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REVISION OF TRANSIONOSPHERIC PROPAGATION MODELS, PREDICTION METHODS AND DATA IN ITU-R

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Summary: This abstract presents the recent and planned contributions of several groups to the ITU-R Study Group 3 on transionospheric propagation.

1 INTRODUCTION

The use of GNSS ground- and space-based measurements and the extensive network of accessible ionosonde data have generated a great wealth of scientific results related to ionospheric characteristics affecting propagation for satellite communication and satellite navigation. Those results have not necessarily been translated into international standards, recommendations or handbooks for system engineers. In particular, the documentation related to transionospheric propagation in Study Group 3 of the Radiocommunication Sector of the International Telecommunications Union (ITU-R SG3) is considered requiring a revision where some methods are outdated or even obsolete. Within the SG3, the Working Party 3L is the one dealing with HF propagation, transionospheric propagation and radio noise. The recommendations are not expected to contain the thorough details on latest scientific results but instead it requires very solid, mature and simple methods.

During WP3L meeting in 2009[1], a number of actions have been taken in relation to the the work on ionospheric propagation in particular for ITU-R recommendation P.531 and grid points maps of foF2 and M3000(F2). A number of mid-term actions have been identified in order to consolidate current recommendations and handbooks.

2 SUMMARY OF REVISIONS

For the topic on transionospheric propagation in terms of ionospheric scintillation characteristics, ITU-R recommendation P.531 has been reviewed covering the following items:

1. Refinement of the definition of the mechanism giving rise to radio waves scintillations. In particular, the distinction between diffractive and refractive scattering approximations is carried out as different mechanisms responsible for low and high scintillation activity respectively.
2. Experimental cases showing how the scintillation activity may depend on the geomagnetic location have been proposed for VHF, UHF, L, and C band signals (mainly from low and high latitude ground stations).
3. Improvements of the GISM model have been also introduced and suggested.
4. More fading statistics have been suggested for insertion into a revised recommendation, taking into account different transmission frequencies and geomagnetic locations.
5. The scintillation activity dependence on the transmission frequency has been discussed further and some improvements have been suggested, by taking into account some comparisons between L and C band signals.

6. The behaviour of power spectral densities for signal intensity and phase has been refined, taking also into account possible scintillation regimes. In particular, power slopes and spectral variability have been taken into account for new suggestions.
7. The dependence of scintillation indices on geometrical aspects has been discussed and a few improvements have been suggested.
8. Besides the classical phase scintillation indices, a new parameter able to estimate the scintillation activity on the phase has been also suggested.

Some revisions have been implemented in the new version of the recommendation (P.531-10[1]). The revisions consist of editorial corrections, removal of background information, and clarifications related to the following topics: ionospheric scintillation level regimes, frequency dependence and other. Additional areas considered to require further consolidation will be considered for the future.

Regarding the maps of foF2 and M(3000)F2, it has been recognised that the present maps are based on data approximately 50 years old and so cannot take account of any contemporary changes, perhaps due to movements of the magnetic poles, which may affect the ionospheric characteristics for some parts of the world. The coefficients sets have been adapted many implementations to suit the needs of the specific models and when comparing them, they do not necessarily gave the same output values. Due to varied algorithms, truncation of the originally reference coefficient files and the need to update the model outputs, two grid point table programs have been examined and verified against each other. The output grid point tables at 1.5 degree resolution, the generating software and complete coefficients set have been harmonised and they are available on the ITU-R SG 3 web site. Recommendation ITU-R P.123[3] has been amended to indicate that these data products are available and can be used to determine foF2, M(3000)F2 and other ionospheric parameters.

Also major changes have been introduced in the NeQuick model topside formulation and important modifications have also been introduced in the bottomside description. In addition, specific revisions have been applied to the computer package associated to NeQuick in order to improve its computational efficiency. The software package for the new model will be available from ITU-R in the near future. Likewise, the GISM ionospheric scintillation model, which includes the NeQuick model as underlying electron density model, has evolved from the version available at ITU-R SG 3 webpage. First of all, it has been adapted including the new NeQuick version, and also some bugs has been identified and corrected. Also this new version is expected to be available in the coming months.

3 FUTURE WORK

The European Space Agency and the Network of Experts in Electromagnetic Wave Propagation are driving a plan to continue the work on ionospheric propagation. This work includes the full revision of the ITU-R Ionospheric Handbook[5], the update of the GISM scintillation model, the update of the original CCIR coefficients based on new ionosonde data and plans to set up a School on Ionospheric Propagation in order to motivate researchers in the area.

Given the fact that a lot of Total Electron Density data is available from ground-based and space-based measurements, it is suggested to prepare reference Vertical and/or Slant TEC data that represent a number of ionospheric situations (nominal, low solar activity, high solar activity). In the same manner, the analysis of accuracy of models and the characterization of the errors associated to them (for different confidence levels) needs to be provided and even the possibility to develop a synthetic error model generator may be considered.

Also taking advantage of the increasing amount of available data, the Nequick model formulation will be updated to improve the model capabilities to provide specification of the ionosphere at global scales by data assimilation.

REFERENCES

[1] ITU-R Document 3L/54-E, Chairman Report on The Meeting of Working Party 3L, 13 July 2009.

[2] ITU-R. “Ionospheric propagation data and prediction methods required for the design of satellite services and systems”, Rec. ITU-R P.531-10, 2009.

[3] ITU-R. “ITU-R reference ionospheric characteristics” , Rec. ITU-R P.1239-2, 2009.

[4] B. Nava, P. Coïsson, S.M. Radicella“HA new version of the NeQuick ionosphere electron density modelH”Journal of Atmospheric and Solar-Terrestrial Physics, Volume 70, Issue 15, December 2008, Pages 1856-1862.

[5] ITU-R. “The Ionosphere and its effects on radiowave propagation. A guide with background to ITU-R procedures for radio planned and users”, ITU-R Handbook, 1998.