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Comparison of the IRI 2001 model with electron density profiles observed from topside sounder on-board the Ohzora (EXOS-C) and the Akebono (EXOS-D) satellites

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Abstract

For the purpose of evaluation of the IRI 2001 model, the topside sounder data obtained from the Ohzora (EXOS-C) and the Akebono (EXOS-D) satellites in the magnetic latitude range from −50° to 50° were compared with the profiles calculated from the IRI model. Based on the electron density profiles obtained from the Ohzora satellite, the difference between the IRI model and observations is within a factor of 0.2–2.0. However, within the magnetic latitude range from 10° to 30° for the local time sector from 19 LT to 21 LT, the calculated peak height and density of the F_2 layer (hmF2 and foF2) were higher and lower than the observational profiles. The IRI 2001 model was able to reproduce well density profiles in the mid-latitude region, on the other hand, it tended to overestimate in the equatorial region. As a result of the comparison with the Akebono satellite sounder data, it was confirmed that the IRI model generally tended to reproduce observed profiles well in lower altitude region (<1000 km) and overestimate in higher altitude region (>1000 km). However, even below 1000 km, the IRI model also overestimated in the magnetic latitude range from −50° to 20° for the local time sector from 00 LT to 09 LT.

Keywords: IRI; Topside ionosphere; Topside sounder; Ohzora (EXOS-C) satellite; Akebono (EXOS-D) satellite

1. Introduction

The IRI (International Reference Ionosphere) model has been proposed as a standard model of the ionosphere, extensively used by many researchers. However, especially in the topside ionosphere, significant differences have been pointed out between the IRI model and the observational data in the altitude range above 1000 km as reported by Bilitza (2004). Fig. 1 shows a typical example of n(h) profiles showing the differences between the observational data by using the sounding rocket L-3H-2 (Oya and Obayashi, 1967) and the IRI model calculated for the same condition. As shown in Fig. 1, significant differences are found in higher altitude region, while the IRI model reproduces well profiles at lower altitude region in the topside ionosphere. Recently, Bilitza (2004) reported the results of the comparison between the IRI model and the Alouette/ISIS sounder data and proposed a correction term. The correction term seems to work well for the Alouette/ISIS data. In this paper, to evaluate the IRI 2001 model in the topside ionosphere, the topside sounder data observed from the Ohzora (EXOS-C) and the Akebono (EXOS-D) satellites were compared with the IRI 2001 model.

2. Data analysis

We analyzed the topside sounder data obtained from the Ohzora and the Akebono satellites. Instrumentations of these topside sounders are almost identical, however, the orbital parameters of these satellites show different characters (Ono, 2005). The Ohzora satellite was launched on

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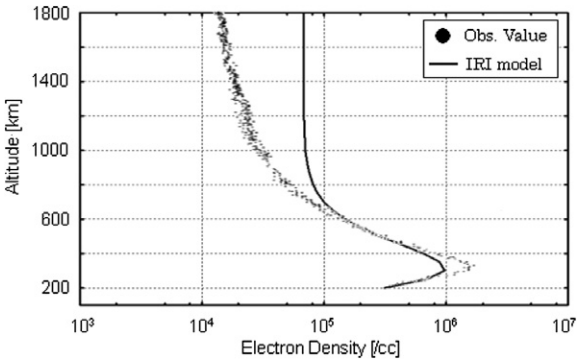

Fig. 1. n(h) profile observed at geographic latitude 31.3°, geographic longitude 131.1°, local time 15.6 LT on 23 July, 1966 using the gyro plasma probe on-board the L-3H-2 rocket (black dots) and calculated one (solid line) using the IRI 2001 model. Vertical axis indicates the altitude and horizontal axis indicate the electron density.

