



GOBIERNO  
DE ESPAÑA

MINISTERIO  
DE INDUSTRIA  
Y TURISMO



## Medida de las Variables Climáticas Esenciales

Día Mundial de la Metrología 2024

20 de Mayo 2024

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# El clima en La Tierra está cambiando, con catastróficas consecuencias para la sociedad

Grupo Intergubernamental de Expertos sobre el Cambio Climático (IPCC) sostiene que probablemente lleguemos a un calentamiento global de 1,5 °C, dependiendo del **aumento año a año**, entre el 2030 y el 2052

Tradicionalmente la cuantificación de estas tendencias requieren décadas de medidas. **No tenemos tanto tiempo!**

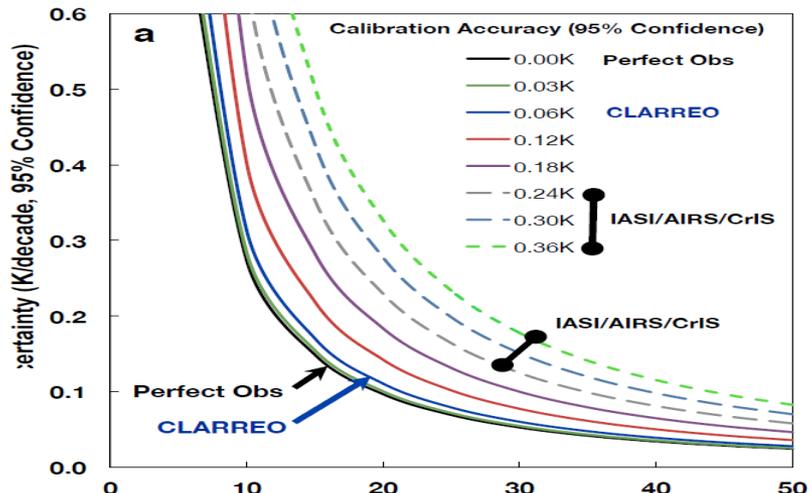
El establecimiento de **estrategias de mitigación y adaptación al cambio climático** deben ser vivas y basarse en una cuantificación robusta de la tendencia.

Una **detección inequívoca de esta tendencia solo es posible si se basa en medidas robustas, comparables y trazables a referencias invariables:**

**Sistema Internacional de Unidades**

## METROLOGIA

**¿Que magnitudes? Flujos de CO2, flujos de calor**





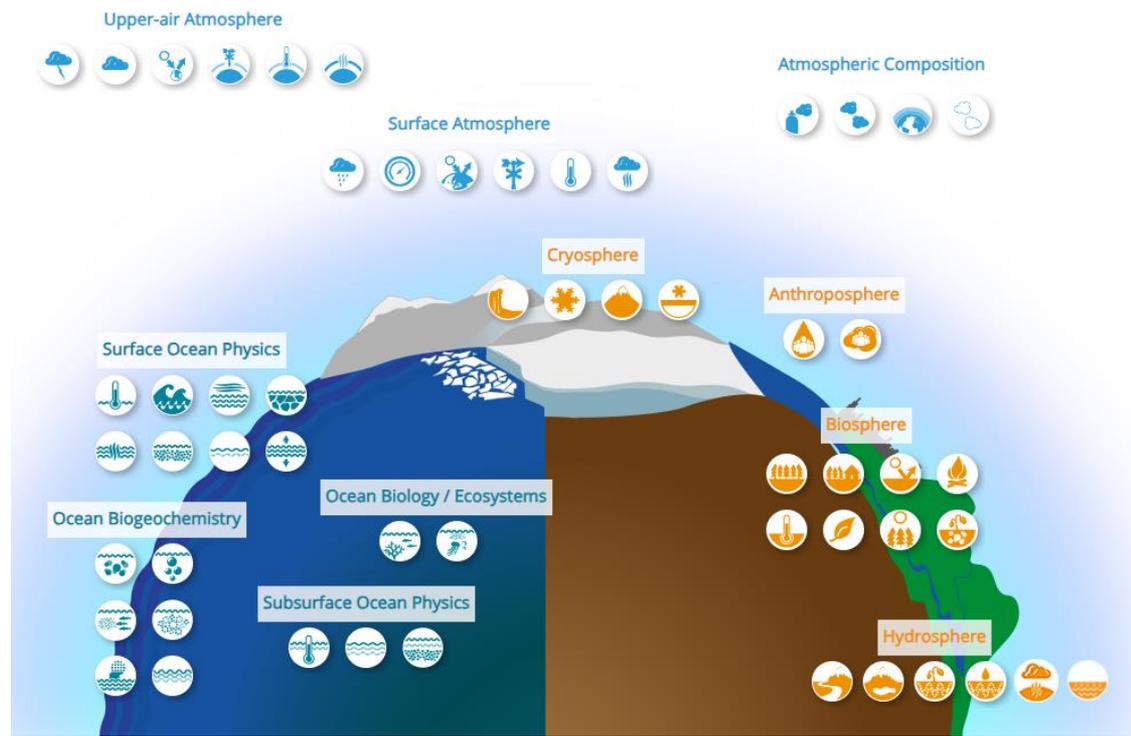
GCOS fue establecido en 1992 para asegurar que las observaciones y la información necesaria para abordar materias referentes al clima sean obtenidas y accesibles a todos los usuarios potenciales

Los paneles de expertos de GCOS mantienen las definiciones de las Variables Climáticas Esenciales. GCOS/ECVs

Una variable climática esencial (ECV) es una variable física, química o biológica o un grupo de variables que contribuye de manera crítica a la caracterización del clima.

En la actualidad hay 55 ECVs:

- Atmósfera
- Océano
- Tierra





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World Meteorological Organization  
Working together in weather, climate and water



**Michel Jarraud, Secretario General de la WMO, firmó el Acuerdo de Reconocimiento mutuo en nombre de la WMO. La firma tuvo lugar el 1 de Abril de 2010**

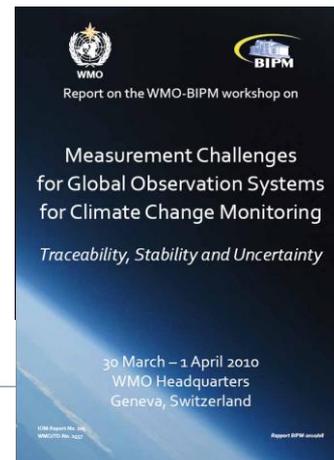


**METROLOGY FOR CLIMATE ACTION**  
26-30 SEPTEMBER 2022



Bureau International des Poids et Mesures  
Report BIPM 2022/15

WORLD METEOROLOGICAL ORGANIZATION  
WMO Report No. 142



La firma del Acuerdo de reconocimiento Mutuo por la WMO ha implicado un acercamiento y aumento de la cooperación, especialmente con miembros trabajando en metrología térmica



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May 2010

## CIPM - CCT Recommendation



25th Meeting of the CCT • 51

### RECOMMENDATION T 3 (2010) On climate and meteorological observations measurements

The Consultative Committee for Thermometry (CCT),

considering that

- global average temperature records are essential in understanding how the climate is

- Alentar a los **Centros Nacionales de Metrología** y a la comunidad científica, especialmente a los **metrólogos térmicos**, a prepararse para **afrentar nuevas perspectivas y actividades** relacionadas con la trazabilidad, aseguramiento de la calidad, procedimientos de calibración y definición de aquellas magnitudes involucradas en los estudios climáticos y observaciones meteorológicas.

