Reviewer 2

We thank the reviewer for the valuable and insightful comments. In response, we have revised the manuscript to extend discussions on the potential challenges and limitations of the approach. As suggested, we also conducted additional simulations using different PBL schemes for case ERA5_Bualoi_Goddard to assess their influence further. Our point-by-point responses are provided below in blue.

The manuscript explores the impact of several microphysics schemes on the polarimetric signature, during radio occultation with polarimetric-capable receivers. The paper shows that the different schemes lead to different expected observables. This difference is clearly above noise for the observable, thus these observations can in principle support the superiority of some microphysical schemes above others.

The theoretical basis for this is in general appropriate, and the authors demonstrate what I understand is the main goal, which is to show that the polarization signature is measurable with better accuracy than the difference between microphysical schemes. Indeed, some schemes lead to significantly better fits than alternative microphysics. This is interesting. Despite this, the authors do not explore sufficiently the caveats of the approach. The relationships between water precipitates and polarization signatures depend on the amount of water/ice, and the average axis ratio. Although the amount of water/ice is quite explicit in any microphysics scheme, the effective axis ratio is hardly an output of any standard scheme. It is here somewhat arbitrarily fixed to a very crude guess of 0.5, and it is unclear how other choices of this quantity may impact the results. It may be a different constant, a profile dependent on the type of precipitate, and depends likely also on turbulence.

Thank you to the reviewer for this insightful comment. We agree that the relationship between cloud hydrometeors and polarization signatures is influenced by multiple complex factors, including the amounts of hydrometeors and the effective axis ratio (*ar*), which is determined by the particle size distribution and orientation. Both factors are difficult to constrain accurately, and this introduces a limitation to our approach.

In our study, we did not assume a constant axis ratio as in some previous works. Instead, we applied a height-dependent profile of $\rho\cdot(1-ar)$, which is based on Fig. 9 of Padullés et al. (2022). This profile assumes a fixed density of $\rho = 0.2\ g\ m^{-3}$ and a variable axis ratio that changes with temperature. The temperature dependence is supported by satellite observations on frozen hydrometeors, as discussed in Padullés et al. (2022). Beyond the defined temperature range (e.g., above the cloud top or below the freezing level), $\rho \cdot (1-ar)$ is held constant at its value at the nearest boundary level (Fig. R2-1a, black line).

In the original manuscript, the same $\rho \cdot (1-ar)$ function was applied to all the hydrometeors, as represented by the black line in Fig. R2-1a. However, since this function was estimated for frozen hydrometeors, we refer to Chang et al. (2009), which suggests an axis ratio of $ar = 0.95$ for liquid rain during typhoon events (with a density of ρ=1 g cm^{-3}). Therefore, a fixed value of $\rho \cdot (1-ar) = 0.05$ is used for rain, as shown by the blue line in Fig. R2-1a. The revised manuscript has been updated accordingly, using different $\rho \cdot (1-ar)$ functions for solid and liquid hydrometeors. This methodology has been clarified in the revised manuscript (Section 2.2).

To further address the concern regarding the fixed axis ratio, we conducted sensitivity tests by applying various constant *ar* values (ranging from 0.1 to 0.9) for solid hydrometeors, and a fixed $ar = 0.95$ for rain, in the ERA5_Bualoi_Goddard case. The results (shown in Fig. R2-1b) reveal that while the general shape of the $\Delta\phi$ curves remain similar, the maximum $\Delta\phi$ tends to occur at higher altitudes. The curve used in the revised manuscript (i.e., the "curve fit") is closer to the PRO observation, indicating a relatively better representation for $\Delta\phi$ calculation. It is also noted that larger *ar* values tend to produce smaller $\Delta\phi$.

In the revised methodology for $\Delta\phi$ estimation, hydrometeor phase (solid or liquid) is taken into account when computing the simulated phase shift. To mitigate potential representativeness errors arising from rainband variability, $\Delta\phi$ values are averaged along the relocated raypath as well as two parallel paths offset by 0.5°. The associated figures presenting $\Delta\phi$ have been updated in the revised manuscript. In addition, we have added a brief discussion in the revised manuscript regarding potential sources of uncertainty and physical factors (e.g., turbulence, particle type, and orientation) that may affect the relationship between PRO measurements and microphysical assumptions.

