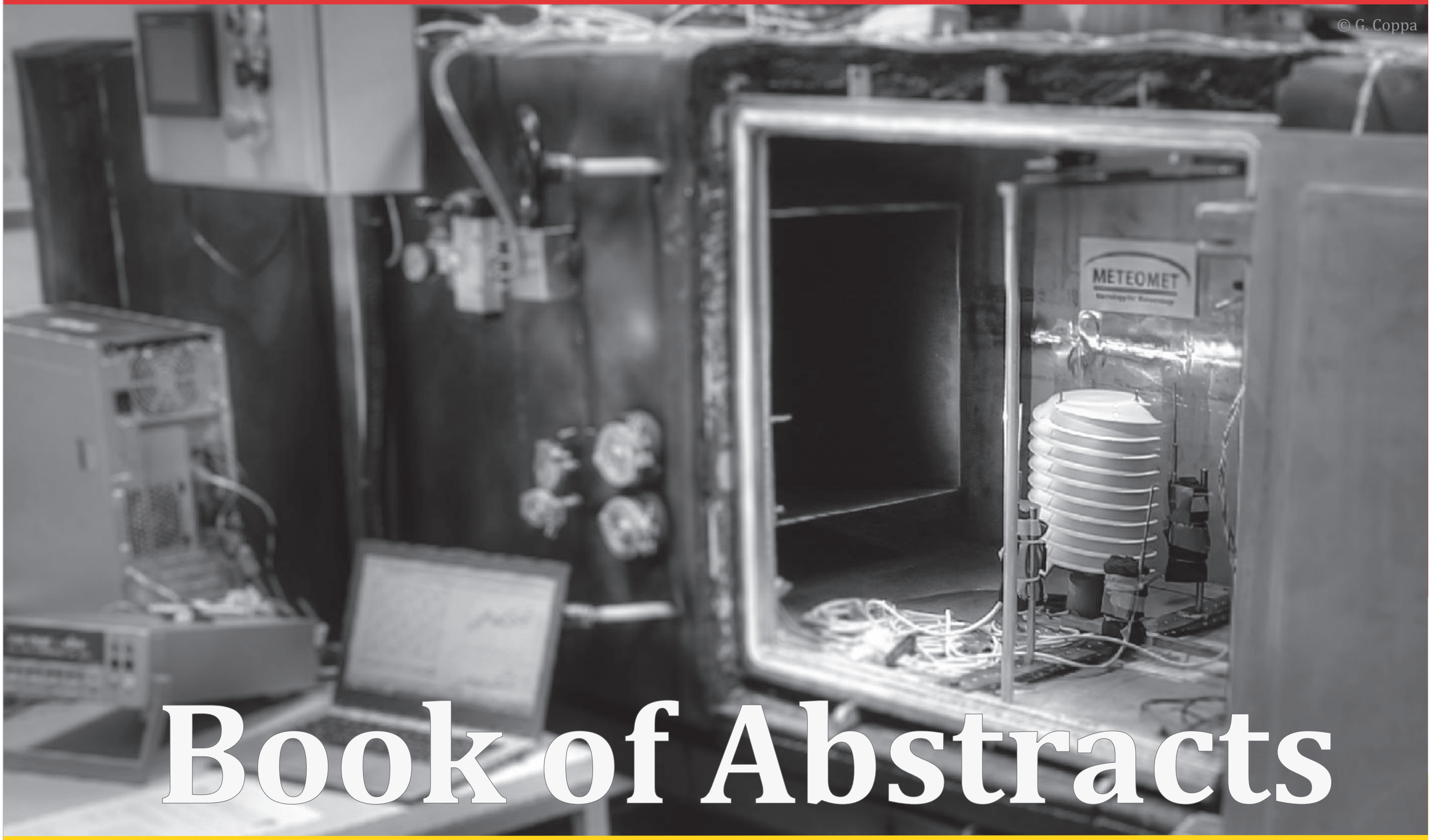
MMC Madrid 2016

METROLOGY FOR METEOROLOGY AND CLIMATE



Book of Abstracts

International Conference *on* Metrology for Meteorology and Climate

in conjuction with

WMO TECO 2016 conference & Meteorological Technology World Expo 2016

Edited by:

Gaber Begeš, Domen Hudoklin, Andrea Merlone, Francesca Sanna

September 26 - 29, 2016
Madrid, Spain

International Conference

on

Metrology for Meteorology and Climate

inconjuction with

WMO TECO 2016 conference

&

Meteorological Technology World Expo 2016

Book of Abstracts

Edited by:

GaberBegeš, DomenHudoklin, Andrea Merlone, Francesca Sanna

September 26 - 29, 2016

Madrid, Spain

Message from Andrea Merlone
MMC 2016 International Panel Committee
Chair person

The first conference "Metrology for Meteorology and Climate", organized in 2014 in Brdo - Slovenia, as a MeteoMet event, was a surprising success. The number of participants and their worldwide provenance, the scientific content of the presentations, the number of satellite events and more in general the program itself, all of those made MMC 2014 a relevant event in the panorama of the conferences on measurements for Meteorology and Climate. Participants to MMC 2014 unanimously recognized the conference in having well scored the scope of mixing in a harmonized balance metrology with meteorology, climate and environmental sciences. The number of submissions required parallel sessions with talks and posters covering a multitude of topics: calibration methods for ground based systems and measurement uncertainty evaluations, metrology applied to ocean research, assessment of the historical temperature data also in terms of instrumental uncertainty, chemical metrology for air and water quality, reference radiosondes measurements, primary and working standards for laboratory and in situ calibrations, metrology methods to asses full traceability to precipitation, wind speed, temperature, humidity, pressure, solar radiation, Arctic climate measurements. Keynote speakers brought high-level contributions from world leading international Institutions and Initiatives.

Since MMC 2014, the last two years saw interesting progresses in metrology applied to metrology and climate. The BIPM CCT[1] now has a Task Group on Environmental issues, addressing robust metrology methods to thermal measurements for climate, EURAMET[2] joint research project funded in 2011 and in 2013 are delivering important results and a new call was launched in 2016 on the topic "Metrology for Environment. High quality papers are published in high-level international journals on advances in studies and experimental activities, by research teams all over the world; metrologists are now bringing their contributions in expert teams of WMO[3] CIMO and CCl[4] and continue their collaborations with GRUAN[5], ISTI[6], GAW[7] and other groups. On top of importance, a new generation of scientists is growing with a new interdisciplinary and multidisciplinary experience and attitude, bringing valuable contributions and results

[1]The Consultative Committee for Thermometry operating at the Bureau International des Poids et Mesures – International office of weights and measures of the CIPM, the International Committee for weights and measures

[2] The European Association on National Institutes of Metrology;

[3] The World Meteorological Organization

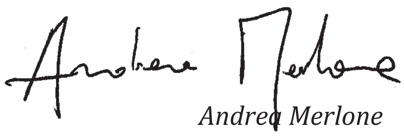
[4] Commission of climatology

[5] Global Climate Observing System (GCOS) Reference Upper Air Network

[6]International Surface Temperature Initiative

[7] Global atmosphere watch of WMO

in this bridging discipline of science. Such young scientist, mainly supported by funds from joint research projects, need stable working opportunities, from National Institutes of Metrology and Meteorological Agencies, for establishing long-term actions to improve data quality in benefit of meteorological and climate studies. Thanks to this enthusiastic work, the contributions at MMC-2014, were of high quality and a selection of papers was published as special issue of the peer-reviewed international journal "Meteorological Applications".
The success and scientific relevance of MMC-2014 was such that the proposal of making it a joint event with TECO, the most important official conference of the WMO Commission of Instruments and Methods of Observation was launched immediately at the end of the conference days in 2014. Works started immediately to find the best solution to merge those two events. The reciprocal interest was the key to solve all organizing aspects and now ....we made it! MMC-2016 is now a joint event with CIMO-TECO, together with the Meteorological Technology World Expo 2016. Madrid, Spain, hosts the Conference, together with a number of satellite events, such as a one-day workshop on soil moisture measurement issues, the plenary MeteoMet meeting, the ENVRIPlus meeting and more.
This second edition received again a significant number of contributions and registrations surpassed again the expectations, causing the need to book larger rooms at the venue! This again emphasizes the great opportunity provided by putting together many of the world experts on the relevant aspects of mathematics, physics, chemistry, biology, metrology, meteorology, climatology and environmental scientists. The number and relevance of International Institutions having endorsed and cosponsored MMC-2016 clearly witness this trend, together with the scientific value of the contributions that many authors submitted, collected and presented here as a book of abstracts. For this edition, the opportunity is again offered to publish a selection of papers to an international review: the BIPM official journal, "Metrologia".
This event would not have been possible without the help of an enthusiastic group: Roger Atkinson, from WMO, who first trusted and promoted the idea of the MMC-TECO joint event; Carmen Garcia Izquierdo, from CEM[8], for her contribution in handling local organization; Francesca Sanna from INRiM[9] for her fundamental work on both scientific and organizational aspects of the conference and program; DomenHudoklin and GaberBeges from UL[10] for the website and conference management. Acknowledgement is well deserved by members of the Scientific and Organizing Committees for their promotion of the event.



Andrea Merlone

[8] Centro Español de Metrología– Spanis National Institute of metrology
[9] Istituto Nazionale di Ricerca Metrologica – Italian National Institute of metrology
[10]University of Ljubljana

Organised by

EURAMET Task Group Environment

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

METEOMET
Metrology for Meteorology

LMK
University *of Ljubljana*
Faculty *of Electrical Engineering*
Laboratory *of Metrology and Quality*

CEM
CENTRO ESPAÑOL
DE **METROLOGÍA**

WORLD
METEOROLOGICAL
ORGANIZATION

Meteorological
TECHNOLOGY
WORLD EXPO 2016

MMC Madrid 2016

METROLOGY FOR METEOROLOGY AND CLIMATE

Organizing committee

Andrea Merlone (INRiM, Italy)

Carmen Garcia Izquierdo (CEM, Spain)

Roger Atkinson (WMO)

Francesca Sanna (IMAMOTER-CNR, Italy)

DomenHudoklin (UL FE, Slovenia)

Gaber Begeš (UL FE, Slovenia)

Julio González Breña (AEMET, Spain)

Scientific committee

Andrea Merlone, conference chair (INRiM)

Roger Atkinson (WMO)

Annarita Baldan (VSL)

Stephanie Bell (NPL)

Richard Brown (NPL)

Janko Drnovsek (University of Ljubljana)

Volker Ebert (PTB)

Ragne Emardson (SP)

Paola Fisicaro (LNE)

Carmen Garcìa Izquierdo (CEM)

Tom Gardiner (NPL)

Eric Georgin (LNE-CETIAT)

Julian Gröbner (PMOD/WRC)

Yong-Gyoo Kim (KRISS)

Susanne Picard (BIPM)

Yves-Alain Roulet (MeteoSwiss)

Francesca Sanna, co-chair (IMAMOTER-CNR)

Fernando Sparasci (LNE-CNAM)

Oksana Tarasova (GAW-WMO)

Peter Thorne (Maynooth University)

Victor Venema (Bonn University)

Vito Vitale (ISAC-CNR)

CONFERENCE PROGRAM

Day 1: Mon 26 Sep 2016	
9:00 - 9:30	**Registration**
9:30 - 9:50	**Opening of MMC-2016** *Andrea Merlone*
9:50 - 10:00	**WMO - representative** *Roger Atkinson*
10:00 - 10:05	**Greetings from Director of CEM** *José Manuel Bernabé Sánchez*
10:05 - 10:35	**Keynote speech** *Victor Venema*
10:35 - 10:40	**Details on events within MMC-2016** *Francesca Sanna*
10:40 - 11:10	**Coffee Break**
11:10 – 18:00	**Oral presentations sessions**
11:10 - 12:45	**Ground Based Measurements Chair: *GrazianoCoppa***
12:45 - 14:15	**Lunch Break (see leaflet for potential locations)**
14:15 - 15:30	**Upper Air Measurements - Chair: *Greg Bodeker***
15:30 - 16:15	**Chemical Metrology and Ocean Research - Chair: *Fernando Sparasci***
16:15 - 16:30	**Coffee Break**
16:30 - 18:00	**Traceability and uncertainty - Chair: *Jovan Bojkovski***
18:00 - 19:00	**Poster Presentations**
	TECO Display area – Hall 4 - Chair: *DomenHudoklin, Francesca Sanna*

WELCOME

Andrea Merlone - Conference Chair
EURAMET and BIPM CCT Task Group Environment Chair person, MeteoMet coordinator, Temperature and Environmental Metrology, IstitutoNazionale di RicercaMetrologica (INRiM), Italy

Roger Atkinson
Scientific Officer, Instruments and Methods of Observation (IMO) – Observing Systems Division, Observing and Information Systems Department, World Meteorological Organization (WMO), Geneva, International

José Manuel Bernabé Sánchez
Director of Spanish Metrology Center (CEM), General Secretary of the National Commission Markets and Competition (CNMC).

