land surface temperature cci

LAND SURFACE TEMPERATURE CCI: APPROACHES TO LONG-TERM DATA FOR CLIMATE

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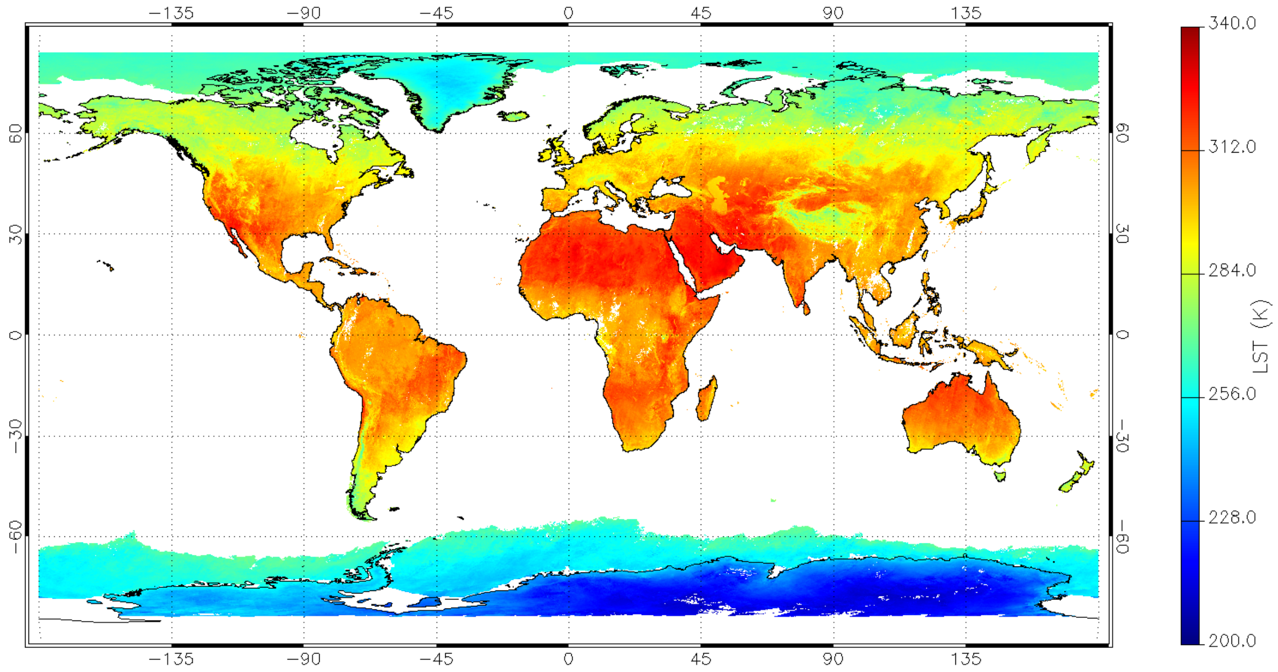
Land Surface Temperature CCI is crucial for climate model evaluation in regions where few in situ measurements of surface air temperature exist



- Products driven by the User Requirements
- Consistency in calibration, algorithms, uncertainty models and cloud detection, over all land, land ice and sea-ice surfaces

USER REQUIREMENTS

LST CCI User Requirements

	Threshold	Breakthrough	Objective
Dataset length	10 years	30 years	> 30 years
Spatial resolution	1 km	< 1 km	< 1 km
Temporal resolution	6 hours	1 hour	< 1 hour
Accuracy	1 K	0.5 K	0.3 K
Precision	1 K	0.5 K	0.3 K
Stability	0.3 K / decade	0.2 K / decade	0.1 K / decade

GCOS LST Requirements

Item	Type	Value
Horizontal resolution	Threshold	0.05°
Temporal resolution	Threshold	Day-night
	Target	≤ 3-hourly
Accuracy	Threshold	<1 K
Precision	Threshold	<1 K
Stability	Threshold	<0.3 K per decade
	Target	<0.1 K per decade
Length of record	Threshold	20 years
	Target	>30 years

