Study of Water Vapor Monitoring in the Open Ocean using Kinematic Precise Point Positioning

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Japan is an archipelago located easternmost of East Asia and influenced by the East Asian monsoon, which is characterized by moist air inflow coming from the ocean that often causes heavy rainfall (Kato 2006, Tsuguti and Kato 2014, Kato 2018). From June 28 to July 8, 2018, extreme rainfall frequented western Japan to the Tokai region, wherein more than 1,000 mm, at the maximum of 1,852.5 mm, precipitation was recorded in several regions (Tsuguti et al. 2018). A press release of Japan Meteorological Agency (JMA) (JMA, 2018) attributed the event to the concentration of two massively moist air streams over western Japan and persistent upward flow. With the frequency of extreme precipitation events, water vapor monitoring over the ocean becomes one of the important issues in Japan. Shoji et al. 2009 exhibited the improvement of a heavy rainfall prediction method by assimilating precipitable water vapor (PWV) estimated via the Global Positioning System (GPS) observation network in East Asia, as well as Japan’s nationwide dense GPS network. The result insisted the importance of water vapor monitoring upstream.

Unlike ground-based fixed GNSS stations, ocean-platform (ship and buoy) GNSS measurements face difficulties in analyzing the variable antenna position simultaneously with the atmospheric delay. However, recent advancement of kinematic precise point positioning technology is beginning to overcome these difficulties. Shoji et al (2017) installed two GNSS antennas on a research vessel, the RYOFU MARU of the Japan Meteorological Agency (JMA), and conducted experimental observations to assess the GNSS derived precipitable water vapor (PWV) from October 19, 2016, to August 6, 2017. The GNSS derived PWVs showed good agreement with the radiosonde observations on the vessel (1.7 mm root mean square difference, −0.7 mm bias, and 3.6% rejection rate).

Kato et al. (2018) introduced a GNSS buoy system for a synthetic geohazard monitoring. The buoy is located about 40 km south of Cape Ashizuri, west of Shikoku, Japan. We succeeded continuous PWV retrieval from June to September 2018. Retrieved PWVs vividly captured water vapor variations associated with north-south shifting of the “BAIU” seasonal rain front and passages of heavy rainfalls and typhoons. The GNSS buoy PWVs also suggest that, compared to over land, uncertainty of water vapor field in JMA’s objective analysis is larger over the ocean (Shoji et al. 2019).

In the year of 2018, we started a new research project to monitor PWV over the ocean west of Kyushu, Japan, getting supports from eight vessels (six regular line cargo vessels, one fisheries research vessel, and one JMA’s research vessel). The purpose of this study is to assess the impact of water vapor monitoring in upward of west Japan on heavy rainfall prediction. Preliminary PWV analyses show about 3 mm rms with about -1 mm bias against JMA’s operational regional objective analysis.

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