land surface temperature cci

LAND SURFACE TEMPERATURE CCI:

APPROACHES TO LONG-TERM DATA FOR CLIMATE

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OBJECTIVES

Consistency in algorithms, cloud masking, uncertainties

Building the first 20+ year climate datasets for LST

Resolving the global diurnal cycle for LST by merging multiple polar orbiting and geostationary data

An objective to be the best source of LST data for the user community:

- LST is an essential parameter for diagnosing Earth System behaviour and evaluating Earth System Models
- Crucial constraint on surface energy budgets, particularly in moisture-limited states
- A metric of surface state when combined with vegetation parameters and soil moisture
- As an independent temperature data set for quantifying climate change complementary to the near-surface air temperature ECV based on in situ measurements and reanalyses

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

← LST CCI User Requirements

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

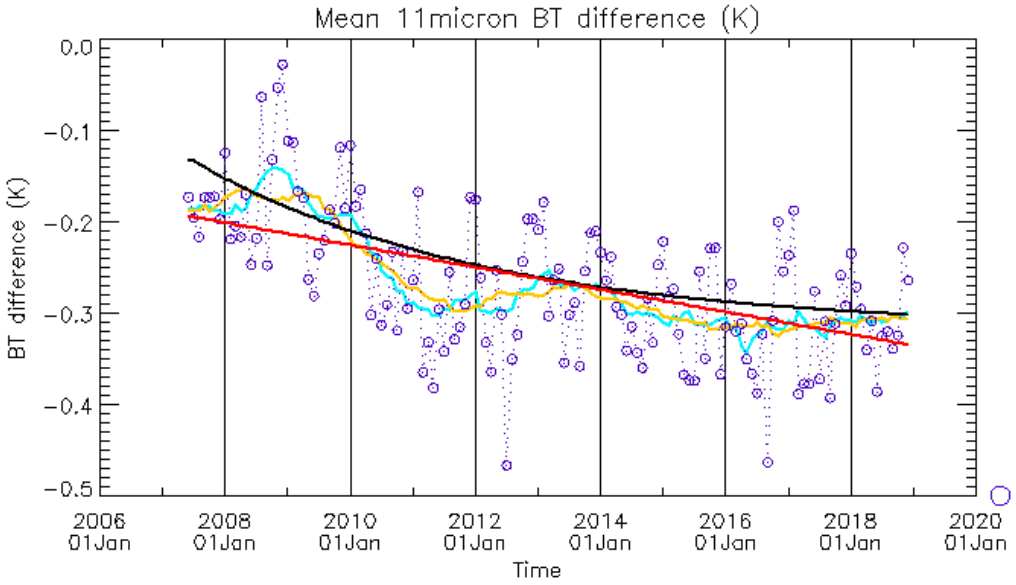
GCOS LST Requirements ↓

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

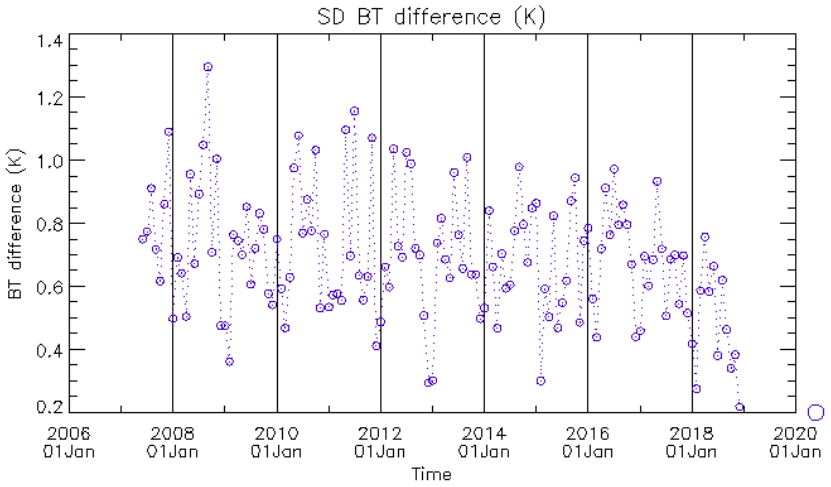
KEY POINTS

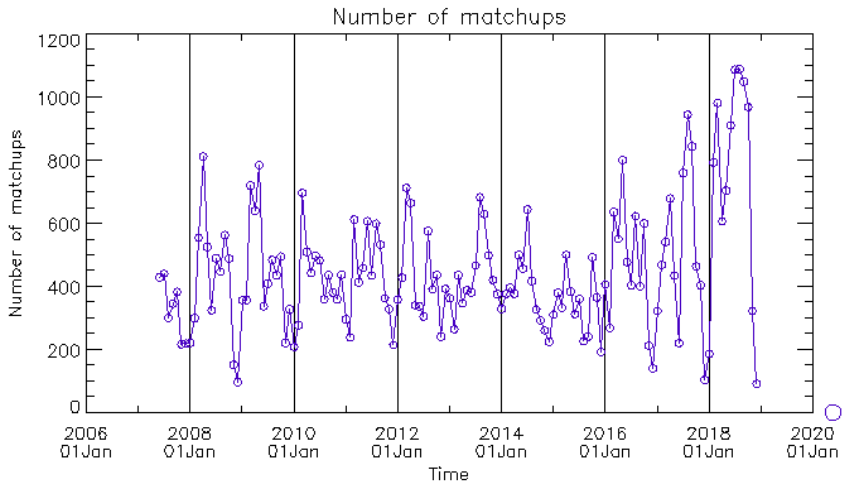
- Implementation of common Calibration and Validation Database
- Consistency in algorithm, uncertainties, cloud masking
- Optimised pipelines for end-to-end (L1B -> L1C -> L2P -> L3U -> L3C) processing
- Implementation of full uncertainty characterisation approach in processing chains
- Dynamic land cover mapping consistent with wider CCI
- Derivation of intercalibration LUTs and time correction LUTs
- Metadata compliant with CCI Data Standards
- LST_cci re-gridding command line tool for users which propagates LST and uncertainties

SENSOR INTERCALIBRATION – EXAMPLE AQUA MODIS, 11 MICRON



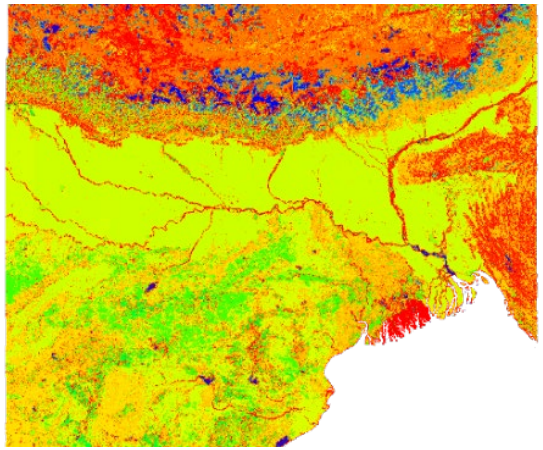
Straight line fit: red
Exponential fit: black
Smoothing 11 month window: blue
Smoothing 23 month window: yellow



