More accurate definition of the characteristics of the ionospheric radio wave propagation according to the OS "Mir" data

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Abstract

One of the best ways to determine the parameters of the ionosphere and use them to refine the model is to measure them with the orbit station. Results from one of these experiments were obtained in 1999 on the OS "Mir". This allowed to refine characteristics of the ionospheric radio wave propagation such as foF2, M3000F2, MUF3000F2 and others in areas inaccessible to ground-based sounding, in particular, in the equatorial regions, and estimate the deviation of the model from the experimental values.

1. Introduction

In the 21 century, just a technological breakthrough was occurred in monitoring the state of the ionosphere. Data of navigation systems (e.g., GPS), tomographic measurements, measurements at low orbit satellites using radio occultation and others are included into practical use. One of the objectives of this monitoring is to provide information to users dealing with radio propagation, which is needed precise knowledge of parameters such as the critical frequency foF2 and the maximum height hmF2. However, most methods are indirect processing information matching the measured values with the necessary parameters. One method of providing direct and most accurate observations of foF2 and hmF2 is an ionospheric radio sounding from space station [1]. On the other hand, to define the propagation conditions are widely used empirical models of the ionosphere, in particular, the IRI model [2]. It is believed that this model allows to obtain the parameters of the ionosphere at middle latitudes, with limited use at auroral and equatorial zones. However, there is evidence that the IRI model can provide the results in these areas which are not worse than in the mid-latitudes. One of the recent papers relates to subauroral zone [3]. For the equatorial zone to compare experimental and model parameters is done in this paper on data of station MIR.

2. Experimental data and determined values

The station orbit was at heights of about 350km. These heights are near the hmF2. The main result is a series of ionograms. More than 10,000 ionograms are obtained, but in this study data for the period March-June 1999 are used, relating mainly to the crossing the equatorial zone by station. Having experimental data on the foF2 and hmF2, we can define such parameters needed for propagation, as M3000F2, MUF3000F2 (using formula Dudeney, based on knowledge of foF2 and hmF2), the equivalent thickness of the ionosphere τ, determined from experimental values of foF2 and the total electron content TEC. Knowledge of the parameter τ allows to monitor the ionosphere [4], as well as to determine the parameter NmF2 from the experimental values of TEC [5]. TEC values are taken from the global maps of TEC. As the model 2 versions are used: IRI2001 [2] and IRI2007 [6] for comparison with experiment.

3. Results

Results are shown as a set of six graphs for each series of ionograms, which contain the trajectory (the dependence of the latitude of longitude), experimental and model values M3000F2, MUF3000F2, foF2, TEC for 3 versions of IRI (IRI2001, IRI2007Cor, IRI2007NeQ) and the parameter τ along each trajectory. Revolution in 2917 (Fig. 1, ionograms 40-48, UT ~ 13h15m) relates to the night time. In this case differences between experimental and model values of propagation parameters are rather large, but there is a good agreement between experimental TEC and the IRI2007 model. The IRI2001 overestimates values of TEC.
The remaining revolutions: 2922-2923 (Fig. 2, ionograms 678-707, UT ~21), 2923-2924 (Fig. 3, ionograms 800-831, UT ~20), 2925-2926 (Fig. 4, ionograms 1041-1086, UT ~23), 2926-2927 (Fig. 5, ionograms 1165-1211, UT ~ 0h30m), 2928-2929 (Fig. 6, ionograms 1424-1447, UT ~3h50m) belong to the local daily conditions.

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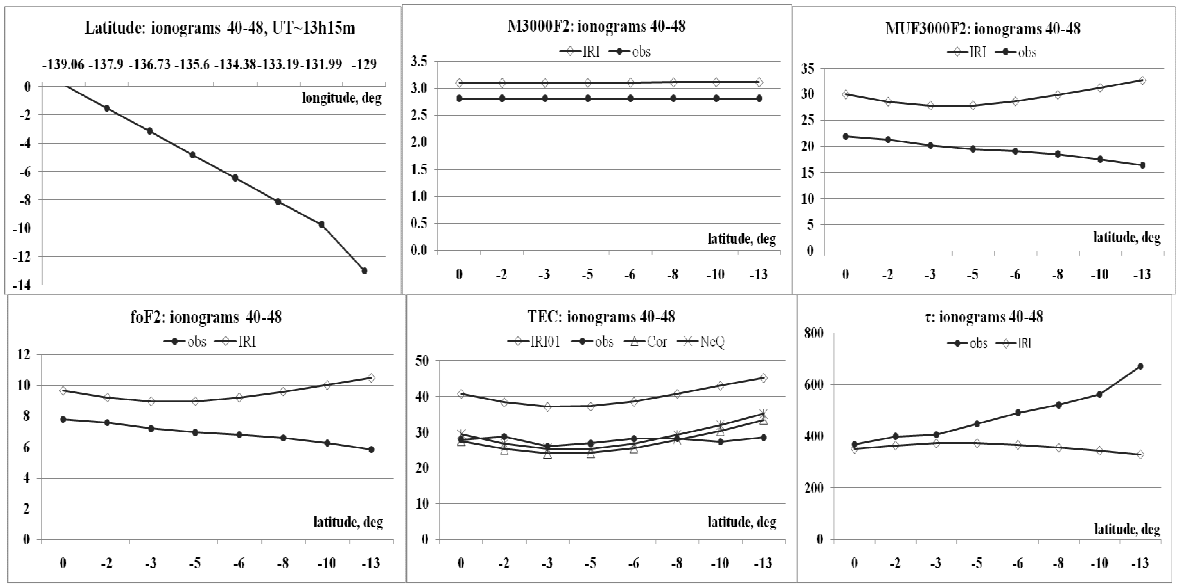


