A Global Survey of COSMIC electron density characteristics in the comparison with Ground-based Ionosonde Measurements

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1. Abstract:

The ionospheric peak electron density and its height measured by FORMOSAT-3/COSMIC satellites in terms of GPS radio occultation technique and a network of ground-based ionosondes distributed around the world are compared and extensively examined during July, 2006 to February, 2007. It is found that, in spite of the latitude, the mean values of the peak electron density measured by COSMIC satellites are systematically smaller than those observed by ground-based ionosondes. The discrepancy between them is dependent on the latitude. Moreover, statistical analysis shows that the slopes of the regression line that is best fitted to the scatter diagrams of occultation-retrieved peak electron density (ordinate axis) versus ionosonde-observed peak density (abscissa axis) are universally less than one. About peak height (hmF2), the former is systematically higher than the latter as large as 20% or more in equatorial and low latitude regions. However, those kinds of data will be processed and compared with a long time period to validate its accuracy and precision.

2. Introduction

The radio-occultated electron density have been examined by using the measurements of ground-based ionosondes and incoherent scatter radars (ISR) to validate its accuracy and precision [1][2]. The statistical comparison of peak electron densities measured by ionosonde and GPS/MET [1]. Schreiner et al. (1999) employed 4-day ionospheric data observed by a network of 45 ionosonde stations with 164 matches to compare with corresponding GPS/MET measurements, etc. Some important difference results were also given out [3]. In this article, we compare the general behaviors of the COSMIC-derived electron density profiles and peak heights with those derived by a network of ground-based ionosondes, including globally spatial distributions, seasonal and diurnal variations. The discussion and the conclusion are made and drawn.

3. Data Sources and Data Processing and Analysis

\[ n_e = \frac{1}{\rho_e} \int \frac{d T E C}{d \lambda} \frac{1}{\sqrt{1 - \lambda^2}} d\lambda \]

Then radio-occultated electron density profiles were adopted to compare with the ground-based ionosonde observations. The corresponding peak electron density NmF2 (NmF) is converted from ionosonde-observed foF2 (Hz) in accordance with the conventional formula \( N_mF2 = 1.24 \times 10^{10} \times \text{foF2}^2 \) (Davies, 1965).

Peak heights of two techniques were also calculated and compared.

4. Results:

Fig. 1. Global distribution of the COSMIC tangent points in 24 hours (left) and Global distribution of ionosonde stations that were employed in this article.

Fig. 2. Sample of Electron density profile of COSMIC Data (left) and Ionogram (right) in Jan 2007

Fig. 3. Scatter diagram of COSMIC-measured versus ionosonde-observed peak electron densities for different geographic zones during period from November 2006 to February 2007.

Fig. 4. The latitudinal variations of the average peak densities (left) and peak height (right) measured by COSMIC satellites (light blue bar) and the ground-based ionosondes (purple bar).

5. Discussion and Conclusion:

1. The peak electron densities measured by COSMIC are systematically smaller than those observed by ground-based ionosondes. However, COSMIC peak height is systematically higher than hmF2. The difference in the two can be as large as 25% or more dependent on latitude regions.

2. The slopes of the regression line of peak electron density in two methods are universally less than one. This feature suggest that the path average effect of the non-uniform electron density distribution along the GPS ray likes the cause leading to the COSMIC-measured peak density systematically smaller than the ionosonde observations.

3. We saw that the correlation between COSMIC and ionosonde peak electron densities is influenced by the fluctuation of the electron density profile. It is believed that the ionospheric plasma irregularities is a crucial factor affecting the discrepancy between COSMIC and ionosonde measurements.

6. Future works:

1. Those kinds of data will be processed and compared with a long time period to validate its accuracy and precision.

2. Find out the factors effect to the difference between two this kinds of techniques.

7. References

