A Performance Analysis of the Leica MS60 MultiStation-Based QDaedalus Astrogeodetic Measurement System at the HEIG-VD Test Station, Switzerland

<u>Müge Albayrak</u> (muge.albayrak@harran.edu.tr)
Institute of Engineering, Harran University, Sanliurfa, Turkey

Daniel Willi & Sébastien Guillaume

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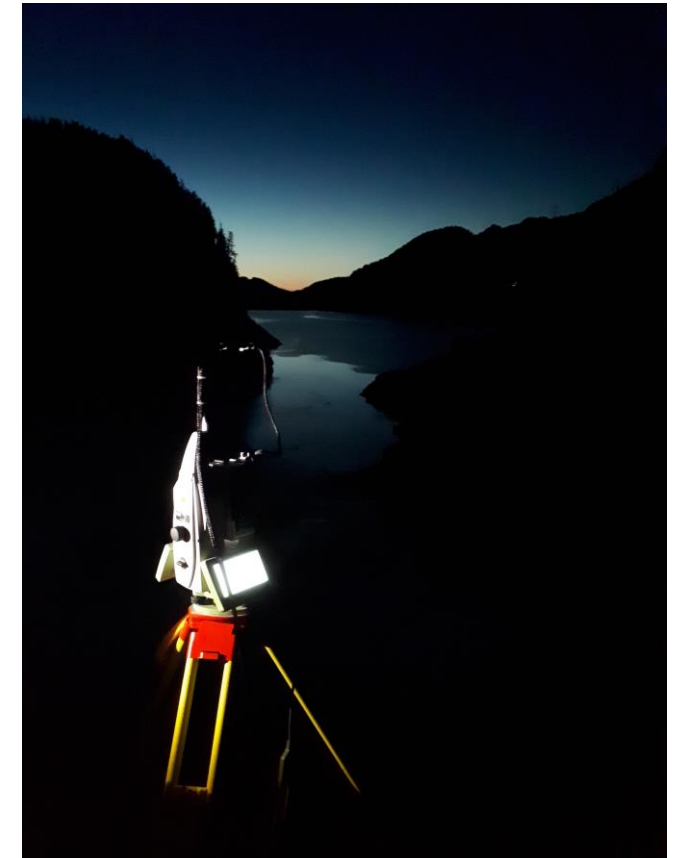
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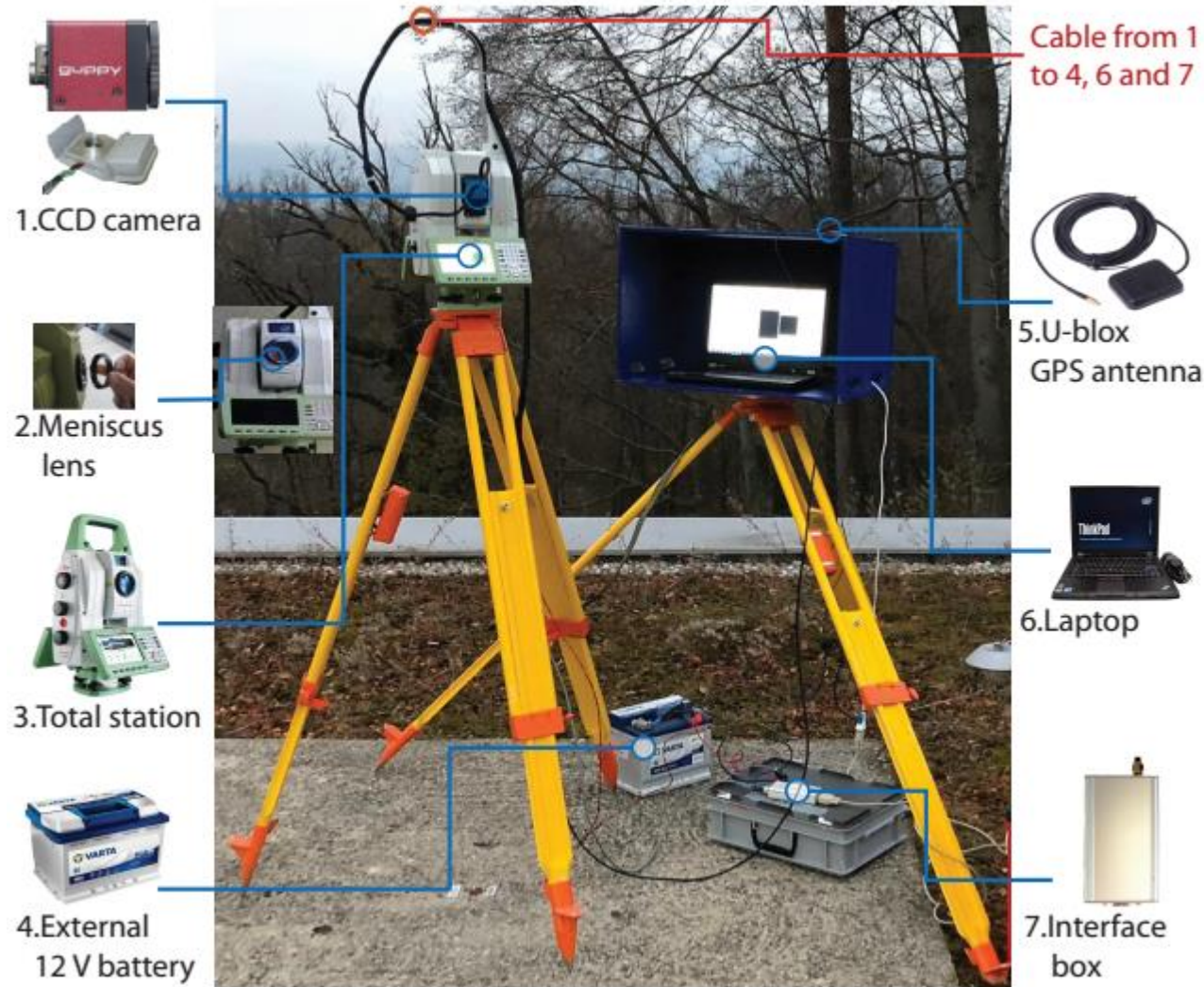**Federal Office of Topography swisstopo**

