FRM4STS International Workshop, National Physical Laboratory, Teddington, UK

Land surface temperature products validation for GOES-R and JPSS missions: status and challenge

Yuhan Rao[1,2], Yunyue (Bob) Yu[3], Peng Yu[1,3], Yuling Liu[1,3], Heshun Wang[1,3]

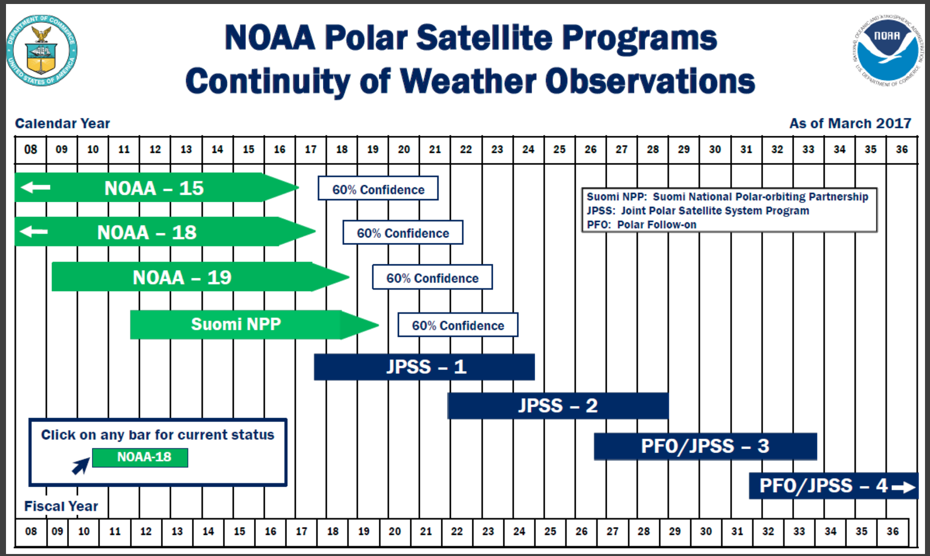
Email: yrao@terpmail.umd.edu

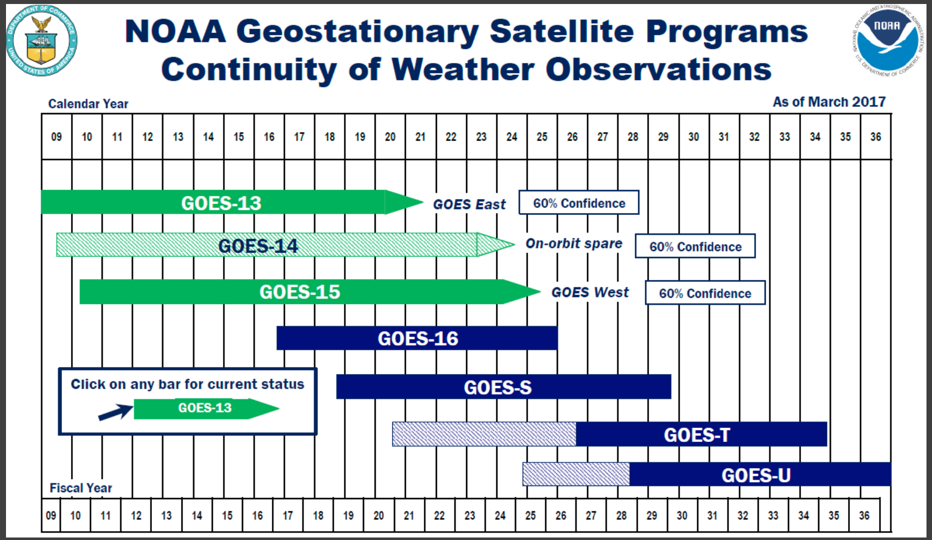
1. Cooperative Institute for Climate and Satellites-Maryland, University of Maryland
2. Department of Geographical Sciences, University of Maryland
3. Center for Satellite Applications and Research, NOAA NESDIS

Contents

- A glimpse of JPSS and GOES-R LST products
- Evolution of LST algorithm for JPSS & GOES-R
- “Point-to-Area” validation: In-situ measurement comparison
- “Area-to-Area” validation: Cross satellite comparison
- Challenges and future plans
- Concluding remarks

A glimpse of JPSS and GOES-R LST products





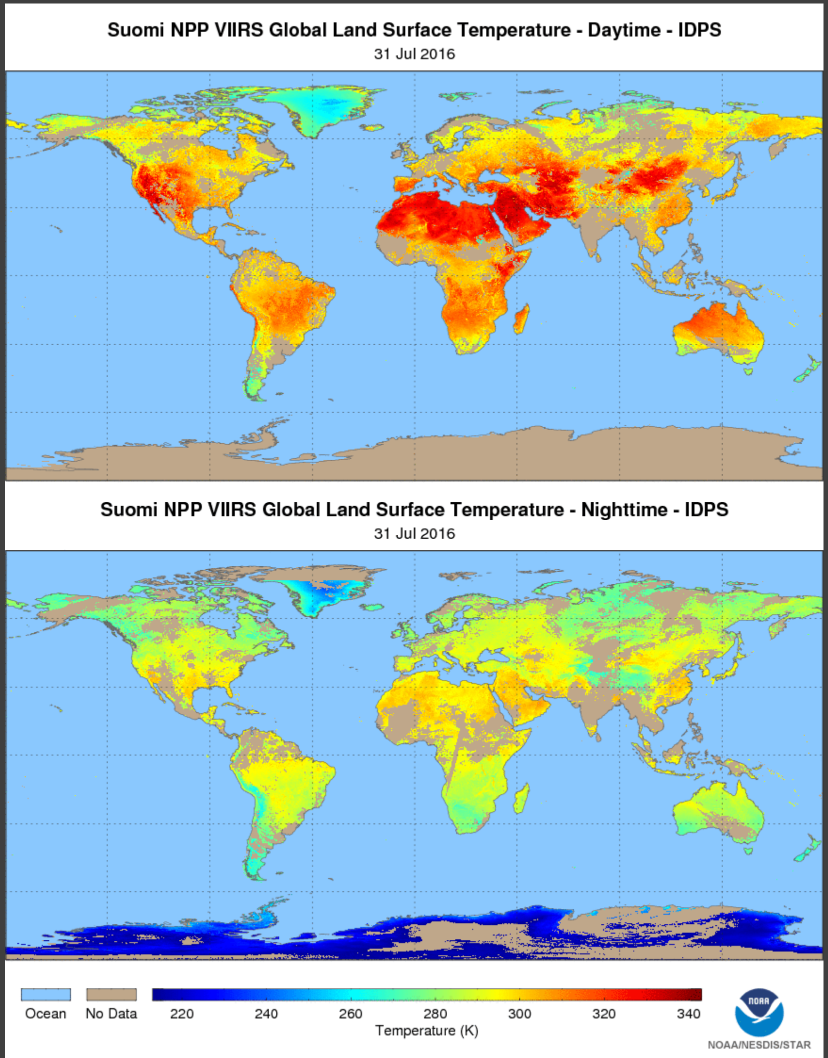
Credit: NOAA NESDIS

JPSS Missions (2011-2038):

- Next generation polar-orbiting operational environmental satellite system;
- Five satellite constellation (Sunomi-NPP, JPSS-1/2/3/4)
- Sunomi-NPP launched October 28, 2011;
- JPSS-1 will be launched November 10, 2017;
- Visible Infrared Imaging Radiometer Suite (VIIRS).

GOES-R Missions (2016-2036):

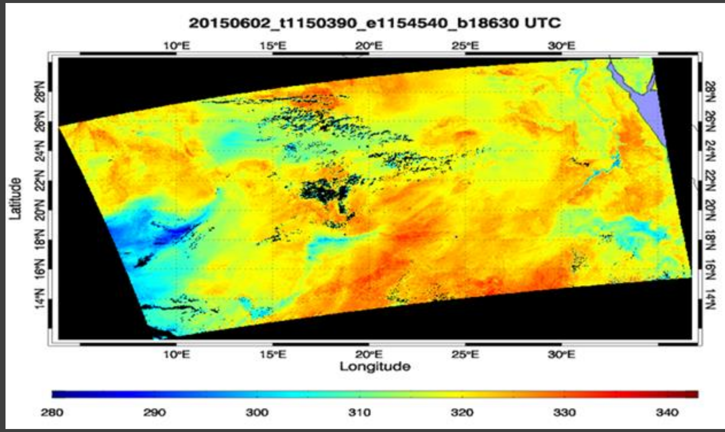
- Next generation geostationary weather satellite
- Four satellites (GOES-R/S/T/U)
- GOES-R(16) launched November 19, 2016
- Advanced Baseline Imager (ABI).



