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GPS radio occultation ionospheric profile fitting and data qualify examination using the empirical orthogonal function analysis

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The Formosat-3 / Constellation Observing System for Meteorology, Ionosphere and Climate (FS3/COSMIC) program places six micro-satellites in low-Earth orbits to receive multi-channel GPS signals in both views of setting and rising and produce ionospheric vertical electron density (Ne) profiles by radio occultation (RO) technique. From our earlier investigations using the FS3/COSMIC ionospheric RO data, we have developed a numerical and phenomenological ionospheric model named the TaiWan Ionospheric model (TWIM), which is divided into F2, F1, E, and/or D layers characterized by an α-Chapman-type function for each layer. In this study we apply the empirical orthogonal function (EOF) analysis to fit the retrieved vertical Ne profiles and do data qualify examination before the TWIM modelling. This EOF analysis could present the eigenstructure of the covariance and spectral density matrices of the retrieved FS3/COSMIC RO Ne profiles. Based on the analyses of five-day training normal and abnormal Ne profiles, the characterized EOF spectra of the normal and abnormal Ne profiles have been obtained. Furthermore, on the basis of the FS3/COSMIC ionospheric RO data in 2008, we find that the abnormal Ne profiles occupy $\sim$15% of all Ne profiles and could perturb ionospheric modelling of the TWIM. The abnormal Ne profiles show the features of irregular F layer caused by spread F, irregular complete profile, sporadic E layer, negative Ne at the topside F2 layer, positive Ne gradient with attitude at the topside F2 layer, and/or other abnormal ionospheric features. The TWIM results including and excluding the abnormal Ne profiles have been compared and evaluated by the ionosonde foF2 data.