Reviewer 1 comments (Blue Italics) and Authors Responses ("AR" Black Regular)

The manuscript by Petropavlovskikh et al. provides an overview of the current status, recent achievements and future outlook of the Network for the Detection of Atmospheric Composition Change (NDACC). About six years after the last comprehensive review of NDACC by De Maziere et al., the manuscript is a useful reference for the more recent developments, current challenges and future directions. I recommend publication in Atmos. Chem. Phys. after consideration of the following specific – mostly minor – comments.

I was surprised that the manuscript does not include a figure or table of the NDACC stations. I would encourage the authors to consider a world map with NDACC and Cooperative Networks stations included.

AR: We appreciate Reviewer 1 comments and understand the value of map for the reader. However, when considering a combined map of NDACC stations and Cooperating Network (CN) sites we found its design prohibitively complicated. Instead, we added the following sentence to the beginning of Section 2. "For an interactive map of NDACC stations see https://www.ndacc.org". We also added the following sentence to the discussion of cooperating networks in Section 2. "A list showing colocation of NDACC long-term measurement stations with those of Cooperating Networks (referenced in the table) is available in the 'Site List' of the 'Measurements and Analyses Directory' in the DATA Tab of the NDACC website."

I didn't see in the manuscript any reference to the special issue. Maybe it would make sense to point to the special issue, if this paper is meant as an introduction?

AR: We modified the sentence in line 116 to

This paper reviews NDACC achievements since the publication of De Mazière et al. (2018) and serves as an introduction to the special issue "Achievements and perspectives of the Network for the Detection of Atmospheric Composition Change after 35 years of operation".

Specific comments:

p2, l49: "11" -> "eleven"

AR: made change

p2, l56: "most of" -> "large parts of"?

AR: made change

p5, l155: reference to Appendix A either here or in line 144, but not needed twice

AR: removed the second reference in L155

p10, l254-263: I am not convinced about the information content of the introductory paragraph. The most useful information in this paragraph is that in total nearly 500 papers since 2018 have been published – clearly an important achievement. I suggest shortening the introductory paragraph to Sec. 4.

AR: “Recent achievements, described in this section, include discoveries related to both stratosphere and troposphere, synergistic collaboration with satellite observations, and advances in network infrastructure. In all endeavors, NDACC’s temporal coverage and emphasis on standardized instruments, data-processing methods and protocols, have been essential in creating the high-quality data required for quantifying chemical composition changes. Nearly 500 publications since 2018 attest to NDACC’s scientific contribution, e.g,, https://ndacc.org/publications. Highlights of stratospheric and tropospheric research appear in Sections 4.1 and Section 4.2 respectively. Although not exhaustive, the examples feature a range of scientific issues and perspectives. Section 4.3 discusses satellite collaborations and NDACC contributions to validation. Section 4.4 illustrates NDACC’s advances in instrumentation, technology and archiving infrastructure, i.e., those capabilities and practices that make NDACC a uniquely valuable resource for the global atmospheric research community.”

Revised to:

“Selected recent achievements are described in this section. These include discoveries related to both stratosphere and troposphere, synergistic collaboration with satellite observations, and advances in network infrastructure. In all endeavors, NDACC’s temporal coverage and adherence to standardized instruments, data-processing methods and protocols, have been essential in creating the high-quality data required for quantifying chemical composition changes and achieving network science goals. Nearly 500 publications since 2018 attest to NDACC’s scientific contribution, (https://ndacc.org/publications). Highlights of stratospheric and tropospheric research appear in Sections 4.1 and Section 4.2 respectively. Section 4.3 discusses satellite collaborations. Section 4.4 illustrates NDACC’s advances in instrumentation, technology and archiving infrastructure.”

p12, l304/305: “trends…compared well”: can this statement be made stronger? E.g. “NDACC data provided support for the trend detection”, or “NDACC data confirmed the in-situ trends”?

AR: “In the Ozone Assessment trends in the Jungfraujoch FTIR time series of CFC-11, CFC-12, HCFC-22, HCFC-142b, CCl4, CF4 and SF6 compared well with those derived from satellite and in situ surface data (Laube et al., 2022; Chapter 1 in WMO 2022).”

