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Interactive comment

Interactive comment on "Detection of reflections in GNSS radio occultation measurements using phase matching" *by* Thomas Sievert et al.

Anonymous Referee #2

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The paper presents a technique to identify surface reflection signatures inside Radio Occultation simulated/real signals. Even if the subject is interesting, it is already investigated (as pointed out also in the Introduction) and several methods to flag occultations when a reflection signature is observable, are already available and are already implemented. The shown technique is based on applying the Phase Matching technique to a somehow truncated signal which removes the noisy contribution coming from atmospheric multipath in the lower and deeper part of the occultation.

The paper does not present all the details, thus it is difficult to understand whether the strategy is effective or not. There is a kind of evidence with the results presented through the 10 examples but, in any case, it would be nice to have an independent validation considering other well consolidated techniques which are quite easy and

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Discussion paper

straightforward to be implemented (visual inspection of the radio holographic / frequency spectra).

Also because I'm rather convinced that what is shown by the authors (maybe this is what they really wanted to show) is not really the entire signature of reflection on the RO signal (to be used for some geophysical analysis), but the diffraction effect of the Earth's surface on the signal. The reflection signature should appear for grazing incidence in the real signal (up to when the doppler departure from the atmospheric doppler is not too big) for longer time (i.e. wider impact height) intervals, not only as a spike. In all the examples shown by the author there is always a spike at around the lowest impact height (which corresponds to the ellipsoidal surface modelling the Earth's surface). I suspect that the spike is always around at a distance of one Fresnel zone from the surface (where the diffraction effect on the signal amplitude is maximum). It is clear that the shown spike is related in some way to the interaction with the Earth's surface and it will allow to detect the presence of the Earth's surface in the occultation event (which might be also an useful information), but it does not reveal the presence of a reflection signature useful for geophysical analysis. By properly cutting the signal, such spike will probably always be found. Instead, reflection signatures will really depend on the surface scattering properties, and might appear or might remain hidden in the atmospheric signal signature.

This should be clearly addressed in the paper (in the abstract, discussion, conclusion), which should be entitled like "Detection of Earth's surface in GNSS RO measurements using phase matching".

Some other specific and technical comments are provided here below.

"Specific Comments"

Page 1

#17: "In many RO... signal". Not sure what does it mean. Of course the atmosphere is always sounded above the place where the signal is reflected. Clarify

Page 2

#24 and below: Data used to obtain Fig 1 are not described properly. Is the U function based on the simulated u(t) or on the measured one on METOP-A? Are the plots the U(a) amplitudes (Eq 1) evaluated when the matching signal is the one for reflected rays described in Annex A2? At #27 you are referring to a certain model. A model of what? The model of the geometrical optical path or the models allowing you to draw the SLTA(ha) for the direct (blue plot) or reflected (red plot) rays? Unclear

Page 3

#4: where n(RE) is taken? Is the colocated ECMWF refraction index profile? An exponential profile as addressed in #9, page 4?

#15: Using the information of the Centre of Curvature is not necessary because you need to exploit "more accurate values of impact height". You need this reference system translation to fulfil the local spherical symmetry assumption.

#21: "simpler geometry of the WOP". Please elaborate more this sentence.

Page 4

The entire Sect 5 should be more clearly addressed. It is quite confusing

#6: If the signal tracking is "lost", you cannot have any u(t), thus you cannot have any amplitude(U). Why are you referring to realistic instrument behaviour here (unless you can provide evidence that you can have an amplitude(U) spike in a realistic occultation signal when the tracking is lost).

#8: Why are you saying "if tracking of the signal..." if Fig 2 is based on simulated occultation? Are you using also an instrument simulator (which provides an idea of the instrument tracking behaviour) together with the WOP?

#9: Again on Fig1. Here you are referring to an exponential profile. Of what? Refraction index? What are you showing in Fig 1? The effects of SLTA(ha) for n(R) based on an exponential profile? See also the comment provided for #4 at Page 3.

#9-10: "This shows... direct rays". The sentence is not clear. Do you want to mean that you can have reflection signatures also at higher SLTAs? This is of course true, up to when the associated Doppler will be within the receiver bandwidth. And thanks to this you can maybe do some geophysical analysis on the reflected signal. That's why I'm saying that what you called "reflection" spike (#13) is not the reflection signature you are dealing with here. In my view this reflection "spike" is the diffraction effect of the Earth's surface.

Page 5

#1: not clear at all which is the truncation strategy. Please add a sentence defining the strategy you used.

#13: what does it mean that all occultation of that day have a reflection signature? Why this should depend on the "day"? Is the reflection signature the spike you was able to identify or is it because the reflection flag in the data was set to 1?

Page 6/7/8: all the plots: Why the amplitude(U) dynamic is so different between simulated (from 0 to 10ˆ-4) and realistic (to 0 from 4) data? Measuring Unit are missing...

Page 11:

#8: this follows geometrical considerations. Also the Bouger's rule which is becomes an easy trigonometrical formulation for n = 1 (rsin(fi) = a).

"Technical corrections"

Page2

#3: processing instead of receiving

#10: address the Annexes content

#14: k or k0? Is this the wave number in vacuum associated to the GNSS carrier frequency?

Page 3

#1: "orbital radii for the satellite are fixed" means "circular orbits"?

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