Provisional Maturity Science Review For
NOAA-21 Land Surface Temperature

Prepared by
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JPSS/GOES-R Data Product Validation Maturity Stages - COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

Outline

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Processing environment
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Check List)
- Conclusion
- Path Forward

NOAA-21 LST Cal/Val Team

Algorithm Cal/Val Team Members

	Name	Organization	Major Task
JSTAR Science	Land Lead: Ivan Csiszar	NOAA/NESDIS/STAR	Project Management
	EDR Lead: Yunyue Yu	NOAA/NESDIS/STAR	Team management, algorithm development, validation advises
	Yuling Liu	NOAA Affiliate, UMD/CISESS	product monitoring and validation ; algorithm development/improvement
	Heshun Wang	NOAA Affiliate, UMD/CISESS	algorithm improvement, product calibration/validation
	Peng Yu	NOAA Affiliate, UMD/CISESS	product validation tool, monitoring, applications
JPSS ASSISTT	Michael Butler	NOAA Affiliate, GAMA-1	ASSISTT Lead
	Mingming Yao	NOAA Affiliate, CIMMS	Algorithm System integration
	Eric Buzan	NOAA Affiliate, GAMA-1	SAlgorithm System integration
	Wilson, Michael	NOAA Affiliate, IMSG	Framework DAP delivery
NOAA/EMC	Michael Barlage	NOAA/EMC/NCEP	user readiness
	Fanglin Yang	NOAA/EMC/NCEP	user readiness
	Weizhong Zheng	NOAA Affiliate	user readiness
	Helin Wei	NOAA Affiliate	user readiness
NOAA/OSPO	Hanjun Ding	NOAA/NESDIS/OSPO	NDE operational Land Lead
	Yufeng Zhu	NOAA Affiliate	NDE operational

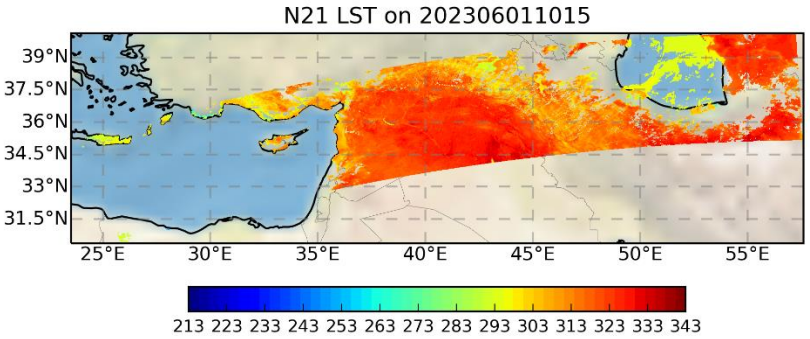
Product Overview

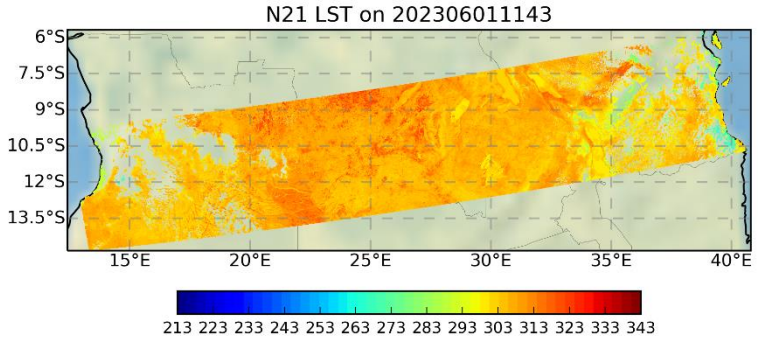
- NOAA-21 VIIRS LST is generated using the enterprise LST algorithm, which is consistent across all JPSS satellite LSTs.

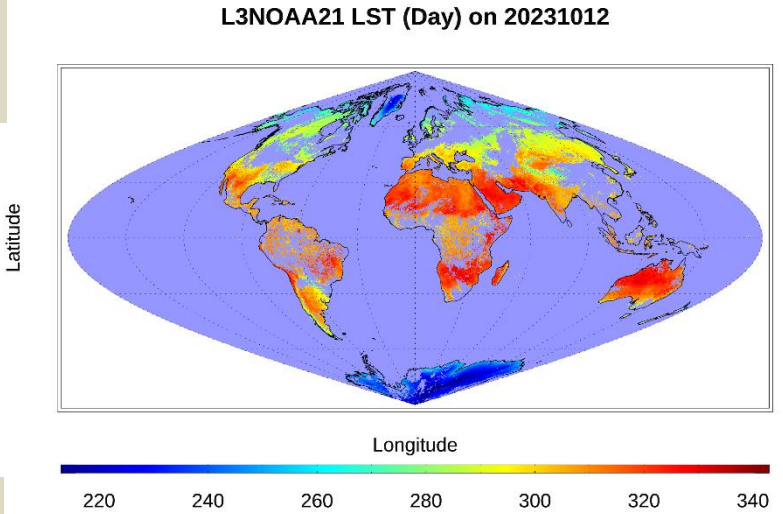
$$T_s = C + A_1 T_{11} + A_2 (T_{11} - T_{12}) + A_3 \varepsilon + A_4 \varepsilon (T_{11} - T_{12}) + A_5 \Delta\varepsilon$$

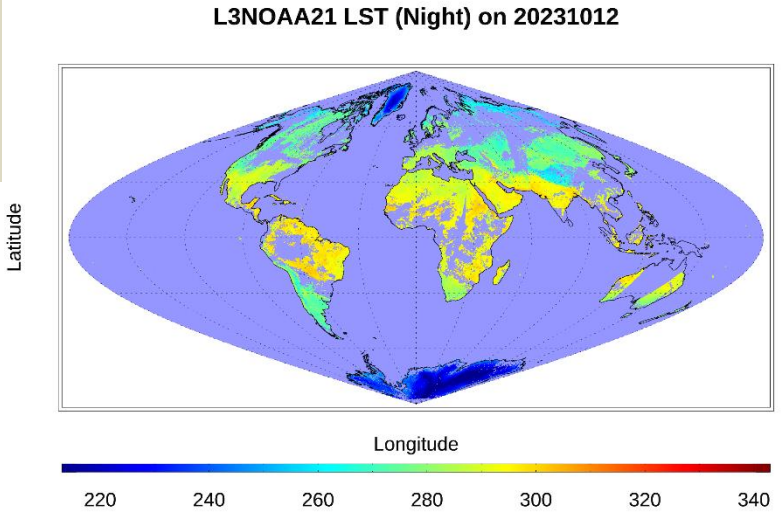
T_{11} and T_{12} represent the top-of-atmosphere brightness temperatures at ~11μm and 12 μm, respectively;
$\varepsilon = (\varepsilon_{11} + \varepsilon_{12})/2$ and $\Delta\varepsilon = (\varepsilon_{11} - \varepsilon_{12})$, where ε_{11} and ε_{12} are the spectral emissivity values of the land surface at ~11μm and 12 μm channels, respectively;
C, A_1, A_2, A_3, A_4, A_5, and A_5 are algorithm coefficients, stratified for different atmospheric conditions (i.e. day/night, total precipitable water vapor and satellite viewing zenith angles).

- It comprises L2 granule LST (bottom figures) with approximately 1010 files in total for each day, and L3 daily gridded LST(right figures), with two files each for daytime and nighttime, respectively.
- A dedicated LUT is created for L2 NOAA-21 VIIRS LST production. This LUT is developed using the comprehensive simulation dataset and the sensor specific spectral response function.









Product Requirements

- Product performance requirements from JPSS Data Product Specification (DPS)

Attribute	L2 Granule LST	L3 Gridded LST
Geographic coverage *Daily global Gridded Product required recently*	At least 90% coverage of the globe every 24 hours (monthly average)	Global coverage
Vertical Coverage		
Vertical Cell Size		
Horizontal Cell Size	0.8 km	0.009 degree
Mapping Uncertainty, 3 Sigma	1 Km at Nadir	
Measurement Range	213 – 343 K	213 – 343 K
Measurement Accuracy(bias)	1.4 K	1.4 K
Measurement Precision(1 sigma)	2.5 K	2.5 K
Refresh rate	Granule	Daily
Latency	96 minutes	30 hours

Processing Environment and Algorithms

- Processing environment and algorithms
  - System: NDE/NCCF
  - Algorithm version
    - L2 LST ---- version # v2r2 *(uncertainty estimation added)*
    - L3 LST ---- version # v1r1. (*composition algorithm improved*)
  - Version of LUTs used
    - The algorithm LUT is developed based on the NOAA-21 spectral response function released in 2019.
  - Effective date
    - L2 LST data stream started from May 29th, 2023
    - L3 LST data stream started from June 8, 2023

***Note**: SNPP and NOAA20 still has the old version of v1r4 and v1r0 in its operational run for L2 and L3, respectively, which results in some differences in the inter-comparison.*

- *Evaluation period: from the beginning of the data stream to present*

Evaluation of algorithm performance to specification requirements

- In-situ reference evaluation
  - Satellite temperature data were compared with ground measurements from SURFRAD, ARM, BSRN and NDBC network.
  - The validation dataset generally covers the time period from May 29, 2023 to December 10, 2023; with global spatial coverage.
  - Long term monitoring tool is available and ready for the test with the ingest of operational NOAA-21 LST.
- Radiance based LST validation
  - Radiative transfer model used: MODTRAN 5.2; atmospheric profiles used were from the NCEP GDAS system
  - Evaluation is conducted over ground stations from the above ground networks, spanning the time period from May 29, 2023 to December 10, 2023
- Inter/Cross sensor comparison
  - Comparison with S-NPP and NOAA-20 LSTs
  - Comparison with MODIS and VNP21 LSTs

LST Validation with ground observations

Ground Station List

ARM sites

ID	Name	Latitude	Longitude	Elevation(m)	Surface Type
1	sgpsirsC1	36.605	-97.485	318	Rangeland (Sandy)
2	sgpsirsE9	37.133	-97.266	386	Pasture
3	sgpsirsE11	36.881	-98.285	360	Pasture
4	sgpsirsE12	36.841	-96.427	331	Native Prairie
5	sgpsirsE13	36.605	-97.485	318	Pasture and Wheat
6	sgpsirsE15	36.431	-98.284	418	Pasture
7	sgpsirsE31	37.1509	-98.362	412.1	Pasture
8	sgpsirsE32	36.819	-97.8199	328	Pasture
9	sgpsirsE33	36.9255	-97.0817	357	grassy field
10	sgpsirsE34	37.0694	-96.7606	417	Pasture
11	sgpsirsE35	35.8615	-97.0695	294.1	Pasture
12	sgpsirsE36	36.1166	-97.5112	336.8	Pasture
13	sgpsirsE37	36.3106	-97.928	378.9	grass
14	sgpsirsE38	35.8797	-98.1728	371.2	pasture
15	sgpsirsE40	36.31937	-96.76203	247	Pasture
16	sgpsirsE41	36.87956	-97.08645	340	Grassy field

SURFRAD stations

No.	Site Name	Station Abb.	Lat	Lon	Elevation (m)	Surface Type
1	Bondville, IL	BON	40.05	-88.37	230	Crop Land
2	Fort Peck, MT	FPk	48.31	-105.10	634	Grass Land
3	Table Mountain, CO	TBL	40.13	-105.24	1689	Grass/Crop Land
4	Desert Rock, NV	DRA	36.63	-116.02	1007	Shrub Land
5	Penn. State Univ., PA	PSU	40.72	-77.93	376	Cropland
6	Sioux Falls, SD	SXF	43.73	-96.62	473	Cropland

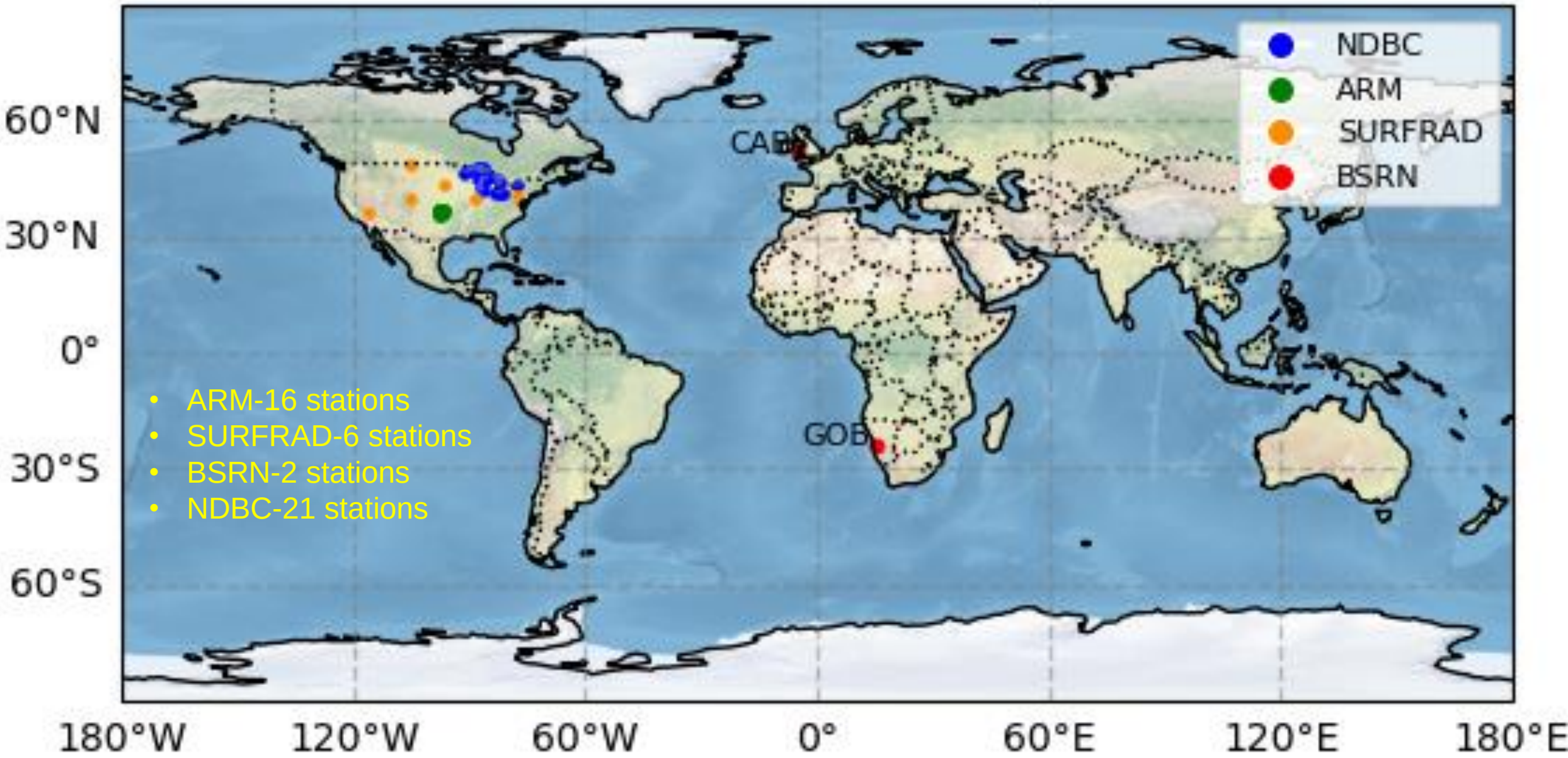
BSRN sites

No.	Site Name	Station Abb.	Lat	Lon	Elevation (m)	Surface Type
1	Cabauw, The Netherlands	CAB	51.97	-4.93	213	Crop Land
2	Gobabeb, Namibia	GOB	-23.56	15.04	407	Bare ground

NDBC sites

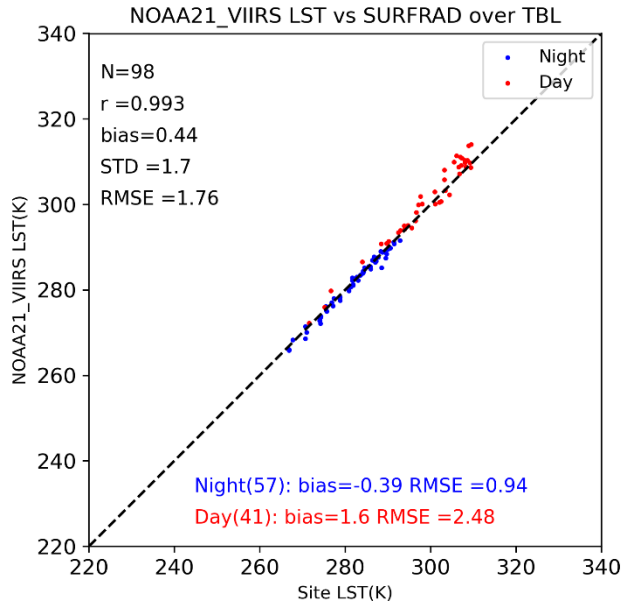
ID	Name	Latitude	Longitude
1	45001	48.061	-87.793
2	45002	45.344	-86.411
3	45003	45.351	-82.84
4	45004	47.585	-86.585
5	45005	41.677	-82.398
6	45006	47.335	-89.793
7	45007	42.674	-87.026
8	45008	44.283	-82.416
9	45012	43.621	-77.401
10	45014	44.794	-87.758
11	45022	45.405	-85.087
12	45024	43.971	-86.554
13	45028	46.814	-91.829
14	45164	41.732	-81.694
15	45165	41.702	-83.261
16	45168	42.397	-86.331
17	45175	45.825	-84.772
18	45176	41.55	-81.765
19	45180	48.034	-87.73
20	45183	44.982	-85.831
21	45194	45.804	-84.792