Revised to:

"In the 2022 Ozone Assessment, trends in the Jungfraujoch FTIR total column time series of CFC-11, CFC-12, HCFC-22, HCFC-142b, CCl_4, CF_4 and SF_6 support and bridge the high precision in situ data and upper troposphere observations from satellites where available (Laube et al., 2022; Chapter 1 in WMO 2022)."

p12, l313: 10°S-60°N: typo? the figure says 60°S-60°N!

AR: Changed to 60ºS - 60ºN

p14, l345: "20S"-> "20°S"

AR Changed to "20ºS"

p16, l394: "affiliated networks" -> "Cooperative Networks"?

"records from NDACC and affiliated networks for four instruments"

AR: changed to "records from NDACC and other atmospheric measurement networks"

Fig.10: Text in the figure too small to read!

AR: We increased the text in figures

p16, l411: "The HEGIFTOM-derived trends mark a turning point for the tropospheric ozone community." How? What exactly does this mean?

AR: WE modified the text

"The HEGIFTOM-derived trends mark a turning point for the tropospheric ozone community because it is the first time that a global picture of changes based on consistently processed observations from multiple ground-based instruments is available. The outcome is a definitive reference dataset for evaluating still-evolving satellite products, some of which cover fewer than 10 years (Hubert et al., TOAR-II Satellite Ozone Report, 2025). For ozone profile trends in the troposphere, there is no substitute for ozonesondes and aircraft data (Thompson et al., 2025; VanMalderen et al., 2025b)."

p17, l420: You may add, that OCS is also a tracer for CO2 uptake by the biosphere?

AR: "Carbonyl sulfide (OCS), the reservoir sulfur species in the free troposphere, is a product of anthropogenic, biogenic and oceanic emissions and the largest source of sulfur transported to the stratosphere during periods of low volcanic emissions, helping maintain the lower stratospheric sulfate aerosol layer."

Revised to:

"Carbonyl sulfide (OCS), the reservoir sulfur species in the free troposphere, is a product of anthropogenic, biogenic and oceanic emissions, a tracer for CO_2 uptake by the biosphere and the largest source of sulfur transported to the stratosphere during periods of low volcanic emissions, helping maintain the lower stratospheric sulfate aerosol layer."

Fig. 11: Please provide the station names (and maybe latitudes?) in the caption. What does the explained variance quantify? What exactly is correlated here? Please give a few more details.

AR: Caption "Fit of the annual anthropogenic emissions inventory from Zumkehr et al. (2018) to annually averaged FTIR OCS data from stations with the longest running data records. The emissions inventory is interpolated to the station location. From Hannigan et al. (2022)."

Revised to:

"Fit of the annual anthropogenic emissions inventory from Zumkehr et al. (2018) to annually averaged FTIR OCS data from stations with the longest running data records. The emissions inventory is interpolated to the station location. From Hannigan et al. (2022). TAB: Thule Air Base 76ºN, KIR: Kiruna 67ºN, ZUG: Zugspitze 47ºN, JFJ: Jungfraujoch 46ºN, IZA: Izana 28ºN, WLG: Wollongong 34ºS, LDR: Lauder 45ºS, AHS: Arrival Heights 79ºS."

L425: "Regression models and available proxies of varying time periods, attribute the varying trends in Fig. 11 are due primarily to anthropogenic emissions."

Revised to:

"They showed that regression models using available geophysical proxies of varying time periods could not adequately explain the multi-decadal OCS variability. For the longest time series through to 2012 the highest correlations to the free tropospheric NDACC time series was with the gridded, bottom up anthropogenic emissions from Zumkehr et. al., 2018. Shown in Fig. 11, between 46% to 77% of the variability can be attributed to anthropogenic sources at stations between 76ºN and 80ºS."

p17, l434: "dynamics" is jargon here. While aerosols, clouds and ozone directly affect UV radiation, it is not immediately clear how "dynamics" affect UV. Please explain or remove "dynamics".

AR: replaced “dynamics” with “other atmospheric composition changes driven by natural and anthropogenic sources, transport and atmospheric mixing”

p21, l517: “See Table A1 (Appendix B)”: do you mean Table C1 in Appendix C?