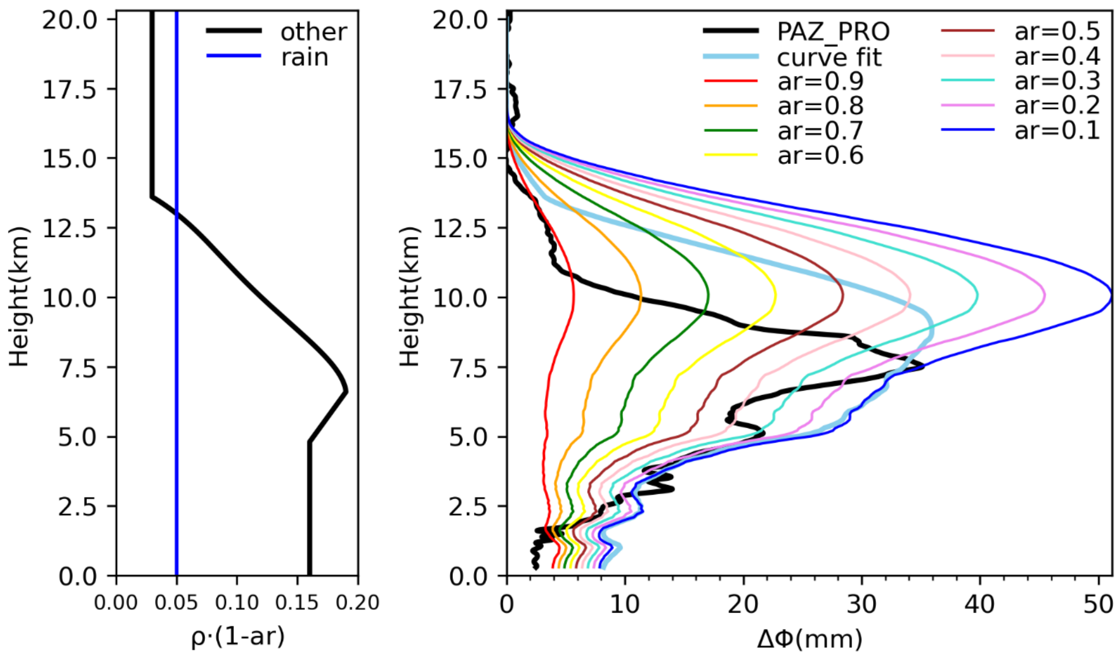

Fig. R2-1. (a) The ρ·(1−*ar*) function used for solid (black line) and liquid (blue line) hydrometeors. (b) Sensitivity test of Δϕ profiles for case ERA5_Bualoi_Goddard, using fixed axis ratio (*ar*) values ranging from 0.1 to 0.9 for solid hydrometeors. The black line represents the PRO observation, and the light blue line shows the curve fitting adopted in the revised manuscript. Other colored lines correspond to different fixed *ar* values, as indicated in the legend.

Besides, the microphysics interact, as is mentioned in the paper, with PBL schemes. Given this wide parameter space, above the mere amount of several precipitate fractions, it is not obvious that we could at this point conclude that some microphysics scheme is superior based on PRO data. We can conclude, however, that through its accuracy and resolution, PRO data has the ability to discern different schemes. It is my understanding that we still ignore too much of the microphysics and of other related parameterizations, such as PBL schemes, to actually benefit from that ability, even if PRO data is available.

We agree that several parameters, including planetary boundary layer (PBL) schemes, can influence precipitation. To assess the uncertainty introduced by PBL parameterizations, we conducted four additional simulations using the ERA5_Bualoi_Goddard setup, but with alternative PBL schemes. While the original configuration used the Yonsei University (YSU) scheme, the new experiments incorporated four other PBL schemes (Table R2-1): Mellor-Yamada-Janjic (MYJ), Mellor-Yamada Nakanishi and Niino Level 3 (MYNN3), Asymmetric Convective Model version 2 (ACM2), and Grenier-Bretherton-McCaa (GBM). Although these different PBL schemes affect the development of hydrometeors and the simulated precipitation fields, the overall variation is less pronounced than that caused by different microphysics schemes, as shown in Fig. R2-2.

