

# COMPARISON OF 4 RTK GNSS DEVICES 30.5.2024

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The measurement place surrounding was partly a backyard and partly a park area at Oulu, Finland, ~10 km from the city to north. There was also an old low building in the park area. The 3 measurement places were all surrounded by trees, mainly spruces, birches and high pines. Place nr 3 was the most heavily covered by trees and place 2 the least, which was also seen in the differences of averaged results. The measurements were done by pole adjusted at 0 degrees angle and also the pole as tilted 15 degrees to S, N, E and W (at this order), 5 measurements at each angle. One measurement was averaged from 5 shots on each device. The pole was tilted using a wooden stand, which minimized the variations in pole tilt angle and azimuth. All measurements in one place were done one after the other so that the number of visible satellites would not change too much.

The tested devices were [Emlid RX](#), [SingularXYZ Sfaira One Plus](#), [South G3](#) and [Tersus Luka](#). All of these except Emlid RX have also tilt correction circuits (IMU), which in principle should enable them to be used even at a pole angle of 60 degrees. The measurement software used were Microsurvey Field Genius Android (RX and G3), SingularPad (Sfaira) and Tersus NUWA (Luka). The coordinate systems used were ETRS-TM35FIN and ETRSGK26 and the geoid file was FIN2005N00. The CORS network was the service by Karera, which is a VRS RTK network. They utilize the NLS (National Land Survey) organization base stations.

The purpose of these measurements was to clarify, 1) if all devices are capable to get RTK FIX, 2) what are the differences in the averaged RTK FIX results and 3) how the tilt compensation works in pretty difficult places like this. We can not say, which of the devices measured the position the most accurately, we can only compare the results between the devices. In the results the deviations mean that the averaged result of each device measured at 0 degree pole angle is calculated and the deviations are the individual results subtracted from the average. So the zero is not the same for different devices. The differences between the averages are shown as N-E results on separate figures. The standard deviations are calculated by using the average of 5 results as one individual result. Thus the SD-numbers of 2-3 mm are possible.

The antenna mask angles were adjusted to 10 degrees. However, the devices should work up to 60 degrees tilt angles, even though tilting affects on the sky visibility. If there are a lot of trees just on the tilted azimuth direction, only some narrow slots of the sky are visible for the receiver. The tilt correction was ON at all measured devices except Emlid RX, which does not have the IMU option.

Temperature during the measurement was ~ +21 C.

Altogether, there were large variations in the results and in the most difficult place (like place 3) the results are not so reliable with any device that the RTK GNSS accuracy could be provided. The 15 degree angle for pole tilt is so large that it is by no means any normal

situation, if the pole is handheld in straight position. But- it was interesting to see, how large are the variations in these kind of environments.

## Place 1

This was the “average” difficult place in this measurement. The measurement was done with 2 coordinate systems, ETRS-TM35FIN and ETRS-GK26. Only the GK26 was available in the Nuwa, so it was compared only to the Sfaira at tilted angles. The average positions were possible to compare with all devices, as Sfaira was measured both with TM35 and GK26-coordinate systems. For some reason the height measurement result for Sfaira was slightly different, when measured using 2 different coordinate systems.

Luka “refused” to operate at tilted angles at all directions and for this reason only the results with pole at 0 degrees angle were used. This may be a good sign also, providing that the results are correct.

In this measurement the differences of averaged results were pretty small (<1 cm) between Sfaira and RX and the difference between average of them to G3 was ~4 cm and to Luka it was ~8 cm.

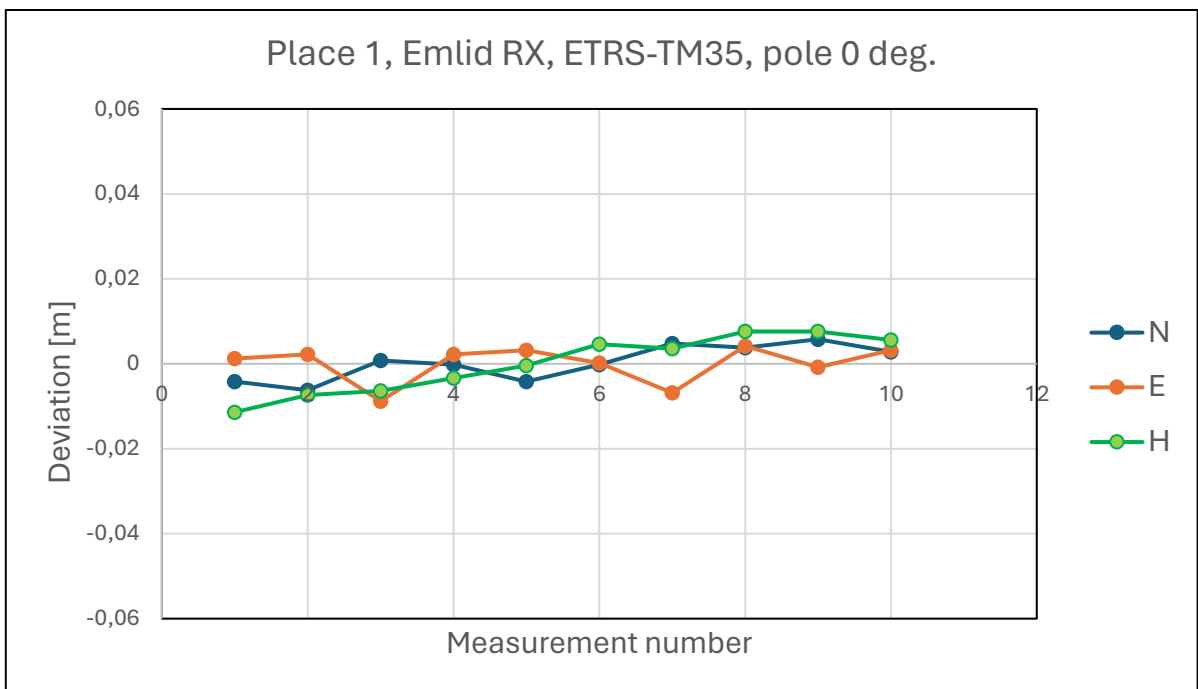
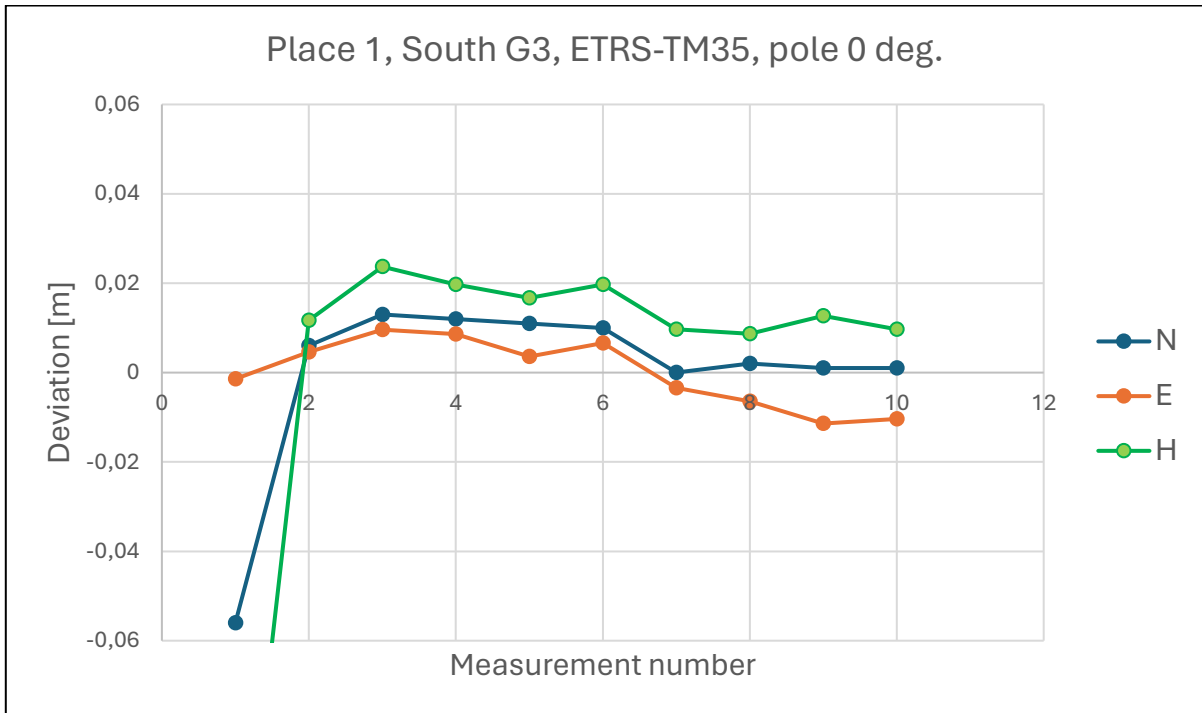


