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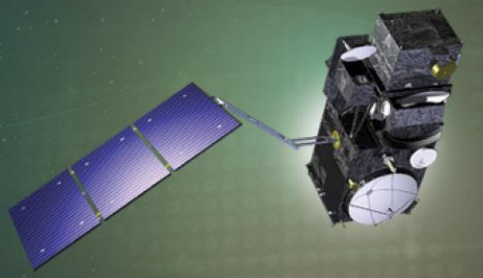

7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Thermal Infra-red Product Inter-comparison and Validation with FRM Radiometers

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[1]Karlsruhe Institute of Technology (GER) & [2]National Oceanography Centre (UK)

FRM: Fiducial Reference Measurements

According to the Sentinel-3 Validation Team, 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.

KIT's validation instrument: Heitronics KT15.85 IIP

- **chopped**, precision radiometer: stability better than **0.12% per year**
- narrow band 9.6µm - 11.5µm
- better than **±0.3K** absolute accuracy
- narrow view angle: 8.5°

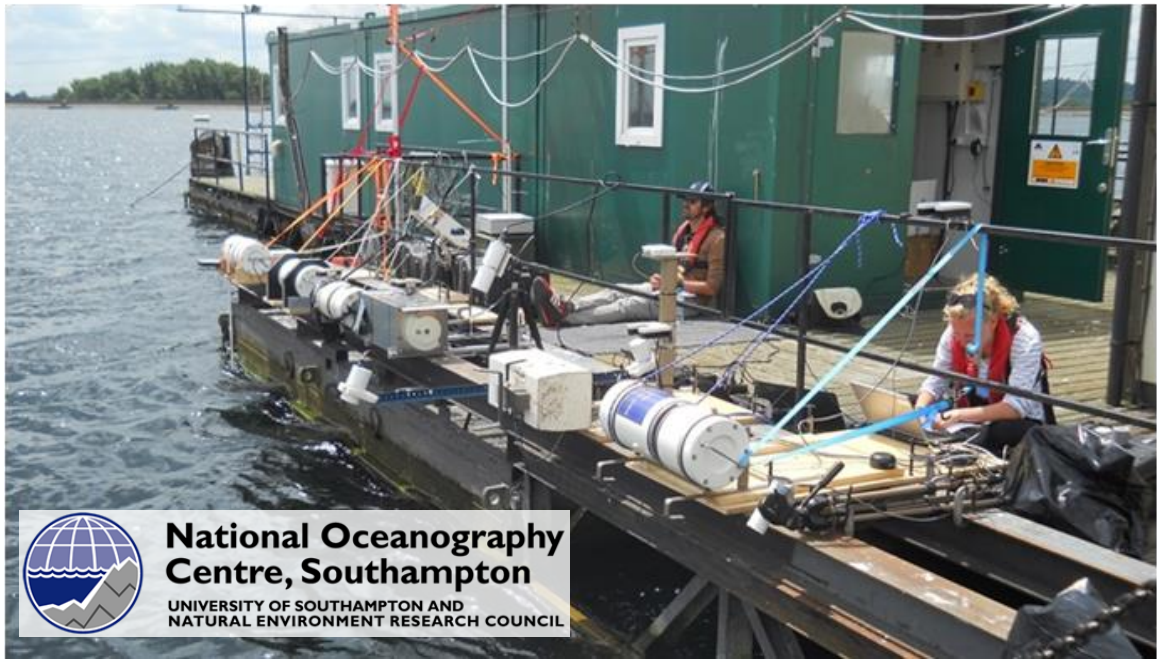
