CIPM

Consultative Committee for Thermometry

Working Group Environment

Report 2020

Members:

- Stephanie Bell (NPL)
- Efrem Ejigu (NMISA)
- Carmen García Izquierdo (CEM)
- Drago Groselj (WMO-CIMO)
- Martti Heinonen (MIKES)
- Murat Kalemci (UME)
- Yong Gyoo Kim (KRISS)
- Christian Monte (PTB)
- Peter Pavlasek (SMU)
- Fernando Sparasci (LNE-Cnam)
- Howard Yoon (NIST)
- Naohiko Sasajima (NMIJ/AIST)
- Eric van der Ham (NMIA)
- Hao Xiaopeng (NIM)
- Victor Fuksov (VNIIM)
- Júlio D. Brionizio (INMETRO)

Chairperson: Andrea Merlone (INRIM)

- Co-opted members:
  Rainer Feistel (Leibniz Institute for Baltic Sea Research)
  Peter Thorne (Maynooth University)

- Invited to attend
  Åge Andreas Falnes Olsen (JV)
  Farzana Masouleh (MSL)
  Gaber Beges (UL-LMK)
  Javier García Skabar (INTI)
  Aleksandra Kowal (INTiBS)
  Krunoslav Premec (WMO)

CCT Working Group Environment

Consultative Committee for Thermometry

Working Group Environment

Meeting 3. 2019 June 11, 6.00 pm – 7.30 pm

Chengdu (China)

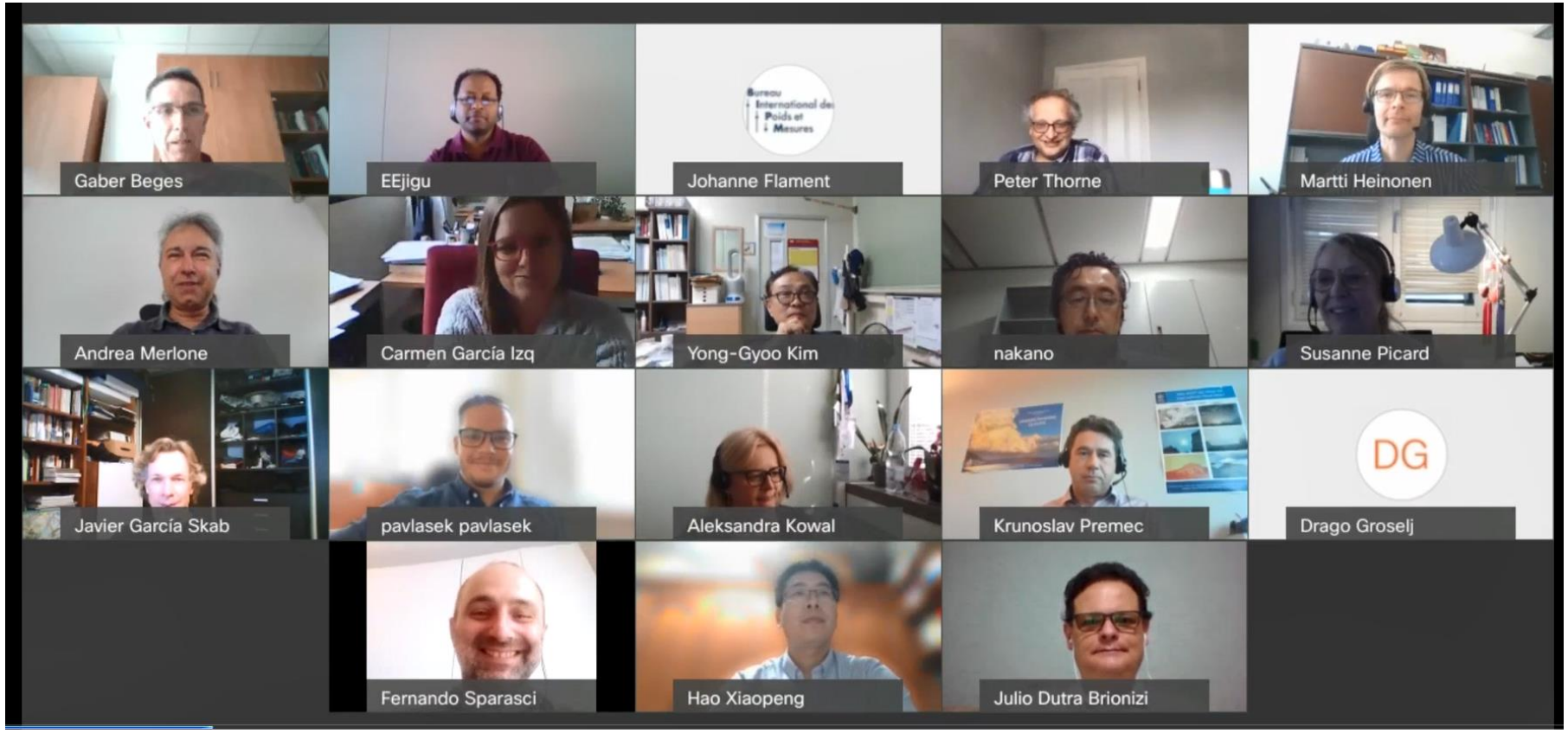
Closing event of the 3rd Metrology for Meteorology and Climate Conference – MMC2019

Consultative Committee for Thermometry

Working Group Environment

Meeting 4. 2020 September 24, 12.00 – 14.00 CET

Teleconference



Reports from members, activities under WMO and other Institutions, projects

Identified fields of study for the CCT WG ENV

CEM, CNAM, DTI, INRiM, KRISS, NIST, NIM, NMIA, NMIJ, NPL, PTB, SMU, UL, VSL

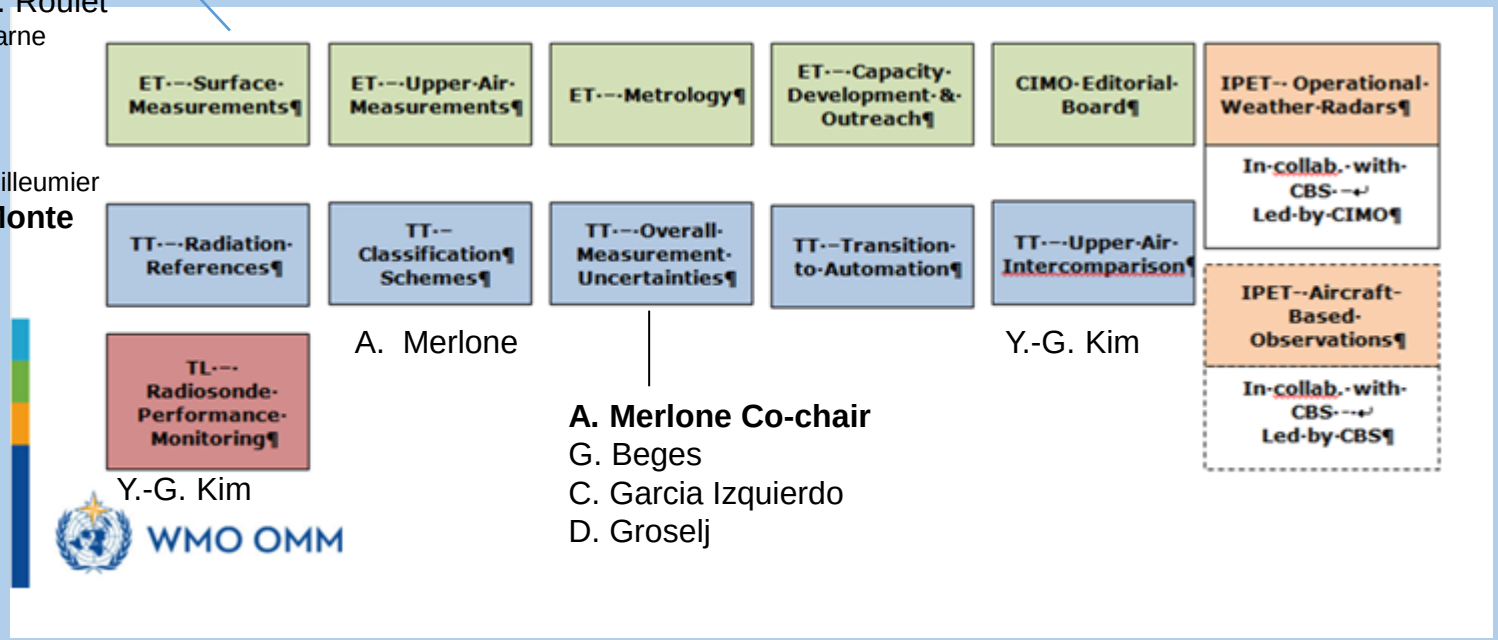
	Air	Water	Soil
Goal	Evaluate components of uncertainty Define reference value for atmospheric Near Surface Temperature	Reduce uncertainty Establish agreed definitions of some parameters, like SST (Sea Surface Temperature) and measurement procedures	Standardize methods
Institutions	CIMO CCl GSRN GRUAN	JPI Oceans Jamstec	GCW Polar programmes GSRN
Existing systems	Self-heating. Characterization of the intrinsic behavior of thermometers Dimensions Shield and radiation correction Calibration in air (ATM) – ILC-IC Radiosondes	Calibration curves	Dataloggers Boreholes features
New instruments	Non contact (NST, radiosonde) Drones – IoT	Fibre optics (for gradients)	Fibre optics (for gradients)
Quantitie of influence	Radiation Wind Condensation/evaporation Site Pressure (radiosonde)	Pressure	Convection
Other	Standards for Precipitation (liquid-Solid) Urban climate	Salinity	Moisture Agriculture

Commission of Instruments and Methods of Observations - CIMO

C. Garcia Izquierdo
A. Merlone
L. Lanza
Y.-A. Roulet
J. Warne

Y.G. Kim

C. Garcia Izquierdo
G. Beges
A. Merlone
M. De Podesta
J. Skabar
D. Groselj



A. Merlone Co-chair
G. Beges
C. Garcia Izquierdo
D. Groselj

Commission of Climatology

Rapporteur group on Reference Stations

A. Merlone - Chair
G. Beges
J. Skabar

Global Cryosphere Watch

Best Practice team on Permafrost

A. Merlone - Chair

Global Climate Observing System

GCOS - Surface Reference Network

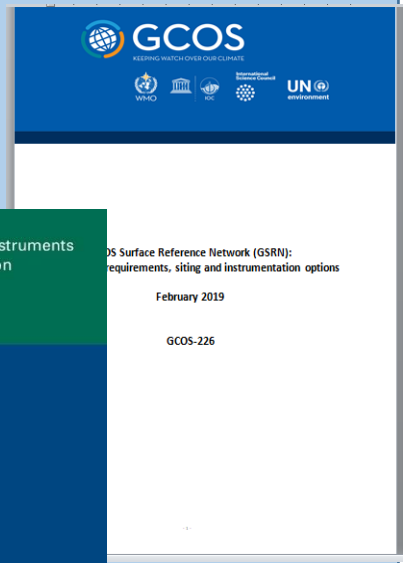
A. Merlone

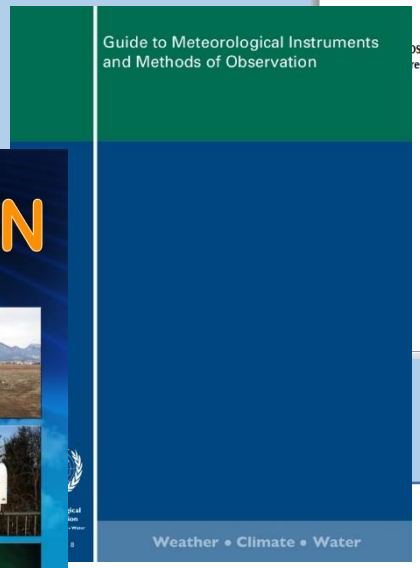
Commission of Instruments and Methods of Observations - CIMO

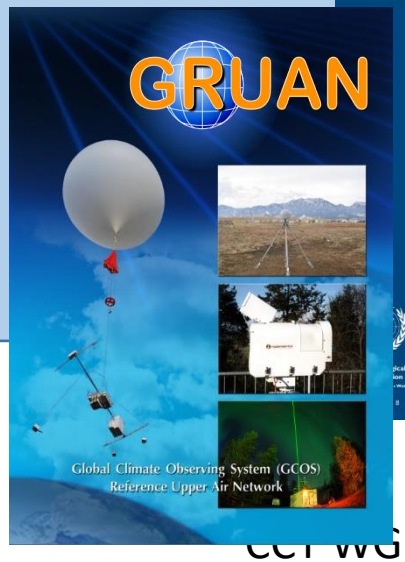
ET “Metrology”
ET “Surface Measurements”
ET “Upper air measurements”
TT “Radiation references”
TT “Uncertainties”
TL “Radiosondes performance”
TT “UA Intercomparison”

Contributions to

Training on measurements, uncertainties and units to be published in WMO web pages
Revision of the “WMO Guide on Instruments and Methods of Observations
Interlaboratory comparisons
Instrument performance classification
Uncertainty evaluation
Siting classification and experiments







Commission of Climatology

Climate Reference Stations

A. Merlone - Chair
Extended document prepared including requirements, features, technical annexes and uncertainty values

Global Cryosphere Watch
Best Practice team on Permafrost
A. Merlone – Chair
Definition of guidelines on Permafrost ECV for inclusion in the WMO guide No. 8

