Annual Report 2025

IAGOS

IN-SERVICE AIRCRAFT FOR A GLOBAL OBSERVING SYSTEM

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Letter from the President of IAGOS-AISBL

Dear Colleagues and Friends of IAGOS,

2025 was a successful and productive year for IAGOS. During this year, IAGOS-CORE performed a record number of flights with NOx measurements, and first studies on the feasibility of expanding IAGOS-CORE to the A350-900 were successfully finished. The further harmonisation of data products and services for the benefits of users is contributing to the WMO Global Atmospheric Watch program and the Copernicus Atmosphere Monitoring Service

IAGOS is considered the benchmark for aircraft-based humidity observations dataset for ice-supersaturated regions necessary for identifying regions of potential persistent contrails. IAGOS humidity data are used by a large number of research teams on contrail prediction, contrail detection by satellites, aviation climate impacts in general, and improved weather forecasts.

As all the years I have been involved in IAGOS since the beginning, it was and still is an exciting, demanding, and productive teamwork with all the members and partners, which is a really great pleasure and still going strong!!

Yours Sincerely
Andreas Wahner

Mission

The mission of IAGOS is to provide high quality data throughout the troposphere and lower stratosphere, and scientific expertise to understand the evolution of atmospheric composition, air quality, and climate.

Vision

IAGOS, using commercial aircraft, will be a crucial pillar of the global observing system, supporting societal needs for a greener and more sustainable future.

Version	Published	EB approval	GA approval
final	14.05.2026	20.03.2026	20.03.2026

Contents

Executive Summary

Since IAGOS was formed as an AISBL in 2014 it has been pursuing the objective of equipping 15-20 aircraft with the aim of feeding the data centre for the scientific community and operational services. This executive summary presents an overview of data, products and services provided by IAGOS which are important European contributions to the integrated global observation system monitoring the state of the Earth system and climate. It sets out how the IAGOS data has been used in regard to the UN sustainable development goals.

IAGOS in the Global Observing System

IAGOS has a central and unique role in the global observing system, providing important measurements in the vertical which surface stations do not provide, and important information in the climate-sensitive upper troposphere and lower stratosphere with a high resolution which satellites cannot acquire. We endeavour to ensure that the data are freely and easily accessible and maintain FAIR data standards. Together with ICOS and ACTRIS, the 2 other RIs from the atmospheric domain, we are working on further harmonisation of data products and services for the benefits of users. IAGOS is a contributing network to the WMO Global Atmospheric Watch program and our data are used in the daily monitoring of global air quality models via the Copernicus Atmosphere Monitoring Service which has been operational for more than six years.

With a time-series of more than 30 years, IAGOS is considered as a 'climate' dataset, for ozone and water vapour. The variability seen over this time frame is important for the ozone assessment report and the Network for the Detection of Atmospheric Composition Change, 'NDACC'.

IAGOS as benchmark for Ice-Supersaturated Regions:
IAGOS is considered the benchmark for aircraft based humidity observations with the dataset for ice-supersaturated regions necessary for identifying regions of potential persistent contrails. Presently, IAGOS humidity data are used by a large number of research teams being active in research on contrail prediction, contrail detection by satellites, aviation climate impacts in general, and improved weather forecasts.

IAGOS Operations

Technology and measurements:
There were a record number of 640 flights in 2025 with NOx, thanks to 4 IAGOS-CORE aircraft equipped with P2b instruments. The installation of the IAGOS-CARIBIC container on the A350 continues to advance with the first flight expected in 2026.

Development and Expansion:
Work continued on the next generation of the IAGOS-CARIBIC for the A350-900. First studies on the feasibility of expanding IAGOS-CORE to the A350-900 were successfully finished.

FAIR and Open Data:
ENVRI-Hub NEXT consolidates and advances the robust conceptual and technical structure established by the ENVRI-Hub to empower the ENVRI Science Cluster to provide interdisciplinary data-driven services. ENVRI-Hub NEXT will facilitate the integration of the environmental sciences community into EOSC, guided by the concept of Essential Climate Variables. ENVRINNOV will co-design, test, and validate a common Innovation Roadmap for the future development of new state-of-the-art technologies and services serving the ENVRI community. IAGOS continues to develop and improve its data management systems towards full compliance with the FAIR principles, with the long-term goal of exposing IAGOS data for interoperable use and interdisciplinary research on the ENVRI-Hub and the service catalogue of the European Open Science Cloud. The first CARIBIC services were integrated into the IRISCC visualisation tool.

Sustainability and stability:
Key to IAGOS, is the sustainability of the RI in the long-term and the stability of the data provision to ensure a long and continuous data-set for addressing climate issues. Work has begun on the miniaturisation of the ozone and carbon monoxide instruments to reduce the payload for more sustainable operation on newer generation aircraft. IAGOS is officially a data-set for climate research purposes as considered by the World Meteorological Organisation. Many of the articles cited below refer to the analysis of trends in atmospheric composition.

Sustainable Development Goals

By nature IAGOS is committed to being relevant to several of the UN sustainable development goals.

SDG 13 "Climate Action": IAGOS has provided continuous measurements of greenhouse gases and short-lived climate forcers on the global scale for more than thirty years being now recognised as a "climate" dataset. It is the continuity of measurements that enables us to assess the impact of mitigation policies and emissions protocols. IAGOS is one of the most important datasets of in-situ observations in the upper troposphere-lower stratosphere with dense and high resolution measurements. Over three decades, IAGOS has acquired the essential characteristic of adding statistical robustness to climatologies and trend analyses.

IAGOS data to understand the budget and trends of tropospheric ozone: The exploitation of IAGOS data in 2025 for the budget and trends have implications on surface ozone (linked to SDG Health). Van Malderen et al. (2025) and Thompson et al. (2025) investigated the different aspects of estimating trends of ozone as part of the TOAR II. Van Malderen validated regional trends in tropospheric ozone columns from satellites with ground based data such as IAGOS finding that pre-COVID trends are greater than post COVID trends, and Thompson looked at tropical ozone trends from IAGOS, ozonesondes and satellites. Sellitto et al (2025) used IAGOS data and an off-line radiative transfer model to estimate the radiative forcing from tropospheric ozone on decadal timesecales. Assuring that IAGOS data are of sufficient quality for trend analysis, Smit et al. (2025) compared the IAGOS-CORE and IAGOS-CARIBIC UV-photometer instruments with the dual-beam UV- Ozone PhotoMeter (OPM) of the World Calibration Center of Ozone Sondes (WCCOS) at the Forschungszentrum Jülich in an environmental simulation chamber. The WCCOS was established 30 years ago as part of the WMO-GAW measurement quality program of the global ozonesonde network. Traceability of ozone measurements from different platforms to one reference standard (OPM) is crucial work for harmonizing long-term ozone records to detect any changes of ozone in the free atmosphere.

IAGOS is important as a validation reference for climate and air-quality models and in the validation of satellite observations. Barret et al. (2025) for example used IAGOS data at 33 airports over the whole period of IAGOS operations (2008-2019) to validate IASI-A CO data. IAGOS data are an essential independent dataset for the validation of Earth System Models routinely through the daily validation of the daily forecasts from the Copernicus Atmosphere Monitoring Service (CAMS) available online. In other model evaluations, Cohen et al. (2025) used IAGOS data to evaluate the climatologies of O_3 , H_2O, CO, and NOy from 4 different models current study confirms the importance of separating the UT and the LS with a dynamical tracer for the evaluation of model results and for model intercomparisons. Lappalainen et al. (2025) discussed integrating diverse data sources, to more effectively incorporate observational data into multi-scale modeling and artificial intelligence (AI) frameworks, highlighting the need for a more integrated approach to establish a new global Ground-Based Earth Observatory. Wang et al. (2025) investigated machine learning for improvement of upper-tropospheric relative humidity in ERA5 weather model data.

Other studies have focused on transport processes near the tropopause. Seguel et al. (2025), measurements from IAGOS in the mid-latitudes (45–60° N), ozonesondes and HALO research aircraft data to analyse intra and interhemispheric differences potentially associated with sudden stratospheric warming events. Emig et al. (2025) looked at cirrus formation near the tropopause using an AIRTOSS and the IAGOS humidity sensor. In Bozem et al. (2025) the IAGOS capacitive hygrometer (ICH) was mounted in the TPC-TOSS to look at gradients around the tropopause new airborne dual platform approach for atmospheric composition measurements at the tropopause. Joppe et al. (2025) highlighted the major role of the warm conveyor belt in transporting of biomass burning aerosol into the extratropical tropopause region over Europe.

Executive Summary

SDG 9 "Industry, Innovation and Infrastructure": As an infrastructure we are implementing global standards for measuring air-quality indicators that meet the standards of the World Meteorological Organisation. We are ensuring that our data meets the FAIR criteria. ENVRI projects, ENVRI-INNOV and ENVRI-Hub -NEXT continue in 2025.

Schneider et al. (2025) described the aerosol mass spectrometer for IAGOS-CARIBIC (CARIBIC-AMS), that was developed, tested and characterized over the past years. The instrument is able to measure the mass concentration of non-refractory aerosol species, namely sulfate, nitrate, ammonium, and organics, in a particle diameter range of approximately 50 – 800 nm.

Aviation Industry: IAGOS data plays an important role in understanding and mitigating the impacts of aviation on climate and understanding the impacts of the environment on aviation. There are two main strands. One focus is on the prediction of ice-supersaturated regions and the formation and persistence of contrails where IAGOS data provide the most reliable data on upper tropospheric humidity. The other main interest is the impact of atmospheric mineral dust on aircraft engine performance and maintenance to ultimately identify and minimise economic impacts for the aviation industry in certain regions of the globe.