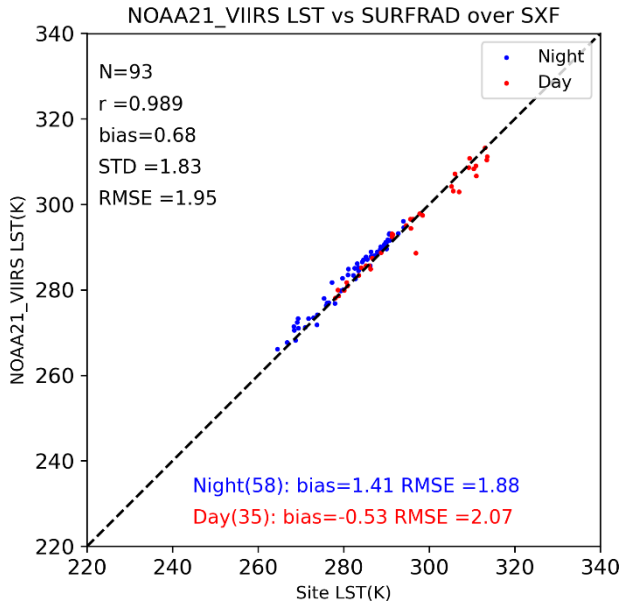
Ground Stations Map

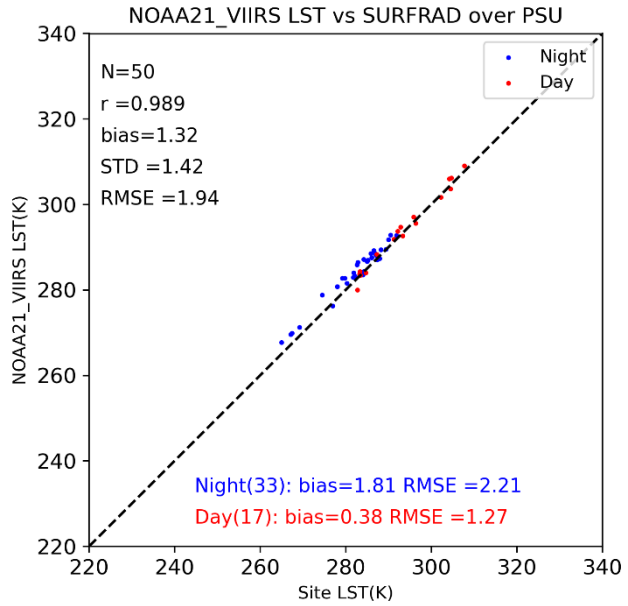


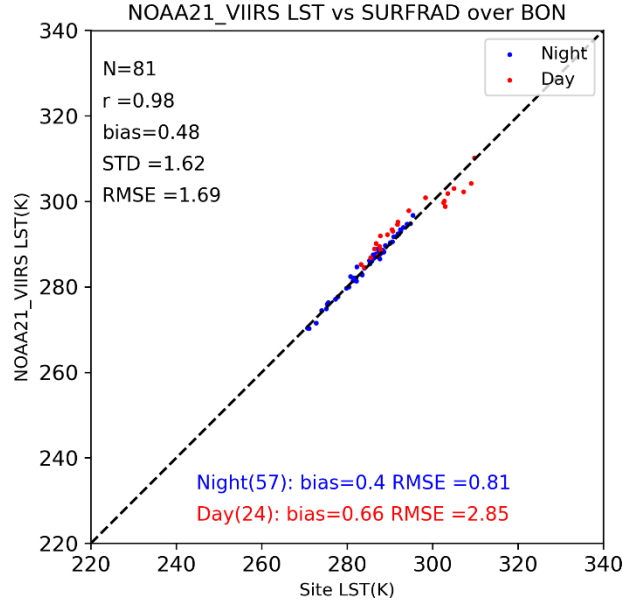
- ARM-16 stations
- SURFRAD-6 stations
- BSRN-2 stations
- NDBC-21 stations

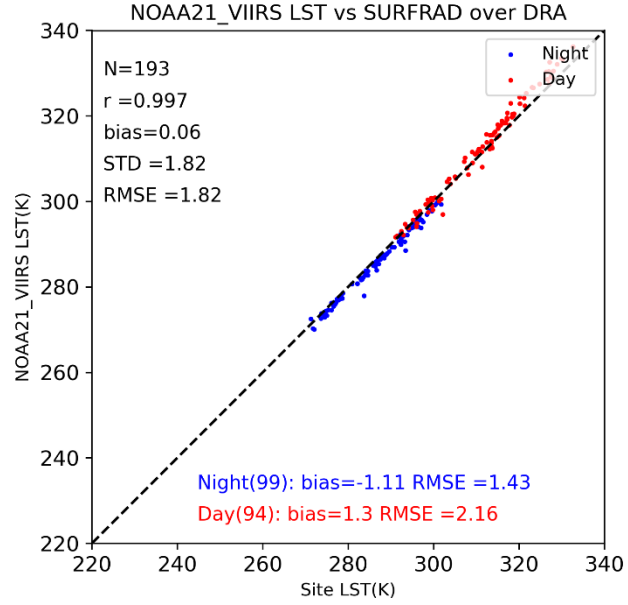
NOAA-21 LST Ground Validation-SURFRAD (1)

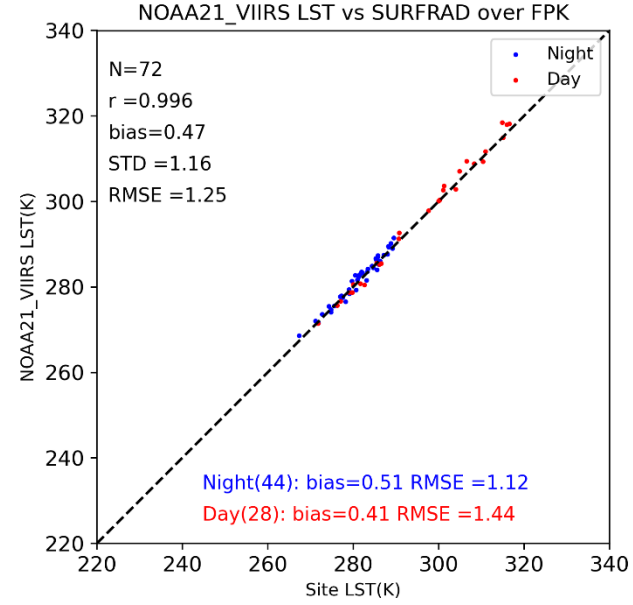






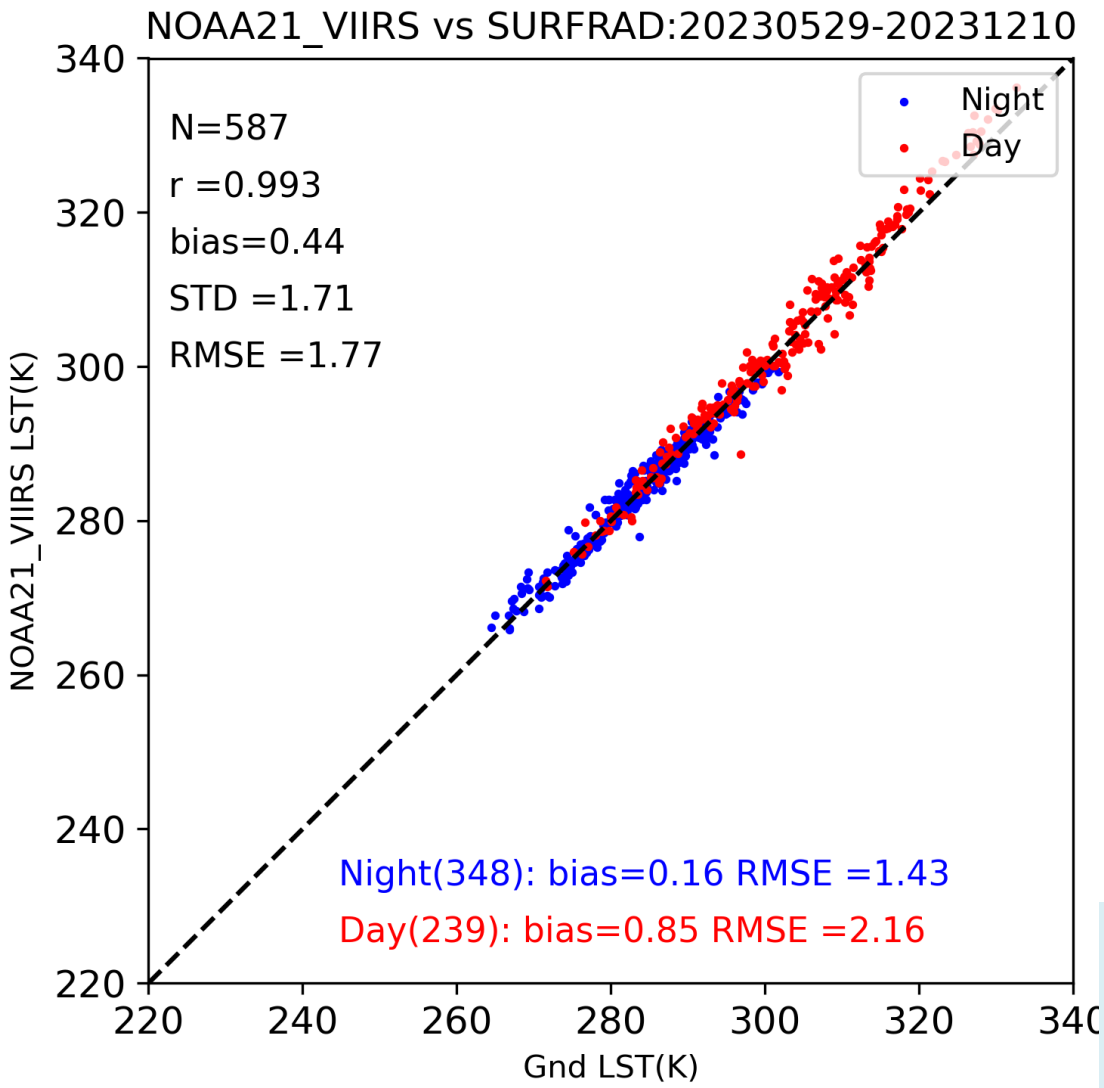


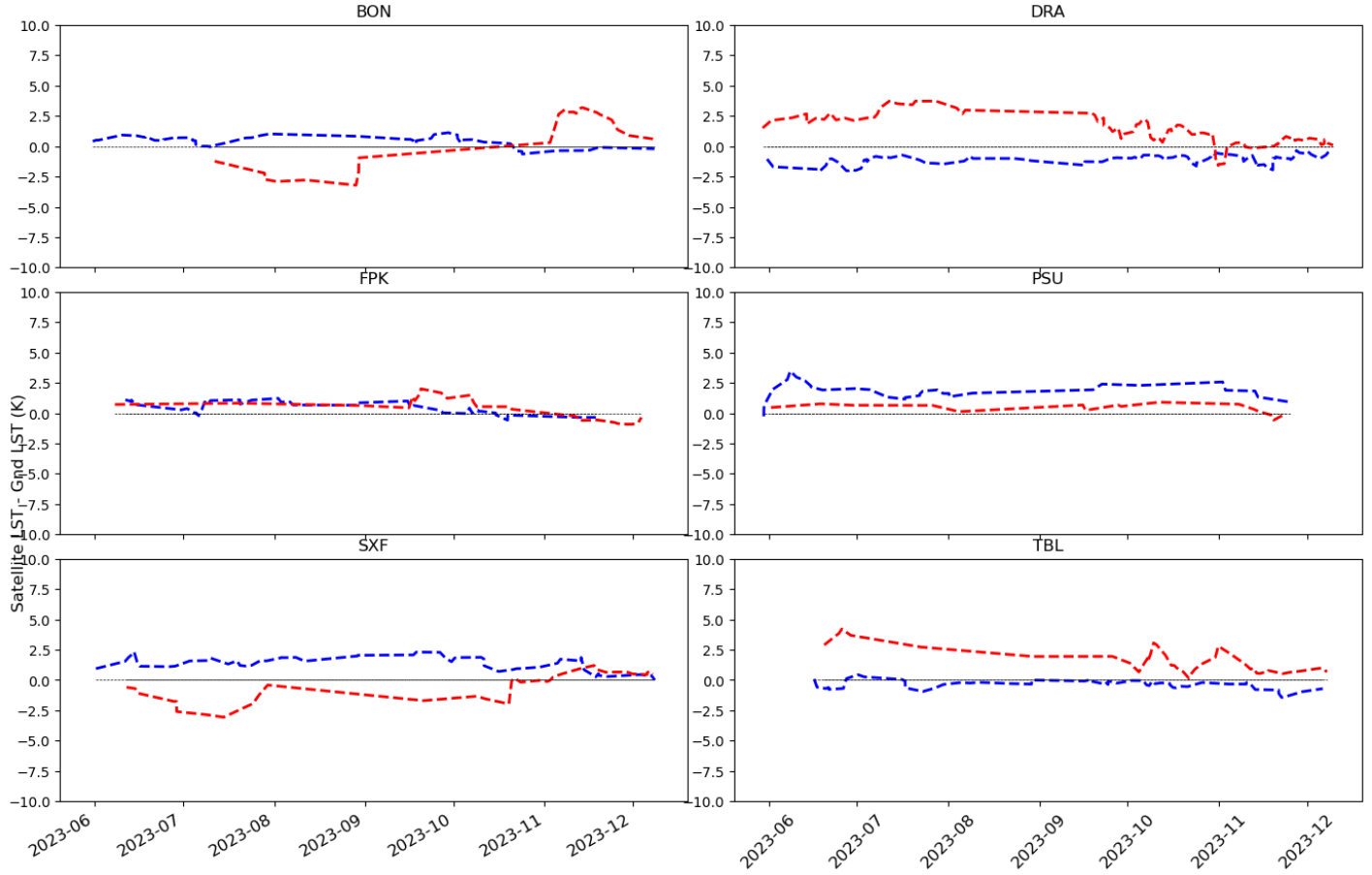




- Six stations from SURFRAD were used for the ground validation, covering time period from May. 29 to Dec. 10th.
- Day/night combined results indicates that the bias is within requirement and precision less than 1.9 K for all stations.
- Daytime exhibits a positive bias over all stations, ranging from 0.38 K to 1.6 K.
- Nighttime bias shows either positive or negative, ranging from -1.1 K to 1.8 K.

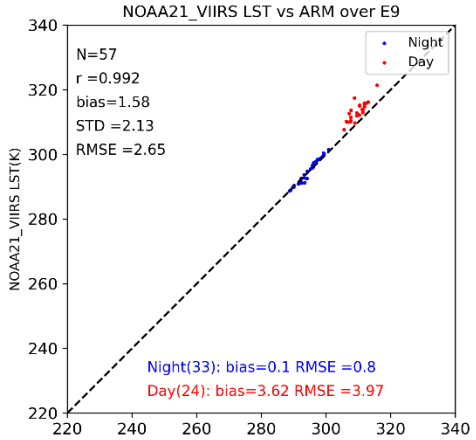
NOAA-21 LST Ground Validation-SURFRAD (2)

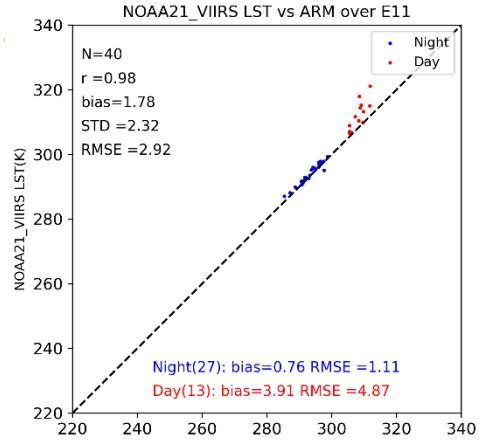


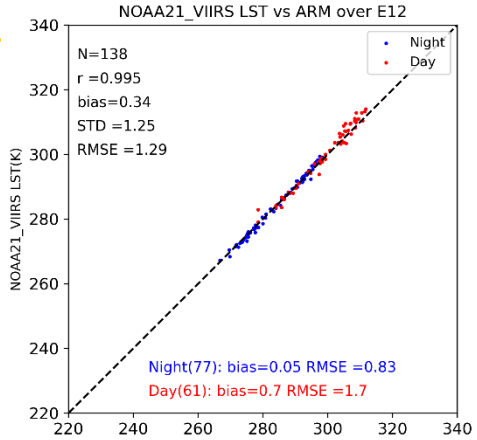


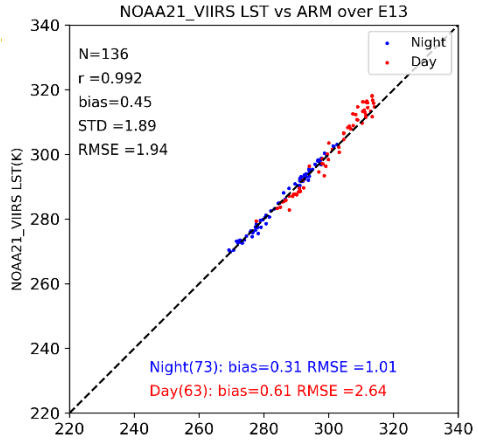
- Left figure presents the combined results from all six stations and the right figure displays the station wide time series of LST errors.
- Day/night combined results indicates a bias of 0.4 K and precision of 1.7 K.
- The time series indicates an overall smaller LST error at nighttime than at daytime except over PSU station

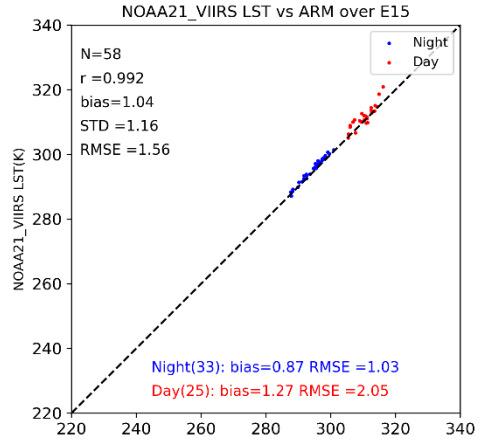
NOAA-21 LST Ground Validation-ARM (1)