- to encourage NMIs and the scientific community, especially temperature metrologists, to be prepared to face new perspectives, needs, projects and activities related to the traceability, quality assurance, calibration procedures and definitions for those quantities involved in the climate studies and meteorological observations;
- to support a strong cooperation between NMIs and Meteorological Institutions at local, national and international levels;
- to encourage NMIs to work with the relevant meteorological networks to support a monitoring framework for traceable climate data over long temporal terms and wide spatial scales based on best practice metrology;
- to consider the most effective means by which CCs involved in climate and environmental activities should cooperate in order to establish a common response to the stated needs of the meteorological community; and
- to encourage CCs to start their relevant working groups to the measurement calibration and

- Apoyar una **cooperación robusta** entre los Centros Nacionales de Metrología y las Instituciones Meteorológicas a nivel local, nacional e internacional
- Fomentar que los **Centros Nacionales de Metrología trabajen en las redes meteorológicas más relevantes** con el fin de apoyar un marco adecuado para la generación de datos climáticos trazables a gran escala, temporal y espacialmente, y basados en buenas prácticas metrológicas



# METROLOGY FOR CLIMATE ACTION

26-30 SEPTEMBER 2022



Bureau International des Poids et Mesures

Rapport BIPM-2023/03

WORLD METEOROLOGICAL ORGANIZATION

IOM Report No. 142

-Rapporteur en la sección de criosfera. Redacción de las recomendaciones derivadas del workshop.

-CIPM Sectorial Task Group on Climate Change and Environment (CIPM-STG-CENV)

-Presidido por Dolores del Campo

1ª Reunión del CIPM Sectorial Task Group on Climate Change and Environment. Del 16 al 18 de Septiembre 2024

-Comprobar el estado de las recomendaciones derivadas del workshop organizado en el 2022

-Enviar resúmenes hasta el 31 de Mayo



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# Colaboración entre WMO-BIPM

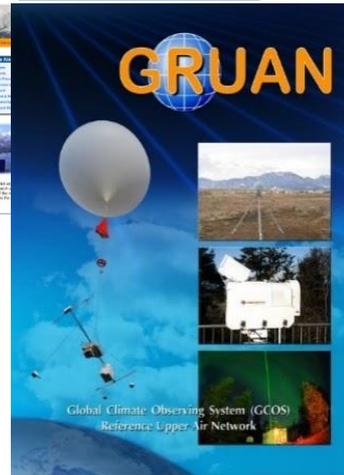
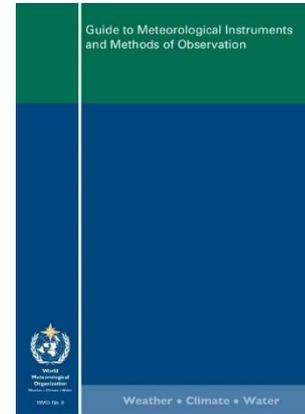


World Meteorological Organization  
Working together in weather, climate and water

-Algunos meteorólogos participan en grupos de expertos de la WMO

## Contribuido en:

- Armonizar el lenguaje, **terminología**
- Cursos de **formación** sobre términos metrológicos, calibración, incertidumbres
- Revisión de la guía “WMO Guide on Instruments and Methods of Observations
- Apoyo a la organización de **comparaciones** de laboratorios y comparaciones de instrumentos
- Experimentos para analizar la **clasificación** de las medidas según su **emplazamiento**
- Apoyo en el establecimiento de una **clasificación de la calidad** de las medidas
- Estudios de **evaluación de Incertidumbres Medida**



Strategy Document for Rolling Programme Development for 2021 to 2030

The Consultative Committee for Thermometry

Achievements 2017-2020	Future Scan 2021-2025	Future Scan 2025-2030+
<b>Working Group for Environment</b>		
<p>CIPM RECOMMENDATION T3 (2010) "On climate and meteorological observations measurements" and the ToR of the CCT WG Environment are the basis for establishing long term collaboration with the scientific community involved in research on climate and environmental monitoring and motivates specific projects and actions from the NMIs.</p>	<p>Data comparability: Include as reliable as possible uncertainty analysis in historical data; study and assess traceability.</p> <p>Water content measurements (air and soil): Develop suitable measurement techniques and guides.</p> <p>Evolving technologies, such as non-contact instruments, for meteorological and climatological measurements will be constantly followed, with dedicated activities and studies.</p>	<p>CCT recommends NMIs to include in their vision documents all possible actions within the expertise of the thermal metrology community contributing to improve measurement quality and knowledge on observation and monitoring of the environment and climate.</p>

Achievements 2017-2020	Future Scan 2021-2025	Future Scan 2025-2030+
<p>The "Metrology for Meteorology and Climate" – MMC Conference series and associated workshops and satellite events</p> <ul style="list-style-type: none"> <li>were fully participated in and endorsed by CCT WG ENV members</li> <li>represent world top level events for increasing the collaboration between thermal metrologists and the stakeholder communities.</li> </ul> <p>Joint Research projects such as MetroMet, INCIPIT, CRS, COAT progressed the scientific studies and technical research on improving calibration and measurement procedures and uncertainty evaluation.</p> <p>A metrology network on climate and ocean observation has been formed by EURAMET.</p> <p>The "ATM – Air Temperature Metrology" EURAMET project was launched in 2018, to execute an intercomparison of calibration procedures for thermometers in air and produce a guide. The project formed the basis to launch global initiatives on solving calibration and measurement issues for air temperature.</p> <p>APMP comparison on air temperature thermometers was also started in 2018. TG Air Temperature established.</p>	<p>Improved techniques, proposals of best practices (also for inclusion in the WMO guide no. 8) and on-site calibration devices will be addressed to cryosphere observations (high mountains and polar areas).</p> <p>Establishing reference test sites with the highest quality SI-traceable measurements of ECVs, including prototypes of climate reference stations and research infrastructures to support the implementation plan of the GSRN.</p> <p>Arctic Metrology: polar activities will continue with on site calibration campaigns, the implementation of the "Metrology Laboratory" at the arctic station in Ny-Alesund, and a WMO intercomparison of thermometers and shields in polar environment.</p> <p>On-site thermometer shield with the minimum environmental effects will be designed and tested.</p> <p>Support in the validation of records associated to extreme events (such as temperature extremes and heat waves, precipitation events, pressure, wind speed etc.), through metrological analysis of the whole measuring process and instrumentation.</p> <p>Improved monitoring techniques for essential fresh water natural and artificial reservoirs and the creation of measurement recommendations.</p>	<p>The WG-ENV will continue to facilitate project proposals for funding and joint activities among the members on activities.</p> <p>WG-ENV members will continue studying and characterizing temperature, humidity and radiation sensors for ocean applications, ground based systems and radiosondes.</p> <p>Provide roadmap to address needs of data quality arising from possible new climate evolution scenarios.</p> <p>The CCT-WG-ENV will promote and contribute to interdisciplinary initiatives, worldwide and at regional level, to create forums and expert teams, to address the stakeholder's needs under coordinated efforts with other areas of metrology, also under future CIPM initiatives.</p>