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QDaedalus Measurement Steps to Observe DoV

QDaedalus system (Albayrak et al. 2022)

The QDaedalus system observation steps:

1. QDaedalus installation
2. CCD camera calibration
3. Orientation to reference star (Polaris, etc.)
4. Astronomical observation
   - ❑ Automatically finds stars at 30° zenith angle
   - ❑ Generally observes single stars four times (via video recording)
   - ❑ Observation duration

     15 min/series, 3-4 series/session
   - ❑ Each series results in 20-40 stars
5. Data Processing (robust estimation of DoV)
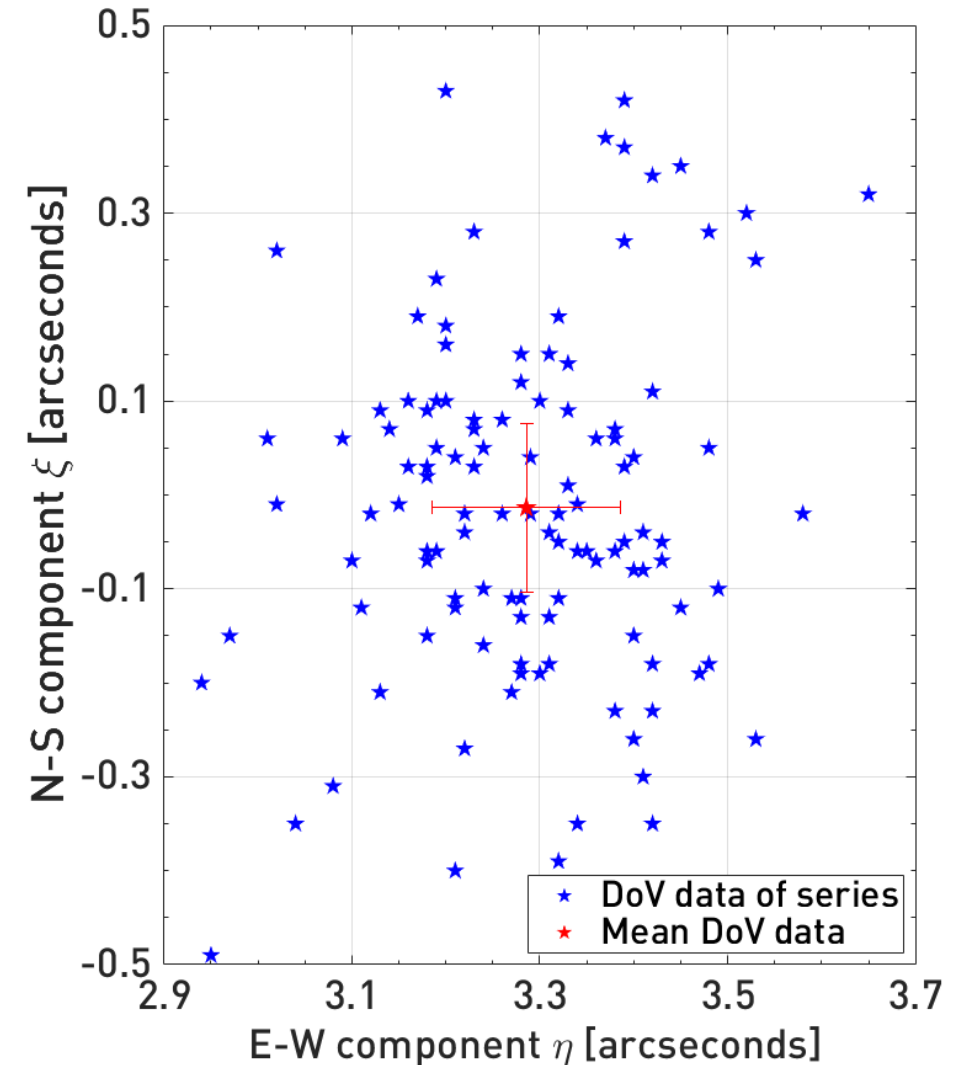
Data Collection