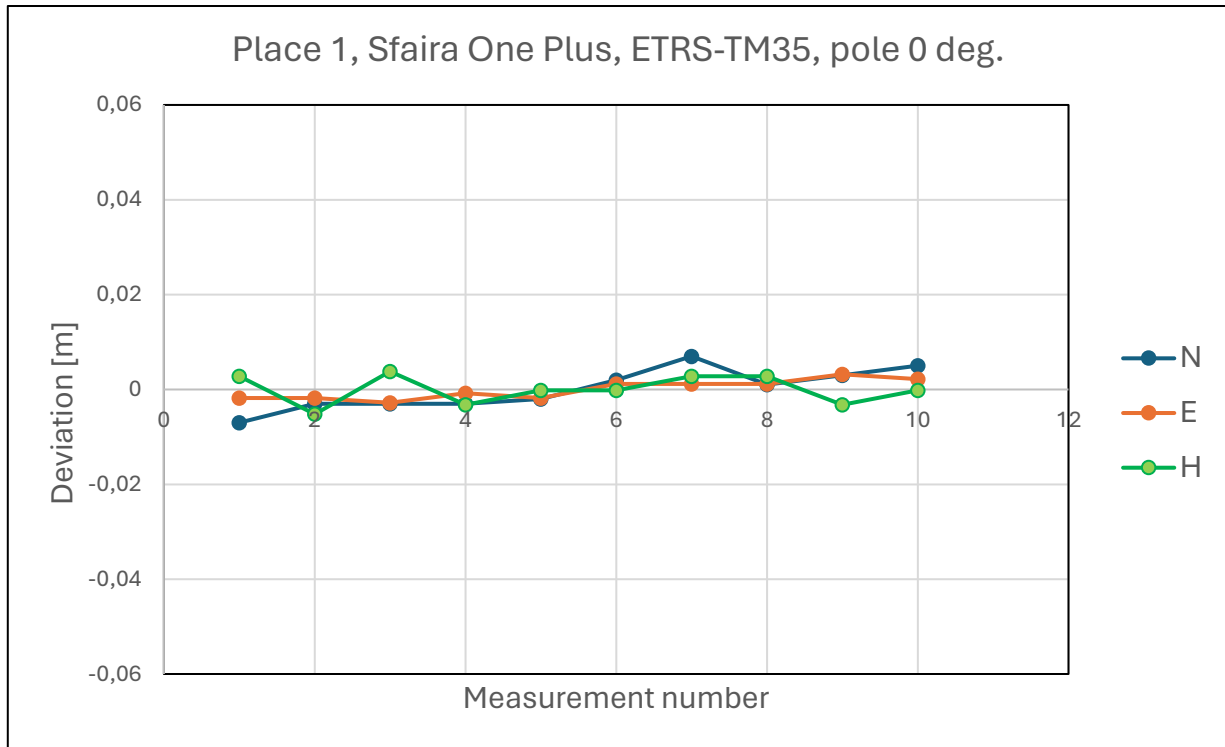
**Coordinate system = ETRS-TM35 & ETRS-GK26**

**Geoid file = FIN2005N00**

With pole at 0 degrees, ETRS-TM35 (tilt correction on, if exists)

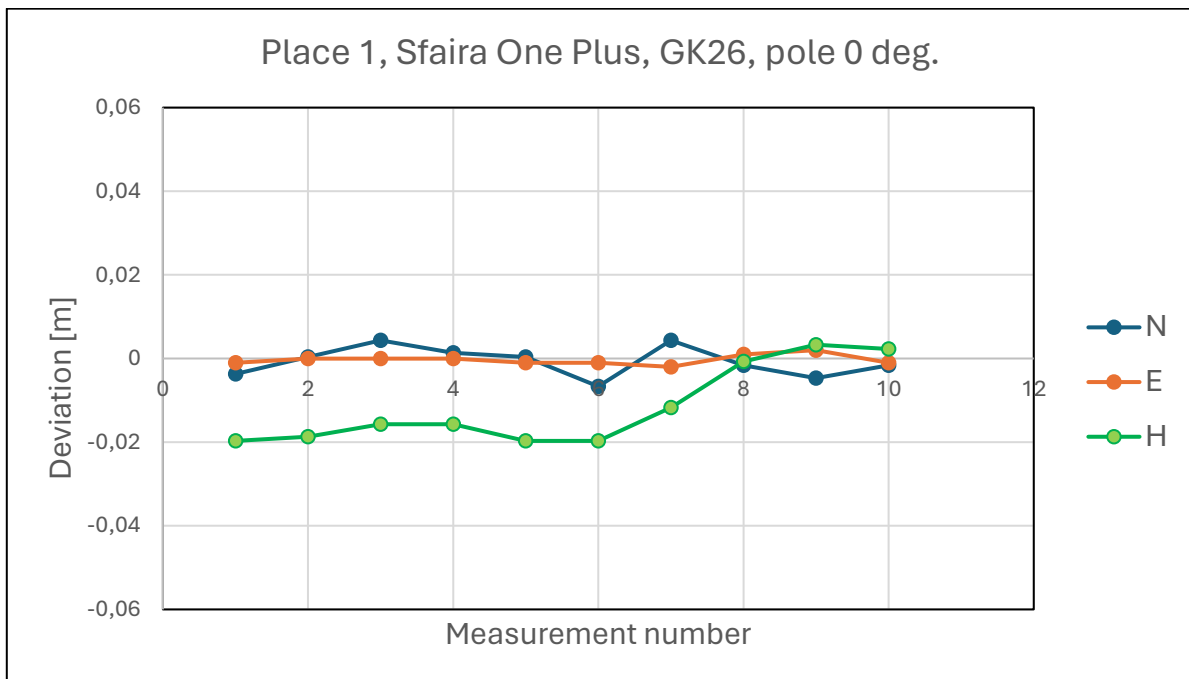
The results were about in a range of +/-1 cm between minimum and maximum, except the 1<sup>st</sup> measurement of G3.

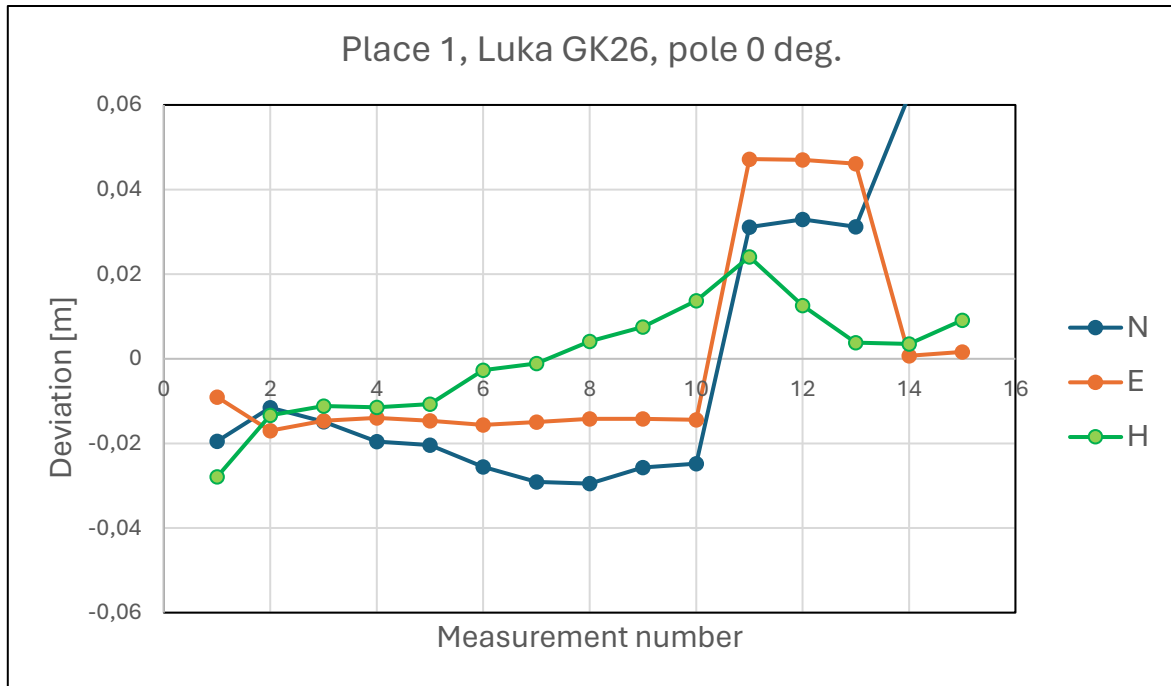




With pole at 0 degrees, GK26 (tilt correction on, if exists)

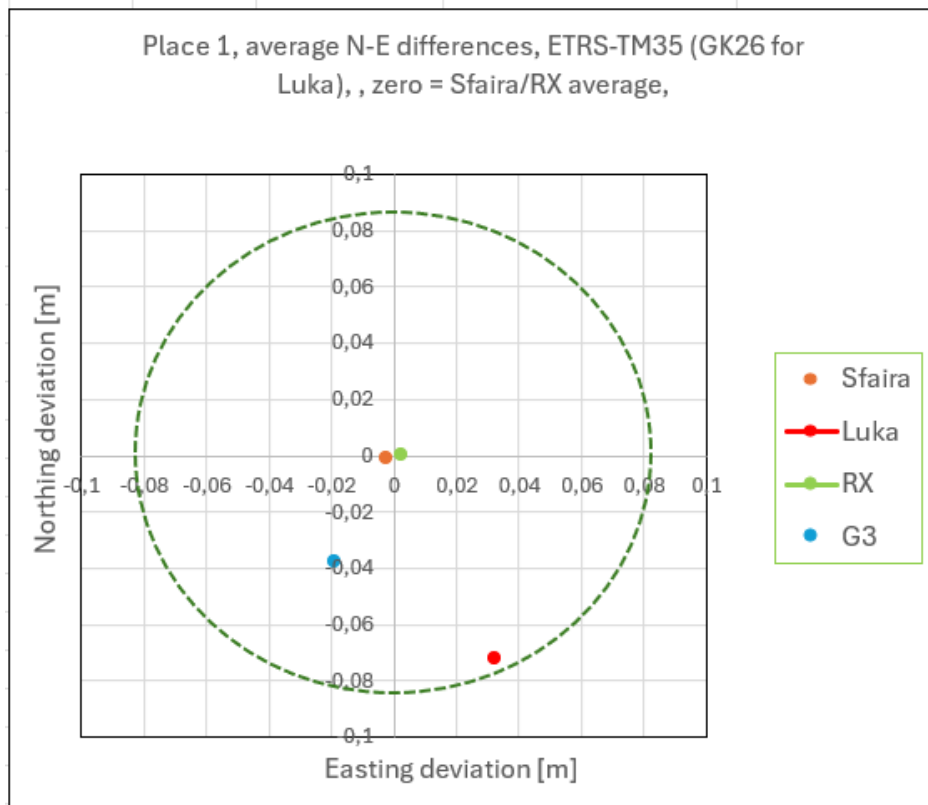
**There was strangely large variation in the results of Luka even at 0 degree pole angle. Luka “refused” to measure, when the pole was tilted 15 deg. to N. For this reason the results with tilted pole are not shown.**

