Land Surface Temperature Field Intercomparison Experiment at Gobabeb, Namibia

Frank-M. Göttsche, LST FICE 2017 team, CEOS Land Product Validation sub-group

INSTITUTE OF METEOROLOGY AND CLIMATE RESEARCH (IMK-ASF)

Fiducial Reference Measurements (FRM)

Karlsruhe Institute of Technology

Sentinel-3 Validation Team:

"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"

FRM must (at least):

1. Document evidence of its traceability to SI
2. Be independent from the satellite geophysical retrieval process
3. Detail an uncertainty budget for the instrumentation and measurement process for the range of conditions it is used over.
4. Adhere to community agreed measurement protocols & management practises.

FRM4STS - objective 1

‘Establish & maintain SI traceability of global Fiducial Reference Measurements (FRM) for satellite derived surface temperature product validation’

Figure 4: Cone-shaped vortex in water as a simple calibrator.

NPL

fiducial reference temperature measurements

esa

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

Technical Report 3
A Framework to Verify the Field Performance of TIR FRM

ESA Contract No. 4000113848_15I-LG

Frank Göttsche, KIT
Folke S. Olesen, KIT
Jacob L. Høyer, DMI
Werenfred Wimmer, Southampton University
Tim Nightingale, STFC

APRIL 2017

Best practises: in situ LST ‘recipe’

- Radiometers shall be traceably calibrated to ±0.3 K or better
- Approx. homogeneous & isothermal targets (on radiometer scale)
- Observations to be performed at near-nadir view angles
- Keep clear of obstructions (trees, buildings, cars, …)
- Measure down-welling sky irradiance ‘simultaneously’
- Estimate **hemispherical** sky irradiance under favourable conditions: completely clear sky or complete uniform stratus
- Obtain instrument-specific emissivity under favourable conditions: stable irradiance (at night), clear sky and low wind speeds
- Synchronise all clocks to time UTC (I know - don’t laugh …)
- …

Committee on Earth Observation Satellites CEOS
Working Group on Calibration and Validation WGCV
Land Product Validation Subgroup LPV

Validation of terrestrial satellite-derived products

Best practices proposed by the CEOS WGCV Land Product Validation sub-group

Pierre Guillevic, Miguel Román, Fernando Camacho de Coca, Jaime Nickeson,
Zhuosen Wang, Frank Göttsche & Christopher Justice

And LPV Focus Area leads

CEOS > WGCV > LPV

CEOS - Committee on Earth Observation Satellites

31 CEOS Members (e.g. space agencies, research centers)

24 Associate Members (e.g. UNEP, WMO, GCOS)

CEOS coordinates civil space-based EO to benefit society

The **Working Group on Calibration and Validation** (WGCV) is one of 5 CEOS working groups

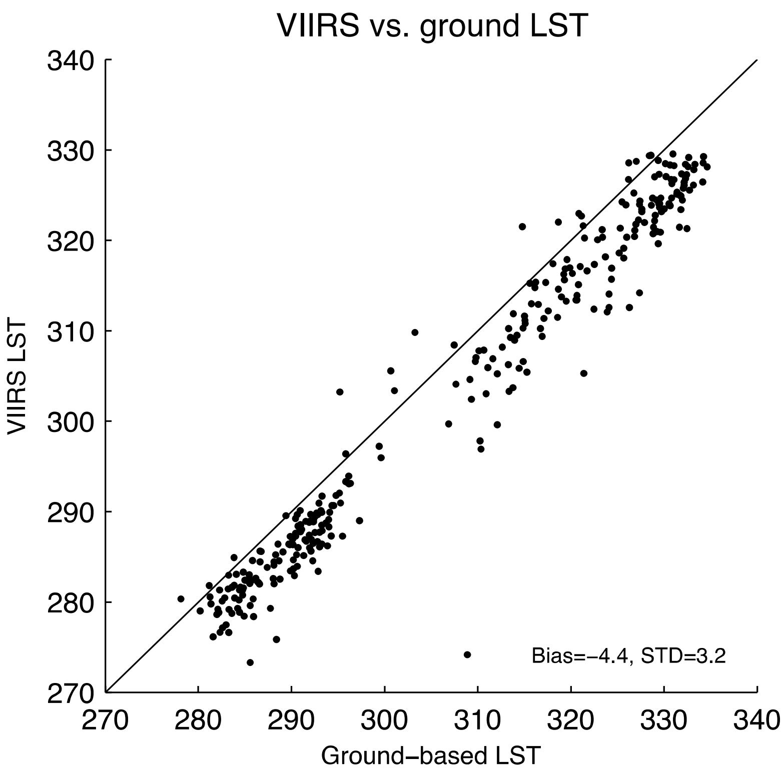
Land Product Validation (LPV) is one of 6 WGCV subgroups

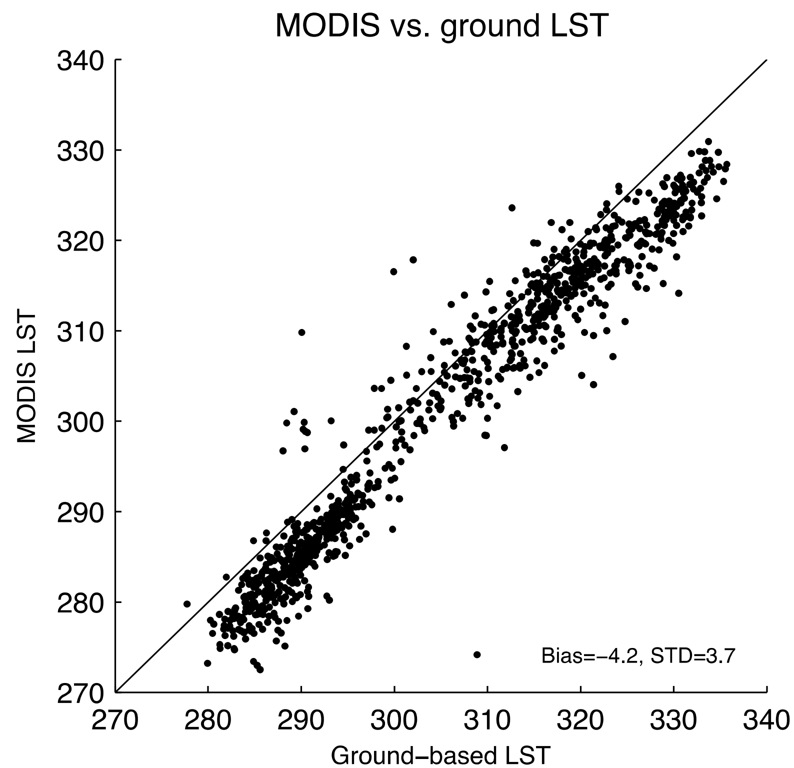
Current LPV Officers:

Chair	Miguel Román	NASA GFSC
Vice-Chair	Fernando Camacho	EOLAB/U. of Valencia
Secretariat	Jaime Nickeson	SSAI/NASA GSFC
Protocol Dev.	Pierre Guillevic	UMD/NASA GSFC
	Zhuosen Wang	UMD/NASA GSFC

+ 11 Focus Areas with 2 co-leads each

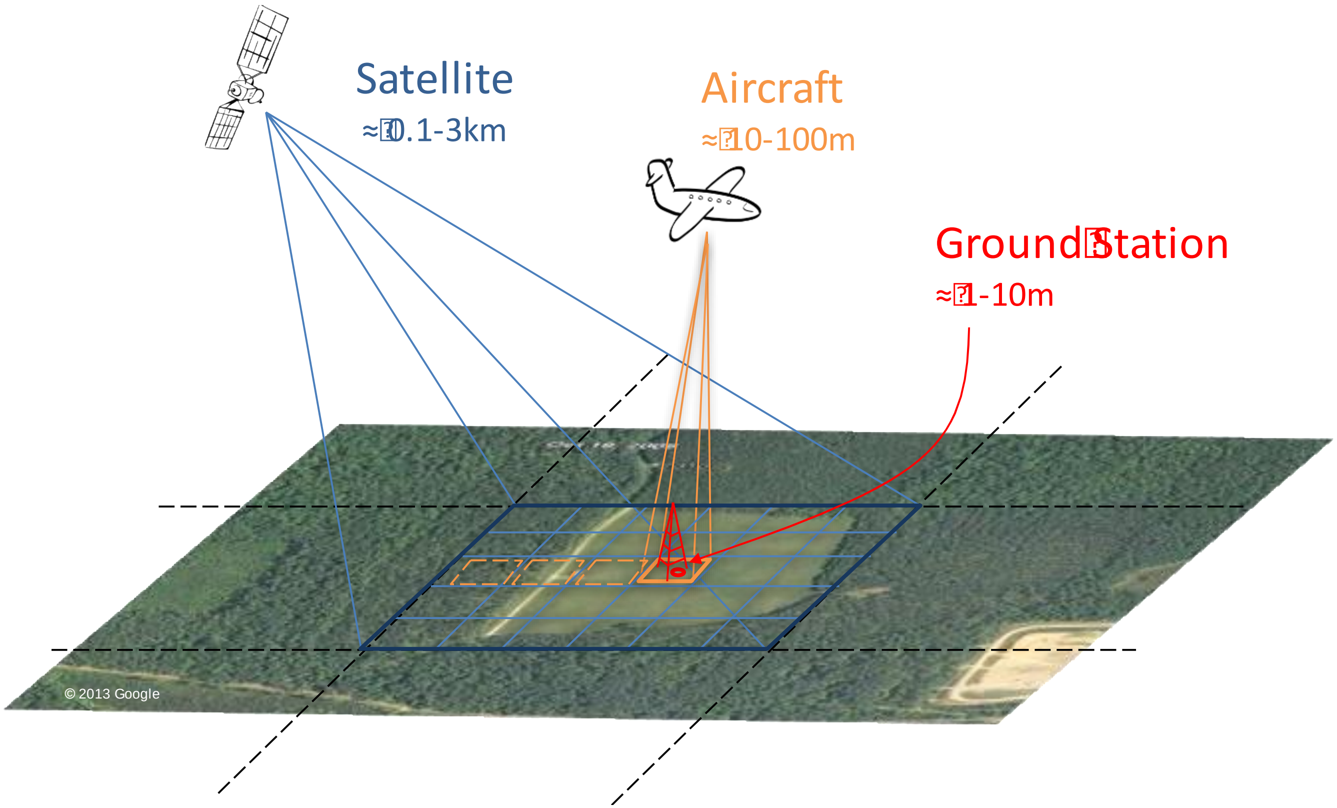
Critical need for ground truth





VIIRS vs. MOD11 algorithms: similar poor performance over arid areas

Spatial scale mismatch in LPV

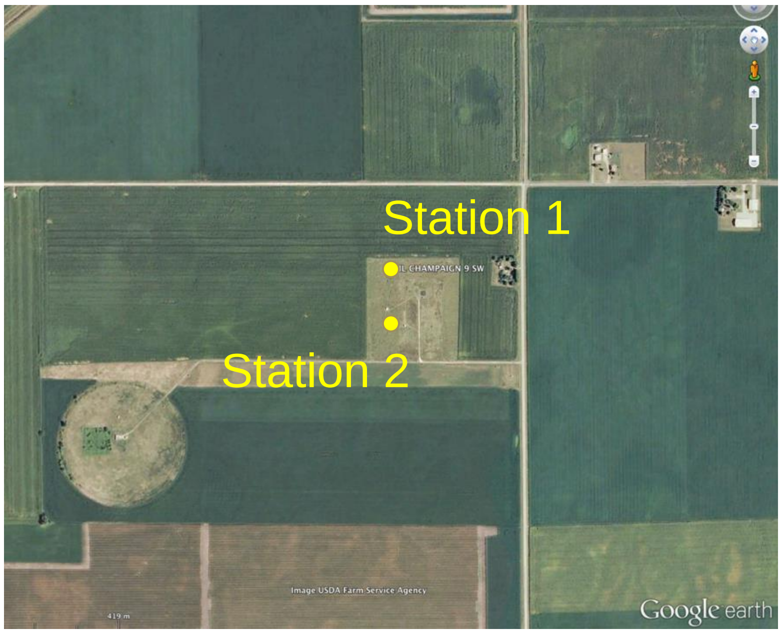


- Characterize both, **in situ** measurements and validation datasets **at satellite product resolution** including uncertainty estimates
- **In situ** needed to characterize **product** uncertainties and identify issues with algorithm, temporal drift, …

