European Metrology Research Programme

Delivering Impact

Ensuring accuracy in the upper atmosphere

Variations in ozone and aerosols in the Earth's atmosphere affect air quality, weather and climate. One critical example of this is climate change, where the build-up of greenhouse gases is driving the warming of the planet's surface. To assess the impact of tiny variations in atmospheric composition on long-term climate change, the Earth observation community needs highly-accurate, comparable measurements of atmospheric composition made using ground-based, aircraft- and satellite-borne instruments.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

Recognising this need, organisations including the European Space Agency (ESA) now require the instrumentation they use to meet the Quality Assurance Framework for Earth Observation (QA4EO) guidelines, which specify the need for measurement traceability. However, while carefully calibrated on the ground prior to launch, Earth observation instruments on board aircraft and satellites can degrade during take-off and while in flight. If these instruments are to provide traceable measurements, they need to be validated in-flight, post launch.

Infrared (IR) Fourier Transform (FT) imaging Spectroradiometers, which provide highly-accurate measurements of the chemical composition of the Earth's atmosphere, are particularly vulnerable and can undergo significant drift during use in-flight. Consequently, their performance needs to be periodically checked against a standard to ensure the reliability of the data they provide.

However, the deep cavity black bodies traditionally used at National Measurement Institutes to calibrate this type of imaging spectroradiometer are too bulky for use on board aircraft and satellites. Compact, lightweight, and highly accurate transfer standards are required to enable airborne IR spectroradiometer validation for studies of atmospheric composition.

Solution

Within the EMRP project *European metrology for earth observation and climate* the new vacuum and low background IR calibration facility at PTB, the German National Measurement Institute was used to provide traceability for airborne spectroradiometers. Two novel robust and compact black body radiation sources, developed in collaboration with University of Wuppertal, were calibrated using the new facility prior to use as transfer standards on board a research aircraft.

Impact

One of the first Earth observation instruments to benefit from the developed blackbody sources characterized on the new calibration facility was GLORIA (the Gimballed Limb Observer for Radiance Imaging of the Atmosphere) the first of a new generation of spectroradiometers for Earth observation. GLORIA's novel infra-red camera measures trace gases in the atmosphere, as well as temperature and cloud structures, with an unprecedented combination of vertical and horizontal resolution that relies upon highly-accurate calibration.

The black body radiation sources have been used in two extensive measurement campaigns on board Russian and German research aircrafts, Geophysica and Halo, to provide traceability to GLORIA for the first time. During the Halo flight from southern Germany around Africa and over the Antarctic, the new transfer standards enabled the first traceable mid infra-red measurements of thermal emissions – a significant step forward in Earth observation research.

When used in combination with the transfer standards developed in the project, GLORIA has demonstrated the suitability of IR spectroradiometers to traceably measure radiance high in the Earth's atmosphere. Black body designs have been further developed and new variants are now available. This newly traceable technology can now be used on board balloons and satellites, plugging the gap in high-quality data needed for robust climate change assessment.

Earth observation metrology

The EMRP project *Metrology for Earth observation and climate* developed new measurement standards, methods and calibration facilities to support the validation of sensors used in Earth observation satellites and aircrafts, both prior to and during flight. These outputs will ensure that accurate, laboratory-quality measurements of key climate parameters can be made from space and used to underpin robust predictions of changes to the Earth's climate.

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