Comparison of electron density profiles extracted from DIAS maps and ionosonde measurements at Nicosia during low solar activity

H. Haralambous

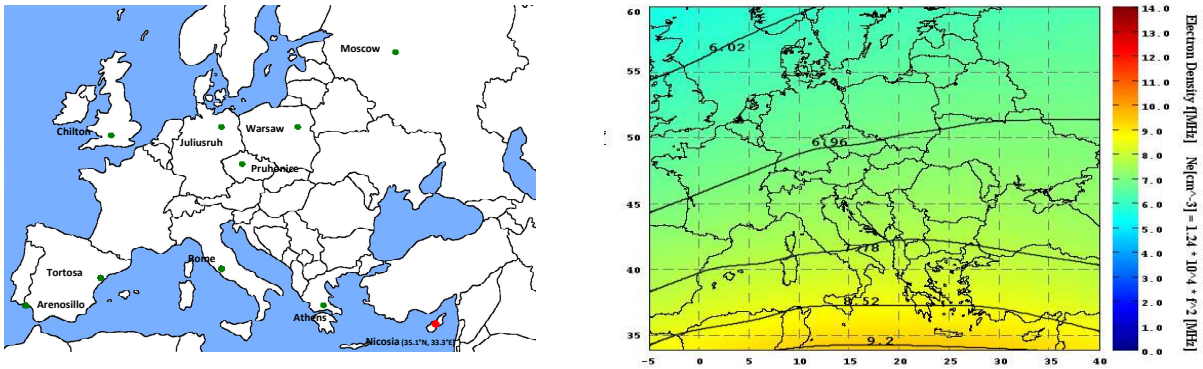
Frederick University
Y. Frederickou Str., 1036 Nicosia, Cyprus
eng.hh@fit.ac.cy

Abstract

This paper presents a comparison of electron density profiles derived from digital ionosonde measurements at the low-middle latitude European station in Nicosia, Cyprus (coordinates: 35°N, 33°E geographic) and the DIAS system at various heights (100,150,200,250,300,350,400 and 450 km). DIAS (European Digital Upper Atmosphere Server) is a service based on a pan-European digital data collection on the state of the upper atmosphere, which offers real-time information and historical data collections provided by most operating ionospheric stations in Europe. Hourly profiles were obtained using manually scaled data over Nicosia during the solar minimum period from January to December 2009. Hourly and monthly root mean squared error values (R.M.S.E) between Nicosia and DIAS maximum electron density values were also computed and comparisons of the observations were made.

1.Introduction

The DIAS products are based on data provided by geographically distributed ionospheric stations with the capability of automatically scaling and transmitting in real time all important parameters characterising the ionosphere. The knowledge on the state of the ionosphere generated by each ionosonde is valid only for a limited area around each station. DIAS integrates in the same environment all the raw ionospheric data gathered by DIAS ionospheric stations therefore transforming this information into usable data, products and services valid over Europe [1,2].



(a) **(b)**

Fig. 1. Ionospheric stations contributing data to DIAS (green dots) and Cyprus station (red dot) and an example of an electron density nowcasting map at 300 km over Europe produced by DIAS.

The electron denstity values used in this study were extracted from ASCII files of nowcasting electron density maps over the European area produced by the DIAS system. These maps are generated by Ne3D, which is a three dimensional instantaneous model of electron density in the ionosphere. Ne3D gives instantaneous values of Ne for a given time, altitude, and for a given location in Europe based on auto-scaled ionospheric parameters measured by DIAS ionosondes. The mapping scheme applied uses a specific technique that fits the background model to the set of measurements [3,4]. To avoid numerical instabilities and ensure a higher accuracy additional data taken from the NeQuick model [5] that is used as a background model are added during the interpolation procedure. In DIAS, the final outputs from the Ne3D nowcasting method are isoline maps of the electron density covering the European

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

area from -5° W to 40° E in longitude and 34° N to 60° N in latitude and for specific ionospheric height (in DIAS system predefined heights are set up to 100, 150, 200, 250, 300, 350, 400 and 450 km)[6].