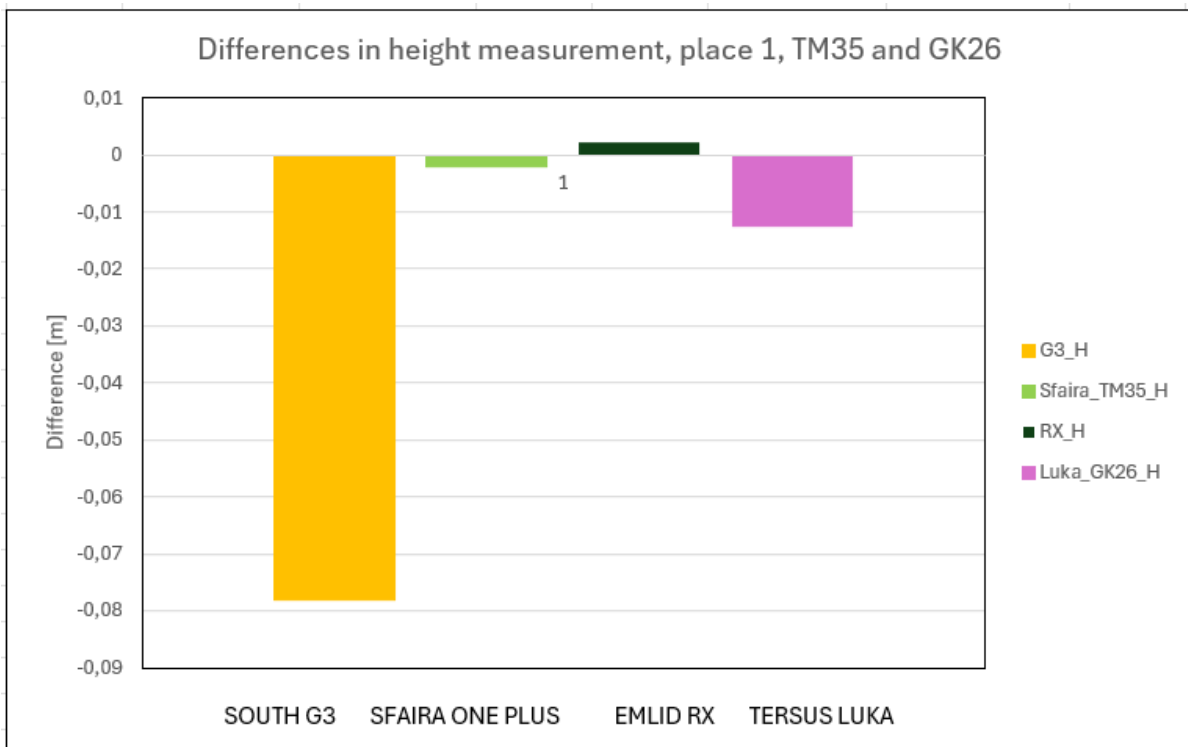




Averaged result differences at pole tilt of 0 deg., zero = average of Sfaira and RX at ETRS-TM35

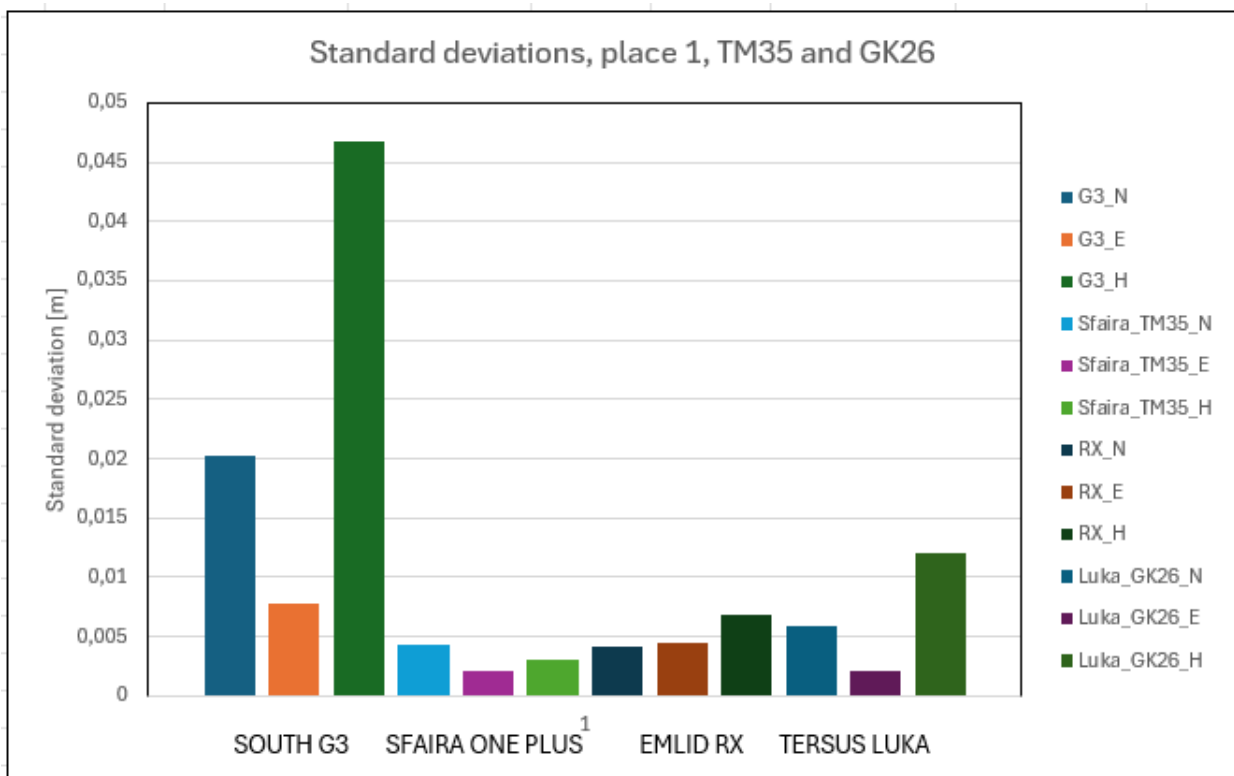
**Result: difference between Sfaira and RX was less than 1 cm and the difference between to G3 was less than 4 cm, difference between Sfaira and Luka was less than 8 cm. Difference in height was < 1 cm with RX and Sfaira, <8 cm with G3 and < 2 cm with Luka.**





