MAXIMISING THE BENEFITS OF SATELLITE LST WITHIN THE USER COMMUNITY:
ESA DUE GLOBTEMPERATURE

DARREN GHENT – UNIVERSITY OF LEICESTER

- **Global LST** over all land surface types including lakes, sea ice and ice/snow
- **Gridded** level 3 and level 4 data, ideally gap-filled and with clear-sky and under-cloud LST. Diurnal data are highly desirable.
- **Long and stable LST time records** for climate (climate data record or CDR) from single sensor types and local times.
- **LST uncertainties** per pixel and on all averaged data sets
- LST uncertainty definition and uncertainty analysis
- Higher accuracy of LST from improved cloud-clearing.
- Validation of both LST data and LST uncertainties; particular challenges in data sparse regions and transition zones.
- Intercomparisons of different satellite LSTs with clear summaries of results.
- NRT data sets, particularly with diurnal coverage and good sampling.
- **Much better access to LST data sets** from both European and non-European satellites.
- Consistent and user-friendly data format for LST data products.
- Open **web portal** serving data from multiple sources.
- Better understanding of land surface air temperature versus land surface radiative temperature
- Better definitions of land surface temperature in varying biomes.
- **Strong links with the upcoming Sentinel-3 mission**
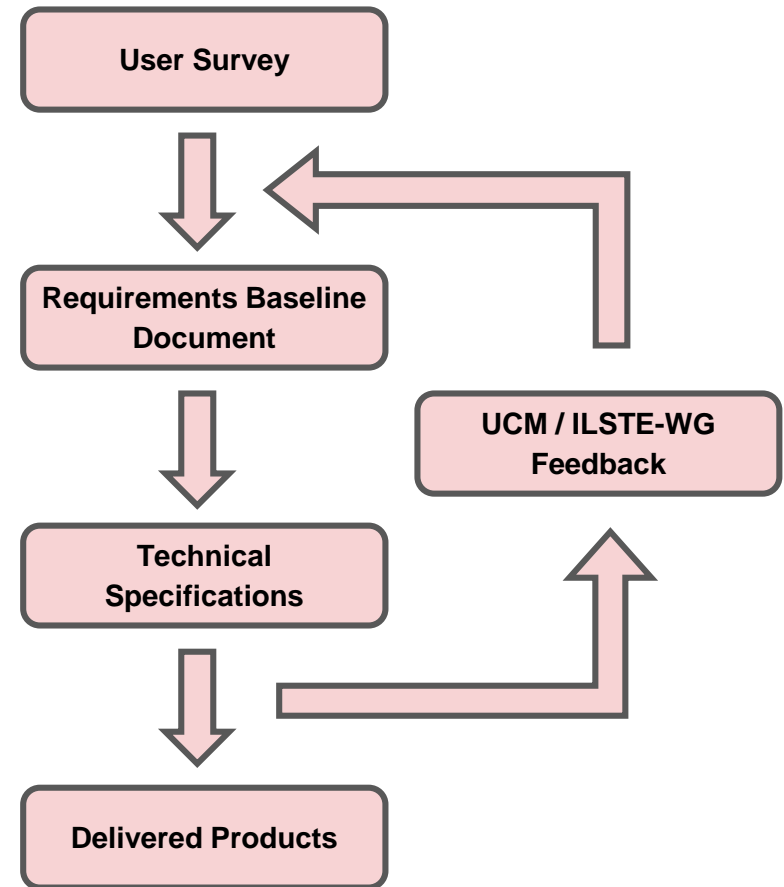- Very high spatial resolution LST (100 m) with good coverage.

