BIRA•IASB

ROYAL BELGIAN INSTITUTE FOR SPACE AERONOMY

ANNUAL REPORT 2017-2018

"Science and everyday life cannot and should not be separated."

Rosalind Franklin

COLOPHON

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INDEX

MARTINE DE MAZIÈRE
DIRECTOR GENERAL A.I.

“All our activities have one goal in common: the broadening of our knowledge of the atmospheres of celestial bodies... to find answers to the societal challenges related to the natural environment we live in.”

Preface

Over the years, aeronomy has become a scientific discipline that covers a vast variety of topics. The Royal Belgian Institute for Space Aeronomy (BIRA-IASB) has evolved with this trend. That makes it more difficult to make a representative choice out of all the research topics and the resulting services that we deal with at the Institute, with every new edition of this activity report. One of the highlights of the past year is certainly the successful observation of the Martian atmosphere by the NOMAD instrument, of which the Principal Investigator is a scientist at BIRA-IASB. Also worth mentioning is the launch of the first atmospheric Sentinel mission (S5P), that provides information about ozone, air quality and climate, and in which BIRA-IASB plays a key role. The success of the Open Doors can be highlighted as well: the event was organized in collaboration with our partner institutes in Uccle during the last weekend of September and attracted around 10 000 visitors!

All these activities have one goal in common: the broadening of our knowledge of the atmospheres of celestial bodies, as a contribution to the scientific legacy of our country, and to find answers to the societal challenges related to the natural environment we live in. Challenges to which we are confronted today, not only in Belgium but also on a global scale. These challenges concern, among others, the impact of emissions on climate change and air quality, the recovery of the ozone layer that protects us against strong UV radiation from the Sun, the impact of space weather on aviation, ...

As can be understood from the projects presented above, the Institute plays a prominent role in the international research community, within the European space program supported by Belgium, and within the Copernicus initiative. Copernicus is the European Union's Earth observation program aiming at the provision of information and services concerning our planet and its environment to all European citizens, based on satellite and other so-called in-situ observations. The Institute is also an important partner of the Belgian industry and contributes to education at Belgian universities. Furthermore, BIRA-IASB sets up exhibitions and gives lectures at schools and for the general public. It is somewhat deplorable to find that, despite the Institute's international recognition and appreciation by the public, the support from the federal government is declining (as is the case for all federal scientific institutions), resulting in difficult working conditions. This threatens the international reputation of federal research and will, in the foreseeable future, harm the competitiveness of the Institute as a partner in international projects.

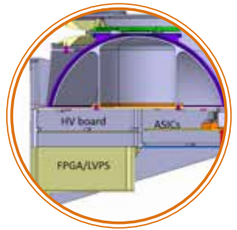
At present, it is a valuable asset of the Royal Belgian Institute for Space Aeronomy that it can count on a large number of dynamic employees: scientists who are passionate about the many aspects of aeronomy research and its importance for society, and administrative/technical employees who are always committed to support science and the efficient functioning of the Institute. I am extremely grateful to them. However, because of the difficult working conditions and uncertain future perspectives there is a risk that competent researchers might look for work abroad or that employees lose their motivation.

Nevertheless, I keep hoping that together we will continue to have the opportunity in the future to play our trump cards by bringing innovative work, to contribute to the knowledge society, and to offer the citizen high-quality scientific information and services.

In this summarizing report, as well as in the more elaborate online version at www.aeronomie.be/annualreport, you will discover numerous examples of our contributions to the aforementioned goals. I invite you to start exploring these fascinating topics.

Martine De Mazière
Director General a.i.
14 December 2018

SPACE PHYSICS



Measuring the solar wind: better, faster

In the context of the THOR space mission proposal, IRAP (Toulouse) and BIRA-IASB designed the fastest and most accurate solar wind measurement apparatus ever. BIRA-IASB devised the "beam tracking" strategy that makes this instrument so innovative. Simulations demonstrate that beam tracking allows rapid data acquisition (< 100 ms) of high angular (1.5°) and energy resolution (<7%) solar wind velocity distributions, while being robust against beam loss. Unfortunately, the THOR mission candidate was not selected for implementation, so the instrument remains a dream—at least for the time being.

Halogen-bearing species on Chury!

From the "zoo" of neutral gases which ROSINA discovered at comet 67P/Churyumov-Gerasimenko, a particular type of "animal" remained very elusive: the halogen-bearing species. These include the hydrogen halides HF, HCl, and HBr, represented in the "zoo" as saltwater fish because they are related to seawater salts. Finding them in ROSINA spectra was particularly difficult, as some of them were hiding behind more abundant species. Hydrogen halides seem to be released mainly from the comet dust and not directly from the comet's nucleus!

Does Earth's magnetic field protect our atmosphere?

In the past, it was believed that a strong intrinsic magnetic field is necessary to protect a planet from having its atmosphere stripped away by the solar wind; it was sometimes said that this is why Mars, which has no (strong) magnetic field, lost most of its atmosphere, while the magnetised planet Earth did not. Our research has shown that this picture is incorrect. The atmospheric escape rate for a hypothetical, unmagnetised Earth would be about the same as—or even a little less than—what it is for the real, magnetized planet where we live.

A meteor radar under construction in Dourbes

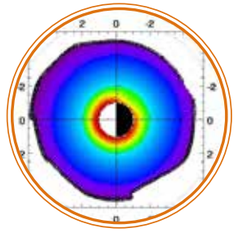
Since 2010, BIRA-IASB has developed the BRAMS (Belgian RAdio Meteor Stations) network in order to detect and characterize meteoroids falling in the Earth's atmosphere. BRAMS relies on a technique called radio "forward scatter", meaning that the receivers and the transmitter are not in the same location. This introduces a number of advantages but also complications. In order to compare the BRAMS results to those obtained with a more traditional "backscatter" system, an in-house meteor radar is currently being built at the Geophysical Center in Dourbes. It is expected to emit its first waves in 2019.

Development and validation of SLP

The Sweeping Langmuir Probe (SLP), developed at BIRA-IASB, is one of the two instruments that will fly on board the ESA CubeSat PICASSO in 2019. SLP will measure the current collected by four cylindrical probes, whose electrical potentials are swept so that the following key ionospheric parameters can be retrieved: electric charge density, electron temperature, ion temperature, and spacecraft potential with respect to the environment. The main objectives of SLP are to get insight into the magnetosphere-ionosphere coupling and aurora.

5 years of EPT observations

The Energetic Particle Telescope (EPT) was launched on the ESA satellite PROBA-V on 7 May 2013 to a LEO polar orbit at an altitude of 820 km. The instrument provides what are now 5 years of observations; these show strong flux variations, especially for the electron fluxes during geomagnetic storms, which are also associated with injections in the inner belt. EPT is a detector designed to discriminate the electrons, protons, and helium ions so that it can make direct unambiguous high-quality measurements in the radiation belts—including in the inner zone, despite the penetrating proton environment.



Dynamic model of the plasmasphere compared to satellite observations

The 3-dimensional dynamic model of the plasmasphere developed at BIRA-IASB is now provided on the SSA (Space Situational Awareness) website of ESA. Comparisons with CLUSTER, CRRES, and THEMIS observations confirm that the plasmapause is formed in the post-midnight sector during geomagnetic storms, validating the assumption made in the model. A statistical study of the observed position of the plasmapause as a function of the Magnetic Local Time sector confirms the excellent agreement with the model results. MAGION-5 satellite data are used to determine the thickness of the plasmapause boundary layer.

