Assessment of the Suomi NPP VIIRS Land Surface Temperature Product-Beta to Provisional Maturity

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Introduction

The Visible Infrared Imaging Radiometer Suite (VIIRS), aboard the Suomi National Polar-orbiting Partnership (*Suomi NPP*) *satellite, is used to provide measurements of the atmosphere, land and ocean, which are referred to as Environmental Data Records (EDR). The Land Surface Temperature (LST) EDR provides the measurement of the skin temperature over global land coverage. LST is derived from VIIRS data using the baseline split-window regression algorithms. Coefficients of the LST algorithm are surface type dependent, referring the 17 International Geosphere-Biosphere Programme (IGBP) types.*
This study presents an evaluation of the LST product based on the on-orbit NPP data. The evaluation is performed through the internal evaluation, which includes flags, maps and upstream inputs, and the external evaluation, which includes the cross comparison with MODIS LST and evaluation against ground in-situ LST.
The evaluation results show that the surface type dependency of the LST product performance is significant; nighttime performance exceeds the daytime performance; LST algorithm tends to overestimate surface temperature at daytime and underestimate at nighttime. To sum up, the LST EDR product has achieved the beta quality and continues to mature. The efforts are being made to reach provisional quality in May, 2013.

VIIRS LST EDR Algorithms

❖ Baseline Split window 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 type.

$$LST_i = a_0(i) + a_1(i)T_{M15} + a_2(i)(T_{M15} - T_{M16}) + a_3(i)(sec\theta - 1) + a_4(i)(T_{M15} - T_{M16})^2 \quad i = 1, \ldots, 17$$

❖ Fallback dul split window algorithm

Fallback to 4-band,3.74µm(M12), 4.05µm(M13), 10.76µm(M15) and 12.01µm(M16).

Daytime:

$$LST_i = a_0(i) + a_1(i)T_{M15} + a_2(i)(T_{M15} - T_{M16}) + a_3(i)(sec\theta - 1) + a_4(i)T_{M12} + a_5(i)T_{M13} + a_6(i)T_{M12}cos\varphi + a_7(i)T_{M13}cos\varphi + a_8(i)(T_{M15} - T_{M16})^2 \quad i = 1, \ldots, 17$$

Nighttime:

$$LST_i = b_0(i) + b_1(i)T_{M15} + b_2(i)(T_{M15} - T_{M16}) + b_3(i)(sec\theta - 1) + b_4(i)T_{M12} + b_5(i)T_{M13} + b_6(i)T_{M12}{}^2 + b_7(i)T_{M12}{}^2 + b_8(i)(T_{M15} - T_{M16})^2 \quad i = 1, \ldots, 17$$

Where
LST_i is the retrieved land surface temperature over surface type i.
A_n and bn are coefficients retrieved from the LST LUT .
Θ is the sensor zenith angle
Φ is the solar zenith angle
T_δ is the brightness temperature at $_\delta$ =VIIRS band M12,M13,M15 and M16

