Speaker	Position(s)	Presentation Title	Abstract
Richard Barker - NPL	Head of Energy and Environment	Scientific evidence in a systems approach to climate action	Addressing climate change is a highly complex endeavour that is dependent on scientific evidence to guide society. As the window of opportunity to act closes and the pressure mounts, science needs to be at its best, if we are to succeed in averting a global climate catastrophe.
Professor Nigel Fox - NPL	NPL Fellow in Earth Observation, Climate and Optical Radiometry Chair of the CEOS WGCV IVOS Subgroup UK science lead for the TRUTHS satellite mission	Metrology for Earth Observation and Climate	Timely, 'fit for purpose' climate action requires policy makers to have confidence in the actions they take and the impact they will have. This confidence derives from an understanding of the sensitivity of the climate to both direct and indirect anthropogenic inputs and how the earth system's various cycles e.g. water, radiation, carbon operate and interact both to human driven forcings and those of a natural more unpredictable origin e.g. volcanoes, solar variation, El nino etc. Uncertainty in these 'understandings' can lead to delayed or even in-action in both mitigation and adaptation. Metrology, not exclusively national metrology institutes (NMIs), has a key role to ensure that any observations used to parameterise and test the models that describe the Earth system and its response are trustworthy and have ascribed to them an uncertainty (adequate level) relative to internationally agreed references ideally tied to the international system of units (SI). Similarly, any transformational algorithms required to derive: bio-geophysical parameters, long time series data and ultimately digestible and actionable 'information' require a similar degree of metrological rigour. Although discrete localised measurements of some parameters provides valuable insight and information on the state of the planet, particularly in assessing mankinds contributions, it is only from space that the necessary global information can be collected to attempt real understanding of the planetary state and its response. This presentation focusses on some of the efforts that are currently underway to improve the uncertainty and SI-traceability of the remote sensing of the Earth from space, primarily in the optical domain as an example, and some of the challenges that are faced. It concludes with a short description of the development of a new satellite mission expressly designed for climate and metrology with the aim to establish direct access to the SI from space and with it help create an SI-traceable global climate observing system fit to meet the needs of society as the world ambitions to target net zero.
Dr Andrea Merlone - INRiM	Senior Researcher at the Italian Istituto Nazionale di Ricerca Metrologica (INRiM) BIPM - CCT WG Environment Chairperson WMO - SC-MINT Expert Team "Measurement Uncertainty" Chairperson	Traceability, uncertainty and reference measurements for in situ climate observations	The talk presents recent initiatives, projects and collaborations between metrologists and the climate and meteorological communities. From scientific open issues to technical measurement needs, several areas and topics of interaction, requiring metrological support, are reported.
Dr James R Whetstone - NIST	Special Assistant to the Director for Greenhouse Gas Measurement	Greenhouse Gas Measurements Program	Cities, and their surrounding urban areas, are major greenhouse gas emitters, producing an estimated 70% of global emissions. Assessment of progress in addressing climate mitigation actions will be strongly bolstered by authoritative, findable, accessible, and usable greenhouse gas emissions information at urban spatial and temporal scales. Such data, from internationally recognized measurement methods, reflects the global nature of mitigation efforts. Recent emissions measurement advances by research teams working in NIST's Urban Greenhouse Gas Emissions Measurement Testbeds integrate socioeconomic and physical atmosphere observational data and analyses. Atmospheric inversion analyses transform atmospheric GHG concentration data, the only observable atmospheric parameter resulting from emissions, to emission and uptake amounts, via atmospheric transport modeling and statistical optimization. Emissions modeling relies on a range of spatially and temporally specific, socioeconomic data inputs and elaboration of IPCC guideline methods to map hourly emissions from US continental to building and road scales. Atmospheric inversion methods conserve the mass of atmospheric GHGs over the modeling domain while emissions models do not. The combination conserves GHG mass while affording finer spatial resolution than available from the meteorological com-ponent of inversion analyses. In effect, the combination calibrates the emissions model whose spatial resolution can identify source locations and, therefore responsible parties, to better monitor and assess mitigation implementation.
