



## **Remote monitoring of lake level heights by ground-based observations of reflected GPS signals**

**A. Helm**, G. Beyerle, Ch. Reigber and M. Rothacher

GeoForschungsZentrum Potsdam, Dept. Geodesy & Remote Sensing, Telegrafenberg,  
D-14473 Potsdam, Germany (helm@gfz-potsdam.de)

Recent studies have shown that ground-based GPS receivers offer the potential to monitor lake level heights by observing GPS signals reflected from the water surface. Reprocessed data from a GPS reflectometry experiment with the OpenGPS receiver are presented, conducted in July 2003 in the Bavarian Alps (Germany) with unobstructed view to the lakes Kochelsee and Walchensee.

The OpenGPS receiver with a separate single patch antenna was positioned at the Fahrenberg location (11.32°E, 47.61°N) about 1026 m above the water level of Kochelsee and 824 m above Walchensee. The 12 channel L1 frequency receiver was modified to allow for open-loop tracking of reflected signals. One channel tracks the direct signal of the observed satellite. The remaining 11 channels are phaselocked to the direct signal and shifted by predefined code delays. In this open-loop delay mapping mode the receiver can measure the coarse/acquisition (C/A) code correlation function of the direct and the reflected signal of one GPS satellite simultaneously. When the correlator generated model signal is phase-locked to the direct signal and has the expected delay in time, variations in the amplitude of the received signal can be observed. These fluctuations are caused by the interference between the coherently reflected signal and the model signal. From these amplitude variations the relative altimetric height of both lake surfaces can be determined.

Several relative height profiles with continuous lengths of several 100 m could be acquired from both lake surfaces. Height changes could be observed with an accuracy within cm range, with amplitudes of about 5 cm at Walchensee and about 10 cm at Kochelsee. Reflections have been measured mainly at elevation angles around 10–15 degrees and distances around 2–4 km from the receiver. The influence of the Tropo-

sphere and the slope of the lake surface caused by the local geoid are discussed.