The International Beacon Satellite Symposium *BSS2010*
P. Doherty, M. Hernández-Pajares, J.M. Juan, J. Sanz and A. Aragon-Angel (Eds)
Campus Nord UPC, Barcelona, 2010

COMPARISON OF PEAK ELECTRON DENSITY VALUES: COSMIC RO AND EUROPEAN DIGISONDES

Irina E. Zakharenkova[*], Irk I. Shagimuratov[*], Andrzej Krankowski[†] and Anna Krepiak-Gregorczuk[†]

[*] West Department of Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation (WD IZMIRAN)
41 Av. Pobeda, 236010, Kaliningrad, Russian Federation
e-mail: zakharenkova@mail.ru
[†] University of Warmia and Mazury in Olsztyn, Geodynamics Research Laboratory (GRL/UWM),
1 Oczapowski St., 10-957, Olsztyn, Poland
e-mail: kand@uwm.edu.pl

Key words: FormoSat-3/COSMIC, Ionosphere, Radio Occultation.

Summary: In the present paper we analyze the properties of ionospheric peak electron density retrieved from FORMOSAT-3/COSMIC radio occultation (RO) measurements in compare with ground-based data. It was used the ionograms recorded by European ionospheric stations (DIAS network) for different months of 2008 year. This comparison results reveal the high degree of correlation between independent measurements of the F2 layer peak electron density (NmF2). Statistical analysis results are also presented.

1 INTRODUCTION

The Radio Occultation technique using GPS signals has been proven to be a promising technique to retrieve accurate profiles of the ionospheric electron density with high vertical resolution on a global scale. FormoSat-3/COSMIC (Constellation Observing System for Meteorology, Ionosphere and Climate) is a joint scientific mission between Taiwan and the U.S.A. The mission placed six small micro-satellites into six different orbits at 700~800 kilometer above the earth surface. Each microsatellite has a GPS Occultation Experiment payload to operate the ionospheric radio occultation (RO). With the ability of performing both rising and setting occultation, FormoSat-3/COSMIC has been producing about 2000 profiles of the ionospheric electron density per day – much more than ever before. However systematic validation work is still needed before using the powerful radio occultation technique for sounding the ionosphere on a routine basis.

2 DATABASE

Since May 2006 the retrieved Ne profiles are available from the Taiwan Analysis Center for COSMIC (TACC, http://tacc.cwb.gov.tw/en/) and the COSMIC Data Analysis and Archive Center (CDACC, http://www.cosmic.ucar.edu/cdacc/). Generally COSMIC can perform over 2000-2500 RO measurements per day, and more than 70% of the RO measurements can be successfully retrieved into Ne profiles. COSMIC soundings points during day have rather good global distribution. For this study we have preferentially selected such occultations whose tangential points of the signal ray path were within the limits of European region. The path of this point during one occultation is named the occultation trace. Usually the total number of occultation traces in European region is about 35-50. For the given study it was analyzed COSMIC RO data of 2008 year. It is necessary to note that a small part of the COSMIC electron density profiles are affected by cycle slips in the GPS phase data. There was need to realize firstly the data quality analysis and control to cull the bad and questionable data before its applying especially in automatic routine.

To validate the reliability of COSMIC data we have used the ionograms, foF2 values and electron density profiles provided by European Digital Upper Atmosphere Server (DIAS).

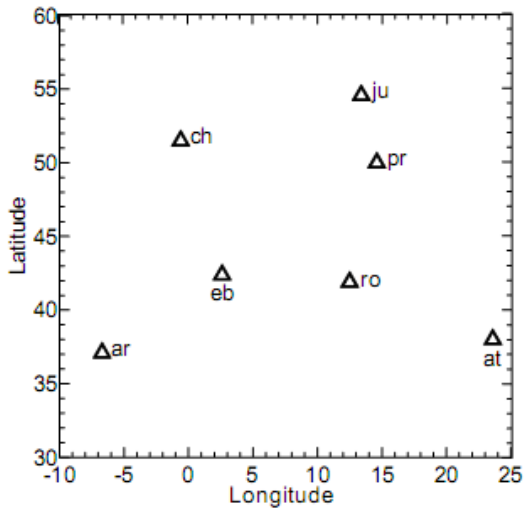

Figure 1: Geographical location of European ionospheric stations (DIAS network)

The DIAS bases on real-time and historical data provided by most operating ionospheric stations in Europe[1]. This server collects information from stations located in Rome, Pruhonice, Juliusruh, Athens, Chilton, Ebre and El Arenosillo (Fig. 1). The DIAS ionosonde network is equipped with the DPS4 digisondes (excepting Ebre and El Arenosillo equipped by DGS-256) produced by the University of Lowell, Massachusetts, United States. NmF2 was calculated from the observed critical plasma frequency foF2 of the F2 layer. Values of foF2 have been scaled manually from ionograms for all considered time-location cases to avoid the evident risks related with using of the autoscaled data that have ionosonde- related errors and uncertainties.