Konjari et al. (2025) found a good agreement between the IAGOS Capacitive Hygrometer (ICH) with CARIBIC and the ECMWF ERA-5, in the upper troposphere but that the ICH was too humid in the lower stratosphere. They correct this bias using IAGOS-CARIBIC measurements. The extensive H_2O dataset from the compact IAGOS sensor can now be used to produce highly resolved H_2O climatologies for the climatically sensitive LMS region.
Wolf et al. (2025) published a correction of the Correction of ERA5 temperature and relative humidity biases by bivariate quantile mapping for contrail formation analysis

Within the project CICONIA, Petzold et al. (2025) used the IAGOS humidity measurements to find that most long-lived contrails form within cirrus clouds with uncertain climate impact creating difficulties for contrail avoidance strategies. Arriolabengoa et al. (2025) modified the cloud scheme in Météo France's ARPEGE model to allow for supersaturation and improve the prediction of ISSRs, a good prediction of which is essential in flight planning for contrail avoidance.

SDG 3 "Good Health and Well Being": The projects RI-URBANS and ICOS cities addressed the way air quality and greenhouse gases are measured in urban areas, thus expanding the observation infrastructures developed by the RIs ACTRIS and ICOS for remote background stations to densely populated areas. Despite vast improvements in recent decades, poor air quality remains a worldwide health problem, causing many deaths every year. In addition, the air pollutants of today are different to those from 15 years ago, creating new hazards that are yet to be studied. Furthermore, the reduction of greenhouse gas emission from urbanised areas is among the major challenges of today. IAGOS contributes to both programmes by the observations of vertical distributions of trace species not accessible otherwise, during landing and take-off phases. These data are of paramount importance for improving the capabilities of local- to regional-scale models by adding vertical distribution information for model validation exercises. The projects successfully ended in 2025 with the services and the tools sustainably maintained by IAGOS for use in further and complementary projects such as IRISCC.

SDG 11 "Sustainable Cities and Communities": The projects RI-URBANS and ICOS cities addressed the way air quality and greenhouse gases are measured in urban areas, thus expanding the observation infrastructures developed by the RIs ACTRIS and ICOS for remote background stations to densely populated areas. The projects successfully ended in 2025 with the services and the tools sustainably maintained by IAGOS for use in further and complementary projects such as IRISCC.

SDG 4 "Quality Education": Many of the institutes in the IAGOS research infrastructure are dedicated to providing education and training. There are a number of Ph.D. and Masters students working directly with IAGOS data. IAGOS also contributed to a Massive Open Online Course on Research Infrastructures as part of the ATMO-ACCESS project. ATMO-ACCESS was successfully terminated in 2025 but services are maintained and improved by IAGOS.

Key Performance Indicators (KPIs)

The KPIs are based on the 10 chosen KPIs from the list of 23 proposed by ESFRI. We implemented these KPIs for the first time in 2020 and the same KPIs are reported here along with a few additional KPIs pertaining to the operations of IAGOS.

Highlights

IAGOS group meeting at KIT

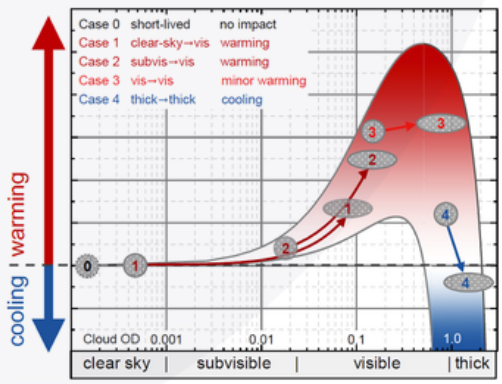
In June 2025, the IAGOS team met at the Karlsruhe Institute for Technology for a strategy meeting and visit to the IAGOS workshops where the IAGOS flying laboratory (IAGOS-CARIBIC) is being developed and constructed. The meeting was combined with talks from the related projects TPChange and OCTAV-UTLS which are important users of IAGOS data. We also had a tour of the ACTRIS AIDA chamber.

Attendees of the IAGOS workshop in KIT.

Contrails inside cirrus clouds predominate with uncertain climate impact

Radiatively impactful long-lived contrails often coincide with natural cirrus. However, the radiative and thus climate impact of those "embedded" contrail-cirrus is largely unknown. This is one of the largest sources of uncertainty when calculating the climate impact of global aviation. Based on more than seven years of routine in-situ humidity measurements on IAGOS passenger aircraft combined with cloud information from global weather models, Petzold et al. (2025) provides for the first time an observation-based, robust analysis of the fraction of contrails forming in clear sky and inside subvisible and visible cirrus clouds. Further, the paper discusses that the climate impact of visible cirrus, which covers about three quarters of the area of potential contrail cirrus formation, is only weak, see figure below . The novel findings of this IAGOS study likely have a strong impact on the debate on flight rerouting and are expected to trigger in-depth model studies on the climate effects of contrails placed in existing ice clouds in contrast to producing them in a cloudless blue sky.

Photo: Jülich, October 2022 by A. Petzold



Petzold et al., Nat Commun, 16, 9695, 2025.

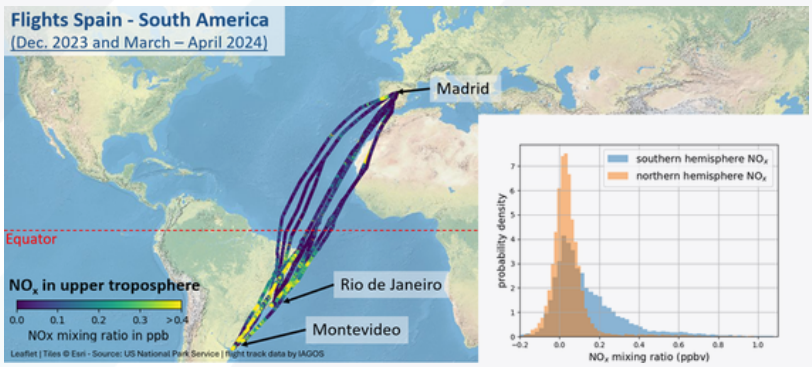
Expected climate effects of contrails forming in different environments in terms of warming and cooling: the left panel shows the schematic impact scheme from Petzold et al. (2025), whereas the right panel illustrates the cases using a photograph of A. Petzold of long-lived contrails over Jülich, Germany.

Upper tropospheric NOx across the ITCZ

Since 2023, an IAGOS-CORE NOx instrument (Package 2b) has been installed aboard an IBERIA Airbus A330-200. Based in Madrid (Spain), this IAGOS-CORE aircraft primarily covers routes to Central and South America, and also to North America.

Between December 2023 and the first half of April 2024 significant enhancements of upper tropospheric NOx were observed by IAGOS south of the Intertropical Convergence Zone (ITCZ), along the east coast and over the east mainland of South America. These elevated NOx observations were correlated with enhanced CO mixing ratios.

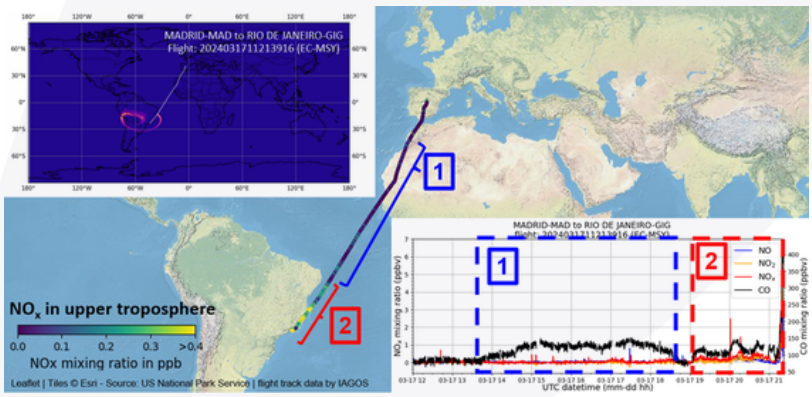
The analysis of the anthropogenic CO source attribution by SOFT-IO and the underlying FLEXPART trajectory data shows the separation of the air masses south and north of the ITCZ. The back trajectories also showed that these air masses were transported over the South American continent for multiple days allowing for an enrichment of NOx and CO in the upper troposphere by lightning and convectively uplifted and polluted boundary layer, affected by anthropogenic emissions and biomass burning.



IAGOS-CORE flight tracks between Madrid and Rio de Janeiro as well as Montevideo (Dec. 2023 and March – April 2024), color-coded by the NOx mixing ratio in the upper troposphere. Right panel: Histograms of the observed NOx mixing ratio on the southern (blue) and northern (orange) hemisphere.

No more significant enhancements of upper tropospheric NOx were observed close to the South American continent in the second half of April 2024. This goes in hand with intrusions of air from North and Central America in this region and generally shorter residence times of the air masses over the continent.

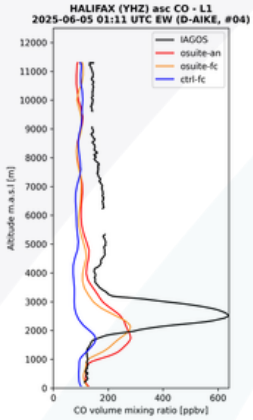
Additional data from 2025 will be included in this analysis, covering the entire southern hemispheric autumn, winter, and early spring.



Map with the flight track of IAGOS-CORE flight 2024031711213916 from Madrid to Rio de Janeiro, color-coded by the NOx mixing ratio in the upper troposphere. Upper left panel: FLEXPART back trajectory data along the flight track. Lower right panel: Timeseries of the NO (blue), NO2 (orange), NOx (red), and CO (black) mixing ratios observed during the flight.

