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Remote sensing of the coastal ocean using standard geodetic GPS stations

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Global sea level rise and local sea level variations due to climate change is believed to significantly impact coastal societies during this century. Thus, it is of great importance to monitor and understand how the sea level is changing. Existing techniques to measure sea level, e.g., tide gauges and altimeters, have provided important insights in this field during the last decades. However, tide gauge measurements are affected by the motion of the land on which they are established and altimeter measurements are affected by drifts as well as problems with accurate near-coast measurements. Therefore, further observations with additional instrumentation are necessary in order to fully understand the underlying processes.

We present the possibility of using Global Positioning System (GPS) signals for creating a new coastal sea level dataset based on analysis of Signal-to-Noise Ratio (SNR) data from existing permanent GPS stations at the coast. A GPS antenna close enough to the ocean is affected by multipath signals from the ocean, i.e. GPS satellite signals reflected off the sea surface. The multipath signals interfere with the direct satellite signals and this becomes especially visible as oscillations in the recorded SNR data. Analysis of the SNR oscillations provides the distance between the sea surface and the GPS antenna phase centre, which changes with changing sea level. Thus, such an installation can be called a GPS tide gauge and can be used to monitor sea level.

The advantage of a GPS tide gauge is that it allows both determination of the sea level and determination of the position with respect to the International Terrestrial Reference Frame, using a single geodetic instrument. This is particularly valuable in areas with land surface motion where the usefulness of traditional tide gauges is restricted.

The technique has been verified through comparison to traditional tide gauges at two sites with both low and high tidal variation, Onsala (Sweden) and Friday Harbor (USA), respectively. The comparison of more than three months long time series resulted in correlation coefficients of better than 0.97 for both sites. For the station with low and high tidal range, the root-mean-square agreement between the GPS results and the tide gauge records were better than 5 and 10 cm, respectively.

In this presentation we show the results after applying this technique to at least one year of data from 5 existing permanent GPS stations around the world.