HYDROLOGICAL EFFECTS IN THE RELATIVE GRAVITY MEASUREMENTS

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ABSTRACT

Relative gravity measurements were carried out to obtained accurate scale factor at the vertical gravity baseline Hochkar (Austria) around the turn of May and June 2006. Due to incessant rain at the beginning of June significant changes in gravity accelerations were anticipated.

The same measurements order was hold five days repeatedly to obtained very accurate scale factor of the relative gravimeters LaCoste & Romberg and Scintrex. Each day measurement was processed in the same way using gravimetric software. The relative gravity accelerations for each day were obtained. A correlation between gravity accelerations and water level in the near river was calculated and statistically evaluated.

The significant correlation between the water level in the river and the gravity acceleration at the point Göstling an der Ybbs **was proved.**

INTRODUCTION

The department of Special Works (Land Survey Office) is carried out gravity measurement at the vertical gravity baseline Hochkar (Austria) annually. The measurements are carried out with the assistance of Bundesamt für Eich und Vermessungwesen (Austria) which is also the founder and administrator of this baseline.

The baseline consist of 20 stations, from these four stations were chosen as the main stations (8091 Göstling, 8092 Lassing, 8093 Aiblboden and 8094 Hochkar – see fig.1). Each main station is relatively connected to an absolute station, which is in close proximity. The vertical gravity baseline Hochkar has gravity difference ≈198 mGal (1 mGal = 10^{-5} ms^{-2}), vertical distance ≈900 m and distance ≈18 km between Göstling and Hochkar. All main stations are easily accessible by car.

Relative gravity measurements at Hochkar baseline together with measurements at the Main Gravity Baseline (MGB) are being used to determine precise scale factors for gravimeters LaCoste and Romberg G No. 1068 and Scintrex CG5 No.10125. These gravimeters are being used for measurement in the Czech Gravity Network.