Kappa distributions in space plasmas

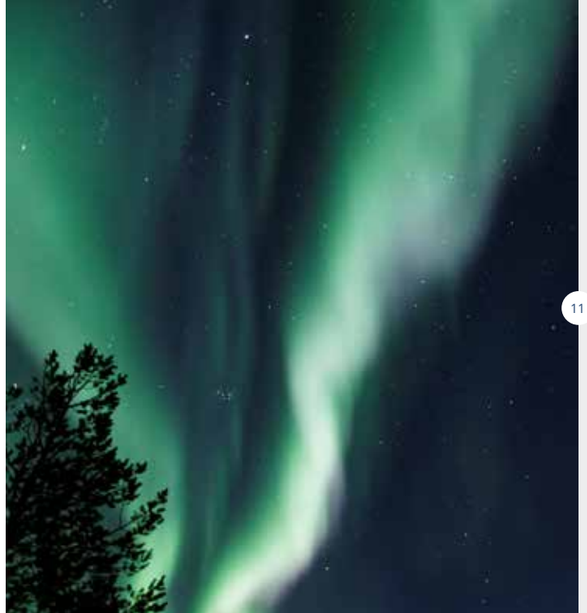
Space plasmas are essentially collisionless gases out of thermal equilibrium, where enhanced populations of suprathermal particles are observed. The typical distributions are generally better described by kappa distributions than by Maxwellians, especially for electrons. This has large consequences, since the small electron mass makes them major agents for plasma energy transport. Suprathermal electrons have a critical role in the heating and acceleration of plasmas, especially in the solar corona and solar wind.

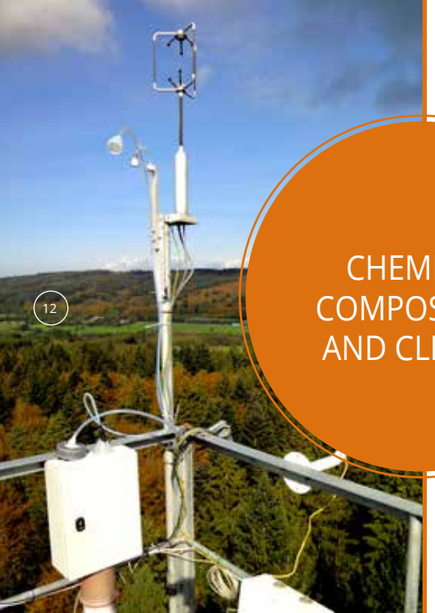
ALF radio bursts: early signatures of plasma waves in solar flares

Solar flares and coronal mass ejections occurring in the solar atmosphere have a profound impact on the space weather near the Earth. While observing solar radio emissions with the large Ukrainian radio telescope URAN-2, BIRA-IASB scientists—in collaboration with Ukrainian colleagues—have identified a new type of solar radio burst associated with solar flares: ALF bursts. Observations of ALF bursts provide unique information on the early stages of solar flares. Theoretical modelling of ALF bursts allowed us to predict kinetic Alfven waves and their amplitudes in the flaring solar atmosphere.

PECASUS – Pan-European Consortium for Aviation Space weather User Services

Space weather can affect aviation by causing degradation of radio/satellite communication, on-board system failure, high radiation doses for air travellers, and disturbances in signal reception from navigation satellites. Air travel is global, and the mitigation of traffic disruptions requires international cooperation. The Council of International Civil Aviation Organisation has designated the PECASUS consortium as one of three global space weather service centres. The Space Weather group at BIRA-IASB will be responsible for the coordination of the radiation expert group within PECASUS and for the provision of scientific support to the operators on duty.





CHEMICAL COMPOSITION AND CLIMATE

Grazing cows affect the emissions of organic compounds

Although half of the world's agricultural land is grazing land, grazing-induced flux measurements of volatile organic compounds (VOC) have not been reported yet. Researchers from BIRA-IASB therefore investigated the exchange of VOCs between a cattle-grazed grassland and the atmosphere at a Walloon ICOS site in Dorinne. Grazing-induced fluxes differed markedly from those in absence of grazing and typically lasted for 2 or 3 days. They were typically one to two orders of magnitude lower than harvest-induced emissions.

VOC measurements in the marine tropical atmosphere

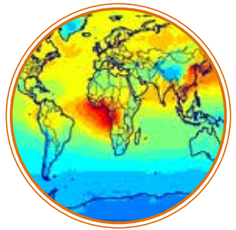
Although volatile organic compounds (VOCs) have a large impact on the oxidative capacity of the atmosphere and on climate, their sources and sinks are not well constrained, especially over tropical marine regions. In the context of the BRAIN-be project OCTAVE, BIRA-IASB started long-term VOC measurements at the high-altitude Maïdo station on Réunion Island in the Indian Ocean. These measurements are needed to identify and quantify VOC sources and sinks on the island, as well as their seasonal evolution, by means of statistical analysis, back trajectory calculations, and 3-dimensional modelling.

Climate-chemistry interactions observed from space

A major feedback between climate and atmospheric chemistry lies in the dependence of the biogenic emission fluxes into the atmosphere on the meteorological conditions. Although the short-term response of biogenic fluxes to meteorological drivers is relatively well established, their long-term response has not yet been assessed due to a lack of long-term observations of biogenic fluxes. We were able to assess, for the first time, the variability of hydrocarbon emission fluxes by using 11 years of space-borne formaldehyde data in combination with multi-year model simulations.

Drastic increase of isoprene fluxes in the future climate

Isoprene is the dominant biogenic hydrocarbon released into the atmosphere. It plays a key role in the composition of the atmosphere because of its influence on tropospheric ozone and its contribution to the formation of fine particles. Isoprene emissions strongly react to changes in temperature and solar radiation and are therefore highly dependent on global warming. We used the MEGAN-MOHYCAN biogenic emission model to estimate, at high resolution, isoprene fluxes over Europe over the past 35 years and in different end-of-century climate projection scenarios.

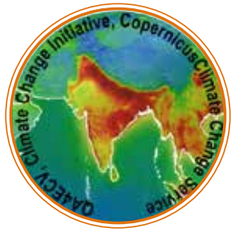


New assessment of the global source of carbon monoxide

The hydroxyl radical (OH) is the main detergent in the atmosphere as its abundance controls the concentrations of carbon monoxide (CO), a primary pollutant. As a result, carbon monoxide emissions determined by inverse modelling, constrained by satellite data, crucially depend on simulated OH levels with models. We combined the observations-related constraints on OH levels, the satellite CO data from the IASI sensor, and the IMAGES atmospheric model to provide better global estimates of CO emissions.

A Quality Assurance Framework for the Copernicus Climate Change Service

In support of the Climate Change Service of EU's Copernicus programme (C3S), the Quality Assurance for Essential Climate Variables (QA4ECV) project prototyped a generic system for the implementation and evaluation of quality assurance (QA) measures for satellite-derived climate data records. The project demonstrated the QA system on six new long-term climate quality data records for atmospheric nitrogen dioxide (NO_2), formaldehyde (HCHO) and carbon monoxide (CO), and for surface albedo, leaf area index, and fraction of absorbed photosynthetically active radiation.