LPV challenges

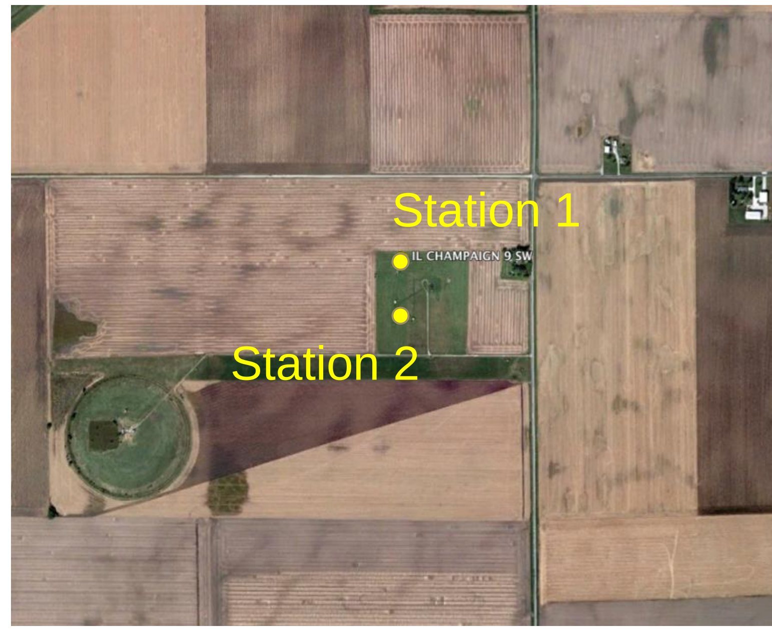
Example: Spatial vs. temporal variability

Before the harvest



1 km

After the harvest



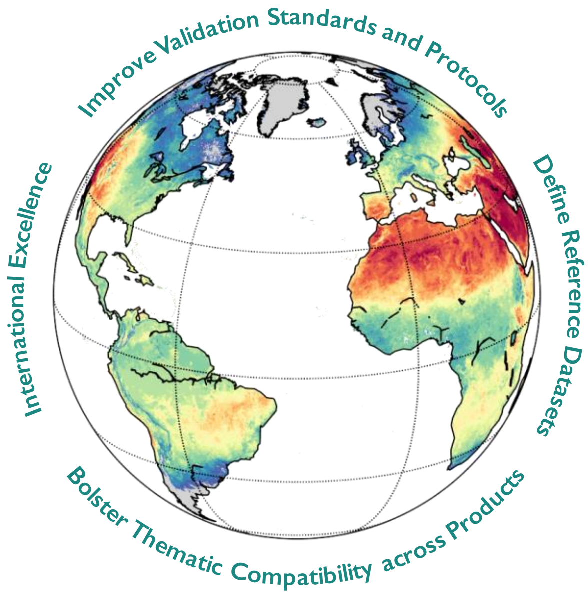
Bondville, IL: Temporal variations of the contribution of the surrounding area to coarse radiometric measurements over croplands

Committee on Earth Observation Satellites
Working Group on Calibration and Validation

Land Product Validation Subgroup

Land Surface Temperature Product Validation Best Practice Protocol

!
!



Version 1.0 - September, 2017

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To be released soon!

FRM4STS - objective 2

fiducial reference temperature measurements

Karlsruhe Institute of Technology

‘International harmonisation and interoperability through a set of intercomparisons’

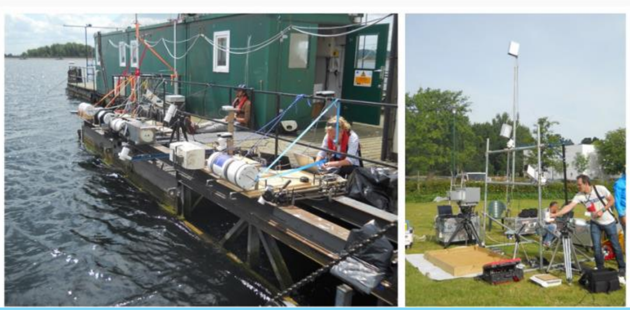
Laboratory Intercomparison

For the Laboratory Intercomparisons there were three types of validation:

- **Controlled laboratory testing (blackbody and radiometer comparisons,**
- **Water Surface Temperature (WST), and**
- **Land Surface Temperature measurements (LST)**

Phase1: Laboratory Intercomparison Exercise

Phase 1: CEOS Laboratory IR Intercomparison, NPL, Hampton UK



Field intercomparison experiments (FICE)

Phase 2A: Shipborne Comparison

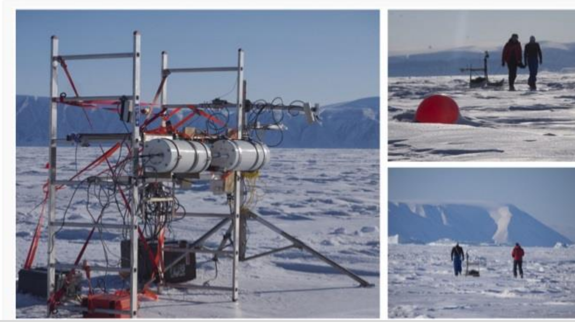
Phase 2A: Ship based Sea Surface Temperature (SST) Comparison

Phase 2B: Land Surface Temperature, Gobabeb

Phase 2B: Land surface Temperature comparison (Gobabeb, Namibia)

