Use of satellite LST in the EUSTACE global surface air temperature analysis

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Abstract

EUSTACE (EU Surface Temperatures for All Corners of Earth) is a Horizon2020 project that will produce a spatially complete, near-surface air temperature (NSAT) analysis for the globe for every day since 1850. The analysis will be based on both satellite and in situ surface temperature observations over land, sea, ice and lakes, which will be combined using state-of-the-art statistical methods. This poster illustrates how satellite land surface temperature (LST) data – sourced from ESA's DUE GlobTemperature project - will be used in the analysis. NSAT must be estimated from satellite observations before the two data types can be combined, because the satellite-observed skin temperature can differ substantially from the NSAT observed in situ at meteorological stations. Two methods will be trialled within EUSTACE, both of which are presented here: an established empirical regression-based approach for predicting NSAT from satellite data, and a new method whereby NSAT is calculated from LST and other parameters using a physics-based model.

1. Overview

EUSTACE

EUSTACE will give publicly available daily estimates of near-surface air temperature since 1850 across the globe for the first time by combining surface and satellite data using novel statistical techniques

Satellite observations will provide additional data for the EUSTACE analysis, and will be particularly valuable where in situ near-surface air temperature (NSAT) data are sparse.

Satellites can provide estimates of the land surface temperature (LST). LST and NSAT are not the same (Figure 1), but NSAT can be inferred from LST and other parameters that influence the LST-NSAT relationship, such as elevation, surface type and time of day. LST is more responsive to solar heating and so the largest LST-NSAT differences are usually seen during the day.

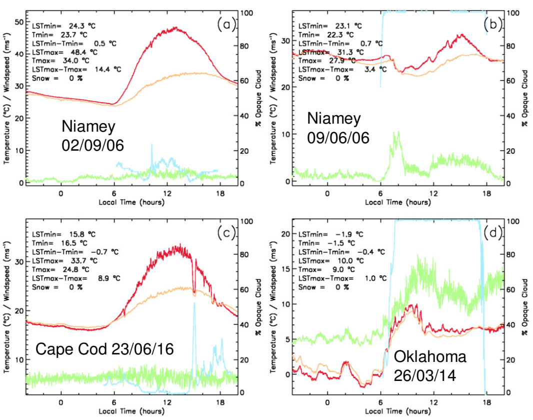


Figure 1: Observations of LST (red), NSAT (orange), wind speed (green) and the % opaque cloud (blue) at Atmospheric Radiation Measurement (ARM) sites (see http://www.arm.gov/). Figure taken from Good (2016), submitted to JGR-Atmospheres.

2. Satellite estimates of NSAT in EUSTACE

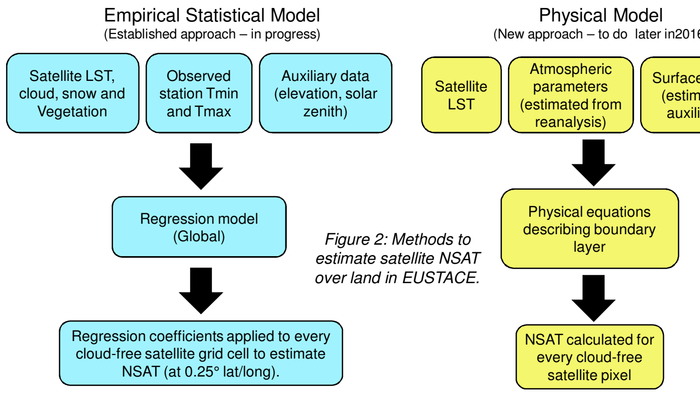


Figure 2: Methods to estimate satellite NSAT over land in EUSTACE.

2.1 Empirical Statistical Model

Satellite_NSAT= $\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots$

	Offset	LST Day	LST Ngt	FVC	DEM	Snow	Solar Zenith
Tmax	0.042	0.494	0.381	4.653	0.00000	0.0828	0.00954
Tmin	-2.426	0.071	0.710	1.091	-0.00046	-0.0054	0.00783
Min x	-	-80°C	-80°C	0.0	0 m	0	0°
Max x	-	65°C	40°C	1.0	4500 m	100	90°

Table 1: Current set of coefficients trained on 5000 stations from Global Historical Climate Network daily (GHCN-D) in 2010. Both daily maximum (Tmax) and minimum (Tmin) NSATs are estimated.

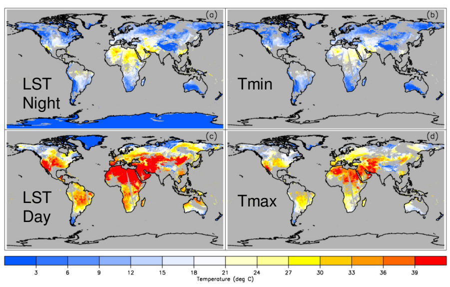


Figure 2: Example of satellite LST and estimated NSAT over land on 1st July 2010. Satellite LSTs are from MODIS Aqua (GlobTemperature product). Aqua overpass is ~1.30 am/pm).

Land Satellite Data in EUSTACE

Satellite LST data: Primarily MODIS/Aqua. Also likely SEVIRI/MSG. Both sourced through ESA GlobTemperature (L2 swath).

Vegetation: Copernicus Global Land Service FCOVER

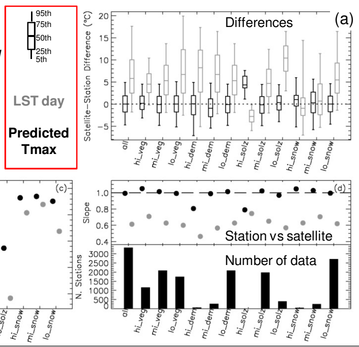
Snow cover: MODIS snow product (MYD10.C1)

3. Evaluation of Satellite NSAT

Uncertainties in EUSTACE

A key aspect of EUSTACE will be in handling uncertainty information. All NSAT data sources in EUSTACE will have estimated uncertainties, which will determine their weighting within the final analysis. For satellite land NSAT estimates this will be determined from the uncertainties on the input satellite LST and other data sets, and the satellite-to-NSAT translation process. Uncertainties in the final EUSTACE products are likely to be represented by an ensemble of realisations.

Figure 3: Global Tmax evaluation using 5000 GHCN-D stations not used in model training. Results are sub-categorised for different surfaces (e.g. high elevation (DEM), high veg fraction).



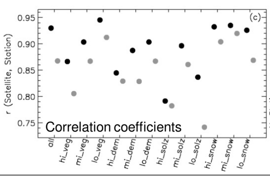
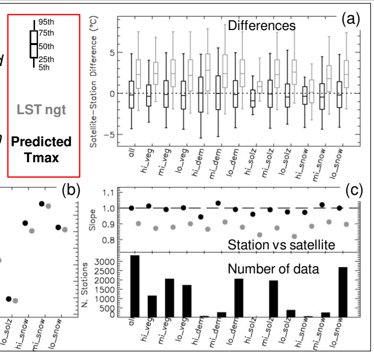
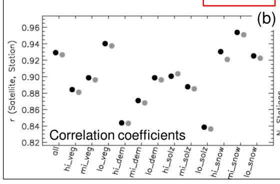


Figure 4: Global Tmin evaluation using 5000 GHCN-D stations not used in model training. Results are sub-categorised for different surfaces (e.g. high elevation (DEM), high veg fraction).





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