Fiducial Reference Measurements for Validation of Surface Temperature from Satellites (FRM4STS) www.FRM4STS.org

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Project Aim:

To establish and maintain SI traceability of global Fiducial Reference Measurements (FRM) for satellite derived surface temperature product validation and help develop a case for their long term sustainability. An ESA funded project on behalf of the international community to establish community agreed best practises and international harmonisation through support of a CEOS WGCV calibration project following on from the 'Miami series of comparison experiments'.

What are Fiducial Reference Measurements?

> ***"The suite of independent ground measurements that provide the maximum return on investment for a satellite mission by delivering, to users, the required confidence in data products, in the form of independent validation results and satellite measurement uncertainty estimation, over the entire end-to-end duration of a satellite mission"***
>
> (Sentinel-3 Validation Team)

An FRM must:

- Have documented evidence of its degree of consistency for its traceability to SI through the results of round robin inter-comparisons and calibrations using formal metrology standards.
- Be independent from the satellite geophysical retrieval process.
- Have a detailed uncertainty budget for the instrumentation and measurement process for the range of conditions it is used over.
- Adhere to community agreed measurement protocols, and management practises.

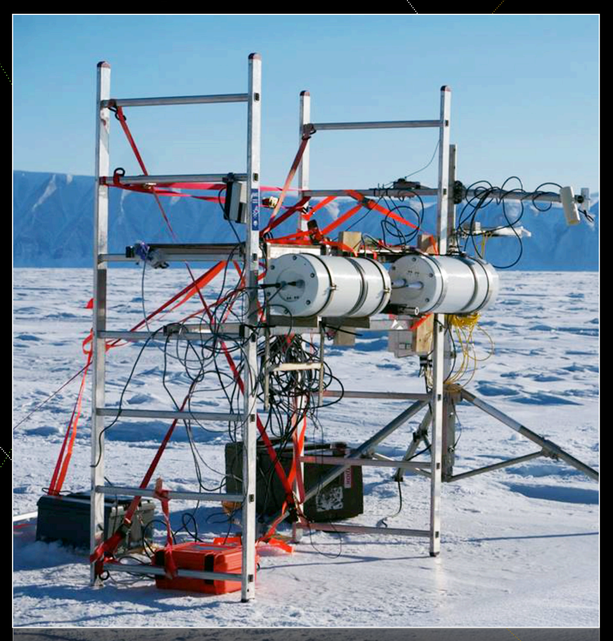
Requirements to achieve Project Objectives:

- Comparisons to ensure consistency between worlds measurement teams
  - Laboratory
  - In-field (operational conditions).
- Common descriptions and evaluation of uncertainties.
- Robust links to SI.
- Experiments to evaluate sources of bias/uncertainty under differing operational conditions.
- Provision of guidance and best practises and access to standards and comparisons.
- Evaluate potential and 'traceability' of non-recoverable FRM systems (Buoys).
- Demonstrate necessity and benefit of obtained from FRM for satellites.

Need for comparisons:

- Must be blind with open and unconstrained reporting of result (even if cause of any error identified, unless not due to participant).
- Should be established to evaluate range of quantity being measured, its potential operational environment, and not bias any method/sensor.
- Provide the means to identify biases and unknown unknowns
- An independent validation of estimated uncertainties of instrument and its use.
- A check on robustness of methods to use instrument.
- Evaluation of 'state of the art' of community.
- If includes references which are a-priori higher accuracy and SI traceable (ideally primary standards of an NMI) it establishes consistency with 'truth'.
- Enables participants to learn from each other in terms of uncertainty evaluation and enable peer based challenge where significant variances exist.
- Gives confidence to participants and their users of the quality of their data.

March/April 2016

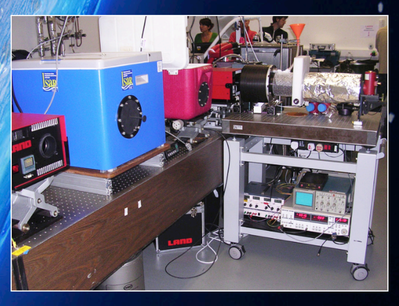


Ice Surface Temperature comparison, led by DMI in Qaanaq, Greenland, 2016

Activities/Timetable

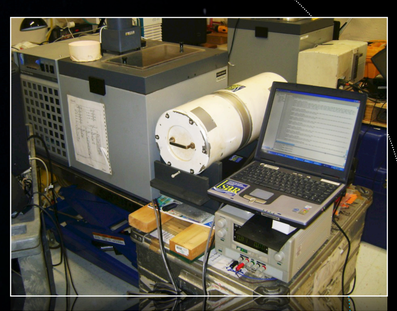
• First call for Participants	Jun 2015
• Comparison of Ice Surface Temp	Mar/Apr 2016
• Comparison protocols	Apr 2016
• Laboratory comparison	Jun 2016
• Water & Land (simulated field) Comparison	Jul 2016
• Land Surface Temp comparison	May/Jun 2017
• Sea Surface Temp comparisons	On-going
• International conference on surface Temperature measurements from Satellites and their validation	Mar 7-10 2017