- ❏ MS60 MultiStation-based QDaedalus system

- ❏ Observation duration

   15 min/series, up to 7 series/session

- ❏ 13 nights (44 days from Feb.–April 2021)

- ❏ 115 series of observations performed over 26 sessions

Results for HEIG-VD Test Station in Yverdon-les-Bains

The SDs of the QDaedalus data;

- ❏ N-S components (ξ): 0.10″

- ❏ E-W components (η): 0.09″

$$s_i = \sqrt{\frac{\sum (SD)^2}{n}}$$

❑ The pooled single session SDs at the TU Munich (TUM) station for three total station based-QDaedalus systems (Hauk et al. 2017, Albayrak et al. 2020)

Location	Total station	Number of sessions	Total number of series	SD ξ ["]	SD η ["]
	TCA2003	4	30	0.13	0.14
TUM	TDA5005	18	56	0.11	0.14
	TCRM1101	12	32	0.09	0.10
HEIG-VD	**MS60**	**26**	**115**	**0.10**	**0.09**

❑ Produced a more extensive data set (26 session and 115 series over 13 nights) than previous studies with fewer sessions and series per system

❑ MS60-based QDaedalus system's observed DoV data as precise for both components as the total station-based QDaedalus systems
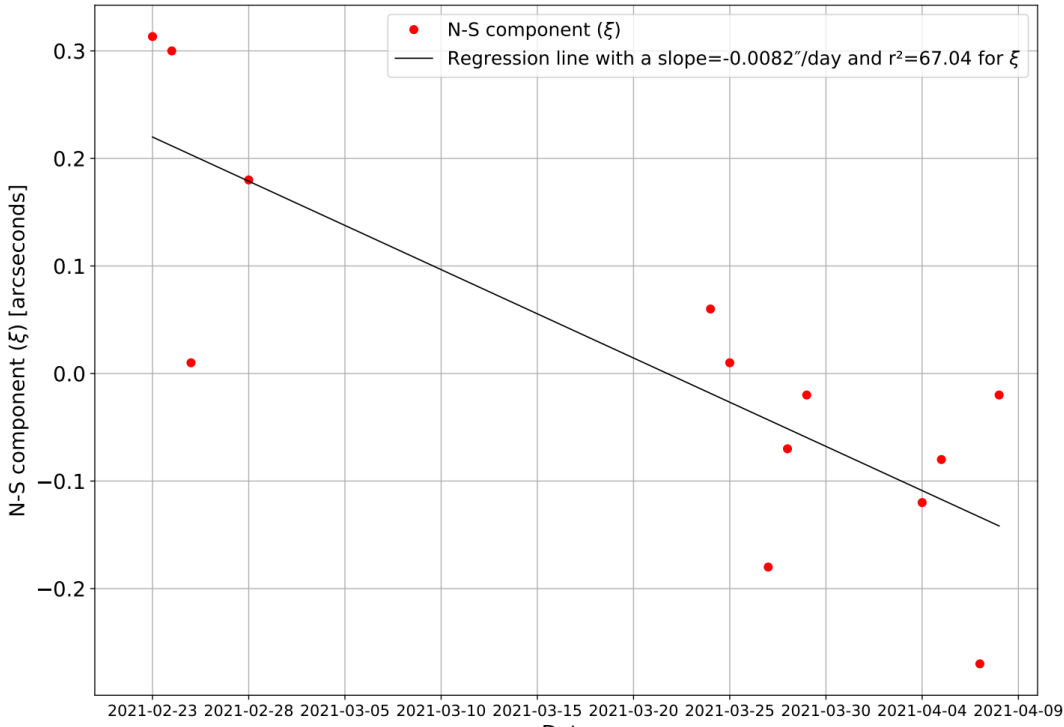
❑ Systematic trend in the observed N-S (ξ) DoV data

