Leibniz
Gemeinschaft

Der Senat

21. März 2023

Stellungnahme zum
Leibniz-Institut für Atmosphärenphysik e. V. an der Universität Rostock, Kühlungsborn (IAP)

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Vorbemerkung

Die Einrichtungen der Forschung und der wissenschaftlichen Infrastruktur, die sich in der Leibniz-Gemeinschaft zusammengeschlossen haben, werden von Bund und Ländern wegen ihrer überregionalen Bedeutung und eines gesamtstaatlichen wissenschaftspolitischen Interesses gemeinsam außerhalb einer Hochschule gefördert. Turnusmäßig, spätestens alle sieben Jahre, überprüfen Bund und Länder, ob die Voraussetzungen für die gemeinsame Förderung einer Leibniz-Einrichtung noch erfüllt sind.[1]

Die wesentliche Grundlage für die Überprüfung in der Gemeinsamen Wissenschaftskonferenz ist regelmäßig eine unabhängige Evaluierung durch den Senat der Leibniz-Gemeinschaft. Die Stellungnahmen des Senats bereitet der Senatsausschuss Evaluierung vor. Für die Bewertung einer Einrichtung setzt der Ausschuss Bewertungsgruppen mit unabhängigen, fachlich einschlägigen Sachverständigen ein.

Vor diesem Hintergrund besuchte eine Bewertungsgruppe am 12. und 13. Mai 2022 das IAP in Kühlungsborn. Ihr stand eine vom IAP erstellte Evaluierungsunterlage zur Verfügung. Die wesentlichen Aussagen dieser Unterlage sind in der Darstellung (Anlage A dieser Stellungnahme) zusammengefasst. Die Bewertungsgruppe erstellte im Anschluss an den Besuch den Bewertungsbericht (Anlage B). Das IAP nahm dazu Stellung (Anlage C). Der Senat der Leibniz-Gemeinschaft verabschiedete am 21. März 2023 auf dieser Grundlage die vorliegende Stellungnahme. Der Senat dankt den Mitgliedern der Bewertungsgruppe und des Senatsausschusses Evaluierung für ihre Arbeit.

1. Beurteilung und Empfehlungen

Der Senat schließt sich den Beurteilungen und Empfehlungen der Bewertungsgruppe an.

Das Leibniz-Institut für Atmosphärenphysik (IAP) in Kühlungsborn widmet sich der Erforschung der *Mesosphere and Lower Thermosphere* (MLT) sowie angrenzender atmosphärischer Schichten. Die experimentellen und theoretischen Untersuchungen von Veränderungen und Kopplungen dieser Schichten, die 50 bis 200 km über der Erdoberfläche liegen, werden im Rahmen eines überzeugenden Gesamtkonzepts erbracht.

Das IAP konnte das bei der letzten Evaluierung festgestellte ausgezeichnete wissenschaftliche Niveau seiner Arbeiten halten. Die **Leistungen** der drei Abteilungen *Optical Soundings and Sounding Rockets* (ORS), *Radar Remote Sensing* (RRS) und *Modelling of Atmospheric Processes* (MOD), werden erneut jeweils als „exzellent" bewertet. Das IAP erarbeitet regelmäßig hervorragende Forschungsergebnisse, z. B. zur Ausbreitung von Schwerewellen oder zur Struktur nachtleuchtender Wolken. Zudem leistet das IAP Pionierarbeit im Design, der Konstruktion und dem Betrieb von stationären und mobilen Beobachtungsinstrumenten, insbesondere Radar- und Lidarsystemen. Messungen erfolgen an der Ostsee, in südamerikanischen Gebirgsregionen und am Polarkreis, wo vor dreißig Jahren auf Initiative des IAP das *Arctic Lidar Observatory for Middle Atmosphere Research* (ALOMAR) in Norwegen eingerichtet wurde. Ein hervorragendes Ergebnis erzielte das

[1] Ausführungsvereinbarung zum GWK-Abkommen über die gemeinsame Förderung der Mitgliedseinrichtungen der Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e. V.

IAP mit der Entwicklung eines Prototyps für eine mobile Lidareinheit, deren Aufbau Bund und Länder in den Jahren 2018/2019 mit zusätzlichen Mitteln förderten.

Mit seinen Messinstrumenten erhebt das Institut Daten von hohem wissenschaftlichem Interesse. Sie stehen vielfach entgeltlos zur Verfügung; die *Open Data*-Strategie sollte konsequent weiterverfolgt werden. Das IAP selbst verwendet die Daten vor allem für innovative Modellierungsarbeiten. Von besonders hoher Bedeutung sind die langjährigen Arbeiten in Bezug auf das *Kühlungsborn Mechanistic Circulation Model* (KMCM). Wie empfohlen beteiligt sich das IAP mittlerweile auch an der Entwicklung von *community models*, wie z.B. mit dem deutschen Gemeinschaftsmodell der oberen Atmosphäre UA-ICON (ICOsahedral Non-hydrostatic GCM).

Im Jahr 2021 ging der langjährige wissenschaftliche Direktor in den Ruhestand. Er prägte das Institut seit seinem Amtsantritt 1999 maßgeblich. Es wird begrüßt, dass die **Institutsleitung** 2021 erneut in gemeinsamer Berufung (W3) mit der Universität Rostock erfolgt ist und mit einer ausgewiesenen Wissenschaftlerin wiederbesetzt wurde. Aus Sicht des Senats sollte der Vorstand, der derzeit nur aus einer Person besteht, um die stellvertretende und die administrative Leitung erweitert werden, wie im Bewertungsbericht angeregt.

Weil sich die neue Direktorin auf die Leitung des IAP konzentriert, wird die von ihrem Vorgänger geführte Abteilung derzeit kommissarisch geleitet. Dies gilt auch für eine weitere Abteilung, deren Leiter 2019 an ein Unternehmen in die USA wechselte. Es ist schlüssig, dass das Aufsichtsgremium frühzeitig vorsah, die neue Institutsleitung in die Besetzung beider Positionen einzubeziehen. Die Besetzungen der beiden **Abteilungsleitungen** in gemeinsamer Berufung mit der Universität Rostock auf W2-Professuren müssen nun zügig vorangetrieben und wie geplant 2023 abgeschlossen werden.

Die **strategischen Planungen** für die Zukunft sind überzeugend. Das IAP plant, künftig verstärkt Schichten einzubeziehen, die an die MLT angrenzen. Die Berücksichtigung der Schichten unterhalb der MLT ist insbesondere für die Anschlussfähigkeit des IAP an Modelle zum Klimawandel relevant. Die Ausweitung der Arbeiten auf Schichten oberhalb der MLT bis hin zur Grenzregion zwischen Atmosphäre und Weltraum dient einem besseren Verständnis des *space weather*. Das IAP hat seine Expertise auf diesem Gebiet bereits durch die Berufung der neuen Direktorin signifikant erweitert.

Der Senat befürwortet, dass das IAP unter der Überschrift „**COSA-SAT (*COnnecting Space and Atmosphere – Science And Transfer*)**“ eine dauerhafte Erhöhung der institutionellen Förderung ab 2025 beantragt. Im Mittelpunkt steht die Einrichtung einer unabhängigen Nachwuchsgruppe (vier Stellen), die auf dem Gebiet der Kopplung von Atmosphäre und Ionosphäre forschen soll. Um die Gruppe an die Abteilungen anzubinden, sieht das IAP zudem je Abteilung eine *Postdoc*-Stelle vor, ferner eine Stelle im Wissenschaftsmanagement. Das IAP sollte im Antrag für die Maßnahme darstellen, welche Vorarbeiten bis zum geplanten Förderbeginn im Jahr 2025 voraussichtlich abgeschlossen sein werden. Die Leitung der Nachwuchsgruppe sieht das IAP als *Tenure-track*-Stelle vor, die Gruppe soll ggf. als vierte Abteilung verstetigt werden. Es wird begrüßt, dass die Empfehlung aufgegriffen wurde, die Nachwuchsgruppenleitung als Juniorprofessur gemeinsam mit der Universität Rostock zu besetzen, wie das zuständige Fachressort im SAE erläuterte.

Es wird begrüßt, dass das IAP empfehlungsgemäß mehr Mittel bei der DFG eingeworben hat. Insgesamt sanken die **Erträge aus Projektförderungen** jedoch von durchschnittlich 1,83 Mio. € p. a. (24 % des Gesamtbudgets) zwischen 2011 und 2013 auf 1,45 Mio. € p. a. (17 %) zwischen 2018 und 2020. Die Einnahmen müssen wie geplant deutlich gesteigert werden. Die bereits erfolgten bzw. anstehenden Neubesetzungen von Leitungspositionen und die wissenschaftlichen Planungen bieten dafür sehr gute Voraussetzungen.

Es wird begrüßt, dass für **Promovierende** zur Ergänzung von Angeboten der Universität Rostock inzwischen ein strukturiertes Programm am IAP eingeführt wurde. Künftig sollten alle Promovierenden in Programme einbezogen sein, um sicherzustellen, dass die Promotionen nach spätestens vier Jahren abgeschlossen werden. Derzeit liegt die Dauer bei 4,8 Jahren. In Anlehnung an das Promotionsprogramm sollte das IAP nun auch die Maßnahmen zur Förderung der ***Postdocs*** weiterentwickeln.

Mit der Besetzung der Direktorenposition hat das IAP den **Anteil an Wissenschaftlerinnen** auf Leitungsebene erhöht, jedoch sank deren Anteil auf allen anderen Hierarchieebenen. Am 31. Dezember 2019 waren unter 37 Personen im Bereich Forschung und Wissenschaftliche Dienstleistungen nur sechs Wissenschaftlerinnen (16 %; 31. Dezember 2013: 26 %). Es wird begrüßt, dass das IAP für die anstehenden Neubesetzungen von Leitungspositionen aktiv nach Kandidatinnen sucht. Das Institut muss den Frauenanteil auf allen Ebenen deutlich erhöhen.

Das IAP arbeitet eng mit der Universität Rostock zusammen. Die Instituts- und Abteilungsleitungen werden gemeinsam berufen (s. o.). Das Institut pflegt zudem enge **Kooperationen** mit dem Deutschen Wetterdienst (DWD) und dem Max-Planck-Institut für Meteorologie im Bereich der Modellierung. Auf Ebene der Leibniz-Gemeinschaft ist das IAP eingebunden in das Netzwerk „Integrierte Erdsystemforschung", in dem u. a. mit dem Leibniz-Institut für Troposphärenforschung (TROPOS) und dem Potsdam-Institut für Klimafolgenforschung (PIK) zusammengearbeitet wird. Die in Zukunft weiter an Bedeutung gewinnende Einbeziehung der MLT in die Modellierung von Szenarien des Klimawandels bietet Möglichkeiten für eine Intensivierung der Kooperationen auf diesem Gebiet. Das IAP pflegt zudem intensive Kontakte zum *German Aerospace Center* (DLR), insbesondere mit dem *Institute of Atmospheric Physics*.

2. Zur Stellungnahme des IAP

Der Senat begrüßt, dass das IAP beabsichtigt, die Empfehlungen und Hinweise aus dem Bewertungsbericht bei seiner weiteren Arbeit zu berücksichtigen.

3. Förderempfehlung

Der Senat der Leibniz-Gemeinschaft empfiehlt Bund und Ländern, das IAP als Einrichtung der Forschung und der wissenschaftlichen Infrastruktur auf der Grundlage der Ausführungsvereinbarung WGL weiter zu fördern.

14 April 2022

Annex A: Status report

Leibniz Institute of Atmospheric Physics e. V. at the University of Rostock, Kühlungsborn (IAP)

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1. Key data, structure and tasks

Key data

Year established:	1992
Admission to joint funding by Federal and *Länder* Governments:	1992
Admission to the Leibniz Association:	1997
Last statement by the Leibniz Senate:	2015
Legal form:	Registered Association
Responsible department at *Länder* level:	Ministry of Science, Culture, Federal and European Affairs of Mecklenburg – Western Pomerania
Responsible department at Federal level:	Federal Ministry of Education and Research (BMBF)

Total budget (2019)

€ 7.7m institutional funding

€ 1.4m revenue from project grants

€ 0.2m revenue from services

Number of staff (as of 31 December 2019)

37 individuals in research and scientific services

16 individuals in service sector

12 individuals in administration

Mission and structure

Mission according to statues

"*The purpose of the Association is the promotion of science and research. The purpose of the statutes is realised in particular by conducting research in the field of atmospheric physics and promoting scientific knowledge in this field. The Institute shall cooperate with national and international institutions and working groups in the field of atmospheric physics.*"

Organisation

IAP operates three departments (for detailed description see chapter 7):

- Optical Soundings and Sounding Rockets department (**ORS**)
- Radar Remote Sensing department (**RRS**)
- Modelling of Atmospheric Processes department (**MOD**)

The working group for Transfer activities including public relations collaborates with the entire Institute. The Administration, Computing Centre, Library, and Workshops are part of central facilities for IAP (see organizational chart in appendix 1).