Operational JPSS Products:

- Single 1.5 min granule data
- Combined 4 x 1.5 min granule data
- Resolution: 750 m

Gridded L3 VIIRS LST product is under development.



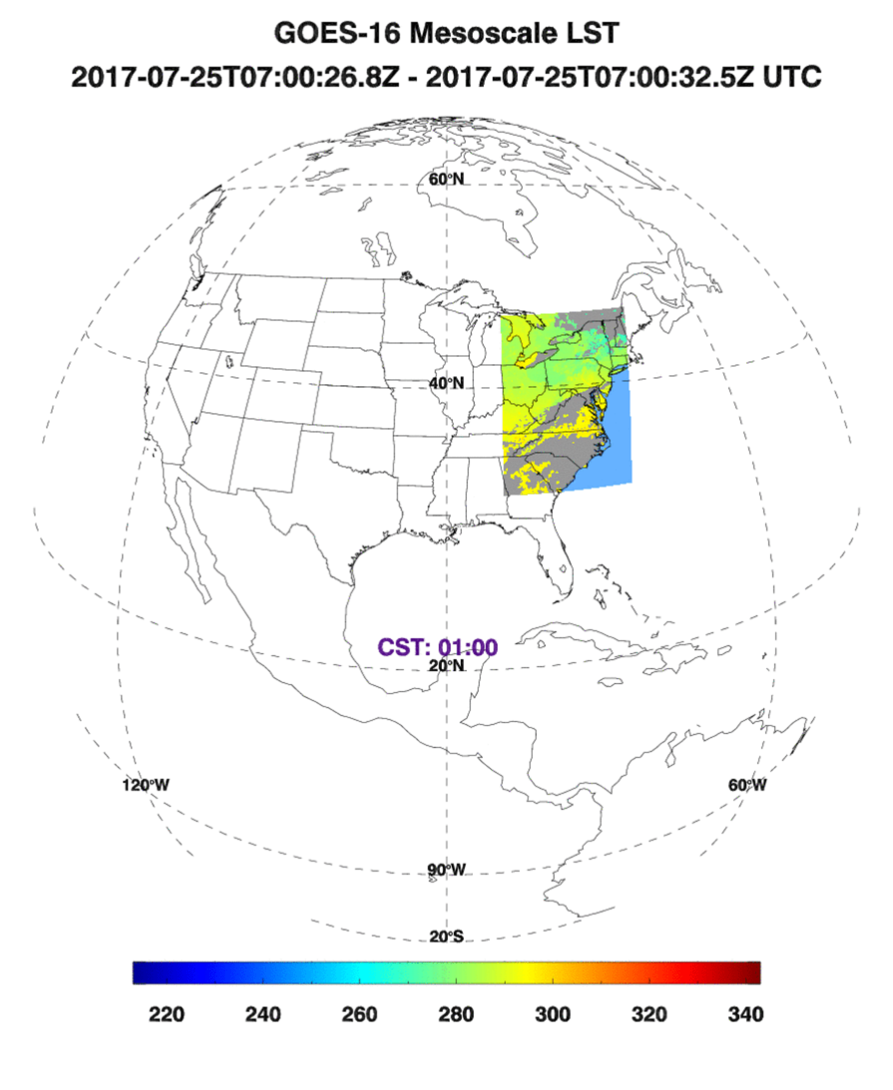
Archive:
https://www.class.noaa.gov/

Validation updates:
ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/single/SNPP_VIIRS/site/all_data/validation/

Monitoring:
https://www.star.nesdis.noaa.gov/jpss/EDRs/products_LST.php

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

A glimpse of JPSS and GOES-R LST products



Products	LST (Skin): CONUS	LST (Skin): Full Disk	LST (Skin): Mesoscale
Geographic Coverage	CONUS	Full Disk	Mesoscale
Horizontal Resolution	2km	10km	2km
Mapping Accuracy	1km	5km	1km
Measurement Range (K)	213 – 330	213 – 330	213 – 330
Measurement Accuracy[1] (K)	2.5	2.5	2.5
Measurement Precision (K)	2.3	2.3	2.3
Refresh Rate	60 minutes	60 minutes	60 minutes
Vendor Allocated Ground latency	3236 seconds	806 seconds	159 seconds
Extent Qualifier	Local Zenith Angle < 70	Local Zenith Angle < 70	Local Zenith Angle < 70

[1] The measurement accuracy 2.5 K is conditional with 1) known emissivity, 2) know atmospheric correction, and 3) 80% channel correction; 5K otherwise.

Scan mode 3:
- Full disk (15 mins), CONUS (5mins)
- Meso (1 min), location may vary

Scan mode 4:
- Full disk (5 mins)
- CONUS extracted from full disk

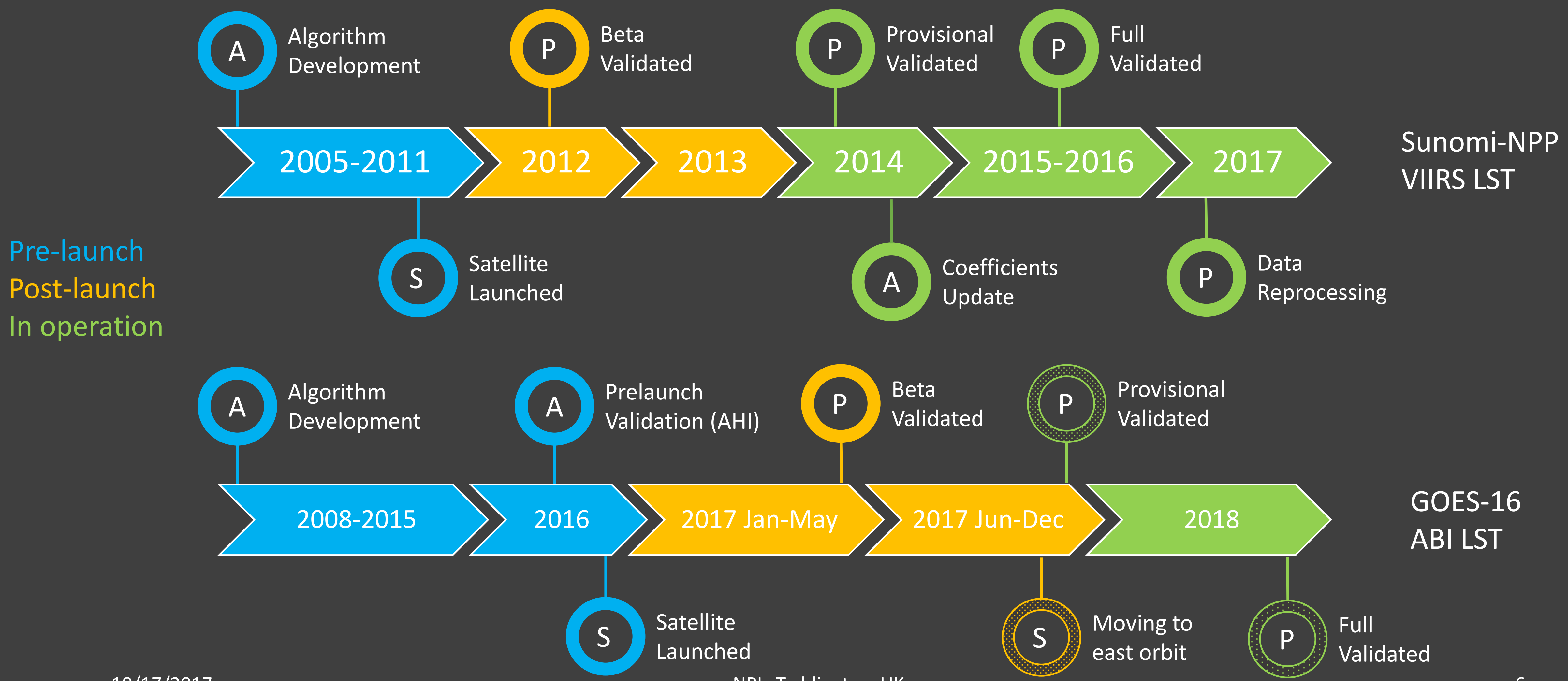
Archive:
https://www.class.noaa.gov/

ATBD:
http://www.goes-r.gov/resources/docs.html#ATBDs

Long term Monitoring:
ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/LTM/single/GOESR_ABI/

