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## Metrology for Climate Actions: PTB’s Innovation Cluster Environment and Climate

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The international metrology community as represented by National Metrology and Designated Institutes has addressed the global and multidisciplinary challenge manifested by climate change and its mitigation. This can be seen on the global level by the inauguration of the Sectorial Task Group Climate Change and Environment [1], as well as on regional levels as, e.g., given by the European Metrology Networks installed by EURAMET [2], or the Focus Group Climate Change and Clean Air [3]. At PTB, topical focussing has been achieved on the institute level by the foundation of so-called Innovation Clusters of which the one for Environment and Climate metrology [4] coordinates all activities in the context of metrology for the environment and climate. This contribution showcases the impact of metrology on climate actions as documented by examples of those activities at PTB in the field. Addressing respective recommendations of the BIPM-WMO-Workshop held in 2022 [5], we will exemplify what directions of work will contribute to the regional and global efforts undertaken by the metrology community explained by two cases:

To help the WMO community, and measuring the longwave downward radiation, for example, the Hemispherical Blackbody (HSBB) of PTB was developed [6]. The HSBB is a blackbody cavity that was specifically designed for the calibration of radiometers used for longwave downward radiation measurements, like, for instance, pyrgeometers and Infrared Integrating Sphere (IRIS) instruments. They are broadband infrared detectors with a hemispherical acceptance angle. Few years ago, the HSBB was employed for comparison measurements conducted at the Physikalisch-Meteorologisches Observatorium Davos / World Radiation Center (PMOD/WRC). With these measurements, the metrological traceability of the worldwide reference for longwave downward radiation measurements, the Tilted Bottom Cavity BB2007 established by the World Meteorological Organization (WMO) and operated at PMOD/WRC, was validated [7]. The results will lead to reduced uncertainties of worldwide longwave downward radiation measurements.

The perspective of active measurements of atmospheric species is tackled at PTB by the development of optical gas standards (OGSs). OGS are laser spectrometers designed to quantify target gas compounds and serving as an instrumental standard with no need of calibration with reference gases. OGSs are operated according to the TILSAM method [8] and determine metrologically traceable amount fractions of small molecular species, as, e.g., those of H<sub>2</sub>O or NO<sub>2</sub>. Whereas the first internationally accepted optical gas standard has been realized as OGS for hydrogen chloride [9], field measurement campaigns have been demonstrated by PTB on water vapor onboard

research aircrafts already. A summary and outlook on PTB's OGS approach will be provided in the talk.

## References

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- [2] EURAMET, European Metrology Networks (EMNs), EMNs Climate and Ocean Observation, Pollution Monitoring, Radiation Protection, etc. URL: <https://www.euramet.org/european-metrology-networks> .
- [3] APMP Focus Group Climate Change and Clean Air (FG CCCA), URL: <https://apmpweb.org/portal/list/index/id/35.html> .
- [4] PTB, Innovation Cluster for Environment and Climate, URL: <https://ptb.de/environment-climate> .
- [5] BIPM-WMO (2023), Rapport BIPM-2023/03, Metrology for climate action – BIPM-WMO Workshop 26-30 September 2022, URL: <https://www.bipm.org/documents/20126/27085544/RapportBIPM-2023-03.pdf> .
- [6] M. Feierabend et al. "Development and operation of the Hemispherical Blackbody (HSBB) for the calibration of infrared radiometers with a hemispherical acceptance angle". In: Optics Express 30.26 (2022), pp. 46991-47003.
- [7] M. Feierabend et al. „Bilateral comparison of irradiance scales between PMOD/WRC and PTB for longwave downward radiation measurements". In: Metrologia 60.2 (2023), p. 025010.
- [8] O. Werhahn, J.C. Petersen (eds.), Traceable Infrared Laser-Spectrometric Amount fraction Measurement (TILSAM) technical protocol, URL: [https://www.euramet.org/Media/docs/projects/934\\_METCHEM\\_Interim\\_Report.pdf](https://www.euramet.org/Media/docs/projects/934_METCHEM_Interim_Report.pdf)
- [9] HCl in nitrogen Calibration and measurement Capability EURAMET-QM-DE-00000OIY-1, BIPM, URL: <https://www.bipm.org/kcdb/cmc/detail-view/39633>