Climate Data Records on atmospheric composition

Changes in the Earth system induced by human activities and their impact on life and natural environment are amongst the greatest current environmental challenges. Over the last decade, BIRA-IASB has been involved in several important initiatives to monitor atmospheric composition changes at the global scale based on long-term satellite observations. In these projects, Climate Data Records of various atmospheric pollutants have been generated, quality-assessed, and used in support of scientific studies, environmental assessments, and for raising general public awareness.

3D dust distribution from satellites

Desert dust particles are uplifted from arid areas by strong winds. They may travel up to thousands of kilometres, for example, from North Africa across the Mediterranean Sea to Europe. Dust particles influence the climate directly by modifying the energy balance (cooling or heating, depending on the conditions) and indirectly through an effect on wind patterns, clouds, and rain. These effects still bear large uncertainties and depend on the 3D distribution of the particles in the air. At BIRA-IASB, we use satellite data to obtain, for the first time, global 3D distributions of dust particles.

Atmospheric species emitted by the Amazon Rainforest

The Amazon Rainforest is a large source of biogenic and biomass burning species affecting the air quality and the global climate. To monitor these species, BIRA-IASB installed a Fourier transform infrared (FTIR) spectrometer at Porto Velho, in Brazil, in July 2016. After one year of measurements, we have observed the seasonal cycle of several biomass burning species, all showing a maximum in July-October, when fires are most intense. These data are crucial not only for satellite validation, but also for improving our knowledge of the Amazonian emissions by comparing them with state-of-the-art models.

Towards European Research Infrastructures

To consolidate the quality, consistency, and long-term availability of ground-based (remote sensing) data needed for satellite validation and model use, it is essential to develop and maintain research infrastructures such as ICOS (for greenhouse gases). Recently, BIRA-IASB has been strongly involved in setting up a new EU research infrastructure for Aerosols, Clouds, and Trace gases (ACTRIS), where it leads the Topical Center for Trace Gas Remote Sensing. Efforts to include ground-based remote sensing techniques into the ICOS network (currently focused on in-situ measurements) are ongoing.

Aerosol data for better climate modelling

Stratospheric aerosols play an important role for the climate, since they affect the propagation and absorption of sunlight. This is why climate models have to take them into account as precisely as possible. This is a challenge because these particles of varying size and composition are difficult to characterize. A key problem in the prediction of the evolution of the climate is the decryption of information provided by satellites, and understanding the limits and imperfections of the measurements, in order to translate them into reliable and precise data that can be easily used in climate models.

Learning from previous experiments to better prepare future missions

The GOMOS experiment flew on board the ENVISAT satellite and measured the composition of the atmosphere from 2002 until 2012. This might seem far back in time, but this instrument, a pioneer in terms of its measuring technique (stellar occultation), still poses a challenge to those who want to explore its data. Despite offering more opportunities for observation than just looking at the one Sun in the solar system, stars produce such weak signals that it questions quite a few principles of data processing methods. It would be best to solve this in preparation of future missions.

AIR QUALITY

The air composition above Kinshasa

The atmosphere above Kinshasa is particularly interesting because emissions from the tropical forest mix with urban pollution. BIRA-IASB has initiated a collaboration with the University of Kinshasa, aiming to quantify several key atmospheric species. A compact remote sensing instrument has been installed at the University, operated in collaboration with Congolese colleagues. Only a few local measurements are performed in Africa, and our instrument will be valuable to validate satellite products and chemistry-transport models developed in house.

Sentinel-5P TROPOMI: the first atmospheric Sentinel

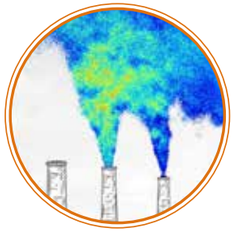
On October 13, 2017, ESA launched Sentinel-5 Precursor (S5P), the first mission dedicated to atmospheric composition in the series of Sentinel missions, as part of the European program for Earth Observation, Copernicus. On board, the instrument TROPOMI measures atmospheric composition data, relaying the information in near-real time. BIRA-IASB has played a key role developing some of the TROPOMI level-2 algorithms, managing the operational validation service, and contributing to the scientific data exploitation.

TROPOMI - global daily mapping of atmospheric constituents with unprecedented resolution

With a spatial resolution of 3.5x7 km², a factor of (at least) 15 better than previous space-based instruments, TROPOMI is able to measure atmospheric trace gases with a remarkable level of detail, on a daily basis and on a global scale. TROPOMI provides added-value information on natural and anthropogenic emissions, and atmospheric processes in relation to air quality, ozone layer, climate change, and natural hazards such as forest fires and volcanic eruptions.

FRM4DOAS: the first centralized processing system for MAX-DOAS air quality measurements

In order to ensure that products delivered by air quality satellite sensors meet user requirements in terms of accuracy, precision, and fitness for purpose, it is essential to develop a robust validation strategy relying on well-established and traceable reference measurements. In this context, the ESA FRM4DOAS project coordinated by BIRA-IASB aims at developing the first centralized processing system delivering harmonized MAX-DOAS measurements of pollutants like NO_2 and HCHO in a near-real-time mode. The availability of such harmonized ground-based data is critical for the validation of present and future satellite missions like the atmospheric Sentinels (S4, S5, S5P) in Europe, GEMS in Asia, and TEMPO in the US.



The NO_2 camera

The NO_2 camera is a new, unique instrument which flows down from the ALTIUS mission. Just like ALTIUS, it takes images of a scene (e.g. smokestack plumes, city skylines) at several wavelengths of interest which are absorbed by a harmful by-product of every combustion process (engines, heating): NO_2. The camera's ultimate goal is the monitoring of NO_2 emissions produced by industrial sites, as well as ambient levels in the urban environment. By doing so, the NO_2 camera could bridge the gap between satellite-borne instruments covering the Earth's surface with a coarse resolution (several km²), and the sparse network of official air quality monitoring stations.

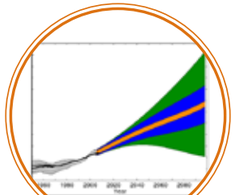
STRATOSPHERIC OZONE MONITORING

LOTUS: evaluation of long-term ozone trends for the 2018 WMO/UNEP Ozone Assessment

The Montreal Protocol, an international treaty signed in 1987, bans the production of chemical substances responsible for the dramatic depletion of the ozone layer. By 2006, it was clear that the thinning of this protective UV-shield had halted in the mid-1990s. However, it took until 2018 to conclude with confidence that stratospheric ozone concentrations are slowly rising again. The confirmation of this long-standing prediction is of great scientific and societal importance, and it was made possible by researchers at BIRA-IASB who initiated and coordinated the international community-wide activity LOTUS, under the auspices of the World Climate Research Programme.

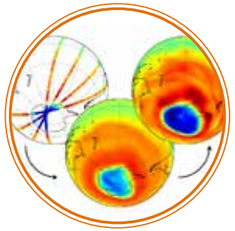
The Copernicus Atmosphere Monitoring Service is now operational with major BIRA-IASB contributions

Copernicus is the European Union's Earth Observation Programme looking at our planet and its environment for the ultimate benefit of all European citizens. It offers six information services based on satellite Earth Observation and in situ (non-space) data. Among these is the Copernicus Atmosphere Monitoring Service (CAMS) which provides near real-time data for air quality and the ozone layer, both globally and with a focus on Europe. BIRA-IASB has teamed up with international consortia to win three competitive tenders, and it is now contributing to this flagship European Programme through product validation and model development.



