Developing Operational Land Surface Temperature Product for U.S. GOES Satellites

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Introduction

Information on land surface temperature (LST) is vital for understanding climate change, modeling the hydrological and biogeochemical cycles, and is a prime candidate parameter for Numerical Weather Prediction assimilation models. In particular, the LST data derived from geostationary operational environmental satellite (GOES) provides unique opportunity for studying LST diurnal variation. Recently, GOES LST at the U.S. NOAA National Environmental Satellite Data and Information System (NESDIS) is an intermediate product derived from sounder data which is limited in resolution and accuracy. High resolution GOES LSTs with better accuracy are required from users such as the U.S. National Center for Environmental Prediction (NCEP) weather forecast and data assimilation model. In order to support the NOAA mission goals in climate, weather, and water, we have developed an operational LST product from measurements of the current GOES Imagers. Some features of the GOES LST product include 1) a consistent regression algorithm with coefficients determined through a regression tree approach, 2) high temporal resolution (30 minutes), 3) full Imager spatial resolution (4 km), 4) emissivity explicit formula, 5) the product is available in full disk and CONUS scan modes. In this presentation we are showing the product development details and some validation results.

GOES Imager and LST requirement

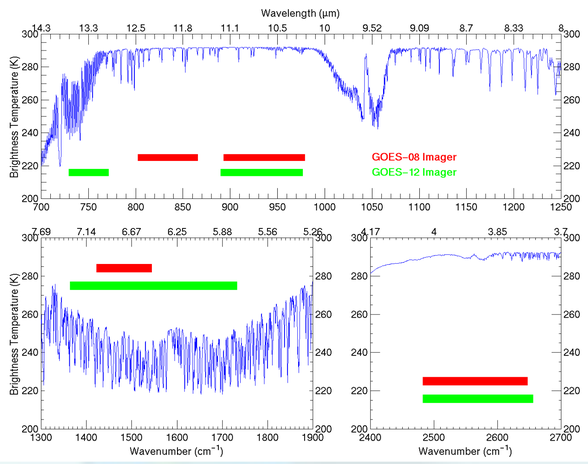
Table 3.2: GOES Imager band nominal spatial resolution (GOES-12 through GOES-15).

GOES Imager Band	Central Wavelength (μm)	Spatial Resolution (km)	Number of Detectors
1	0.65	1	8
2	3.9	4	2
3	6.48	4	2
4	10.7	4	2
6	13.3	8 (GOES-12/13) 4 (GOES-14/15)	1 (GOES-12/13) 2 (GOES-14/15)

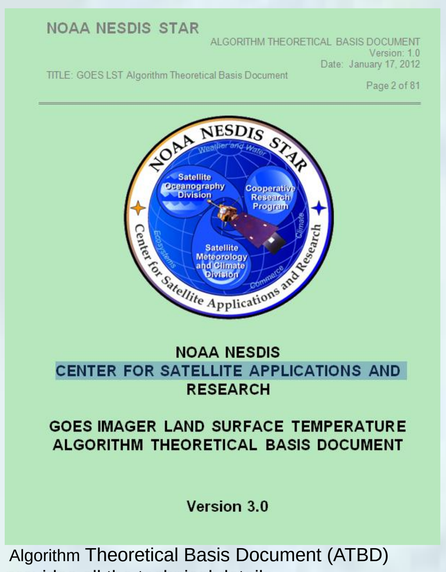
GOES Imager Specification.

Observational Requirement	LEVEL[1]	Geographic Coverage[2]	Horiz. Res.	Mapping Accuracy	Msmnt. Range (K)	Msmnt. Accuracy[3] (K)	Msmnt. Precision (K)	Data Latency	Long-term SI GOES imagerity	Extent Qualifier[4]
LST (Skin): CONUS	T	C	4 km	4 km	210 – 350	2.5	2.3	60 min	TBD	LZA <70
LST (Skin): Hemispheric	T	FD	12 km	4 km	210 – 350	2.5	2.3	60 min	TBD	LZA <70

GOES LST Product Requirements.