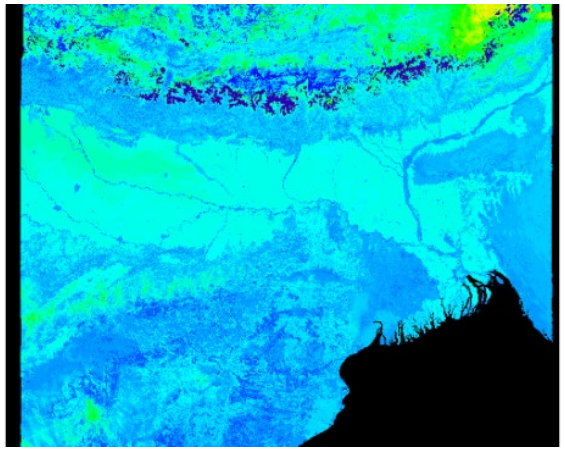


UNCERTAINTY BREAKDOWN – EXAMPLE SLSTR L2P

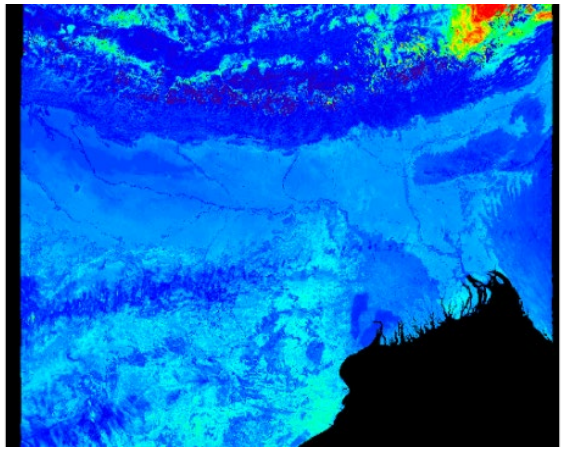
Total uncertainty



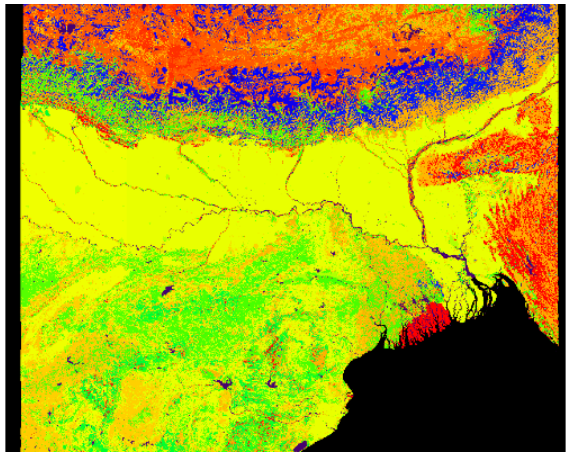
Random



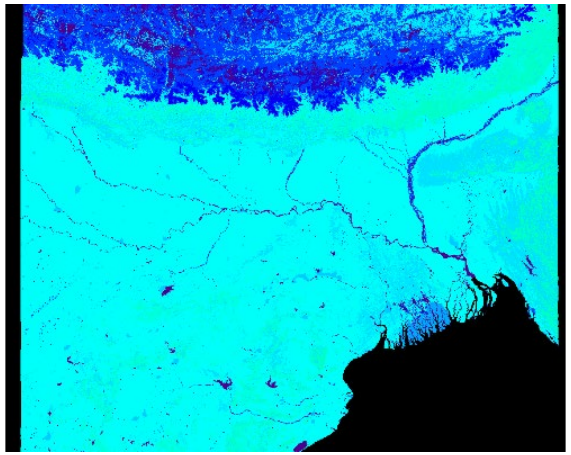
Calibration



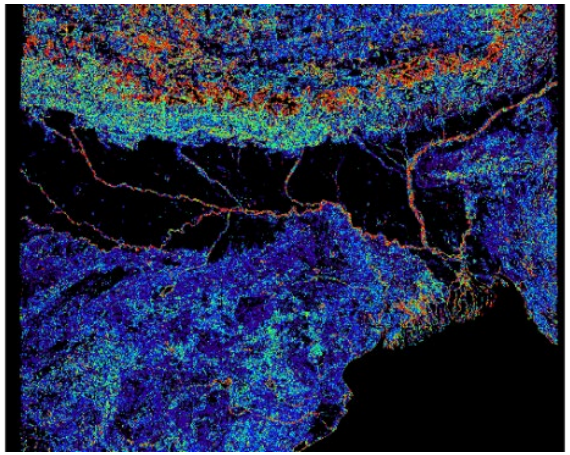
Atmosphere



Surface

