Overview. Events for discussing ideas for the following call for projects are becoming valuable occasions for the metrology community and stakeholders for preparing the proposed research topics. The workshop for the targeted programme “Environment” was held on 23 and 24 October 2018 at LNE in Paris. This event was combined with the workshop on Energy topic, in order to allow participants to attend both workshops. About 70 participants from almost all the European NMIs and main DIIs attended the event. An additional meeting of the “Copernicus Climate Change Service2 Lot 3 on near surface temperature was also organized.

The first half day was dedicated to presenting plenary keynote lecturers. Members of the EURAMET Task Group Environment (TG ENV) presented the state-of-the-art of the involvement of the metrology community in climate and environmental research and current measurement needs and challenges. The TG ENV convenor presented the needs of the stakeholders that were collected during the preparation of the call scope proposal. Letters were received by key parties such as the World Meteorological Organizations (WMO), the Global Climate Observing System (GCOS), the Marine community (JPI Ocean), the Global Cryosphere watch programme and other. The talk also summarised a number of joint events, during the last two-three years where metrologists and stakeholders met. Thekla Kiffmeyer from PTB was finally invited to present a closing remark on the role of the regulations and EU directives and needs.

At the end of the first day’s session the TG ENV members met for discussing the activities and possible progress of the team.

In the second half day separate breakout sessions were chaired by experts and TG ENV members on a number of identified key topics.

The meeting agenda, report of each breakout session and minutes of the TG ENV meeting are attached

November 2019 TG ENV Members
# Environment Workshop Agenda

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<td>Reference-grade measurements of in situ physical observations for climate</td>
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<td>How to provide traceable measurements of atmospheric remote sensing products</td>
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<td>Metrology for radionuclides in air, water, surface and soil and for environmental ionizing radiation dosimetry</td>
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Venue: rue Gaston Boissier 75724 Paris Cedex 15
Gas and particle metrology for air quality, emissions monitoring and atmospheric science

Chair: Paul Brewer (NPL)
Participants : 18

The session aims were to stimulate research topics for the 2019 EMPIR Environment call. Its focus was also to prioritise those that align with the needs of stakeholders, deliver high impact, advance the state of the art in measurement science and progress cooperation within EURAMET.

Potential future research topics discussed in the session are detailed below.

• NPL presented the requirements for research on developing reference materials to underpin heteroatoms containing volatile organic compounds as climate tracers. This work is particularly challenging given the reactive nature of the compounds of interest. The group discussed the drivers and the importance of focussing on atmospheric monitoring.

• NPL also presented a follow up to the Black Carbon project to address outstanding metrology challenges related to measuring mass absorption cross section for different types of real absorbing aerosol (supported by modelling), allowing conversion to (not-just-“equivalent”) Black Carbon, developing methods to analyse multi-wavelength absorption data and extending the validation of field calibration methods.

• NPL then presented some general topics for discussion (low cost sensor networks related to sensor characterisation of performance, agricultural emissions, industrial diffusive emissions sources, atmospheric radiative transfer and underpinning greenhouse gas inventories.

• PTB presented a research topic on transport emissions that would involve expertise in gas analysis and aerosols for the calibration of sensors.

• PTB presented a series of potential research topics related to nitrogen dioxide with each serving as a possible follow up to the current METNO2 project. The first was focussed on accurate calibration of in vehicle Portable Emissions Measurement systems (PEMs). Calibration of nitrogen dioxide is key and there are requirements to address cross interference from CO, CO₂ and water vapour detailed in the regulation. The second research topic focussed on validation of sensor networks to provide air quality data for high special resolution. There is a requirement for metrology to underpin these developments and provide calibration procedures (target range nmol mol⁻¹ to µmol mol⁻¹). PTB also presented a focus on vehicle exhaust measurements with PEMs (1 – 5000 µmol mol⁻¹ range) for measurements of NO2 as well as CO, CO₂ and particle number concentration. This would involve both vehicle type approval and inspection procedures in stationary vehicles using new low-cost sensors (there is regulation but currently no standardisation for NO2). PTB also presented potential research at higher amount fractions of NO2 to improve our understanding of the contribution of ship emissions.

• A follow up to the AEROMET project was also discussed. There are additional measurement requirements which need to be addressed with a focus on low cost sensors.
• NPL presented developments in underpinning measurements of isotope ratio in the gas phase for providing the data to understand the sources and sinks of CO₂ and CH₄. It was stressed that this was particularly important to make existing infrastructure more robust and meet the requirements presented from the advent of commercial spectroscopy analysers. There is already significant progress in working towards SI traceability for CO₂ (isotope ratio is currently a traceability exception under the MRA) and it is important this work is continued. Focus on CH₄ isotope ratio was also mentioned as there is currently no WMO Central Calibration Laboratory for providing the reference for atmospheric measurements. This was also presented to the group by Empa.