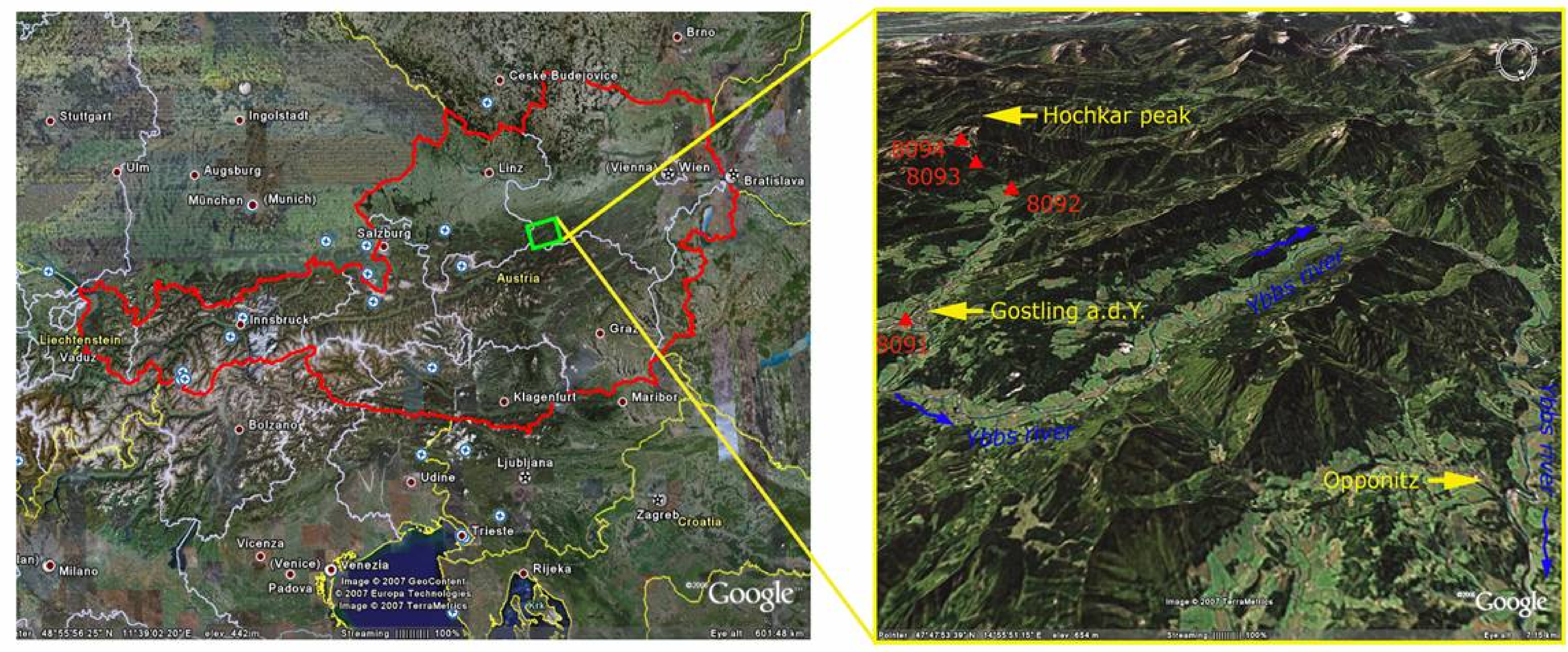

FIG.1 *The location of the vertical gravity baseline Hochkar at the territory of Austria.*

The measurements were affected by the negative weather conditions in the spring 2006. The combination of an incessant rain (in places with higher altitude snowfall) and of the subsequent quick temperature rising caused very sudden upturn of the Ybbs river surface (see fig.2a, b) (It was also necessary to reduce the fourth day unit measurement because of the very big snowfall at the top part of the baseline).

The weather is the reason for very big changes in the mass distribution in the nearest neighborhood of the station 8091 Göstling (very big growth of the water level in the nearest Ybbs river).

The aim of this poster is a study of a possible linear correlation between the changes in the river flow rate (mass growth) and the gravity at the Göstling station (adjusted values for the day units) and its possible impact on the scale factor changes.

