Response to reviewer 1

The manuscript presents a new application of an O3 DIAL system based on SRS shifting of a 266 nm laser beam at 289 nm based on a HCF fiber filled with D2.

The measurements presented suffer from several drawbacks.

The authors thank the anonymous reviewer 1 for their comments and suggestions. These comments have helped us identify where the objectives and scope of the study required clarification. **All the line numbers in this document refer to the manuscript with highlighted changes (Latexdiff).**

We recognize that the original abstract and introduction could suggest a more advanced stage of instrument development than the results support. DIABLO is currently a proof-of-concept prototype. The objective of this work is to characterize a low-pulse-energy, deuterium-filled hollow-core-fiber Raman source, integrate it into an ozone DIAL configuration, and demonstrate its feasibility through initial atmospheric measurements. The ozone profiles presented provide a first assessment of the instrument's measurement capabilities, but they do not establish its absolute accuracy or readiness for routine autonomous operation.

Further work is required to characterize transmitter and coupling stability into the HCF, quantify instrumental and atmospheric sources of uncertainty, improve the retrieval processing, and validate the ozone profiles with independent vertical observations. We have revised the abstract and introduction and adjusted the discussion and conclusions to distinguish the demonstrated results from the developments still needed. Our point-by-point responses below describe these revisions and address the limitations highlighted by the reviewer.

1) No systematic approach is provided to calculate (estimate through simulations) the systematic errors on O3 DIAL measurements (from aerosols, SO2 and NO2 concentrations) in the PBL as stated by numerous papers in the 80's and 90's. To this end a new section is required (see my specific comments in the manuscript).

We agree that the original manuscript did not sufficiently describe all the systematic errors affecting the ozone retrievals. We have expanded Section 2.3 ("Data processing") to identify the main uncertainty sources and provide quantitative sensitivity estimates for the 266/289 nm wavelength pair, following Leblanc et al. (2016). **(Lines 206 to 217)**

The revised text states that an assumed 2 % uncertainty in the individual ozone absorption cross-sections produces approximately 2 % uncertainty in ozone when the relative uncertainties are fully correlated between wavelengths, corresponding to 1.2–1.6 $\mu g.m^{-3}$ for the concentrations measured here. We also specify that "the sensitivity to uncertainties in NO_2 and SO_2 mass concentrations is approximately 0.007 and 0.045 $\mu g.m^{-3}$ of ozone per $\mu g.m^{-3}$ of the interfering gas, respectively." These coefficients allow the contribution of each gas to be estimated for specified concentration uncertainties. The absorption term for interfering gases has also been added to the DIAL equation. Additional contributions associated with air number density error, Rayleigh cross-sections uncertainty and O_2 absorption correction at 266 nm are now discussed.

For aerosols, we have replaced the previous unsupported uncertainty estimate with a discussion supported by complementary observations (see our response to comment 2). We explicitly acknowledge that these observations do not quantify aerosol-related uncertainty, particularly near the boundary-layer top, where backscatter gradients may affect the retrieval. The discussion now cites previous studies addressing aerosol interference, including Browell et al. 1985, Papayannis et al. 1990 and Kuang et al. 2020

These additions are included within the existing processing section to connect the uncertainty discussion directly to the retrieval equation and the measurements presented. We distinguish the contributions included in the displayed uncertainties—detection noise, background subtraction and ozone absorption cross-sections—from the remaining systematic contributions. Accordingly, the revised manuscript explicitly states that these sensitivity estimates "do not constitute a complete uncertainty budget for DIABLO." A measurement-specific assessment of the remaining contributions is required in subsequent processing developments.

2) No statistical and systematic errors are provided in the retrieved O3 vertical profiles (cf. Fig. 6) taking into account NO2 and aerosol data profiles obtained from ceilometer and even by CAMS model. The reference to ceilometer profile data is not scientifically supported as no data are provided.

We agree that the original statement referring to ceilometer observations was insufficiently supported. We have modified the relevant section. **(Lines 226 to 234)**

We provide complementary observations from the Paris-Jussieu AERONET station and the SLIM2 aerosol microlidar for the measurement period in this answer.