Imager channel spectral distribution of GOES-8 (similar to GOES-11) and GOES-12 (similar to GOES 13, 14, 15)



Algorithm Theoretical Basis Document (ATBD) provides all the technical details

GOES LST Generation

A regression algorithm has been applied to generate GOES LST product using brightness temperatures at channels 2 and 4 ($T_{3.9}$ and T_{11}). Spectral emissivity at channel 4 (ε_{11}) is also applied. Solar zenith angle (θ_s) is applied for the daytime retrieval; View zenith angle (θ) is included for atmospheric correction. The algorithm coefficients set $\{a_i\}$ is a regression tree structure, determined from simulation database.

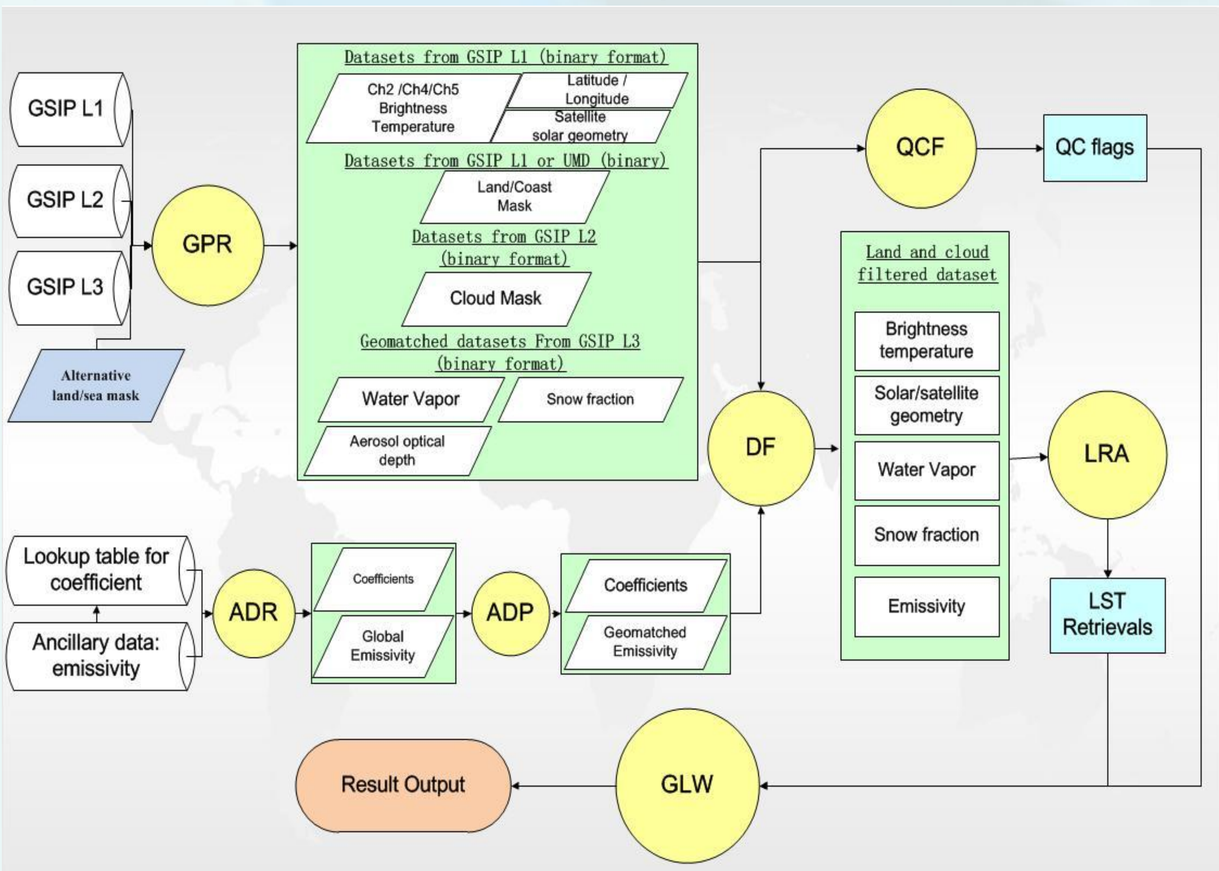
Daytime

$$LST = a_0 + a_1 T_{11} + a_2 (T_{11} - T_{3.9}) + a_3 (T_{11} - T_{3.9})^2 + a_4 T_{3.9} \cos\theta_s + a_5 (1 - \varepsilon_{11}) + a_6 (\sec\theta - 1)$$

