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Airborne Interferometry using GNSS Reflections for Surface Level Estimation

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The interferometric use of GNSS reflections for ocean altimetry can fill the gap in coverage of ocean observations. Today radar altimeters are used for large scale ocean observations to monitor e.g. global sea level change or circulation processes like El Niño. Spacial and temporal resolution of a single radar altimeter, however, is insufficient to observe mesoscale ocean phenomena like large oceanic eddies that are important indicators of climate change. The high coverage expected for a spaceborne altimeter based on GNSS reflections stimulated investigations on according interferometric methods. Several airborne experiments have been conducted using code observations. Carrier observations have a better precision but are severely affected by noise and have mostly been used in ground-based experiments. A new interferometric approach is presented using carrier observations for airborne application. Implementing a spectral retrieval noise reduction is achieved.

A flight experiment was conducted with a Zeppelin airship on 2010/10/12 over Lake Constance at the border between Austria, Germany and Switzerland. The lake surface with an area of 536km^2 is suitable for altimetric study as its decimeter range Geoid undulations are well-known. Three GNSS receiver were installed on the airship. A Javad Delta receiver recording direct signals for navigation. The DLR G-REX receiver recording reflected signals for scatterometry and the GORS (GNSS Occultation Reflectometry Scatterometry) receiver recording direct and reflected signals for interferometry. The airship's trajectory is determined from navigation data with a precision better than 10cm using regional augmentation.

This presentation focuses on the interferometric analysis of GORS observations. Ray tracing calculations are used to model the difference of direct and reflected signals' path. Spectral retrieval is applied to determine Doppler residuals of modelled path difference and interferometric observations. Lake level is estimated inversely, based on the correlation of Doppler residuals and trial heights, with decimeter precision. Estimates are validated with tide gauge reference data.

Wave-induced surface roughness disturbs interferometric observations introducing noise on short time scales < 1s. This effect is mitigated by the spectral retrieval. Geoid undulations affect the observations on longer time scales > 100s and pose a challenge to spectral retrieval. To address this challenge phase data is considered to overcome the poor resolution of spectral retrievals. The phase data shows residual Doppler shifts. The Doppler induced by Geoid undulation (< 25cm) is small (typically about 1mHz). Other effects, typical for GNSS observations, are important to reach this precision. The Doppler related to unmodelled variations of water vapour and the airship's trajectory is in the same range and masks the altimetric effect of Geoid undulation.