Karlsruhe Institute of Technology

KT15.85 IIP uncertainty budget

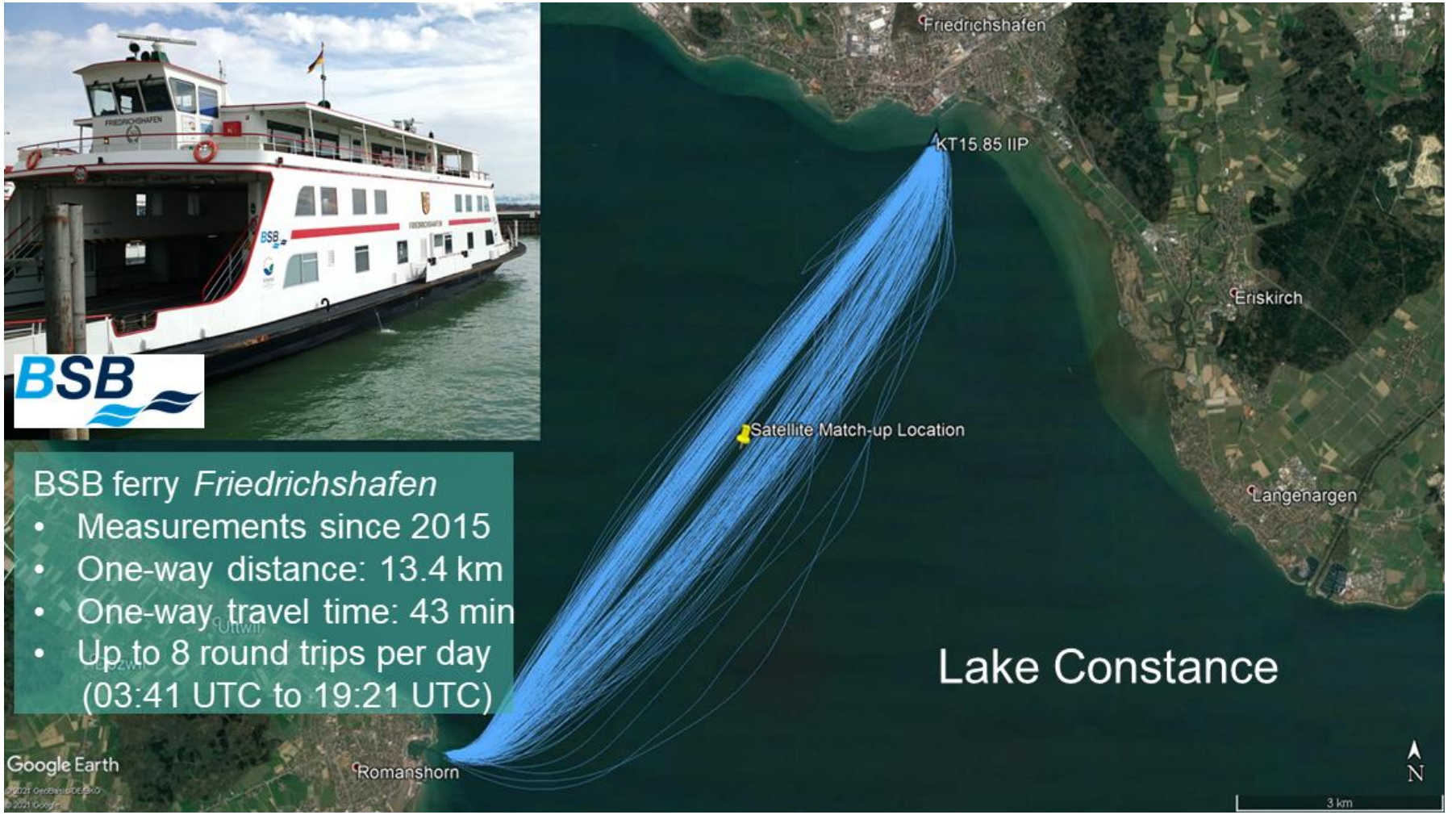
Uncertainty Contribution	Type A Uncertainty in Value / %	Type B Uncertainty in Value / (appropriate units)	Uncertainty in Brightness temperature K
Repeatability of measurement	0.12		0.024
Reproducibility of measurement	0.12		0.024
Primary calibration		0.250 K	0.250
Water emissivity		0.1%	0.067
Water surface "roughness"		2.0 m/s	0.033
Angle of view to nadir		2.5 °	0.117
Linearity of radiometer		0.053 K	0.053
Drift since last calibration		0.176 K	0.176
Temperature resolution		0.035 K	0.035
Ambient temperature fluctuations		0.035 K	0.035
Atmospheric absorption/emission		0.035 K	0.035
Down-welling sky radiance		0.004 K	0.004
RMS total	0.173		0.347