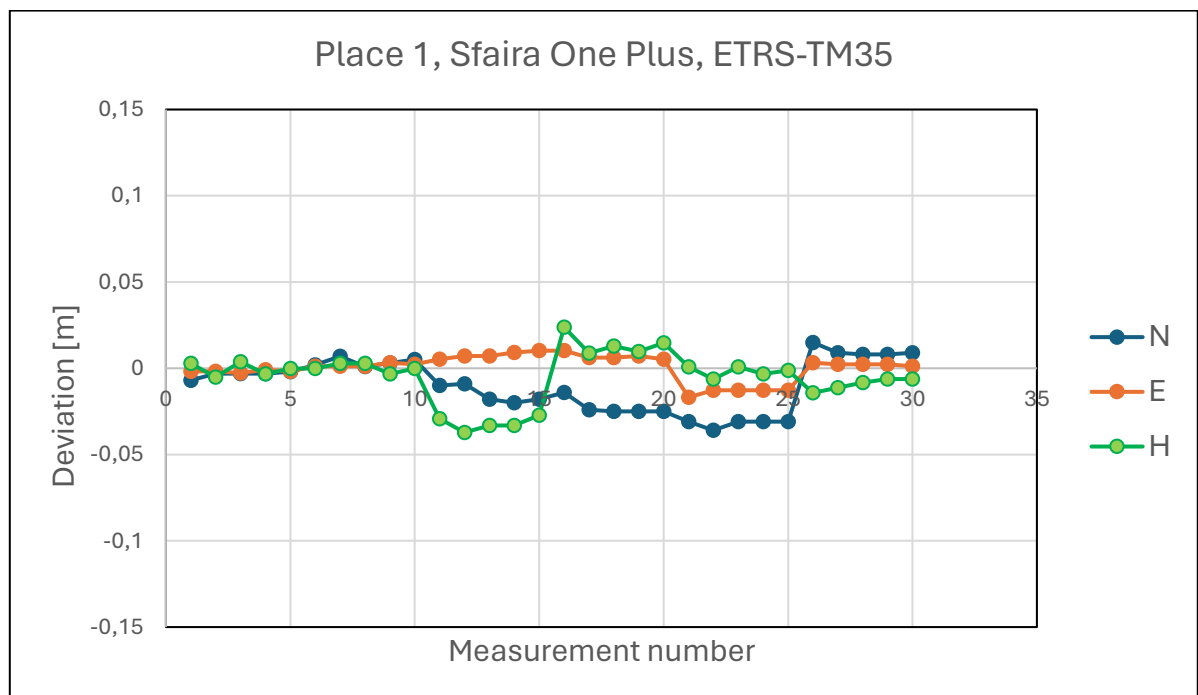
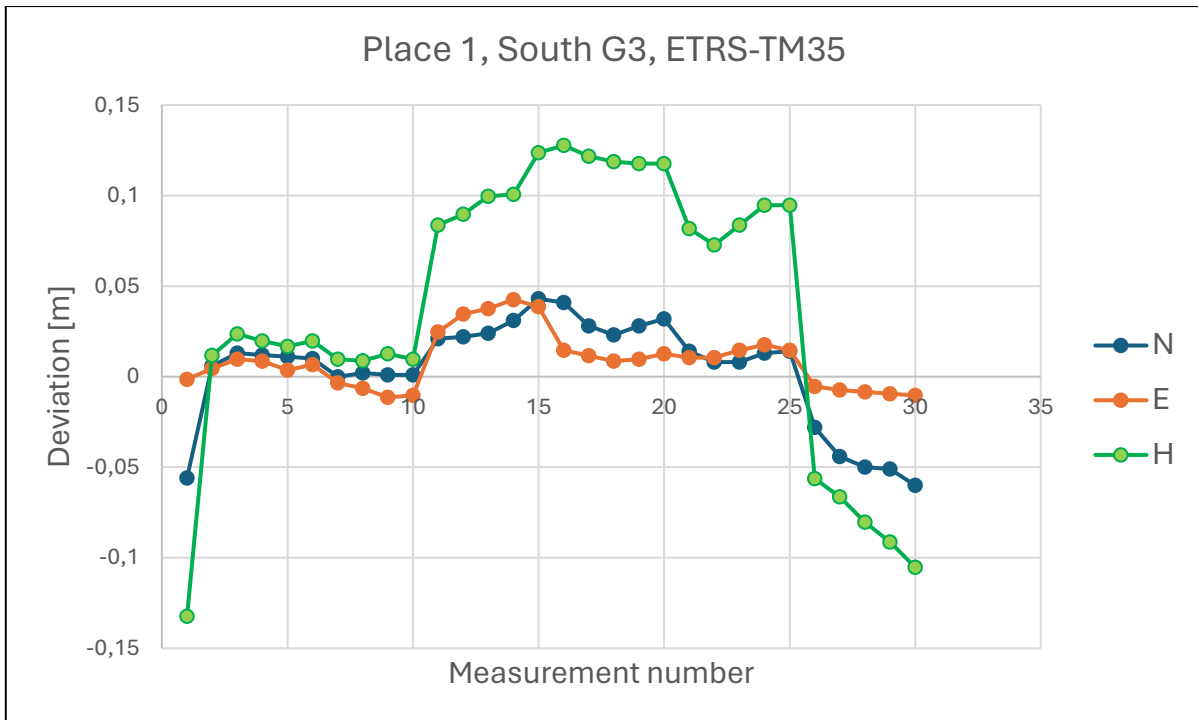
### Standard deviations at pole angle of 0 deg, place 1

The SD of Sfaira One Plus was the smallest, next Luka and RX about with even results and G3 had clearly the highest SD.



Pole tilt angle varied, 15 degrees to S, N, E and W

The N-E variation of G3 was < 6 cm and the height variation was < 14 cm. The variation of Sfaira results was < 4 cm in N,E and H results. No results were achieved with Luka and tilted pole.





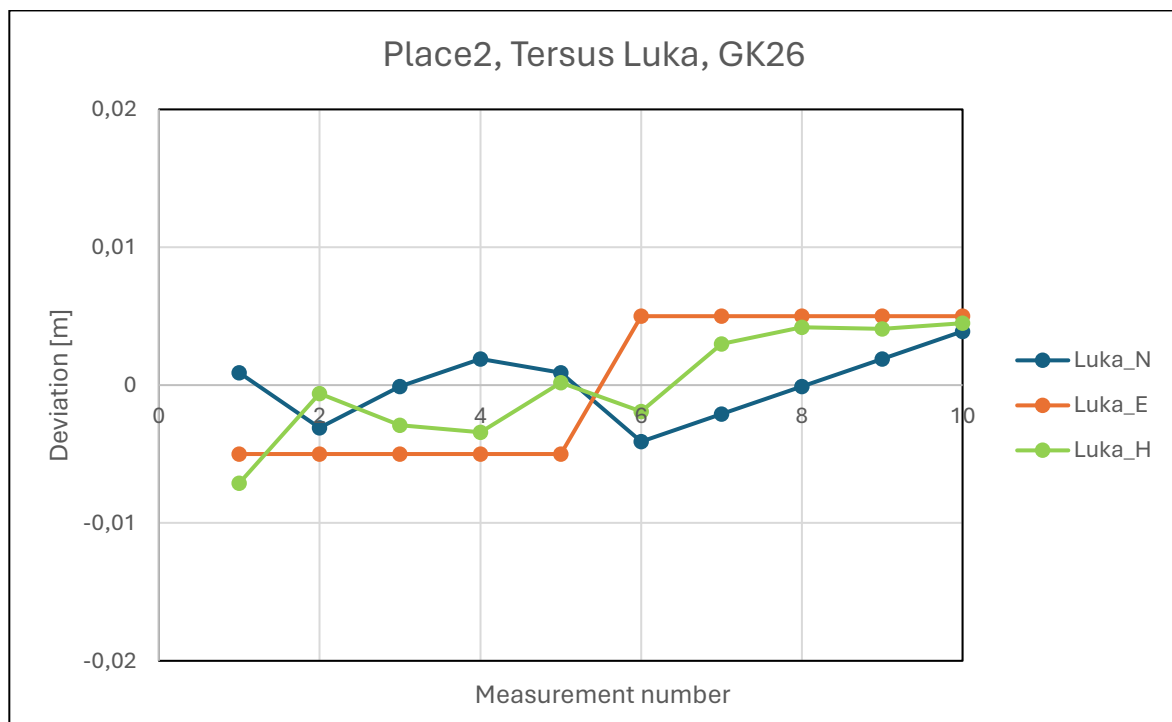
## Place 2

Coordinate system = GK26

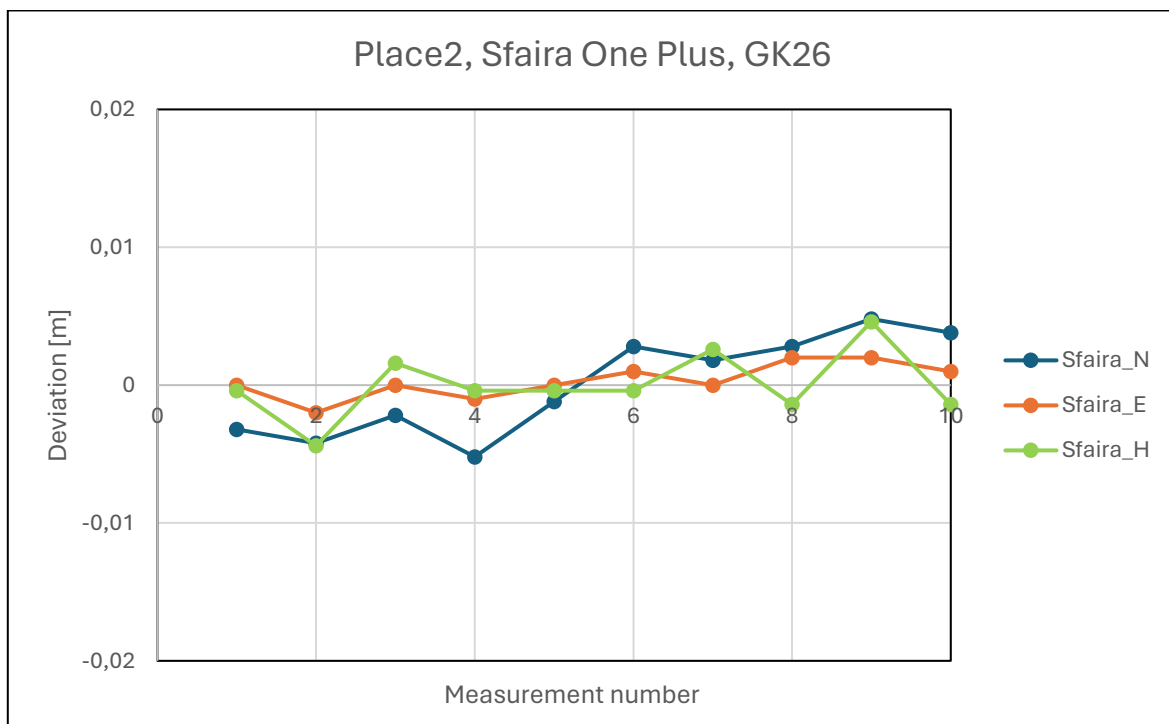
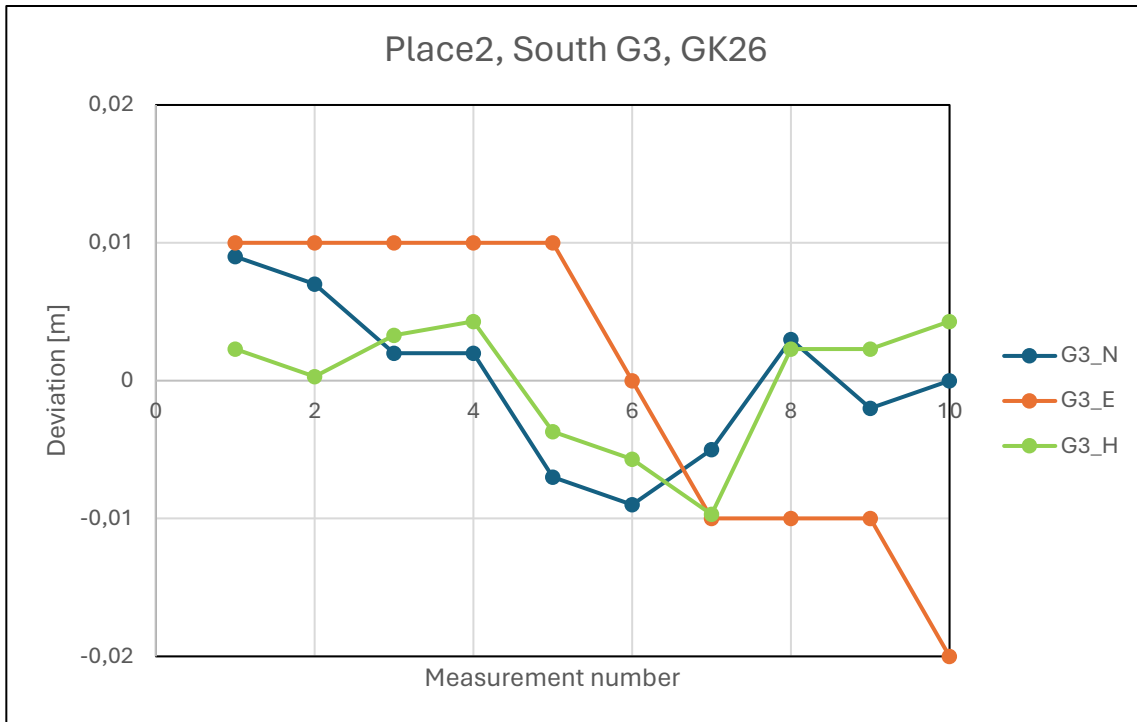
Geoid file = FIN2005N00