• VSL discussed a potential research to underpin indoor air quality with a particular focus on construction products and directives on efficiency of buildings. There is a requirement to develop capabilities such as emissions testing chambers and providing quality assurance.

• VSL also mentioned potential research on underpinning emerging pollutants for which there is limited or no traceability (e.g. HF and freon).

• Empa highlighted the measurement requirements for fluorinated gases in order to improve data and models for climate. It would focus on new components for which there is currently no reference materials or traceability. Empa also outlined the importance in metrology for underpinning measurements of oxygenated volatile organic compounds in the atmosphere.

• Metrology for measuring radon was also discussed and radiocarbon.

• There was also interest expressed on spectroscopic-based isotopic signature measurements in the gas phase, particularly CO₂.
Reference-grade measurements of in situ physical observations for climate

Chair: Andrea Merlone (INRiM)

Participants: 22

Participants:

NMIs: CEM, CMI, DTI, EIM, IMBiH, INRiM, INTiBS, LNE, LNE-CNAM, NPL, PTB, SMU, UME

External: Univ. Campania “l. Vanvitelli”; IMAA CNR (representing GRUAN), ISAC-CNR

Not present (but having expressed interest): BEV, JV, UL-LMK, VTT, ARSO

The purpose of the meeting has been the presentation, discussion and collection of ideas for the preparation of a proposal to be submitted as potential research topic at the coming EMPIR ENV call. Participants presented their ideas, capabilities and, where clearly identified, the needs motivating the activities.

- The main stakeholders identified as primary beneficiaries for this topic are the Global Climate Observing System (GCOS) and the World Meteorological Organisation (WMO).

The discussion led to the agreement of the following points:

- The proposal will mainly be oriented towards reference-grade measurements of in situ physical observations requiring a specific contribution from the thermal metrology: participants were mainly members of the EURAMET TC-T and of the CIPM-CCT.
- It will deal with atmospheric near surface and upper air measurements, soil and ice observations. It will not include marine studies or remote sensing techniques.
- The idea, in its advanced state, will be presented at the kickoff meeting of the EMN on “Climate” (13 December 2018) as an aligned contribution and input
- The proposal will follow from the two previous MeteoMet 1 and 2 JRPs and will also include topics completing some open issues not included in the previous deliverables. MeteoMet is considered now a well-recognised initiative by the stakeholders and it’s worth to associated this proposal to the results and knowledge already achieved, also in line with the EMN long terms vision.
- Four main areas have been identified:
  - **Area A**: addressing needs of the WMO Commission of Climatology and of the Global Climate Observing System (GCOS)
  - **Area B**: addressing needs of the WMO Global Cryosphere Watch Programme
  - **Area C**: addressing needs of the WMO Commission of Instruments and Methods of Observations
  - **Area D**: Impact: delivering contribution to guidelines, prescriptions for installations and data quality
- The proposal will be connected to the agreed EURAMET project 1479 “ATM” (Air Temperature Metrology) possibly contributing to further points of investigation
- It will address a project based on a sound balance of practical dissemination laboratory and field studies, scientific innovation and impact, as already delivered by the previous MeteoMet
- It will take into account EU recommendations and initiatives (such as the Copernicus Climate Change Service - C3S) or the UN regulations and institutions directly driving EU strategies
Propose activities

**Area A: CCI and GCOS - Climatology**
- Test installation for a GCOS Surface Reference Network (GSRN) station. Instrument comparison, uncertainty analysis. Comparison with USCRN network features and performances. Study of metadata format (considering OSCAR). Evaluation of optimal time resolution to detect maximum and minimum values. Key principle: establishing traceability to SI and data comparability within the network.
- Terrestrial ECV: soil moisture and soil temperature for climate reference sites
- Precipitation. Measurements properties for reference grade data for climatology

**Area B: GCW - Cryosphere**
- Intercomparison of thermometers and shields in Polar Environment (Suggested: Ny-Ålesund)
- Selections of best instrumental properties and measurement methods for an Alpine GCW surface and permafrost reference station, taking into account dynamics and environmental conditions
- Towards a GCW station in the Arctic: field study of the instrumental and measurements characteristics. On site calibration at the arctic station, measurement uncertainty, instrument capabilities under polar conditions.
- Co-location of a GSRN and GCW station. Common issues in terms of uncertainties and measurement methods.
- Use of fibre optics, associated to contact thermometers for detecting temperature trends in permafrost boreholes