Victor Venema
Chair of the Task Team on Homogenization (TT-HOM) of the WMO Commission for Climatology (CCl) and of the Parallel Observations Science Team (ISTI-POST), member of the Steering Committee of the WMO MEditerranean climate DAtaREscue (MEDARE) Initiative and of the International Surface Temperature Initiative. Scientist, Meteorological Institute, University of Bonn – Germany

Francesca Sanna
Temperature and Environmental Metrology, IstitutoNazionale di RicercaMetrologica (INRiM), Department of Food, Forest and Agriculture Science (DiSAFA) – University of Turin, Research associate at National Research Council (IMAMOTER-CNR), Italy

CONFERENCE PRESENTATIONS

paper #	Keynote Speech	Monday 10:05 to 10:35 Room S21

Victor Venema
Meteorological Institute, University of Bonn, Germany

BIASES IN THE GLOBAL TEMPERATURE TRENDS - EVIDENCES AND MEASUREMENT CHALLENGES

paper #	Ground Based Measurements	Monday 11:10 to 12:45 Room S21

Session Chairman: Graziano Coppa

O-10 EVALUATION OF THE ENVIRONMENT AND THE RADIATION SHIELD INFLUENCE ON THE SELF-HEATING EFFECT OF METEOROLOGICAL TEMPERATURE SENSORS

C.G. Izquierdo, Centro Español de Metrología, Madrid, Spain
L. Šindelářová, Czech Metrology Institute, Prague, Czech Republic
S. Hernández, Centro Español de Metrología, Madrid, Spain
A. González, Centro Español de Metrología, Madrid, Spain
R. Strnad, Czech Metrology Institute, Prague, Czech Republic

O-06 NUMERICAL SIMULATION FOR DETERMINING INFLUENCE OF RADIATION SHIELDS TO AIR TEMPERATURE MEASUREMENT

D. Sestan, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia
M. Dobre, Service de la Métrologie, Brussels, Belgium
A. Merlone, INRIM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy

O-03 ASSESSING MEASURE UNCERTAINTY IN URBAN ENVIRONMENTS

S. Curci, Climate Consulting, Milano, Italy
G. Frustaci, Climate Consulting, Milano, Italy and Fondazione Meteo Duomo, Milano, Italy
C. Lavecchia, Climate Consulting, Milano, Italy
S. Pilati, Climate Consulting, Milano, Italy
R. Paolini, Politecnico di Milano, Dept. of Architecture, Built environment and Construction engineering Milano, Italy

O-11 DIFFERENTIAL MICROWAVES HYGROMETER FOR MOISTURE MEASUREMENTS ON A WIDE WATER VAPOR CONCENTRATION

N. Chiodo, LNE-Cnam, La Plaine Saint-Denis, France
A. Cappella, LNE-Cnam, La Plaine Saint-Denis, France
B. Buée, LNE-Cnam, La Plaine Saint-Denis, France
L. Pitre, LNE-Cnam, La Plaine Saint-Denis, France
F. Sparasci, LNE-Cnam, La Plaine Saint-Denis, France
L. Risegari, LNE-Cnam, La Plaine Saint-Denis, France
M. Plimmer, LNE-Cnam, La Plaine Saint-Denis, France
E. Georgin, CETIAT, Villeurbanne, France

O-15 AN IMPROVED NON-CONTACT THERMOMETER AND HYGROMETER WITH RAPID RESPONSE

R. Underwood, National Physical Laboratory, Teddington, UK
T. Gardiner, National Physical Laboratory, Teddington, UK
A. Finlayson, National Physical Laboratory, Teddington, UK
S. Bell, National Physical Laboratory, Teddington, UK
M. de Podesta, National Physical Laboratory, Teddington, UK

O-17 QUANTIFYING EFFECTS OF DRIFT OF WEATHER-STATION HUMIDITY SENSORS

P. A. Carroll, National Physical Laboratory, Teddington, UK
S. A. Bell, National Physical Laboratory, Teddington, UK
S. L. Beardmore, National Physical Laboratory, Teddington, UK
C. England, Met Office, Exeter, UK
N. Mander, Met Office, Exeter, UK

paper	**Upper Air Measurements**	Monday

Session Chairman: Greg Bodeker

O-01 EFFECTS OF WIND SPEED ON THE TEMPERATURE CORRECTION FOR SOLAR RADIATION OF DUAL THERMISTOR RADIOSONDES

Y.-G. Kim, Korea Research Institute of Standards and Science, Daejeon, Korea
S.-W. Lee, Korea Research Institute of Standards and Science, Daejeon, Korea
W. Kang, Korea Research Institute of Standards and Science, Daejeon, Korea
S.C. Park, Korea Research Institute of Standards and Science, Daejeon, Korea

O-05 DEVELOPING BEST ESTIMATES OF THE ATMOSPHERIC STATE FROM UPPER AIR MEASUREMENTS

T. Gardiner, National Physical Laboratory, Teddington, UK
T. Reale, National Oceanic and Atmospheric Administration, USA
J. Tradowsky, Bodeker Scientific, New Zealand
L. Borg, University of Wisconsin, USA
J. Dykema, Havard University, USA
R. Querel, National Institute of Water and Atmospheric Research, New Zealand

O-07 CORRECTION OF M10 HUMIDITY MEASUREMENTS DURING THE DEMEVAP CAMPAIGN

J. Badosa, Ecole Polytechnique, Palaiseau, France
M. Haeffelin, CNRS-IPSL, Palaiseau, France
J.C. Dupont, IPSL, Palaiseau, France
G. Clain, Meteomodem, Ury, France

O-19 TRACEABLE, ABSOLUTE RESPONSE VALIDATION OF A DTDLAS LASER HYGROMETER

B. Buchholz, Physikalisch-Technische Bundesanstalt Braunschweig, Germany, Center of Smart Interfaces, Technische Universität Darmstadt, Germany, currently at Department of Civil and Environmental Engineering, Princeton University, USA
N. Böse, Physikalisch-Technische Bundesanstalt Braunschweig, Germany
V. Ebert, Physikalisch-Technische Bundesanstalt Braunschweig, Germany, Center of Smart Interfaces, Technische Universität Darmstadt, Germany

O-21 LATEST IMPROVEMENTS FOR THE RADIOSONDE HUMIDITY CALIBRATION APPARATUS

H. Sairanen, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
M. Heinonen, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
R. Högström, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
J. Salminen, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
S. Saxholm, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
H. Kajastie, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland

#		15:30 to 16:15 Room S21

Session Chairman: Fernando Sparasci

O-12 KEY-VOCs PROJECT: METROLOGY FOR VOC INDICATORS FOR AIR POLLUTION AND CLIMATE CHANGE

A. Baldan, VSL Dutch Metrology Institute, Delft, The Netherlands
J. Li, VSL Dutch Metrology Institute, Delft, The Netherlands
S. Persijn, VSL Dutch Metrology Institute, Delft, The Netherlands
A. Demichelis, INRiM, Torino, Italy
M.P. Sassi, INRiM, Torino, Italy
T. Macé, LNE, Paris, France
C. Pascale, METAS, Berne, Switzerland
M. Corbel, NPL, London, United Kingdom
D. Worton, NPL, London, United Kingdom
A. Nutsch, PTB, Berlin, Germany
J. Englert, DWD, Hohenpeissenberg, Germany
G. Sassi, Politecnico di Torino, Torino, Italy

O-02 EFFECT OF SUSPENDED SAND ON SEAWATER CONDUCTIVITY MEASUREMENTS

M. Le Menn, Service Hydrographique et Océanographique de la Marine (SHOM), Brest Cedex, France
L. Pacaud, Service Hydrographique et Océanographique de la Marine (SHOM), Brest Cedex, France

O-13 TOWARDS THE METROLOGICAL CHARACTERIZATION OF ROUTINE *p*CO_2 MEASUREMENTS IN SEAWATER

M. Sega, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy
R. Nair, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy
C. Comici, OGS-Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Sgonico (Trieste), Italy
N. Medeot, OGS-Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Sgonico (Trieste), Italy
E. Pessana, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy
F. Rolle, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy

paper	**Traceability and Uncertainty**	Monday

Session Chairman: Jovan Bojkovski

O-09 SI-TRACEABLE AND DYNAMIC REFERENCE GAS MIXTURES FOR WATER VAPOUR AND VOCS AT ATMOSPHERIC LEVELS

M. Guillevic, METAS, Laboratory Gas Analysis, Bern, Switzerland
C. Pascale, METAS, Laboratory Gas Analysis, Bern, Switzerland
A. Ackermann, METAS, Laboratory Gas Analysis, Bern, Switzerland
D. Leuenberger, METAS, Laboratory Gas Analysis, Bern, Switzerland
B. Niederhauser, METAS, Laboratory Gas Analysis, Bern, Switzerland

O-18 EFFECT OF PRESSURE ON DEEP-OCEAN THERMOMETERS

A. Peruzzi, VSL, Dutch Metrology Institute, Delft, The Netherlands
S. Ober, NIOZ, Royal Netherlands Institute for Sea Research, Texel, The Netherlands
R. Bosma, VSL, Dutch Metrology Institute, Delft, The Netherlands

O-20 INTEGRATING THIRD PARTY DATA FROM PARTNER NETWORKS: QUALITY CONTROL USING METEOSWISS' ACCEPTANCE PROCEDURE FOR AUTOMATIC WEATHER STATIONS

J. Fisler, MeteoSwiss, Zurich, Switzerland
M. Kube, MeteoSwiss, Zurich, Switzerland
C. Stocker, MeteoSwiss, Zurich, Switzerland
E. Grüter, MeteoSwiss, Zurich, Switzerland
B. Calpini, MeteoSwiss, Zurich, Switzerland

O-16 RECENT ACTIVITIES ON TRACEABILITY AND INSPECTION OF METEOROLOGICAL INSTRUMENTS IN JAPAN

Y. Nomura, Meteorological Instrument Center, Japan Meteorological Agency, Tsukuba, Japan
K. Umehara, Meteorological Instrument Center, Japan Meteorological Agency, Tsukuba, Japan

O-22 EXPERIMENTAL EVALUATION OF TEMPERATURE UNCERTAINTY COMPONENTS DUE TO SITING CONDITIONS WITH RESPECT TO WMO CLASSIFICATION: PRELIMINARY RESULTS

G. Coppa, Istituto Nazionale di Ricerca Metrologica (INRiM), Turin, Italy
C. G. Izquierdo, Centro Español de Metrologia (CEM), Tres Cantos, Spain
N. Jandric, Institut za mjeriteljstvo Bosne i Hercegovine (IMBiH), Sarajevo, Bosnia and Herzegovina
C. Musacchio, Società Meteorologica Italiana, Turin, Italy
A. Quarello, Università degli Studi di Torino, Turin, Italy
M. Voldan, Český metrologický institute (ČMI), Prague, Czech Republic
A. Merlone, Istituto Nazionale di Ricerca Metrologica (INRiM), Turin, Italy

#		18:00 to 19:00 TECO Display Area – Hall 4

Session Chairman: Domen Hudoklin, Francesca Sanna

P-1 GIVING TRACEABILITY TO THE HISTORICAL TEMPERATURE TIME SERIES: COMBINING METROLOGICAL AND HOMOGENISATION TECHNIQUES TO ESTIMATE THE UNCERTAINTY BUDGET

A. Gilabert, University Rovira i Virgili, Centre for Climate Change (C3), Geography Department, Tortosa, Spain
M. Brunet, University Rovira i Virgili, Centre for Climate Change (C3), Geography Department, Tortosa, Spain, Climatic Research Unit, School of Environmental Sciences, Univ. of East Anglia, Norwich, UK
E. Aguilar, University Rovira i Virgili, Centre for Climate Change (C3), Geography Department, Tortosa, Spain
A. Merlone, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
G. Lopardo, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
F. Bertiglia, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy

P-2 RELATIONSHIP ANALYSIS SEA LEVEL PRESSURE IN DARWIN, TAHITI, AND ANOMALY SEA LEVEL PRESSURE IN INDONESIA

J.G. Sea, Hasanuddin University, Makassar, Indonesian
Y.B. Pata, Hasanuddin University, Makassar, Indonesian

P-7 CALIBRATION OF SOLAR RADIATION EFFECT ON TEMPERATURE SENSORS OF RADIOSONDES AT LOW TEMPERATURE AND LOW PRESSURE

S.-W. Lee, Korea Research Institute of Standards and Science, Daejeon, Korea
B. I. Choi, Korea Research Institute of Standards and Science, Daejeon, Korea
S. G. Yang, Jinyang Industrial, Ansung, Korea
Y.-G. Kim, Korea Research Institute of Standards and Science, Daejeon, Korea

P-8 HOW TO PREPARE ILC - CASE STUDY METEOROLOGICAL LABORATORIES

J. Bojkovski, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia
D. Hudoklin, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia
D. Groselj, Slovenian Environment Agency, Ljubljana, Slovenia
J. Drnovsek, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia
G. Beges, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia

P-9 UNCERTAINTY EVALUATION APPROACH FOR A KINETIC RATE

HUMIDITY SENSORS

P. A. Carroll, National Physical Laboratory, Teddington, UK
S. A. Bell, National Physical Laboratory, Teddington, UK
S. L. Beardmore, National Physical Laboratory, Teddington, UK
C. England, Met Office, Exeter, UK
N. Mander, Met Office, Exeter, UK

P-34 HUMIDITY CALIBRATION APPARATUS FOR RADIOSONDES ACCORDING TO GRUAN SPECIFICATIONS

H. Sairanen, VTT Technical Research Centre, MIKES, Finland
M. Heinonen, VTT Technical Research Centre, MIKES, Finland
R. Högström, VTT Technical Research Centre, MIKES, Finland
J. Salminen, VTT Technical Research Centre, MIKES, Finland
S. Saxholm, VTT Technical Research Centre, MIKES, Finland
H. Kajastie, VTT Technical Research Centre, MIKES, Finland

P-38 INFERENCE OF SNOW COVER DURATION FROM GROUND SURFACE TEMPERATURES AT THE COL D'OLEN ROCK GLACIER LTER SITE

S. Fratianni, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Centro di Ricerca sui Rischi Naturali in Ambiente Montano e Collinare (NatRisk), Grugliasco, Italy
F. Acquaotta, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Centro di Ricerca sui Rischi Naturali in Ambiente Montano e Collinare (NatRisk), Grugliasco, Italy
E. Giaccone, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Institut des Dynamiques de la Surface Terrestre, Université de Lausanne, Switzerland
D. Guenzi, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy
G. Coppa, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
N. Colombo, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Dep. of Geography and Environmental Studies, Carleton University, Ottawa, Canada

Index of contents

MMC Madrid 2016

METROLOGY FOR METEOROLOGY AND CLIMATE

KEYNOTE SPEECH

Monday 10:05 to 10:35

Room S21

Victor Venema

Dr.**Victor Venema**works at the University of Bonn, Germany, on the removal of non-climatic changes from historical stations data (homogenization). He authored the benchmarking study of statistical homogenization methods of the COST Action HOME. This work is continued in the Benchmarking and Assessment Working Group (BAWG) of the International Surface Temperature Initiative (ISTI).