❑ The spread of the data in the N-S (ξ) direction (0.92″) is larger than in the E-W (η) direction (0.71″)

❑ Linear regression lines fitted to model the trend in the N-S comp.

   ❑ N-S comp.: 0.008″/day
      (total of 0.38″ change over the 44 days)

❑ Linear regression line for E-W DoV not included due to 0.0018″/day change

❑ N-S DoV drift is five times bigger than E-W DoV drift over the 44 days
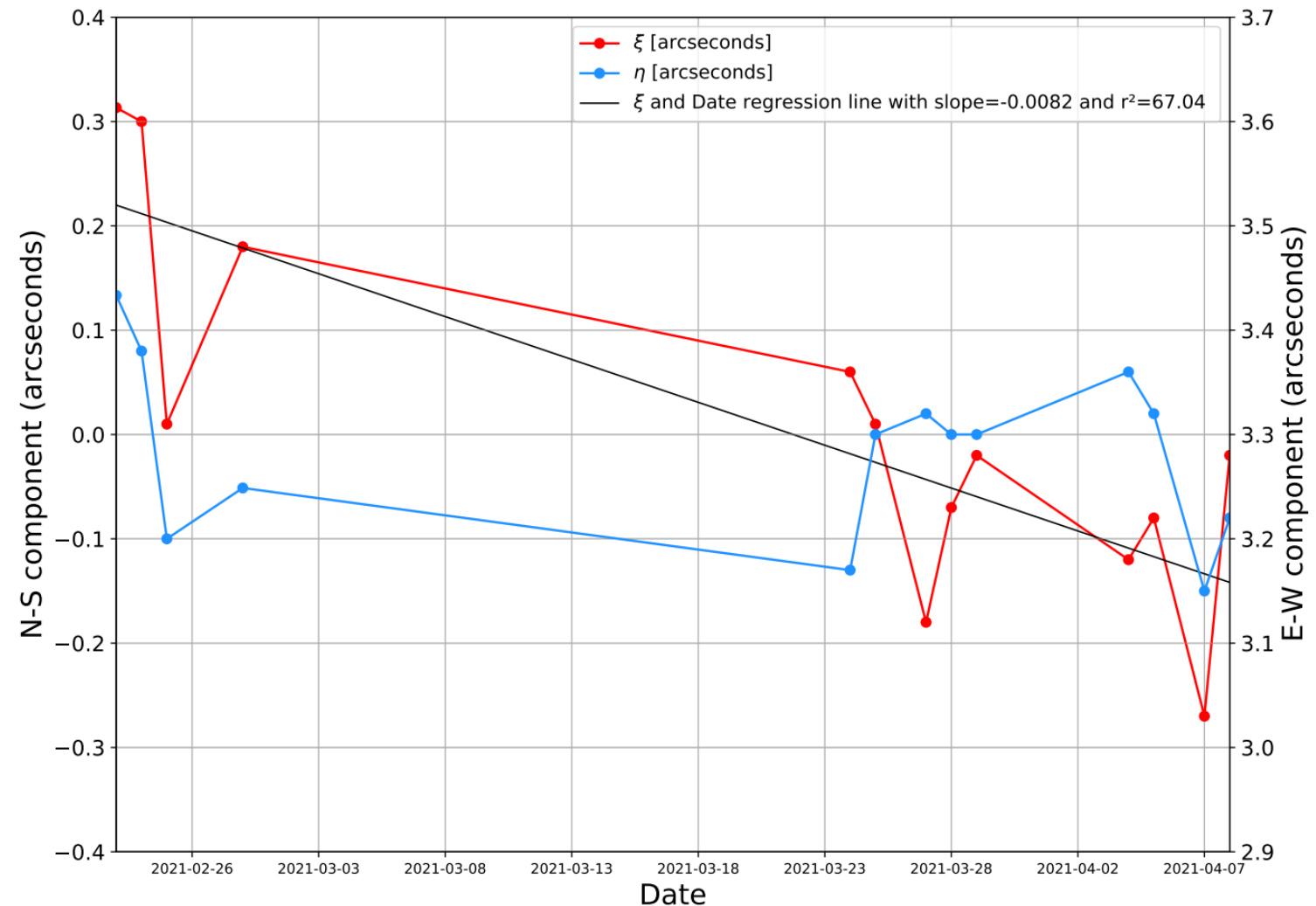