STAR LST Homepage:
https://www.star.nesdis.noaa.gov/goesr/product_land_lst.php

A timeline of JPSS & GOES-R LST products



Evolution of LST algorithm for JPSS & GOES-R

VIIRS LST

$$T_s = C + A_1 T_{11} + A_2 (T_{11} - T_{12}) + A_3 (\sec\theta - 1) + A_4 (T_{11} - T_{12})^2$$

Surface type dependent algorithm;
Look-up-table dimension: surface type, day/night

ABI LST

$$T_s = C + A_1 T_{11} + A_2 (T_{11} - T_{12}) + A_3 \varepsilon + A_4 \varepsilon (T_{11} - T_{12})(\sec\theta - 1)$$

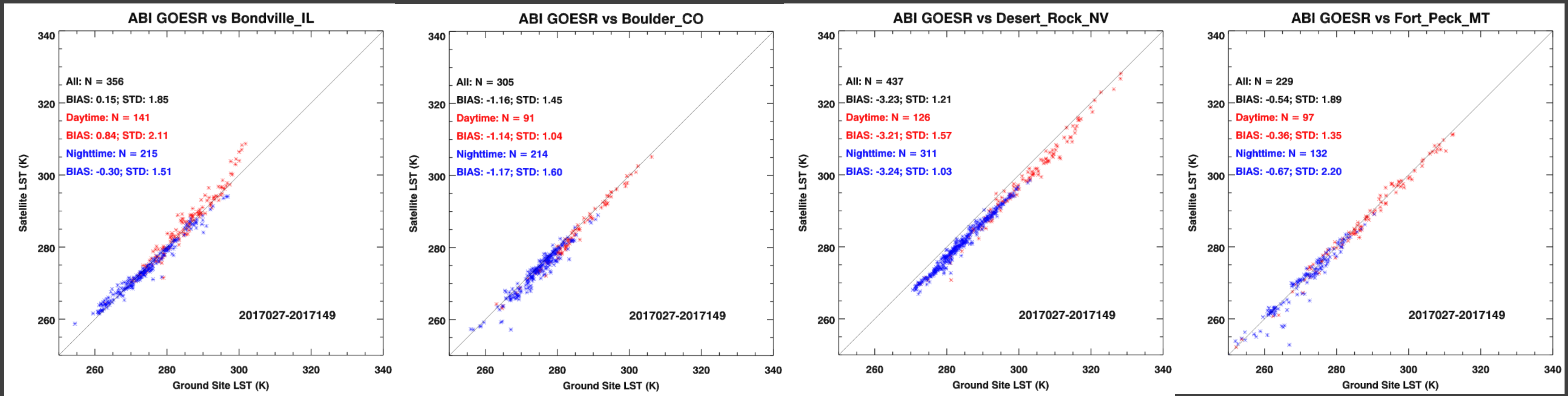
Emissivity explicit algorithm with view angle correction;
Look-up-table dimension: day/night, dry/moist

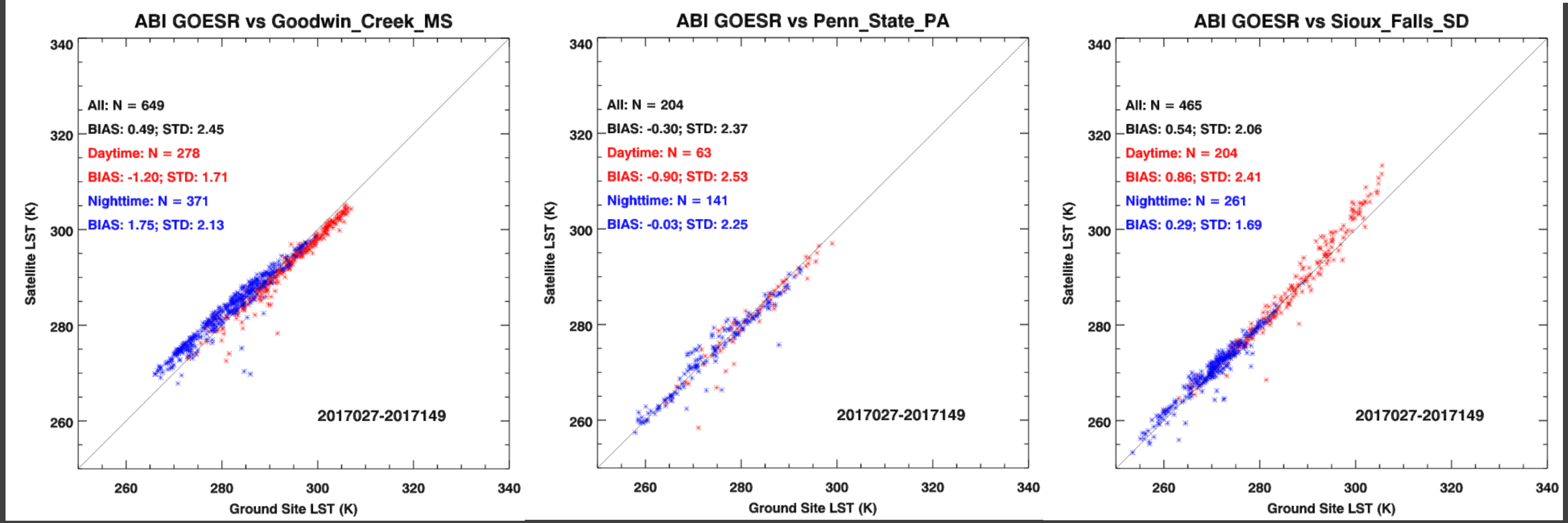
Enterprise LST

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

Unified emissivity explicit algorithm;
Look-up-table dimension: 3 TPW, 5 view angle, day/night)

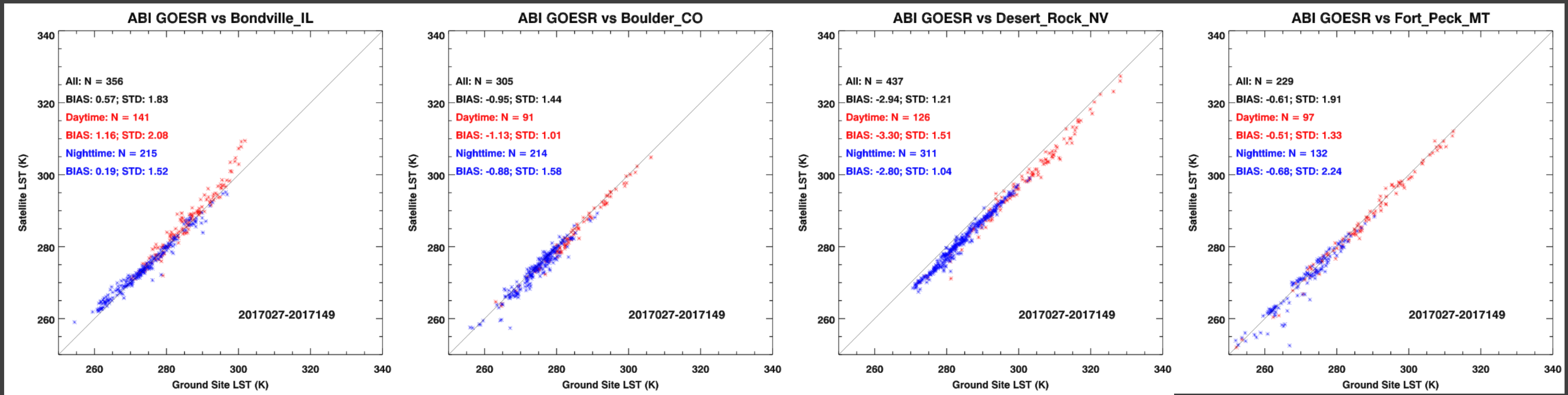
“Point-to-area” validation: ABI LST validation