AR: “ changed to “Table C1 in Appendix C”

p22, l549: “The Global Lidar Analysis Software Suite (GLASS).” should be part of the previous sentence(?)

AR: The NDACC Lidar Working Group recently built its initial centralized lidar data processor: the Global Lidar Analysis Software Suite (GLASS).

Revised to:

The NDACC Lidar Working Group recently built its initial centralized lidar data processor: the Global Lidar Analysis Software Suite (GLASS).

p22, l561: “Like the FTIR CDPS (see below)…”: Text would flow better if this statement is moved after the CDPS discussion.

AR: ”Like the FTIR CDPS (see below) this system is also integrated within the ACTRIS Centre for Reactive Trace Remote Sensing Central Facility.”

To avoid confusion, we revised paragraph to:

AR: ”The NDACC Lidar Working Group recently made significant efforts towards the development of centralized lidar data processing. The Global Lidar Analysis Software Suite (GLASS) was initially developed to retrieve stratospheric ozone, temperature, aerosol, tropospheric ozone, and water vapor for the four NASA/JPL lidars. It was then expanded to process the raw data of more than a dozen lidar instruments contributing to NDACC, TOLNet and GRUAN (GCOS reference Upper Air Network). GLASS is used to support several NDACC-contributing stations on a routine basis and has served as a transfer standard during campaigns (e.g., the SCOOP and STOIC campaigns in 2016 and 2024 respectively). Another centralized lidar data processor was also installed at ACTRIS for the analysis of several European NDACC lidars. is integrated within the ACTRIS Centre for Reactive Trace Remote Sensing Central Facility.”

p23, l604-611: in this section on the Data Handling Facility (DHF), it is not clear if CLaMS model data (and which) are available through the DHF

AR: We removed text discussing CLaMS model data as these are not provided on the DHF website.

Section 4.4.3: Suggestion: say something about mirroring of NDACC data at other data centers

AR: We added this statement "NILU provides a mirror of the NDACC DHF and a backup of the website content."

Table C1: Please use subscripts in chemical formulas

AR: we applied the requested appropriate formatting

Reviewer 2 comments and Authors Responses
General remarks:

This paper serves as the introductory article for the ACP/AMT special issue on the achievements and perspectives of NDACC after 35 years of operation. In this context, the paper outlines NDACC's organizational structure, recent accomplishments, and its strategic response to challenges regarding resource sustainability, aging infrastructure, and data gaps. The network proposes a three-pronged strategy to modernize stations, promote data usage, and expand coverage in under-sampled regions. Furthermore, the paper reviews and updates the accomplishments of NDACC since De Mazière et al. (2018).

Both as a reference paper for NDACC and as an introduction to the ACP/AMT special issue, it is well-structured and well-written. Its content is of good to excellent quality in most technical and scientific aspects. Therefore, I recommend it for publication, albeit with some revisions.
RA: The authors are grateful to the reviewers for their insightful comments and constructive feedback.

I have a few critical remarks for revision concerning:

(i) Chapters 2 and 3 on the organizational structure of NDACC. These chapters, particularly Chapter 3, are too long and too detailed, while their scientific content is rather low. Much of this content, along with Figures 3 and 4, should be moved to an appendix.

AR: We appreciate the reviewer's perspective on the manuscript's structure. Although the "scientific content" of Sections 2 and 3 seem "low" to the reviewer, the readers of this paper need to understand and appreciate the critical strategic infrastructure and collaborative framework developed by NDACC. These aspects of NDACC are essential for addressing contemporary research questions regarding atmospheric composition changes. Section 2 provides a concise update to the foundational work of DeMaziere et al. (2018), whereas Section 3 highlights NDACC's role as a highly-valued and respected community entity. By detailing NDACC's collaboration with international bodies (WMO, UNEP) and partnerships with agencies like NASA and ESA, CEOS and ACTRIS intergovernmental groups, this section details NDACC's strategic and unique role in global atmospheric monitoring, while ensuring that ground-based observations are directly integrated into climate and Montreal protocol assessments. One of the primary NDACC roles is satellite validation. Consequently, we document why the NDACC strategy focuses on providing high-quality Fiducial Reference Measurements (FRM) characterized by traceability and documented uncertainty budgets. Because the NDACC's success is fundamentally built on these collaborations, Section 3 is vital to the core narrative and remains in the main text rather than in an Appendix. We did, however, shorten the text of Section 3 (see resubmitted manuscript).