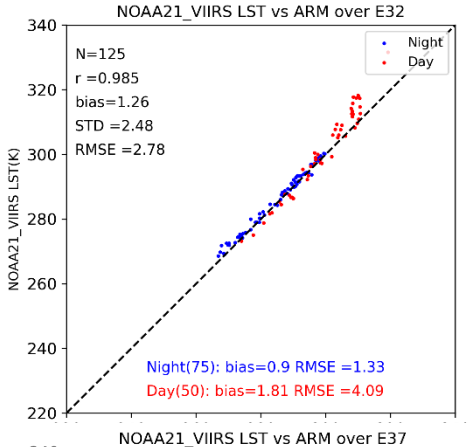


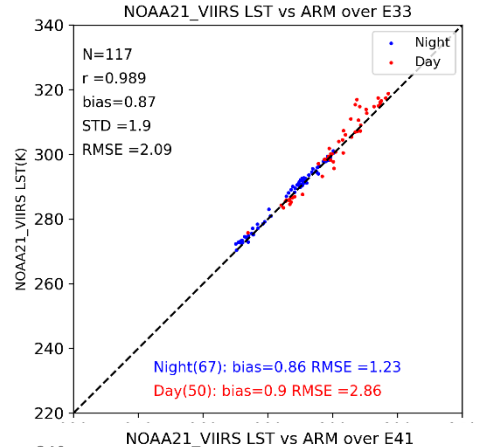


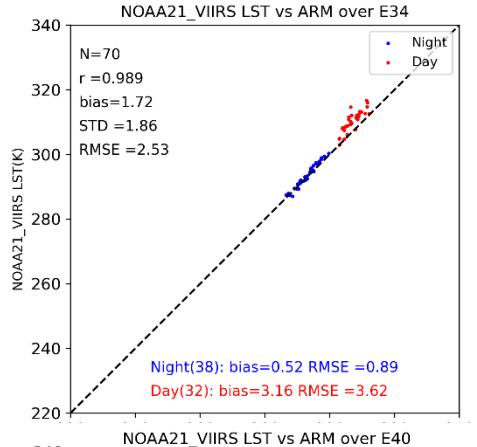


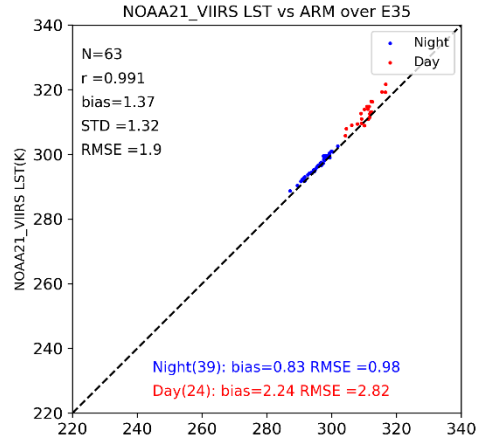


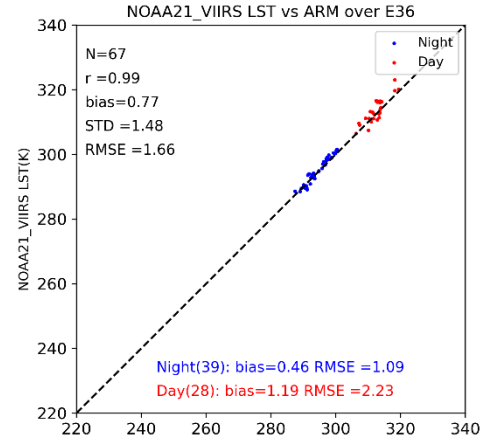


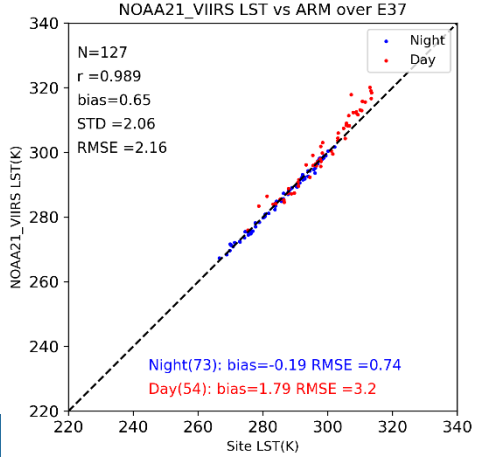


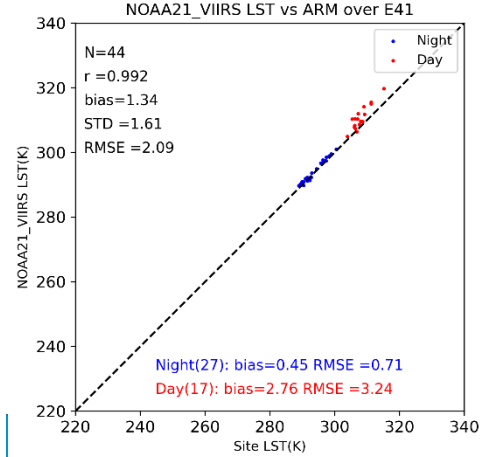


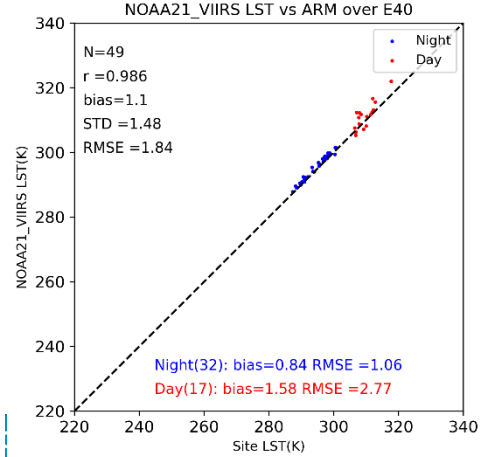






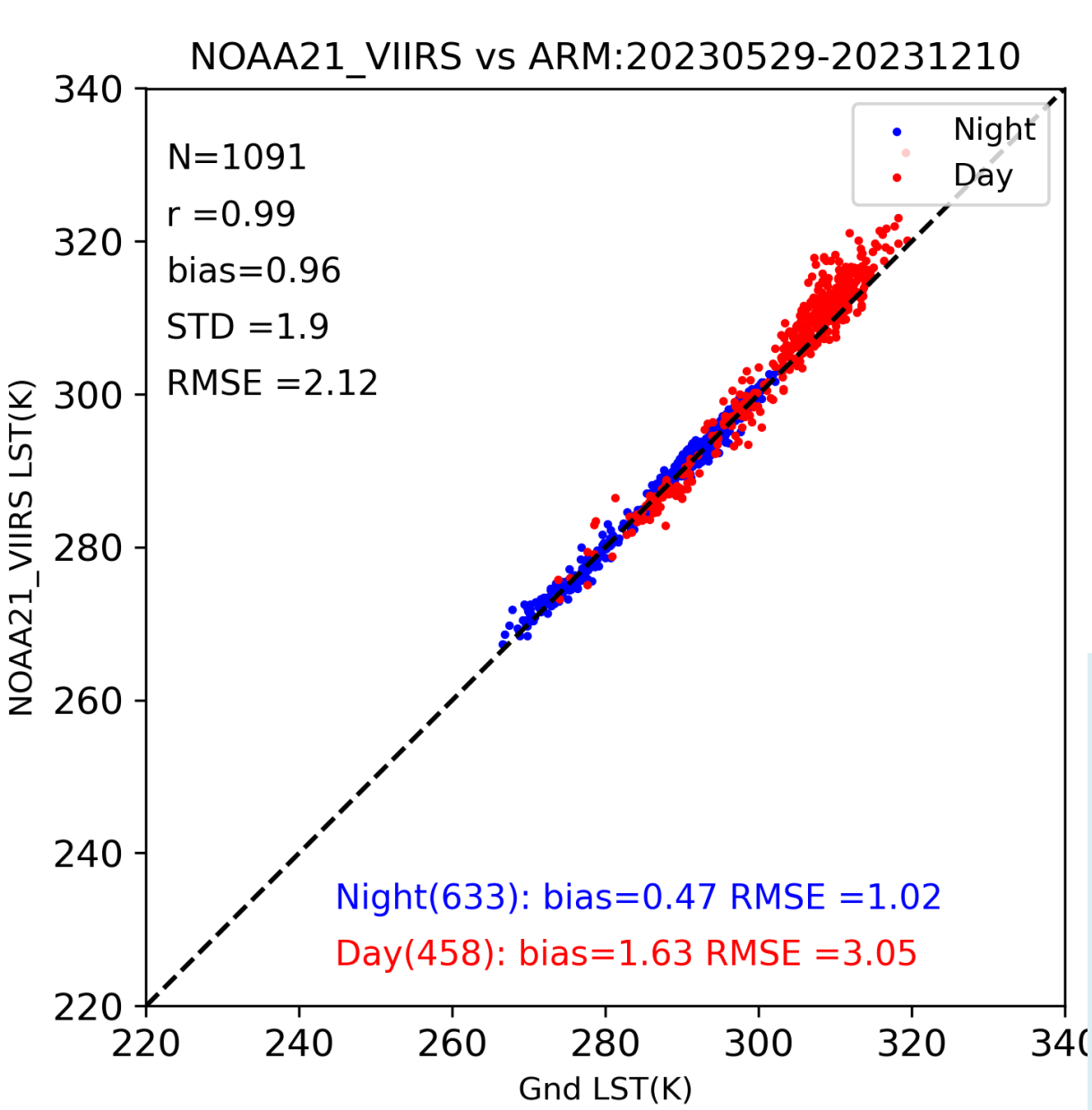


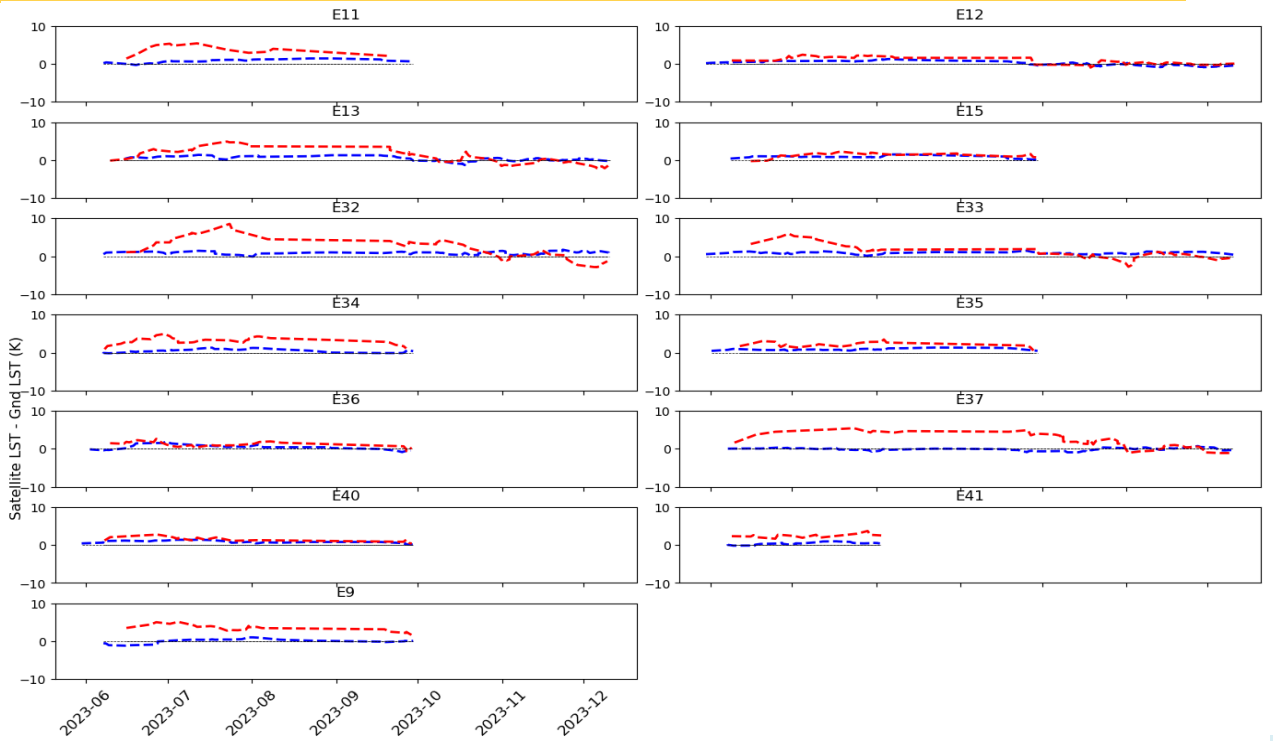




- Thirteen stations from ARM were used for the ground validation, covering time period from May. 29 to Dec. 10th.
- Daytime exhibits a positive bias over all stations, ranging from 0.6 K to 3.9 K.
- Nighttime bias shows either positive or negative, ranging from -0.2 K to 0.9 K with RMSE less than 1.4 K over all stations.

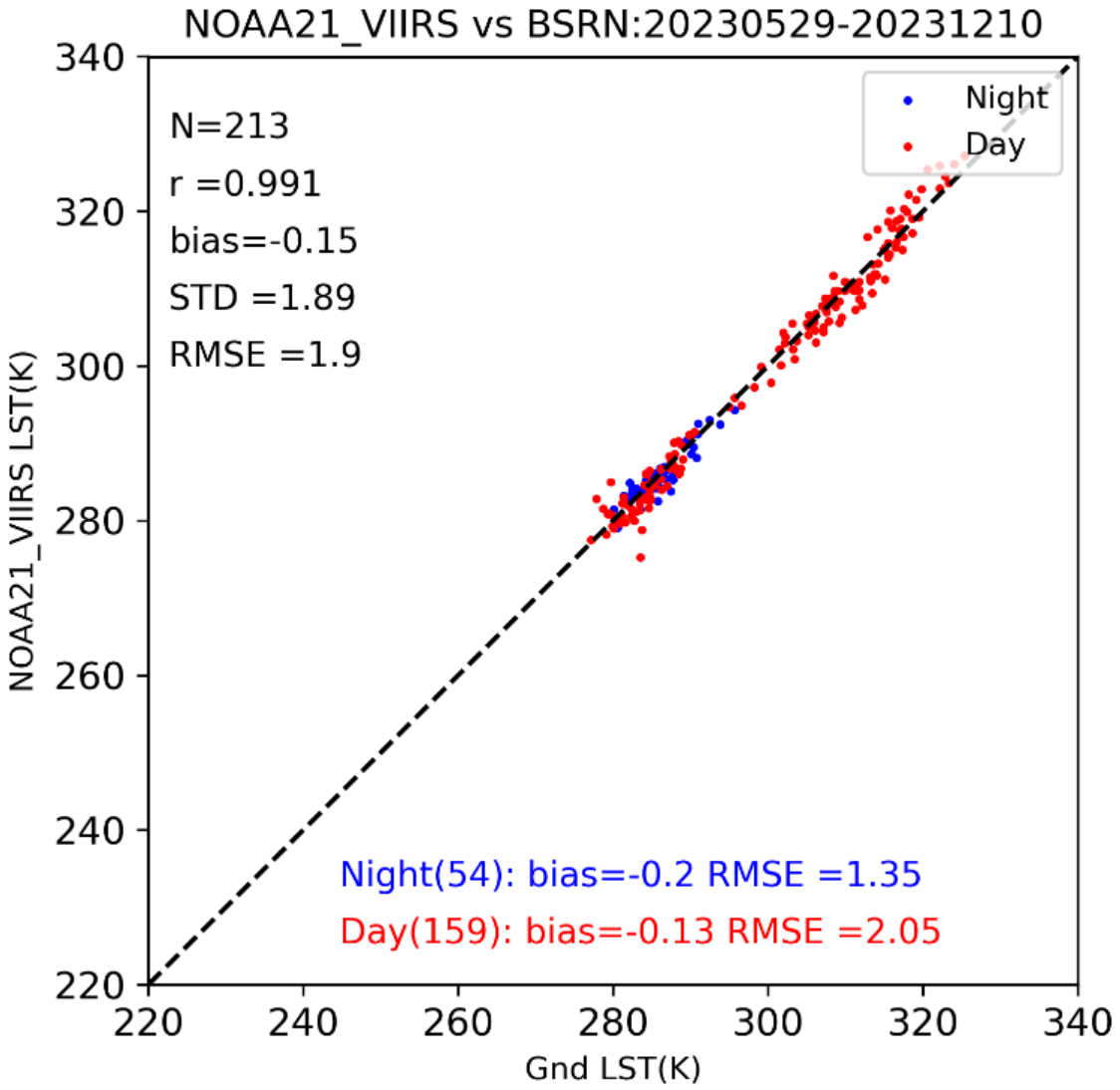
NOAA-21 LST Ground Validation-ARM (2)

