SEA ALTIMETRY AND SCATEROMETRY USING GPS EARTH REFLECTED SIGNALS

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1. INTRODUCTION

The Global Navigation Satellite Systems (GNSS) transmit L-band signals (see the Reference [1]). The GNSS receivers, as its main objective, measure the time elapsed from the transmission to the reception of L Band signals to infer the distance transmitter-receiver and to derive the three coordinates and time status of the receiver. The same signals could be recorded after its reflection on the Earth Surface. The shape of such reflected signals could be used to infer the rugosity of the sea surface (scatterometry) and its delay contain information on the position of the reflecting surface (altimetry). This concept, called GNSS-Reflections (GNSS-R) or PAssive Reflectometry and Interferometry System (PARIS) was proposed in 1993 [2]. The main observables produced by the present GNSS-R receivers are the waveforms: the cross-correlation of the reflected signals with its computed replicas when available. (See [3] for a description of such signals).

Different research groups have carried out experiments whith the aim of exploring the capacity of the technique for the remote sensing of the different components of the Earth surface (sea, ice, soil moisture, etc). The following references are some examples: [4], [5], [6], [7], [8], [9], [10]

Our goal is to provide a method to obtain, from each recorded waveform, two quantities: the specular and the scatterometic delays which contains the information needed to determine the sea surface state and the mean sea level. To verify the adequacy and the limitations of such method we acquired GNSS-R data during a flying a receiver at 3000 meters altitude. We will describe the results obtained and discuss the limitations of the proposed technique.

2. ALTIMETRIC AND SCATTEROMETRIC INFORMATION CONTENT

A suitable model to describe the GNSS-R waveforms has been given in [11]. The model is expressed as an integral equation which relates the observed waveforms with the parameters describing the instrumental setup, the position of the transmitter and the receiver , and the variables describing the geometry of the reflecting surface (i.e. the ellipsoidal heigth of the reflecting surface) and the normalized bistatic cross section of the sea surface. The applicability of the GNSS-R technique resides on the possibility of inverting this integral equation.

In our inversion procedure we follow the suggestion given in [12]: the altimetric information could be extracted from the delay corresponding to the maximum of the derivative of the waveform (specular delay) and the scatterometric information is carried by the delay corresponding to the maximum of the waveform (scatterometric delay). In reality the limited sampling rate of the actual GNSS-R receivers and the different sources of noise and unaccuracies limit the applicability of such concept.

3. EXPERIMENTAL WORK AND DATA ANALYSIS

With the GOLD_RTR instrument (described in detail in [13]) we performed an experiment using an aircraft at 3000 m near Norway. Such experiment has been reported in [14].

The acquired GNSS-R data has been analyzed jointly with other ancillary information like the aircraft orientation and reference GPS stations, to determine with high accuracy the position of the receiving antennas, and an apriori mean sea level. Our instrument measured the waveforms with an approximate resolution of 15 meters, corresponding to the bandwidth of our instrument (20 Mhz) which matches the transmitted GPS signals.

4. CONCLUSIONS

We have analyzed a GNSS-R experiment using information extracted from the derivative of the reflected waveforms. Preliminary results, indicate that with our setup we obtain accuracies in the altimetry potentially useful for mesoscale altimetry. The limits encountered in our research could be circumvented by including requiring the capability of calibrating the instrumental delays (cables and electronics) and avoiding multipath delays in the direct signal

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