- ❏ Possible causes of 0.008″/day trend (N-S):
  - ❏ Water level changes
  - ❏ Temperature variations
- ❏ We calculated the effect of a one metre water layer (Lake Neuchâtel) using QGravity software (Guillaume 2015)
- ❏ QGravity calculations show that the DoV difference for a one-metre lake level change is 0.004″
- ❏ There was an ~0.3-meter rise in the water level of Lake Neuchâtel in Yverdon-les-Bains over the 44-day observation period
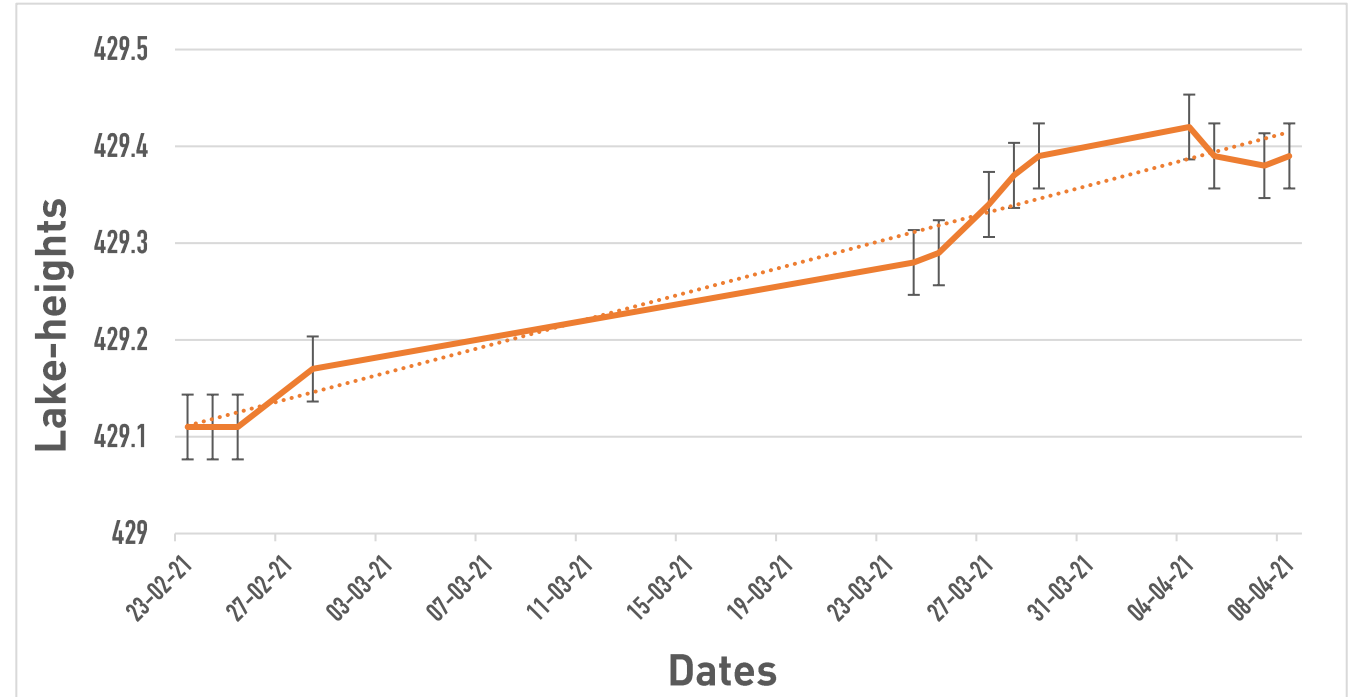

