Status of Land Surface Temperature Product Development for JPSS Mission

Yuling Liu [1,2], Yunyue Yu[2], Peng Yu[1,2] and Heshun Wang[1,2]

[1]ESSIC at University of Maryland, College Park, MD USA
[2]Center for Satellite Applications and Research, NOAA/NESDIS

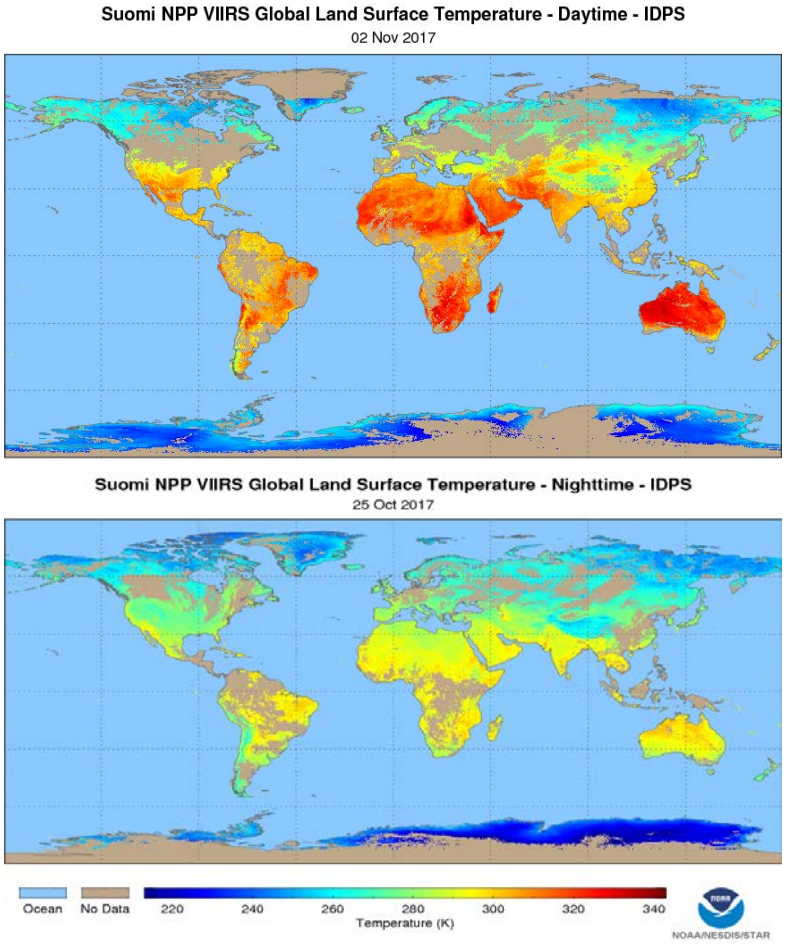
Outline

- LST product background
- Enterprise VIIRS LST product development
- Gridded LST development
- Issues and summary

JPSS LST Introduction

Operational JPSS Products:

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



Archive:
https://www.class.noaa.gov/
SCDR: 4 months data "VLSTO"

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

Enterprise LST Development

A unified LST retrieval algorithm is necessary for consistent LST production with different satellite missions

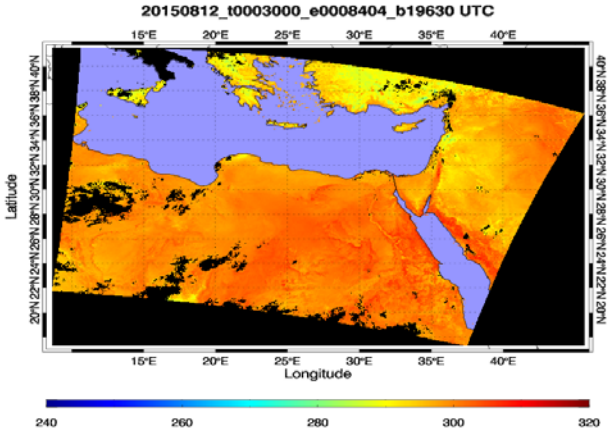
- Applicable to both GEO and LEO satellite missions: JPSS and GOES-R
- Consistent quality flags for users and for evaluation analysis
- Better Cross-satellite evaluation
- Better global validation effort
- Engineering and maintenance easiness

JPSS LST algorithms

2018--

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

Unified emissivity explicit algorithm;
Look-up-table dimension: 3 TPW, 5 view angle, ay/night (adjustable)
ε and Δε are the mean and difference of the spectral emissivity of the two split windows.