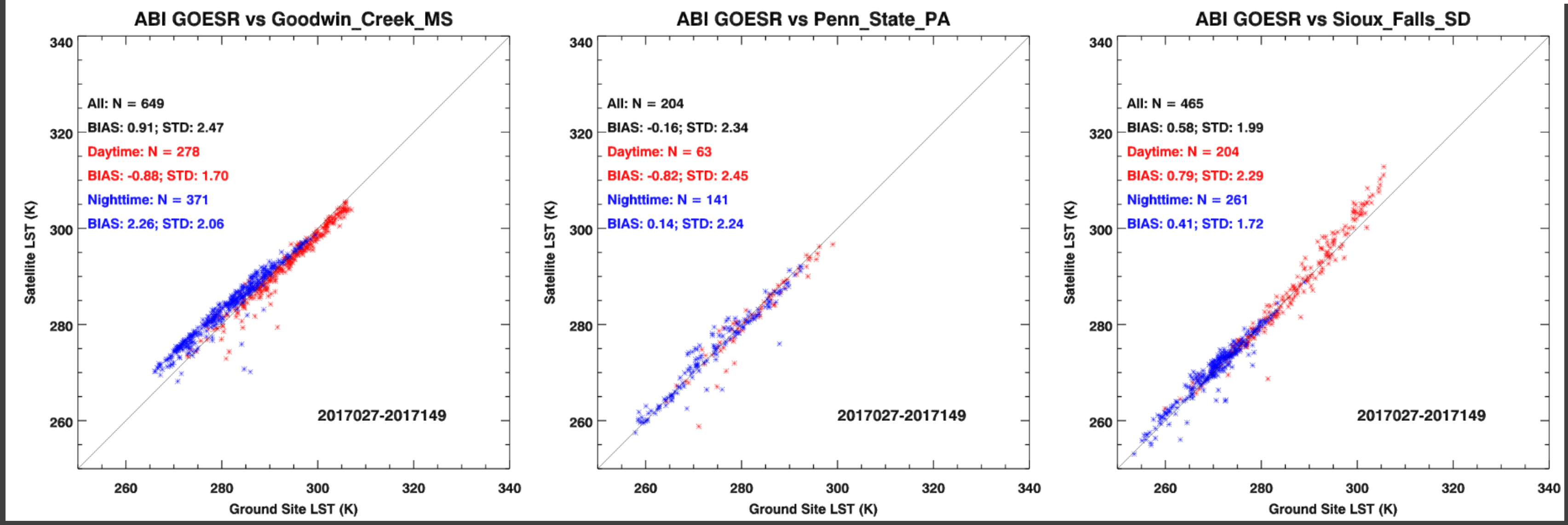




Sites	Record #	BIAS (K)	STD (K)	RMSE (K)
Bondville	356	0.15	1.85	1.86
Boulder	305	-1.16	1.45	1.86
Desert Rock	437	-3.23	1.21	3.45
Fort Peck	229	-0.54	1.89	1.96
Goodwin Creek	649	0.49	2.45	2.49
Penn State	204	-0.30	2.37	2.38
Sioux Falls	465	0.54	2.06	2.12

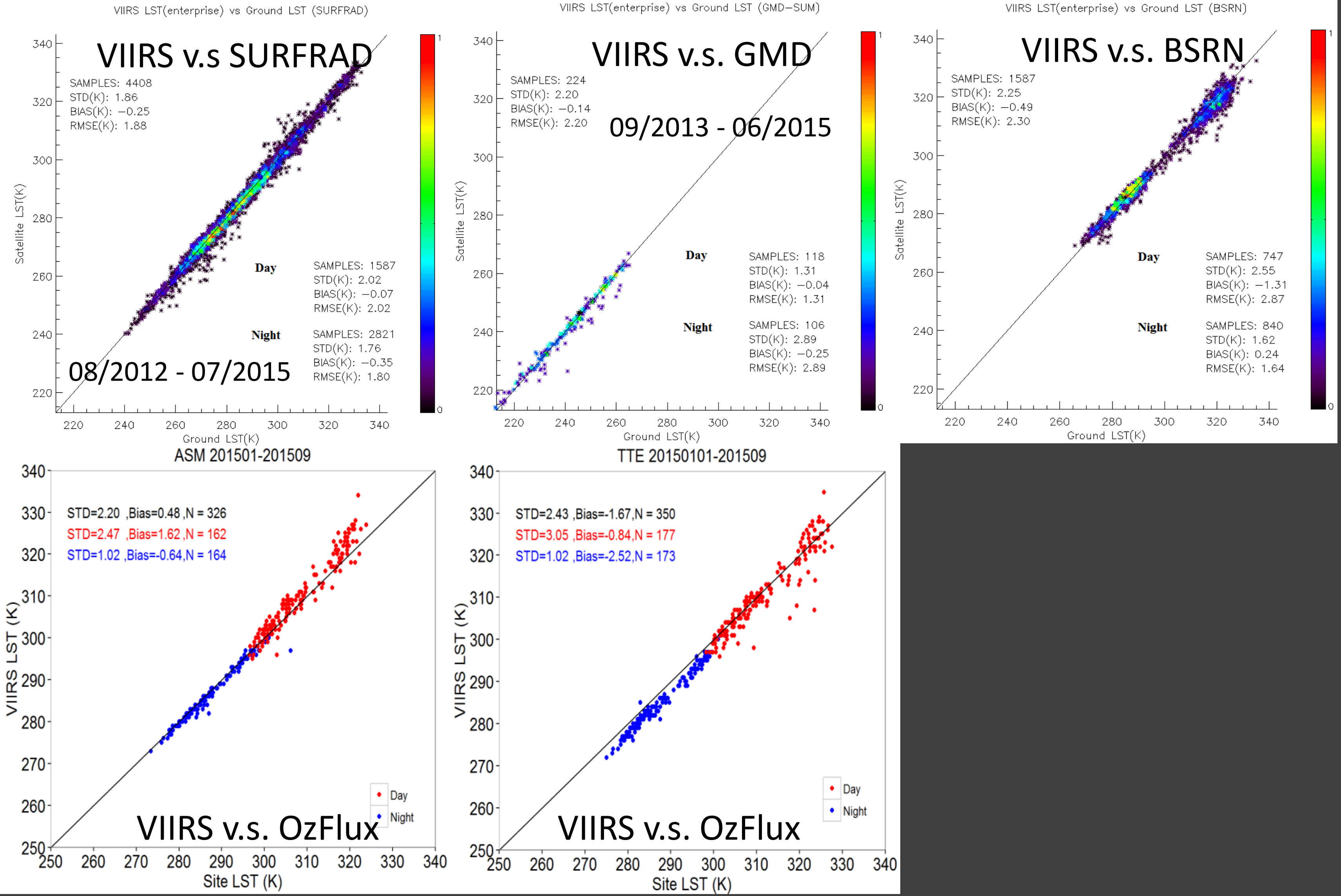
"Point-to-area" validation: Enterprise LST validation