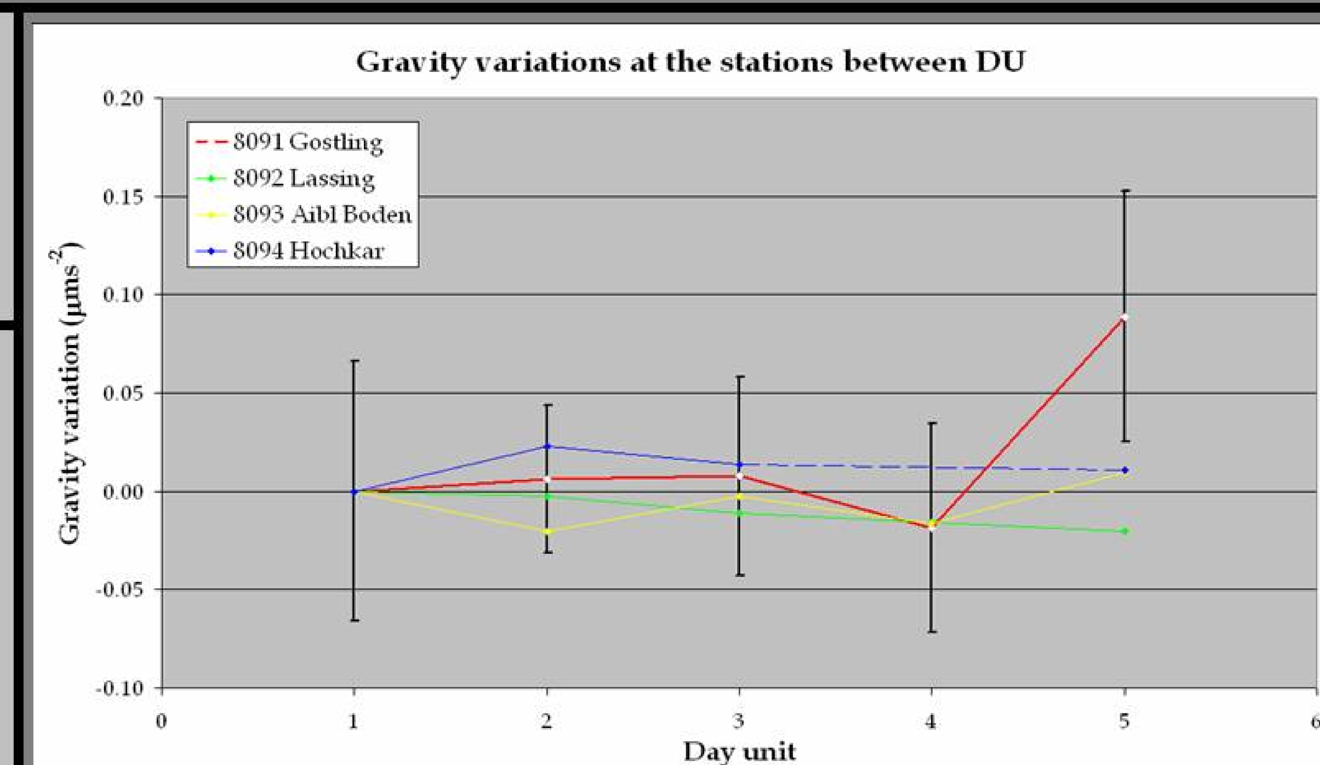

FIG.4 *Gravity variations (towards 1st day unit) at the stations of the baseline as the results of the day units adjustment (3 supporting stations determining the network level (8092 Lassing, 8093 Aiblboden and 8094 Hochkar) and 1 station adjusted (8091 Göstling)) with 2.5 multiple of standard deviations for variations at Göstling station .*