Modelling past and future climate change in the stratosphere

Climate change impacts the whole atmosphere, from the surface to the thermosphere. The changing temperatures and wind fields in the stratosphere will influence the rate of recovery of the ozone layer. Climate models are developed worldwide to improve our understanding of past climate change and project the future state of the atmosphere under varying scenarios, but this requires careful validations against observation-based datasets such as those created by BIRA-IASB. In order to fully address these topics, the Institute has recently installed and started research with the Whole Atmosphere Community Climate Model (WACCM).



The stratospheric composition since 2004

BIRA-IASB is developing a data assimilation system dedicated to stratospheric composition. It combines local observations with the global view of a model to provide global analyses of the stratosphere. We applied this technique for the first time to a satellite instrument that measured ozone and ozone-related species continuously for 14 years. This reanalysis will be used, in particular, by the World Meteorological Organization (WMO) to produce the Ozone Bulletin that describes the chemical state of the Antarctic stratosphere during the ozone hole season.

SOLAR RADIATION

Improving our Sun knowledge while certifying our instruments

Measuring the solar spectrum from above the atmosphere is the obvious approach for scientists who want to know the amount of solar energy reaching our planet before any extinction takes place. Nevertheless, with ground-based instruments and from renowned high-altitude observatories, we can approach the quality of space-based measurements with the added advantage of being able to follow the instrument's performances. The assessment of the radiometric performances of both spatial and ground-based instruments is done in BIRA-IASB's radiometric laboratories.

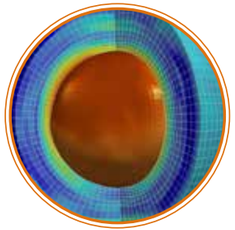
Sun, here we come!

Human beings know that they are indebted to the Sun. Life on Earth, cradle of humankind! These last few centuries, humans have wanted to understand the physics and chemistry behind this privileged Sun-to-Earth link. Now, thanks to the rise of science and space technologies, humans have developed instrumentation to measure the spectral shape of sunlight. BIRA-IASB contributed to this quest with the SOLAR/SOLSPEC instrument on board the ISS. In collaboration with the French laboratory LATMOS, a new accurate reference solar spectrum named SOLAR-ISS was published. This is a key input for modelling in solar physics and atmospheric sciences.

PLANETARY AERONOMY

NOMAD on ExoMars Trace Gas Orbiter started its science phase in April 2018 – First results

After a long aerobraking phase, followed by a series of engineering tests, NOMAD—an instrument on the ExoMars Trace Gas Orbiter, that was designed and built at BIRA-IASB—started making scientific observations in early April 2018. Observations of H_2O, HDO, CO, CO_2, and O_3 are now performed routinely in nadir and solar occultation modes. The start of the science observations luckily coincided with the onset of a global dust storm on Mars, an event which is quite rare and still not fully understood. NOMAD will help us to elucidate what happens to the Martian atmosphere during these extraordinary events.



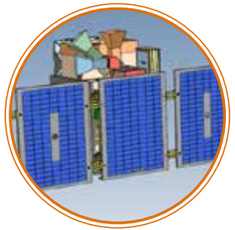
Simulating weather, climate, and atmospheric chemistry on Mars

BIRA-IASB developed a weather and climate model for Mars, similar to weather forecast models on Earth, to simulate the atmospheric chemistry on Mars. The destruction of the more abundant carbon dioxide (CO_2) and water vapour (H_2O) molecules in the Martian atmosphere by sunlight leads to the formation of minor species such as oxygen (O_2), carbon monoxide (CO), ozone (O_3), and hydrogen peroxide (H_2O_2). The BIRA-IASB model is able to simulate the concentrations and variations of these molecules with good precision. The model will support the data analysis of the NOMAD instrument on the ExoMars Trace Gas Orbiter.

SPACE MISSION DEVELOPMENT

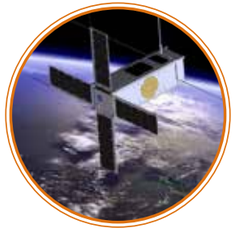
MAJIS: exploring Jupiter's Icy Moons

For a long time, scientists have extensively studied the existing relationship between the Sun's radiation and the Earth's biosphere. With the rise of astronomy, planets and moons were discovered overnight, piquing scientists' insatiable curiosity. After the famous jump to the Moon, mankind will now make a 'magic' jump to Jupiter and three of its icy moons! MAJIS is a space project involving BIRA-IASB, the Royal Observatory of Belgium, and the Institut d'Astrophysique Spatiale, France. BIRA-IASB's contribution is to develop a laboratory facility for the characterization of the detector of the VIS and NIR channels of this instrument that will fly on board the JUICE mission.



ALTIUS: Atmospheric Limb Tracker for the Investigation of the Upcoming Stratosphere

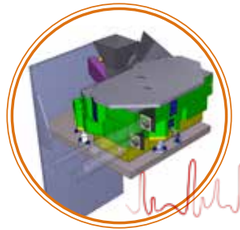
Stratospheric depletion of ozone and climate change by greenhouse gases represent two major challenges for our present and future existence on Earth, and the need to monitor the evolution of these gases is widely accepted. ALTIUS is a BIRA-IASB satellite instrument that is proposed as a solution to the near-future lack of instruments able to measure global altitude-resolved concentration profiles for a number of atmospheric species. The project benefits from multiple connections with Belgian universities and other international research groups. Its launch is scheduled in 2022.



PICASSO: a PICo-satellite for Atmospheric and Space Science Observations

PICASSO is an ESA In-Orbit-Demonstration CubeSat mission initiated by BIRA-IASB. With this miniature low-cost satellite, the ambition is to retrieve the ozone distribution in the stratosphere, the temperature profile up to the mesosphere, and the electronic density and temperature in the ionosphere. It will take measurements for 2 years from a polar orbit at about 500 km altitude. Its payload consists of a miniaturized imaging spectrometer (VISION) and a 4-needle-like Sweeping Langmuir Probe (SLP). The CubeSat integration and final tests are foreseen to take place in 2019 before being delivered for a forthcoming VEGA launch.

SUPPORTING SERVICES



The radio frequency heartbeat of ALTIUS

ENGINEERING

In 2022, ALTIUS should be circling around the Earth, looking permanently at the sun-lit atmospheric limb, and keeping a close eye on the amount of ozone in our air. Deeply hidden in the body of the ALTIUS spectrometer is a piece of electronics hardware that truly creates the heartbeat of this unique instrument. Pulsating at a rhythm millions times faster than our own heart, using radio frequency signals, it allows the very eyes of ALTIUS—the Acousto-Optical Tunable Filters—to capture light at any place in the spectral domain.

Sniff'n ride (The bike)

ENGINEERING

Monitoring the composition of the (polluted) troposphere, the layer of the atmosphere we live in, has become a key topic in Earth observation from space. The Sentinel-5P satellite is the latest endeavour of ESA in this field. Scientists of BIRA-IASB are heavily involved in data processing from TROPOMI, the only instrument on board this spacecraft. Measurements from orbit can only be reliably interpreted if in-parallel ground-based validation measurements are performed. Networks with Differential Optical Absorption Spectrometers (DOAS) are being set up for this purpose worldwide. So why not tie a DOAS to the back of your bike and "sniff" the air while you ride?