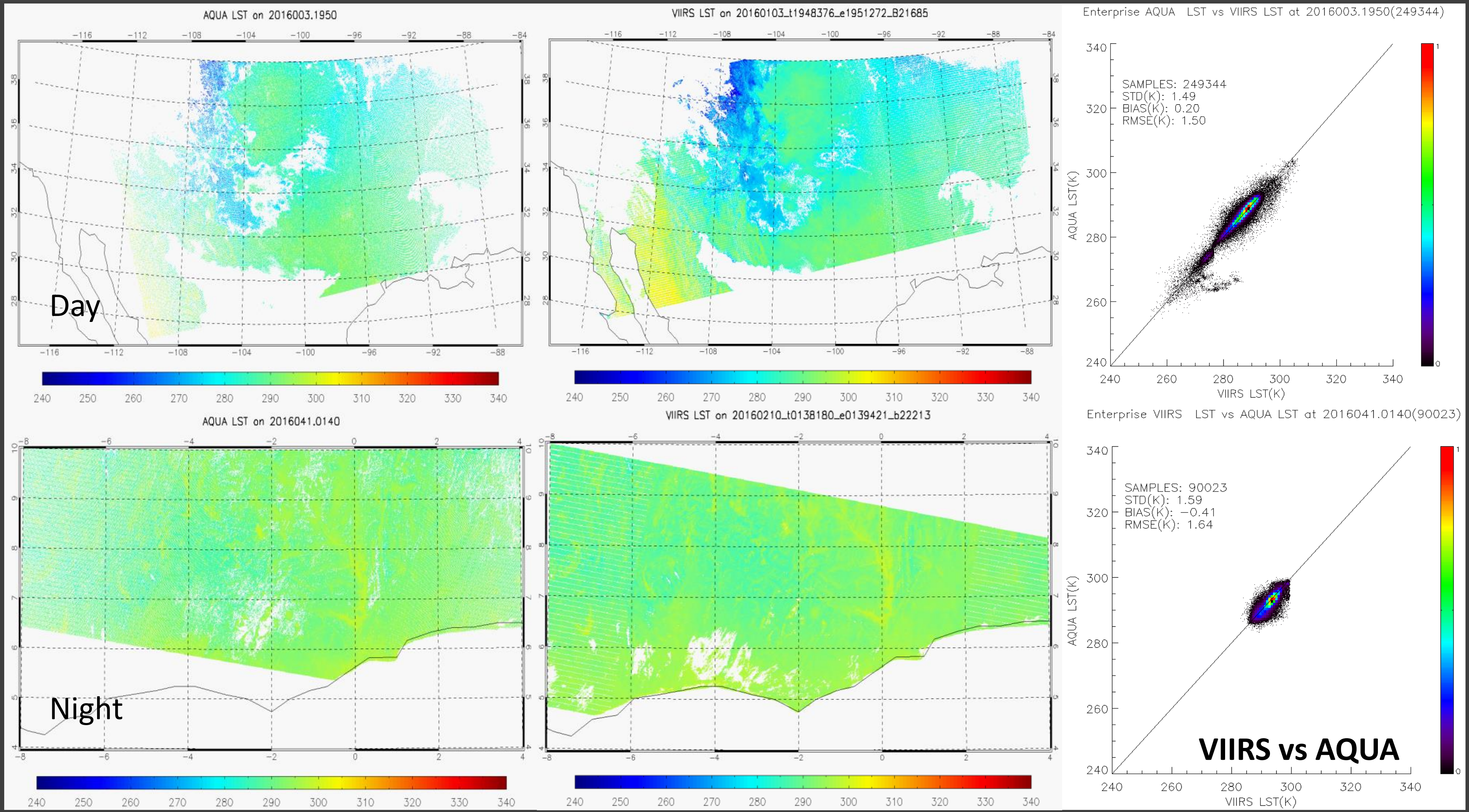


Sites	Record #	BIAS (K)	STD (K)	RMSE (K)
Bondville	356	0.57	1.83	1.91
Boulder	305	-0.95	1.43	1.71
Desert Rock	437	-2.94	1.21	3.18
Fort Peck	229	-0.61	1.91	2.00
Goodwin Creek	649	0.91	2.47	2.63
Penn State	204	-0.16	2.34	2.34
Sioux Falls	465	0.58	1.99	2.07

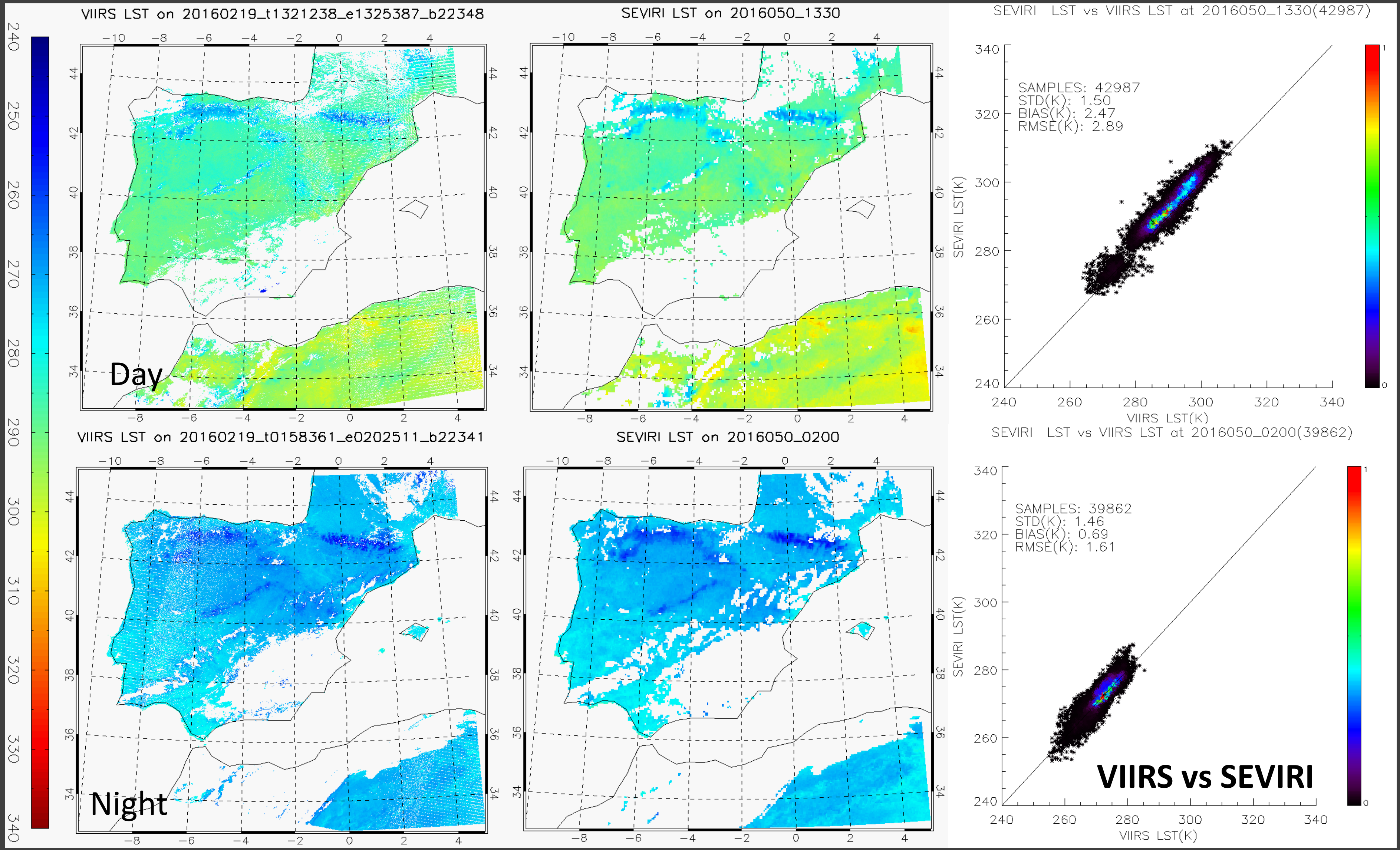
“Point-to-area” validation: Enterprise LST validation