2. Overall concept and core results

Overall Concept

The Leibniz Institute of Atmospheric Physics at the University of Rostock (IAP) studies the mesosphere and lower thermosphere (MLT) addressing atmospheric layers between about 50 and 200 km altitude. Activities are directed particularly at fundamental physical processes that are different from or coexist with those that dominate in the lower or upper atmosphere and ionosphere. Scientific questions in this region concern the coexistence of hydro-, thermo-, and electrodynamic processes and other physical peculiarities.

As a transition region between the lower and middle atmosphere and space, the MLT is influenced by dynamical processes of the atmosphere, as well as by solar electromagnetic and particle radiation present in the near-Earth space environment. It is challenging to obtain observations of the MLT, since the region is too low for current satellite missions, which could regularly cross various regions and take in situ observations with a multi-parameter payload, and too high for balloon-borne in situ measurements. Therefore, remote sensing by ground-based lidars and radars as well as scientific rocket campaigns are used as tools to access the MLT.

Due to this high sensitivity, the MLT is an excellent indicator for climate change scenarios. In addition, there are feedback mechanisms between global atmospheric circulation and changes in the MLT. These geophysical processes are currently subjects of research at IAP. By developing physical understanding and running analyses of long-term time series of data and models, IAP aims at making contributions to quantify anthropogenic influences to global atmospheric climate change and to understand the interplay between solar radiation variability and atmospheric dynamics.

Each of IAP's three departments contributes to three overarching research themes with experimental and analytical tools. These are

- Exploration of the mesosphere and lower thermosphere **(T1)**
- Coupling of the mesosphere and lower thermosphere to atmospheric layers below and above **(T2)**
- Long-term changes in the mesosphere and lower thermosphere, and adjacent regions **(T3)**

Core results

Research

The main activity of IAP is centred on research. Between 2018-2020, work at IAP led to 131 publications in peer-reviewed journals (see appendix 2). IAP refers to the following ten most important results that have been published since the last evaluation, indicating the covered research themes (T1, T2, T3) and involved departments (ORS, RRS, MOD):

1. *First consistent observation of inertia gravity waves in temperatures and winds by lidar (T1, ORS, Baumgarten et al., 2015)*: A new technique called DORIS was developed at IAP and was employed to measure winds by lidar in the stratosphere and mesosphere at ALOMAR. Gravity wave (GW) parameters are derived from wind fluctuations. The same lidar observes temperature profiles and their modulations caused by waves. These common volume and simultaneous observations of GWs in winds and temperatures were used to derive the kinetic and potential energy density of an inertia gravity wave, as well as momentum fluxes. The observations demonstrate the capability of lidars to reveal details of GW morphology that are not achievable by any other method.
2. *A novel multistatic radar for MLT studies (T1, RRS, Chau et al., 2019):* Recently, the observation network „SIMONe" was conceived and implemented. It combines radar practices (e.g. MIMO), spread-spectrum, and compressed sensing. Systems have been installed in Germany, Norway, southern Argentina, and Peru. „SIMONe" systems allow observing the MLT mesoscale dynamics, which are currently parameterised in global circulation models.
3. *Small scale structures in noctilucent clouds [NLC] (T1, ORS, Schäfer et al., 2020):* In 1400 h of lidar observations, IAP observed fine-scale structures quasi-permanently that allow for a deeper insight into wave breaking and dissipation. These observations were further interpreted using winds measured by IAP radars.
4. *4D observations of Kelvin-Helmholtz instabilities (KHI) in the mesosphere (T1, RRS, MOD, Chau et al., 2020):* IAP developed a new radar imaging mode in northern Norway, allowing to characterize a KHI event in four dimensions. The spatial, temporal, and velocity characterization, analysed in the context of stratified turbulence theory, allows to estimate the level of turbulence and stratification of the event.
5. *Physics of polar mesosphere winter echoes (PMWE) clarified (T1, ORS, RRS, Strelnikov et al., 2021):* A field campaign involving sounding rockets, radars, and lidars was performed at Andøya Space (69°N) to study radar echoes called PMWE. In situ observations of small-scale fluctuations in the neutral gas and the plasma density demonstrate that neutral air turbulence is the prime driver for PMWE. This physical understanding of PMWE allows IAP to use the radar echoes as a proxy for turbulence and gain an understanding of its temporal and spatial distribution.
6. *The role of multi-step vertical coupling of GWs (T2, MOD, Becker and Vadas, 2018):* Multi-step vertical coupling implies that primary GWs, generated in the troposphere, propagate into the winter stratosphere and lower mesosphere, where they dissipate and generate secondary GWs. These propagate into the lower thermosphere, dissipate, and generate tertiary GWs. Conventional GW parameterisation in *General Circulation Models* (GCMs) assumes only primary GWs propagating up to the MLT and yields unrealistic zonal winds in the winter polar upper mesosphere. On the other hand, simulations with the *Kühlungsborn Mechanistic Circulation Model* (KMCM) showed that secondary GWs generate an eastward GW drag in the winter MLT, giving rise to realistic mean zonal winds in the model.

7. *Mesopause jumps over Antarctica (T1, T2, ORS, RRS, MOD, Lübken et al., 2017):* IAP's high-resolution iron lidar observations at Davis, Antarctica, have revealed a new phenomenon called "mesopause jumps", which refers to a sudden increase of the mesopause height around summer solstice. IAP scientists showed that the reason for this jump is related to a late break-down of the stratospheric polar vortex that controls the propagation conditions for GWs. Mesopause jumps can be used as a benchmark test for models of GW propagation and their impact on the background atmosphere.
8. *Lower atmospheric processes influencing MLT dynamics (T1, T2, RRS, MOD, Conte et al., 2019):* MLT coupling to adjacent layers has been one of the main research topics since the last evaluation. Using 15 years of MLT winds over high and middle latitudes, IAP scientists showed relationships between the MLT's dynamical behaviour and large-scale meteorological processes related to sudden stratospheric warming (SSW) events, including polar-night jet oscillations (PJOs). To assess the impact of the stratospheric disturbed conditions on the MLT region, a 30-year nudged simulation of a Canadian GCM was investigated. Analysis of geopotential height disturbances suggests that changes in the location of the polar vortex at mesospheric heights are responsible for the jets observed in the MLT mean winds during strong PJOs.
9. *Extreme vertical drafts in the mesosphere (T1, T2, RRS, ORS, Chau et al. 2021):* Vertical drafts exceeding more than three times the standard variability of vertical velocities have been recently discovered. These observations were made over northern Norway with IAP's MAARSY system using polar mesospheric summer echoes as tracers. Due to the radar imaging capabilities of MAARSY, this event was observed to be localised in space and time, resembling a mesospheric bore but with a much larger vertical extent and associated vertical velocities.
10. *Climate effects in NLCs (T3, ORS, Lübken et al., 2018):* To investigate the role of NLCs in detecting climate change in the middle atmosphere, IAP scientists have developed a model of the background atmosphere on centennial time scales and applied microphysical processes relevant to NLCs. It has been found that the increase of methane (oxidized to water in the middle atmosphere) leads to a significant enhancement of NLC brightness and occurrence. Concurrently, the rise in carbon dioxide causes general cooling in the mesosphere, which has led to lower NLC brightness and lower NLC altitudes. The model results are consistent with long-term observations of NLCs.

Research Infrastructure

IAP operates two large atmospheric and climate observatories:

1. In northern Germany, i.e., Kühlungsborn and Juliusruh, combined facilities include lidars and radars that provide relevant measurements in the mid-latitudes. The institute indicates to operate the only ionosonde in Germany with the longest ionospheric time series in Europe, providing data that is an integrative part of global networks and supports IAP's research in T2 and T3. Additionally, there are two atmospheric radars, a magnetometer and a low-frequency receiver.

2. The ALOMAR site on the island of Andøya in northern Norway allows IAP access to measurements of the Arctic middle atmosphere. It includes lidars and radars with capabilities like daylight capable lidars, and 4D capable radars. IAP also develops sounding rocket concepts and flies multi-parameter instruments in coordinated rocket launches at Andøya Space, complementing the routine data acquisitions at ALOMAR and supporting research theme T1.

Besides these large facilities, IAP operates distributed systems and mobile portable instruments in northern Germany and northern Norway, and more recently, in South America. The distributed facilities are operated in cooperation with national and international institutions and consist of multistatic meteor radars (e.g., SIMONe) and NLC cameras. The multistatic meteor radars in turn consist of various receivers located within 30 km to 200 km distance to a transmitter. The NLC cameras are at different latitudes in Europe. The operation of instrumentation worldwide fosters international collaboration with local partners and allows joint data analyses.

The ionosonde data are publicly available via the international ionosonde network GIRO and the European ionosonde network DIAS. The lidar and radar data are open for collaboration partners upon request. Quicklook plots and metadata describing the observations are available in near real-time through IAP's website.

Transfer

Initiatives of technology transfer, either via patents or partnerships with industry, are promoted internally and externally. The institute holds a patent portfolio of 6 patents and 4 patent families. Between 2018-2020 it filed a total of 2 applications giving rise to a right of property (see appendix 2).

To transfer IAP's knowledge to society, a working group on transfer activities was established in 2021. Activities include all channels of communication between IAP and the non-academic world, e.g., press releases, public view days, patents, etc. IAP advises the federal armed forces (Bundeswehr), e.g., by providing regular and ad-hoc reports on radio wave propagation conditions based on the Juliusruh ionosonde data. The working group is currently managed by IAP's scientific and administrative staff in addition to their main scientific tasks. IAP plans to extend its transfer activities in the near future (see chapter 3).

3. Changes and planning

Development since the previous evaluation

Structural developments

Since the last evaluation, major developments have occurred in staffing and governance at IAP:

- **10/2021:** A new Director was appointed at IAP and as professor (W3) at the University of Rostock (UR), following the retirement of the former director and head of the ORS department. The ORS department is currently led by an acting head.
- **2021:** Appointment of a new head of the IT group.

- **2021:** Establishment of a transfer working group under the supervision of the head of the RRS department.
- **10/2019:** The head of the MOD department moved to NRWA, Boulder, Colorado, USA. Since then, the MOD leadership has been held successively for temporary terms by three IAP scientists. At the moment, the Director is acting as head of the department.
- **2017:** Appointment of a new Administrative head.
- **2015:** The rocket activities were transferred from the RRS department to the ORS department for an efficient management of projects.

Developments in research

Since the last evaluation, the institute has applied existing expertise to observe and model atmospheric processes with a particular focus on the MLT. Researchers also considered specific problems of atmospheric physics in other atmospheric layers, such as the troposphere, stratosphere, and ionosphere. At the same time, new experimental and modelling tools have been developed and applied. A new aspect of these activities is to expand IAP's research capabilities from local to regional scales of a few to several hundred kilometres. Long-term measurements at IAP's large facilities have been used to derive climatological patterns and/or to study atmospheric trends.

Following a positive recommendation during the previous evaluation, IAP received temporary additional funding ("temporary extraordinary item of expenditure") of € 0.69 and € 1.13 million in 2018 and 2019, respectively. IAP developed a compact state-of-the-art lidar system VAHCOLI (Vertical And Horizontal COverage by LIdar) for applications in the middle atmosphere (between 10 – 100 km) and to deploy several of these systems as a regional network to achieve horizontal coverage in addition to the traditional vertical and temporal coverage. To this aim, a new building for production and testing of the new systems was constructed and a prototype was built. The concept and first results have been recently published.