Achievements 2017-2020	Future Scan 2021-2025	Future Scan 2025-2030+
<p><b>Collaboration and stakeholders</b></p> <p>WG-ENV members are formally members of expert teams in the WMO INFCOM and SERCOM, in the Global Cryosphere Watch, the GCOS (GRUAN and GSRN Task Teams) and the BSRN.</p> <p>WG-ENV members are involved and supporting official WMO worldwide laboratory intercomparisons in Europe, Asia, Latin America and Africa.</p> <p>Formal collaborations with national meteorological and hydrological services, universities, research centres and manufacturers have been established.</p>	<p><b>Collaboration and stakeholders</b></p> <p>The relationships with key world and international Institutions such as WMO, GCOS, and IAPWS will be sustained to provide channels for impact in the work of the WG-ENV.</p> <p>CCT-WG-ENV members will continue to contribute as experts in WMO, GCOS task teams.</p> <p>CCT-WG-ENV, together with operational meteorologists, climatologists and metrologists, to contribute with studies and activities to GCOS for the definition of the key aspects of GSRN in terms of station features, data characteristics and target uncertainties.</p>	<p><b>Collaboration and stakeholders</b></p> <p>Impact: CCT members continue to organize events, meetings, workshops, conferences and training to discuss and plan common activities with the climate and environmental communities.</p> <p>The GCOS Surface Reference Network (GSRN) of observing stations on land implementation plan was approved by WMO in 2021 and will require a continuous support from the thermal metrology community, being temperature and humidity of air and soil key observables.</p>
<b>Task Group for Air Temperature</b>		
<p>In 2020 a new Task Group on "Air temperature" was formed, tasked:</p> <ul style="list-style-type: none"> <li>To work towards and propose a practical definition of air temperature</li> <li>To work towards and propose how to evaluate the uncertainty contributions in air temperature measurements</li> </ul> <p>To develop guidelines for the calibration of thermometers in air.</p>	<p>Practical definition of air temperature proposed</p> <p>Method proposed on how to evaluate the uncertainty contributions in air temperature measurements</p> <p>Draft guide for the calibration of thermometers in air</p>	<p>Practical definition of air temperature agreed by CCT and promulgated to key stakeholders</p> <p>Method for evaluating the uncertainty contributions in air temperature measurement agreed by CCT</p> <p>Guide for the calibration of thermometers in air published on CCT website</p>

Plan Estratégico (2021-2030) :

Objetivos, actividades y apoyo a proyectos:

WMO (INFCOM and SERCOM) (\*),

GCOS (AOPC and GSRN) (\*),

Ciencia de la Criosfera (GCW),

Oceanografía (\*)

Mediambiente Ártico (SIOS) (\*)

Metrología para la temperatura del aire (ATM) (\*)

(\*) Participación del CEM

## Red Europea de Metrología para el Clima y observaciones de los Océanos

- Necesidad de establecer un dialogo a largo plazo con la comunidad climática
- Cambio climático: reto de la Unión Europea.

**Objetivo:** La Creación de una estructura metrológica, formada por Institutos Nacionales de metrología que trabaje a nivel global

- Estrechar lazos con Instituciones que trabajen en materia de Clima y Océano.
- Detectar necesidades metrológicas y ofrecer soluciones.
- Coordinar la Metrología Europea para satisfacer las necesidades detectadas
- Mostrar lo que la metrología puede hacer
- Resaltar la importancia de la metrología.

**33 Centros Nacionales de Metrología Europeos forman parte de la RED**



**Mayo 2018:** Declaración de la RED

**Junio 2019:** Formalización de la RED

**Diciembre 2020:** Documento con las necesidades a abordar por la Red

<https://www.euramet.org/climate-and-ocean-observation/>

CEM: Coordinador del proyecto CryoMet: Metrología para la criosfera:

Inicio: Febrero 2024

Objetivo: desarrollar una hoja de ruta sobre las necesidades metroológicas en la Criosfera



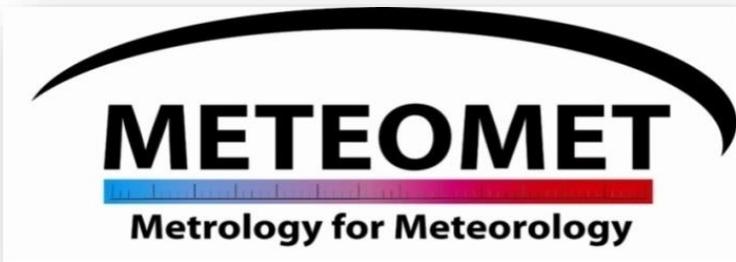


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# Actividades técnicas de CEM. Metrología para el clima: Comenzamos en el 2011/Europa



## EMRP

European Metrology Research Programme  
Programme of EURAMET



The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union



- 24 Institutos Nacionales de Metrología
- 12 Universidades
- 13 Centros de Investigación
- 9 Fabricantes de instrumentación
- 12 Agencias de Meteorología



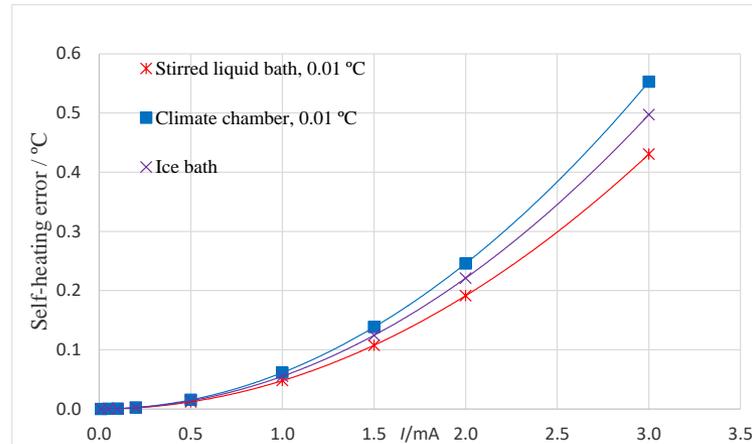


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## Desarrollo de procedimientos para el estudio y caracterización de termómetros:



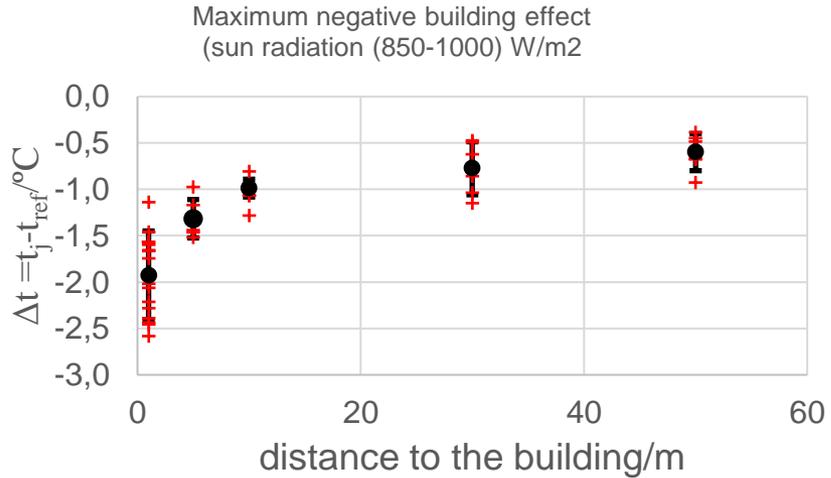
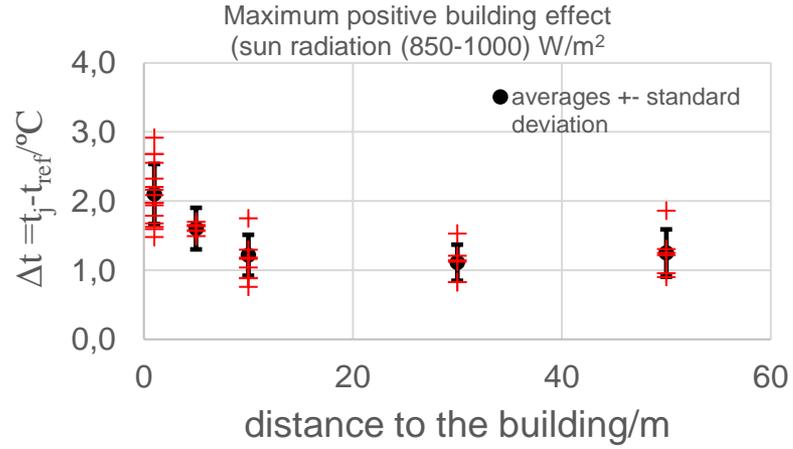
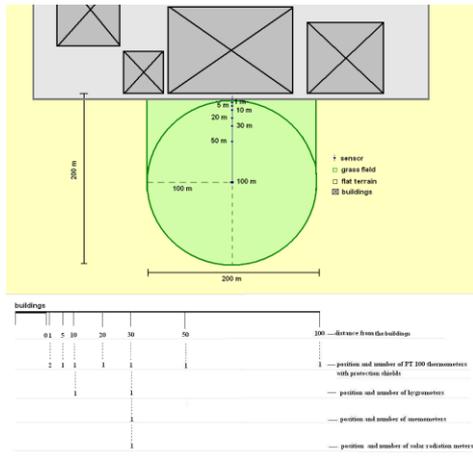