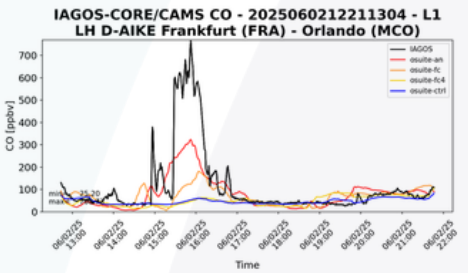
Canada's Wildfire Season 2025

In 2025, Canada recorded its second-highest annual total of carbon emissions from wildfires since the start of the fire emissions dataset established by the Copernicus Atmosphere Monitoring Service in 2003. Canada's wildfire season started particularly early with nearly 3.2 million hectares of forest burnt across Saskatchewen and Manitoba by early June. Degradations in air-quality due to these mega-fires were detected by measurement networks, including IAGOS, at local and continental scale. The figure (right) shows a large peak in carbon monoxide over Halifax on 5th June 2025. The IAGOS measurements (In black) are compared with the CAMS forecast with and without assimilation (yellow and blue respectively) and the CAMS analysis (red).

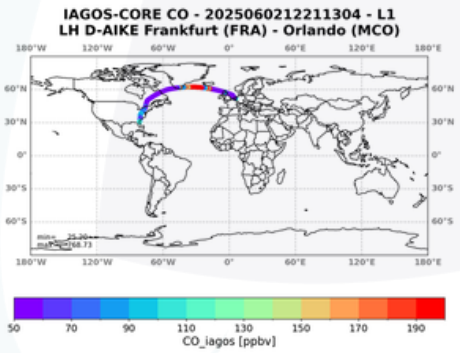


IAGOS profile at Halifax (black) with the 3 CAMS model simulations.

Smoke plumes from these Canadian mega-fires were also detected at cruise altitude over the Atlantic Ocean on a flight from Frankfurt to Orlando on 2nd June 2025.

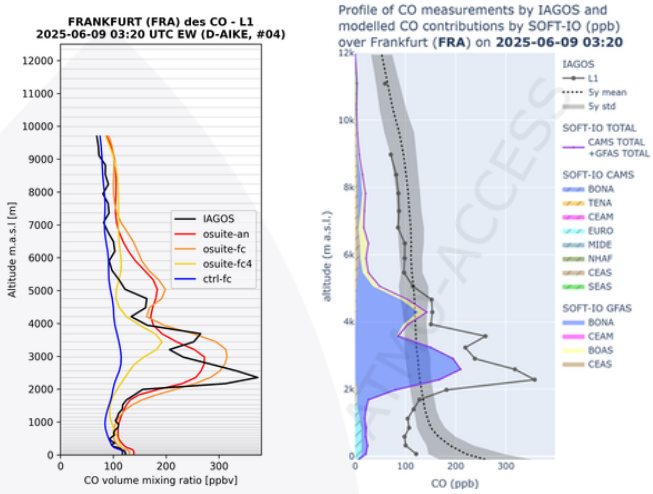


IAGOS flight from Frankfurt to Orlando (black) with the 3 CAMS model simulations.



IAGOS flight from Frankfurt to Orlando coloured by mixing ratio of carmon monoxide.

The smoke plume then arrived in Europe and was detected at Frankfurt on 9th June (below left) . The origin of the anomaly in CO, was confirmed by the ATMO-ACCESS footprint tool (below right). The blue shading confirms the provenance of the airmass as wildfire emissions from the region of Boral North America (BONA).

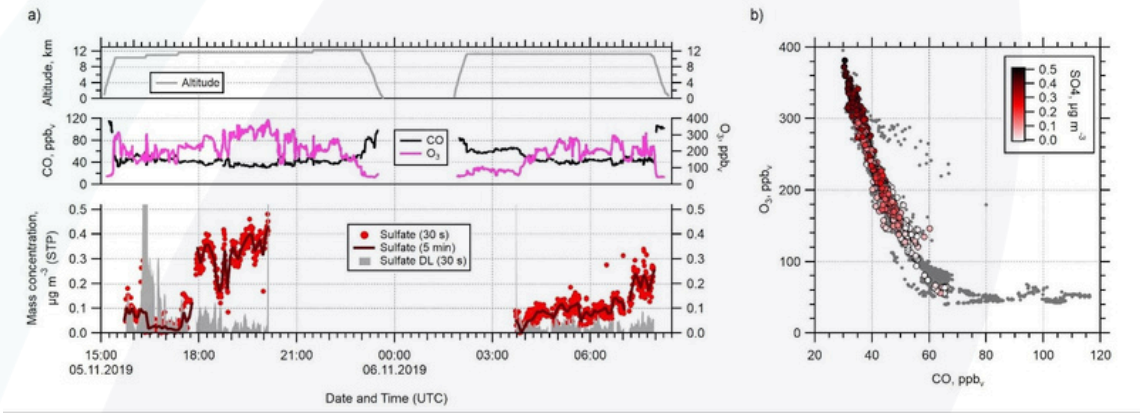


(left) IAGOS profile at Frankfurt (black) with the 3 CAMS model simulations and (right), IAGOS profile of CO with provenance indicated by the ATMO-ACCESS foorpront tool.

The observations from the various European Research Infrastructures were combined to produce a short article which illustrates the advantage in the cooperation of the environmental RIs.
https://www.insu.cnrs.fr/fr/cnrsinfo/megas-feux-canadiens-les-infrastructures-de-recherche-oeuvrent-de-concert

Design and characterization of an aerosol mass spectrometer for IAGOS-CARIBIC

The aerosol mass spectrometer for IAGOS-CARIBIC (CARIBIC-AMS), was developed, tested and characterized over the past years. The instrument is able to measure the mass concentration of non-refractory aerosol species, namely sulfate, nitrate, ammonium, and organics, in a particle diameter range of approximately 50 – 800 nm. The main challenge for the integration into the IAGOS-CARIBIC container-laboratory was the mechanical and electrical redesign of a commercial instrument in order to comply with the operating and safety requirements in the container-laboratory before and during flight. In the container-laboratory, the instrument has to operate fully autonomously, typically during four consecutive long-haul flights of 10 h. The CARIBIC-AMS weighs 74 kg, has a volume of 0.16 m^3, and consumes 360 W of electrical power during regular operation. Due to the short time for evacuation of the vacuum chamber to sufficiently low pressures before measurement, etection limits are higher during regular flights than during ground operation and were determined to be 0.035 μgm^3 for sulfate, 0.05 μgm^3 for nitrate, 0.69 μgm^3 for organics, 0.38 μgm^3 for ammonium, and 0.022 μgm^3 for chloride (all at STP), for a time resolution of 30 s. These values represent typical averages under flight conditions. Since the IAGOS-CARIBIC project aims for climatological, regular, long-term data, longer data averaging times are possible, thereby lowering the detection limits by the square root of the number of averaged data points. Data validation, calibration, and instrument characterization were conducted by means of laboratory-based comparisons with existing established aerosol mass spectrometers. The CARIBIC-AMS was operated in the IAGOS-CARIBIC container-laboratory from May 2018 until March 2020, when the Lufthansa Airbus A3400-600 was taken out of service. In June 2024, it was operated onboard a Learjet during the TPEx (Tropopause Composition Gradients and Small-scale Mixing Experiment) field campaign over northern Europe.



Time series of CO, O_3 , and particulate sulfate from IAGOS-CARIBIC flights FL578 and FL579, conducted on 5 and 6 November 2019, between Munich and Boston.

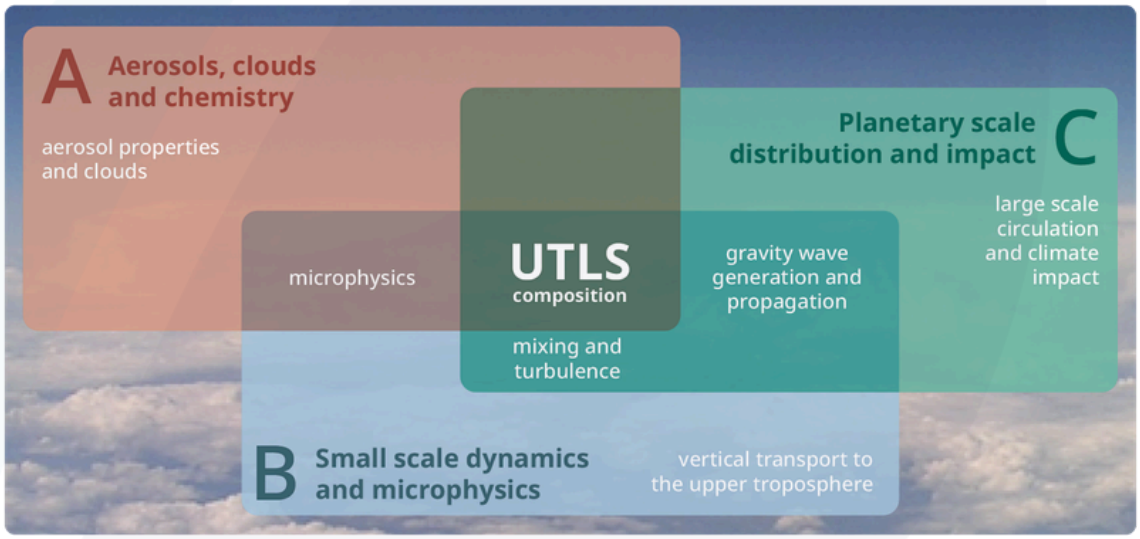
New and Forthcoming Projects

TPChange

The first phase of the Collaborative Research Center (CRC) under the name of "TPChange" (The Tropopause Region in a Changing Atmosphere, https://tpchange.de/) started in Germany in July 2021 and has now been renewed in a second phase, running from 01. 01. 2026 until 30. 06. 2029. In the Collaborative Research Centre TPChange, UTLS processes and their feedbacks in climate models will be studied by a combination of field measurements, laboratory studies, theoretical approaches, and multiscale numerical modelling. Based on an improved understanding of relevant processes at different scales, TPChange will develop parameterizations to improve state-of-the-art climate models. The goal is to specify the impact of UTLS processes on composition, dynamics and ultimately on future climate and climate variability. The research areas dedicated to the upper troposphere/lower stratosphere (UTLS) cover aerosols, clouds and chemistry, small scale dynamics and microphysics and planetary scale distribution and impact.