Global Climate Observing System
GCOS - Surface Reference Network
A. Merlone
Conclusion of GSRN - GCOS 226

Commission of Instruments and Methods of Observations - CIMO

ET “Metrology”
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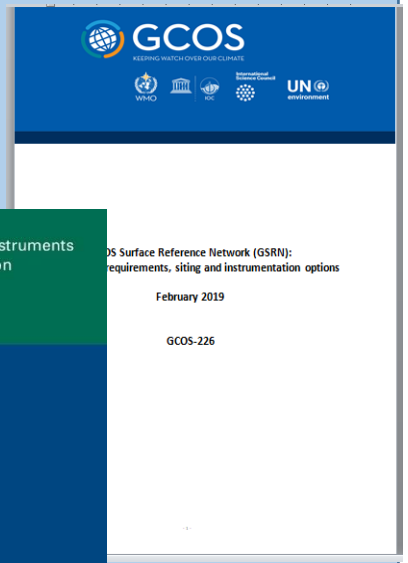

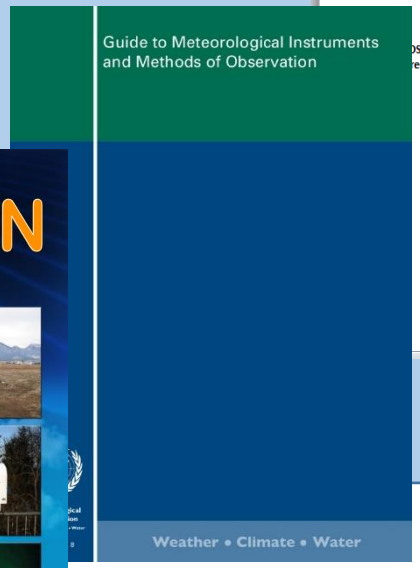

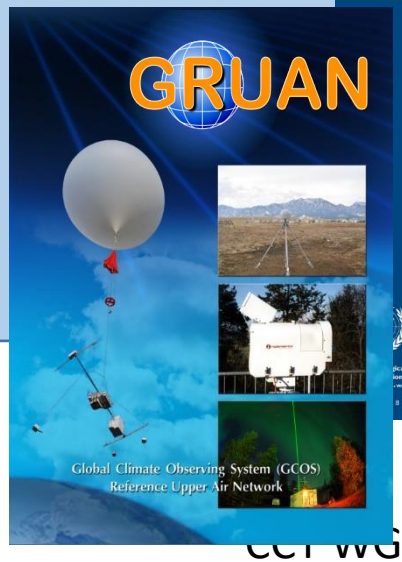

Commission of Climatology

Climate Reference Stations

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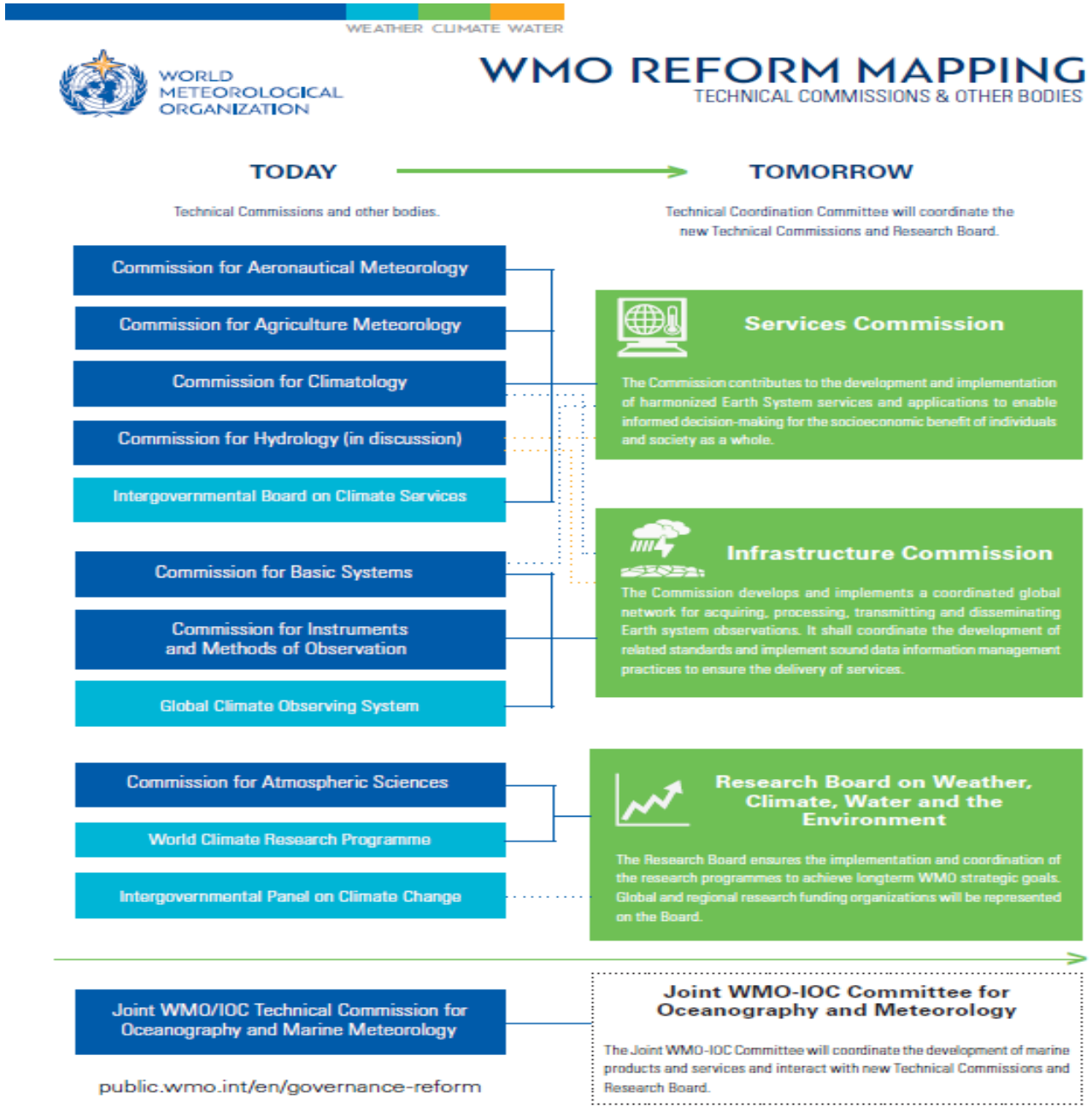
Global Climate Observing System
GCOS - Surface Reference Network
A. Merlone
Conclusion of GSRN - GCOS 226
Implementation plan 2020-2024



New Task teams are being created.

CCT Members are expected to contribute in the SC-MINT of the INFCOMM

(Standing Committee on Measurements, Instrumentation and Traceability)

News Nov 2020

Andrea Merlone – **Chair** ET MU + Member ET QTC
Christian Monte – **Vice Chair** ET – Radiation
Carmen G. Izquierdo – Member ET QTC + ET Surface
Stephanie Bell – Member ET QTC
Yon Gyoo Kim – Member ET MU – ET Upper Air

Projects

Chief Stakeholder	World Meteorological Organisation (WMO)
Contact:	Bertrand Calpini - Permanent Representative on CIMO WMO
Address:	Ch. de l'Aérologie 1, CH-1530 Payerne
Phone:	+41 58 460 92 45
Email:	bertrand.calpini@meteoswiss.ch

This project will develop traceable calibration methods for non-catching precipitation gauges that are implemented in a form that can be incorporated into standards.

no.	Participant Type	Short Name	Organisation legal full name	Country
1	Internal Funded Partner	INRIM	Istituto Nazionale di Ricerca Metrologica	Italy
2	Internal Funded Partner	CEM	Centro Español de Metrología	Spain
3	Internal Funded Partner	DTI	Teknologisk Institut	Denmark
4	Internal Funded Partner	SMD	Federale Overheidsdienst Economie, KMO, Middenstand en Energie	Belgium
5	External Funded Partner	UNIGE	Università degli Studi di Genova	Italy
6	Unfunded Partner	EDI	Eidgenössische Departement des Innern	Switzerland

METEOMET
Metrology for Meteorology

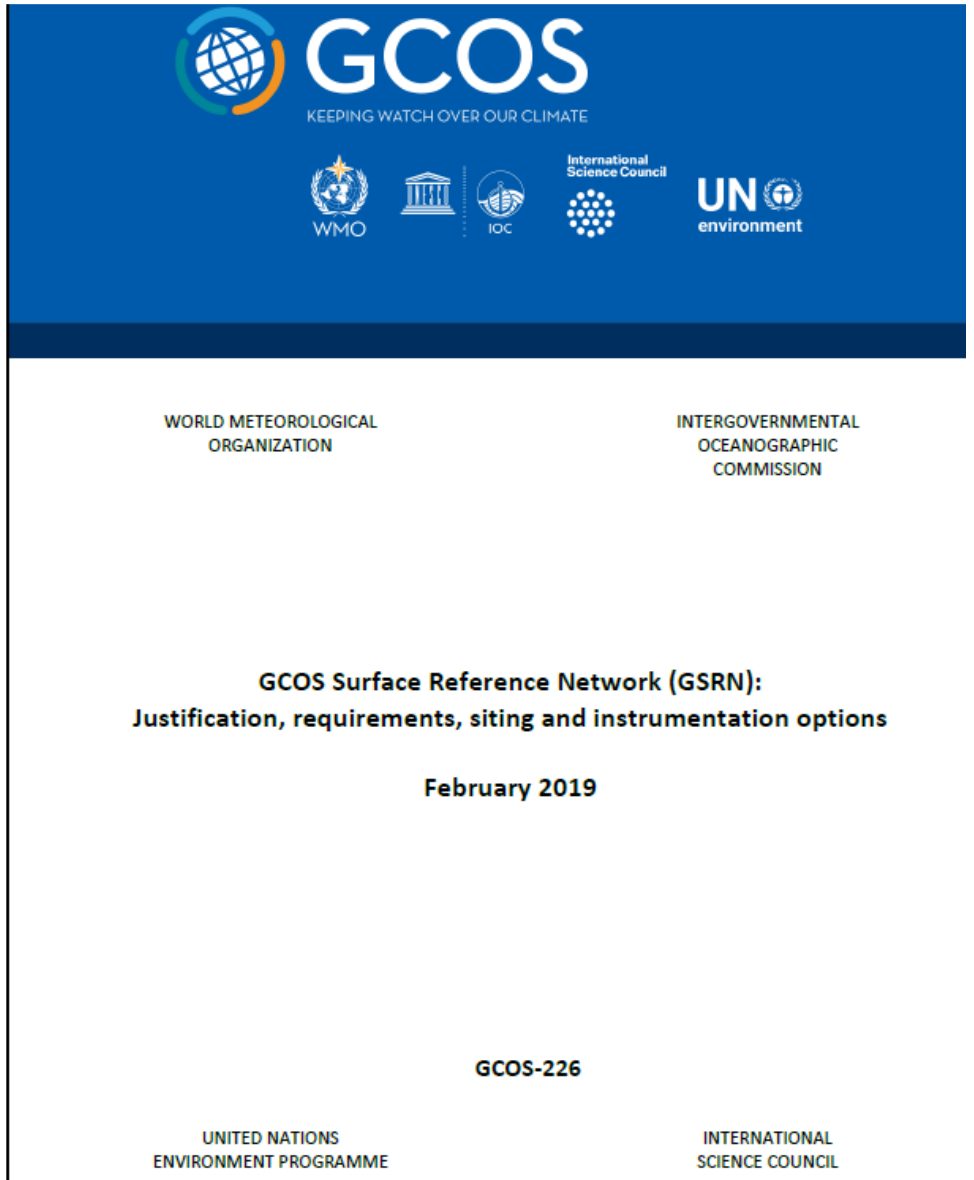
CRS
Climate Reference Station
a MeteoMet initiative

EMPIR 19SIP03 - «Climate Reference Station»

Coordinator: A. Merlone

Primary supporter: WMO

November 2020 – October 2023


GCOS
KEEPING WATCH OVER OUR CLIMATE

WMO IOC International Science Council UN environment

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

GCOS Surface Reference Network (GSRN):
Justification, requirements, siting and instrumentation options

