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Evaluation of low-cost GNSS receiver and Multi-GNSS Advanced Demonstration Tool for Orbit and Clock Analysis (MADOCA) Precise Point Positioning (PPP) for water level monitoring

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Two monitoring systems were developed for sea level monitoring using low-cost GNSS receiver. First, was the development of a tide gauge (TG) float and second was a buoy. The TG system was assembled with the horizontal movement of the antenna constrained by a 15cm plastic tube and only allowed to move up and down using a float attached to the antenna. The GNSS receiver is placed inside a waterproof Tibox with the other electronics. The tube is attached to the column pier located in the Manila Bay North Harbor. The buoy system includes 3 float balls and 2 life buoy rings surrounding the plastic enclosure containing the battery, receiver, and other electronics. The buoy was attached to an anchor to constrain its' movement. The power supply comes from solar panels. Both systems used the U-blox-Zed-F9P module, a multi-band low-cost GNSS receiver. The software used for data logging and processing was the RTKLib installed in Raspberry Pi minicomputer.

The low-cost GNSS TG was tested in Manila Bay where a RADAR sensor is installed. The measurements from the latter were used for validation. The Physical Oceanography Division (POD) of the National Mapping and Resource Information Authority (NAMRIA) is maintaining the TG. The tests were conducted in January 29-30, February 3-4, 22-24, and March 4-12, 2021. Two solutions were processed for these tests: 1) MADOCA offline using downloaded State Space Representation (SSR) files and post-processed solution using the University of the Philippines (UoP) GNSS base station as reference. The results showed a RMSE of 0.59m offset from the RADAR sensor measurements using the MADOCA offline solution. The post-processed solution showed better fit with the RADAR sensor measurements with a RMSE of 0.05m. The real-time MADOCA PPP solution was also tested but the observations were very noisy and have many data gaps.

The deployment of low-cost GNSS buoy in Manila Bay did not push through due to the lockdown brought by COVID-19. The buoy was instead tested in the University of the Philippines lagoon. The tests were conducted for 24 days between October 22 to December 10, 2021. With the arrival of the MADOCA receiver from University of Tokyo through the assistance of Dr. Dinesh Manandhar, the U-blox F9P receiver was replaced by another U-blox receiver integrated with MADOCA decoder. Thus, the MADOCA PPP real time solution was tested and compared with the offline solution. The comparison of the two solutions showed an average of 0.19m and a RMSE of 11m for the real time solution and an average of 0.003m and a RMSE of 0.25m for the offline solution. The real time solution was dominated by many data gaps which indicate that no direct satellite corrections from Quazi-Zenith Satellite System (QZSS) were being decoded. This is probably the reason why the big offset in the vertical was observed. The offline solution produced the better results. However, the 0.25m error is still large for sea level measurements. The presence of many typhoons during the period of observation also affected the solutions. Refinements to the design and further testing will be conducted to improve the performance of the buoy.

This study explored the possibility of using low-cost GNSS receiver for water level monitoring. This has possible applications for river flooding monitoring and sea level monitoring near the coast and offshore. With refinements to the presented systems, the feasibility of GNSS technology for water level monitoring is becoming more affordable.

KEYWORDS: MADOCA, low-cost GNSS receiver, water level monitoring