High quality data more important than spatially complete fields

High temporal resolution more important for global studies

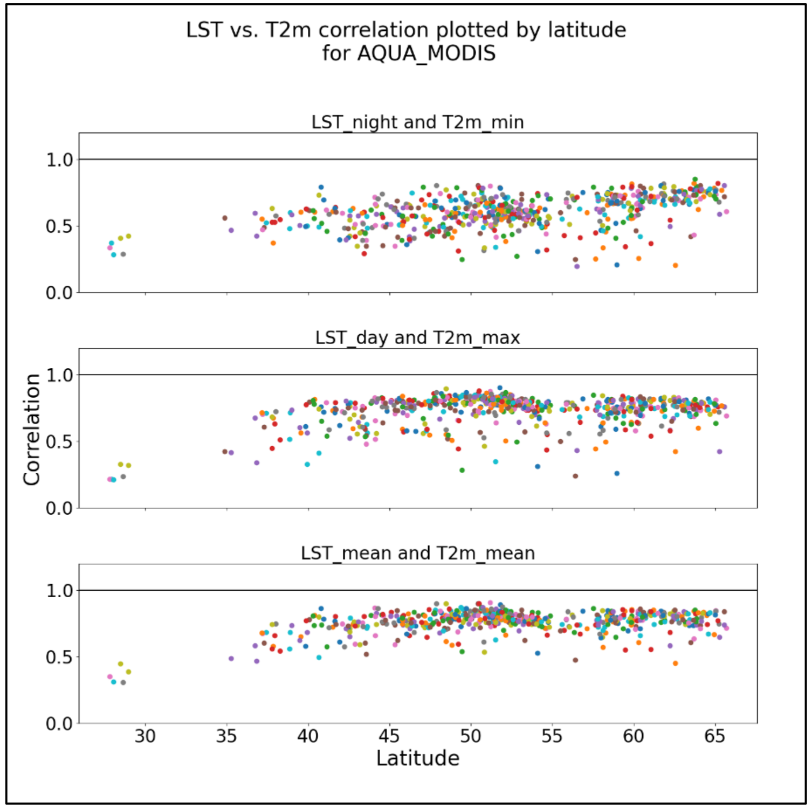
High spatial resolution more important for local studies

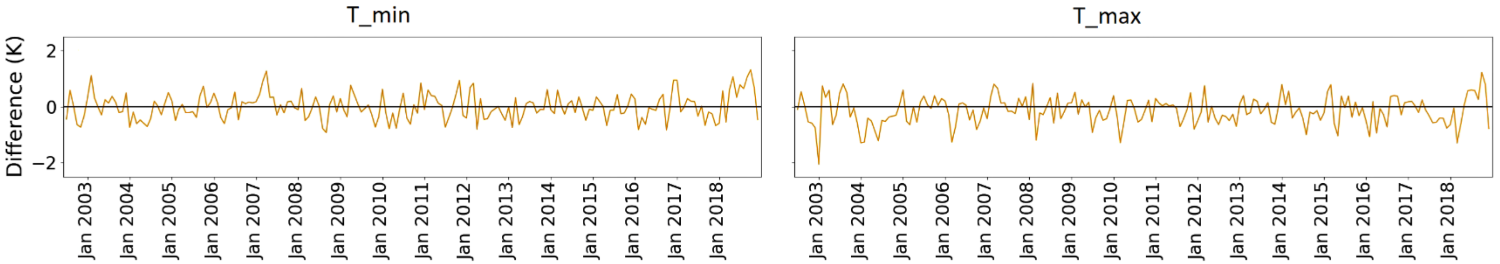
Dataset length is more important for global studies, whilst high data resolution is more important for local studies