February 2019

GCOS-226

UNITED NATIONS ENVIRONMENT PROGRAMME

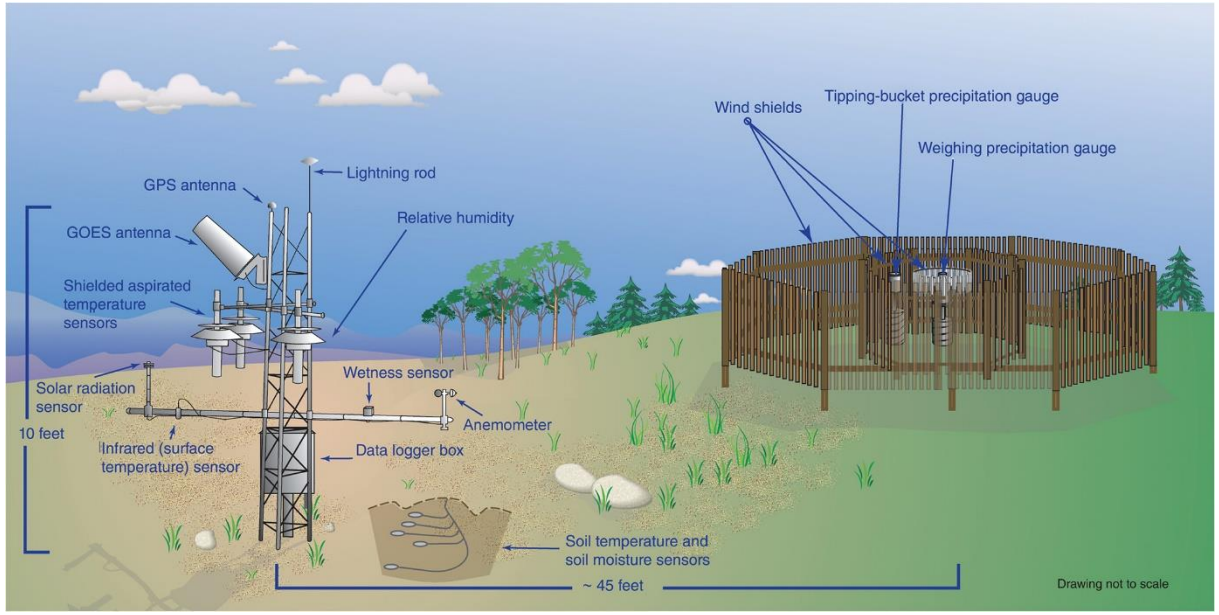
INTERNATIONAL SCIENCE COUNCIL

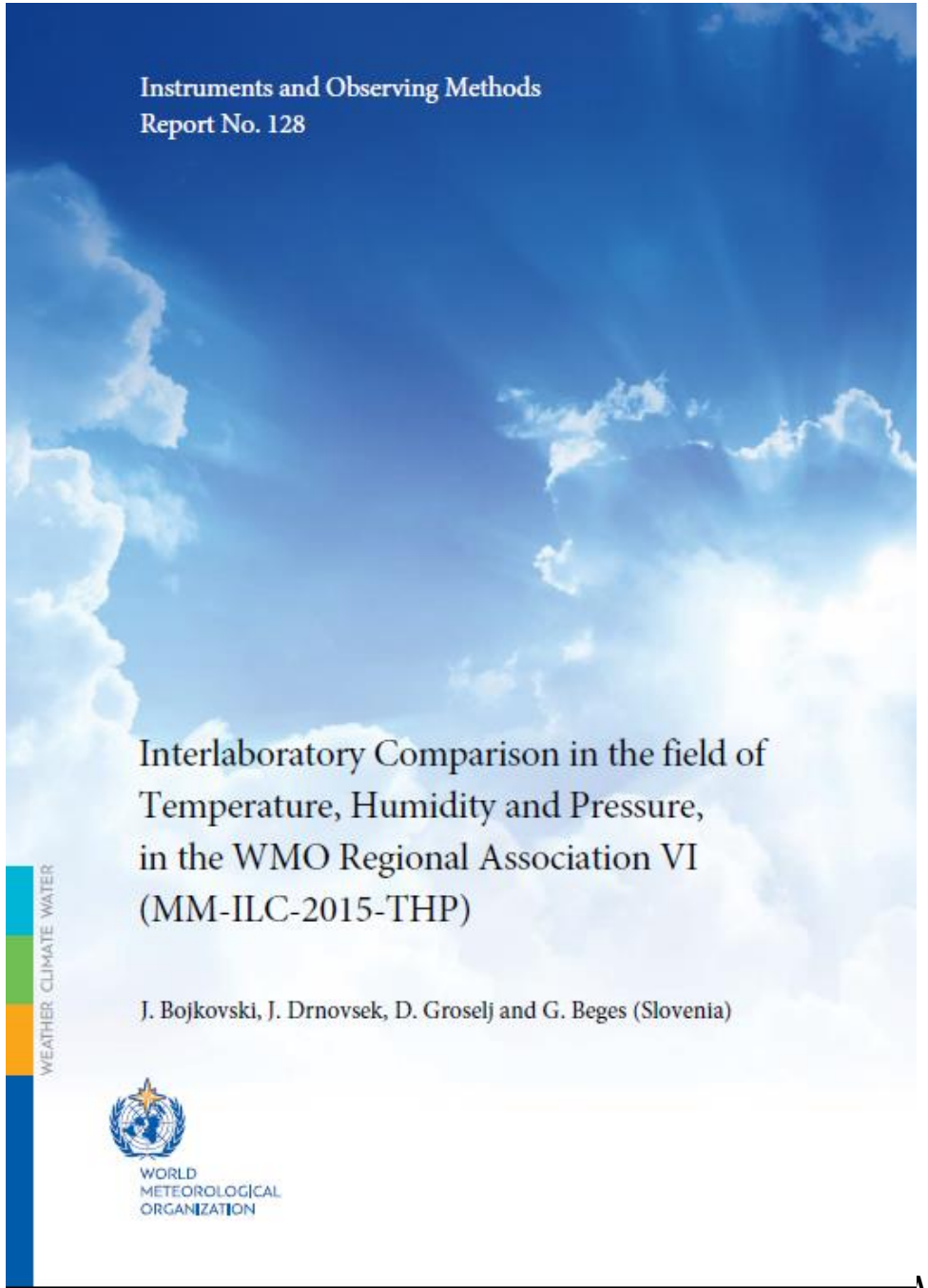
EMPIR 19SIP03 – CRS
Climate Reference Stations

Start date: Nov 2020

Primary Supporter:	World Meteorological Organisation
Contact:	Manola Brunet – WMO CCl President
Address:	Centre for Climate Change (C3) at University Rovira I Virgili - Carrer de l`Escorxador, s/n, 43003 Tarragona - Spain

Support the definition of the instrumental features required for reference climatological stations and their recommendation to the WMO Commission of Climatology and for the Global Climate Observing System Surface Reference Network (GSRN) for implementation.





METEOMET
Metrology for Meteorology

Originated as MeteoMet task, for the European Meteorological ad Hydrological services, it extended (concluded) in Asia and is now planned in South America and Africa

WMO-MM-ILC-2015-THP in WMO region VI
published as IOM Report No. 128

University of Ljubljana Faculty of electrical engineering

WMO-MM-ILC-2018-THP-2 in WMO region II and V
is in a final draft stage

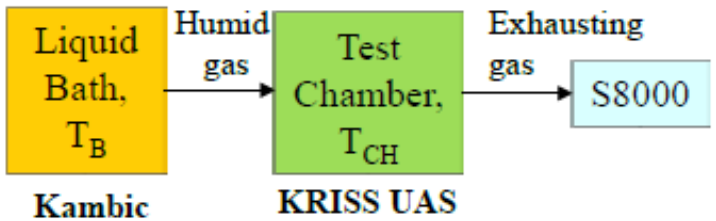
気象庁 Japan Meteorological Agency

To spread the same idea is planned
WMO-MM-ILC-2020-THP in WMO region I, III and IV

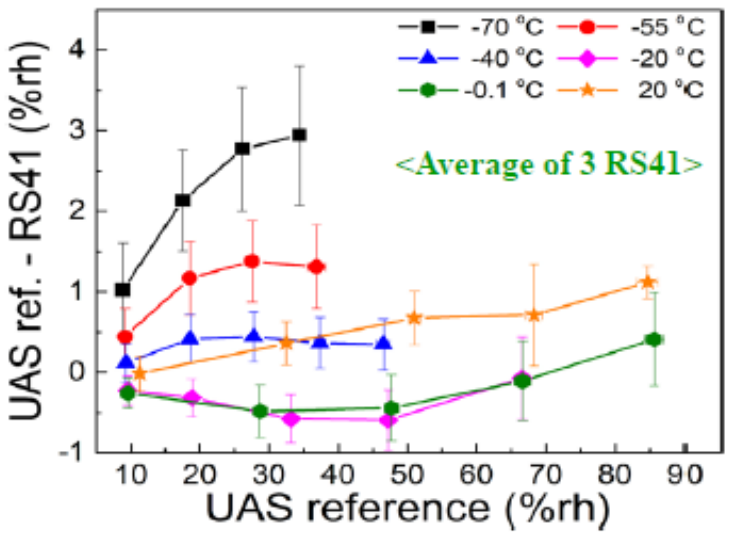
Instituto Nacional de Tecnología Industrial INTI

Construction of radiosonde humidity test facility

- Humidity generation using 2T method
  - Temperature range down to -70 °C
  - Radiosonde inside test chamber
  - Combining with chilled mirror hygrometer (Michell S8000)
  - Calibration uncertainty of (1.0 ~ 1.5) %rh ($k = 2$)



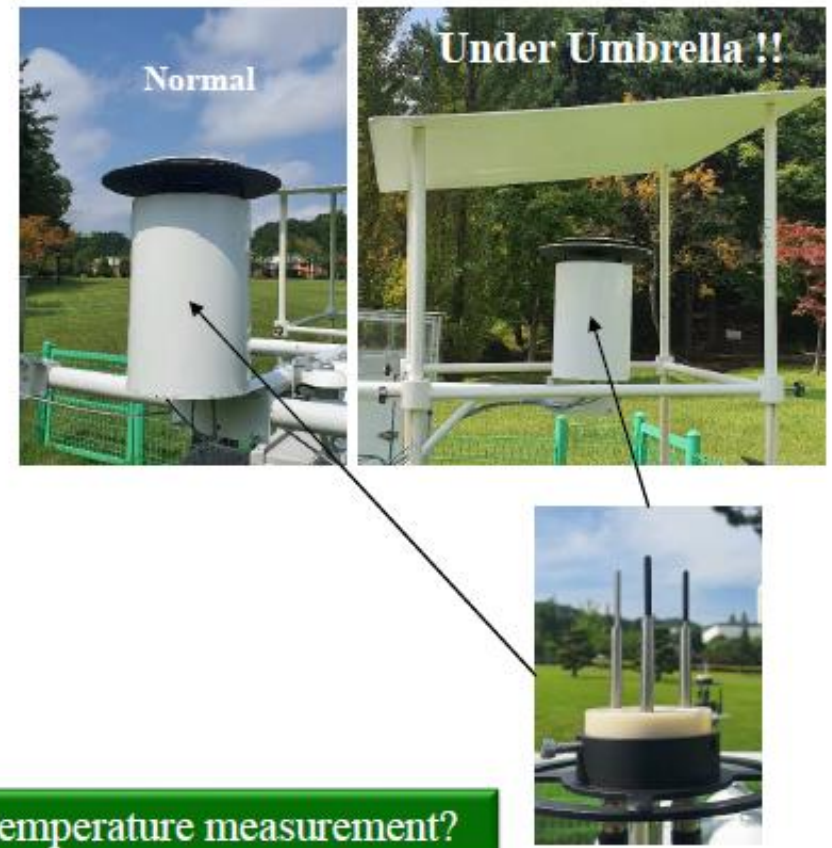
<Calibration example of RS41>



Studies on Air Temperature Measurement

- **KRISS AWS station**
  - 5 thermometer screens
    - 2 KRISS, 2 Barani, 1 Vaisala
  - Barometer, Anemometer, Radiometer
- KRISS-made radiation screens
  - Forced convection type (2~3 m/s)
  - One white, two black-coated PT100s inside
    - To study the effects of albedo
  - **Normal vs Umbrella style**
    - **My key point!**
- **Umbrella screen**
  - Screen under umbrella (first trial in the world in my knowledge!)
  - **Umbrella can protect from direct sunlight, rain, and snow.**
- Comparison of thermometer screen
  - **KRISS vs Barani vs Vaisala**

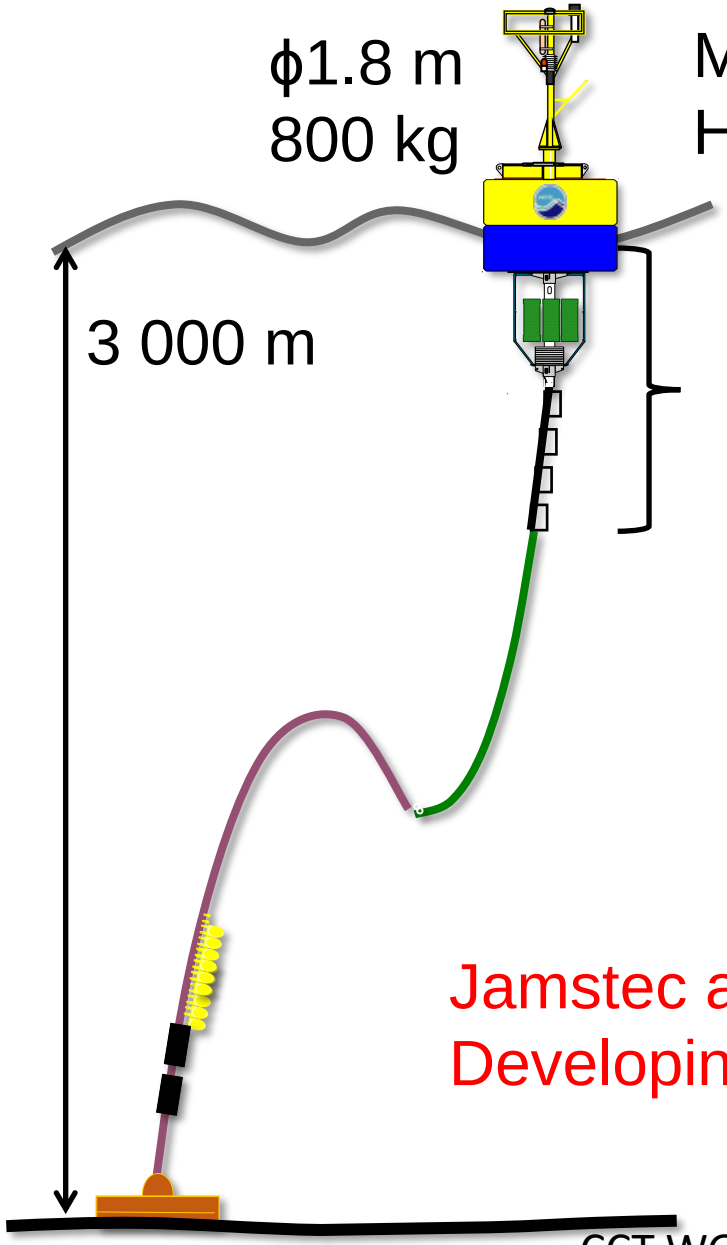
KRISS-made radiation screens



Which type of screen is the best for air temperature measurement?