There are 7 partner institutes across Germany of which MPIC, FZJ and DLR are also members of IAGOS and others are connected to IAGOS via their instruments planned for the IAGOS-CARIBIC container. Long-term global UTLS data sets such as IAGOS-CORE and IAGOS-CARIBIC are extremely important for the work of TPChange. Therefore numerous projects will directly include IAGOS data for modelling studies or for extensive analysis and comparison with their own experimental data. Several researchers active in IAGOS are also active as principal investigators or project partners in TPChange (e.g., Johannes Schneider, MPIC; Heiko Bozem, JGU; Andreas Petzold, FZJ; Ulrich Bundke, FZJ; Susanne Rohs, FZJ; Yun Li, FZJ; Harald Boenisch, KIT).

TP CHANGE



The different and overlapping topics covered in TPChange.

CICONIA MET

CICONIA MET is the next phase in the SESAR project CICONIA which began in 2023 and is co-ordinated again by Airbus. The objective is to develop meteorological and climate services for Airlines, Air Navigation Service Providers (ANSPs) and Network Managers which aim to improve flight safety and efficiency through enhancing mitigation actions for adverse weather conditions (convection, icing, turbulence) and reducing aviation's environmental impact. These two services are supporting the optimisation of the trajectory in regards to climate and weather effects. CICONIA MET makes use of existing and next generation aircraft sensor outputs as well as datalink infrastructure which can feed recently developed weather and climate forecast models. After sharing sensor data with ground services, the dataset can be enriched with alternative ground sensor data and consumed by weather and climate forecast models. The results can then be shared through various links with end users to apply the services. The project will design the service and data architecture, define interfaces and support the standardization activities to facilitate follow on services. The results will be validated in lab-based exercises as well as flight tests.

ATMO-SERV

ATMO-SERV was submitted in 2025 and will begin in summer 2026. ATMO-SERV brings together all the European atmospheric Research Infrastructures (RIs) – ACTRIS, ICOS, IAGOS, EISCAT_3D and SIOS complemented by the ARISE and ASCENT networks, the health-focused EIRENE RI, and international access providers in South Africa, India, Lebanon, Brazil and the USA. For the first time, this unique consortium integrates the full spectrum of atmospheric observations, from the Earth's surface to the upper atmosphere, as well as the human exposure research, addressing the intertwined challenges of climate change, air quality, extreme events and health impacts. Users will benefit from integrated, interoperable and FAIR services spanning simulation chambers, airborne facilities, observation networks, laboratories, data repositories and digital tools. ATMO-SERV targets knowledge gaps in chemical mechanisms, atmospheric layers and their coupling, and exposure pathways that underpin climate and health assessments – specifically in (1) chemistry of emissions; (2) aerosol formation, multiphase processes, and aerosol-cloud precipitation interactions; (3) atmospheric dynamics and chemistry at interfaces between atmospheric layers; and (4) air pollution, exposome and human health linkages.

EOSC MESH

The EOSC Mesh project (HORIZON-INFRA-2025-01), funded with €9.5 million, marks a strategic transition for the European Open Science Cloud into a distributed "system of systems." A central pillar of this new architecture is the ENVRI EOSC Node, which serves as the formal thematic entry point for the environmental science cluster. This Node provides coherent, interoperable access to high-quality in-situ observational data across the atmospheric, marine, terrestrial, and solid Earth domains.

It is essential to distinguish between the ENVRI-Hub and the newly established ENVRI Node. The ENVRI-Hub acts as the technical integration layer and gateway, offering mature services developed through successive projects like ENVRI-FAIR and ENVRI-HUB NEXT. The ENVRI Node is the operational entity that federates these assets—specifically the Catalogue of Services (CoS) and the LLM-enabled Knowledge Base (KB)—into the EOSC Federation. IAGOS AISBL, participating through Forschungszentrum Jülich (FZJ), holds a pivotal leadership role by contributing the Technical Director for the ENVRI-Hub, overseeing the technical evolution and integration of these federating capabilities into the EOSC Mesh.

The Node launches with five mature Research Infrastructures (RIs)—ACTRIS ERIC, IAGOS, LifeWatch, SIOS, and EPOS—and includes a scalable framework for onboarding further ENVRI members. Other key partners in the consortium include EMSO ERIC, NILU, DataTerra, and CMCC (via the GlobalCoast initiative). These participants collaborate on cross-node use cases, such as analyzing the environmental impact of volcanic eruptions and coastal ocean events, which require the orchestration of thematic, generic, and core EOSC services.

The ENVRI cluster has formally applied to join the second wave of the EOSC Association, moving from the "Build-up" phase to full operational status. While the project budget supports the initial technical integration and the alignment with EOSC core capabilities (such as AAI and PID services), the long-term sustainability of the Node will be guaranteed by a self-financing model managed by the participating RIs. This ensures that authoritative environmental data remains a permanent, FAIR-aligned resource for the global research community and policy-makers addressing the European Green Deal.

Organisation

IAGOS-AISBL

IAGOS is organised as an International not-for-profit Association (AISBL) with its seat in Brussels.
Members of IAGOS-AISBL are:

Forschungszentrum Jülich GmbH
Jülich, Germany (FZJ)

Centre National de la Recherche Scientifique
Paris, France (CNRS)

Max-Planck Gesellschaft zur Förderung der Wissenschaften e.V.
München, Germany (MPG)

Météo France
Toulouse, France (MF)

The University of Manchester
Manchester, United Kingdom (UMAN)

Deutsches Zentrum für Luft- und Raumfahrt e.V.
Köln, Germany (DLR)

Leibniz-Institut für Troposphärenforschung e.V.
Leipzig, Germany (TROPOS)

Karlsruher Institut für Technologie
Karlsruhe, Germany (KIT)

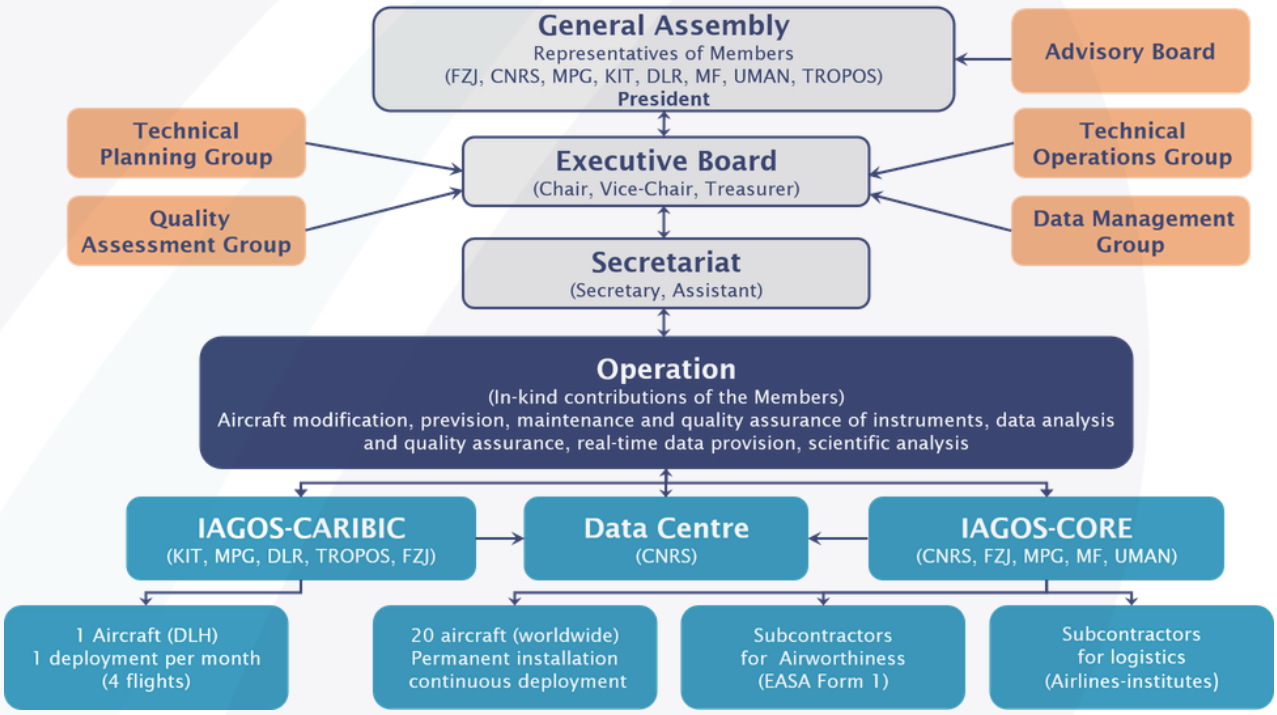
Activities of IAGOS-AISBL

The activities of IAGOS-AISBL are twofold (Statutes are available for download at http://www.iagos.org):

- Activities conducted by the organs of the Association
- Coordination of the technical and scientific activities carried out by the Members from their own resources.

The governance structure of the Association is shown below. The General Assembly (GA) is the highest decision making body. It is composed of the representatives of the Members and is chaired by the President, Andreas Wahner, representative of FZJ. Jean-Marie Flaud, representative of CNRS, serves as Vice-President.