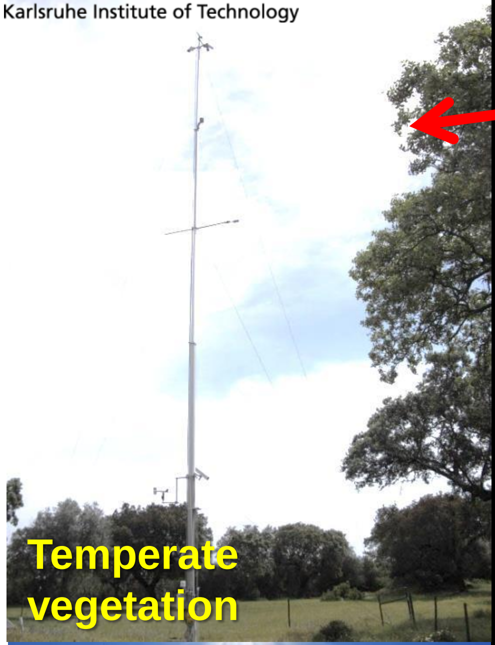
Phase 2C: Ice Surface Temperature, Greenland

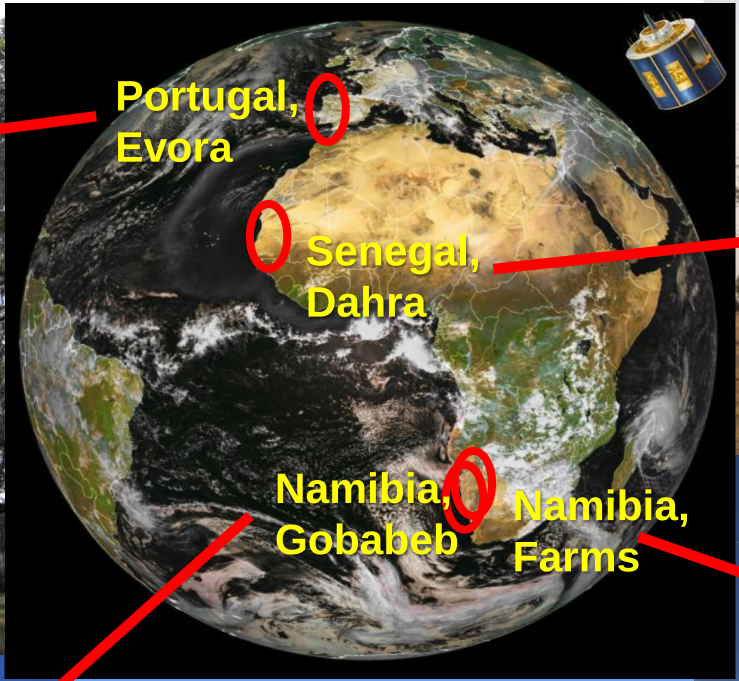
Phase 2C: Ice surface Temperature measurements, Greenland, Arctic

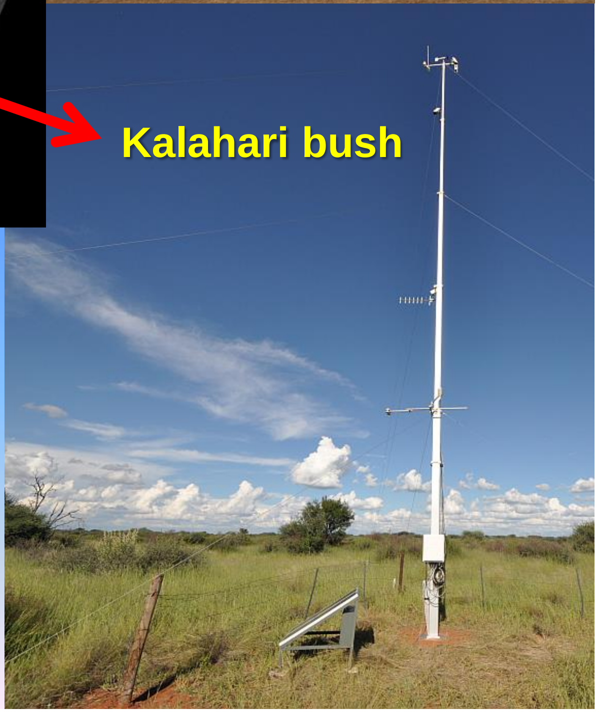


Source: **www.frm4sts.org**

KIT Validation Stations







- Large, **homogeneous** sites
- Well **characterised**
- Different climates & biomes
- **Dedicated** to LST validation

LST FICE 2017 at Gobabeb

Main objective: Coordinate & demonstrate field inter-comparison activities for TIR FRM.

Participants & instruments

Institution	Instrument(s)
Universidad de la Laguna (GOTA-ULL), Spain	- Radiometer CIMEL CE312-2 (six bands)
Office National d'Etudes et Recherches Aérospatiales (ONERA), France	- 2 Radiometer Heitronics KT 19.85 II - Spectroradiometer BOMEM MR354 SC (3-13 µm) - Black Body MIKRON M345 5x5''
University of Southampton, United Kingdom	- Infrared Sea Surface Temperature Autonomous Radiometer (ISAR) - Black Body CASOTS 2
University of Valencia, Spain	- Radiometer CIMEL CE-312-2 (six bands)
THEMACS Ingénierie, France	- Custom-built emissometer (radiometer) - TIR camera with calibration targets
Karlsruhe Institute of Technology (KIT), Germany	- 2 Radiometer Heitronics KT15.85 IIP - Mobile radiometric measurement system

Report from the Field Inter-Comparison Experiment (FICE) for Land Surface Temperature