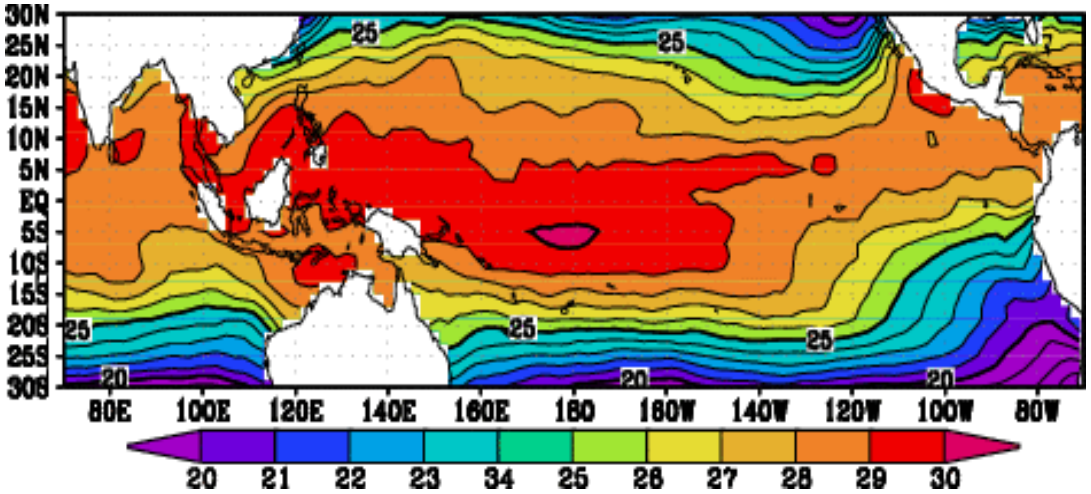
KRISS Korea Research Institute of Standards and Science

Observation Mooring System



Meteorological sensors; Temperature, Humidity, Wind, Radiation, Rain gauge

Under water sensors (0 – 750 m) ;
Temperature,
Salinity, Depth, Current

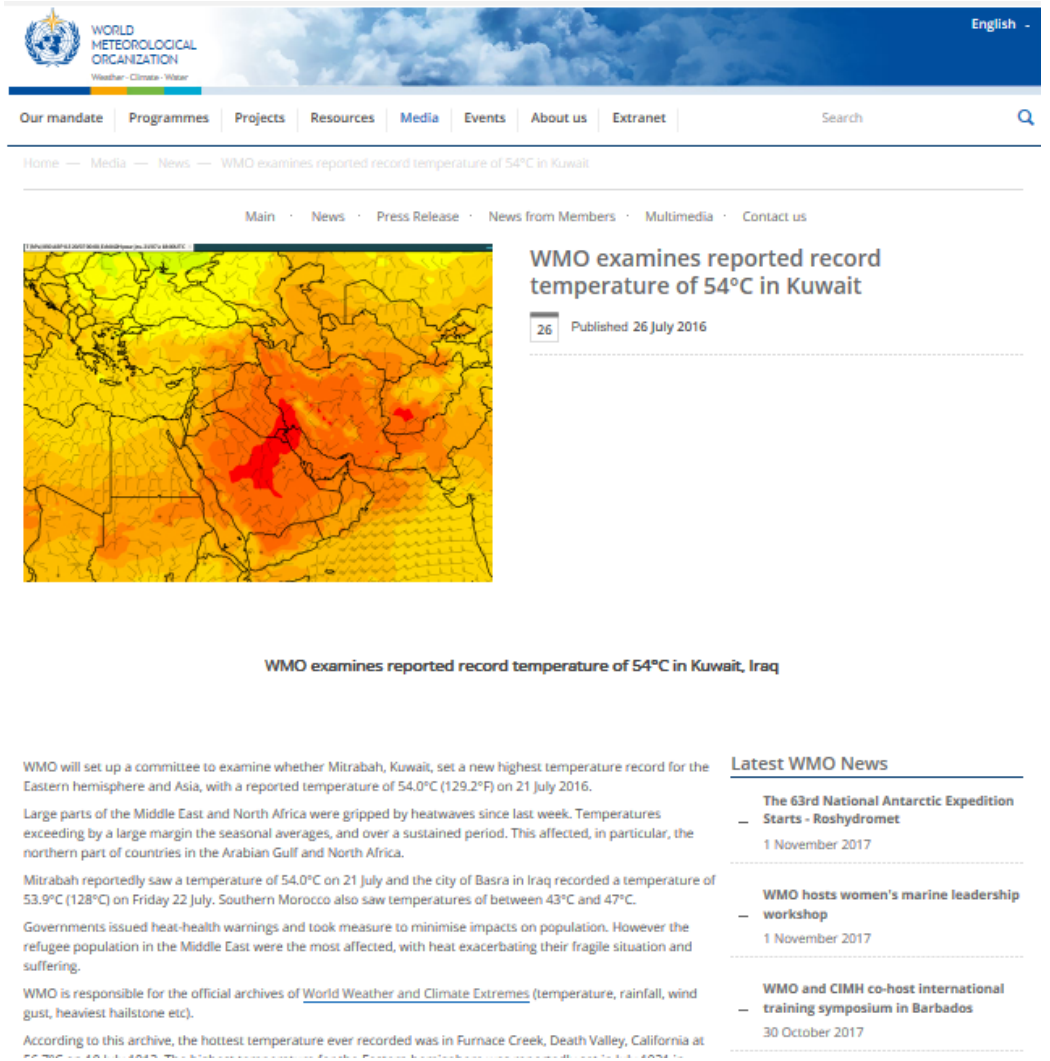


Jamstec and NMIJ/AIST :
Developing a calibration system for ocean therms*

* S. Baba et al.; Tuesday, Session O 4.8

Extreme temperature record: 54 °C

For the first time the metrology community (CCT) was requested to contribute to the validation process



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Home — Media — News — WMO examines reported record temperature of 54°C in Kuwait

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WMO examines reported record temperature of 54°C in Kuwait

26 Published 26 July 2016

WMO examines reported record temperature of 54°C in Kuwait, Iraq

WMO will set up a committee to examine whether Mitrabah, Kuwait, set a new highest temperature record for the Eastern hemisphere and Asia, with a reported temperature of 54.0°C (129.2°F) on 21 July 2016.

Large parts of the Middle East and North Africa were gripped by heatwaves since last week. Temperatures exceeding by a large margin the seasonal averages, and over a sustained period. This affected, in particular, the northern part of countries in the Arabian Gulf and North Africa.

Mitrabah reportedly saw a temperature of 54.0°C on 21 July and the city of Basra in Iraq recorded a temperature of 53.9°C (128°C) on Friday 22 July. Southern Morocco also saw temperatures of between 43°C and 47°C.

Governments issued heat-health warnings and took measure to minimise impacts on population. However the refugee population in the Middle East were the most affected, with heat exacerbating their fragile situation and suffering.

WMO is responsible for the official archives of World Weather and Climate Extremes (temperature, rainfall, wind gust, heaviest hailstone etc).

According to this archive, the hottest temperature ever recorded was in Furnace Creek, Death Valley, California at

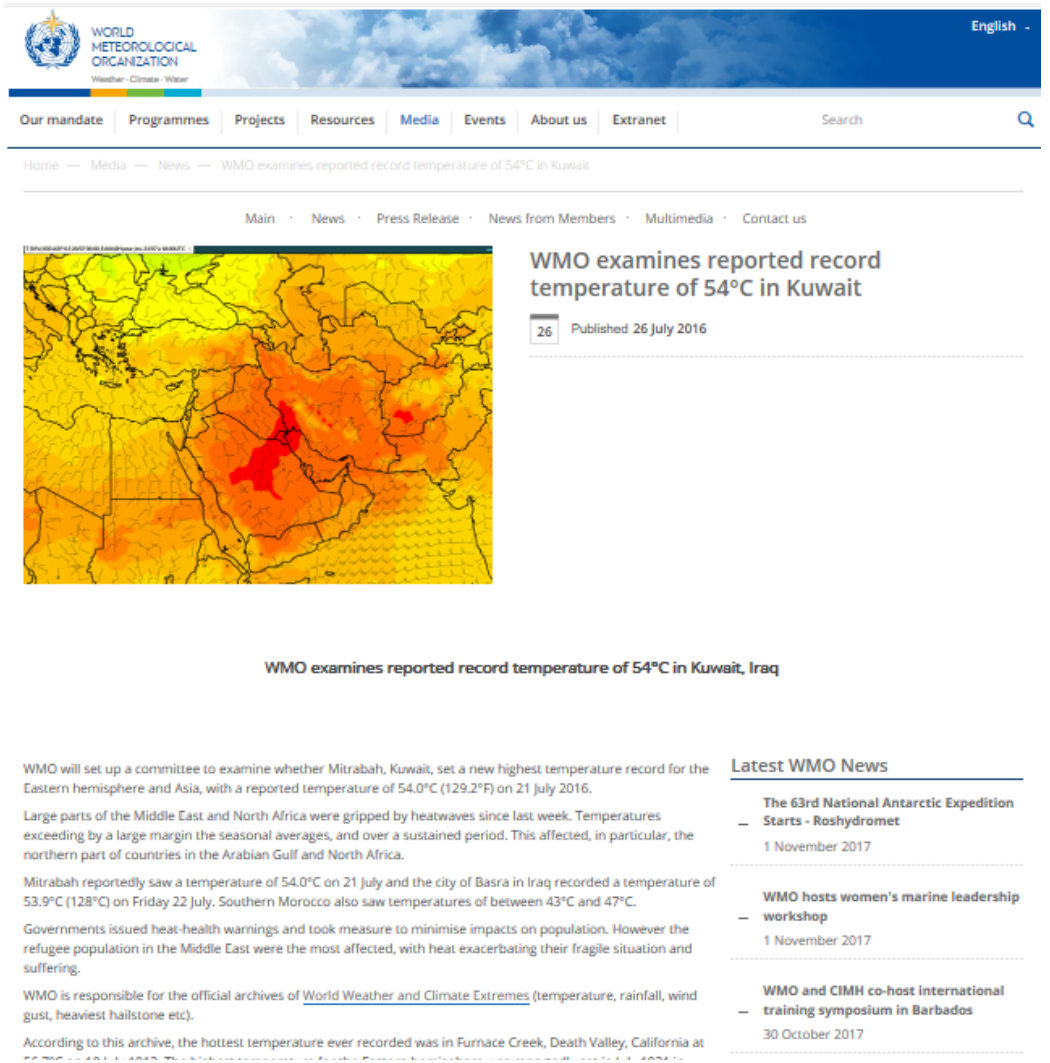
Latest WMO News

- The 63rd National Antarctic Expedition Starts - Roshydromet
  1 November 2017
- WMO hosts women's marine leadership workshop
  1 November 2017
- WMO and CIMH co-host international training symposium in Barbados
  30 October 2017

WMO Formally requests to validate two temperature records, being the third value ever recorded and the highest in Asia

2016 Mitribah - Kuwait 54 °C
2017 Turbat - Pakistan 54 °C

Study and research on conditions, heat wave, instruments, uncertainties



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Home — Media — News — WMO examines reported record temperature of 54°C in Kuwait

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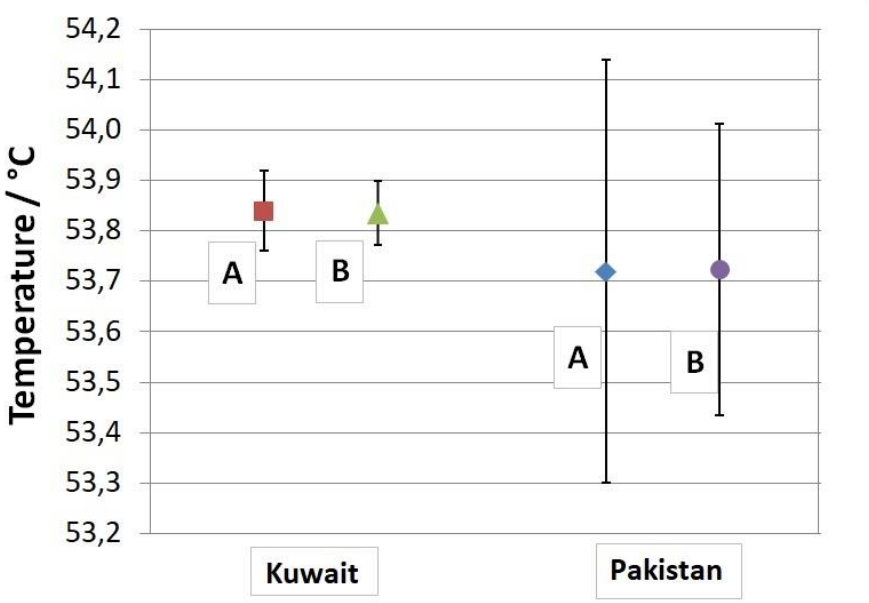
Results

