Review report on " Importance of subpixel Earth surface reflectance and altitude for atmospheric trace gas retrievals from passive satellite instruments"

The manuscript is generally well structured. The theoretical motivation is clear, and the self-consistent FOCAL-CO2M simulations provide useful evidence that the proposed correction can substantially reduce XCO2 biases in heterogeneous terrain. The paper has clear potential for publication. However, several aspects require further clarification or additional analysis before publication. In particular, the validity range of the first-order approximation, the representative of Sentinel-2 bands for CO2M bands

Major comments

1. The physical meaning of "albedo-weighted altitude" should be stated more carefully

In a real satellite measurement the contribution of each subpixel to the detector signal is not determined by surface reflectance alone. It also depends on:

the instrument point spread function or spatial response function; viewing and illumination geometry; surface BRDF ….

I recommend that the authors make this limitation clearer in the abstract, introduction, and conclusion. The current wording may give the impression that albedo weighting alone is generally sufficient, whereas the derivation assumes a non-scattering atmosphere, Lambert surface, homogeneous spatial response, and small altitude variability.

2 The validity range of the first-order Taylor approximation needs clearer quantification

The theoretical derivation starts from a nonlinear expression for the effective altitude and then applies a first-order Taylor expansion. This is reasonable, but its applicability depends on the magnitude of subpixel altitude variability and albedo contrast.

The Mont Blanc case clearly shows that the proposed method substantially reduces the bias, but residual errors can still reach about ±2.5 ppm, which is well above the CO2M systematic error requirement. This suggests that the first-order approximation may not be adequate in highly complex mountainous terrain.

- The authors should quantify the validity range more explicitly.
- For what values of subpixel altitude standard deviation σz is the method reliable?
- At what altitude second-order terms become important?

- How does the approximation error depend on albedo contrast?
- Does the threshold depend on background altitude, SZA, VZA, or scattering conditions?

3 The use of Sentinel-2 bands as proxies for CO2M bands is ok?

For SWIR2, the mismatch is even more significant: CO2M covers approximately 1990–2095 nm, while Sentinel-2 B12 covers roughly 2100–2280 nm. Snow, ice, vegetation, dry soil, rock, and mining surfaces may have substantial spectral differences across this interval.

Clearly state in the conclusion that the current results rely on the approximation of CO2M band reflectance using Sentinel-2 bands.

This directly affects the albedo-weighted surface altitude, especially in scenarios involving snow-covered mountains, vegetation boundaries, bare rock, and mining areas.

Minor/technique comments:

1. The manuscript uses “albedo” and “surface reflectance” . Since Sentinel-2 provides surface reflectance and FOCAL retrieves Lambertian-equivalent albedo polynomial coefficients, it would be useful to clarify how these quantities are related in this study.
2. In Eq. (13): the starting point for the summation should be 1 rather than i?
3. In Eq. (16):It would be better for the subscripts to be consistent with the surrounding context.
4. At some points, ΔXCO2 appears to denote a correction term; else where it denotes the deviation from the true input value of 400 ppm. Please check it