2022 DRAGON 5 SYMPOSIUM

MID-TERM RESULTS REPORTING

17-21 OCTOBER 2022

PROJECT ID 59318

ALL-WEATHER LAND SURFACE TEMPERATURE AT HIGH SPATIAL RESOLUTION: VALIDATION AND APPLICATIONS

FRIDAY, 21/OCT/2022

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PROJECT TITLE: ALL-WEATHER LAND SURFACE TEMPERATURE AT HIGH SPATIAL RESOLUTION: VALIDATION AND APPLICATIONS

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PRESENTED BY: F.-M. GOETTSCHE

EO Data Delivery

ESA Third Party Missions	No. Scenes
1.	
2.	
3.	
4.	
5.	
6.	
Total:	
Issues:	

ESA Third Party Missions	No. Scenes
1. Sentinel-3 SLSTR	500+
2.	
3.	
4.	
5.	
6.	
Total:	500+
Issues:	

Chinese EO data	No. Scenes
1. FY-3B MWR	500+
2. FY-4A	500+
3. FY-2 LST	500+
4.	
5.	
6.	
Total:	1500+
Issues:	

European Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Lluis Perez-Planells	Karlsruhe Institute of Technology	-	Validating the All-weather LST

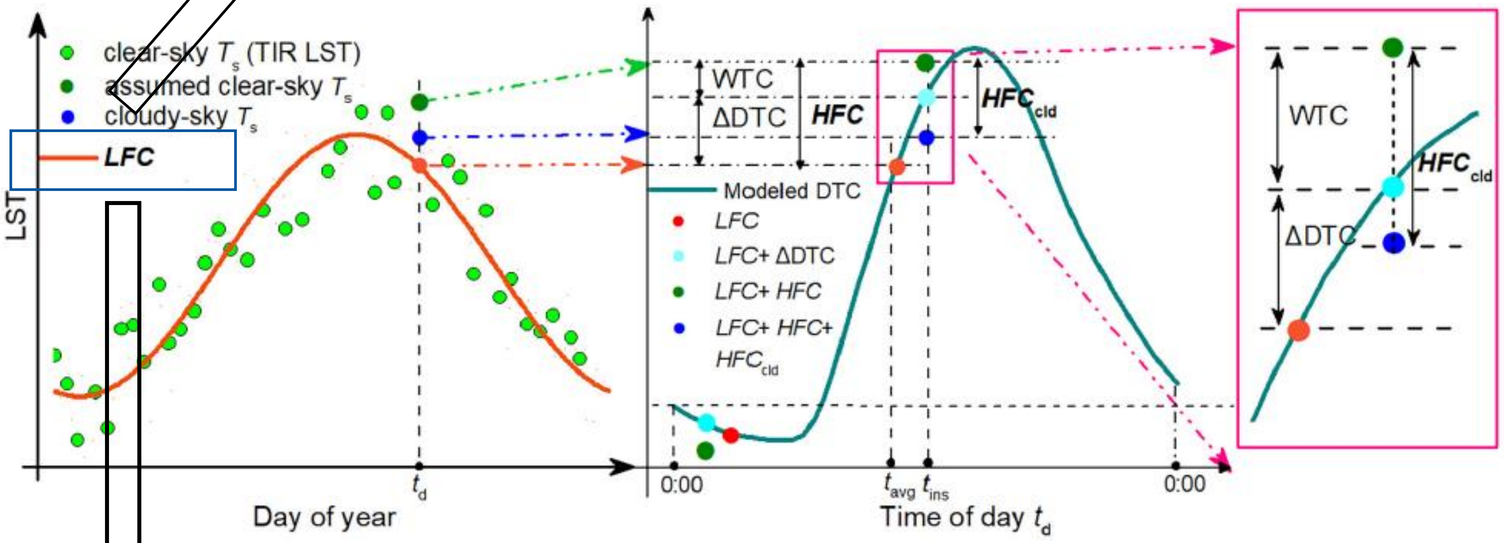
Chinese Young scientists contributions in Dragon 5

Name	Institution	Poster title	Contribution
Wenbin Tang	University of Electronic Science and Technology of China	-	Generating the All-weather LST
Lirong Ding	University of Electronic Science and Technology of China	-	Generating the All-weather LST
Jin Ma	University of Electronic Science and Technology of China	-	Validating the All-weather LST

UESTC all-weather LST: from Temporal Component Decomposition (TCD) to Reanalysis and Thermal infrared remote sensing Merging (RTM)

TCD：ATC：

ATC denotes an ideal clear LST variation at the intra-annual average observation time of a TIR sensor



LFC (low-frequency component)：

the annual-scale LST component under completely clear-sky conditions (ideal)

TCD

$$M_T(t_d, t_{ins}) = ATC(t_d) + (\Delta DTC(t_d, t_{ins}) + WTC(t_d, t_{ins}))$$

RTM

1) Clear

$$M_{clr-T}(t_d, t_{ins}) = ATC_{clr}(t_d) + (\Delta DTC_{clr}(t_d, t_{ins}) + WTC_{clr}(t_d, t_{ins})) = LFC(t_d, t_{ins}) + HFC(t_d, t_{ins})$$

(**low-frequency component**) (**high-frequency components**)

2) Cloudy

$$M_{cld-T}(t_d, t_{ins}) = M_{clr-T}(t_d, t_{ins}) + M_{CORRECTION}(t_d, t_{ins}) = LFC + HFC + HFC_{-cld}$$

(**Under-cloud Correction Term for high-frequency components**)

