This study describes an evaluation of the Formosat Satellite-3/Constellation Observing System for Meteorology, Ionosphere and Climate (FORMOSAT-3/COSMIC) and the FORMOSAT-7/COSMIC Global Navigation Satellite System (GNSS) Radio Occultation (RO) data on ionospheric Numerical Weather Prediction (NWP) by using data assimilation. Both electron density profile and slant Total Electron Content (sTEC) probed by the FORMOSAT-3/COSMIC and the FORMOSAT-7/COSMIC-2 are assimilated into a coupled model of the thermosphere and ionosphere by using ensemble-based square root filters. The impact of different approaches of assimilating the FORMOSAT-3/COSMIC and the FORMOSAT-7/COSMIC-2 GNSS RO data are assessed with the purpose of improving ionospheric specification and forecasting.

The importance of ion-neutral coupling on ionospheric specification and forecast are examined by assimilating the FORMOSAT-3/COSMIC electron density profiles into a coupled model of thermosphere and ionosphere, the Thermosphere-Ionosphere-Electrodynamics General Circulation Model (TIE-GCM), using Ensemble Adjustment Kalman Filter (EAKF) provided by the Data Assimilation Research Testbed (DART). Combining the DART and the first-principles TIE-GCM allows a self-consistent treatment of thermosphere and ionosphere coupling in the data assimilation and forecast. By comparing the OSSE results of updating different variables, the role of ion-neutral coupling in the ionospheric NWP is accessed. It is demonstrated that the incorporation of ion-neutral coupling can significantly improve ionospheric electron density analysis and forecast, and thermospheric composition is the most significant state variable that affects ionospheric analysis and forecast.

In the second part, instead of electron density profiles, the data assimilation of the FORMOSAT-7/COSMIC sTEC is carried out to avoid the error introduced by the assumption of a spherical symmetric ionospheric electron density distribution when deriving electron density profiles. The DART/TIE-GCM is replaced by another data assimilation system, the Community Gridpoint Statistical Interpolation (GSI) Ionosphere. The GSI Ionosphere is constructed using the GSI Ensemble Square Root Filter (EnSRF) and the Global Ionosphere Plasmasphere and the TIE-GCM (GIP/TIE-GCM). OSSEs of the FORMOSAT-7/COSMIC are carried out to examine the ability of the GSI Ionosphere to improve the low- and mid-geomagnetic ionospheric specification and to make a quantitative assessment of the impact of GNSS RO sTEC on the ionospheric specification and forecasting. The result shows that assimilation of synthetic sTEC from the FORMOSAT-7/COSMIC-2 can considerably improve the low- and mid-geomagnetic ionospheric specification through the application of the GSI Ionosphere.

In the third part, a real case under quiet time and low solar activity conditions is carried out by assimilating real FORMOSAT-3/COSMIC GNSS RO sTEC into the GSI Ionosphere with the aim of demonstrating the potential of the system on real-time low- and mid-latitude ionospheric monitoring and forecasting. Incorporating FORMOSAT-7/COSMIC-2 data with GSI Ionosphere demonstrates great potential for improving low- and mid-latitude ionospheric NWP in the future, since the sTEC data volume will be increased considerably.