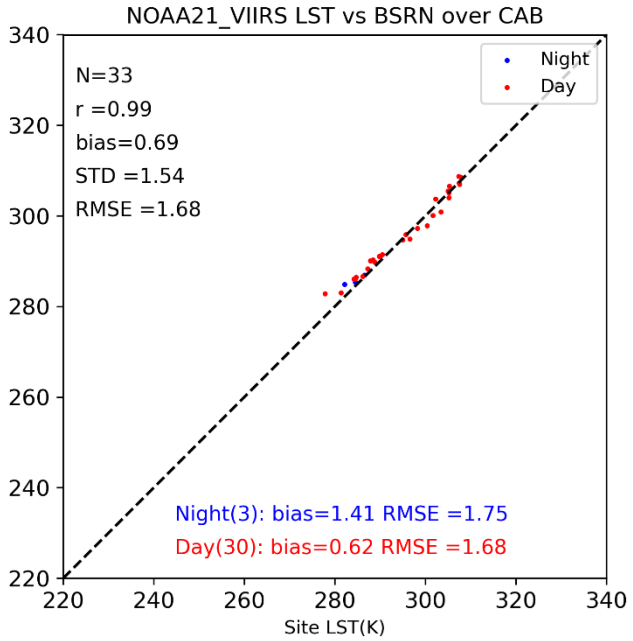


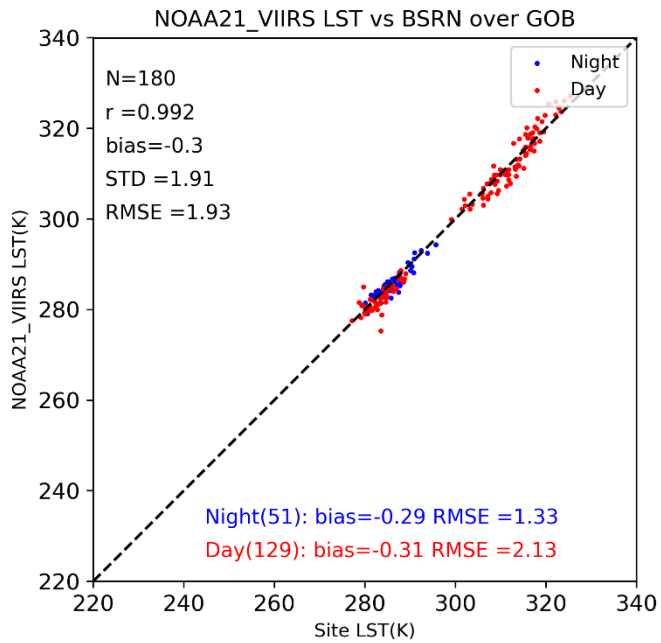


- Left figure presents the combined results from all thirteen stations, while the right figure displays the sitewide LST error time series.
- Day/night combined results indicates a bias of 0.96 K and a precision of 1.9 K.
- Seasonal overestimation is observed over some stations, such as E11, E13, E32, E33, E34 and E9 at the beginning of June. The overestimation is attributed to the seasonal mismatch between satellite LST and in-situ LST in early grow phase of crops

NOAA-21 LST Ground Validation-BSRN

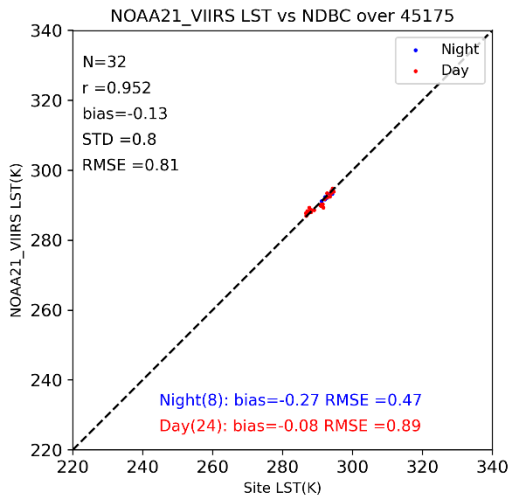


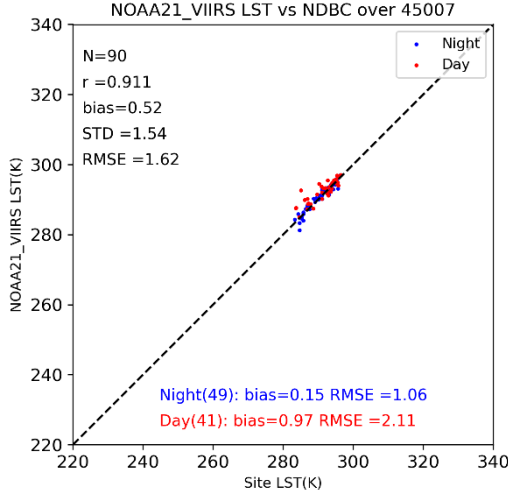


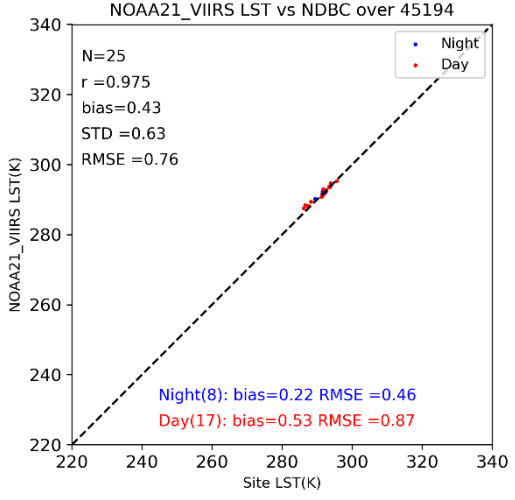


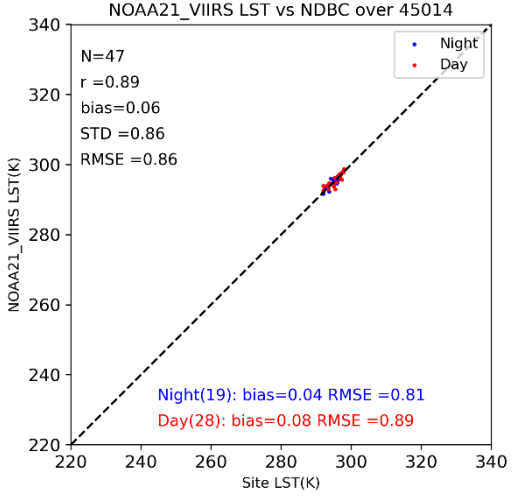
- Two stations from BSRN were used for the ground validation, covering time period from May to November 2023.
- Left figure presents the combined validation results from two BSRN stations, while the right two figure displays the site wide validation results: CAB(middle) and GOB station(right)
- Day/night combined results indicates a bias of -0.15 K and a precision of 1.9 K with a correlation of 0.99. Nighttime outperforms daytime with a RMSE of 1.4 K, while it is 2.1 K for daytime.
- It shows a bias of 0.7 K and a precision of 1.5K over CAB station, while it is -0.3 K and 1.9 K over GOB station.

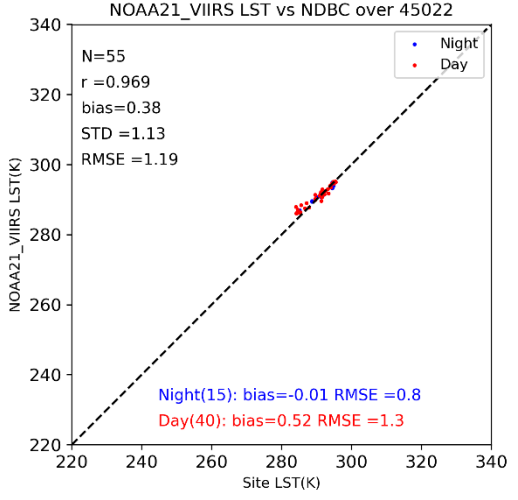
NOAA-21 LST Ground Validation-NDBC (1)

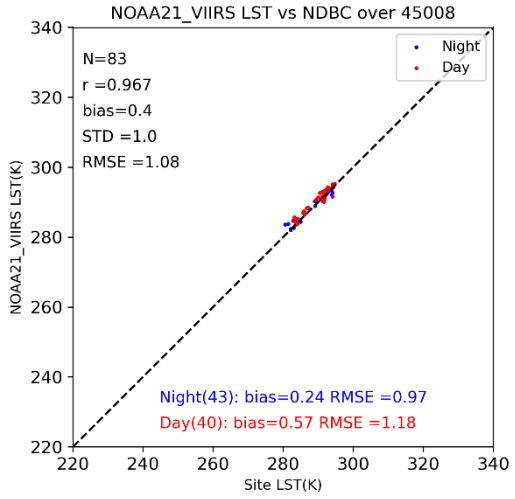


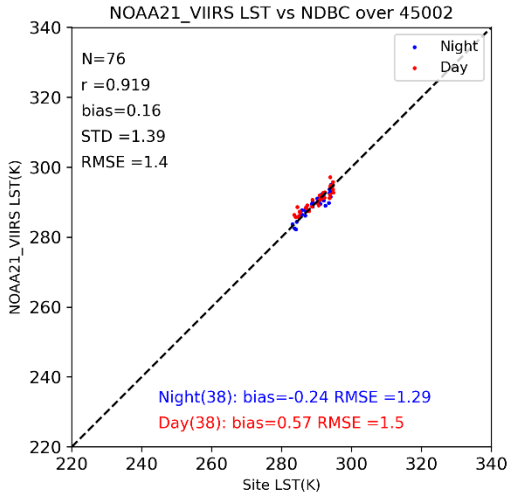


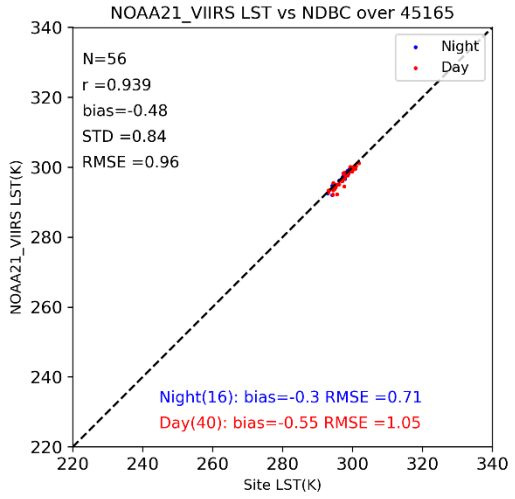


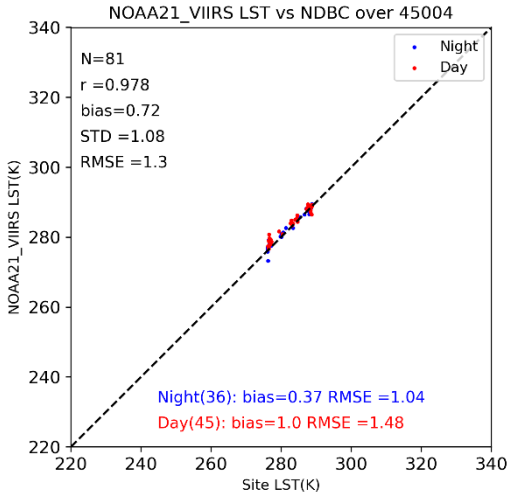


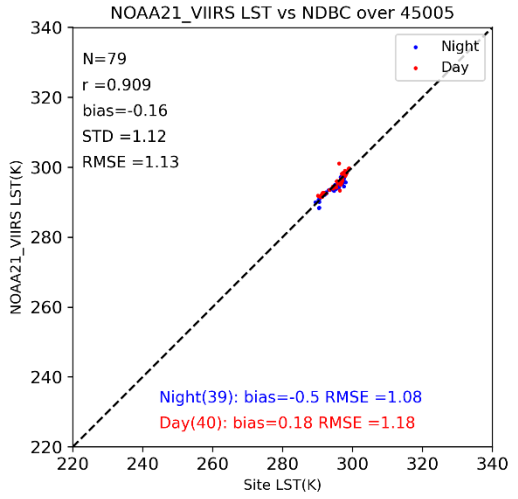






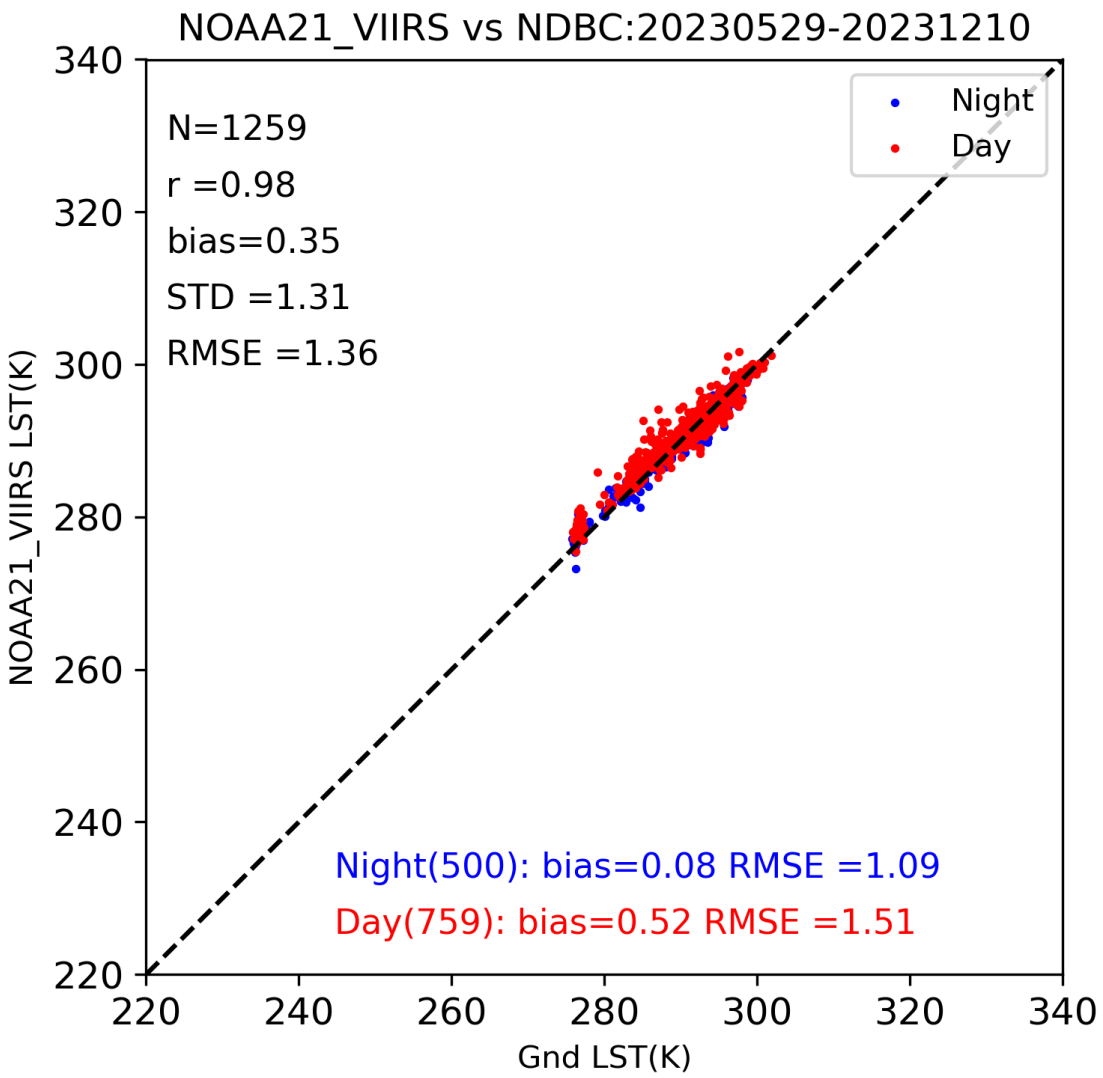


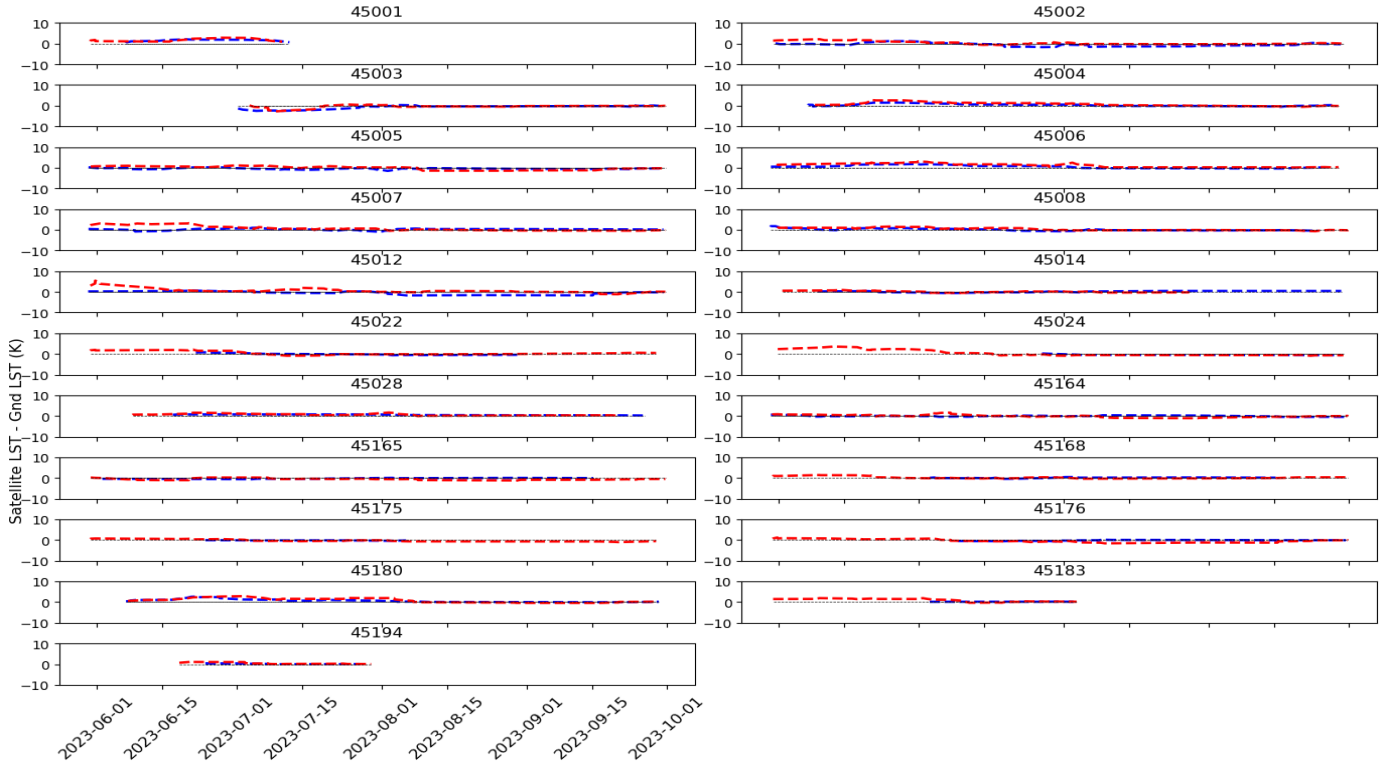




- Twenty two stations from NDBC were employed for ground validation, covering the time period from June to October 2023. The validation involves a direct comparison between satellite LST and buoy observations.
- This slide presents validation results for selected stations.