The RTM to reconstruct 1-km all-weather

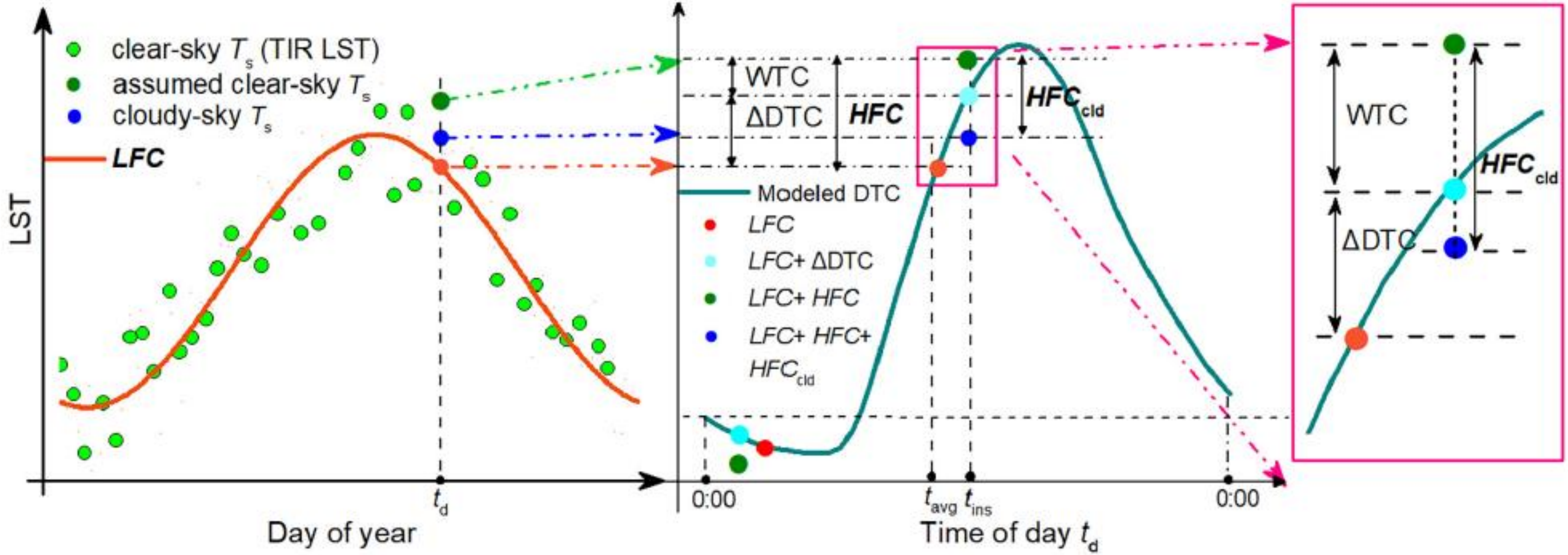
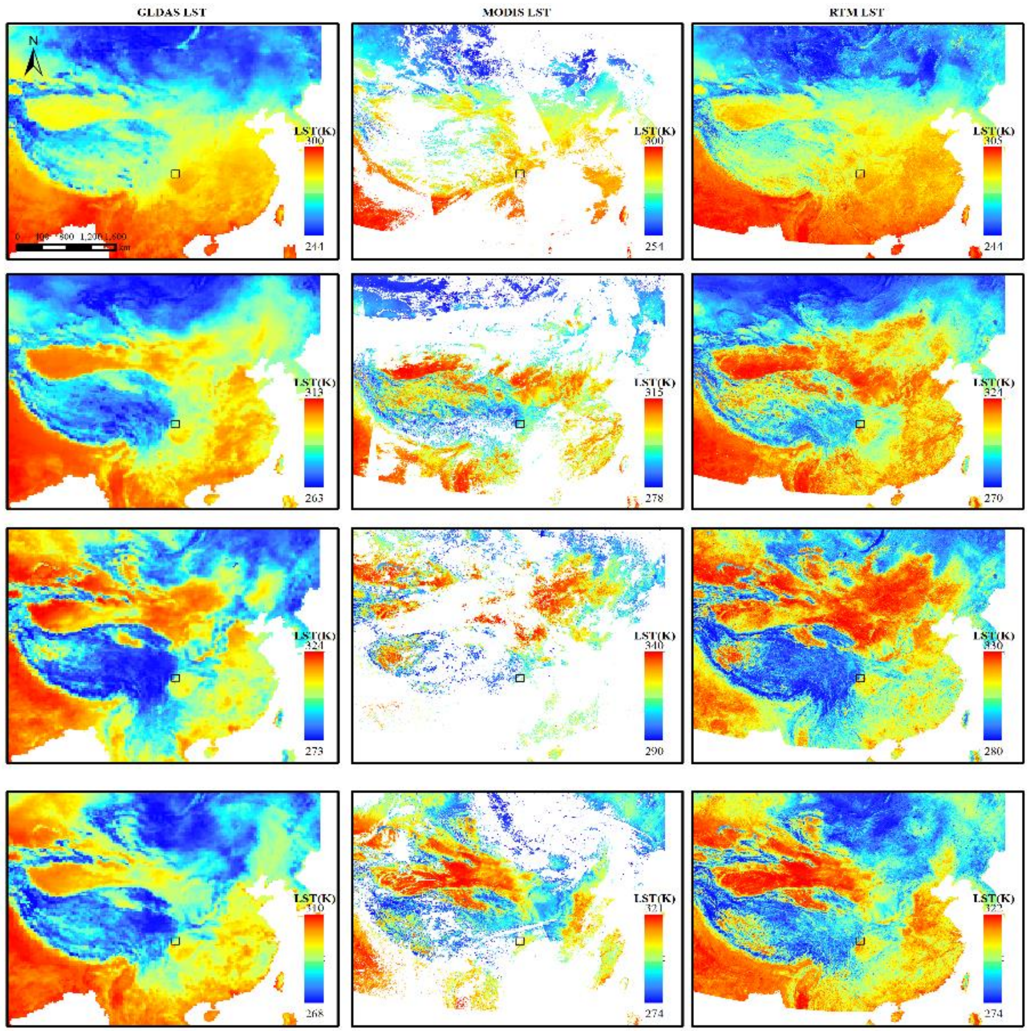


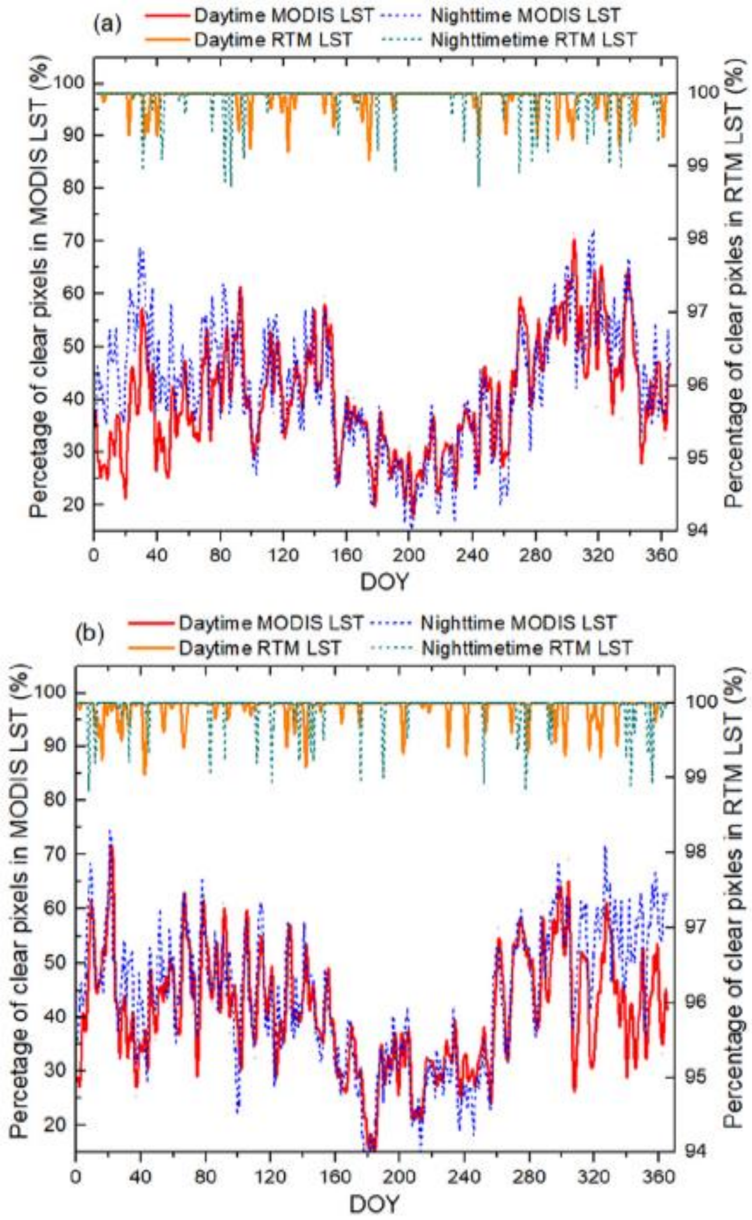
Diagram of LST time series decomposition of a 1-km satellite pixel on DOY t_d. In this diagram, the pixel is under cloudy conditions at t_{ins} (i.e. the observation time of a TIR sensor). Please note that the deep blue circle denotes the **true cloudy** LST at t_{ins} on DOY t_d while the deep green circle denotes the corresponding **assumed clear** LST. Also note that HFC_{cld} can be positive or negative.

Zhang, X., Zhou, J., Liang, S., Wang, D., 2021. A practical **reanalysis** data and **thermal** infrared remote sensing data **merging (RTM)** method for reconstruction of a 1-km all-weather land surface temperature. Remote Sensing of Environment 260, 112437.