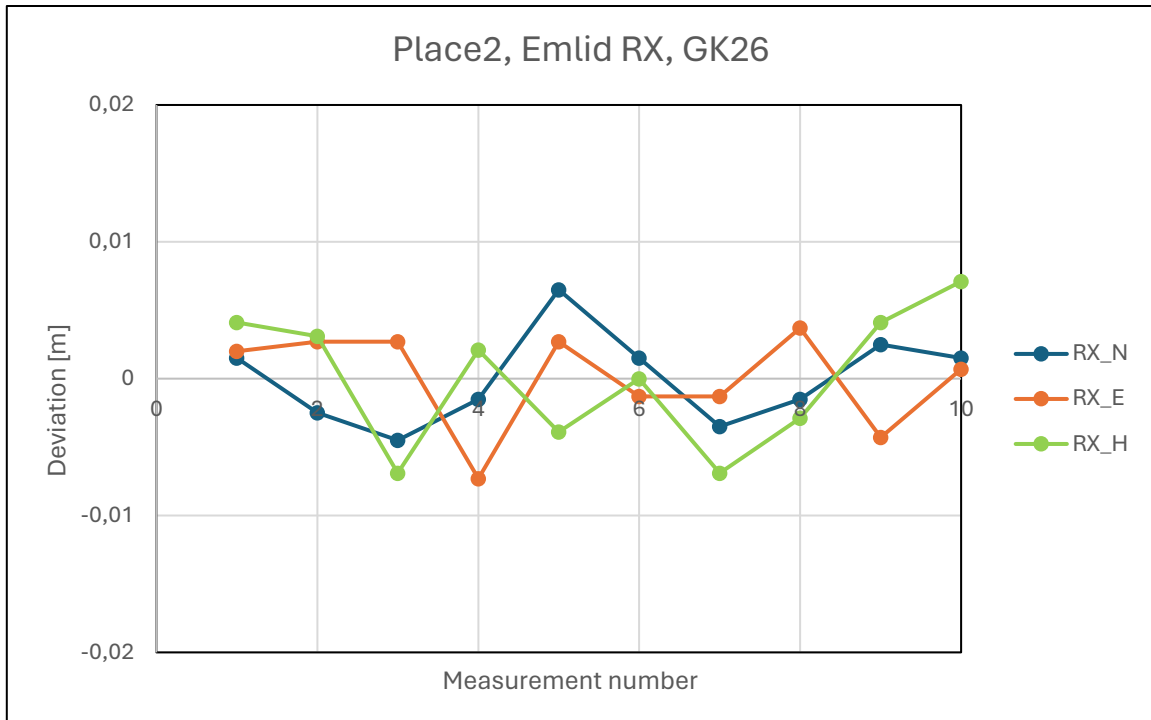


With pole at 0 degrees (tilt correction on, if exists)