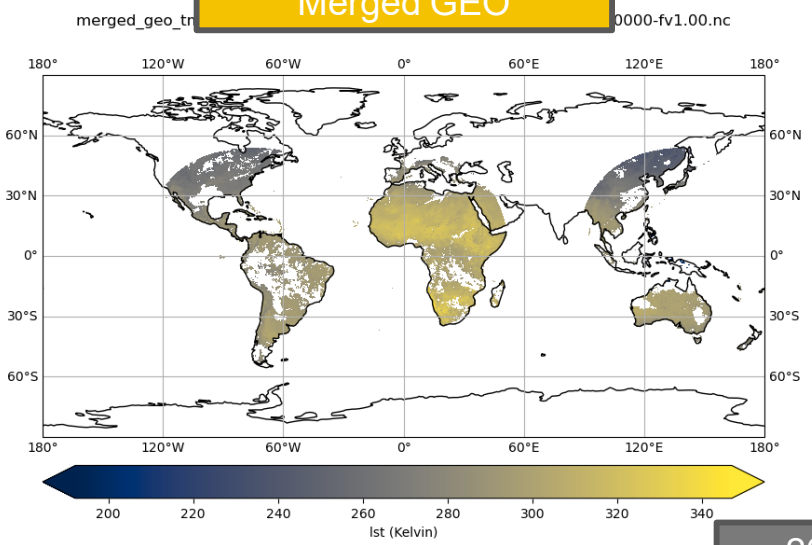


Geolocation

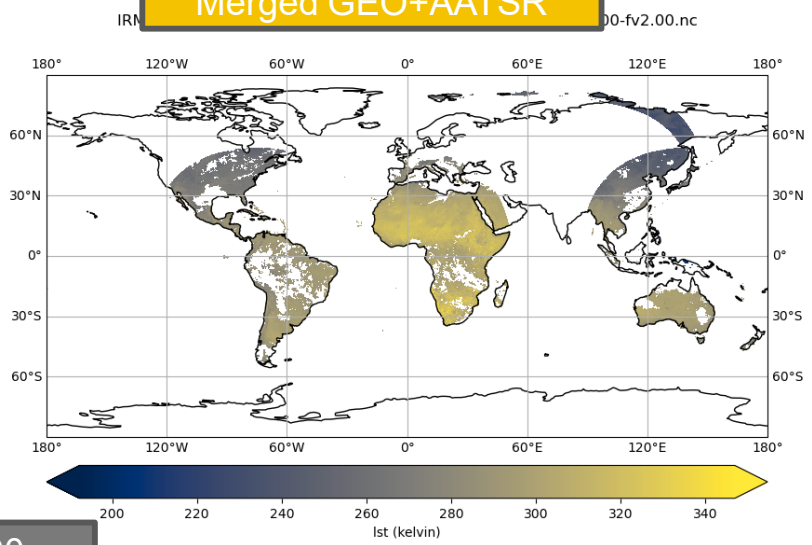


MERGED PRODUCT V1.00

Merged GEO

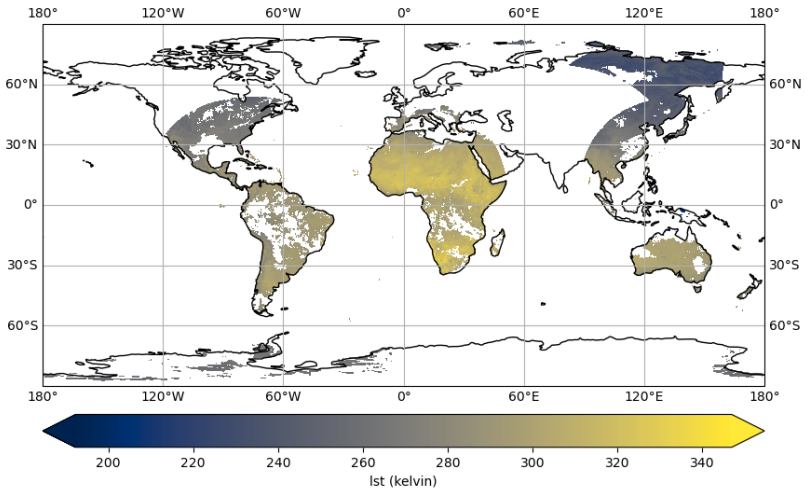


Merged GEO+AATSR

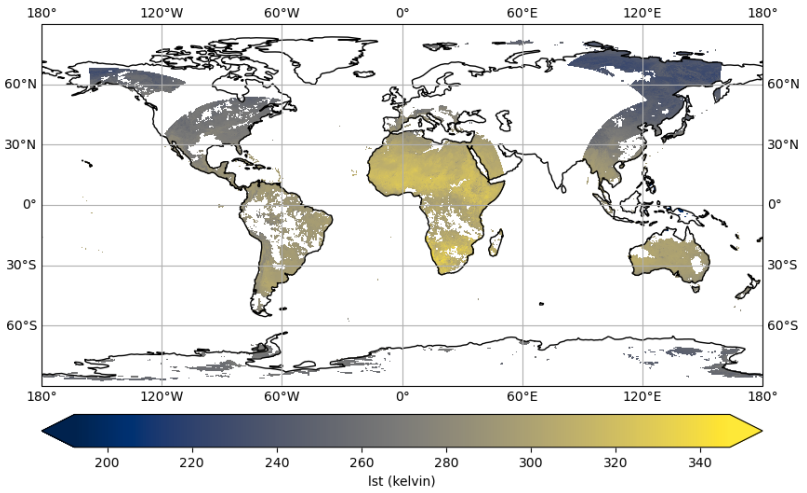


2010/01/15 12:00

Merged GEO+AATSR+MODIST



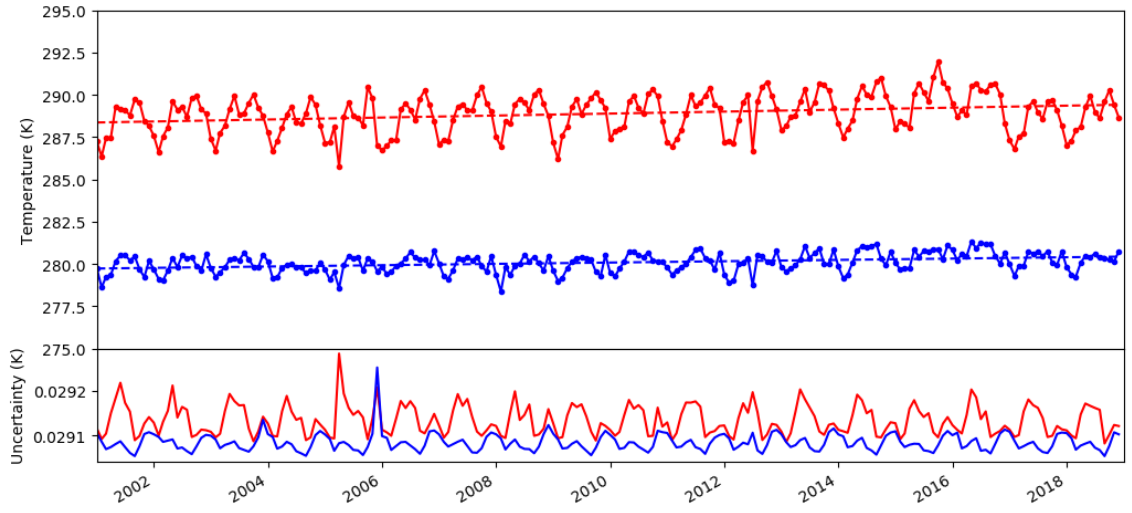