The water heights changes in the Lake Neuchâtel (www.hydrodaten.admin.ch/)

- ❏ Therefore, the possible effect of lake level changes on the N-S component would only be 0.004″/m x 0.3 m = 0.0012″ over the 44-day observation period.
- ❏ We conclude that the lake water level changes have no effect on the measured trend of the N-S DoV at the HEIG-VD test station.
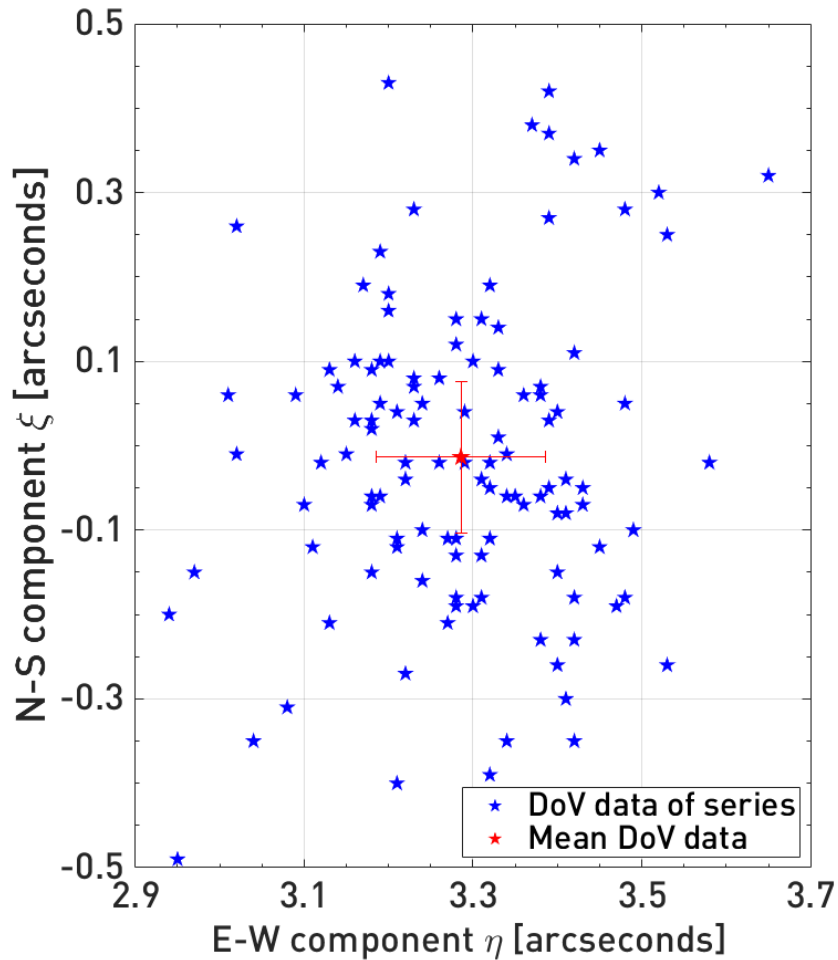
N–S and E–W DoV for the 118 series of observations (Feb.–April 2021)

SD ξ ["]	SD η ["]
0.10	0.09

❑ To further investigate the cause of the N–S trend, we conducted a new observation campaign in summer 2021.