NOAA-21 LST Ground Validation-NDBC (2)

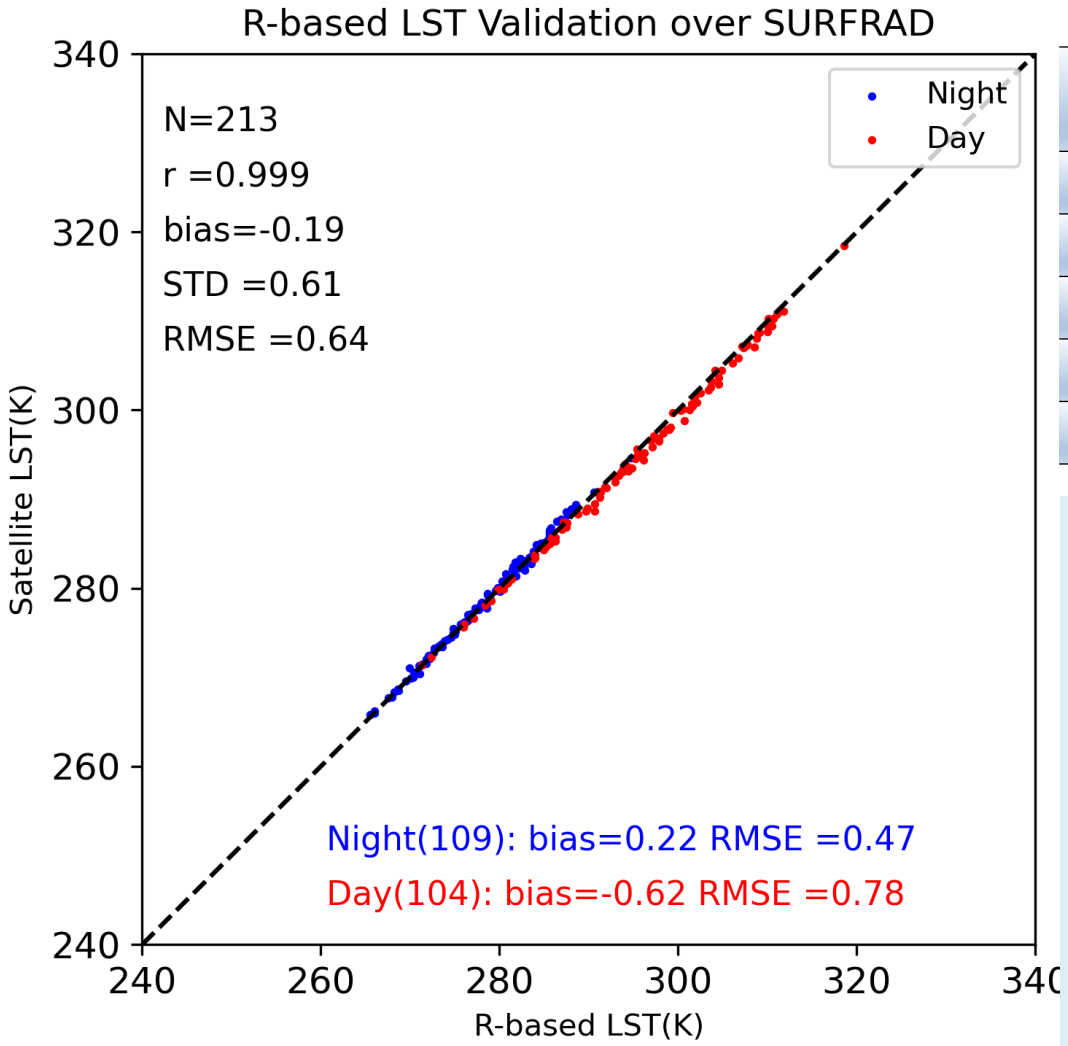




- Left figure presents the combined validation results from 22 NDBC stations, while the right figure displays the sitewide LST error time series.
- The combined day/night results indicate a bias of 0.35 K and a precision of 1.3 K. Nighttime outperforms daytime with a bias of 0.1 K and RMSE of 1.1 K, while it is 0.5 K and 1.5 K for daytime.
- The time series indicates a generally stable result over time with slight variation in early summer time..

Radiance based LST validation

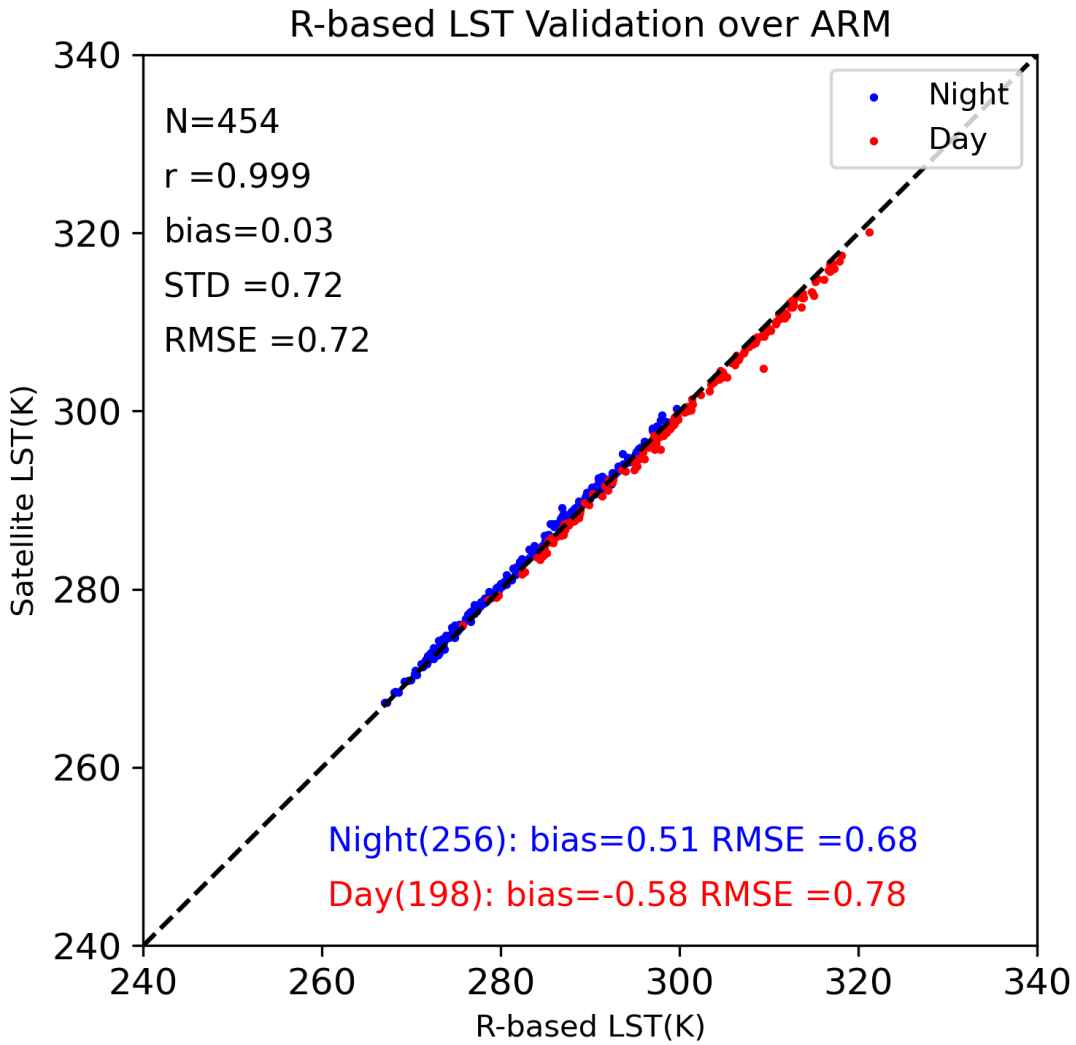
R-based LST Validation over SURFRAD Stations



Station Name	Total	Bias	STD	Sample (N)	Bias (N)	STD (N)	Sample (D)	Bias (D)	STD (D)
BND	54	-0.27	0.77	27	0.23	0.65	27	-0.77	0.5
TBL	63	-0.11	0.36	37	0.12	0.2	26	-0.43	0.28
FPK	37	-0.25	0.69	15	0.42	0.34	22	-0.7	0.46
PSU	15	-0.21	0.43	7	0.1	0.19	8	-0.48	0.39
SXF	44	-0.16	0.64	23	0.28	0.35	21	-0.64	0.53

- R-based NOAA-21 VIIRS LST validation was conducted over SURFRAD stations for the time period from May 29, 2023 to December 10, 2023.
- The left figure displays the combined results from five SURFRAD stations, revealing an overall bias of -0.2 K and a STD of 0.6 K.
- The sitewide results indicates a positive bias during nighttime, ranging from 0.1 to 0.4 K, with STD values below 0.7 K. A negative bias is observed during daytime, ranging from -0.77 K to -0.43 K with STD values below 0.5 K

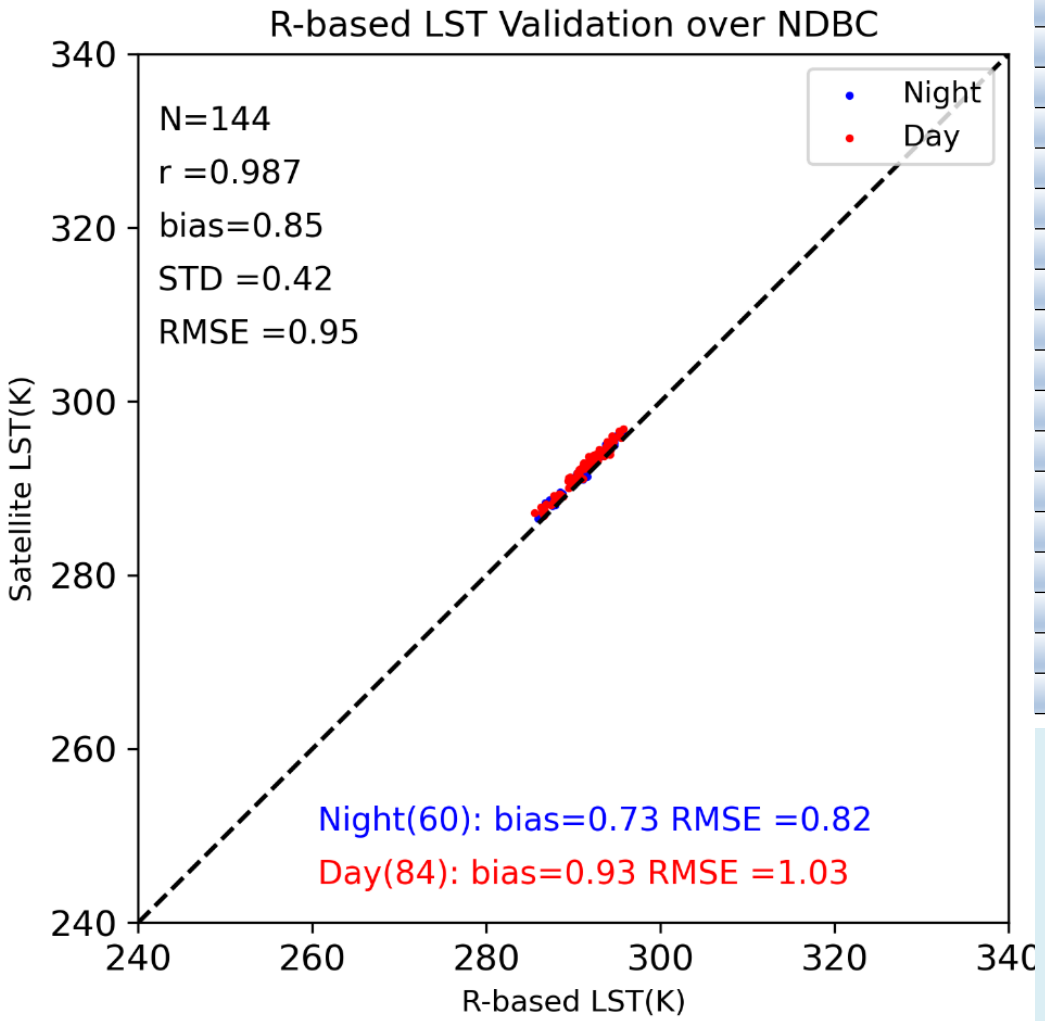
R-based LST validation over ARM Stations



Station Name	Samples	Bias	RMSE	Sample (N)	Bias (N)	STD (N)	Sample (D)	Bias (D)	STD (D)
sgpsirsE11	7	0.48	0.99	5	1.03	0.56	2	-0.9	--
sgpsirsE12	81	-0.02	0.69	46	0.47	0.45	35	-0.66	0.33
sgpsirsE13	82	-0.1	0.64	44	0.34	0.41	38	-0.62	0.43
sgpsirsE15	11	-0.14	0.72	6	0.34	0.66	5	-0.71	0.12
sgpsirsE32	74	0.16	0.59	44	0.53	0.39	30	-0.39	0.36
sgpsirsE33	63	-0.03	0.64	33	0.44	0.4	30	-0.55	0.4
sgpsirsE34	12	-0.09	1.57	8	0.78	0.34	4	-1.83	1.62
sgpsirsE35	8	0.46	0.59	6	0.69	0.51	2	-0.22	--
sgpsirsE36	11	0.1	0.78	7	0.59	0.48	4	-0.76	0.29
sgpsirsE37	83	0.07	0.67	43	0.56	0.35	40	-0.47	0.49
sgpsirsE40	8	0.65	0.81	6	0.95	0.71	2	-0.24	--
sgpsirsE9	14	-0.12	0.85	8	0.44	0.51	6	-0.87	0.61

- R-based validation of NOAA-21 VIIRS LST was conducted over ARM stations for the time period from May 29, 2023 to December 10, 2023.
- The left figure displays the combined results from thirteen ARM stations, revealing an overall bias of 0.03 K and a STD of 0.7 K.
- The sitewide results show a positive bias during nighttime, ranging from 0.34 K to 1.03 K, with STD below 0.7 K. A negative bias is observed during daytime, ranging from -1.83 K to -0.22 K with STD values below 1.6 K. It is essential to note that the site wide statistics are not considered significant due to the small sample size.

R-based LST validation over NDBC



Station Name	Samples	Bias	STD	sample(N)	bias(N)	STD(N)	sample(D)	bias(D)	STD(D)
45002	10	0.79	0.47	6	0.58	0.36	4	1.12	0.42
45003	9	0.89	0.34	6	0.94	0.41	3	0.8	0.02
45004	12	0.89	0.44	5	0.89	0.43	7	0.89	0.45
45005	10	0.82	0.39	4	0.78	0.43	6	0.85	0.35
45006	10	0.9	0.41	3	0.85	0.5	7	0.92	0.36
45007	7	1.18	0.46	3	0.82	0.26	4	1.45	0.39
45008	7	0.81	0.28	4	0.8	0.31	3	0.83	0.23
45012	12	0.78	0.3	6	0.86	0.33	6	0.7	0.23
45014	2	0.85	nan	2	0.85	0.22	0	nan	nan
45022	6	0.83	0.57	1	-0.18	nan	5	1.03	0.38
45024	6	1.06	0.63	1	0.62	nan	5	1.15	0.66
45028	5	0.73	0.43	3	0.45	0.3	2	1.15	nan
45164	11	0.89	0.4	5	0.66	0.24	6	1.08	0.41
45165	11	0.61	0.46	2	0.38	nan	9	0.66	0.49
45168	8	0.94	0.38	2	0.65	nan	6	1.04	0.39
45175	2	0.85	nan	0	nan	nan	2	0.85	nan
45176	8	0.75	0.25	4	0.66	0.27	4	0.84	0.19
45180	8	0.79	0.34	3	0.79	0.16	5	0.8	0.41

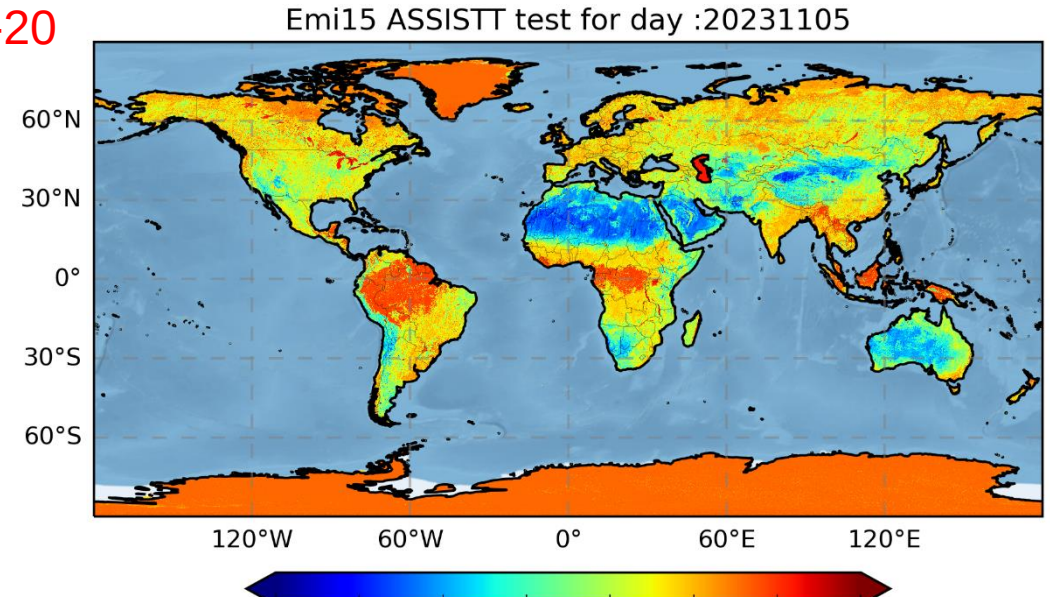
- R-based validation of NOAA-21 VIIRS LST was conducted over NDBC stations for the time period from Aug. 22 to Sep. 30, 2023.
- The left figure displays combined results from 22 NDBC stations, revealing an overall bias of 0.4 K and STD of 0.85 K.
- The sitewide results shows a positive bias for both daytime and nighttime over all stations, with a small STD below 0.6 K.
- It is essential to note that the site wide statistics are not considered significant due to the small sample size.