RTM to reconstruct 1-km all-weather LST

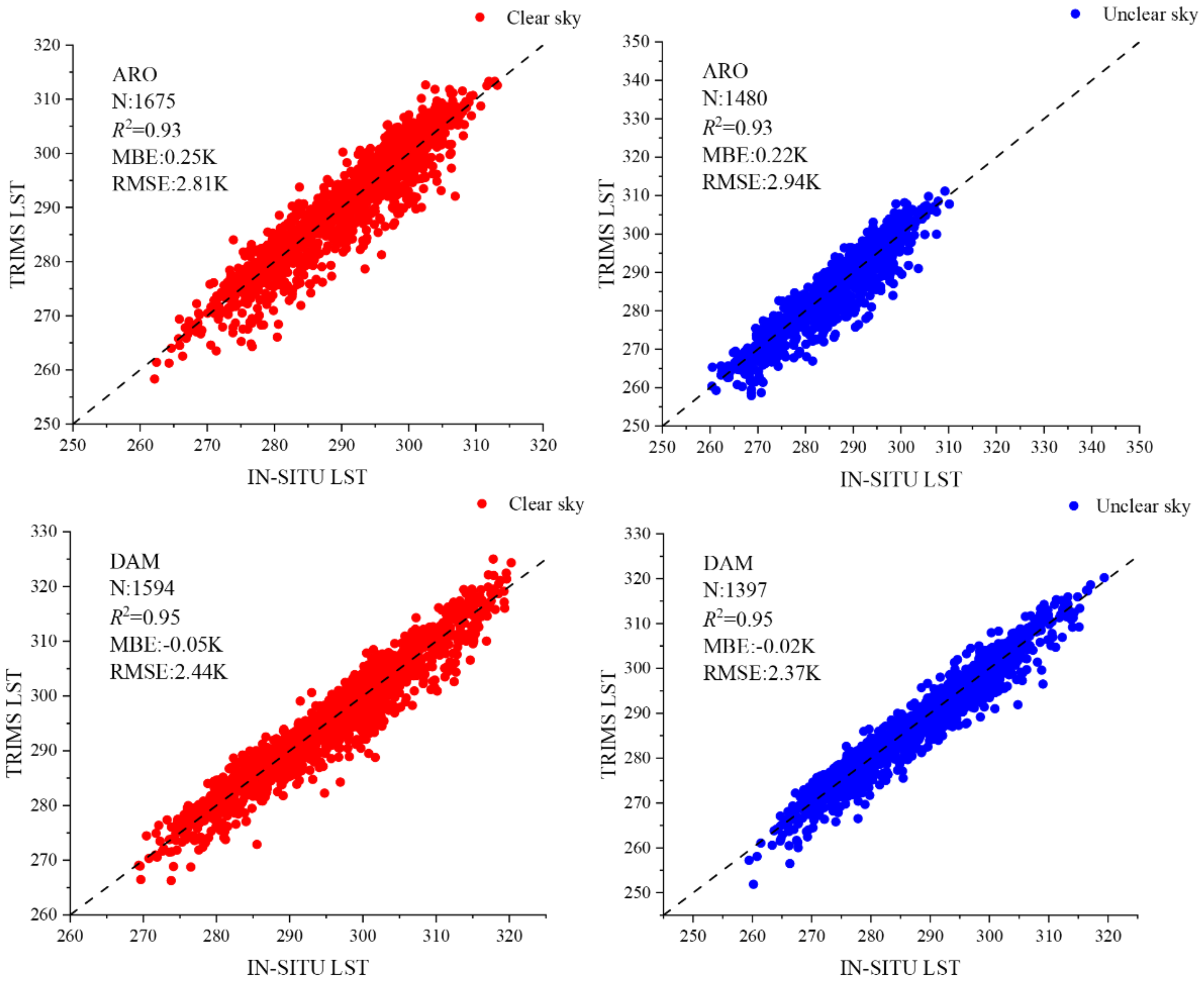


Daytime GLDAS LST, Aqua MODIS LST, and RTM LST different days of year in 2003.



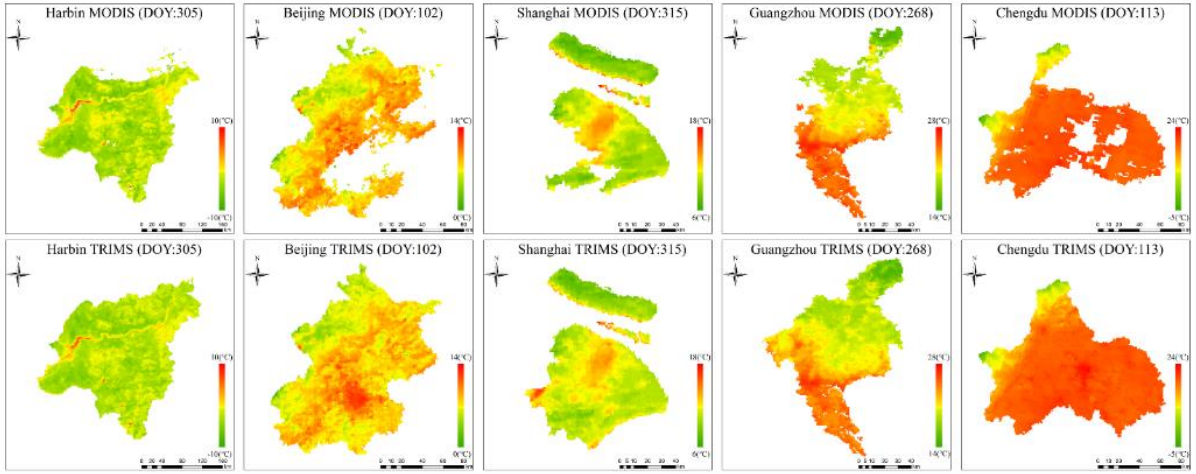
Intra-annual variations of percentage of valid pixels in LST before RTM (i.e. MODIS LST) and RTM LST in 2003 (a) and 2014 (b).

RTM to reconstruct 1-km all-weather LST



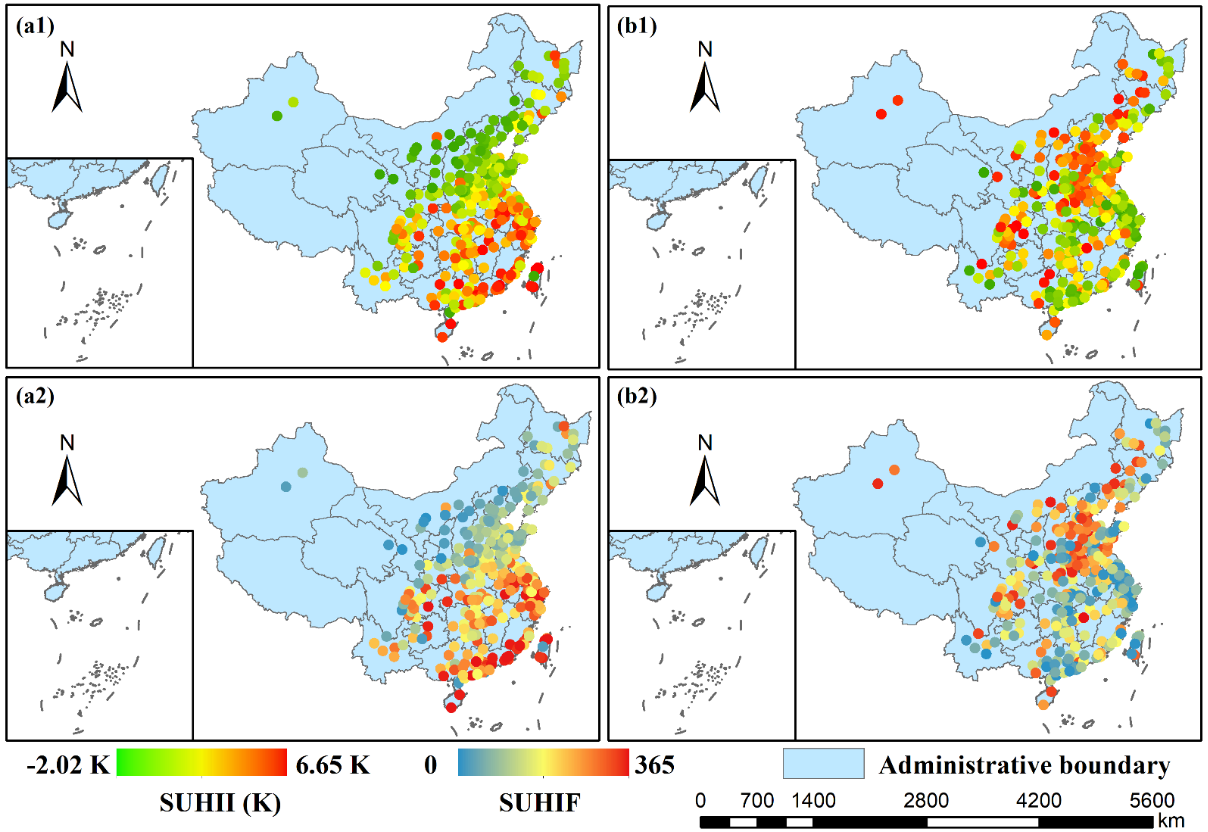
RTM was applied to merge (MODIS) and Global/China Land Data Assimilation System (GLDAS/CLDAS) data over the TP and the surrounding area. Validation results based on in-situ LST show that the RTM LST has RMSEs of 2.03–3.98 K.

