Karlsruhe Institute of Technology

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LSA SAF Land Surface Analysis

Institute of Meteorology and Climate Research
Meteorological Satellite Analysis (MSA) Group
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# LSA SAF 'Derived LST products' for MSG/SEVIRI

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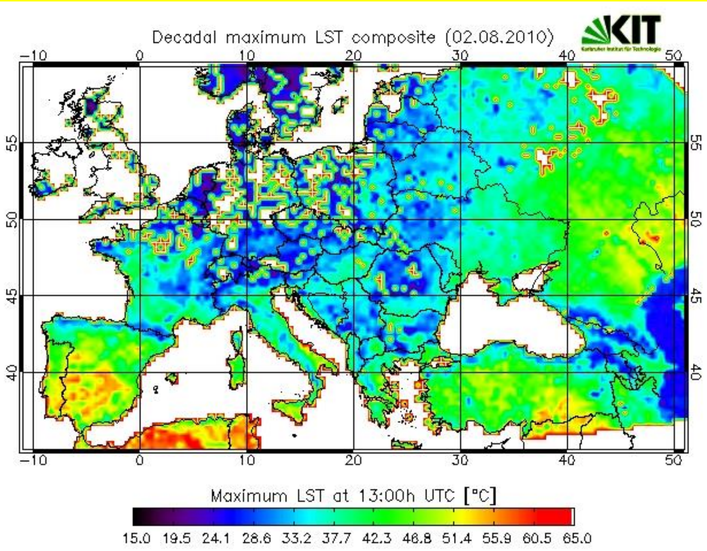
**Introduction**

Diurnal Temperature Cycles (DTC) of the Land Surface Temperature (LST) are influenced by the previous weather situation, e.g. by the cloud cover and by moisture availability. On the other hand, annual and inter-annual variations, e.g. in the growth of vegetation or changes in land use, can have a significant influence on the DTC. For analyses of such variations instantaneous LST values are of limited use. In analogy to vegetation parameters, e.g. the Normalized Difference Vegetation Index (NDVI), LSA SAF currently implements algorithms for generating 10 day maximum and median LST composites. The resulting LST composites have significantly fewer gaps due to clouds than individual days.

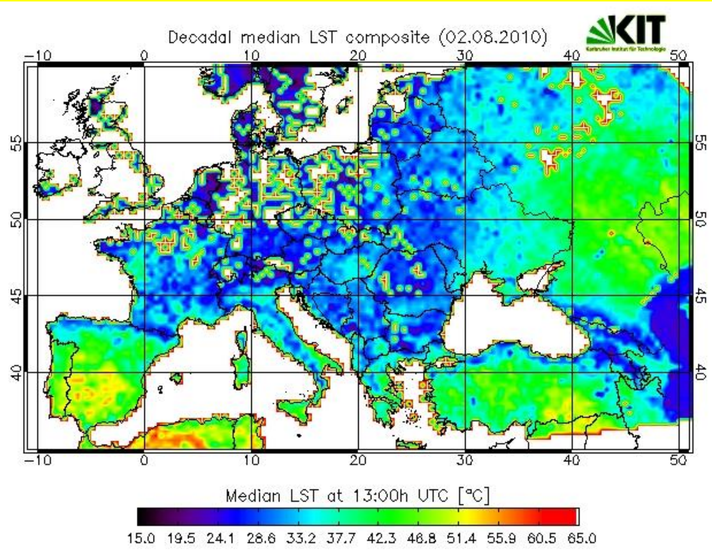
Maximum LST approximate the hottest (driest) day in the composite-interval: therefore, the composites have a high contrast and a bias to high temperatures. The median LST for each pixel location and slot in the composite-interval approximates the most frequently encountered (typical) day in the interval and has a slightly lower contrast. In a further processing step a model of the DTC is fitted to the two types of composites to obtain so-called thermal surface parameters (TSP), e.g. minimum temperature and temperature amplitude. The TSP are spatially highly continuous and approximate cloud-free conditions, which eases combined analyses with vegetation parameters.