3 RESULTS

Since the location of RO profiles depends only on the LEO satellite path the special attention was paid to the consideration of geographical position of occultation traces in European region and its location relative to places of ionosperic stations. In fact as the sounders provide no direct information on the profile above the maximum electron density we can compare only that part of RO trace which corresponds to heights up to the F layer peak and it is important how far this part of trace is located from the ionospheric station. Figure 1a illustrates the case with 2 simultaneous RO events near Pruhonice ionospheric station registered at 14.14 UT on March 05, 2008. Figure 1b shows 3D-vizualization of occultation traces for these events. It is evident that in the case when the bottom side (thick part of line) of occultation trace is located close the ionosonde's place (and column up to the hmF2), the agreement between profiles would be better.

To obtain statistical results of comparison COSMIC and ionosonde data it was analyzed RO profiles corresponding to the different seasons of 2008: January, April, July and October. For this purpose it was selected occultation traces with peak point located in the vicinity of digisondes (R~5º). As example we demonstrate results for October 2008; total number of analyzed profiles was 545. To summarize the agreement between COSMIC and ionosonde measurements we show in Figure 3 the scatter plots of COSMIC NmF2 values against the corresponding ionosonde's one. The line drawn corresponds to the best fit line. The scatter plot shows a high degree of correlation (0.96) between two independent estimates of NmF2.

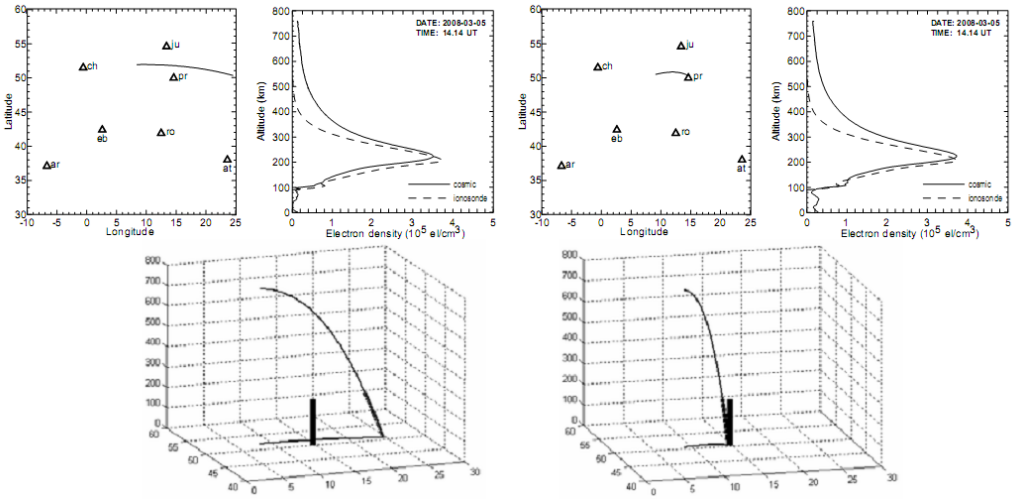

Figure 2: Example of two simultaneous occultatation events near Pruhonice digisonde. Bottom panel shows 3-D vizualization of occultation traces and the digisonde position.

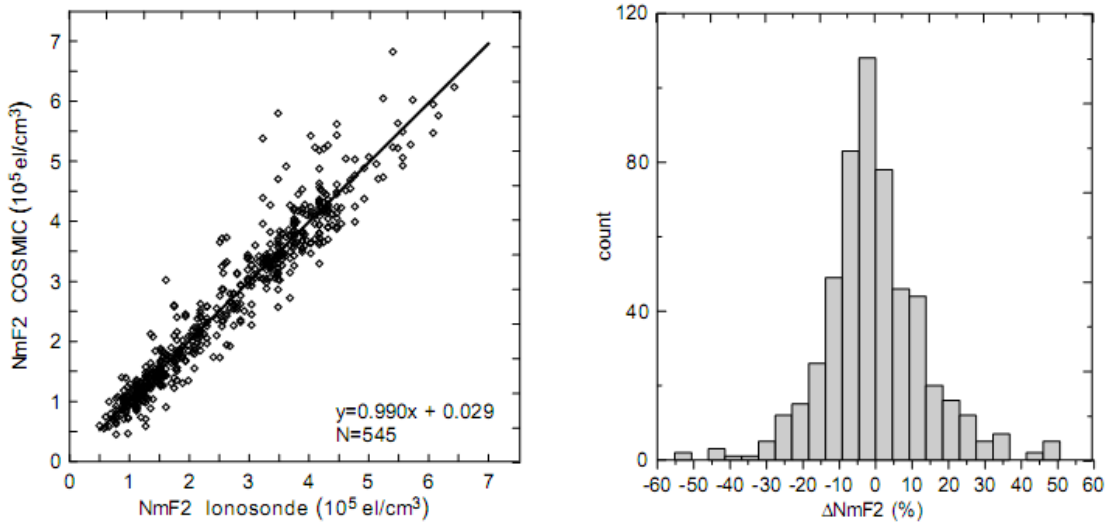

Figure 3: The scatter plot of COSMIC NmF2 values against the corresponding ionosonde's one during October 2008. The line drawn corresponds to the best fit line. At the right panel there is distribution of ΔNmF2 values

