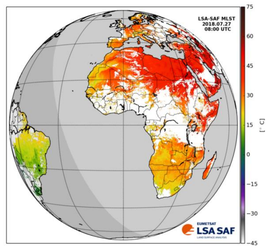
Uncertainty in LSA SAF Land Surface Temperature Climate Data Records

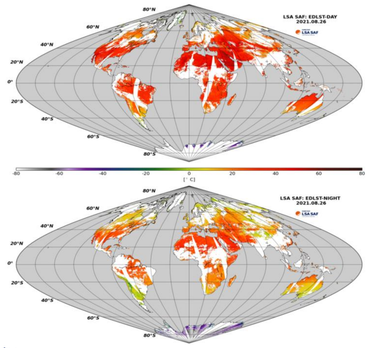
Isabel F. Trigo and Sofia L. Ermida

Land Surface Temperature (LST) datasets provided by the EUMETSAT Satellite Applications Facility on Land Surface Analysis (**LSA SAF**):

SEVIRI/Meteosat Second Generation
- ✓ Every 15-minute
- ✓ 3km at nadir (regular 0.05ºx0.05º grid)
- ✓ Since 2004, updated in Near Real Time



AVHRR/Metop – Twice daily
- ✓ 1km (regular 0.01ºx0.01º grid)
- ✓ Since 2007, update in NRT



Both
- ✓ available in NRT and offline
- ✓ Distributed with (pixel-by-pixel) uncertainty

LST Algorithm – Generalized Split-Window:

$$LST = f(A_k[TCWV, VZA], \varepsilon_{11}, \varepsilon_{12}, Tb_{11}, Tb_{12})$$

A_k – model parameters, calibrated for classes of Total Column Water Vapour and View Zenith Angle: TCWV, VZA are implicit inputs

Tb_{11}, Tb_{12} – Brightness temperature for split-wind channels (centred at ~11μm and ~12μm, respectively)

ε_{11}, ε_{12} – surface emissivity for split-window channels

LST Uncertainty (Level 2 products)

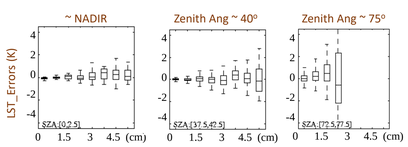
$$S^2_{LST} = \sum_i \left(\frac{\partial f}{\partial X_i}\right)^2 \sigma^2_{X_i} + \sum_k P\left(W_{fc\_i} \middle| W_{obs\_k}\right) \sigma^2_{LST}\left(W_{fc\_i} \middle| W_{obs\_k}\right) + \sigma^2_{GSW\_Alg}$$

σ_{Xi} – inputs' uncertainty: emissivity ($\sigma\varepsilon_{11}$, $\sigma\varepsilon_{12}$) and sensor noise (σ_{Tb11}, σ_{Tb12})

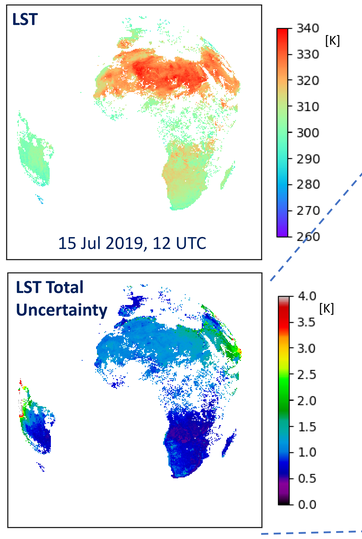
$P\left(W_{fc\_i} \middle| W_{obs\_k}\right)$ - Probability of using the wrong split-window coefficients (X impact on LST uncertainty)

σ_{GSW_Alg} – uncertainty of the split-window algorithm – depends on atmospheric optical depth

σ_{GSW_Alg} estimated considering:
- ✓ MODTRAN simulations > 15700 profiles + Split-window error with "perfect inputs"



Freitas, S. C., Trigo, I. F., Bioucas-Dias, J. M., Goettsche, F.-M. (2010) in *IEEE Trans. Geosci. Remote* Sens. DOI: 10.1109/TGRS.2009.2027697



