Validation of GGMplus and CHGeo2004 Using Observed Deflection of the Vertical Data from QDaedalus and CODIAC Systems in the Mountainous Terrain of the Surses Region, Switzerland

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Abstract

State-of-the-art astrogeodetic measurement systems—Digital Zenith Camera Systems (DZCSs) and the tachymeter-based QDaedalus systems—are currently used to obtain astrogeodetic deflection of the vertical (DoV) components. In this study, we use the CODIAC DZCS (accuracy ˜0.05") and two QDaedalus systems (accuracy ˜0.20") developed by ETH Zurich to collect DoV data in the Surses Region (Canton of Grisons), Switzerland. Based on these data, we assess the quality of the DoV predicted by the Global Gravity Model GGMplus and the Swiss Geoid model CHGeo2004. DoV data previously observed with the QDaedalus system in coastal (Istanbul) and smooth (Munich region) terrain areas were compared with GGMplus to determine the accuracy of the model for both types of terrain. The Surses Region was chosen for these observations because of its mountainous nature to examine the quality of the GGMplus model in mountainous terrain, as well as the GGMplus' quality with the CHGeo2004. Astrogeodetic observations were conducted at 15 benchmarks in the astrogeodetic profile, at elevations ranging from 1185-1800 m and a station spacing of ˜1.5 km. At one benchmark (BM12), observations were done with all three systems (eccentric BMs), while at 13 benchmarks, observations were only completed with the QDaedalus systems. Observations at the final benchmark were completed only with the CODIAC (00 zenith angle) due to line of sight obstacles. The standard deviations of the QDaedalus data for each session are 0.04"-0.22" and 0.01"-0.20" for the N-S and E-W components, respectively. These high-quality data were compared to DoV data derived from GGMplus and CHGeo2004. The residuals from GGMplus are: The N-S component exhibit large residuals ranging from -2.31" to 1.75", while the E-W component residuals are -0.27" to 1.80". The residuals from CHGeo2004 range from -0.60 to 1.21 for the N-S components, and -1.01 to 0.32 for the E-W components. The results show that the predicted DoV data from CHGeo2004 are closer to the observed DoV, and more accurate than GGMplus. We conclude from these results that GGMplus is of significantly lower quality in mountainous terrain than in the smooth terrain of the Munich region (˜0.2", and reaching a maximum of 0.3" and 0.4" for the N-S and E-W components).

