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A test of height transfer using digital zenith camera VESTA and GNSS

Inese Varna, Ansis Zarins, Gunars Silabriedis, Katerina Runde, Armands Celms

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INTRODUCTION

- Traditional geometrical leveling
- Alternative approach using GNSS and geoid undulations
  - Vertical Deflection Measurements by Digital Zenith Camera VESTA (Vertical by STArs)
  - GNSS
  - Test application of height transfer using quasi-geoid undulation extrapolation
- Survey examples (Australia, Switzerland, USA)

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DIGITAL ZENITH CAMERA VESTA (VErtical by STArs)

VESTA prototype camera (2016)

VESTA (2019)

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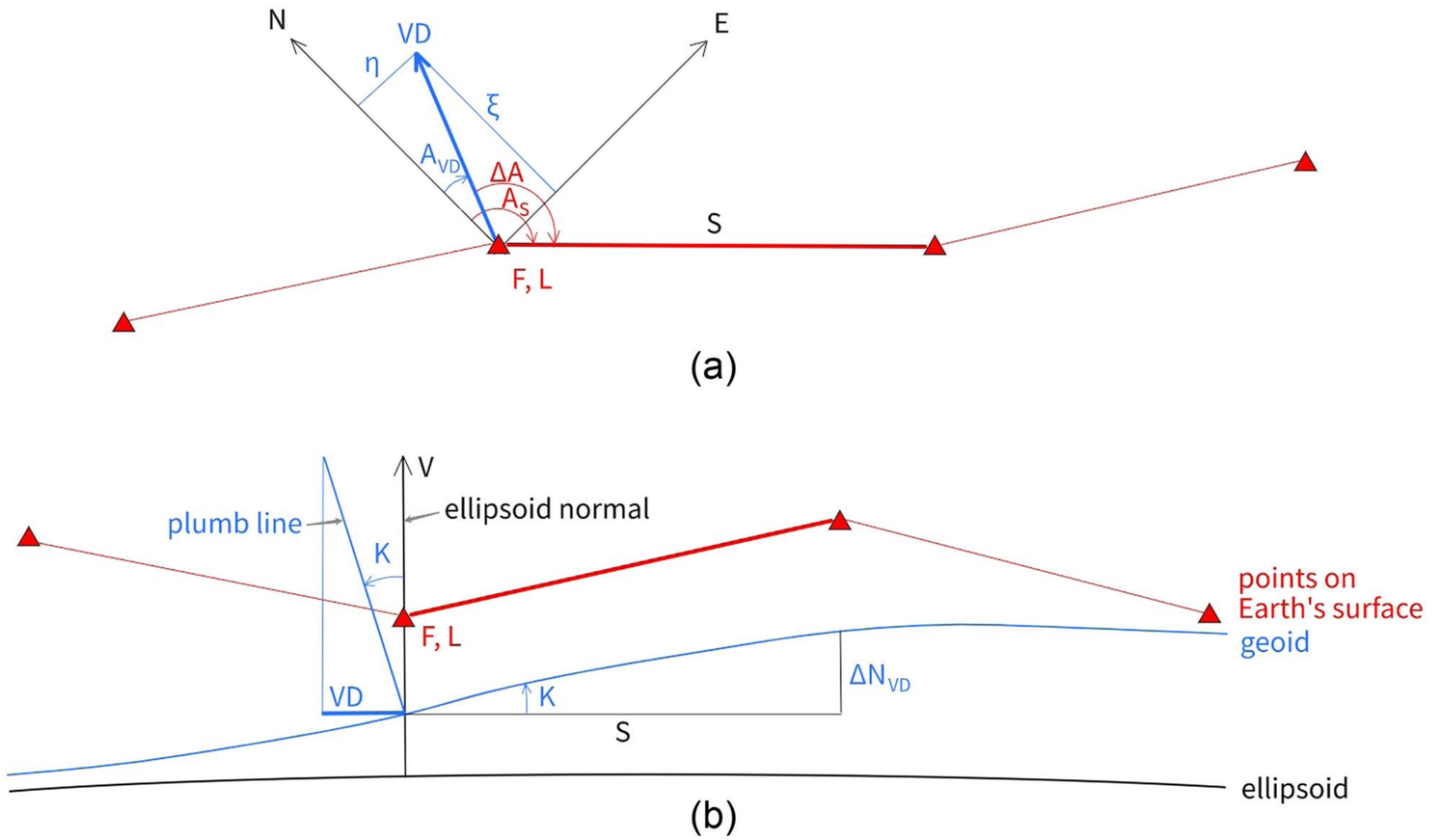
MEASUREMENTS