Application to Surface Urban Heat Island (SUHI)



The LST map of five big cities in China under clear-sky (Upper) and all-weather conditions (Lower)

- A SUHI difference of about -4 K to 1 K between the under all-weather and clear sky conditions can be found.
- The real SUHI effects under all-weather conditions has north-south contrast at daytime, i.e., the SUHI is higher in the south and weaker in the north, the phenomenon is reversed at night.



Spatial distribution of SUHII and SUHIF at daytime (a) and nighttime (b) in China. The spatial maps in the first row represent SUHII (a1,b1). The second row maps represent SUHIF (a2,b2).

LSA SAF (IPMA) All-Sky LST – will be a CDR!

Clear sky LST

IR retrievals for clear sky (Generalized Split-Windows Algorithm, standard L2 LST for SEVIRI)

Cloudy Sky LST

Skin temperature from a surface energy balance model, forced by LSA-SAF products and ECMWF meteorological data

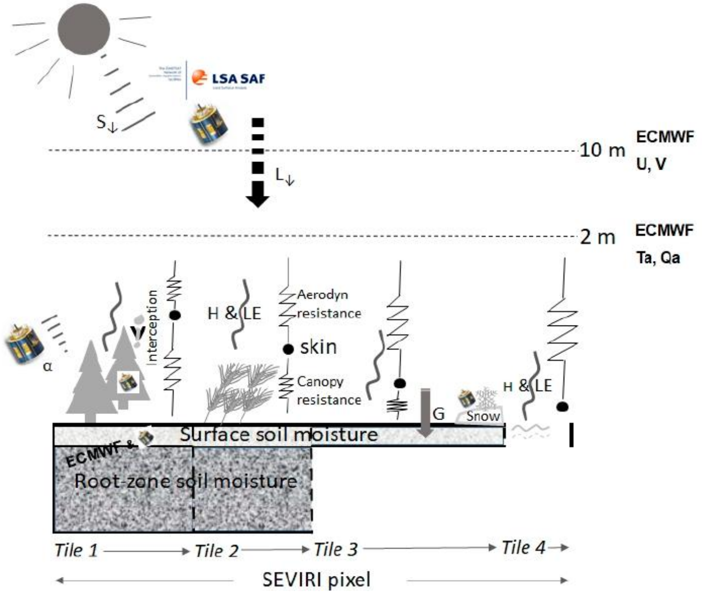
Inputs:

- LSA SAF: $L_{\downarrow}$, $S_{\downarrow}$, Albedo, *LAI*
- ECMWF: T_{air}, q_{air}, *u*, *v*
- soil moisture (H-SAF)

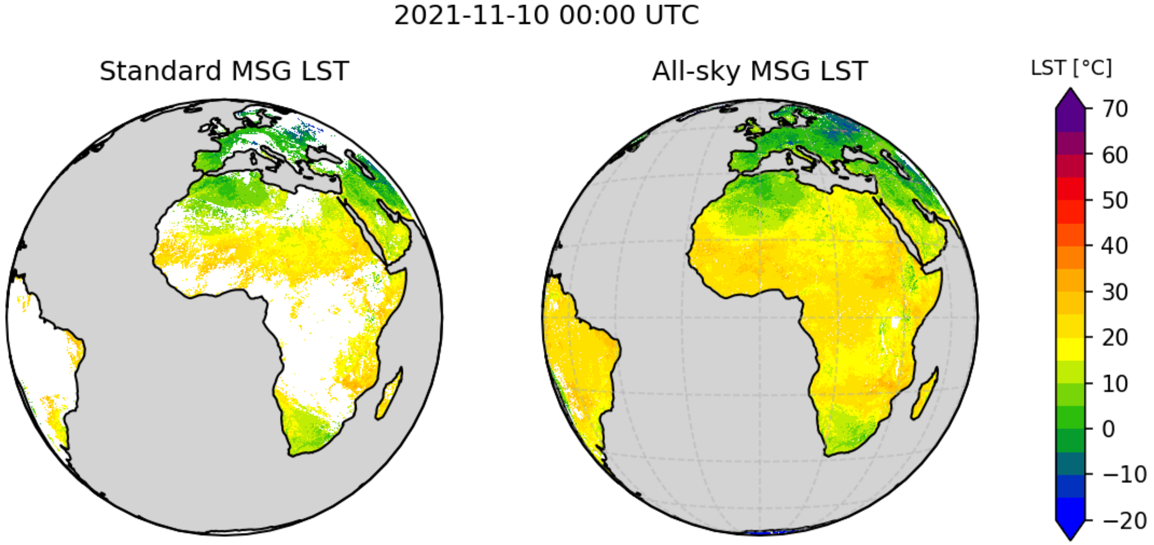
Outputs:

- *H*, *LE* (and evapotranspiration) and ***SKT***

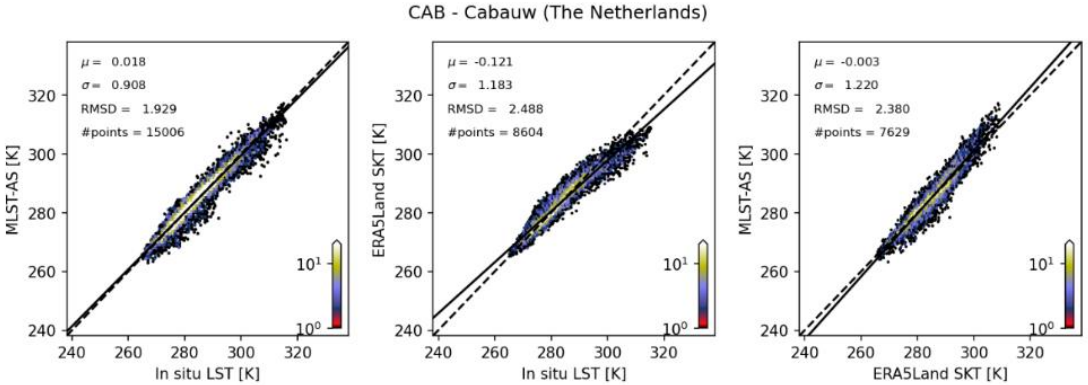
Martins, J., Trigo. I., Ghilain. N., Jimenez. C., Göttsche. F.-M., Ermida, S., Olesen F.-S., Gellens-Meulenberghs, F., Arboleda, A., 2019. An All-Weather Land Surface Temperature Product Based on MSG/SEVIRI Observations. Remote Sensing, doi: 10.3390/rs11243044



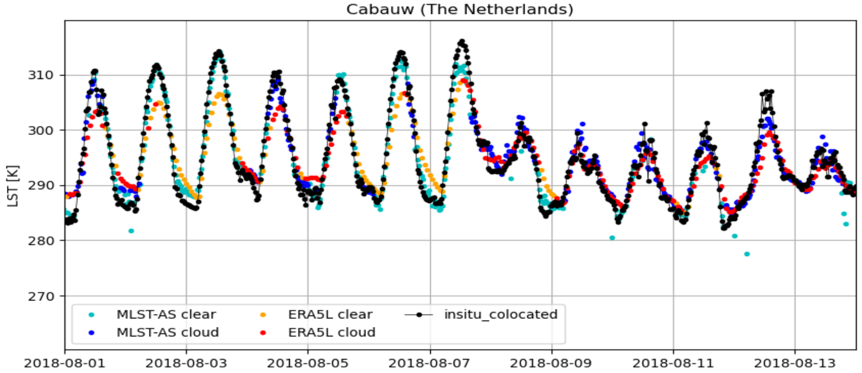
- **Maximizes use of remote sensing data (mostly LSA-SAF)**
- **Scheme based on the H-TESSEL surface model (ECMWF)**
- **Runs every 30 min**
- **Available soon from 2004-onwards**