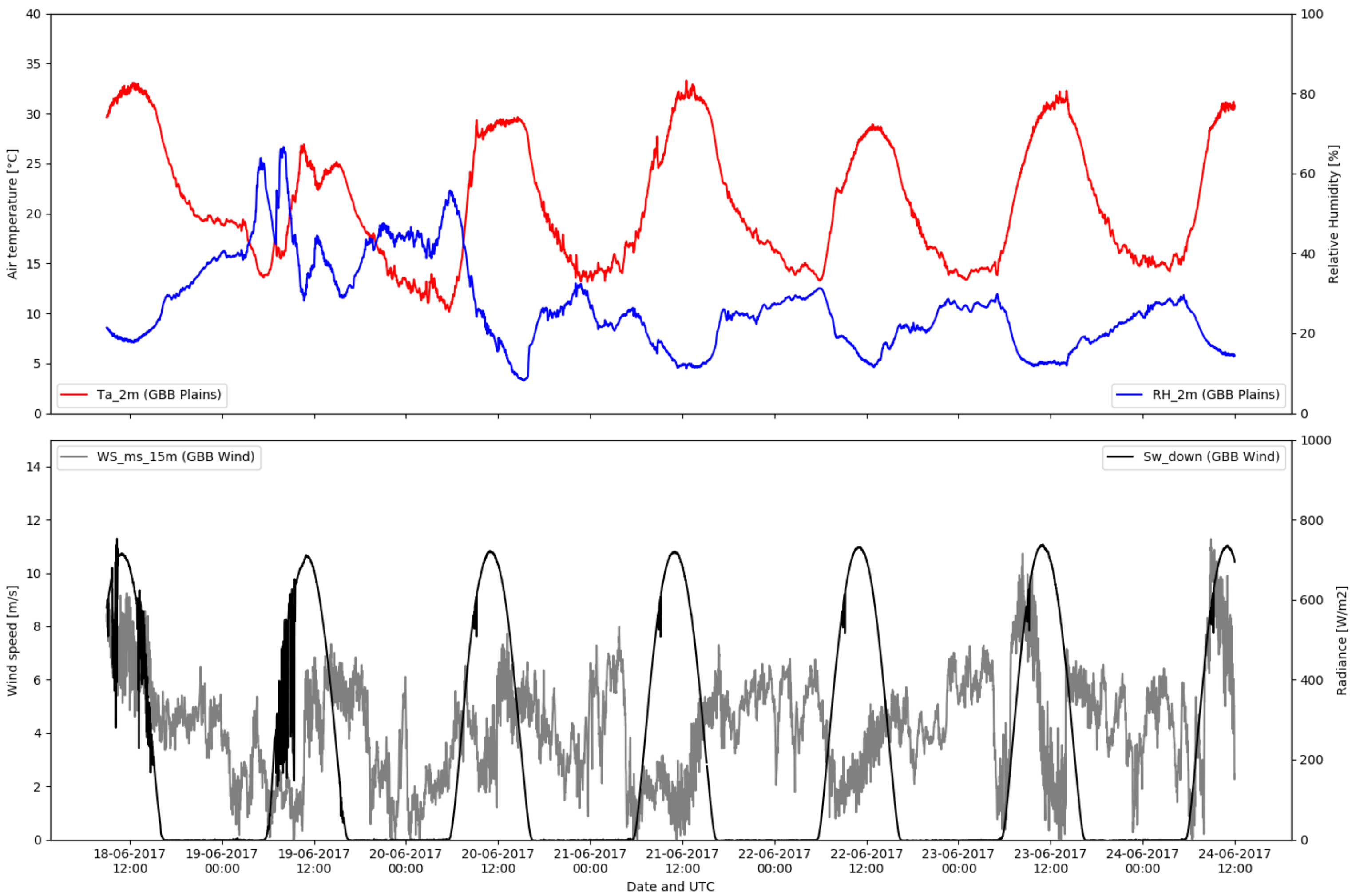
Frank-M. Göttsche[1], Folke Olesen[1], Laurent Poutier[2], Stéphane Langlois[2], Werenfrid Wimmer[3], Vicente Garcia Santos[4], César Coll[4], Raquel Niclos[4], Manuel Arbelo[5] and Jean-Pierre Monchau[6]

[1]Karlsruhe Institute of Technology, Germany, [2]Office National d'Etudes et Recherches Aérospatiales, France, [3]National Oceanographic Centre, United Kingdom, [4]University of Valencia, Spain, [5]Universidad de la Laguna, Spain, [6]THEMACS Ingénierie, France

LST FICE 2017 team at Gobabeb, Namibia

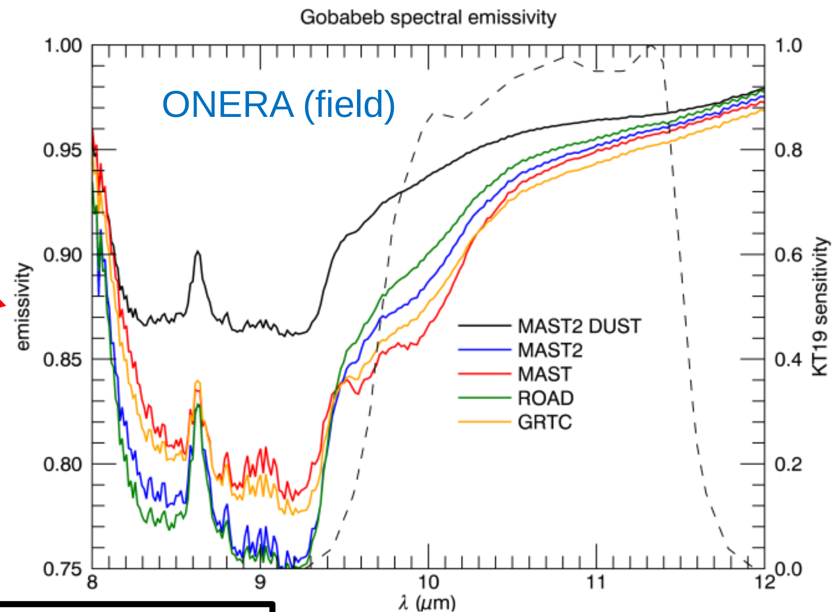
Karlsruhe Institute of Technology

Weather conditions during LST FICE 2017



Field calibration & emissivity determination

Emissivity determination



THEMACS (field)

Location, wind mast	Emissivity (8-14 µm)
point1	0.914
point2	0.900
point3	0.893
point4	0.917
point5	0.877
point6	0.902
mean	**0.901**
stddev	**0.015**