Left: **KT15.85 IIP** uncertainties. From FRM4STS inter-comparison experiment 2016 (Wraysbury reservoir, UK)

Infrared Sea Surface Temperature Autonomous Radiometer (**ISAR**): self-calibrating radiometer with two internal reference blackbodies, accuracy of ±0.1 K



Bodensee-Schiffsbetriebe (BSB) car ferry ‘Friedrichshafen’



Project Objectives

EUMETSAT
National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL
KIT Karlsruhe Institute of Technology

- Perform an inter-comparison experiment over several weeks between Heitronics **KT15.85 IIP** (KIT) and **ISAR** (UoS) on Lake Constance
- Acquire an in-situ data set of Lake Water Surface Temperature (LWST) & Sea Surface Temperature (SST) from the two FRM radiometers
- Inter-compare in-situ surface temperatures (ST) and uncertainties
- Compare satellite ST products (focus on Sentinel-3) with in-situ ST

Lake Constance Radiometer Inter-comparison Experiment

September 2020

National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

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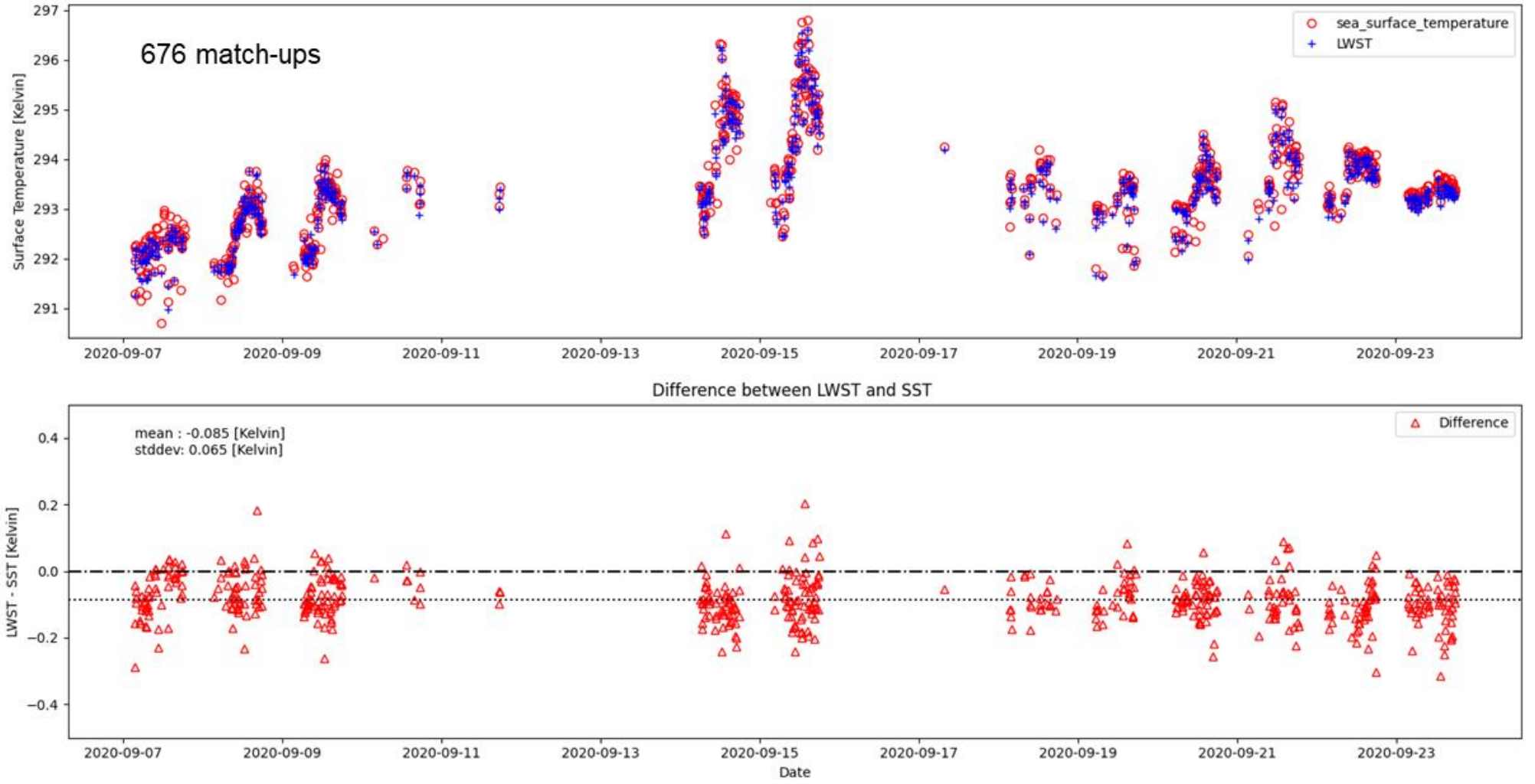
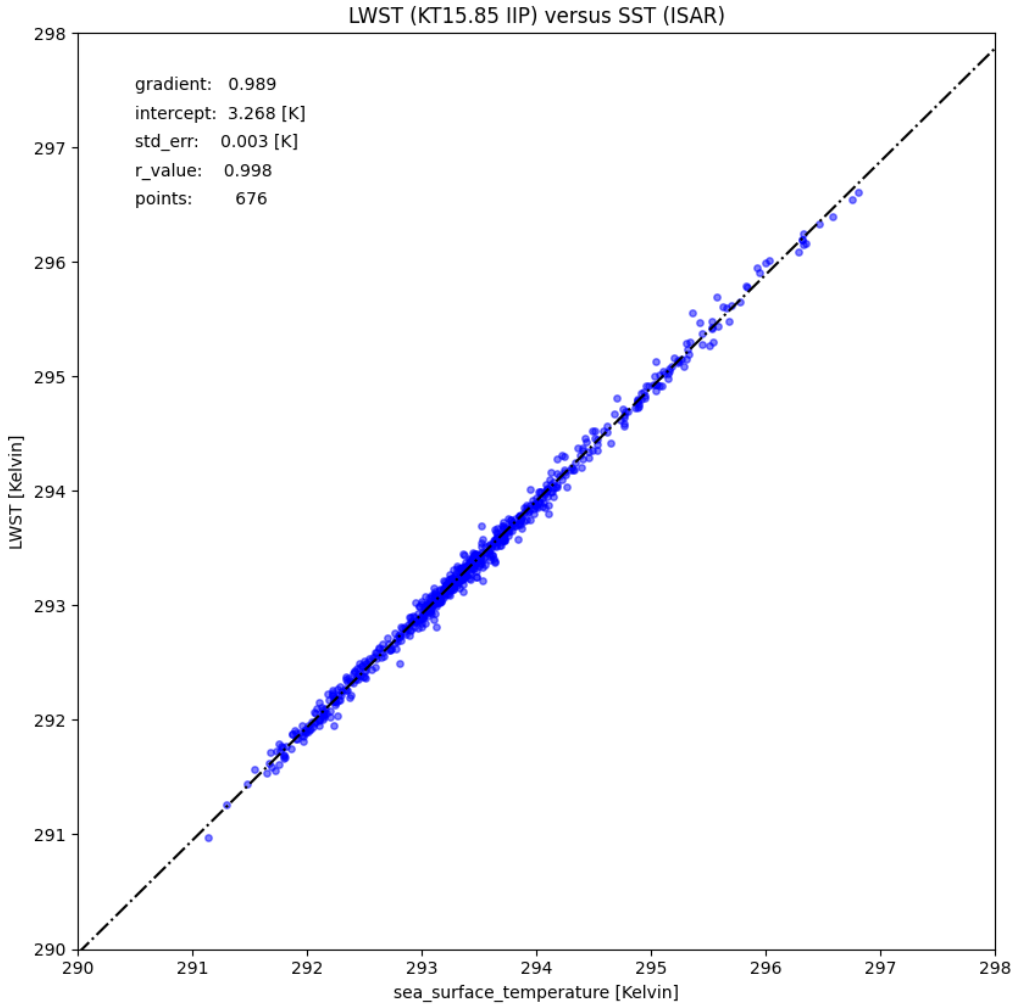
In-situ SST (ISAR) & LWST (KT15.85 IIP) for Lake Constance