From data to insight: IT services for research

IT

On top of the standard IT portfolio, the Aeronomy IT service provides additional specialised support for the research activities of the institute. Dedicated team members offer in-house consultancy in the domains of data management and storage, high performance scientific computing, and the development of dedicated websites and web-based services. These specific competences are employed to deliver an adapted work environment that unburdens the researchers from supporting tasks and to facilitate research, collaboration, and dissemination activities.

Thousands of visitors discover the Institute for Space Aeronomy

COMMUNICATION

During the weekend of 29 and 30 October 2018, the Uccle site opened its doors to the general public. For this occasion, the three scientific institutes worked together to offer a fun and educational weekend for both the young and old. BIRA-IASB's presentation was articulated around its main research themes: air quality, climate, ozone, planetary aeronomy, engineering, solar radiation, and space physics, not forgetting all of the support services and B.USOC. The weekend opened with an exclusive preview for schools and a visit reserved for partners, politicians, and the press.

Education and public outreach

COMMUNICATION

BIRA-IASB is keen to take on its share in the scientific development of young people within the fascinating context of aeronomy. BIRA-IASB scientists give lectures on atmospheric chemistry, space weather, or techniques for data processing at no less than 6 universities across Belgium (KU Leuven, UGent, VUB, ULB, ULiège and UCLouvain). In the past 2 years, they have supervised 8 doctorates. Through a wide range of public outreach activities (exhibitions, lectures, STEM activities, etc.), the Institute also tries to bring its knowledge and expertise to the general public.

Digitization of historical scientific heritage

DOCUMENTATION

The documentation centre is engaged in digitizing the Institute's publications and making them accessible to the public via ORFEO, the Federal Open Access Repository (http://orfeo.kbr.be). The *Aeronomica Acta*, a periodical formerly published by the Institute, was completely digitized. This unique collection consists of more than 400 publications, representing pioneering scientific research. ORFEO currently holds all BIRA-IASB publications, preserving and ensuring continuous access to more than 3100 publications from 1959 onwards. By participating in DIGIT-04, BIRA-IASB will expand the current project to photographs, negatives, and film.

Repositories and the Open Science Challenge

DOCUMENTATION

The Open Science movement is rapidly changing the landscape of research data management and scientific journal publications, an important outcome of the institute's activities. The H2020 Open Research Data Pilot, the FAIR Data Actions Plan, and the European Open Science Cloud (EOSC) are merely a few recent initiatives that emphasize the necessity to meet the evolving requirements for institutional repositories. BIRA-IASB's documentation centre remains committed to meeting the standards set by policymakers and funding agencies, and it maintains the institutional Research Data Repository (http://repository.aeronomie.be) and publication repository (https://orfeo.kbr.be) accordingly.

BELGIAN USER SUPPORT AND OPERATIONS CENTRE

Nine years of Sun tracking on board the ISS

On February 15, 2017, B.USOC switched off the external platform SOLAR on board the International Space Station after nine years of successful operations (so far, the longest running experiment of the Columbus module). The SOLAR operations accumulated 12 000 Sun trackings over 106 Sun Visibility Windows, requiring 35 120 hours on console and 30 150 hours of preparation. In order for SOLAR to observe full 27-day solar rotations, NASA performed—at B.USOC's request—a change of the ISS attitude four times. SOLAR hosted three instruments (SOLSPEC, SOL-ACES, and SOVIM) dedicated to the study of spectral solar irradiance.

Hunting elves, sprites, blue jets, and gamma ray flashes from the ISS

On April 13, 2018, B.USOC operators received the first telemetries of the Atmosphere-Space Interactions Monitor (ASIM) after its successful installation outside of the European Columbus module of the International Space Station. With its two instruments, MMIA capturing infrared and ultraviolet images and MXGS detecting the sources of x- and gamma-rays, ASIM will give insight into the luminous phenomena that take place over violent thunderstorms (elves, sprites, blue jets, and terrestrial gamma ray bursts). Since then, B.USOC is operating ASIM continuously and transfers its data to the scientists.

Studying shaken granular samples in microgravity

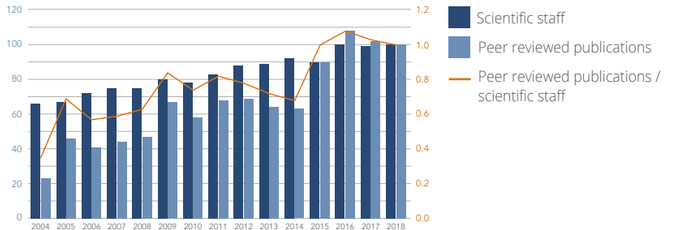
On July 19, 2018, Alexander Gerst installed the Soft Matter Dynamics Experiment Container inside the Fluid Science Laboratory on board the International Space Station. The container was loaded with four CompGran sample units to study the dynamics of granular material under microgravity conditions. The B.USOC operators were commanding the payload and executed about 800 runs in 2018, during which various densities of spherical granules are shaken and their movement is observed through a technique known as dynamic light scattering. The result should improve the understanding of granular dynamics.

PUBLICATIONS

BIRA-IASB has published research output in Open Access (OA) since the start of the movement in the 1990s. In 2007, the number of OA peer-reviewed publications crossed the 40% threshold for the first time. The increase of OA publications is a universal trend. However, the OA percentage at BIRA-IASB is exceptionally high compared to other research institutions and universities. In 2012, BIRA-IASB's documentation center started emphasizing the importance of publishing in OA, and liaised with researchers on various OA options, resulting in a steady average OA percentage of 50% from 2013 onwards. The annual average of peer-reviewed publications per researcher has increased significantly, reaching one publication per researcher per year.

Word cloud based on the titles of BIRA-IASB publications of 2017 and 2018.
The size of the words indicates the number of occurrences in publications titles.

Peer-reviewed publications per scientific staff member



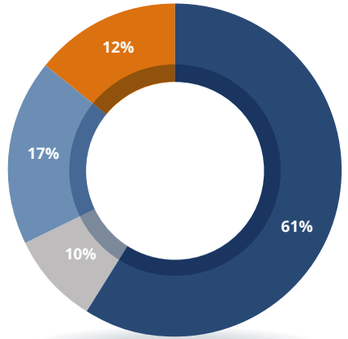
Evolution of peer-reviewed publications and publications in Open Access

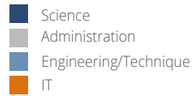
PEOPLE AND FIGURES

The previous chapters of this activity report illustrate the large variety of results obtained by the scientists at BIRA-IASB. Their activities strongly rely on the support of services such as engineering, IT, communication, administration and infrastructure. This non-scientific staff adds up to almost 40% of the 161 employees working at the institute at the end of 2018. In what follows, we give some more insight in the profiles of the people working at BIRA-IASB.

