The GOES-R Land Surface Temperature Product

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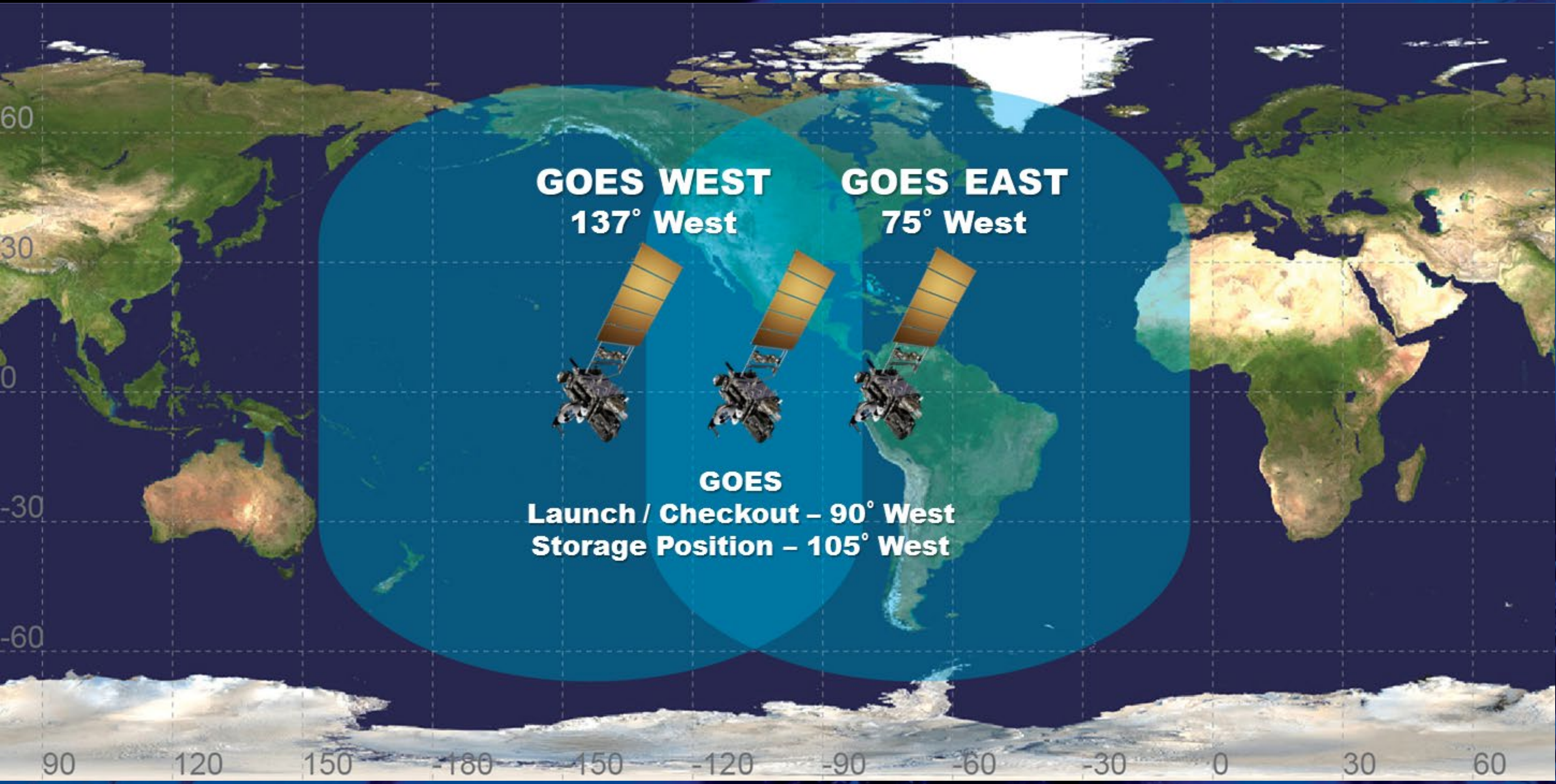
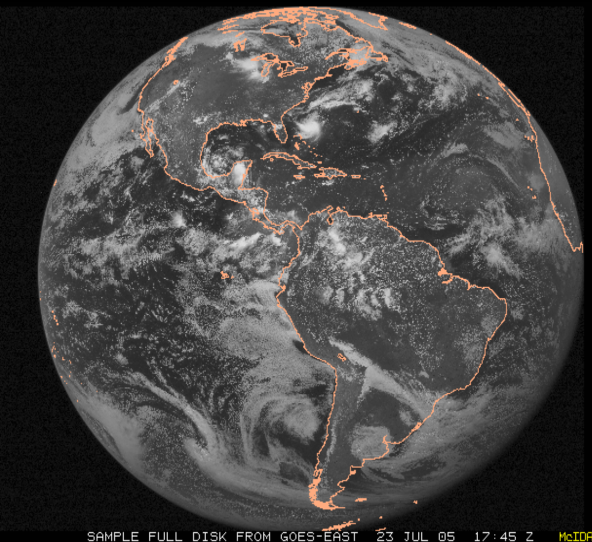
Outlines

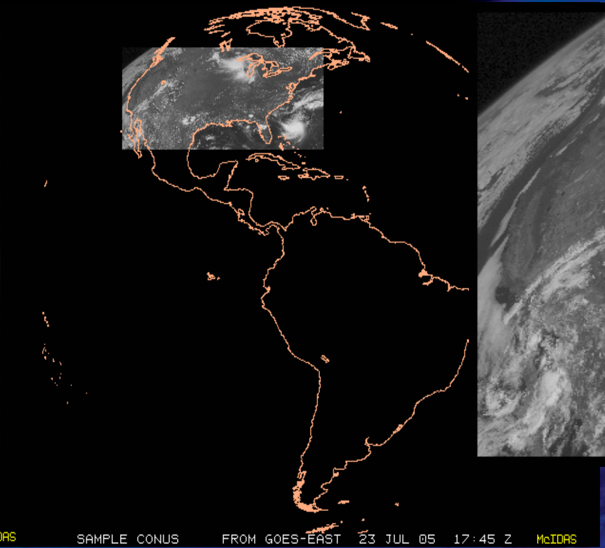
- Overview
- GOES-R LST Product and its Current Status
- Challenges and Strategies
- Summary

