nature astronomy

SUPPLEMENTARY INFORMATION

VOLUME: 1 | ARTICLE NUMBER: 0004

In the format provided by the authors and unedited.

# Variability in the atmosphere of the hot giant planet HAT-P-7 b

## Supplementary Information Table and Figure Legends

### Tables

Table 1: HAT-P-7 Input Parameters[6]. † BJD=Barycentric Julian Date.

### Supplementary Figures

Supplementary Figure 1: Independent best fitting parameters. Variation in peak amplitude (top, blue), peak offset (middle, red) and secondary eclipse depth (bottom, green). Best fit parameters resulting from fits to discrete lightcurve segments are shown, resulting in fewer, but independent, points than the convolution method leading to Figure 1. The *Kepler* quarter boundaries are shown as vertical dashed lines. Error bars are 1σ errors on the fit parameters.

Supplementary Figure 2: The data segments used to derive the fit parameters of Supplementary Figure 1. The best fit models are plotted in green. Reading left to right and top to bottom, they correspond to each datapoint shown in that Figure. Each segment has been binned to 100 bins for clarity. Error bars are the standard error on the mean of the datapoints contributing to each bin.

Supplementary Figure 3: Best fitting parameters from injection tests. Panel a: As Supplementary Figure 1 for KIC11027406 after injection with a constant HAT-P-7 b phase curve. Panel b: As Supplementary Figure 1, for KIC10861893 after injection with a constant HAT-P-7 b phase curve. Marginally significant variation in $A_p$ is seen for KIC10861893, implying the presence of systematic noise biasing the fits. The variations in $\Theta$, while showing some structure, are on a much smaller scale than those observed in HAT-P-7 b. Error bars are 1σ errors on the fit parameters.

Supplementary Figure 4: MCMC parameter correlations. Triangle plot of an MCMC run applied to a phase curve segment at time 226 (BJD-2454833), with significant positive $\Theta$. The outputs are consistent with those of the prayer bead analysis, although the errors from the MCMC are slightly smaller. The larger errors are used for final values. An additional parameter, f, is fit for which scales up the errors by a factor of ~2, to account for correlated noise not present in the given errors.

Supplementary Figure 5: MCMC parameter correlations. As Supplementary Figure 4 for a phase curve segment at time 1238 (BJD-2454833). This segment has significant negative $\Theta$. The parameters are again consistent with the prayer bead results, with the MCMC analysis giving slightly smaller errors.

Supplementary Figure 6: Peak offset predicted by model. As Figure 4 for $T_C$ = 1600K (top), $T_C$ = 1800K (bottom) and $\kappa$=40. Reducing the value of $\kappa$ makes negative contours less deep, but does not change the structure of the grid. Producing all the observed values of $\Theta$ requires transitioning through a regime disallowed by the observed amplitude, but is possible.

Supplementary Figure 7: Peak offset predicted by model. As Figure 4 for $T_C$ = 2200K and $\kappa$=40. Reducing the value of $\kappa$ makes negative contours less deep, but does not change the structure of the grid. The grid has been extended up to $\varepsilon$=80, as it is not possible to achieve the maximum negative offset in the previously used $\varepsilon$=[0,20] grid range.

Supplementary Figure 8: Lightcurve detrending process. *Kepler* data of HAT-P-7 before detrending (top), after detrending (middle) and zoomed in to show 4 planetary orbits (bottom).

Supplementary Figure 9: HAT-P-7 b phase curve, showing the entire dataset. The unbinned data are in blue, and 100 bins shown in red. The planetary transit is at phase 0 and is below the scale of the graph. Error bars are the 1σ photometric errors on each datapoint.



© 2016 Macmillan Publishers Limited, part of Springer Nature. All rights reserved.

## Other Files

Video 1: Visualisation of the dayside of HAT-P-7b. See Methods for description, and for the assumptions used to simulate the dayside emission.

Dataset 1: fitparams_table.csv (51kb): Values for individual fits and their errors. Columns are described in the file header.



© 2016 Macmillan Publishers Limited, part of Springer Nature. All rights reserved.