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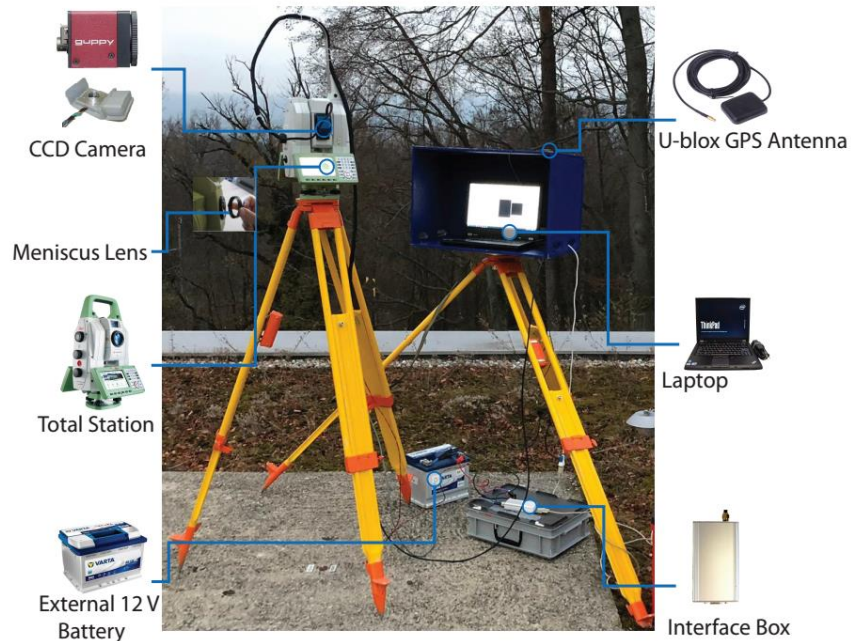
[1] La Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud, Institute of Territorial Engineering, Yverdon-les-Bains, Switzerland
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[3] ETH Swiss Federal Institute of Technology Zurich, Institute of Geodesy and Photogrammetry, Zurich, Switzerland
[4] Technical University of Munich, Institute for Advanced Study, Munich, Germany,
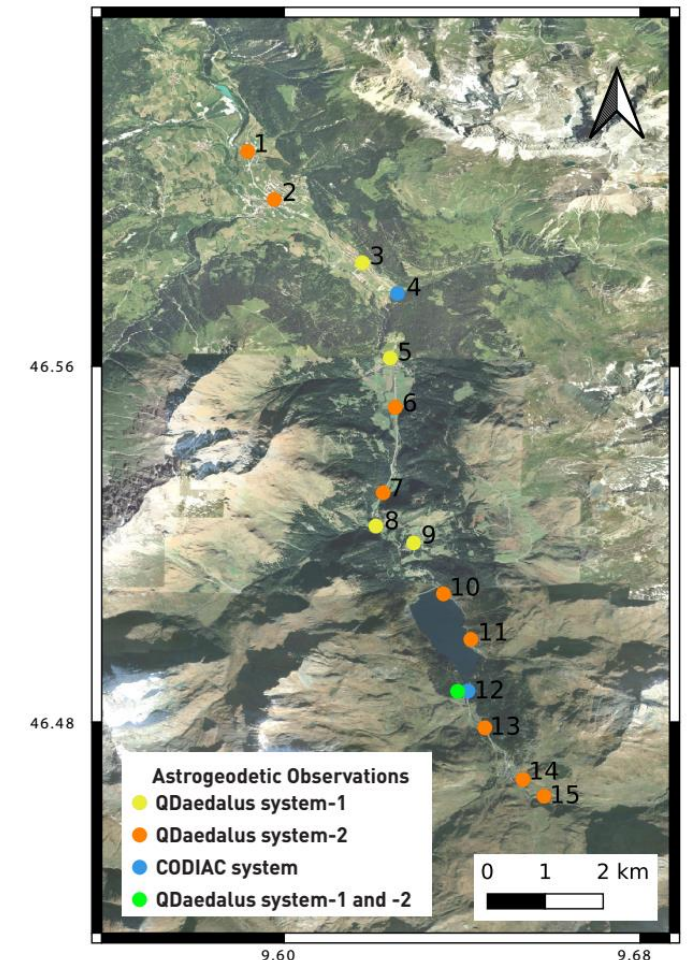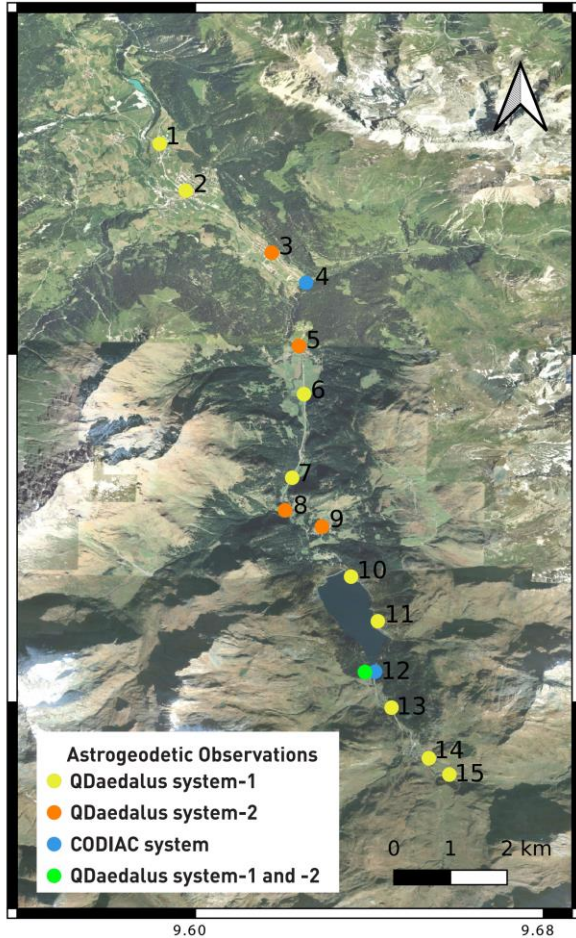[5] State Surveying Agency of Lower Saxony (LGLN), Hannover, Germany