WORKFORCE 2016

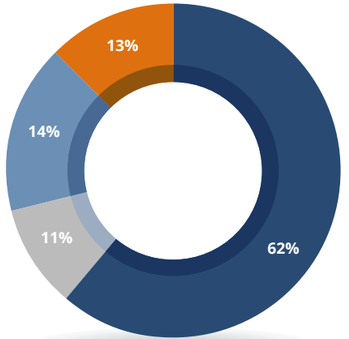
100% = 163





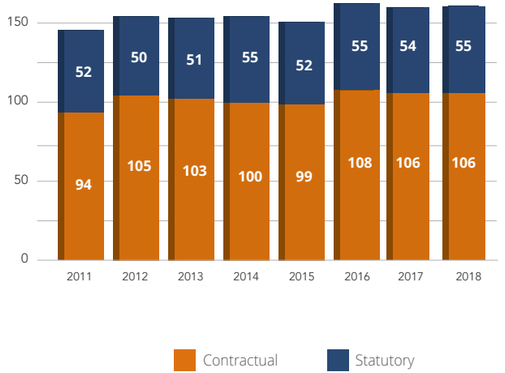
WORKFORCE 2018

100% = 161



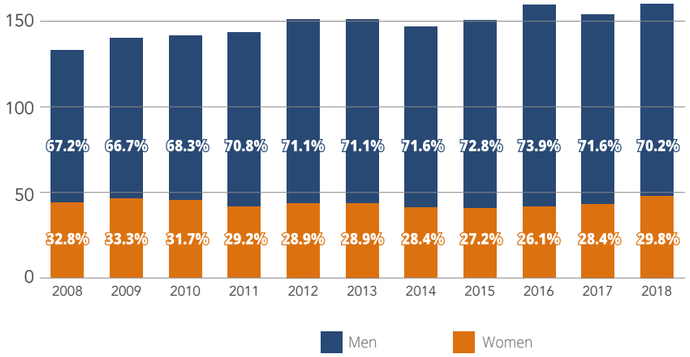
EVOLUTION WORKFORCE

Comparison in statute

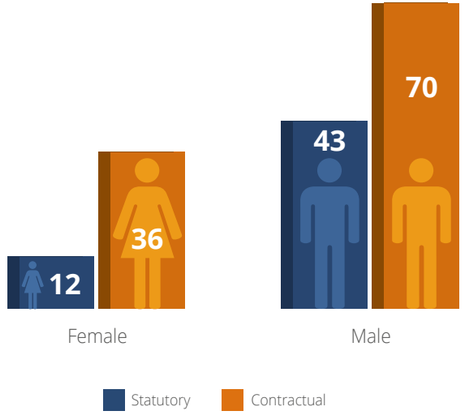


GENDER DISTRIBUTION IN THE WORKPLACE

Recently, gender has been a subject of significant debate in all areas of society. Scientific environments have not escaped scrutiny and are often labeled as a man's world. The overall male-female ratio at BIRA-IASB in 2018 was 70% men compared to 30% women and hardly changed over the last decade. This ratio is due to the fact that 90% of the personnel belongs to STEM disciplines (science, technology, engineering and mathematics), where we find the same distribution. BIRA-IASB reaches the recommended ratio of at least one third of women.

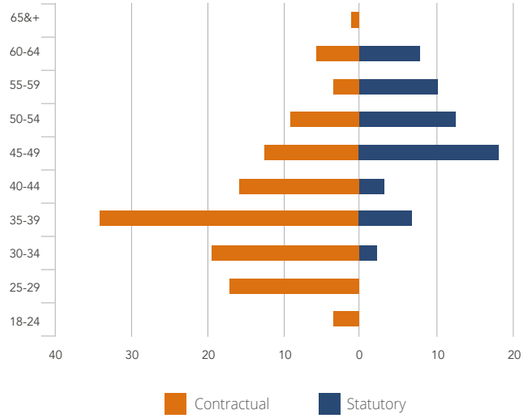


GENDER AND STATUTE - 2018

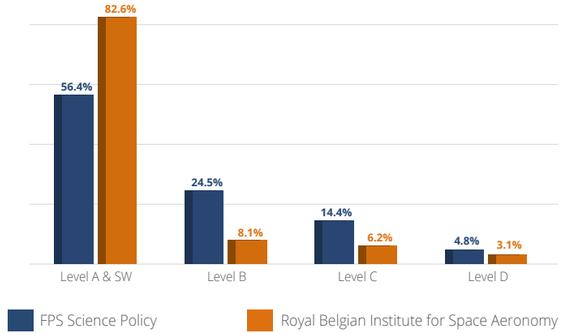


Only 25% of the female employees are statutory, as opposed to 38% of the male employees. However, most of the statutory female workforce This means that statutory women have at least as many opportunities as statutory men to obtain a leadership position.

AGE PYRAMID AND STATUTE - 2018



SHARE BY LEVEL - 2018



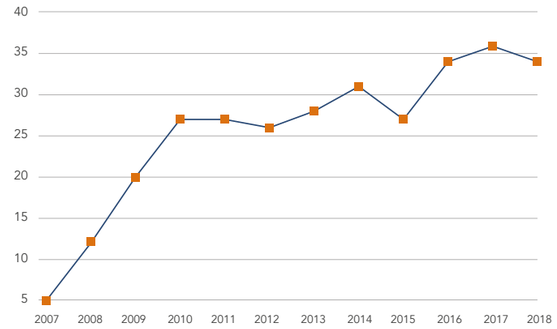
BIRA-IASB shows a greater percentage of personnel with a Master's degree (A level) or Master of Science degree (SW level) compared to FPS Science Policy, both due to the scientific research activities of the Institute, and the fact that other scientific institutions also play a major public role (e.g. museum exhibitions or public document disclosure).

DIVERSITY

Nationality personnel 2018

Belgium	France	Netherlands	Italy
Greece	Spain	Portugal	United Kingdom
Germany	Czech Republic	Romania	Ukraine
Croatia	Cyprus	Sweden	Denmark
Japan	China	Mexico	United States

Evolution of non-Belgians at BIRA-IASB



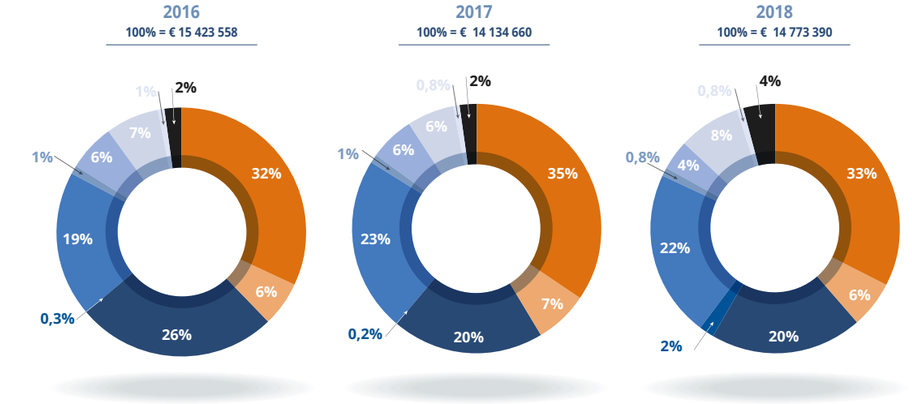
At the end of 2018, a total of 34 non-Belgians (21% of the staff) worked at the Institute. This brings us to a total of 20 different nationalities (including Belgian) stretching over 3 continents.

