Space geodetic study of the 2019 typhoon Hagibis: PWV and crustal subsidence

Kosuke Heki¹, Syachrul Arief¹, Mizuki Yoshida¹, and Zhan Wei²

¹Hokkaido University, Dept. Earth Planet. Sci., Sapporo, Japan (heki@sci.hokudai.ac.jp)
²The First Monitoring and Application Center, China Earthquake Administration, Tianjin, China

Strong typhoons hit the Japanese Islands repeatedly in 2019. Here we study one of these typhoons (2019 #19 Hagibis 915 hPa, 86 casualties) that landed central Japan on Oct.12 (local time) during the Rugby World Cup tournament, using two different space geodetic approaches, i.e. water vapor and crustal deformation. The first approach is the recovery of Precipitable Water Vapor (PWV) using the zenith wet delays (ZWD) estimated by the dense GNSS array in Japan GEONET. Because atmospheric water vapor concentrates in relatively low altitudes, high humidity is often difficult to recognize in ZWDs when the surface altitude is high. To overcome the difficulty, we reconstructed ZWDs, converted to sea-level values, by spatially integrating the tropospheric delay gradient (azimuthal asymmetry of water vapor) vectors. We also calculated convergence of such delay gradients, equivalent to water vapor convergence index (WVCI) proposed by Shoji (2013 Jour. Met. Soc. Japan). We found that very strong rainfall occurs in the region where both reconstructed ZWD and the delay gradient convergence index are high. Next, we studied vertical crustal movements associated with the water load brought by the typhoon, using the two solutions of the GEONET station coordinates, one from the official F3 solution and the other from the UNR data base. We confirmed subsidence down to ~2 cm in multiple regions where severe flood occurred. Such subsidence was observed to recover with a time constant of 1-2 days reflecting rapid drain of rain water to ocean due to large topographic slope and proximity to the sea. We could not identify, however, crustal uplift due to the low atmospheric pressure at the center of the typhoon.