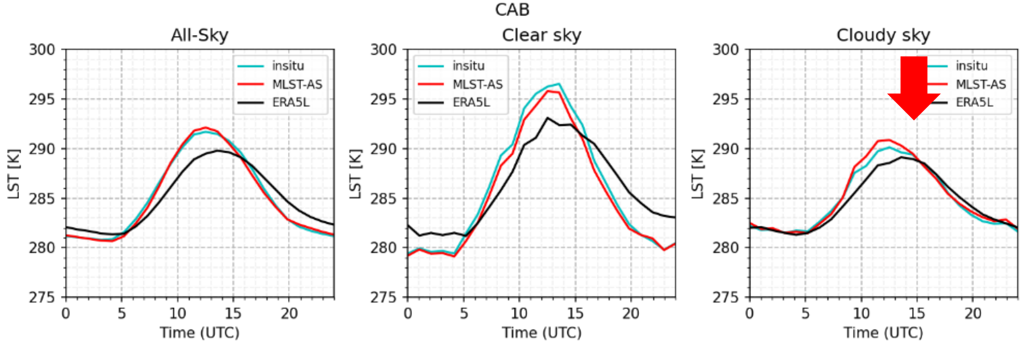


LSA SAF (IPMA) All-Sky LST - validation



EUMETSAT LSA SAF LAND SURFACE ANALYSIS





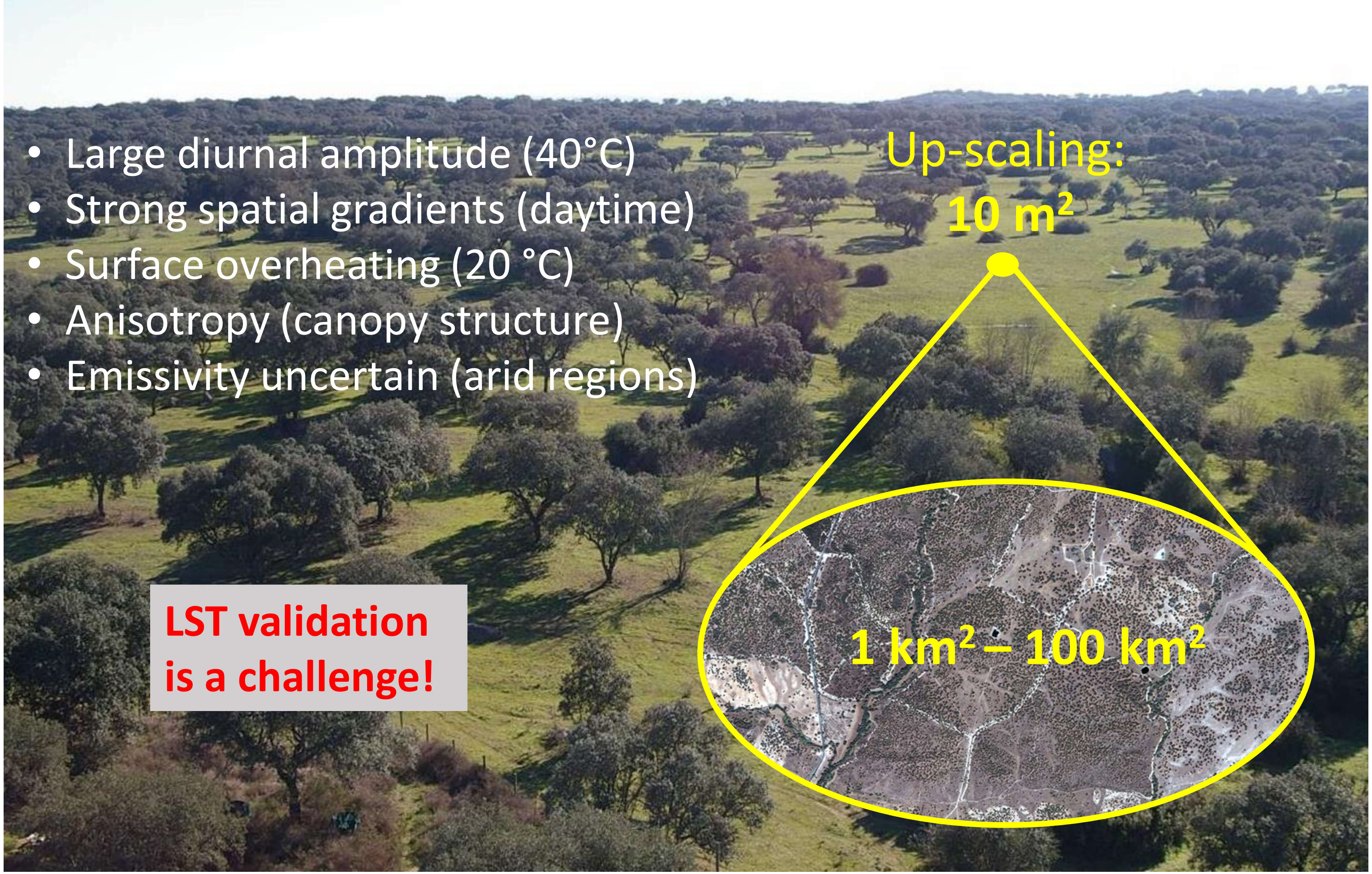
Overall stats for the 33 stations (BSRN + EFDC + KIT)

	MLSTS – in situ			ERA5-Land – in situ			MLSTS – ERA5-Land		
	All	Clear	Cloudy	All	Clear	Cloudy	All	Clear	Cloudy
μ (K)	0.0	**-0.2**	**0.2**	0.2	0.1	0.3	-0.2	-0.2	-0.2
σ (K)	1.5	1.4	1.5	1.6	2.1	1.3	1.7	2.1	1.2
RMSD (K)	2.9	2.8	2.8	2.9	3.3	2.6	3.1	3.5	2.4

- **Compares very well with in situ estimates**
- **Statistics for cloudy sky estimates are similar to clear sky**
- **Compares well to ERA5-Land**
- **Some problems in the representation of the diurnal cycle (phase shift, amplitude)**

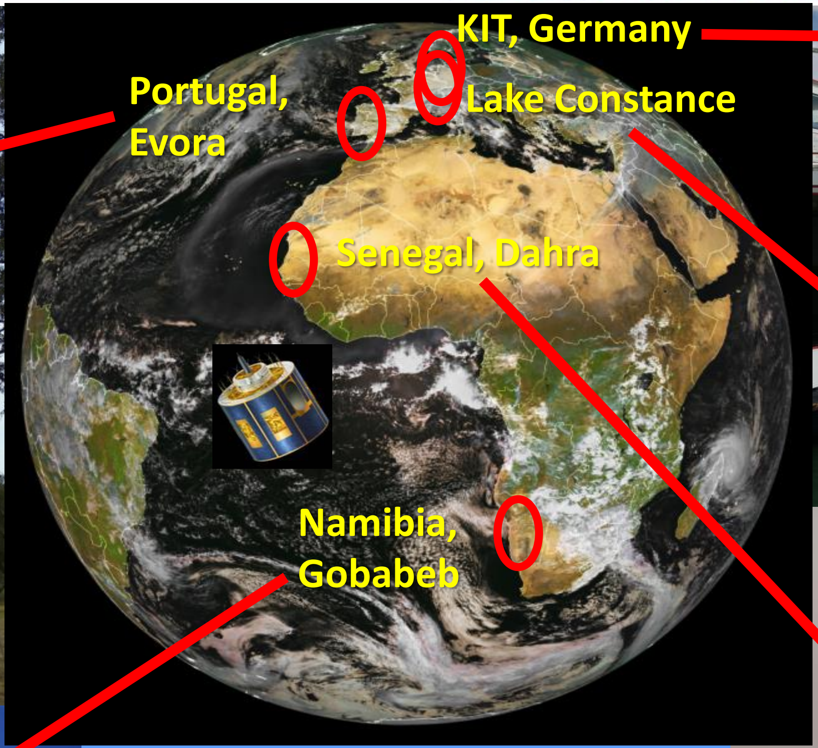
LST validation with in-situ measurements

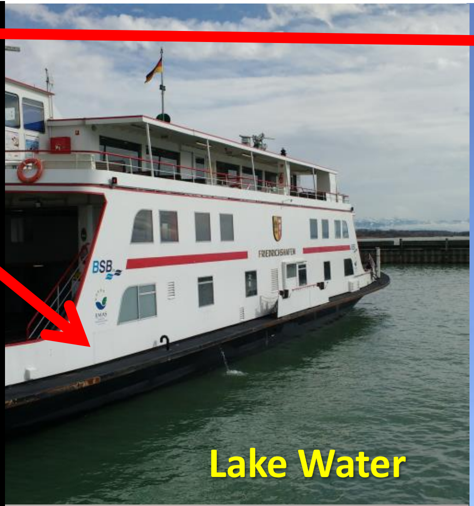
- Large diurnal amplitude (40°C)
- Strong spatial gradients (daytime)
- Surface overheating (20 °C)
- Anisotropy (canopy structure)
- Emissivity uncertain (arid regions)



LST validation is a challenge!