TS60-based QDaedalus system (x2)
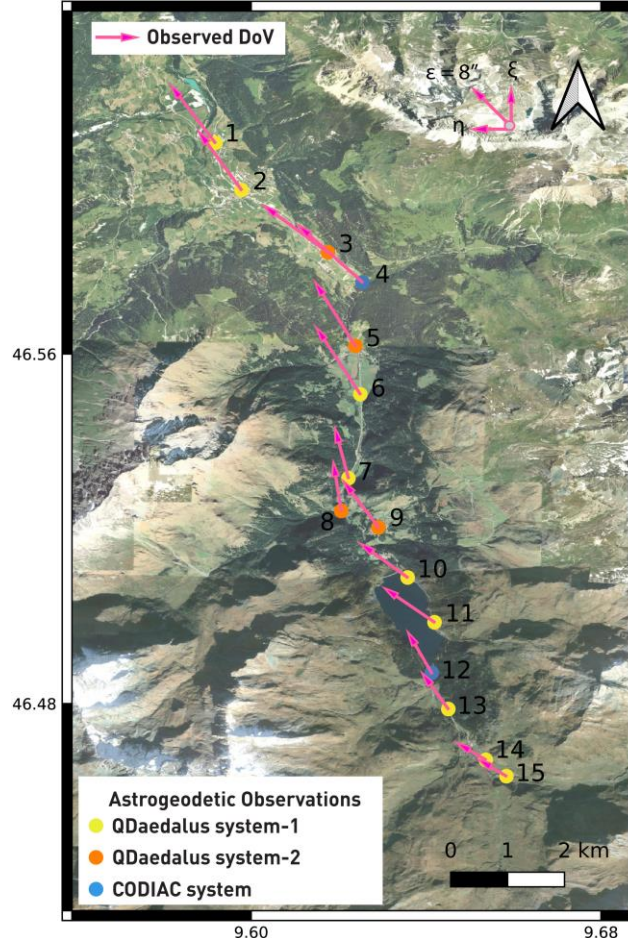Accuracy of 0.1″, 30° Zenith Angle (ZA)

Zenith telescope-based CODIAC system
Accuracy of 0.05″, 0° ZA

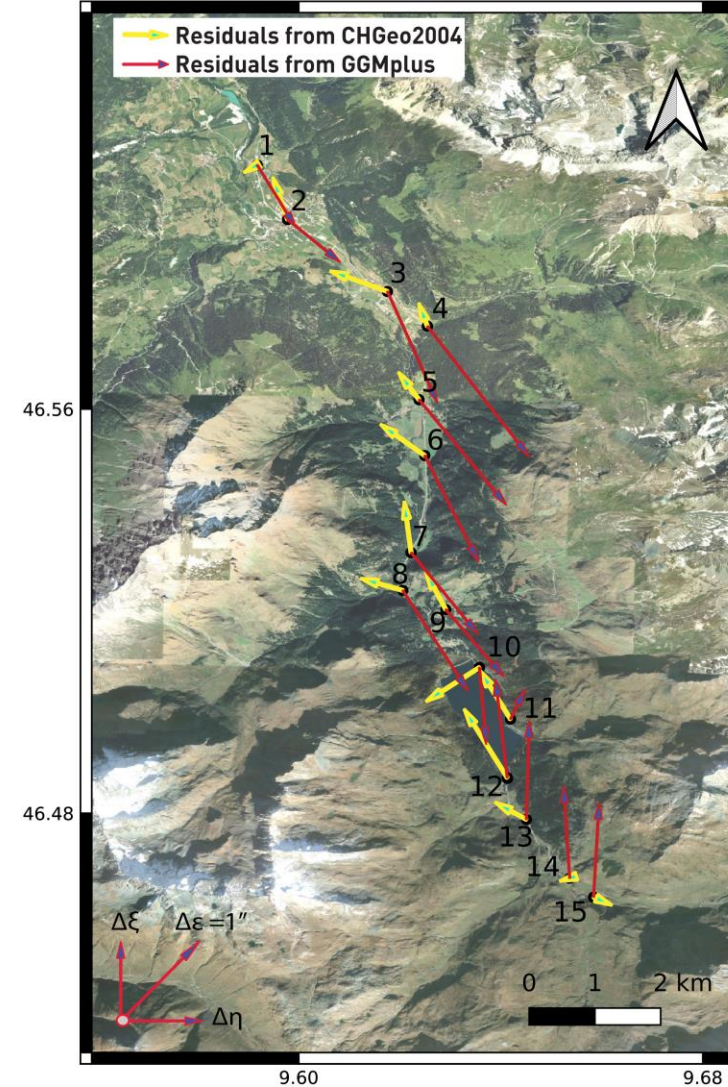# DoV comparisons between observed and derived DoV data in the Surses Region