14 February, 1984 into a semi polar orbit. The initial apogee and perigee were 865 and 354 km and the initial inclination was 74.6°. The frequency range, sampling time and resolution of echo pulses of the topside sounder on-board the Ohzora satellite are from 0.1 to 16 MHz, 7.325 ms and 2 bits, respectively (Oya et al., 1985). The Ohzora satellite was operated as the topside sounder until December, 1988. About 10,000 ionograms were obtained all over the world. The Akebono satellite was launched on 21 February, 1989 into a semi polar orbit. The initial apogee and perigee were 10,570 and 274 km with the initial inclination of 75.0°. The frequency range, sampling time and resolution of echo pulses of the typical topside sounder observation mode of the Akebono satellite are from 0.3 to 11.4 MHz, 31.2 ms and 4 bits, respectively (Oya et al., 1990). The Akebono satellite has been operated until now and about 10,000 ionograms have been obtained especially in the polar region. The amount of ionograms obtained from the Akebono satellite is almost same as that from the Ohzora satellite because the sounder operation has not been performed recent years due to the difficulty of the power resource. To deduce vertical electron density profiles from topside sounder data (ionograms), we adopted the parabolic in $\log N$ lamination method proposed by Jackson (1969a). The maximum error of the conversion from echo traces on ionograms into real density profiles was estimated to be about 20 km for the Ohzora and 60 km for the Akebono satellites. The error is different because it depends on the satellite altitude due to the fact that the influences of non-vertical propagation tend to be more effective in higher altitudes as mentioned by Jackson (1969b).

In this paper, we analyzed the sounder data in the magnetic latitude range from −50° to 50° because Bilitza (2004) reported that the differences between data and model values tend to be larger in the equatorial region. Fig. 2a and b shows the sounder data coverage of the Ohzora and the Akebono satellites for the present study. We used data of 1709 n(h) profiles from the Ohzora satellite and 655 n(h) profiles from the Akebono satellite obtained as a result of analysis in this study. The amount of these available data is small due to the facts that one of the major science targets of the both satellites is to clarify dynamics in the polar ionosphere and to perform the active plasma wave experiments.

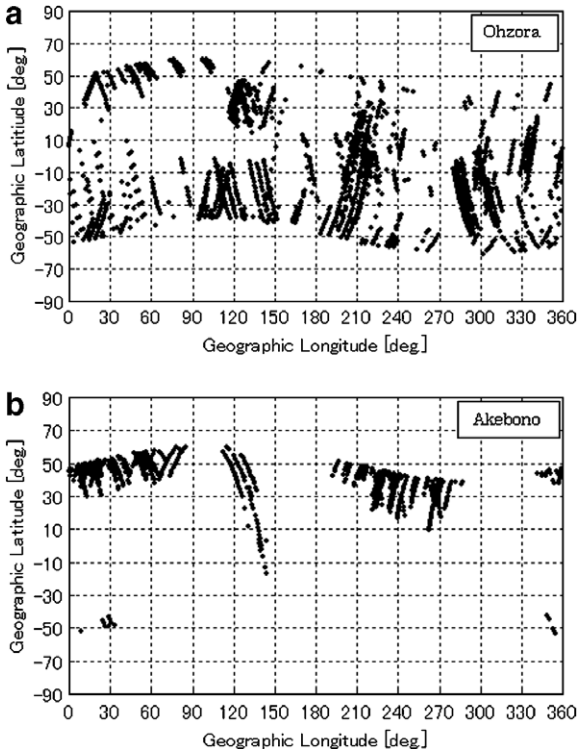

Fig. 2. (a) Coverage of analyzed sounder data (1709 ionograms) observed from the Ohzora satellite. Vertical axis indicates the geographic latitude and horizontal axis indicates the geographic longitude. (b) Coverage of analyzed sounder data (655 ionograms) observed from the Akebono satellite.

3. Results and discussions

Fig. 3 shows altitude variation of the ratios of observed density at each altitude from the topside sounder on-board the Ohzora satellite over the calculated one from the IRI model. The red triangles and black dots indicate the ratios obtained in the magnetic latitude range from 10° to 30° for the local time sector from 19 LT to 21 LT, and all of the other ratios, respectively. As shown in Fig. 3, most of the differences were indicated within a ratio of 0.2–2.0 except for the red triangle data. Fig. 4 shows typical examples of the n(h) profiles observed in the magnetic latitude range from 10° to 30° for the local time sector from 19 LT to 21 LT (red triangles data in Fig. 3) and model profiles calculated from the IRI 2001 model for each observational condition. As shown in Fig. 4, such a large difference seems to come from the estimated hmF2 and foF2 used in the IRI 2001 model that tends to be higher altitude and lower density.