Land Surface Temperature
LSA SAF Operational Products

LSA SAF LST Team: I. F. Trigo, S. C. Freitas, C. C. Dacamara, S. Ermida, C. Barroso, F. Göttsche, F. Olesen

The EUMETSAT Network of Satellite Application Facilities

LSA SAF Land Surface Analysis

Algorithm Generalized Split-Window

MSG/ SEVIRI & AVHRR/Metop

Two-Channel → 10.7 μm & 12.0 μm

$$LST = (A_1 + A_2\frac{1-\varepsilon}{\varepsilon} + A_3\frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_{10.8}+T_{12.0}}{2} + (B_1 + B_2\frac{1-\varepsilon}{\varepsilon} + B_3\frac{\Delta\varepsilon}{\varepsilon^2})\frac{T_{10.8}-T_{12.0}}{2} + C$$

Parameters A_k, B_k & C depend on:

- **Total Column Water Vapour** — From Numerical Weather Prediction Models (ECMWF)
- **Satellite View Angle**

(Generalized Split Window developed for MODIS and adapted to **SEVIRI-MSG** – Freitas et al., 2010)

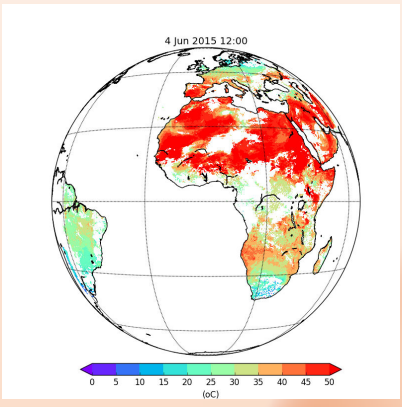
LST Uncertainty

$$S^2_{LST} = \sum_i \left(\frac{\partial f}{\partial X_i}\right)^2 \sigma^2_{X_i} + \sum_j \left(\frac{\partial f}{\partial \theta_j}\right)^2 \sigma^2_{\theta_j} + \Delta LST^2$$

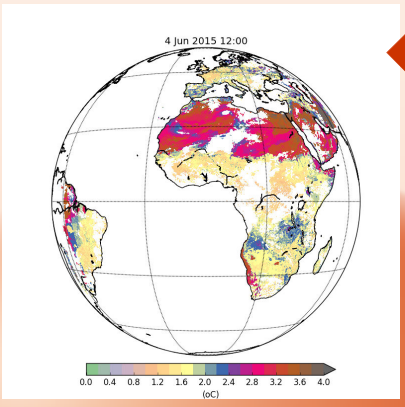
- ΔLST^2 → **Algorithm uncertainty** [depend on retrieval conditions → total optical path]
- $\sigma^2_{\theta_j}$ → Errors in algorithm parameters [depend on implicit input variables → column water vapour; view angle; land cover]
- $\sigma^2_{X_i}$ → Errors in explicit algorithm inputs [sensor noise; emissivity]

SEVIRI 15 min Product

Land Surface Temperature



Uncertainty



Example of LST product and error-bar distributed to users (4 Jun 2015 at 12 UTC).
Highest LST error-bars (uncertainty) associated with: (i) high emissivity uncertainty under dry atmospheres (semi-arid regions); (ii) high view angles; (iii) large water vapour content.

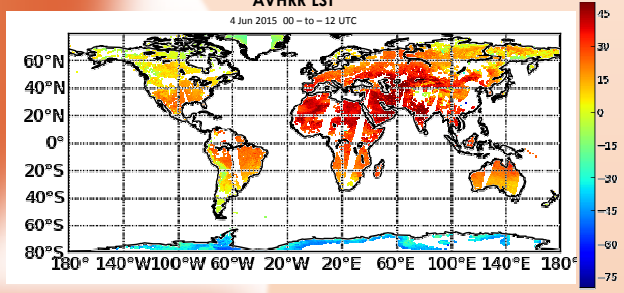
SEVIRI/MSG

- Nadir pixel sampling distance: 3km
- 15 min;
  - Available since 2005
  - Re-processment in 2015: 2004 – 2012 using current LST Alogrithm
- 10-daily maximum / median
  - Available since 2012 (internal)
- 30-daily maximum / median
  - Available since 2012 (internal)

AVHRR/Metop

- Nadir pixel sampling distance: ~1.1 km
- Twice-daily;
  - Available since 2015
  - Earlier data on demand

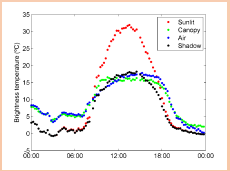
AVHRR LST



Validation

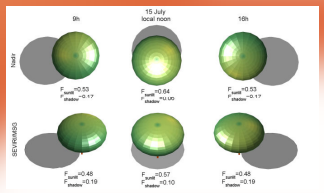
- Comparison against in situ (reference) data
- Comparison with similar products from other sensors – for consistency assessment purposes and complementary to ground data.