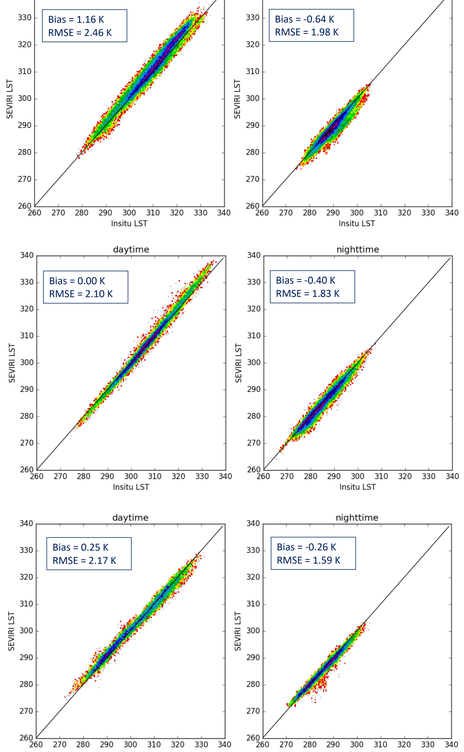
LST Total Uncertainty & Uncertainty Budget

- ✓ Emissivity has the largest contribution to total LST uncertainty – especially under dry atmospheres
  - West Sahara – emiss impact is reduced where water vapour increases
- ✓ Higher algorithm uncertainty for high view angles & high water vapour
- ✓ Impact of sensor noise also increases with view zenith angle and Total Column Water Vapour (TCWC)
- ✓ The impact of TCWV uncertainties is generally lower than other components (errors mitigated by implicit use of this variable)

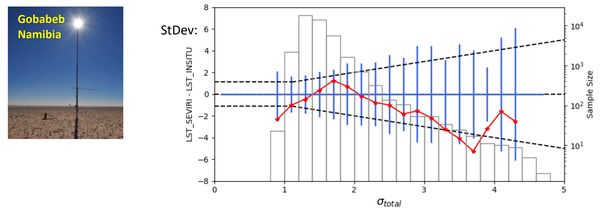
Validation

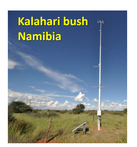
Satellite (SEVIRI) LST *versus* in situ LST

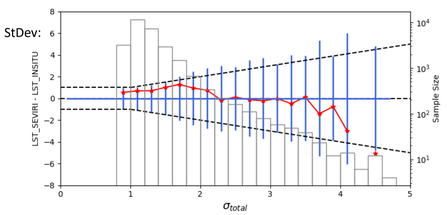
2016-2018

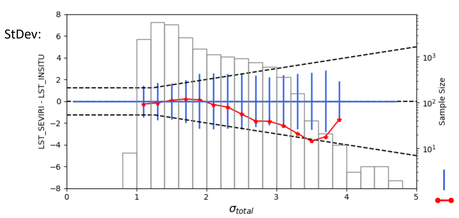


Standard Deviation (LST_Satellite – LST_Insitu) *versus* σ_{total}









$$\sigma_{total} = \sqrt{\sigma^2_{sat} + \sigma^2_{insitu} + \sigma^2_{time} + \sigma^2_{space}}$$

→ Satellite product total uncertainty

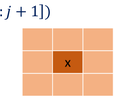
$$\sigma_{insitu} = \sqrt{\sigma^2_{PTC} + \sigma^2_{canopy\_size}} + \sqrt{\sigma^2_{BT} + \sigma^2_{emiss}}$$

Station upscaling model (Evora site only)

In situ sensor noise & In situ emissivity

$$\sigma_{space} = std(LST_{sat}[i-1:i+1, j-1:j+1])$$

For a match at pixels i, j surrounding the site.



$$\sigma_{space} = std(LST_{sat}[i-1:i+1, j-1:j+1])$$

For a the pixel i, j that best matches the site.

Based on approach followed at LST CCI / FIDUCEO:; see, e.g.,: Ghent, D.; Veal, K.; Trent, T.; Dodd, E.; Sembhi, H.; Remedios (2019) in *Remote Sens.*, DOI: 10.3390/rs11091021

Standard deviation of LST errors (LST_SEVIRI – LST_InSitu) per bin of σ_{total}
(LST_SEVIRI – LST_InSitu) median error per bin of σ_{total}
Perfectly estimated uncertainty; minimum value when $\sigma_{sat} = 0$

Contacts: isabel.trigo@ipma.pt, sofia.ermida@ipma.pt

https://lsa-saf.eumetsat.int

METROLOGY FOR CLIMATE ACTION