13 BM obs. with the QDaedalus–1 or –2
1 BM obs. with the CODIAC
1 BM obs. with all three systems

SDs of the QDaedalus data
ξ & η : 0.04″–0.22″

SDs of the CODIAC
ξ & η: 0.02″–0.04″

Residuals from GGMplus
$\Delta\xi$: –2.31″ to 1.75″
$\Delta\eta$: –0.27″ to 1.80″

Residuals from CHGeo2004
$\Delta\xi$: –0.60″ to 1.21″
$\Delta\eta$: –1.01″ to 0.32″

The predicted DoV data from CHGeo2004 are closer to the observed DoV and more accurate than GGMplus.

Residuals from GGMplus and QDaedalus

Coastal terrain (Istanbul) for 15 BMs

$\Delta\xi$: 2″ and 6″

$\Delta\eta$: > 2″ at 3 BMs

Smooth terrain (Munich region) for 10 BMs
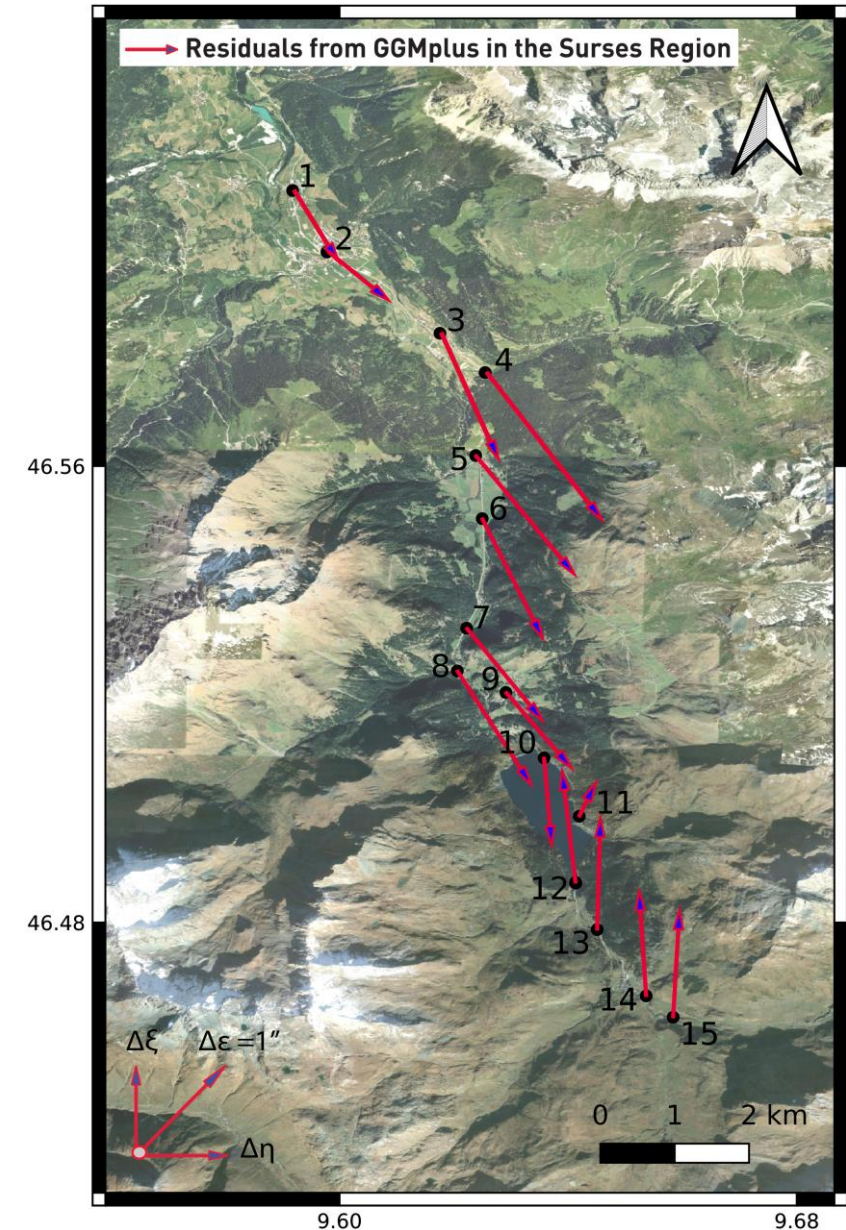
$\Delta\xi$ & $\Delta\eta$: ~0.2″