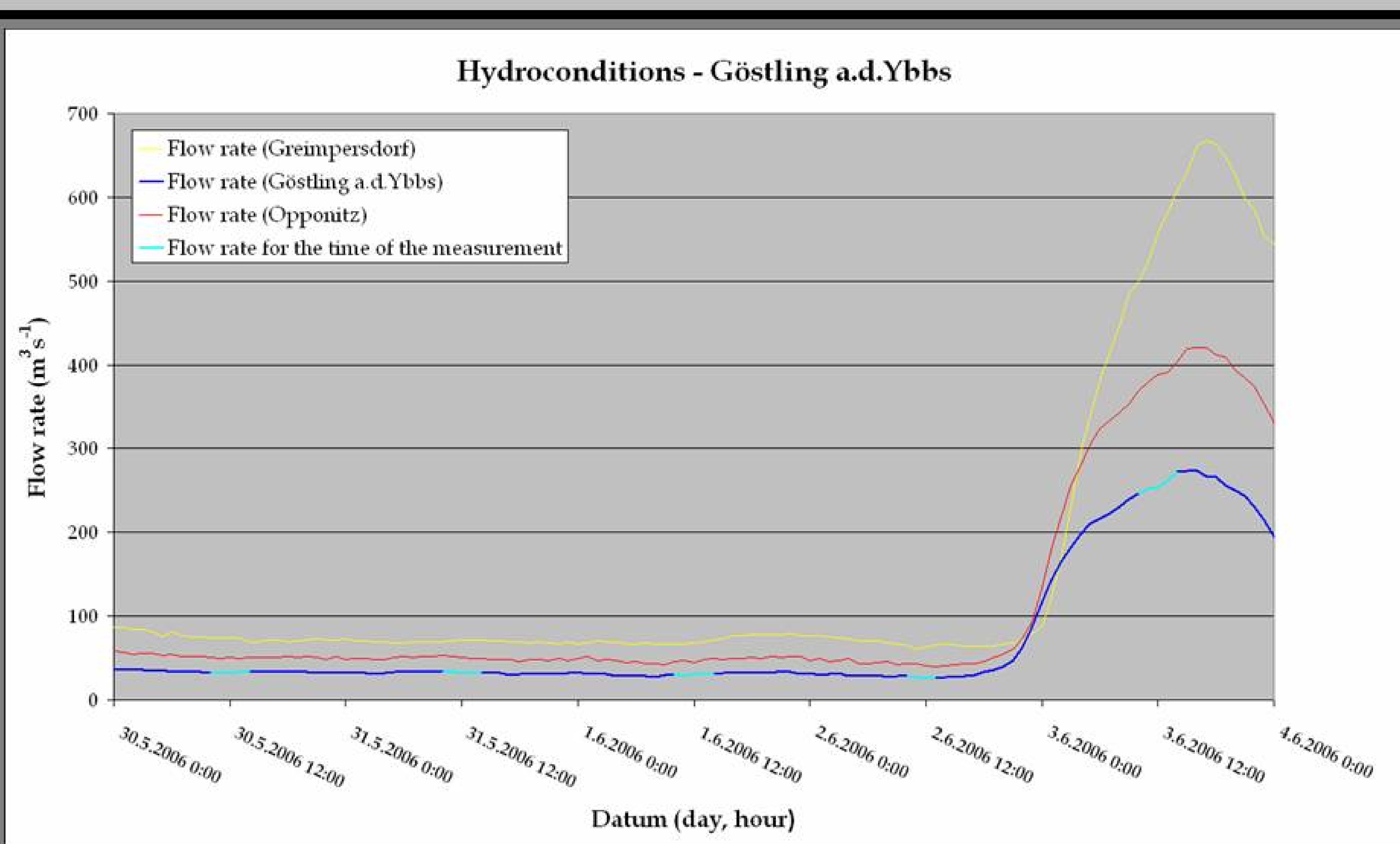

FIG.3 *Hydroconditions at the hydrographs Opponitz and Greimpersdorf and derivated conditions close the Göstling station.*

HYDROLOGICAL DATA

Hydrological data (hour averages of a water level and of a flow rate) from the hydrographs Opponitz (33.9 km down the river) and Greimpersdorf (75.4 km down the river) were provided with kindness of the Amt der Niederösterreichischen Landesregierung.

The water level values of the Ybbs river were not used for the correlation studying. We suppose a non linear dependency of the water level upturn on the flow rate, because of the non linearity of the banks surface (bank overflowing). Therefore the flow rate values are better for the mass growth description. Possible changes in the flow speed are not considered.

Flow rate in the Ybbs river for Göstling station (depending on time) was determined subsequently:
The time lag of the flow rate changes (start of growing, maximum) was detected empirically and its value for the hydrographs Greimpersdorf (towards hydrograph Opponitz) was fixed at 2 hours. The time lag value for the Göstling station (towards hydrograph Opponitz) was fixed with the respect of Göstling Opponitz Greimpersdorf distances and with the respect of the higher speed of the water in the upper part of the river at 1 hour. This very simple empirical method can be considered as sufficient because we have only discrete (1 hour averages) hydrograph data and only one adjusted value of the gravity acceleration for the Göstling station for each day unit.

The estimation of water mass amount at the Göstling station was detected also empirically using confrontation (considering time lag) of the momentary flow rate at the hydrographs Greimpersdorf and Opponitz. The momentary flow rate at the station Göstling was computed by the linear extrapolation (with the respect of the distances Göstling Opponitz Greimpersdorf) (see fig.3). In our case only the linear correlation between the flow rate and the gravity value was computed, so this linear extrapolation does not affect the results.

FIG.2a *The Ybbs river in the nearest neighborhood of the station 8091 Göstling an der Ybbs. Situation in the fifth day.*