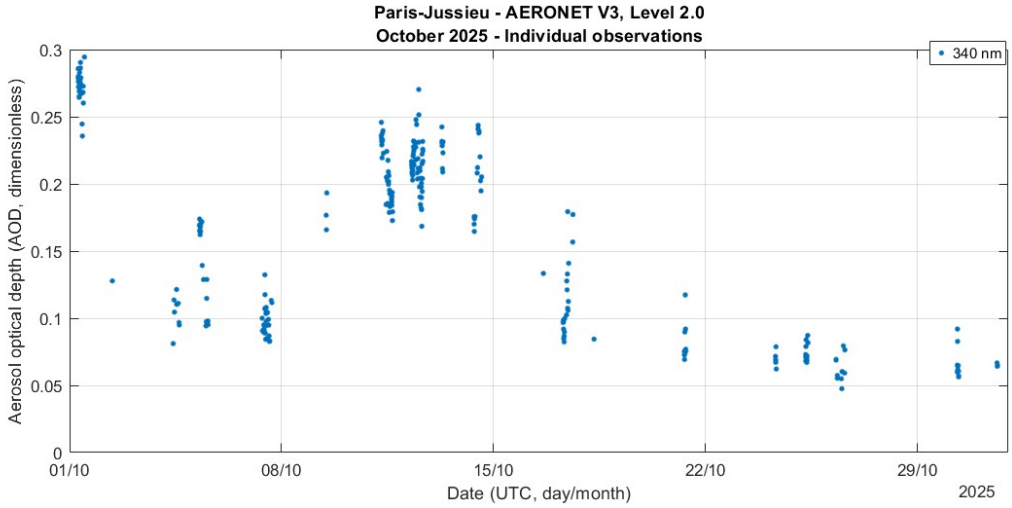


Figure R1.1: Aerosol optical depth at 340 nm measured at the Paris-Jussieu AERONET station during October 2025 (Version 3, Level 2.0). Available observations on 30 and 31 October, the days of the DIABLO measurements, remain below 0.1. Data were obtained from the AERONET database.

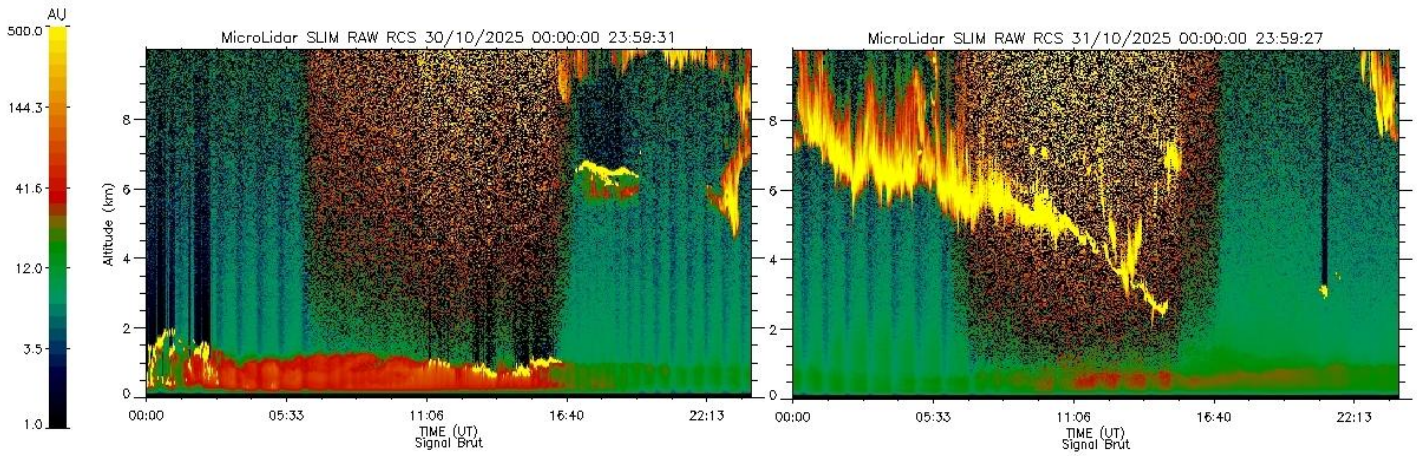


Figure R1.2: Time–height distributions of the range-corrected signal measured by the SLIM2 aerosol microlidar in Paris on 30 October (left) and 31 October 2025 (right). Colours represent signal intensity in arbitrary units. These quicklooks provide qualitative information on the vertical structure of atmospheric scattering layers during the DIABLO measurements.

The available daytime AERONET Version 3 Level 2.0 observations on 30 and 31 October 2025 show aerosol optical depths below 0.1 at 340 nm, indicating a low column-integrated aerosol load. The SLIM2 range-corrected signal quicklooks provide complementary information on the vertical distribution of scattering layers. During the ozone measurement periods, they indicate a relatively homogeneous scattering layer in the lower atmosphere, with a transition near the boundary-layer top, around 1 km. No distinct elevated aerosol layer is apparent between this transition and approximately 2 km, which includes the upper part of the DIABLO measurement range.