Merged GEO+AATSR+MODIST+MODISA



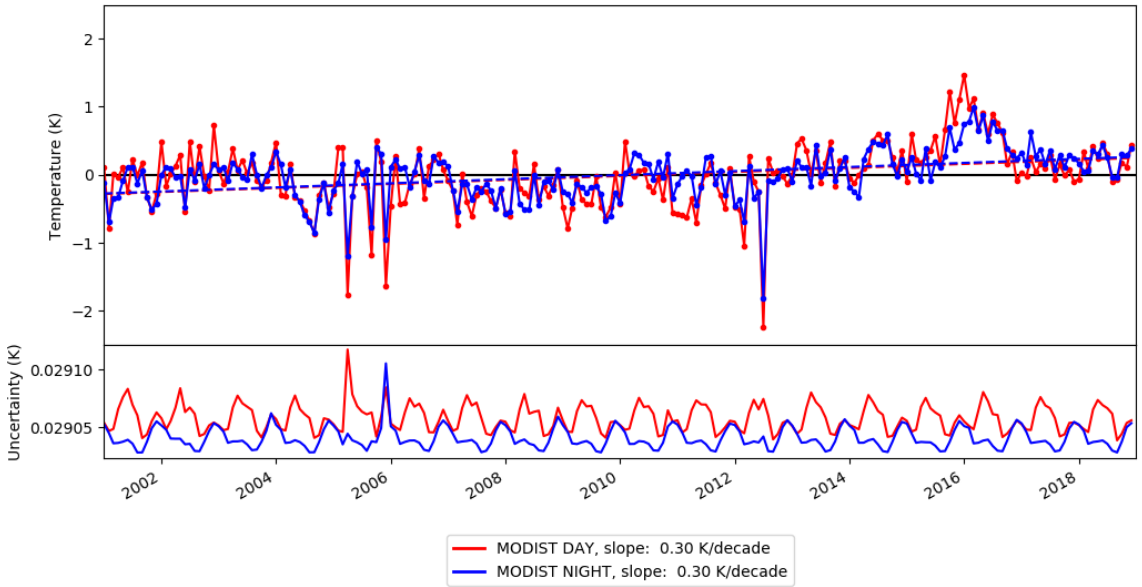
IN SITU VALIDATION - BIAS

- Bias: median (satellite LST – in situ LST)
- IR products are performing well for most stations
- Night-time bias smaller, large rdifferences in daytime bias (depending on station)
- MW data sets: investigate larger area than IR data sets