LST ECV Products

Instrument	Satellite(s)	Phase-1 (Access)	Phase-2 Cycle 1	Phase-2 Cycle 2	Products	Comments
ATSR-2	ERS-2	1995-2003 (CEDA/ODP)	1995-2003	1995-2003	1 km L2P 0.01° Daily + Monthly L3C	Including sea-ice
AATSR	Envisat	2002-2012 (CEDA/ODP)	2002-2012	2002-2012		
MODIS	Terra	2000-2018 (CEDA/ODP)	2000-2021	1999-2023		
	Aqua	2002-2018 (CEDA/ODP)	2002-2021	2002-2023		
SLSTR	Sentinel-3A	2016-2020 (CEDA/ODP)	2016-2021	2016-2023		
	Sentinel-3B	2018-2020 (CEDA/ODP)	2018-2021	2018-2023		
AVHRR/3	NOAA-15 to 19	2010-2020 Prototype (Private)	2010-2021	1998-2021	0.05° Daily + Monthly L3C	GAC (4km)
	Metop-A to C	2010 Prototype (Private)	2007-2021	2007-2023	0.01° Daily + Monthly L3C	FRAC (1km)
AVHRR/2	NOAA-7, 9, 11, 12, 14			1981-2005	0.05° Daily + Monthly L3C	GAC (4km)
VIIRS	Suomi-NPP + JPSS-1			2012-2023	750m L2P	
SEVIRI	MSG-1-4	2004-2020 (CEDA/ODP)	2004-2021	2004-2023	0.05° Hourly L3U	MVIRI produced by CM SAF
Imager	GOES 12,13,16	2009-2020 (CEDA/ODP)	2004-2021	2004-2023	0.05° 3-hourly / HourlyL3U	
JAMI	MTSAT 1-2	2009-2015 (CEDA/ODP)	2009-2015	2009-2015	0.05° 3-hourly L3U	
AHI	Himawari 8-9			2015-2023	0.05° Hourly L3U	
SSM/I	DMSP F-13,17	1995-2018 (CEDA/ODP)	1995-2021	1995-2023	0.25° Daily L3C	
AMSR-E	Aqua		2002-2011	2002-2011	0.125° Daily + Monthly L3C	
AMSR2	GCOM-W			2012-2023		
Merged IR CDR	GEO+LEO IR above	2009-2020 (CEDA/ODP)	2004-2021	2004-2023	0.05° 3-hourly L3S	
ATSR-S3 CDR	ATSR, MODIS, SLSTR	1995-2020 (CEDA/ODP)	1995-2021	1995-2023	0.05° Daily + Monthly L3S	ATSR-2 to SLSTR including sea-ice
Prototype EO-SIP AVHRR	NOAA + Metop			1982-2019	750m / 1 km L2P 0.01° Daily L3C	Prototype - Europe only
Prototype HR	Landsat Downscaled SLSTR / MODIS		2014-2021	2000-2023	100m select areas	Downscaled from 1km
Prototype IR+MW	Multiple			2010		

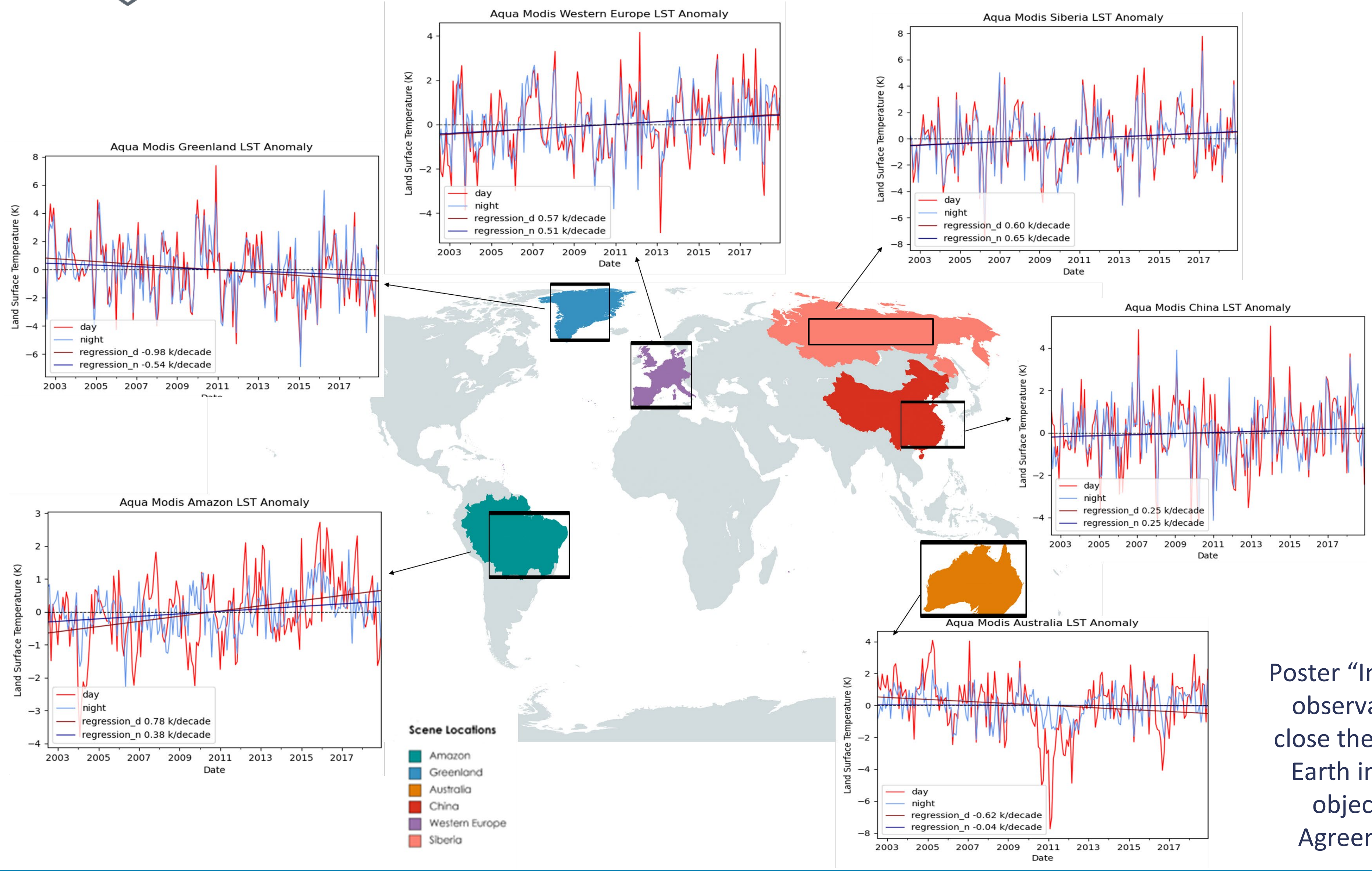
EXAMPLE LST_CCI AQUA-MODIS: DATASET STABILITY





