The Multi-path Effect on PWV Retrieved from Shipborne GNSS Measurements

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Water vapor plays a significant role on development of hazardous cumulus convection. Water vapor monitoring with high temporal and spatial resolution is indispensable for both predicting and monitoring of such disastrous weather phenomenon. In Japan, a nationwide dense continuous ground based GNSS (global navigation satellite system) network named GEONET (GNSS Earth Observation Network, http://www.gsi.go.jp/ENGLISH/page_e30030.html) has also been utilized as a continuous water vapor monitoring network by the Japan Meteorological Agency since 2009.

In order to capture finer water vapor variation, we have been developing observation system of water vapor over the ocean using GNSS receivers equipped on top of floating buoys and vessels (Shoji et al. 2016). One of the most important points of the application is its real-time availability. We have tested MADOCA (Multi-GNSS Advanced Demonstration tool for Orbit and Clock Analysis) real-time ephemerides (https://ssl.tksc.jaxa.jp/madoca/public/public_index_en.html) applied to the program package for GNSS positioning “RTKLIB (http://www.rtklib.com/)” version 2.4.2 (patch 11).

In year 2015, we conducted observations using four shipborne GNSS receivers on three research vessels and one passenger ferry to assess the real-time practicality of measuring GNSS-derived precipitable water vapor (PWV) over the ocean. All antennas were equipped on the upper-most deck of each vessel. A kinematic precise point positioning strategy was used for the GNSS analysis with a real-time GNSS satellite ephemerides (orbit and clock information).

The analyzed time series of PWV was contaminated with unrealistic sharp variations that occasionally occurred. Periodic occurrence of a spiky variation with a cycle of one sidereal day, along with post-fit phase residuals averaged at each elevation and azimuth, indicated that one of the causes of the unrealistically large time variation was interference of reflected signals (multi-path).

A simple quality control (QC) procedure based on the amount of PWV time variation was proposed. After the QC was applied, the retrieved PWVs had 3.4 –5.4mm root mean square (RMS) differences against radiosonde observations, and 2.3 –3.7mm RMS against those retrieved at nearby ground GNSS stations. The proposed QC procedure rejected more than 60 percent of retrieved PWV on research vessels and 6 – 11 percent on a passenger ferry. The results demonstrate the great potential of the real-time ephemerides and the necessity for careful consideration of the observation environment.

On 20 October 2016, we introduced an additional GNSS antenna on top of the mast of a vessel and conducted campaign observation till March 2017. Comparison with PWVs analyzed at nearby GEONET stations resulted that both antennas (mast top and deck) show about 2 mm RMS. In the case of the mast top observation, about 1 percent of retrieved PWV were rejected while more than 30 percent were rejected in the case of the deck observation.

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