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# Estudio de la influencia de los edificios en las medidas de la temperatura del aire:



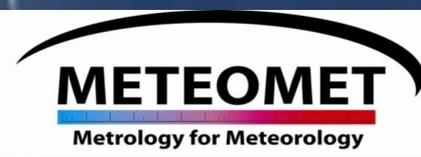
Trabajo considerado por la WMO en el establecimiento de reglas de clasificación de las medidas:

• Atmosphere 15(2):209, DOI: [10.3390/atmos15020209](https://doi.org/10.3390/atmos15020209)

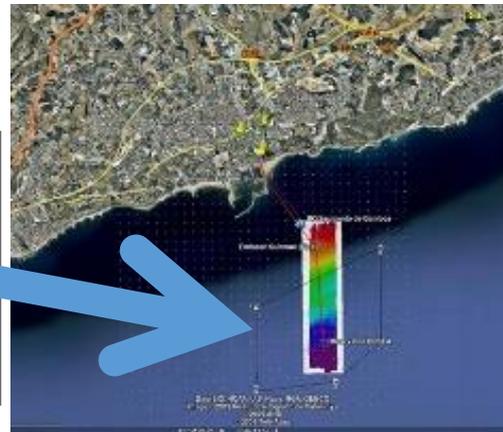
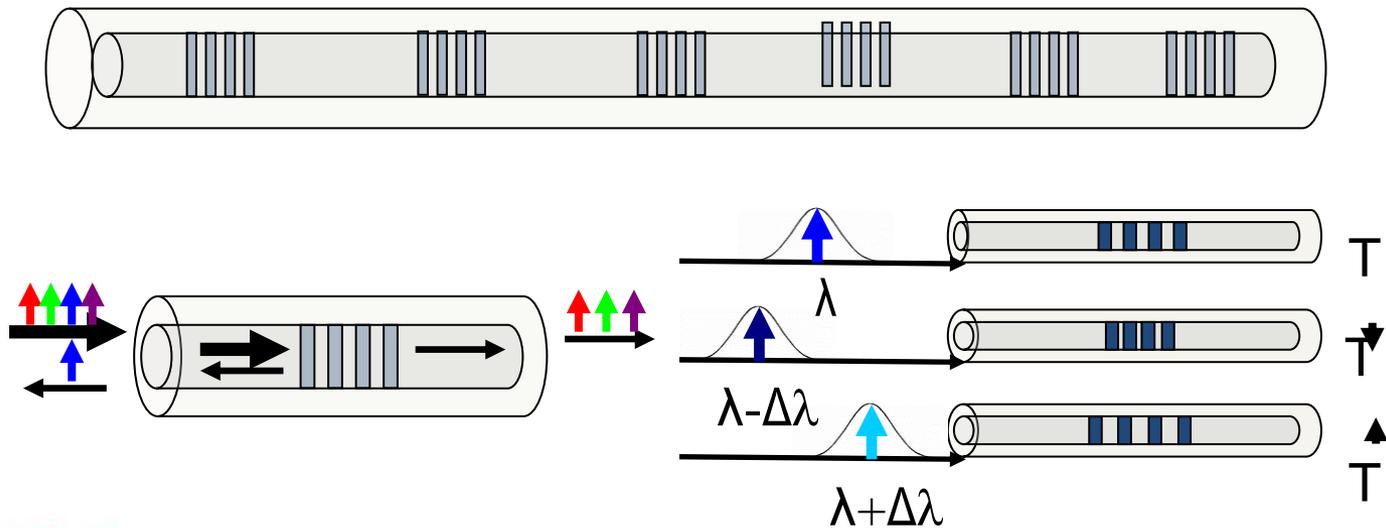


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### Medidas de la temperatura del **agua del mar** con fibra óptica/redes de Bragg:





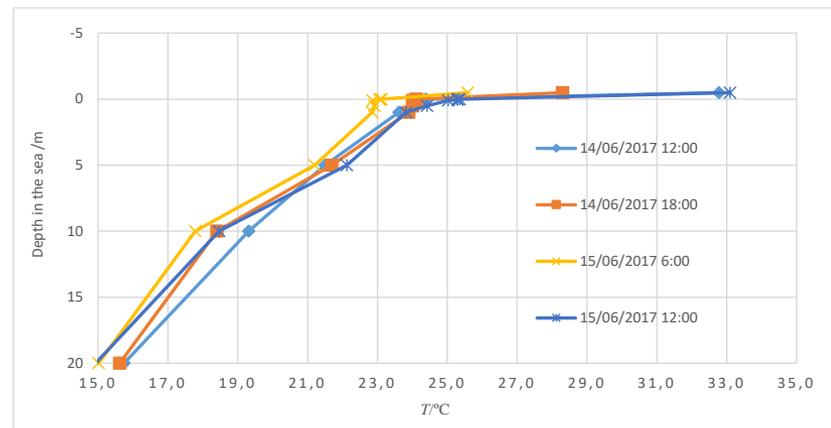
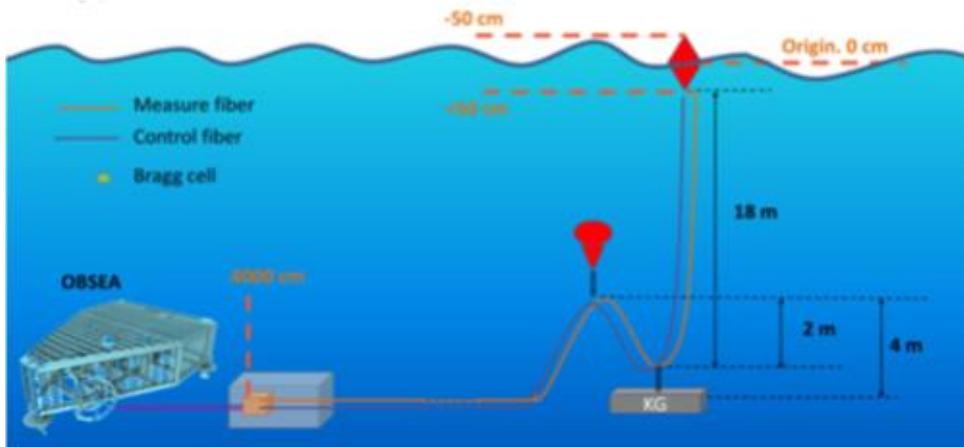
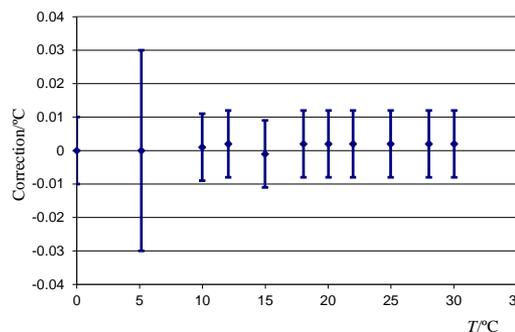
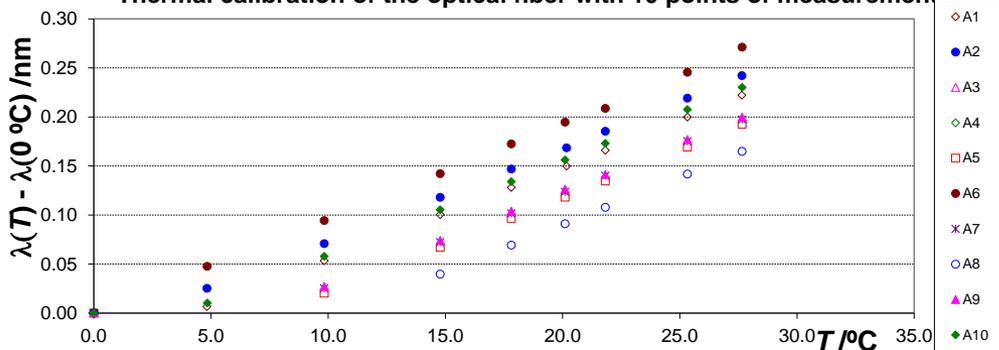
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## Medidas de la temperatura del agua del mar con fibra óptica:

Thermal calibration of the optical fiber with 10 points of measurement



Publicación: Measurements 127 (2018) 124–133, <https://doi.org/10.1016/j.measurement.2018.05.056>



Medidas de **precipitación** por métodos de no contacto: Contribuir al desarrollo de documentos

normativos en CEN TC318 sobre medidas de precipitación por métodos de no contacto.



Definir la cadena de trazabilidad óptima

Establecer procedimientos de Calibración

**CALIBRATION AND ACCURACY OF NON-CATCHING INSTRUMENTS TO MEASURE LIQUID/SOLID ATMOSPHERIC PRECIPITATION**

**EURAMET**  
**EMPIR**

**COP25 CHILE MADRID 2019**

**STAIR - EMPIR**  
TC 318 «Hydrometry»  
WG 12 «Precipitation Intensity»  
WG Chair: Luca G. Lanza

**NEED**  
Standardization needs and suggestions for metrology research:  
**PRECIPITATION MEASUREMENT INSTRUMENTS**  
Lack of standards    Test results ...    Innovation ...

**IMPLEMENTATION**  
In the laboratory ...  
Development of traceable procedures for the calibration of non-catching gauges and the associated calibration uncertainty assessment.

**VISION**  
Metrology to foster innovation in weather and climate networks while supporting standardised traceable calibration of contact-less, multi-purpose and low-maintenance non-catching instruments

**IMPACT**  
United Nations  
WMO  
WIGOS  
GCOS  
Global Surface Reference Network (GSRN)  
Chief Stakeholder  
National Weather Services  
Standardization bodies  
Industry

**EXCELLENCE**  
Complementarity of metrological institutes, research institutes, experts on standardization and weather services  
Uniqueness of NMI partners dealing with metrology in precipitation meas.

**PARTNERS**  
CEN  
WMO  
HMEI  
economie

**www.precipitation-intensity.it**





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## Coordinación del proyecto19SIP06 COAT:

Mejorar la comparabilidad de las medidas de temperatura del aire en ambientes extremos.

### *Comparación de termómetros y pantallas de radiación en el Ártico*

- **4 socios:** CEM (España), INRiM (Italia), CNR-ISP (Italia), EDI (Suiza)

+ CEM:

+ INRiM:

+ CNR-ISP:

+ EDI (Meteoswiss)

- **Socio Externo Primario**

- Visión multidisciplinar: (metrología, meteorología/clima, ciencias polares)

- Octubre 2020-Abril 2024



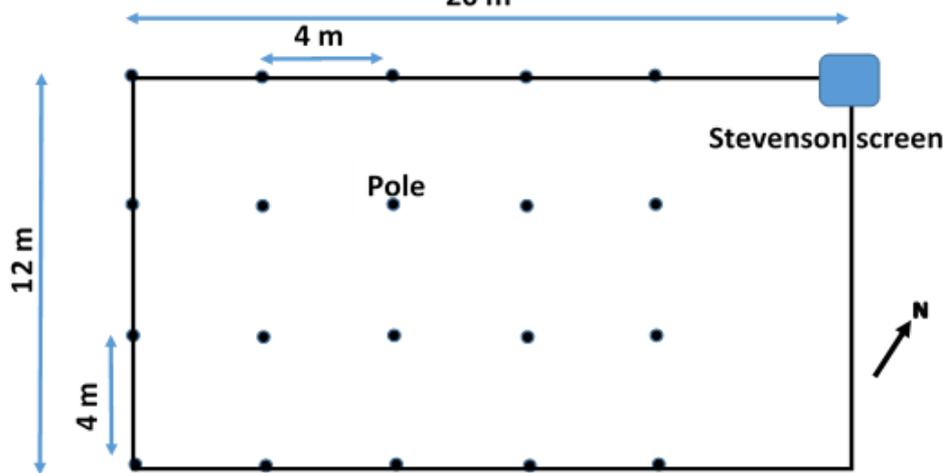
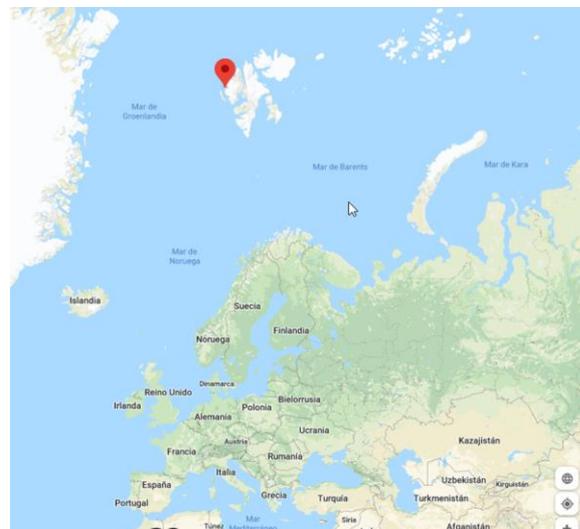


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Localización: Ny-Ålesund-Svalbard 78.55' N (Norway).