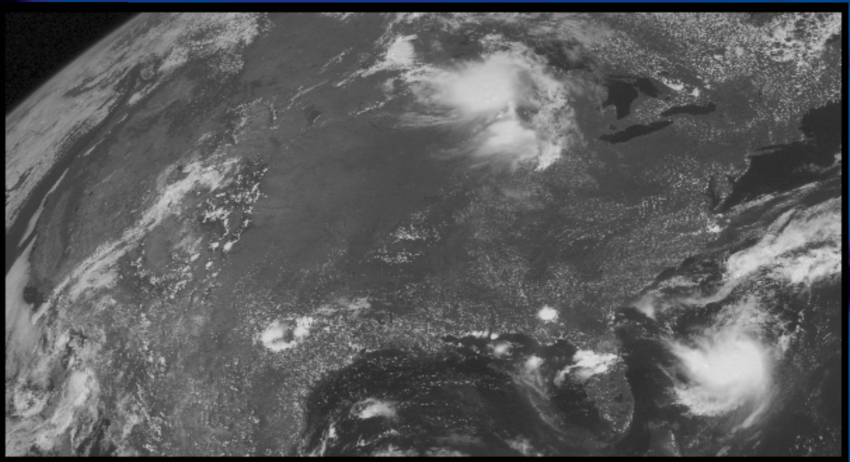
GOES-R Overview

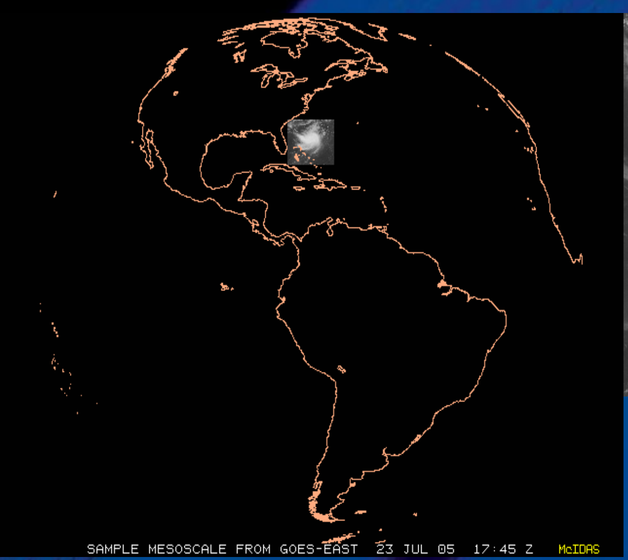


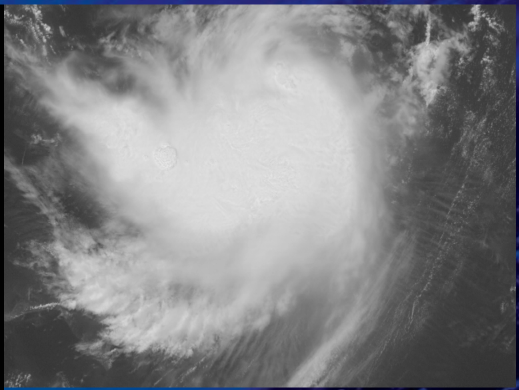
Advanced Baseline Imager
-Scan Modes











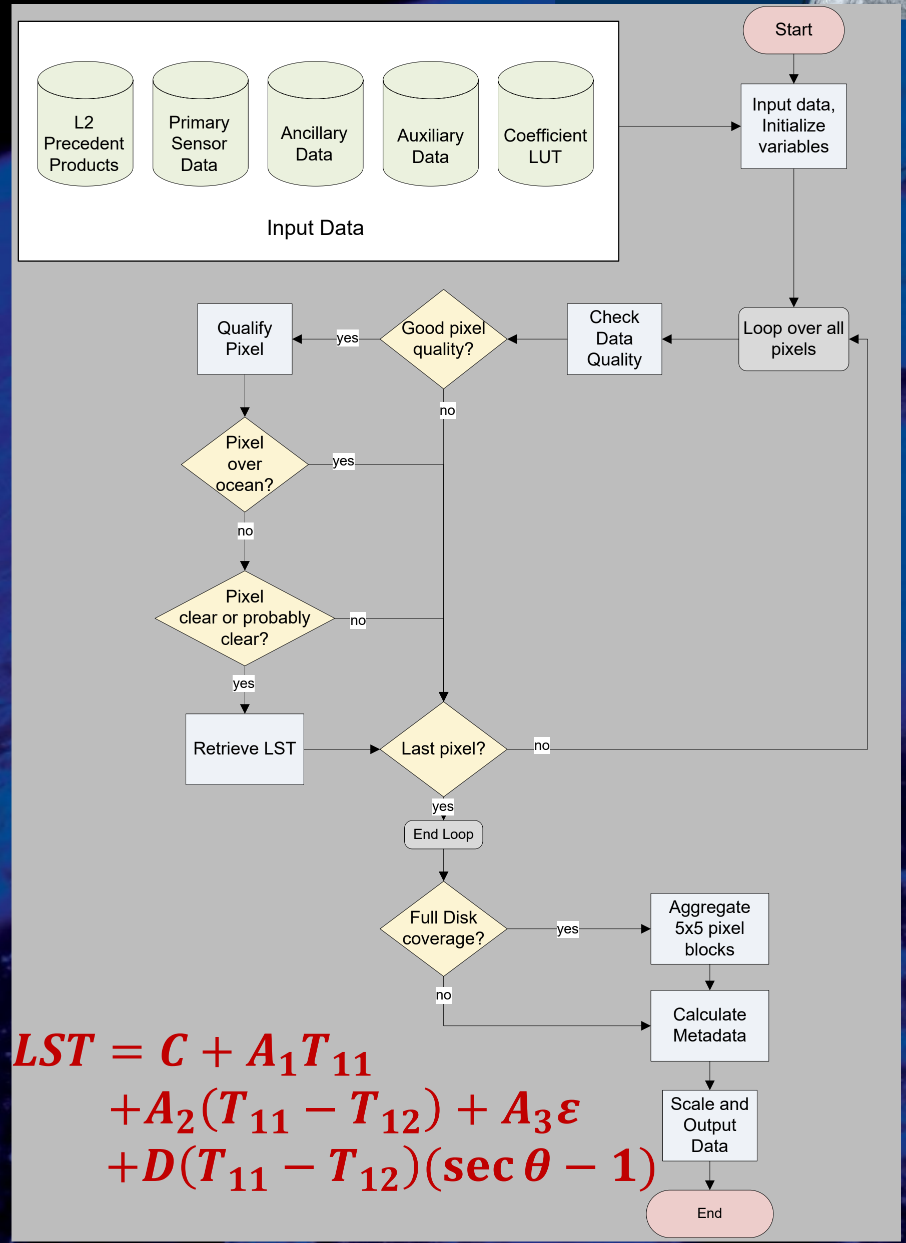
There are three scan modes for the ABI:

- 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

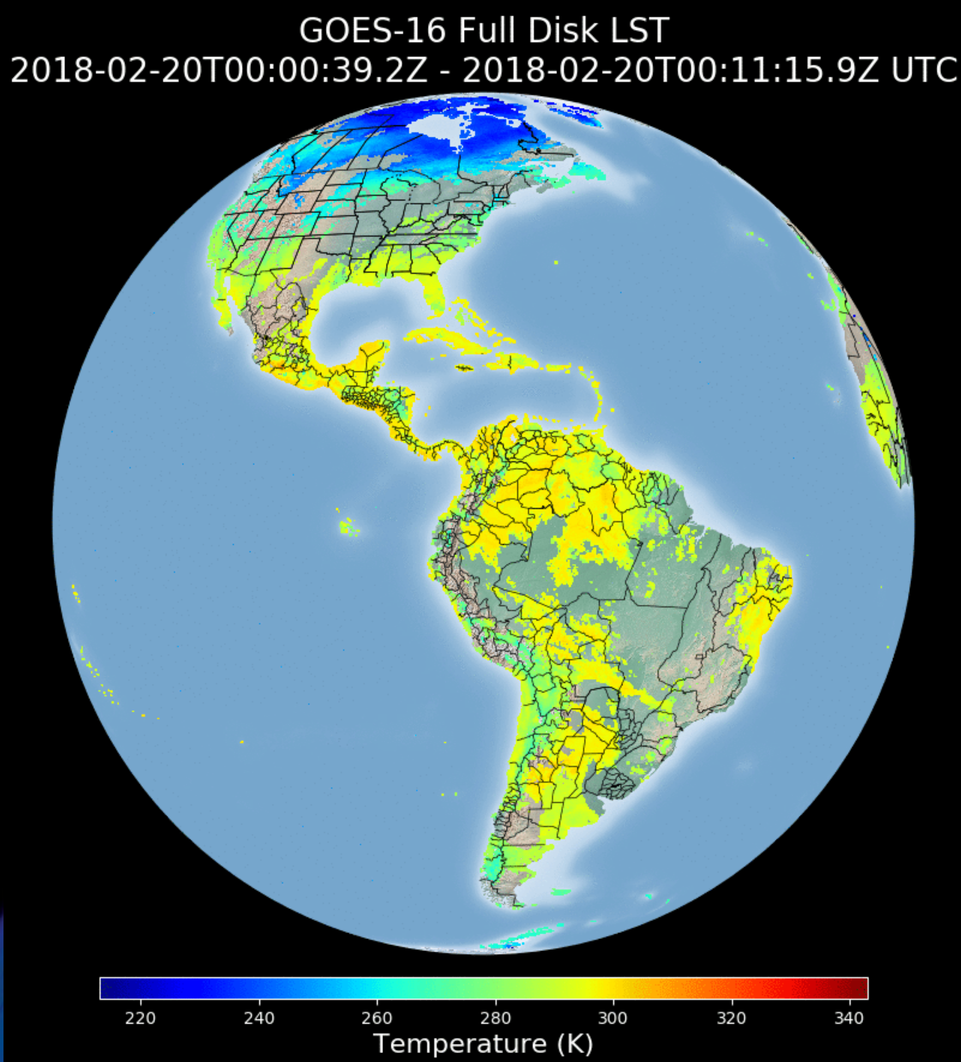
GOES-R LST Product

- **LST retrieval is performed**
  - *Good input data*
  - *Land surface pixels*
  - *"clear" and "probably clear" pixels*
- **Cloud detection**
  - *ABI Cloud Mask EDR*
- **Atmospheric absorption correction**
  - *Split-window bands Brightness Temperature difference*
  - *Path correction term*
  - *Algorithm coefficients stratification for different atmospheric conditions (TPW EDR and NWP)*
- **Surface emissivity variation**
  - *Develop dynamic emissivity data for split-window bands*
- **Quality control flags**
  - *Data Quality Flag (DQF)*
  - *Product Quality Indicator (PQI)*