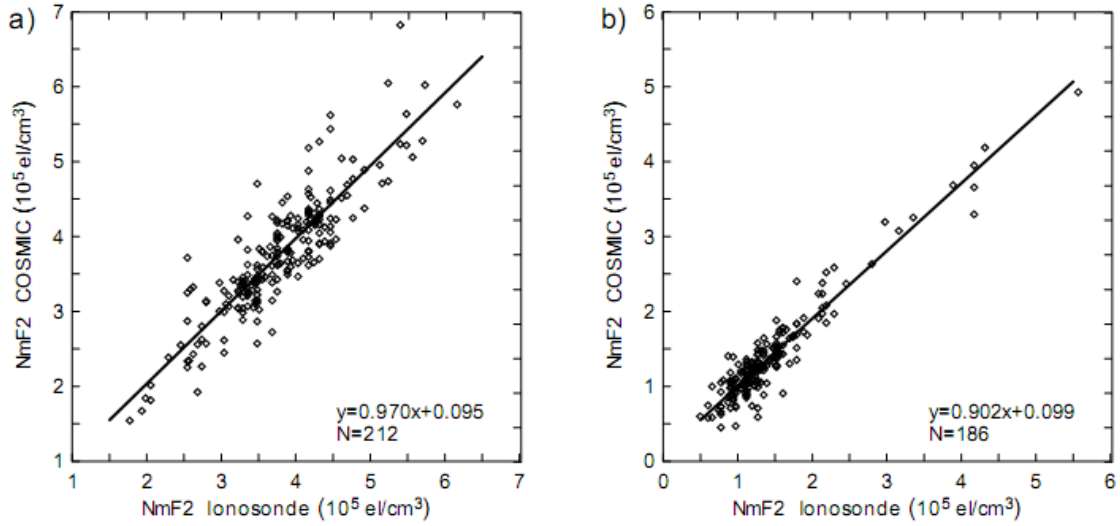

Figure 4: The scatter plot of COSMIC NmF2 values against the corresponding ionosonde's one: a) day-time, b) night-time

At the right panel of Figure 3 one can see the histograms presented the percentage differences between COSMIC and ionosonde NmF2 values. It is possible to estimate the dispersion of these values and calculate the average meanings. The NmF2 differences are characterized by distribution with a mean of 0.40% and a standard deviation of 15.6%. The main part of all deviations is accumulated in central classes close to zero. For other month statistical characteristics were rather similar with mean value within the limits of ±2% and standard deviation less than 18%. It is the evidence of rather good agreement between COSMIC RO and ground-based data for European region. The obtained results are rather good comparable with earlier studies estimated the accuracy of retrieved GPS/MET and CHAMP Ne profiles[2,3].

Also it was analyzed the variation of NmF2 depending on the day time. For each month it was selected day-time and night-time intervals determined by the local time of sunrise and sunset ±1-2 h. For example, at Figure 4 there are presented scatter plots of NmF2 values (COSMIC vs. ionosondes) for mentioned October 2008. In this month considered intervals were 8-17 LT for day-time and 20-06 LT for night-time. Correlation coefficients for these cases were 0.88 and 0.95 correspondingly. It is visible that for night-time scatter plot is characterized by more compact point distribution mainly corresponded to critical frequencies less than 4 MHz; however due to the smaller values the standard deviation of ΔNmF2 (%) is higher than for daytime – 16.7% vs. 10.6%.

4 CONCLUSIONS

In order to assess the accuracy of the COSMIC ionospheric electron density retrievals, coincidences of ionosonde data with COSMIC occultations have been examined. The comparison results show rather good agreement for the derived peak electron density values (NmF2) at European midlatitude observations.

ACKNOWLEDGEMENTS

We acknowledge the Taiwan's National Space Organization (NSPO) and the University Corporation for Atmospheric Research (UCAR) for providing COSMIC Data. We are grateful to European Digital Upper Atmosphere Server (DIAS) for providing the ionosondes' products.

REFERENCES

[1] Belehaki A., Cander Lj., Zolesi B., Bremer J., Juren C., Stanislawska I., Dialetis D., Hatzopoulos M. "DIAS Project: The establishment of a European digital upper atmosphere server". *J. Atmos. Solar-Terr. Phys.*, 67, 12, pp. 1092-1099 (2005).

[2] Hajj, G. A. and L. J. Romans. "Ionospheric electron density profiles obtained with the Global Positioning System: Results from the GPS/MET experiment". *Radio Sc*i., 33, pp.175-190 (1998), doi: 10.1029/97RS03183.

[3] Jakowski, N., Wehrenpfennig, A., Heise, S., Reigber, C., Lühr, H., Grunwaldt, L. and T.K. Meehan. "GPS radio occultation measurements of the ionosphere from CHAMP: Early results", *Geophys. Res. Lett.*, 29(10), 1457 (2002), doi:10.1029/2001GL014364.