TIME SERIES



18-Year Terra MODIS LST



Terra MODIS Monthly LST Anomalies

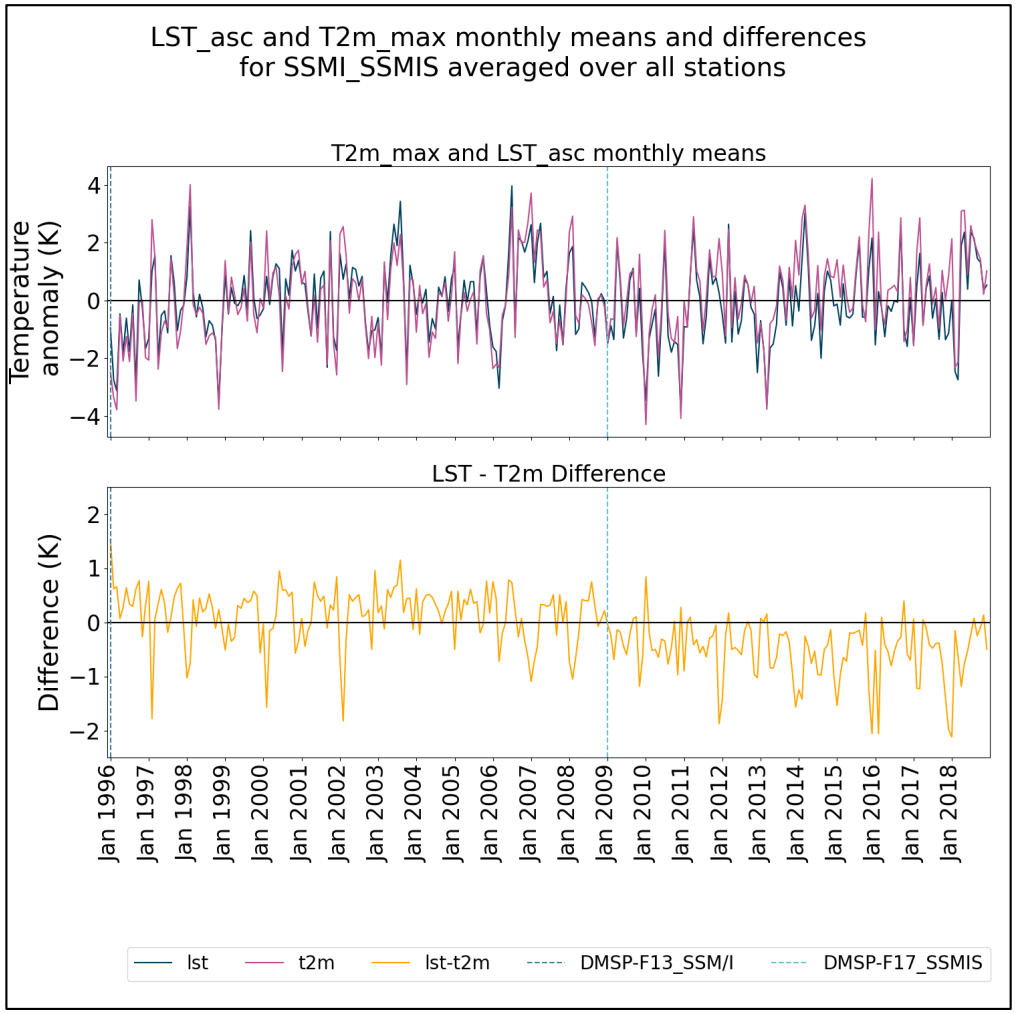
LST ECV PRODUCTS

Instrument	Satellite(s)	Phase-1 (Access)	Next Cycle (2023)	Final Cycle (2025)	Products	Comments
ATSR-2	ERS-2	1995-2003 (CCI ODP)	1995-2003	1995-2003	0.01° Daily + Monthly L3C	Including sea-ice
AATSR	Envisat	2002-2012 (CCI ODP)	2002-2012	2002-2012		
MODIS	Terra	2000-2018 (CCI ODP)	2000-2021	1999-2023		
	Aqua	2002-2018 (CCI ODP)	2002-2021	2002-2023		
SLSTR	Sentinel-3A	2016-2020 (CCI ODP)	2016-2021	2016-2023		
	Sentinel-3B	2018-2020 (CCI 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 (CCI ODP)	2004-2021	2004-2023	0.05° Hourly L3U	MVIRI produced by CM SAF
Imager	GOES 12,13,16	2009-2020 (CCI ODP)	2004-2021	2004-2023	0.05° 3-hourly / HourlyL3U	
JAMI	MTSAT 1-2	2009-2015 (CCI 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 (CCI 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 (CCI ODP)	2004-2021	2004-2023	0.05° 3-hourly L3S	
ATSR-S3 CDR	ATSR, MODIS, SLSTR	1995-2020 (CCI 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		

