Geological Survey of Austria

Determination of flight altitude and correction of vegetation using a high resolution laser-altimeter

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For more than two decades the Geological Survey of Austria (GBA) operates its own helicopter-based airborne geophysical system. This complex system consists of a digital multifrequency aeroelectromagnetic (AEM) system and a Cs-magnetometer, the main DAS inside the helicopter, a gamma-ray-spectrometer (8 "downward looking" crystals with 33.2 l and 1 "upward looking" crystal with 4.2 l), an L-band-antenna (soil moisture) and an infrared-sensor (surface temperature). In addition air-pressure, air temperature and dew-point are measured. The positions of the bird and the helicopter are determined by two differential GPS-systems, the flight-path is recorded on a VHS-tape and the flight altitude of the helicopter above ground is measured by a radar-altimeter (Sperry RT 220) and a high resolution laser altimeter (Riegl LD90-3800VHS-FLP).

Flight altitude

The main problem in using radar-altimeters for measuring the flight altitude is that the radar-signal is not able to penetrate vegetation. As a consequence, in afforested areas the measured flight altitude is much too low. Using this altitude in the inversion of AEM-data will cause an unrealistic increase of the resistivity in these areas (see fig. 1, pictures A and B).

Using a high resolution laser altimeter improves the ability to measure the real flight altitude. While the first pulse of the laser-altimeter represents the treetop, the last pulse often penetrates the vegetation and is reflected at the ground. Some of the "last" pulses reflect off the ground but some just reflect off lower levels of the vegetation. Careful screening of these populations of pulses can be used to determine the distance to a surface that is quite close to the earth's surface (see fig. 2). Using this laser-altitude instead of the radar-altitude in an AEM-inversion produces a much more homogeneous resistivity distribution in the survey area (see fig. 1, pictures A and C). Considering the uniform geological situation in this area, this homogeneous resistivity distribution is much more realistic.