Dr Hong Lin - NIM	Group Leader of Greenhouse Gas and Air Pollutant Inventory Research	SI-Traceable Greenhouse Gas Inventory Measurement in Megacity	Climate change is one of the most serious challenges in the world, and it is the common responsibility of all mankind to jointly solve it. Greenhouse gas emissions must be controlled and all the countries need to assume corresponding responsibilities and obligations. China has proposed a national commitment of carbon emission peak and carbon neutrality. To ensure the authenticity and accuracy of carbon emission data is the basis of achieving carbon targets. In 2019, IPCC put forward further requirements for GHG inventories, such as new requirements on the enterprise-level data quality, integrated revision of traditional inventories based on measurement inversion, and improved uncertainty analysis of traditional inventories. Therefore, it is

			urgent to establish China's carbon emission monitoring and measurement system and uncertainty analysis method of carbon inventory data to improve the accuracy of traditional inventory data. At present, NIM (National Institute of Metrology, China) has carried out a series of measurements of carbon data in Zhengzhou city. First of all, accurate measurement of industrial enterprises organized emissions is achieved through the flue flow metering standard device, and the emission factor of enterprise data is revised. It is found that the enterprise fuel accounting is higher than the direct measurement of emissions, leading to the overestimation of industrial enterprises carbon emissions. Secondly, the small area inversion monitoring and measurement technology can be used to obtain the accurate location and emission amount of the fugitive emissions. Meanwhile, combined with differential absorption lidar technology, the spatial and temporal distribution of gas concentration and emission amount can be realized. Besides, based on the multi-source traffic static and dynamic data obtained in cooperation with the transportation department, a high-resolution and real-time monitoring system for urban road traffic emissions is established. This system provides a dynamic and real-time traffic emission inventory, helping city administrators build a precise and efficient city traffic control and management mode. Finally, to establish the emission inversion system, the optimal location of carbon monitoring station is first obtained by clustering algorithm and atmospheric transmission model, considering the spatial coverage efficiency and urban carbon contribution of stations. Bayesian theory and atmospheric transport model are selected to establish the inversion model. Combined with prior carbon emission fluxes and carbon observation values, the inversion CO_2 grid emission are obtained to revise the carbon inventory, achieving international mutual acceptance of carbon data.
Dr David Sexton - Met Office Hadley Centre	Manager, Ensemble Climate Projection	The importance of confidence in observations to constrain climate projections used to inform adaption actions	The latest set of national climate projections for the UK published in 2018 (UKCP18) provides several products designed to help inform impacts studies and the statutory 5-yearly climate change risk assessments, which then inform our National Adaptation Plan. The products are all based on multiple climate simulations evaluated against observed long-term averages and trends for several variables. One product is a set of probabilistic projections designed to help planners use a risk-based approach to deciding how to adapt to climate change. These are generated using a Bayesian framework where multivariate realisations of future climate are sampled statistically (statistics are trained on raw model output) and then weighted to account for goodness-of-fit to observations. Other products are based on providing raw model output from climate simulations that have been evaluated against observations and assessed as plausible – there are other candidate simulations not used as they were deemed implausible and filtered out. Both the weighting and filtering are based on comparisons of the model output with observations and take into account uncertainties in both the model data and the observational data. This has two benefits. First, weighting or filtering is then dominated by variables that have relatively low combined model and observational uncertainty; that is, by variables that are well represented in models, and for which there is good global coverage by observations that have relatively low measurement and representation uncertainty. Accounting for these uncertainties helps to prevent us providing over-confident projections that can lead to overly targeted adaptation. The second benefit, is that projections can be better constrained by improvements to the observations and the climate models. This talk will present the method, with a focus on the observational uncertainty, and the current pragmatic approach we take to quantify observational uncertainties, followed by future directions for needs for evaluating climate and Earth System models.