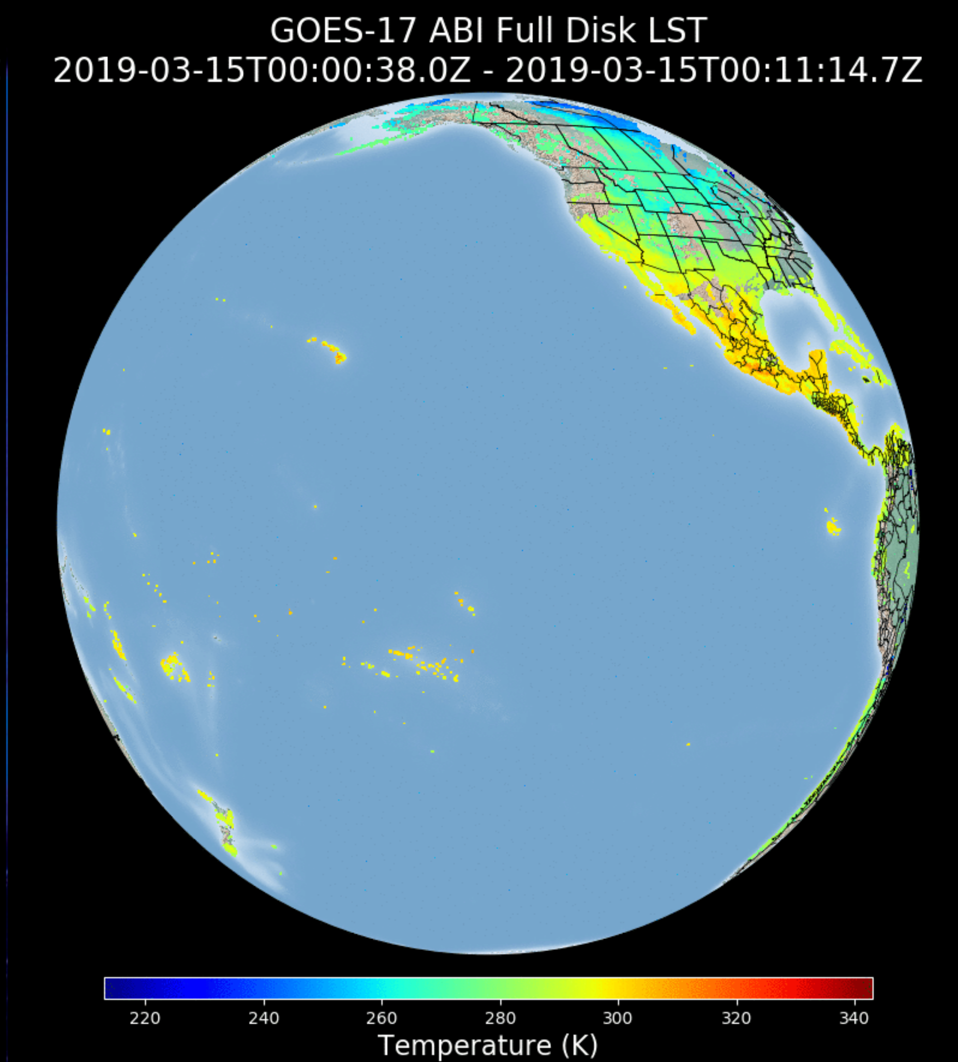


$$LST = C + A_1 T_{11} + A_2(T_{11} - T_{12}) + A_3\varepsilon + D(T_{11} - T_{12})(\sec\theta - 1)$$

GOES-East and GOES-West LST



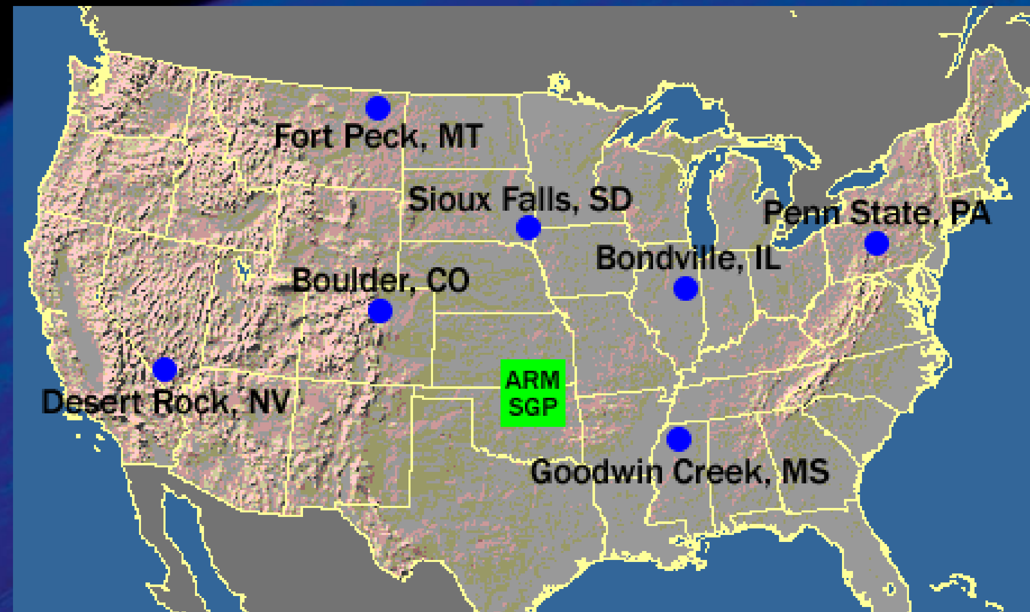
GOES-East

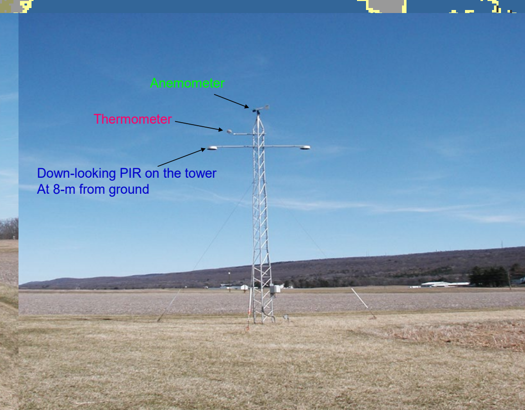


GOES-West

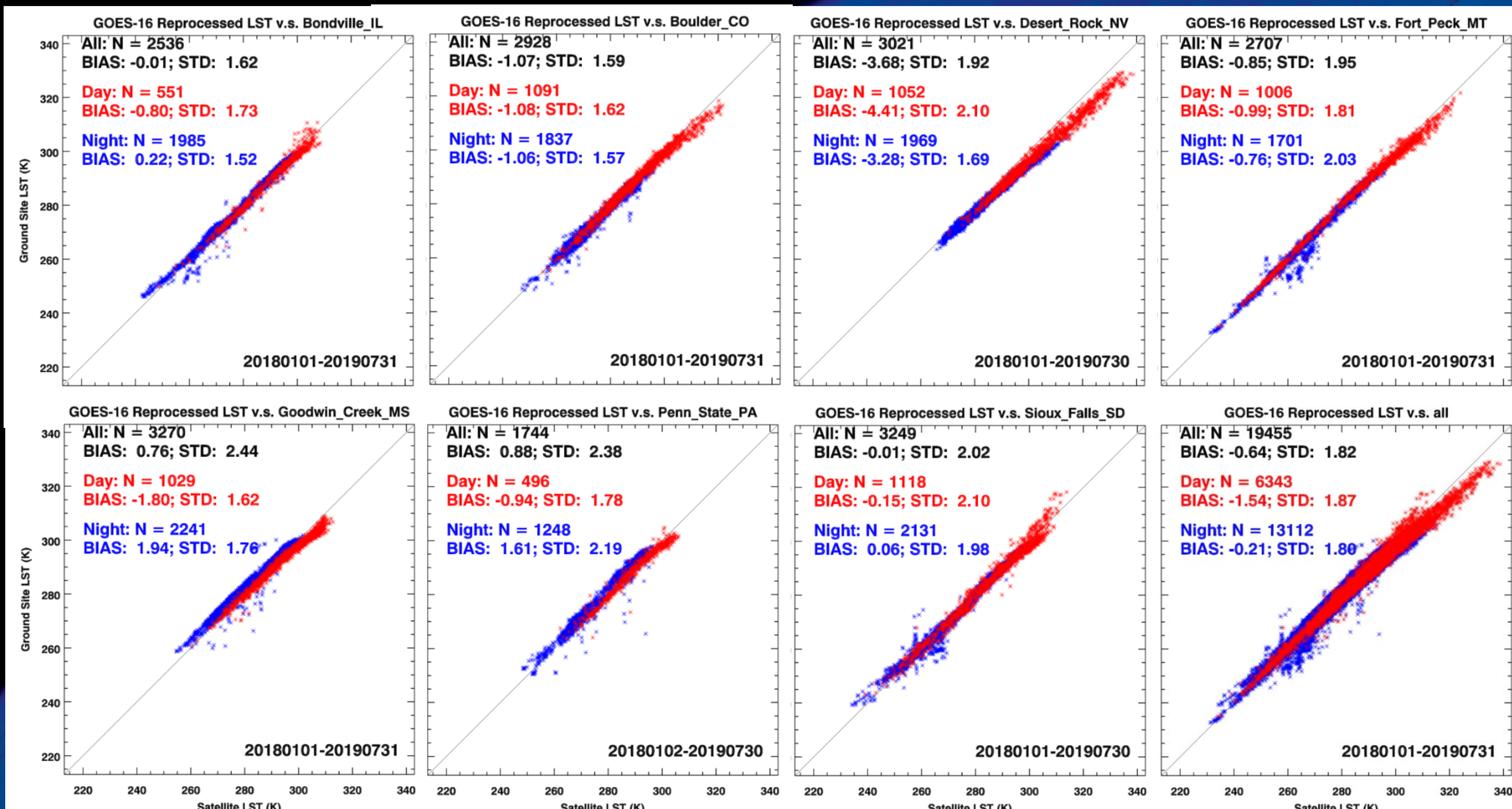
In-situ Ground Observations

- Surface Radiation Budget Network (SURFRAD) – seven operational sites in CONUS
  - Radiometer measuring broadband radiation every minute
  - Available within a day or two of observation
  - Instrument calibrated annually and well maintained
  - $LST = \frac{F\uparrow - (1-\varepsilon)F\downarrow}{\varepsilon\sigma}$
- **We need high-quality data , especially outside US, e.g., in Central and South America**

