Reviewer #1

- Comment: The authors claim the technique is a good detector, but this cannot be claimed when tested in only 10 cases, and especially if no assessment is done about the false positives. Moreover, they do not provide any way for the reader to cross-check whether these 10 cases do present indeed reflected signals, or not.
- Response: The intention is not to present a fully developed detector, but rather to highlight that reflections appear in the PM amplitude. To make this clearer, we changed the title from ”Detection” to ”Analysis”, and avoid referring to this as a ”detection method”. We added radio holographic images of the events we present as a means of validating the existence of reflection.

Reviewer #1

- Comment: The authors present a forward model for the relationship between reflected bending and impact parameter as original, but this operator is already given in Gorbunov et al. 2016
- Response: The relationship between reflected bending angle and impact parameter was never intended to be presented as our original contribution. We have clarified by adding appropriate references.

Reviewer #1

- Comment: The manuscript only mentions the canonical transform as an alternative way of detecting reflected signals in RO, while the ROM SAF is providing a list […] (support vector machine) […]
- Response: A more thorough description of the publications we refer to has been added to the introduction.

Reviewer #2

- Comment: […] in any case, it would be nice to have an independent validation considering other well consolidated techniques which are quite easy and straightforward to implement (visual inspection of the radio holographic / frequency spectra).
- Response: Radio holographic images have been added to the figures in the results section for validation. The trails going into negative frequencies indicate that the events contain reflections, and noisier radio holograms correspond to noisier phase matching amplitudes.

Reviewer #2

- Comment: […] but [the spike] 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.
- Response: We maintain that the spike does indeed reveal the presence of a reflection signature – Fig. 1 in the paper motivates this. The reflected signal is present everywhere where there is a direct signal (except for the very deep direct signals), but only the lower parts of the reflected signal is picked up by the instrument. The direct and reflected rays merge at the impact parameter (and SLTA) corresponding to the Earth surface. At this point the direct signal is diffracted by the presence of the Earth. By truncating the signal at a much higher SLTA we remove the diffracted ray. The reason for the spike-like appearance of the reflection in the impact parameter domain is also explained by figure 1. Where it is seen that a large interval in SLTA for the reflected ray is compacted into a rather small interval in impact parameter. This has been elaborated in Sect. 5.

Reviewer #2

- Comment: 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
- Response: This was an unclear sentence, the point was to say that the signal is often reflected. It has been changed to be clearer.

Reviewer #2

- Comment: 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
- Response: The model we refer to is the model of impact height vs SLTA, shown by the overlayed plots red and blue in Fig. 1. These plots are described by equations (2) and (3) and based on data from co-located ECMWF profiles. The black curves are |U| plots generated by measured MetOp-A data, which we have clarified. Appendix A2 serves to show that the PM operator admits reflected rays as well as direct ones, so the U functions shown in the figure are for different segments of the measured signal.

Reviewer #2

- Comment: Page 3#4: where n(RE) is taken? Is the colocated ECMWF refraction index profile? An exponential profile as addressed in #9, page 4?
- Response: n(RE) is taken from the colocated ECMWF profile. This information is added. In the last version of the manuscript we referred to an exponential profile. This is incorrect and has been removed.

Reviewer #2

- Comment: Page 3#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.
- Response: This has been corrected.

Reviewer #2

- Comment: Page 3#21: ”simpler geometry of the WOP”. Please elaborate more this sentence.
- Response: We were referring to a two-dimensional geometry with a stationary GNSS transmitter. This has been elaborated in Sect. 4.

Reviewer #2

- Comment: Page 4: The entire Sect 5 should be more clearly addressed. It is quite confusing.
- Response: Sect 5 has been rewritten.

Reviewer #2

- Comment: Page 4#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).
- Response: Since the U function is an integral over the entire u(t), there cannot be ”tracking” for any single point in U. Thus, U is defined for any impact parameter a, and the amplitude can tell us if a specific value of a corresponds to a ray or if it is just noise. The time span in which we have u(t) is considered the time when the instrument tracks the signal. What we mean when we say ”tracking is lost” is that beyond that value of t we have no signal. We have added an explanation of how, in the WOP, we can mimic the measurement results of the instrument tracking down to a specific SLTA. This was added to Sect. 4.

Reviewer #2

- Comment: Page 4#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?
- Response: What we mean to say is that the has been simulated down to a certain SLTA. By changing separation angle parameter in the WOP, we can mimic the measurement results that would be produced from an instrument tracking to lower or higher SLTA. A clarification of this was added to Sect 4.

Reviewer #2

- Comment: Page 4#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.
- Response: Any reference to an exponential profile is a mistake and has been removed.

Reviewer #2

- Comment: Page 4#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.
- Response: Yes, what we mean is that reflected rays are received at higher SLTAs than the direct rays diffracted by the Earth’s surface. If we process the whole signal however, the contribution of these rays overlap at the same impact height. We have added clarifying remarks in Sect 5 about this.

Reviewer #2

- Comment: Page 5#1: not clear at all which is the truncation strategy. Please add a sentence defining the strategy you used.
- Response: The truncation strategy is to cut the signal well above SLTAmin, and apply a tapering window to avoid artifacts. We do this to remove the direct rays corresponding to the bottom of the atmosphere. We elaborate on this in Sect. 5, and we explain for each of the ten measurements in their figure captions where we truncate and which SLTA we need to stay above.

Reviewer #2

- Comment: Page 5#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?
- Response: In referring to ”this day”, we meant to refer to ”the data we have looked at”, since we looked at one day’s worth of data. Our point was that for every |U| we came across that looked a certain way, there was reflection. As this was not a clear wording, we changed it to make the point come across clearer: ”*When the measurements are sufficiently deep, and the noise level of |U| is low, there are very clear reflection spikes.”.* This is what we seek to highlight with the category 1 cases we present.

Reviewer #2

- Comment: 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).
- Response: We corrected this accordingly.