(ii) Section 4.4, where the level of detail could be reduced, particularly in Section 4.4.3.
AR: We reduced a discussion of CLAMS model output since it is not provided through the NDACC DHF portal. We also reduced other parts of that section to improve its readability (see resubmitted manuscript).

(iii) A table and figure displaying the NDACC stations and their respective measurements is missing; as a NDACC reference paper, these should be included.

AR: We added the following sentence to the beginning of Section 2. "For an interactive map of NDACC stations see https://www.ndacc.org". A list showing NDACC long-term measurement stations is available in the 'Site List' of the 'Measurements and Analyses Directory' in the DATA Tab of the NDACC website. We do not currently have a map that can be searched for specific observation though it can be filtered by measuring instrument type. Figure 1 shows a chart of NDACC observational capabilities that lists the parameters measured by each instrument working group. Per comments from Reviewer 1 we added the following text in the paragraph describing the Cooperating networks, which will be also useful for the reader who would like to know more about measurements at each station.

"A list showing colocation of NDACC long-term measurement stations with those of Cooperating Networks (referenced in the table) is available in the 'Site List' of the 'Measurements and Analyses Directory' in the DATA Tab of the NDACC website. We do not currently show a map showing colocation with Cooperating Networks.

Minor comments:

L172: In Figure 2, the IAGOS aircraft programme is missing; it is essential for the troposphere and UTLS.

AR: The reviewer is correct about the role of IAGOS but it is not formally affiliated with NDACC as the other illustrated Programs are.

L292: The reference Millan et al., 2025 is missing.
AR: There are two relevant Millan papers from 2025. The trend results paper is meant and has been added to the Reference list.

L. Millán, P. Hoor, M. I. Hegglin, G. L. Manney, P. S. Jeffery, F. M. Weyland, T. Leblanc, K. A. Walker, H. Boenisch, D. Kunkel, I. Petropavlovskikh, H. Ye First published: 16 November 2025
https://doi.org/10.1029/2025GL118651Digital Object Identifier (DOI)

L708: Section 5.1.2.2 on "Enhancing network efficiency and expanding NDACC."

In this context, a more general discussion on NDACC-role in "Tiered Networks" or "Integrated Networks" is missing. Hereby FTIR or Brewer/Dobson could be used as examples.
AR: We have not yet identified how the NDACC fits in the WIGOS integrated network concept. Currently NDACC is the internally integrated network of remote sensing, in-situ, and satellite atmospheric composition observations and modeling tools for their interpretation. The "tiered system" might be considered within the NDACC once the recently developed (and future) mobile observational systems will be incorporated in the NDACC (i.e. SMOL, and compact FTIRs). The new set of requirements will be designed for the short and long-term data obtained with these instruments. NDACC is open to partner with other networks to discuss the needs for integration and cost-effectiveness.

L796: Section 5.2.3.4

Is NDACC anticipating "Potential Atmospheric Accumulation and Radiative Impact of the Coming Increase in Satellite Reentry Frequency", from Maloney et al, JGR, 2025 ?
AR: NDACC supports atmospheric composition monitoring and is open for the development of new data products for future research topics relevant to its mission. However, NDACC itself covers only data provided by six instrument working groups. In support of the work discussed in Maloney et al. 2025 paper, we have ozone, temperature, aerosol, water vapor profiling and total column capabilities, including from locations in the high latitude regions. In many research papers, NDACC PIs collaborate with Cooperating networks to assess atmospheric composition change from multiple observational and modeling angles. Some Cooperating Networks may respond to emerging research on "space debris."

What is missing in the paper is a section on the recent and future role of AI within NDACC and its applications…..
AR: Although AI (or machine learning) is a fast-developing tool, NDACC's primary focus is on assurance of high accuracy and high-quality observations. In the future, each Instrument Working Group (IWG) will investigate ML capabilities for creating datasets of comparable quality that could be of interest to the research community. The data archived at NDACC are open access and NDACC is working to improve its compatibility with the AI requirements.