Review of paper
"Identification and localization of layers in the ionosphere using the eikonal and amplitude of radio occultation signals"
by A. G. Pavelyev, K. Zhang, J. Wickert, T. Schmidt, Y.-A. Liou, V. N. Gubenko, A. Pavelyev, R. R. Salimzjanov, and Y. Kuleshov

1. Introduction

Page 1467, Line 13: *The amplitude of RO signal presents new potential and capability for the research of the ionosphere (Sokolovskiy, 2000, 2002; Igarashi et al., 2000, 2001; Pavelyev et al., 2002, 2004, 2007, 2008a, b, 2009, 2010a; Liou et al., 2002, 2003, 2005, 2007; Liou and Pavelyev, 2006).*
There are some other papers where ionosphere was investigated by using both phase and amplitude of RO signals:
V. V. Vorob'ev, A. S. Gurvich, V. Kan, S. V. Sokolovskiy, O. V. Fedorova, and A. V. Shmakov, The structure of the ionosphere from the GPS-``Microlab-1" radio occultation data: Preliminary results, Cosmic Research, 1997, No. 4, 74-83.
M. E. Gorbunov, A. S. Gurvich, and A. V. Shmakov, Back-propagation and radio-holographic methods for investigation of sporadic ionospheric E-layers from Microlab-1 data, International Journal of Remote Sensing, 2002, 23(4), 675–685.
These must be mentioned too.

Page 1467, Line 15: *The goal of this paper is*

- *(i)* *to introduce the description of different kinds of the ionospheric influence on the GPS RO signals within the altitudes of h(T) between 40 and 90 km,*
- *(ii)* *to present an analytical model for the refractive attenuation and phase path (eikonal) excess of electromagnetic waves in locally spherical symmetric media, and*
- *(iii)* *to demonstrate the possibility to identify contributions and to measure parameters of the inclined plasma layers by means of analyzing the CHAMP RO experimental data.*

Below we will discuss to what extent these goals have been achieved.

2. Types of ionospheric influence on CHAMP RO signal

Page 1468, Line 14: *Previously, the RO technology has been based mainly on analyzing the phase of the electromagnetic wave after propagating through the ionosphere and atmosphere (Ware et al., 1996).*
Do the authors really know nothing about Back Propagation, Canonical Transform, Full Spectrum Inversion, Phase Matching, Wigner Distribution Function? All these methods utilize the full complex field and the use of amplitude is crucial.

Figure 2: the descriptions of curves 1–4 must be given in the figure caption.

Page 1469, Line 12: *These examples support suggestion that there exist the inclined ionospheric layers located along the RO ray trajectory.*
In the text I don't find any argumentation in support of this statement. In what way Figure 2 supports the assumption that the ionospheric layers are inclined?

Page 1469, Line 24: $\Delta h = h' - h \approx 50$ km.
In what way did the authors arrive at this estimate? Note, this repeats the statements from (Wickert et al, 2004):

If the plasma layer is located in the E-region, then $\Delta h = 50$ km. *If it is located in the F-region* $\Delta h = 200$ km.
But I didn't find any substantiation of these estimates in (Wickert, 2004) either. I don't understand either why (Wickert, 2004) with the same $\Delta h = 50$ km arrives at different estimates of δ and d. According to this paper, $\delta = 6^\circ$ and $d = 700$ km. According to (Wickert, 2004), $\delta = 7.5^\circ$ and $d = 450$ km. Where does this difference come from? What is the novelty of this material with respect to (Wickert, 2004) published 7 years ago?

Page 1470, Line 5: *Strong ionospheric influence with diffraction structures in the RO signals is demonstrated in Fig. 4 (right) at the heights 98–105 km. This case can be considered as a consequence of diffraction of electromagnetic waves on sharp gradients of the electron density in a sporadic E-layer.*
Why should this case be considered as a consequence of diffraction effects? What is the criterion? Did the authors make any estimates of the difference between geometric optical and diffractive amplitude for this case?