Reaches a maximum of 0.3″ for $\Delta\xi$ and 0.4″ for $\Delta\eta$

GGMplus is lower quality in mountainous terrain than in the smooth terrain of the Munich region.

GGMplus is higher quality in mountainous terrain than in the coastal terrain of Istanbul.

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Residuals from GGMplus in the Surses Region

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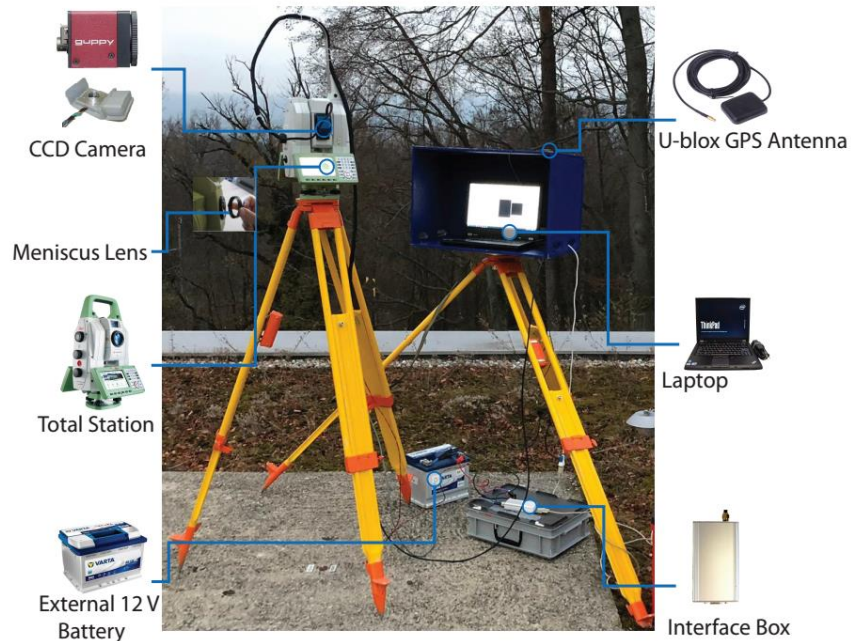
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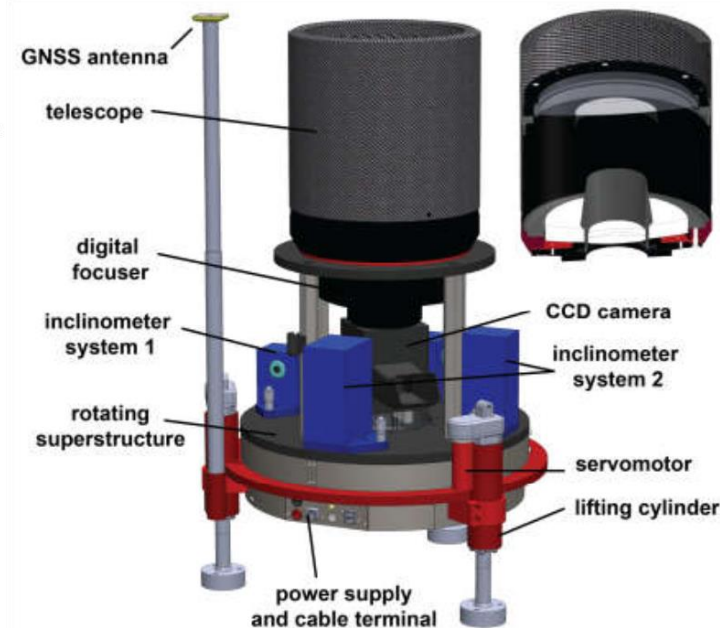[2] Federal Office of Topography swisstopo, Wabern, Switzerland

