Ground-Based Photometric Follow-up of TESS Exoplanet Candidates: A Case Study of TOI-5956.01

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Abstract

The confirmation and characterization of TESS exoplanet candidates require extensive ground-based follow-up to refine transit parameters and rule out false positives. In this work, we present photometric observations of **TOI-5956.01**, carried out with the **TRAPPIST-North** telescope at Oukaimeden Observatory in Morocco.

Our data capture a full transit event and were processed and modeled using standard photometric pipelines. The refined transit depth, duration, and mid-transit time are consistent with those from TESS, validating the planetary nature of the candidate and improving the accuracy of its predicted future transit timings.

This study highlights the critical role of ground-based observatories in supporting space missions by improving the accuracy of exoplanet parameters and enabling long-term monitoring. It also demonstrates the contribution of regional facilities to global exoplanet science and their value in the broader context of planetary demographics.

Observations & Methodology

Photometric observations of **TOI-5956.01** were carried out on *31 May 2025* using the **TRAPPIST-North** telescope, located at the *Oukaimeden Observatory* in the High Atlas Mountains of Morocco (31°12'22"N, 7°51'29"W; altitude: 2751 m). The observatory benefits from a high-altitude, semi-arid climate with low atmospheric turbulence and minimal light pollution, making it an excellent site for precision photometry.

TRAPPIST-North (TRAnsiting Planets and PlanetesImals Small Telescope–North) is a fully robotic 60-cm Ritchey–Chrétien telescope equipped with a thermoelectrically cooled CCD camera and a custom-built filter wheel. The telescope was designed specifically for exoplanet transit monitoring and cometary activity studies, and is the northern counterpart to the TRAPPIST-South facility in Chile.

Figure 1. The TRAPPIST-North 60-cm robotic telescope at Oukaimeden Observatory, Morocco.

Observations were performed using the **Exo filter**, a broadband blue-blocking filter optimized for transit photometry in the 700–900 nm range. This filter suppresses atmospheric scattering and enhances contrast for planetary transits, especially around cooler host stars. A **1×1 binning** configuration was used to preserve spatial resolution, and the **exposure time was set to 140 seconds**, as determined by the Exoplanet Transit Calculator ETC link of the University of Liège, to ensure a high signal-to-noise ratio without saturating the detector.

Differential Photometry Results of TOI-5956.01

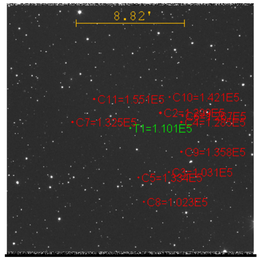

Figure 2. TOI-5956 field-of-view from TRAPPIST-North on UT May 31 2025. Comparisonstars (in red), chosen for having similar brightness to TOI-5956 (in green), were selected from the transit observation using AstroImageJ

After applying bias, dark, and flat-field corrections, differential photometry was performed on **TOI-5956** to measure the target brightness. The target's flux was measured relative to nearby stable comparison stars in the same CCD frame, minimizing systematic effects such as airmass and seeing variations. This method isolates the intrinsic dimming caused by the exoplanet transit.

The derived transit parameters include a depth of approximately **3.8%** and a duration of **1.04 hours**, consistent with TESS data. The fit residuals exhibit an RMS of **0.00533** mag, indicating reliable photometric precision.

Light Curve Analysis

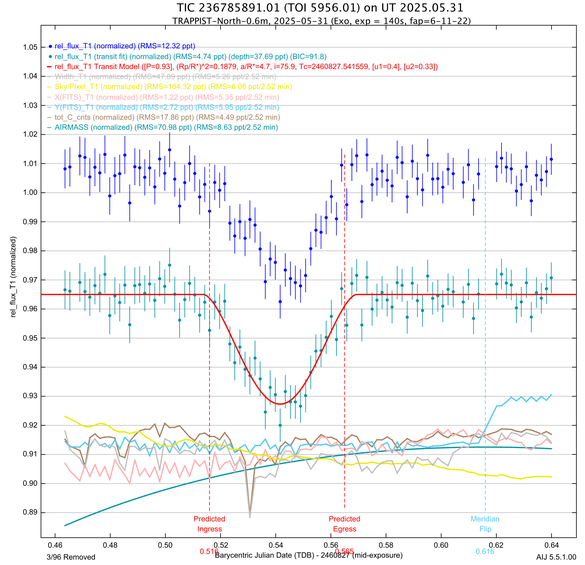

Figure 3. Detrended light curve of **TOI-5956.01**, displaying the transit event as processed using AstroImageJ.

Photometric observations of **TOI-5956.01** confirm the presence of a transit signal aligned with predicted ephemeris. The use of stable comparison stars, low residual scatter, and effective detrending allowed precise extraction of transit parameters consistent with archival values.

TESS vs. TRAPPIST-North Parameter Comparison

Planetary parameters for TOI-5956.01 from TESS and TRAPPIST-North show strong agreement.

Parameter	TESS (TOI-5956.01)	TRAPPIST-North
Orbital Period (days)	0.9292 ± 0.00008	Not fitted (single transit)
Mid-transit Time (BJD)	$2459853.83173 \pm 0.00144$	$2460271.54156 \pm 0.00052$
Transit Depth (ppt)	45.24 ± 3.4	37.7 ± 5.2
Transit Duration (hours)	0.984 ± 0.13	1.04 ± 0.10
Planet-to-Star Radius Ratio (R_p/R_*)	0.2156 ± 0.06265	0.194 ± 0.0139

Table 1. Comparison of key planetary parameters from TESS and TRAPPIST-North observations of TOI-5956.01.

TESS provides precise orbital and transit data through continuous monitoring, while TRAPPIST-North captures a clear single transit with accurate depth and duration. Both confirm consistent planet size and near edge-on inclination. Despite minor differences in some parameters due to fitting methods, the combined datasets highlight the value of coordinated space and ground observations for robust exoplanet characterization.

Conclusion

The transit parameters of TOI-5956.01 derived from both TESS and TRAPPIST-North exhibit strong agreement, validating key properties such as transit depth, planet-to-star radius ratio, and orbital inclination. Variations in the scaled semi-major axis are attributed to differences in observational cadence and modeling approaches but do not undermine the overall consistency. The high photometric precision of the TRAPPIST-North data reinforces the reliability of ground-based follow-up observations. The estimated radius suggests TOI-5956.01 is likely a gas-dominated planet, fitting within the characteristics of known gas giants. These results underscore the importance of combining space and ground-based data to accurately characterize exoplanet candidates and contribute to the broader understanding of planetary system architectures.

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