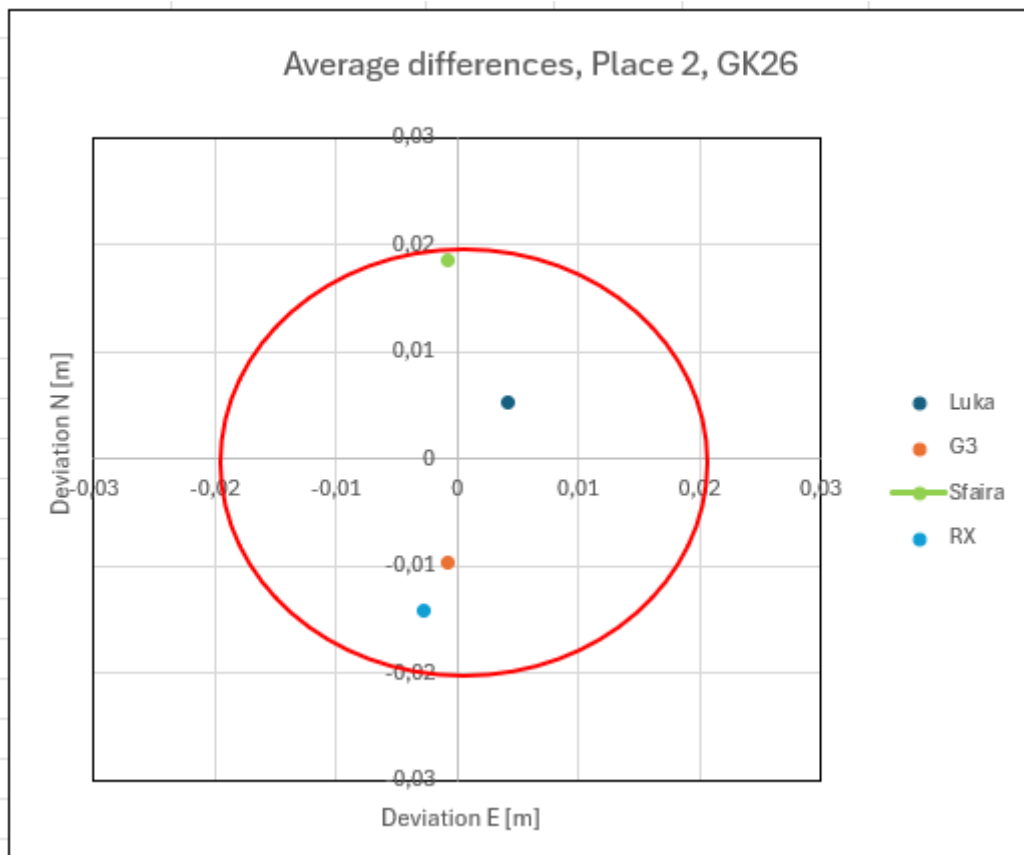






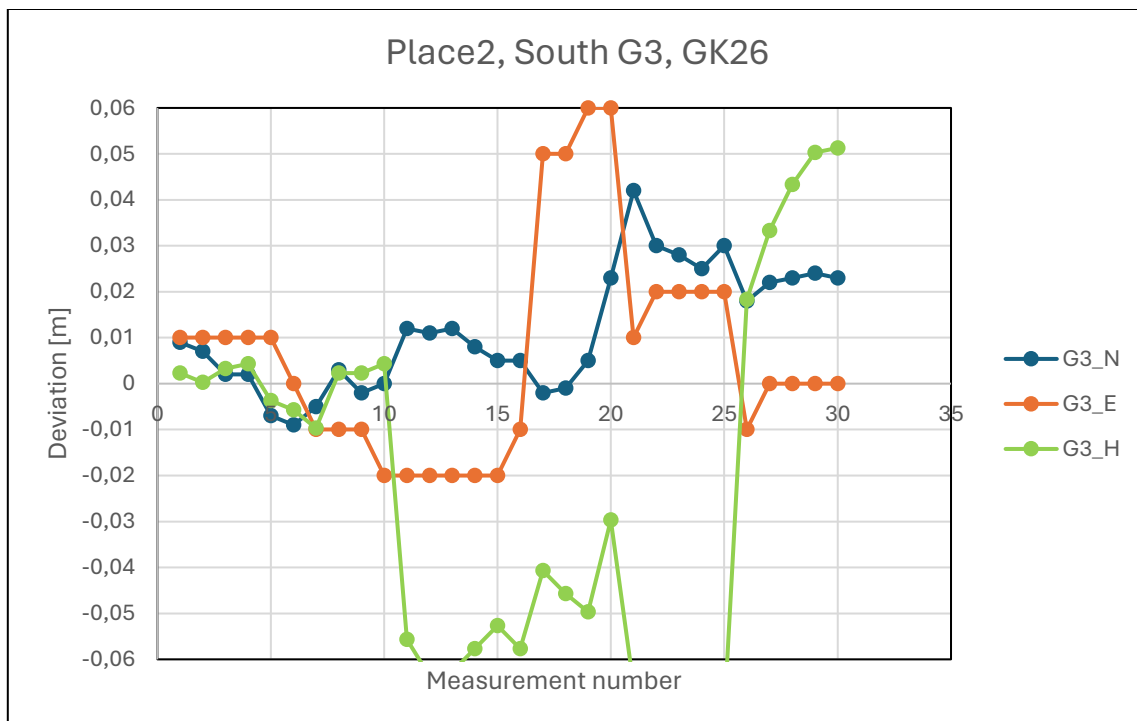
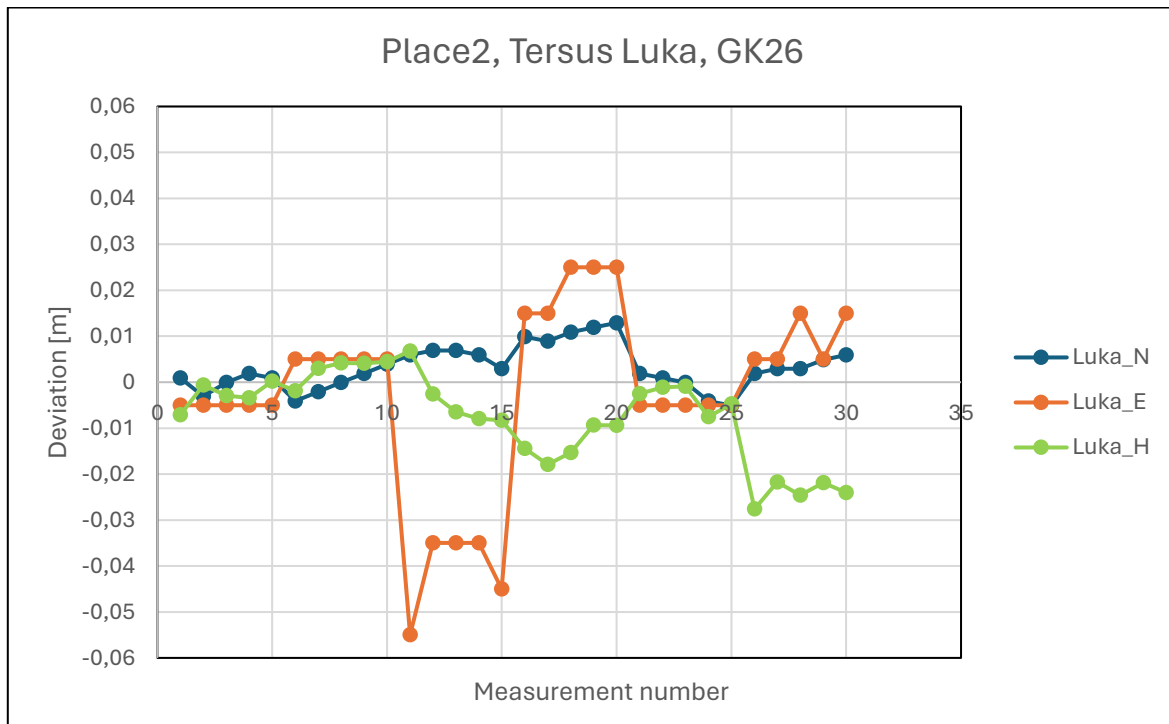
Average deviations at pole tilt of 0 deg., zero = average of all results

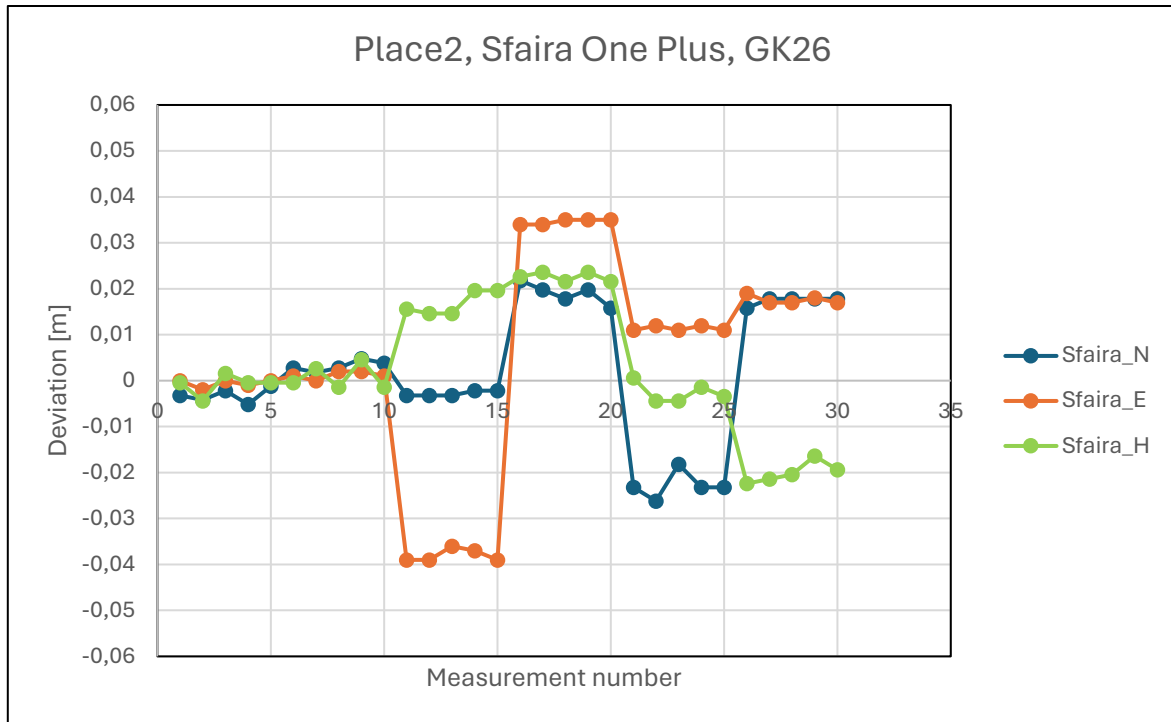
The differences in the averaged results were small, < 2 cm with all devices.



Pole tilt angle varied, 15 degrees to S, N, E and W

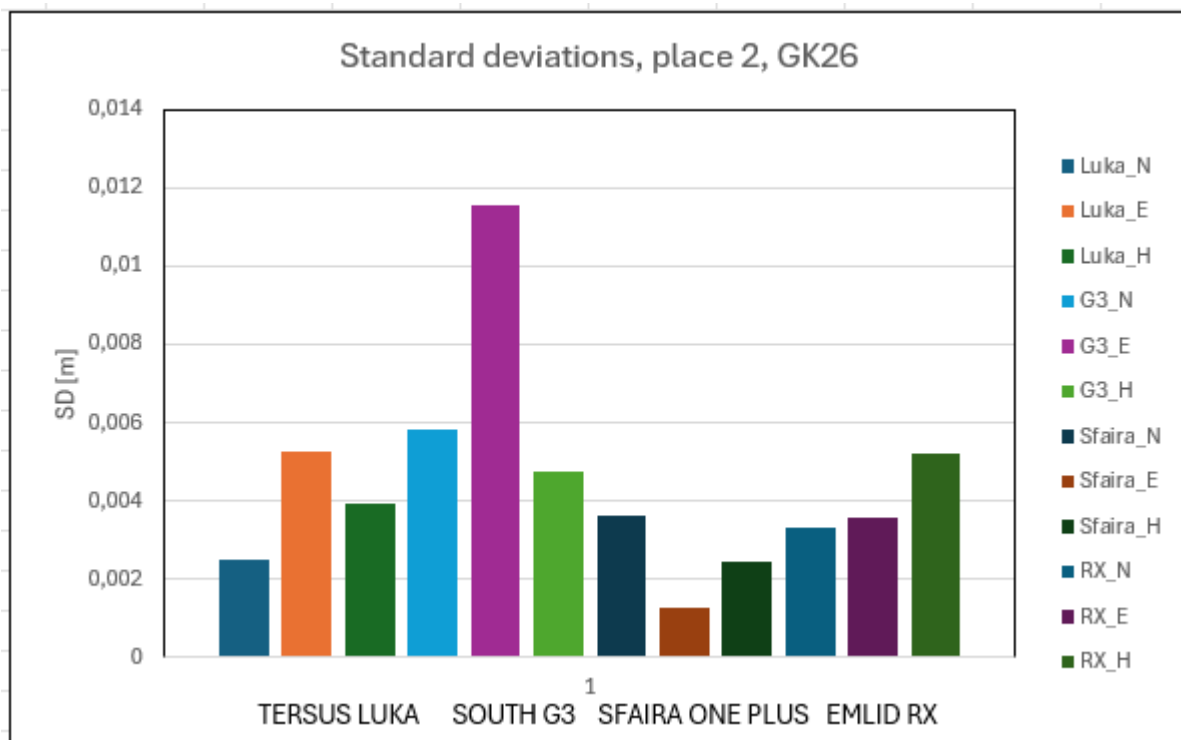
With tilted pole the N-E variations of Luka and Sfaira were about equal on magnitude. The variation in height in Luka was the smallest.



