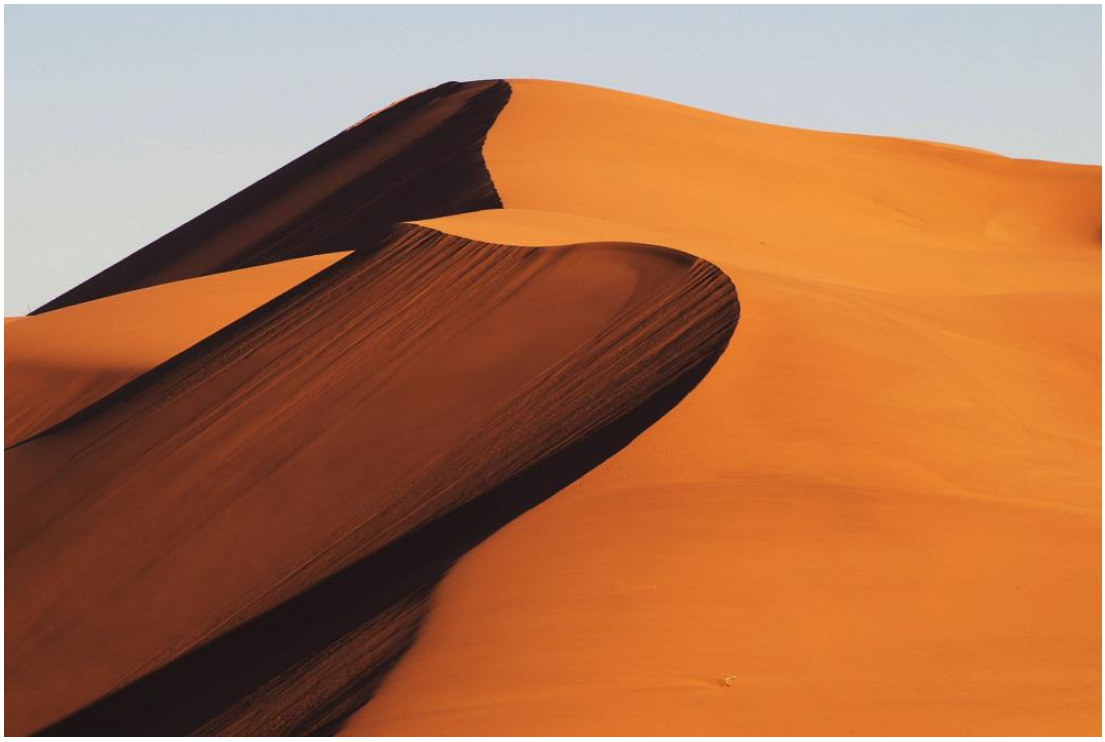
Fiducial Reference Measurements for validation of Surface Temperature from Satellites (FRM4STS) – Land Surface Temperature (LST) Field Inter-Comparison Experiment (FICE)

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

ESA Contract No. 4000113848_15I-LG

Folke Olesen & Frank Göttsche



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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

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

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ACRONYMS AND ABBREVIATIONS

ASL	Above Sea Level
CEOS	Committee on Earth Observation Satellites
FICE	Field Inter-comparison Experiment
FOV	Field of View
GTRC	Gobabeb Training and Research 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 Training and Research Centre' (GTRC; 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.

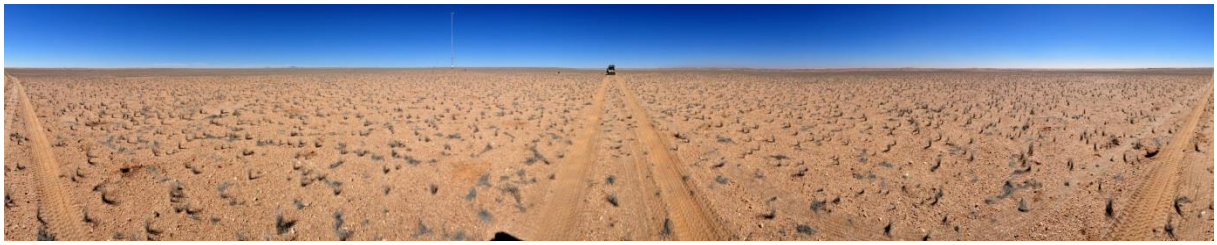

Figure 1: KIT Site 'Plains' in the Namib. 360 degree panorama with the 20 m mast left of the car.

