



fiducial reference
temperature
measurements



esa

Fiducial Reference Measurements for validation of Surface Temperature from Satellites (FRM4STS)

ESA Contract No. 4000113848_15I-LG

D-150: Reports to CEOS bodies

Nigel Fox

AUGUST 2018

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Fiducial Reference Measurements for validation of Surface Temperature from Satellites (FRM4STS)

D-150 Reports to CEOS bodies

Nigel Fox



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National Physical Laboratory
Hampton Road, Teddington, Middlesex, TW11 0LW



CONTENTS

DOCUMENT MANAGEMENT

DOCUMENT APPROVAL

APPLICABLE DOCUMENTS	7
INTRODUCTION	8
CEOS CV8 – WGCV PLENARY 40	8
CEOS ‘MIAMI IV’ COMPARISON ++	14
CEOS CV8 – WGCV PLENARY 39	21




DOCUMENT MANAGEMENT

Issue	Revision	Date of Issue/revision	Description of Changes
1	1	31.08.2018	Complete draft submitted for review

DOCUMENT APPROVAL

Contractor Approval

Name	Role in Project	Signature & Date (dd/mm/yyyy)
Dr Nigel Fox	Technical Leader	
Dr Andrew Brown	Project Manager	 Andrew Brown, NPL 31 August 2018

Customer Approval

Name	Role in Project	Signature	Date (dd/mm/yyyy)



APPLICABLE DOCUMENTS

AD Ref.	Ver. /Iss.	Title
EOP- SM/2642	1	Fiducial Reference Measurements for Thermal Infrared Satellite Validation (FRM4STS) Statement of Work



INTRODUCTION

A collection of the reports presented to CEOS during the lifetime of the project. CEOS is the mechanism that brings organisations together to collaborate on missions, data systems, and global initiatives that benefit society and align with their own Agency missions and priorities.

CEOS CV8 – WGCV PLENARY 40

CEOS

FRM4STS: Fiducial Reference measurements for validation of Surface Temperature from Satellites (ceos cv8)

Nigel Fox
NPL (ESA Project)
WGCV Plenary # 40

NPL National Physical Laboratory
Centre for Carbon Measurement
UNIVERSITY OF Southampton
Science & Technology Facilities Council
PIB
KIT Karlsruhe Institute of Technology
DMI

Working Group on Calibration and Validation

ESA sponsored project (FRM4STS) to:



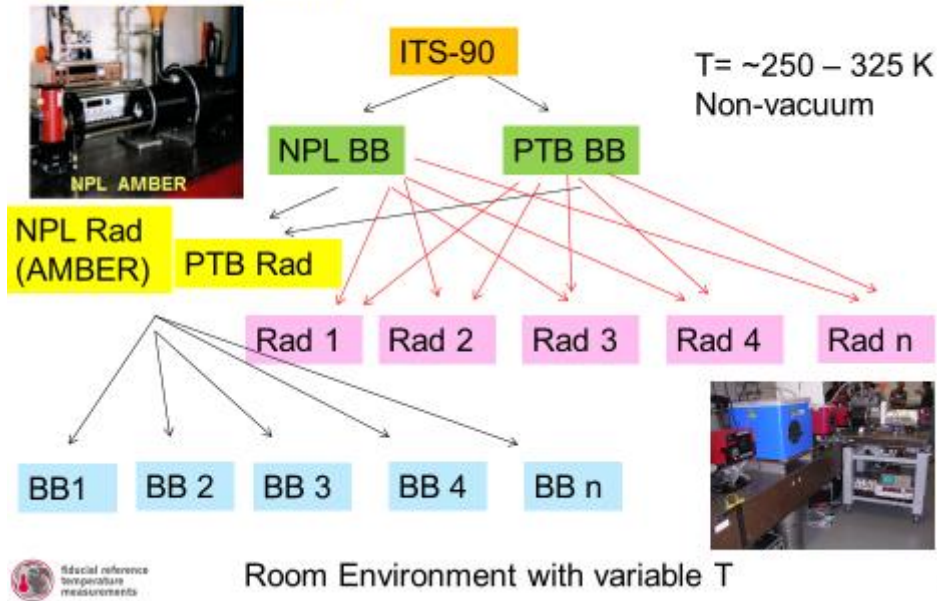
- Design and implement a laboratory-based comparison of the results of participants calibration processes for FRM TIR radiometers (SST, LST, IST)
- Design and implement a laboratory-based comparison to verify TIR blackbody sources used to maintain calibration of FRM TIR radiometers.
- Conduct external comparison 'experiments' of LST and WST to evaluate environmental effects e.g. sky radiance
- Design and implement field inter-comparisons of SST using pairs of FRM TIR radiometers on board ships to build a database of knowledge over a several yrs
- Conduct field-campaigns for FRM TIR of LST and IST to assess environmental effects in real world sites.
- Develop a set of best practise protocols for the calibration, operation and performance of FRM of Surface temperatures.
- Carry out comparisons and analysis to SI standards with full metrological rigour (e.g. detailed uncertainty breakdown).
- Perform a study of means to establish traceability and potential benefits to satellites validation and CDRs of high accuracy Ocean temperature measurements using buoys and similar floating systems.