Dr Robert Wielgosz - BIPM	Steering Committee Member: BIPM-WMO Metrology for Climate Action Initiative	Metrology for Climate Action Initiative 2022	The Metrology for Climate Action Workshop will be hosted by the BIPM and the World Meteorological Organization (WMO) on 26-30 September 2022. The workshop covers the themes of metrology in support of the physical science basis of climate change and climate observations, as well as metrology in support of greenhouse gas mitigation. It aims are to present progress and identify requirements for further development of advanced measurements, standards, reference data, comparisons, calibrations and metrological techniques to support the physical science basis for and adaptation to climate change, as well as efforts to mitigate greenhouse gas emissions. The output of the workshop will be a set of recommendations on key technical challenge areas for metrology and contributing to a road map on the evolving needs in metrology over the next decade. This initiative follows on from two previous events, one on Measurement Challenges for Global Observation Systems for Climate Change Monitoring (2010) and the second on Global to Urban Scale Carbon Measurements (2015). Learn more on the topics to be covered in the workshop themes and how to become involved either as a participant or as a partner or stakeholder organization.
Dr Bruce Forgan - WMO	Vice-president of the WMO Commission for Observation, Infrastructure and Information Systems (Infrastructure Commission)	Metrology for Climate Action: A perspective developed over 50 years	Charles Keeling, of the Mauna Loa CO_2 record fame once said: without a traceable SI measurement time works against you, but with a traceable SI measurement time works for you. Climate information traceable to SI, and the models applying that information are crucial for societal policy development and our future. There have been numerous successes in environmental metrology that have led to very good outcomes. But measurement uncertainty being a positive rather than a negative can be difficult to fathom for non-metrologists. Communication remains a key both with the user community and the milieu that is environmental science. However, as recognised at the BIPM-WMO Workshop in 2010, much more work is required. Crucial to the success of future policy underpinned by climate information is the continuous improvement in transforming satellite observations into climate information for both knowing the past and predicting future climate,and ensuring increased traceability and reduction of the uncertainty of all remotely sensed environmental measurements. As climate issues press more on the government and hence environmental agency landscape, attention needs to be paid to informing our current and future government and agency leaders of the increased value environmental metrology has to their decision and policy making, hence a proactive information process should remain a focus area.
Dr Susanne Mecklenburg - ESA	Head of ESA Climate Office	Observations from space and metrology: how to best use them in our quest to tackle climate change	Climate change represents the biggest global threat of the 21st century. This has been widely recognized and is currently responded to by major international initiatives, summarizing the most pressing, globally relevant requirements in addressing the effects of a changing climate, such as the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement, the UN's "2030 Agenda for Sustainable Development" and the Sendai Framework for Disaster Risk Reduction 2015–2030. The European Space Agency (ESA) is already addressing a large number of the requirements that respond to the above main drivers for climate action through being a main developer of European Earth Observation (EO) capabilities to deliver climate science and services. ESA's satellites provide the global view, enabling the science community to detect signs of change, identify significant trends and constrain the models to predict the future. Through its role as a major provider of systematic and global climate observations ESA interacts with a number of international organisations, stakeholders and users, within the climate landscape that are working toward strengthening the scientific understanding and projection of climate and addressing the consequences of future change.

			One of the keystones of ESA’s climate activities is the Climate Change Initiative (CCI), which has been running for more than 10 years and is led by the ESA Climate Office. This unique scientific effort involves ca. 450 world-leading experts across ESA Member States to generate global multi-mission and multi-decadal datasets satisfying the requirements for 22 Essential Climate Variables (ECVs) defined by the Global Climate Observing System (GCOS), on behalf of UNFCCC. These datasets have fully characterised uncertainties and are validated using independent, traceable, in-situ measurements. They provide an impartial yardstick to understand climate processes and to improve and validate climate models, thereby enhancing the quality, credibility and exploitation of model predictions. In association with Earth System Models (ESMs), CCI data also provide the observational record to study drivers, interactions and feedbacks due to climate change, as well as reservoirs, teleconnections, tipping points, global energy, water and carbon budgets and other Earth-system cycles, etc. The scientific results of the CCI programme, published in more than 900 papers to date, are a major contribution to the physical science base of IPCC Assessment Reports. The keynote will provide an assessment on the challenges and opportunities that space-borne data provide in our quest to tackle climate change, and where the climate science community sees most value in working with the metrology community.