Measuring sea level with GPS-equipped buoys: a multicomparison experiment at Aix island

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ABSTRACT

Preliminary results obtained in a multicomparison experiment with three GPS-equipped buoys conceived to measure sea level and deployed at Aix Island on the 27-28 March 2012 are presented. Sea level measurements obtained with the buoys were compared with the ones provided by a radar tide gauge with a Van de Casteele test in order to evaluate their quality. First results show a good correspondence between sea level data provided by both types of instruments.

THE EXPERIMENT

The potential of GPS-equipped buoys had already been shown in previous papers (Watson *et al.*, 2008; Vallu *et al.*, 2009; Bouin *et al.*, 2009a; 2009b; Fund *et al.*, 2012), in particular for the calibration of tide gauges. On 27-28 March 2012, three prototypes of buoys equipped with GPS and developed independently by three institutions (SHOM, INSU and IPGP) were deployed at the Aix Island (NW coast of France) in a relatively sheltered area of 10 m depth (Fig. 1) in order to explore their capabilities for the measurement of sea level. More details about the prototypes are provided in Figure 2. The deployment area was located near a harbour pier, where a tide pole and a radar tide gauge, belonging to the SHOM-RONIM network are installed. On 28 March, sea level heights were measured manually over a tidal cycle using a tide pole and one optical probe. Other complementary measurements included relative and absolute gravimetric measurements, currents and leveling.

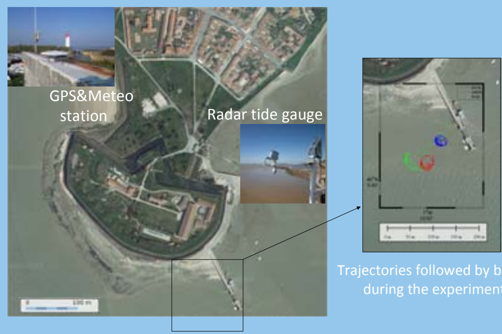

Figure 1. The Aix island has a sea level observatory with a radar tide gauge, a meteorological station and a GPS station.

GPS DATA PROCESSING

The buoy kinematic GPS data were processed in differential mode with respect to fixed on-land stations, following two steps. First, data from the on-land reference station were processed in static mode using GAMIT software (Herring *et al.*, 2006) and second, the position of the buoys was estimated with respect to this reference station using the TRACK package from the GAMIT/GLOBK suit. The static and kinematic analyses were made using IGS precise orbits and a 10° elevation cut-off angle for all stations. We used both frequencies (L1 and L2) separately which is known to give better results for short baselines than using the ionosphere-free linear combination. Ionosphere and troposphere are assumed to be identical between the reference on-land station and the buoys.

Figure 2. Main characteristics of the GPS-equipped buoys used in the experiment

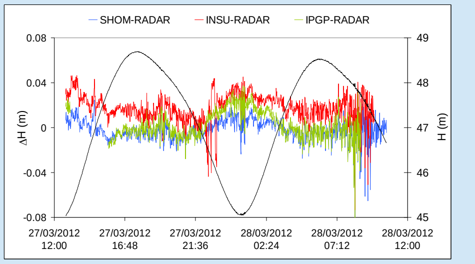

Figure 3. Differences between sea level height measured by the buoys and the radar tide gauge. Sea level height measured by the radar is also shown (black line, right Y axis)

RESULTS: VAN DE CASTEELE TEST

The Van de Casteele test is used to assess the performance of a tide gauge (IOC, 1985) and it implies taking simultaneous sea level heights both with the gauge being checked and with a reference gauge. Differences between both measurements are calculated (ΔH) and plotted in the X axis while sea level height (H) is plotted in the Y axis. Assuming that the reference gauge provides high-quality data, a vertical line centered at zero will indicate that the gauge we are checking is also providing good data. In our case, visual measurements taken at a tide pole on 28 March were used as a reference. Despite being somewhat rudimentary, visual measurements taken by experienced operators under calm sea conditions can be very reliable.

First step: Checking the performance of the radar tide gauge

Despite being a well-known technology used in many tide gauge networks including France, radar sensors must be regularly checked to ensure a correct performance. The results of the Van de Casteele test are depicted in Figure 4, showing a vertical line centered at zero. The root mean square error (RMS) for the ΔH time series is < 2 cm, which is comparable with previous results obtained during maintenance operations of the RONIM network (Martin Miguez *et al.*, 2008) and is suitable for tidal applications.

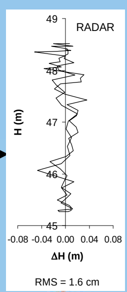

Figure 4.

Second step: Exploring the performance of the GPS-equipped buoys

After verifying the proper performance of the radar tide gauge, we used it as a reference to assess the reliability of the GPS-equipped buoys. Several factors may contribute to the up-to-2 cm height difference found with the buoys (Fig.3 and Fig.5) and are still being investigated: 1) error in the antenna floating height estimate of the buoy above water, 2) tilting of the IPGP buoy at low tides, 3) changes in dynamic topography due to wind and currents. In spite of the differences, overall the results prove that the three buoys delivered data comparable to the data provided by the radar.

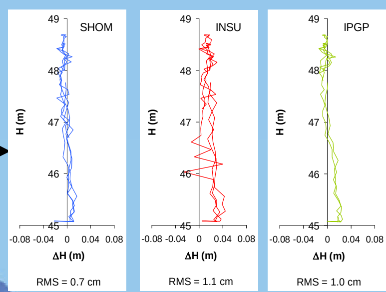

Figure 5. Results of the Van de Casteele test using radar as a reference

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FUTURE WORK

The encouraging first results obtained during the experiment open exciting new perspectives:

Beyond the tide: we will undertake the comparison of the 1 Hz time series to assess the buoys capacity to study other phenomena in the supratidal range such as seiches or waves. We are also interested in assessing the impact of the buoy design in its capacity to filter out/record certain frequencies in the signal.

PPP processing: GPS data will be processed in PPP (Precise Point Positioning) mode. This is a less precise method since it only uses data from one receiver and many of the most common errors (troposphere, orbits) do not cancel out. However, if reasonable results were to be found, the use of this type of buoys would no longer be restricted to coastal areas.

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