FIG.2b *The same place. The situation in the first day.*

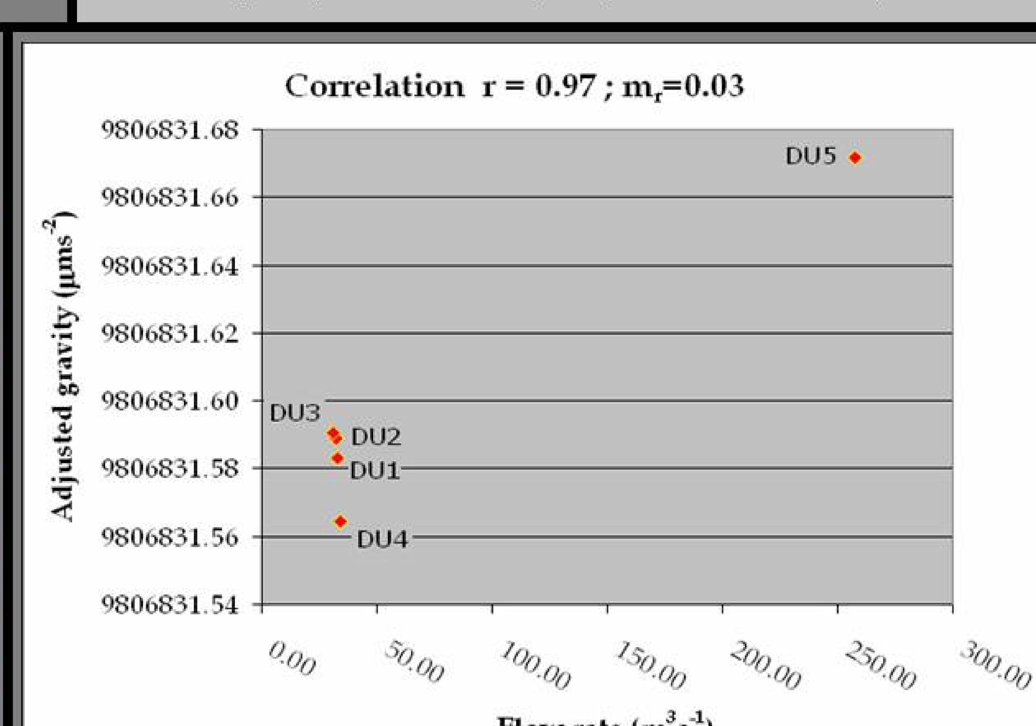

FIG.5 *Input data for the post-processing (gravity accelerations and flow rates at Göstling station).*

GRAVIMETRIC DATA

Relative gravity measurements at the Hochkar baseline usually consist of 5 day units where each of them includes 13 measurements. Methodology of measurement is characterized by the schema A B A B A In the measurements are considered other influences like: the height of the measuring system of the gravimeter above the station stabilization, tides, drift etc. The duration of the diurnal measurement was about 5 hours.

In the next study we suppose that the scale factor of gravimeter is unchanging during the five days of the measurement. Hence the scale factor was given to the adjustment as a constant (value from the Czech Gravity Baseline determined in year 2006). Then only changes in the gravity accelerations at the gravity stations will be obtained.

Adjustment of the day units was processed by the scientific software in three variations:

1. One supporting station (8092 Lassing) determining the network level and three stations adjusted (8091 Göstling, 8093 Aiblboden and 8094 Hochkar)

2. Three station fixed (invariable) (8092 Lassing, 8093 Aiblboden and 8094 Hochkar) and one station adjusted (8091 Göstling)

3. Three supporting stations determining the network level (8092 Lassing, 8093 Aiblboden an 8094 Hochkar) and one station adjusted (8091 Göstling)

For the correlation study was chosen as the most appropriate the third variation (see fig.4), because of the hypothesis of the invariability of the gravity at the stations 8092, 8093 and 8094. Possible changes in the gravity affected these stations (soil moister growth) have to be approximately the same for each station. Gravity changes are expected at the station 8091 Göstling only, because of the near river.

PROCESSING

Correlation

We have the following data for the post processing:

- One adjusted value of the gravity acceleration at the station 8091 Göstling for each day unit
- Corresponding averages of the river flow rates (time corresponding one hour data)

So it is possible to compute the linear correlation coefficient (gravity acceleration value – depending on the river flow rate) from the 5 pairs (see fig.5).

Scale factor

In the next adjustment is studied the behavior of the scale factor (which is the subject of our interest in the Hochkar measurements) during the whole measurement at the Hochkar baseline. The scale factor is computed as the unknown in the common five day units adjustment (Gravity values at the gravity stations are taken as fixed). The resultant scale factor is impacted by the precondition of gravity invariance at the stations (in the case of the station 8091 evidently unreal). The importance of this impact was studied by the confrontation of the scale factors computed separately for every day unit by the precondition of gravity values invariance (see fig.6).