ACCOUNTING

The accounting department manages the finances of the Institute, under the supervision of the Management Committee of the Institution, the Belgian Science Policy, and the Court of Auditors. Compared to other Federal Scientific Institutes, a large part of the budget of BIRA-IASB (56%) comes from competitive project funding by external organisations, such as ESA, EUMETSAT, the European Commission, and (to a lesser extent) national research funds. ESA and PRODEX (ESA), with a contribution of more than 70% of the external project funding, and the European Copernicus programme are major sources of income to the institute.

REVENUES BY SOURCE

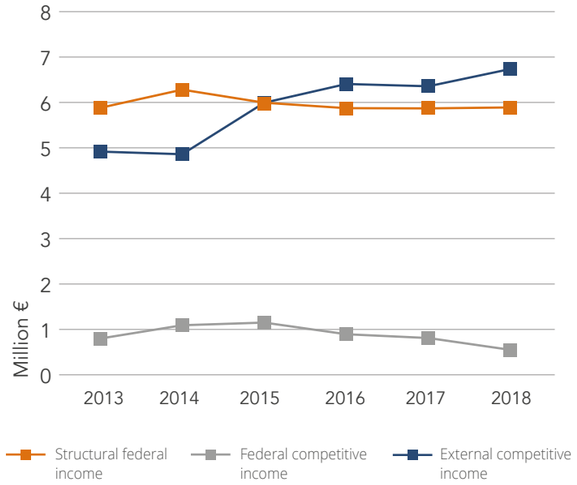
- Dotation
- STCE
- ESA
- FNRS & FWO
- PRODEX
- Commercial income
- European Union
- Eumetsat
- ECMWF subvention
- Federal subvention



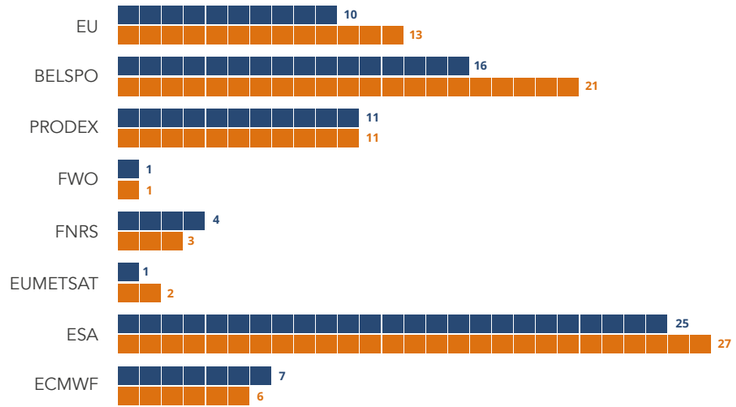
The numbers for the dotation include the personnel envelope.

EVOLUTION OF DIFFERENT TYPES OF INCOME

BIRA-IASB is supported on a structural basis by the Federal Science Policy through the dotation, the Solar-Terrestrial Centre of Excellence (STCE) and the personnel envelope. Taking into account the index-change, our effective structural income has decreased by 16% between 2012 and 2018, i.e., about -2.7% per year. The federal non-structural, competitive, income (e.g. BRAIN, FED-tWIN, ...) is steadily decreasing since 2015, as there are fewer and fewer opportunities. We notice, however, a strong rise in the external competitive income, pointing to a clear dynamism within the Institute to compensate for this by searching for external funding involving intensive competition.

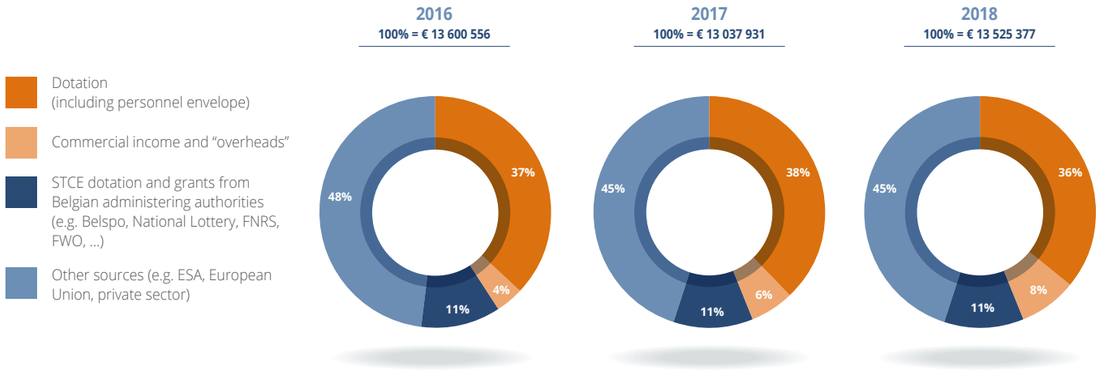


ONGOING PROJECTS PER FUNDER

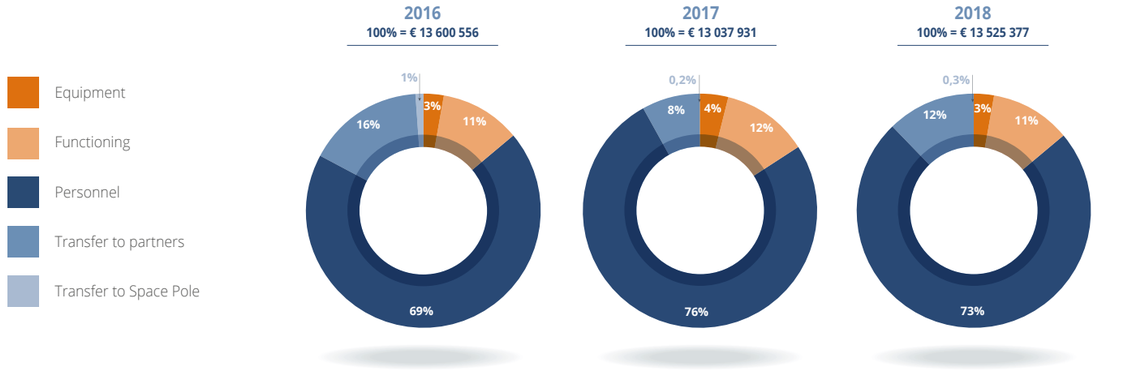


There were a total of 75 ongoing projects for 2017 and 84 ongoing projects for 2018. BIRA-IASB was the coordinator for about half of them. These, however, are often short-term projects that provide little funding. On the other hand, they require a lot of work from the Contract Management department: a team of two people who, in collaboration with the scientific project managers, handle the financial, contractual and administrative management of all projects.