**Area C: CIMO – Instruments**
- Non-contact thermometry for air temperature measurements. Acoustic and optically based techniques. Field evaluation of quantities of influence (winds, humidity, air composition) on existing systems (sonic anemometers).
- Impact on the presence of river and lake in the vicinity of a surface observing station. Siting classification for CIMO guide n.8
- Small size contact thermometer and shield. “The smaller the better” as reference for “Class A” installations. Link with ATM
- Innovative frost point generators for challenging humidity, pressure and temperature range met by radiosondes

**Area D: Dissemination, directives, best practices.**
- Promote a forum for strengthening the cooperation and promoting sustainable engagement between the European metrology and meteorology communities to establish an infrastructure for traceability of reference measurement grid of climate variables.
- Disseminate and promote the adoption of the GSRN technical features for climate observing stations, here studied, for the creation of a sustainable European climate reference network (EUCRN).
- Contribution to the WMO “Measurement quality classifications for surface observing stations on land”.
- Bringing 17025 in field. Can a field verification become a calibration and deliver a certificate?
- Metrological contribution for the creation of GSRN
- Support GCW best practice guidelines. Contribution to the GCW Guide Chapter 8 – Permafrost observations
- Contribution to the WMO Guide on “Instruments and Methods of Observation”
“Metrology for essential oceanic variables”
Chair: Paola Fisicaro (LNE)
Participants : 18

The objective of the session was to foster discussions and to brainstorm in order to identify the stakeholder’s needs and the possible contributions of a core group of interested NMIs/DIs. Some of the participants presented their ideas for possible PRTs/JRPs. The main points of discussion were the parameters for which metrological issues are still open and which stakeholders would support the work to be done.

A summary of the presentations is given here:

**INRIM**
- pCO2: Application of NDIR technique to link CO2 measurements carried out in atmosphere and seawater; extend the use of metrologically traceable gas mixtures to the calibration of pCO2 sensors
- δ13C in seawater: use of reference CO2 mixtures with known δ13C values, prepared by gravimetry and dynamic dilution, and use of Fourier Transform Infrared Spectroscopy (FTIR) to determine the isotopic composition (δ13C) of dissolved inorganic carbon
- Density as measurand to define absolute salinity. Density used for the metrological traceability of Standard Seawater (SSW) to the International System of units (SI); realization of a new sensor to carry out measurements of seawater density in field to map ocean circulation.
- Sea Surface Temperature: Evaluation of calibration uncertainty for commonly used contact thermometers for in situ SST and evaluation of the effect of radiation on in situ measurement of SST up to 10 m immersion

It was discussed that density, salinity, speed of sound, which are all linked among them, could be part of the same task. Surface Seawater Temperature was debated. Open issues are the SST definition and the lack of thermal models.

**VSL**
work has been done in MeteoMet2 on SBE3 and SBE3S thermometers + observation of pressure effect (1-2 mK at 600 bar SBE3S, difficult to say if pressure dependent or not) (SBE3 not reproducible pressure effect within few mK). The pressure chamber that has been developed at VSL could be used on a large number of SBE thermometers to create a statistic.

**PTB**
- Metrological characterization of high pressure conductance sensors (metrological traceability for CTD sensors not yet established).
- Measure of seawater pH under high pressure would have a high metrological interest but, due to the very early stage, probably there would not be a large stakeholder interested.
- Metrology in oceanography 4.0 (pilot project): data quality, development of a “metrology data base”. Pilot project could be based on exemplary EOVs (salinity, pH, ...)

**SMD**
Proposal on sediment plumes (measurement of suspended particle matter with multibeam echosounder installed on a boat) was presented. There would be the possibility to use the new Belgian Federal Research Vessel as experimental facility.

**Aalto**
A real-time water analyser (Sensmet) for chemical analysis of seawater (alkaline metals, heavy metals) was presented. Issues for the calibration with SSW and with multicomponent reference solutions were discussed. Maybe sensitivity is not enough for open sea concentration, but might be enough for coastal waters.

CEM
The design and development a sub-mili kelvin facility for the thermal calibration of CTDs and study about the definition and measurement procedure of Sea Surface Temperature (SST) was proposed.

CNAM
It was shown the progress done on the development of the calibration bench for absolute salinity sensors and the improvements that are needed.

LNE
The presentation given at the plenary was shown and the priority for acidification parameters was discussed.

It was debated the structure of a possible project and how to deal with such high number of EOVs. One of the challenges that could be addressed is the “deep sea measurements”. Another option would be the “reliability of the in-situ measurements”. This will need further discussion, particularly based on the interaction with the stakeholders, who will help in prioritizing the actions.
How to provide traceable measurements of atmospheric remote sensing products

Chair: Julian Groebner (PMOD-WRC)

Participants: 10

- Potential PRT on atmospheric trace gases - lead by Li Gang, PTB
  Interested partners, Joerg Hollandt, PTB, Julian Groebner, PMOD/WRC, Tom Gardiner, NPL, Martti Heinonen, Aalto Univ., Christof Janssen, LERMA

One suggestion was to aim for one overall topic ("big picture") in view of justifying the project, and specifically address several case studies.