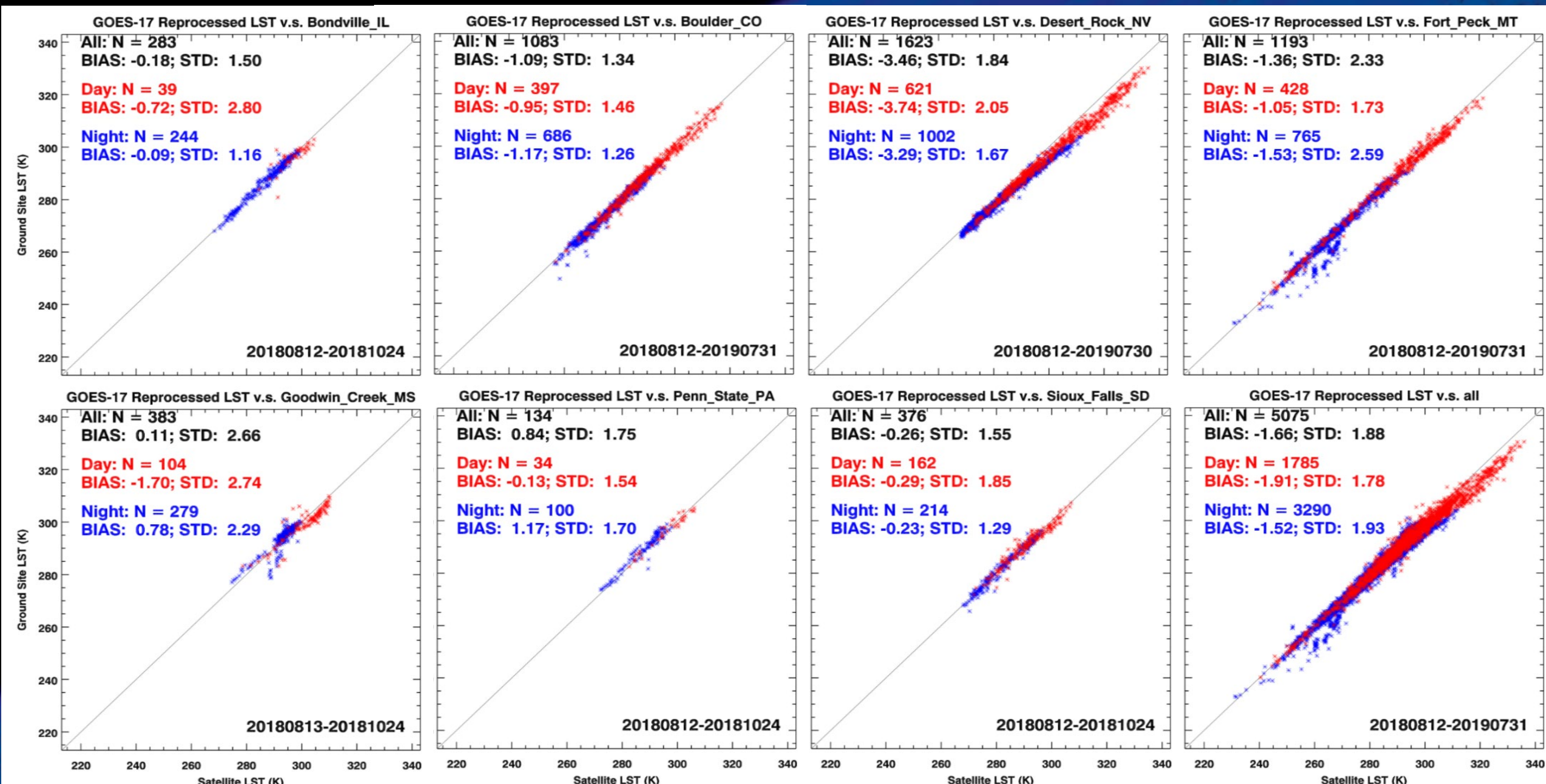




Product Validation Results
-GOES-16 CONUS LST



Product Validation Results
-GOES-17 CONUS LST



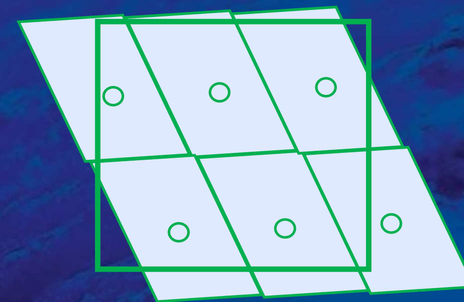
Product Validation Results
-FD & MESO

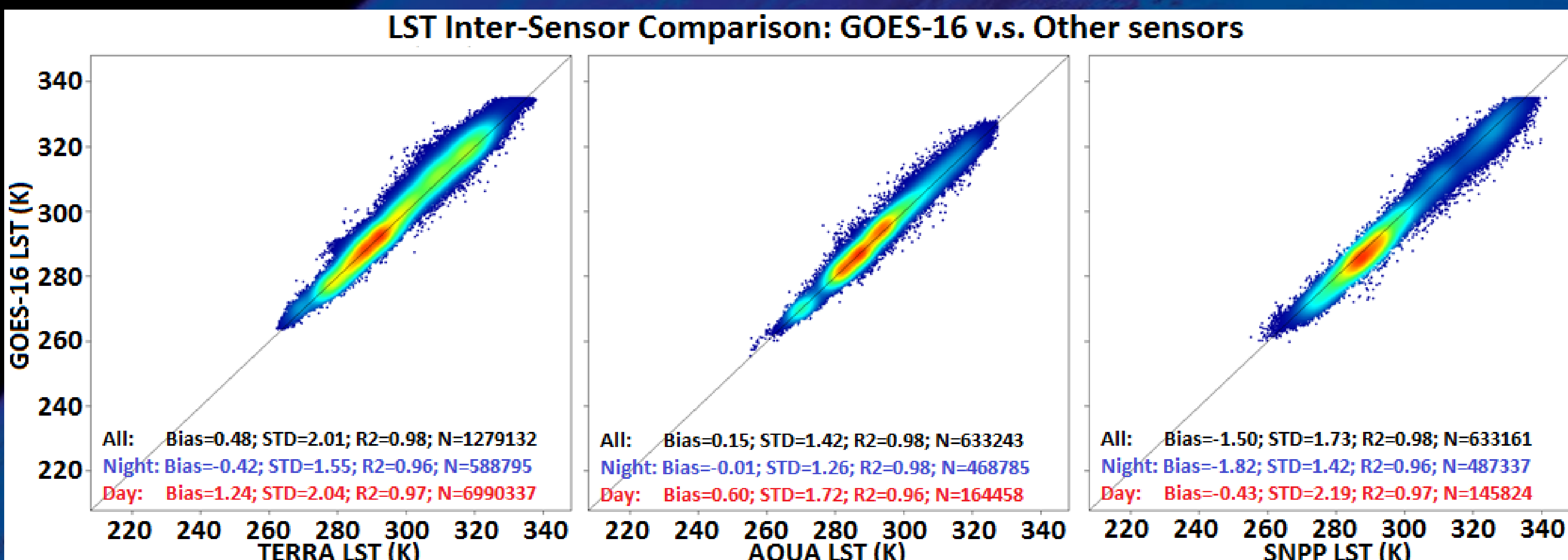
Satellite	Site	MESO			Full Disk		
		Num	Accuracy (K)	Precision (K)	Num	Accuracy (K)	Precision (K)
GOES-16	Bondville_IL	1012	0.04	2.27	1100	-0.17	2.08
	Boulder_CO	108	-0.98	1.95	767	-1.54	2.01
	Desert_Rock_NV	112	-4.82	1.36	358	-6.00	1.79
	Fort_Peck_MT	29	-1.09	1.65	784	-1.04	1.88
	Goodwin_Creek_MS	1169	0.68	2.37	1180	3.35	2.67
	Penn_State_PA	602	0.65	2.39	701	1.52	2.16
	Sioux_Falls_SD	217	-0.57	1.95	1104	-0.24	1.60
	Overall	3249	0.13	2.27	5994	0.07	2.09
GOES-17	Bondville_IL	24	0.14	2.69	470	-0.53	1.25
	Boulder_CO	371	-1.55	1.67	357	-0.71	1.73
	Desert_Rock_NV	738	-3.56	2.15	278	-4.65	2.10
	Fort_Peck_MT	2	-1.89	0.11	326	-0.48	2.21
	Goodwin_Creek_MS	43	0.96	3.43	325	-0.33	3.18
	Penn_State_PA	18	0.20	1.62	76	0.60	1.55
	Sioux_Falls_SD	0	NA	NA	666	0.12	1.89
	Overall	1196	-2.64	2.01	2498	-0.77	1.80