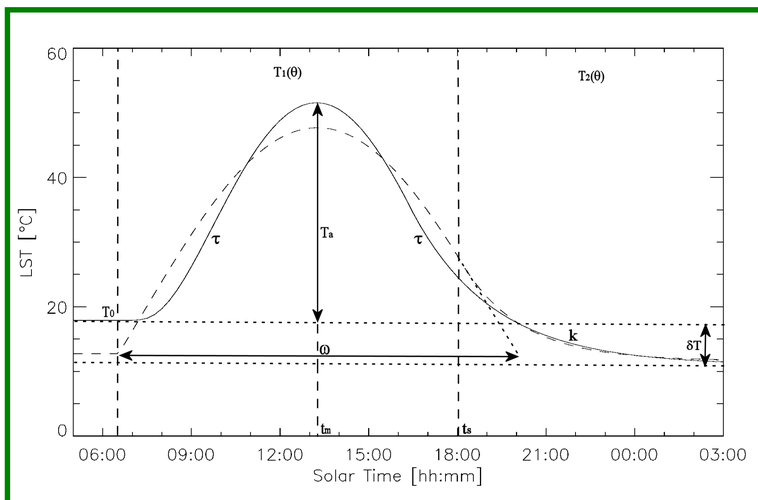
*Supported by EUMETSAT*




## 10-day composites of LSA SAF LST

- One composite for each of SEVIRI's 96 slots
- 'Synthetic' DTCs represent 10 days
- Strongly reduced gaps, e.g. due to clouds
- Data reduction by a factor of 10




DTC models Goe2001 (broken line) and Goe2008 (solid line). The effect of the sun on LST is described by a cosine plus a zenith angle dependent atmospheric attenuation term for Goe2008. The decrease of LST at night is modelled by an exponential decay term.

**DTC model and parameters:**

| | |
|---|---|
| $T_o$ | Residual temperature |
| $T_a$ | Diurnal temp. amplitude |
| $t_m$ | Time of maximum temp. |
| $t_s$ | Starting time of attenuation |
| $\omega$ | Half period of cosine term |
| k | Attenuation constant |
| $\delta T$ | $T(t\rightarrow\infty)$ - $T_o$ |
| $\tau$ | Total optical thickness (only Goe2008) |

Goe2008 and its first derivatives are assumed to be continuous at hour angle $\theta_s$ (end of cosine term and start of exponential decay). Subscripts "z" and "min" indicate zenith angle and minimum, respectively:

$$\left.\begin{aligned} T_1(\theta) &= T_0 + T_a \cdot \cos(\theta_z) \cdot \frac{e^{\tau(m_{min} - m(\theta_z))}}{\cos(\theta_{z,min})} \end{aligned}\right\} \quad \theta < \theta_s$$

$$\left.\begin{aligned} T_2(\theta) &= (T_0 + \delta T) + \left[ T_a \cdot \cos(\theta_{zs}) \cdot \frac{e^{\tau(m_{min} - m(\theta_{zs}))}}{\cos(\theta_{z,min})} - \delta T \right] \cdot e^{\frac{-12h}{\pi k}(\theta - \theta_s)} \end{aligned}\right\} \quad \theta \geq \theta_s$$