- **Requirements Baseline Document:**
  - ❖ Quantitative analysis from the responses of over 80 user survey participants
  - ❖ http://www.globtemperature.info/index.php/public-documentation/deliverables-1/71-requirements-baseline-document-del-05
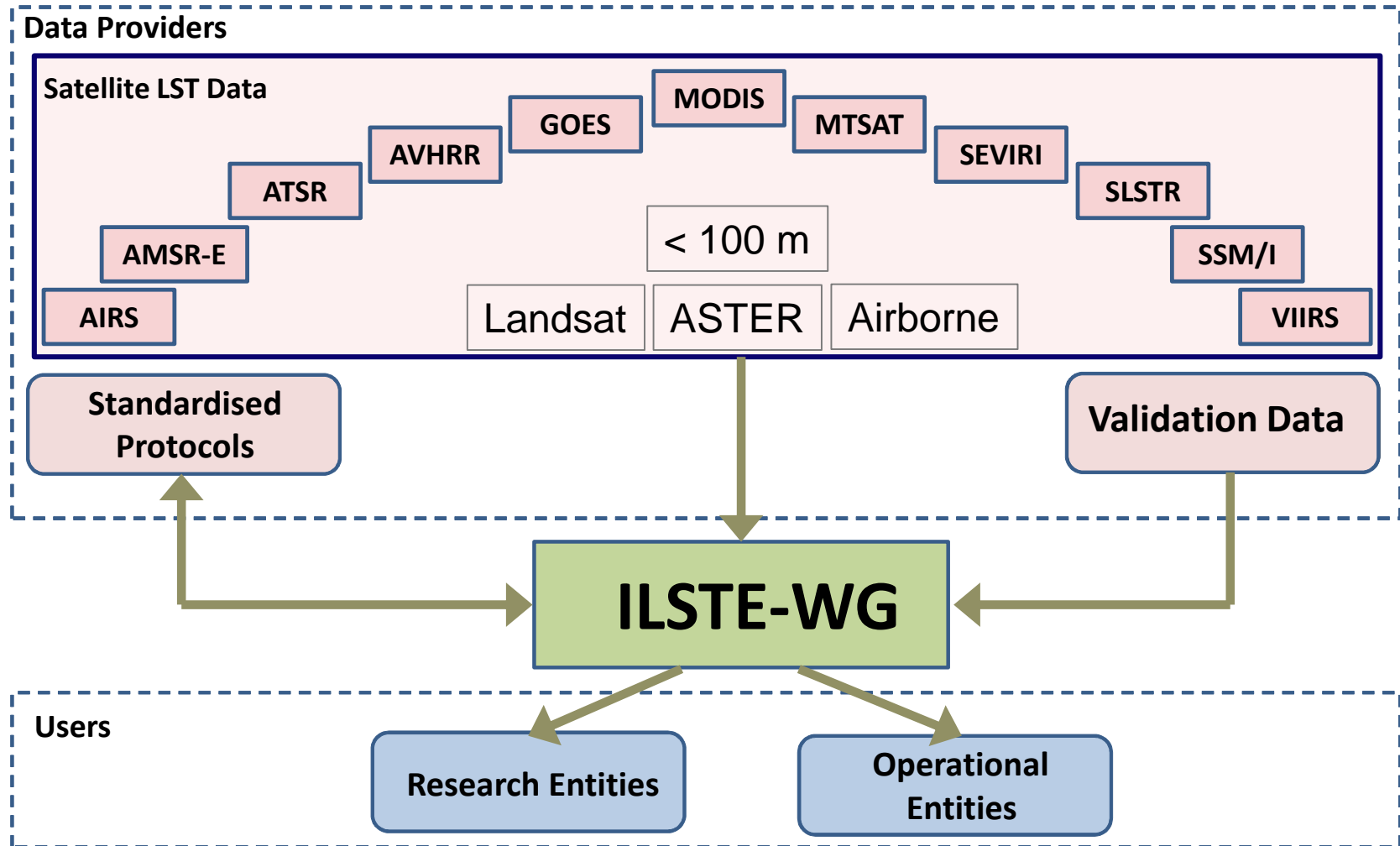
- **User Consultation Meetings (UCMs):**
  - ❖ UCM #2: June 2014, Karlsruhe, Germany:
  - ❖ Feedback on User Requirements
  - ❖ UCM #3: 11-12 June 2015 – Reading, UK