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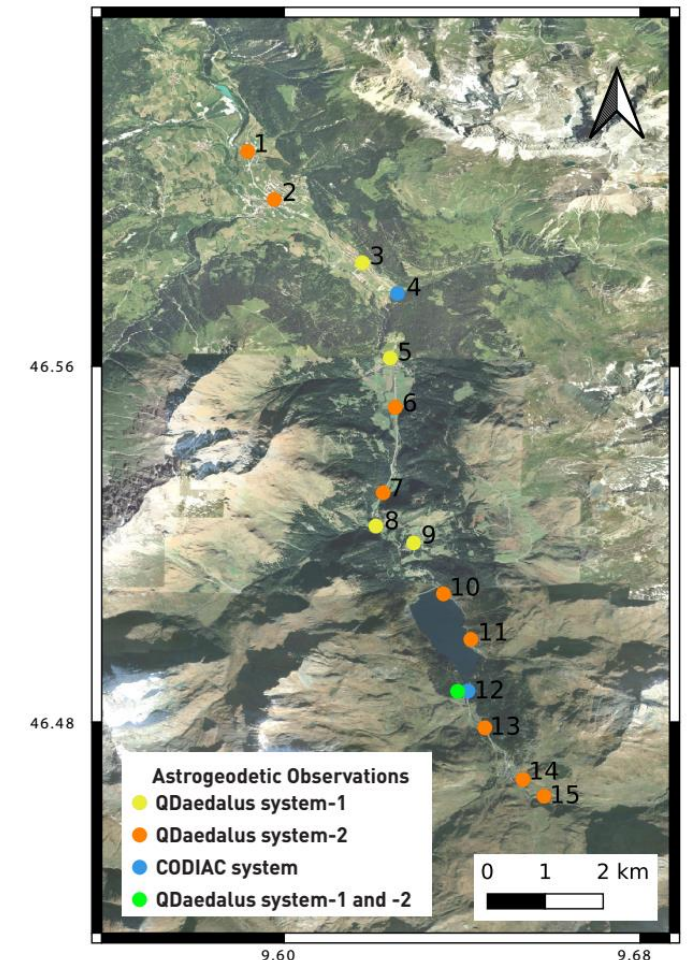
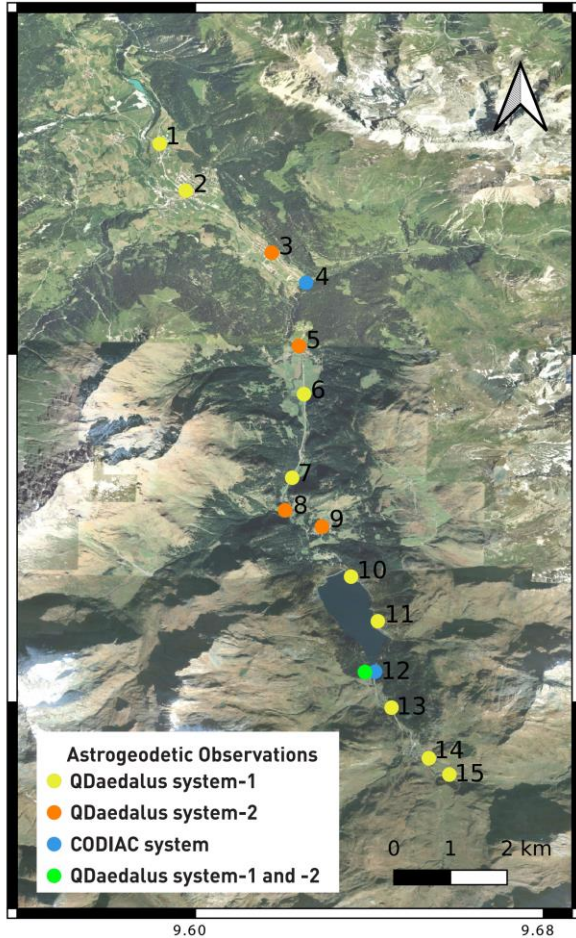[5] State Surveying Agency of Lower Saxony (LGLN), Hannover, Germany