Dedicated LST Validation Stations



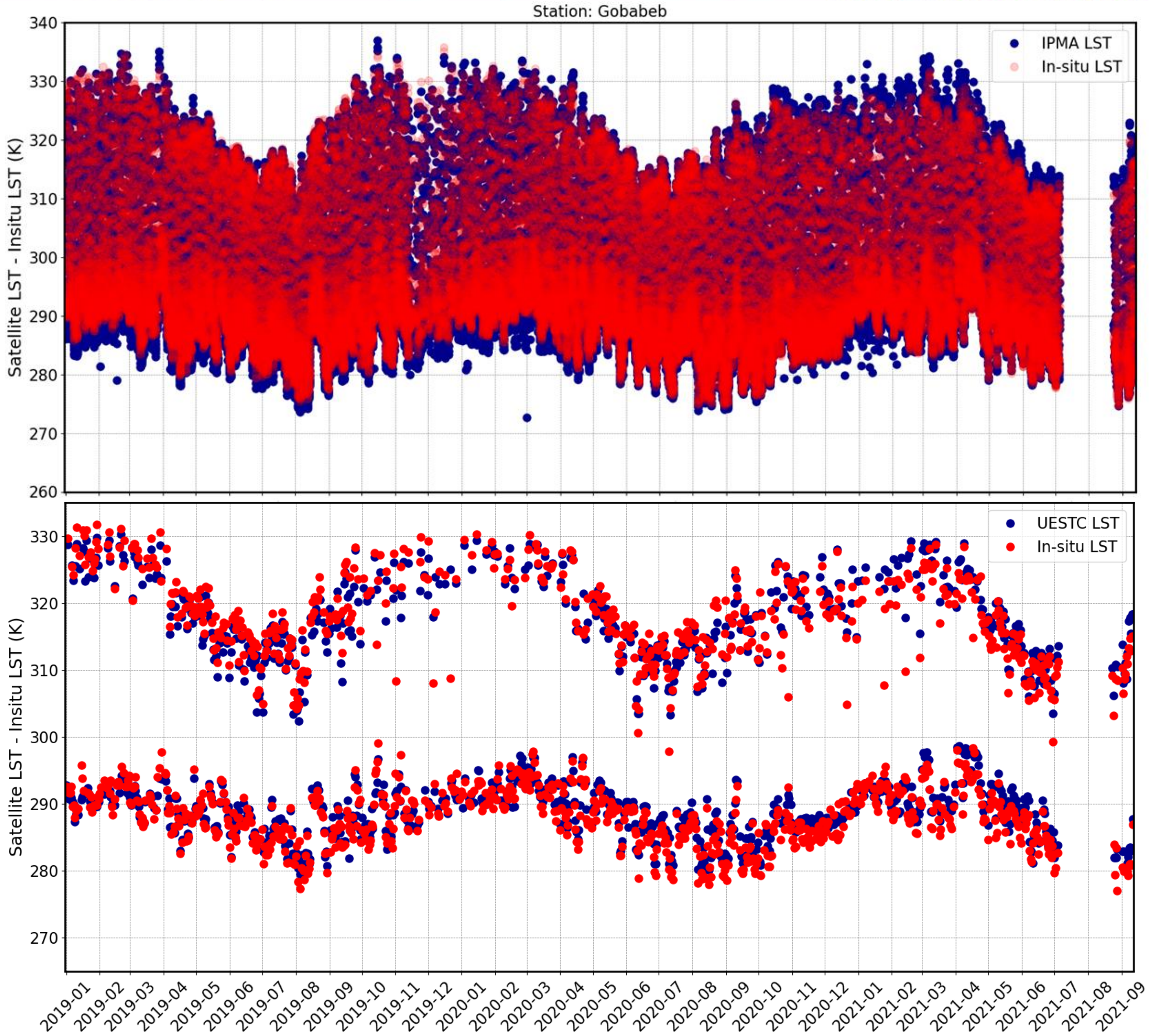


- Large, **homogeneous** sites
- Well **characterised**
- Different climates & biomes
- **Dedicated** to LST validation

Copernicus LAW project

for Sentinel-3 validation

In-situ Validation of both all-weather LST products



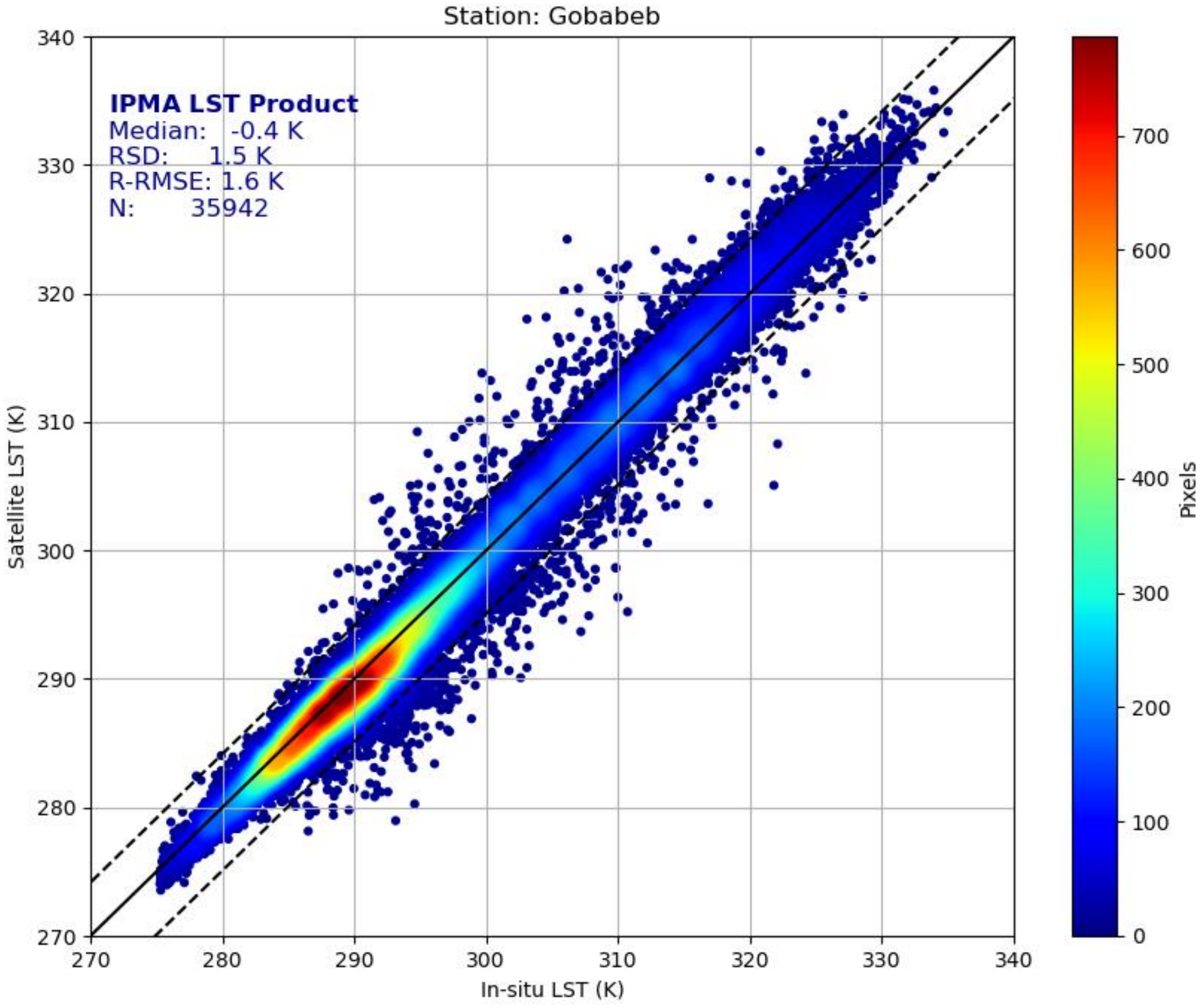
LSA SAF (IPMA) all-weather LST:

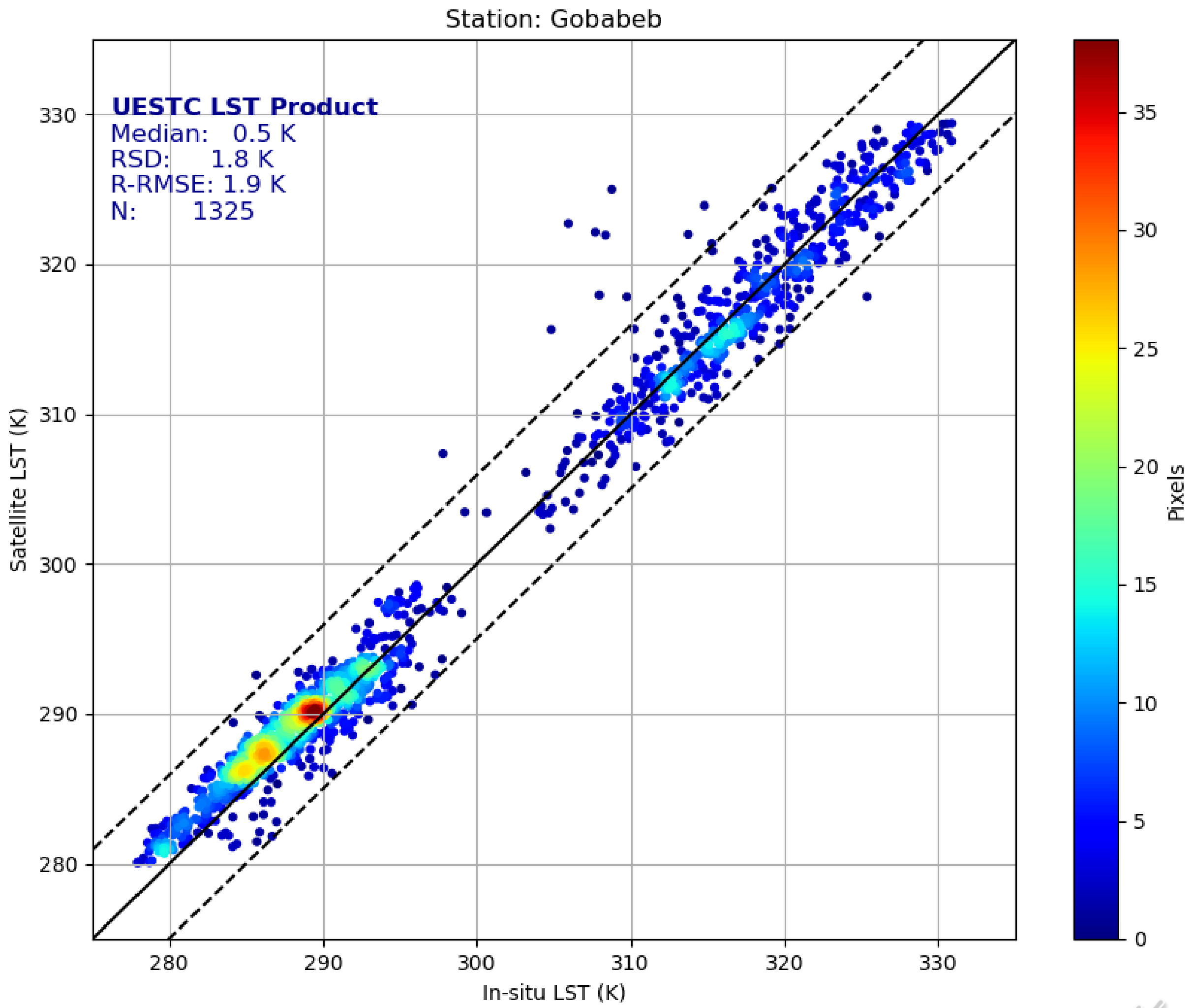
- Based on H-TESSEL surface model (ECMWF)
- Maximizes use of remote sensing data (LSA-SAF)
- Runs every 30 min, i.e. 48 LST per day
- Coverage: earth disk of geostationary satellite (MSG)
- 3 km spatial sampling distance at nadir
- Operational LSA SAF product (2004 - now)

UESTC all-weather LST:

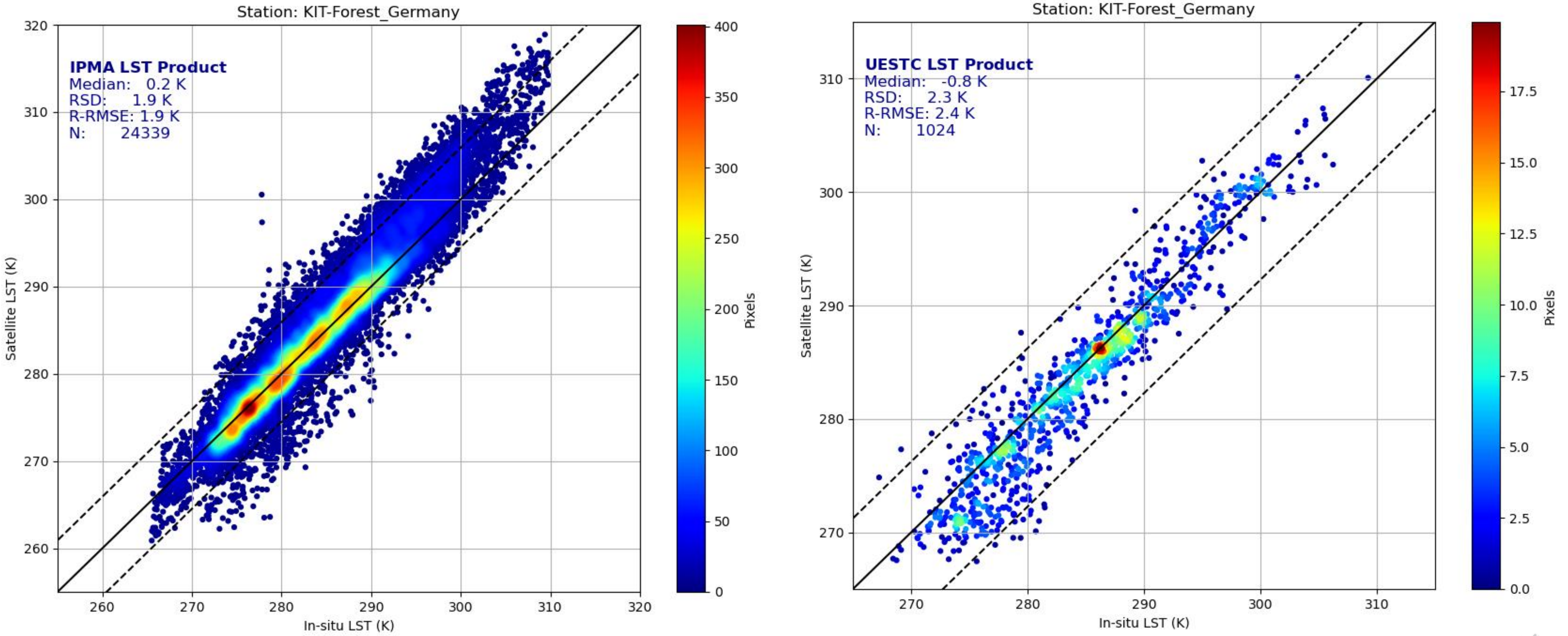
- Merges GLDAS reanalysis LST with satellite TIR LST
- Twice daily, e.g. for Aqua/MODIS at 1:30 AM & PM
- Global coverage with single sun-synchronous satellite
- 1 km spatial resolution at nadir