- **International LST and Emissivity Working Group (ILSTE-WG)**

User Survey → Requirements Baseline Document → Technical Specifications → Delivered Products → UCM / ILSTE-WG Feedback → User Survey
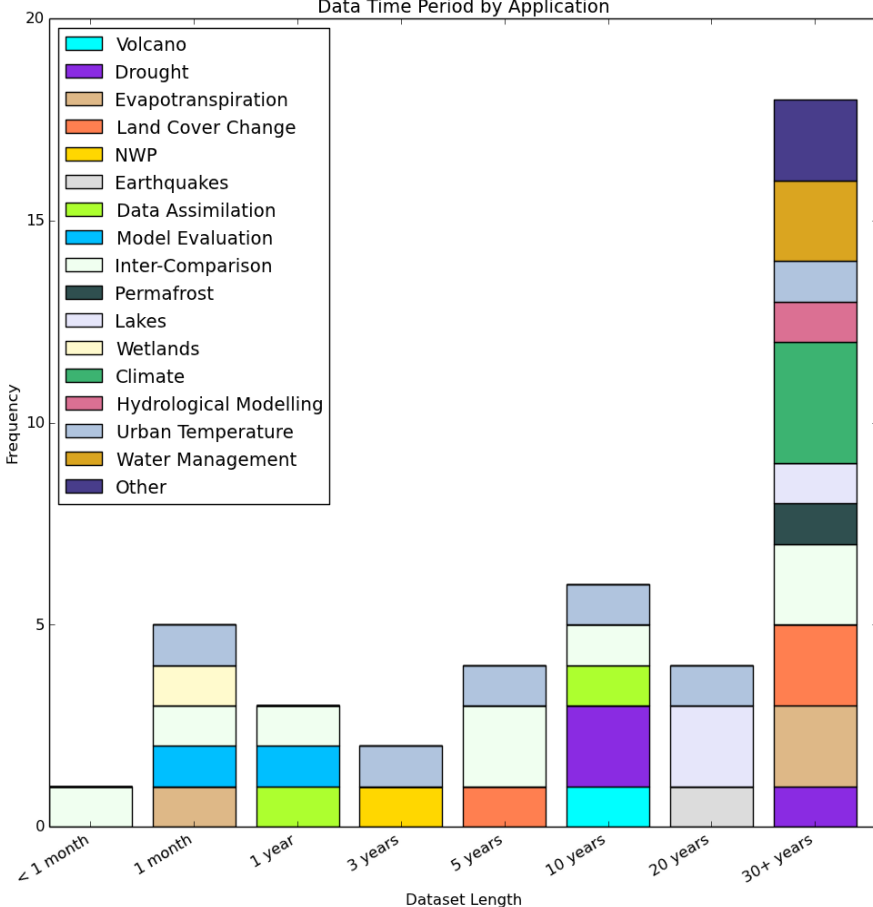
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The ILSTE-WG will enable the LST & LSE community to achieve breakthroughs in the provision and exploitation of data in key areas:

- It represents the best available expertise in LST & LSE data techniques and LST-related science, sharing best practice amongst data providers and data experts.

- It acts as an international forum for regular interactions between LST Measurement Teams, enabling improvements in data algorithms and data quality, and increased understandings of user requirements

- It delivers a range of user-provider meetings and workshops, increasing links across the community.

- It support the alignment of LST best practice with the planned activities and data provision of operational agencies

- It provides an opportunity to agree standardised protocols for data formats, validation and access to data, appropriate to key sectors of the LST user community.

- It provides an independent source of advice and appraisal, as requested, for related projects such as the NASA MEaSUREs (Making Earth System Data Records for Use in Research Environments) Projects and the ESA DUE GlobTemperature Project.
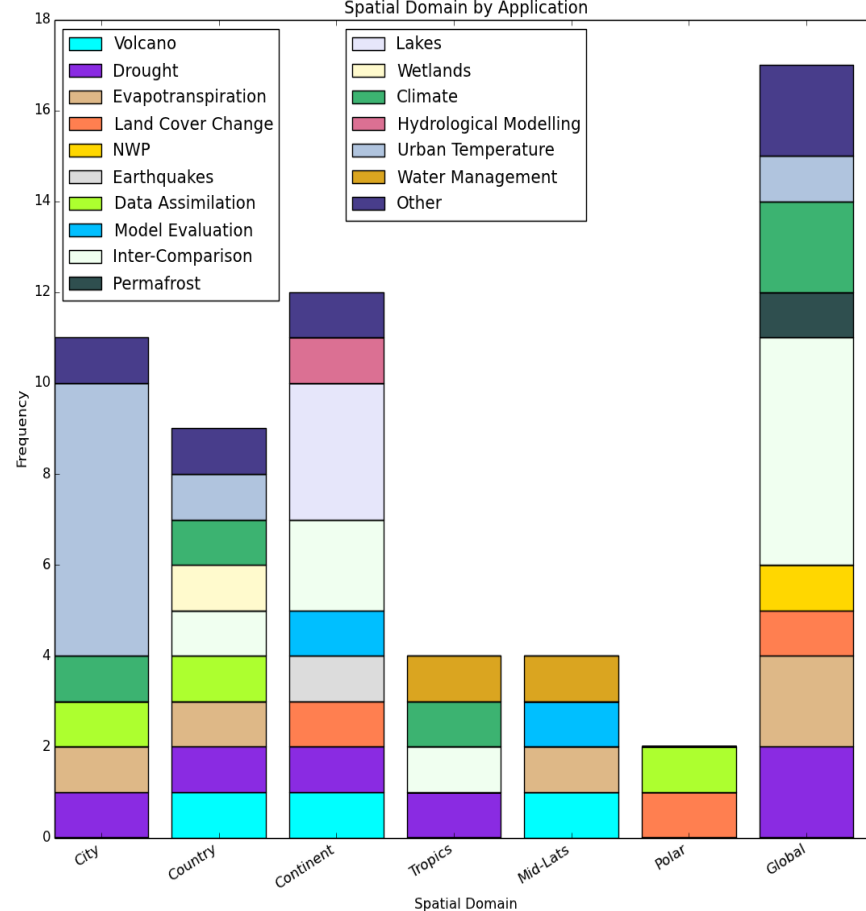
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Data Providers