Acknowledgement

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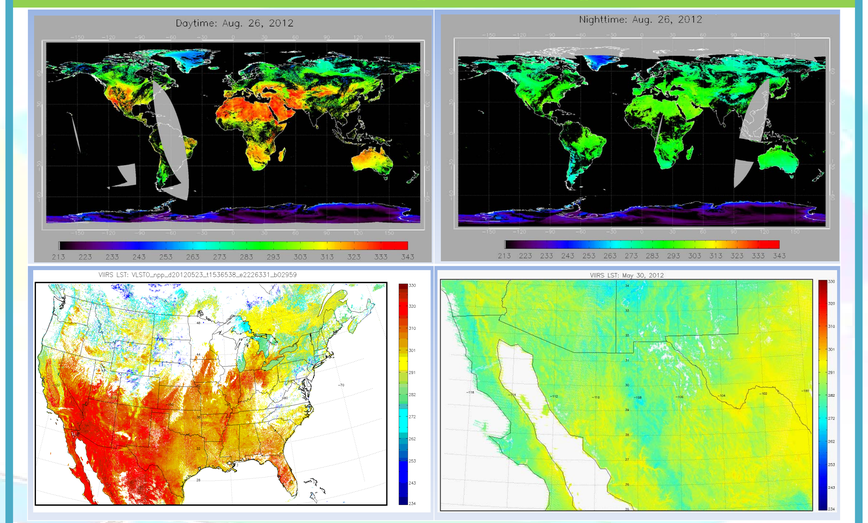
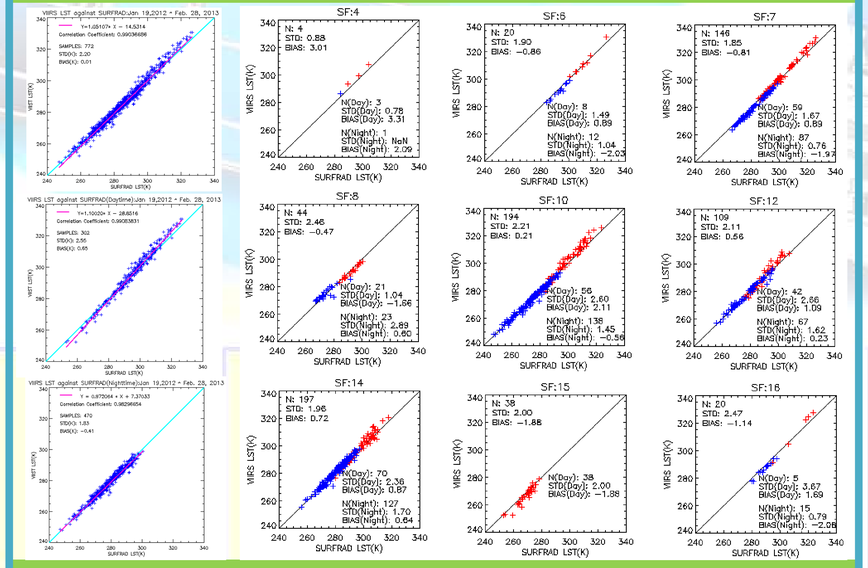
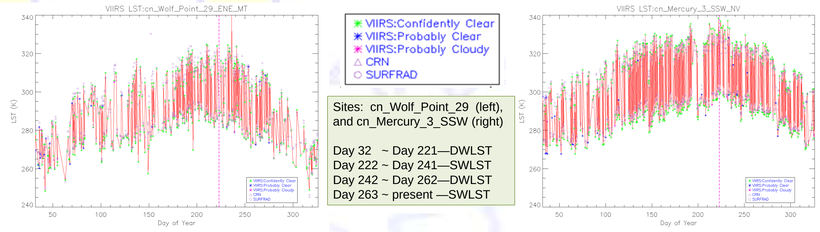
Global and Regional LST Images



Ground evaluation



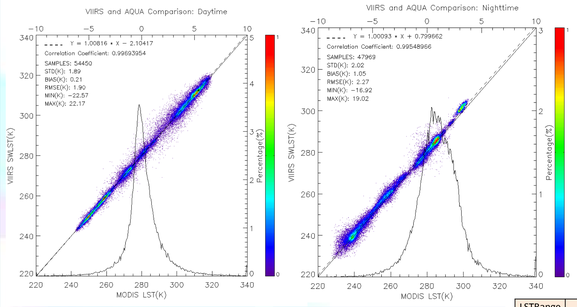
Near Real Time Monitoring



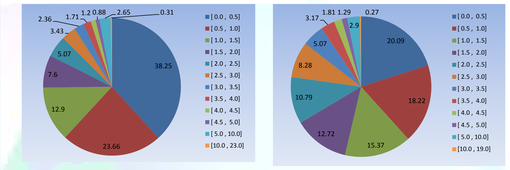
•Near real time monitoring of VIIRS LST under different cloud conditions and surface types
•The monitoring starts from February 1, 2012 to present
•Two sites are selected including cn_Wolf_Point_29 in Montana with grass land type and cn_Mercury_3_SSW in Nevada with open shrub land type.
•CRN and SURFRAD ground truth data are used as reference for the monitoring

Cross-satellite evaluation

❖ MODIS Aqua LST vs. VIIRS LST



Daytime and Nighttime comparison between the VIIRS LST and MODIS LST (MYD11_L2) . Color bar represents density of LST pairs in each bin.
The Simultaneous Nadir Overpass (SNOs) prediction service is utilized to get the scenes for the evaluation. The SNO extension over US are selected for the comparison. The temporal difference is controlled within 10 minutes.
Multiple recent scenes from October 2012 to March 2013 have been included into the comparison.