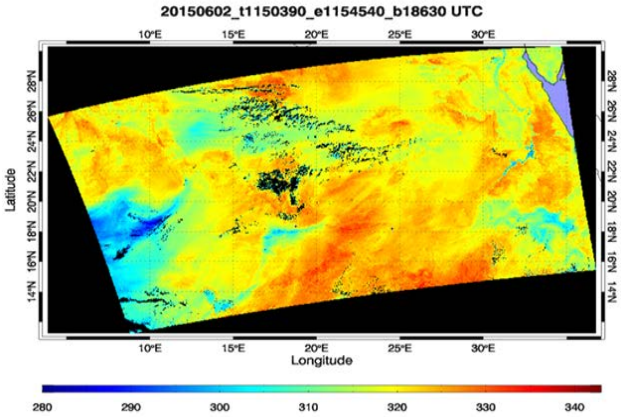


J1 era and after

2011-2017

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

Surface type dependent algorithm;
Look-up-table dimension: 17 IGBP surface type, day/night



SNPP

J1 early stage

File Name	Data Variables	Description	Dimension	Type
Primary Sensor Data(SDR)				
NPP_VIIRS_2016152_0836_19_VIIRS_SDR_MULTIRES_L1B_Band15_750M.nc	BT(11μm)	brightness temperature at 11μm	granule (xsize, ysize)	float
	Bad pixel mask	SDR QC for BT at 11μm	granule (xsize, ysize)	byte
NPP_VIIRS_2016152_0836_19_VIIRS_SDR_MULTIRES_L1B_Band16_750M.nc	BT(12μm)	brightness temperature at 12μm	granule (xsize, ysize)	float
	Bad pixel mask	SDR QC for BT at 12μm	granule (xsize, ysize)	byte
NPP_VIIRS_2016152_0836_19_VIIRS_SDR_MULTIRES_NAV_750M.nc	Solar zenith	solar zenith angles	granule (xsize, ysize)	float
	View Zenith	Satellite view zenith angle	granule (xsize, ysize)	float
	Space mask*	Out of space indicator	granule (xsize, ysize)	byte
Derived Sensor Data				
NPP_VIIRS_2016152_0836_19_NPP_BAYES_CLOUD_MASK.nc	Cloud mask	Cloud mask indicator and quality flag for thin cirrus and fire detection	granule (xsize, ysize)	byte
NPP_VIIRS_2016152_0836_19_SNOW_MASK_NWP.nc	Snow/ice mask	Level 2 snow/ice mask data	granule (xsize, ysize)	byte
NPP_VIIRS_2016152_0836_19_LAND_MASK_NASA_1KM.nc	Land/sea mask	Level 2 land/sea mask data	granule (xsize, ysize)	byte
NPP_VIIRS_2016152_0836_19_TPW_NWP.nc	water vapor	NCEP tpw data	granule (xsize, ysize)	float
*NPP_VIIRS_2016152_0836_19_SFC_EMISS_STAR.nc	Emissivity data items	Emissivity at 11micron; 12 micron; Broad band emissivity and emissivity QC	granule (xsize, ysize,4)	float(emi) byte(QC)
NPP_VIIRS_2016152_0836_19_AWG_AER_AOD.nc	AOD	Level2 AOD data	granule (xsize, ysize)	byte
LUT and Configuration File				
NPP_VIIRS_LST_LUT.nc	Coefficients LUT	Algorithm coefficient file	2(day/night)*3(wv)*5(stz)*7(coef items)	Unitless
NPP_VIIRS_LST_Config.nc	Parameter control	Configuration value file	10*1	float