Evaluation of the effect of required algorithm inputs

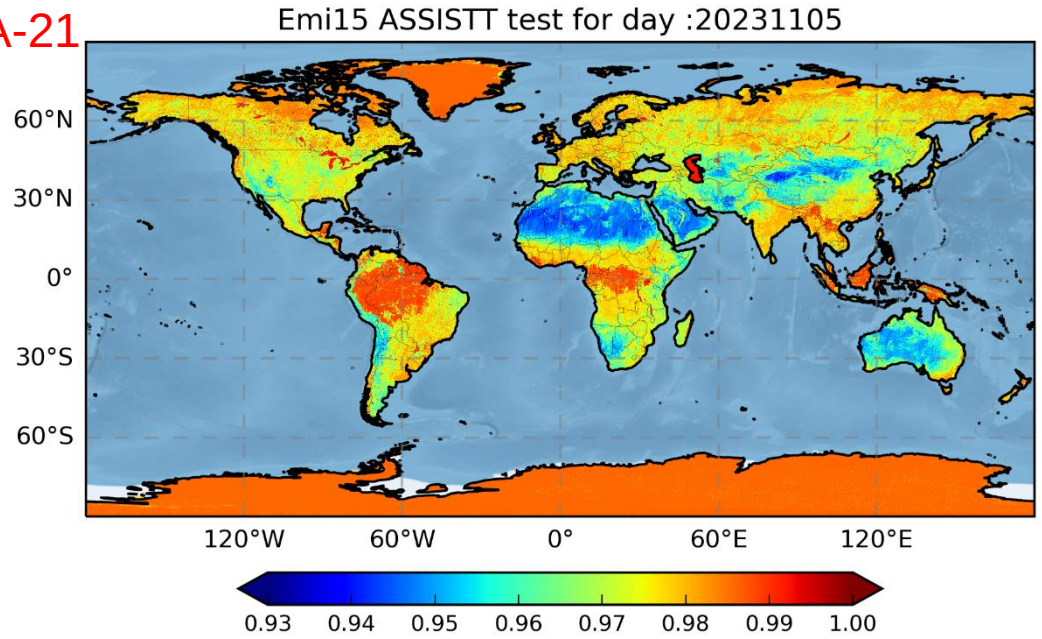
- Required Algorithm Inputs
  - Primary Sensor Data
    - VIIRS M-band SDR(M15 and M16 brightness temperature), geometry and geolocation
  - Ancillary Data
    - Land/sea mask
  - Upstream algorithms
    - LSE, AOD, Cloud mask, snow mask, GFS forecast (total precipitable water vapor)
  - LUTs / PCTs
    - LST LUT, configuration parameters
- Evaluation of the effect of required algorithm inputs
  - NOAA-21 LSE data evaluation
    - Visual analysis
    - Inter-sensor comparison with S-NPP and NOAA20 LSE data

LSE Evaluation

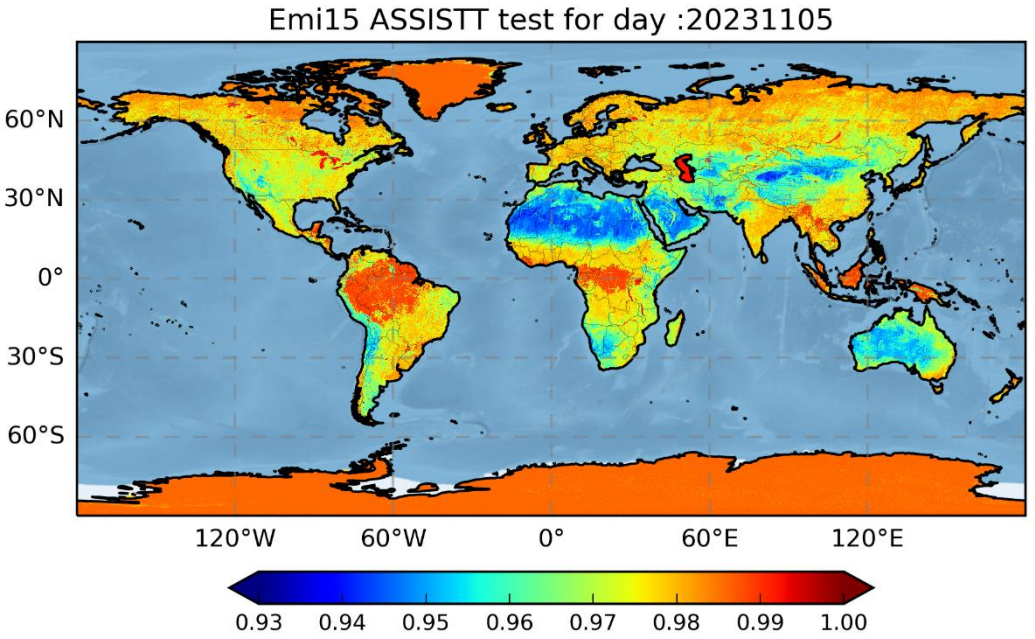
NOAA-20



NOAA-21



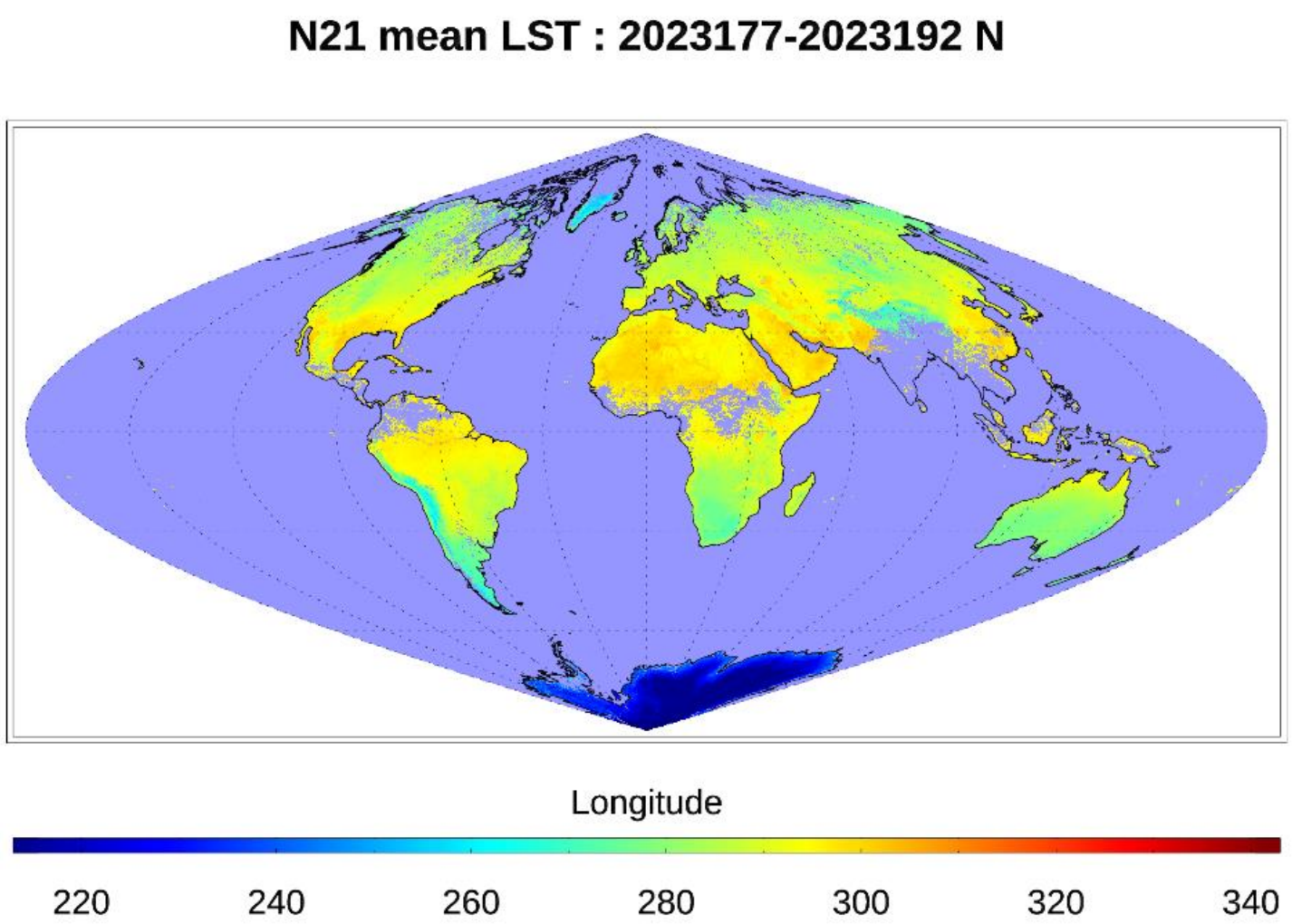
SNPP

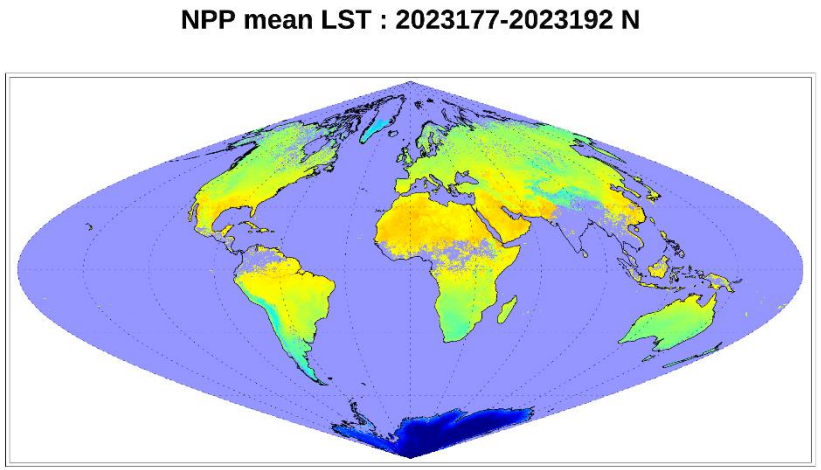


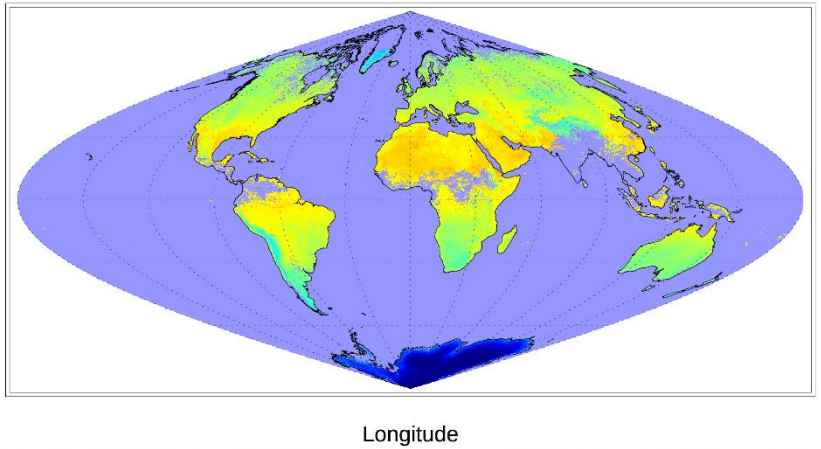
- This slide shows LSE data from three satellites: NOAA-20(top left), S-NPP(bottom left), and NOAA-21(top right)
- The LSE data is overall consistent among the three satellites.
- Differences are mainly observed over snow covered area, which is expected due to the differences in the snow input. However, the impact on LST is statistically insignificant.
- It agrees well in non-snow areas.

Inter-comparison with
L3 SNPP and NOAA-20 VIIRS LST
Cross-comparison with
L3 MODIS LST and VNP21A1 LST

L3 VIIRS LST Inter-comparison- Nighttime

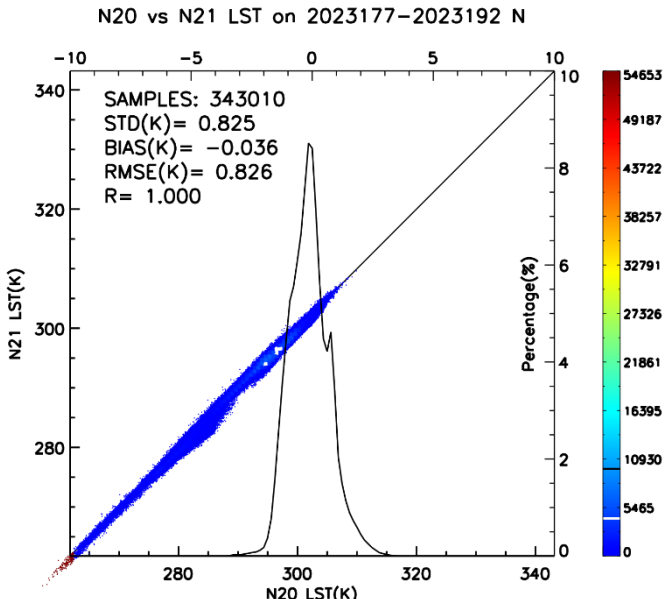


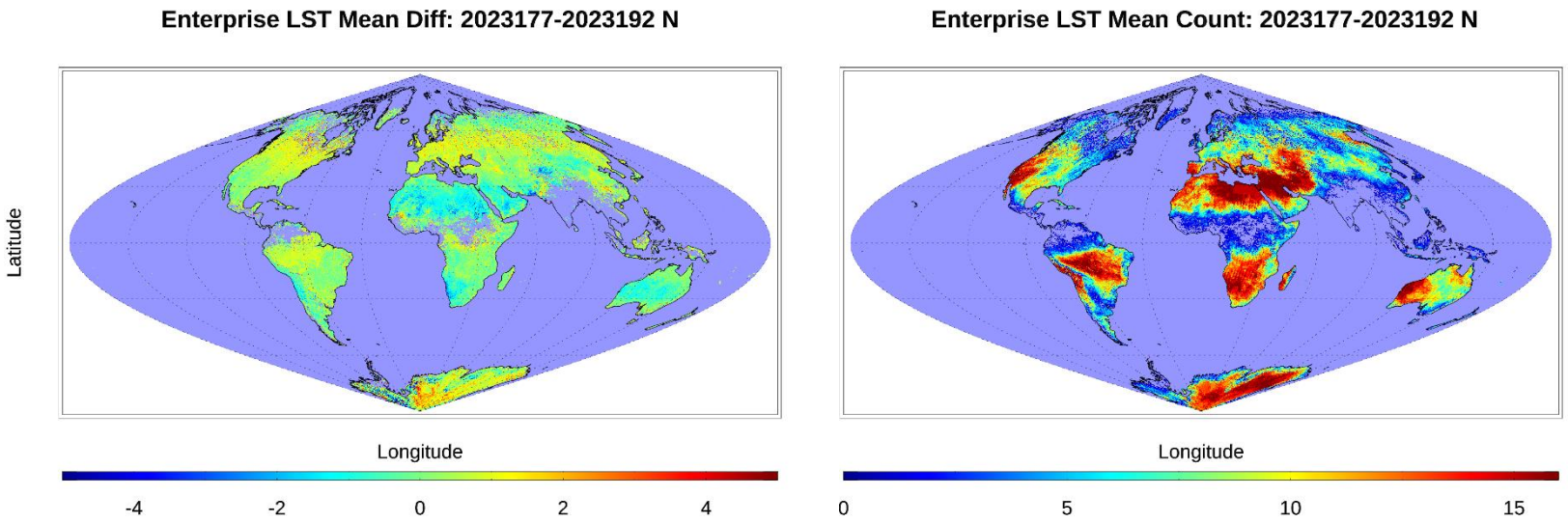




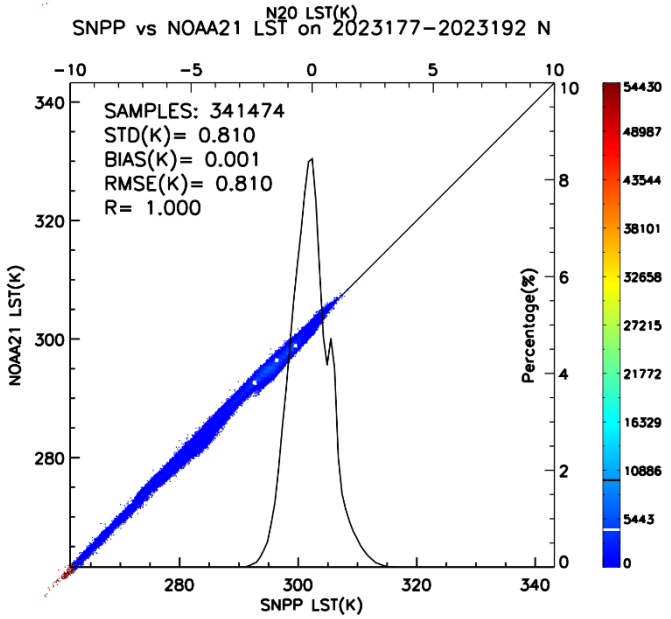
- The nighttime inter-comparison among JPSS VIIRS LSTs is conducted based on the mean LST calculated within consecutive 16-day time periods to mitigate the impact from viewing angle and view time. The time period covers from June 26 to July 11, 2023.
- The comparison used only cloud clear pixels in the statistics. The left figure display the mean LST for NOAA21, the top right figure shows the mean LST for SNPP, while the bottom right shows the mean LST for NOAA-20.