- Compared LST_cci anomalies with homogenised near-surface air temperature anomalies from EUSTACE dataset.
- LST vs T2m correlations are significantly improved in in the datasets recently released to the CCI Open Data Portal (compared to earlier versions).
- Conclusion is datasets, such as LST_cci Aqua-MODIS, are considered homogeneous and thus suitable for use for robust climate trend analysis.
- Good et al. *An Analysis of the Stability and Trends in the LST_cci Land Surface Temperature 1 Datasets over Europe.* In Review

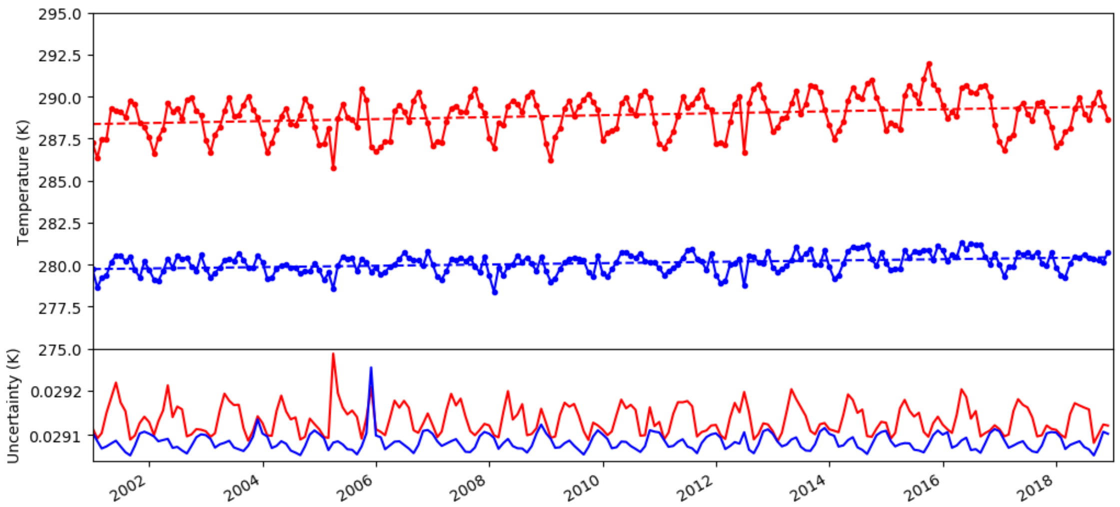