Nighttime

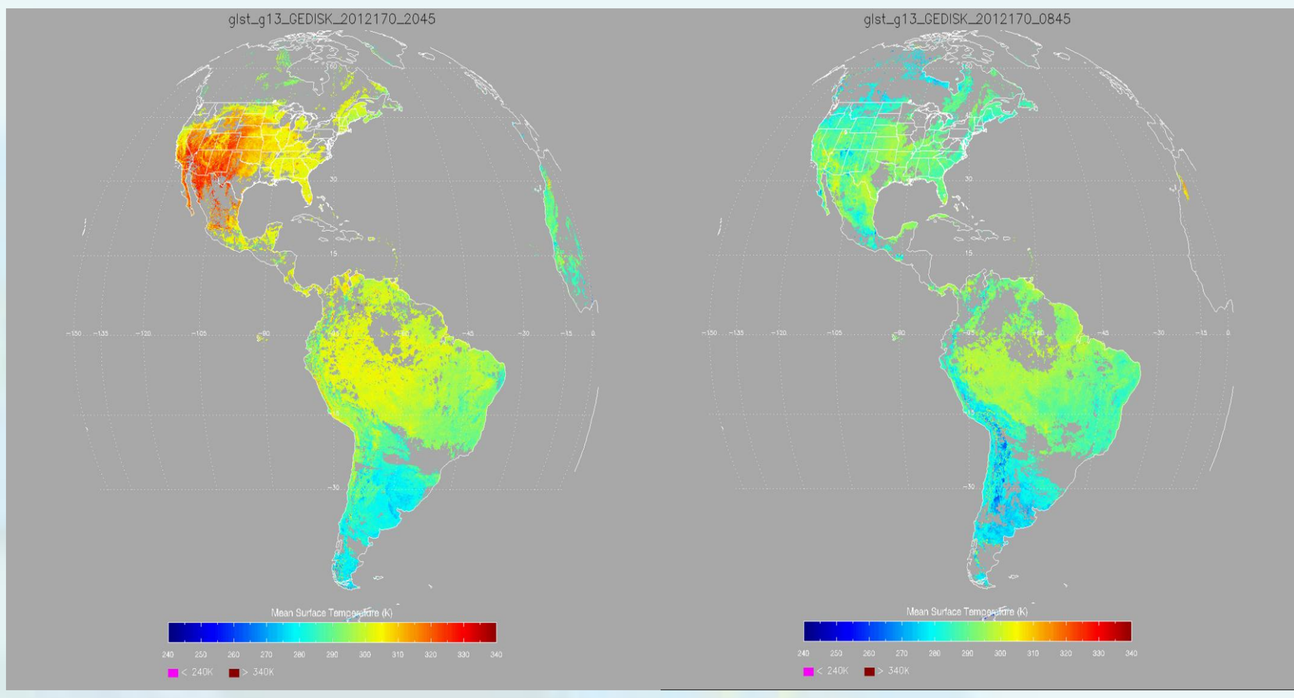
$$LST = a_0 + a_1 T_{11} + a_2 (T_{11} - T_{3.9}) + a_3 (T_{11} - T_{3.9})^2 + a_4 (1 - \varepsilon_{11}) + a_5 (\sec\theta - 1)$$

System Data flowchart of the GOES LST production:

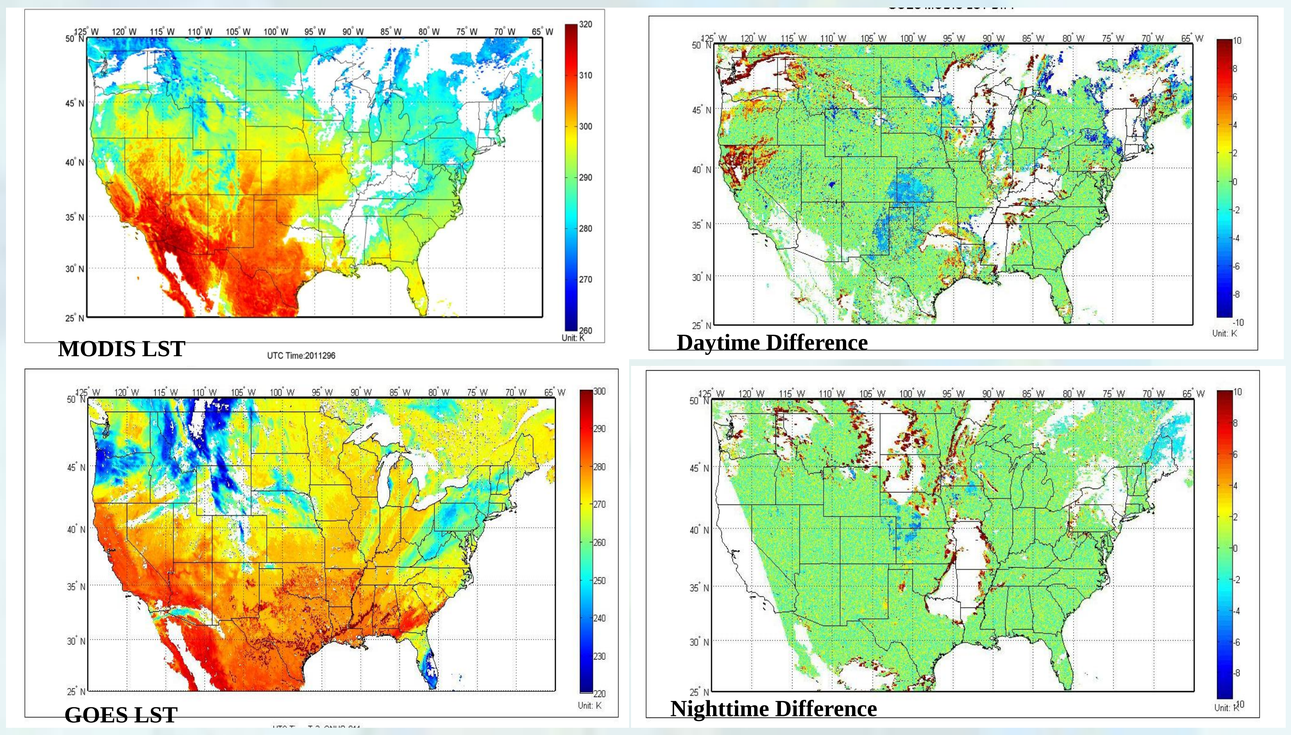


GSIP=, GPR=GSIP Product Reader, ADR=Ancillary Data Reader, DF=Data Filter, ADP=Ancillary Data Processor, QCF=Quality Control Flag, GLW=GOES LST Write, LRA=LST Retrieval Algorithm