Measurement traverse (starting from northernmost point): asterisks = VD measurement points; circles = leveling network points



Geometry of height transfer: (a) top; and (b) side

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RESULTS

Point No	Catalogue normal height H (m)	Ellipsoidal height h (m)	Geoid undulation $N = h - H$ (m)	$\Delta N_{GNSS/level}$ relative to point No 1295 (mm)	ΔN_{VD} relative to point No 1295 (mm)
1295	81.009	103.161 ± 10 mm	22.152 ± ~10 mm	0	0
137	75.750	97.939 ± 10 mm	22.189 ± ~10 mm	37 ± ~14	44 ± 1
1557	82.106	104.347 ± 10 mm	22.241 ± ~10 mm	89 ± ~14	104 ± 2

- Levelling network point normal heights *H* from catalogue;
- ellipsoidal heights *h* measured by GNSS;
- geoid undulation *N*, and geoid undulations $\Delta N_{GNSS/level}$ relative to point No 1295 obtained from GNSS measured ellipsoidal heights and catalogue normal heights;
- and geoid undulations ΔN_{VD} obtained from VD measurements;
- *dh=10* mm and $d\Delta N_{VD}$*=0.5* mm/km assumed.

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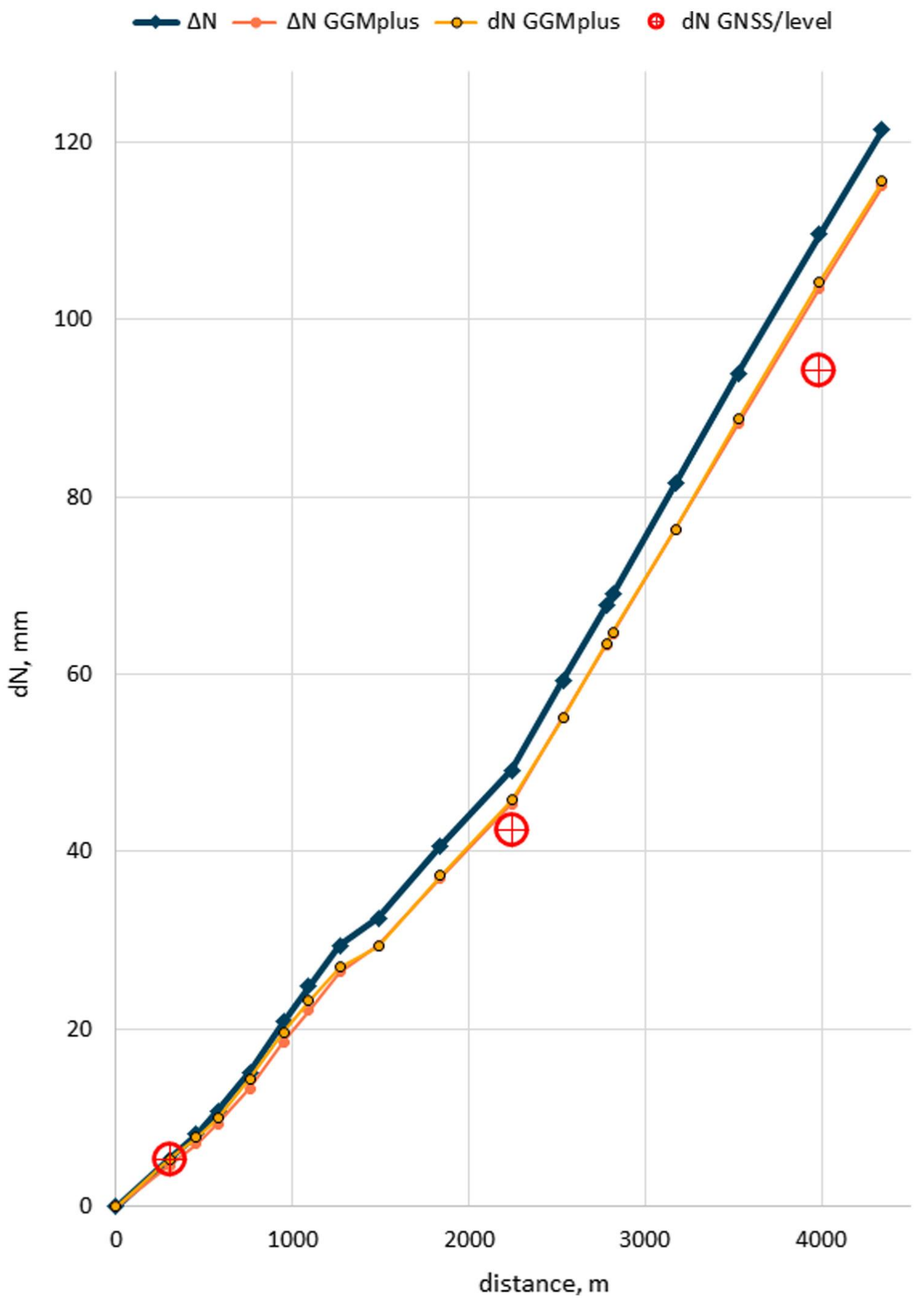
RESULTS