Within the ISTI he also leads the Parallel Observations Science Team (POST), that aims to study non-climatic changes in (daily) climate data using parallel measurements representing the old and new situation (in terms of e.g. instruments, location).

Victor Venema chairs the Task Team on Homogenization (TT-HOM) of the Open Panel on Climate Monitoring and Assessment (OPACE 2) of the WMO Commission for Climatology (CCl) and member of the Steering Committee of the WMO MEditerranean climate DAta REscue (MEDARE) Initiative.

He is co-convener of the Climate monitoring session (data rescue, management, quality and homogenization) at the Annual Meeting of the European Meteorological Society (EMS) and blogs at Variable Variability.

BIASES IN THE GLOBAL TEMPERATURE TRENDS - EVIDENCESAND MEASUREMENT CHALLENGES

Victor Venema
Meteorological Institute, University of Bonn, Germany

National (regional) datasets can be better homogenized than global ones. We have compared homogenized national temperature series with national average series computed from the data in the global and continental collections BEST, CRUCY, CRUTEM4, GHCN, GISS and ECA&D. Several countries with well-homogenized national datasets show a stronger temperature trend. The differences are smaller for CRU and GHCN, than for BEST and GISS.

This bias has renewed our interest in parallel measurements to independently study measurement problems that lead to biases in the climate record. Parallel measurements often show that inhomogeneities in the tails of the distribution, under difficult measurement conditions, are larger than those in the mean. We are currently studying:

1. the influence of the transition to Stevenson screens; this is a known bias, but it looks as if we underestimated the warming bias due to radiation errors of early temperature observations.
2. the influence of relocations, which likely cause cooling jumps, and hence can counteract the influence of "urbanization" (note, that also villages are warmer than their surroundings).
3. the ongoing introduction of automatic weather stations for temperature and precipitation. This transition results in strong inhomogeneities in many networks. Especially automatically measuring solid precipitation is difficult.

To reduce inhomogeneity problems for future climatologists a stable global climate reference network would be invaluable. Past problems can inform us about the design of such a network. For more information: http://tinyurl.com/ISTI-Parallel.

GROUND BASED MEASUREMENTS

Monday 11:10 to 12:45

Room S21

Session Chairman: GrazianoCoppa

Papers

O-10 EVALUATION OF THE ENVIRONMENT AND THE RADIATION SHIELD INFLUENCE ON THE SELF-HEATING EFFECT OF METEOROLOGICAL TEMPERATURE SENSORS

O-06 NUMERICAL SIMULATION FOR DETERMINING INFLUENCE OF RADIATION SHIELDS TO AIR TEMPERATURE MEASUREMENT

O-03 SSESSING MEASURE UNCERTAINTY IN URBAN ENVIRONMENTS

O-11 DIFFERENTIAL MICROWAVES HYGROMETER FOR MOISTURE MEASUREMENTS ON A WIDE WATER VAPOR CONCENTRATION

O-15 AN IMPROVED NON-CONTACT THERMOMETER AND HYGROMETER WITH RAPID RESPONSE

O-17 QUANTIFYING EFFECTS OF DRIFT OF WEATHER-STATION HUMIDITY SENSORS

EVALUATION OF THE ENVIRONMENT AND THE RADIATION SHIELD INFLUENCE ON THE SELF-HEATING EFFECT OF METEOROLOGICAL TEMPERATURE SENSOR

C.G. Izequierdo, Centro Español de Metrología, Madrid, Spain
L. Šindelářová, Czech Metrology Institute, Prague, Czech Republic
S. Hernández, Centro Español de Metrología, Madrid, Spain
A. González, Centro Español de Metrología, Madrid, Spain
R. Strnad, Czech Metrology Institute, Prague, Czech Republic

Self-heating of resistance sensors is an important issue to be considered in the uncertainty of air temperature measurements. The influence of sensor self-heating is usually determined in calibration laboratories under fixed conditions of temperature, humidity and air speed. But these conditions are highly variable when the thermometer is performing measurements on site and under real environmental conditions. Besides, sometimes the resistance thermometers are used with currents very different with respect to it was used in their calibrations.

This paper describes the evaluation of the self-heating effect, by applying different currents to different models of thermometers used for meteorological applications. The evaluation of the self-heating effect is analyzed with the thermometer immersed in different isothermal enclosures, fixed points, stirred liquid bath and climate chamber. The influence of the radiation shield on self heating effect is also studied, as well as, the influence of some meteorological variables, air temperature, humidity and wind speed. Results are compared for laboratory conditions, climatic chambers and normal environments with different air movement conditions.

This research is included in an EMRP Joint Research Project “Env58. MeteoMet2” jointly funded by the EMRP participating countries within EURAMET and the European Union.

NUMERICAL SIMULATION FOR DETERMINING INFLUENCE OF RADIATION SHIELDS TO AIR TEMPERATURE MEASUREMENT

D. Sestan, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, Croatia
M. Dobre, Service de la Métrologie, Brussels, Belgium
A. Merlone, INRIM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy

In weather stations, the sensors used for measuring air temperature are mounted inside several different types of enclosures, designed to protect the sensor from precipitations and direct solar radiation. As a consequence, the air temperature inside the shield is measured, instead of open field air temperature. Existing studies on radiation shields influence on air temperature measurements, either experimental or numerical, focuses on differences between various shield designs and choice of the most appropriate configuration to minimize measurement errors. While this approach is useful for the installation of new weather stations, there are drawbacks for the existing ones. This paper will present methods and results of numerical simulations of the heat transfer between different types of air temperature sensor and meteorological radiation shields for some typical cases of environmental conditions and sensor positions inside the shields. The data obtained this way will be used for finding corrections to be applied to temperature sensor readings in order to estimate open field air temperatures. The presented method may also be used for finding the optimal position of the temperature sensors inside the radiation shields, to achieve the lowest uncertainty of the measurements.

This work is done during the researcher mobility grant, in the scope of the project 'Metrology for essential climate variables' (ENV58 MeteoMet2).

ASSESSING MEASURE UNCERTAINTY IN URBAN ENVIRONMENTS

S. Curci, ClimateConsulting, Milano, Italy
G. Frustaci, ClimateConsulting, Milano, Italy and Fondazione Meteo Duomo, Milano, Italy
C. Lavecchia, ClimateConsulting, Milano, Italy
S. Pilati, ClimateConsulting, Milano, Italy
R. Paolini, Politecnico di Milano, Dept. of Architecture, Built environment and Construction engineering Milano, Italy

Measure uncertainty in meteorology (especially relevant in a climate changing word) has been addressed in a number of recent programmes and projects. In an urban environment uncertainty is raised by local and siting effects, which are more difficult to manage than for synoptic stations. This is likely the reason for a lack of studies on this specific field: nevertheless, cities are more and more important from a social and economical point of view and need to be accurately monitored and understood. The availability of an automated meteorological network, that has been planned, implemented and managed in Milano since the beginning (2011) with accurate metrological and homogeneity criteria, represents a unique opportunity to investigate the effects of sensor siting and to estimate the related uncertainty. As a first step an extended metadata set has been established for a number of station in a limited and homogeneous area downtown, taking in quantitative consideration exposure and siting details. A statistical evaluation on the basis of a 5 years operation period allows an assessment of the network homogeneity, quality and reliability. Systematic deviations from mean values are then analyzed for selected local weather types in order to investigate exposure and siting effects. In this paper a methodological description is given and preliminary results discussed.

DIFFERENTIAL MICROWAVES HYGROMETER FOR MOISTURE MEASUREMENTS ON A WIDE WATERVAPORCONCENTRATION

N. Chiodo, LNE-Cnam, La Plaine Saint-Denis, France
A. Cappella, LNE-Cnam, La Plaine Saint-Denis, France
B. Buée, LNE-Cnam, La Plaine Saint-Denis, France
L. Pitre, LNE-Cnam, La Plaine Saint-Denis, France
F. Sparasci, LNE-Cnam, La Plaine Saint-Denis, France
L. Risegari, LNE-Cnam, La Plaine Saint-Denis, France
M. Plimmer, LNE-Cnam, La Plaine Saint-Denis, France
E. Georgin, CETIAT, Villeurbanne, France

We have developed a differential microwave hygrometer (DMWH) for the measurement of the water vapour concentration in gases in a wide dynamic range from a few parts per million by volume (ppmv) to 105 ppmv with a resolution of 1 ppmv over all the spanned concentration range. The objective was to realize a simple and robust device, for an accurate measurement of the humidity of air in hard environments, like the upper stratosphere or the polar regions.

The DMWH is composed of two nearly identical quasi-spherical microwave resonators, measuring the polarizability change in a moist gas in relation to the same gas devoid of humidity. The change causes a linear shift of resonance frequencies in the resonator filled with the moist gas, in relation to the other filled by a dehydrated sample of the same gas. Differential measurement is used to remove any dependency of the resonance frequency shifts on gas pressure and temperature variations.
Mass flow controllers are used to balance the pressure between the two resonators. A temperature-controlled vacuum enclosure is used to control the resonator's temperatures at the millikelvin level.

The resonator inner surface shapes are not perfect spheres but rather prolate spheroids. In this way the TM11 and TE11 microwave modes display a triplet of well-separated resonances to which it is easy to servo-lock the frequency of an oscillator. The microwave frequencies are around 5 GHz; water vapour induced frequency shifts lie in the range 5 Hz to 500 kHz. If the water vapour concentration remains constant, the frequency difference can be measured in a few seconds making the apparatus essentially a real-time hygrometer.

The humidity determined using the instrument is found to be in accordance with that measured by a chilled-mirror reference hygrometer, which suggests that the DMWH is a promising metrological tool for water vapour concentration measurements.

This work has been carried out within the frame of the European Metrology Research Program (EMRP) joint research project 'ENV58 MeteoMet'. The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

AN IMPROVED NON-CONTACT THERMOMETER AND HYGROMETER WITH RAPID RESPONSE

R. Underwood, National Physical Laboratory, Teddington, UK
T. Gardiner, National Physical Laboratory, Teddington, UK
A. Finlayson, National Physical Laboratory, Teddington, UK
S. Bell, National Physical Laboratory, Teddington, UK
M. de Podesta, National Physical Laboratory, Teddington, UK

Previously (2015:DOI:10.1002/met.1513) we reported first tests of a device capable of simultaneous, non-contact, temperature and humidity (NCTAH) measurements in air. The device used an acoustic thermometer and a tuneable diode laser absorption spectrometer (TDLAS), a combination which should be capable of an extremely rapid response to changes in humidity as it does not require moisture in a solid-state matrix to equilibrate with the surrounding air. In this paper we report recent developments of the instrument focussed on reducing its response time so that it can be used as a reference instrument for assessing the response time of conventional humidity sensors.

The TDLAS measures water molecule number density based on the transmission of an infrared beam (wavelength 1360 nm) through a 0.7 m path length. This device now records transmission profiles and fits them to absorption profiles calculated using the HITRAN database 50 times each second, yielding a real-time estimate of the water molecule number density every 20 milliseconds.

The acoustic thermometer is based around a fixed-path acoustic interferometer, and the response time of this has been substantially improved by use of an FPGA-based lock-in amplifier. A single calibration point at a known temperature determines the effective path length of the interferometer, and the speed of sound in the air, and consequently its temperature, are then inferred from the acoustic frequencies. The instrument reports 50 temperature estimates per second, although these are not fully independent. Instead, the instrument displays an RC filter-like response, with time constant of approximately 50 milliseconds.

In addition, the interdependence of the temperature and humidity estimates is now accounted for in real-time using an iterative procedure, which eliminates the need for data post-processing.

Tests have been carried out in a climatic chamber through a temperature range of -40 °C to +40 °C and a dew point range of -43 °C to +38 °C, at atmospheric pressure, comparing the instrument readings with those from a calibrated hygrometer and four platinum resistance thermometers. In steady-state conditions, the instrument readings are in good agreement with the conventional sensors, with temperature differences less than 1 °C (repeatability 0.1 C), and humidity differences mostly within 1% of mixing ratio.

In this paper we describe how the rapid response of the improved instrument can be used to evaluate the response times of conventional sensors under transient conditions.