Inter-Sensor LST Comparison

- LST products :
  - » GOES-16 ABI LST;
  - » LSTs from TERRA MODIS, AQUA MODIS, and SNPP VIIRS
- 24 days data are used in the comparison (one day per week, 2017.05 ~ 2017.10);

Aggregation scheme

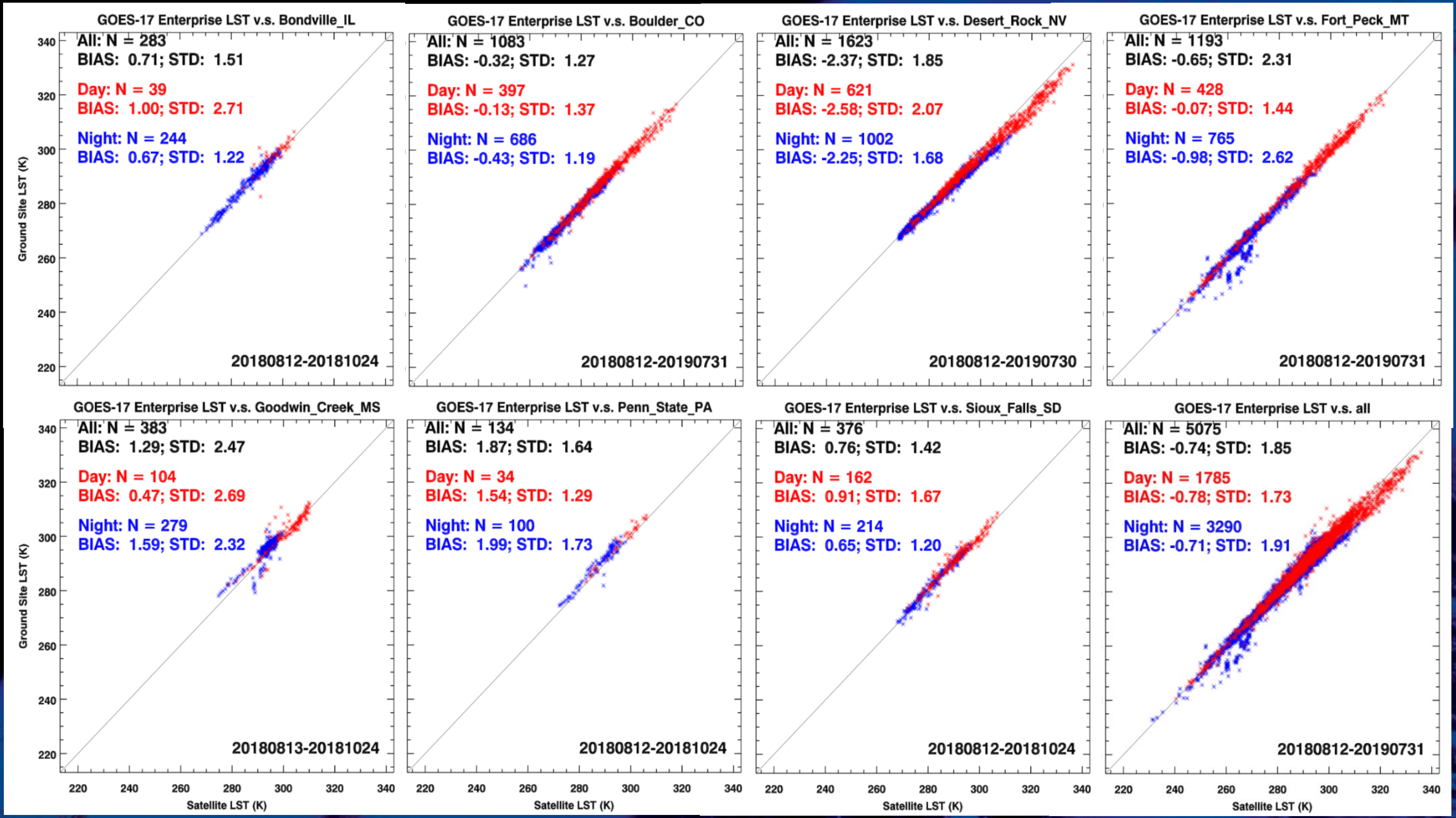




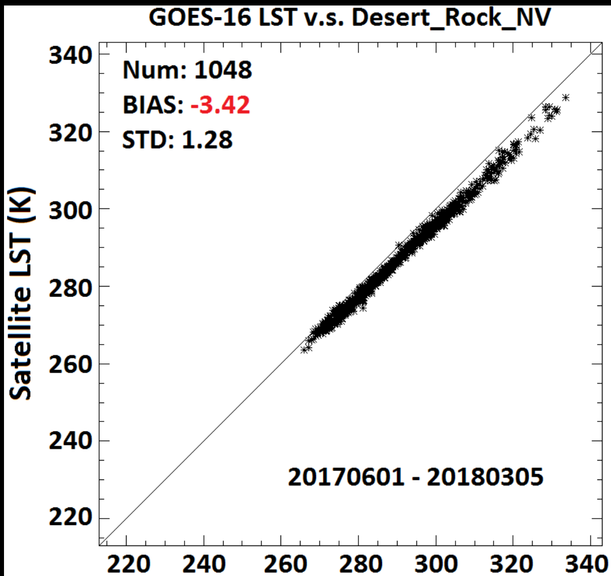
Major Challenges

- Product Quality
  - » Algorithm improvement
  - » Emissivity quality improvement
- In-situ observations
  - » High-quality in-situ stations are limited
  - » In-situ observations' representativeness
- GOES-17 ABI Loop heat pipe overheating
  - » Impact on each band is different
  - » How to improve the overall data quality and usability

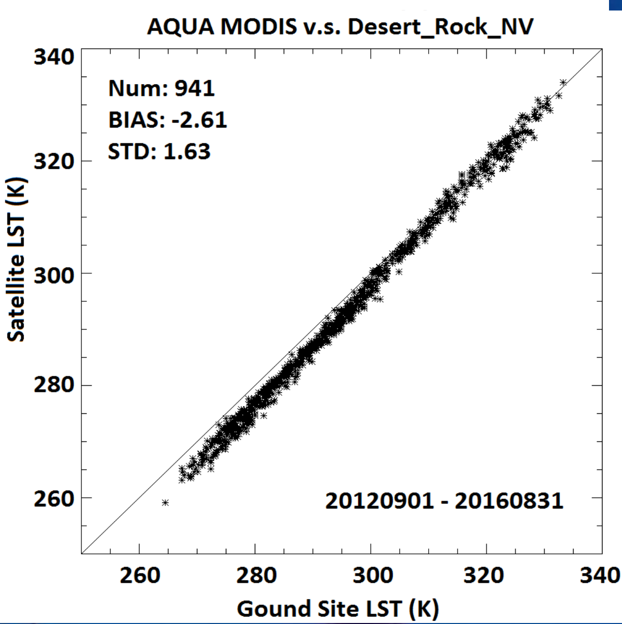
Enterprise Algorithm

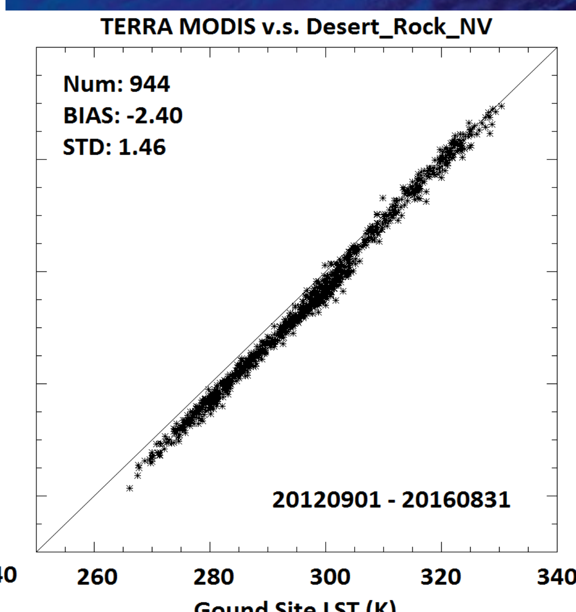


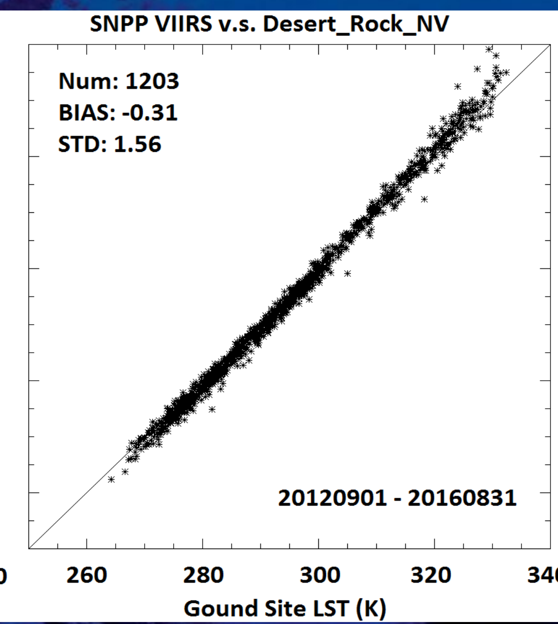
Desert Rock Validation Results
-Multiple Sensors