In-situ LWST (KT15.85 IIP) versus in-situ SST (ISAR)



- 676 valid matchups (07.-23. Sep. 2020)
- Excellent agreement between the two time-series of in-situ surface temperatures
- Average deviation between KT15.85 IIP and ISAR was -0.085 K ± 0.065 K
- KT15.85 IIP uncertainty budget for water bodies can be refined, i.e. reduced

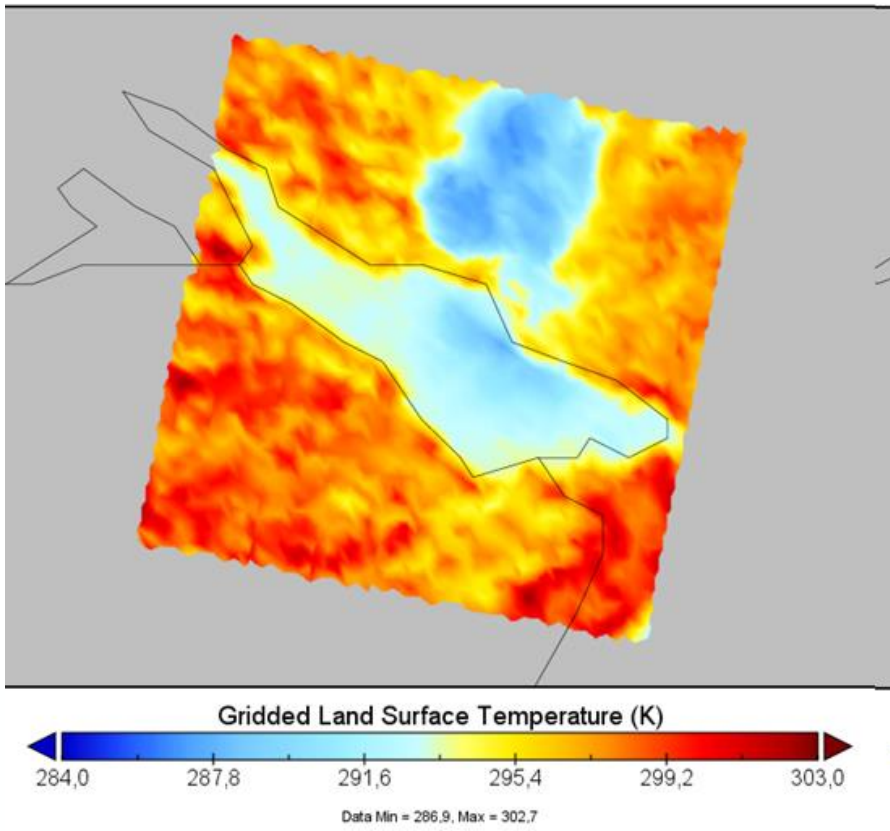
SST and LST satellite products versus in-situ LWST

