Fiducial Reference Measurements for validation of Surface Temperature from Satellites (FRM4STS) – Land Surface Temperature (LST) Field Inter-Comparison Experiment (FICE)

D130 - Implementation plan for the FRM4STS LST FICE (FICE-IP)

ESA Contract No. 4000113848_15I-LG

Folke Olesen & Frank Göttsche

OCTOBER 2016

Reference	OFE-D130-V1-Iss-2-Ver-3
Issue	2
Revision	3
Date of Issue	13.02.2017
Status	Final
Document Type	FICE-IP

INTENTIONALLY BLANK

Fiducial Reference Measurements for validation of Surface Temperature from Satellites (FRM4STS) – Land Surface Temperature (LST) Field Inter-Comparison Experiment (FICE)

D-130 Implementation Plan for the FRM4STS LST FICE (FICE-IP)

Folke Olesen & Frank Göttsche
Karlsruhe Institute of Technology (KIT)

CONTENTS

DOCUMENT MANAGEMENT

Issue and Revision

Issue	Revision	Date of Issue/revision	Description of Changes
1	1	10-Oct-15	Creation of document
2	1	17-Aug-16	FICE limited to Gobabeb & shifted to June 2017
2	2	03-Feb-17	FICE adjusted to available accommodation; updated list of participants
2	3	13-Feb-17	Re-adjustment of FICE schedule to available accommodation Gobabeb

DOCUMENT APPROVAL

Contractor Approval

Name	Role in Project	Signature	Date
Folke Olesen	Responsible Scientist for LST FICE		
Nigel Fox	Technical Lead		
David Gibbs	Project Manager		

Customer Approval

Name	Role in Project	Signature	Date
C Donlon	ESA Technical Officer		

APPLICABLE DOCUMENTS

AD Ref.	Ver. /Iss.	Title
ESA Ref: AO/1-7912/14/I-LG	Issue 1/ Rev.159	– Fiducial Reference Measurements for Thermal Infrared Satellite Validation (FRM4STS) NPL Management Ltd, STFC RAL Space, Soton, KIT, DMI Scottish Marine Institute, PTB Issue 1, Rev 151 NPL Management Ltd – Commercial

ACRONYMS AND ABBREVIATIONS

ASL	Above Sea Level
CEOS	Committee on Earth Observation Satellites
FICE	Field Inter-comparison Experiment
FOV	Field of View
GRTC	Gobabeb Research and Training Centre
KIT	Karlsruhe Institute of Meteorology
LSE	Land Surface Emissivity
LST	Land Surface Temperature
MET	Ministry of Environment and Tourism
NPL	National Physical Laboratory
PTB	Physikalisch-Technische Bundesanstalt
SST	Sea Surface Temperature

1 INTRODUCTION

Satellite remote sensing of surface parameters is an essential part of the global observation system and provides inputs for weather forecast, climate studies and many other applications. One of the important variables is surface temperature. Satellites have been monitoring global surface temperature for several decades 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 quantities are fully anchored to SI units and that there is a direct correlation with "true" surface/in-situ based quantities, which must be derived from completely independent measurements, i.e. without using any data from the satellite data processing.

There are currently several systems and instruments which provide state of the art ground based validation measurements for obtaining in-situ LST. However, so far neither the instruments nor their field deployment have been compared and there are no established standards to ensure SI-traceability. Thus it is intended to complement the laboratory comparison experiments (LCE) in this project with field inter-comparison experiments (FICE). The most accurate of these surface based measurements (used for validation) are derived from field deployed IR radiometers. These are in principle calibrated traceably to SI units, generally through a reference radiance blackbody. Such instrumentation is of varying design, operated by different teams in different parts of the globe. It is essential for the integrity of their use, to provide validation data for satellites both in-flight and to provide the link to future sensors, so that any differences in the results obtained between them are understood. This knowledge will allow any potential biases to be removed and not transferred to satellite sensors. This knowledge can only be determined through formal comparison of the instrumentation, both in terms of its primary "lab based" calibration and in its use in the field. The provision of a fully traceable link to SI ensures that the data are robust and can claim its status as a "climate data record".

This Implementation Plan (IP) describes the rationale and relevant technical details of the LST FICE, which is scheduled to take place in June 2017 in Namibia. The IP describes the comparison activities that will be carried out and provides logistical information for participants' planning.

