data.hatsurveys.org>

This is a web service that allows users to search for objects of interest by coordinates, object identifiers, and cross-matching to uploaded target lists. A Google Maps style browser for the entire HATSouth field of view is available as well. The following datasets are currently available, with the complete release of lightcurves for all objects in this field expected by end-2015 (Bhatti, et al. 2015, in prep):

- All HATSouth neighbors within 1 arcminute of K2.7 targets falling on the HATSouth field of view
- All HATSouth direct matches to K2.7 targets
- All HATSouth exoplanet transit candidates in this field

The HAT Data Server will become the central point of distribution of public HATSouth Exoplanet Survey data and light curves. We plan to serve data from the HATNet Exoplanet Survey and all K2 light curves reduced using HAT tools and methods (Huang, et al. 2015) from this portal as well.



## References

- Bakos, G. A., Csabry, Z., Penev, K., et al. 2013, PASP, 125, 154  
Brahm, R. Jordán, A., Hartman, J. D., et al. 2015, AJ, 150, 33  
Brahm, R., Jordán, A., Bakos, G. A., et al. 2015, arXiv:1510.05758  
Hartman, J. D., Bayliss, D., Brahm, R., et al. 2015, AJ, 149, 166  
Huang, C. X., Penev, K., Hartman, J. D., et al. 2015, arXiv:1507.07578  
Howell, S. B., Sobeck, C., Haas, M., et al. 2014, PASP, 126, 398

