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Vertical water velocity measurements from virtual mooring of underwater glider

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Ocean observation has rapidly evolved into integrated autonomous systems which are cost-effective and do not have any weather-bias. The autonomous observation network consists primarily of time-series observations with mooring and spatial observations using autonomous mobile platforms like underwater glider. Underwater gliders play the most important role on large-scale (>O(100km)) spatial observation in the observing network. However, in terms of autonomous observation network, slow-speed feature of underwater glider must be complemented with moored observations in order to measure spatio-temporally varying ocean. The moored measurements in the open oceans requires significant amount of costs for installation and maintenance as well as is not subject to change their locations for the purpose of adjusting to dynamic ocean environments. The virtual mooring is one of glider operational technique to stay a glider in a designated location while reciprocating between sea surface and a certain depth. Such technique can expand applicability of underwater glider as well as improve the scalability of the existing moored observations. Based on the optimized mission design for the East/Japan Sea, the precise virtual mooring control using a Slocum deep glider (KG643) has been succeeded. The glider conducted the virtual mooring for about 260 hours (about 10 days) from June 19 to June 29, 2017, which maintain its locations within 60 m (RMS distance) radius from the designated point (37.° 47.79.′, 129.° 33.90.′). During the virtual mooring, it measures temperature, salinity, and chlorophyll-a concentration profiles upper 400m, under the depth-averaged current of less than 10 cm/s and the surface currents of up to 60 cm/s. Since it is drifted by strong surface currents during satellite communication, it moves toward the designated point during descending so that the precise virtual mooring is possible only while it is ascending. The rudder system of Slocum glider which can provide a smaller turning radius of less than 10 m, helps it to keep close to the virtual mooring point by flying in a spiral pattern. Using vertical glider velocity obtained from the highly precise virtual mooring measurements, we estimated vertical water velocity under the assumption that the glider flight characteristics remain the same for about 10 days. The anomalous glider vertical velocity which is regarded as vertical water velocity has strong high frequency oscillations which turns out the baroclinic internal tide. This observational result can be a direct observational evidence to show that strong vertical water velocity can be measured by properly analyzing vertical velocities of underwater glider.