Strategic work planning for the coming years

Personnel planning

IAP is preparing for the following major personnel changes in leadership positions in the upcoming months:

- IAP plans to recruit a new head of the MOD department in a joint appointment with the UR (W2). This position already exists within IAP's staffing plan and also in the cooperation agreement with the UR. IAP plans to fill this position until 2023.
- IAP plans to recruit a new head of the ORS department in a joint appointment with the UR (W2). This position still has to be included in IAP's staffing plan and also in the cooperation agreement with the UR. IAP plans to fill this position until 2023.
- IAP plans to recruit a new representative for transfer activities (salary level E13 and limited to three years with the possibility of prolongation), particularly to cover aspects of public outreach, e.g., press releases, training and education, representation

in the web and in social networks. IAP plans to fill this position in 2022. The position will strengthen the transfer group.

Research planning

IAP plans to continue and expand its activities on middle atmosphere research and expand the capabilities toward global exploration of the MLT. In particular, IAP plans to get involved in the following new fields:

- addressing new scientific questions of the MLT, e.g., including intermittency and ion-neutral coupling,
- extending to mobile ground-based facilities and campaigns;
- exploitation of satellite data and of global and regional modelling.

IAP has recently formulated its Institute's mission and future activities are organized around its three research themes (T1, T2, and T3):

T1: *Exploration of the mesosphere and lower thermosphere (T1)*

IAP plans to extend its observational and modelling capabilities to the upper part of the lower thermosphere (i.e., 100 – 200 km). For that purpose, IAP will pursue extending lidar and sounding rocket expertise and radar measuring capabilities to those altitudes. To achieve this aim, new expertise in experimental and theoretical (e.g., plasma-neutral coupling) methods will have to be developed. IAP plans to combine ground- and space-based observations and model analyses to complement local high-resolution measurements with global coverage to investigate the MLT dynamics. Furthermore, scientists will investigate the atmospheric composition to understand the drivers of potential changes and their effects on the layers in the MLT. Such knowledge allows to include relevant layers for studying atmospheric processes that cannot be observed with other methods (e.g., those at altitudes between 80 and 200 km).

T2: *Coupling of the mesosphere and lower thermosphere to atmospheric layers below and above*

The importance of the MLT for the whole atmosphere, including weather and climate close to the surface, originates from vertical coupling between the lower atmosphere and the MLT due to dynamical processes. IAP plans to further explore the generation, propagation, interactions, and breaking of all relevant atmospheric waves in order to achieve an improved understanding of the dynamical control of and by the MLT. Furthermore, building up expertise in the lower thermosphere and lower ionosphere at an altitude of around 100 km will be part of the Institute's development through increased experimental and theoretical knowledge and appropriate hiring.

T3: *Long-term changes in the mesosphere and lower thermosphere, and adjacent regions*

IAP's long-term studies will continue to focus on decadal-scale observations, complemented by century-scale modelling. IAP runs instruments covering numerous decades and parameters, including radio wave meso-spheric reflection heights (since 1956), various properties of noctilucent clouds (since 1994), and ionosonde observations at Juliusruh that constitute the longest ionospheric record in Europe (since 1957). Furthermore, mesospheric ice layers remain an essential tool for trend studies since they constitute the longest measurement record in the MLT (first observations in 1885) and are very sensitive to background conditions, i.e., temperatures and water vapour.

Planning of transfer activities

In the upcoming years, IAP's transfer strategy is to identify and conduct selected activities to promote an efficient and valuable exchange with the general public, commercial partners, as well as authorities and policymakers.

The following activities exemplify future efforts of IAP: *Public Outreach* (e.g., organising IAP public view days, issuing posts for journalists, etc.); *Training* (e.g., training of school students); *Capacity Building* (e.g., training of foreign professionals); *Citizen Science* (e.g., sharing real-time observations, connecting to amateur radio and aviation communities); *Technology Transfer*, by establishing collaboration with industrial partners through projects of commercialising technical development. IAP expects revenues from patents that have been obtained in the last few years.

Planning for additional funds deriving from institutional funding

IAP plans to apply for a permanent increase of its institutional funding (minor extraordinary item of expenditure of a scientific-strategic nature) in order to establish a scientific structure called **COSA-SAT** (COnnecting Space and Atmosphere – Science And Transfer). The new structure shall provide a basis to engage in national, European, and international consortia to further secure additional external funding for IAP through appropriate projects. COSA-SAT results shall be integrated in whole atmosphere community models and support extended climate models. The results will also be used to define novel concepts for very-low Earth orbit satellites, to increase knowledge of the MLT, and thus contribute to space sustainability. Thereby, IAP plans to evolve towards a strategic partner within the Leibniz Association with the potential to emit to agencies and to international networks of atmosphere-space interests (Earth System Sciences). IAP plans the following structural items and investments:

1. IAP plans to establish a <u>new junior research group COSA-SAT</u> (1 Scientist E14, 1 Postdoc E13, 2 PhDs E13 [0.75 %]). The group shall be dedicated to global scale studies by using satellite observations to investigate atmosphere-ionosphere coupling. This work shall be performed in strong collaboration with IAP's research departments, for example, to integrate data from ground-based facilities and models that extend into the altitude region between 100 km and 200 km. Engagement in ongoing and new satellite projects to study the MLT-Ionosphere is of particular interest. The position of the group head will be advertised as a tenure position. In the long term, IAP plans to develop the group into a department.
2. To achieve its goals, COSA-SAT shall provide <u>investment funds</u> of approx. €190k p.a. for IT (e.g., storage for satellite data, enhanced firewall capabilities, external network

lines, etc.), extend lidar and rocket sounding capabilities towards altitudes above 100 km, and build up a global network of IAP's ground-based instruments.

3. With the new research activities IAP sees a need to also extend science and project management. With the appointment of a new Science manager (E14) IAP wants to respond to the need of reaching out to external funding agencies for suitable funding programmes (e.g., EU, ESA, ministries, industrial sponsors, among others) and increasing the communication with space agencies and industry to position IAP's role in near-Earth space research and technological development.
4. In order to extend the experimental (lidar, radar, and rocket soundings) and modelling (regional and global) expertise in the three departments towards the lower thermosphere and ionosphere on a global-scale IAP plans to appoint one additional Postdoc in each department (3 times E13). This shall also ensure a deep integration of the departments into the new concept and allow for a close cooperation with the junior research group.

The costs to finance the 8 additional positions (2 E14, 4 E13, 2 PhDs E13 [0.75 %]) and the additional investments of €190k p.a. amount to an approx. total of €1.1m p.a. of which IAP finances €200k from its existing budget. Therefore, IAP sees a need for an increase of its institutional funding of approx. €900 k€ p.a. (see table below).

„Extraordinary item of expenditure“: summary of funds planning

	2025	2026	Permanently
Own funds + additional funds = „extraordinary item of expenditure“	*1092 k€*	*1118 k€*	*1118 k€*
Own funds from existing funding by institution (at least 3 % of core budget)	*211 k€*	*211 k€*	*211 k€*
Additional funds of institutional funding	*881 k€*	*907 k€*	*907 k€*

4. Controlling and quality management

Facilities, equipment and funding

Funding (see appendix 3)

In 2020, the institutional funding totalled €6.7m. Due to the temporary increase of the funding for VAHCOLI (see above) it has been higher in 2018 (by €630k) and 2019 (by €1.13m).

Between 2018-2020, revenue from project grants totalled Ø €1.45m p.a., corresponding to 17 % of the overall budget. Thereof, Ø € 645k p.a. were raised from Federal and *Länder* Governments, Ø € 521k p.a. from the DFG, Ø € 265k p.a. from the Leibniz Association, Ø € 14k p.a. from the EU and € 3k p.a. from Foundations.

From services, IAP generated revenue in the amount of Ø €129k p.a. (mostly from commissioned work).

Facilities and equipment

The IAP facilities are located in Kühlungsborn. The administration offices and a new lecture hall are housed in a new building that was constructed with external funding (European Regional Development Fund) in 2014-2015. This new hall allows to organise large national and international workshops and symposia. In addition, IAP maintains a number of specialised infrastructure units. These include the facilities in Juliusruh and ALOMAR (see chapter 2).

IT infrastructure

IAP hosts its main IT infrastructure in Kühlungsborn including desktop and mobile computers, servers, data storage (about 4 petabyte of data), and a high-performance computer (HPC). In recent years, the IT infrastructure has been extended in order to store large amounts of data, including raw data from remote large facilities and small distributed systems. This also provides resources to perform computationally-demanding simulations of complex atmospheric processes. Research data collected by IAP's scientific instruments are further stored redundantly in a tape library. IAP uses the research data repository *RADAR* for data publications. These data publications are open access. The handling, access, and publication of research data at IAP is regulated by the *IAP Research Data Policy*.

The HPC cluster is currently built with a total number of 928 cores and 7.5 terabytes of total memory. The system will be extended with graphical processing units using modern Nvidia A100 nodes in 2022. The HPC, the tape library, as well as most of the servers are placed in an oxygen-reduced environment. An uninterruptible power supply protects against power failure. Network communication is provided by the German National Research and Education Network (DFN). IT services include self-hosted cloud services and VPN solutions to support its remote infrastructure and mobile working.

The services provided by the IT team cover software provision, update, backup, data storage, communication, as well as relevant contract management. A dedicated working group ("Rechnerkommission") consisting of representatives from IT, each scientific department and administration meets regularly to address new demands arising from novel scientific questions and emerging IT solutions.

Organisational and operational structure

The Director is the Executive Board of the Association in the sense of § 26 BGB (German Civil Code). The three departments are managed by one department head each. In each department there are weekly or bi-weekly meetings to exchange institutional information and present new developments of projects. These meetings also discuss internal and external collaborations and review their development in line with the strategic work plan.

In 2021, a Directorate has been formed. It consists of the Director, the Department Heads, and the Head of Administration. It holds bi-weekly meetings in order to steer major developments at the institute. These include developing the Strategic Science Plan, the work plan and biennial reports. Furthermore, new institutional regulations, personnel development and the financial strategic planning are discussed.

An IAP plenary meeting is held at least once per year in which the directorate summarises IAP's major developments and gives projections to the coming months. The plenary meeting gives the opportunity to widely discuss critical items raised by the employees with institutional concern on both scientific and operational level.

Quality Management

IAP follows the recommendations for good scientific practice as developed by the DFG and adopted by the Leibniz Association. IAP has an ombudsperson.

IAP scientists are encouraged to publish in open access journals or consider the Leibniz Association's Open Access Publishing Fund. Also, IAP participates in the Wiley DEAL agreement negotiated by the DEAL project. Between 2018 and 2021, about 70% of the publications are open access; 9 out of 10 of IAP's highlights (see ch. 2) are published open access.

IAP has issued research data policy guidelines according to accessibility, traceability, and sustainable publication in the sense of the open science idea. Research data of the IAP, which represent a particular added value by their use in networks, should be made available additionally by international data centres, if these centres conduct a data policy satisfying IAP's data policy. For example, the data of the Juliusruh ionosonde are distributed via the international ionosonde network GIRO and the European ionosonde network DIAS. Though nowadays requested by an increasing number of publishers, IAP emphasises that research data used in publications shall be published in open access. IAP uses the research data repository RADAR for data publications that are open access.

The program budget is the central formal document which allows for a discussion and assessment of performance as evidenced by a set of performance indicators between institute and funding bodies. It includes guiding objectives, structural objectives, a performance profile, and management principles. It is defined by the institute's directorate in consultation with the Scientific Advisory Board and approved by the Board of Trustees. Bases of the scientific controlling are the institute's internal evaluations of regularly recorded performance parameters, for example, the number of publications per scientist, external funding revenues, as well as the overall ratio of income and expenses.

IAP plans to introduce a performance-based funding allocation (*LOM: leistungsorientierte Mittelvergabe*) from 2023 onwards. The review of the achievement of target quotas will be documented transparently on an annual basis.

Quality management by advisory boards and supervisory board

The Scientific Advisory Board (SAB) advises the Board of Members, the Board of Trustees, and the Director on all scientific matters of the Institute. It consists of six to ten external experts in the research fields of IAP covering expertise in relevant scientific and experimental topics. The members are appointed by the Board of Trustees (see below) for four years and one consecutive reappointment is possible. Out of the current 9 SAB members, 3 are women and 1 is from abroad. The full Board gathers every two years and carries out an audit. The last audit took place in 2021.

