

The manuscript “Evaluating satellite limb measurements of nitrous oxide” by Saunders et al. provides intercomparison and validation of nitrous oxide (N₂O) with different satellite and balloon-borne measurements. This validation study serves as a prerequisite for merging N₂O into a continuous timeseries in the framework of ESA Climate Change Initiative. N₂O is an important greenhouse gas, it is a long-lived tracer and any variations in its abundance reflect changes in tropical upwelling of the Brewer-Dobson circulation (BDC).

The authors do not follow the usual structure of describing the methods first and then presenting the results. Instead, they explain the methods together with the results, dividing this discussion into two sections: the intercomparison of satellite N₂O data (Sect. 3) and their validation with balloon measurements (Sect. 4). In my opinion, the manuscript is easy to follow in its current form. However, I recommend that the authors explain this structure clearly in the last paragraph of the Introduction, where they describe the structure of the paper. Currently this explanation is very brief and does not really prepare the reader to the “unusual” structure of the manuscript. I find it useful that in both Sect. 3.1 and 4.1 the authors discuss different collocation criteria and report the results of testing different criteria. Below I provide a few additional general comments, which will be followed by more detailed comments. I recommend the paper for the major revision. However, I believe that addressing the comments below would improve the clarity of the presented analysis. The notation **P L** stands for **Page** and **Line** in the manuscript.

General comments

- Photolysis of N₂O does not produce reactive nitrogen (**P1 L17**). Most of N₂O is indeed photodissociated but only the slow oxidation with O¹D leads to production of NO and consequent reaction NO + O₃ produces NO₂ + O₂. (e.g. *Seinfeld and Pandis, 2012*; *Prather et al., 2023*, or *Krysztowiak et al., 2023* that authors already cite).
- What are the consequences of the imminent data desert described by *Salawitch et al., 2025* on N₂O? I believe a short discussion on this would strengthen the motivation of the manuscript.
- colocated or coincident? Please, choose one term and use it throughout the manuscript.
- I recommend to split Sect. 3.1 to “Sect. 3.1.1 Colocation (or coincident) criteria” and “Sect. 3.1.2 Types of figures”. Similar suggestion for Sect. 4.1.
- Why do not authors use sPV (or similar metrics) for the intercomparison of satellite profiles described in Sect. 3 and only for the validation with balloon data (Sect.4)? Would it not help to improve the intercomparison to ensure that “tested” and “comparison” dataset represent the same air mass? It should improve the results in Fig.1, 60-90N in MAM and 60-90S in SON.
- I was wondering if the authors could add the number of colocated profiles to the text or Figures or maybe any existing/new tables? Especially, taking into account that MIPAS data are treated separately based whether they are full- or reduced resolution, the number of collocations with tested instrument will be very much different. Same comment for the validation section (Sect.4): it would be great to know the number of collocations that the presented results are based on.

- Please, increase markers of the profile plots (e.g. Fig. 1, 12, 14). Also, brown and orange are very similar, maybe increasing both line width and markers will help. Otherwise please, consider another color for either of the datasets.

Detailed comments

P1 L2 "... have become available from the suite of limb-viewing satellite instruments." And what about occultation instruments? Especially since authors include one of them to analysis?

P1 L10 the two MIPAS datasets → this is confusing by the time the reader gets to Sect. 2.1.3. Maybe the following would be better: "both MIPAS scientific and operational datasets"

P2 L42 I suggest : "**Together**, these recent (*i.e.*, since 2002) satellite-based datasets comprise a continuous 23-year global record of N₂O". Otherwise the sentence gives an impression that each of the datasets is 23-years long.

P2 L44 I recommend to use "valuable" (as in the abstract) instead of "excellent".

Table 2. Why is there mean latitude for Table 1 and not for Table 2? Why is there Date/time for Table 1 and not for Table 2? The meaning of e.g. 01, n3, n3a etc. in the Sequence is not clear.

P8 L200 "*It is not reasonable to search for coincidences between six datasets simultaneously*" → please finish the thought by providing the reason why, e.g. "... because it would lead to only a few collocated measurements" or so.

P8 L 202 Regarding "tested" and "comparison" dataset → based on the style of authors' writing, it is important for the reader to understand what is tested and what is comparison dataset. However, the next sentence/paragraph on **P9 L204** starts a new discussion. The expected explanation comes only on **P9 L219**, which makes it hard to follow. Please, consider merging this text together. Would it make sense to mention that SMR is "tested" in Fig. 1? And others are "comparison" datasets. Currently Fig. 1 does not mention "tested" and "compared" terminology, I think if authors want to keep it, they should use it throughout the manuscript.

P9 L204 "All analyzed" instead of "the"

P9 L206 "" ...Supplement Information, **see S1**" or something like this (same for P10 L240). Please, add references to your Supplements.

P9 L216 "...per latitude band" → I recommend that authors introduce the latitude bands here (as they did in Sect. 4.1).

P9 L221 "are made up" (and L222) → calculated from/ are based on

also I recommend

"For other instruments" → "For each other instrument"

Fig. 1. I think adding MIPAS full-resolution and reduced-resolution on the legend would make it easier to follow the text in the manuscript. Same for Fig.2? On **P4 L117-119** the authors stated that MIPAS data are often treated separately, but unfortunately it was not clear that it is exactly what authors do too.

P10-11 While explaining Fig.2, please refer to specific panels in the text.

Fig.2. Please, unify throughout manuscript: M-ESA or MIPAS-ESA-V8 (same with IMK; same with SMR → figures legends have it labeled as Odin-SMR, see e.g. Fig. 1, caption says SMR but legend shows Odin-SMR).

P11 L299 Please, add a sentence and say that Figs.4-11 will discuss median absolute and relative biases of each instrument compared to every other instrument.

P14 L393-394 “The left panels show...” it is unclear which figures the authors are referring to.

P18 L518 “..difficulty in measuring in the upper troposphere” → upper stratosphere? Or maybe middle stratosphere?

References.

1. Seinfeld, J.H. and Pandis, S.N. (2012) Atmospheric Chemistry and Physics: From Air Pollution to Climate Change. John Wiley & Sons, Hoboken.
2. Prather, M. J., Froidevaux, L., and Livesey, N. J.: Observed changes in stratospheric circulation: decreasing lifetime of N₂O, 2005–2021, *Atmos. Chem. Phys.*, 23, 843–849, <https://doi.org/10.5194/acp-23-843-2023>, 2023.
3. Krysztofciak, G.; Catoire, V.; Dudok de Wit, T.; Kinnison, D.E.; Ravishankara, A.R.; Brocchi, V.; Atlas, E.; Bozem, H.; Commane, R.; D’Amato, F.; et al. N₂O Temporal Variability from the Middle Troposphere to the Middle Stratosphere Based on Airborne and Balloon-Borne Observations during the Period 1987–2018. *Atmosphere* 2023, 14, 585. <https://doi.org/10.3390/atmos14030585>
4. Salawitch, R. J., and Coauthors, 2025: The Imminent Data Desert: The Future of Stratospheric Monitoring in a Rapidly Changing World. *Bull. Amer. Meteor. Soc.*, 106, E540–E563, <https://doi.org/10.1175/BAMS-D-23-0281.1>.