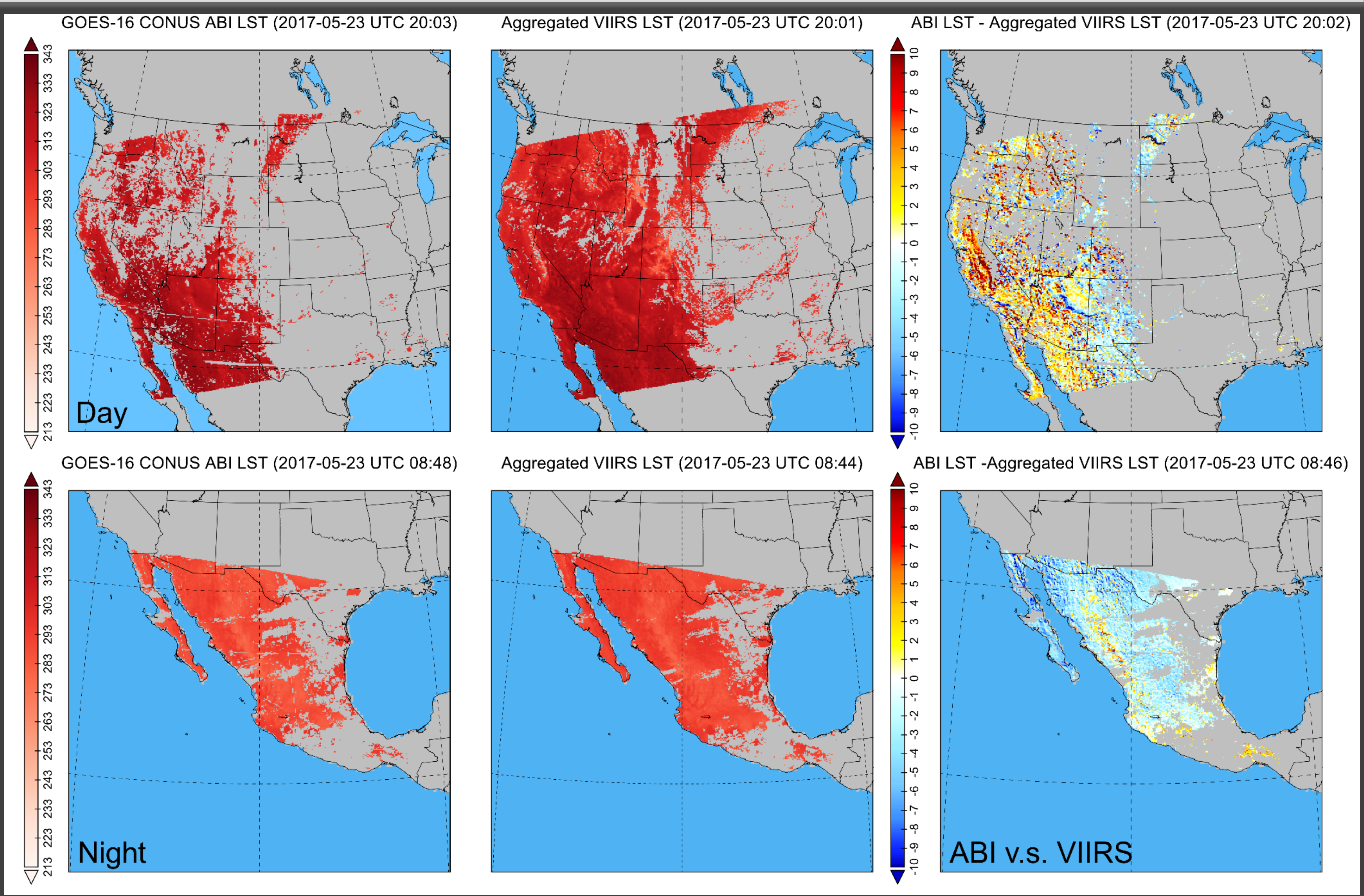
“Area-to-Area” validation: LEO v.s. LEO



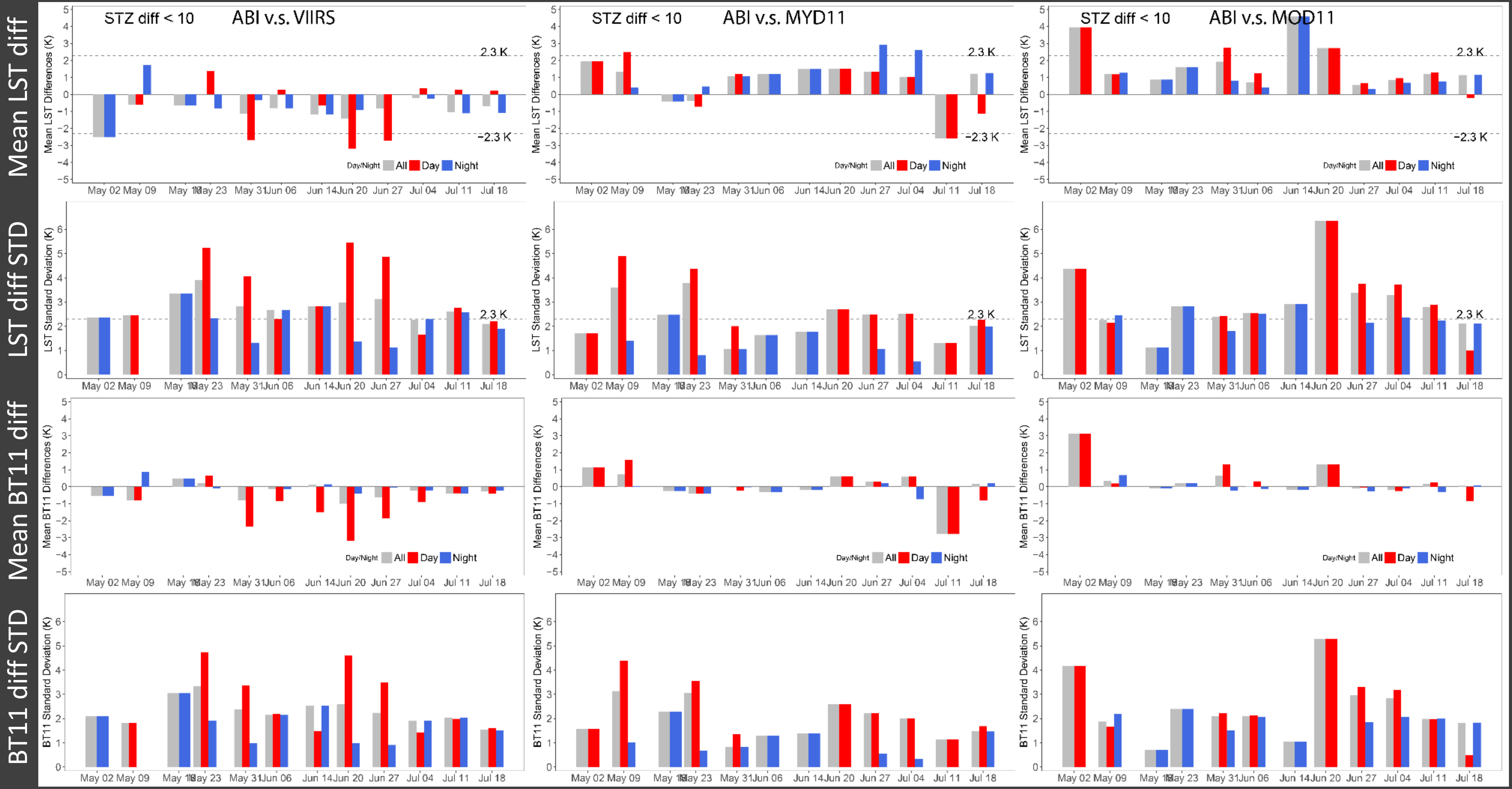
"Area-to-Area" validation: GEO v.s. LEO



“Area-to-Area” validation: GEO v.s. LEO

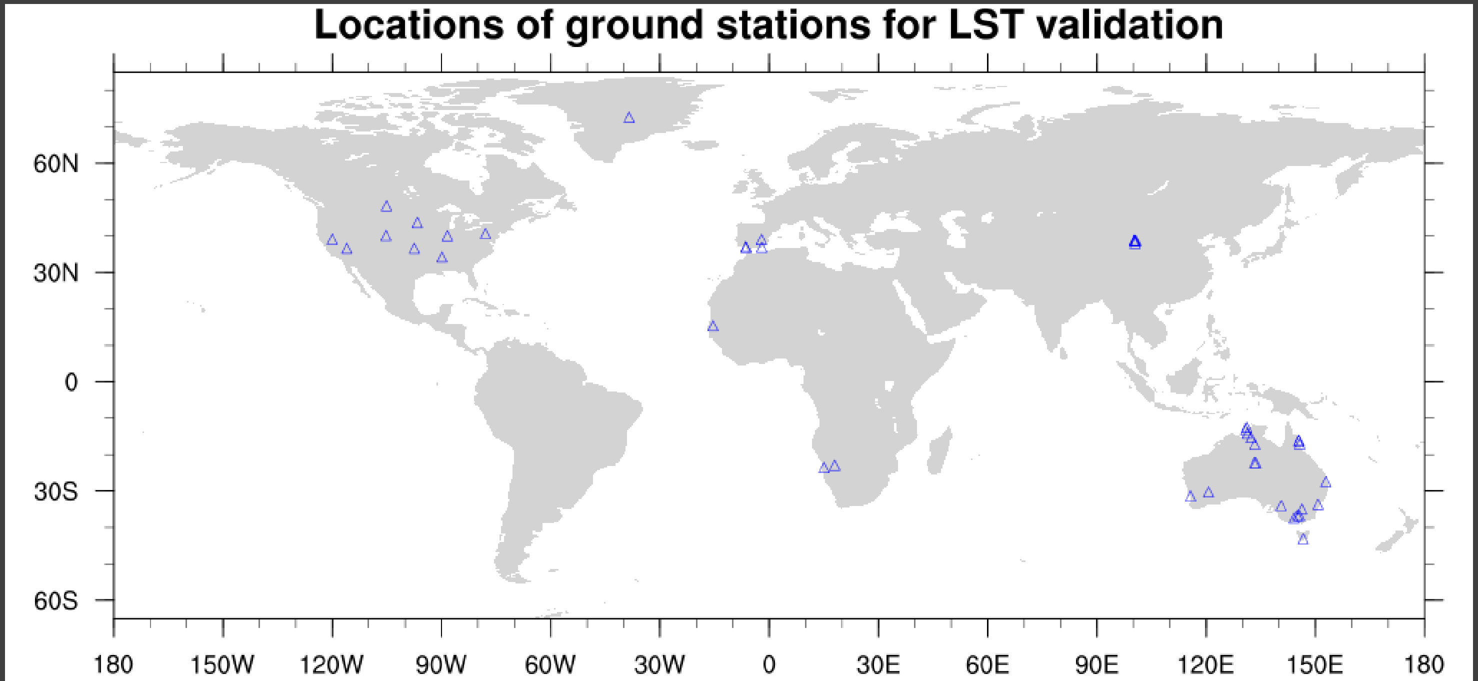


“Area-to-Area” validation: GEO v.s. LEO



Challenges and future plans

- Distribution of stations is remarkably biased;
- Lack of standard protocol for measurement and quality control;
- Missing validation practice protocol across missions.



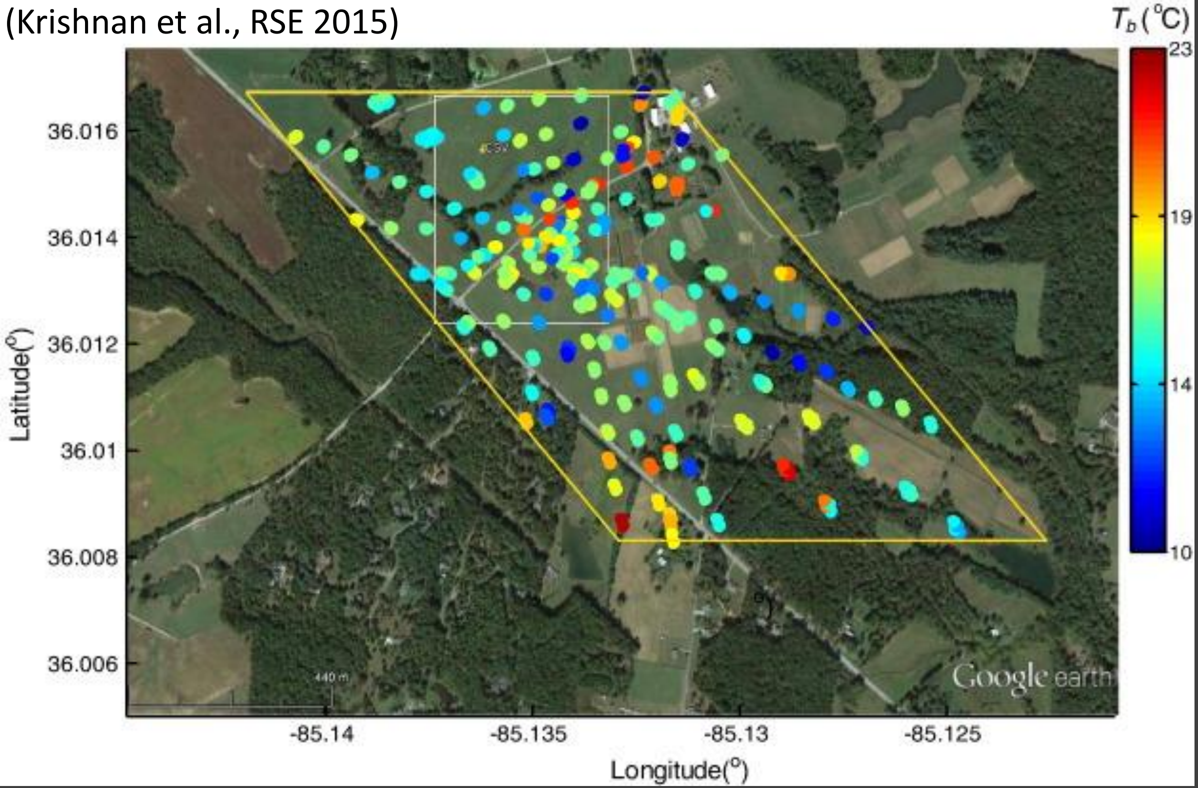
(Data are extracted from previous publications using in situ measurements.)

