

Trigonometric altitude determination

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1. Introduction

The report explores using trigonometric measurements to determine altitude, specifically examining the impact of temperature on refraction and measurement accuracy. It confirms a linear relationship between refraction and temperature and demonstrates that trigonometric altitude measurements are more accurate than anticipated. The report proposes an experiment to refine the refraction coefficient based on temperature categories and emphasizes the need for further measurements for comprehensive scientific evaluation.

2. Measurement program 2023

This year, it was possible to fill measurement gaps between -10 and -20 °C in a few days. In addition to the cold weather, the distant destinations of La Dôle, Chasseral and Feldberg (Germany) were recognizable on these days - depending on the weather, they were clear but also somewhat blurred.



Figure 1. Main measures 2023.

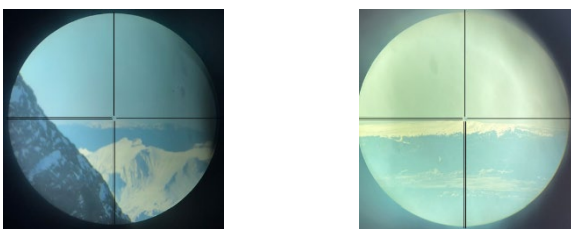


Figure 2. Destination 'La Dôle' and 'Chasseral'

3. Results 2023

Figures 3a, 4a and 5a show that the results calculated from the refraction coefficient 0.13 are highly dependent on temperature. However, even under the best optical conditions, some results are officially incorrect (points outlined in red). On the other hand, there were also coherent results in which the goal was more guessed than precisely defined. That's what makes science exciting! Depending on many other measurements, we will explain how this can occur.

4. Experiment Δ Refraction Coefficient

With the theoretical approach of including the refraction coefficient as a function of temperature categories

- 0 to -10°C: 0.14 κ
- 10 to -20°C: 0.15 κ
- 20 to -30°C: 0.16 κ

Figures 3b, 4b and 5b show considerable results for these very large distances.

The deviation from the trend line still appears to be considerable. However, it is important to note that these deviations are significantly below the error ethical error. The mean error over distances of 150 km are less than 2 m and at 100 km even less than 1 m. This is pleasing and also allows us to recognize how George Everest achieved his very good results in the 19th century¹.

¹ Report 2019

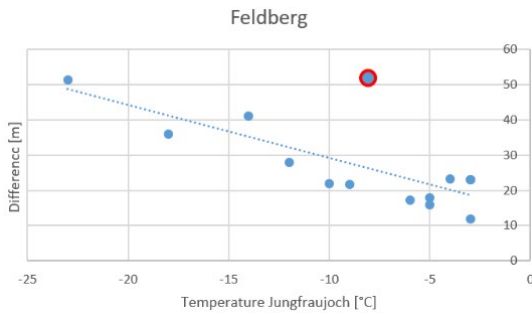


Figure 3a. Feldberg (147 km/-2078m) - average 27.50 m

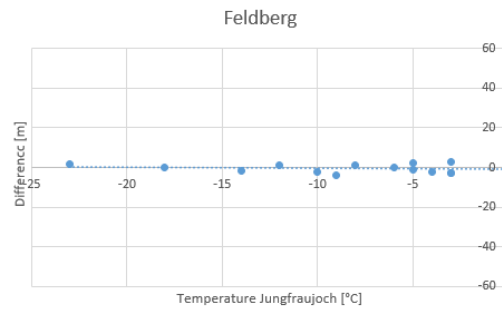


Figure 3b. Medium error 1.93 m

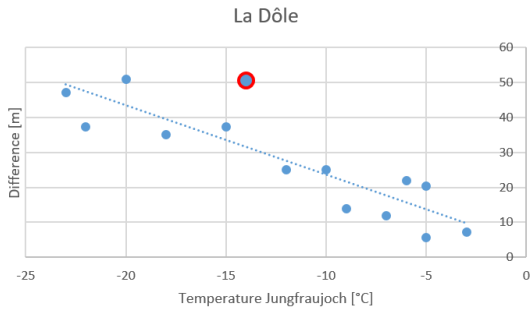


Figure 4a. La Dôle (145 km/-1901m) - average 27.80 m

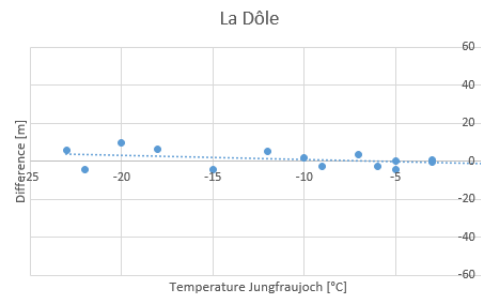


Figure 4b. Medium error 2.73 m

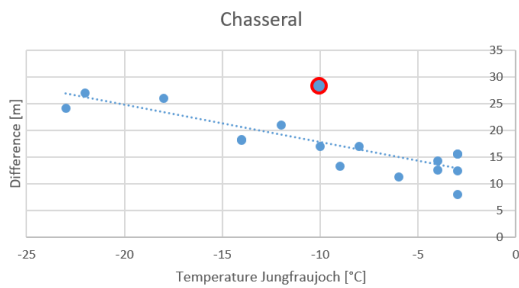


Figure 5a. Chasseral (96 km/-1972m) - average 17.70 m

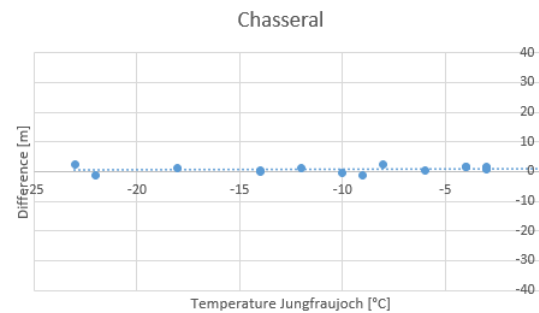


Figure 5b. Medium error 0.71 m

5. Outlook

'A theory is good if it fulfils two conditions: It must contain a **large number of observations** and thus describe the basis of a model that contains **only a few arbitrary elements**'².

From this and from the interest in finding out how the obviously incorrect results are to be classified, many more measurements are needed at every temperature.

Finally, the possibility of systematic perpendicular deviation of the site should be investigated. The Federal Office of Topography swisstopo will work together on this issue.

To be continued.

References

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- Wolfgang Torge Geodesy, Walter de Gruyter 1991.
- Gerber MAS 'Untersuchung von Refraktionseffekten in alpinem geodätischem Monitoring'

Internet data bases

<https://www.swisstopo.admin.ch/> ⇒ knowledge and facts ⇒ Surveying / Geodesy ⇒ FAQ ⇒ terrestrial curvature

Collaborating partners / networks

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