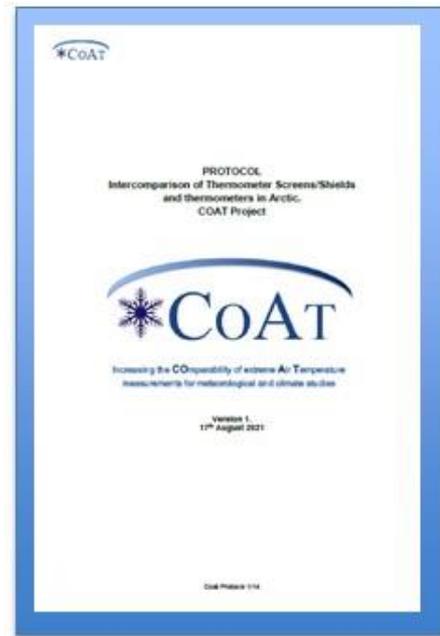
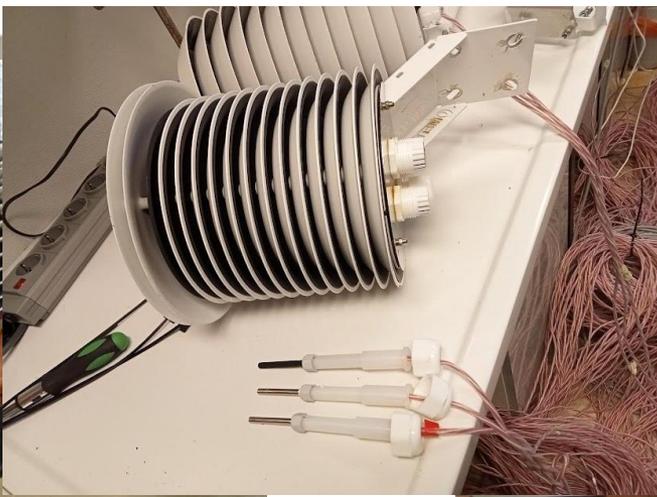


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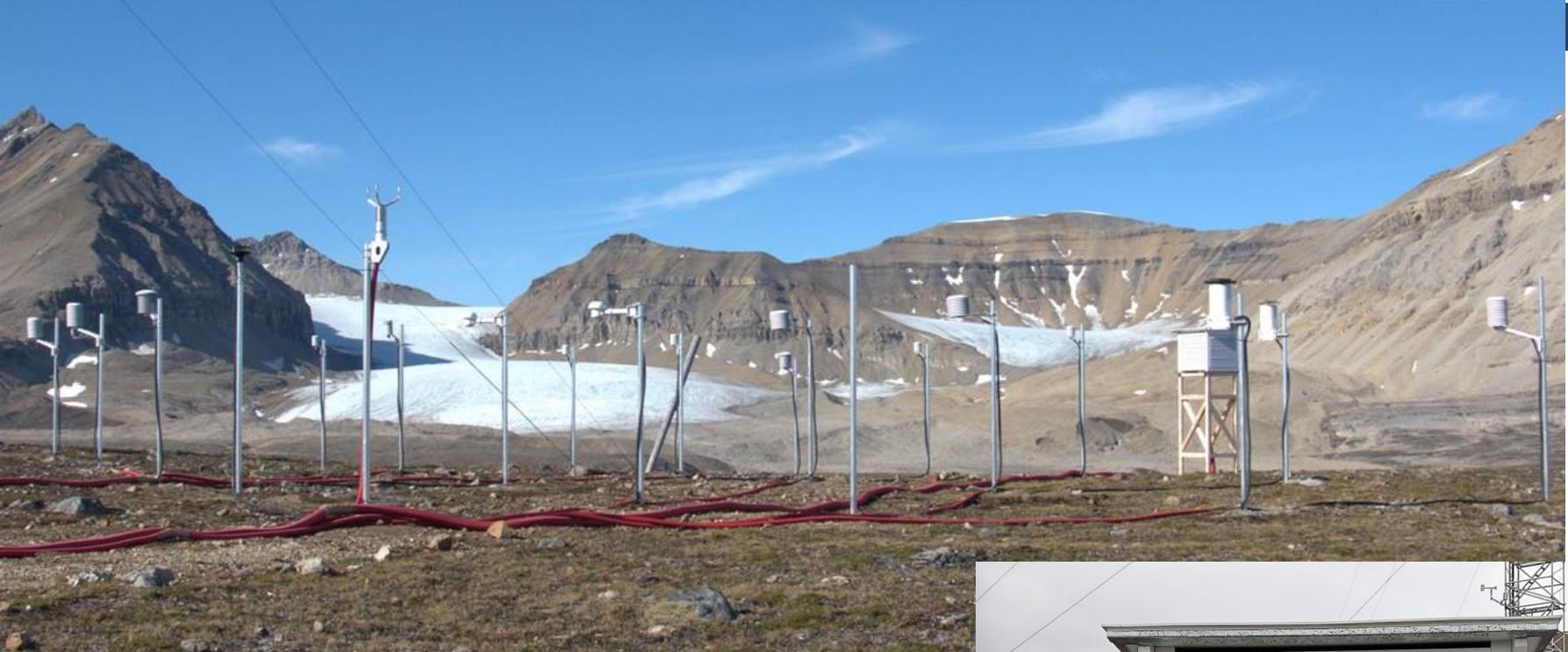
## - Protocolo de la comparación. Documento realizado en colaboración con la WMO



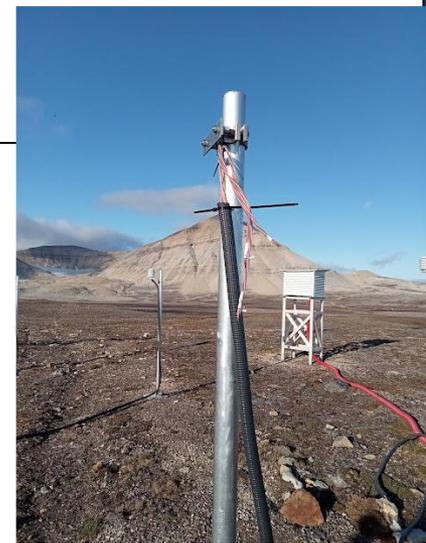


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- Chequeo diario de los datos
- Tuvimos que resolver diversos problemas de manera remota



Angelo Viola



Mauro Mazzola



Marco Casula



Simonetta Montaguti



Ombreta Dell'Acqua

	July	August	September	October	November	December	January	February	March	April	May	June	July	August	total
ideal number of datalogger samplings	11520	22320	21600	22320	21600	22320	22320	20160	22320	21600	21600	21600	22320	22320	295920
real number of datalogger samplings , fluke	10454	22091	21600	22320	21600	22320	22318	20103	22296	16131	13155	21174	21817	22320	279699
real number of datalogger samplings , datalogger A	10407	18327	20447	22319	21600	22320	22319	20159	22319	719	1781	4319	4446	4463	195945
real number of datalogger samplings , datalogger B	10221	21360	21578	22320	21600	22320	22318	20160	22296	16131	13155	21600	22320	22320	279699
percentage of no sampling, fluke	9.3	1.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	25.3	39.1	2.0	2.3	0.0	5.5
percentage of no sampling, datalogger A	9.7	17.9	5.3	0.0	0.0	0.0	0.0	0.0	0.0	96.7	58.8	0.0	0.4	0.0	33.8
percentage of no sampling, datalogger B	11.3	4.3	0.1	0.0	0.0	0.0	0.0	0.0	0.1	25.3	39.1	0.0	0.0	0.0	5.5

