

Investigation of Atmospheric Anomalous Refraction Using the Digital Zenith Camera VESTA

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Abstract

The Digital Zenith Camera (DZC) VESTA (VERTical by STArs) is a complex astrogeodetic instrument designed to measure deflections of the vertical (DoV), defined as the angle between the ellipsoid normal and the plumb line. These deflections characterize the Earth's gravity field by representing the inclination of the geoid relative to the reference ellipsoid. VESTA consists of a vertically oriented 8-inch telescope, a high-resolution two-axis tiltmeter, a GNSS receiver, a CCD camera, linear actuators, and an embedded computer. Observations are conducted at night using stellar images referenced to precise star catalogues. From the earliest tests, temporal variations in DoV measurements have been detected and consistently observed in subsequent campaigns. One likely source of these variations is atmospheric anomalous refraction (AR), a phenomenon that causes irregular angular displacements of stars in ground-based astrometric observations. AR can produce fluctuations with amplitudes up to 0.2–0.5 arcseconds and periods ranging from minutes to several hours, potentially degrading measurement accuracy during a typical 40–60 minute VESTA session. A project, “Investigation of Anomalous Refraction Effect by Using Automated Digital Zenith Camera VESTA,” has been launched at the University of Latvia. The project aims to improve understanding of AR behavior using DZC VESTA and to develop methods to mitigate its impact on astrometric observations. Long-term overnight campaigns are being conducted in diverse environments—flat fields, hilly terrain, and coastal areas—across different seasons and weather conditions. Parallel observations with two adjacent DZCs and a dedicated meteorological sensor network are supporting analysis of spatial and vertical AR characteristics. Initial observations indicate substantial night-to-night variability, highlighting the complexity of AR effects and the need for systematic investigation. Currently a simple model of anomalous refraction influence on digital zenith camera measurements is created. A calculation algorithm has been developed allowing for estimation of magnitude and direction of anomalous refraction.

Keywords: Digital zenith camera, deflection of the vertical, anomalous refraction, gravity field