VIIRS LST Quality Assessment and Product Development

Yuling Liu[1,2], Yunyue Yu[1], Zhen Song[2], Peng Yu[1,2] ,Heshun Wang[2], Lihang Zhou[1] and Ivan Csiszar[1]

[1] NOAA/NESDIS Center for Satellite Applications and Research; [2]Earth System Science Interdisciplinary Center, University of Maryland

Abstract

Land surface temperature (LST) plays an important role in the weather and climate system controlling surface heat and water exchange with the atmosphere. It has been widely used in a variety of fields such as numerical weather prediction models and data assimilation systems, irrigation and hydrological cycle particularly agricultural drought monitoring, and urban heat island monitoring.

The S-NPP VIIRS LST, a granule product, has been available at CLASS since 2011. In this study, the VIIRS LST quality is assessed using most recent ground in-situ data from SURFace RADiation network (SURFRAD), Atmospheric Radiation Measurement (ARM), Baseline Surface Radiation Network (BSRN) and Global Monitoring Division (GMD) radiation observatories. The results overall indicate a close agreement between the satellite LST estimation and ground observations, in which an accuracy of 0.06 K and precision of 1.97 K is obtained over SURFRAD sites; an accuracy of -0.22 K and precision of 2.05 K over BSRN site in Cabauw, The Netherland; an accuracy of -0.69 K and precision of 1.79 K over BSRN site in Gobabeb, Namibia; an accuracy of 0.04 K and precision of 1.88 K over ARM site in SGP_CF1, Oklahoma, and precision of 2.1 K over GMD site in Summit, Greenland. The assessment covers a variety of surface types including cropland, shrub lands, snow/ice surface, barren surface and grassland etc. The validation results over each site are mainly influenced by the representativeness of the ground measurements and cloud residue effect.

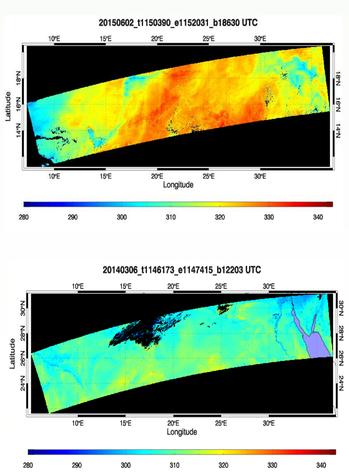
Based on the VIIRS level 2 granule LST, a gridding VIIRS LST product development is on the way. It will be a daily global product providing two spatial resolutions at 0.009 degree and 0.036 degree. The gridded LST is under local test and expected to be available in the near future.

VIIRS LST EDR Algorithm

Establish the 2-band 10.76μm(M15) and 12.01μm(M16) split window algorithm for both day and night based on regression equation for each of the 17 IGBP surface types.

$$LST_{i,j} = a_0(i,j) + a_1(i,j)T_{15} + a_2(i,j)(T_{15}-T_{16}) + a_3(i,j)(\sec\theta - 1) + a_4(i,j)(T_{15}-T_{16})^2$$

Where $a_k(i,j)$ (with k=0 to 4) are coefficients depending on surface type (with i =0 to 16 for 17 IGBP surface types) and day/night condition (with j=0 to 1), and θ is satellite viewing zenith angle.