	Corrected Value (°C)	Uncertainty (°C)
Kuwait calibration (A)	53.87	±0.080
Kuwait comparison (B)	53.84	±0.064
Pakistan calibration (A)	53.72	±0.40
Pakistan comparison (B)	53.72	±0.29



Received: 29 October 2018 | Revised: 6 May 2019 | Accepted: 7 May 2019
DOI: 10.1002/joc.6132

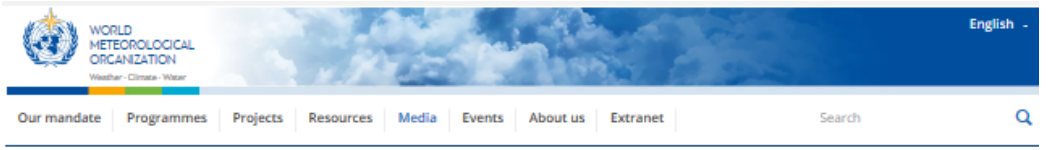
RESEARCH ARTICLE

International Journal of Climatology | RMetS

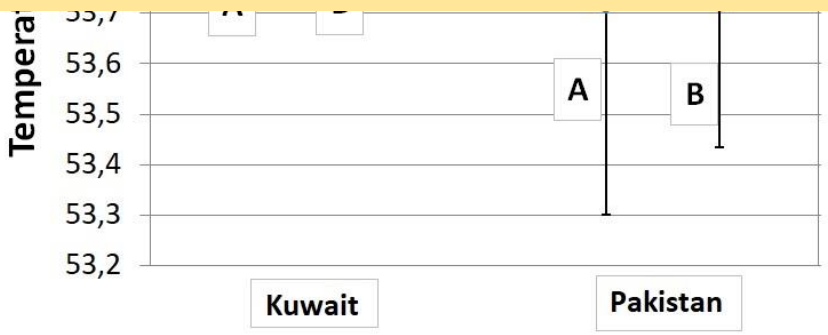
Temperature extreme records: World Meteorological Organization metrological and meteorological evaluation of the 54.0°C observations in Mitribah, Kuwait and Turbat, Pakistan in 2016/2017

Andrea Merlone[1] | Hassan Al-Dashti[2] | Nadeem Faisal[3] | Randall S. Cerveny[4] | Said AlSarmi[5] | Pierre Bessemoulin[6] | Manola Brunet[7,8,9] | Fatima Driouech[10] | Yelena Khalatyan[11] | Thomas C. Peterson[8] | Fatemeh Rahimzadeh[12] | Blair Trewin[13] | M. M. Abdel Wahab[14] | Serpil Yagan[15] | Graziano Coppa[1] | Denis Smorgon[1] | Chiara Musacchio[1] | Daniel Krahenbuhl[4]

Results



NOV 2020 - A new task included in the workplan of the WMO INFCOM Expert Team «Measurement Uncertainties» on establihshing a continuous process for validating extreme records at occurrence.



Organization metrological and meteorological evaluation of the 54.0°C observations in Mitribah, Kuwait and Turbat, Pakistan in 2016/2017

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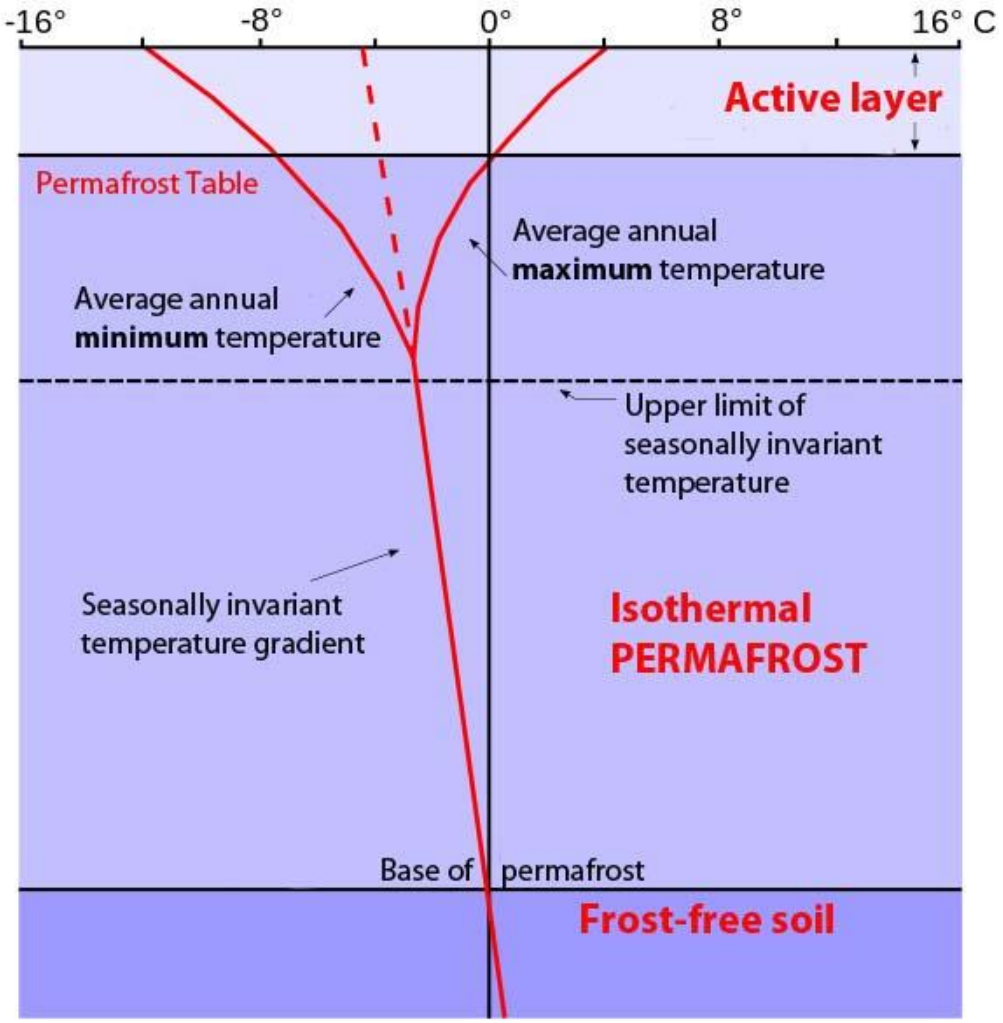
Permafrost: an amplified indicator of climate change.

Permafrost is ground (soil, rocks, sediments) that continuously remains frozen extending from the surface to to several kilometers deep under the Earth's surface.

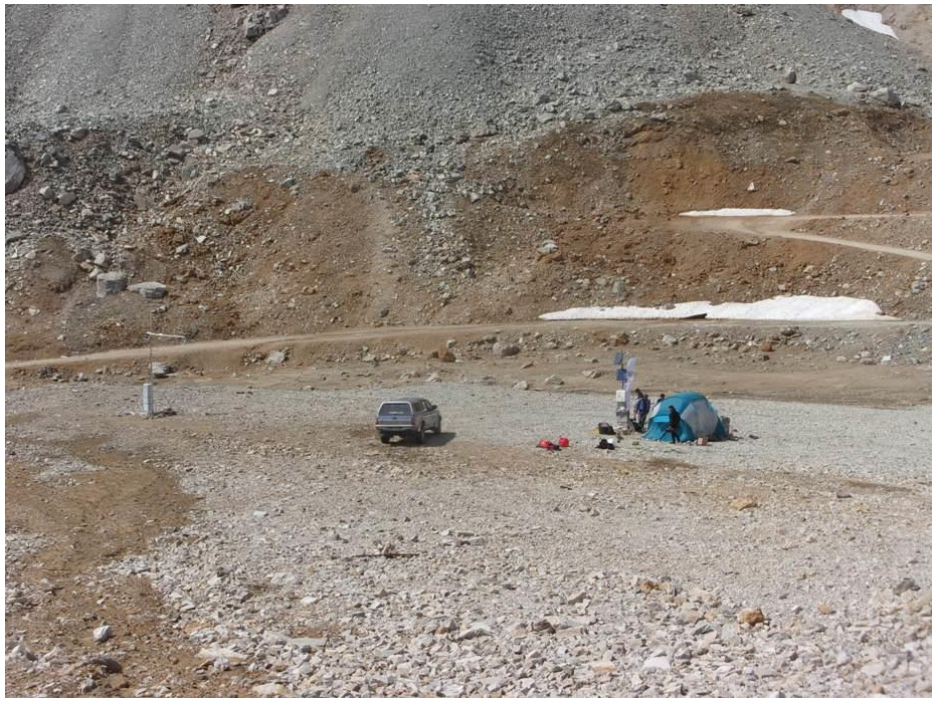
Permafrost is present in polar areas, cold regions and high mountains.

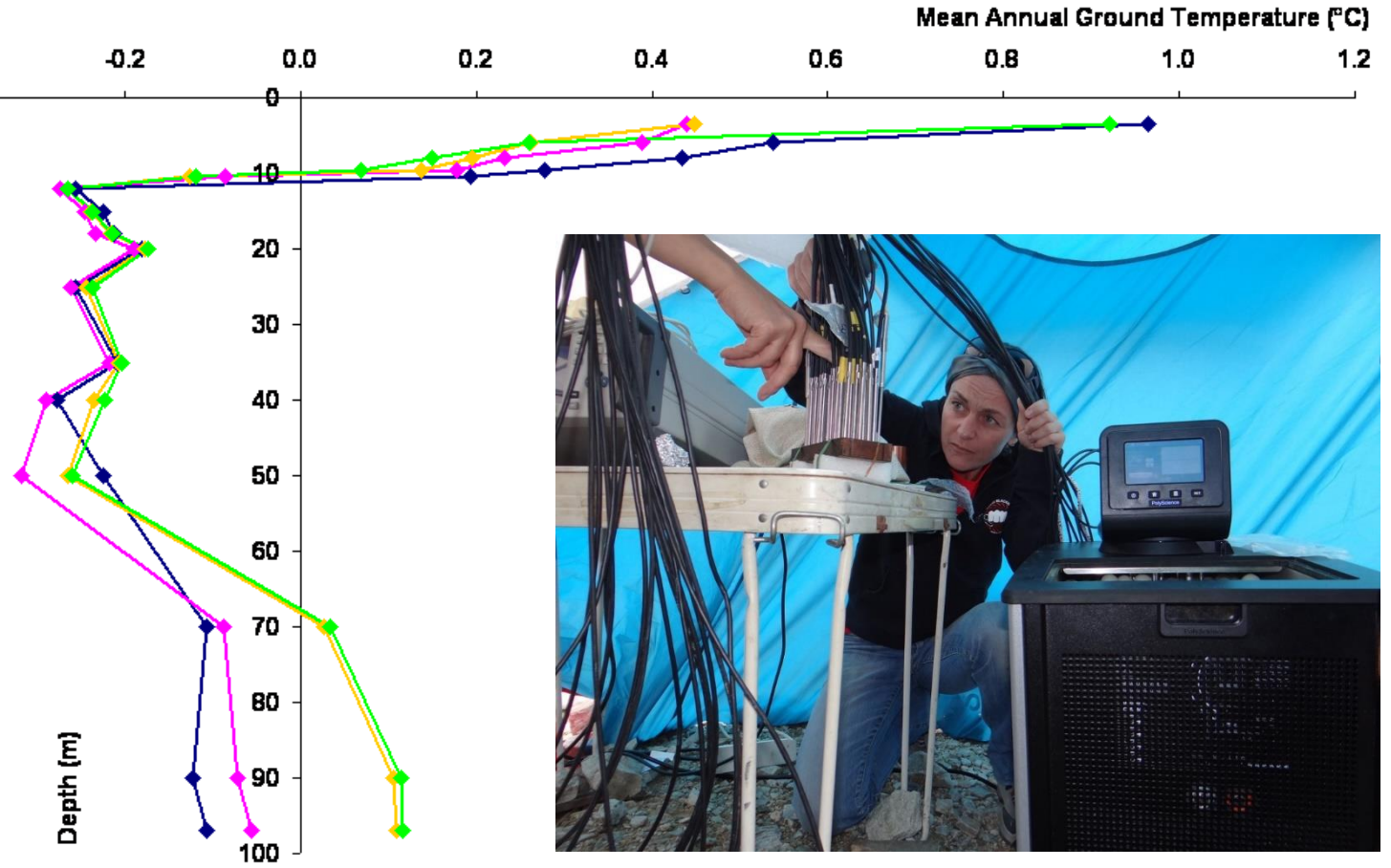
It freezes and thaws annually in its upper part, called «active layer». The active layer depth increases in the years, due to global warming. Permafrost is slowly disappearing in some areas, such as in the Alps.

Detecting the depth of the active layer requires temperature **measurements at the level of 0.02 °C**, which is challenging in such conditions and locations.