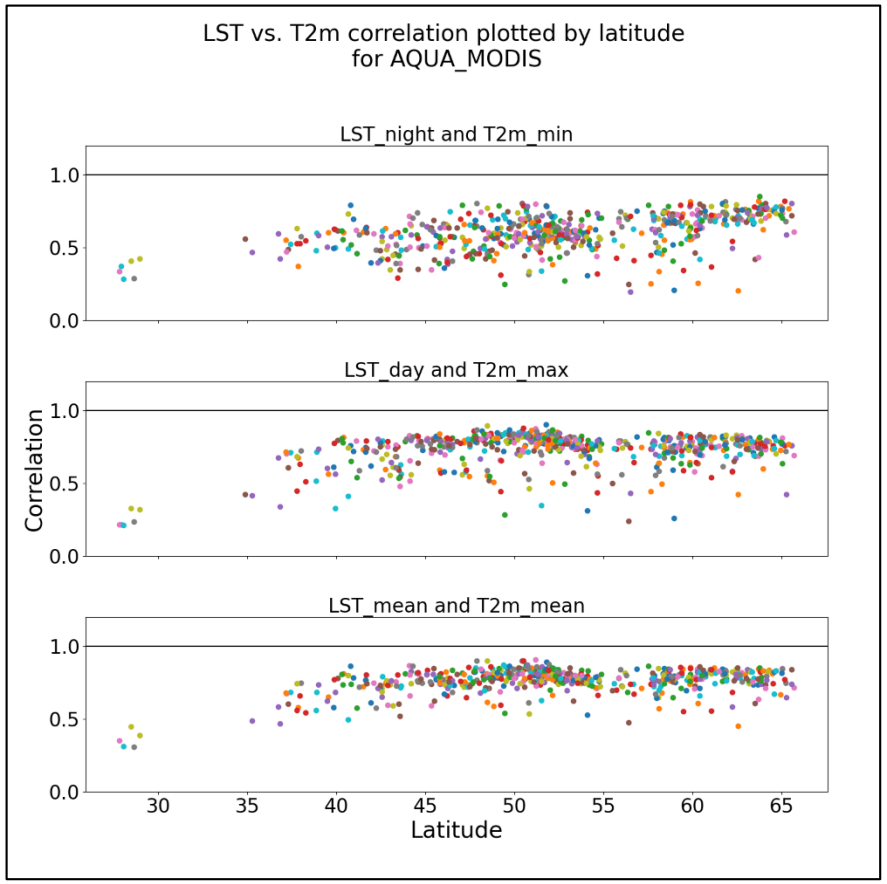
APPLICATIONS

Title	Key points
Stability of LST_cci products assessed by comparison to homogenised in-situ air temperature data over Europe	A strong relationship between LSTs and T2m anomalies is observed (correlation and slopes range between 0.6 and 0.9) More mature products appear stable, with products in developments showing some non-climatic discontinuities associated with sensor changes and/or drift over time
Assess the impact of including observed LST data to improve simulations of ice sheet melt and retention	Improved estimates of Greenland ice sheet mass budget with assimilation of observed skin temperatures The resulting L4 product performs satisfactorily in terms of quality when compared with surface temperature from IceBridge
Investigate the temporal behavior of SUHIIs (hysteresis loops) and the relationship between SUHII and City size per climate zone	The SUHII estimates and hysteretic cycles calculated from the 0.01° LST_cci custom products agree with the published literature
