U-CORS: An Underwater Continuously Operating Reference Station for Deep Seafloor Geodesy

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We designed and tested a novel GNSS-Acoustic system for deep seafloor geodesy. A ship or autonomous surface vessel (ASV) whose location is precisely tracked using high-rate GNSS acts as a GPS satellite constellation, sending out precisely time-tagged acoustic pulses (consisting of carrier-phase modulated pseudorandom sequences). These are received by the seafloor unit, the "C-DOG", whose location we aim to determine. Rather than responding by echoing the received signal, the C-DOG correlates the consecutive arrivals of the pulses received by its hydrophone against a database of known codes, and time-stamps them relative to a chip-scale atomic clock. Only the time stamps are recorded, and these are recovered for subsurface location determination in post-processing. We tested our system (comprising four seafloor units and one surface vessel) in shallow (Boston Harbor) and deep (5000 m) water (offshore Bermuda). We estimate the quality of geodetic position determination at great depth in the ocean using our system. Future development and testing will see the wake-up of the units from a long state of dormancy on the seafloor, from which they will not be recovered, yet temporarily revisited by autonomous surface vessels.

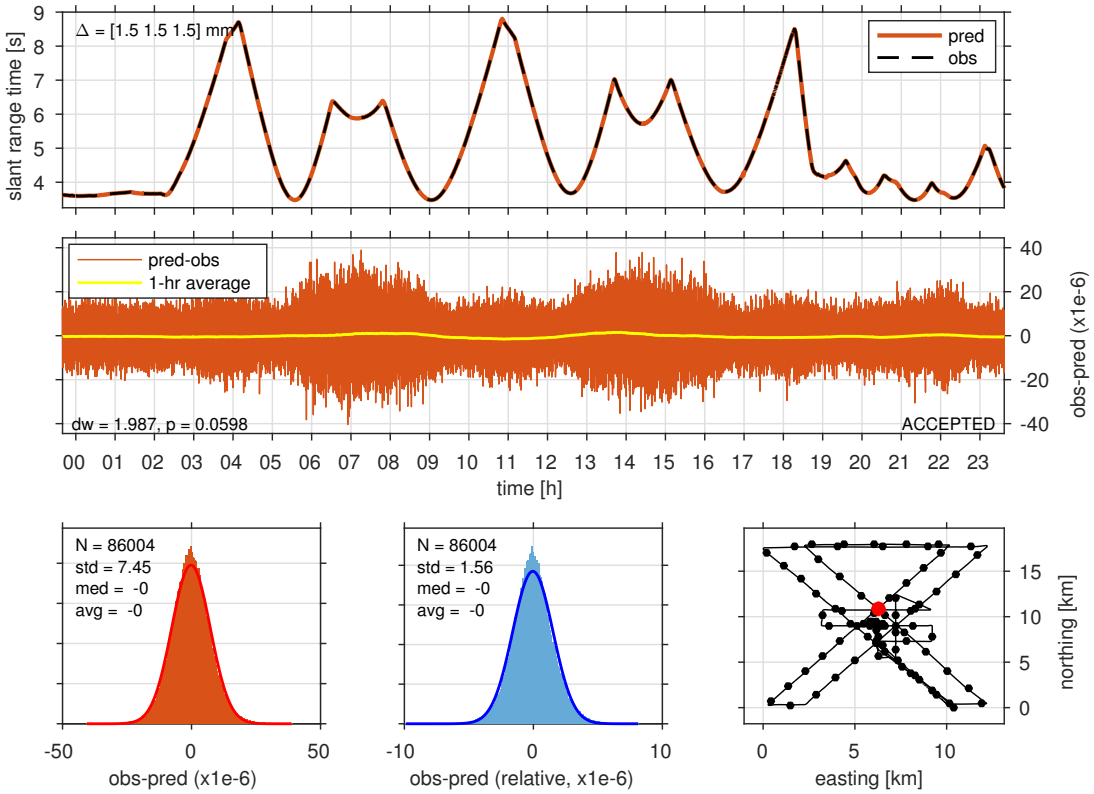

Figure 1: A synthetic, based on real data, to illustrate the principle of our method. Noisily observed and predicted slant ranges, and their absolute and relative differences, for the ship trajectory corresponding to the 2020 Bermuda test in 5 km water. The predictions are based on a location 2.6 mm off from the truth.