QUANTIFYING EFFECTS OF DRIFT OF WEATHER-STATION HUMIDITY SENSORS

P. A. Carroll, National Physical Laboratory, Teddington, UK
S. A. Bell, National Physical Laboratory, Teddington, UK
S. L. Beardmore, National Physical Laboratory, Teddington, UK
C. England, Met Office, Exeter, UK
N. Mander, Met Office, Exeter, UK

Air humidity measurements in weather stations are essential observations of current weather, and the same data are also used ultimately in analysis of climate. Validated long-term and global humidity datasets are beginning to be compiled, and workers have begun to attribute uncertainties to the dataset values. In doing so, the question arises of how to allow for humidity measurement uncertainty, and whether any bias in data might be expected due to instrument performance. It is well known that relative humidity sensors can suffer drift in service, due to condensation and contamination-related ageing processes. This question is especially of interest when a change in instrument technology is made, where the techniques may tend to differ in uncertainty or bias.

The work presented is a study of a large dataset of weather-station humidity sensors, to demonstrate a methodology for assessing typical drift, and associated uncertainty, for a population of sensors. Such generalised estimates of instrumental drift and generalised associated uncertainties can be used to inform climate analyses that use pooled data from large numbers of humidity observations.

The study used a dataset provided by the calibration laboratory of the UK Met Office, for humidity sensors calibrated before deployment in weather stations, and then re-checked after return to the laboratory. Because the records span before and after deployment, estimates of sensor drift in service can be made. This study covers a large set of sensors, demonstrating how drift data for individual sensors can be generalised for the population of instruments. The method and example results will be presented, showing typical drift of sensors to be several percent relative humidity at high humidities. The consequences for interpreting aggregated data for relative humidity will be discussed.

MMC Madrid 2016

METROLOGY FOR METEOROLOGY AND CLIMATE

UPPER AIR MEASUREMENTS

Monday 14:15 to 15:30

Room S21

Session Chairman: Greg Bodeker

Papers

O-01 EFFECTS OF WIND SPEED ON THE TEMPERATURE CORRECTION FOR SOLAR RADIATION OF DUAL THERMISTOR RADIOSONDES

O-05 DEVELOPING BEST ESTIMATES OF THE ATMOSPHERIC STATE FROM UPPER AIR MEASUREMENTS

O-07 CORRECTION OF M10 HUMIDITY MEASUREMENTS DURING THE DEMEVAP CAMPAIGN

O-19 TRACEABLE, ABSOLUTE RESPONSE VALIDATION OF A DTDLAS LASER HYGROMETER

O-21 LATEST IMPROVEMENTS FOR THE RADIOSONDE HUMIDITY CALIBRATION APPARATUS

EFFECTS OF WIND SPEED ON THE TEMPERATURE CORRECTION FOR SOLAR RADIATION OF DUAL THERMISTOR RADIOSONDES

Y.-G. Kim, Korea Research Institute of Standards and Science, Daejeon, Korea
S.-W. Lee, Korea Research Institute of Standards and Science, Daejeon, Korea
W. Kang, Korea Research Institute of Standards and Science, Daejeon, Korea
S.C. Park, Korea Research Institute of Standards and Science, Daejeon, Korea

It is well-known that air temperature measurements of radiosonde in upper air are greatly affected by solar radiation. To get an accurate temperature value, many radiosonde manufacturers have applied their own correction algorithms to compensate solar radiation effect. Recently KRISS and Jinyang have developed a unique correction technique against solar radiation by using two thermistor sensors of different emissivity, named as Dual Thermistor Radiosonde (DTR). This technique is basically based on the fact that temperature difference between two thermistors of different emissivity is a function of solar radiation and air pressure. It is recently reported that air pressure is critical for the solar radiation correction because the heat transfer between air and temperature sensor strongly depends on the air pressure1).

In this work, we investigate the effects of wind speed on the solar radiation correction of the DTR by varying wind speed up to 5 m/s, which simulates an ascent rate of DTR in the atmosphere. Two thermistors are located in the well-controlled open-type subsonic wind tunnel and solar radiation is given to the two thermistors through a set of steering optics from a solar simulator. From this study, it is expected to estimate the effects of wind speed on the operation characteristics of the DTR quantitatively.

1)S.W.Lee et al., Importance of air pressure in the compensation for solar radiation effect on temperature sensors of radiosondes, Meteorol. Appl., (in press)

Sang-Wook Lee: sangwook@kriss.re.kr

Woong Kang: woong.kang@kriss.re.kr

Seong Chong Park: spark@kriss.re.kr

DEVELOPING BEST ESTIMATES OF THE ATMOSPHERIC STATE FROM UPPER AIR MEASUREMENTS

T. Gardiner, National Physical Laboratory, Teddington, UK
T. Reale, National Oceanic and Atmospheric Administration, USA
J. Tradowsky, Bodeker Scientific, New Zealand
L. Borg, University of Wisconsin, USA
J. Dykema, Havard University, USA
R. Querel, National Institute of Water and Atmospheric Research, New Zealand

The Global Climate Observing System (GCOS) Reference Upper Air Network (GRUAN) aims to provide reference quality measurements of key climate variables in the upper atmosphere through a global network of 20-30 sites. The measurements from the network provide data for long term climate trend determination and for validation of more spatially extensive measurements such as those made with satellites and the wider meteorological monitoring networks.

A key element of the GRUAN measurement concept is the combination of measurements of the same climate variable made with multiple independent sensors at each site. This provides quality assurance and data comparability assessment for the measurements, data redundancy in the event of sensor issues, and is particularly important in ensuring continuity of data quality during change management activities. In addition, different sensor types have different strengths and weaknesses in terms of sensitivity, temporal coverage, spatial resolution, etc. Work is underway within the network to develop the tools to combine the results from different measurement sources, with their various spatial and temporal properties and uncertainties, to derive the best estimate of the atmospheric state above a site at a particular time together with robust uncertainties for this estimate. The presentation will discuss the concept and objectives of this activity and provide a summary of the latest research within the network, including work to develop Site Atmospheric State Best Estimates (SASBEs) for intercomparison of GRUAN and satellite measurements, a study evaluating the potential of using radiosonde measurements from nearby launch stations to characterise the temperature profile above a GRUAN site, and the use of bracketing radiosonde launches to constrain the atmospheric state estimate at the time of a satellite overpass and provide information on the atmospheric variability.

CORRECTION OF M10 HUMIDITY MEASUREMENTS DURING THE DEMEVAP CAMPAIGN

J. Badosa, EcolePolytechnique, Palaiseau, France
M. Haeffelin, CNRS-IPSL, Palaiseau, France
J.C. Dupont, IPSL, Palaiseau, France
G. Clain, Meteomodem, Ury, France

The field experiment conducted in the framework of the DEMEVAP (Development of Methodologies for Water Vapour Measurement) project took place at Observatoire de Haute Provence in September-October 2011 and was dedicated to the improvement of humidity sounding techniques. Four types of radiosondes including Modem M2K2-DC and M10 were tested during 26 night-time radiosonde launches, performed simultaneously with LIDAR measurements, ground based meteorological measurements and GPS observations during 16 clear sky nights. The results revealed a dry bias in M10 humidity observations.

The objective of our work is to introduce recently developed corrections for relative humidity. The relative humidity measured by the M10 radiosonde is provided based on a capacitive sensor that undergoes physical phenomena and uncertainties. Certification by the GRUAN network of the M10 sonde requires that these measurement errors and uncertainties be evaluated and corrected. A joint effort of the manufacturer together with IPSL has led to the development of corrections that account for the following effects: (1) the capacitive sensor frequency dependence to temperature; (2) the dry bias due to the higher temperature of the capacity sensor compared to the air temperature; (3) the measurement time lag at cold temperatures that affect measurements in regions of strong relative humidity gradients; (4) a second time lag due to the slow diffusion of molecules through the sensor especially at very high and very low relative humidity conditions.

The corrections have been tested, using the DEMEVAP campaign as an independent dataset. The results show that M10 relative humidity measurements corrected for the four effects are consistent with RS92 relative humidity values within 2% at all altitudes, when the average RH profiles from M10 and RS92 are compared.

TRACEABLE, ABSOLUTE RESPONSE VALIDATION OF A DTDLAS LASER HYGROMETER

B. Buchholz, Physikalisch-TechnischeBundesanstaltBraunschweig, Germany, Center of Smart Interfaces, TechnischeUniversität Darmstadt, Germany, currently at Department of Civil and Environmental Engineering, Princeton University, USA
N. Böse, Physikalisch-Technische Bundesanstalt Braunschweig, Germany
V. Ebert, Physikalisch-Technische Bundesanstalt Braunschweig, Germany, Center of Smart Interfaces, Technische Universität Darmstadt, Germany

An accurate and precise quantification of gas humidity is important for science as well as industry. In environmental sciences the knowledge of the atmospheric humidity is an important prerequisite for numerous science questions ranging from cloud studies to climate models. Many industrial processes, e.g. in semiconductor fabrication, combustion process development or food industry, also need reliable humidity determination for process or product optimization. On the other hand, it is still quite common that hygrometers are calibrated, but not traced back to a metrological humidity scale. This holds even more for instruments applied to harsh conditions or intended to resolve fast humidity changes. Commonly gas hygrometers rely on a sampling process and a multi-dimensional sensor calibration (pressure, temperature, concentration, gas matrix). For highly adsorptive molecules such as water this process is quite tedious, time consuming and complex, which often limits the utility of the water vapor measurement. A recent large, externally reviewed, blind inter-comparison of airborne hygrometers [1] resulted in relative deviations of up to 20%, even for the so called “core”-instruments (i.e. mature instruments which had often been deployed before). To improve industrial as well as environmental science related gas humidity measurements, Physikalisch-TechnischeBundesanstalt (PTB) over the last years bridged interests from the different stakeholder groups. In order to develop a novel class of traceable, spectroscopy-based, optical hygrometers we combined highly accurate measurements of spectral line data of water with the development of mobile, laser-hygrometers to target a spectroscopic humidity transfer standards for mobile operation in harsh environment such as field or airborne applications. This lead to a class of novel, calibration-free, airborne TDLAS-hygrometers [2], such as SEALDH-II. SEALDH-II is a gas sampling, i.e. extractive, autonomous, optical hygrometer which uses a 1.4 μm diode laser source, a closed optical cell, and in particular an entirely self-controlled, “turn-key”, operating and control software. SEALDH-IIs absolute response was metrologically validated via a side-by-side comparison with PTBs primary humidity standards. Its accuracy, precision, long-term-stability, resistance to variations in ambient temperature, pressure and humidity was carefully evaluated and optimized. E.g. its relative calibration-free long-term stability over 18 month was determined to be 0.35% (tested concentration range 600 – 8000 ppmv, pressure range 75 – 900 hPa). This is on the same level like the uncertainties of the primary standard. SEALDH-II thus demonstrates a remarkable step forward towards a reliable, traceable transfer standard for water vapor measurements. We will present the concept and validation results of SEALDH-II, typical application results in airborne field campaigns and address how a strong link between meteorology and science/industry could benefit future humidity measurements.

[1] D. W. FAHEY, et al The AquaVIT-1 Intercomparison of Atmospheric Water Vapor Measurement Techniques, Atmos. Meas. Tech., 7, 3177-3213, 2014
[2] B. Buchholz, N. Böse, and V. Ebert, “Absolute validation of a diode laser hygrometer via intercomparison with the German national primary water vapor standard,” ApplPhys B, 116, 4, 883–899, (2014)

LATEST IMPROVEMENTS FOR THE RADIOSONDE HUMIDITY CALIBRATION APPARATUS

H. Sairanen, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
M. Heinonen, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
R. Högström, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
J. Salminen, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
S. Saxholm, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland
H. Kajastie, VTT Technical Research Centre Ltd., Centre for Metrology MIKES, Finland

Global Climate Observing System (GCOS) concluded that quality of observed climate data requires improvements. As a step toward improved accuracy and more reliable data GCOS launched GCOS Reference Upper-Air Network (GRUAN) which specifies accuracy and uncertainty requirements for measurement instruments that are used in GRUAN stations. GRUAN also recognised the importance of traceability to International System of Units (SI) in climatic measurements.

Within the MeteoMet projects of the European Metrology Research Programme, the Centre for Metrology MIKES of the VTT Technical Research Centre of Finland designed and constructed a humidity calibration apparatus fulfilling the GRUAN requirements. The apparatus was designed for calibrations of reference radiosondes but it can be applied to other humidity sensors as well. Within this work latest developments including low pressure operation and updated uncertainty analysis are presented along with preliminary measurements carried out with a prototype reference radiosonde (RR01) from Vaisala's reference radiosonde programme.

Measurements shown here indicate that GRUAN requirements fulfilling calibration capability and uncertainty requirements were achieved within measurement ranges from 10 hPa to about 1050 hPa, from -80 °C to 20 °C and from -90 °C to 10 °C in terms of absolute pressure, temperature and dew/frost-point temperature, respectively.

This work was supported by the European Metrology Research Programme (EMRP) jointly funded by the EMRP participating countries within EURAMET and the European Union.