2. Results

In total, 7067 hourly electron density profiles were used in the comparison of observed and DIAS values in this investigation. Missing profiles for a particular hour occurred either due to non-existing observations at Nicosia or non-existing DIAS nowcasting maps. The former was primarily due to the lack of scalable ionograms because of the presence of a strong sporadic E layer which completely blankets the F region, especially during the Summer. The latter was due to cases where not sufficient DIAS stations could contribute to the generation of a map and as a matter of product quality the map was not provided. The scatter plots in Fig.2. depict the electron densities generated at various heights by the DIAS system and the corresponding values measured over Cyprus.

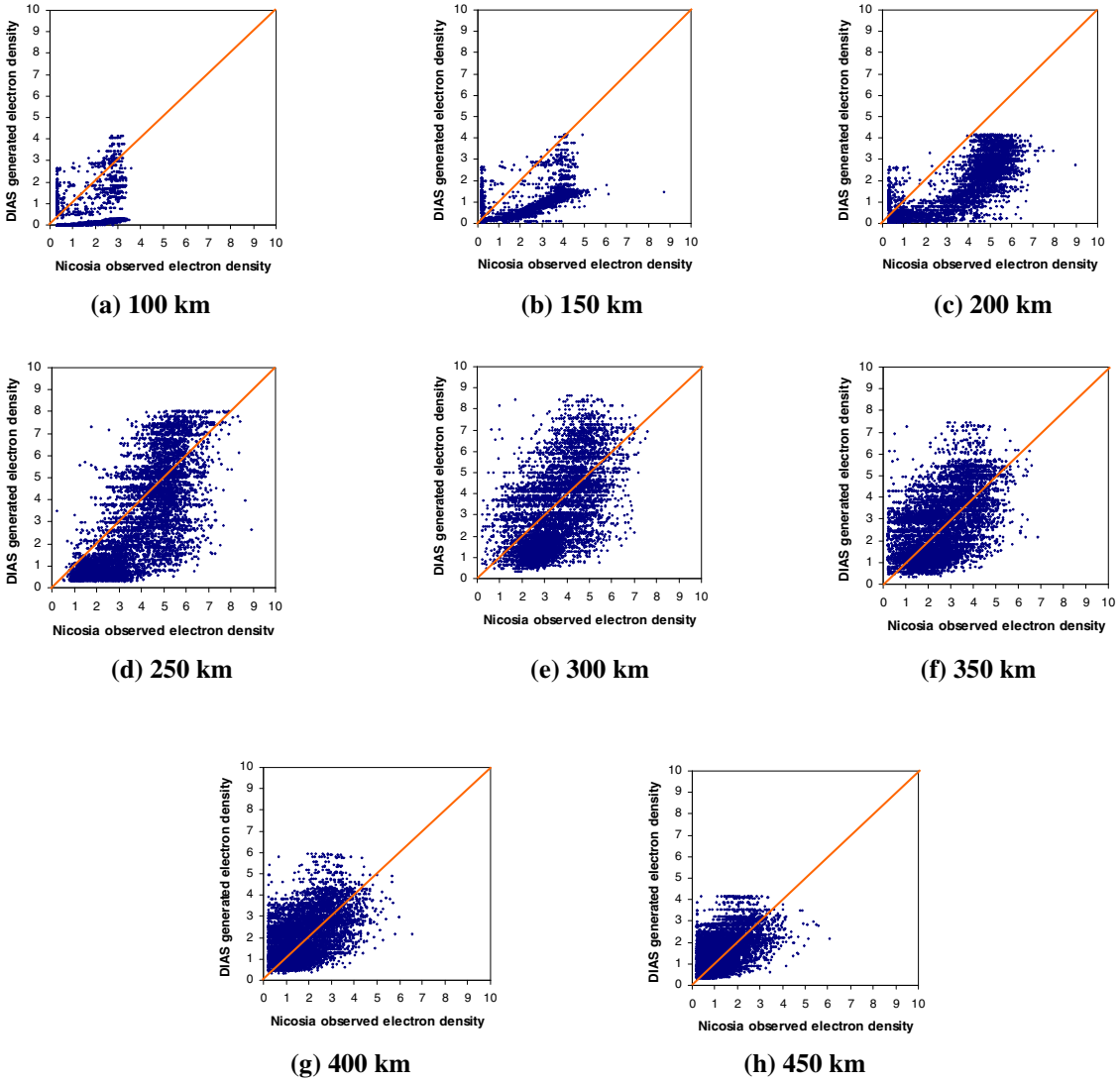


Fig. 2. Scatter plots of DIAS values versus Nicosia electron densities at various profile heights. (Both axes in each plot are in 10^5 cm^{-3}).