The Board of Trustees *(*BoT*; Kuratorium)* consists of the representatives of the *Land Mecklenburg-Vorpommern* and the Federal Ministry of Education and Research (BMBF), the Dean of the Faculty of Mathematics and Natural Sciences of the University of Rostock, and one member elected by the Board of Members. The chair of the SAB is permanent guest in the meetings. The BoT meets at least once a year. Beyond appointing of the Director, the department heads and the SAB members, the Board's functions include supervising the legality, expediency, and economic efficiency of the management. The BoT also supervises the Strategic Science Plan and the financial planning through the program budget.

The Board of Members (*Mitgliederversammlung*) decides, among others, on the approval of the annual accounts, the discharge of the BoT and the Director, on amendments to the statutes, and appoints the financial auditor.

5. Human Resources

As of 31 December 2019, IAP had 65 employees (without assistants and scholarship recipients, see appendix 4). 37 persons worked in research and scientific services. Furthermore, 16 persons were occupied in science-supporting service positions and 12 in science-supporting administrative positions (see appendix 4).

Leading scientific and administrative positions

IAP generally fills the positions of the scientific director by joint professorial appointments through a cooperation agreement with the University of Rostock (UR). A joint selection committee is chaired by a professor of the UR and consists of professors at the UR and of other universities (both regional, national, and international), as well as of IAP senior scientists, students, and an equal opportunity representative.

For department heads, a joint appointment follows according to the same procedure as it has been the case for the head of the department RRS. IAP plans to also appoint the heads of the departments ORS and MOD jointly with the UR. A new Head of Administration has been appointed in 2017.

Staff with a doctoral degree

At IAP, staff with a doctoral degree are employees on fixed-term positions, i.e., postdocs within 6 years after their PhD defence, and scientists with more than 6 years since graduation. Staff with a doctoral degree on permanent positions are senior scientists. The majority of postdocs are hired to work on a specific project, either funded externally or by institutional funds. Initial contract durations vary between 1 and 3 years, depending on the project. In addition, IAP has hosted two competitive Alexander-von-Humboldt awardees.

Both postdoctoral researchers and scientists, are offered the following opportunities to promote their academic development: (a) assist teaching at the University of Rostock within the master programme of Atmospheric and Ocean Physics; (b) gain experience at and strengthen collaboration with national and international research institutes, e.g., as visiting scientists; (c) participate in externally funded projects, either leading or collaborating; and (d) co-advise IAP PhD students. IAP also promotes leadership experience by forming small research groups within the departments that are supervised by the scientists. This opportunity is particularly attractive for scientists with the aspirations to lead a larger group in the future, including those with already permanent contracts.

The decision to offer a permanent contract to a scientist depends on the Institute's strategic goals, the department's needs, and the performance and skills of the potential candidates. In all cases, candidates are expected to publish in refereed journals, e.g., at least one first-authored article per year. A suitable candidate should also be motivated and experienced in submitting successful proposals to funding agencies and co-supervising students.

In cases of the need to continue long-term expertise (longer than 3 years, e.g., continuing expertise by a senior scientist that is close to retirement or intends leaving IAP, or to add staff to a long-term project, etc.), official job announcements are advertised with the option for possible continuation after 3 years, subject to performance and available funds. In this procedure, postdocs and scientists with the required skills and expertise are encouraged to apply. This strategy was established to keep the balance between offering a career perspective at IAP to early career scientists and bringing new staff and matching knowledge into the institute.

Of the 19 scientists whose fixed-term contracts were completed between 2015 and 2021, 7 scientists were tenured at IAP, 6 continued at other research institutions, 4 went to industry, and 2 became school teachers.

Doctoral Candidates

As of 31 December 2019, there were 15 doctoral candidates employed at IAP and one scholarship recipient (see appendix 4). Between 2018 and 2020, seven doctoral researchers completed their work at IAP. Out of the 13 doctoral students who graduated since the last evaluation, 5 of them went into industry, while 8 found positions at academic and non-academic research institutions. On average it takes 5.2 years to complete a doctoral degree at IAP. Doctoral candidates are admitted in a PhD program at the UR. An IAP professor or a professor at the UR that is not affiliated with IAP take the position of the supervisor. In the latter case an IAP professor is the co-supervisor.

IAP has formulated doctoral guidelines and an appropriate organisational structure for PhD candidates since the last evaluation in addition to the offers and guidelines set by the UR. A doctoral commission is established for each candidate. The supervision of the doctoral candidates currently includes periodic meetings with the main and co-supervisor (every 1 to 4 weeks), frequent presentations of the research progress in the department meetings (2 - 3 per year), and quarterly meetings with the student's doctoral commission. IAP organises institute-wide, weekly doctoral seminars during each academic semester. Furthermore, doctoral students are encouraged to participate in student summer schools and research stays at other institutions abroad. During the reporting period, IAP started a cotutelle program between UR, IAP and École Centrale de Lyon. This program offers students to graduate with degrees from universities in two different countries.

Science supporting staff

The vocational training of non-scientific staff focuses on activities that indirectly or directly support research. These trainings are given by external institutions or experts and by employees of IAP. Administration staff and technicians have received training related to research activities. Technicians have been also trained on scientific instrumentation, to support operations, signal processing, visualization, and quality control measures. Training opportunities on non-scientific topics have also been provided by IAP during this period to scientists, e.g. on “Data protection rules and practices”. In 2018, one apprentice has successfully completed a traineeship at the administration division.

Equal opportunities and work-life balance

Equal opportunities

As of 31 December 2019, out of the 37 employees in research and scientific services 6 were female (16 %). The director was male, and out of the three department heads, one was female (Currently, the director is female and also heads one department, the other two departments are led by males). Out of the 19 scientists in non-executive positions, 2 were female (11 %) and out of the 15 doctoral candidates 3 were female (20 %).

IAP is engaged in implementing the DFG’s research-oriented equality standards and the Leibniz Equality Standards. In 2019 the institute adopted its gender equality plan aiming for a share of 40 % of female scientists. IAP encourages female scientists to participate in mentoring programs such as those offered by the Leibniz Association. Further training opportunities have been offered within the DFG funded collaborative projects.

Regular meetings between the equal opportunities officer (EOO), the director, and the administrative head have been established to discuss equal opportunity developments. Furthermore, the EOO participates in the Leibniz Equal Opportunities and Diversity Working Group. In addition, an “Equal Opportunities Panel” has been established. It consists of the EOO and representatives of each department and profession.

Work-life balance

IAP follows regulated guidelines for flexible working hours, which supports both women and men in families. The institute prepared agreements that are accessible by all employees to support work life balance, including the gender equality plan, an occupational health and safety management system, and the establishment of a parent-child office. Since 2014, the institute has been continuously awarded the certificate “Audit berufundfamilie”.

6. Cooperation and environment

Cooperation with the University of Rostock

The institute’s cooperation with the University of Rostock (UR) is regulated on the basis of a cooperation agreement. The contract regulates the joint appointment of the director and currently of two department heads. The joint appointments enable IAP scientists lecturing of students, supervision of theses at all three education levels (i.e., Bachelor of Science, Master of Science and PhD) as well as participation in multi-disciplinary research and academic activities. IAP, along with the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), forms the core of one of the four Master of Science specialisations in Physics at the UR, i.e., Master of Science in Physics of the Atmosphere and Oceanography. During the evaluation period, IAP professors have taught six classes every year.

Academic activities at other universities

Besides UR academic activities, IAP scientific staff have been involved in activities at other universities like annual lectures in the MSc programme at UNIS (Norway), co-advising PhD students at the University of Potsdam (1) and at the Wismar University of Applied Sciences (5), seminars and colloquia at different national and international universities (e.g., University of Greifswald in Germany, Boston University in the USA), and reviewing PhD theses from national and international universities, and participating in their doctoral committees.

Collaboration with non-university partners

IAP main partner in the Leibniz Association is the IOW. In addition to the joint master programme (see above) IAP and IOW collaborate in two projects, funded within the Leibniz Competition program. Furthermore, the IAP is a member of the Leibniz Research Network "Mathematical Modelling and Simulation" (MMS) and the institute also participates in the Leibniz Research Network "Integrated Earth System Research", which aims to investigate the interaction of humankind with Earth's hydrosphere and biosphere.

IAP cooperates also with other non-university partners as the German Aerospace Center (DLR), Hemholtz Centre Potsdam – GFZ German Centre for Geosciences, German Weather Service (DWD), Max Planck Institute for Meteorology in Hamburg, and Forschungszentrum Jülich.

Cooperation with further national and international institutions

IAP has interacted with 144 institutions during the last seven years, including 36 from Germany and 108 from other countries (wherefrom 25 are in the USA). Nearly two-thirds of IAP publications contain contributions from external partners.

IAP has enabled short- and long-term visits for external scientists at the institute. Between 2015 and 2021, 174 scientists visited IAP for less than three months and four for more than three months. 61 visiting scientists came from German institutions. During the same period, 51 (2) IAP scientists spent less than (more than) three months at other institutes.

Institution's status in the specialist environment

According to IAP, the combination of experimental and modelling expertise to study the middle atmosphere at middle and high latitudes as well as slightly higher latitudes in the future, is unique worldwide, and so are some of the capabilities.

On a national level, the institute names the *Institute of Atmospheric Physics* (IPA) at DLR that takes a similar position. On an international level, IAP names the *Geophysical Institute at the University of Alaska at Fairbanks* (USA), the *Laboratoire Atmosphères, Milieux, Observations Spatiales* (LATMOS, France), the *University of Colorado at Boulder* (USA) as well as the *PANSY* *group* (Japan) that perform research and use experimental capabilities that are relevant to IAP.

7. Departments of the IAP

Optical Soundings and Sounding Rockets (ORS) department

[20.9 FTE, thereof 8.0 FTE Research and scientific services, 3.5 FTE Doctoral candidates, and 9.4 FTE Service staff]

The department develops and uses lidar remote sensing and *in-situ* soundings with rockets and balloons. Measurements of temperatures, densities, aerosols, clouds (e.g., noctilucent clouds), and other trace constituents are performed from the upper troposphere to the lower thermosphere.

The department has developed daylight capable lidars, allowing for studying the middle atmosphere throughout the whole year at middle and high latitudes. The study of lidar data at multiple wavelengths is utilized to extract information on aerosols across the middle atmosphere. A new technique called DORIS, developed at IAP, was applied at ALOMAR, and wind profiles throughout the stratosphere and mesosphere spanning the whole day are now acquired regularly. The measurements are used to calculate and interpret the potential and kinetic energy of waves simultaneously.

Another capability of the department is the identification and quantitative analysis of individual wave trains, allowing for the detection of wave generation, including downward propagating waves in the vicinity of the polar vortex. The combination of lidar and *in-situ* soundings covers a broad range of scales, and measurements of all relevant scales of the energy cascade are performed.

VAHCOLI, a new lidar concept, was addressed by developing and building a prototype for a 1 m^3 mobile lidar unit. The most critical components, such as the newly developed Alexandrite ring laser, performed nominally in first light measurements. Currently, four lidars with five beams each are being built to provide extensive regional coverage.

Between 2018 and 2020, the department published 44 articles in peer-reviewed journals. The revenue from project grants totalled approx. € 2.6m (Ø €876k p.a.). € 1.9m (Ø € 633k p.a.) thereof were obtained from federal and *Länder* governments, € 473k (Ø € 158k p.a.) from DFG, € 258k (€ 86k p.a.) from the Leibniz Association (competitive procedure) and € 13.2k (€4.4k p.a.) from the EU. Another €155k (Ø € 52k p.a.) were acquired as revenue from services. As of 31 December 2019, 5 patents in 3 patent families were held and 1 application giving rise to a right of priority was filed between 2018 and 2020. In the three-year period, 5 doctoral degrees were completed.

Radar Remote Sensing (RRS) department

[16.9 FTE, thereof 7.0 FTE Research and scientific services, 3.4 FTE Doctoral candidates, and 6.5 FTE Service staff]

The department employs ground-based radar and radio remote sensing techniques that work under all weather conditions. The focus is on studies of MLT dynamics at different scales (from kilometre to planetary scales), and their connection to lower and upper atmospheric layers, by resolving time and spatial ambiguities of atmospheric and ionospheric parameters.

