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Atmospheric Measurement Techniques Discussions

Interactive comment on "Reflected ray retrieval from radio occultation data using radio holographic filtering of wave fields in ray space" *by* Michael E. Gorbunov et al.

Anonymous Referee #2

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This paper presents a new approach in the retrieval and identification of reflected signals in RO data using radioholographic (RH) techniques. It is this reviewer's belief that the use of reflected signal is currently being underutilized, and this paper represents a step forward in the right direction. Overall, I find the paper technically interesting, although at times unfocused, with some concepts/motivations not well explained.

(1) The WDF method was used throughout the paper to illustrate the presence/absence of reflection in the bending angle/impact parameter space. However, the paper uses a CT-based technique to retrieve the reflected signal. It is not clear why the authors could not simply use WDF. Please explain.

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Discussion paper

(2) Section 2.1, p.5: The authors wrote that the “impact parameter interval for reflected rays is usually as narrow as 100-200 m. This requires a narrow filter window of about 20 m, while the typical setting for processing direct rays in the lowest troposphere is 250 m.” This served as the motivation for a modified impact parameter described in Section 2.2. However, I do not understand why this is a problem in practice. What exactly is the problem of using a narrow filter window?

(3) Section 2.2, p.5: The modified impact parameter approach was introduced here and almost immediately discarded because “the presence of the tunable parameter beta.” If this method is not useful, why did the authors bother to introduce it here at all?

(4) Section 2.3, p.5: “The CT2 algorithm is designed for the retrieval of the bending angle profiles in multipath areas, where the profiles are non-monotonic. This is not the case for bending angle profiles of reflected rays, which always monotonically increase.” The explanation for the second statement came much later, in p. 9. I suggest either alerting the readers that the explanation will come later or moving the explanation up. Now about that explanation. . ..

(5) p. 9: “. . . explained by eq. (18), where the derivative of the second, reflective term proves to be much stronger than that of the first, refractive term, for any possible conditions.” I’d like to see a proof of that, using more realistic atmospheric conditions than modified MSIS. Close to the surface, the direct and reflected rays are almost merging. If multipath can affect direct rays, couldn’t it also affect reflected rays?

(6) Section 2.3: My understanding is that the RH approach was ultimately only used to filter out the direct signal (eq. 17) and then transform back to the time domain. This begs the question of whether RH is really necessary. Can you show an example where the identification using sliding spectrum in the time domain is problematic but solved using the RH filtering approach?

(7) Section 2.4: “Figure 2 through Figure 5 show examples of reflections detected in COSMIC observations.” There were very few discussions of the individual figures.

First, the reflection features in these figures should be clearly marked. Second, provide more details on what differentiates these figures. If they are not sufficiently different, please consider eliminating some of them.

(8) p. 7: “Often epsilon_R(p) is a multi-valued function.” Doesn’t that contradict the earlier statement that it “always monotonically increase”?

(9) p. 8: “r_E is the Earth’s curvature radius with the account of the surface height above the reference ellipsoid.” Do you mean the height over the geoid or terrain height?

(10) Eq. (24), p. 9: Please define A(t) and S(t). Are these the amplitude and phase of the complex signal that has already gone through the RH filtering of Eq. (17). If so, why is the spectral amplitude so large at positive impact parameters?

(11) The reflection index depends on a number of subjective parameters (Eqs 25-28). Please quantify sensitivity of the reflection index on these parameters. Giving the value of reflection index in such high precision (e.g., 20.755) seems misleading.

(12) Figs. 9-13: Please describe how the uncertainties are derived and what they mean. They are so large that they seem consistent with no reflections?

(13) The RH formulation presented assumes spherical symmetry. What if the atmosphere is spherically symmetric but the surface is not? In Beyerle et al., there was discussion of how surface tilts will affect the reflected Doppler shift. Could you comment on how a surface tilt will affect your analysis?

Minor corrections:

(14) Throughout: “phase excess” should be replaced by “excess phase”

(15) Above Eq. (24), p. 9: “S_{MR}(r)” -> “S_{MR}(t)”

(16) p. 13: “None index” -> “No index”

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