Page 1470–1471: *According to the analysis of CHAMP RO amplitude and phase data, five types of ionospheric influence on the RO signals can be established at the RO ray perigee altitudes between 40 km and 90 km: … These types can be compared with the results obtained earlier by Karasawa et al. (1985) … This coincidence in the types of CHAMP RO amplitude scintillations 10 and the amplitude variations observed in the Earth-based experiments indicates common ionospheric mechanisms of their origin.*
Where in the paper can we find such an analysis of CHAMP RO data that allows for the classification of ionospheric influence? Where in the paper can we see any quantitative comparison of the CHAMP RO data with the data of Karasawa? What means the statement that these types **can be compared** with the results by Karasawa? Were they really compared?
What means, for example, the statement that "*The C-type is similar to noisy variations 5 without any significant regular or periodical structure in the amplitude changes of the transionospheric signals*"? Did the authors compute the spectral density of these fluctuations and compared it to that obtained from the data by Karasawa?
Are just 5 examples sufficient for these far-reaching conclusions?

3 Analytical model for the phase path excess and refractive attenuation of RO signals

Page 1474, Line 4: *The developed analytical model allows ray tracing of the RO signals.*
Ray tracing does not require this model. It is based on the ray equation in an arbitrary inhomogeneous medium and any 3D model of the ionospheric refractivity and its gradient. The 3D field of the ionospheric refractivity can be specified either in the form of an analytical model or as an interpolated gridded field (like International Reference Ionosphere).
A general formula for the amplitude of RO signal taking into account horizontal gradients can be found in the paper:
M. E. Gorbunov and G. Kirchengast, Processing X/K Band Radio Occultation Data in Pres-ence of Turbulence, Radio Science, 2005, V. 40, No. 6, RS6001, doi: 10. 1029/2005RS003263.

Page 1475, Line 10: *As follows from the introduced model the ionospheric contribution in the RO signals can be significant at different altitudes of the RO ray perigee in 40–90km interval if the following two necessary and sufficient conditions are fulfilled: (i) the ionospheric part of the RO signals path contains a tangent point; and (ii) there is a refractivity layer with sharp gradient perpendicular to the ray G1B1B2L in the vicinity of the tangent point. In the simplest case, when an inclined plasma layer exists only on one part of the ray G1B1B2L and the influence of the neutral atmosphere is weak, the analytical model predicts the displacement of*

the tangent point from the ray perigee T to a plasma layer. As a result one may observe unusually strong amplitude and phase variations of the RO signals in the 40–90 km interval of the RO ray perigee height h(T).
This follows from the model, but by now the text does not present any substantiation that this model is really useful for the description of ionospheric fluctuations of RO signals.

4 Identification and location of plasma layers

Page 1477: *The eikonal acceleration* a *has been estimated numerically by double differentiation over a fixed time interval* Δt. *The value of* Δt *as equal to 0.42 s. The strongest variations of the eikonal acceleration are observed almost in the same altitude intervals as for the refractive attenuation. In this interval the eikonal acceleration and refractive attenuation variations are strongly connected and may be considered as coherent oscillations caused by layered structures. It is important that at altitudes of below 72km and higher than 98 km the refractive attenuation variations are small and do not have any connection with changes of the eikonal acceleration (Fig. 7, right panel). This indicates different incoherent mechanism of the significant eikonal variations at the heights* $h \leq 72$ km *and* $h \geq 98$ km.
Why is Δt chosen to equal 0.42 s? By looking at the plots in the right panel of Figure 7, I would say that amplitude variations are not well correlated with the eikonal acceleration also in the height interval 72–98 km. For example, near 72 km we see the first area of stronger amplitude fluctuations, but there is nothing special about the eikonal acceleration. Near 90 km, eikonal acceleration is slightly stronger, but again this does not correspond to the strength of the amplitude fluctuations. As to small-scale structure of the amplitude fluctuation, it is very different from that of the eikonal acceleration. But, to some extent, this should be expected, because small scale fluctuations (with scales 1 km and smaller) should be affected by diffraction, which is not described by equations (12,13) based on geometrical optics.

Page 1478, Line 18: *The corresponding values* Δh *change in the 2–30 km interval. Identification of the sporadic Es layer justifies the application of the Abel transform for solving the inverse problem.*
And what about the initialization of the Abel transform at large heights? It is known that ionosphere occupies heights up to 1000 km (or even higher), its maximum is located at heights around 300–600 km. But CHAMP measurements are only available below 90–120 km.

Conclusion of review

The declared goal (i) is not achieved as explained above. On the other hand, the description of task (i) lacks novelty, because this material was published 7 years ago in (Wickert, 2004).
The model (ii) is derived, but it is not clear in what way it is used in this paper. In Section 4 I don’t see any references to equations (4–11) describing the model.
So parts (i) and (ii) can be excluded. As to (iii), its description should be enlarged and more details about the electron density retrieval from CHAMP data must be provided.