Archive: https://www.class.noaa.gov/

ATBD: https://www.star.nesdis.noaa.gov/jpss/documents/ATBD/

Long term Monitoring: ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/

STAR LST Homepage: https://www.star.nesdis.noaa.gov/jpss/lst.php

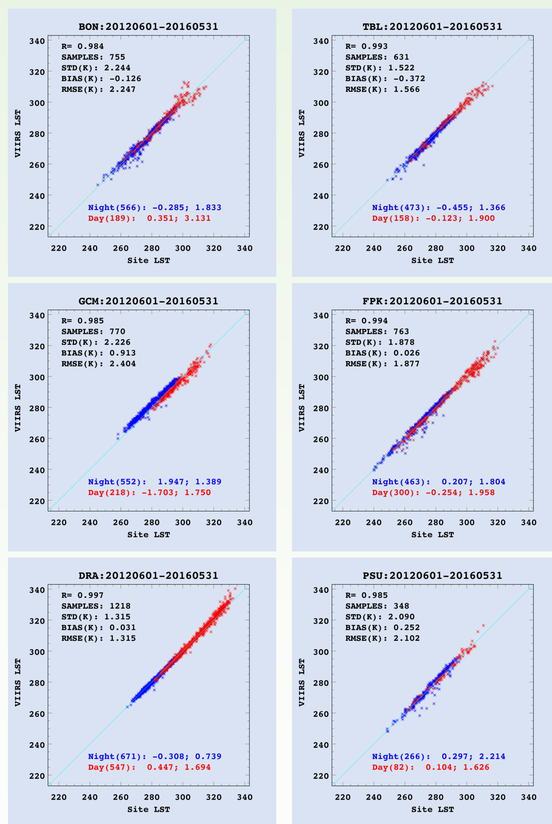
Validation Protocols

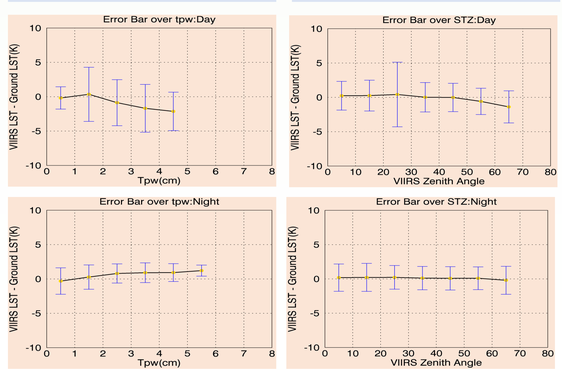
- Spatially closest pixel to the ground site location
- Minimum temporal difference with the satellite overpass
- Quality control of the ground observations
- Confidently cloud clear condition
- To reduce the cloud contamination impact, additional cloud filtering procedure applied :

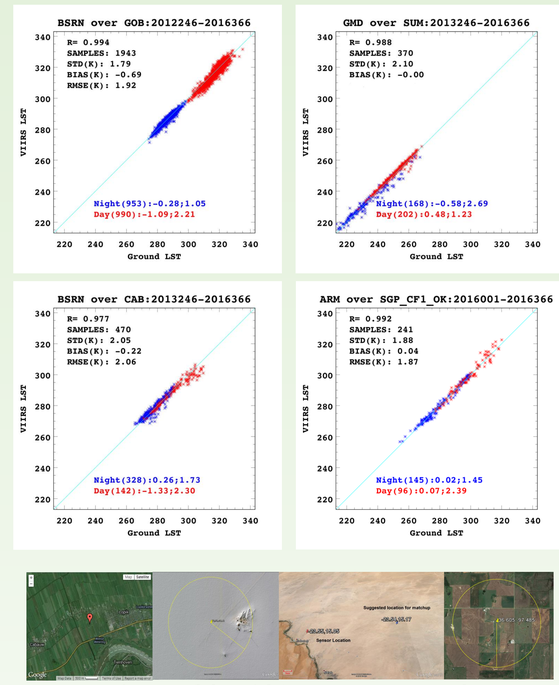
a) StdDev (PIR), standard deviation of downwelling sky irradiance measured at the ground site during the past 30 minutes centered at the satellite overpass time, threshold of 1.2 is used .

b) StdDev(BT11), standard deviation of 3 by 3 pixel array of brightness temperature at 11micron, threshold of 1.5 is used.