Satellite LST Data

GOES · MODIS · MTSAT · AVHRR · SEVIRI · ATSR · SLSTR · AMSR-E · SSM/I · AIRS

< 100 m

Landsat · ASTER · Airborne · VIIRS

Standardised Protocols

Validation Data

ILSTE-WG

Users

Research Entities

Operational Entities

5

Over what time period and spatial domain do you require data within this dataset?
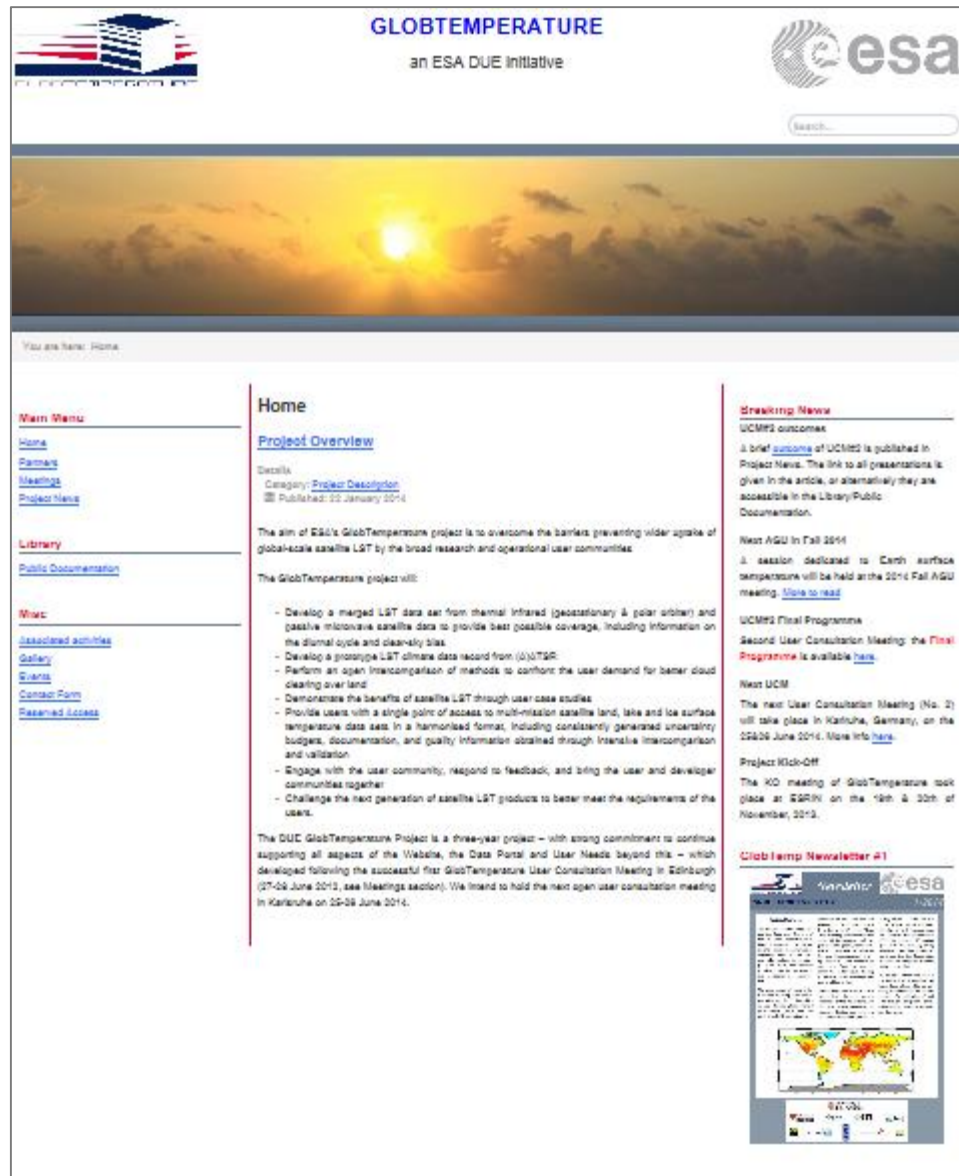
Objectives:

- **To illustrate the benefits that use of satellite LST can bring to five different application fields**

- **To assess practical elements of the GlobTemperature products such as file formats and product consistency/quality assurance**

UCS	Partner	Application
UCS #1	Met Office Hadley Centre	Surface temperature reconstruction for climate
UCS #2	Estellus	Estimation of evapotranspiration
UCS #3	DMI	Driving of sea-ice state in a coupled ocean model
UCS #4	UNIVERSITY OF COPENHAGEN	Soil moisture assessment
UCS #5	Met Office	Assimilation of LST in NWP

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http://www.globtemperature.info/

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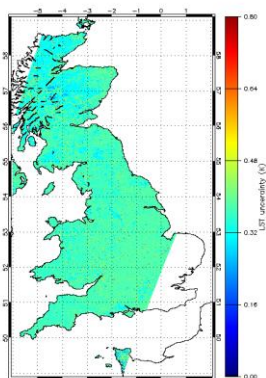
http://data.globtemperature.info/

- **Database structure is operational**

- **Mechanism of data dissemination is operational**

- **First four datasets are available (ATSR-2, AATSR, SEVIRI and SSM/I)**

- **All datasets are delivered in NetCDF-4 CF-Compliant "Harmonised Format"**
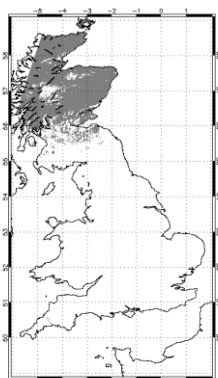
- **Links to external datasets (eg ASTER GED)**

LST LST uncertainty Cloud Mask

Biome Frac. Veg. Water Vapour

Monthly Sea-ice IST average Jan 2004

Mean surface temperature (℃)

Single-Sensor LST SEVIRI / MSG

❖ **Hourly data**

❖ **Reprojected onto a 0.05 x 0.05 regular grid**

❖ **Harmonized Format (NetCDF + Metadata)**

❖ **2007 - 2013 uploaded to Data Portal**

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T_s estimation from microwaves

- **SSM/I dataset available on the Data Portal**

- A methodology developed to estimate the T_s, along with water vapour, cloud liquid water, and surface emissivities over land, from passive microwave imagers based on a neural network inversion trained on a large data set of simulated radiances

- This method has been applied to SSM/I for 2003 and T_s have been estimated with a spatial resolution of 0.25° x 0.25°, at least twice daily, depending on the number of SSM/I instruments in space

- SSM/I T_s have been compared with the GlobTemperature AATSR LST dataset

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Merged LST Product

Combining GEO and LEO LST Products

Linear regression model:

1.Remove systematic differences : linear regression between collocated GEO and LEO LST, restricting to **similar VZA's**

2.Build linear regression model: linear regressions between **unbiased** GEO and LEO LST for **classes of VZA**, daytime and night-time separately

$$LST_{LEO} = a\, LST_{GEO} + b$$

Where a and *b* estimated for different View Angle Differences (6 classes) and for day & night-time separately

→ Model with 24 parameters

Kernel model:
(based on Vinnikov et al., 2012)

$$\frac{T(\theta_v, \theta_i, \Delta\phi)}{T_0} = 1 + \mathbf{A}\Phi(\theta_v) + \mathbf{D}\Psi(\theta_v, \theta_i, \Delta\phi)$$

$$\Phi(\theta_v) = 1 - \cos(\theta_v)$$

$$\Psi(\theta_v, \theta_i, \Delta\phi) = \sin(\theta_v)\cos(\theta_i)\sin(\theta_i)\cos(\theta_i - \theta_v)\cos(\Delta\phi)$$

1. **Remove systematic differences :** linear regression between collocated GEO and LEO LST, restricting to **similar VZA's**