MMC 2016 Madrid

METROLOGY FOR METEOROLOGY AND CLIMATE

CHEMICAL METROLOGY AND OCEAN RESEARCH

Monday 15:30 to 16:15

Room S21

Session Chairman: FermandoSparasci

Papers

O-12 KEY-VOCs PROJECT: METROLOGY FOR VOC INDICATORS FOR AIR POLLUTION AND CLIMATE CHANGE

O-02 EFFECT OF SUSPENDED SAND ON SEAWATER CONDUCTIVITY MEASUREMENTS

O-13 TOWARDS THE METROLOGICAL CHARACTERIZATION OF ROUTINE pCO2 MEASUREMENTS IN SEAWATER

KEY-VOCs PROJECT: METROLOGY FOR VOC INDICATORS FOR AIR POLLUTION AND CLIMATE CHANGE

A. Baldan, VSL Dutch Metrology Institute, Delft, The Netherlands
J. Li, VSL Dutch Metrology Institute, Delft, The Netherlands
S. Persijn, VSL Dutch Metrology Institute, Delft, The Netherlands
A. Demichelis, INRiM, Torino, Italy
M.P. Sassi, INRiM, Torino, Italy
T. Macé, LNE, Paris, France
C. Pascale, METAS, Berne, Switzerland
M. Corbel, NPL, London, United Kingdom
D. Worton, NPL, London, United Kingdom
A. Nutsch, PTB, Berlin, Germany
J. Englert, DWD, Hohenpeissenberg, Germany
G. Sassi, Politecnico di Torino, Torino, Italy

The EMRP KEY-VOCs project focuses on providing gas standards and reference materials for selected key Volatile Organic Compounds (VOCs) in air that lack of accuracy and traceability. In addition, this project aims at evaluating low-cost new measurement systems (sensors-based) for benzene in air.
The selection of VOC species and concentration levels dealt in this project is based on their relevance in climate, air quality and indoor air monitoring programmes. Those key VOCs are in fact dangerous to human health or can harm the environment by influencing the oxidative capacity of the atmosphere, contributing to the production of other air pollutants and by being involved in the formation of secondary organic aerosols (SOA). VOCs range from oxygenated (e.g. alcohols, formaldehyde) to mono-terpenes (e.g. pinene) particularly interesting for climate studies, from polar (e.g. acetic acid) to semi-volatiles (e.g. D6 cyclic siloxane, eicosane) more specific for indoor air measurements.
One important activity in this project is the development of accurate and stable trace level gas standards (part-per-billion) for a priority list of VOCs needed by the WMO GAW VOC network.
The preparation of standard gas mixtures at such low levels is done in compressed gas cylinders by gravimetric method and by use of (portable) dynamic generation systems. The research work is challenged by the fact that VOCs are prone to adsorb on contact surfaces and that they are reactive. Therefore, an evaluation of the best suitable materials and passivation techniques for storing, sampling and measuring of VOC gases has been carried out.
In addition, to guarantee the accuracy of VOC composition at trace concentration levels, the zero gas (air and nitrogen) used for the dilution needs to be VOC-free. This project has tested purification systems for VOC-free zero gas, having developed methods able to measure VOCs at few part-per-trillion levels.
The presentation gives an overview of the project and the progress achieved at its mid-term.

EFFECT OF SUSPENDED SAND ON SEAWATER CONDUCTIVITY MEASUREMENTS

M. Le Menn, Service HydrographiqueetOcéanographique de la Marine (SHOM), Brest Cedex, France
L. Pacaud, Service HydrographiqueetOcéanographique de la Marine (SHOM), Brest Cedex, France

The seawater absolute salinity is assessed by conductivity measurements and the calculation of a practical salinity. The effect of low concentrations of suspended particulate matter on these measurements has never been documented, but the theories developed to explain and predict the conductivity of sediments show clearly that under an electrical field, they interact with the ionic composition of seawater. This presentation describes a measurement method settled to measure the effect of sand particles on seawater conductivity and proposes relations to explain and predict the observed phenomenon.

The study of the effect of different concentrations of sand on seawater conductivity has been made with an experimental assembly composed of a cylindrical container, a CTD instrument from Sea-Bird Electronics Company and a stirring propeller. The container is filled with seawater, and immersed in a calibration bath stabilized to better than 1mK during measurements.
Before to be used, one part of the sand is dried, another part is washed or 'desalted' and a last part is used without drying. These samples are mixed with natural seawaters of practical salinities close to 34, 35 or 38.

To explain the observation, we have settled a relation who relies the measured conductivity to the seawater conductivity, the formation factor FF of the sand, its volume, the volume of water and the efficiency of pumping. By choosing an appropriate FF, this relation fit the measurements up to 1.1 g l-1. Beyond this value, a cumulative effect appears. It can be described by a geometric series which common ratio is a part of the previous relation.

This work shows clearly that the sediments in suspension modify the seawater conductivity measurements. Beyond 0.2 g l-1, the needed accuracy of 0.002 in salinity assessments can't be kept. The settled relations can predict the amount of this error, particularly for low and high concentrations, when measurements are disturbed by the noise and the efficiency of pumping.

TOWARDS THE METROLOGICAL CHARACTERIZATION OF ROUTINE *p*CO_2 MEASUREMENTS IN SEAWATER

M. Sega, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy
R. Nair, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy
C. Comici, OGS-Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Sgonico (Trieste), Italy
N. Medeot, OGS-Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Sgonico (Trieste), Italy
E. Pessana, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy
F. Rolle, INRiM-Istituto Nazionale di Ricerca Metrologica, Torino, Italy

There is unequivocal evidence indicating that fundamental changes are occurring in seawater carbonate chemistry due to the rising levels of carbon dioxide (CO2) in the atmosphere. The oceans are absorbing more CO2 from the atmosphere, which is decreasing seawater pH and leading to the acidification of marine waters, with important consequences for the global ecosystem. Currently, the partial pressure of CO2 (pCO2) in seawater is one of the few marine CO2 system variables that can be measured in situ using autonomous, networked sensors able to relay observations in real-time or near real-time. For this reason, it is fast becoming one of the essential variables of any monitoring activity relating to climate change. But, even if in situ sensors for the parameter are commercially available, there is a pressing need for means to establish continued, post-purchase conformity of instrument performance to user requirements, particularly in relation to the effective measurement uncertainties.

The present work gives an overview of the main difficulties encountered in ensuring the reliability of observations in the field with contemporary marine pCO2 sensors, highlighting the need for better establishing metrological traceability, also by developing suitable reference materials for calibration and/or control of these instruments during their routine use.

MMC Madrid 2016

METROLOGY FOR METEOROLOGY AND CLIMATE

TRACEABILITY AND UNCERTAINTY

Monday 16:30 to 18:00

Room S21

Session Chairman: Jovan Bojkovski

Papers

O-09 SI-TRACEABLE AND DYNAMIC REFERENCE GAS MIXTURES FOR WATER VAPOUR AND VOCS AT ATMOSPHERIC LEVELS

O-18 EFFECT OF PRESSURE ON DEEP-OCEAN THERMOMETERS

O-20 INTEGRATING THIRD PARTY DATA FROM PARTNER NETWORKS: QUALITY CONTROL USING METEOSWISS' ACCEPTANCE PROCEDURE FOR AUTOMATIC WEATHER STATIONS

O-14 CALIBRATION INTERVALS

O-16 RECENT ACTIVITIES ON TRACEABILITY AND INSPECTION OF METEOROLOGICAL INSTRUMENTS IN JAPAN

O-22 EXPERIMENTAL EVALUATION OF TEMPERATURE UNCERTAINTY COMPONENTS DUE TO SITING CONDITIONS WITH RESPECT TO WMO CLASSIFICATION: PRELIMINARY RESULTS

SI-TRACEABLE AND DYNAMIC REFERENCE GAS MIXTURES FOR WATER VAPOUR AND VOCS AT ATMOSPHERIC LEVELS

M. Guillevic, METAS, Laboratory Gas Analysis, Bern, Switzerland
C. Pascale, METAS, Laboratory Gas Analysis, Bern, Switzerland
A. Ackermann, METAS, Laboratory Gas Analysis, Bern, Switzerland
D. Leuenberger, METAS, Laboratory Gas Analysis, Bern, Switzerland
B. Niederhauser, METAS, Laboratory Gas Analysis, Bern, Switzerland

In the framework of METAS' AtmoChem-ECV project, we are currently developing new facilities to generate reference gas mixtures for water vapour at concentrations measured in the high troposphere and especially in the range 1-20 μmol/mol. The generation method is dynamic (the mixture is produced continuously over time) and SI-traceable (i.e. the amount of substance fraction in mole per mole is traceable to the definition of SI-units). Here we present the realisation of such standards for water vapour as well as for other reactive, sticky compounds such as volatile organic compounds, relevant for air pollution/biosphere monitoring.

The generation process is composed of three successive steps. The first step is to purify the matrix gas, nitrogen or synthetic air. Second, this matrix gas is spiked with the pure substance using a permeation technique: a permeation device contains a few grams of the pure substance (e.g., water) in the liquid form and loses it linearly over time by permeation through a membrane. In a third step, to reach the desired concentration, the first, high concentration mixture exiting the permeation chamber is then diluted with a chosen flow of matrix gas with one or two subsequent dilution steps. All flows are piloted by mass flow controllers. All parts in contact with the gas mixture are passivated using coated surfaces, to reduce adsorption/desorption processes as much as possible.

We are developing two generators, one fixed in our lab in Bern with an expanded uncertainty of ≤ 1.5% (k=2, 95% confidence interval) and a portable one to use in the field with a target uncertainty of less than 3%. The presented dynamic techniques can be adapted to a large variety of molecules (e.g., NO2, BTEX, NH3, CFCs, HCFCs, HFCs and other refrigerants) and are particularly suitable for gas species and/or concentration ranges that are not stable in cylinders.

EFFECT OF PRESSURE ON DEEP-OCEAN THERMOMETERS

A. Peruzzi, VSL, Dutch Metrology Institute, Delft, The Netherlands
S. Ober, NIOZ, Royal Netherlands Institute for Sea Research, Texel, The Netherlands
R. Bosma, VSL, Dutch Metrology Institute, Delft, The Netherlands

Approximately 93% of the heat added to the Earth climate system by global warming in the last 50 years is stored in the oceans [1]. Though the strongest warming is found near the sea surface (110 mK/decade in the upper 75 m and 15 mK/decade at 700 m depth since 1971), the large volume of the deep ocean (deeper than 700 m) makes its contribution to the total energy stored in the oceans not negligible (36 %). The large inertia of the oceans implies that they naturally integrate over short-term variability and provide a clearer signal of long-term change than other components of the climate systems. Observations of ocean temperature change therefore provide a means to track the evolution of climate change and a relevant benchmark for climate models.
The measurement of decadal temperature change of deep ocean sets challenging requirements for the accuracy of temperature measurements in deep ocean (≈ 1 mK accuracy).
Accurate deep ocean temperature measurements are currently performed using a combination of a high-accuracy (0.2 mK claimed), high-stability (0.14 $mK \cdot yr^{-1}$) reference thermistor (SBE35, Sea-Bird Electronics) with 0.5 s response time and a lower accuracy (0.7 mK claimed), lower stability (2 $mK \cdot yr^{-1}$) thermistor (SBE3, Sea-Bird Electronics) with faster response time (70 ms), see Figure 1.
A laboratory experiment was devised and performed to investigate the pressure dependence of SeaBird Electronics SBE35 and SBE3 deep ocean thermometers. The thermometers were mounted in a massive brass comparator together with a calibrated Standard Platinum Resistance Thermometer. The measurements were performed in a pressure chamber in the pressure range 0.1 MPa to 60 MPa. The results showed that both the investigated SBE35 and the SBE3 are pressure dependence, with a pressure sensitivity of +72 $\mu K \cdot MPa^{-1}$ and -89 $\mu K \cdot MPa^{-1}$, respectively.

INTEGRATING THIRD PARTY DATA FROM PARTNER NETWORKS: QUALITY CONTROL USING METEOSWISS' ACCEPTANCE PROCEDURE FOR AUTOMATIC WEATHER STATIONS

J. Fisler, MeteoSwiss, Zurich, Switzerland
M. Kube, MeteoSwiss, Zurich, Switzerland
C. Stocker, MeteoSwiss, Zurich, Switzerland
E. Grüter, MeteoSwiss, Zurich, Switzerland
B. Calpini, MeteoSwiss, Zurich, Switzerland

In 2005 MeteoSwiss – the Swiss National Met Service – started to integrate weather stations from networks of public institutions (e.g. cantons or research institutes) and private weather services into its central data storage platform. This integration significantly increased the coverage of available meteorological surface observation data over Switzerland. Ultimately, more observation data leads to a higher accuracy and better predictions in the field of nowcasting, warnings and hydrology.

However, integrating weather stations from other networks also brings challenges concerning the data quality and uncertainty. ThereforeMeteoSwiss developed a neutral certification process called "METEO-Cert". Based on WMO principles and regulations METEO-Cert assesses (carried out since 2013 by the Swiss Institute of Metrology METAS) the quality of 3rd party network data and MeteoSwiss' own observation network "SwissMetNet". The procedure identifies the uncertainty and the siting quality of each weather station, which is of great importance for further data processing. The integration of this quality and uncertainty information into the central data storage platform follows the principle of WIGOS and brings a clear overall improvement in the evolution of practices for both the national agency as well as private partners.

As a result about 10% of the assessed stations have been improved their quality based on the findings. In addition, the stations managers became more sensitive to changes concerning the station. If not addressed and solved, those changes can increase the uncertainty of the observation data. In order to monitor these improvements METEO-Cert is applied to a weather station every five years.

Currently the METEO-Cert procedure and its findings are being published as a CIMO IOM report. The IOM report draft version presented at the TECO 2016 maps out the principles and challenges associated with this process. It further provides background information on how METEO-Cert operates. Finally, it shows how the tool can be adapted and used by decision makers of other national meteorological and hydrological services to evaluate the quality of partner networks in their country and to decide whether the data should be integrated.