Validation Results







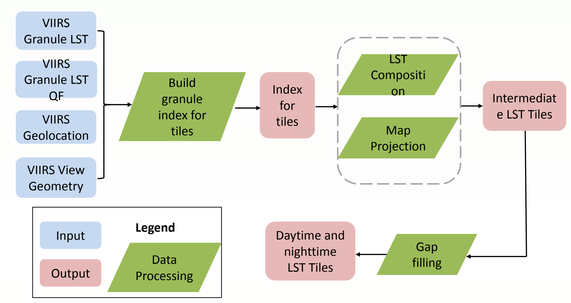
Site maps (left to right): CAB, SUM, GOB and SGP

Gridded LST Product Development

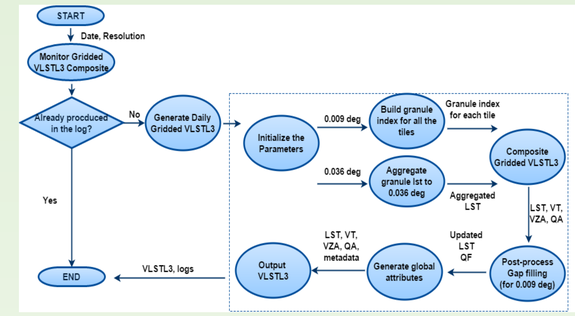
- Current VIIRS LST EDR is a granule instantaneous product. A global continuous gridded product of daily LST is needed for the end users.
- Based on the current granule LST product, our Level-3 VIIRS Gridded LST product development is on the way, which will have the following features:
  - Global coverage with two spatial resolutions provided: 0.036 degree and 0.009 degree
  - Gridded with tile system management
  - Gap-filled at invalid pixel
  - Daily product at daytime and nighttime

Table Gridded product information

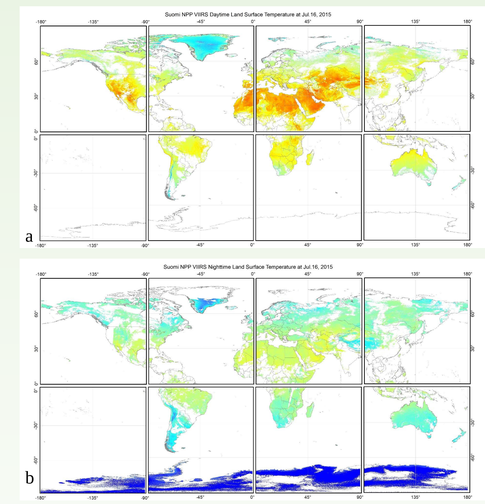
Data Type	Product Level	Data Grid	Spatial Resolution	Spatial Scale	Temporal Resolution	Map Projection
VLSTL3_C1	L3	10000 *10000	0.009° by 0.009°	90° by 90°	daily	Lat/lon geographic
VLSTL3_C2	L3	5000 * 10000	0.036° by 0.036°	360° by 180°	daily	Lat/lon geographic



High level processing flow chart



Software processing flowchart for VLSTL3



1km Gridded VIIRS Land Surface Temperature for daytime (a) and nighttime(b) (4×2 tiles for globe)

Discussion and Conclusions

- VIIRS LST is validated using ground measurements from SURFRAD, BSRN, ARM and GMD observatories. The validation covers major surface type e.g. cropland, grass land, shrub lands, barren soil, snow/ice surface etc. The validation quality is mostly affected by the ground data representativeness and cloud residue impact.
- The performance is site and day/night dependent. Nighttime performance is mostly better than that at daytime except over PSU and SUM sites attributed to the suspicious cloud contamination particularly over snow/ice surface.
- The daytime bias is mostly below 0.5 K except over GCM, CAB and GOB sites in which there is an underestimation around 1.7 K, 1.3 K and 1 K, respectively. The daytime bias tends to increase with water vapor and viewing angle toward the negative direction. The nighttime bias is mostly below 0.3 K except over GCM site where there is an overestimation around 1.9K.. The nighttime bias tends to increase with water vapor toward the positive direction but it hardly changes with the viewing angle.
- The standard deviation varies from 1.2 K to 3.1 K for daytime and 0.7 K to 2.7 K for nighttime.
- Seasonal deviation is observed over BON site where overestimation appears in late May and early June and underestimation is observed in Summer. It might be related to the harvest cycle in this area.
- Gridded LST fata development is on the way based on the granule level 2 LST product. It will provide two spatial resolutions of 0.009 degree and 0.036 degree. Test data of the gridded LST has been delivered to NOAA.EMC for the model output verification.