2 OBJECTIVES

The overarching objective of the TIR FRM Field Inter-comparison Experiments (FICE) is "to coordinate and demonstrate field inter-comparison activities for TIR FRM". Inter-comparison experiments in the field cannot be controlled to the same extent as in the laboratory: therefore, selecting naturally homogenous sites is of key importance. The purpose of this document is to describe the implementation plan (IP) for the LST FICE to be performed on the Namib gravel plains and sand sea.

3 FIELD SITE

Only a few places in the world offer such large homogeneous areas with long-term stable land covers and land use as Namibia. KIT has in-depth knowledge about local infrastructure (logistics, power supply, telecommunication, etc.), closely co-operates with the 'Gobabeb Research and Training Centre' (www.gobabebtrc.org), a permanently staffed desert research station. Gobabeb is located at the transition between the vast Namib sand sea and large gravel plains. Continuous in-situ measurements are performed from KIT's permanent stations 'Wind tower' and 'Plains' (see Figure 1). Both stations are located at ~ 400 m ASL in hyper arid desert climate.

Figure 1: KIT Site 'Plains' in the Namib. 360 degree panorama with the 20 m mast left of the car.

4 ORGANIZATION

4.1 PILOT

NPL, the UK national metrology institute (NMI) will serve as pilot for the LST FICE and will be responsible for the analysis of data, following appropriate processing by individual participants. NPL, as pilot, will be the only organisation to have access and to view all data from all participants. This data will remain confidential to the participant and NPL at all times, until the publication of the report showing results of the comparison to participants.

4.2 PARTICIPANTS

Table 1 lists the participants of the LST FICE in Namibia. Dates for the comparison activities are provided in section 4.5. All participants should be able to demonstrate independent traceability to SI of the instrumentation that they use, or make clear the route of traceability via another named laboratory. By their declared intention to participate in this key comparison, the participants accept the general instructions and the technical protocols written down in this document and commit themselves to follow the procedures strictly.

Once the protocol (described in TR-3) and list of participants have been reviewed and agreed, no change to the protocol may be made without prior agreement of all participants.

Where required, demonstrable traceability to SI will be obtained through participation of PTB and NPL as pilot.

Table 1: Contact details of LST FICE participants (grey) and people involved (white).

Contact person	Short version	Institute	Contact details
Nigel Fox	NPL	National Physical Laboratory, Teddington, UK	email: nigel.fox@npl.co.uk Tel: +44 20 8943 6825
Frank Göttsche	KIT	Karlsruhe Institute of Technology (KIT), Inst. of Meteorology and Climate Research (IMK-ASF), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany	email: frank.goettsche@kit.edu Tel: +49 721 608-23821
Folke Olesen	KIT	Karlsruhe Institute of Technology (KIT), Inst. of Meteorology and Climate Research (IMK-ASF), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany	email: folke.olesen@kit.edu Tel: +49 721 608-22109
Manuel Arbelo	GOTA	Grupo de Observacion de la Tierra y la Atmosfera (GOTA), Universidad de la Laguna, C/Molinos De Agua S/N, 38200 La Laguna, Canary Islands, Spain	email: marbelo@ull.es
Laurent Poutier	ONERA	Office National d'Etudes et Recherches Aérospatiales, BP74025 2 avenue Edouard Belin, FR-31055 TOULOUSE, CEDEX 4, France	email: laurent.poutier@onera.fr

Stéphane Langlois	ONERA	Office National d'Etudes et Recherches Aérospatiales, DOTA/ERIO, Chemin de la Hunière, 91760 PALAISEAU CEDEX, France	email: stephane.langlois@onera.fr
Martin Wooster	King's College London	King's College London, Dept of Geography, Strand, London WC2R 2LS, United Kingdom	email: martin.wooster@kcl.ac.uk
Werenfried Wimmer	University of Southhampton	University of Southhampton, European Way, Southampton, S014 3ZH, United Kingdom	email: w.wimmer@soton.ac.uk
Jean-Pierre Monchau	THEMACS	THEMACS Ingénierie, 23 rue Alfred NOBEL, 77420 Champs sur Marne, France	email: monchau@themacs.fr
Vicente Garcia Santos	UV-ES	Dept. of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Dr. Moliner, 50. 46100 Burjassot, Spain	email: Vicente.Garcia-Santos@uv.es
Raquel Niclos	UV-ES	Dept. of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Spain	email: Raquel.Niclos@uv.es
Dr. César Coll	UV-ES	Dept. of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Spain	email: Cesar.Coll@uv.es