- GOES-16 LST underestimate at Desert Rock site
- Four years LST time series from AQUA, TERRA, and SNPP are compared to Desert Rock LST as a comparison
- SNPP VIIRS LST performs much better with an underestimate as low as 0.31 k
  - ➢ Surface Type dependent algorithm

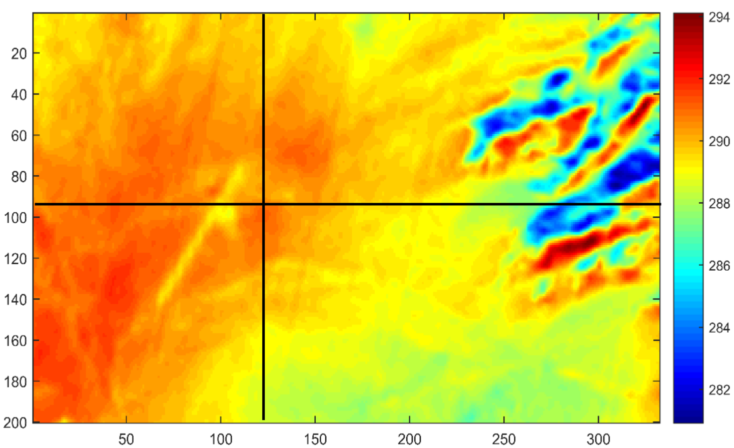




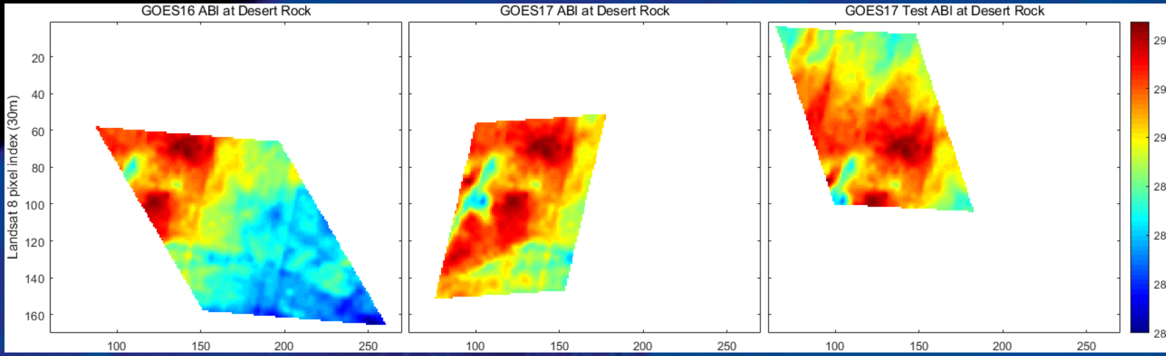


Validation Challenge
-Desert Rock

30m Landsat 8 BT11 (B10) at Desert Rock, 20180128

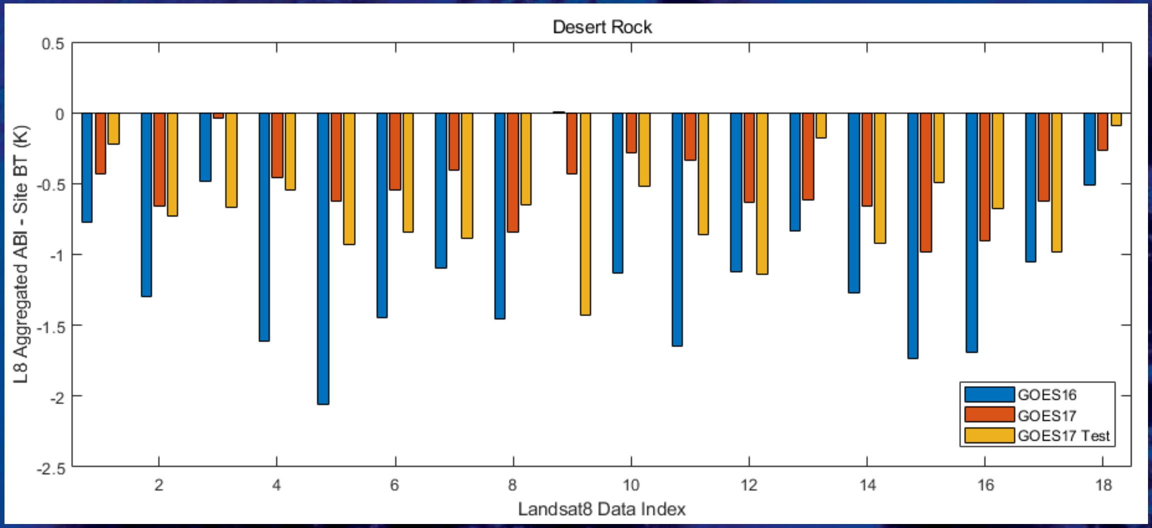


Desert Rock Landsat 8 BT11 Image
Left: GOES16; Center: GOES17ABI;Right: GOES17 Test



Red: GOES-East; Blue: GOES-West; Yellow: GOES17-Test

Aggregated ABI BT – Site L8 BT
G16 East (-1.18K); G17 West(-0.54K); G17 Test(-0.71K)

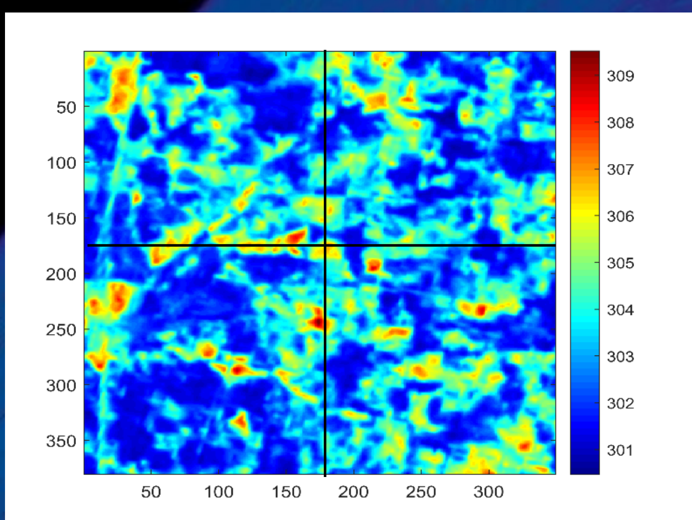


Validation Challenge
-Goodwin Creek

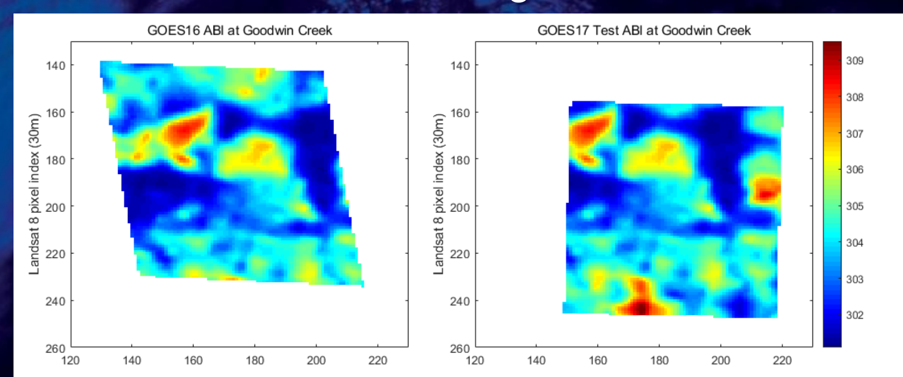
Goodwin Creek (Red: G16 East; Blue: G17 West; Yellow: G17 Test)

- Validation based on direct comparison with in-situ observation: pixel to point
- Site representativeness of the satellite pixel is key: good homogeneity required
- The complicated surface type shown on the right leads to high uncertainty when comparing the point temperature to pixel temperature
- Full Disk LST has 10 km resolution at nadir, a homogeneous site in such a large area is not available in CONUS.