RECENT ACTIVITIES ON TRACEABILITY AND INSPECTION OF METEOROLOGICAL INSTRUMENTS IN JAPAN

Y. Nomura, Meteorological Instrument Center, Japan Meteorological Agency, Tsukuba, Japan
K. Umehara, Meteorological Instrument Center, Japan Meteorological Agency, Tsukuba, Japan

The Japan Meteorological Agency (JMA) has operated its Meteorological Instrument Center (MIC) since 1970, engaging in (1) quality assurance for meteorological instruments, (2) investigation and experimentation on observation methods and instruments, and (3) technical cooperation and capacity development for international traceability.

JMA operates around 1,300 weather stations nationwide, and MIC inspects/calibrates operational instruments at these stations (e.g., anemometers and thermometers) using a wind tunnel, thermostatic chambers and other equipment. With regard to instrument traceability, MIC (an ISO 17025-accredited temperature, pressure and humidity calibration laboratory) maintains JMA's standards based on regular calibration with Japan's national standards.

In Japan, the Meteorological Service Act requires meteorological instruments used for public announcements and disaster prevention/mitigation to meet certain technical and performance standards. To this end, MIC issues official certifications on the mechanical structures of instruments and calibrates meteorological instrument manufacturers' working standards. Within this legal framework, JMA enjoys the benefits of high-quality meteorological observation data provided by organizations other than JMA, such as central and local governments.

MIC also conducts investigations and experiments toward the improvement of instruments and more appropriate measurement. In recent years, environmental changes of observation fields caused by rapid urbanization and other factors have been highlighted, and MIC has conducted several field experiments on how such changes affect meteorological observation variables such as temperature and precipitation.

On the subject of international traceability, MIC was designated in 1996 as a Regional Instrument Centre (RIC Tsukuba) in Region II (Asia) under the framework of the World Meteorological Organization (WMO). The Centre engages in technical collaboration with other Met Services, with activities including calibration of Member countries' standards, provision of practical training, and hosting of workshops for related capacity development.

EXPERIMENTAL EVALUATION OF TEMPERATURE UNCERTAINTY COMPONENTS DUE TO SITING CONDITIONS WITH RESPECT TO WMO CLASSIFICATION: PRELIMINARY RESULTS

G. Coppa, Istituto Nazionale di Ricerca Metrologica (INRiM), Turin, Italy
C. G. Izquierdo, Centro Español de Metrologia (CEM), Tres Cantos, Spain
N. Jandric, Institut za mjeriteljstvoBosne i Hercegovine (IMBiH), Sarajevo, Bosnia and Herzegovina
C. Musacchio, Società Meteorologica Italiana, Turin, Italy
A. Quarello, Università degli Studi di Torino, Turin, Italy
M. Voldan, Českýmetrologickýinstitute (ČMI), Prague, Czech Republic
A. Merlone, Istituto Nazionale di Ricerca Metrologica (INRiM), Turin, Italy

Surface atmospheric air temperature measurements are influenced by the obstacles surrounding the measurement site itself. WMO guide #8 (Annex 1.B) establishes a qualitative/quantitative classification of measurement sites for some surface atmospheric quantities' measurements by itemizing different site conditions, in terms of obstacles proximity, ground slopes, projected shades etc. In the context of climatologic studies and in meteorology, where air temperature measurements are key and a wide multitude of instruments, in very different sites and conditions, are used, such a classification seems not sufficient.
In the framework of EMRP ENV58.MeteoMet2 project and in order to improve the WMO siting classification for air temperature measurements, a one-year lasting experiment has been devised with the aim to perform a metrological evaluation of the influence of several obstacles in air temperature measurements under a large range of atmospheric conditions.
The experiment consists in a 100 m long array of Automatic Weather Stations (AWSs), placed on a flat grass field at increasing distances from an obstacle, such that the farthest station fulfils current WMO requirements for a Class 1 site. Each AWS is equipped with one Pt100 thermometer, calibrated against reference standards, in a ventilated radiation shield; quantities of influence are also measured by dedicated sensors (hygrometers, solar radiation sensors and sonic anemometers), in some of the AWSs. Three identical experimental setups have been designed, built and characterized. Each system is built in different experimental sites, located in three different nations (Italy, Czech Republic and Spain). In each country, the effect of a different obstacle on air temperature measurements will be evaluated: asphalt roads (Italy), trees (Czech Republic) and buildings (Spain).
This work will present some preliminary results of the analysis, applied to the road siting part, employing a shared and uniform approach in order to reduce biases and provide a robust evaluation of air temperature measurement uncertainty under the different siting conditions.standards, provision of practical training, and hosting of workshops for related capacity development.

MMC Madrid 2016

METROLOGY FOR METEOROLOGY AND CLIMATE

POSTER SESSION

Monday 18:00 to 19:00

TECO Display Area - Hall 4

Session Chairman: DomenHudoklin, Francesca Sanna

Papers

1 GIVING TRACEABILITY TO THE HISTORICAL TEMPERATURE TIME SERIES: COMBINING METROLOGICAL AND HOMOGENISATION TECHNIQUES TO ESTIMATE THE UNCERTAINTY BUDGET

2 RELATIONSHIP ANALYSIS SEA LEVEL PRESSURE IN DARWIN, TAHITI, AND ANOMALY SEA LEVEL PRESSURE IN INDONESIA

7 CALIBRATION OF SOLAR RADIATION EFFECT ON TEMPERATURE SENSORS OF RADIOSONDES AT LOW TEMPERATURE AND LOW PRESSURE

8 HOW TO PREPARE ILC - CASE STUDY METEOROLOGICAL LABORATORIES

9 UNCERTAINTY EVALUATION APPROACH FOR A KINETIC RATE CONSTANT

10 INFLUENCE OF THE NEAR FOREST COVER ON THE AWS MEASUREMENT RESULTS

11 DUAL-LASER CAVITY RING-DOWN SPECTROSCOPY

12 EXPERIMENTAL SITE FOR THE MEASUREMENT OF METEOROLOGICAL PARAMETERS IN PROTECTED CULTIVATION AND VARIABILITY OF A TOMATO CULTIVAR

16 UNCERTAINTY CONTRIBUTIONS IN THE CALIBRATION OF RAIN GAUGES

17 PROGRESS BUILDING A CALIBRATION FACILITY FOR AN ABSOLUTE SALINOMETER BASED ON THE INDEX OF REFRACTION OF SEAWATER

18 EVALUATION OF RADIOSONDE HUMIDITY SENSORS USING LOW-TEMPERATURE HUMIDITY CHAMBER

20 EVALUATION OF THE HYSTERESIS EFFECT OF SOME METEOROLOGICAL THERMOMETERS

22 CALIBRATION UNCERTAINTIES OF CTDs IN A LARGE VOLUME LIQUID BATH

25 ABSOLUTE SALINITY MEASUREMENTS IN THE NORTHWESTERN MEDITERRANEAN: NOSS PROFILING FLOATS OBSERVATIONS

29 A LABORATORY RAINFALL SIMULATOR TO CALIBRATE NON-CATCHING TYPE GAUGES

30 QUANTIFYING EFFECTS OF DRIFT OF WEATHER-STATION HUMIDITY SENSORS

34 HUMIDITY CALIBRATION APPARATUS FOR RADIOSONDES ACCORDING TO GRUAN SPECIFICATIONS

38 INFERENCE OF SNOW COVER DURATION FROM GROUND SURFACE TEMPERATURES AT THE COL D'OLEN ROCK GLACIER LTER SITE

GIVING TRACEABILITY TO THE HISTORICAL TEMPERATURE TIME SERIES: COMBINING METROLOGICAL AND HOMOGENISATION TECHNIQUES TO ESTIMATE THE UNCERTAINTY BUDGET

A. Gilabert, University RoviraiVirgili, Centre for Climate Change (C3), Geography Department, Tortosa, Spain
M. Brunet, University RoviraiVirgili, Centre for Climate Change (C3), Geography Department, Tortosa, Spain, Climatic Research Unit, School of Environmental Sciences, Univ. of East Anglia, Norwich, UK
E. Aguilar, University RoviraiVirgili, Centre for Climate Change (C3), Geography Department, Tortosa, Spain
A. Merlone, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
G. Lopardo, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
F. Bertiglia, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy

In the last few decades, interest in the climate and climate changes studies has increased. From a climatological point of view, reliability and robustness of any climate study strongly depends on the availability of climatic time-series of proven quality and homogeneity. But these also depend on the adoption of metrological procedures to ensure measurement traceability.
Here we present a double analysis, to first demonstrate how the introduction of metrological calibration procedures can give traceability and improve the quality of the temperature time series and, secondly, how to compute a combined calibration plus homogenisation uncertainty budget of our homogenised data.
To analyse the influence of the calibration procedures to the temperature observations, we analyse the air temperature observations recorded at Moncalieri Observatory (North Italy, 44º59’52’’N-07º41’43’’E) by a calibrated automatic weather station (01/07/2012 to 30/06/2013). We evaluate the differences caused by applying or omitting the calibration results. The largest differences were observed for Tmin readings with a Root-Mean Square Deviation (RMSD) of 0.48 °C, while Tmax had a RMSD of 0.35 °C. The impact of the seasonal temperature cycle is evident in both daily parameters, with the largest negative differences estimated for winter months.
In addition, we have homogenised the monthly Tmax and Tmin series recorded at the centennial observatory of Moncalieri (1866-2012), in order to estimate a combined uncertainty budget, including the estimation of homogenisation adjustments uncertainty to ensure an enhanced traceability of the measurements and derived time-series.
This work represents an example of incorporation of metrological techniques in the scientific field of high-quality climate time-series development.

RELATIONSHIP ANALYSIS SEA LEVEL PRESSURE IN DARWIN, TAHITI, AND ANOMALY SEA LEVEL PRESSURE IN INDONESIA

J.G. Sea, Hasanuddin University, Makassar, Indonesian
Y.B. Pata, Hasanuddin University, Makassar, Indonesian

Anomaly Sea level pressure in Indonesia into one measure of climate phenomenon in Indonesia. Anomaly sea level pressure in Indonesia is strongly influenced by ENSO. Has conducted research using secondary data on the relationship between Darwin sea level pressure and Tahiti sea level pressure against anomaly sea level pressure in Indonesia from 1951 - 2014. The study was conducted with statistical analysis Correlations and Linear Regression. Analysis of Correlations between Darwin sea level pressure, Tahiti sea level pressure, and anomaly sea level pressure in Indonesia carried out on each month. The results obtained are of relationship sea level pressure between Darwin, Tahiti and Indonesian. Darwin sea level pressure affects the sea level pressure Anomaly in Indonesia every month from 1951 - 2014. Tahiti sea level pressure affects the sea level pressure Anomaly in Indonesia in October and March. In April and September, the influence of Tahiti sea level pressure weakened and in May, June, July, and August, Tahiti sea level pressure does not affect anomaly sea level pressure in Indonesia. In linear regression analysis, obtained a significant relationship between Darwin and Tahiti sea level pressure sea level pressure against Anomaly sea level pressure in Indonesia. The result of the calculation of correlation coefficients (R^2) is 0.555 which states that the effect of sea level pressure in Darwin and Tahiti against Anomaly sea level pressure in Indonesia is 55.5% and the rest influenced by other things. This proves that the Anomaly sea level pressure in Indonesia affected by changes in Darwin and Tahiti sea level pressure.

CALIBRATION OF SOLAR RADIATION EFFECT ON TEMPERATURE SENSORS OF RADIOSONDES AT LOW TEMPERATURE AND LOW PRESSURE

S.-W. Lee, Korea Research Institute of Standards and Science, Daejeon, Korea
B. I. Choi, Korea Research Institute of Standards and Science, Daejeon, Korea
S. G. Yang, Jinyang Industrial, Ansung, Korea
Y.-G. Kim, Korea Research Institute of Standards and Science, Daejeon, Korea

Measurements of upper-air environments are important for the prediction of climate and weather as well as safety issues. One of the challenges in the measurement of upper-air temperature using balloon-borne radiosondes is the correction of solar radiation effect which is known to induce warm biases. In order to conduct corrections traceable to SI units, a prerequisite is to measure the solar irradiance in-situ, irrespective of latitude and solar angle.

In this presentation, the concept of dual temperature sensors having different emissivity in a radiosonde will be introduced for the calibration of solar radiation using a ground-based facility. The calibration facility is consisting of a chamber, a freezer, a solar simulator, and pressure control/measurement units. The environment inside the chamber containing radiosonde temperature sensors is allowed to simulate upper air environments in the temperature range from -80 °C to 30 °C, the pressure range from 1 kPa to 100 kPa, and the solar irradiance from 0 to 1200 W/m2 independently. Under various circumstances, the temperature variation of each sensor and the temperature difference between two temperature sensors with different emissivity are recorded for the measurement and the calibration of solar radiation. The time-scale of solar radiation measurements and the uncertainty of each parameter will be further discussed.