July 2017, August 2018, September 2020.
Permafrost monitoring. A metrology lab at 3000 m





WORLD METEOROLOGICAL ORGANIZATION
Weather • Climate • Water

Global Cryosphere Watch

2019 creation of the Permafrost best practice group

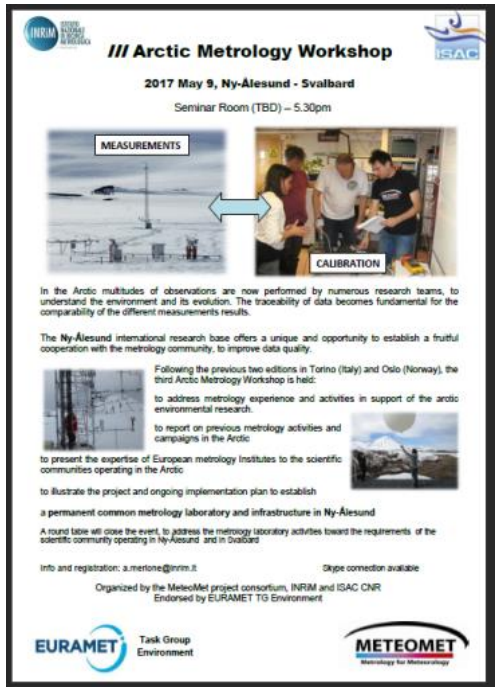
Andrea Merlone	INRiM (IT)	co-chair
Anna Irrgang	AWI (DE)	co chair
Rodica Nitu	WMO-GCW	secretariat
Jeanette Noetzli	SLF (CH)	member
Philippe Schoeneich	Univ.Grenoble (FR)	member
Ketil Isaksen	Meteo Norway (NO)	member

Develop recommended practices for permafrost observations, as well as uncertainty evaluations associated with present, operational stations, for inclusion in the WMO guide No. 8.

2017-2018 metrology in the Arctic

- **Field campaigns for the calibration of temperature and pressure sensonrs**
- **New Metrology lab opened and presented at the station leaders in Ny-Ålesund**

Arctic Metrology Workshops



/// Arctic Metrology Workshop

2017 May 9, Ny-Ålesund - Svalbard

Seminar Room (TBD) – 5.30pm

MEASUREMENTS

CALIBRATION

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Info and registration: a.merlone@inrim.it Skype connection available

Organized by the MeteoMet project consortium, INRIM and ISAC CNR
Endorsed by EURAMET TG Environment

EURAMET Task Group Environment

METEOMET Metrology for Meteorology

1st Torino, April 2015

2nd Oslo, May 2016

3rd Ny-Ålesund, May 2017

4th Oslo, November 2019

Svalbard Integrated Arctic Earth Observing System - SIOS

METEOMET
Metrology for Meteorology

CoAT

Increasing the COmparability of extreme Air Temperature measurements for meteorological and climate studies

EMPIR 06 SIP 19 – (MeteoMet SIP) – Coordinator Carmen Garcia Izquierdo – CEM – Oct 2020 – Sept. 2023

WMO Intercomparison of thermometers and shields in polar environment

Primary Supporter:

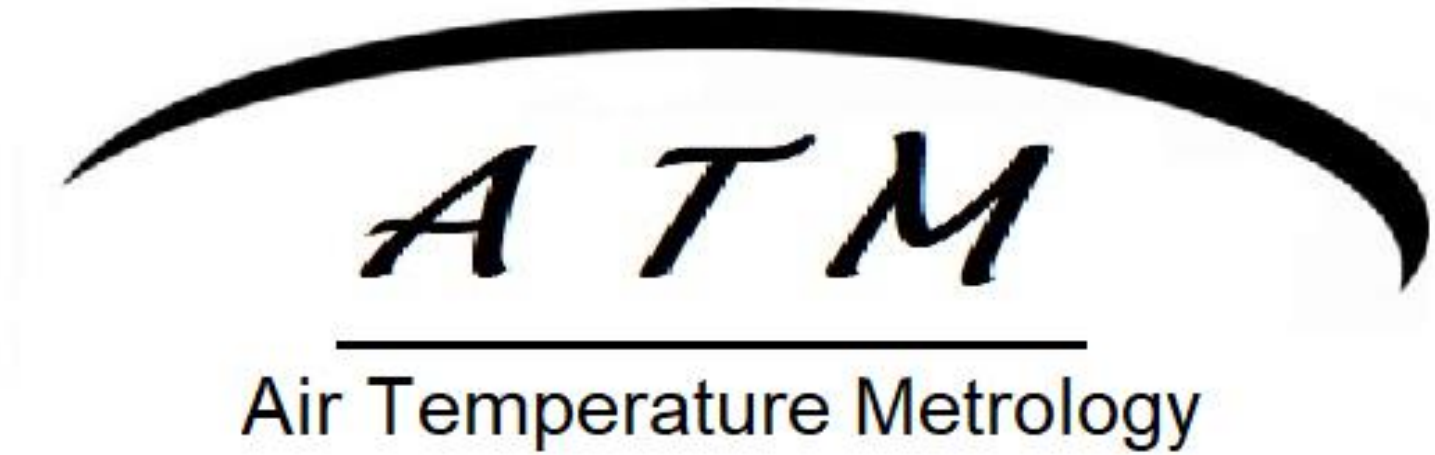
Primary Supporter:	World Meteorological Organization
Contact:	Bruce W. Forgan
Address:	WMO Secretariat – 7 bis, avenue de la Paix – Case postale 2300 – CH 1211 Genève 2 – Suisse

Participant details:

a. Partners (participants who will accede to the Grant Agreement)

no.	Participant Type	Short Name	Organisation legal full name	Country
1	Internal Funded Partner	CEM	Centro Español de Metrología	Spain
2	Internal Funded Partner	INRIM	Istituto Nazionale di Ricerca Metrologica	Italy
3	External Funded Partner	CNR	Consiglio Nazionale delle Ricerche	Italy
4	Unfunded Partner	EDI	Eidgenössische Departement des Innern	Switzerland

Air temperature


A T M
Air Temperature Metrology

Strategy Document for Rolling Programme Development for 2018 to 2027

The Consultative Committee for Thermometry

https://www.bipm.org/utils/en/pdf/CCT-strategy-document.pdf

	traceability of measurements.	
Guides on thermometry		
The guide on specialised fixed points has been prepared and is online.	Within the next year to have the two thermocouple guides (general thermocouple thermometry and reference thermocouples) online.	
	CCT recommends NMIs to include in their vision documents coordinated efforts of single NMIs, groups of NMI and RMOs towards the development of guidelines • for calibration of thermometers in air • for the evaluation of uncertainty components for temperature measurements in air, water (deep sea and sea surface, rivers, lakes, underground), ice and soil • to support the definition of target uncertainties and instrumental aspects in the creation of reference observing networks for climatology • to support metrology aspects in managing changes and transition from different instrument typologies (manual to automatic recordings)	CCT recommends NMIs to include in their vision documents coordinated efforts of single NMIs, groups of NMI and RMOs towards the identification of appropriate actions to disseminate best practice and adoption of metrological methods and terminology, also considering the opportunity of adapting such methods and terminologies, to practical use and input from the external communities

The **air temperature measurements** still present open issues in identifying the components of the uncertainties budget and in their evaluation. The evaluation of the uncertainty in atmospheric air temperature measurements, both at ground level and in upper atmosphere, together with a fully documented traceability, is the fundamental condition to achieve data comparability within and among observing networks, in space and time and for the validation of different techniques.
WG Environment to initiate studies and publication on this subject.
In a long-term vision, it is expected that the joint work of metrologists and the user community will improve the knowledge on this key measurement for atmospheric studies and climate monitoring.

ATM

Air Temperature Metrology

Two main tasks:

1. Perform a **pilot study** in the form of interlaboratory comparisons, to explore issues around calibration in air of temperature sensors ;

2. Feed into a **guidance document** the findings from the pilot study. (main objective)

EURAMET Project Form

Document: G-OPS-TMP-024 Version: 2.0
Approved: Head of Secretariat 2013-02-01

EURAMET

1	**Status**	X proposed ☐agreed	**Reference No**: *(if already existing)*
2	**Subject Field**	T - Temperature T - Temperature	
3	**Type of collaboration**	Cooperation in Research	
3A	**In the case of a comparison** Registered as Key comparison (KC) or Supplementary Comparison (SC) in the KCDB: X no ☐yes If yes: No. of KC/SC: In case of a KC: Protocol approved by the responsible CC WG? ☐no ☐yes		
4	**Coordinator** Institute/Country: Name: Phone: E-mail:	 INRiM - Italy Andrea Merlone +39011 3919 734 a.merlone@inrim.itT	
5	**Participating Partners**		
5A	EURAMET members or associates (Institute's standard acronym with country code in brackets) as registered on EURAMET website. INRiM (IT) CEM (ES) CMI (CZ) DTI (DK) LNE (FR) INTiBs (PL) NPL (UK) NSAI NML (IE) MIRS/UL-FE/LMK (SI) SMD (BE) UME (TK)		

ATM
Air Temperature Metrology

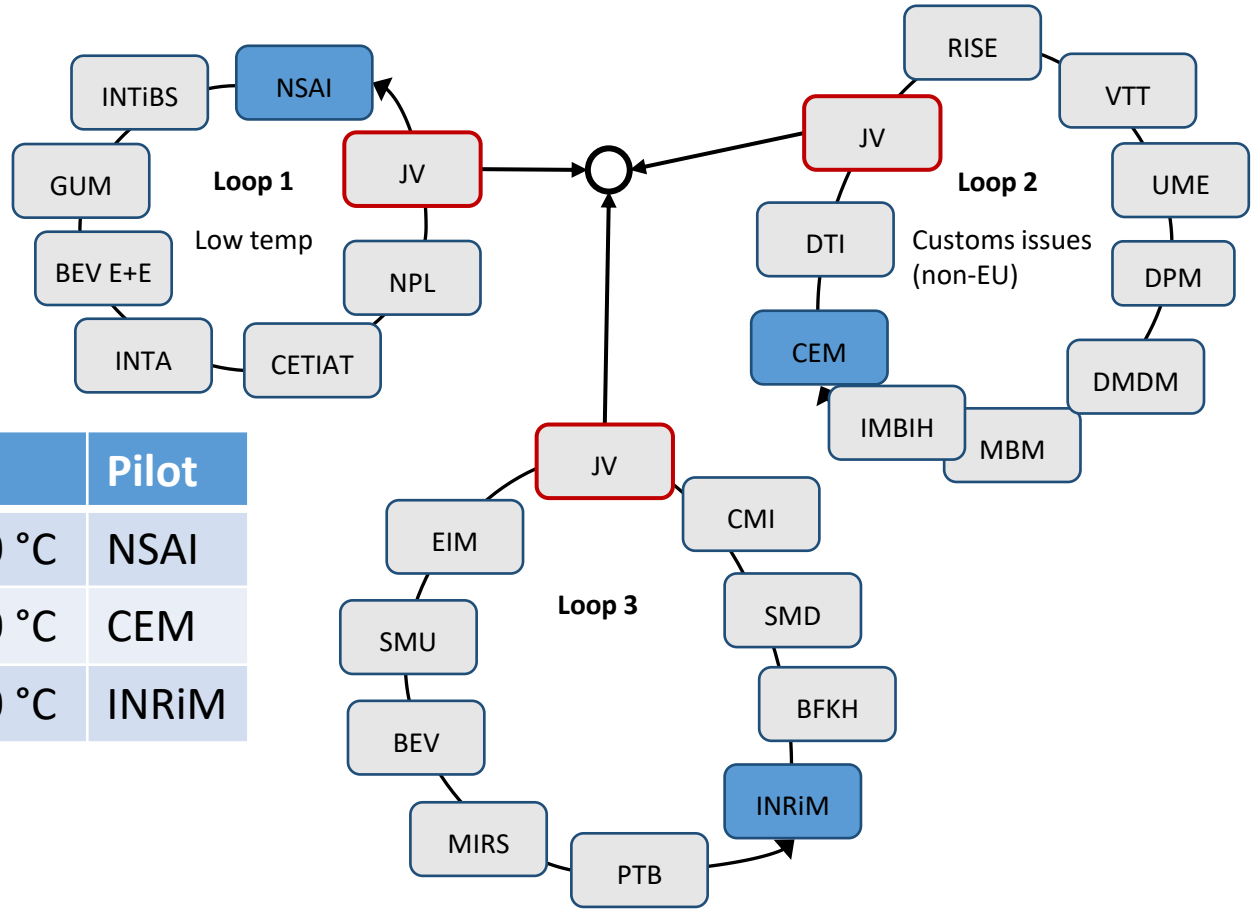
European air temperature Piloit Study - ILC

Goals:

- Identify calibration issues with common air temperature sensors
- Input to best practice for air temperature sensor calibration
- Help support CMCs (this ILC likely needs to be followed up)

Air Temperature Metrology

ILC Topology



Loop	Range	Pilot
Loop 1	-80 °C to 60 °C	NSAI
Loop 2	-60 °C to 60 °C	CEM
Loop 3	-60 °C to 60 °C	INRiM