Extrapolation of geoid undulation ΔN_{VD} along measurement traverse (starting at northernmost point) compared with GNSS/leveling data ($dN_{GNSS/level}$) and same extrapolation using VD derived from GGMplus ($\Delta N_{GGMplus}$) and geoid undulation derived from GGM_{plus} ($dN_{GGMplus}$).

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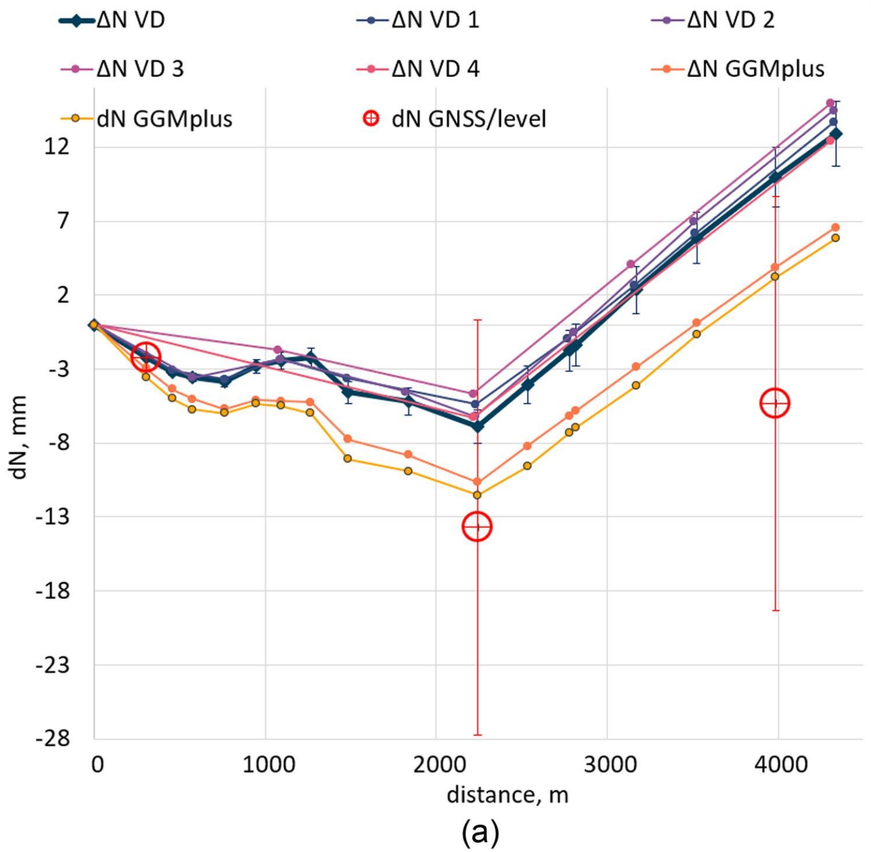
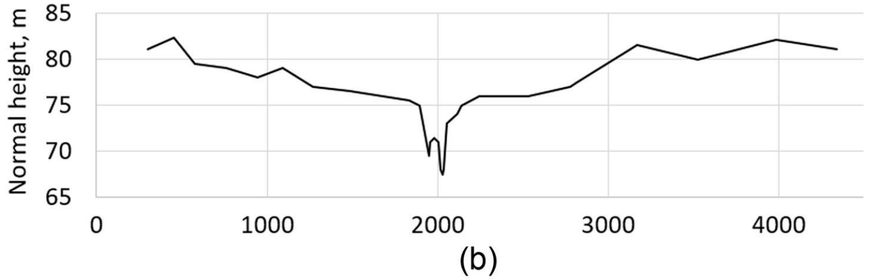
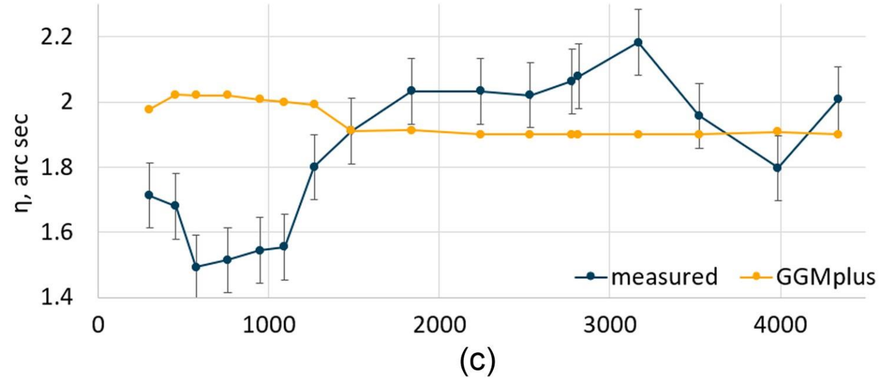
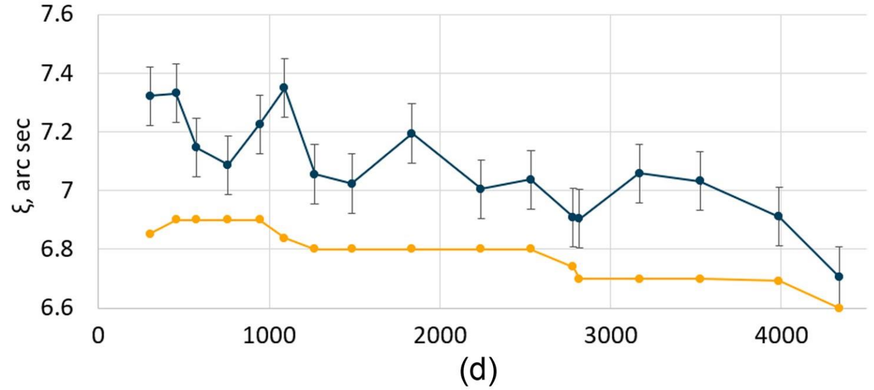
RESULTS