Aerosol interference in the DIAL retrieval involves differential extinction between 266 and 289 nm and the derivative of the logarithm of the total backscatter-coefficient ratio. The SLIM2 quicklooks indicate a relatively homogeneous scattering layer below approximately 1 km, a transition near the boundary-layer top, and no distinct aerosol layer apparent above it within the DIABLO measurement range. The backscatter-ratio contribution is therefore expected to be smaller away from this transition, while the low observed AOD suggests limited integrated aerosol extinction. However, the gradient near 1 km may introduce a substantial local bias in the ozone retrieval up to 20% according to Papayannis et al. (1990). No aerosol correction was applied to the ozone profiles presented in this initial demonstration, and the associated systematic contribution remains unquantified. Future processing developments will include aerosol corrections and propagation of their uncertainties using calibrated aerosol profiles as part of the complete instrument uncertainty budget required before operational deployment.

The influence of NO_2 absorption is addressed separately in our response to Comment 1, with the assumed concentrations and corresponding sensitivity estimates explicitly stated.

3) The gluing technique for the analog and photo counting signals has to be presented.

We have expanded the data-processing section to explain how the logarithmic slopes obtained from the two detection modes are combined. **(Lines 193 à 200)**

For each channel, the gluing interval is selected where the analog and photon-counting logarithmic slopes exhibit consistent values. We exclude ranges affected by photon-counting saturation, where the signal is over 90% of the maximum of the counting signal, and insufficient analog signal-to-noise ratio, where the SNR is below approximately 10. Within this interval, the slopes are combined using a linear weight: the analog weight decreases from one to zero, while the photon-counting weight increases from zero to one. Below the transition interval, the analog slope is used, and the photon-counting slope is used above it.

4) The CAMS model is used as a "reference" without its inherent uncertainties discussed.

We agree that the original presentation did not sufficiently distinguish comparison with model estimates from independent validation of the lidar measurements. We have rewritten the discussion of Fig. 6 to clarify the respective roles and limitations of the in situ observations and CAMS estimates. **(Lines 287 to 331)**

CAMS is used to compare the order of magnitude of the retrieved ozone concentrations and their vertical distribution with regional model estimates. Although the model assimilates observations, it remains subject to model errors and representativeness uncertainties, which have not been quantified for the specific profiles considered here. The revised figure now shows the mean CAMS concentrations across the four selected model times, with horizontal bars spanning their minimum and maximum values. The caption explicitly identifies these bars as temporal variability, rather than model uncertainty.

Below approximately 1 km, CAMS and the lidar profiles show broadly comparable concentration levels and an overall increase with height. Above this altitude, their vertical structures differ. In the comparisons presented in figure 6, we cannot determine the respective contributions of model limitations, sampling differences and lidar retrieval uncertainties to these discrepancies. We do not interpret the agreement with CAMS as validation of the lidar measurements. Independent, coincident vertical ozone observations remain necessary to assess retrieval accuracy.

5) Several parts of the manuscript need further analysis and discussion and support based on published papers, as explicitly explained in the annotated manuscript.

We thank the reviewer for the detailed annotations. We have revised the relevant passages to improve the explanations and bibliographic support, particularly in the introduction **(lines 71 to 90),** the discussion of retrieval uncertainties **(lines 206 to 234)**, and the interpretation of the atmospheric comparisons **(lines 291 to 300 and 303 to 331)**. We have also clarified the LICEL acquisition parameters, specifying the 12-bit analog digitization, the 7.5 m analog range sampling interval corresponding to 50 ns (20 MHz), and the 30 m photon-counting range-bin spacing **(lines 154 to 155)**. The conclusions have also been revised to clarify the scope of the demonstration and the need for independent validation **(lines 343 to 349, 357 to 363, and 373 to 384)**.

6) The Conclusions part needs improvement based on comments provided in the attached annotated manuscript.

We agree that the conclusions should more clearly reflect the scope and development stage of the instrument. We have rewritten this section **(Lines 343 to 384)** to emphasize the demonstrated contribution: the characterization and integration of a low-pulse-energy, deuterium-filled HCF Raman source into an ozone DIAL prototype, followed by the acquisition of initial atmospheric ozone profiles between approximately 400 and 1700 m. These results constitute a proof-of-concept demonstration and do not establish measurement accuracy or readiness for continuous autonomous operation.

The revised perspectives identify the development of an industrial prototype as an intermediate step towards potential network deployment. Three main objectives are discussed. First, extending the usable measurement range will require a dedicated receiver design, improved short-range overlap, and increased sensitivity at longer ranges through collection efficiency, spectral filtering and signal integration. Second, continuous operation will require extended characterization of laser lifetime, potential fiber ageing, gas retention, output-energy stability and sensitivity to temperature variations. Third, improving measurement accuracy will involve optimizing acquisition and processing to target integration times of 5 to 15 min, incorporating relevant instrumental and atmospheric corrections, and propagating their associated uncertainties.

The conclusions also identify deployment alongside an aerosol lidar as a mean to better constrain aerosol interference, and independent, coincident vertical ozone observations as a necessity to assess retrieval accuracy. These revisions distinguish the results obtained in this study from the development and validation work still required.