Fig. 1. Results for revolution 2917

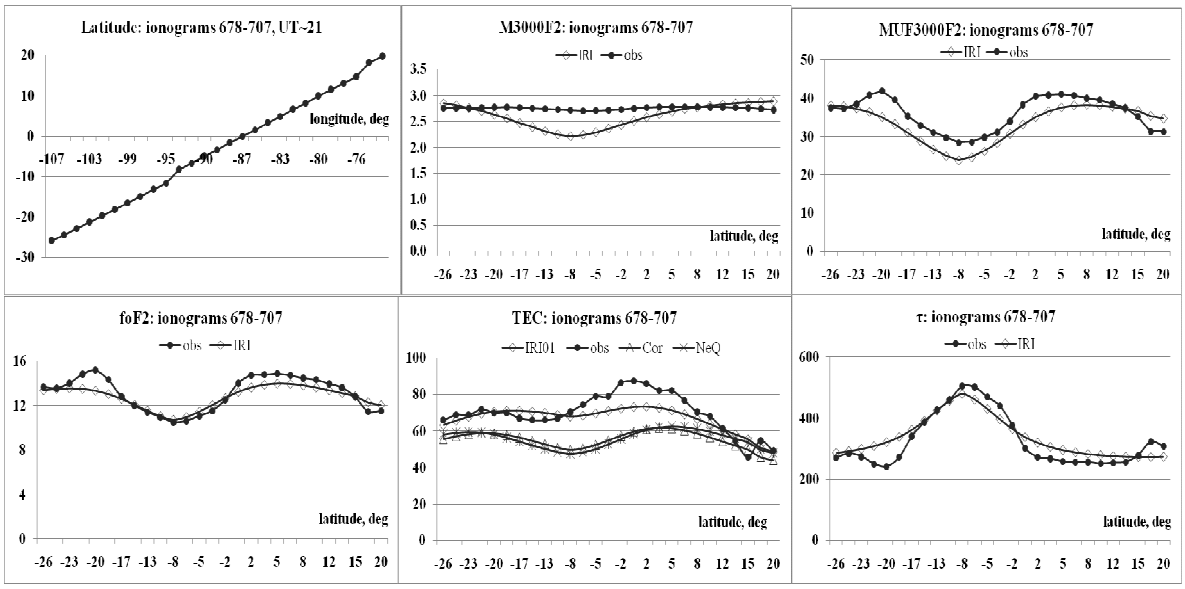
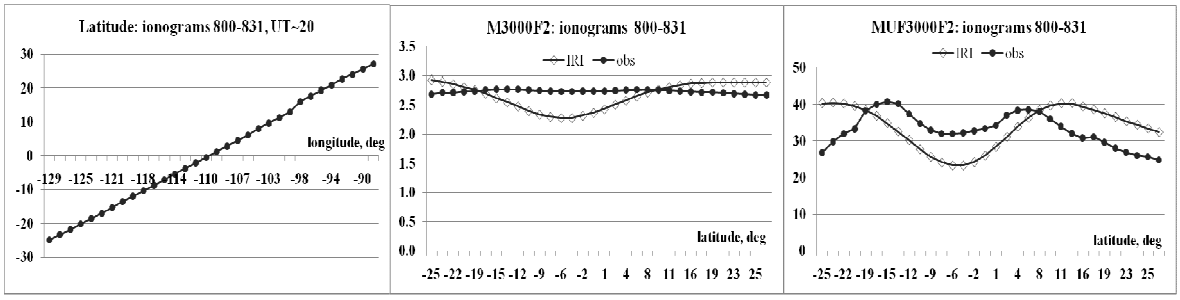