SD ξ ["]	SD η ["]
0.12	0.21
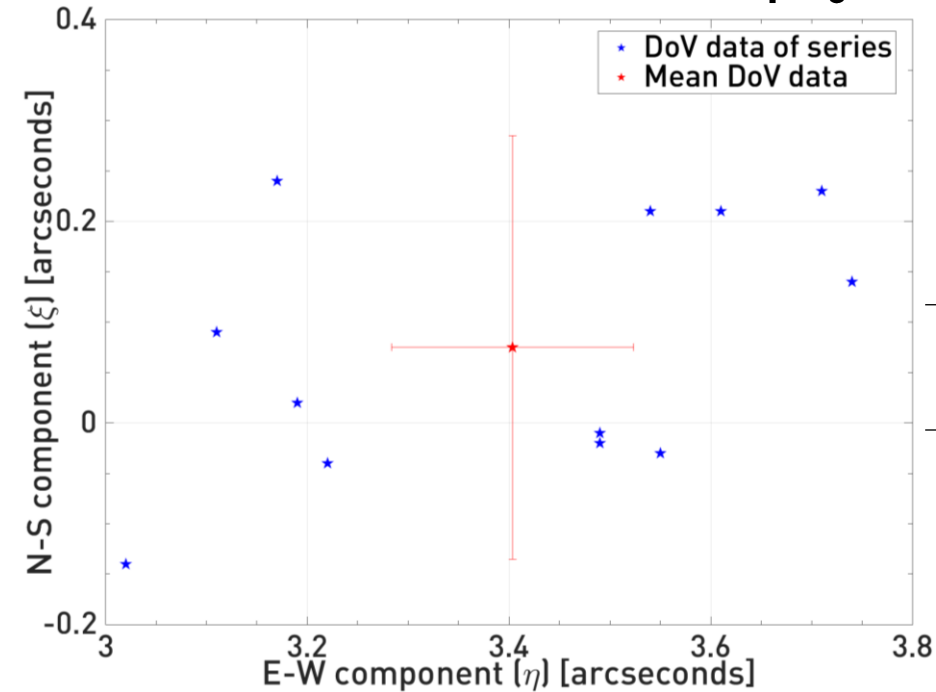
N–S and E–W DoV for the 12 series of observations (May 30–31, 2021)

❑ No systematic trend observe in Summer 2021 campaign.

❑ Therefore, we assume that the N–S trend could be related to large temperature variations in winter; however, further investigation require.

Summary and Conclusions

❏ We used a Leica MS60-based QDaedalus system to collect DoV data.

❏ The precision of the system was found to be 0.1″ for the N-S and E-W components.

❏ The applied method shows that the MS60-based QDaedalus system is at least as reliable as the previously reported total station-based QDaedalus systems.

❏ 0.008″/day trend was observed in the N-S components at the HEIG-VD test station.

❏ Cause of N-S trend remains unexplained and requires further investigation.

    ❏ Lake water level changes have no effect on the measured drift in the N-S DoV (0.0012″ over the 44 days).

    ❏ No systematic trend observed in Summer 2021; large temperature variations in winter could be a possible cause.

❏ The QDaedalus system can be used very effectively for observation campaigns.

The full DoV data set with geodetic coordinates
is available from Albayrak et al. (2022)

References

❑ Albayrak, M., et al. 2020. Quality assessment of global gravity models in coastal zones: A case study using astrogeodetic vertical deflections in Istanbul, Turkey. Studia Geophysica et Geodaetica, 64(3), 306–329. DOI:10.1007/s11200-019-0591-2

❑ Albayrak, M., Willi, D. and Guillaume, S., 2022. Field comparison of the total station-based QDaedalus and the zenith telescope-based CODIAC astrogeodetic systems for measurements of the deflection of the vertical. Survey Review. DOI:10.1080/00396265.2022.2054108

❑ Guillaume, S., 2015. Determination of a precise gravity field for the CLIC feasibility studies. PhD Thesis, Dissertation Nr. 22590, Eidgenössische Technische Hochschule ETH Zurich, Switzerland. DOI:10.3929/ethz-a-010549038

❑ Guillaume, S., Bürki, B., Griffet, S., Durand, H.M., 2012. QDaedalus: Augmentation of total stations by CCD sensor for automated contactless high-precision metrology. In FIG Working Week, Rome, Italy.

❑ Hauk, M., Hirt, C., and Ackermann, C., 2017. Experiences with the QDaedalus system for astrogeodetic determination of deflections of the vertical. Survey Review, 49(355), 294–301. DOI:10.1080/00396265.2016.1171960

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✉ muge.albayrak@harran.edu.tr