The scientists use large facilities as well as small but distributed portable radars. The development of multistatic specular meteor radar networks by the department (e.g., SIMONe), in combination with airglow imagers and satellite measurements, as well as model simulations, allow studies of MLT planetary-scale and mesoscale dynamics, including coupling mechanisms across altitudes and latitudes. At mesoscales, the interplay of gravity waves and stratified turbulence is studied with the second-order statistics approach that was recently developed by the department.

As part of the research portfolio, ionospheric monitoring is being performed at Juliusruh station since the 1950s. While the long dataset is used to study ionospheric trends, the routine observations are utilized for space weather sensitive applications related to navigation and communications. Most of these activities are done in collaboration not only with national and international groups, but also within IAP. Besides the scientific exchange, national and international cooperation is also needed, e.g., to implement new concepts like MAARSY-3D; to carry out multi-instrument campaigns; to deploy radar networks; to further explore and exploit existing datasets. Examples of these initiatives are: enhanced radar imaging at MAARSY, multistatic configuration, MIMO and spread-spectrum concepts in MAARSY and SIMONe, phase differencing and high-resolution wavelet analysis, and more recently, automated signal recognition by machine learning.

Between 2018 and 2020, the department published 62 articles in peer-reviewed journals. The revenue from project grants totalled approx. €827k (Ø € 276k p.a.). € 532k (Ø € 177k p.a.) thereof were obtained from DFG, € 216k (Ø € 72k p.a.) from the Leibniz Association (competitive procedure), € 51k (€ 17k p.a.) from federal and *Länder* governments and € 28k (€ 9.3k p.a.) from the EU. Another € 227k (Ø € 76k p.a.) were acquired as revenue from commissioned work. As of 31 December 2019, 1 patent in 1 patent family were held and 1 application giving rise to a right of priority were filed between 2018 and 2020. In the three-year period, 2 doctoral degrees were completed.

Modelling of Atmospheric Processes (MOD) department

[9.6 FTE, thereof 6.2 FTE Research and scientific services, 2.6 FTE Doctoral candidates, and 0.8 FTE Service staff]

The department applies advanced diagnostics to study physical systems of different levels of complexity, utilises models for process understanding, and develops numerical models. The department applies and develops both *General Circulation Models* (GCMs) and models for specific physical processes.

The *Kühlungsborn Mechanistic Circulation Model* (KMCM) is a hydrostatic GCM from the surface to the lower thermosphere with particular emphasis on dynamical interaction between different scales and altitude regions. It has been developed at IAP and is now being improved to include novel parametrization schemes related to subgrid turbulence and waves. The department succeeded with the resolution of higher-order gravity waves in

KMCM, simulating realistic winds in the MLT for the first time and thus theoretically proving their importance for global circulations.

Recently, IAP implemented the German community model *Upper Atmosphere version of the ICOsahedral Non-hydrostatic GCM* (UA-ICON), and currently evaluates its role in perspectively contributing to further develop its upper atmosphere part, e.g., the MLT. The department has hired two postdoctoral researchers and a scientist, that have started in 2021 or will start early 2022 to exploit different aspects of UA-ICON.

The department plans to make a significant contribution to strengthen the national and European communities on the concept of whole atmosphere modelling. With respect to specified process models, scientists have developed a *Chemistry Transport Model* for simulations of airglow and plasma chemistry to support long-term studies of MLT trends. Furthermore, direct numerical simulations to quantify the impact of stratified turbulence for the interpretation of IAP's high-resolution observations will be applied. Also, long-term climatological studies on mesosphere temperatures and on feedback mechanisms from the stratosphere to the troposphere have been undertaken during the reporting period.

Between 2018 and 2020, the department published 49 articles in peer-reviewed journals. The revenue from project grants totalled approx. € 932k (Ø € 311k p.a.). € 558k (Ø € 186k p.a.) thereof were obtained from DFG, € 321k (Ø € 107k p.a.) from the Leibniz Association (competitive procedure) and € 1,1k (Ø € 0.4k p.a. from federal and *Länder* governments. Another € 3.3k (Ø €1.1k p.a.) were acquired as revenue from services. In the three-year period, 0 doctoral degrees were completed.

8. Handling of recommendations from the previous evaluation

IAP responded as follows to the six recommendations of the last external evaluation (highlighted in italics, see also the statement of the Senate of the Leibniz Association issued on 17 March 2016, pages B-2/B-3):

1) *„The IAP is increasingly in a position to include so-called **community models** (models developed jointly by several institutions) in its research and to contribute to their further development. The Institute is encouraged to further strengthen its efforts in this area, if necessary, also within the framework of new cooperation".*

   The institute applied runs from different GCMs to complement IAP's research activities. These activities have resulted in active collaborations with Max Planck Institute (MPI) for Meteorology Hamburg (HAMMONIA), German Weather Service (DWD) and the MPI (UA-ICON), National Center for Atmospheric Research – High Altitude Observatory (NCAR-HAO, USA) (WACCM-X, WACCM-D) or National Research Laboratory (NRL, USA) (NAVGEM-HA). The use of community models, e.g., UA-ICON, is now implemented in all departments of IAP. In the next two years, IAP will focus on validating the performance of UA-ICON at MLT altitudes against its own and globally distributed observations. From there, IAP will formulate relevant recommendations for future model developments. Active development of the upper atmosphere modules of UA-

ICON by enhancing dedicated formulations with respect to physical dynamics or chemical kinetics for high-resolution and long-term runs is a future goal of IAP.

2) *„In order to strengthen its international position, the IAP plans to acquire a highly innovative measurement system that would fully exploit the potential of its many years of technological and scientific experience.* ***VAHCOLI*** *(Vertical and Horizontal Coverage by Lidar) is of the highest strategic importance for the development of the Institute. It would contribute to securing the IAP's leading international position in atmospheric research of the stratosphere and mesosphere and favour further cooperative relationships. The realisation of this project with additional funds on the basis of an extraordinary item of expenditure is strongly advocated."*

   Following the positive recommendation during the previous evaluation, IAP was granted approval for the "temporary extraordinary item of expenditure" VAHCOLI, with expenditures of € 0.69 and € 1.13 million received in 2018 and 2019, respectively. A prototype was developed and the first measurements were performed (see ch. 3). The concept and preliminary findings were recently published.

3) *„In future, the IAP should again regularly acquire funds from the* ***German Research Foundation (DFG)*** *at least in the amount of the fees to DFG."*

   According to IAP, the institute has been successful in acquiring funding from DFG. Between 2015 and 2020, IAP received on average € 500kper year, which is about triple the annual fees of average € 150k per year to DFG (see ch. 4).

4) *„In the long-term, the IAP must achieve an appropriate* ***proportion of women in leadership positions*** *and, to this end, further intensify its measures to promote female scientists. The active promotion of young female scientists should also include their participation in mentoring programmes. Furthermore, women should be encouraged to apply for leadership positions even more strongly than before."*

   At the time of the last evaluation in 2015, all leadership positions at IAP at the director, department, and administrative level were held by men. The last two hires, e.g., the director and the administrative head in 2021 and 2017, respectively, have been women. Currently, 1 out of 3 scientific leadership positions are held by women (see ch. 5).

5) *„The IAP must intensify its efforts and take appropriate* ***measures to shorten doctoral studies*** *to between three to three and a half years."*

   IAP has carefully undertaken measures for shortening doctoral studies. These involve the intensification of the doctoral seminars, the establishment of doctoral commissions, and the formulation of doctoral guidelines in 2018. These new measures reduced the time of doctoral studies slightly (see ch. 5). The current average duration of doctoral studies between 2015 and 2021 has been 5.2 years, considering four students that started before 2013 and graduated, on average after 6 years. Without these early graduates, the average duration has been 4.8 years[1].

In addition, recruiting new qualified students has been challenging during the last few years, due to personnel changes of professor positions at IAP. However, the institute will continue to enhance the selection of candidates and guiding procedures to ensure the successful commencement and timely completion of PhD dissertations.

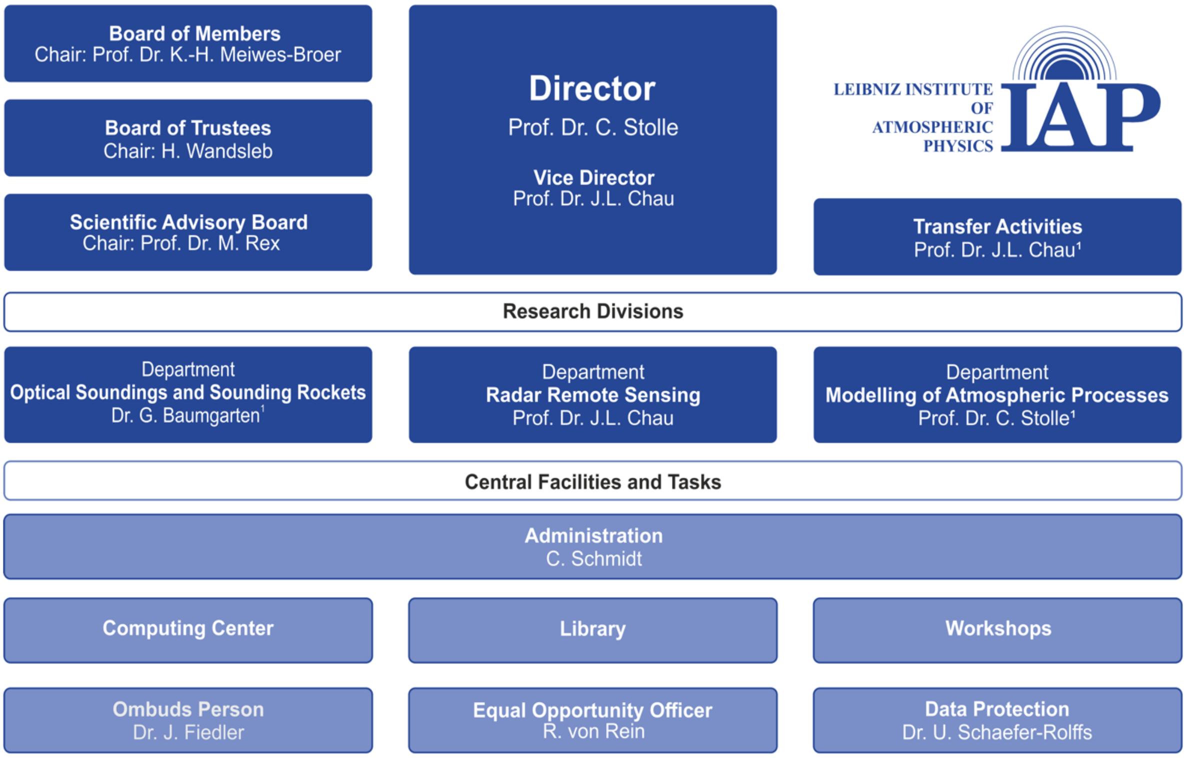
6) *„The IAP should examine whether the number of highly qualified* ***young researchers with doctorates*** *can be increased through the establishment of third-party funded junior research groups, for example within the framework of the DFG's Emmy Noether Programme or through junior professorships. The "Theory and Modelling" department in particular would benefit from such an increase in personnel."*

According to IAP, in 2018, the acting head of the "Theory and Modelling" department was filled with an early career scientist of the department. In addition, a postdoctoral researcher of this department has submitted a proposal for DFG's Emmy-Noether Programme in 2020, which was unfortunately not accepted for funding. Within IAP, early career scientists will be encouraged to follow different opportunities (such as grants from the European Research Council, Leibniz-Junior Research Groups or Women Professors within Leibniz Competition). For example, IAP applies for a Junior Research Group building its own Research Division within COSA-SAT (see ch. 3).

[1] The average durations of PhD studies in physics in Germany is 4.6 years (https://www.academics.de/ratgeber/promotion-dauer#subnav_wie_lange_dauert_eine_promotion_im_durchschnitt (German only)).