AQUA-MODIS: REGIONAL ANALYSES

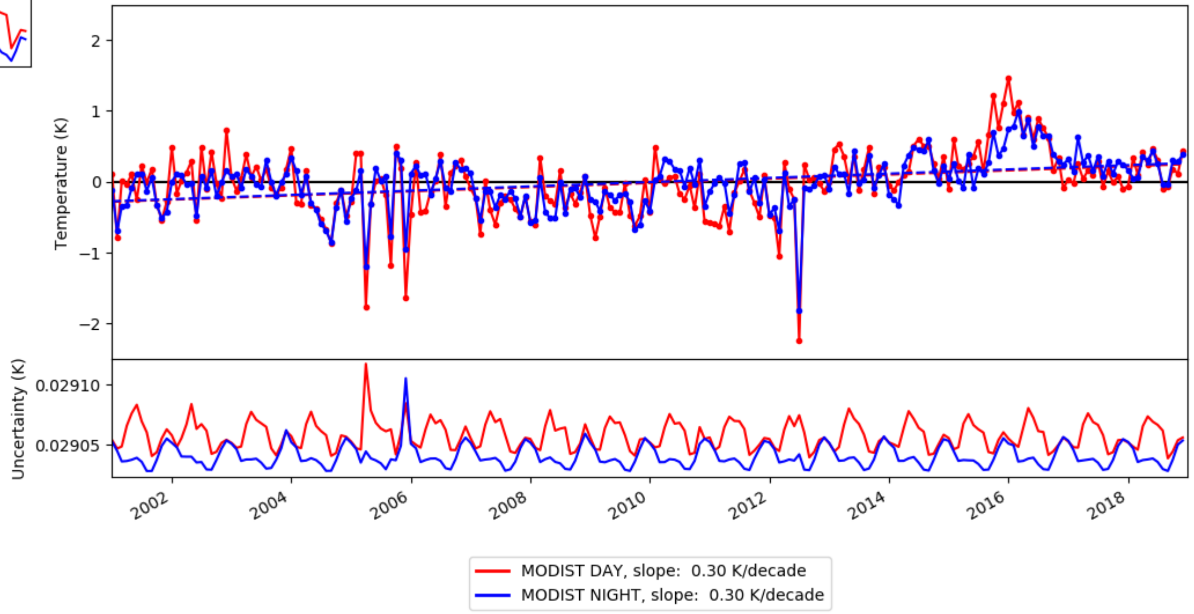


Poster "Improving temperature observations from Space to close the energy budget of the Earth in support of UNFCCC objectives and the Paris Agreement"; Waring et al.

EXAMPLE LST_CCI TERRA-MODIS: 18-YEAR LST CDR

Global Terra-MODIS LST and anomalies





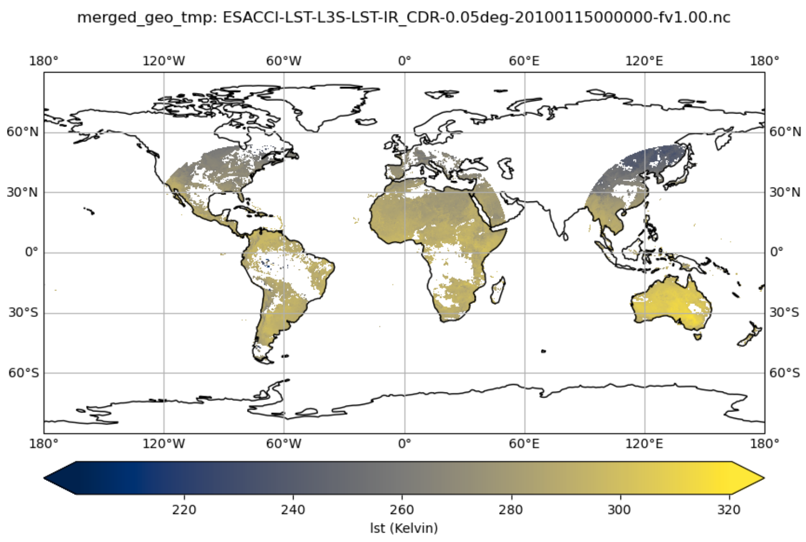
ATSR-S3 CDR

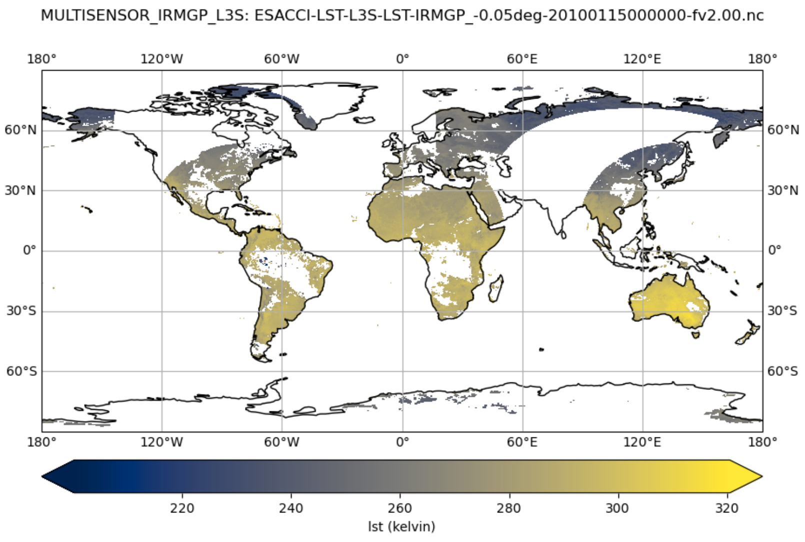
- Long-term LST Climate Data Record (CDR) from ATSR-2, AATSR, SLSTR with Terra MODIS filling gap between AATSR and SLSTR