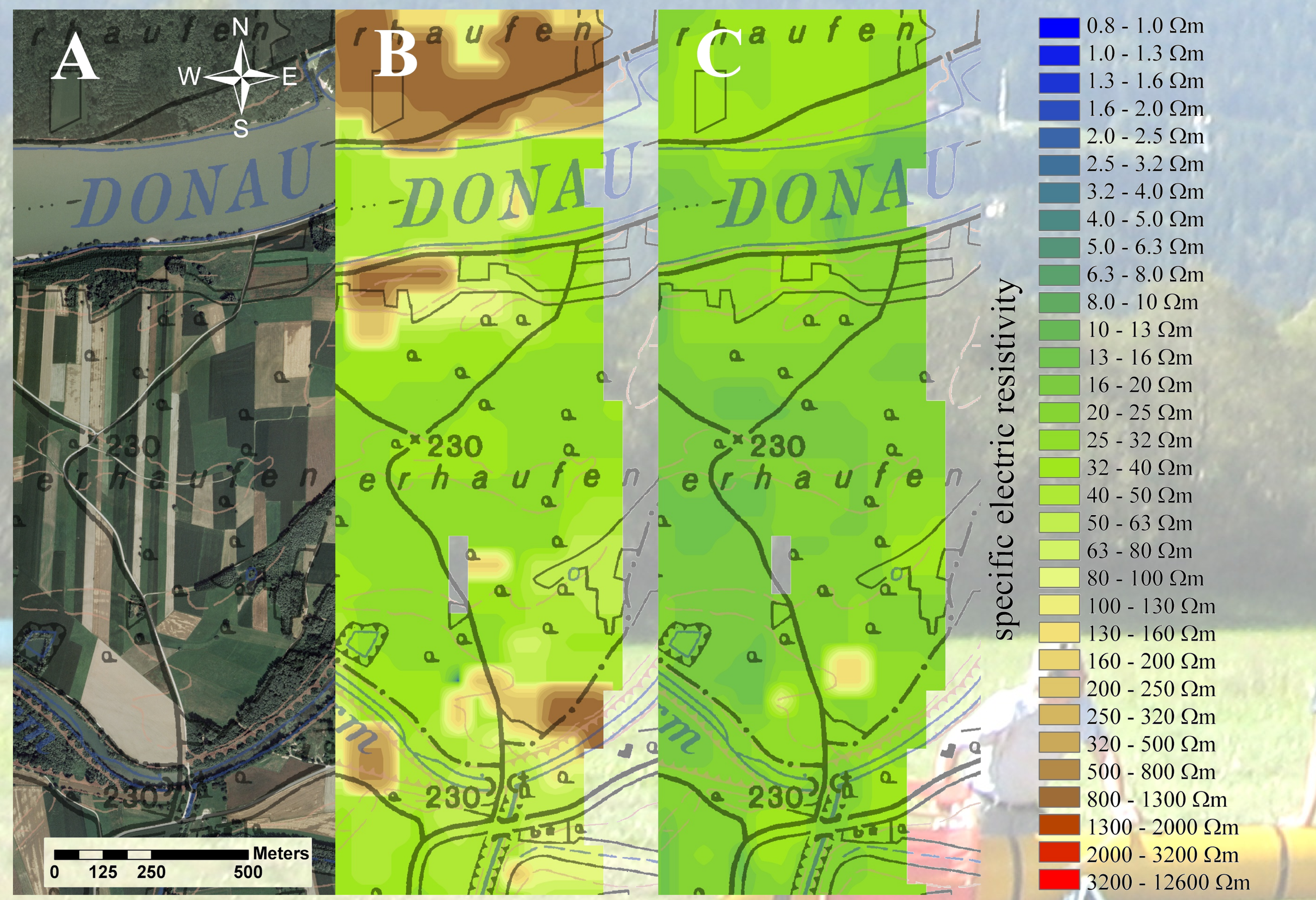

***Figure 1**: Detailed map of the survey area. The figure shows an aerial photo (A) and the results of a homogeneous halfspace inversion of the AEM data (B and C). In one of the inversions we used the flight altitude from the radar-altimeter (B), in the other inversion we used the flight altitude from the laser altimeter (C).*