Appendix 1

Organisational Chart



[1] acting

February 2022

Appendix 2

Publications, patents, and expert reviews

	Period		
	2018	2019	2020
Monographs	3	1	3
Individual contributions to edited volumes	1	4	1
Articles in peer-reviewed journals	57	46	28
Articles in other journals	4	8	0
Editorship of edited volumes	1	1	0

Patents	**2018**	**2019**	**2020**
Applications giving rise to a right of priority (in the calendar year)	1	1	0
Patents (number held as of 31.12. of the year)	6	6	6
Patent families (number held as of 31.12. of the year)	3	4	4

	2018	**2019**	**2020**
Number of expert reviews	0	1	1

Appendix 3 Revenue and Expenditure

Revenue		2018			2019			2020		
		k€	**%**	**%**	**k€**	**%**	**%**	**k€**	**%**	**%**
Total revenue (sum of I., II. and III.; excluding DFG fees)		**10.823,3**			**10.180,2**			**8.547,4**		
I.	**Revenue (sum of I.1., I.2. and I.3)**	**9.121,1**	**100 %**		**9.224,4**	**100 %**		**7.922,2**	**100 %**	
1.	INSTITUTIONAL FUNDING (EXCLUDING CONSTRUCTION PROJECTS AND ACQUISITION OF PROPERTY)	7.174,1	78,7 %		7.668,4	83,1 %		6.697,2	84,5 %	
1.1	Institutional funding (excluding construction projects and acquisition of property) by Federal and *Länder* governments according to AV-WGL	7.174,1			7.668,4			6.697,2		
1.2	Institutional funding (excluding construction projects and acquisition of property) not received in accordance with AV-WGL									
2.	REVENUE FROM PROJECT GRANTS	1.819,3	19,9 %	100 %	1.425,9	16 %	100 %	1.097,3	14 %	100 %
2.1	DFG	520		28,6 %	663		46,5 %	380,4		34,7 %
2.2	Leibniz Association (competitive procedure)	571,6		31,4 %	91,2		6,4 %	132		12 %
2.3	Federal, *Länder* governments	727,7		40 %	630,6		44,2 %	576,9		52,6 %
2.4	EU				41,1		2,9 %			
2.5	Foundations							8		0,7 %
3.	REVENUE FROM SERVICES	127,7	1,4 %		130,1	1,4 %		127,7	1,6 %	
3.1	Revenue from commissioned work	124,1			126,6			127,7		
3.2	Revenue from conferences/workshops at IAP	3,6			3,5					
II.	**Miscellaneous revenue** (e.g. membership fees, donations, rental income, funds drawn from reserves)	**1.702,2**			**955,8**			**625,2**		

Expenditures		2018 k€	2019 k€	2020 k€
Expenditures (excluding DFG fees)		**9.919,6**	**9.620**	**7.410,3**
1.	Personnel	4.556,6	4.380,2	4.139,4
2.	Material expenses	3.171,1	2.512,1	2.145,2
2.1	*Proportion of these expenditures used for registering industrial property rights (patents, utility models etc.)*	14,4	18,3	4,1
3.	Equipment investments	1.533,4	2.314,7	996
4.	Construction projects, acquisition of property	658,5	413	129,7
DFG fees (if paid for the institution – 2.5% of revenue from institutional funding)		178,9	191,6	166,8

Appendix 4

Staff

(Basic financing and third-party funding / proportion of women (as of: 31 December 2019)

	Full time equivalents		Employees		Female employees		foreign-ers
	Total	on third-party funding	Total	on tem-porary contracts	Total	on tem-porary contracts	Total
	Number	Percent	Number	Percent	Number	Percent	Number
Research and scientific services	**30,7**	**29,7**	**37**	**59,5**	**6**	**83,3**	**15**
1st level (scientific directors)	1	-	1	-	-	-	-
2nd level (department leaders or equi.)	2	-	2	-	1	-	1
Scientists in non-executive positions (A13, A14, E13, E14 or equivalent)	18,2	16,5	19	36,8	2	100	6
Doctoral candidates (A13, E13, E13/2 or equi.)	9,5	64,4	15	100	3	100	8
Science supporting staff (laboratories, technical support etc.)	**15,3**	**-**	**16**				
Laboratory (E9 to E12, upper-mid-level service)	7,8	-	8				
Laboratory (E5 to E8, mid-level service)	5	-	5				
Library (E9 to E12, upper-mid-level service)	0,5	-	1				
Information technology - IT (E9 to E12, upper-mid-level service)	2	-	2				
Science supporting staff (administration)	**4**	**15,8**	**12**				
Head of the administration	1		1				
Staff positions (from E13, senior service)	1,7	100	2				
Internal administration (financial administration, personnel etc.) (from E13, senior service)	1	-	1				
Internal administration (financial administration, personnel etc.) (E9 to E12, upper-mid-level service)	1,5	-	1				
Internal administration (financial administration, personnel etc.) (E5 to E8, upper-mid-level service)	4,6	-	5				
Building service (E1 to E4)	1,1	5	2				
Student assistants	**2,9**	**-**	**6**				
Scholarship recipients at the institution	**1**	**100**	**1**		**-**		**1**
Doctoral candidates	1	100	1		-		1

30 September 2022

Annex B: Evaluation Report

Leibniz Institute of Atmospheric Physics e. V. at the University of Rostock, Kühlungsborn (IAP)

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Appendix:
Members of review board

1. Summary and main recommendations

The Leibniz Institute of Atmospheric Physics (IAP) in Kühlungsborn conducts research on the mesosphere and lower thermosphere (MLT) and adjacent atmospheric layers between 50 and 200 km altitude. As part of a convincing overall concept, it conducts experimental and theoretical research on long-term changes in these layers and their coupling processes. The IAP is organised into three departments, two of which deal with research on and with lidar and radar systems (**Li**ght/**Ra**dio **d**etection **a**nd **r**anging), respectively. The third department uses the data from the other two to carry out numerical modelling.

The output of all three departments, which work closely together, has been assessed as 'excellent'. The IAP regularly produces outstanding research results highly regarded in the scientific community. In addition, the IAP does pioneering work in the design, construction and operation of lidar, rocket soundings and radar systems. The stationary and mobile measuring instruments are deployed at the sites in Kühlungsborn and Juliusruh, at the *Arctic Lidar Observatory for Middle Atmosphere Research* (ALOMAR) in northern Norway, and in South America. The IAP uses the collected data to carry out innovative modelling projects. The long-term projects employing the *Kühlungsborn Mechanistic Circulation Model* (KMCM) are particularly important. As recommended during the last evaluation, the IAP is now also involved in developing community models (models developed jointly by several institutions). Worth highlighting here is the work on the *Upper Atmosphere* extension of the *ICOsahedral Non-hydrostatic Model* (UA-ICON).

The IAP has maintained the scientific quality of its work, which was recognised as excellent during the last evaluation. The continuing strategic plans for the future are convincing. Based on its MLT research work, the IAP is planning, firstly, to intensify its research on the coupling of these layers with the lower atmosphere, which is important for weather and climate. Secondly, it plans to extend the observation and modelling of layers above the MLT to include the border region between atmosphere and space. The aim is to contribute to a better understanding of 'space weather'.

The IAP has significantly expanded its expertise in this area by appointing its new Director who has been leading the institute since October 2021. She came to the IAP from Helmholtz Centre Potsdam – the GFZ German Research Centre for Geosciences. The previous long-standing Scientific Director, who had made a significant impact on the institute since he took up the post in 1999, has retired. There will be more personnel changes at the scientific leadership level because new department heads need to be appointed for two of the three departments.

The institute collaborates closely with the University of Rostock. The institute Director and department heads are appointed jointly with the university to W3 or W2 professorships. In collaboration with the university, the IAP offers outstanding development opportunities for scientists in the qualification phase. The institute also maintains close relationships with the *German Weather Service* (DWD), the *Max Planck Institute for Meteorology* and the *German Aerospace Center* (DLR).

Special consideration should be given to the following main recommendations in the evaluation report (highlighted in **bold face** in the text):

Overall concept, activities and results (chapter 2)

1. The institute collects **data** of high scientific interest and makes much of it freely accessible through certain international data centres. The IAP should continue its efforts to make the data even more widely known in the scientific community.

Changes and planning (chapter 3)

2. The decision to wait until the institute Director was in place before **appointing two department heads** in a joint appointment procedure (W2 professorship) with the University of Rostock makes sense. Both procedures must now be pursued rapidly, as planned, by the responsible boards at the institute and the university, and the positions filled with experts in the fields of lidar (and rocket sounding) systems and numerical modelling.
3. The IAP plans to apply for a permanent increase in institutional funding under the heading **"COSA-SAT" (COnnecting Space and Atmosphere – Science And Transfer).** The plans include establishing an independent junior research group (one early-career scientist as head, one Postdoc and two PhDs) dedicated to global-scale studies, using satellite observations to investigate atmosphere-ionosphere coupling. The IAP also plans to appoint one additional postdoc in each department to facilitate close cooperation with the junior research group, and to appoint a new Science Manager to increase the communication with space agencies and industry. The cost of financing the eight additional positions and investments amounts to approx. € 1.1m p.a., of which the IAP will provide around € 200,000 p.a. from its own funds. The remaining € 900,000 p.a. is to be provided by a permanent increase in institutional funding from 2025 onwards.

   An application for this measure in the federal and Länder government procedure is expressly endorsed. In its application, the IAP should show which preliminary work has already taken place or is likely to be completed by the planned funding start date in 2025. The IAP plans to advertise the position of a junior research group leader as a tenure-track position and to potentially put the group on a permanent footing by developing it into a fourth department. In the context of these plans, the application should clarify whether the University of Rostock can already be involved in the appointment procedure for the junior group leader, e.g. through a joint appointment as a junior professor.

Controlling and quality management (chapter 4)

4. It is laudable that the institute has significantly increased the amount of project funding it receives from the DFG, as recommended during the last evaluation. However, the overall amount of project funding decreased from € 1.83m p.a. on average between 2011 and 2013 (corresponding to 24 % of the overall budget) to € 1.45m p.a. on average between 2018 and 2020 (corresponding to 17 % of the overall budget). The **revenue from project grants** should be increased significantly – in line with the goal that the IAP has set itself. The scientific plans for the future offer a wide range of opportunities to achieve this.

Human resources (chapter 5)

5. **Postdocs** have adequate further training opportunities available. Similar to the approach used for the doctoral programme, the IAP should further improve the structure of postdoc support and advice for further career planning, including outside of academia, and make these measures visible to its employees.
6. Doctoral candidates receive very good support. However, the **time to completion of a PhD** is still too long, with an average of 5.2 years. The IAP needs to develop and implement suitable measures, as planned, to reduce this to the IAP's target duration of 4 years.
7. The appointment of the new Director has increased the **proportion of female researchers** at the executive level. Still, the proportion of female researchers at all other hierarchy levels has fallen. The IAP must increase the proportion of women at all levels of the organisation. It is good to see that it is already actively contacting suitable female candidates for upcoming leadership appointments.

2. Overall concept, activities and results

Overall concept and activities

The Leibniz Institute of Atmospheric Physics (IAP) in Kühlungsborn conducts research on the mesosphere and lower thermosphere (MLT) and adjacent atmospheric layers between 50 and 200 km altitude. As part of a convincing overall concept, it conducts experimental and theoretical research on long-term changes in these layers and their coupling processes.

The IAP is organised into three departments that collaborate closely with one another. The Optical Soundings and Sounding Rockets (ORS) department and the Radar Remote Sensing (RRS) department conduct research on and with lidar and radar systems (**Li**ght/**Ra**dio **d**etection **a**nd **r**anging), respectively. The Modelling of Atmospheric Processes (MOD) department uses the data from the other two departments to carry out numerical modelling. The work of all three departments has been assessed as 'excellent' (see chapter 7 for details).

Results

Research

The IAP regularly produces outstanding research results highly regarded in the scientific community. Highlights include new insights into polar mesosphere winter and summer echoes, gravity waves and the structure of noctilucent clouds. The IAP regularly publishes its research results in the relevant journals, including a high number of first-author publications. It is very good to see that open access articles account for almost three-quarters of the publications.

Research infrastructure

The institute does pioneering work in the design, construction and operation of lidar and radar systems. These unique IAP developments are tailored to the research topics in question. The stationary and mobile measuring instruments are deployed at the sites in Kühlungsborn and Juliusruh, at the *Arctic Lidar Observatory for Middle Atmosphere Research* (ALOMAR) in northern Norway, and in South America. The development and installation of new software and hardware enabling lidar remote operation and semi-automated operations at the sites in Kühlungsborn and ALOMAR were very important (see also chapter 4). This enabled continuous measurements, even during the COVID-19 pandemic.

