The Status of the GOES-R Land Surface Temperature Product

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Introduction

Land Surface Temperature (LST) is one of the key variables in the weather and climate system controlling surface heat and water exchange at the land atmosphere interface. Satellite measured LST is mostly based on thermal infrared band observations which theoretically gives the temperature at some nominal skin depth of the surface. Knowledge of the LST gives critical information on temporal and spatial variations of the surface equilibrium state and is of fundamental importance to many aspects of geosciences, *e.g.*, the net radiation budget at the Earth surface and to monitoring the state of crops and vegetation, as well as an important indicator of both the greenhouse effect and the energy flux between the atmosphere and the land.

The first Geostationary Operational Environmental Satellite-R Series (GOES-R) satellite, the GOES-16, was launched in November 2016, joined by its successor, the GOES-17, in March 2018. The Advanced Baseline Imager (ABI) onboard both platforms has 16 spectral bands (compared to five from previous GOES satellite imagers), including the Split-window (SW) channels used for LST retrieval. The LST product, as one of the baseline ABI products, has been operationally produced since January 2017. The GOES-16 LST was validated with the in-situ surface temperature estimates from the SURFRAD network and results show that the bias and precision required by the mission were met for all three LST products (CONUS, FD, and MESO). As a result, the GOES-16 LST reached its Provisional maturity in March 2018. Its GOES-17 counterpart during "cool" period reached the Provisional maturity in June 2019. This presentation will provide detailed information about the product's validation and evaluation results, their current status, and future direction.

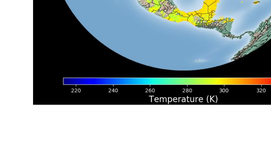
GOES-R ABI Land Surface Temperature Product

GOES-R mission requirements for LST

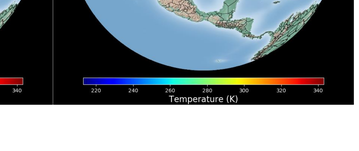
Observational Requirement	LEVEL[1]	Geographic Coverage[2]	Horiz. Res.	Mapping Accuracy	Msmnt. Range (K)	Msmnt. Accuracy[3] (K)	Msmnt. Precision (K)	Refresh Rate	VAGL[4]	Extent Qualifier[5]
CONUS	T	C	2 km	1 km	213 – 330	2.5	2.3	60 min	3236 sec	LZA <70
Full Disk	T	FD	10 km	5 km	213 – 330	2.5	2.3	60 min	806 sec	LZA <70
Mesoscale	T	M	2 km	1 km	213 – 330	2.5	2.3	60 min	159 sec	LZA <70

[1] T=target, G=goal [2] C=CONUS, FD=full disk, H=hemisphere, M=mesoscale
[3]The measurement accuracy 2.5K is conditional with 1) known emissivity, 2) known atmospheric correction and 3) 80% channel correction; 5 K otherwise. [4] VAGL=Vender Allocated Ground Latency.
[5] LZA=local zenith angle.

Product Timeline



Hourly Output Frequency



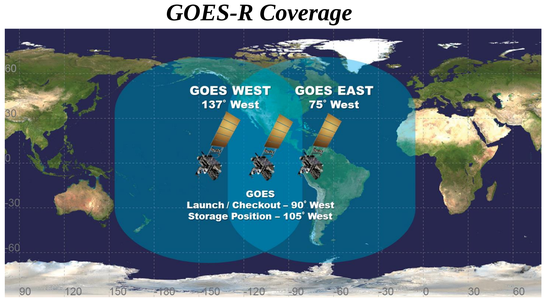
Geostationary satellites' scan frequency is higher than that of polar-orbit satellites. A comparison to LSTs combined from both SNPP and NOAA-20, the GOES-16 LST is able to more accurately characterize the LST diurnal variation.