LSTRange	SAMPLES		BIAS		STD	
	Day	Night	Day	Night	Day	Night
223-233		403		-1.029		2.426
233-243	53	9632	-0.677	0.841	0.572	2.428
243-253	7710	6144	-0.265	1.318	0.812	2.057
253-263	8972	6780	-0.155	1.324	1.023	1.628
263-273	5278	3142	-0.226	1.146	1.906	2.072
273-283	5016	7138	0.289	0.088	2.067	1.878
283-293	3213	9188	0.475	0.868	2.827	1.738
293-303	5876	4785	0.481	2.285	2.949	1.029
303-313	13957	757	0.532	3.017	1.805	0.828
313-323	4375		0.622		1.541	

❖MODIS LST *vs. VIIRS LST* over 17 IGBP surface types

IGBP Land Type	Sample Size		BIAS(K)		STD(K)	
	Day	Night	Day	Night	Day	Night
Evergreen Needle Leaf Forests	2038	4409	0.535	0.748	2.344	2.519
Evergreen Broadleaf Forests		6		-0.852		2.071
Deciduous Needle leaf Forests	3	176	-0.708	0.604	0.183	2.179
Deciduous Broadleaf Forests	7	248	2.095	0.753	1.48	1.87
Mixed Forests	1322	10207	0.472	0.779	1.782	2.042
Closed Shrub Lands	1	88	-0.038	2.165	NaN	0.996
Open Shrub Lands	2248	6285	0.55	2.062	3.786	1.76
Woody Savannahs	99	1443	0.557	1.113	1.853	2.827
Savannahs	13	2147	0.942	1.052	1.315	2.214
Grasslands	2131	6218	0.793	1.196	2.421	1.691
Permanent Wetlands	5	1750	0.31	-0.217	1.059	1.716
Croplands	1082	10023	0.618	1.192	1.942	1.509
Urban Built-Up	111	147	1.244	0.429	2.427	2.122
Natural Vegetation Mosaics	104	2820	1.139	0.586	2.246	1.604
Snow ice	23014		-0.194		1.266	
Barren	21921	12	0.462	-0.204	1.937	2.75
Water Bodies	351	1990	-0.136	0.456	2.845	2.787

Summary

❖ VIIRS LST Performance Over Surface Types

IGBP	Overall		Daytime		Night	
	Bias	Std	Bias	Std	Bias	Std
Total	0.01	202	0.65	2.55	-0.41	1.83
4	0.88	3.01	0.78	3.31	2.09	
6	-0.86	1.9	0.89	1.49	-2.03	1.04
7	-0.81	1.85	0.89	1.67	-1.97	0.76
8	-0.47	2.46	-1.66	1.04	0.6	2.89
10	0.21	2.21	2.11	2.6	-0.56	1.45
12	0.56	2.11	1.09	2.66	0.23	1.62
14	0.72	1.98	0.87	2.36	0.64	1.7
15	-1.88	2.00	-1.88	2.00		
16	-1.14	2.47	1.69	3.67	-2.06	0.79

❖ Concluding Remarks

- The dependency of VIIRS LST performance on surface types and day/night condition is significant.
- Nighttime performance exceeds the daytime performance.
- VIIRS LST and MODIS LST produce a consistent measurement of land surface temperature. But the difference between VIIRS LST and MODIS LST varies over surface types.
- The comparison to SURFRAD ground data suggests that VIIRS LST is retrieved warmer than ground at daytime and colder at nighttime for the combination of surface types including IGBP 4,6,7,8,10,12,14,15 and 16.
- The evaluation is performed with limited ground data (surface types)
- LST product has achieved the beta quality in December 2012 and it performs beyond the beta according to our continuous evaluations.
- We will continue to monitor the LST data quality and make efforts to reach provisional maturity in May, 2013.