NPL National Physical Laboratory

CEOS WGCV comparison of infrared radiometers for sea-surface temperature measurement

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Overview

The measurement of the Earth's surface temperature is a critical product for meteorology and an essential parameter/indicator for climate monitoring. Satellites have been monitoring global sea surface temperature (SST) for some time, and have established sufficient consistency and accuracy between in-flight sensors to claim that it is of "climate quality". However, it is essential that such measurements are fully anchored to SI units and that there is a direct regular correlation with "true" surface/in-situ based measurements.

The most accurate of these surface-based measurements (used for validation) are derived from field deployed ship-borne Thermal Infrared (TIR) radiometers. It is essential for the integrity of their use, to provide validation data for satellites in-flight and to provide the link to future sensors, that any differences in the results obtained between them are understood. This knowledge can only be determined through formal comparison of the instrumentation, both in terms of its measurement capabilities in relation to primary "lab based" calibration facilities, and its use in the field.

This presentation describes the Fifth CEOS WGCV TIR radiometer comparison activities undertaken in June 2022 at NPL and at the seaside pier. (No results will be reported since analysis is still in progress.)

Objective

- To establish degree of equivalence of radiometric scales between field deployed ship-borne TIR radiometers
- Ensure robust traceability to SI

Past Comparisons

2001 (Miami), 2009 (NPL & Miami), 2016 (NPL)

Scope of the comparison

Laboratory-based and field-based exercise to compare

- against the SI via NPL references (lab-comparison, @NPL, 13th – 17th June 2022)
  - Blackbodies viewed by reference radiometer
  - TIR radiometers viewing reference blackbodies
- against each other (field-comparison, @ Boscombe Pier, Bournemouth, UK, 20th – 24th June 2022).
  - TIR radiometers as used viewing the ocean

Participants

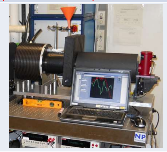
Attendee	Institute
Yoshiro Yamada Subrena Harris	National Physical Laboratory United Kingdom
Werenfrid Wimmer	National Oceanography Centre United Kingdom
Tim Nightingale Arrow Lee	STFC Rutherford Appleton Laboratory United Kingdom
Nis Jepsen	Danish Meteorological Institute Denmark
Nicole Morgan	CSIRO / Australian Bureau of Meteorology Australia
Frank-M. Göttsche	IMK-ASF / Karlsruhe Institute of Technology Germany
Raquel Niclòs Martin Perello Vicente Garcia-Santos	University of Valencia Spain

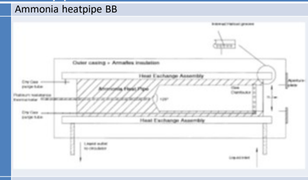
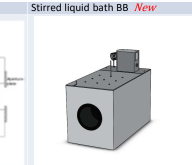
Timeline

Event	Date
Invitation to participate	December 2021
Preparation and formal agreement of protocol	January - May 2022
Preparation of the reference standards, transfer standard and facilities at the NPL	February - April 2022
Participants send preliminary report of measurement system and uncertainty to pilot	May 2022
Calibration of the reference and transfer standards at NPL/ Calibration of the participants' radiometers before dispatch	~ June 2022
Lab Comparison / Field Comparison	*June 2022*
Stability check measurement of the reference and transfer standards at NPL/ Stability check measurement of the participants' radiometers after return	June - July 2022
Participants send all data and reports to pilot	August 2022
Pre-Draft A result sent to individual participants	September 2022
Draft A report circulated to participants for comments	October 2022
Draft A report (final version) circulated to participants for approval	November 2022
Draft B submitted to CEOS WGCV	January 2023
Final Report published	March 2023

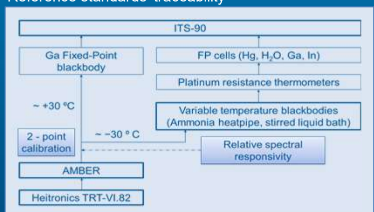
Lab-based comparison

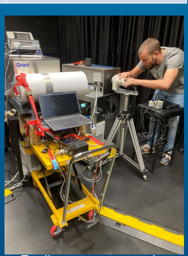
NPL reference standards

Radiometer specifications		
	AMBER (Absolute Measurements of Blackbody Emitted Radiance) (reference standard)	Heitronics TRT-IV.82 *New* (transfer standard)
		
Wavelength	10.1 µm (9 µm – 11 µm)	8 µm - 14 µm
Target size	φ 5 mm	φ 8.7 mm
Measurement distance	70 mm	503 mm
Effective lens diameter	φ 13 mm	φ 57 mm
Scale realization	Through relative spectral response measurement and a fixed-point blackbody measurement at the Ga melting point.	By comparison with AMBER

Variable-temperature blackbody specifications		
	Ammonia heatpipe BB	Stirred liquid bath BB *New*
		
Aperture diameter	φ 75 mm max	φ 160 mm max
Aperture distance from front panel	75 mm	35 mm
Emissivity	0.9993	>0.99965 @10 µm
Temperature range	-40 °C – 50 °C	-10 °C – 40 °C
Reference thermometer	Standard platinum resistance thermometer	Platinum resistance thermometer

Reference standards' traceability





Radiometer comparison

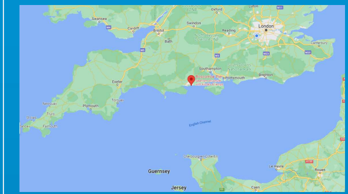
Blackbody comparison

Comparison temperature points

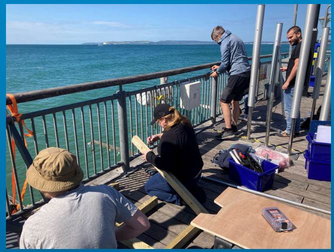
Comparison type	Nominal temperature / °C
Blackbody comparison [*1]	10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60
Radiometer comparison	
Ammonia heatpipe BB [*1]	-30, -15, 0, 30, 35, 40, 50
Stirred liquid bath BB	0, 10, 20, 30

[*1]: Higher temperature points included for participants with Land Surface Temperature (LST) measurement interest

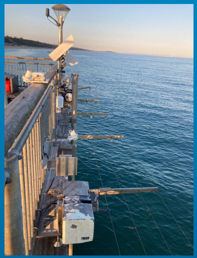
Field-based comparison



Venue: Boscombe Pier, Bournemouth



Preparation



After set-up

Future plans

- Data analysis in progress
- Reports to be submitted to CEOS WGCV and published
- Journal papers to be produced

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