Investigate how LST characteristics affect simulated carbon fluxes, e.g. diurnal information, gap-filled vs non-gap filled, view geometry, etc.	Results suggest that LST informs the models efficiently on conditions of energy and water limitation for the fluxes
Inter-comparison and integrated use of LST in urban climate studies over Romania	LST is very well correlated with T2m under clear-sky conditions, the outputs are relevant for integrated urban climate research approaching both SUHI and UHI
Integration of LST_cci LST in STIC (SEB model) to understand the relationship between aerodynamic temperature and LST	Results show that the differences between aerodynamic and radiometric temperature occur due to constrained evaporation triggered by soil water stress and rising atmospheric water deficits at the arid and semiarid ecosystems, and due to evaporation induced cooling in mesic ecosystems.

MW product stability much improved

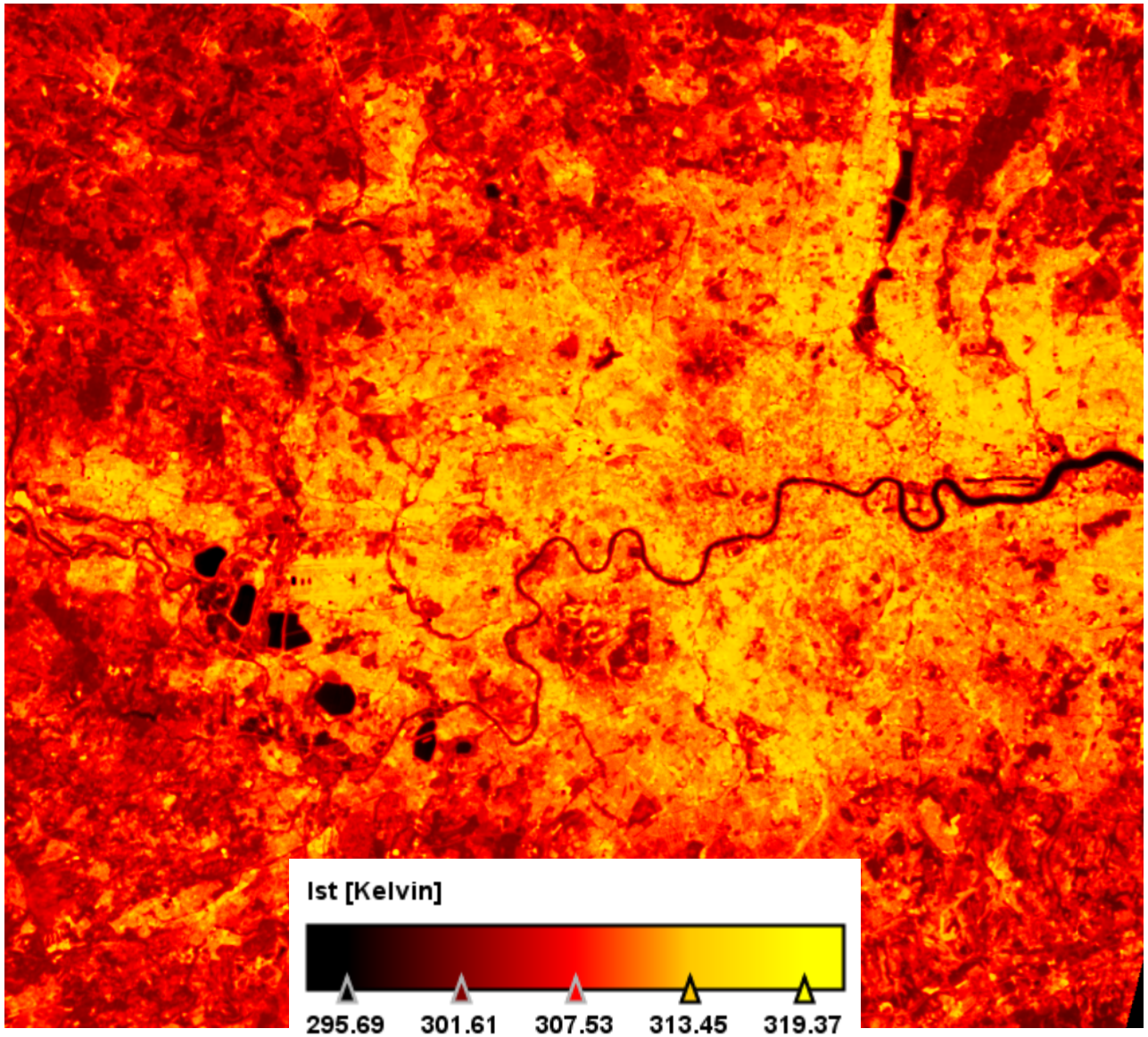


LST vs T2m correlations much improved in v3.0 IR products.