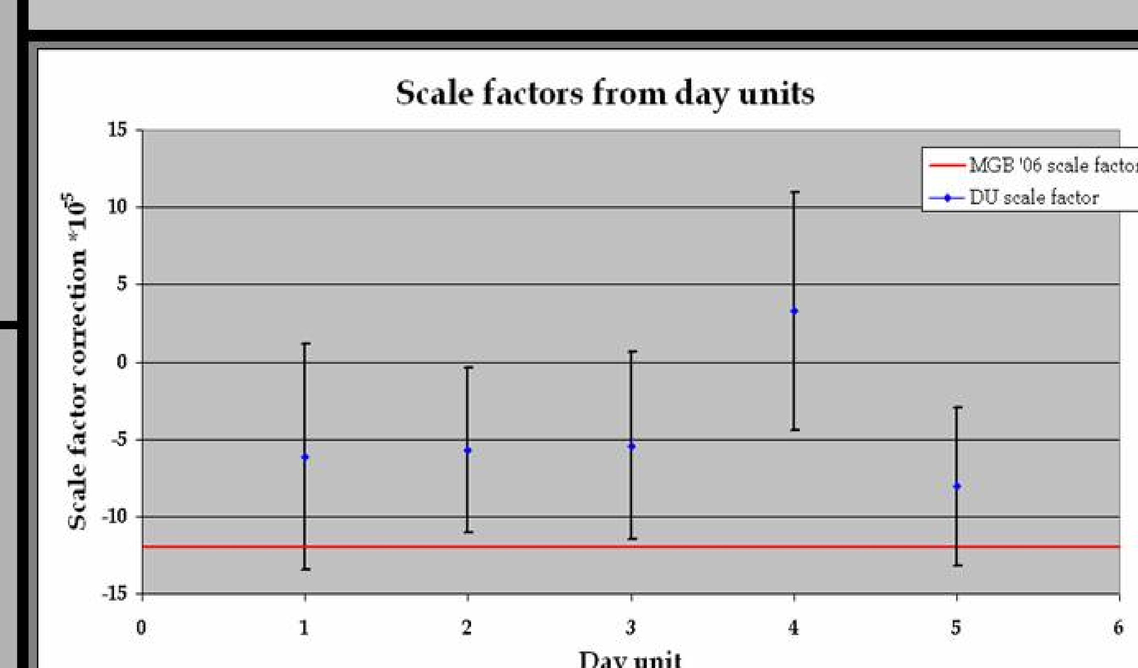

FIG.6 *Scale factor corrections as the results of individual day units adjustment with 2.5 multiple of their standard deviations. The gravity at the stations of the baseline is preconditioned as invariant.*

CONCLUSION

The dependence of the water quantity in the Ybbs river (represented by the river flow rate) on the gravity acceleration at the station 8091 Göstling is evident (see fig.5). The value of the linear correlation coefficient is r=0.97 (m_r=0.03). Statistically was proved this dependence as significant.

The comparison of the scale factors (influenced by the gravity changes at the station 8091 Göstling) as the results of the separate adjustment of the individual day units is depict in the picture 6. In the fifth day unit may be seen small shift in the scale factor value caused by the gravity change at the station 8091 Göstling, but this shift is smaller then its standard deviation. The bigger change in scale factor and also bigger standard deviation was detected in the fourth day unit, where the station 8094 Hochkar was missed because of a snowfall at the top part of the baseline.

It was demonstrated that the influence of this significant water level growth does not affect the resultant scale factor up to limits of their standard deviation. Significantly bigger changes in the water quantity are not supposable, therefore it is not necessary to consider the influence of water level in the Ybbs river in the next measurements. On the other side, bigger change in scale factor was caused by missing one station from the baseline. This fact has to be the next object of our study related to vertical gravity baseline Hochkar.

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