The daily management is conducted by the Executive Board (EB). It is composed of Martin Gallagher, Andreas Petzold (Treasurer), Valerie Thouret (Chair), Andreas Zahn (Vice-Chair) , Christoph Gerbig and Hannah Clark (Executive Secretary).



An Advisory Board (AB) regularly reviews the progress made and gives advice to the Members of IAGOS-ASBL for future development and strategic orientation of the IAGOS research infrastructure in the global landscape. The members of the AB are: Jonathan Preist, Airbus, Toulouse (Chair); Owen Cooper NOAA, USA; Volker Grewe, DLR Germany, and Delft University of Technology, The Netherlands; Gelsomina Pappalardo, CNR, Italy; Vincent-Henri Peuch, ECMWF, Germany; Cyril Crevoisier, LMD, France.

The Technical Planning group and Technical Operations Group oversee the technical operation and development of the infrastructure. The TOG works closely with the aeronautical subcontractors and the associated airlines. In 2024, these were: Deutsche Lufthansa, Air France, China Airlines, Cathay Pacific, Hawaiian Airlines, Air Canada, and Iberia (see pictures below for details of the aircraft involved). The Quality Assessment Group (QAG) is in charge of the quality assurance and quality control of the data transferred to the data centre and the Data Management Group (DMG) is concerned with the data transmission chains and the evolution of the data centre.

For more information and statutes see www.iagos.org.

Activities of the Association

Executive Board

Activities of the Association included four meetings of the Executive Board, two meetings of the General Assembly, one meeting of the Advisory Board, and 2 Meetings of the Technical Planning Group.

13 January 2025
(5 EB members, P, ES)

- Status of Operations and Planning
- Preparation of the March GA
- Group Meeting KIT
- Plans for new members
- CAMS-IAGOS contract

12 February 2025
5 EB members, ES

- Agenda of the next GA
- Preparation of the KIT meeting
- News on new members

10 April 2025
(5 EB members, ES)

- Preparation of the KIT meeting
- NDACC conference participation and abstract
- Upcoming ESFRI meetings
- INFRA-SERV call summary

19 September 2025
(5 EB members, P, VP, ES)

- Preparation of the 22nd GA
- Preparation of the AB MeetingComposition of the EB
- CAMS contract update
- Regular science zooms and user forum
- Users' and annual meeting
- Preparation of the 24th GA
- Preparation of the AB Meeting
- Executive Secretary Activities

General Assembly

26 March 2025

- Report from TPG Chair
- Report from TOG Chair
- Current status of IAGOS-CARIBIC
- Current status of IAGOS-CORE on A350
- Reports from DMG and QAG
- Agenda for annual meeting
- Approval of the Activity Plan and Implementation plan for 2025
- Updates on projects and funding
- Decision on threshold for voting rights
- Approval of the Budget for 2024
- Report of Executive Secretary
- Approval of the Annual Report for 2024

19 November 2025

- Report on Operations and Planning
- Report from IAGOS-CARIBIC
- Report from Advisory Board Chair
- Report from Executive Board Chair
- Exoneration of the EB
- Election of new EB members
- Approval of the draft budget for 2026
- Approval of the Activity Plan for 2026, pending availability of Members' resources (to be confirmed in spring 2026)
- Report on activities on EU projects

Technical Planning Group

26 March 2025 - TPG presentation to GA

- Current aircraft operations
- Package 2 strategy and planning
- Airbus Aircraft: A350 MSN001, Beluga XL

29 November 2025 – TPG presentation to GA

- Current aircraft operations
- Package 2 strategy and planning
- Airbus Aircraft: A350 MSN001, Beluga XL

Advisory Board

18 November 2025

- Review of progress and planning
- Review of actions in response to recommendations made at last meeting
- Renewing and extending the fleet
- Tracking data delivery
- Project map
- Value to Users
- IAGOS Purpose

Technical Operations Group

Teleconferences

(01.2025, 09.2025, 11.2025
The teleconferences cover the same five topics with additional points discussed when necessary.

1. Status of IAGOS-CORE operations P1, ICH, BCP, P2b, P2d on A340/330 aircraft
2. Status of Maintenance Centre Operations
3. Status of IAGOS-CARIBIC Operations
4. Certification Activities
5. Status of aircraft installations

Activities of Members under Coordination of IAGOS-AISBL

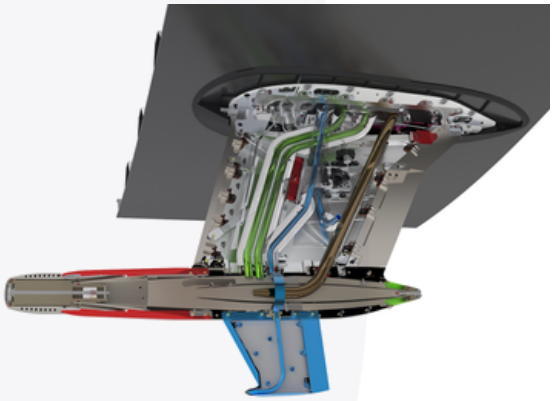
IAGOS-CARIBIC

AIRBUS A350-900 "Erfurt" (D-AIXJ) with the new air inlet, installed at Lufthansa Technik Munich in March 2023 for a test flight (top) and the logos of all IAGOS-AISBL members, scientific and commercial partners involved in the CARIBIC@A350 project (bottom).

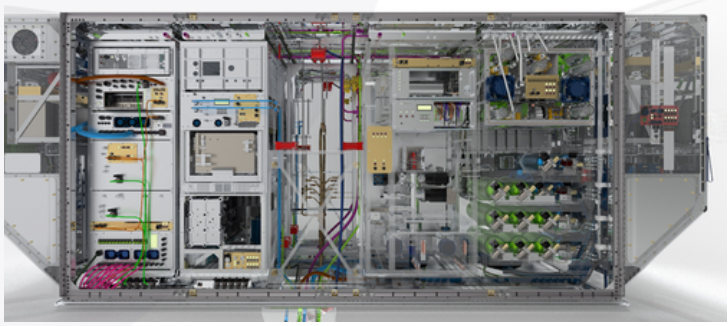
After the premature phase-out of the IAGOS-CARIBIC A340-600 aircraft in April 2020 due to the COVID-19 pandemic, the modification of the Lufthansa AIRBUS A350-900 "Erfurt" (D-AIXJ) has been started to operate the new IAGOS-CARIBIC container laboratory. It is a heavily modified air cargo container (LD6 with additional "ears" on the sides) that is equipped with state-of-the art instrumentation for in-situ measurements of trace gases and aerosol particles and for the collection of whole air and aerosol samples. The figure (right) shows a CAD view of the actual design with 16 considered instruments.

On the A350, many improvements and new features are realized such as the standardised certification of scientific instrumentation to strongly accelerate the integration of new instruments (at a moderate price), the installation of new instruments the integration of a new low-turbulent multi-function air inlet system (Figure below) for aerosol particles of up to 10 microns, for cloud particles, and for the high-frequency measurement of temperature and pressure and the satellite-based uplink of real-time measurement data to a ground-station.

The IAGOS-CARIBIC operation is discontinuous with in total about 500 flight hours per year. The number of consecutive flights per deployment can be extended from 4 to 8. Various delays (first as a consequence of the COVID pandemic and following economic dislocations and as of 2023 due to limited access to the EASA flight authorities, see also below) led to a strongly delayed restart of IAGOS-CARIBIC operation, now foreseen in late 2026.



New multi-function air inlet system for aerosol particles (red front part), cloud particles (blue fin), trace gases (green tubes) and a modified Rosemount system for temperature and pressure sensing.



CAD drawing (partially transparent) of the new CARIBIC laboratory (width x height x depth = 406 x 162 x 153 cm, total weight: ~2.0 t), with the gas cylinder rack (right) and parts of the safety, communication and ventilation systems in the side compartments. The electrical and pneumatic connection to the A350 systems and the air inlet system occurs through the floor breakthrough in the middle section.

Activities 2025

The decision of the EASA in January 2024 to certify the container as part of the aircraft (and not as an "active" freight as before) caused a massively aggravated design, production, documentation and certification effort with a further time delay of at least 18 months.

In 2025, the safety concept could be finalized, including ground and laboratory tests with the presence of EASA experts at the airport Munich and at ACC Columbia (Schwelm, Germany). The parallel, the technical modifications of the instruments required for the strongly aggravated certification are implemented, e.g. the adaptation to the new supply voltage of 270 VDC or the implementation of various safety relevant requirements (e.g. regarding thermal fuses, flammable materials or fixation of heavier components above ~2 kg).

Following the time plan agreed during the CARIBIC Annual Meeting in September 2024, the preparation of certification documents for most instruments has been started by the instrument PIs with the support of KIT.

The 12 CARIBIC partners from Europe (Germany, Ireland, France) and the US modified existing instruments and developed/assembled new instruments, see table below.