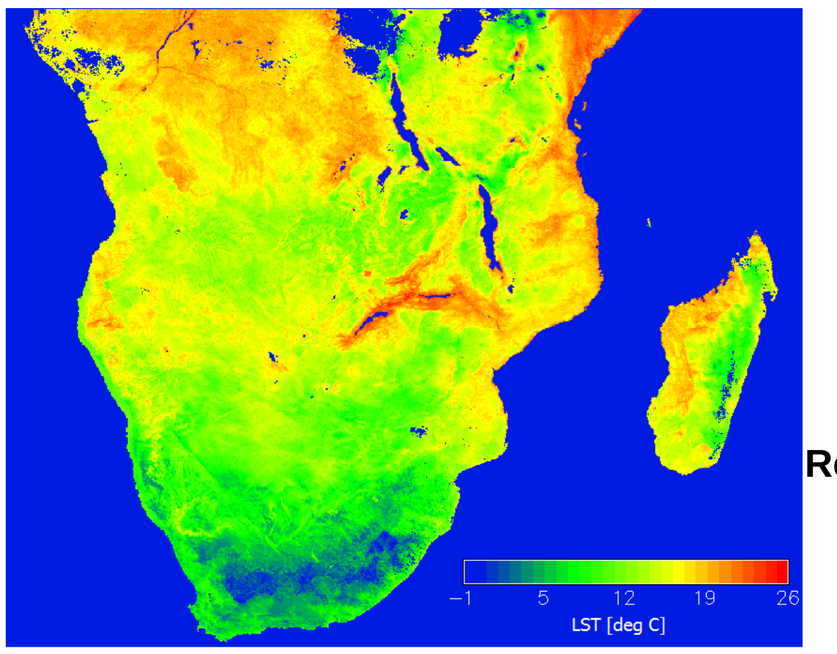
$$k = \frac{12h}{\pi \cdot \frac{d\theta_z(\theta_s)}{d\theta}} \cdot \frac{\cos(\theta_{zs}) - \frac{\delta T}{T_a} \cdot \frac{\cos(\theta_{z,min})}{e^{\tau(m_{min} - m(\theta_{zs}))}}}{\sin(\theta_{zs}) + \tau \cdot \cos(\theta_{zs}) \cdot \frac{\partial m(\theta_{zs})}{\partial \theta_z}}$$

e.g. with air mass m as:

$$m_{simple}(\theta_z) = \frac{1}{\cos(\theta_z)}$$

**Reference:**

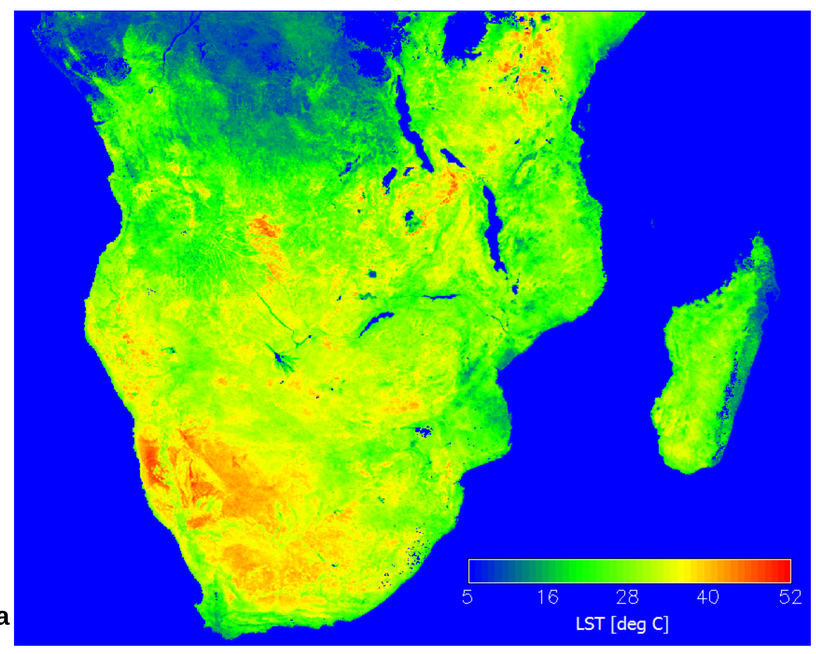
Göttsche, F.-M., & Olesen, F.-S., Modelling the effect of optical thickness on diurnal cycles of land surface temperature, *Remote Sensing of Environment* (2009), doi:10.1016/j.rse.2009.06.006




**Residual temperature $T_0$**

TSP determined from median composites of LSA SAF LST between 1. and 10. October 2009. The TSP summarize up to 960 individual LST, provide additional information and are of high quality (low-noise, continuous fields).

**Temperature amplitude $T_a$**




## Conclusions

- Maximum & median composite algorithms are reliable and pre-operational
- The DTC model was successfully evaluated and applied by several researchers
- TSP provide accurate and low noise estimates of **residual temperature** (~ at sunrise), **temperature amplitude**, and the **timing of maximum temperature**
- DTC algorithm is stable and pre-operational

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