Link is provided by JV

ATM
Air Temperature Metrology

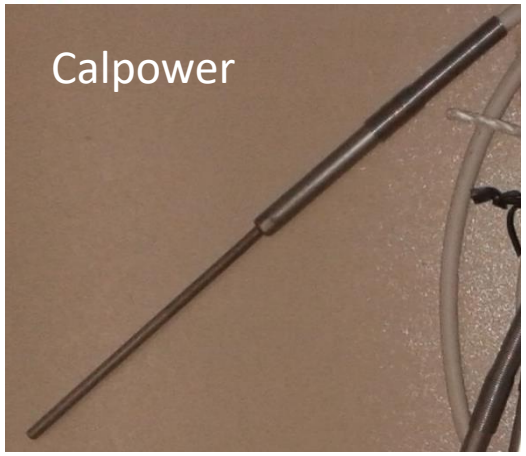
Sensors

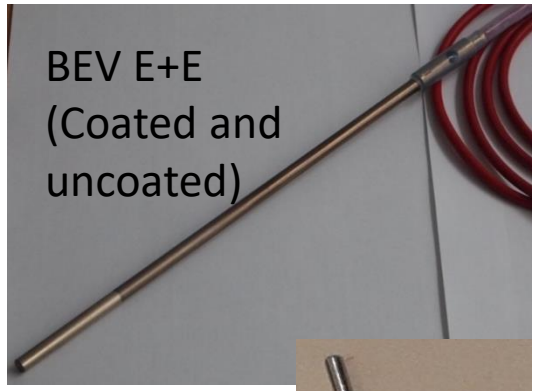
Manufacturer/Type	Probe dimensions (mm)	
	Length	Diameter
VAISALA/ TMP1	130	6
Calpower/ NS	130	3
WIKA/ TR60 Special	44	7.76
WIKA/ Model CTP5000-170B	350	6
PHYSICUS/ PT100/10	117	5
BEV E+E/PT100	230	6
BEV E+E/PT100 Coated	230	6
MBW	40	4

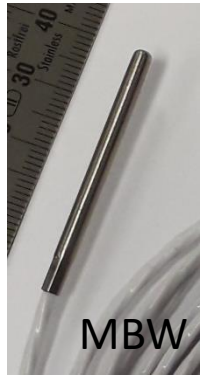
- All PRTs
- Wide range of mechanical shapes
- Different quality of electrical insulation
- Some handle immersion in liquid, some does not
- Minor repairs carried out by participants
- Cycling and careful characterisations carried out at pilots

ATM
Air Temperature Metrology

Sensors







Physicus PT100/10

ATM
Air Temperature Metrology

Observations

- ILC is close to the end. Data analysis will follow
- Sensors:
  - Some humidity issues seen (irreproducible measurements)
  - A few trivial fixes (cables, insulation)
  - Additional heat treatment twice
- Rescheduling
  - Twice in response to participant needs
  - Once due to customs issues
- Some difficulty reaching the lowest temperatures
- Very different approaches in the laboratories
  - Encouraged from the start to support the research objectives
  - Hopefully valuable input to best practice

ATM

Air Temperature Metrology

NMIs from other RMOs
are invited to join the project for
producing a common best practice guide
for calibration of thermometers in air.

Atmospheric air temperature.

Definition -> Position paper

It was concluded that air temperature is an underrated measurement problem/difficulty in metrology and a widely measured variable in numerous studies and as a quantity of influence. The preparation of a position paper on understanding and evaluating uncertainties in air temperature measurements has so been proposed.

A task group is proposed (not limited to WG ENV Members)**…**

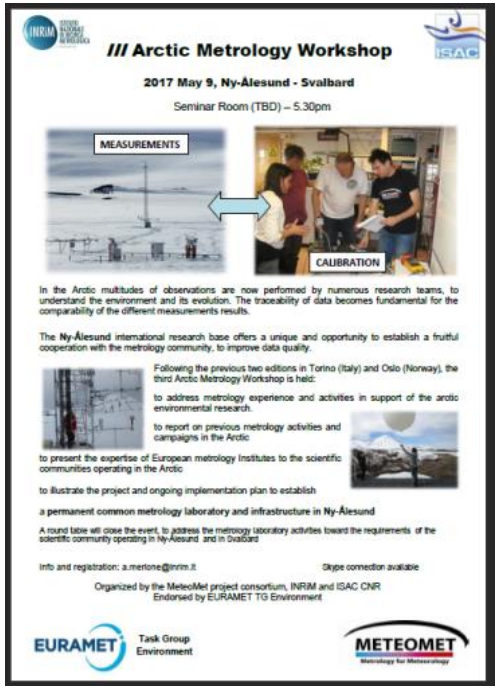
- Prepare the position paper
- Identify needs, promote and coordinate activities on the various open issues about evaluating uncertainties in air *t*
- Deliver a proposal for an operative definition of air *t*

Events

V Arctic Metrology Workshop

Longyearbyen – Svalbard

Hosted by University of Svalbard and SIOS date ?



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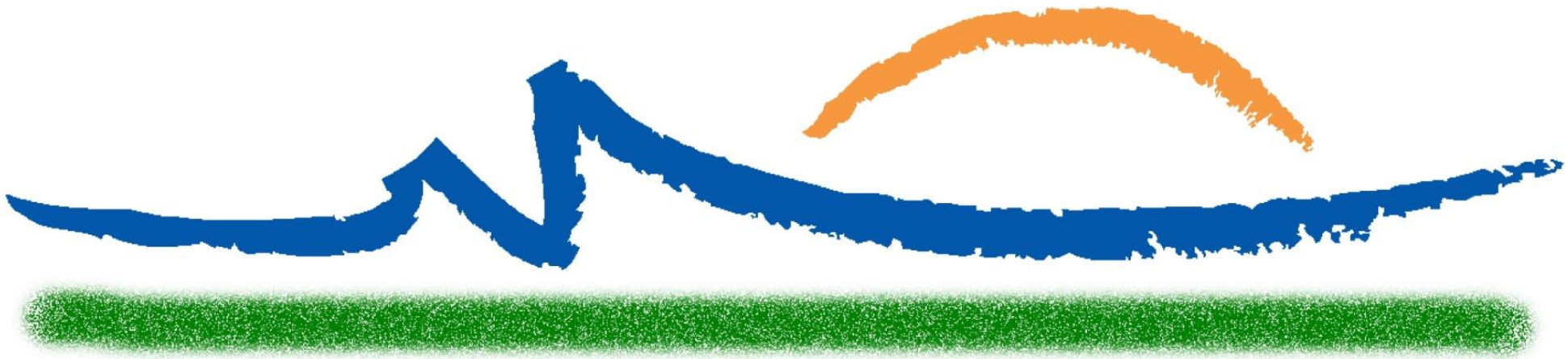
METEOMET

MMC Exeter – UK 2021



METROLOGY FOR METEOROLOGY AND CLIMATE

MMC 2021

Exeter – UK Met Office
September 2021

CCT WG Env – Report 2020 – A. Merlone

MMC2021

- Proposed as hybrid event: both in person (if possible) and with web-based attendees (to increase participation and reduce travel costs and travel impact)

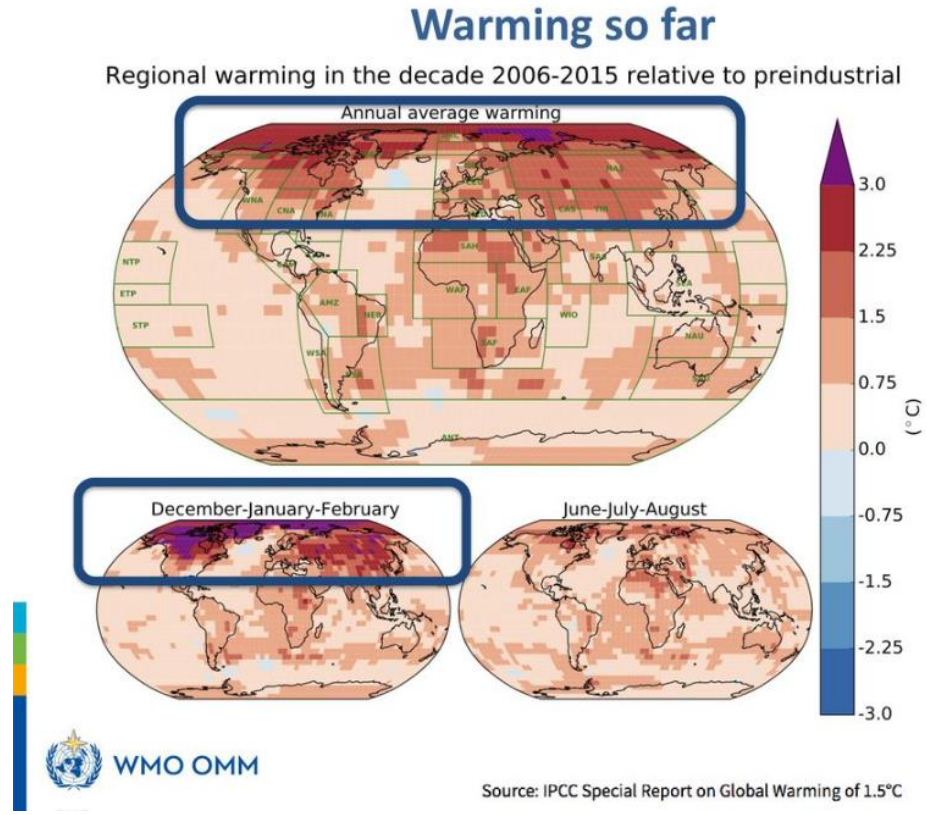
- Conference moved to Spring (April-May) 2022
- A "*Waiting for MMC*" webinar in October 2021.

- Same location (Exeter – UK – Met Office)

- WMO Secretariat proposes to have the SC-MINT meeting as satellite event

- CCT WG Environment can also meet (both in person and remotely)

So, what can we, thermal metrologists do for climate science?



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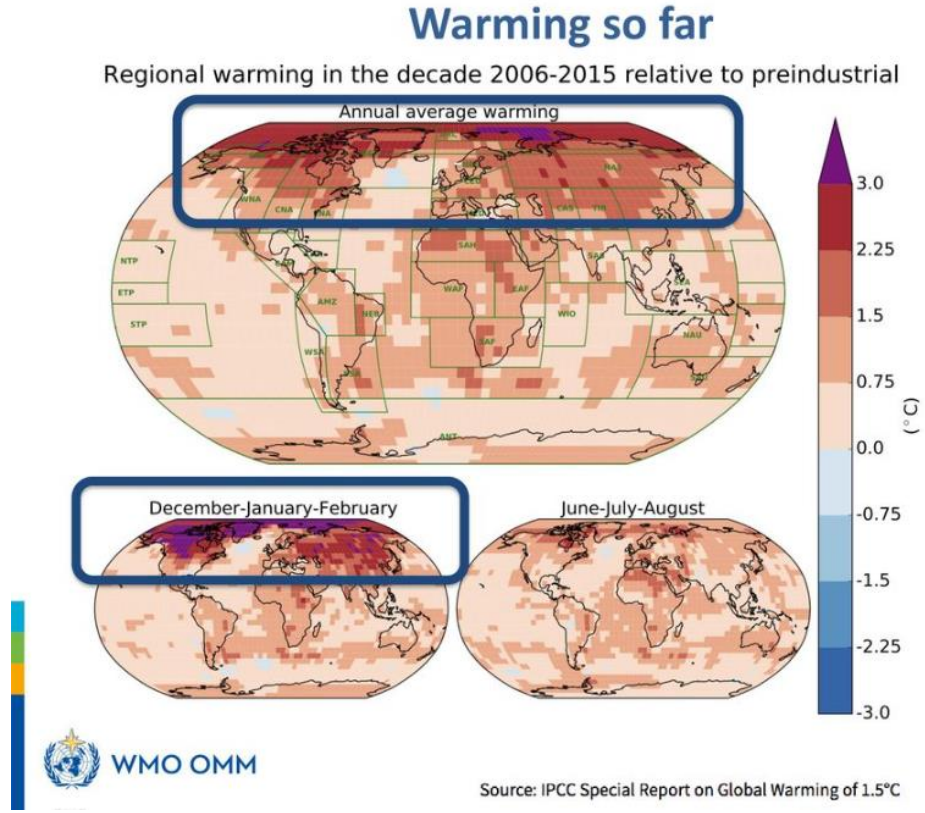
Just the thing we do better,



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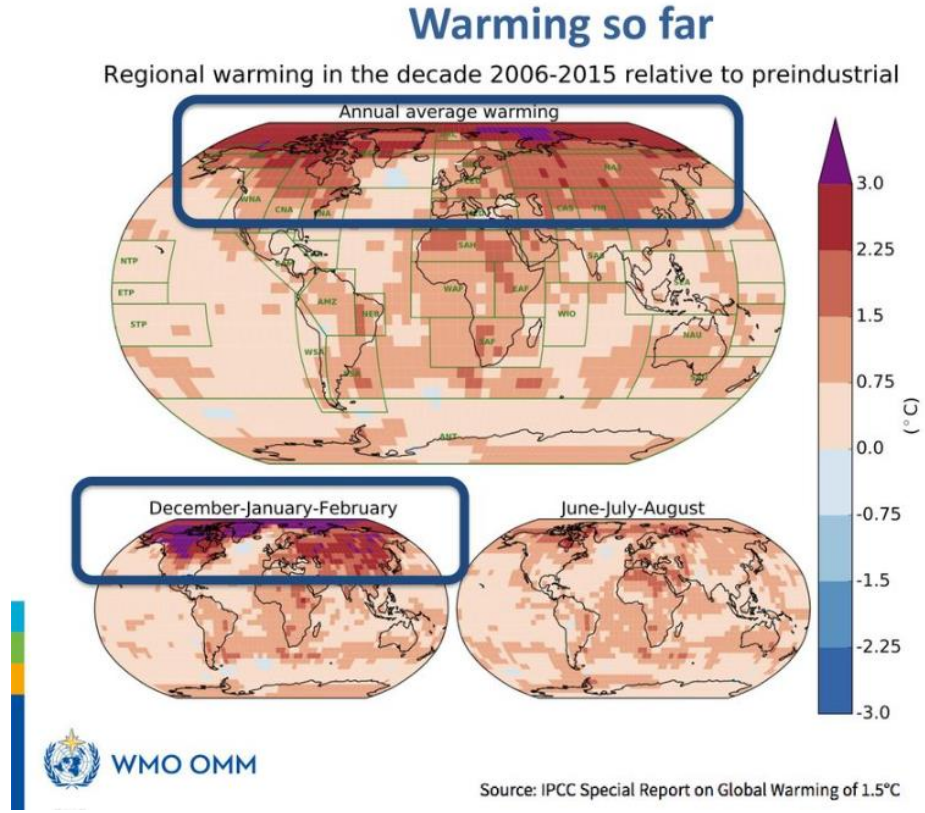