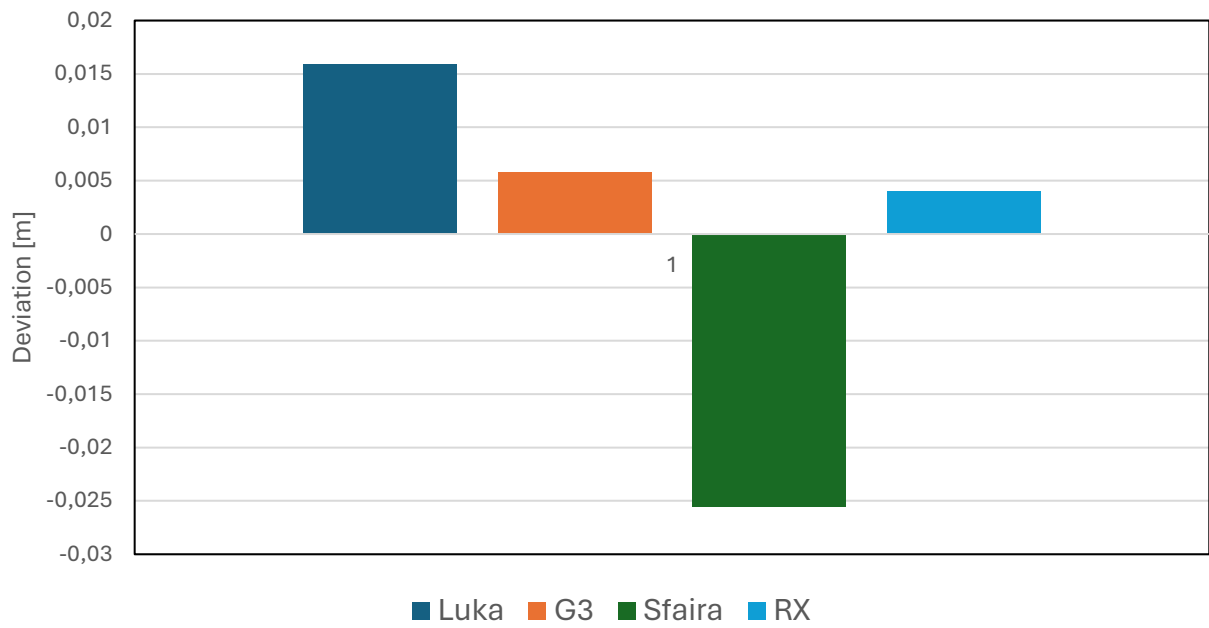


### Standard deviations at pole angle of 0 deg, place 2

The SD of Sfaira was the smallest with straight pole, then about equal results with RX and Luka and G3 had the highest SD. The differences in height results were small, Sfaira having the greatest difference to the average of all results, being about 2.6 cm.



Place 2, deviation of height from the average of all results at 0 deg. pole angle





## Place 3

**Coordinate system = ETRS-TM35FIN**

**Geoid file = FIN2005N00**

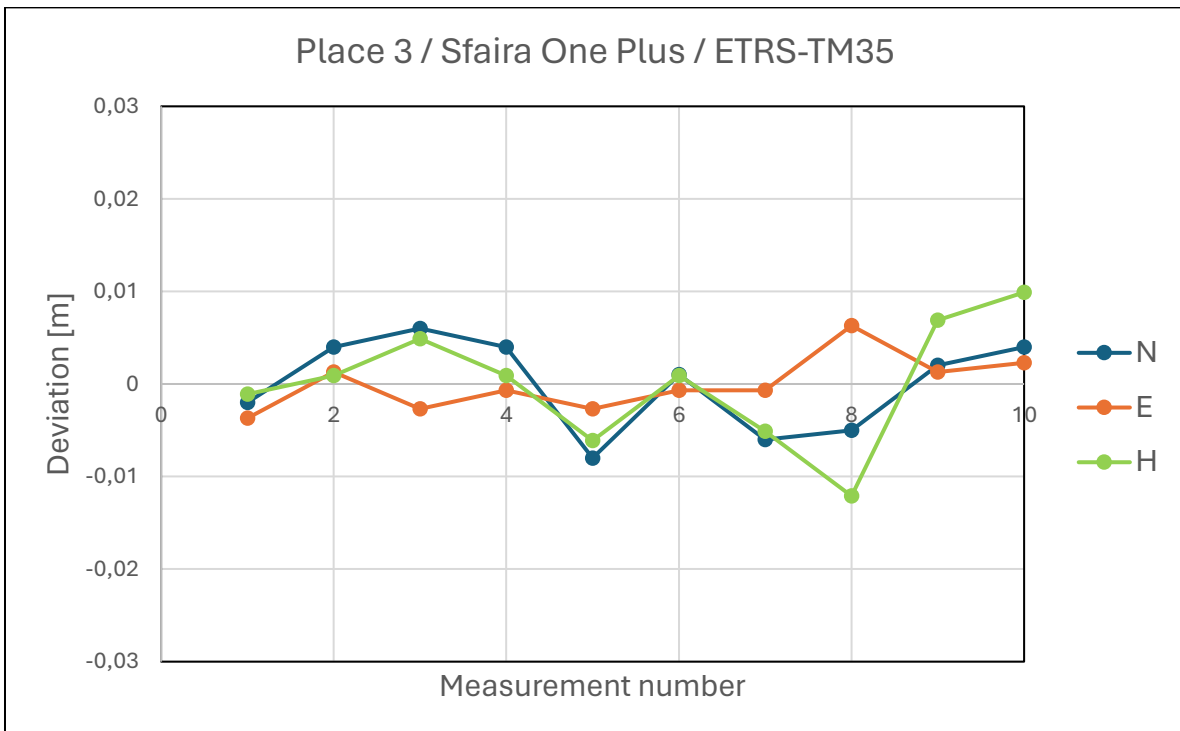
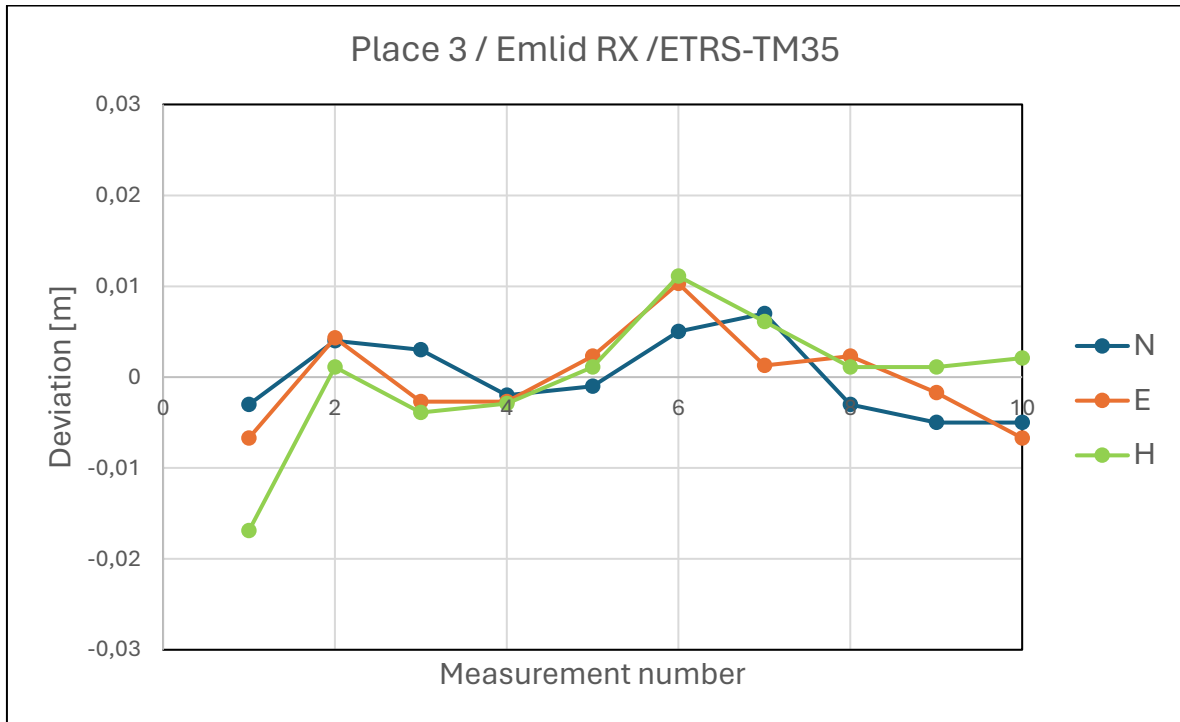
Only parts of open sky are available, as can be seen based on these photos.

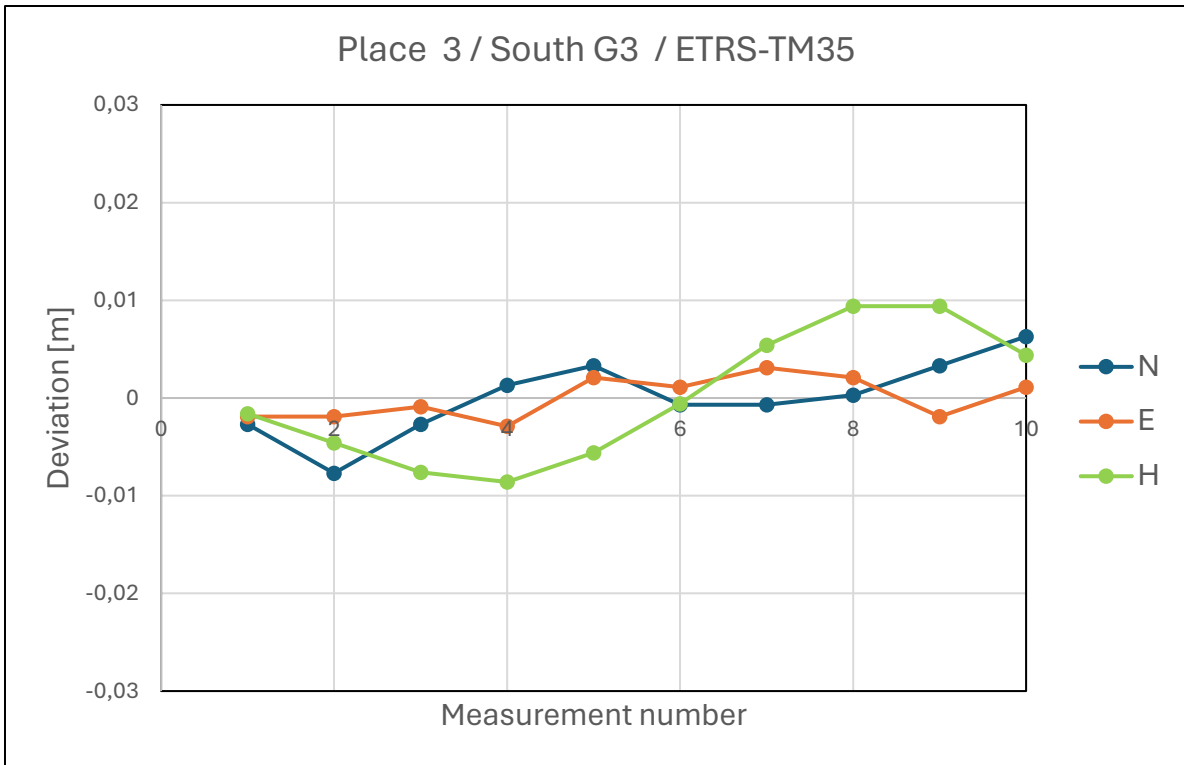




With pole at 0 degrees (tilt correction on, if exists)