Input

Enterprise LST Output

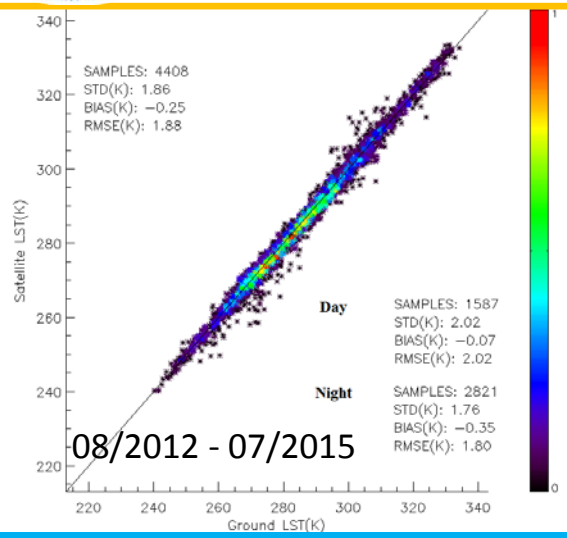
Name	Description	Data Type	Dimension	Unit
LST values	Retrieved land surface temperature value for each pixel	Short	granule (xsize, ysize)	K
LST QC flags	LST Quality control flags for each pixel	Short	granule (xsize, ysize)	unitless
Emissivity at 11µm	Spectral emissivity value for band at 11µm	Byte	granule (xsize, ysize)	unitless
Emissivity at 12µm	Spectral emissivity value for band at 12µm	Byte	granule (xsize, ysize)	unitless
Broadband Emissivity	Broadband emissivity value	Byte	granule (xsize, ysize)	unitless
Emissivity QF	Emissivity data quality flag	Byte	granule (xsize, ysize)	unitless

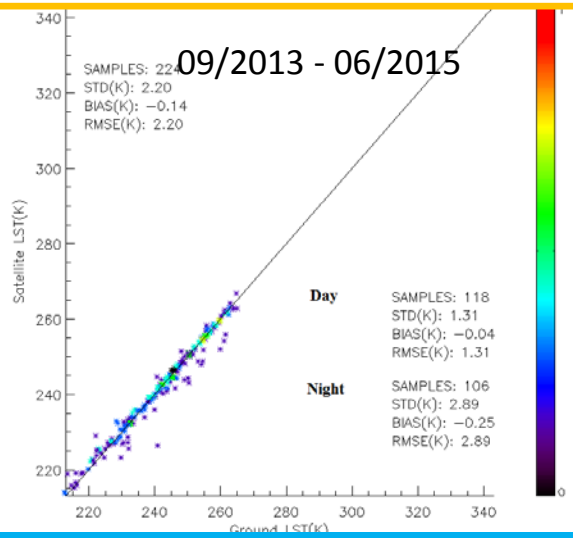
*The granule level metadata is also included in the LST output.

