



# The importance of metrology is beyond measure

**Dr Julian Gröbner** is the coordinator of a project aiming to provide traceable solar UV irradiance measurements with an uncertainty of less than 2 per cent. He discusses his inspirations, current activities, the benefits of collaboration and how his research will evolve in the future

**You are head of the World Calibration Center for UV at the Physikalisch-Meteorologisches Observatorium Davos/World Radiation Center (PMOD/WRC). What inspired you to link general meteorological and environmental measurements to metrology?**

Environmental measurements have become a fundamental element in our understanding of nature. For example, measurements of the total amount of ozone in the atmosphere led to the discovery of the ozone hole and the implementation of the Montreal protocol to phase out use of substances that destroyed the ozone. The responsibility of demonstrating the reliability of measurements – that can lead to far-reaching consequences at a global level – requires that one can trust them. One must understand all aspects of the measurement, including the range of our trust – that is, the degree of uncertainty attached to a measurement.

I have always been fascinated by the measurement process. It consists of taking an instrument and characterising it as best as possible to understand its behaviour under all reasonable circumstances, then producing measurements of an environmental parameter (such as solar UV irradiance) and combining these with an uncertainty that describes the level of understanding we have.

**Can you describe the main activities you and your colleagues are engaged in at PMOD WRC?**

PMOD/WRC was established in 1971 in order to homogenise solar radiation measurements worldwide. Over the course of the next few decades, three more sections were added to the original Solar Radiometry Section – the World Optical Depth Research and Calibration Center, the Infrared Radiometry Section and the World Calibration Center for UV.

In these Centers and Sections, we develop and host instruments that represent the 'world reference' for meteorological and environmental parameters. We disseminate these through calibrations and instrument intercomparisons and, from this activity, increasingly more measurements across the world are becoming traceable to PMOD/WRC.

**Over the past several years, you have been working on two important projects at PMOD/WRC. Project SolarUV's goal was to decrease uncertainties of spectral solar UV radiation measurements from  $\pm 5$  per cent to values of  $\pm 1-2$  per cent. What were the results?**

The project brought together the leading metrological institutes in Europe to tackle nearly all aspects of solar UV measurements, from calibrating laboratories, to developing new monitoring devices, to holding a large international field campaign to disseminate the results to the end-user community. While we achieved the most important task – reducing the uncertainty of our QASUME reference spectroradiometer nearly twofold – we were not as successful with regard to using novel array spectroradiometers for measuring solar UV radiation. We observed intrinsic problems related to the design of these instruments, which currently prohibit their use at the shortest wavelengths below 305 nanometres. Nevertheless, it was an important finding and we could clearly define the boundaries in which these instruments should be used.

**Collaboration is an important part of your scientific accomplishments. Can you elaborate on what it enables you to accomplish?**

In order to address the objectives of our projects, we need to combine expertise that is simply not available within a single institute. The challenge of linking the metrological to

the environmental world is also a challenge in terms of bringing different cultures together. This is largely because the first operates in a laboratory environment under well-controlled conditions, while the second needs to adapt to the changes imposed by an environment that is sometimes under extreme ambient conditions, such as the Polar Regions. The European Metrology Research Programme (EMRP) and its follow up – the European Programme for Innovation and Research (EMPIR) – provides funds drawn equally from the EU's framework programme for research and innovation and the European Association of Metrology Institutes (EURAMET), to support collaborations on an international level to achieve the necessary critical mass.

**How do you foresee your activities evolving in the coming years?**

The importance of providing traceable environmental measurements with known uncertainties will drive our field of research. Our role as World Radiation Center will continue to provide a reference for solar radiation measurements and will expand to also include atmospheric constituents retrieved from remote sensing measurements. The necessity of providing surface-based reference measurements for validating satellite-based Earth observations will expand; so too will the requirements for a comprehensive assessment of the quality of the measurement process.





The Physikalisch-Meteorologische Observatorium Davos, World Radiation Center.

## Applying metrology to solar UV radiation and atmospheric ozone

The European Metrology Research Programme is a metrology-focused programme that facilitates closer integration of national research activities. In recent years, it has funded the **SolarUV** and **ATMOZ** projects, which have heralded significant advancements in environmental measurements



The reference spectroradiometer being calibrated in the clean room at Physikalisch Technische Bundesanstalt.

**THE IMPORTANCE OF** being able to take measurements accurately can hardly be overstated. Indeed, without units, standards and measurement instruments, innovations and discoveries within the fields of science and technology would be extremely difficult to achieve.

One only has to look at the history of the most well-known SI unit in the world to know this to be true – the kilogram. While the SI scale of measurement goes all the way back to the late 1700s, the kilogram did not find its start until 1875 when representatives of 15 countries converged upon the Convention du Metre in France and agreed to cast an artefact made using an alloy of 90 per cent platinum and 10 per cent iridium.

After several attempts in Paris to cast the artefact, in 1879 George Matthey of Johnson, Matthey and Co of London announced that he

was successful in making a metal cylinder, which is now known to science as the kilogram. Since 1889, this single cylinder has been the standard against which every other kilogram is judged. However, it is not without problems.

As those in the field of metrology know, in order to acquire, quantify and share knowledge, one must be able to perform measurements in a reliable way that can be cross-referenced around the world, and unfortunately for the kilogram, the mass of the cylinder on which it is based is slowly changing.

While metrologists have not yet figured out how to address the problem of the changing kilogram, a group based at the world famous Physikalisch-Meteorologisches Observatorium Davos (PMOD)/World Radiation Center (WRC) is leading a European consortium of national metrology institutes to make impressive headway in improving tools and requirements

needed to more accurately measure solar UV radiation and total ozone.