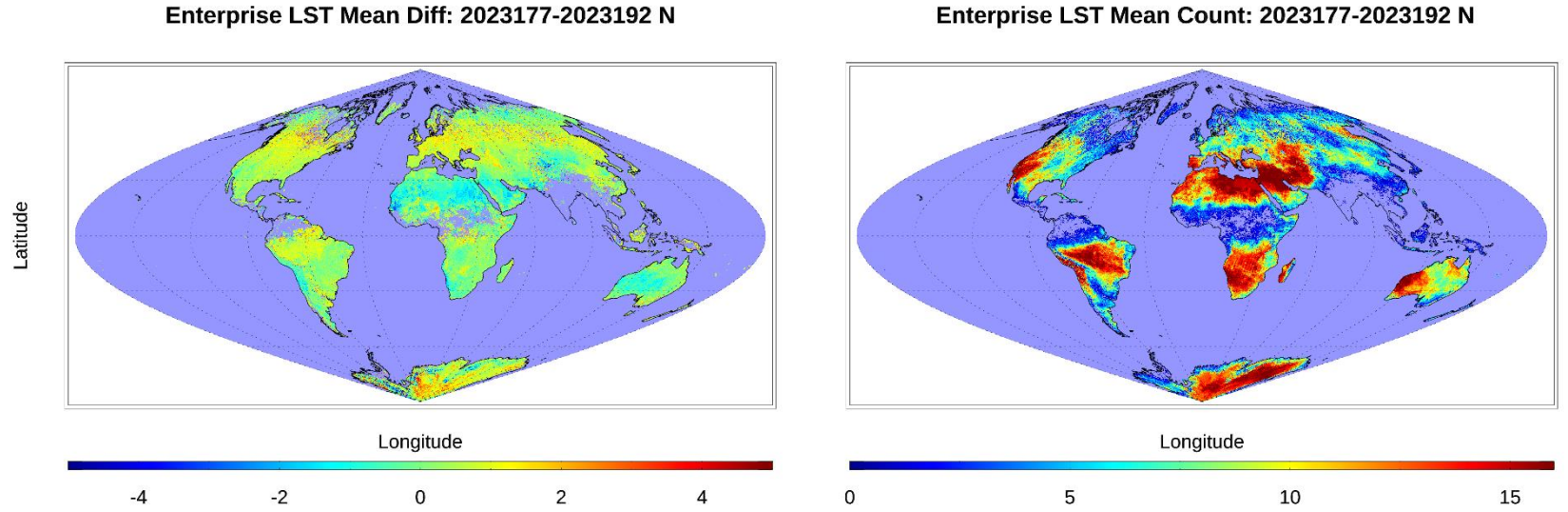
L3 VIIRS LST Inter-comparison- Nighttime





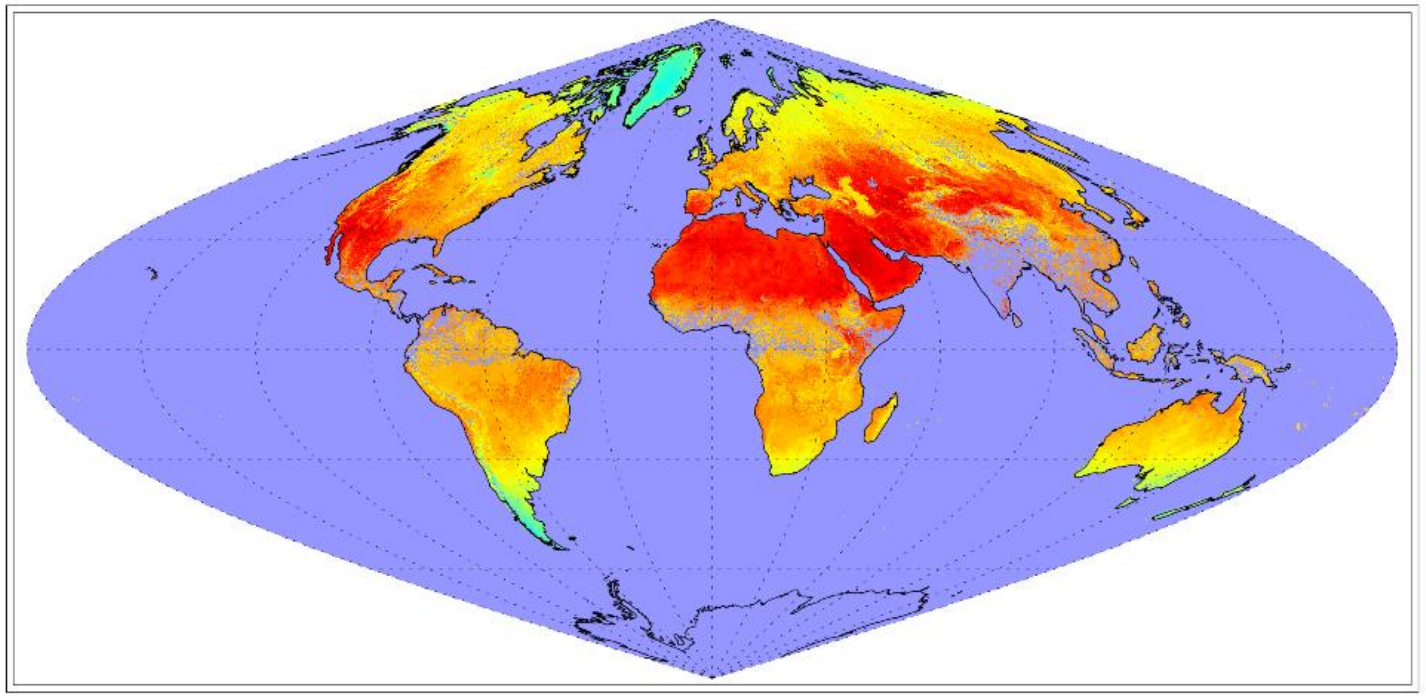
N20

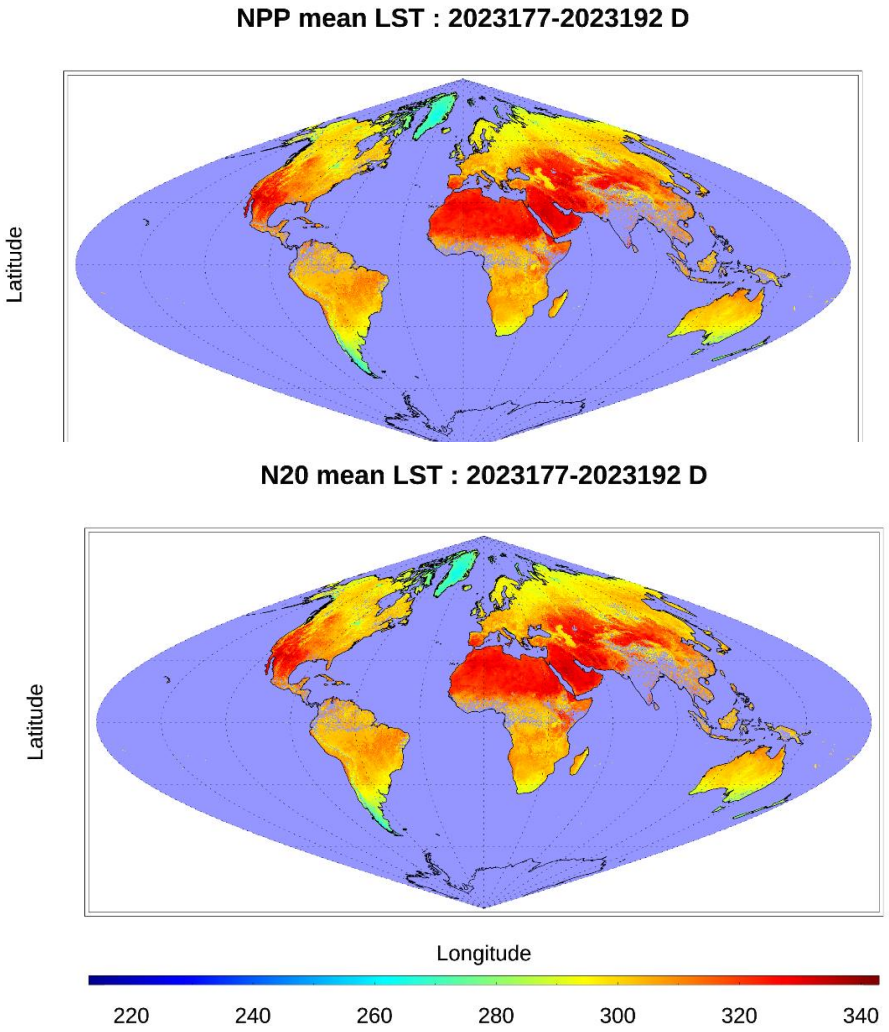




SNPP

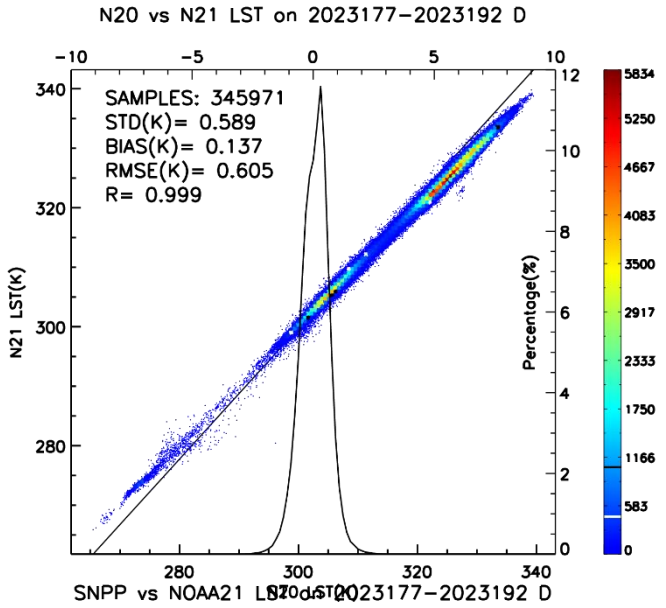
L3 VIIRS LST Inter-comparison- Daytime

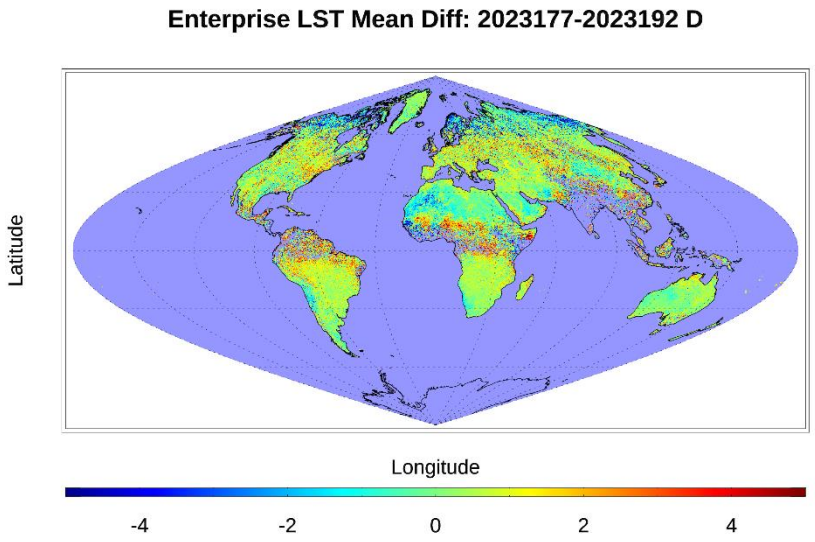


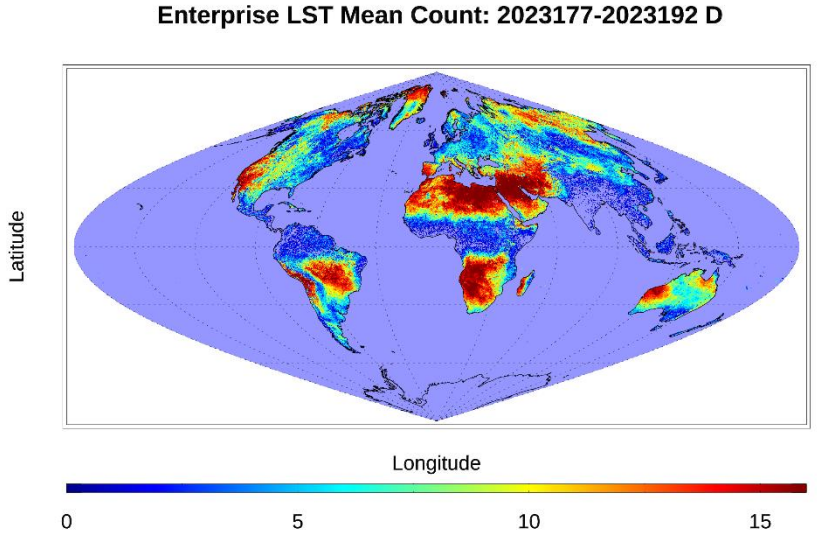


- The daytime inter-comparison among JPSS VIIRS LSTs is conducted based on the mean LST calculated within consecutive 16-day time periods to mitigate the impact from viewing angle and view time. The time period covers from June 26 to July 11, 2023.
- The comparison used only cloud clear pixels in the statistics. The left figure display the mean LST for NOAA21, the top right figure shows the mean LST for SNPP, while the bottom right shows the mean LST for NOAA-20.