Laboratory comparisons – June 2016

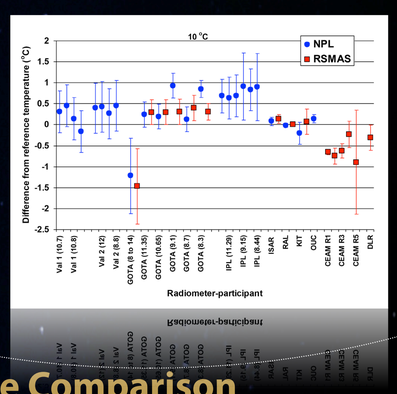


Black bodies being compared using NPL reference radiometer AMBER at NPL in 2009 comparison

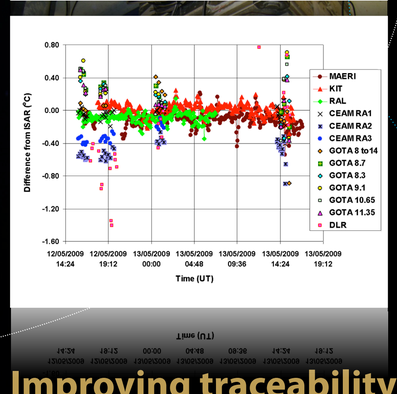
- Currently 19 participants from 4 continents will take part at NPL with traceability to SI from NPL and PTB
  - 10 Black bodies
  - 30 Radiometers (Land and Ocean)
- Comparisons over range -50 °C to + 50 °C
- Results will allow robust corrections to be applied for field comparisons and confidence in future satellite validations



ISAR and SISTER radiometers being compared against NPL primary reference black body at NPL in 2009 comparison

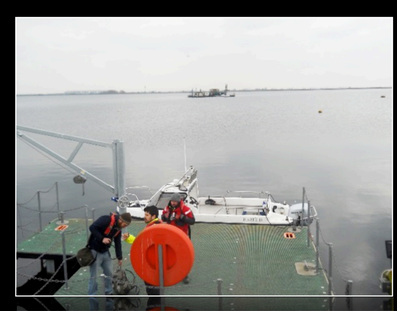


Difference between radiometers viewing an SI reference black body at 10 °C in 2009 (blue NPL, Red NIST



Difference between radiometers viewing the ocean off the coast of Miami in 2009

Field comparison experiments – July 2016



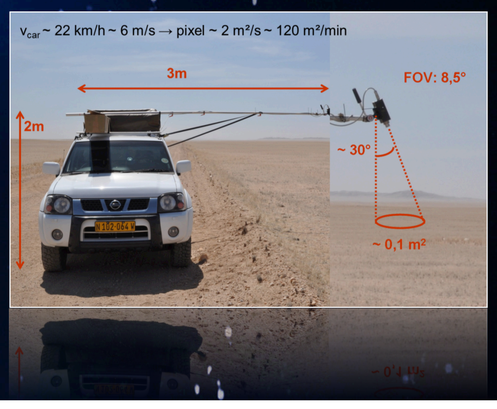
The NPL hydrophone test facility in the middle of the Wraysbury reservoir (near Heathrow airport) will be used to perform radiometer comparisons of water temperature to account for potential errors due to sky brightness etc.

NPL antenna range and sports field provide the venue for a range of targets for Land Surface Temperature measurements.

– Short Grass – Long Grass
– Sand – Tarmac
– Gravel – Brown Soil

These will look to evaluate effects of emissivity and sky brightness.

Land Surface Temperature Comparison Gobabeb Namibia – May/June 2017



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- At least 5 teams taking part
- Gravel, Sand, Bush (Kalahari)
- Different Sampling strategies
- Emissivity evaluations

KIT performing mobile radiometric measurements across the gravel plains at Gobabeb, Namibia

Improving traceability of buoys to enable Fiducial reference status

Analysis by DML of potential and improvements needed for drifting buoys to be considered Fiducial reference measurements

Conclusion

FRM4STS is the first of a series of ESA sponsored projects to establish SI traceable 'fiducial' reference standards/methods and associated best practises for both the current and future generations of satellites. Trust and long term sustainability of the quality of these vital validation measurements requires a strategy incorporating regular comparisons and robust evidence of traceability to SI.

Unless measurement systems have demonstrated their quality through participation in formal comparisons such as these any user should be highly cautious in the use of any resultant data.

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