#	Instrum.	Institutions	Species / Parameters	type	parameter	new	Status
1	CO	KIT	CO	in-situ	trace gas		
2	O3	KIT	O_3 (0.25 Hz and 5 Hz)	in-situ	trace gas		
3	PTRMS	KIT	VOCs (~5/min)	in-situ	trace gas		delayed
4	UMAQS	Uni Mainz & KIT	N_2O, CH_4, CO, C_2H_6	in-situ	trace gas	new	delayed
5	VOCUS	MPI-C, KIT	VOCs (>20/sec)	in-situ	trace gas	new	delayed
6	Picarro	MPI-BGC	CO_2, CH_4	in-situ	trace gas		
7	CARDINO	Uni Cork, NOAA, KIT	NO_2, NO_3, N_2O_5, O_3	in-situ	trace gas	new	
8	FunMass	FZJ (ICE-4)	SO_2, HCN, some acids	in-situ	trace gas	new	
9	HIRES	Uni Frankfurt	N_2O, CH_4, CO_2, SF_6, NMHC, HCs	lab	trace gas		
10	WIBS	MPI-C	bacteria, fungi, pollen	in-situ	aerosol		
11	SP2	MPI-C	soot	in-situ	aerosol		
12	AMS	MPI-C & TROPOS	aerosol composition	in-situ	aerosol		
13	OPSS	TROPOS	aerosol size distribution	in-situ	aerosol		delayed
14	Core-slot1	FZJ (ICE-3)	aerosol particle number & size distribution (organic/inorganic) (package 2c)	in-situ	aerosol		delayed
15	Core-slot2	FZJ (ICE-3)	aerosol particle number & size distribution & extinction + NO_2 (package 2e)	in-situ	aerosol	new	
16	PNC	TROPOS	aerosol particle number concentration	in-situ	aerosol	new	delayed
17	HERA	TROPOS	ice nuclei	lab	aerosol	new	delayed
18	H2O	KIT	H_2O, cloud water/ice content	in-situ	water / cloud		
19	OFCEAS	Uni Grenoble, KIT	H/D, $^{16}O/^{18}O$ in H_2O and clouds	in-situ	water / cloud	new	

table 1. Instrumentation of the new IAGOS-CARIBIC payload on the Lufthansa Airbus A350. Some instruments will be integrated delayed (last column). Eight new instruments are planned (second last column).

A significant part of the work at KIT was dedicated to the airworthiness certification of the CARIBIC-Lab (STC Step 3). In collaboration with the involved companies, particularly enviscope, Lufthansa Technik, Lufthansa, Safran, ACC Columbia, Apsys and Dynatec, the design data and documentation required for certification were produced, and the necessary laboratory and ground tests were planned and carried out.

KIT coordinated and operated IAGOS-CARIBIC from April 2015, until March 2020 on the Lufthansa Airbus A340-600 "Leverkusen" (D-AIHE). Since then, KIT put all efforts into bringing the next generation of IAGOS-CARIBIC on the new Lufthansa Airbus A350-900, see description above.

Furthermore, KIT is responsible for four instruments (for O_3, H_2O, cloud water/ice, and organic compounds, VOCs) and is currently involved in the development of another three instruments (see table), e.g. a dual quantum cascade laser system by Aerodyne Research that allows high precision and high frequency (>1 Hz) measurements of N_2O, CH_4, CO and C_2H_6 (together with the university Mainz) or a two-channel laser spectrometer (OF-CEAS) for the stable isotopologues in water vapour and cloud particles (together with the university Grenoble). All data are of high relevance for the new German DFG funded Collaborative Research Centre "TPChange" (The Tropopause Region in a Changing Atmosphere) in which several IAGOS researchers are involved.

MPIC operates an aerosol mass spectrometer (CARIBIC-AMS) in collaboration with TROPOS, a single particle soot photometer (SP2) and a bio-aerosol analyser (WIBS). The CARIBIC-AMS, the SP2 and the WIBS had to be modified by MPIC for the new A350 platform. For this, modifications of the flow systems and power supplies of the instruments were necessary. These modifications are nearly completed. MPIC is part of the DFG-funded Collaborative Research Center "TPChange", which passed the evaluation in September 2025 successfully and was extended by the DFG into the second phase, lasting until June 30, 2029.

In addition to the work on the modification of the instruments, MPIC maintained a GC system for N-and S-containing species that is used to measure the altogether 88 air samples collected by HIRES during one flight sequence. In collaboration with Goethe University Frankfurt (GUF), a second HIRES flask sampling unit has been constructed to increase the number of laboratory analyses that can be performed between flights. In addition, the construction of a new, redesigned pump and control unit for the flask sampling system is in progress. This has become necessary for future use onboard the A350. At GUF, regular analysis of samples for halogenated trace gases will be performed. The air sampling system was operated jointly with MPIC until 2025, after which MPIC ended its involvement in the HIRES system and GUF took over the system completely. GUF is also a partner of the Collaborative Research Center "TPChange", where IAGOS-CARIBIC data are a central part of the university's contribution.

DLR was responsible for the operation of the NOy instrument (Table 1, #14) measuring nitrogen oxide (NO) and total odd nitrogen (NOy) in the CARIBIC Container-Lab. The data gained on the Airbus A340-600 until it was taken out of service in April 2020 was evaluated and made available for the database.
Following a decision by the management of the DLR Institute of Atmospheric Physics, further operation of the nitrogen oxide sensor for IAGOS-CARIBIC will not be pursued. There are plans to measure hydrogen in co-operation with other partners in the future. However, there are no finalised plans or valid agreements as yet.

TROPOS is planning for instruments measuring the number concentration of small aerosol particles (PNC), the particle size distribution (OPSS) and (in cooperation with MPI-C) the chemical particle composition (AMS) (see Table 1). In the first step, TROPOS has started to modify the OPSS instrument for the transfer to the A350. Therefore, work on a new data acquisition system was done. In parallel, a new housing and new sensors were purchased and tested.

FZJ-CARIBIC is responsible for the two IAGOS-CORE instrument slots in the new A350 Container-Lab. Foreseen instruments will jointly measure key aerosol parameters, such as particle number concentration for total aerosol and non-volatile particles as indicator for the mixing status of the aerosol, particle size distribution , and aerosol extinction coefficients as a proxy for aerosol mass concentration. In addition, NO_2 will be measured by this "IAGOS AirQuality" instrument. Both instruments have been fully tested in the laboratory and await installation. On top of this, FZJ will bring in a new highly sophisticated aircraft mass spectrometer instrument (FunMass). FunMass has been previously deployed on research aircraft and it is now modified for the deployment in the CARIBIC Container-Lab. FunMass is a very versatile instrument (Table 1) that can measure many reactive trace gases, and that will fill a long-lasting observational gap in CARIBIC – SO_2measurements.

MPI-BGC-CARIBIC is responsible for the Picarro CRDS carbon dioxide and methane measurement system. MPI-BGC has continued implementing the modification of the instrument for the changeover to the A350 platform. These modifications are mainly related to the new power supply (270 VDC), communication and front plate connector standards in the new Container-Lab. Final design decisions have been made, ready for manufacturing of the new front plate.

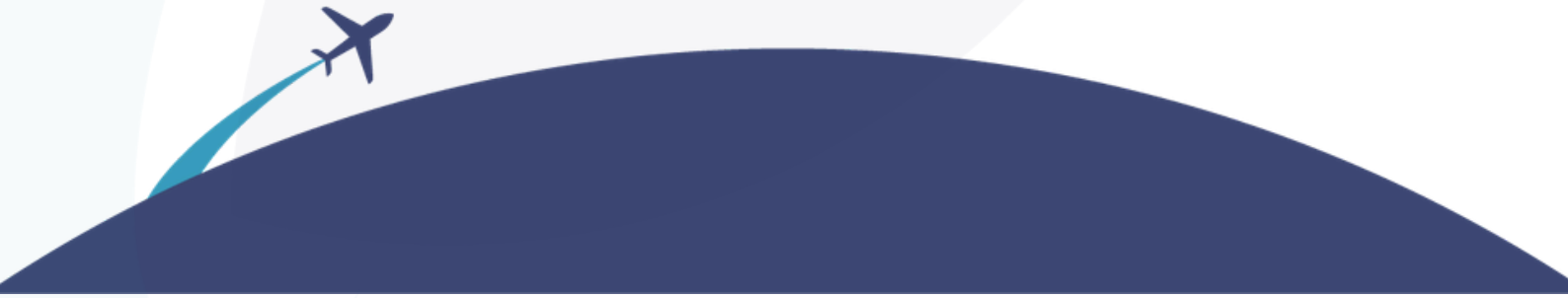
IAGOS-CORE

IAGOS cooperates with several airlines for quasi-continuous measurements of trace gases, aerosol and cloud particles from a fleet of long-haul passenger aircraft. Each aircraft carries the IAGOS-CORE rack with provisions for installing fully automated instruments measuring ozone, carbon monoxide, humidity and cloud particles (denoted P1), and provisions for installing a second instrument package (denoted P2) for measurements of nitrogen oxides (P2b), greenhouse gases (P2d) or air quality proxies such as NO_2 and aerosol parameters (P2e). A special plate with dedicated inlet probes for the different instruments is mounted on the fuselage in the vicinity of the rack. The ten aircraft shown (next page) are currently all equipped with the IAGOS-CORE Rack and P1. Package P2b is flying on Deutsche Lufthansa D-AIGT, China Airlines B-18316 and Iberia EC-MSY, a fourth instrument is scheduled for installation on Air France F-GZCO in early 2025. Two Package P2d are flying on Deutsche Lufthansa D-AIKO and on China Airlines B-18317. Package P2e is scheduled for its first installation on Deutsche Lufthansa D-AIKE.

Instrumentation

Installation and operation on commercial aircraft requires that IAGOS instruments are fully compliant with design standards, safety regulations, and quality management of civil aviation. The aircraft modification has been approved by the European Aviation Safety Agency (EASA) as a Supplemental Type Certificate (STC), which was issued in 2011 for A340 and in 2013 for A330 aircraft. For installation in countries outside the EU, the EASA-STC has to be adopted by the national authorities responsible for the airline of concern. This process was successfully completed in 2012 for Taiwan (China Airlines), in 2013 for Hong Kong (Cathay Pacific), and in 2018 for the USA (Hawaiian Airlines). Each new aircraft to be equipped with the IAGOS modification must be investigated for compliance with the technical requirements of the IAGOS installation in terms of structure, electrical load and safety.