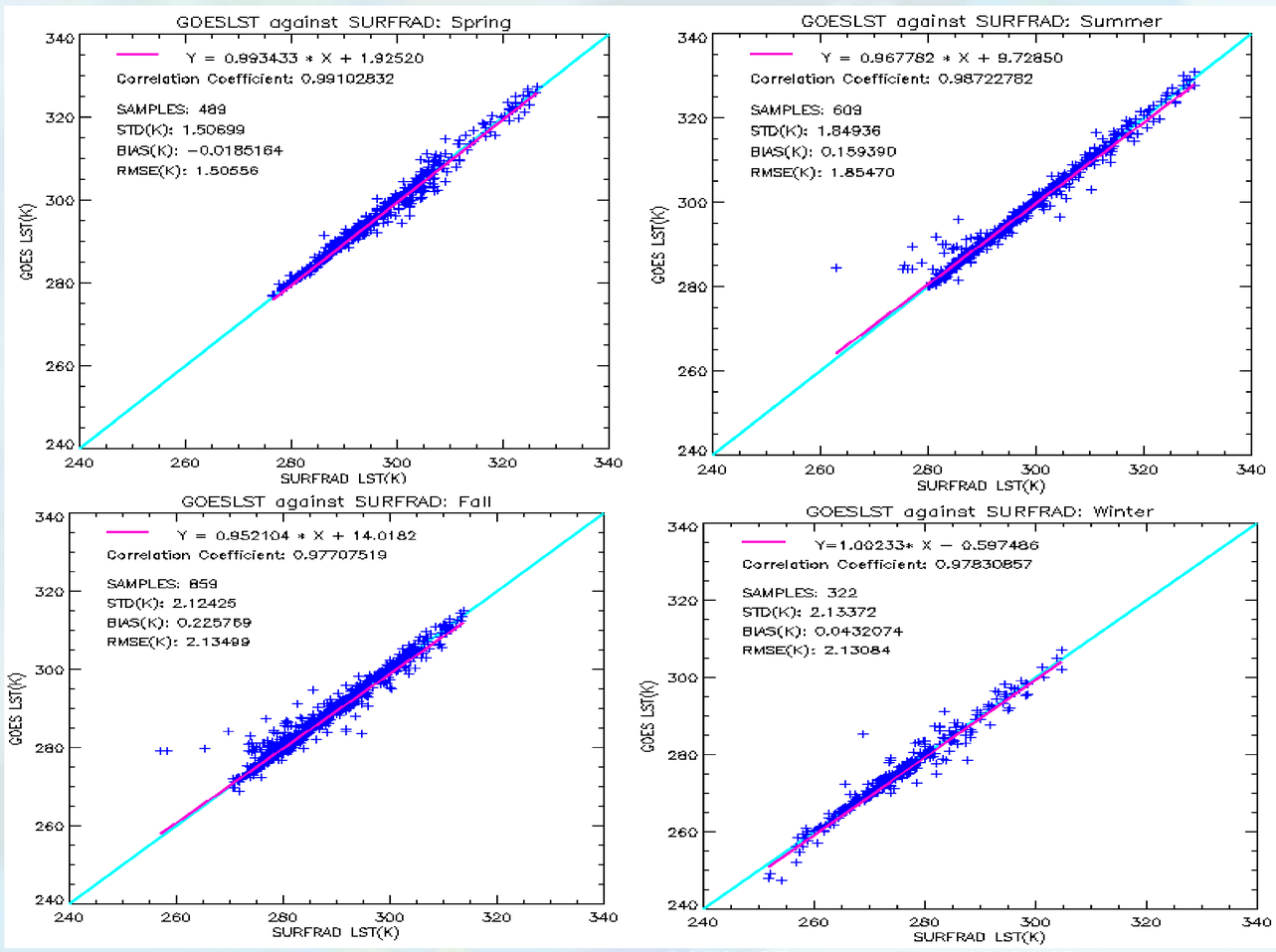
GOES LST Product and Validation



Sample GOES LST images : Full Disk GOES-13 LSTs on day 170 of 2012, at 2045 (left,) and 0845 (right).



GOES LSTs (bottom-left) compared to MODIS LSTs (top-left); LST differences for cases of daytime (top-right) and nighttime (bottom-right) ..The data are collected on Oct 23rd, 2011.



GOES LST compared to MODIS LSTs, for cases of daytime (left panels) and nighttime (right panels).

Overall GOES LSTs comparisons to ground station LSTs.

Ground validation summary:

- Validation GOES LST product using the U.S. SURFRAD observations.
- Time period: April 2010-Feb. 2011
- The overall precision of these validation data is 1.96K
- Cloud contaminated pixels cause big errors in winter cases (Dec.2010)

Table 17 Validation against SURFRAD for GOES 12-Q

Date	Sample	Accuracy	STD
2010.04	602	1.714	1.382392
2010.05	1271	1.578	1.768281
2010.06	1447	1.141	1.098715
2010.07	1591	1.166	1.156118
2010.08	1267	1.241	1.192376
2010.09	1407	1.667	2.314091
2010.10	1406	1.673	2.323325
2010.11	1473	1.666	2.636779
2010.12	726	1.846	2.769092
2011.01	974	1.685	2.293576
2011.02	959	1.768	2.608252
Average			1.958454

* The accuracy and STD represents the mean bias (difference) error (K) and standard deviation error (K) between GOES-LST and SURFRAD observations