HOW TO PREPARE ILC - CASE STUDYMETEOROLOGICALLABORATORIES

J. Bojkovski, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia
D. Hudoklin, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia
D. Groselj, Slovenian Environment Agency, Ljubljana, Slovenia
J. Drnovsek, University of Ljubljana, Faculty of Electrical EngineeringLaboratory of Metrology and Quality, Ljubljana, Slovenia
G. Beges, University of Ljubljana, Faculty of Electrical Engineering, Laboratory of Metrology and Quality, Ljubljana, Slovenia

Interlaboratory comparison (ILC) serves as a tool for comparison of measurement results carried out by accredited or non-accredited calibration laboratories in the relevant field of measurement. ILC represents very effective means to demonstrate technical competence of the participant and also serves as a technical base for accreditation. Furthermore, it is the most important element for monitoring of quality of measurement results as required by ISO/IEC 17025:2005 standard for laboratories in part 5.9. It is important, that measured values are comparable within laboratories.

The paper presents activities and results concerning task within European Metrology Research Program (EMRP) METEOMET 2 project, dealing with preparation of a procedure and a protocol for the ILC in the field of temperature, humidity and pressure for meteorological laboratories. The protocol and procedure were prepared according to international standard EN ISO/IEC 17043:2010 Conformity assessment - General requirements for proficiency testing (also known as ISO/CASCO 17043:2010). In this paper emphasize will be given on all important steps in the preparation of the comparison, choosing the right equipment, running the intercomparison, post processing data and presentation of the final results. . Within the METEOMET 2 project task, the procedure for execution of the ILC was prepared.

Documents were checked by meteorology society and finalized with some details typical for meteorology field and activities in their laboratories. In addition, a questionnaire was prepared for meteorological laboratories, gathering crucial information about potential participants in the ILC and their capabilities in order to prepare the details for initiation and execution of a real ILC within meteorological laboratories, beyond the METEOMET 2 project.

UNCERTAINTY EVALUATION APPROACH FOR A KINETIC RATE CONSTANT

E. Pessana, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
M. Sega, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy

Nitrogen oxides (NO_X) are binary mixtures of nitric oxide (NO) and nitrogen dioxide (NO_2) that are emitted during combustion at high temperature of fossil fuels. NO_2 is a secondary pollutant, because it very often generates from oxidation of NO in the atmosphere. It is fundamental in photochemical smog as it acts as an intermediate in production of other secondary pollutants highly dangerous as ozone (O_3), nitric acid (HNO_3), nitrous acid (HNO_2), alkyl nitrates, peroxy alkyl nitrates. NO is not very dangerous for human health, but due to the fast oxidation to NO_2 we often refer to this latest pollutant that is more toxic for human health. NO_2 is an irritating gas; it can contribute to an alteration of lung functionality: e.g. chronic bronchitis, asthma, pulmonary emphysema. In addition, extended exposure to NO_2 at low concentration can reduce lungs defences and as a consequence it can increase the risk for respiratory diseases.

There are many examples in literature related to the determination of the kinetic rate constant for the formation of NO_2 starting from NO, but a little attention has been paid to the evaluation of the uncertainty associated to this parameter.

At INRiM the reaction of transformation of NO into NO_2 was followed by FTIR, by mixing in a sealed gas cell a mixture of NO in nitrogen with synthetic air, hence in the presence of an excess of oxygen (O_2). The disappearance of the NO peaks and the corresponding appearance of NO_2 peaks were monitored. Starting from the kinetic equation model of the reaction, a proper uncertainty budget was calculated, taking into account the main uncertainty sources and the associated covariances.

INFLUENCE OF THE NEAR FOREST COVER ON THE AWS MEASUREMENT RESULTS

M. Voldán, Czech Metrology Institute, Prague, Czech Republic
L. Šindelářová, Czech Metrology Institute, Prague, Czech Republic
G. Coppa, Istituto Nazionale di Ricerca Metrologica, Italy
A. Merlone, Istituto Nazionale di Ricerca Metrologica, Italy

Automatic weather stations (AWSs) are spread all over the world. They are one of the biggest sources of essential climate variables (ECVs) data, which are necessary to understand the environmental conditions on the surface of the planet. In most cases these stations are located near objects that significantly influence the results of the measurement. The World Meteorological Organization (WMO) in its guide WMO-No.8 (2008-2010) indicates an estimation of the uncertainty on temperature measurements, with respect to the distance of obstacles, such as trees, roads, buildings, from the measuring point. Such estimation is by now based on field practice and experience, and few are the experiment made to evaluate this effect. A rigorous metrological approach studied and experimentally developed to evaluate the effect of the presence of trees on the uncertainty in air temperature measurements is here presented, as a potential contribution to the revision and improvement of the current estimation.

This contribution describes an experiment to evaluate the influence of trees proximity on AWS's behavior, its spatial configuration and measurement results, as estimated from seven measuring points at different distances from the forest. Each point consists of a pole hosting a thermometer in an aspirated shield. The point at maximum distance is placed in agreement with the lower uncertainty class as by now defined by the WMO guide. Other "ancillary" measurements, such as humidity, wind speed and direction, solar radiation are recorded in a central point to detect influencing factors on the experiment results.

This research is included in an EMRP Joint Research Project "ENV58 MeteoMet 2" jointly funded by the EMRP participating countries within EURAMET and the European Union.

DUAL-LASER CAVITY RING-DOWN SPECTROSCOPY

E. Fasci, Dipartimento di Matematica e Fisica, Seconda Università di Napoli, Caserta, Italy
A. Castrillo, Dipartimento di Matematica e Fisica, Seconda Università di Napoli, Caserta, Italy
L. Gianfrani, Dipartimento di Matematica e Fisica, Seconda Università di Napoli, Caserta, Italy

In this work, recent efforts toward the development of a new approach of frequency-stabilized cavity ring-down spectroscopy (FS-CRDS) are reported. The spectrometer is based on a pair of offset-frequency locked extended cavity diode lasers at 1.39 μm. One of the two lasers acts as reference oscillator, while the second laser (namely, the probe laser) is actively controlled so that its emission frequency maintains a given offset with respect to the frequency of the reference laser.

The probe laser is injected into an ultra-stable high finesse cavity, made with a new ZERODUR spacer whose length is 43 cm. Compared to the first version, we have replaced the dielectric mirrors so as to increase the finesse up to 105 and, consequently, the detection sensitivity. A tracking servo-loop electronics was implemented for cavity ring-down measurements with high temporal resolution, while scanning the offset-frequency of the probe laser around a given center frequency. The complete characterization of the cavity was performed, also measuring a ring-down time (under empty cavity conditions) of about 60 μs. Repeated determinations revealed a precision of 0.4%.

The dual laser approach allowed us to build an absolute and highly-reproducible frequency scale underneath the absorption spectra, thus satisfying one of the main requirements for absolute and low uncertainty determinations. Our approach appears to be very promising, showing all the requisites to act as a primary method for determinations of amount of substance for water vapor, at trace levels.

EXPERIMENTAL SITE FOR THE MEASUREMENT OF METEOROLOGICAL PARAMETERS IN PROTECTED CULTIVATION AND VARIABILITY OF A TOMATO CULTIVAR

F. Sanna, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy, IMAMOTER-CNR, Turin, Italy, DiSAFA - Università degli Torino, Turin, Italy
R. Deboli, IMAMOTER-CNR, Torino, Italy
G. Coppa, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
A. Calvo, DiSAFA - Università degli Torino, Italy

Light is a limiting factor of paramount importance for plants since, in addition to providing the radiant energy for photosynthesis, it modulates the growth and development in response to environmental conditions. When operating in protected cultivation the amount and the spectral distribution of solar radiation inside the greenhouse undergo a modification that depends on the type of cover used. UV radiation is considered as a stress factor, which is able to affect the characteristics of plant growth and to trigger a variety of physiological responses that lead to an accumulation of secondary metabolites that increase the plant resistance.
Currently, accurate measurements of meteorological parameters in protected cultivation are unavailable, neither are known the measurement uncertainties of environmental parameters that can be resolved in percentage uncertainties on the variability of the product.
The research activities concern the quality of table tomatoes harvested in protected cultivation. The following aspects will be evaluated: (i) microclimate and solar radiation measurement of the spectral distribution, using calibrated and traceable instrumentation, within the different cultivation environments; (ii) monitoring of the optical and radiometric properties of the films used as covering material; (iii) identification of the physiological processes of crops in response to the type of plastic film adopted by phenological, morphological and physiological observations.
The microclimate conditions will be monitored by sensors for: solar radiation, operating in the spectral range from 290 nm to 2800 nm; air temperature in the range between -10 °C and 45 °C with a target uncertainty of 0.3 °C; air relative humidity between 10% and 98% with a target uncertainty of 1.5%; soil moisture, measuring the volumetric water content between 1% and 100%, inside and outside the tunnel with different covering materials. The instruments used will follow calibration procedures defined ad hoc.
The expected results are 1- to assess the productivity of the agricultural product as a function of the meteorological parameters measurement uncertainty within the protected cultivation; 2- to assess quality through the chemical characterization of the crop with a focus on classes of compounds with nutraceutical properties (health promoting compounds).

UNCERTAINTY CONTRIBUTIONS IN THE CALIBRATION OF RAIN GAUGES

M. A. A. Santana, National Institute For Space Research / Center for Weather Forecasting and Climate Research, CachoeiraPaulista, São Paulo, Brazil
P. L. O. Guimarães, University of Genova, Dept. of Civil Chemical and Environmental Engineering, Genoa, Italy
L. G. Lanza, WMO/CIMO Lead Centre “B. Castelli” on PrecipitationIntensity, Italy

The use of metadata relating to the calibration of hydrometeorological instrumentation, especially the expanded uncertainty of measurement calibration, is essential to know the level of reliability of measurements in environmental monitoring.

This paper presents a study of the uncertainty contributions of type A (repeatability) and type B (specification and calibration certificate of the standards, environmental conditions, influence of metrologist, specification of the object under test) in the laboratory calibration processes for some types of rain gauges (ordinary, capacitive siphoning, weighing and tipping bucket) based on input and output methods, i.e., volumetric and gravimetric methods.

Since the rain measurements are performed indirectly, i.e., there is no comparison to a “materialized measurement” or standard of rain, the sources of error and uncertainty contributions of each component composing the rain gauge calibration system were analyzed.

It was found that the uncertainty propagation studies is enormously large and some sources of uncertainty observed in the field (wind, evaporation, splashing, etc.) do not appear to be measurable accurately in the laboratory and the CMC - “calibration and measurement capabilities” - depends on the measuring principle of the equipment and the measurement method and procedure.

PROGRESS BUILDING A CALIBRATION FACILITY FOR AN ABSOLUTE SALINOMETER BASED ON THE INDEX OF REFRACTION OF SEAWATER

F. Sparasci, LNE-Cnam, La Plaine Saint-Denis, France
L. Pitre, LNE-Cnam, La Plaine Saint-Denis, France
M. Le Menn, SHOM, Brest, France
D. Malardé, NKE Instrumentation, Hennebont, France

In 2011 LNE-Cnam has started a series of European research projects focusing on the subject of the "Metrology for the environment" (EURAMET EMRP joint research projects "MeteoMet"). In these projects, one of the main research topics is the improvement of the traceability of absolute salinity measurements.

The objective is to carry out a full metrological characterization of a novel absolute salinometerprototype, named NOSS, developed by a French research consortium[1] The device measures the refractive index of a seawater sample, to allow the determination of the absolute salinity through the measurement of the density.
NKE Instrumentation has concluded the industrial development of the sensor, but the metrological performances cannot be assessed in the full working range of the device. The first limit comes from the accuracy of the Millard-Seaver[2] relationship, which expresses the index of refraction of seawater over temperature, pressure, salinity, density and wavelength. The second is the lack of an appropriate calibration facility, for the characterization of the salinometer under traceable temperature and pressure conditions, inside a sample of seawater of well-characterized and traceable salinity.

This work describes the progress accomplished in the realization of a calibration facility composed of an adiabatic calorimeter equipped with a pressure vessel, containing the NOSS salinometer immersed in a sample of standard seawater. The temperature and the pressure inside the pressure vessel can be accurately controlled and traceably measured, respectively from 0 °C to 40 °C and from 0.1 MPa to 25 MPa.

This work is carried out within the frame of the European Metrology Research Program (EMRP) joint research project 'ENV58 MeteoMet'. The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union.

---

[1] TELECOM Bretagne, SHOM, NKE Instrumentation, Ifremer

[2] R.C. Millard, G. Seaver, An index of refraction algorithm for seawater over temperature, pressure, salinity, density, and wavelength, Deep Sea Research, vol. 37, no. 12, pp. 1909-1926, 1990

EVALUATION OF RADIOSONDE HUMIDITY SENSORS USING LOW-TEMPERATURE HUMIDITY CHAMBER

B.I. Choi, Korea Research Institute of Standards and Science, Daejeon, Korea
S.-W. Lee, Korea Research Institute of Standards and Science, Daejeon, Korea
S.B. Woo, Korea Research Institute of Standards and Science, Daejeon, Korea
J.C. Kim, Korea Research Institute of Standards and Science, Daejeon, Korea
Y.-G. Kim, Korea Research Institute of Standards and Science, Daejeon, Korea

Accurate measurements of temperature and water vapour in the upper-air are of great interest in relation to weather prediction and climate change. Those measurement is mostly conducted using radiosondes equipped with a variety of sensors that are flown by a balloon up to lower stratosphere (~ 35 km) and transmit sensing signals to the ground. Reference Upper Air Network (GRUAN) has identified water vapour pressure as one of the most important measurands and has set an accuracy requirement of 2% in terms of the mixing ratio.
In this paper, the sensitivity characteristic and response time of radiosonde humidity sensors were investigated in temperature (-80 ~ 20) °C range, using new developed low-temperature humidity chamber which is based on two-pressure humidity generator This chamber can provide calibrations for radiosondes with 2% uncertainty and traceability to SI units.