SI traceability: LCE (June 2016)

Necessary for all participants to assess biases to SI under Laboratory conditions

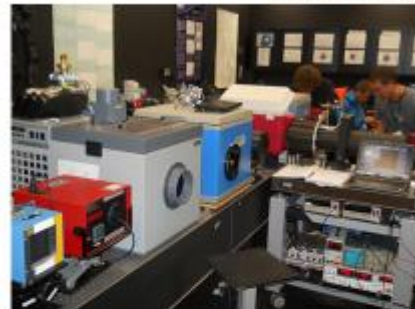


Room Environment with variable T

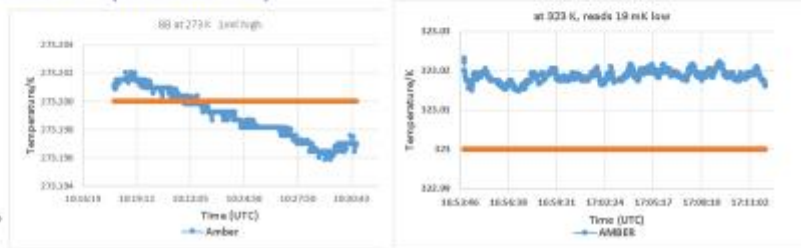
BB comparison (June 2016)



1. Miami University - USA
2. ONERA - France
3. University of Valencia- Spain
4. University of Southampton - UK
5. Qing Dao -China
6. RAL - UK
7. CSIRO - Australia
8. KIT- Germany



273 K to 323 K (0 to 50 °C)





Radiometer comparison

1. Miami University (USA)
2. ONERA (France)
3. University of Valencia (Spain)
4. University of Southampton (UK)
5. Qing Dao (China) -1
6. Qing Dao (China) -2
7. RAL (UK)
8. CSIRO (Australia)
9. KIT (Germany)
10. DMI (Denmark)
11. GOTA (Canary Islands)
12. JPL NASA (USA)
13. Ian Barton (Australia)

240 K to 318 K



MAERI (UofM) viewing NPL ammonia Heat pipe



SISTER (RAL) viewing NPL ammonia Heat pipe

5



Water Surface Temp (near NPL) (Jun/Jul 2016)



The floating platform from which WST measurements are due to take place is in the middle of the Wraysbury reservoir. The depth of the reservoir is 20 m.