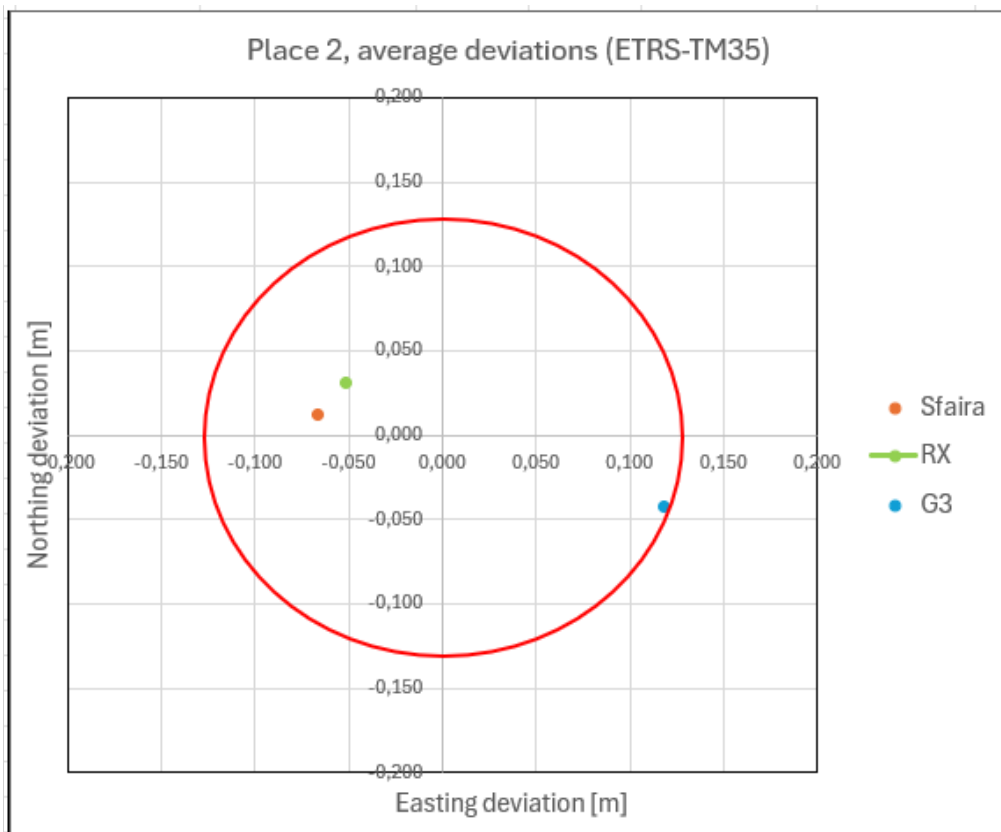
The variation in the results was about equal between all devices with pole at 0 degrees angle. Luka worked also with 0 deg. pole, but refused to work with tilted pole to any direction.





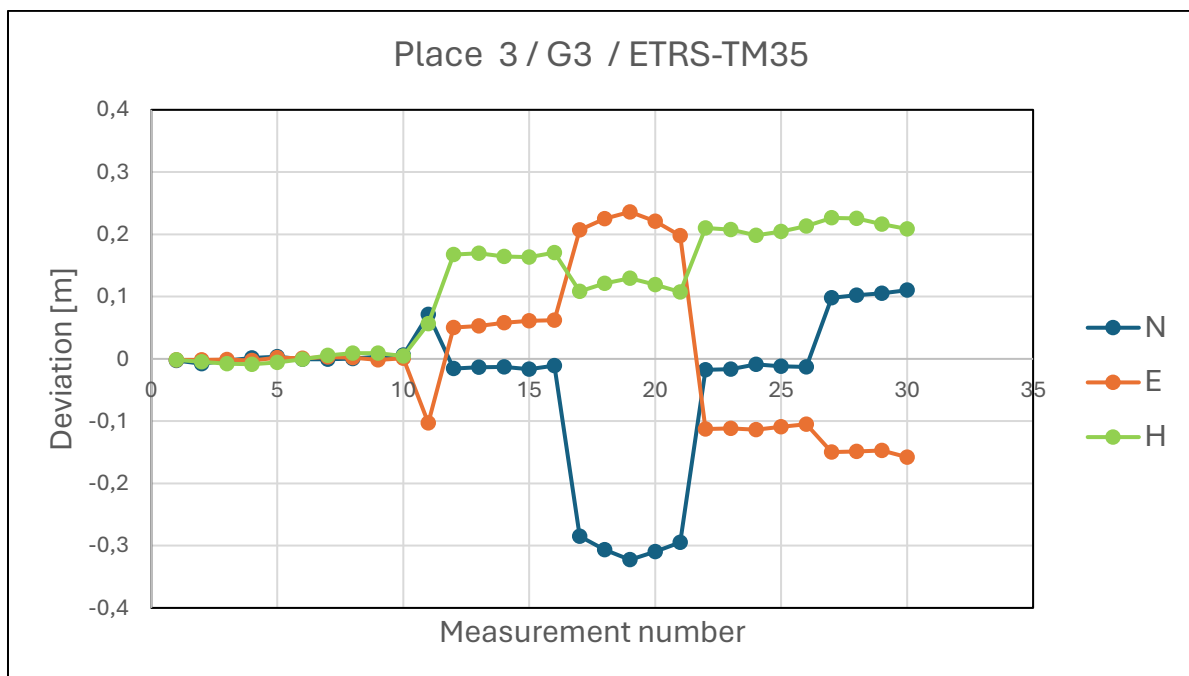
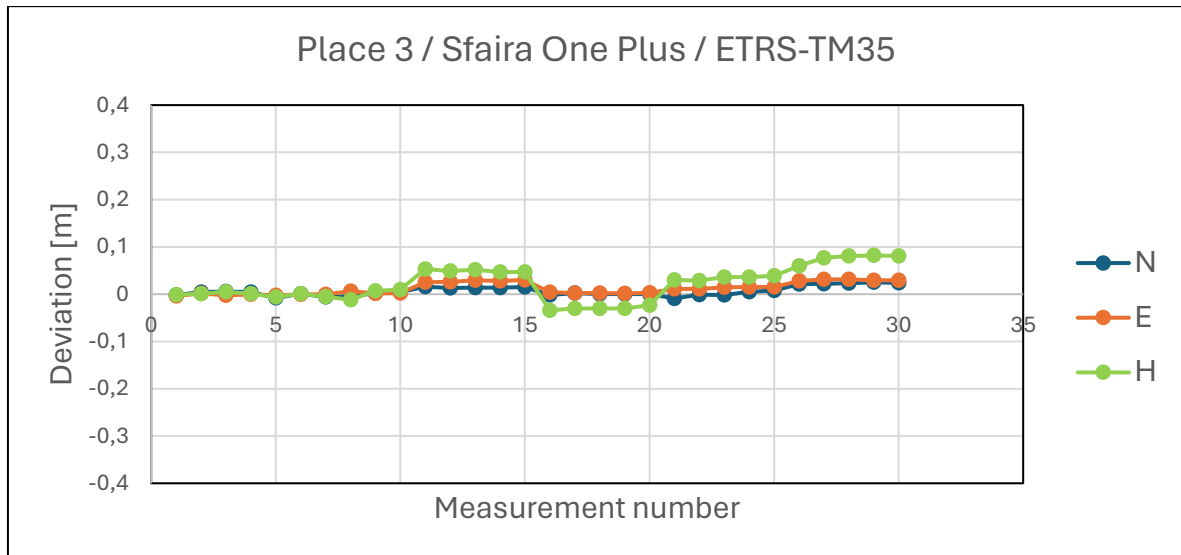
Average deviations at pole tilt of 0 deg., zero = average of all results

The differences in the averaged results were quite large, about 13 cm max. However, Sfaira and RX were quite close to each other in the results. It is hard to say based on this measurement, what is the correct result. Earlier measurements showed the difference between G3 and RX to be ~11cm in nearly the same place, but the direction was SW from G3 to RX, not NW, like here.



## Pole tilt angle varied, 15 degrees to S, N, E and W

With tilted pole the variation in the G3 result was really high, from -32 cm to +24 cm (note the difference in scale to precious figures). The variation of the Sfaira result was remarkably smaller, between -5 cm and +9 cm, but because the difference in the average readings between G3 and Sfaira was so large (close to 20 cm) it is difficult to say, which is the right value, if any. Luka “refused” to give any results with tilted angle, which can be a wise decision as the results with tilted angle are not inside the RTK GNSS accuracy.



### Standard deviations at pole angle of 0 deg, place 3

The SD values of all devices were about equal. South G3 had the smallest N-E SD in this measurement. However, the differences in the height position measurements were large, about 12 cm max.