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 who already had signed up in response to the first LST FICE invitation as well as further potential participants. Dates for the comparison activities are provided in section 4.5. A full invitation to the international community through CEOS and other relevant bodies will be carried out to ensure that full opportunity and encouragement is provided to all interested researchers. 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.

Participants' details

Table 1: Contact Details of Potential Participants (initial list, not assumed to be complete)

Contact person	Short version	Institute	Contact details
Nigel Fox	NPL	National Physical Laboratory	email: nigel.fox@npl.co.uk Tel: +44 20 8943 6825
Frank Göttsche	KIT	Karlsruhe Institute of Technology (KIT), Institute 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), Institute 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), ULL, Spain	email: marbelo@ull.es
Laurent Poutier	ONERA	Office National d'Etudes et Recherches Aérospatiales	email: laurent.poutier@onera.fr

		BP74025 2 avenue Edouard Belin, FR-31055 TOULOUSE, CEDEX 4, France	
Simon Hook	JPL-NASA	Carbon Cycle and Ecosystems MS 183-501, Jet Propulsion Laboratory 4800 Oak Grove Drive, Pasadena, CA 91109, USA	email: simon.j.hook@jpl.nasa.gov
Gerardo Rivera	JPL-NASA	Jet Propulsion Laboratory, M/S 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109, USA	email: gerardo.rivera@jpl.nasa.gov
Pierre C. Guillevic	UMD-NASA	Department of Geographical Sciences, University of Maryland Terrestrial Information Systems Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA	Email: pierreg@umd.edu
J. A. Sobrino	IPL	Imaging Processing Laboratory (IPL) Parque Científico, Universitat de Valencia Poligono La Coma s/n, 46980 Paterna Spain	Email: sobrino@uv.es Tel: +34 96 354 3115;
Juan Carlos Jimenez-Muñoz	IPL	Global Change Unit (GCU), Image Processing Laboratory (IPL), University of Valencia (Science Park), C/ Catedratico Jose Beltran, n-2, 46980 Paterna, Spain	email: jcjm@uv.es Tel.: +34 963 543 781

		(Valencia), SPAIN	
Raquel Niclos	UV-ES	Dept. of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Dr. Moliner, 50. 46100 Burjassot, Spain	email: Raquel.Niclos@uv.es
Dr. César Coll	UV-ES	Dept. of Earth Physics and Thermodynamics, Faculty of Physics, University of Valencia, Dr. Moliner, 50. 46100 Burjassot, Spain	email Cesar.Coll@uv.es
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

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 2 days will be performed. If an instrument requires a power-line, its measurements are limited to targets found on the premises of Gobabeb Training and Research 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	Beginning of June 2017
Field campaign	First half of June 2017
Participants send their data and 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.

The LST FICE will take place in first half of June 2017 at various locations around Gobabeb Training & Research Centre, Namibia . A detailed schedule of the LST FICE is given in Table 3. The arrival in Windhoek must be on a weekday (e.g. Friday the 2nd of June 2017) to allow sufficient time for catering; a Saturday might not provide long enough opening hours. During the early part of Phase 1 (Preparation), the participants have do decide on their preferred arrival dates in Windhoek (see Table 3).

Day	Night	Task	Weekday
1	Aircraft	Night-flight to Windhoek	Thu
2	Windhoek	Arrival; car and catering	Fri
3	Gobabeb	Transfer to Gobabeb	Sat
4	Gobabeb	Select locations & setup sand	Sun
5	Gobabeb	Measurements sand	Mon
6	Gobabeb	Measurements sand	Tue
7	Gobabeb	Setup & measurements on gravel plains	Wed
8	Gobabeb	Measurements on gravel plains; re-supply trip to Walvis Bay (food & fuel)	Thu
9	Gobabeb	Measurements on gravel plains	Fri
10	Gobabeb	Mobile measurements & spare	Sat
11	Gobabeb	Day off & BBQ dinner	Sun
12	Gobabeb	Mobile measurements & spare	Mon
13	Gobabeb	Wrap up	Tue
14	Gobabeb	Transfer to WDH, flight back	Wed
15	Home	Switch to northern summer	Thu

Table 3: Schedule of the LST FICE planned for June 2017 in Namibia.

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 Training and Research Centre (GTRC; 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 GTRC the application is

much easier: The field campaign must be announced to GTRC 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.