OCEAN WIND MEASUREMENTS WITH GPS MULTISTATIC RADAR FROM HIGH-ALTITUDE AIRCRAFT

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1. INTRODUCTION

During the last decade a number of airborne experiments have been performed to study feasibility of GPS reflection technique to measure ocean surface winds (see, e.g. [1-3]). From a theoretical model [4] it follows that the characteristics of reflected signals, such as the shape of the correlation waveform, can be related to the rms of L-band limited surface slopes, and from there, to a near-surface wind speed. This relationship holds only for well-developed seas, i.e. if the local wind is the only source of sea roughness in the vicinity of the reflection point. Significant progress was made during this period in designing and testing various types of GPS reflection receivers [5-7] which are appropriate to regard as GPS multistatic radars. This technique might be attractive when considering high altitude/long endurance (HALE) Unmanned Aircraft Systems (UAS) because of the small size, small weight, and low energy consumption of GPS receivers. Use of high-altitude (~ 20 km) UAS platforms is especially beneficial providing swaths ~100 km wide.

2. SENSOR DESCRIPTION

Because of the significant increase in high-speed digital data storage capabilities, recent interest has shifted from real-time delay-mapping GPS receivers to so-called software GPS receivers. In contrast to a real-time receiver, a software receiver simply records raw in-phase and phase-quadrature data for the direct and ocean reflected GPS signals. Then post-processing can be performed after the measurement using varying parameters to obtain the best result depending on the measurement conditions. Accelerated post-processing algorithms make possible obtaining geophysical results from the raw data over a relatively short time, of order of several days. In [7] a rack-size software GPS system was proposed for radio-occultation retrievals of the atmospheric water vapor and for surface scatterometric measurements from a Gulfstream-V aircraft. In [8] results were presented of an ocean scatterometric experiment in September 2008 performed with a significantly smaller and less expensive GPS software receiver designed at the Colorado University/Aerospace Engineering Sciences. The purpose of that experiment was to test this new inexpensive and portable sensor and compare wind retrievals with data available from other instruments to assess the capability of this bistatic GPS radar to monitor winds or ocean surface roughness from 2-3 km flight altitudes.

3. HIGH-ALTITUDE EXPERIMENT

A modified version of the CU bistatic radar with a larger bandwidth front end was installed on the NOAA Gulfstream-IV jet aircraft and operated during a flight on October 19, 2009 to test the system at higher altitudes, ~10 km, which should give insight into the feasibility of using this technique for high-altitude UAS platforms using the smallest possible form factor and minimal power. The portion of the flight track ran across the Gulf of Mexico (see Fig. 1) and the GPS reflected signal was recorded from all available satellites. Overall, 100 s of reflection data were obtained from ten GPS and two geostationary WAAS satellites.

The examples of raw GPS reflected waveforms are shown in Fig. 2. Wind retrievals from the Step Frequency Microwave Radiometer (SFMR) flown on the same aircraft are available to assess the capability of this multistatic GPS radar to monitor winds or ocean surface roughness. Also, wind and surface wave spectrum data was available from NOAA buoys in the vicinity of the flight track. We will report comparisons between GPS and SFMR wind retrievals. Comparisons with scattering modeling results will be discussed as well. For the next phase of the sensor development we plan to expand capabilities to all three GPS frequencies, including the wider band L5 signal (well suited for the ocean altimetry), while still keeping the size small and cost low.

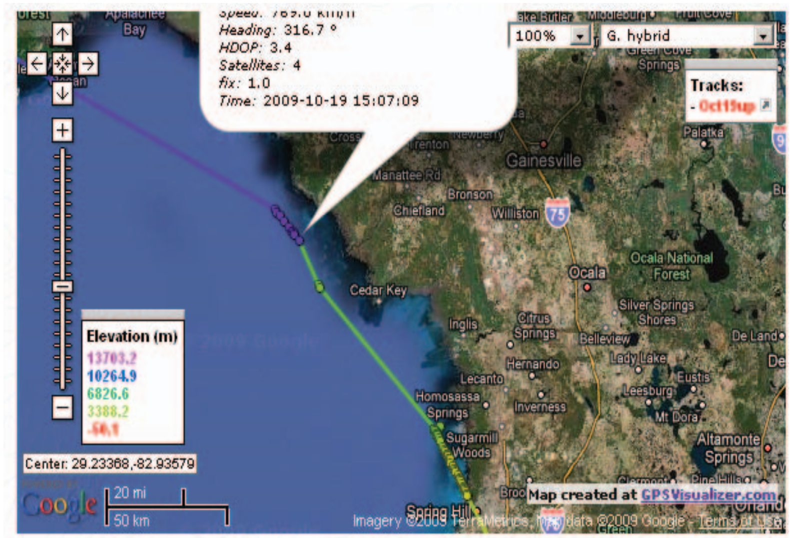

Fig. 1. The aircraft flight track on Oct. 19, 2009

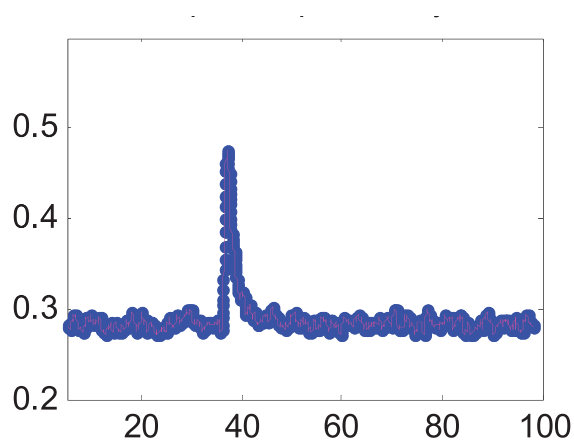

Fig. 2. An example of the reflected GPS waveform averaged over 1 s.

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