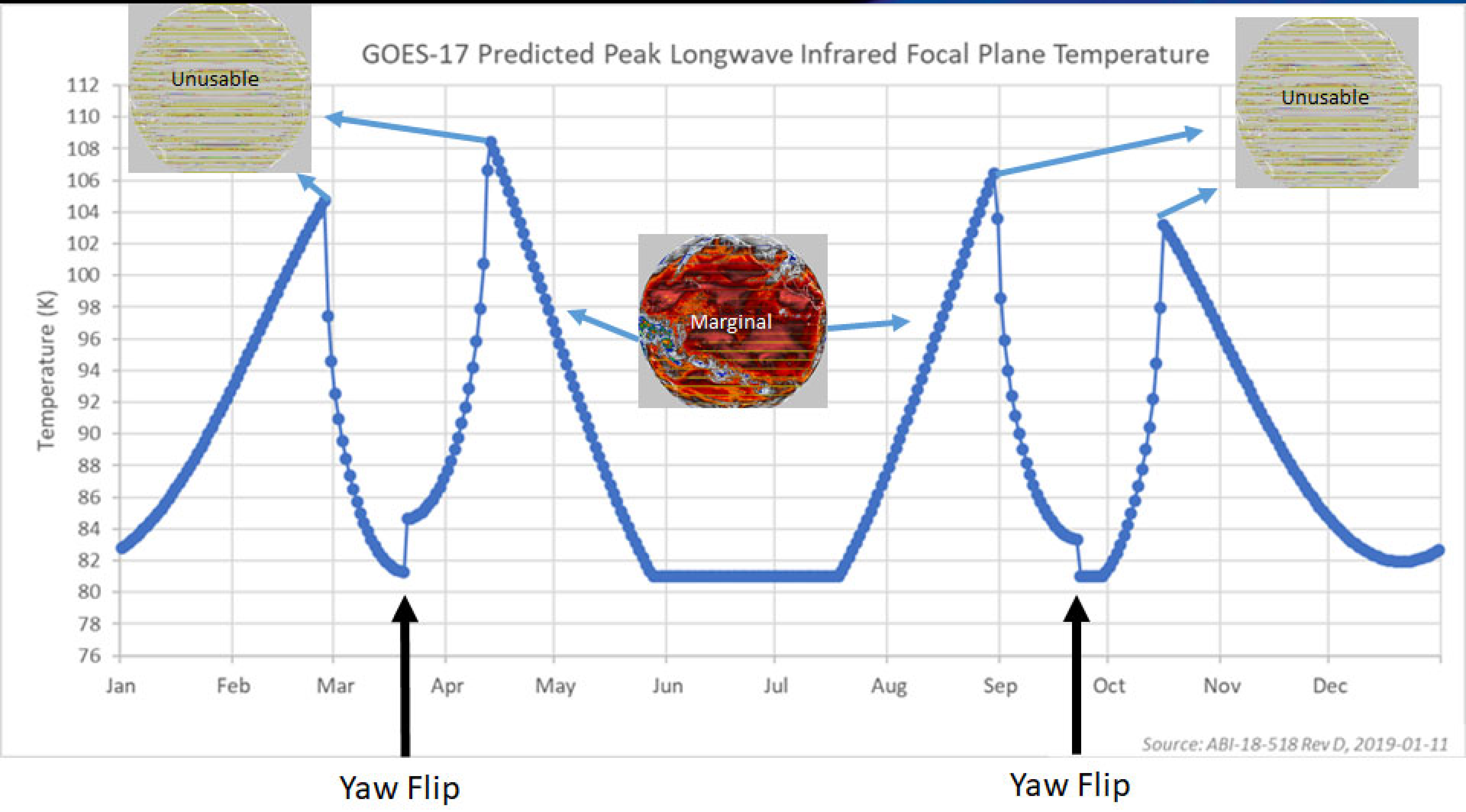
L8 BT11 at Goodwin Creek, 20180607



Goodwin Creek Landsat 8 BT11 Image
Left: GOES16 East; Right: GOES17 Test



GOES-17 Loop Heat Pipe Overheating Issue



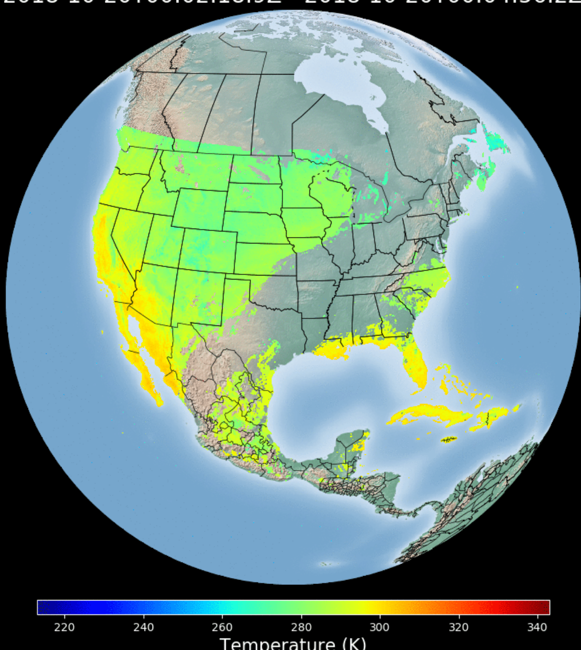
FPM Temperature Impact

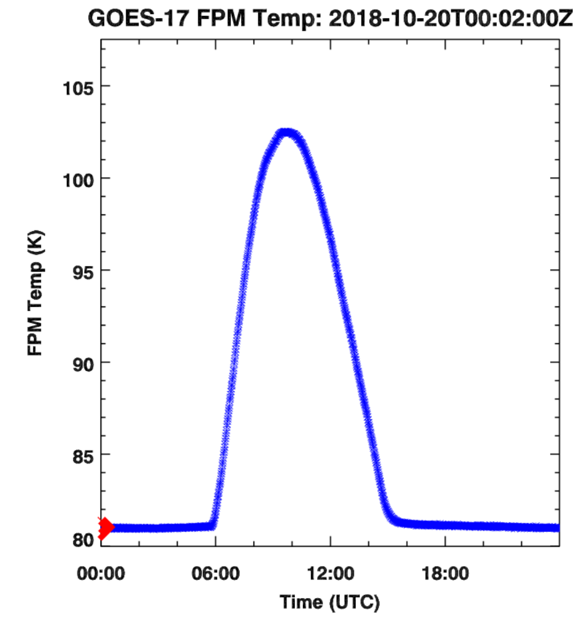
GOES-17 ABI Full Disk LST
2018-10-20T00:00:37.9Z - 2018-10-20T00:11:14.6Z