Protocol for high quality in situ measurement is essential for LST validation.

Challenges and future plans

- Accounting for heterogeneity of station is challenging;
- The heterogeneity could increase the uncertainty of in situ based validation;
- Although challenging, it is necessary to characterize heterogeneity of ground stations for future validation activity;

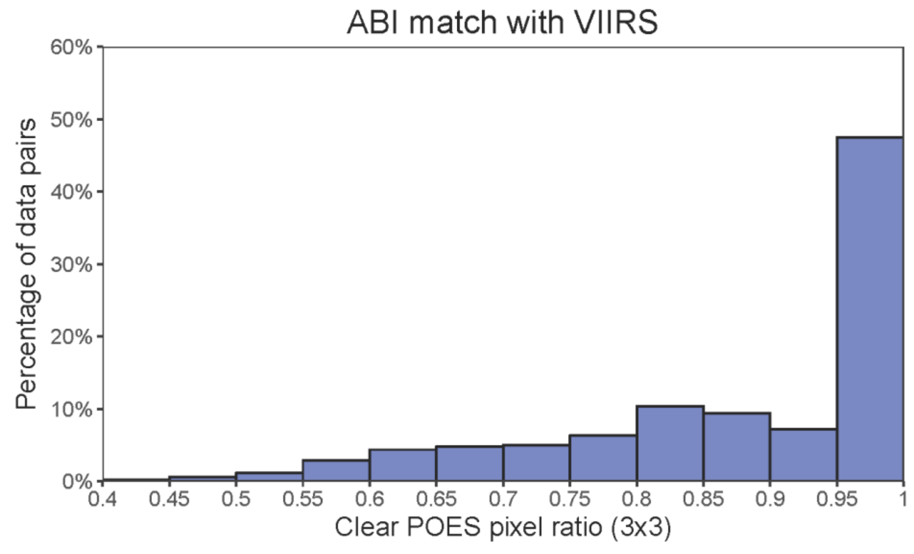
(Krishnan et al., RSE 2015)

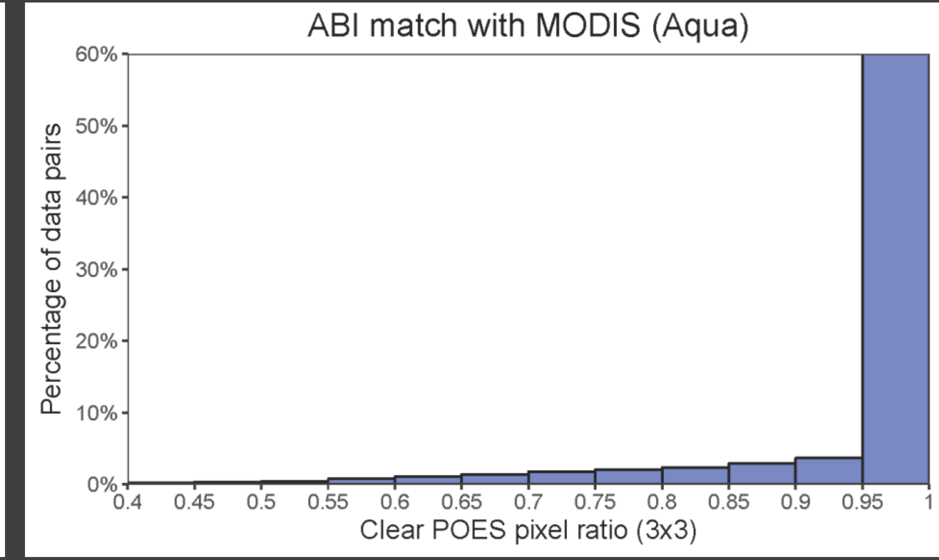


Comparison of temperature measurements from station, aircraft and satellite (MODIS).