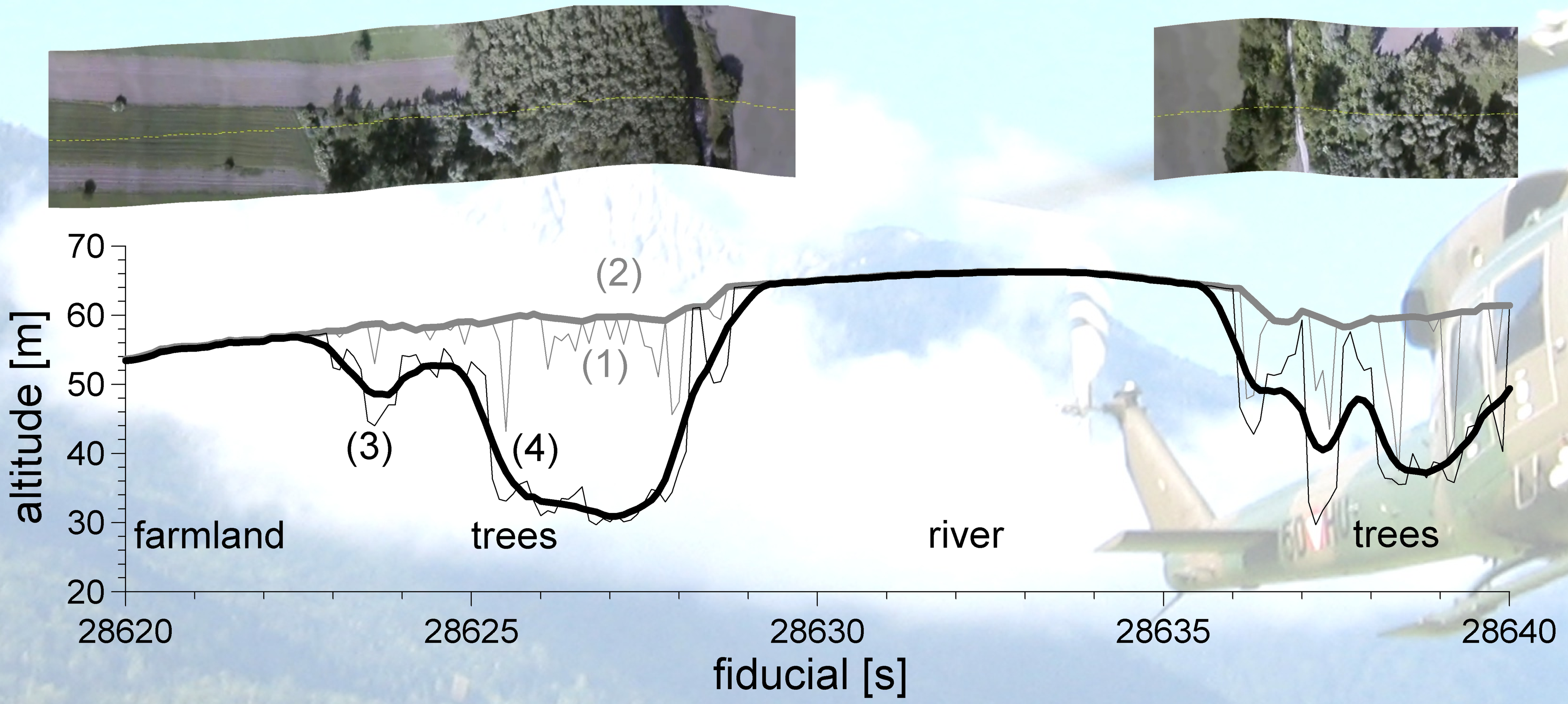

***Figure 2**: Signals and interpretation of the laser-altimeter over a small section of a profile. (1) Last pulse, (2) determined flight altitude, (3) first pulse, (4) averaged first pulse.*

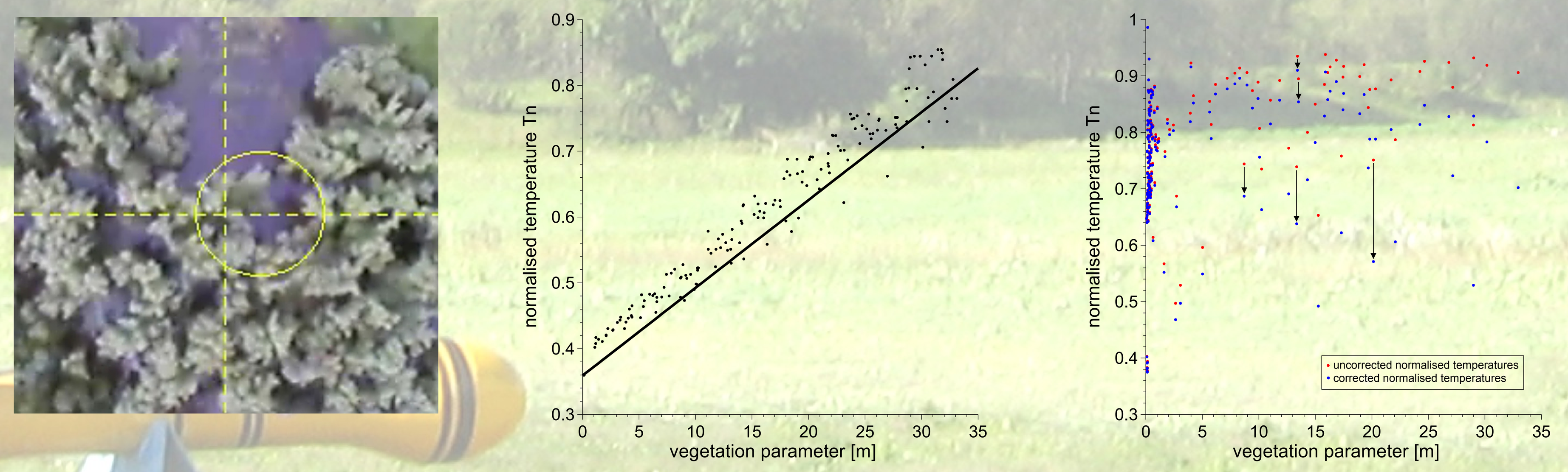

***Figure 3**: Relation between the vegetation parameter and the normalised temperature Tn for flooded areas and application of the correction.*

Vegetation parameter

In a next step we included the first reflections in our considerations. Using the difference between the flight altitude (line no. 2 in fig. 2) and the averaged distance given by the first reflection (line no. 4 in fig. 2) provides a parameter which characterizes the vegetation.

In this study we used this vegetation parameter for the correction of the damping effects of the vegetation on soil moisture data. To measure soil moisture we use an L-band-antenna in combination with an infrared-sensor. Together they give us the normalised temperature Tn which is indirect proportional to soil moisture.

At the time of the survey the water meadows of the survey area were partly flooded. So we had grassland, bushes and trees completely surrounded by water (see fig. 3). In these areas we can expect minimal Tn values. Due to the damping effects of vegetation we effectively measure higher values. For this study we used the data from these flooded areas to determine a correlation-function between the derived vegetation parameter and the normalized temperature Tn (see fig. 3).

