Royal Belgian Institute for Space Aeronomy - BIRA-IASB

Cutting-edge research about Earth, planetary and cometary atmospheres

A Belgian federal scientific research institute, the Royal Belgian Institute for Space Aeronomy (BIRA-IASB) is dedicated to research and scientific service in space aeronomy, which is the physics and chemistry of the atmosphere of the Earth and other solar system bodies, and of outer space. Its research relies on observations, theoretical and numerical models and laboratory experiments.

BIRA-IASB relies on a staff of 160 people, including 97 scientists, and is currently involved in around 130 ongoing research projects. Its annual budget reaches around 13.5 million euros per year.

BIRA-IASB is structured in four scientific divisions: "space physics", "sources and sinks of atmospheric constituents", "reactive gases in the atmosphere", and "solar radiation in atmospheres". Observations from space are key to the research in all four divisions. BIRA-IASB also hosts the Belgian User Support and Operations Centre (B.USOC) which delivers support to all Belgian scientific institutions that are involved in space projects. Thanks to this hyper specialized expertise, BIRA-IASB is involved in many projects with the European Space Agency (ESA) and the European Commission.

Current highlights that have reached major milestones in 2017 are ALTIUS and TROPOMI. ALTIUS is a space mission fully conceived in Belgium, under the leadership of BIRA-IASB. Its concept is an innovative limb imaging spectrometer with the aim of monitoring the vertical distribution of ozone and some key constituents in the upper troposphere and stratosphere. In December 2016 the ALTIUS mission has been adopted by ESA as an "Earth watch" mission, and has the full support from the Belgian federal government. The design of the platform and payload are being done together with Belgian space industries (Qinetiq and OIP in particular). The launch is planned in the early twenties.

BIRA-IASB is also a key actor in the TROPOMI satellite mission. The satellite has been launched on October 13 2017 from the Russian ground station Plesetsk, and has been placed in a sun-synchronous orbit around the Earth at about 800 km altitude. The first results on the good functioning of this instrument were transmitted in November 2017 and they are impressive. TROPOMI looks towards the nadir and focuses on ozone, air quality, and climate. It has a spatial resolution improved by a factor of 10 compared to its predecessor while maintaining the same quality of spectrum. BIRA-IASB has been involved in this mission from the beginning, as member of the Mission Advisory Group; now about 25 scientists from the Institute will be involved in the data production, especially for the ozone, SO_2 and formaldehyde products, in the data validation and exploitation.

The TROPOMI mission is an element of the series of Sentinel missions that are part of the COPERNICUS program, an important joint initiative of ESA and the European Commission. ESA is responsible for the space segment (preparation and launch) while the European Commission supports the resulting data products and services. The development of the atmospheric Sentinel missions (in which BIRA-IASB is involved) is a long-term effort supported by the Belgian PRODEX program.

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The TROPOMI satellite instrument that will play an essential role in providing data for forecasting and monitoring air quality around the world.

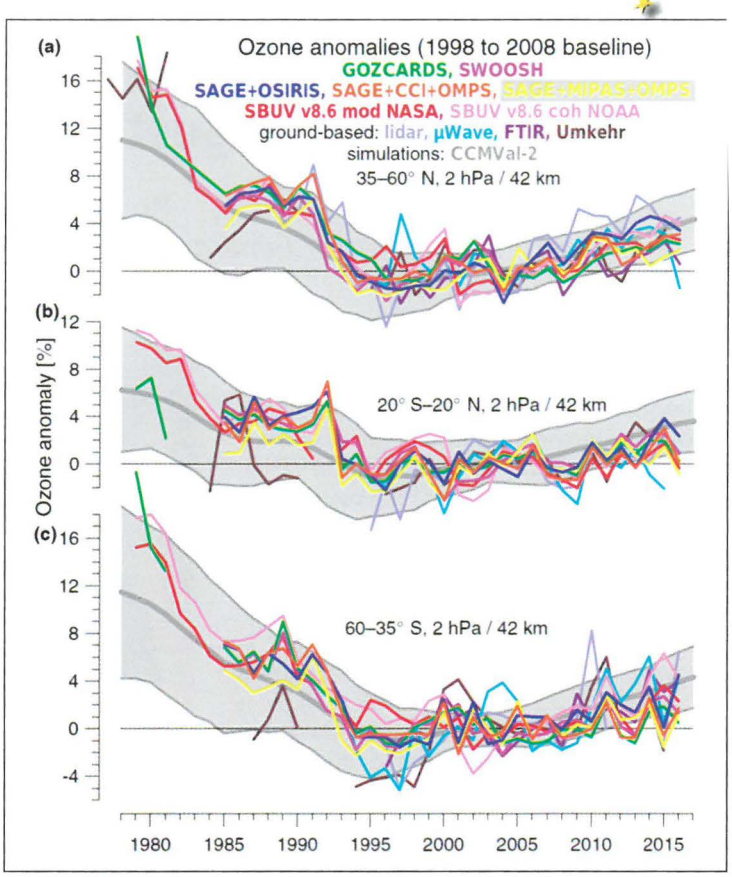
Another key activity for BIRA-IASB is research on ozone. The Montreal Protocol celebrated its 30th anniversary in 2017 and we can certainly say that it is a great success. Without its entry into force the ozone layer would probably have disappeared - with all the risks to human health that such a disappearance entails. From the beginning, BIRA-IASB was involved in determining ozone trends from satellite measurements and ground reference data long term series. It was able to confirm that the ozone layer has begun to recover in the upper stratosphere.