Challenges and future plans

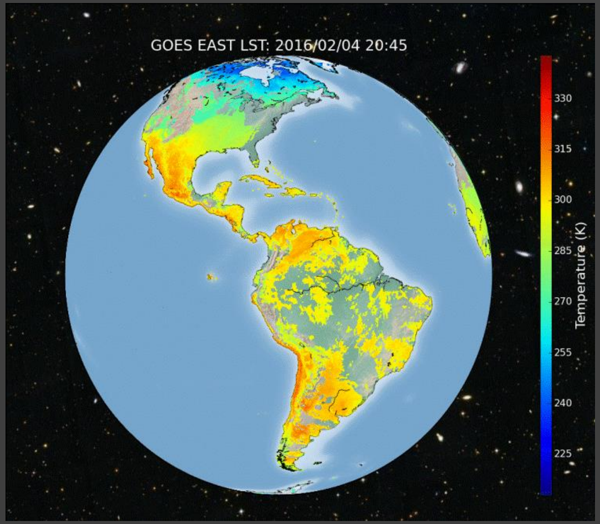
- Viewing geometry across sensors could create challenges for cross-satellite comparison;
- Different standard for cloud masking increase the inconsistency.

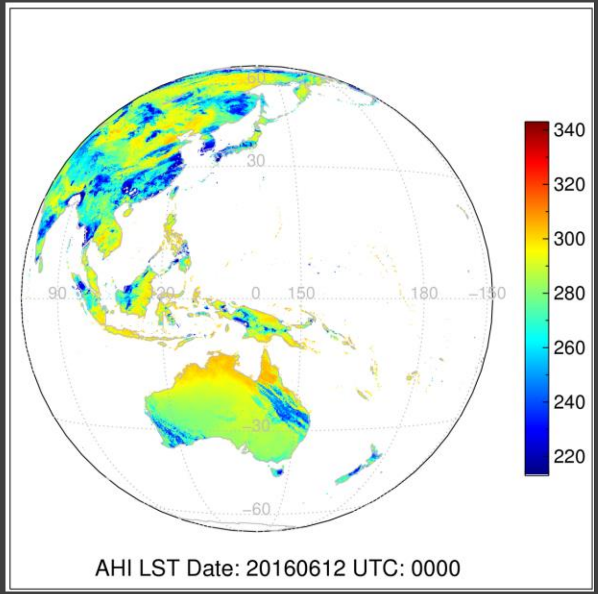


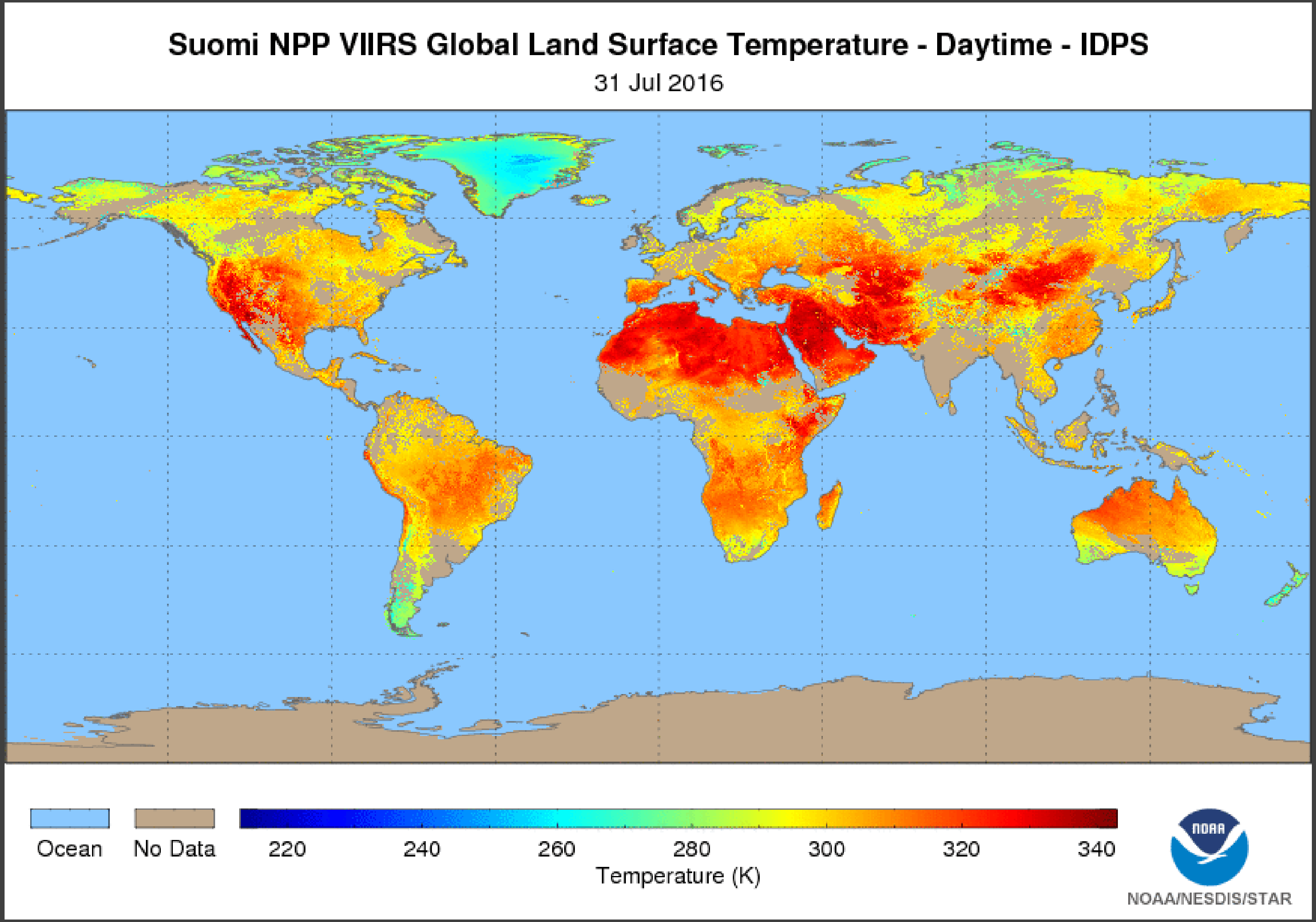


Concluding remarks

- Land surface temperature are critical environmental data record for continuous JPSS and GOES-R missions;
- Current LST validation activities for JPSS and GOES-R missions mainly rely on in situ measurements (e.g., SURFRAD) and cross products comparison;
- Station distribution, data quality, station heterogeneity, and sensor difference create challenges for LST products validation;
- Protocols for data collection and validation practice are necessary for generating consistent and reliable conclusions;


GOES EAST LST: 2016/02/04 20:45
330
315
300
285
270
255
240
225
Temperature (K)


340
320
300
280
260
240
220
AHI LST Date: 20160612 UTC: 0000


Suomi NPP VIIRS Global Land Surface Temperature - Daytime - IDPS
31 Jul 2016
Ocean
No Data
220
240
260
280
300
320
340
Temperature (K)
NOAA/NESDIS/STAR