4.3 OVERVIEW OF THE FORM OF COMPARISONS (SEE TR-3 FOR A FULL AND DETAILED DESCRIPTION OF PROTOCOLS AND PROCEDURES TO BE FOLLOWED)

The 2017 LST FICE in Namibia covers a number of individual comparisons. Each comparison will have its own specific characteristics but will in principle take the same form, i.e. it will seek to observe a common entity of a 'target'. The analyses of the results will be made by reference to the mean value observed by all participants. In some cases, to remove potential systematic biases from the measurand under evaluation, results will undergo a normalisation.

4.4 LST FICE OVERVIEW

The main aim of the FICE is the comparison of the in-situ LST determined by the different measurement teams. The experiments consist of daytime and night-time measurements of all radiometers viewing a variety of natural targets, e.g. sand, gravel, dry grass, and rocks. In order to minimise differences due to LST anisotropy, the measurements will be performed at near-nadir view angles (<30°). Where instruments allow this, continuous measurements of up to 3 days will be performed. If an instrument requires a power-line, its measurements are limited to targets found on the premises of Gobabeb Research and Training Centre or a generator must be provided.

During the FICE large diurnal LST amplitudes (about 40 K) and surface-overheating of 20 K or more is to be expected. Since LST is not directly measured but derived from surface brightness temperature (BT), sky BT and emissivity, all participants shall provide their LST, measured BT, and emissivity estimates and provide the corresponding time (UTC) and geolocation (decimal degrees lat/lon) for EACH data record. All data will be submitted in a common table format specified by the pilot. For more detailed analyses the spectral range for the instrument and the times of calibration should also be provided. A summary of the procedure to be followed during the FICE is given below:

- Each participant radiometer should be mounted on one of the provided masts so that it views the target area indicated by the pilot (e.g. a patch on the gravel plains).
- The "clock" of each participant has to be synchronised to UTC.
- Following an indication from the pilot, each participant will measure the target BT and record it together with sky BT at time intervals that suit each radiometer. Different approaches for obtaining hemispherical sky radiance will be compared (via representative angle of 53°, zenith observation of BT, crinkled aluminium foil). The host will provide some additional meteorological data, e.g. air temperature and humidity.

- After completing a measurement sequence, participants will have to carry out any necessary post processing, e.g. calculation of emissivity and correction for reflected down-welling sky radiance etc., before submitting their final results to the pilot. This will include processed Land Surface Temperatures (LST) as well as independently estimated LSE values for each target.

- Choosing favourable environmental conditions, e.g. at night-time for clear sky and low wind speeds, the host will provide 'true' LST at one specific time for each target, allowing the participants to obtain an instrument-specific Land Surface Emissivity (LSE) that will also be part of the evaluation.

- For lightweight radiometers additional measurements from a 4WD car along a 20 km track across the gravel plains will be performed, which will increase the number of samples and the representativeness of the results considerably.

- The results should not be discussed with any participant other than the pilot until the pilot gives permission.

Due to the homogeneity and isotropy of the large sand areas the choice of sampling method for the Namib sand sea is expected to be uncritical. In contrast, the sampling of the gravel plains, which represent a mixture of gravel and dry grass, has to account for the different FOVs of the radiometers: among others, it has to be ensured that the FOVs are representative of the same gravel and dry grass mixture, which requires that they cover several square meters. For narrow FOV radiometers this can be achieved by raising them sufficiently above the ground: KIT's telescopic masts can accommodate about 4 lightweight radiometers at a time. One mast has a top load of about 5 kg and can be carried by two people. The other mast has 50 kg top load and weighs ~ 200 kg, i.e. trailer transport has to be arranged. KIT will arrange this transport and will set the mast up at the chosen locations before the start of the field work. In order to mount the instruments to the masts, KIT will provide 1 1/3" (~34 mm) metal tubes: participants need to ensure that their instruments can be fitted to this diameter. Additional tubes and fittings can be made available on request; please contact Folke Olesen at KIT to enquire (email: folke.olesen@kit.edu, tel: +49 721 608-22109).