- Current product release:
  - Took advantage of improvements to single sensor records to build a multi-sensor CDR
  - Intercalibration of sensors with IASI
  - Time correction applied to account for different overpass times
  - View angle restriction for consistency across instruments
  - Perry, M., Ghent, D., Jimenez, C., Dodd, E., Ermida, S., Trigo, I. F., and Veal, K. (2020). Multi-Sensor thermal infrared and microwave land surface temperature algorithm intercomparison. Remote Sensing, 12(24), 4164

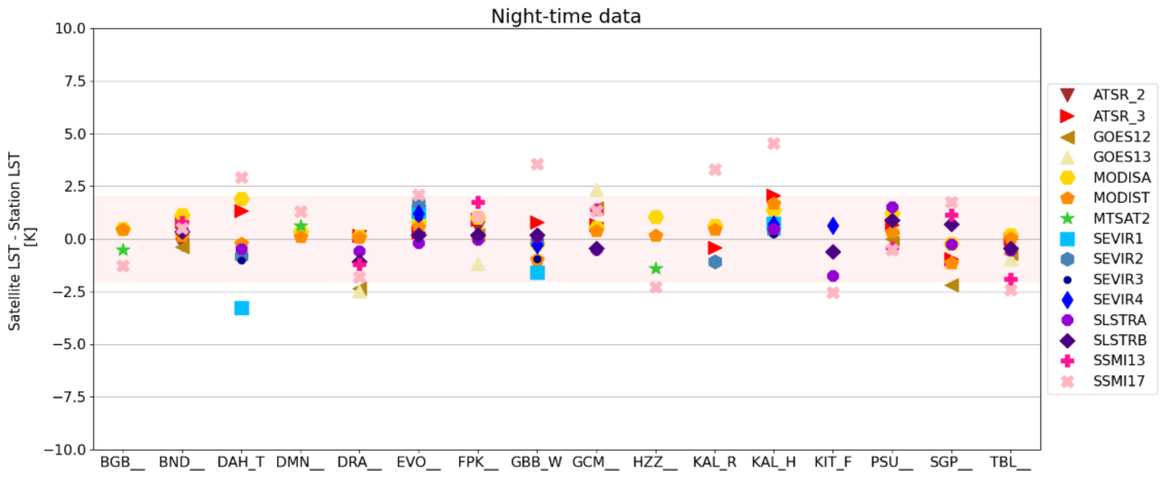
- Improvements being made:
  - Extend geographical coverage over sea-ice
  - Incorporate improvements to single sensor algorithms such as further advances in uncertainty characterisation and cloud-clearing
  - Improvements to intercalibration
  - Time correction – improve diurnal model to reduce uncertainties in the time correction

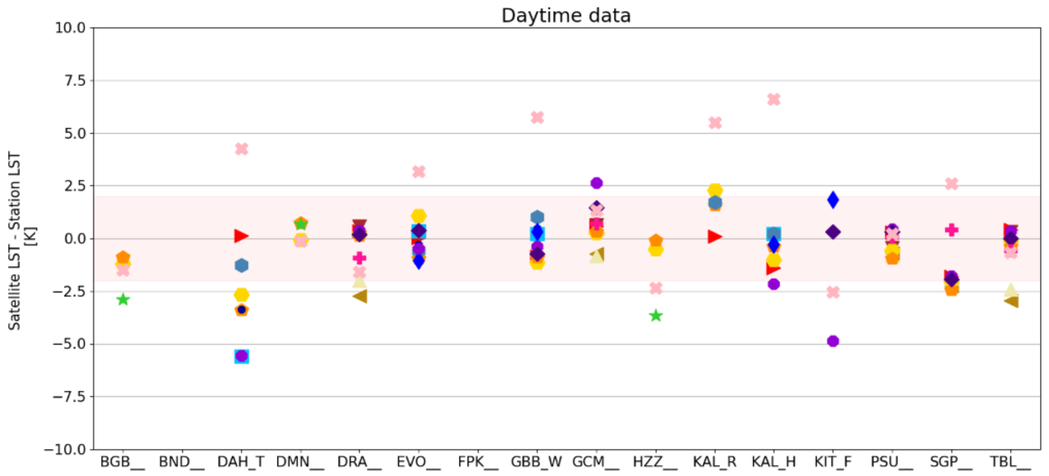
- The aim of the Merged IR CDR is to integrate polar and geostationary infrared-based LST to deliver information on the diurnal variation of LST at a global scale, including for the polar regions:
  - The LEO IR and GEO IR data are combined using all the building blocks in place for consistency across products
  - LSTs fields are provided at 3 hourly intervals each day (00:00, 03:00, 06:00, 09:00, 12:00, 15:00, 18:00 and 21:00 UTC); Temporal coverage is 2009 – 2020
  - Instruments include: GEOs - IMAGER s on GOES 12 and 13; Advanced Baseline Imager on GOES 16, SEVIRIs on MSGs 1-4; JAMI on MTSAT 1 and 2; LEOs - AATSR; MODIS on Aqua and Terra; SLSTRs on Sentinel-3A and Sentinel-3B.
- Future improvements:
  - Extend the Merged IR CDR forwards through to 2023 and backwards to 2004
  - Include data from AVHRR/3 from NOAA and Metop, and new sensors such as VIIRS and Himawari