- Discussed species were NO2, using DOAS techniques, in-situ sampling, combined with spectroscopic measurements of the NO2 cross-sections. Discussed was also a combination of remote sensing of UV/VIS and NIR, for example NO2 and CH4.
- A specific target could be the need for traceability of CO2 and CH4 in view of the Paris agreement and the first verification in 2025.
- A further possibility might be to validate the OCO2 satellite from traceable ground-based measurements, e.g. TCON network.
- Joerg Hollandt proposed to continue work on the OH molecule (work currently undertaken in METEOC III) for atmospheric temperature determination.
- Christof Janssen mentioned the TCON station in Paris.

- Potential PRT on Aerosol optical properties
  Interested Partners, Julian Gröbner, PMOD/WRC, Tom Gardiner, NPL, Saulius Nevas, PTB

To provide traceability to global AOD measuring networks such as AERONET, GAW-PFR, SKYNET,...

Specific task within this PRT would be the determination of absolute extra-terrestrial solar spectrum from UV to MIR at the sub-percent level.

Additional topics of interest:

- Water continuum absorption is still open to debate.
- Validation of Langley procedure and comparison between AOD retrieved from Langley versus absolutely calibrated instruments.
- Radiance calibrations.
- Possibly polarisation.

Faton Krasniqi, PTB presented a proposal on measuring ionising radiation (alpha particles) using NO2 fluorescence.

- Using a drone to cover large areas in short time.

- Measuring the specific NO2 fluorescence signals in the UV range, and in the 200-280 nm range to be insensitive to solar radiation.

- there is a need for expertise from the solar remote sensing community to support the measurements (atmospheric correction between drone and surface).
Metrology for radionuclides in air, water, surface and soil and for environmental ionizing radiation dosimetry

Chair: Stefan Neumaier (PTB)

Participants: 9

The meeting consisted of two main parts:

- PRTs proposed prior to the meeting were presented by the participants or by SN and discussed.
- Further proposals were discussed in terms of a brainstorming meeting.

The following ten PRT proposals were presented (Proposal of // Presented by):

1. **Metrology for drinking water** (H. Wershofen, D. Zapata, PTB; Hannah Wiedner, F-J Mahringer, BEV // SN)
2. **Proposal for MetroRAWS (Radioactivity in Air, Water and Soil)** (Ben Russel, NPL, UK // SN)
3. **Detection of Alpha particle emitters with optical methods** (F. Krasniqi, PTB)
5. **MetroNORM II** (Hannah Wiedner, BEV)
6. **Traceability of Radionuclide Activity Concentrations in building materials** (C-L Tugulan, M- Razvan Ioan // SN)
7. **Validation of metal tritides standards for Accelerator Mass Spectrometer detector calibration** (C. Postolache, Mihail-Razvan Ioan // SN)
8. **Ionising radiation metrology for preventing illicit trafficking of radioactive materials through State Borders** (A. Clouvas, AUTH)
9. **Radioactive characterization of tritiated water using ESR spectrometry** (C. Postolache, M.-Razvan Ioan, IFIN-HH, Romania // SN)
10. **The improvement of the accuracy of the ultra-low-level dose rate measurements** (S. Bercea, M.-Razvan Ioan, IFIN-HH, Romania // SN)

A discussion topic was also sent with no associated or requested breakout session.

**Metrology for very low-frequency sound and vibration for disaster warning and climate monitoring**

To monitoring the climate changes and disaster warnings, new measurement systems and technologies in sound and vibration domains can be considered. The evaluation of propagation of infrasound in atmosphere can help to understand and quantify the dynamic exchanges in the different layers of atmosphere. The seismic activity can be monitored to detect disaster warnings like typhoon, earthquakes, volcanos … Similarly to infrasound, underwater acoustics at low frequencies can help to survey the climate change in oceans and to assess the ocean noise pollution.

The interest of using low-frequency sound and vibration in this context is that low frequency waves propagates at long distances with low attenuation and can bring information about the propagation field. Another important point to be mentioned is that the network of sensors for a such monitoring is already operational. The IMS (International Monitoring System) provided by the CTBTO (Comprehensive Nuclear-Test-Ban Treaty Organization) includes more than 250 sensors around the world covering infrasound, seismic and underwater acoustics technologies. The CTBTO provides a free access to these data and they are already used by stakeholders in the context of the climate change monitoring (See ARISE Project).

However, the lack of traceability to the SI of the concerned sensors at low frequencies and the lack of agreed measurements methodologies is a brake in the use of results. This project will aims to overcome these lacks.