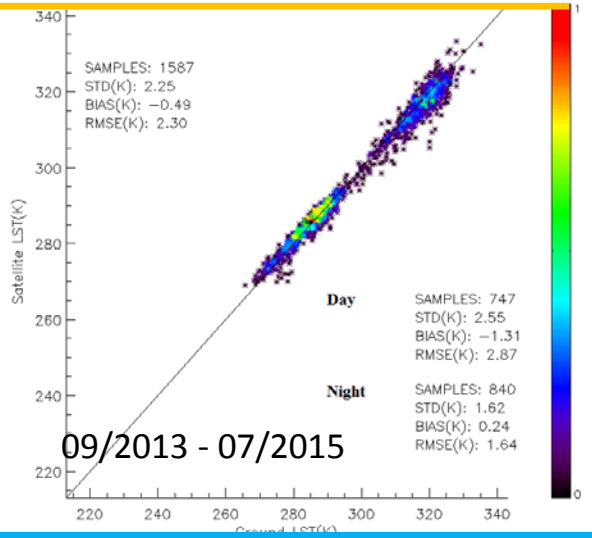
Quality Flag list

bit	Flag	Source	description
0-1	LST quality	LST	00=high, 01=medium, 10=low, 11=no retrieval
2-3	Cloud condition	Cloud mask	00=confidently clear, 01=probably clear,10=probably cloudy,11=confidently cloudy
4	SDR quality	SDR	0=normal, 1=bad data (bad quality or missing or out of space)
5	Aerosol Optical Thickness at 550 nm (slant path)	AOD	0=within range(AOD<=1.0);1=outside range (AOD >1)
6-7	Land surface cover	land/sea mask snow/ice mask	00=land;01=snow/ice;10=in land water;11=coastal
8-9	Water vapor condition	Tpw input	00=very dry atmosphere(wv<1.5g/cm^2) ; 01= dry [1.5,3); 10=moist atmosphere[3,4.5); 11= very moist[4.5+)
10	Emissivity quality	Emissivity	0=within LSE uncertainty, 1=beyond LSE uncertainty requirement(0.015)
11	Degradation by large viewing angle	SDR	0=no degradation, 1=large view degradation (VIIRS: <=40 degree, ABI: <=55 degree)
12	Day/night flag	SDR	0=night(solar zenith angle > 85degree), 1=day
13	Thin cirrus	Cloud Mask	0= no thin cirrus, 1= thin cirrus (Only available for daytime)
14	Fire contamination flag	Cloud mask	0= no , 1= yes
15	Reserved		Reserved for future use