GOES-17 ABI Full Disk LST
2019-03-15T00:00:38.0Z - 2019-03-15T00:11:14.7Z

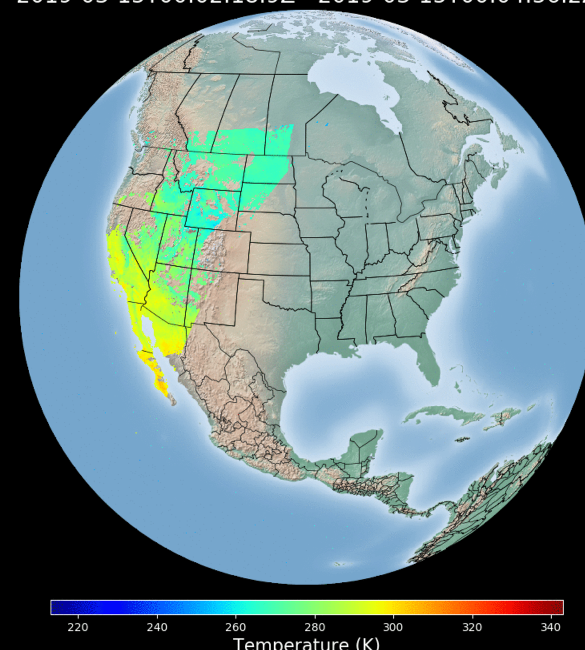
G17 FPM Temp
2018-10-20

GOES-17 ABI CONUS LST
2018-10-20T00:02:18.9Z - 2018-10-20T00:04:56.2Z

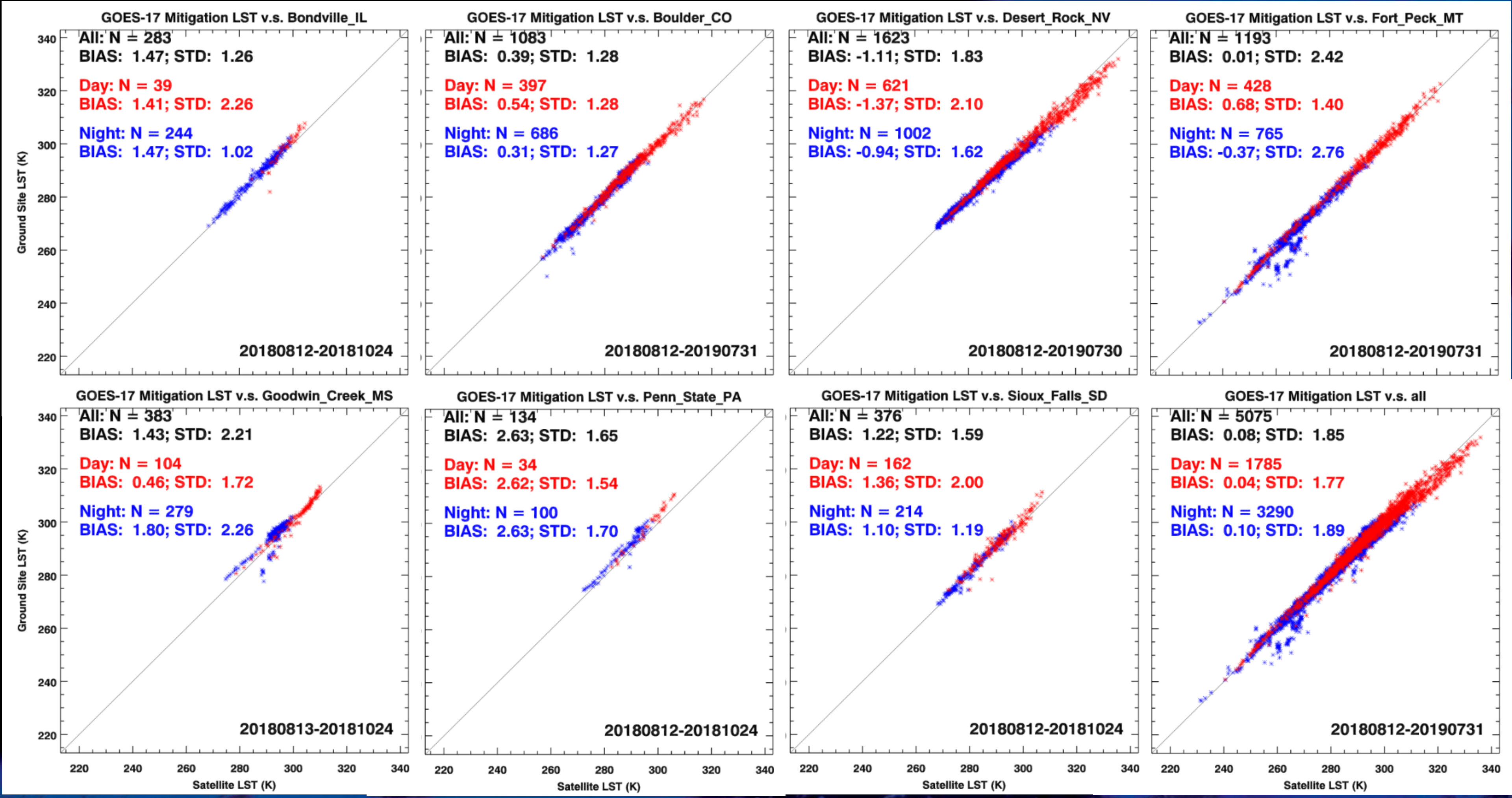




GOES-17 ABI CONUS LST
2019-03-15T00:02:18.9Z - 2019-03-15T00:04:56.2Z



Mitigation Algorithm

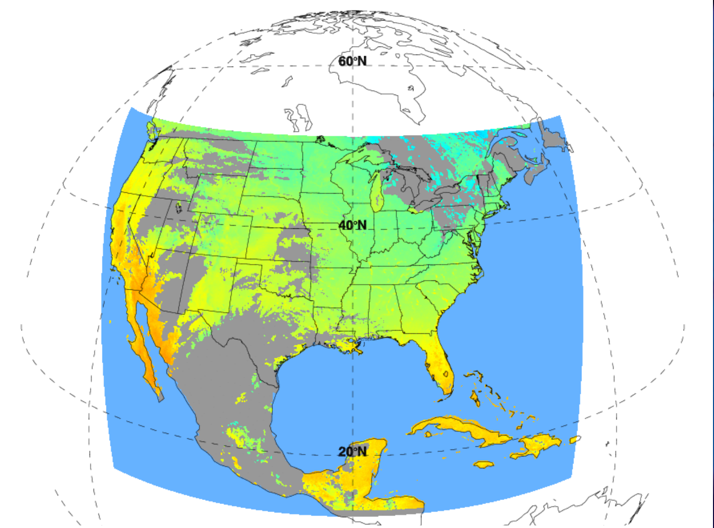


Alternative band is being used in mitigation

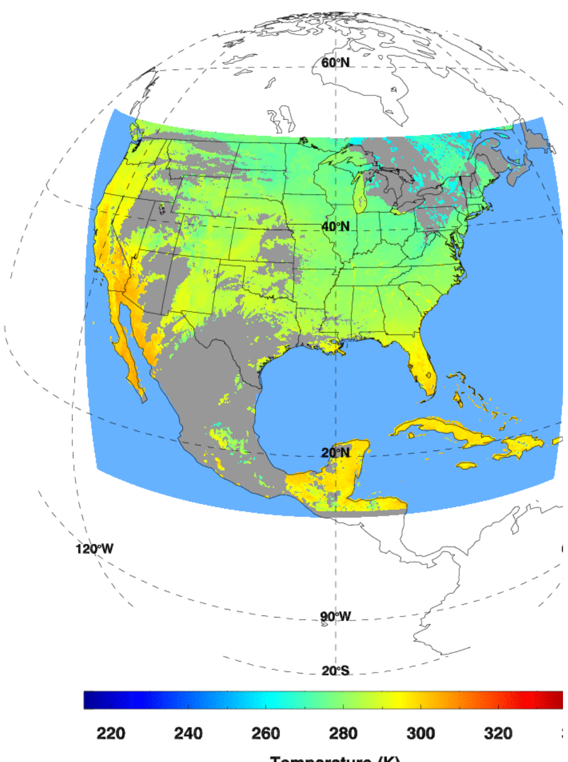
Comparison with GOES-East LST

- Level-1b data from GOES-17
- Level-2 inputs (Cloud Mask, Total Precipitable Water) from GOES-16 projected to GOES-17 grids
- Reference: Enterprise GOES-16 LST projected to GOES-17 grids (Top right)
- Algorithms: baseline (Left), enterprise (Center), and mitigation (Right)

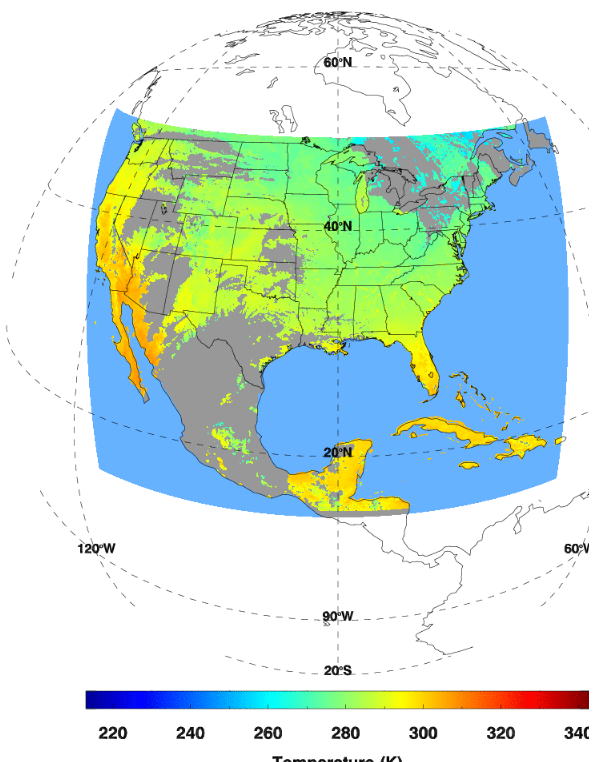
GOES-16 LST (Enterprise, proj to West)
201810220002 UTC



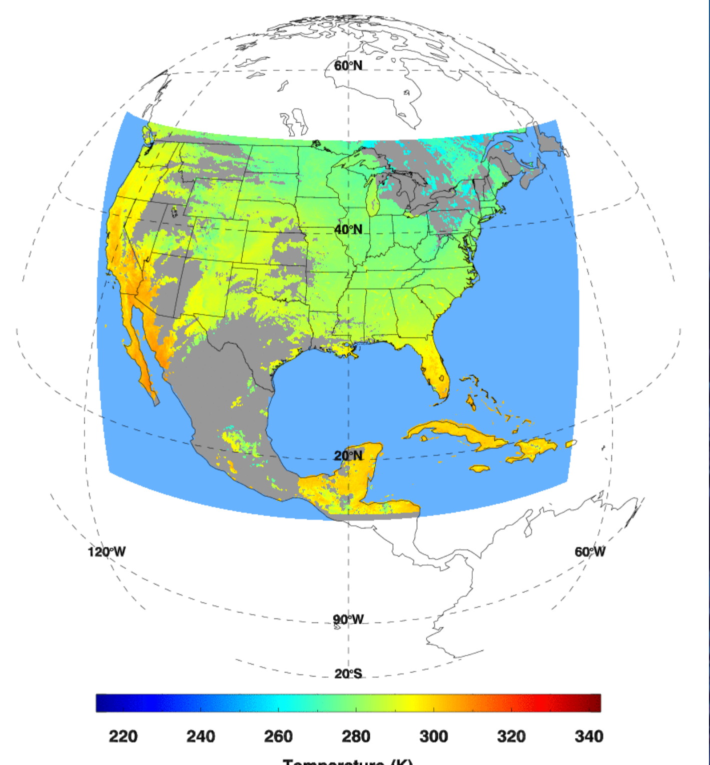
GOES-17 LST (Reprocessed, g16 TPW)
201810220002 UTC



GOES-17 LST (Enterprise, g16 TPW)
201810220002 UTC



GOES-17 LST (Mitigation, g16 TPW)
201810220002 UTC



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 have been developed and delivered.
  - The algorithm outperforms the current baseline algorithm.
- To address the loop heat pipe overheating issue, an mitigation algorithm has been developed and tested
  - The product quality is improved
  - The data usable period increases.
- The Enterprise/Mitigation algorithms are expected to be implemented in the ground system in June 2020.