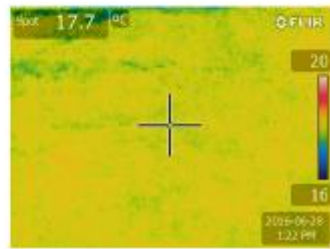




WST comparison



1. University of Valencia (Spain)
2. University of Southampton (UK)
3. Qing Dao (China) -1
4. Qing Dao (China) -2
5. RAL (UK)
6. CSIRO (Australia)
7. KIT (Germany)
8. DMI (Denmark)
9. GOTIA (Canary Islands)
10. JPL NASA (USA)



LST measurements @ NPL (impact of environment e.g. sky in context of ϵ) July 2016



Planned LST measurement targets

- The following “targets” are being planned (on the advice of KIT):
- Short green grass (high emissivity at 10 μm).
- Short dry grass (low emissivity at 10 μm).
- Sand / gravel with different SiO_2 contents and grain sizes
- “Dark soil”.
- Tarmac.

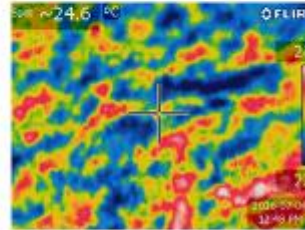
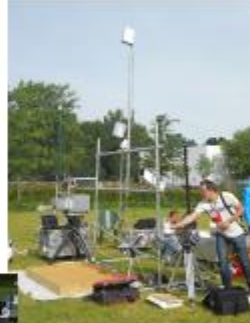




LST (Sun & Cloud)



- 1. University of Valencia (Spain)
- 2. KIT (Germany)
- 3. JPL NASA (USA)
- 4. ONERA (France)



Emissivity



LST @ Namibia Jun 2017



Implementation plan for the FRM4-CEOS field Inter-comparison Experiments (FICE) in Namibia

ESA Contract No. 4000212040, 251-60
Prepared by Folke Glaser (KIT)



Gobabeb 'station dune'

30 m high 'Wind Tower' in the Namib





Summary / Actions / Next steps



- Results from participants end of August
- Analysis by NPL
- Discuss with participants (individually about U_c) and as a group on results after confirmed U_c)
- Publish

International Conf/workshop @ NPL, UK 7-9 March 2017





CEOS 'MIAMI IV' COMPARISON ++

NPL National Physical Laboratory | **Centre for Carbon Measurement** *Supporting climate research and a low carbon future*

Fiducial Reference Measurements For validation of Surface Temperature of Satellites (FRM4STS)

CEOS (ESA: 4000113846/I-LG) **esa**

(CEOS 'Miami IV' comparison ++)

Dr Nigel Fox (project Lead)
Head of Science EO, Climate & Optical

fiducial reference temperature measurements | Science & Technology Facilities Council | PIB | KIT | University of Southampton | DMI

Overview of 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

Requires:

- Comparisons to ensure consistency between measurement teams
- Accessible common descriptions and evaluation of uncertainties
- Robust links to SI
- Experiments to evaluate sources of bias/uncertainty under differing operational conditions
- International community buy-in (customer and supplier) of added value and how to achieve – through provision of guidance and best practises and access to standards and comparisons

Context: CEOS plenary (2014) endorsed a project to carry out a series of comparisons of instrumentation & methods used to validate satellite IR measurements of surface (Ocean, Land) Temp to ensure international harmonisation



(an extension of previous 'Miami series')





ESA sponsored project (FRM4STS) to:



- Design and implement a laboratory-based comparison of the results of participants calibration processes for FRM TIR radiometers (SST, LST, IST)
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Activities and participation



All teams making satellite validation measurements (particularly for S3, are strongly encouraged to participate)

Activity / Action	Key Date
Completion of 'expression to participate' form	1 December 2015
Final Invitation to participate distributed with draft protocols	10 January 2016
Webinar on comparisons- community Q&A	5 February 2016
Formal commitment to participate in comparisons	1 March 2016 (for Ice comparison-10 February 2016)
Ice Surface Temperature comparison start in Greenland	April 2016 (exact date to be confirmed)
Laboratory comparison and calibrations @ NPL, UK	20 June 2016
External comparisons of Land and water Temp measurements (environmental effects) @ NPL, UK	27 June – 9 July 2016
Land Surface Temperature comparisons, Namibia	November 2016