Fig. 2. Results for revolutions 2922-2923



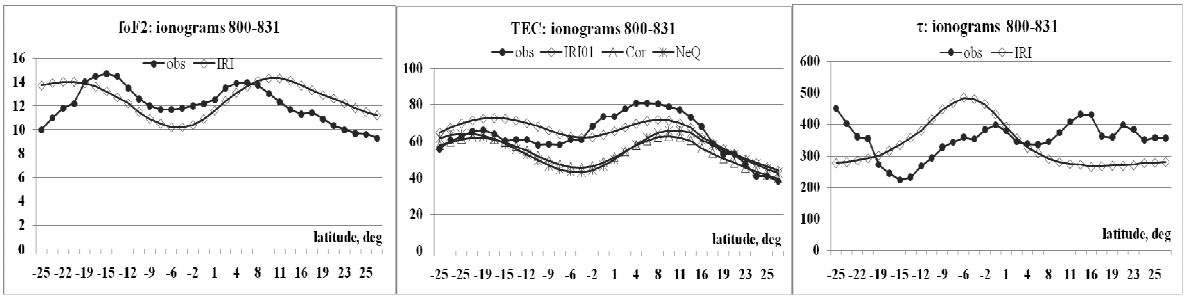


Fig. 3. Results for revolutions 2923-2924

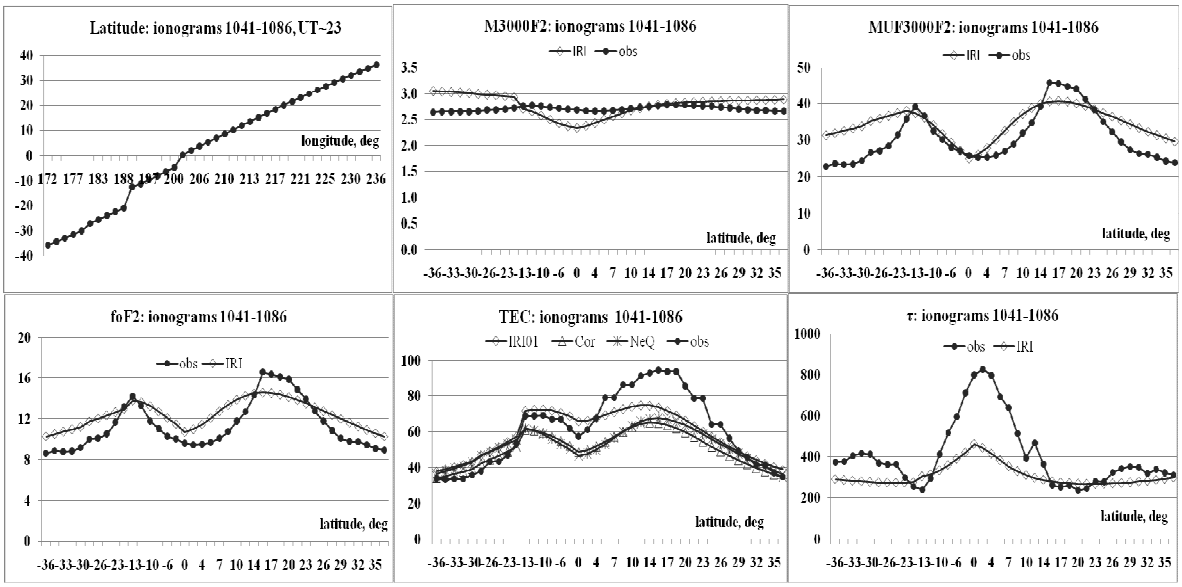


Fig. 4. Results for revolutions 2923-2924

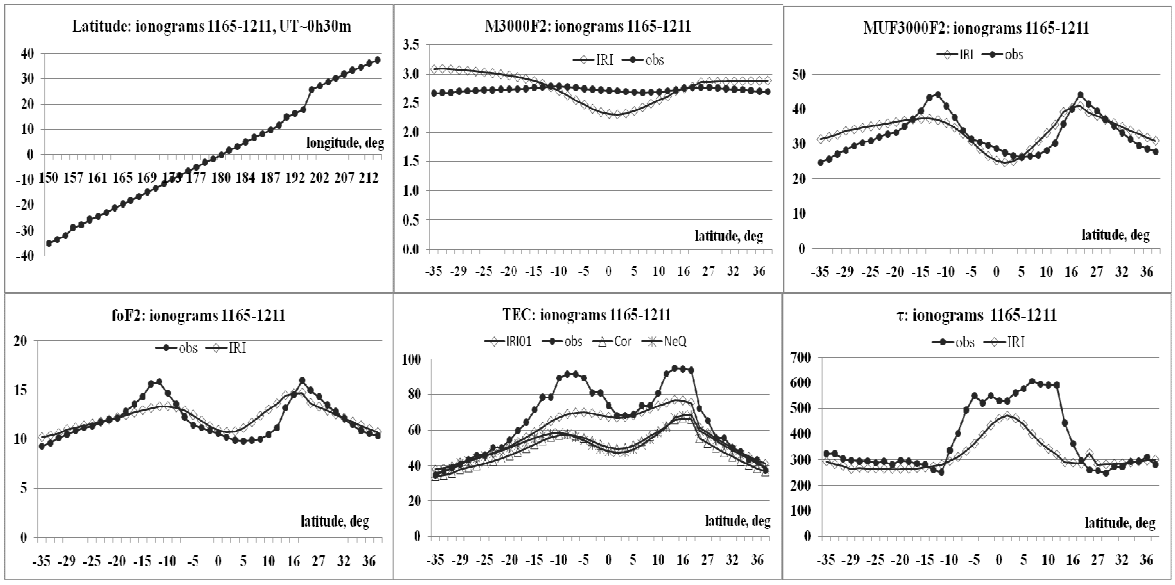


Fig. 5. Results for revolutions 2926-2927

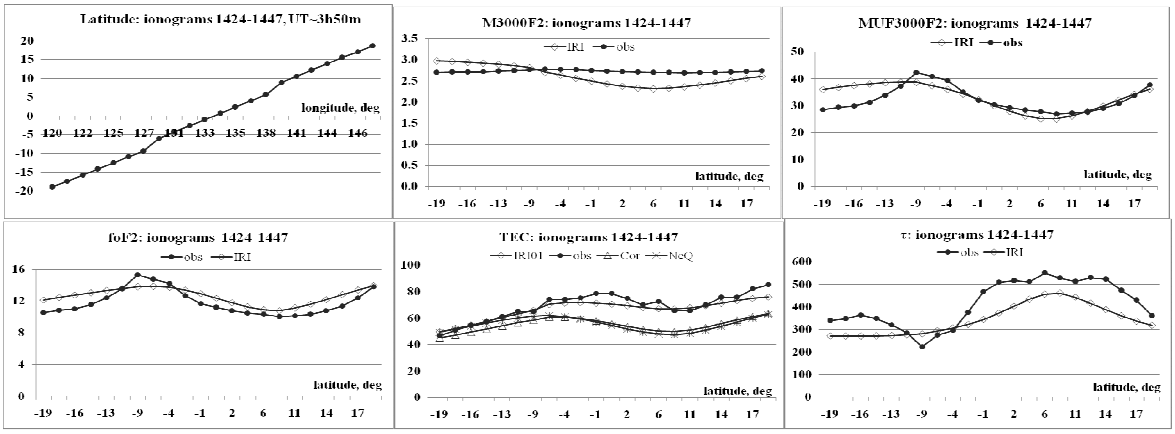


Fig. 6. Results for revolutions 2928-2929

Behavior of the parameters is as follows. Experimental parameter M3000F2 is characterized by consistency of values. The model M3000F2 has the small minimum. This difference is not fundamental in nature, as it is evident from the behavior of MUF3000F2, which demonstrates the good correspondence of the maxima and minima, in most cases. This is associated with the same good agreement between experimental and model values of foF2. The biggest difference between the experimental and model values is associated with parameter TEC. In this case, the greatest match is obtained for the model IRI2001. New versions IRI2007 give the same values that are significantly lower than the experimental ones. Behavior of the parameter τ near the equator shows its increase, despite the reduction of values foF2 and TEC. The same results were obtained for other periods.

4. Conclusion