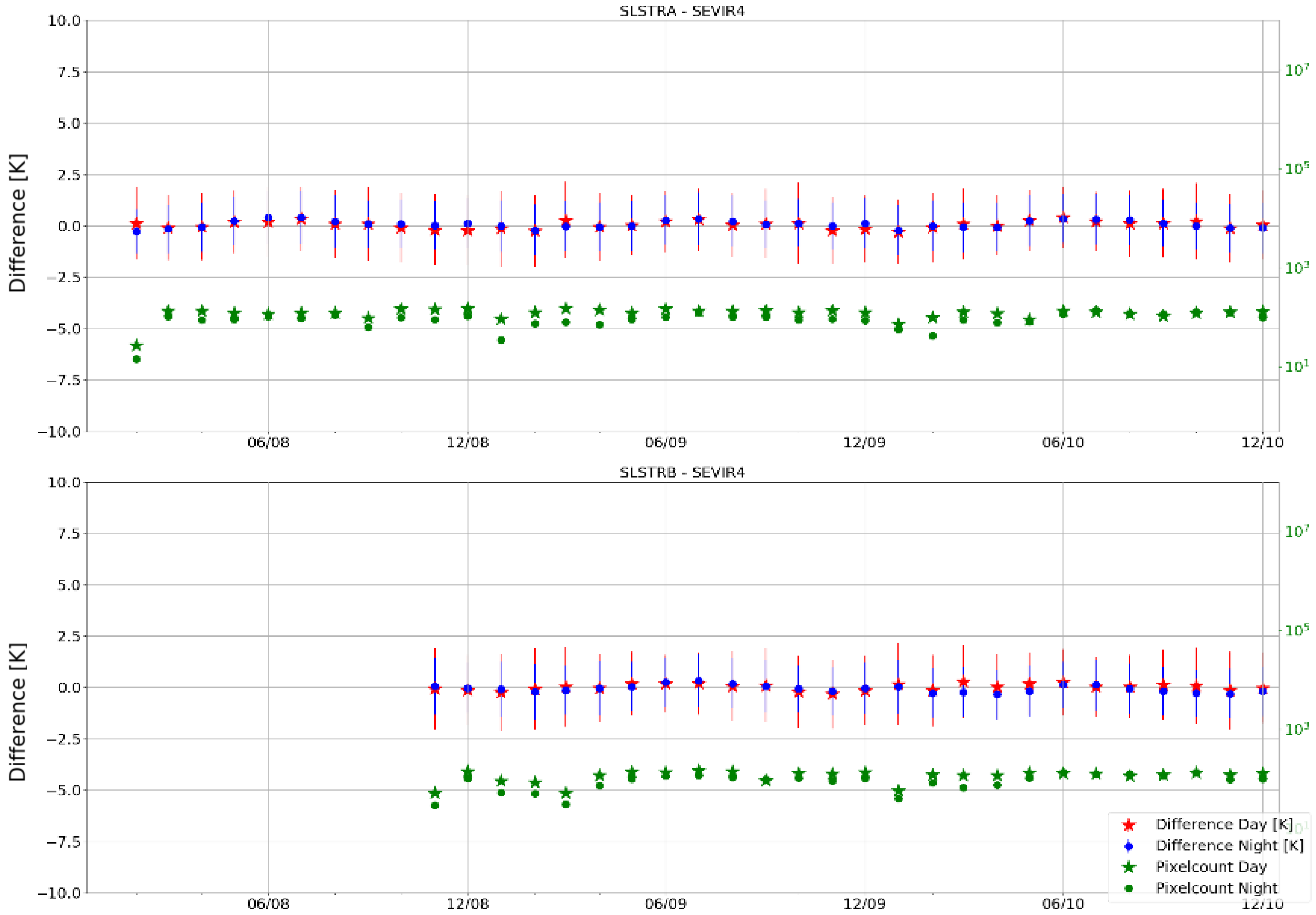


- Bias: median(satellite LST – in situ LST)
- LST_cci IR products are performing well for most stations
- Night-time bias smaller, slightly larger differences in daytime bias (depending on station)
- MW data sets: larger footprint than IR data sets and so representativeness with respect to in situ station is more challenging





Intercomparisons – Results Over Africa 2018 - 2020



Team	Title
Met Office Hadley Centre	Regional and Global Trends in LST
DMI	Assimilating Greenland ice sheet surface ice temperature into atmosphere and ice sheet models
Ruhr University Bochum	Characterisation of Surface Urban Heat Islands
MPI-BCG	Biosphere-atmosphere exchange of sensible and latent heat
MeteoRomania	Intercomparison and integrated use of LST in urban climate studies
LIST	Integration of LST into a physically-based surface energy balance model

Cheval, S., Dumitrescu, A., Irașoc, A., Paraschiv, M-G., Perry, M., and Ghent, D. (2022). MODIS-based climatology of the Surface Urban Heat Island at country scale (Romania), Urban Climate, 41, 101056

Good, E. J., Aldred, F. M., Ghent, D. J., Veal, K. L., and Jimenez, C. (2022). An Analysis of the Stability and Trends in the LST_cci Land Surface Temperature Datasets over Europe. Earth and Space Science, 9, e2022EA002317, https://doi.org/10.1029/2022EA002317

Karagali, I., Barfod Suhr, M., Mottram, R., Nielsen-Englyst, P., Dybkjær, G., Ghent, D., and Høyer, J. L. (2022). A new L4 multi-sensor ice surface temperature product for the Greenland Ice Sheet, The Cryosphere, 16, 3703–3721

Mallick, K., Baldocchi, D., Jarvis, A., Hu, T., Trebs, I., Sulis, M., Bhattarai, N., Bossung, C., Eid, Y., Cleverly, J., Beringer, J., Woodgate, W., Silberstein, R., Hinko-Najera, N., Meyer, W. S., Ghent, D., Szantoi, Z., Boulet, G., Kustas, W. P. (2022). Insights into the aerodynamic versus radiometric surface temperature debate in thermal-based evaporation modeling. Geophysical Research Letters, 49, e2021GL097568

Sismanidis, P., Bechtel, B., Perry, M., and Ghent, D. (2022). The Seasonality of Surface Urban Heat Islands across Climates. Remote Sensing, 14, 2318

