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Simultaneous observations of the northern TESS sectors by the Zwicky Transient Facility

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The Transiting Exoplanet Survey Satellite (TESS) (J Schliegel 2017) is a powerful facility for studying a broad range of astrophysical objects. The Zwicky Transient Facility (ZTF) (Bellm et al. 2019; Graham et al. 2019; Masci et al. 2019) is conducting a nightly public survey of all 13 TESS northern sectors in 2019-2020. ZTF will observe the portions of the current TESS sector visible from Palomar Observatory each night. Each ZTF pointing will have one exposure each with g and r filters, totaling two images per night. The first northern sector, Sector 14, was observed from July 18 – August 15, 2019. The observations of the second northern sector, Sector 15, began on August 15, 2019. The majority of Sectors 14 and 15 have been covered by ZTF, except for a portion of TESS Camera 4, due to the visibility limits. ZTF is also making additional nightly g- and r-band observations of denser stellar regions (e.g. near the Galactic Plane) to better facilitate variability studies of Galactic objects.

ZTF has a FOV of 55.0 square degrees and a light-sensitive area of 47.7 square degrees within that FOV. A TESS sector can be completely covered with about 60 ZTF fields. ZTF has 1″ pixels (2″ PSF) compared to the TESS 21″ pixels (50% enclosed flux). Consequently, ZTF observations will allow identification of transient and variable sources within a TESS pixel, particularly important if more than one source contributes to the variable flux. In addition, ZTF goes deeper than TESS, having a median 5-σ limiting magnitude of 20.6 in r-band and 20.8 in g-band. This allows the identification of weak sources that may be contributing to the TESS measured flux. See Figure 1 for an example of ZTF and TESS images of the same field. ZTF g- and r-band measurements will complement TESS 600-1000 nm observations, allowing estimates of temperature and other spectral characteristics. See the comparison of spectral bands in Figure 1. ZTF saturates between m$\sim$12-13.

ZTF will release data from TESS fields in three forms: in addition to the nightly alerts distributed by established ZTF brokers, nightly alerts converted to JSON format are distributed via ZTF's bucket on Google Cloud as a tarball (Duev 2019), and monthly photometric light curves also distributed via Google Cloud. Because ZTF alerts are issued nightly, they can identify transient and variable sources that are active, allowing ground-based follow-up by the community on a prompt timescale, faster than the timescale on which TESS data is typically available. Initial results are provided in earlier ATELs (Yan et al. 2019; Burdge et al. 2019).

Details on how to access alerts and light curves are given in a Jupyter notebook accessible, e.g. via Google Colaboratory (Duev 2019). ZTF-TESS alerts are cross-matched against several external catalogs, including 2MASS PSC, AllWISE, IPHAS DR2 and Gaia DR2. Finally, we note that no filtering is applied to the ZTF-TESS alerts prior to their public release. We encourage spectroscopic followup of alert candidates as quickly as possible to maximize the potential science return from the ZTF-TESS observations. In addition, supernova candidates identified using a com-

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bination of automated filters and human vetting by the ZTF collaboration are automatically posted to the Transient Name Server (TNS) (Transient Name Server 2016) with the "sender" keyword set to "ZTF_TESS".

ZTF light curves for all objects observed concurrently by TESS and ZTF will be available publicly less than one month from the end of a TESS sector observation campaign. Details on how to access and filter the ZTF light curve data will be given in the same Jupyter notebook as mentioned above. More functionality to work with ZTF light curve data will also be available with subsequent light curve releases.

Tractor (Lang et al. 2016) models of ZTF images can be used to simulate the overlapping TESS observations. This technique exploits the higher resolution of ZTF to resolve the position and intensities of sources that may be blended in TESS images. The modelling software used to produce co-added ZTF images and simulated TESS images corresponding to the TESS fields is available on Github (Lang 2019a,b). Example code and detailed documentation for ZTF/TESS modelling will be disseminated in the coming months.