Nevertheless, the primary objective of our study is to assess the potential of PRO observations. The comparisons of different microphysics and PBL schemes are intended to illustrate possible sources of model uncertainty, rather than to provide a comprehensive evaluation of all parameterization options. This preliminary comparison demonstrates the value of PRO data in evaluating model performance. Accordingly, we have revised the manuscript to mention these sources of uncertainty and have softened the conclusions to reflect these findings.

Table R2-1. The abbreviated names and planetary boundary layer schemes used and their corresponding WRF options.

Abbreviated name	**PBL scheme**	**WRF options**
YSU	Yonsei University scheme	1
MYJ	Mellor-Yamada-Janjic scheme	2
MYNN3	Mellor-Yamada Nakanishi and Niino Level 3 scheme	6
ACM2	ACM2 scheme	7
GBM	Grenier-Bretherton-McCaa scheme	12

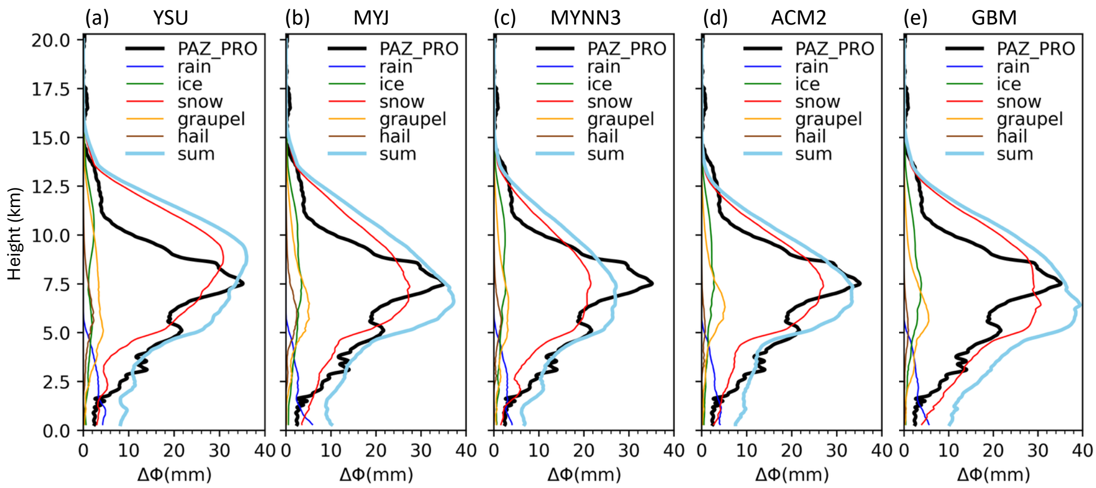

Fig. R2-2. Sensitivity of simulated $\Delta\phi$ profiles to different planetary boundary layer (PBL) schemes using the ERA5_Bualoi_Goddard configuration. The panels show simulations using (from left to right) the YSU, MYJ, MYNN3, ACM2, and GBM PBL schemes. The black line indicates the observed $\Delta\phi$ from PAZ PRO. Colored lines represent the contributions from individual hydrometeor types: rain (blue), ice (green), snow (red), graupel (orange), and hail (brown). The light blue line indicates the sum of all hydrometeor contributions.

I thus encourage the authors to underscore the difficulties that would limit the task of supporting a scheme as unconditionally superior to others, based on PRO, and further develop the caveats of the approach. I believe that this can be done with an appropriately extended comments and conclusion section (beyond the few comments in lines 393-etc).

We agree with the reviewer and sincerely thank you for the valuable suggestion. We have revised the manuscript to better highlight the limitations of our approach. The revisions aim to clarify the scope and constraints of our findings, and to emphasize the importance of considering interactions with other parameterizations.