EVALUATION OF THE HYSTERESIS EFFECT OF SOME METEOROLOGICAL THERMOMETERS

C. G. Izquierdo, CEM-Centro Español de Metrología, Tres Cantos, Spain
S. Hernandez, CEM-Centro Español de Metrología, Tres Cantos, Spain
A. González, CEM-Centro Español de Metrología, Tres Cantos, Spain
D. del Campo, CEM-Centro Español de Metrología, Tres Cantos, Spain

Fast and abrupt changes of air temperature are usual on real weather conditions what could cause hysteresis on the resistance thermometers used for onsite air temperature measurements. In order to have a more reliable knowledge about the uncertainty of air temperature onsite measurements, the hysteresis effect should be evaluated. This evaluation is usually performed in the calibration laboratories, but considering the sensor alone.

This paper presents the results of the study of the hysteresis effect in a group of resistance thermometers used in automatic weather stations. The influence of the radiation shield on hysteresis effect is also evaluated. Furthermore, a comparison of two methods for the evaluation of the hysteresis is performed. The behaviour of the thermometers to a hysteresis cycle is presented as well as the results of the measurement of an intermediate temperature calibration point after the exposure of the thermometers at extreme conditions of temperature and humidity. These measurements have been performed in two different isothermal enclosures: a liquid stirred bath and a climate chamber.

This research is included in an EMRP Joint Research Project "Env58. MeteoMet2" jointly funded by the EMRP participating countries within EURAMET and the European Union.

CALIBRATION UNCERTAINTIES OF CTDs IN A LARGE VOLUME LIQUID BATH

C. G. Izquierdo, CEM-Centro Español de Metrología, Tres Cantos, Spain
D. del Campo, CEM-Centro Español de Metrología, Tres Cantos, Spain
S. Hernandez, CEM-Centro Español de Metrología, Tres Cantos, Spain
A. González, CEM-Centro Español de Metrología, Tres Cantos, Spain
A. Garcia-Benadí, UniversitatPolitècnica de Catalunya (UPC), Vilanova i la Geltrú, Spain
J. del-Río-Fernández, UniversitatPolitècnica de Catalunya (UPC), Vilanova i la Geltrú, Spain
M. Nogueras-Cervera, UniversitatPolitècnica de Catalunya (UPC), Vilanova i la Geltrú, Spain

In the framework of the EMRP project "ENV 58. Metrology for essential climate variables", the temperature sensor calibration of marine devices for the measurement of salinity, temperature and depth, CTDs is planned. These devices are usually long dimensions and for hence, large calibrations baths are needed.

This paper describes the calibration procedure developed for the CTDs SeaBird Electronics models 16plus and 37SMP (with dimensions, (808 x 136) mm (564 x 103) mm). These instruments are currently in use in the submarine observatory (www.obsea.com). The assembly and characterization of this large volume calibration bath as well as the all instrumentation involved in the process are presented. Besides, the calibration uncertainty model, with the analysis of each of the components is analyzed.

ABSOLUTE SALINITY MEASUREMENTS IN THE NORTHWESTERN MEDITERRANEAN: NOSS PROFILING FLOATS OBSERVATIONS

D. Malardé, NKE Instrumentation, Hennebont, France
A. David, NKE Instrumentation, Hennebont, France
M. Le Menn, SHOM, Brest, France
P. Brault, NKE Instrumentation, Hennebont, France
S. Le Reste, IFREMER, RDT/I2M, Plouzané, France

In recent years, the Thermodynamic Equations of Seawater have been redefined and it has introduced the concept of absolute salinity in the calculation of seawater density. In contrast to practical salinity (depending on conductivity), absolute salinity is expressed in SI units and it includes the influence of the small spatial variations of seawater composition in the global ocean. The traceability of its measurement to the SI has become crucial and the development of absolute salinity measurement methods and tools are essential.

An in situ salinity-density sensor (called NOSS) based on refractive index measurement of the seawater has previously been characterized and qualified. Laboratory performances are compliant with the target in terms of measurements uncertainties. Two Argo profiling floats were equipped with NOSS sensors, in addition to the usual temperature, pressure and conductivity sensors fitting out these floats. They were deployed in the northwestern Mediterranean during spring 2015 in order to complete the evaluation of the NOSS sensor in real conditions.

Time series of temperature, conductivity, pressure and refractive index were recorded, and absolute salinity and in situ density were calculated, at a high vertical resolution of about 2 m in the 0 - 2000 m layer. These data were analyzed to characterize the mixed layer depth and evaluate the potential anomalies of composition in the area.

A specific calibration of the NOSS sensor was developed using Millard – Seaver relations, which accounted for the pressure and the temperature influence. A post calibration check at the end of the mission was performed to determine if the sensor signal drifted from the previous calibration because of the growth of biofouling on optical windows. Seawater samples from multi-bottle sampling array were extracted to evaluate biogeochemical and physicochemical measurements at float locations at the beginning of deployment and during the recovery of floats.

Floats data were thus compared with reference density and salinity data observations. In this study, the NOSS sensor is presented as one of the first underwater sensors for in situ refractive index measurement in the past years, opening up the scope of possibilities of direct access to density parameter. The NOSS floats will contribute to improve the knowledge of in situ density and absolute salinity of seawater across TEOS-10 by exploiting the potentiality of the coupled NOSS sensor and CTD observations.

A LABORATORY RAINFALL SIMULATOR TO CALIBRATE NON-CATCHING TYPE GAUGES

M. Stagnaro, University of Genova, Italy
M. Colli, University of Genova, Italy
L. G. Lanza, University of Genova, Italy

The liquid precipitation at the ground level is measured by means of different techniques and technologies for areal and point-scale quantification of rainfall intensity RI (mmh^{-1}) and the resulting total precipitation amount h (mm). Point-scale precipitation gauges fall in two main categories: catching type gauges, which collect the liquid equivalent precipitation into a measuring bucket, and non-catching type gauges, where the collection of water is not required. Since these categories of gauges employ a variety of measuring principles, the development of a unified calibration procedure is still an open issue.
Modern non-catching type gauges are generally able to provide multiple information about the observed precipitation. These are typically the drop size distribution N(d) ($m^3s^{-1}mm^{-1}$), drops terminal velocity v (ms^{-1}) and the resulting RI for a given sensing area/volume. Noticeable error figures of the rainfall intensity indications obtained by non-catching type instruments have been highlighted in the recent WMO Field Intercomparison of Rain Intensity Gauges experiment. During the campaign, reference RI values were provided by a selection of catching-type gauges whose performance had been validated in the laboratory. Such low performance are ascribed to the yet unsolved difficulties in establishing reliable relations between the rainfall rate and the measured quantity values from optical, acoustic or radar sensor indications.
This work describes the requirements, the design and preliminary testing of a laboratory rainfall simulation system capable of generating non-continuous water flows (droplets shower) with controlled RI and N(d). The first prototype is based on the precise control and monitoring of the dispensing frequency of fixed droplet volumes. A real-world drops size distribution is approximated by simplifying the domain of droplets diameter d (mm) in three main categories of fixed size. The drop forming principle is composed by a set of three calibrated nozzles driven by precision pumps. The second rainfall simulation prototype under development upgrades the capabilities of the first system by adding the control of the droplets sizes thanks to the employment of several micro-displacement actuators.
The technical advantage derived from the availability of such devices arises from their suitability to calibrate non-catching type gauges. The uncertainty associated with the generated RI and N(d) values is quantified by means of dedicated tests performed in a controlled environment.

QUANTIFYING EFFECTS OF DRIFT OF WEATHER-STATION HUMIDITY SENSORS

P. A. Carroll, National Physical Laboratory, Teddington, UK
S. A. Bell, National Physical Laboratory, Teddington, UK
S. L. Beardmore, National Physical Laboratory, Teddington, UK
C. England, Met Office, Exeter, UK
N. Mander, Met Office, Exeter, UK

Air humidity measurements in weather stations are essential observations of current weather, and the same data are also used ultimately in analysis of climate. Validated long-term and global humidity datasets are beginning to be compiled, and workers have begun to attribute uncertainties to the dataset values. In doing so, the question arises of how to allow for humidity measurement uncertainty, and whether any bias in data might be expected due to instrument performance. It is well known that relative humidity sensors can suffer drift in service, due to condensation and contamination-related ageing processes. This question is especially of interest when a change in instrument technology is made, where the techniques may tend to differ in uncertainty or bias.

The work presented is a study of a large dataset of weather-station humidity sensors, to demonstrate a methodology for assessing typical drift, and associated uncertainty, for a population of sensors. Such generalised estimates of instrumental drift and generalised associated uncertainties can be used to inform climate analyses that use pooled data from large numbers of humidity observations.

The study used a dataset provided by the calibration laboratory of the UK Met Office, for humidity sensors calibrated before deployment in weather stations, and then re-checked after return to the laboratory. Because the records span before and after deployment, estimates of sensor drift in service can be made. This study covers a large set of sensors, demonstrating how drift data for individual sensors can be generalised for the population of instruments. The method and example results will be presented, showing typical drift of sensors to be several percent relative humidity at high humidities. The consequences for interpreting aggregated data for relative humidity will be discussed.

HUMIDITY CALIBRATION APPARATUS FOR RADIOSONDES ACCORDING TO GRUAN SPECIFICATIONS

H. Sairanen, VTT Technical Research Centre, MIKES, Finland
M. Heinonen, VTT Technical Research Centre, MIKES, Finland
R. Högström, VTT Technical Research Centre, MIKES, Finland
J. Salminen, VTT Technical Research Centre, MIKES, Finland
S. Saxholm, VTT Technical Research Centre, MIKES, Finland
H. Kajastie, VTT Technical Research Centre, MIKES, Finland

Global Climate Observing System (GCOS) concluded that quality of observed climate data requires improvements. As a step toward improved accuracy and more reliable data GCOS launched GCOS Reference Upper-Air Network (GRUAN) which specifies accuracy and uncertainty requirements for measurement instruments that are used in GRUAN stations. GRUAN also recognised the importance of traceability to International System of Units (SI) in climatic measurements.

New apparatus enabling GRUAN requirements fulfilling radiosonde calibrations was constructed at VTT Technical Research Centre of Finland MIKES metrology in 2011-2016. The apparatus operates within temperature range from -80 °C to 20 °C and dew/frost-point temperature range from -90 °C to 10 °C. Designed absolute pressure range of the apparatus is from 10 hPa to ground level pressures i.e. about 1050 hPa.

Within this poster the apparatus and its characterization is presented in details. As a part of the characterization uncertainties of the apparatus were analyzed. The combined uncertainty shows clearly that the apparatus meets the requirements set by GRUAN.

This work was supported by the European Metrology Research Programme (EMRP) jointly funded by the EMRP participating countries within EURAMET and the European Union.

INFERENCE OF SNOW COVER DURATION FROM GROUND SURFACE TEMPERATURES AT THE COL D'OLEN ROCK GLACIER LTER SITE

S. Fratianni, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Centro di Ricerca sui Rischi Naturali in Ambiente Montano e Collinare (NatRisk), Grugliasco, Italy
F. Acquaotta, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Centro di Ricerca sui Rischi Naturali in Ambiente Montano e Collinare (NatRisk), Grugliasco, Italy
E. Giaccone, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, InstitutdesDynamiques de la Surface Terrestre, Université de Lausanne, Switzerland
D. Guenzi, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy
G. Coppa, Istituto Nazionale di Ricerca Metrologica (INRiM), Torino, Italy
N. Colombo, Dipartimento di Scienze della Terra, Università degli Studi di Torino, Italy, Department of Geography and EnvironmentalStudies, CarletonUniversity, Ottawa, Canada

In this study two years results of the surface thermal monitoring at the Col d'Olen rock glacier LTER site (NW Italian Alps) are presented. The rock glacier typology is talus-tongue shaped and the elevation of the front is ca. 2760 m a.s.l., covering a total area of 37.500 m^2. A total of 74 Maxim iButton® DS1922L minithermocrons, which measure the Ground Surface Temperature (GST) every three hours, were installed at 5/10 cm of depth, during the summer 2014 in order to study the GST spatial variability and indirectly detect the snow cover duration. The main parameters analysed are: mean annual ground surface temperature (MAGST), variability of MAGST on rock glacier surface, WeqT, shallow temperature of ground in summertime (STG), snow onset day, snow melt-out date, basal-ripening day and ground freezing index (FrezInd). These dataloggerswill be downloaded during July-August 2016, the temperature data will be analysed and the snow cover duration estimated. Moreover, a network of portable instruments (e.g. Automatic Weather Stations – AWS) has been established in the rock glacier area for collecting meteorological data, after a dedicated calibration procedure to assess the uncertainties of temperature measurements.

Book of Abstracts of the MMC 2016– International Conference on Metrology for Meteorology and Climate *in conjunction with* WMO CIMO-TECO 2016 & Meteorological Technology World Expo 2016

26 – 29 September 2016, Madrid, Spain

Editors: GaberBegeš,DomenHudoklin, Andrea Merlone, Francesca Sanna
Cover photograph: GrazianoCoppa

Torino, 2016

METEOMET

Metrology for Meteorology

CENTRO ESPAÑOL DE METROLOGÍA

INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA

LMK

University of Ljubljana
Faculty of Electrical Engineering
Laboratory of Metrology and Quality