Validation of All-weather LST at Gobabeb, Namibia

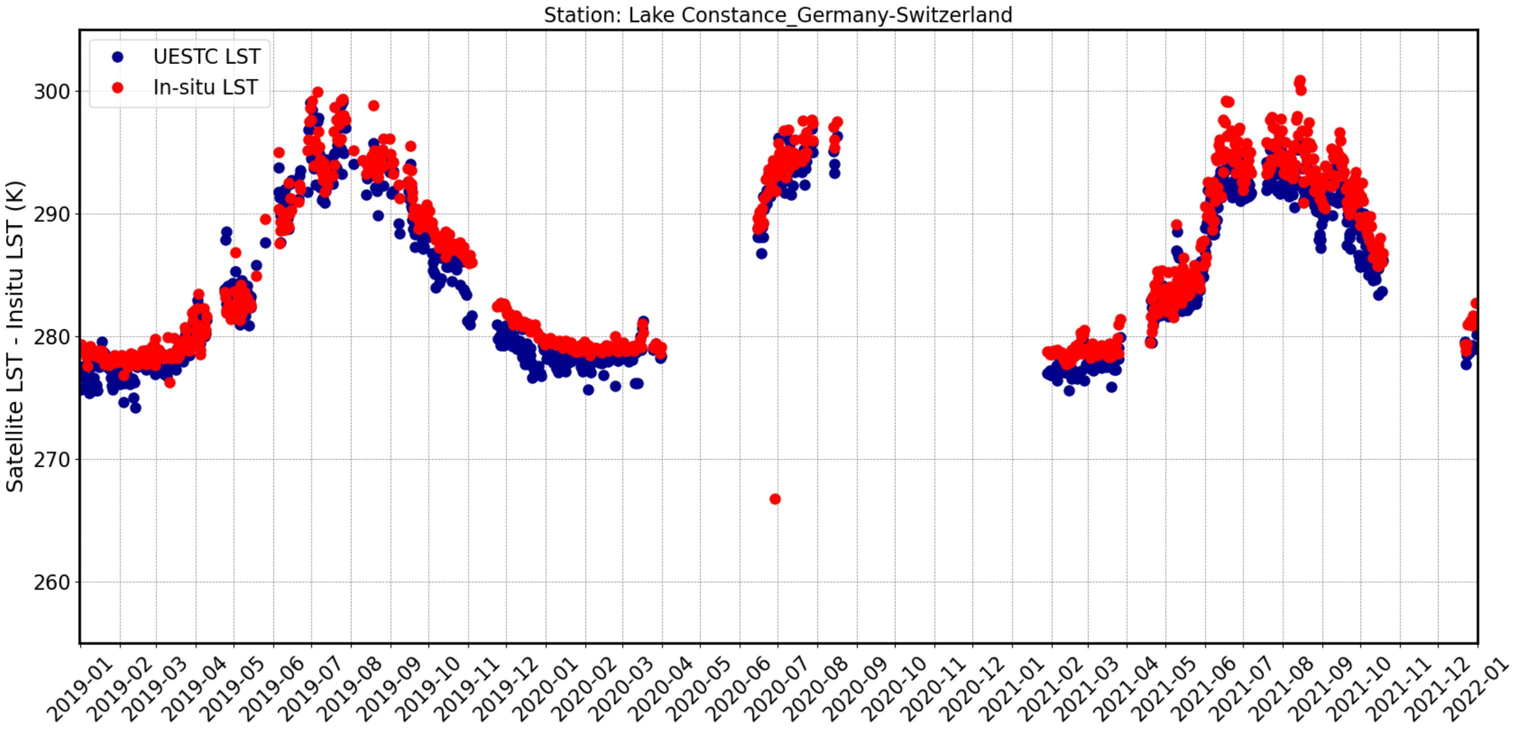


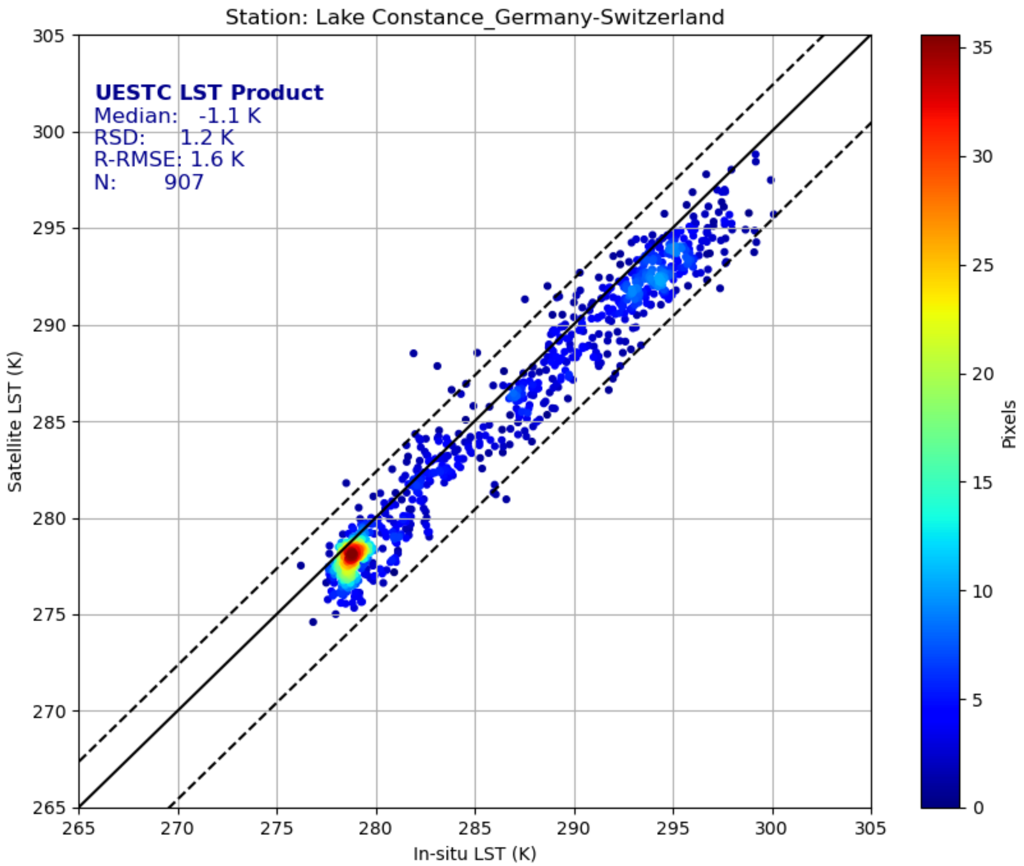


Validation of All-weather LST at KIT-Forest, Germany



Validation of All-weather LST at Lake Constance





Göttsche, F.-M., Wimmer, W., Martin, M. Pérez Planells, L., 2021. Report on the Thermal Infra-red Product Inter-comparison and Validation Study on Lake Constance. EUMETSAT study report EUM/RSP/DOC/21/1243520 (www.eumetsat.int/TIR-radiometer-inter-comparison).

Yang, J., Zhou, J., Göttsche, F.-M., Long, Z., Ma, J., Luo, R., 2020. Investigation and validation of algorithms for estimating land surface temperature from Sentinel-3 SLSTR data. International Journal of Applied Earth Observation and Geoinformation, doi: 10.1016/j.jag.2020.102136.

Summary and Outlook

- UESTC generated daily 1-km all-weather LST for Western China V1 (2003-2018) and Thermal and Reanalysis Integrating Medium-resolution Spatial-seamless LST for China (TRIMS LST-China; 2000-2019)
- IPMA generated half-hourly all-weather LST for MSG/SEVIRI (operational LSA SAF product LSA-005; available from 2004 onwards)
- KIT validated both all-weather LST products with in-situ LST from various stations
- The plan to set up an LST validation station in China had to be abandoned; however, KIT set up five new stations within the Copernicus LAW project (law.acri-st.fr/home)
- All-weather LST from IPMA-LSA SAF were also compared against ERA5-Land ST data

Further objectives:

- Identify main causes for differences between LST from UESTC, IPMA-LSA SAF, ERA5
- Employ UESTC all-weather LST to simulate and study freeze / thaw on Tibetan Plateau
- Initiate further applications, e.g. as demonstrated by UESTC's SUHI study