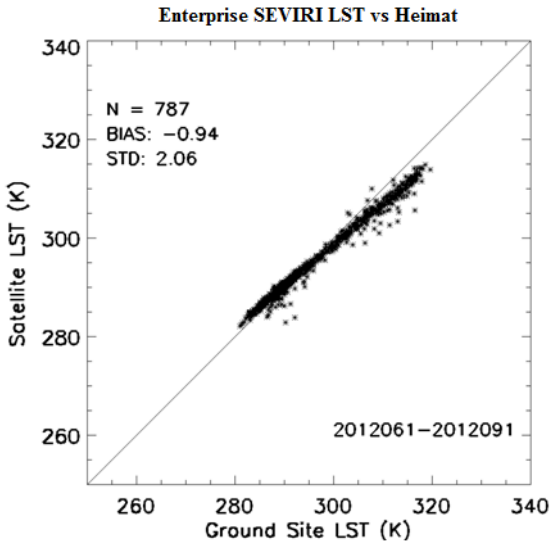
Enterprise VIIRS LST Evaluation

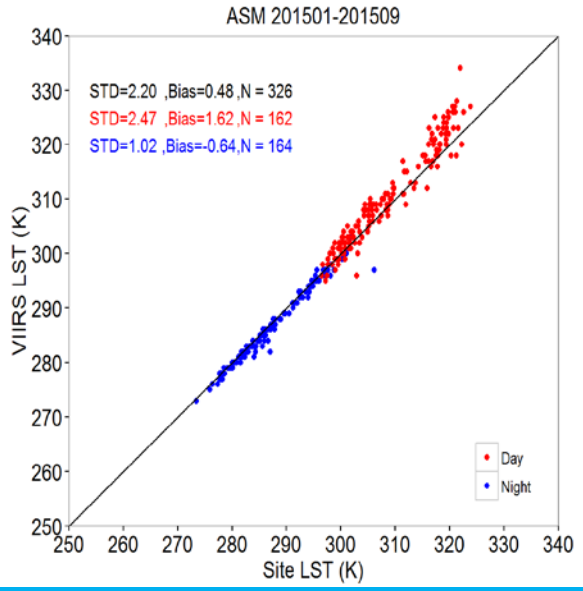


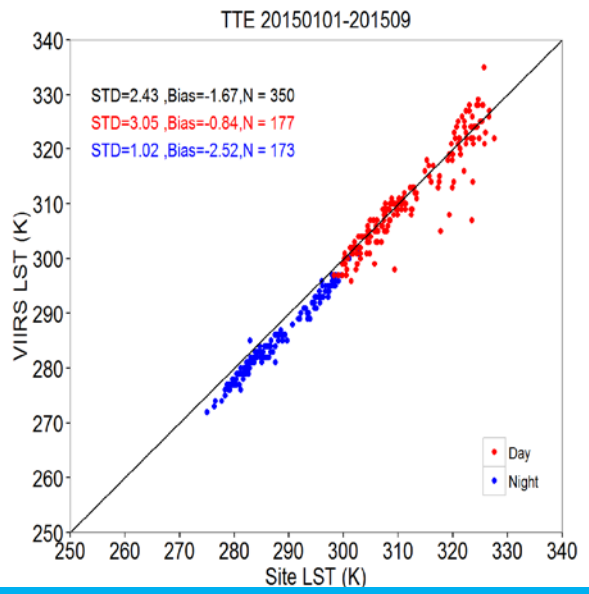




Enterprise VIIRS LST against ground data from SURFRAD, BSRN and GMD



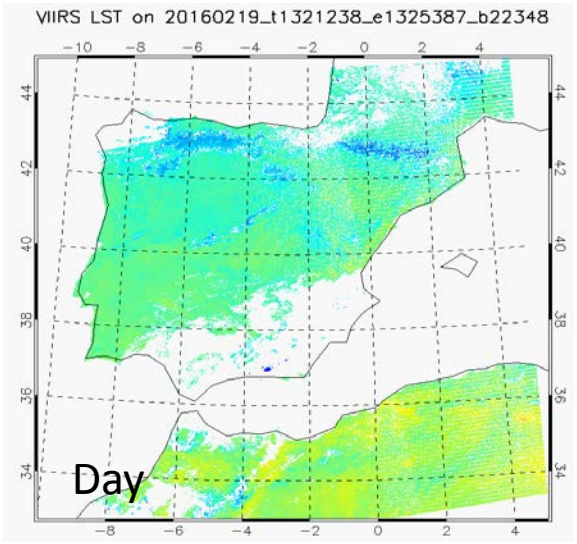


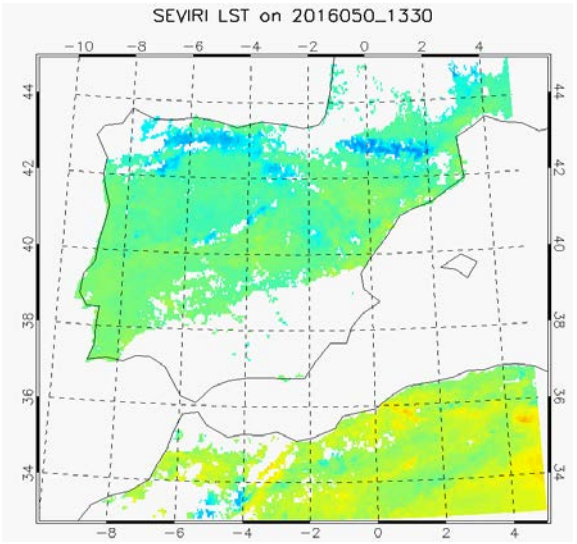


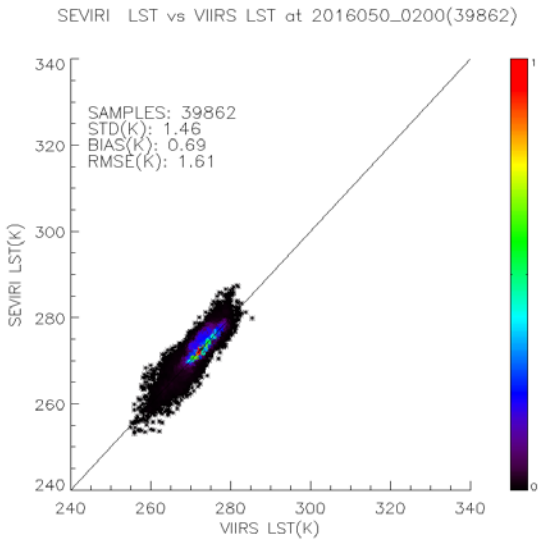
Enterprise SEVIRI and VIIRS LST against ground data from KIT(left) and OZFlux(Middle and Right)