EXPENSES PER SECTION



EXPENSES PER CATEGORY

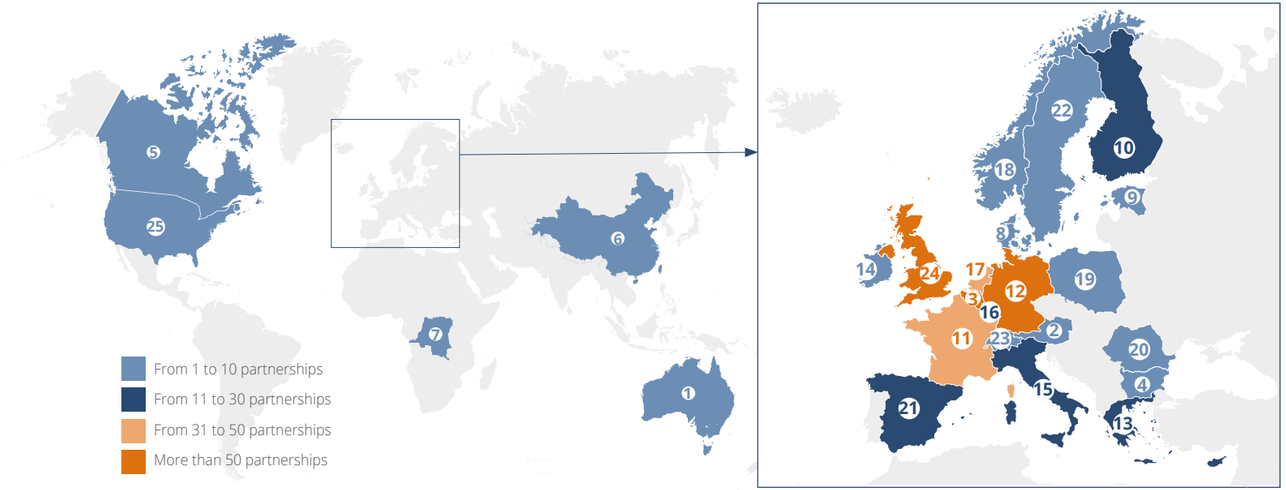


NUMBER OF PARTNERSHIPS AND PARTNERS PER COUNTRY IN 2017-2018

The following table shows the partners, representing the different (research) institutions in each country with whom we collaborate on a project basis. The partnerships indicate the number of collaborations with partners from these countries, for all the different projects.

Country	Partnerships	Partners
1. AUSTRALIA	1	1
2. AUSTRIA	9	8
3. BELGIUM	91	25
4. BULGARIA	1	1
5. CANADA	5	2
6. CHINA	1	1
7. CONGO	1	1
8. DENMARK	7	4
9. ESTONIA	1	1
10. FINLAND	24	6
11. FRANCE	35	19
12. GERMANY	85	27
13. GREECE	18	10

Country	Partnerships	Partners
14. IRELAND	2	2
15. ITALY	21	9
16. LUXEMBOURG	1	1
17. NETHERLANDS	36	9
18. NORWAY	10	4
19. POLAND	2	1
20. ROMANIA	4	3
21. SPAIN	13	9
22. SWEDEN	5	3
23. SWITZERLAND	9	7
24. UNITED KINGDOM	60	30
25. UNITED STATES	1	1



Team Building 2018

THANK YOU

Our sources of income: Belspo, ESA, EU, EUMETSAT, ECMWF, FWO&FNRS, PRODEX.

And all of our colleagues who worked at BIRA-IASB during 2017-2018:

Amelynck Crist
Anciaux Michel
Aoki Shohei
Baker Noel
Bauwens Maite
Beeckman Bram
Berkenbosch Sophie
Bevernaegie Jessica
Bingen Christine
Bogaerts Brigitte
Bolsée David
Bonnewijn Sabrina
Borremans Kris
Botek Edith
Brenot Hugues
Brouckmans Kristien
Brun Nicolas
Bulcke Johan
Calders Stijn
Calegaro Antoine
Callewaert Sieglinde
Cambier Pascale
Camy-Peyret Claude
Cardoen Pepijn
Cessateur Gael
Chabanski Sophie
Chabrillat Simon
Christophe Yves
Cierkens Jana
Cisneros Miriam
Clairquin Roland
Compernolle Steven
Counerotte Frédéric
Crosby Norma
Da Pieve Fabiana
Daerden Frank
Danckaert Thomas
Darrouzet Fabien
Debosscher Jonas
De Donder Erwin
De Keyser Johan
De Mazière Martine
De Pauw Samuel
De Ridder Sven
De Rudder Anne
De Smedt Isabelle
De Wachter Evelyn
de Wergifosse Marc
Dekemper Emmanuel
Demoulin Philippe
Depiesse Cédric
Dhooghe Frederik
Dierckxsens Mark
Dils Bart
Dimitropoulou Ermioni
Echim Marius
Egerickx Tom
Equeter Eddy
Errera Quentin
Erwin Justin Tyler
Fayt Caroline
Fedullo Leonardo
Ferriere Olivier
Fonteyn Dominique
Fourneau Thierry
Franssens Ghislain
Fratta Stéphanie
Friedrich Martina
Fussen Didier
Gaffé Dominique
Gamby Emmanuel
Gerard Pierre
Geunes Yves
Granville José
Gunell Herbert
Haumont Etienne
Hamdaoui Mohamed
Helderweirt Anuschka
Hemerijckx Geert
Hendrick François
Hermans Christian
Hetey Laszlo
Heymans Carine
Hizette Christiane
Hrsak Dalibor
Hubert Daan
Iterbeke Philippe
Jacobs Lars
Kalb Nathalie
Keppens Arno
Koubi Ismail
Kruglanski Michel
Kumps Nicolas
Lambert Jean-Christopher
Lamort Lucie
Lamy Hervé
Langerock Bavo
Leclere Fabienne
Lefebvre Arnaud
Lefever Karolien
Lerot Christophe
Letocart Vincent
Liber Corentin
Lopez Rosson Graciela
Maes Jeroen
Maes Lukas
Maggiolo Romain
Mahieux Arnaud
Marcourt Loïck
Martinez Tarin Ana
Martins Pais Ana Cristina
Massano Santos Cristina
Mateshvili Nina
Merlaud Alexis
Messios Neophytos
Michel Alice
Middernacht Michael
Minganti Daniele
Minion Jean Louis
Moreau Didier
Mozaffar Ahsan
Muller Alexis
Muller Christian
Müller Jean-François
Nay Maïté
Neary Lori
Neefs Eduard
Noel Christian
Ooms Tim
Pauwels Dirk
Pereira Dos Santos Nuno
Piccialli Arianna
Pieck Gerry
Pieroux Didier
Pierrard Viviane
Pinardi Gaia
Queirolo Claudio
Ranvier Sylvain
Rasoanaivo Hobimalala Andoniaina
Rasson Olivier
Ristic Bojan
Robert Séverine
Robert Charles
Santos Branca Claudia
Sathiyananthan Viththakhan
Sayyed Umar
Schoon Niels
Scolas Francis
Sha Kumar Mahesh
Sluse Dominique Gilles
Somerhausen André
Somers Tim
Soumaré Ablaye
Stavrakou Trissevgeni
Tack Frederik
Tetard Cédric
Theys Nicolas
Thoemel Jan
Thomas Ian
Trompet Loic
Van den Wyngaert Guido
Van Gent Jeroen
Van Opstal Albert
Van Roozendael Michel
Vandaele Ann Carine
Vandenbussche Sophie
Vanhamel Jurgen
Vanhellemont Philip
Verbracke Fabian
Verhoelst Tijl
Verreyken Bert
Vigouroux Corinne
Viscardy Sebastien
Vlietinck Jonas
Voytenko Yuriy
Willame Yannick
Wilquet Valérie
Yu Huan
Zhou Minqiang
Zychova Lenka

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The Royal Belgian Institute for Space Aeronomy (BIRA-IASB)
Getty Images
Reuters

This booklet offers you a glance into the wealth of fascinating projects in which BIRA-IASB was involved in 2017-2018. We invite you to read the full stories of our achievements, activities, people and figures on our website:

Ce rapport annuel est également disponible en français.
Dit jaarverslag is eveneens beschikbaar in het Nederlands.

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