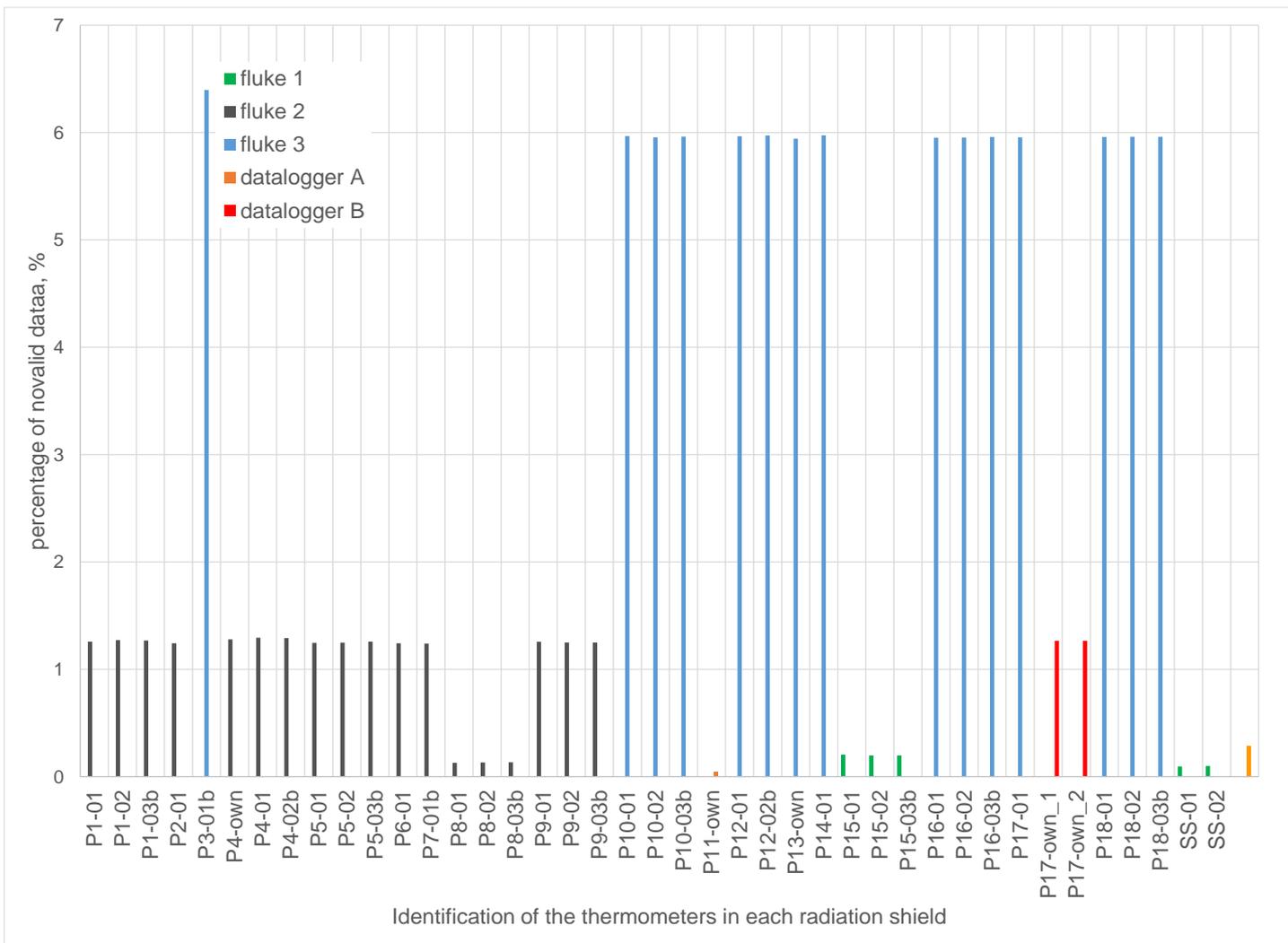


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### Control de calidad a todos los datos:





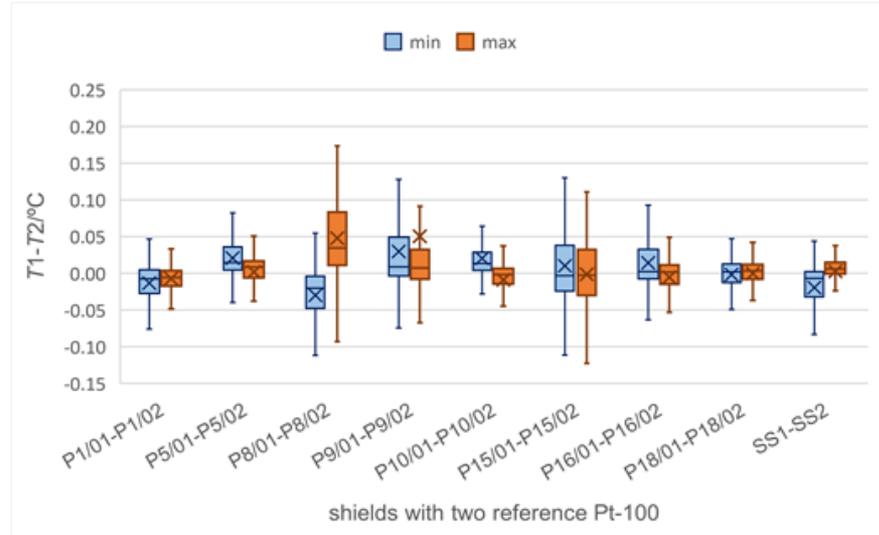
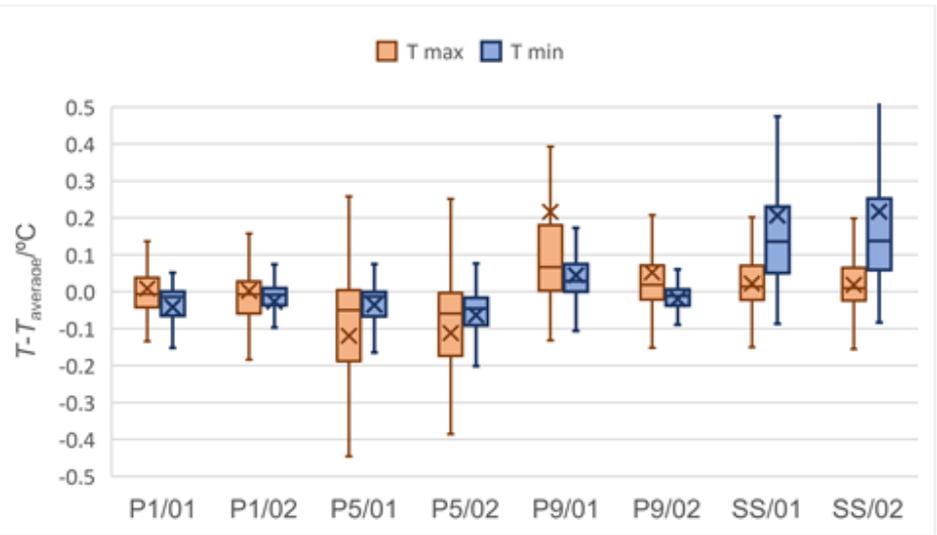
### Reference shield

ISO 17714:2007 says that “screens that are cooler during the day and warmer during the night are likely to be giving measurements that are closest to the truth”.

Mayor factor de influencia: **la irradiación solar**

Para la selección de la pantalla de radiación de referencia:

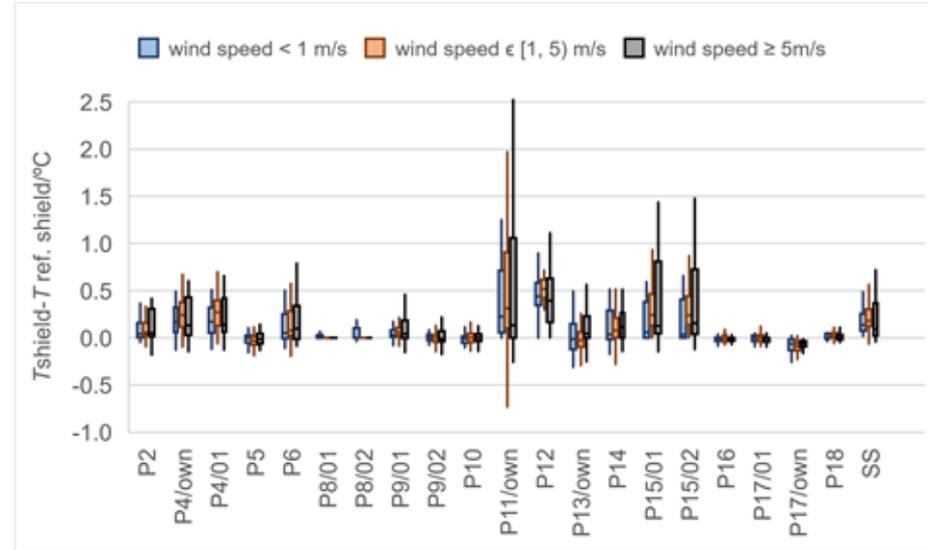
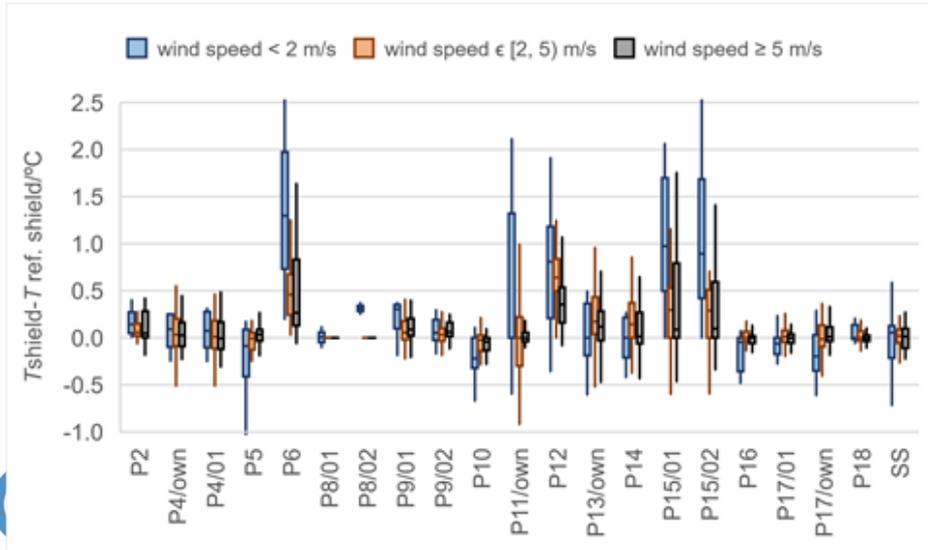
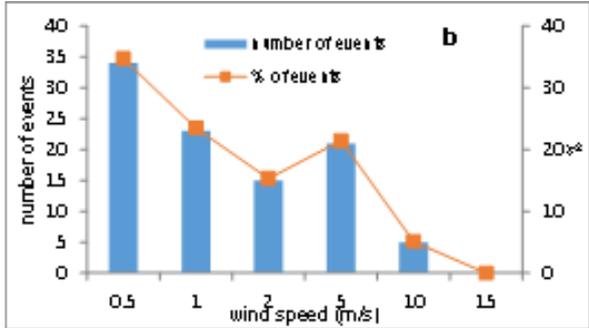
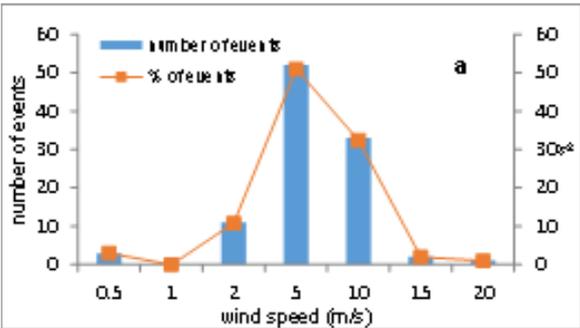
- Se examine la temperatura máxima y mínima diaria para días con una irradiación solar mayor a unos valores determinados.
- Algunas pantallas de radiación incluían dos termómetros. En esas pantallas la diferencia entre los dos termómetros se analizó para las situaciones de temperaturas extremas diarias.





## Comparación de las pantallas de radiación

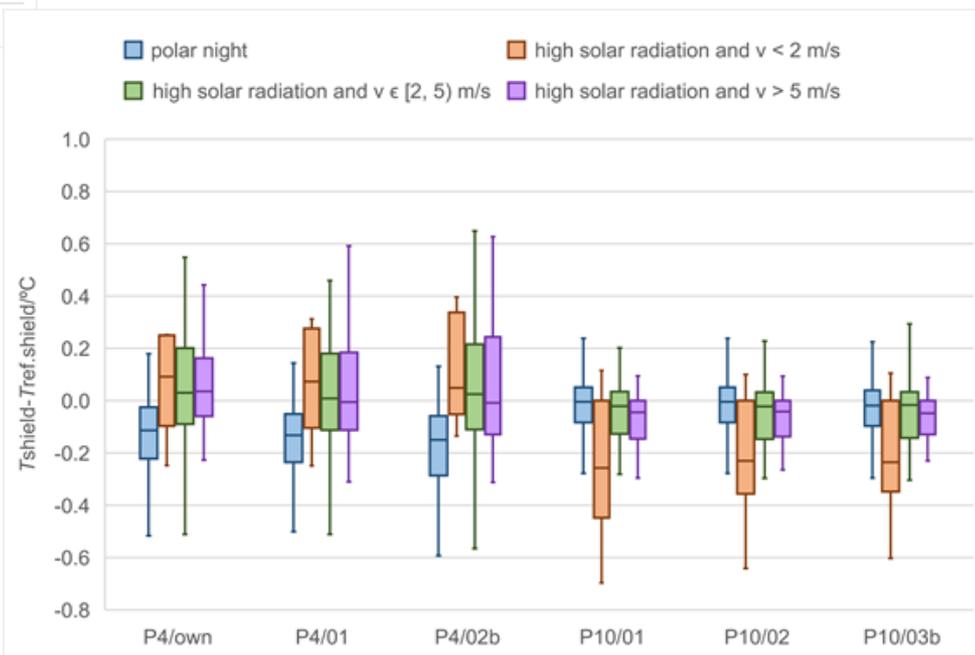
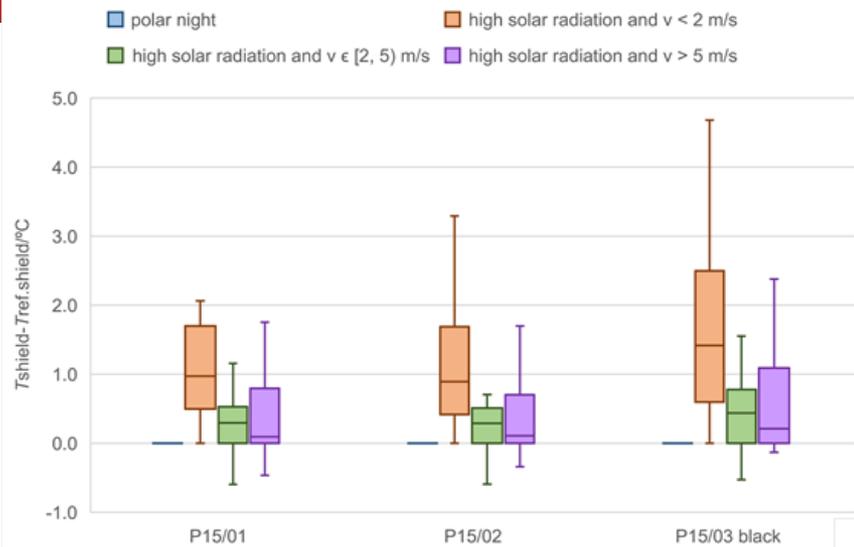
- días con una irradiación solar promedio mayor a un especificado valor.
- se analizo un histograma sobre los eventos de velocidad de viento para los momentos diarios de  $T_{max}$  y  $T_{min}$





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**Gracias**