ONERA (field)

Target	Mean	Stddev
MAST2_DUST	0.953	0.015
MAST2_SAMPLE	0.927	[illegible]
MAST_TARGET_GLOB	0.918	[illegible]
ROAD	0.933	[illegible]
GRTC	0.918	0.015

emissivity for KT19

THEMACS (lab)

Material	Emissivity for spectral band 2-17µm	8-14µm	8-12µm	9.6-11.5µm
Sand	0.937	0.925	0.909	0.937
Gravel	0.873	0.806	0.758	0.894

Intercomparison at Gobabeb ‘wind mast’

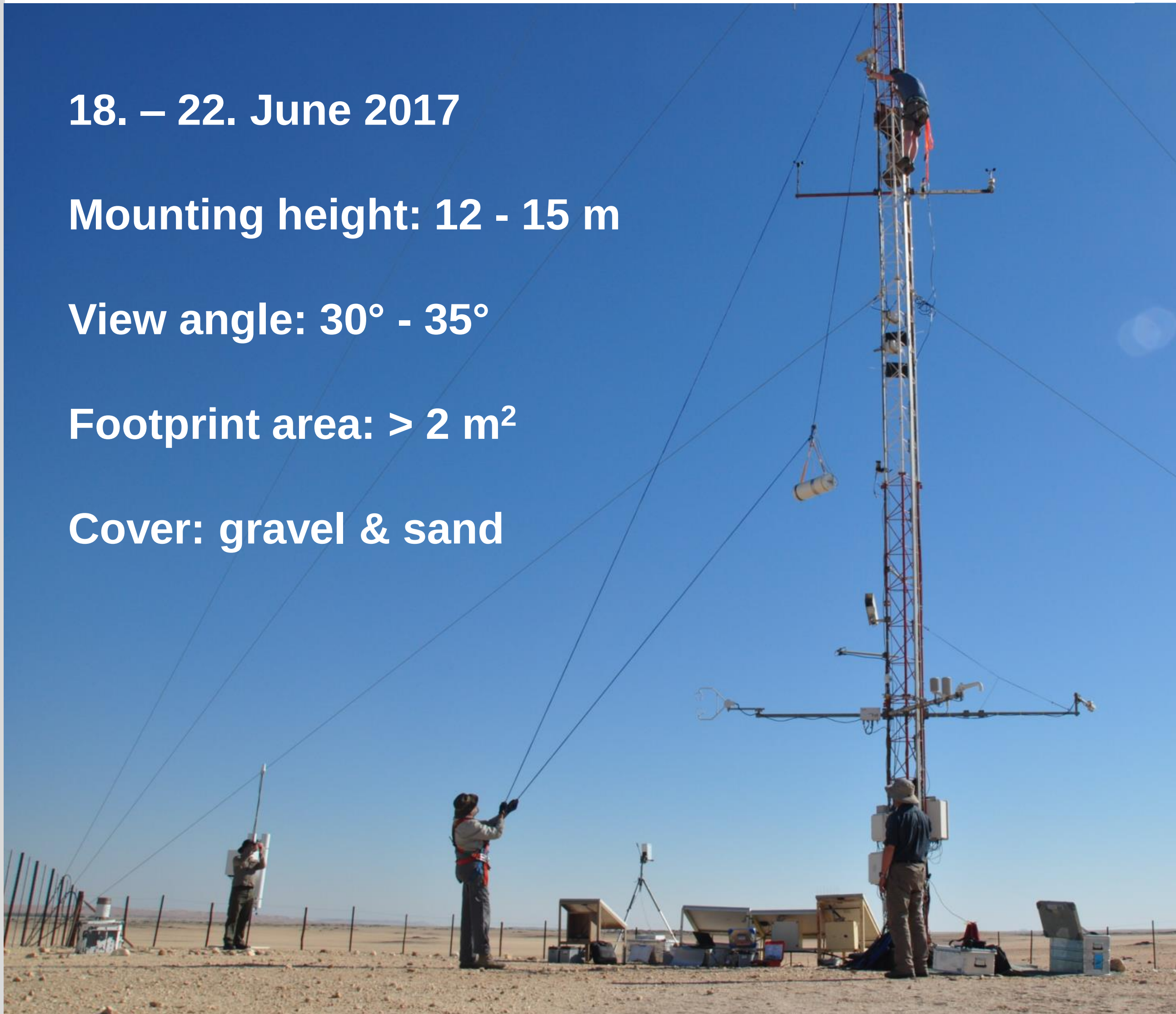
18. – 22. June 2017

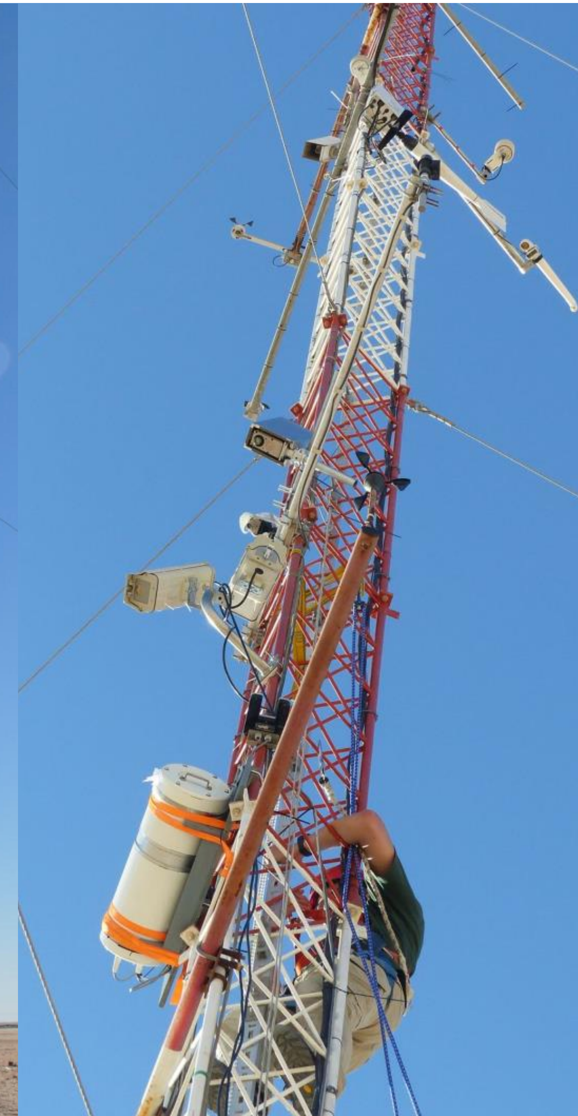