For info on the project: www.FRM4STS.org





Activities and participation



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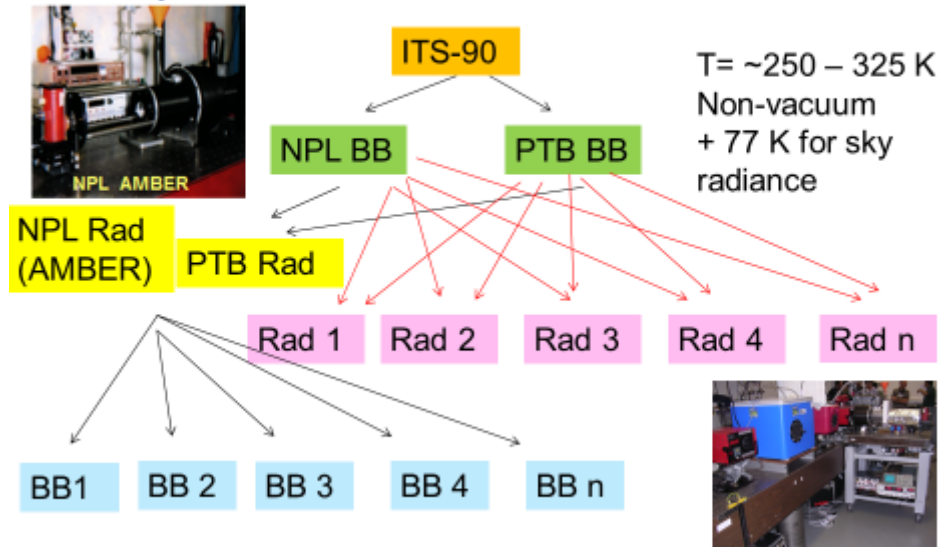
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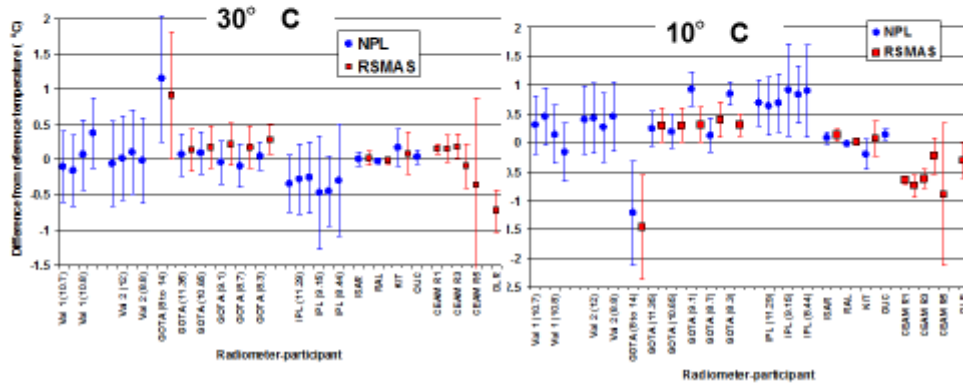
Room Environment with variable T

5



MIAMI 3 (2010) Results of radiometers to a “standard black body” in Lab (NPL and RSMAS (NIST))

- Excellent agreement near ambient but increased variance between participants at cooler temperatures
- Results in UK and US consistent showing stability of radiometers and also agreement between NPL and NIST



Water Surface Temp (near NPL) (Jun/Jul 2016)



The floating platform from which WST measurements are due to take place is in the middle of the Wraysbury reservoir. The depth of the reservoir is 20 m.





LST measurements @ NPL (impact of environment e.g. sky in context of ϵ) July 2016



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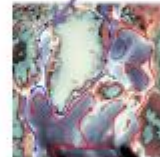
IST ‘pilot’ comparison (April 2016)

The aim with this study is to evaluate potential variances (non-equivalences) in FRM of TIR radiometers under high latitude sea ice field conditions.

