Retrieving Land Surface Temperature from Remote Sensing Observations

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Algorithm Generalized Split-Window

MSG/ SEVIRI & AVHRR/Metop

Two-Channel → 10.7 μm & 12.0 μm

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

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

Parameters A_k, B_k & C depend on:

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

LST Uncertainty

$$S_{LST}^2 = \sum_i \left(\frac{\partial f}{\partial X_i}\right)^2 \sigma_{X_i}^2 + \sum_j \left(\frac{\partial f}{\partial \theta_j}\right)^2 \sigma_{\theta_j}^2 + \overline{\Delta LST^2}$$

Algorithm uncertainty [depend on retrieval conditions → total optical path]

Errors in algorithm parameters [depend on implicit input variables → column water vapour; view angle; land cover]

Errors in explicit algorithm inputs [sensor noise; emissivity]

SEVIRI 15 min Product

Land Surface Temperature

LST 14 Oct 2017 11:00

Uncertainty

LST Uncertainty 14 Oct 2017 11:00

SEVIRI/MSG

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

- Largest uncertainty in LST retrievals associated to land surface emissivity.
    ➢ Impact is largest under dry conditions

Other souces of uncertainty not quantified in the LST Error Bar
- ➢ Cloud clearing
- ➢ Aeorosol load
- ➢ Non-isotropy of 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 (°C) 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 (°C; 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., 2016).

October 2011 – September 2012

MSG/SEVIRI vs Geometric Model

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

Modelling Directional Effects in LST

- LST varibility with view angle depends on local spatial heterogeneity.
- Different models (e.g. Vinikiv et al, 2012) calbrated with MODIS & geostationary (MSG, GOES-E and MTSAT) LST fields collocated in space and time

Model proposed by Vinikov et al. (2012)

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

Solar Kernel

Emissivity Kernel

$T(\theta_v, \theta_i, \Delta\phi)$: LST at any illumination & view angles
T_0 : LST measured from nadir view

Emissivity kernel:
$\Phi(\theta_v) = 1 - \cos(\theta_v)$

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

LST GEO 15 Jul 2011 00UTC

Local Time: ~16:00 ~00:00 ~08:00

Merged LST Product: GOES-E + SEVIRI/MSG + MTSAT

GEO LST – "Nadir LST" 15 Jul 2011 00UTC

Local Time: ~16:00 ~00:00 ~08:00

Estimated difference to "nadir-view" LST provided by the Kernel model.

- Most users consider LST regardless of its variability with view angle: Directional Effects correspond to a source of uncertainty in those conditions.
- Directional effects in LST can be represented by parametric models: **Kernel** (Vinikov et al., 2012); Other models are being tested.
- The goal is to estimate the uncertainty of LST associated to directional effects, i.e., the expected deviation to nadir view LST.
- At continental (global) scale, model calibration is sensitive to inconsistencies among the collocated LST data due to: differences in algorithms, input data, observation time.

References

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