Data obtained from radio sounding the ionosphere by the space station allow to clarify the characteristics of radio wave propagation, to obtain data for comparison with the model. Such a comparison indicates the adequacy of the IRI model conditions in the equatorial zone.

5. Acknowledgments

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6. References

1. N. P. Danilkin, “The Results of the Satellite Radio Sounding of the Ionosphere in the Vicinity of the *F* Layer Maximum,” *Int. J. Geomagn. Aeron*. **3** (2), 2001, pp.173-178.

2. D.Bilitza, “International Reference Ionosphere”, *Radio Sci*. **36** (2), 2001, pp. 261-275.

3. O. A. Maltseva and N.S. Moshaeva, “Comparison of HF propagation conditions for the European mid -latitudinal and subauroral paths”, HF2010, Nordic HF Conference, 17-19 August 2010, Faro, N81, 2010, pp. 1-10.

4. S. M. Stankov and R. Warnant, “Ionospheric slab thickness – Analysis, modeling and monitoring “, *Adv. Space Res.* **44**(11), 2009, pp. 1295-1303.

5. O.A. Maltseva, G.A.Zhbankov, and Trinh Quang T. “Improvement of the real time total electron content based on the International Reference Ionosphere”, *Adv. Space Res*., **46**, 2010, pp. 1008-1015.

6. D. Bilitza, “Evaluation of the IRI-2007 model options for topside electron density”, *Adv. Space Res*. **45**, doi:10.1016/j.asr.2009.04.036, 2009.