GOES-R ABI LST Product

$$T_s = C + A_1 T_{11} + A_2 (T_{11} - T_{12}) + A_3 \varepsilon + D(T_{11} - T_{12})(\sec\theta - 1)$$

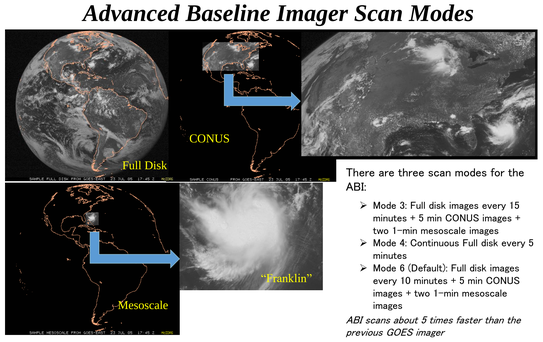
Data Access: https://www.avl.class.noaa.gov/saa/products/search?sub_id=0&datatype_family=GRABIPRD
GOES-16: May 24., 2017 – Present; GOES-17 LST: August 27, 2018 – Present
GOES-R LST ATBD: https://www.star.nesdis.noaa.gov/goesr/documents/ATBDs/Baseline/ATBD_GOES-R_LST_v2.5_Jul2012.pdf
GOES-R PUG: https://www.goes-r.gov/products/docs/PUG-L2+-vol5.pdf
Long-Term Monitoring Web: https://www.star.nesdis.noaa.gov/smcd/emb/land/index.php
Long-Term Monitoring FTP: ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/single/

GOES-R Coverage



- GOES-16 at GOES-EAST
- GOES-17 at GOES-WEST
- Two platforms overlap at the CONUS
- Hourly output frequency revealed more detailed temporal evolution compared to sensors onboard polar orbiting satellites, e.g., JPSS and SNPP

Advanced Baseline Imager Scan Modes



There are three scan modes for the ABI:

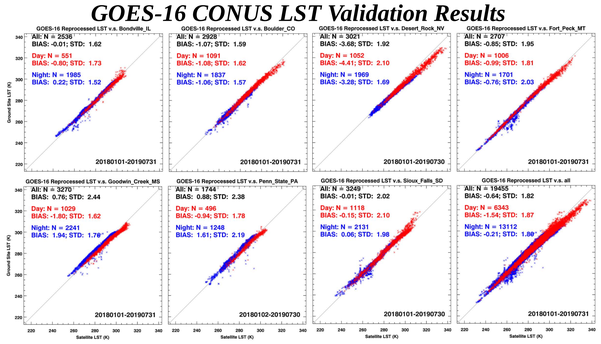
- Mode 3: Full disk images every 15 minutes + 5 min CONUS images + two 1−min mesoscale images
- Mode 4: Continuous Full disk every 5 minutes
- Mode 6 (Default): Full disk images every 10 minutes + 5 min CONUS images + two 1−min mesoscale images

ABI scans about 5 times faster than the previous GOES imager

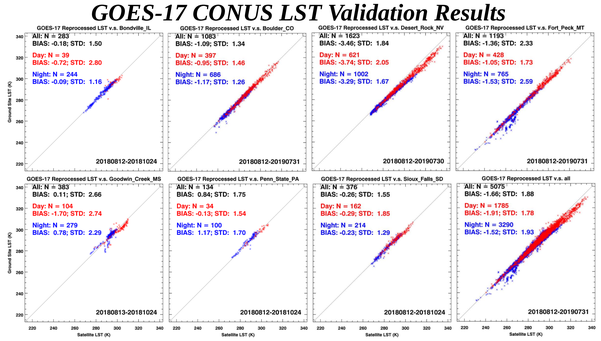
GOES-R Long-Term Monitoring Output Examples