2. Adjust **A** for **night-time** observations $(\Psi(\theta_v, \theta_i \geq 90°, \Delta\phi) \equiv 0)$

3. Adjust **D** for **daytime** observations, assuming **A** is know

→ 2 parameters

GOALS

- **Provide the best near-global diurnal coverage through merged LST products**

- **Extend the area coverage of merged LST LEO products to the polar regions (3-6 hourly)**

- **Test the development of an All-Weather LST product (clear and cloudy sky) through the combination of IR and Micro-wave retrievals (10-day synthesis)**

SEVIRI LST minus SEVIRI LST after MODIS bias correction

SEVIRI - SEVIRIcorr

SEVIRI LST minus SEVIRI LST after correcting to nadir view

SEVIRI - SEVIRInadir, Regression model

SEVIRI - SEVIRInadir, Kernel model

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Prototype Merged GEO + LEO LST Product at 09:00 UTC on 1st January 2011 between 70°S and 70°N

Calibrated AATSR + Calibrated Terra-MODIS + Calibrated Aqua-MODIS + Calibrated GEOs (SEVIRI, GOES , MTSAT)

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GlobTemperature includes

'... a strong component providing globally representative and consistent **in-situ validation** and **intercomparison** of LST products over major land cover types, informing users of the absolute and relative performance of the products on the portal.'

Categories of validation

A - comparison with in-situ measurements

B - radiance-based validation

C – inter-comparison with other datasets

D - time series analysis for data screening

Schneider, P., Ghent, D., Corlett, G., Prata, F., and Remedios, J. (2012). LST Validation Protocol. Report, ESA Contract Number: 19054/05/NL/FF, available at lst.nilu.no

University of **Reading**

Freely open to participation: contact Claire Bulgin (c.e.bulgin@reading.ac.uk)

The CCRR will run from 1st June 2015 to 30th November 2015

Utilisation of a videowall cloud masking tool to manually mask the selected scenes for the CCRR.

Sliders to set cloud masks based on different tests

RGB

Different channels/tests

Zoom in and select edge pixels manually

Collated Mask

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Product	Data Period	Archive	Format
(A)ATSR	1991-2012	GlobTemp	Harmonised
(A)ATSR Climate Data Record	1991-2012	GlobTemp	Harmonised
AMSR-E	2008-2010	GlobTemp	Harmonised
ArcLake	1991-2011	External	NetCDF-4
ASTER Global Emissivity	2000-2012	External	HDF-5
Metop-AVHRR (FRAC)	2007 onwards	GlobTemp	Harmonised
NOAA/Metop AVHRR (GAC)	1981 onwards	GlobTemp	Harmonised
GOES	2009 onwards	GlobTemp	Harmonised
Metop-IASI	2007 onwards	GlobTemp	Harmonised
Matchup DB	All data	GlobTemp	Harmonised
Merged LST	2010-2014 (GEO/LEO); 2003-2009 (LEO, continental GEO); NRT Demo	GlobTemp	Harmonised
NASA MEaSUREs LST&E	2000 onwards	External	
MODIS MOD11/MYD11	2000 onwards	External	HDF-EOS
MODIS MOD21/MYD21	2000 onwards	External	HDF-EOS
MTSAT	2010 onwards	GlobTemp	Harmonised
SEVIRI	2003 onwards	GlobTemp	Harmonised
SLSTR	2016 onwards	GlobTemp	Harmonised
SSM/I	2003	GlobTemp	Harmonised
VIIRS (standard EDR)	2012 onwards	External	HDF-5

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ESA: Simon Pinnock (Technical Officer)

U. Leicester: John Remedios (Project Director), Darren Ghent (Project Scientist)

ACRI-ST: Jerome Bruniquel (Project Manager), Olivier Sardou

U. Reading: Chris Merchant, Claire Bulgin

IPMA: Isabel Trigo, Ana Pires, Sofia Ermida (PhD student – U. Lisbon)

KIT: Frank Goettsche, Folke Olesen, Maria Martin

Estellus: Catherine Prigent, Filipe Aires, Carlos Jimenez

Hadley Centre: Nick Rayner, Colin Morice, Elizabeth Good

Met Office: Roger Saunders, Brett Candy, Richard Renshaw

DMI: Jacob Hoyer, Till Andreas Soya Rasmussen, Mads Hvid Ribergaard

U. Copenhagen: Hakan Torbern Tagesson, Stephanie Horion, Rasmus Fensholt