## QUANTIFYING OUR EXPOSURE TO RADIATION

Solar UV radiation is the ultraviolet radiation that the Sun emits. Human exposure to solar UV radiation has several important implications on public health, with skin cancer and malignant melanoma being two of the severest health effects associated with it. As has been well documented in recent times, the global climate system is changing and the exact ways in which those changes manifest is the subject of ongoing studies.

European Metrology Research Programme (EMPR) – which is jointly funded by the European Association of National Metrology Institutes (EURAMET) and the EU's Seventh Framework Programme – enlisted Dr Julian Gröbner and his team at PMOD/WRC to start drilling down into these changes. As such, the 'Traceability for surface spectral solar ultraviolet radiation' (SolarUV) project – which ran from 2011 to 2014 – was established with the aim of improving the accuracy of measuring spectral solar UV radiation at the Earth's surface. Specifically, Gröbner's team wanted to enhance the reliability of the measurements in the wavelength range of 300-400 nanometres, ultimately providing new techniques and devices to provide traceable solar UV irradiance measurements with an uncertainty of less than 2 per cent. These activities are an essential requirement when quantifying the changes in solar UV radiation brought about by global climate change.

ATMOZ has taken traceability to a new level and has added the complexity of including an atmospheric retrieval model to derive an atmospheric trace gas into the traceability chain

Gröbner's team incorporated novel and cutting-edge scientific activities to achieve its aims. One highlight of the project was the use of tuneable laser sources as calibration sources to reduce the spectral irradiance calibration chain, and the team made visits to the German national metrological institute to validate their new approaches against the current primary standard. "For the first time, we could actually use laboratory calibration sources comparable

in intensity to the solar irradiance," explains Gröbner. "The results demonstrated the equivalence of both calibrations to within their uncertainties of better than  $\pm 1$  per cent."

## FROM SOLARUV TO BEYOND

Following on from the success of SolarUV, Gröbner and his team have implemented another joint research project to continue their work. Called the 'Traceability for atmospheric total column ozone' (ATMOZ) project, it began in 2014 and is scheduled to run until 2017. Its aim is to take what was learned throughout the course of SolarUV and apply it to the retrieval of total column ozone. The ability to quantify the amount of atmospheric ozone is crucial in understanding the extent to which human activities are impacting upon the protection the ozone layer offers the global population.

One of ATMOZ's chief aims is to provide alternative technologies to those currently employed. "The instruments used for retrieving total column ozone were developed 40-90 years ago," explains Gröbner. "By regrouping a comprehensive consortium and involving the end-user community directly into the decision process, we hope to make use of the technological developments of recent years." Ensuring this is achieved is crucial to guaranteeing the long-term global monitoring effort of the ozone layer, in addition to ensuring ever more efficient use of resources and the automation of the measurement process.

## FROM METROLOGY TO METEOROLOGY

Thus far, ATMOZ has seen several exciting results. It has taken traceability to a new level and has added the complexity of including an atmospheric retrieval model to derive an atmospheric trace gas into the traceability chain – something that is a considerable achievement. "To do this is quite challenging as it takes the concept of traceability from a purely metrological perspective to including an atmospheric remote sensing parameter that cannot be realised in the laboratory," explains Gröbner. "If we are successful, this will open a new era for the metrological traceability of the remote sensing of the atmosphere."

Achieving this notable aim would have the effect of linking the world of metrology with the world of meteorology and climate. However, ultimately, what Gröbner and his team are signalling is a new era of traceability, where scientists can measure minute changes in our atmosphere to an incredibly accurate degree. The bearing this could have on our understanding of our environment – and the consequences of our actions – could have dramatic impacts upon future legislation and policy. The potential importance of Gröbner and his team's ongoing research is, somewhat ironically, almost beyond measure.

## RESEARCH PROJECTS SOLARUV AND ATMOZ

### OBJECTIVES

- To improve spectral global solar ultraviolet measurements by decreasing the uncertainty of the world reference spectroradiometer
- To improve the characterisation of array spectroradiometers
- To establish a new portable UV reference spectroradiometer
- To develop new technologies, methods and software for applications in the solar UV end-user community responsible for environmental and human health protection

### KEY COLLABORATORS

**Dr Luca Egli**, Physikalisch-Meteorologisches Observatorium Davos and World Radiation Center (PMOD/WRC), Switzerland • **Dr Saulius Nevas**, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany • **Dr Petri Kärhä**, Aalto University, Finland • **Dr Marek Smid**, Český Metrologický Institut Bro, Czech Republic • **Dr Omar El Gawhary**, VSL, Netherlands

### PARTNERS

Kipp & Zonen BV, Netherlands

### FUNDING

EURAMET • EU Seventh Framework Programme (FP7)

### CONTACT

**Dr Julian Gröbner**

Head of the World Calibration Center for UV (WCC-UV), Head of the Infrared Radiometry Section of World Radiation Center (WRC), Head of the World Optical Depth Research and Calibration Center (WORCC)

PMOD/WRC  
Dorfstrasse 33  
7260 Davos Dorf  
Switzerland

T +41 58 467 5157

E julian.groebner@pmodwrc.ch

<https://projects.pmodwrc.ch/env03>

<http://projects.pmodwrc.ch/atmoz>



**DR JULIAN GRÖBNER** has been working at PMOD/WRC since 2005. He is currently Head of the Infrared Radiometry Section of WRC, Head of the World Optical Depth Research and Calibration Center of WRC and Head of the World Calibration Center for UV.

*pmod* wrc