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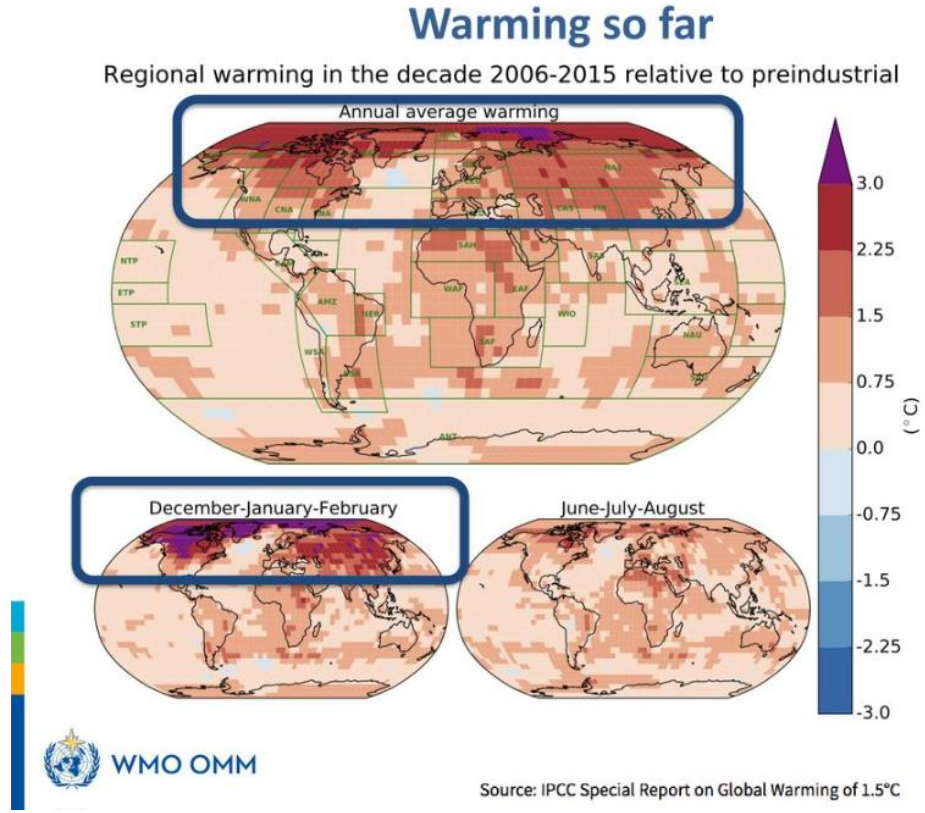

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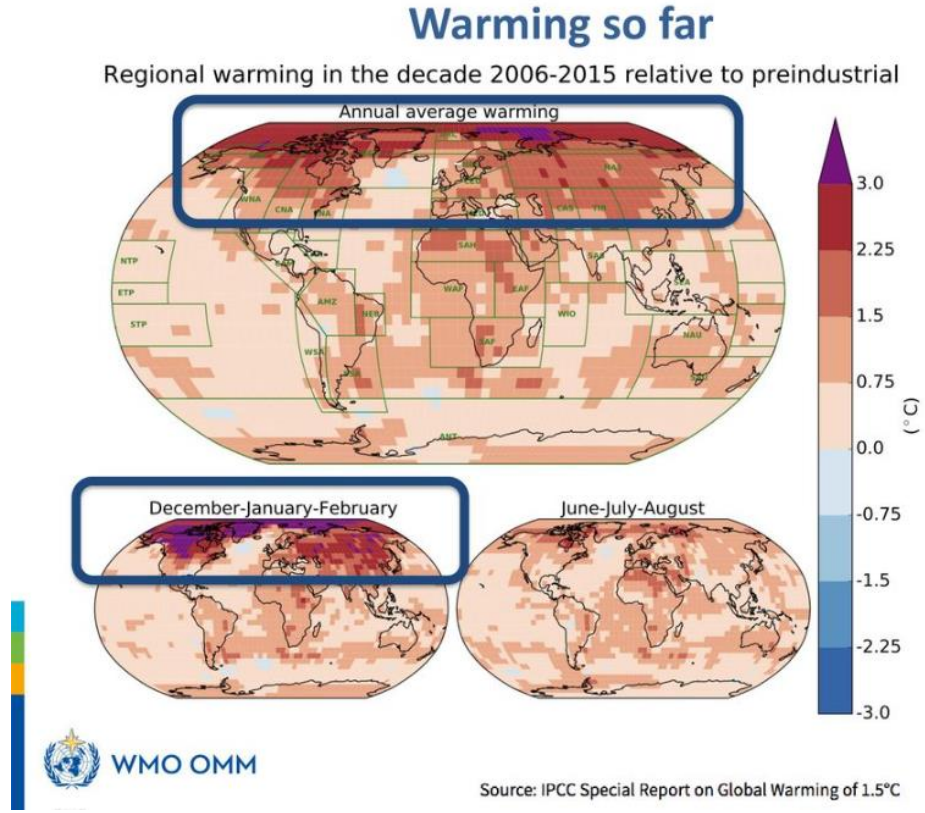

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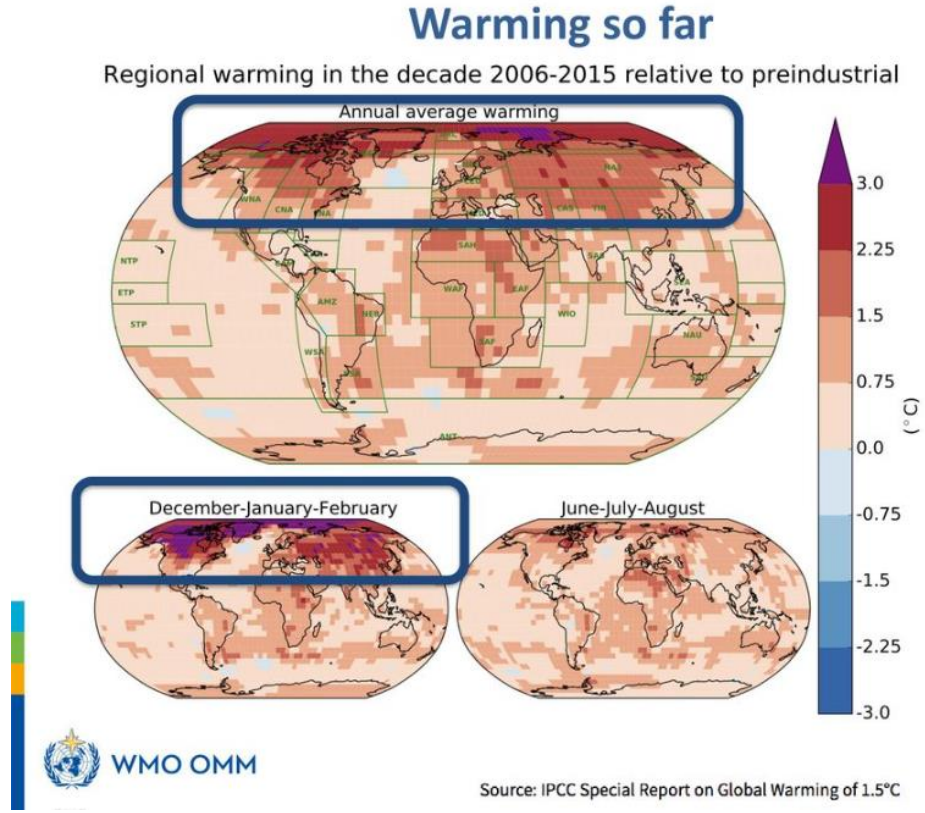
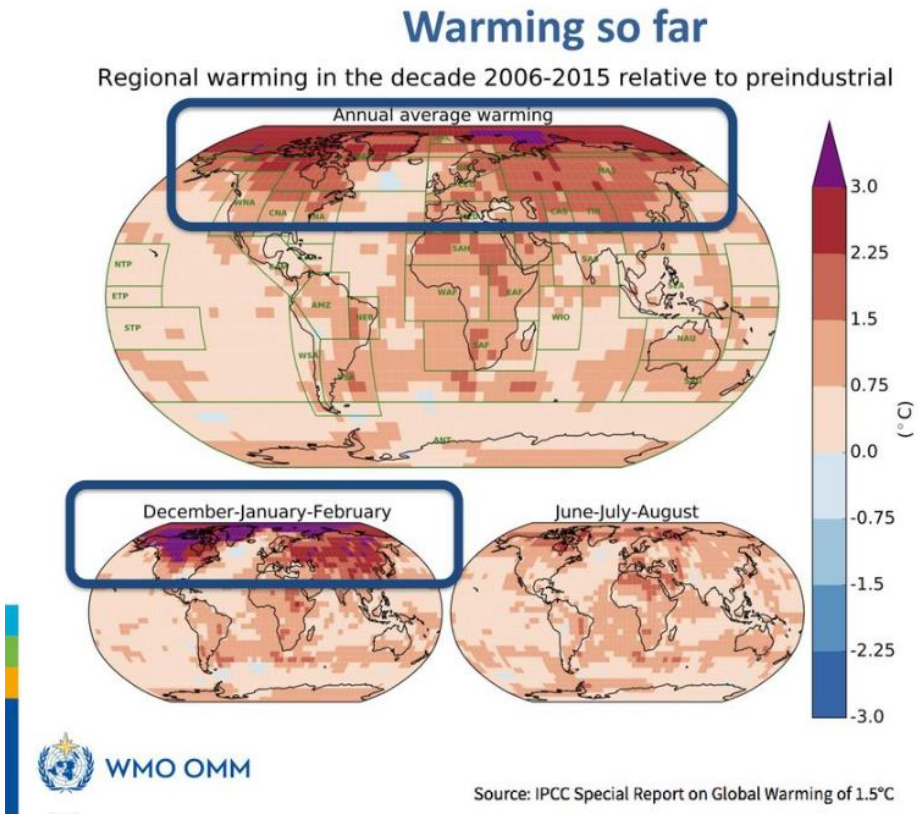
In air, water, soil, ice

And contribute in improving instruments, methods and uncertainty evaluations



As a motivated and united community



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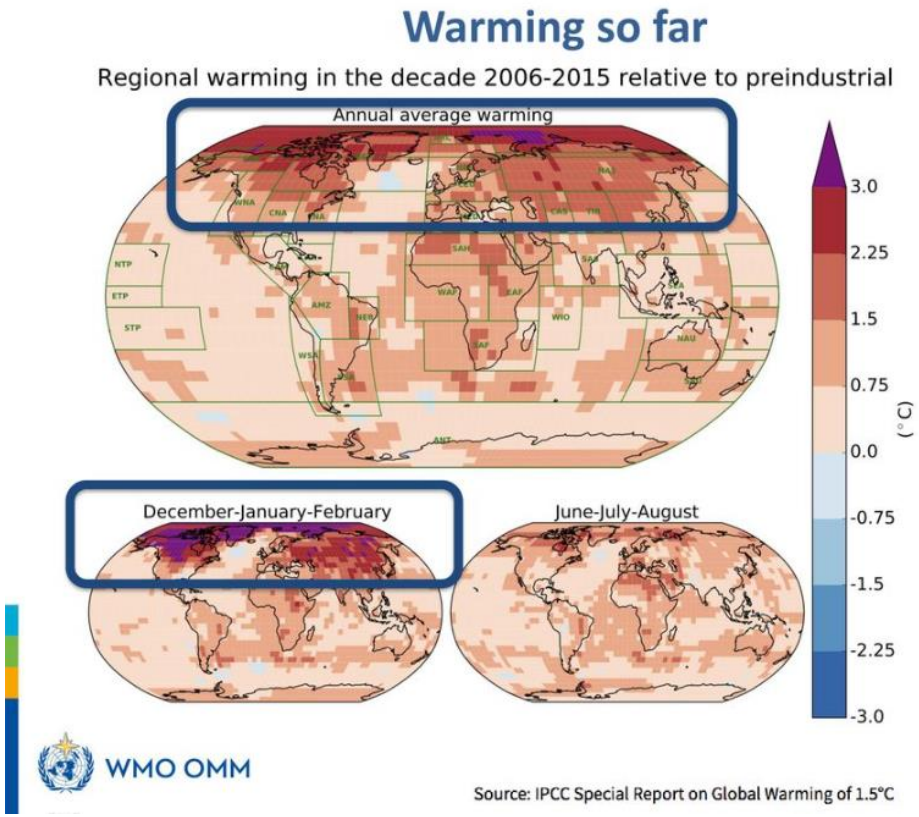

Hoping to meet in person soon

Thank you