Today it is up to the ALTIUS project to provide researchers with future data to enable continued research on the evolution of the ozone layer. Indeed surveillance of ozone must be maintained because of the uncertainties caused mainly by climate change. It is necessary to rely on a succession of satellites to trace a trend over 20 years and more. Yet the combination of several short series to make a long series does not necessarily ensure sufficient reliability. "To remedy this, comparisons with high-quality data from reference ground-based network observations are key to success" Martine De Mazière, ad interim general director of BIRA-IASB, stresses.

BIRA-IASB is also a key contributer to the ROSETTA project: the ESA's Rosetta comet probe met comet 67P / Churyumov-Gerasimenko from 2014 to 2016. On board was a mass spectrometer (ROSINA-DFMS) that could determine the isotopic ratios. BIRA-IASB contributed to the development and construction of this instrument and remains involved in the in-depth analysis of measurements. ROSINA-DFMS has established the amounts of stable isotopes of xenon in the cometary atmosphere. The mixture of xenon isotopes seems to be very particular. This particular mixture should already be present in the material from which the solar system was formed. By continuing their reflections on observed xenon isotope ratios, researchers are now convinced that comets have brought about a quarter of the xenon to Earth. Whereas it was previously thought that the Earth's original atmosphere was formed during the 100 million years that followed the formation of the Earth (4.5 billion years ago), it is now believed that this period lasted longer. In addition, at the end of 2017, the ROSINA-DFMS team published the results of a study on the isotopes of hydrogen. Here too, the ratio of isotope abundances corresponds to an origin that precedes the birth of the solar system.

Other instruments bear proof of BIRA-IASB's long-standing experience in instrumentation. This is the case of SOLSPEC. Between 2008 and 2017 this scientific apparatus observed continuously the sun from the International Space Station (ISS). It measured almost the entire power of the radiation emitted by the solar star across the electromagnetic spectrum. "Thanks to its observations we gained a better knowledge of the sun and scientists were able to create very accurate computer models and predict its behavior. This is an important step towards a better understanding of the influences of man and the sun on the climate of the Earth" Martine De Mazière states.

From the sun to volcanic observations in Congo there is only one step that BIRA-IASB crossed briskly. In June 2017, scientists from BIRA-IASB participated in a 12 day scientific measurement campaign in and around the main crater of the Nyiragongo volcano (in the Virunga Volcanic Province, Democratic Republic of Congo). The aim of the campaign was to collect scientific data with different types of instruments in order to better understand the physical mechanisms that drive volcanic processes in the region. "BIRA-IASB was part of the team and contributed with several instruments for quantifying the amount of sulphur dioxide (SO_2) emitted by the volcano" Martine De Mazière explains. In the



Annual mean ozone anomalies near 42 km altitude, as recorded by merged satellite data sets and ground-based stations. Anomalies are referenced to the 1998 to 2008 climatological annual cycle of each individual data set, and are averaged over the indicated zonal bands. Grey lines show mean ozone anomalies from multimodel simulations with the grey shading giving the uncertainty envelope.

coming months, research will be conducted to extract the most relevant information from the SO_2 measurements under various conditions and observation geometries. The ultimate objective is to build a high-quality SO_2 flux dataset for the whole campaign duration, from a combination of data from satellite instruments on the one hand and the UV camera deployed on the ground on the other hand. The campaign benefited from the RESIST STEREO project: funded by BELSPO, it contributes to the understanding of the source mechanisms driving volcanic eruptions and landslides in the Kivu Basin region.

Four years after its celebrating its 50th anniversary, BIRA-IASB's excellence is fully recognized. "The Baron Nicolet Prize 2014-2015, named after the first director of the Royal Belgian Institute of Space Aeronomy, was awarded to our colleague Arnaud Mahieux for his research in planetary aeronomy" Martine De Mazière rejoices. This prize, which rewards young scientists under 40, is awarded by the Royal Belgian Academy of Sciences, Letters and Fine Arts. A dazzling proof of the importance of research in aeronomy.

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