In Situ Measurements
Evora, Southern Portugal: Oak Trees



Radiometric temperature (ºC) at Évora in a summer day: sunlit ground (red dots); tree canopy (green docs); shaded ground (black dots). The near Surface air temperature is also shown (ºC; blue dots).

Upscaling



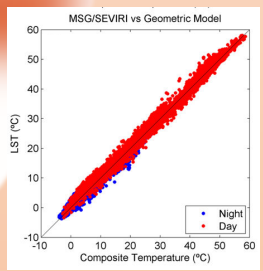
Idealized single tree view at Évora:
Nadir & SEVIRI view at different local times in July.

Geometric Model – To estimate shapes of objects seen by the sensor

Boolean model – To derive overlap probabilities and the actual fraction of each end-member

Validation – Upscaling issues are more easily solved in areas with more homogeneous landscapes; see LST validation with desert station in Gobabeb (Goettsche et al., 2013).

October 2011 – September 2012



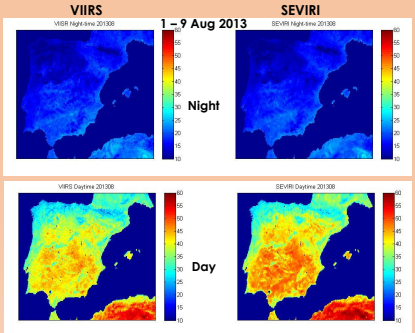
SEVIRI LST (y-axis) versus ground estimates (x-axis) obtained using the geometric model of Evora site and measurements of sunlit/shaded ground and tree canopy.

SEVIRI vs In situ
Bias / Standard Deviation of differences (°C)

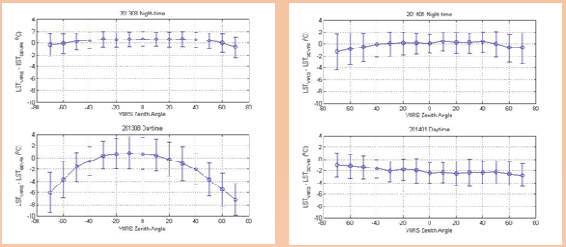
	Daytime	Night-time
Upscaling: Simple averga of in situ measurements	-1.2/2.2	-0.1/1.2
Upscaling: Geometric Model	0.5/1.4	0.1/1.2

Comparison with other Satellite Products: VIIRS/NPP

NOAA Land Surface Temperature Product (http://viirsland.gsfc.nasa.gov/Products/LSTEDR.html) Collocated in time and space with SEVIRI LST:

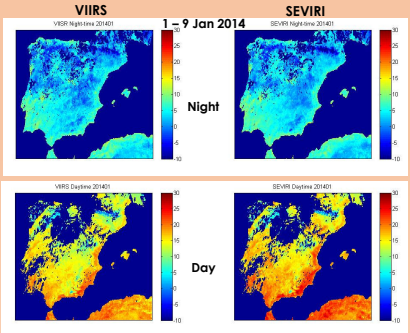


VIIRS and SEVIRI LST(°C) collocated in space & time, averaged over 1-9 Aug 2013: VIIRS night-time (top) and daytime (bottom) overpass.



Mean difference of VIIRS LST minus SEVIRI LST (circles) and its standard deviation (vertical bars), for the period 1-to-10 August 2013 (left) and 1-10 January 2014 (right), over the Iberian Peninsula. Upper/lower panels show night-time/daytime differences. The statistics are shown for classes of VIIRS zenith angle. Higher surface heterogeneity during summer leads to a strong dependency of product differences on viewing geometry.

	1-9 August 2013		1-9 January 2014	
	Bias (ºC)	RMSD (ºC)	Bias (ºC)	RMSD (ºC)
Night-time	+ 0.26	1.55	- 0.15	2.16
Daytime	- 2.95	4.76	- 2.02	2.81



VIIRS and SEVIRI LST(°C) collocated in space & time, averaged over 1-9 Jan 2014: VIIRS night-time (top) and daytime (bottom) overpass.

References

- Ermida, S. L., I. F. Trigo, C. C. DaCamara, F. M. Göttsche, F. S. Olesen, G. Hulley, 2014: Validation of remotely sensed surface temperature over an oakwood landscape – The problem of viewing and illumination geometries. *Remote Sens. Env.*, DOI:10.1016/j.rse.2014.03.016.
- Freitas, S. C., Trigo, I. F., Bioucas-Dias, J. M., Goettsche, F.-M., 2010: Quantifying the Uncertainty of Land Surface Temperature Retrievals From SEVIRI/Meteosat, *IEEE Trans. Geosci. Remote Sens.* DOI: 10.1109/TGRS.2009.2027697.
- Goettsche, F.M., F.S. Olesen, A. Bork-Unkelbach (2013): Validation of land surface temperature derived from MSG/SEVIRI with in situ measurements at Gobabeb, Namibia, *Int. J. Remote Sens*, DOI: 10.1080/01431161.2012.716539