Mounting height: 12 - 15 m

View angle: 30° - 35°

Footprint area: > 2 m^2

Cover: gravel & sand

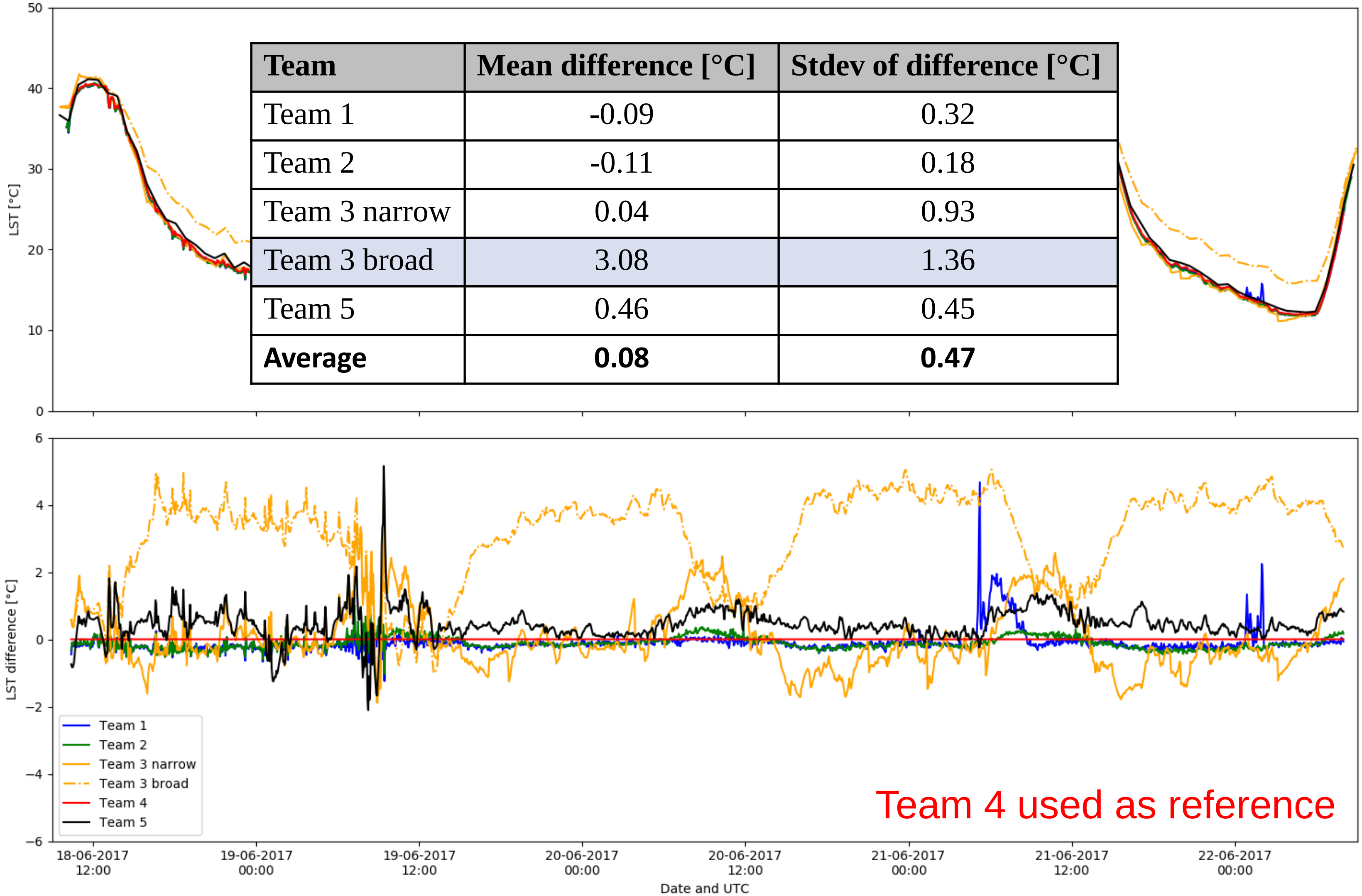




LST intercomparison at Gobabeb wind mast

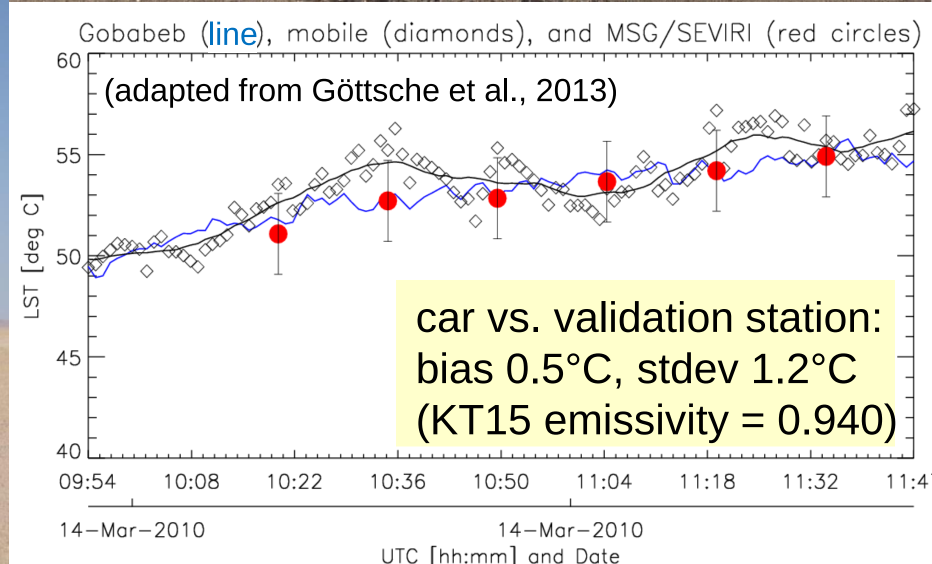
Karlsruhe Institute of Technology

Team	Mean difference [°C]	Stdev of difference [°C]
Team 1	-0.09	0.32
Team 2	-0.11	0.18
Team 3 narrow	0.04	0.93
Team 3 broad	3.08	1.36
Team 5	0.46	0.45
Average	**0.08**	**0.47**