4.5 TIMETABLE

Clear sky conditions are preferable for the field measurements since down-welling radiance is easy to determine and varies relatively slowly and smoothly over the day. Since Gobabeb is located in the Namib Desert frequent clear sky conditions can be expected almost all year around. The LST FICE is implemented in three main phases (Table 2): the first phase prepares the LST FICE, the second phase is the execution of field measurements and the third phase covers the analysis and report writing.

PHASE 1: Preparation	
Invitation to participate in LST FICE	October 2016
Preparation and formal agreement on protocol	December 2016
Booking of facilities at Gobabeb	January 2017
Shipping of material to Namibia	April 2017
PHASE 2: Field work	
Arrival in Windhoek	15th of June 2017
Field campaign	16th to 26th of June 2017
Participants send their data & field reports to pilot	End of July 2017
PHASE 3: Evaluation	
Participants send preliminary evaluation reports to pilot (shared amongst all participants)	September 2017
Deadline for comments from participants	October 2017
Draft A (results circulated to participants)	November 2017
Final draft of report circulated to participants	December 2017
Draft B submitted to CEOS WGCV	TBC
Publication of Final Report	TBC

Table 2: Overall schedule for LST FICE.

Due to the very tight accommodation situation at GRTC, Namibia, the LST FICE will now take place between **Friday the 16th and Monday the 26th of June 2017**. Table 3 gives the detailed schedule of the LST FICE. The suggested arrival in Windhoek is on Thursday the 15th of June in morning, where you can pick up a 4x4 car, which needs to be pre-booked (!), e.g. from www.ascocarhire.com. The suggested schedule allows sufficient time for catering in Windhoek. Participants, who do not require 4x4 cars, can alternatively fly to Walvis Bay and arrange a pick up by GRTC (preferably as a group). Please note that our 'weekend' is now Monday the 19th to Wednesday the 21st of June ('days off'): there is no free accommodation at GRTC during these days. A good way to spend the three days would be in a guesthouse in Swakopmund and / or exploring the Namib-Naukluft National Park.

Day	Night	Task	Date	Weekday
1	Aircraft	Night-flight to Windhoek	**14.06.**	**Wed**
2	Windhoek	Arrival in the morning; car & catering	**15.06.**	**Thu**
3	Gobabeb	Transfer to Gobabeb	**16.06.**	**Fri**
4	Gobabeb	Setup & measure sand	**17.06.**	**Sat**
5	Gobabeb	Vacate accommodation; setup gravel	**18.06.**	**Sun**
6	Day off	Automated measurements	**19.06.**	**Mon**
7	Day off	Automated measurements	**20.06.**	**Tue**
8	Day off	Automated measurements	**21.06.**	**Wed**
9	Gobabeb	Return; setup & measure rocks	**22.06.**	**Thu**
10	Gobabeb	Mobile measurements & other	**23.06.**	**Fri**
11	Gobabeb	Mobile measurements & other	**24.06.**	**Sat**
12	Gobabeb	Spare & Wrap up	**25.06.**	**Sun**
13	Aircraft	Transfer to WDH, flight back	**26.06.**	**Mon**
14	Home	Switch to northern summer	**27.06.**	**Tue**

Table 3: Schedule of the LST FICE planned for June 2017 in Namibia. The three days off have to be spend elsewhere (Mon 19.06. to Wed 21.06. Gobabeb is fully booked; we leave GRTC on Sunday the 18th in the afternoon and will return on Thursday the 22nd in the morning). Accommodation is available in Walvis Bay, Swakopmund and at guest farms & lodges. Excursions into the Namib-Naukluft National Park (individual or guided) are highly recommended.

5 LOGISTICS

5.1 SHIPPING

It is the responsibility of all participants to ensure that any instrumentation required by them is shipped with sufficient time to clear any customs requirements of the host country, in this case Namibia. This includes transportation from any port of entry to the site of the comparison and any delay could result in them being excluded from the comparison. Namibia allows import and export on a carnet lasting up to one year, which is the method of choice.