Special mention should also be made of unique developments, such as daylight-capable lidars, which make it possible to study the middle atmosphere throughout the whole year at middle and high latitudes, as well as the new *DORIS* (Doppler Rayleigh Iodine Spectrometer) technique. A further highlight is the mobile portable observation network called *SIMONe*. It combines radar practices (e.g. MIMO), spread-spectrum and compressed sensing and can be used to observe MLT mesoscale dynamics.

The IAP achieved another outstanding result with developing a globally unique prototype for a 1 m^3 mobile lidar unit called VAHCOLI *(Vertical And Horizontal Coverage by Lidar).* The concept and first results were published recently. Following a positive recommendation during the previous evaluation, IAP received temporary additional funding of approx. € 1.8m in 2018/2019 for the development of VAHCOLI. A new building for production and testing of the new systems has been constructed.

The institute collects data of high scientific interest and makes much of it freely accessible through certain international data centres (see chapter 4). One highlight is an ionospheric time series that dates back to 1957, providing data that is an integrative part of global networks. **The IAP should continue its efforts to make the data even more widely known in the scientific community.**

The IAP uses the collected data to carry out innovative modelling projects. The long-term projects relating to the *Kühlungsborn Mechanistic Circulation Model* (KMCM) are particularly important. It is good to see that the model was developed further with partners into a high-top general circulation model (HIAMCM) to cover high altitudes. As recommended during the last evaluation, the IAP is now also involved in the development of community models (models developed jointly by several institutions). Worth highlighting here is the work on the *Upper Atmosphere* extension of the *ICOsahedral Non-hydrostatic Model* (UA-ICON).

Transfer

To promote the transfer of results, a working group on transfer activities was established in 2021. Activities include all channels of communication between the IAP and the non-academic world, e.g. press releases, public view days, patents, etc. The institute holds a patent portfolio of six patents and four patent families. Between 2018 and 2020, it filed a total of two applications that give rise to a right of property. The IAP advises the federal armed forces (*Bundeswehr*), e.g. by providing regular and ad-hoc reports on radio wave propagation conditions based on the Juliusruh ionosonde data. The IAP plans to extend its transfer activities in the near future.

3. Changes and planning

Development since the previous evaluation

The IAP has maintained the scientific quality of its work, which was recognised as excellent during the last evaluation. Last year, the long-standing Scientific Director retired. He had made a significant impact on the institute since he took up the post in 1999. It is good to see that his position was filled in October 2021 with a female researcher with a strong track record. She was previously at the Helmholtz Centre Potsdam – the GFZ German Research Centre for Geosciences.

New appointments are now pending for department heads in two of the three departments. The ORS department, which is responsible for lidar and rocket soundings and has previously been led by the former institute Director, is currently being run by an acting head. The MOD department, which deals with modelling, has been under an acting head since 2019 and is currently led by the new institute Director, but she will in the future concentrate on running the institute. The former, very successful department head left in 2019 to join a firm in Boulder, USA.

The decision to wait until the institute Director was in place before appointing two department heads in a joint appointment procedure (W2 professorship) with the University of Rostock makes sense. Both procedures must now be pursued rapidly, as planned, by the responsible boards at the institute and the university, and the positions filled with experts in the fields of lidar (and rocket sounding) systems and numerical modelling.

Strategic work planning for the coming years

The continuing strategic plans for the future are convincing. Based on its MLT research work, the IAP is planning, firstly, to intensify its research on the coupling of these layers with the lower atmosphere, which is important for weather and climate. This will enable the IAP to contribute toward the increasingly important inclusion of the MLT in climate models.

The IAP also plans to extend its observation and modelling of layers above the MLT to include the border region between atmosphere and space. The aim is to contribute to a better understanding of 'space weather'. An important field of application is enabling more precise determination of trajectories of rockets, satellites and space debris. This is particularly important because of the increasingly intensive civil and commercial use of space. The IAP has significantly expanded its expertise in this area by appointing the new Director. She has conducted research in this field, for instance, as head of the DFG-funded "Dynamic Earth" priority programme and in projects funded by the European Space Agency (ESA) and the EU.

Planning for additional funds deriving from institutional funding

The IAP plans to apply for a permanent increase in institutional funding under the heading "COSA-SAT" (COnnecting Space and Atmosphere – Science And Transfer). The plans include establishing an independent junior research group (one early-

career scientist as head, one Postdoc and two PhDs) dedicated to global-scale studies, using satellite observations to investigate atmosphere-ionosphere coupling. The IAP also plans to appoint one additional postdoc in each department to facilitate close cooperation with the junior research group, and to appoint a new Science Manager to increase the communication with space agencies and industry. The cost of financing the eight additional positions and investments amounts to approx. € 1.1m p.a., of which the IAP will provide around € 200,000 p.a. from its own funds. The remaining € 900,000 p.a. is to be provided by a permanent increase in institutional funding from 2025 onwards.

An application for this measure in the federal and Länder government procedure is expressly endorsed. In its application, the IAP should show which preliminary work has already taken place or is likely to be completed by the planned funding start date in 2025. The IAP plans to advertise the position of a junior research group leader as a tenure-track position and to put the group on a permanent footing by developing it into a fourth department, if appropriate. In the context of these plans, the application should clarify whether the University of Rostock can already be involved in the appointment procedure for the junior group leader, e.g. through a joint appointment as a junior professor.

4. Controlling and quality management

Facilities, equipment and funding

Funding

The institutional funding of the IAP is deemed sufficient for its current activities. It rose from € 5.8m in 2013 to € 6.7m in 2020.

It is laudable that the institute has significantly increased the amount of project funding it receives from the DFG, as recommended during the last evaluation. However, the overall amount of project funding decreased from € 1.83m p.a. on average between 2011 and 2013 (corresponding to 24 % of the overall budget) to € 1.45m p.a. on average between 2018 and 2020 (corresponding to 17 % of the overall budget). The revenue from project grants should be increased significantly – in line with the goal that the IAP has set itself. The scientific plans for the future offer a wide range of opportunities to achieve this. It is good to see that the IAP is submitting funding applications, including through very competitive processes, such as for ERC grants and Emmy Noether junior research groups.

In addition, the IAP also generates revenue from services, mainly from commissioned work (approx. € 129,000 p.a.). The planned expansion of the IAP's work in the border region between atmosphere and space offers the opportunity to increase revenue from services by providing technical instruments and consultancy to industry partners.

Facilities and equipment

The IAP has appropriate premises. At the Kühlungsborn site, the administration offices and a new lecture hall have been housed since 2015 in a new building constructed with external funding (European Regional Development Fund). In addition, a laboratory building was built in 2019 as part of the VAHCOLI project (see chapter 2). The Board of Trustees should work towards improving the accessibility of the institute by public transport from Rostock and Kühlungsborn, as planned, so that the young scientists in particular can arrange their working hours at the institute more flexibly.

The excellent equipment in Kühlungsborn and Juliusruh includes lidars and radars that provide relevant measurements in the mid-latitudes and the institute also operates an ionosonde. Additionally, there are two atmospheric radars, a magnetometer and a low-frequency receiver.

The IAP makes a very important contribution to the *Arctic Lidar Observatory for Middle Atmosphere Research* (ALOMAR, see also chapter 2). This research infrastructure on the island of Andøya in northern Norway gives the IAP access to measurements of the Arctic middle atmosphere. It includes lidars and radars with unique capabilities such as daylight-capable lidars, and 4D-capable radars. The IAP also develops sounding rocket concepts and flies multi-parameter instruments in coordinated rocket launches at Andøya Space, complementing the routine data acquisition at ALOMAR.

IT infrastructure

The IAP has outstanding IT infrastructure it can use for its computationally-demanding simulations of complex atmospheric processes, including servers, data storage facilities and a high-performance computer (HPC). In recent years, the IT infrastructure has been extended to store large amounts of data, including raw data from remote large facilities and small distributed systems. Research data collected by the IAP's scientific instruments are further stored redundantly in a tape library. The IAP uses the *RADAR* research data repository for data publications. These data publications are open access. The handling of, access to, and publication of research data at the IAP is governed by the *IAP Research Data Policy.*

Organisational and operational structure

The organisational and operational structure of the IAP is appropriate. According to the institute's statutes, the Director is the Executive Board as per § 26 of the German Civil Code (BGB). The Board of Trustees (see below) appoints one of the department heads as Deputy Director. The Director appoints the Head of Administration to the role of Budget Officer. Internal communication is collegial and smooth. The IAP should reconsider whether the Executive Board should be enlarged by adding the Head of Administration and another scientific member, especially if the institute expands by integrating a junior research group with a view to putting it on a permanent footing as a department.

It is good to see that a Directorate was formed in 2021. It consists of the Director, the department heads, and the Head of Administration. It holds bi-weekly meetings to steer major developments at the institute.

Quality management

The institute's quality management is aligned with the established standards. Rules are in place to ensure good scientific practice, which follows the recommendations of the German Research Foundation (DFG). The IAP has an ombudsperson.

The IAP encourages its scientists to publish in open-access journals. It is welcomed that about 70 % of the publications between 2018 and 2021 were open access. The *RADAR* research data repository is used for this purpose. The IAP also participates in the WILEY DEAL, an agreement negotiated by the DEAL project under the auspices of the German Rectors' Conference *(Hochschulrektorenkonferenz).*

The institute has issued research data policy guidelines regarding accessibility, traceability, and sustainable publication, in line with the open science idea. The IAP makes research data available to international data centres. For example, the data from the Juliusruh ionosonde is distributed via the GIRO international ionosonde network and the DIAS European ionosonde network.

The programme budget is the central formal document which allows for a discussion and assessment of performance, as evidenced by a set of performance indicators, between institute and funding bodies. It is good to see that the IAP plans to implement performance-based funding allocation (LOM) from 2023 onwards.

Quality management by advisory boards and supervisory board

The Board of Trustees *(Kuratorium)* and Scientific Advisory Board (SAB) fulfil their role adequately. The SAB meets once a year. In 2018, it conducted an audit of the institute as a whole and of its individual departments, a common practice for Leibniz institutes.

5. Human resources

Leading scientific and administrative positions

The Director, who was appointed in October 2021, runs the IAP well together with the other leadership staff. The Head of Administration, who has been at the IAP since 2017, fulfils her role with dedication.

The IAP fills leading scientific positions through joint appointments with the University of Rostock as W3 (Director) and W2 positions (department heads). The upcoming appointments to the two vacant department head positions will further stabilise the personnel situation in terms of scientific leadership. These departments are currently being managed on a provisional basis by the Director (MOD department) and an experienced IAP scientist (ORS department).

Staff with a doctoral degree

The IAP provides a stimulating environment for young researchers. Its excellent scientific infrastructure offers outstanding development opportunities. The success of the IAP's support can be seen in the fact that, since the last evaluation, of the 19 scientists who came to the end of their fixed-term contracts, seven were tenured at the IAP and 12 moved to other academic and non-academic institutions. **Postdocs have adequate further training opportunities available. Similar to the approach used for the doctoral programme, the IAP should further improve the structure of postdoc support and advice for further career planning, including outside of academia, and make these measures visible to its employees** (see below).

Doctoral candidates

Doctoral candidates receive very good support. As of 31 December 2019, there were 15 doctoral candidates employed at the IAP and one scholarship recipient. Between 2018 and 2020, seven doctoral researchers completed their work at the IAP. **However, the time to completion of a PhD is still too long, with an average of 5.2 years. The IAP needs to develop and implement suitable measures, as planned, to reduce this to the IAP's target duration of 4 years.**

It is good to see that the IAP has formulated doctoral guidelines and established an appropriate organisational structure for doctoral candidates, in addition to the opportunities and guidelines provided by the University of Rostock. A doctoral committee is established for each candidate. Also worth highlighting is the establishment of a cotutelle programme between the University of Rostock, the IAP and École Centrale de Lyon. This programme enables students to graduate with degrees from universities in two different countries.

Scientific support staff

The vocational training of non-scientific staff is appropriate and focuses on activities that indirectly or directly support research. These trainings are given by external institutions or experts and employees of the IAP. In 2018, one apprentice successfully completed their training in the administration division.

Equal opportunities and work-life balance

As of 31 December 2019, of the 37 employees in research and scientific services, six were female (16 %; in 2013: 26 %). Of the 19 scientists in non-executive positions, two were female (11 %; in 2013: 24 %), and of the 15 doctoral candidates directly funded by the IAP, three were female (20 %; in 2013: 31 %).