This option will be conducted as four main tasks:

- Plan and arrange a FICE with focus upon FRM for ice surface temperature
- Conduct an IST FICE in Qaanaaq, Greenland with at least 2 independent FRM TIR radiometers
- Process the field campaign data with focus upon SI traceability
- Report the results in a technical report/publication

Qaanaaq





LST @ Namibia Nov 2016







Implementation plan for the FRM4-CEOS field Inter-comparison Experiments (FICE) in Namibia

ESA Contract No. 4000212040, 251-60
Prepared by Folke Glaser (KIT)



Gobabeb 'station dune'

30 m high 'Wind Tower' in the Namib



LST comparison with various methods (under expertise of KIT)

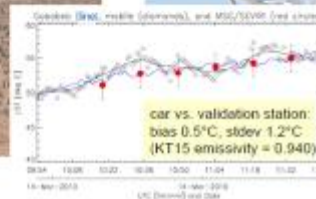
- Gobabeb gravel plains
- Kalahari bush

3 telescopic masts

1. Max. 25m high
30kg payload
needs trailer, ca. 200 kg
2. Max. 14 m high
5 kg payload
portable by 2 people
3. Max. 15 m high
10 kg payload
portable by 2 people



Spatial averaging over gravel plains





Summary / Actions / Next steps



- Major set of international comparisons planned with defined dates
- Detailed protocols and guidance on Uncertainty evaluation will be provided
- To be considered 'Fiducial' participation is required
- Completion of registration (Dec 1st) www.FRM4ST.org
- Make aware and encourage international participation
- Questions (webinar in Jan 2016) or Nigel.fox@npl.co.uk

International Conf/workshop @ NPL, UK 7-9 March 2017





CEOS CV8 – WGCV PLENARY 39

CEOS

SST/LST comparison CEOS CV8

Nigel Fox
NPL (with ESA support)
WGCV Plenary # 39
Berlin
May 6 - 8, 2015

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Working Group on Calibration and Validation

CEOS Delivery through ESA funded
Project: FRM4STS

Fiducial Reference Measurements For validation of Surface Temperature of Satellites (FRM4STS)


- Organise and analyse CEOS comparisons (Laboratory and Field) for SST/LST/IST
 - Ensure traceability to SI through NMI standards
 - Evaluate sensitivities of radiometers to operational conditions (e.g. sky brightness)
 - Report results
 - Develop strategy to maintain measurement systems and their quality
- Review/Consolidate and Document best practises for establishing/maintaining and demonstrating 'traceability' (Fiducial nature of measurement system)
- Review state of art and means to improve the traceability of 'non-recoverable' measurement systems

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Working Group on Calibration and Validation



CEOS project: comparisons

- **Laboratory (controlled conditions) comparison of SST and LST measuring radiometers and associated travelling reference black bodies @NPL UK Q1/1.5 2016**
 - Traceability to NPL and PTB standards (SI)
 - Range of Temperatures (250 -315 K) TBC
 - updated protocols of Miami 3 comparison (2010)
 - Require detailed uncertainty budgets (training given as needed)
- **Intermediate (external near controlled conditions) comparison**
 - Investigate environmental effects (sky brightness, view angle etc)
 - @/near NPL same time frame
 - NPL facility on reservoir near LHR for SST
 - Artificial targets of gravel, sand, Grass @ NPL for LST
- **Field comparison of radiometers for LST @ Gobabeb Namibia (KIT) (Q3, Q4 2016 Q1 2017) TBC**
- **Pilot Field comparison of Radiometers for SST (bi-lateral) + protocol and database for follow-ons**
- **Pilot for IST (Greenland) Mar/Apr 2016 (TBC)**

Working Group on Calibration and Validation

CEOS Invitation to participate

- **Invitation letter to participate in one or more of planned comparisons to be sent to community via CEOS and other Mechanisms within 1 Month**
 - to include some options on dates (attempt a consensus)
 - confirmation of intent to participate and any issues on funding (Note: as CEOS project expect key participants to be supported)
 - Types of instruments planned to participate
- **Website to be created linked through Cal/Val portal (www.FRM4STS.org)**
 - Details
 - Protocols
 - Photos and videos of activities when happening

Working Group on Calibration and Validation



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-END OF DOCUMENT-