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Raytracing Through Tropical Cyclone Meranti With GNSS and GFS/WRF/ERA (Young Scientist Travel Award)

Elżbieta Lasota (1), Witold Rohm (1), Guergana Guerova (2), and Chian-Yi Liu (3)

(1) Institute of Geodesy and Geoinformatics, Wrocław University of Environmental and Life Sciences, Wrocław, Poland (elzbieta.lasota@upwr.edu.pl; witold.rohm@upwr.edu.pl), (2) Department of Meteorology and Geophysics, Physics Faculty, Sofia University, Sofia, Bulgaria (guerova@phys.uni-sofia.bg), (3) Center for Space and Remote Sensing Research, National Central University, Taoyuan, Taiwan (cyliu@csrsr.ncu.edu.tw)

Tropical cyclones (TCs) cause large economic losses, and early warning of them is of critical importance. TC prediction has improved in the last decade, but studying their structure and dynamics remains a challenging task due to limited in-situ observations. The global navigation satellite system (GNSS) technique has many advantages, such as low-cost operability, permanent measurements, dense spatial coverage and, ultimately, it allows the state of the troposphere to be obtained with a high level of accuracy in all weather conditions. For this study, GNSS slant total delays (STDs) were derived during the passage of TC Meranti, which affected Taiwan and was the strongest TC in 2016. Observations from 28 GNSS stations, uniformly distributed over Taiwan, were processed using the precise point positioning strategy. Three meteorological datasets – the Weather Research and Forecasting (WRF) model, Global Forecast System (GFS) and ERA-Interim (ERA) – were employed to reconstruct the STDs using a 2D ray-tracing technique. Furthermore, two strategies were tested – including and excluding delays due to liquid and ice water content. The results reveal a good consistency between GNSS and ray-traced STDs. The best overall performance was from the WRF model, with a mean difference of -1.5 mm and a standard deviation of 27.3 mm when hydrometeor delay was neglected. The mean hydrometeor contribution reached up to 2.2 mm for the WRF model, while for the ERA and GFS, it was a factor of seven lower. Our results confirm that fractional STD differences are independent of the elevation angle for the same station and time interval. The recorded absolute fractional differences were greater for the HENC station (mostly within 0.8%) than for the GOLI station (on average below 0.5%) due to a closer location to the passing TC Meranti. At the HENC station, the largest errors – of 2.5% and 1.5% in ERA and WRF, respectively – occurred during the passage of the cyclone eye at 00 UTC on 14 September 2016. The most significant biases – of about -7% and exceeding -3% for ERA and GFS, respectively – were seen for the PLIM station, located in the Central Mountain Range. Despite the fact that the WRF model assimilates the GNSS zenith total delay, significant differences were seen in the vertical model structure (below 10 km), with one case where an overestimation of up to 15% was registered when compared to the GFS.