Sensor ST product(s)	**Satellite(s)**	**Spatial resolution** Data format	**Satellite operator** Data source
SLSTR WCT WST SL_2_LST	**Sentinel-3 (A,B)**	**1 km** netCDF netCDF netCDF	**Copernicus / ESA** EUMETSAT (internal) EUMETSAT (CODA) Scihub (Uni Leicester)
MODIS LST (MOD21) SST (MODIST/A)	**Terra / Aqua**	**1 km** HDF-EOS netCDF	**NASA** Earthdata Earthdata
AVHRR SST (OSI-204) LST (LSA-002)	**MetOp (B,C)**	**1 km** netCDF HDF-5	**EUMETSAT** OSI SAF LSA SAF
VIIRS SST LST (VNP21)	**Suomi NPP**	**1 km** netCDF (GHRSST) netCDF	**NOAA / NASA** Earthdata Earthdata

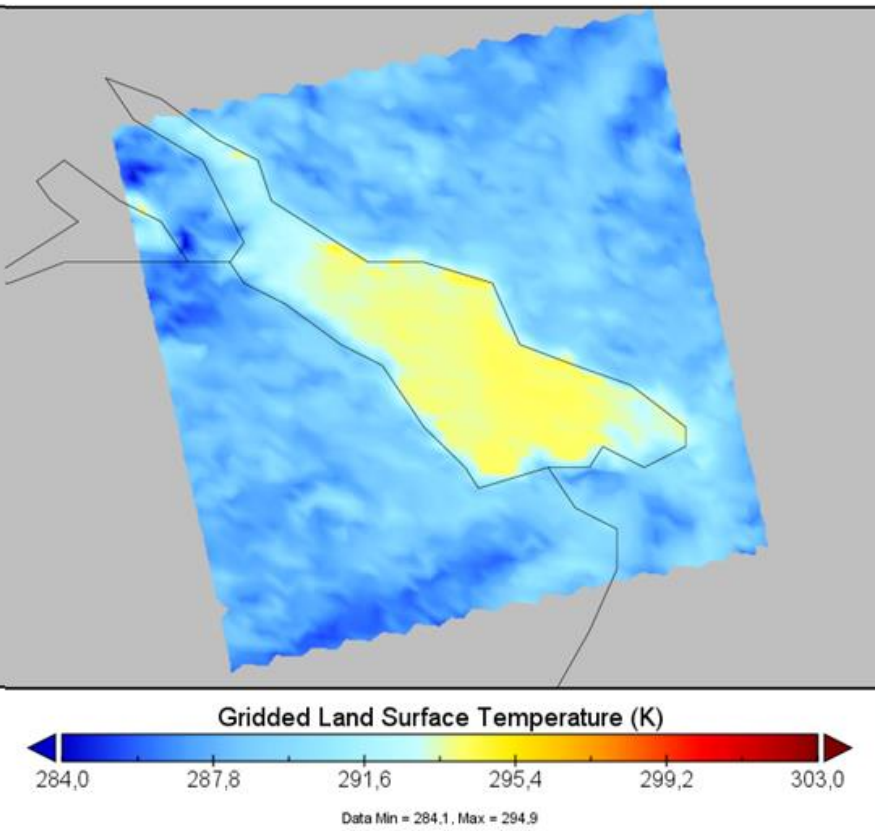
Preparation of satellite ST product subsets into netCDF files