The P2b and the P2d instruments are certified by EASA-STC whereas P2e is certified as Minor Change. The extension of this EASA - STC has been successfully managed for CAA to prepare the operation on China Airlines aircraft. The transfer of the P2 STC to other non-European authorities (e.g., FAA) is in preparation, such that finally the instruments can be installed successively on all IAGOS-CORE aircraft.



IAGOS-CORE Fleet in 2025.

Activities 2025

The Members involved in IAGOS-CORE, Forschungszentrum Jülich (**FZJ**), Centre National de la Recherche Scientifique (**CNRS**), Max-Planck Gesellschaft zur Förderung der Wissenschaften (**MPG**), Météo France (**MF**), and The University of Manchester (**UMAN**), concluded the following tasks:

FZJ acts together with CNRS as one of the leading institutions in operating the Research Infrastructure. Its Institute of Climate and Energy Systems 3 - Troposphere coordinates the German contributions to the European Research Infrastructure and ensures smooth operation of the IAGOS Maintenance Center (IMC), the latter in close collaboration with the company enviscope GmbH which operates the IMC. FZJ ICE-3 coordinates the IAGOS Technical Operations Group and the Data Quality Assurance and Quality Control (QA/QC) activities. Together with CNRS, FZJ is responsible for the close contact to the participating airlines, including contract management and installations of IAGOS equipment on aircraft.

FZJ is further responsible for the maintenance, operation and data production from scientific instrumentation for the measurement of relative humidity over ice, water vapour and nitrogen oxides on IAGOS-CORE and aerosol particles on IAGOS-CARIBIC. Particular focus is put on the implementation and commissioning of a novel instrument for the measurement of key air quality parameters NO2 and particulate matter (PM). FZJ is operating fully automated and scalable data management and QA(QC workflows for the IAGOS instrumentation on water vapour/RHice, NOx and greenhouse gases, the latter in close collaboration with MPI-BGC.

FZJ also served as the technical coordinator for the EU H2020 project ENVRI-Hub NEXT (ENVironmental Research Infrastructures delivering an open access Hub and NEXT-level interdisciplinary research framework providing services for advancing science and society; https://envri.eu/envri-hub-next/) which is funded under Grant Agreement No 101131141 and started on 01 February 2024.

FZJ maintains its strong engagement in the scientific analysis of the data set from its own resources. As in the past for MOZAIC, this is achieved through close collaborations with leading universities and instrument manufacturers, particularly on the topics of upper tropospheric water vapour distribution, cirrus clouds, aerosols and chemical composition in general. FZJ coordinates together with KIT the collaboration with the joint research project TPChange (The Tropopause Region in a Changing Atmosphere; https://tpchange.de/) of the German Research Council DFG. FZJ is also engaged in the Copernicus Atmosphere Monitoring Service.

In the reporting period 2025, major progress was achieved in the field of instrument deployment, near real time data transmission, and data analysis: (1) In 2025, the largest number of flights providing data on NOx per year has been collected. The scientific exploration of this huge data set together with colleagues from the National Institute for Environmental Studies in Japan has been started. . (2) The automated data inversion algorithm for water vapour permits the operational provision of data in NRT mode to Copernicus Atmosphere Monitoring Services; this algorithm was generalised for broader application to all IAGOS instrumentation and is redesigned in compliance with the FAIR principles for the operational environment based on Python. (3) A very well-received study on the fraction of long-lived contrails existing inside natural cirrus clouds is expected to making a strong impact on the current research on aviation climate impact and contrail avoidance strategies.

Together with its longstanding partners Deutsche Lufthansa/Lufthansa Technik and *enviscope* GmbH, FZJ continued the activities on the transfer of the IAGOS-CORE system to the new platform Airbus A350-900. The feasibility study finished in 2023 sets the framework for the installation of measuring devices on the new platform, specifies the technically necessary steps and quantifies the costs to be expected. FZJ and its partners from the aviation industry sector have developed the concept of a IAGOS Science Box as a first step towards the realisation of the system transfer to the A350.

As part of the Horizon Europe project CICONIA (Climate effects reduced by Innovative Concept of Operations - Needs and Impacts Assessment; Grant Agreement 101114613) FZJ prepares the operational assessment of humidity forecast products for an improved flight planning for climate-optimised routings of aircraft. The basis for this activity is the regular observation of water vapour and relative humidity with respect to ice by IAGOS aircraft under the guidance of FZJ. With its expertise in this field, FZJ also contributed to a Workshop of the World Meteorological Organisation on Aircraft-Based Observations of parameters relevant for aviation (https://wmo.int/events/global-aviation-stakeholders-meeting-abo-and-expert-team-aircraft-based-observations-et-abo-meeting) , and to a contrail modelling workshop at Imperial Collge, London. IAGOS routine humidity observations are seen as a leading example for the network of aircraft-based humidity observations to be developed for greener aviation.

CNRS acts, together with FZJ, as one of the leading institutions in operating the Research Infrastructure. Laboratoire d'Aérologie (LAERO), UMR5560, of CNRS coordinates the technical and legal work in France, and with the main partners from other countries, particularly FZJ in Germany, assumes responsibility for establishing contracts with airlines and maintenance organisations in order to ensure the timely progression of the work. CNRS acts as the leading French partner in cooperation with partners in Germany and U.K., on aircraft modification, including the acquisition of the IAGOS modification kits. CNRS ensures the performance, sustainable operation and data quality of the ozone and CO instruments by pre- and post-calibration procedures in its laboratory. CNRS also ensures the coordination of the IAGOS Data Centre in close collaboration with the French data centre AERIS (http://www.aeris-data.fr).

CNRS coordinates IAGOS-FR (CNRS and MF), the national Research Infrastructure of the French Ministry for Higher Education, and Research (MESR), which is the French contribution to IAGOS. In France, since 2022, the OBS4CLIM Equipex+ project allows additional resources to pursue the objectives of upgrading and innovating the IAGOS fleet and its automatic instruments, in collaboration with the French components of ICOS and ACTRIS. In 2023, the CNRS has launched the pre-study to evaluate the feasibility and costs of equipping 2 aircraft from a new type (Beluga XL). Despite positive feedback, the installation is unfortunately not possible because of recent changes in the load of the BelugaXL itself preventing an additional 150 kg to be embarked. Equipping Belugas will be postponed until lighter and smaller instruments are available.

CNRS maintains its strong engagement in the scientific analysis of the dataset from its own resources. Since the beginning of MOZAIC, this has been achieved through data analysis and modelling activities in collaboration with data users worldwide. CNRS is also engaged in the Copernicus Atmosphere Monitoring Service, in particular for the validation of the regional and global models. Since 2019, this validation has also included the water vapour, and very recently carbon dioxide and methane, as data are available in NRT. See the highlights section above and the dedicated pages at http://www.iagos.org/products which is regularly updated, including the plots for the intercomparisons at cruise level and subsections dedicated to pilot cities defined by the European project RI-Urbans.

In 2025, no aircraft was equipped. However CNRS has ordered one P1, anticipating future installations.

A major part of the CNRS activities still concerned the finalisation of the maintenance process and the operation of the equipment (including the acquisition system and transmissions, secured through a new personnel recruited by CNRS on a permanent position). In 2025, CNRS activities included logistics, maintenance, quality assurance of the ozone and carbon monoxide data, and provision of the data and metadata to the IAGOS database. CNRS fulfils its responsibility to deliver the data in near real time (NRT) to ECMWF for the CAMS thanks to the development of software for data analysis, quality assurance for faster validation, and availability. CNRS continues this engagement in Copernicus through the phase 2 of Copernicus (until 2028). Indeed, from 2022 on, CNRS is still a sub-contractor of KNMI in the CAMS2-82 and CAMS2-83 contracts, which focus on the evaluation of regional and global models with ozone, CO, and water vapour data, as well as greenhouse gases. CNRS produces periodical reports for CAMS.

Development of the database in 2025 included the continuous improvement of the database, data portal and reception servers in Toulouse. The provision of added-value products produced with SOFT-IO, such as meteorological information and air-mass history are continuous efforts in addition to the improvement of the data workflow with automation, integration of new QA/QC metadata, and flight comparisons. In 2025, further improvements have been reached in the context of the finishing ATMO-ACCESS and RI-URBANS projects (started in April and November 2021 respectively, both finished in October 2025; The two services developed within ATMO-ACCESS are maintained and updated thanks to CNRS resources. In 2025, CNRS also continued the development of complementary services in the context of the new EU INFRA-SERV project IRISCC (Integrated Research Infrastructure Services for Climate Change from April 2024 to October 2028). Automatic calculation and visualization tools of climatologies and associated anomalies have been made publicly available in Spring 2025. As in ATMO-ACCESS, CNRS is a leading partner for the Virtual Access services in general and contributes to 2 demonstrators on Fires and Heatwaves impact on atmospheric composition. Further engaging in those responsibilities, CNRS has contributed to the proposal for ATMO-SERV in response of the INFRA-DEV call, as work package leader for Virtual Access. The project has been submitted in September 2025.

In 2024, CNRS also started the development of complementary services in the context of the new EU INFRA-SERV project IRISCC (Integrated Research Infrastructure Services for Climate Change from April 2024 to October 2028). Automatic calculation and visualization tools of climatologies and associated anomalies will be made publicly available in Spring 2025. As in ATMO-ACCESS, CNRS is a leading partner for the Virtual Access services in general and contributes to 2 demonstrators on Fires and Heatwaves impact on atmospheric composition.

The Institute of Biogeochemistry (**MPI-BCG)** of MPG is responsible for the operation of instruments for the measurement of greenhouse gases (GHGs), namely carbon dioxide and methane, as well as carbon monoxide and water vapour. The instrument is referred to as Package 2d (P2d). It has obtained approval by the European Aviation Safety Agency (EASA) for deployment aboard passenger aircraft as part of the IAGOS-CORE installation.