It is evident from the plots that the DIAS system underestimates the electron densities over Cyprus significantly up to 200 km for all hours of day. At 250 km it tends to underestimate electron densities over Cyprus for low values (that reasonably correspond to night-time values) whereas it overestimates for higher electron densities (that reasonably correspond to daytime values). Above 300 km the plots look similar as expected since both DIAS and digisonde electron densities are based on topside models. A further investigation was undertaken based on the maximum electron density NmF2 shown in Fig.3.

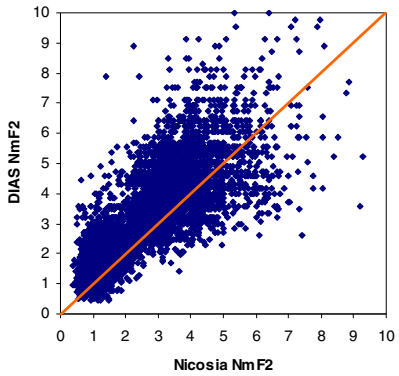


Fig. 3. Scatter plot of DIAS maximum electron density NmF2 (10^5 cm^{-3}) versus Nicosia values.

A comparison between the two data series of NmF2 was conducted on the basis of the R.M.S.E. The minimum R.M.S.E was $0.022*10^5$ cm^{-3} corresponding to NmF2 values at noon and the maximum approximately $0.122*10^5$ cm^{-3} between 7:00 to 10:00 UT. On a monthly basis, R.M.S.E was maximum in October and minimum in September. The scatter plot in Fig.3. demonstrates the fact that the DIAS system tends to overestimate NmF2 Nicosia data both at low NmF2 (night-time) and high NmF2 values (daytime). The correlation coefficient corresponding to the plot was 0.81. In the frames of the study undertaken in this paper we need to bear in mind that the comparison is made between electron density profiles from manually scaled ionograms in Nicosia with DIAS electron density profiles from nowcasting maps based on automatically scaled data from each station. The auto-scaling error is thus introduced in the comparison which could be significantly less in the unrealistic case of the stations providing manually scaled data for DIAS to produce the electron density nowcasting maps.

3. Conclusions

In this study, the nowcasting service of electron density profile maps provided by DIAS was evaluated over Cyprus based on manually scaled data from ionograms at Nicosia station during the low solar activity year 2009. The electron density scatter plots at various heights provided a clear visual indication of the electron density representation above Cyprus by the DIAS system. It was demonstrated that below 250 km the DIAS system underestimates the observed values whereas the opposite is observed for the peak electron density NmF2. Although 2009 was characterised by low solar and geomagnetic activity, since the next solar cycle has officially started we will evaluate DIAS performance at Nicosia further when the increase of solar and geomagnetic activity anticipated in the forthcoming years will offer even greater challenges for such a task.

4. Acknowledgments

This paper is funded by the Cyprus Research Promotion Foundation.

5. References

1. Belehaki A., L. Cander, B. Zolesi, J. Bremer, C. Juren, I. Stanislawska, D. Dialetis, M. Hatzopoulos, DIAS project: The establishment of a European digital upper atmosphere server, Journal of Atmospheric and Solar-Terrestrial Physics, 67 (12): 1092-1099, 2005.

2. Tsagouri I. and A. Belehaki, Upgraded DIAS system, COSTES0803 2nd Workshop, Paris, France, 22 - 24 March 2010.

3. Stanislawska, I., Juchnikowski, G., Hanbaba, R., Rothkaehl, H., Sole, G., Zbyszynski, Z., COST251 Recommended Instantaneous Mapping Model of Ionosphere Characteristics – PLES, Phys. Chem. Earth(C), Vol.25, No.4, pp.291-294, 2000.

4. Stanislawska, I., G. Juchnikowski, Z. Zbyszynski, Generation of instantaneous maps of ionospheric characteristics, Radio Sci., Vol. 36, No. 5, pp. 1073–1081, 2001.

5. Leitinger, R., Radicella, S., Nova, B., Electron density models for assessments studies – new developments, Acta Geodetica Hungarica, 37(2-3), 183-193, 2002.

6. DIAS manual, 2005.