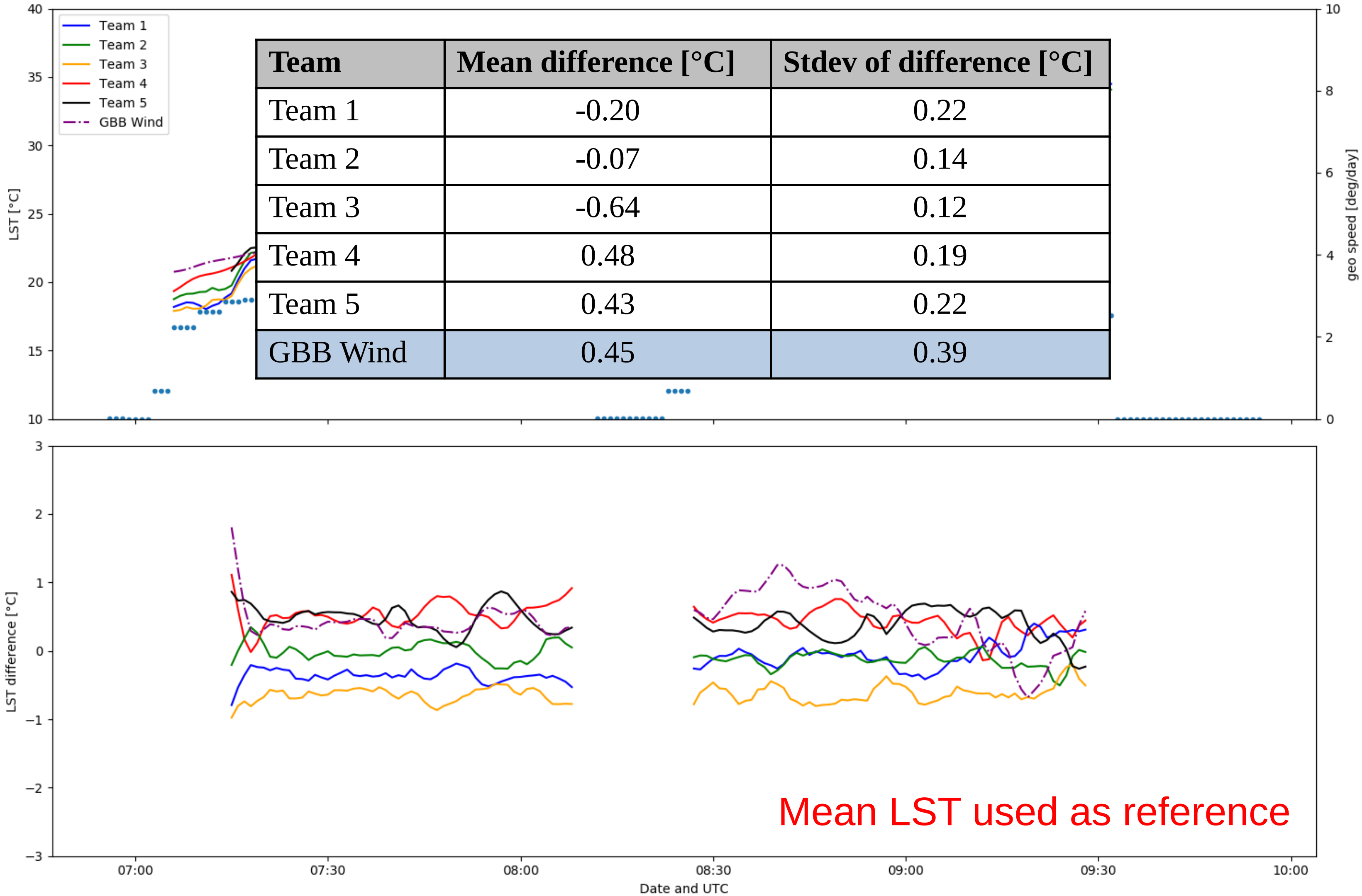
Spatial averaging over gravel plains

Three return trips on 23.6. and 24.6.:
- Length: 20 km, 16 km, and 24 km
- Speed: 10-15 km/h
- Mounting height: 1.8 m
- View angle: 35°
- Footprint Ø ≈ 30 cm



LST intercomparison across gravel plains

Team	Mean difference [°C]	Stdev of difference [°C]
Team 1	-0.20	0.22
Team 2	-0.07	0.14
Team 3	-0.64	0.12
Team 4	0.48	0.19
Team 5	0.43	0.22
GBB Wind	0.45	0.39



Conclusions & outlook

- Successful **temporal** intercomparison (4 days, 5 radiometers)
- Average deviation from reference LST was **0.08 ± 0.47°C**
- Ignoring outliers, for two data sets stdev was about 0.2°C
- Gravel plains homogeneous for radiometer **footprint > 2m^2**
- Broad channel (8-14 µm) problematic for long path length (17m)

- For the **spatial** intercomparison average absolute difference from mean LST was **0.36°C** and average standard deviation **0.18°C**
- Gobabeb wind mast LST were 0.45°C warmer than mean LST from the spatial intercomparison, while stdev was 0.39°C
- The LST FICE highlighted the importance of **in-situ** emissivity
- The measurement protocol lead to highly comparable in-situ LST
- FICE allow teams to compare their measurement approaches and to understand possible differences between their results

Thank you!