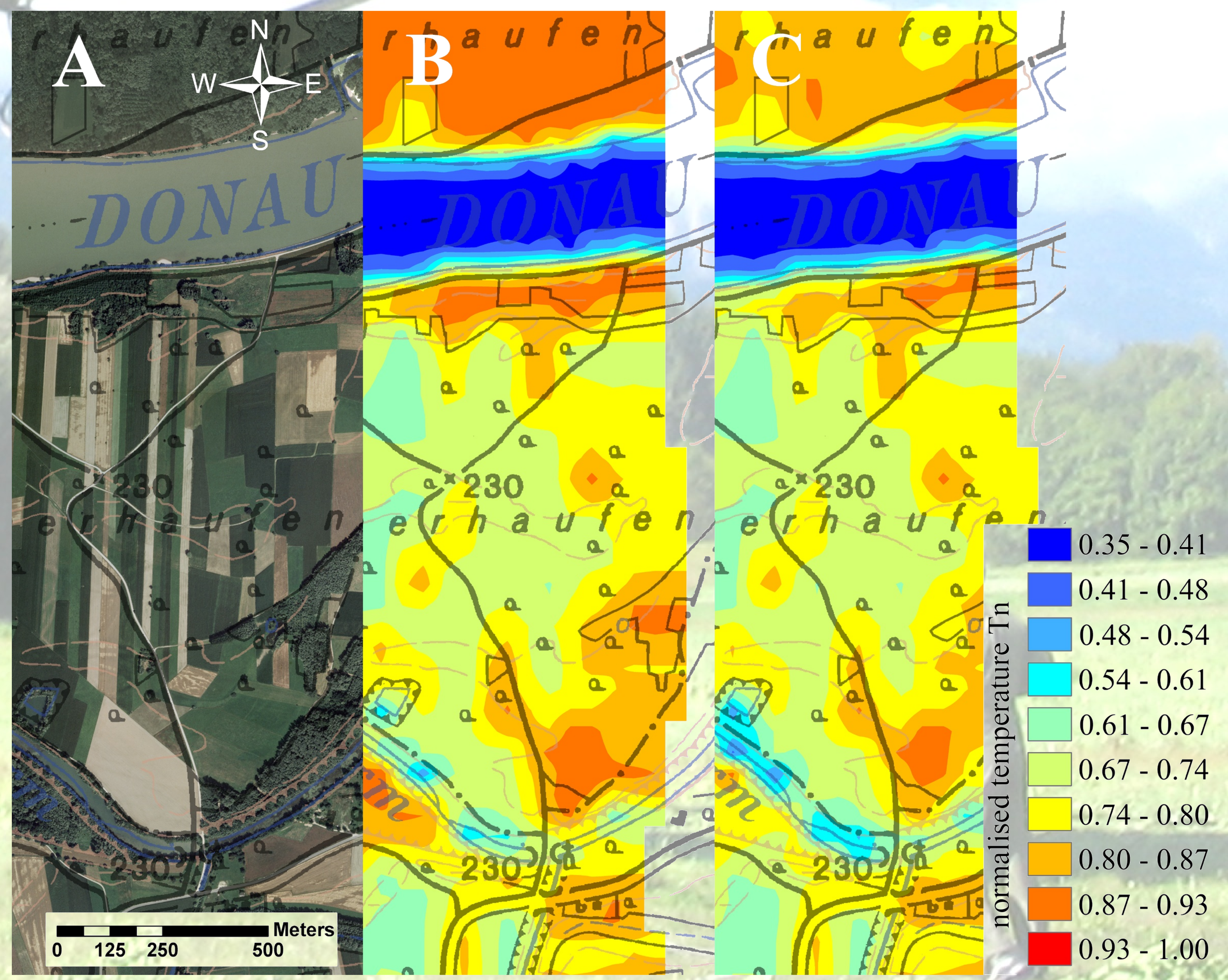

***Figure 4**: Detailed map of the survey area. The figure shows an aerial photo (A) and the normalised temperature Tn. Picture B shows the uncorrected Tn-values, picture C shows the Tn-values after correction of vegetation.*

This correlation function was used to correct the Tn-values in the whole survey area. A comparison between corrected and uncorrected Tn is shown in figure 4. Please note that the area north of the river Danube appears to be uniformly dry in uncorrected data. In the corrected data a variation in Tn can be seen. It is also remarkable that the small anabranch in the southern part of the displayed area is much more clearly visible in the corrected Tn -data.

Conclusion

In recent years the high resolution laser-altimeter has become a more and more important part of the survey equipment. It offers a means to correct several sources of error in airborne geophysical data. In AEM, gamma-ray-spectrometry and soil-moisture-mapping these corrections are essential for high resolution mapping. For the future we are planning to use the results of the laser-altimeter, together with corrected GPS-positions, to create digital elevation models in poorly investigated areas.