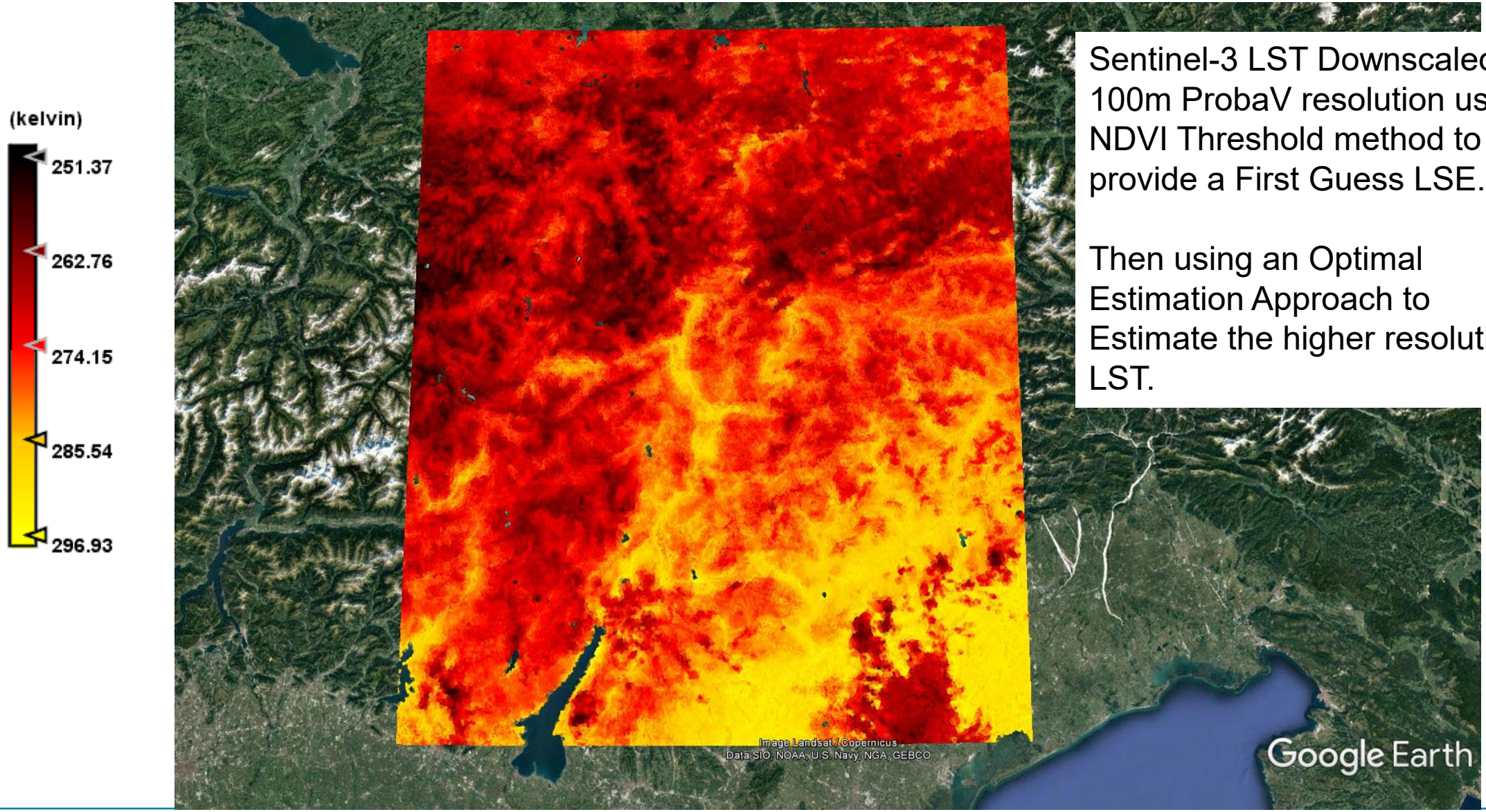


HIGH RESOLUTION LST FOR REGIONAL CROSS-CCI STUDIES

- **Optimal Estimation retrieved LST from LANDSAT**
- **Applied to Landsat-8 and now Landsat-9**



DOWNSCALING LST FOR HIGH RESOLUTION REGIONAL CROSS-CCI STUDIES



Sentinel-3 LST Downscaled to 100m ProbaV resolution using NDVI Threshold method to provide a First Guess LSE.

Then using an Optimal Estimation Approach to Estimate the higher resolution LST.

NEXT STEPS: PHASE-2

- 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, and time difference corrections of level-1 data for multi-mission CDRs.
- First climate quality LST at high spatial resolution from Landsat and downscaling developments.