51 x 51 pixel subsets of ESA operational SLSTR Level-2 LST product

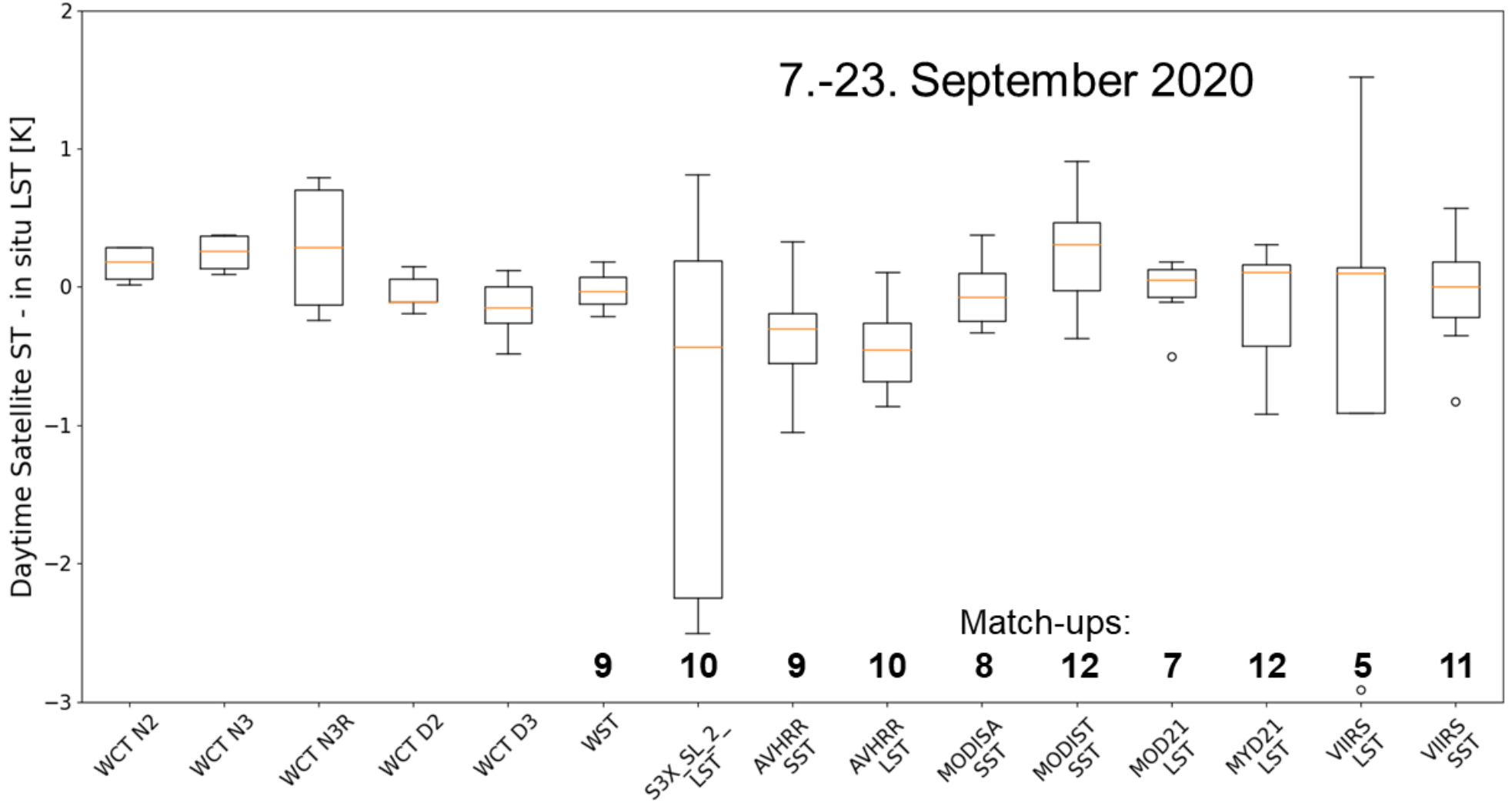
S3A_SL_2_LST_20200909T**093541**



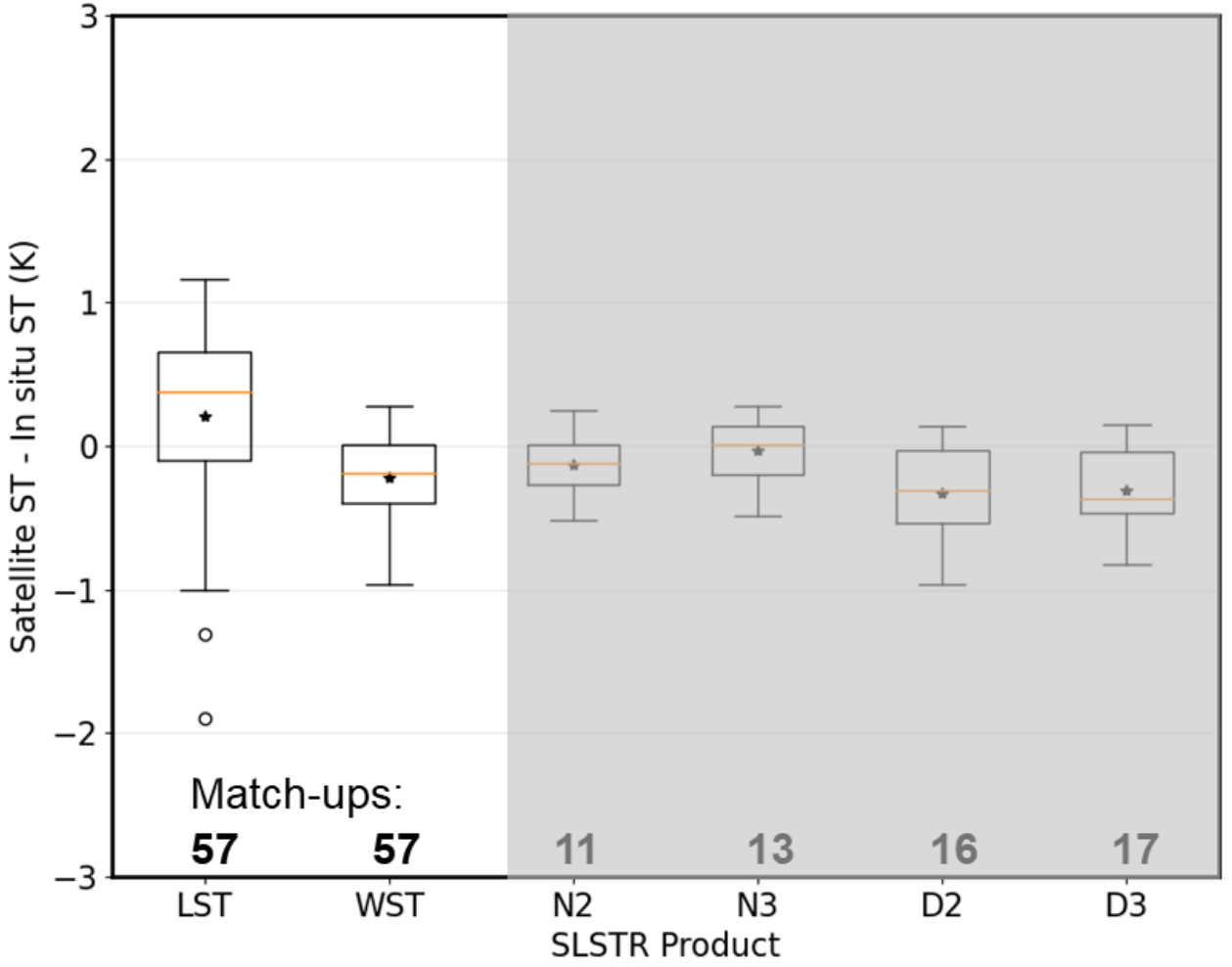
S3A_SL_2_LST_20200909T**205835**



Daytime validation results for investigated SST & LST products



Extended SLSTR LST & SST validation (Apr 2020 - Jun 2021)



- Cloud-filtering (probability & flag): 339 → 57 match-ups
- LST: mean bias +0.2 K, SD 0.6 K (median bias +0.4 K)
- WST: mean bias -0.2 K, SD 0.3 K

Legend:
- Whiskers: minima & maxima
- Orange line: median
- Black star: mean
- Box: lower & upper quartile ranges
- Circles: LST outliers (VZA ≈ 50°)

Summary & Conclusions

- Successful bilateral field campaign during COVID-19 pandemic: 17 days of valid in-situ measurements
- Excellent performance of KT15.85 IIP (KIT) vs ISAR (UoS)
- KT15.85 IIP uncertainty budget for water bodies ≈ 0.2 K
- SLSTR WST product performs well over Lake Constance
- Benefit of long-term monitoring: more reliable statistics