Validation Results

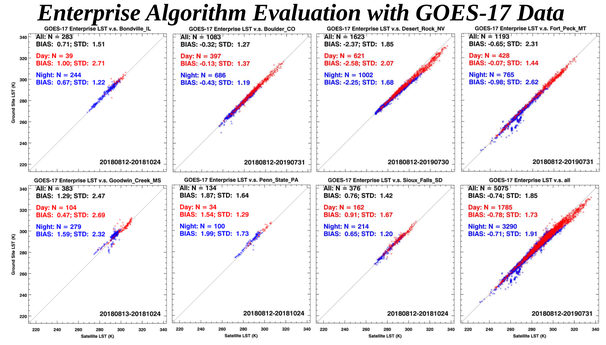
GOES-16 CONUS LST Validation Results



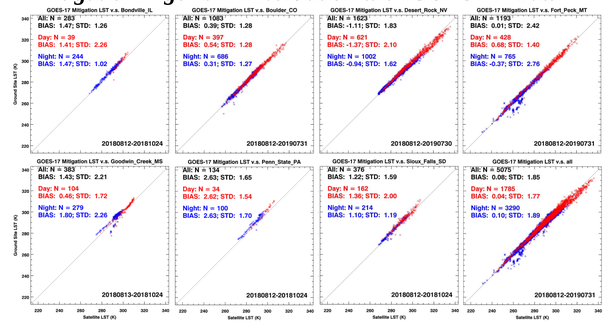
GOES-17 CONUS LST Validation Results



Enterprise Algorithm Evaluation with GOES-17 Data

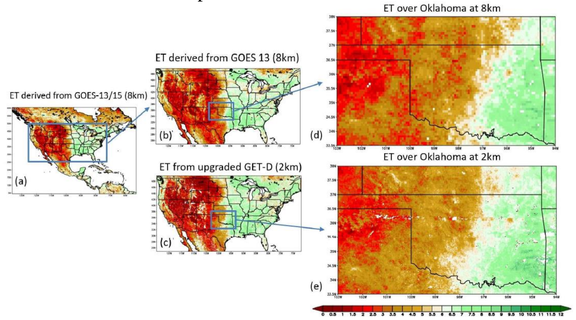


Mitigation Algorithm Evaluation with GOES-17 Data

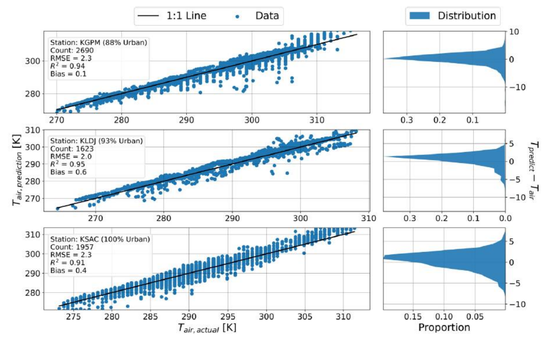


Application Examples

- GOES-R LST is used in numerical weather forecast model output verification.
- GOES Evapotranspiration and Drought System
- Urban air surface temperature model



ET estimates comparis on between operational GOES-13/15 based 8 km product (a: over North America domain and b: over CONUS domain) and upgraded GOES-16 based 2 km product (c), with regional comparison over Oklahoma at 8km (d) and 2km (e). Monthly composite of July 2017 (mm/day).



Scatter and difference plots for ground station and satellite-predicted air temperature for three individual stations in Dallas, TX (top), Elizabeth, NJ (middle),and Sacramento, CA (bottom). Each station is at least 70% urban. The scatter shows the adherence of the prediction algorithm to the true ground station temperatures. The distribution shows the distribution of the scatter.

Summary

- GOES-16 LST and GOES-17 LST (during "cool" period only) reached provisional maturity in March 2018 and June 2019, respectively. All products, FD, CONUS, and MESOs, meet the mission requirement based on the validation results.
- An enterprise LST retrieval algorithm applicable to multiple sensors has been developed and delivered to ASSISTT. The evaluation results indicate it outperforms the current baseline algorithm.
- To address the loop heat pipe overheating issue, an mitigation algorithm has been developed to improve the product quality and increase its usable period during "warm" period. The preliminary evaluation results are satisfactory.
- The Enterprise/Mitigation package are expected to be implemented in the ground system in August 2020.
- The product has been widely used in different applications