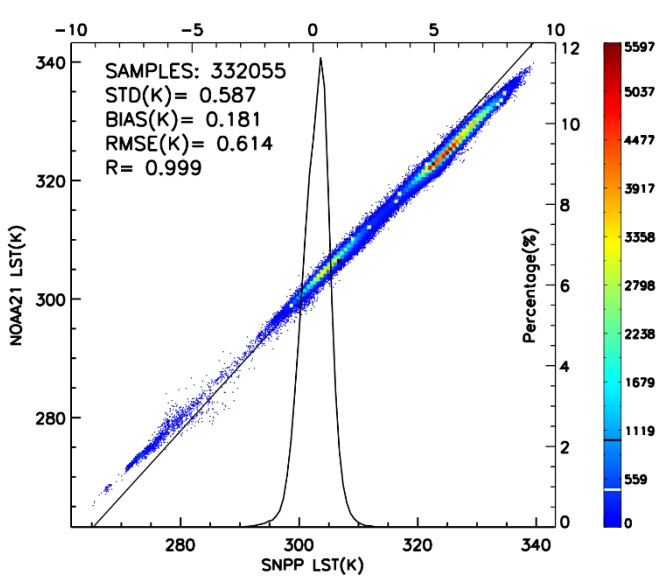
L3 VIIRS LST Inter-comparison- Daytime

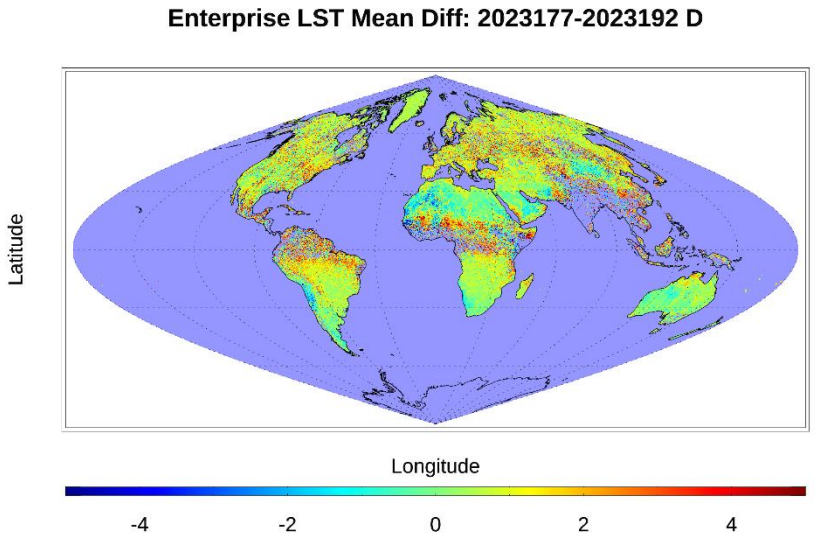


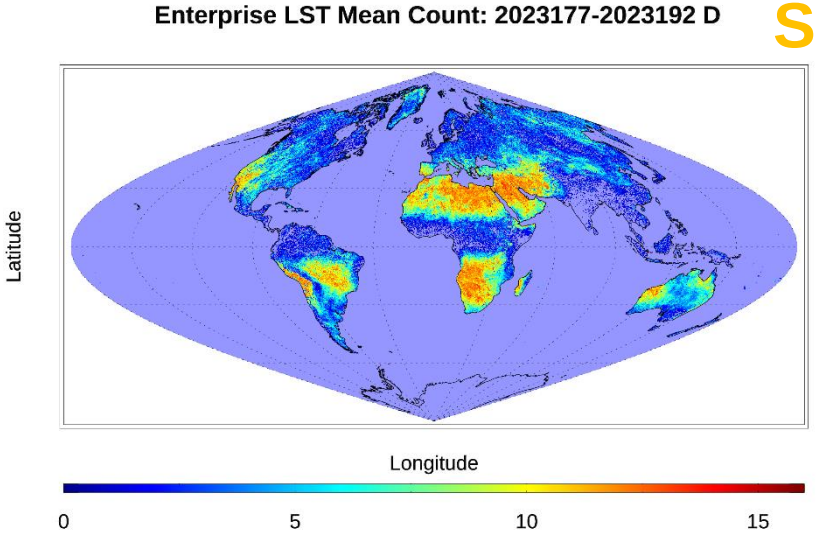




N20

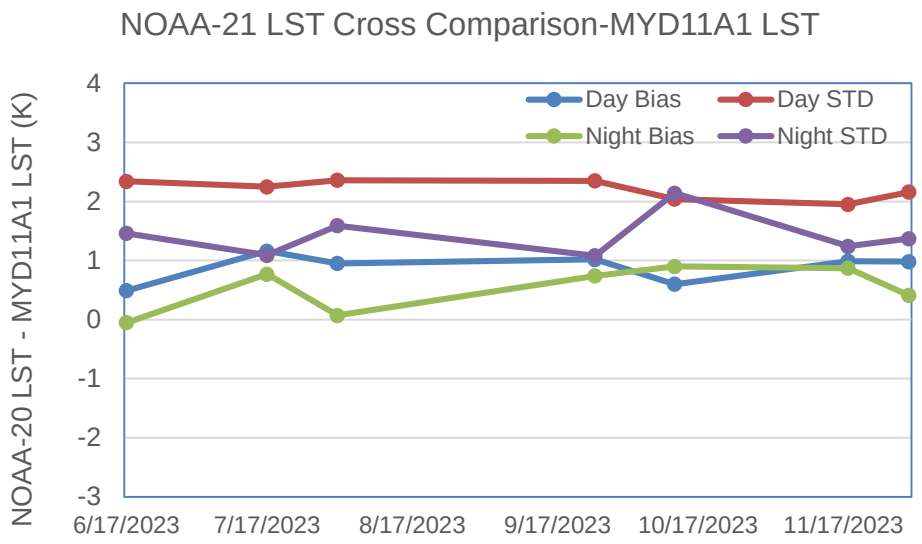




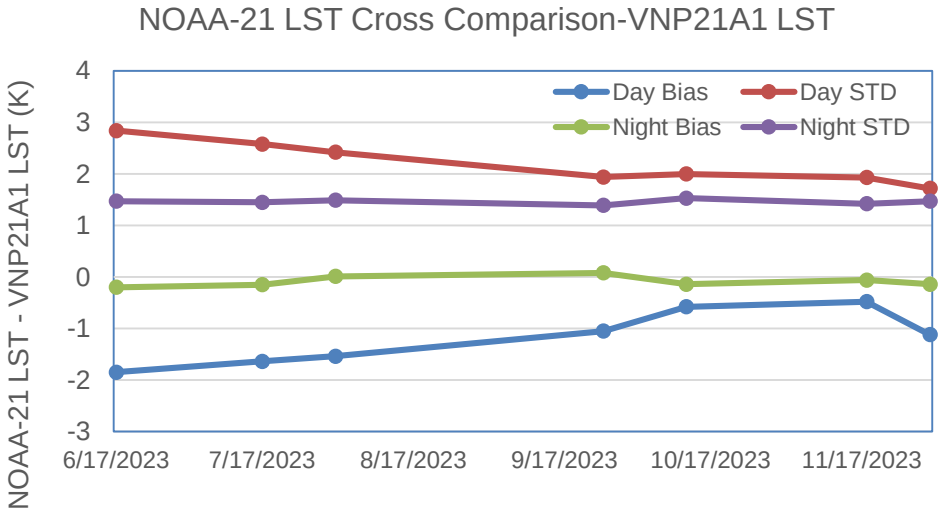


SNPP

Cross comparison with MYD11A1 and VNP21A1



- Spatial coverage: global
- Temporal coverage : on day in each month from June to December, 2023
- Day/night: both included
- MODIS Product selection: MYD11A1, L3 daily Aqua MODIS LST latest version in 061 was selected for the cross comparison.
- VNP21A1 LST Product, L3 daily SNPP VIIRS LST, were also used for the comparison
- Comparison criteria: both cloud clear, MODIS/VNP high quality, absolute viewing angle difference less than 10 degree; temporal difference less than 12 minutes for MYD11A1; while it is 24 minutes for VNP21A1 due to the distinct orbit colocation with NOAA-21.



- Overall the comparison results indicate more variations in both bias and STD in comparison with MYD11A1, compared to that with VNP21A1.
- During the daytime, NOAA-21 LST tends to be higher than MYD11A1 LST, but lower than VNP21A1 LST.
- At nighttime, NOAA-21 LST closely aligns with VNP21A1 LST, while NOAA-21 LST is higher than MYD11A1 LST.
- NOAA-21 LST falls between the two reference LSTs for both daytime and nighttime.
- This cross compassion result is influenced by various factors, including LST retrieval algorithm, composition method, temporal variations, impact of cloud residues.

Error Budget

Attribute Analyzed	DPS	Requirement/ Threshold	On-orbit Performance			Meet Requirement?	Additional Comments
			NOAA-21	NOAA-20	S-NPP		
Accuracy		1.4 K	SURFRAD:0.44 k ARM:0.96k BSRN: -0.15 K NDBC: 0.35 k	SURFRAD: -0.45K ARM:0.34 k BSRN: -0.23 K	SURFRAD: -0.37k ARM: -0.06 k BSRN:-0.19K	YES	Results for S-NPP and NOAA-20 are based on a long term data record
Precision		2.5 K	SURFRAD: 1.71 k ARM: 1.90 k BSRN: 1.89 k NDBC: 1.31 k	SURFRAD: 1.86 k ARM: 1.69 k BSRN:1.94 K	SURFRAD: 1.92k ARM: 1.7 k BSRN:1.92 K	YES	
Uncertainty							

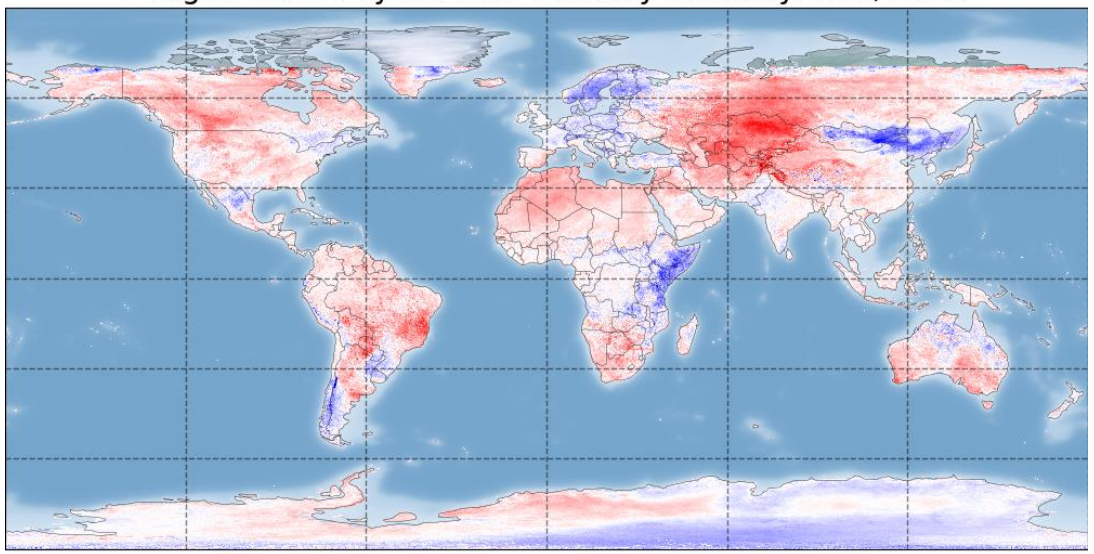
- The LST error statistics is based on the validation against independent ground measurements over a limited six month period. The error budget is constrained by factors such as ground data quality control, cloud filtering procedures, upstream data uncertainties, and inherent heterogeneity in the matchup process.
- To address these limitations, we will strengthen ground data quality control procedure, implement advanced view angle correction technique, further improve the matchup procedure, develop techniques to systematically address bias and mitigate errors, and conduct a comprehensive analysis using extended long term data.

User Feedback

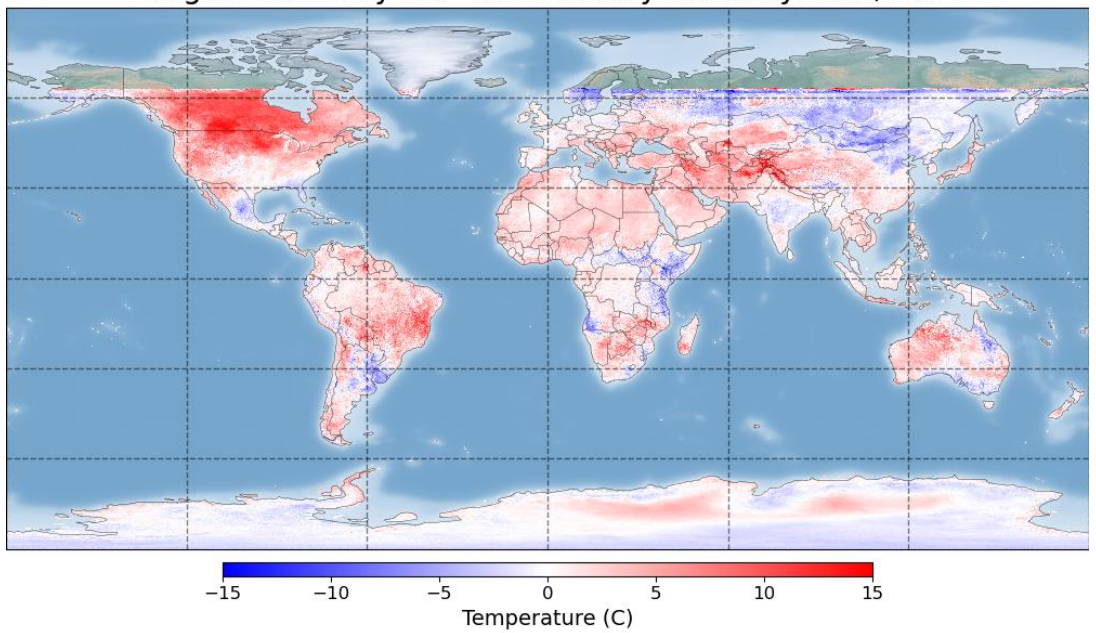
Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Jifu Yin	STAR/NESIS	Soil moisture product downscaling from 25 km to 1 km	There is an inherent relationship between soil moisture and land surface temperature, which provides ancillary information on soil moisture distributions and estimations. In addition, microwave soil moisture product has coarse spatial resolution (25 km), the VIIRS LST product with high spatial resolution thus can be used to produce finer resolution satellite soil moisture retrievals. The gridded LST over CONUS and global domain has been routinely ingested in the generation of soil moisture product in high spatial resolution.
Li Fang	STAR/NESIS	Global ET product generation based on VIIRS LST product at 1 km spatial resolution	VIIRS day/night LST product has been routinely collected as a key input in the global ET/drought system.
Michael Barlage	NCEP/EMC	EMC NWP Models	EMC Priority product for Land Data Assimilation.

Global Monthly LST analysis: December 2023

Merged VIIRS daytime LST monthly anomaly: Nov, 2023



Merged VIIRS daytime LST monthly anomaly: Dec, 2023

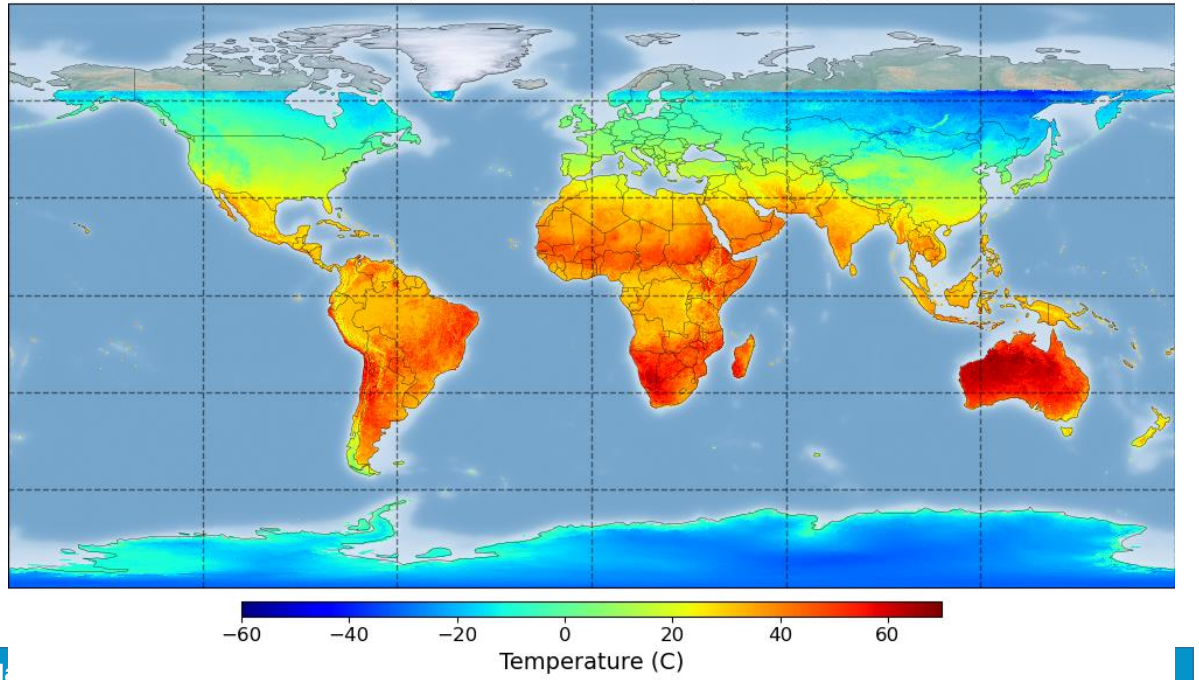


According to numerous reports, including Copernicus, ABC, New York Times, Reuters, CBS News, the Guardian, BBC, etc. this year has been confirmed as the hottest year on record surpassing 2016, the previous hottest year, by a large margin. The data for this record goes back to 1850.

Similar to November, the main theme of this month remained warmer than usual throughout the globe, with few exceptions, mainly the high latitude area of Europe and Asia,

While the broad warm anomaly in Central Asia subsided somewhat, an intense heatwave encompassed nearly all of Canada.

Merged VIIRS daytime LST monthly average: Dec, 2023



Risks, Actions, and Mitigations

- Provide updates for the status of the risks/actions identified during the previous maturity review(s); add new ones as needed

Identified Risk	Description	Impact	Action/Mitigation and Schedule
Land Surface Emissivity	The GVF issue was observed in NPP and NOAA20 and it was confirmed that the same issue occurs to NOAA-21 as well. GVF at the beginning is of poor quality, which also affects the quality of LSE.	Issues in LSE will affect LST quality	The issue in NOAA-21 GVF has been resolved since June 16, 2023.
LST composition method update	The new composition method has been applied in NOAA-21 LST, while NOAA-20 and SNPP are still using the previous composition method.	Inconsistency among the L3 VIIRS LST.	Further testing will be conducted upon the application of updates to SNPP and NOAA20. Meanwhile, monitor the performance of NOAA-21 LST over an extended time period.
Data missing	The data stream is not stable yet. Data missing happens sometime.	Incomplete LST dataset. Statistical and time series analysis might be affected	Timely notifications about the data missing are reported to NDE I&T. Some instances of missing are attributed to the unavailability of IDPS data stream. Meanwhile, others have been addressed and are under continuous monitoring.

Documentations (Check List, 1 slide)

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes
System Maintenance Manual (for ESPC products)	Yes
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	Yes

Check List - Provisional Maturity

Provisional Maturity End State	Assessment
Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from select locations, periods, and associated ground truth or field campaign efforts.	Yes. A comprehensive evaluation was conducted using available independent ground measurements from multiple networks. The validation included radiance based LST validation using radiative transfer modeling (Modtran). Additionally LST data form SNPP LST, NOAA-20, and the latest MODIS AQUA LST used in the cross comparison.
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	Yes.
Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.	Yes
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	Yes. Limitations are noted in the Readme.

Conclusion

– **Team recommends algorithm Provisional maturity**

- The NOAA-21 LST data has been validated using ground observations from multiple networks including SURFRAD, ARM, BSRN, and NDBC, representing diverse surface types. The statistical results meet the specified requirements.
- Radiance based validation has been performed across multiple stations, revealing a bias ranging from -0.19 K to 0.85 K and a STD ranging from 0.42 K to 0.72 K, well below the requirements.
- The inter-comparison among the three VIIRS LSTs has been conducted, demonstrating overall close statistics for both daytime and nighttime.

Path Forward

- Lessons learned for NOAA-21 Cal/Val
  - The limited availability of data imposes constraints on conducting a seasonal analysis and assessing the long term stability for the statistical evaluation of the product's performance
- Planned improvements
  - NOAA-21 LST LUT may need a tune-up
  - Comprehensive evaluation is planned using longer time period of data.
  - Closely monitor the differences among the VIIRS LSTs from SNPP, NOAA-20 and NOAA-21 resulting from the implementation of the new composition method.
- Future Cal/Val activities / milestones
  - Validated maturity review in 12 months