The appointment of the new Director has increased the proportion of female researchers at the executive level. Still, the proportion of female researchers at all other hierarchy levels has fallen. The IAP must increase the proportion of women at all levels of the organisation. It is good to see that it is already actively contacting suitable female candidates for upcoming leadership appointments.

The measures to support a better work-life balance are appropriate. In 2021, the IAP was re-certified by the "berufundfamilie" audit.

6. Cooperation and environment

Cooperation with the University of Rostock

The IAP is closely connected with the University of Rostock based on a cooperation agreement. The IAP's leading scientists are jointly appointed (see chapter 5). Furthermore, the IAP and the Leibniz Institute for Baltic Sea Research in Warnemünde (IOW) have joined forces to offer a Master of Science course in Physics of the Atmosphere and Oceanography in Rostock. The IAP also works closely with the university in the area of research, cooperating in the DFG priority programme 1798 "Compressed Sensing in Information Processing" (CoSIP) on a project basis. Furthermore, the IAP actively participated in the *AMELIE* project led by the university on studies of the ionospheric D region and mesospheric dynamics.

National collaborations

The IAP collaborates with the *German Weather Service* (DWD) and the *Max Planck Institute for Meteorology*, Hamburg, e.g. concerning the UA-ICON community model. Within the Leibniz Association, the IAP collaborates with the Leibniz Institute for Tropospheric Research (TROPOS) and the Potsdam Institute for Climate Impact Research (PIK) within the "Integrated Earth System Research" network. Including the MLT region in the modelling of climate change scenarios, which will become increasingly important in the future, offers opportunities to further intensify collaboration with these four institutions. Moreover, it is good to see that the IAP collaborates with the Leibniz Institute for Baltic Sea Research in Warnemünde (IOW) within the *FORMOSA* project coordinated by the IAP and funded by the Leibniz Competition programme.

The IAP maintains a close relationship with the *German Aerospace Center* (DLR), especially with the *Institute of Atmospheric Physics,* which is led by a former department head of the IAP. He played a leading role in establishing the *Institute for Solar-Terrestrial Physics* (DLR-SO) in Neustrelitz, Germany. The plans for the IAP, the University of Rostock and the DLR-SO to collaborate in joint projects in the future are very welcome.

International cooperation and visibility

The IAP's international network is very good, and its reputation in the scientific community is strong. Together with the Arctic University of Norway in Tromsø, the institute runs the research infrastructure *Arctic Lidar Observatory for Middle Atmosphere Research* (ALOMAR) very successfully.

In the field of modelling, the institute cooperates successfully with the University of Colorado (Boulder, USA) in the NASA DRIVE Science Center WAVE project. In addition, the IAP works closely with NWRA, a company in Boulder, in the USA, where the former head of the MOD department is employed. Also worth highlighting is the collaboration with the École Centrale de Lyon (France) and the aerospace company GATS (Boulder, USA) that provided direct numerical simulations to complement the IAP's *in situ* turbulence and 4D mesospheric instability observations with an industrial approach.

7. Departments of the IAP

Optical Soundings and Sounding Rockets (ORS) department

[20.9 FTE, of whom 8.0 FTE research and scientific services staff, 3.5 FTE doctoral candidates, and 9.4 FTE service staff]

The department is one of the world's leading groups in the area of developing and operating lidar remote sensing and also *in situ* soundings with rockets and balloons. The decision to transfer the sounding rocket activities from the RRS department to the ORS department shortly after the last evaluation in 2015 made sense. With the help of innovative instruments, the department studies temperatures, densities, aerosols, clouds and other trace constituents from the upper troposphere to the lower thermosphere.

The department has achieved outstanding research results since the last evaluation. Worth highlighting are systematic investigations of various parameters of noctilucent clouds (NLCs), such as solar and lunar tides, climate effects, and small-scale structures. Furthermore, the department successfully clarified the physics of polar mesosphere winter echoes (PMWE) in an extensive and collaborative field campaign involving sounding rockets, radars and lidars. The comprehensive research on atmospheric gravity waves (GWs), some of which was carried out in a DFG-funded research group, is also noteworthy.

The department has further advanced its impressive array of research instrumentation through in-house developments. Special mention should be made of unique developments, such as daylight-capable lidars, which make it possible to study the middle atmosphere throughout the year at middle and high latitudes to extract information on aerosols. Furthermore, the *DORIS* (Doppler Rayleigh Iodine Spectrometer) technique was developed and applied at the IAP's ALOMAR research site in northern Norway to investigate wind profiles throughout the stratosphere and mesosphere spanning the whole day. The development and installation of new software and hardware enabling lidar remote operation and semi-automated operations at the sites in Kühlungsborn and ALOMAR were very important. This enabled continuous measurements, even during the COVID-19 pandemic. A further highlight is the development of a prototype for a 1 m^3 mobile lidar unit for the lidar array VAHCOLI *(Vertical And Horizontal Coverage by Lidar).* The system is unique worldwide and can be used in the middle atmosphere, e.g. for GW analysis. Currently, four lidars with five beams each are being built to provide extensive regional coverage. In the future, the department should evaluate possible fields of application in industry with relevant partners.

The instrumentation developed by the department offers many opportunities for future research projects. It is welcomed that the department plans further observations in different parts of the world, e.g. in the equatorial region. The review board also sees further potential for studies in Antarctica. The further development of the department will depend to a large extent on the new department head. This position should now be filled without delay, as planned, with an individual with a strong track record in the field of lidar measurements.

The Optical Soundings and Sounding Rockets department is rated as 'excellent'.

Radar Remote Sensing (RRS) department

[16.9 FTE, of whom 7.0 FTE research and scientific services staff, 3.4 FTE doctoral candidates, and 6.5 FTE service staff]

The department is extremely successful at developing and employing ground-based radar and radio remote sensing techniques that work in all weather conditions. The focus is the study of MLT planetary-scale and mesoscale dynamics, including coupling mechanisms across altitudes and latitudes, by resolving time and spatial ambiguities of atmospheric and ionospheric parameters.

The department has developed exceptionally well since the last evaluation. It regularly produces outstanding research results within the framework of a very versatile research programme. Special mention should be made of the discovery of extreme vertical drafts in the mesosphere. The department also successfully investigated the interplay of gravity waves and stratified turbulence with a second-order statistics approach that was developed recently. A further highlight is the observation of polar mesospheric summer echoes (PMSE) by the multistatic MAARSY system. Some of the work was carried out in the DFG-funded priority programmes on “Dynamic Earth” and “Compressed Sensing in Information Processing”.

The department very successfully designs, builds and operates its own pioneering instruments tailored to its research topics. These high-resolution devices might also be interesting for applications in other areas, e.g. in industry. A further highlight is the novel multistatic radar observation network called *SIMONe*. It combines radar practices, e.g. the recently introduced *multiple-input and multiple-output* (MIMO) radar, spread-spectrum, and compressed sensing, making it possible to observe MLT mesoscale dynamics, which are currently parameterised in global circulation models in collaboration with the MOD department. The long-term datasets collected since 1957 at the Juliusruh station by ionospheric monitoring to study ionospheric trends are extremely valuable. Further routine observations are utilised for space-weather-sensitive applications relating to navigation and communications. The distributed facilities installed in Germany, Norway, southern Argentina and Peru are operated in cooperation with national and international institutions.

The future plans are convincing. Firstly, the department plans to continue expanding its activities to South America, a development introduced since the last evaluation. Secondly, it plans to develop further the various instruments for measurements in the MLT region to enable research on other atmospheric layers.

The Radar Remote Sensing department is rated as ‘excellent’.

Modelling of Atmospheric Processes (MOD) department

[9.6 FTE, of whom 6.2 FTE research and scientific services staff, 2.6 FTE doctoral candidates, and 0.8 FTE service staff]

The department very successfully develops and applies numerical models to study physical systems at different levels of complexity. The models are produced in close consultation with the other two departments and based on the data they collect. In turn, the numerical models play an important role in planning future experiments.

The department's research is deeply anchored in fundamental physics and covers a wide range of phenomena. This is visible in the very successful development of the G*eneral Circulation Models* (GCMs) and models for specific physical processes, e.g. the C*hemical Transport Model* (CTM). The department is specifically encouraged to continue its highly successful work on the *Kühlungsborn Mechanistic Circulation Model* (KMCM), a hydrostatic GCM from the surface to the lower thermosphere with a particular emphasis on the dynamic interaction between different scales and altitude regions. Following a recommendation of the last evaluation, the department also utilises community models. It implemented the *Upper Atmosphere version of the ICOsahedral Non-hydrostatic GCM* (UA-ICON) in a German community model developed by the *Max Planck Institute for Meteorology* and the *German Weather Service* (*DWD*). This integration will foster future collaboration with the general model community.

Outstanding research results have been achieved with the help of the various models. Particularly worth highlighting are the models of multi-step vertical coupling of gravity waves using the KMCM. This work was carried out in part within the third-party-funded Collaborative Research Center TRR 181 on "Energy Transfers in Atmosphere and Ocean" and has had a very wide impact in the scientific community. It is good to see that after the former department head moved to NWRA in Boulder (USA), there is now a very close relationship with this company, which resulted in the development of the high-top general circulation model HIAMCM based on the KMCM to cover high altitudes.

The further development of the department will depend to a large extent on the new department head. This position should now be filled without delay, as planned, with an individual with a strong track record in the field of numerical modelling. Once the department head has been appointed, they will also need to hire new staff due to upcoming retirements.

The Modelling of Atmospheric Processes department is rated as 'excellent'.

8. Handling of recommendations of the last external evaluation

The IAP has successfully addressed most of the recommendations made by the Leibniz Association Senate in 2016 (see the status report, p. A-19f). The recommendations on gender equality and the length of doctoral studies (recommendations 4 and 5) still apply.

Appendix

1. Review Board

Chair (Member of the Leibniz Senate Evaluation Committee)

Ulrike **Woggon**	Institute of Optics and Atomic Physics, Technical University Berlin

Deputy Chair (Member of the Leibniz Senate Evaluation Committee)

Nicola **Fohrer**	Institute for Natural Resource Conservation, Department of Hydrology and Water Resources Management, Kiel University

Reviewers

Thomas **Birner**	Meteorological Institute Munich, Ludwig-Maximilians-Universität München
Joachim **Ender**	Fraunhofer Institute for High Frequency Physics and Radar Techniques, FHR, Wachtberg
Lesley **Gray**	Department of Physics, University of Oxford, UK
Michael **Kosch**	Department of Physics, Lancaster University, UK
Kirstin **Krüger**	Department of Geosciences, University of Oslo, NOR
Bernard **Legras**	Laboratoire de Météorologie Dynamique, École Normale Supérieure, Paris, FR
Clemens **Simmer**	Institute for Geosciences – Meteorology Section, University of Bonn
Mark **Weber**	Institute of Environmental Physics, University of Bremen

Representative of the federal government

Volker **Wiesenthal**	Federal Ministry of Education and Research, Berlin

Representative of the Länder *governments (member of the Leibniz Senate Evaluation Committee)*

No participation

27 October 2022

Annex C: Statement of the Institution on the Evaluation Report

Leibniz Institute of Atmospheric Physics e. V.
at the University of Rostock, Kühlungsborn (IAP)

The Leibniz Institute of Atmospheric Physics (IAP) at the University of Rostock would like to thank the review panel for having conducted a comprehensive and constructive evaluation of the institute. We are grateful that the evaluation report recognizes IAP's excellent scientific achievements and motivates to implement IAP's strategic science plan for the upcoming years.

We particularly welcome that our planned minor extraordinary item of expenditure of a scientific-strategic nature, COSA-SAT, has been expressly endorsed by the panel. COSA-SAT will importantly support our plans in extending our methodological and instrumental capabilities towards the interaction between atmosphere and space, to which IAP has highly suited prerequisites. It provides the opportunity to further connect our basic research to space operations and future climate monitoring and modelling in an extended atmospheric view.

IAP also thanks the panel for constructive recommendations. We are going to evaluate them together with our Scientific Advisory Board and integrate them into our future developments of the next several years.

With all these considerations in mind and the motivation received by the evaluation report we are encouraged to conduct prospective research, infrastructural development, and transfer activities.