Key Activities for Phase-2

- Improve intercalibration of polar-orbiters
- Extension to Algorithm Intercomparison exercise to include new algorithms
- The best algorithm for each respective sensor
- Extend the cloud assessment under different conditions
- To correct for the drift in local time
- To properly characterise the clear-sky only sampling uncertainty
- Extend coverage of LEOs to include sea-ice
- Develop an experimental all-sky product from combining IR and MW LST

Summary

- An expected accuracy and precision of all the LST ECV Products will be < 1 K.
- An assessment of the stability of LST ECV Products to ensure they meet they threshold requirement < 0.3 K / decade.
- A global thermal infrared LST CDR from ATSR through to SLSTR with record length of 28 years.
- A passive microwave time series from SSM/I and SSMIS with record length of over 28 years.
- A passive microwave time series from AMSR-E and AMSR-2 with record length of over 21 years.
- The long-term time series from AVHRRs from the 1980s to present is also expected to make significant contributions towards the GCOS requirements.
- Implementation of existing FCDRs, and where these are not available intercalibration of level-1 data for CDRs.
- Time difference corrections of level-1 data for multi-mission CDRs.

SUMMARY

- Consistency across all LST ECV Products, in terms of retrieval algorithms, uncertainty characterisation, and coefficient generation.
- Optimisation of best cloud clearing detection across new sensors.
- The project is ensuring where possible consistency is maintained with other ECV products.
- First climate quality LST at high spatial resolution from Landsat and downscaling developments.
- Fully independent and rigorous product validation and intercomparison extended to new sites and external datasets.
- Significant increase in maturity levels of all LST ECV Products
- Demonstration of climate applications resulting in several journal papers published, accepted, or in review – many led by users in the Climate Research Group.