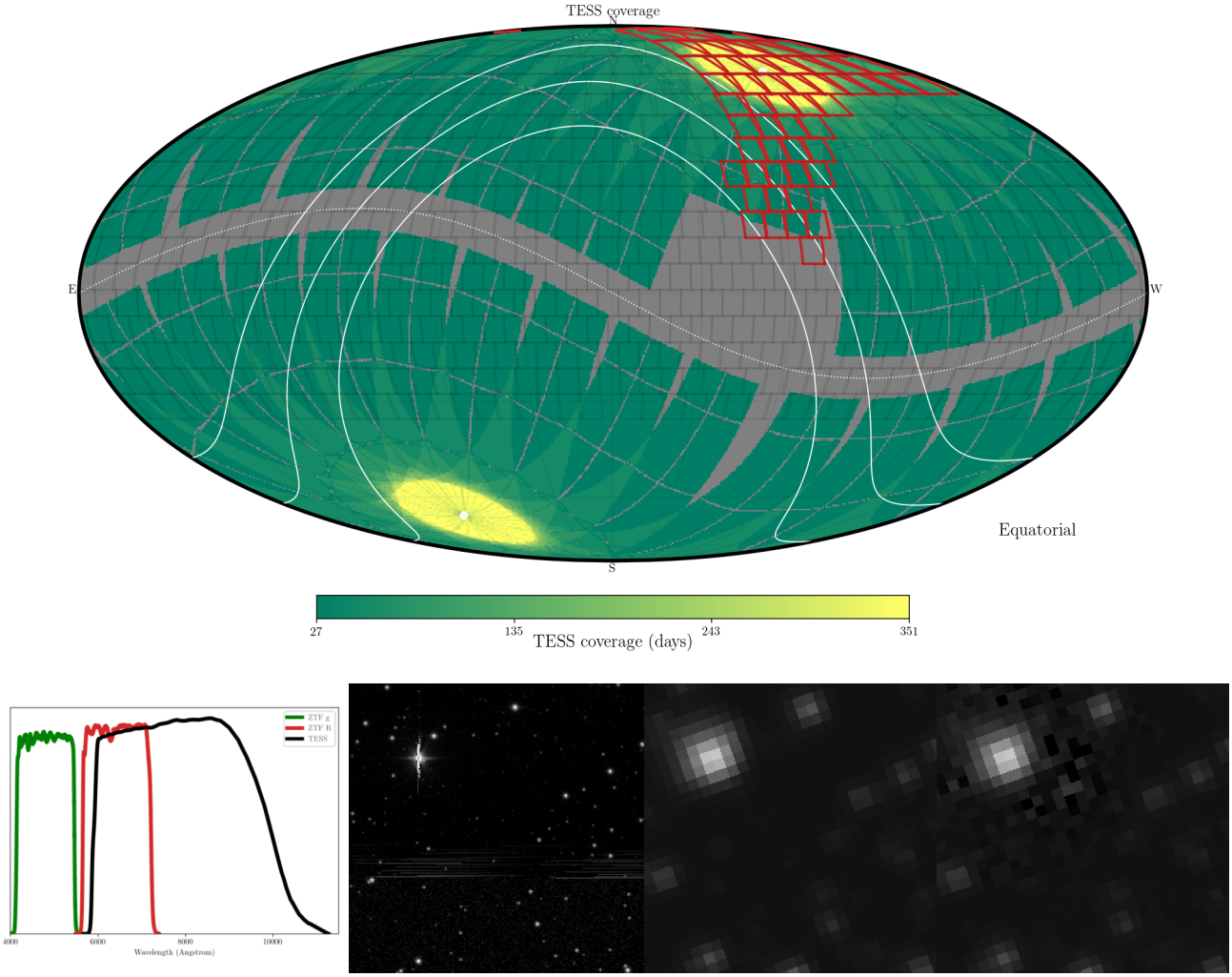

Figure 1. The sky coverage of TESS for the first 2 years of observations. The color indicates how many days an area is observed by TESS. The ZTF-fields that cover TESS-sector 14 are over-plotted in red. In the lower left, the filter response curves are shown, green and red indicate ZTF g and r, black shows the TESS bandpass. The pictures on the lower right show a ZTF image, a TESS image of the same area, and a simulated TESS images based on the ZTF image using Tractor.

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