a) Same as previous slide, minus 25-mm/km trend and with variants omitting measurement points (ΔN_{VD1} … ΔN_{VD4}) added;
(b) height profile of trace;
(c) north–south component of VD;
(d) east–west component of VD.

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CONCLUSIONS

- Extrapolation of geoid undulation from measured VD values can be used for accurate transfer of undulation changes and, in combination with GNSS ellipsoidal height measurements, for transfer of height above sea level.
- The accuracy of geoid undulation transfer can be ~0.1 mm/km at a VD accuracy of ~0.1 arcsec and an average distance between measurement points of a few hundred meters. If the geoid surface is smooth, the distance between points can be greater, probably up to 1–2 km. In complicated topography (e.g., mountain regions), smaller distances between points may be needed.

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CONCLUSIONS

- Several advantages over geometrical levelling:
  - VD and ellipsoidal height measurements can be obtained independently for intermediate points, allowing the use of old data in conjunction with new measurements;
  - long-distance profiles or natural or administrative obstacles in a profile;
  - the distance between measurement points can be an order of magnitude greater than that obtained via geometrical levelling;
  - VD measurements using DZC VESTA are fully automatic, requiring only one operator.
- Disadvantages:
  - Clear sky required;
  - Night shift work.

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THANK YOU!

Varna I., Zarins A., Silabriedis G., Morozova K., Celms A. (2023) **A Test of Height Transfer Using Vertical Deflection Measurements by the Digital Zenith Camera VESTA**, *Journal of Surveying Engineering*, 149 (4), 04023017. 10.1061/JSUED2.SUENG-1434

Inese Varna, PhD
inese.varna@lu.lv