Package 2d was operated onboard the Lufthansa A330 aircraft (tail sign D-AIKO) during deployment phases from 9 December 2024 until 10 November 2025 (with P2D-SN03) and subsequently exchanged with P2D-SN01. High quality GHG data was retrieved through automated transmission via GSM, but also through manual download by LH personnel. D-AIKO was transferred to discover airlines in early 2025. A scheduled replacement of a relais took place in early 2025, unfortunately a corresponding change of a cable related to the IAGOS operation could only be changed in September, further delaying P2d operation. As also P2d-SN03 showed a malfunction, data became only available after the swap to P2d-SN01 in late November onward. Furthermore, P2d was operated onboard China Airlines (tail sign B-18317) from 27 June 2024 onward. Due to a lack of GSM connection of P1 there was no automated data transfer. High quality GHG data was retrieved through regular manual download by CAL personnel. Instrument malfunction developed in July 2025, which was finally confirmed in November 2025. A replacement system is in maintenance.

Processing of data for P2d SN01, SN02, SN03 and SN04 are now implemented within the IAGOS Instrument Database. Data have been made available for more than 30 flights of D-AIKO, and for more than 200 flights of B-18317. Note that the China Airlines flights are significantly shorter, causing a larger number of flights per day.

At the end of 2025, one P2D system (SN01) is installed on D-AIKO from Lufthansa, one (SN02) on B-18317, two further P2d systems (SN03 and SN04) are ready for deployment after maintenance. For completion of SN05 and SN06 further cavities have now be acquired as their original cavities have been used in the other systems. In addition, a full new system is in delivery from Picarro, which will ease the completion of a total of six P2d systems.

Since 2023, **Météo France** has been involved in the European SESAR3 CICONIA project dedicated to the mitigation of non-CO2 impacts of aviation. Météo-France co-ordinates the work package 2 dedicated to meteorological topics with a focus on contrails (observations, forecast). Météo-France conducts research activities on the forecasting of ice-supersaturated regions and the validation of the forecasts with measurements of humidity from IAGOS.

This will continue through the next phase of CICONIA, CICONIA-MET (due to begin in summer 2026) which will further support IAGOS and Météo France.

Météo France is also responsible for maintaining the links between IAGOS and the numerical weather prediction services, particularly with respect to Environment Canada, and the upper air observations division of the World Meteorological Organisation.

UMAN is responsible for operation of the Backscatter Cloud Probe (BCP) aboard all IAGOS-CORE aircraft. The BCP was originally designed as a simple cloud detector/spectrometer for detection of particles in the size range 5-65µm. BCP still requires substantial work for characterisation of its performance with regard to analysing the size distribution of cloud particles and new, improved versions are currently being assessed for future replacement to provide enhanced cloud and dust particle data.

In 2025, administrative responsibility of UMAN's involvement in IAGOS was handed over to Dr N Bojdo of the Dept. of Mechanical and Aerospace Engineering and DUST Research Group, to help capitalise on new opportunities in the area of atmospheric threats to aircraft engines. Extensive analysis of IAGOS BCP and FAAM aircraft BCP-DPOL databases is ongoing as part of a PhD studentship looking at the impact of atmospheric mineral dust on aircraft engine performance and maintenance. The focus of this work will be to improve concentration hindcasts for long term monitoring of dust ingestion rates, to ultimately identify and minimise economic impacts for the aviation industry in certain regions of the globe.

IAGOS Maintenance Centre

The company *enviscope* GmbH is in charge of the maintenance and aeronautical management of the instruments operated on board of civil aircraft. Instrument calibration is conducted at the laboratories of the scientific partners while enviscope is responsible for the coordination of the calibration activities and for the quality assurance related to continued airworthiness of the equipment. The company is involved in IAGOS since the beginning with respect to instrument development and aeronautical certification. Hence, in-depth knowledge of deployed techniques and aeronautical procedures is ensured.

Activities in the reporting period covered the following issues: (i) maintenance of Maintenance Centre Website; (ii) improvements of data base to handle logistics, orders, and documentation; (iii) enhancement of storage and room for preparation of shipments; (iv) handling of instrument exchange intervals (see Table 1); (v) instrument maintenance (testing, repair, and organization of cylinder hydrostatic tests) and production; (vi) European and international logistics (instrument and spare part distribution, dangerous goods, customs declaration) established for an increasing number of items; (vii) coordination with Lufthansa to prepare Package2e installation on one aircraft; (viii) activities for approving legal aviation requirements; (ix) participation in Technical Operations Group, organisation of teleconferences and face-to-face meetings; (x) communication with airlines to organize logistics and replacements; (xi) update of internal procedures to adapt to ACC COLUMBIA Jet Service (ACJ) quality management system; (xii) audits by LBA with minor findings; (xiii) trainings to keep enviscope being a station of ACJ for production and maintenance; (xiv) 6 enviscope employees (trained as certifying staff of ACJ) can issue dual release EASA Form1 (for FAA) as repair station for all IAGOS components (despite of Package1 unit and pump box); (xv) manufacturing of 15 new ICH; (xvi) meetings and preparation of work packages for the shift of IAGOS-CORE to A350.

Item	Member					Airline						
	FZJ	CNRS	UMAN	MPG	other	DLH	CAL	CPA	AFR	HAL	ACA	IBE
Package 1		1						1				
Pump Box		3					2	1			2	1
BCP		1						1				
ICH	81	1			1	20	20	3	3		4	3
Package 2b	16					1	1					
HelOx/SynAir	52					4	3		3			4
Package 2d				4		1	1					
AIR				8		2	2					
Package 2e	1											

Table 2: Shipments of instruments and auxiliary parts for IAGOS-CORE operation in 2025 (slight increase of shipments for P2b, P2d and ICH compared to year before, decrease for P1 and BCP.)

Financial Information

Balance 2025

Income	
Membership Fees ***	130,000€
IMC Operation	60,639€
Total Income	**190,639€**
Expenditure	
Personnel incl. overheads	66,476€
Services and other expenses	71,505€
Total Expenditure	**137,981€**
Amount carried forward from 2024	**157,765€**
Total Balance December 2025	**210,423€**

***One member paid their membership fee for 2025 at the end of 2024.

Resources dedicated to IAGOS by the Members

In 2025, the Members contributed in total approximately 6.4 Million Euros from their own resources in the form of personnel, equipment and consumables to construction and operation of the IAGOS Research Infrastructure according to the Statutes of IAGOS-AISBL. The breakdown of costs, calculated according to Article 22 of the Statues, is listed in Table 3.

Member	Operation & hardware (k€)	Personnel (k€)	Total (k€)
FZJ	1032	1157	2189
CNRS	677	1321	1998
MPG	303	303	607
MF	32	11	43
UMAN	45	125	171
DLR	102	13	115
TROPOS	56	94	149
KIT	494	668	1162
TOTAL	**2741**	**3692**	**6434**

Table 3: Contributions by the Members to construction and operation of the infrastructure from institutional resources and national funding [1]

1 *NOTES: Personnel costs are calculated based on the average salaries of FZJ and CNRS, including overheads (82.4%). Acquisition of hardware is included by 10% annual depreciation. Not included are Membership fees, funding from European projects, and work related to scientific activities.*

Additional resources of approximately 140k€ were deployed in 2025 due to co-funding by the European Union for projects ATMO-ACCESS, RI-URBANS, ENVRI-FAIR and contributions to the Copernicus Programme (CAMS2-82/83). In addition CNRS gets 50k€ from OBS4CLIM., and 100 k€ from the SOERE (as managed by MESR). These resources are used for the salary of non-permanent personnel at CNRS, and 30k€ have been used for the spare inlet plate.

Acknowledgements

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Bundesministerium für Bildung und Forschung

MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR, DE LA RECHERCHE ET DE L'INNOVATION

AERIS

The participating Airlines contribute significantly to operation of the IAGOS infrastructure by waving the additional fuel costs incurred by carrying the IAGOS-CORE installation and by providing technical expertise during installation and deployment of the equipment.

AIRFRANCE

IBERIA

AIR CANADA

CHINA AIRLINES

HAWAIIAN AIRLINES

discover. airlines

Lufthansa

CATHAY PACIFIC

Peer-reviewed Publications

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International Panel Discussions and Presentations

- Petzold, A. Martina Krämer, Sebastian D. Eastham, and Colin S. Tully, Keynote: Ice Cloud Workshop, University of Vienna, 24 - 25 April 2025.
- Petzold, A., and Martina Krämer. Most contrails form within cirrus clouds with uncertain climate impact, International Commission on Clouds and Precipitation Journal Club Lectures, online, 27 August 2025.
- Petzold, A., IAGOS Research Infrastructure for Global-Scale Atmosphere Monitoring by Passenger Aircraft, Aviation Non-CO2 Experts Network Plenary Meeting, Cologne, 12 March 2025.
- Petzold, A., Keynote: Which fraction of long-lived contrails form within cirrus clouds and what is their climate impact? Results from a recent IAGOS study, 2025 Contrail Modelling Workshop, Imperial College London, 20 October 2025.

Presentations at International Conferences

- Hienola, A., Petzold, A., and Bundke, U., A Researcher's Journey: Navigating Interdisciplinary Science with ENVRI RDIs and Tools, https://doi.org/10.5194/egusphere-egu25-6121.
- Petzold, A., Khan, N.F., Li, Y., Rohs, S., Crewell, S., and Krämer, M., Distribution of RHice inside thin and thick cirrus clouds over the Northern Mid-latitudes and in a Subtropical Region, https://doi.org/10.5194/egusphere-egu25-12954.
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