TS60-based QDaedalus system (x2)
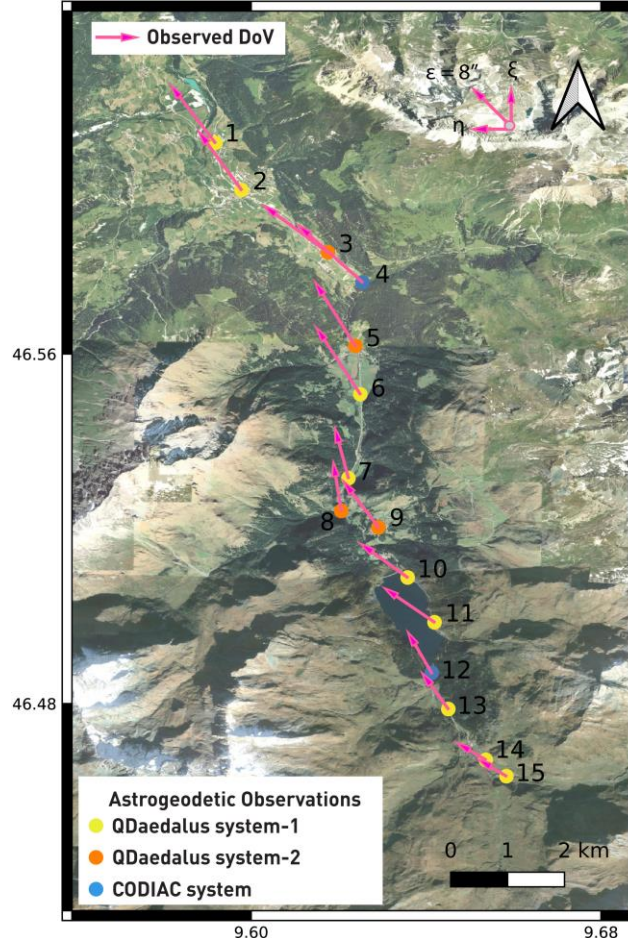Accuracy of 0.1″, 30° Zenith Angle (ZA)

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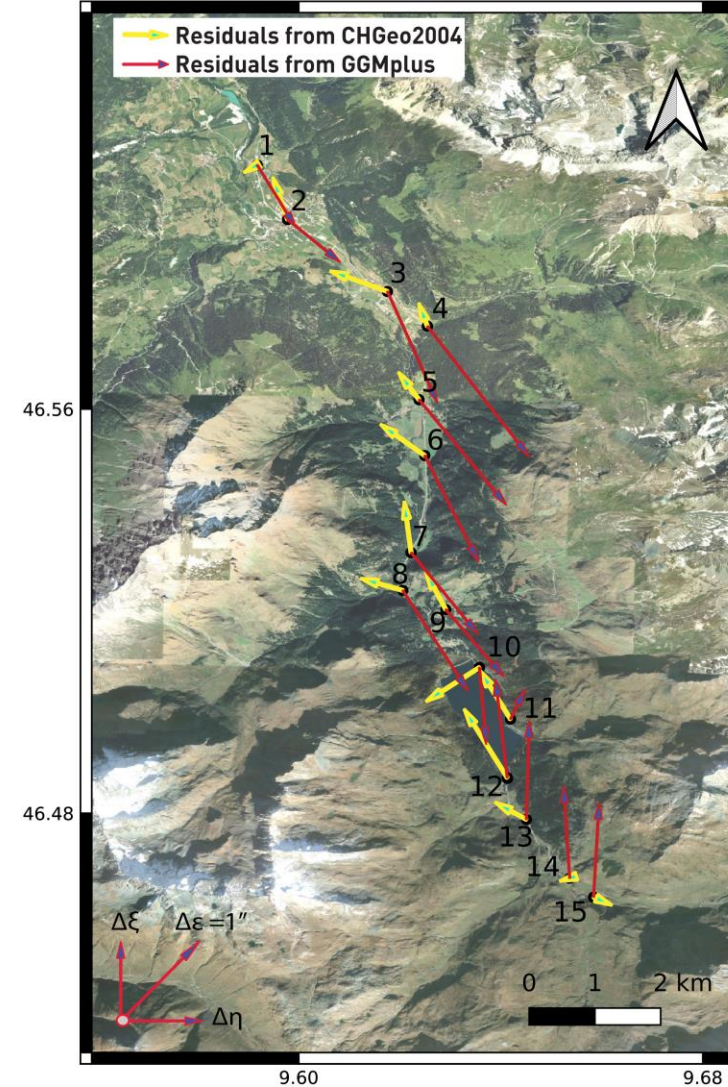# DoV comparisons between observed and derived DoV data in the Surses Region

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