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Atmospheric Measurement Techniques Discussions

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Interactive Comment

Interactive comment on "Progress in turbulence detection via GNSS occultation data" *by* L. B. Cornman et al.

Anonymous Referee #2

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General comments

The manuscript aims to find by use of analysis of GNSS radio occultations (RO) data the strength and location of turbulent structures. A theoretical approach includes the derivation of a model for the power spectrum of the log-amplitude and phase ïňĆuc-tuations of RO signal by use of the first Rytov approximation. Parameter estimators are introduced and some of their statistical properties are studied. These estimators are then applied to simulated log-amplitude RO signals. This includes the analysis of global statistics derived from a large number of simulated realizations. The estimation techniques are then applied to two cases of real occultation data.

Unfortunately only limited results are obtained.

1. The manuscript addresses a potentially interesting topic, which is the possible description of parameters of the atmospheric turbulent structures with high resolution retrieval of RO data. However, it contains a main problem that should be discussed before application to interpretation of GNSS RO data in decimeter wavelength band: In the manuscript the remaining part of the received GPS RO signal (after subtracting a trend) is considered as "a Gaussian random process" (p.3417). However, the remaining part of GPS RO signals may contain a significant contribution of regular layers, which in general case does not obey the standard rules of Gaussian statistics. The possible influence of the tropopause and regular layers in the lower stratosphere can be significant in the two cases of real occultation data analyzed in the manuscript. Note, that the identification, location, and estimation of the contribution of regular layers in RO signals can be fulfilled by a new method described, for example, in papers:

Pavelyev A.G., Liou Y.A., Wickert J., Gavrik A.L., Lee C.C. Eikonal acceleration technique for studying of the Earth and planetary atmospheres by radio occultation method Geophys. Res. Lett. 2009. V. 36. doi:10.1029/2009GL040979, L21807, 1-5.

Y. A. Liou and A. G. Pavelyev Simultaneous observations of radio wave phase and intensity variations for locating the plasma layers in the ionosphere Geophysical Research Letters, Vol. 33, No. 23, L231021-5, doi:10.1029/2006GL027112, 2006.

These papers introduced some progress in the revealing the turbulence contribution in RO signals.

For radio occultation in the centimeter frequency band and for stellar occultation the interpretation of the amplitude and phase variations as connected with anisotropic and isotropic turbulence contribution may be possible, and published in several papers, for example:

V. Kan, S.S. Matyugov, and O.I. Yakovlev The structure of stratospheric irregularities according to radio-occultation data obtained using satellite-to-satellite paths. Radio Physics and Quantum Electronics, Vol. 45, No. 8, 2002.

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2. The first approximation of Rytov, carefully described by the Authors, should be supplemented in the case of strong amplitude fluctuations by a more accurate theory described in several papers, for example:

Prokhorov, A.M.; Bunkin, F.V.; Gochelashvili, K.S.; Shishov, V.I. Propagation of laser radiation in randomly inhomogeneous media. Soviet Physics Uspekhi, Volume 17, Issue 6, pp. 826-847 (1975).

Prokhorov, A.M.; Bunkin, F.V.; Gochelashvili, K.S.; Shishov, V.I. Laser irradiance propagation in turbulent media. IEEE, Proceedings, vol. 63, May 1975, p. 790-811. These papers concern the coherence functions of the radio fields and should be referenced in connection with the log-amplitude and phase correlations.

3. The manuscript is very long (53 figures and 97 pages) if considered as a standard AMT paper. It is reasonable to reduce significantly (about five times) the manuscript size.

Therefore major revision of the manuscript is necessary before publication.

Detailed comments

Abstract

"This includes the derivation of a model for the power spectrum of the log-amplitude and phase fluctuations of the permittivity (or index of refraction) field."(p. 3402, lines 4-6) This is an unclear sentence. The log-amplitude and phase ïňĆuctuations correspond to the radio field.

1. Introduction

On my opinion, the introduction should concern first of all the topics formulated in the manuscript's title "Progress in turbulence detection via GNSS occultation data". The title concerns only GNSS occultation and not the satellite-to-Earth-based station and similar communication links. It is useful to show clearly the motivation and place of the manuscript among the current occultation publications. From my point of view the main task of application of GNSS technology to the turbulence analysis consists in separating of the regular layers contribution from that one of turbulence (the relevant papers are indicated, for example, in general comments).

2. Wave propagation theory

The preliminary notes in section 2 give nice systematic introduction to the Authors conception of turbulence. However it is necessary (1) to discuss an applicable domain of the theory connected with possible influence of regular layers; (2) to describe limitations of the Rytov approximation; and (3) to introduce a figure explaining the coordinates and geometrical parameters of the RO scheme as applied to a turbulence analysis. Without such a figure it is unclear how one can estimate the distance to a turbulent layer by use of the suggested theory.

3. Parameter estimation

Assuming that the received signal is a Gaussian random process, its spectral values at each frequency will have an exponential distribution. . .. . . An example of this is shown in Fig.4. (p.3417, lines 5-11). As I understood, this sentence corresponds to spectral values in a power spectrum. However in Fig. 4 one can see the title "The amplitude spectrum".

4. Simulation studies

The main conclusions in section 4 are valid in the unbiased cases of the parameters estimations. However the influence of the systematic errors connected with impact of regular layers can provide additional difficulties in the statistical analysis, and, possibly, may introduce an unexpected bias. This impact should be accounted for. Also lacking of a figure with a coordinate system does not allow understanding a clear way to measure the parameter n from GNSS RO data.

5. GPS-COSMIC occultation analysis

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This section is important for understanding of the Authors theoretical approach. "In this section, an analysis of two case studies from GPS-COSMIC occultations is presented. These cases occurred in relative space and time) proximity to the Air France 447 accident that occurred on 1 June 2009." (p.3433-3434, lines 26,27, 1)." Figure 42 shows the amplitude time series over the course of occultation 2 (arbitrary nomenclature)." (p. 3434, lines 8,9).

The Fig. 42 does not contain information on the altitudes in the atmosphere, geographical coordinates, and the event time. This information is necessary for the focused analysis of all silent features of the events, including a position of the tropopause. The tropopause can introduce significant impact on the statistical estimations. The same remark concerns the Fig. 46 and the text explaining the Figures 42, 46.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 3401, 2011.