There are two standard options for shipping: by Air Cargo or by sea container. If the equipment is heavy, i.e. more than 100 kg, or if large batteries without IATA certificate need to be shipped, the sea container is the best choice. The participants might agree on sharing a container that is loaded in Europe and then shipped to Gobabeb with one transport. However, this is a slow method and 6 weeks of shipping time should be allowed (shipments are known to have lasted even longer). More reliable, faster and thus better for smaller equipment is air cargo.

In both cases, we strongly recommend to use the services of Trans World Cargo in Windhoek: KIT has good experience with their custom clearing and handling. The cargo can either be picked up in Windhoek or delivered to Gobabeb. The latter method has the risk of rough handling and transport on the Namibian gravel roads. Therefore, we recommend the pick-up in Windhoek.

Please note that the coordinator and host have no insurance for any loss or damage of the instrumentation during transportation or whilst in use during the LST FICE, however all reasonable efforts will be made to aid participants in any security.

5.2 FACILITIES AT GOBABEB

Participants should note that Gobabeb is – by European standards – at a rather remote location. Refuelling of cars, shopping, and drawing of cash (the only excepted method of payment at Gobabeb) all requires a trip back to the nearest ‘town’, which for Gobabeb means a 120 km one-way drive on gravel roads to Walvis Bay. All sustenance and accommodation costs will be at the expense of the participants.

Gobabeb Research and Training Centre (www.gobabebtrc.org) is located in the Namib National Park and therefore all activities need allowance from the Ministry of Environment and Tourism (MET); a lengthy procedure. Since KIT co-operates with GRTC the application is

much easier: The field campaign must be announced to GRTC well before the beginning of the planned activities with a brief description and a two page form needs to be filled out.

The travelling time between Windhoek, the country's only major airport, and Gobabeb is one day. Gobabeb provides self-catering accommodation: there is no 'restaurant'. However, partial catering (cooked dinner) can be arranged and the various accommodations provide beds, cooking on a gas stove, a fridge and bathroom. Rooms with two beds, 5 beds and some so-called "villas" with separate sleeping rooms, a shared kitchen, bath- and living room are available. Gobabeb also provides tents and has a large number of camping facilities.

Gobabeb has a simple workshop, provides slow internet access and has mobile phone reception. Electric power (220V) is limited (the entire Research Centre runs on solar power), e.g. a hair dryer will trigger the fuse. Also be aware that Namibia and South Africa use electric plugs NOT included in the usual "world traveller adapter": it is recommended to buy an appropriate adapter on arrival in Windhoek.

5.3 VISA

Officially all participants need 'conference visa', which requires an application some weeks before the trip; please check the current regulation for your country. However, you may decide to combine work with tourism and put the main emphasis of your trip on touristic aspects (Namibia offers fantastic landscapes and wild life): in this case you can simply obtain a tourist visa on arrival in Windhoek. However, in order to smoothly pass through immigration, you then must state that your ONLY purpose for visiting Namibia is tourism (it is NOT possible to declare several purposes).

5.4 CAR RENTAL

The Namibian gravel roads and the access to the measurement sites require a 4x4 off-road vehicle. KIT has good experience with 'ASCO Car Hire' in Windhoek (www.ascocarhire.com). ASCO also provides transfer from WDH Airport to downtown Windhoek, even if customers arrive at odd and different times.

5.5 ESTIMATED COST FOR PARTICIPATING IN THE LST FICE

The estimated cost for each participant of the LST FICE is as follows:

Flight	1.200 € (e.g. Frankfurt-Windhoek with Air Namibia)
Car rental	650 € (13 days * 100 € / 2 passengers)
Petrol	200 € (400 € / 2 passengers)
Accomm. & food :	840 € (12 nights * 70 €; 2 nights in aircraft)

5.6 OTHER INFORMATION

Six months prior to the field campaign in Namibia, participants will be required to supply to the pilot a description of the instrumentation that they will bring to the LST FICE. This will include any specific operational characteristics where heights/mountings may be critical as well as a full description of its characterisation, traceability and associated uncertainties under both laboratory and field conditions. These uncertainties will be reviewed by NPL for consistency and circulated to all participants for comment and peer review. Submitted uncertainty budgets can be revised as part of this review process but only in the direction to increase the estimate in light of any comments.