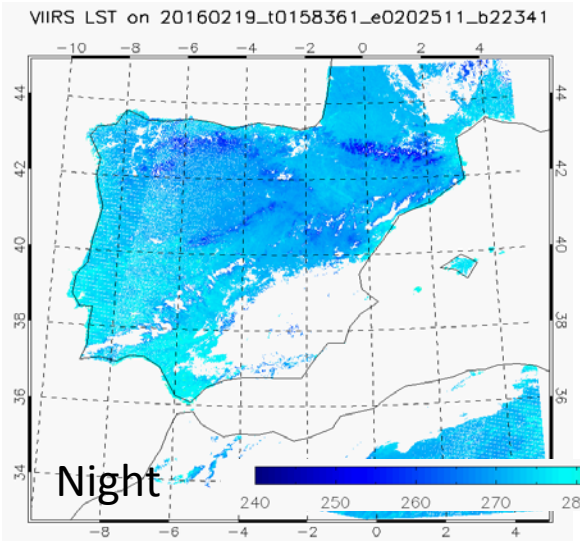
Algorithm Evaluation

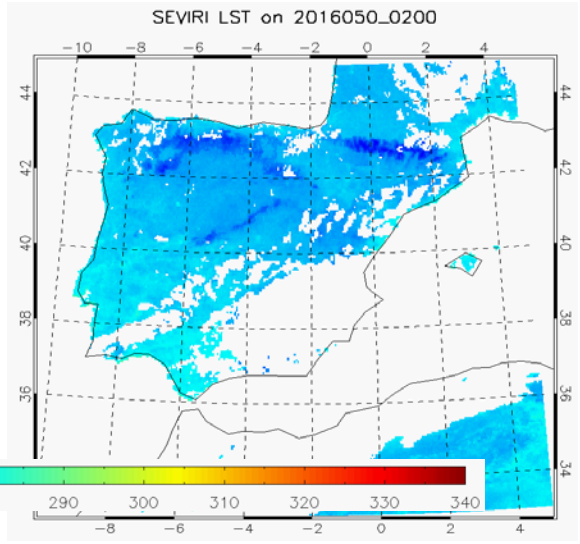
Cross Satellite Comparison

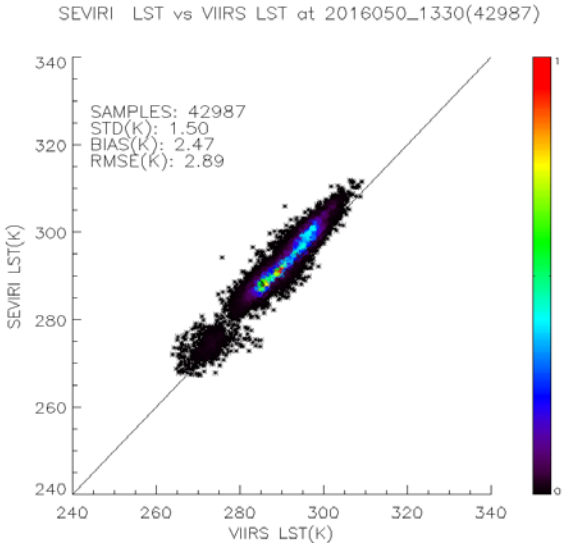






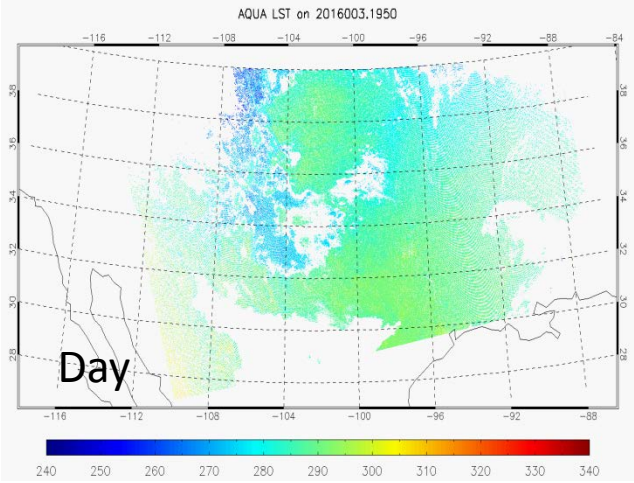


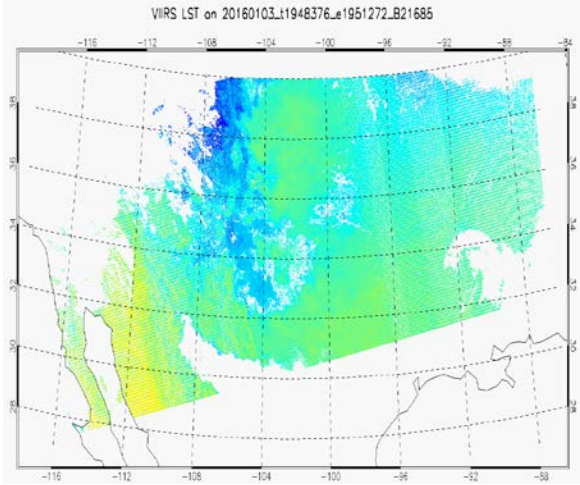


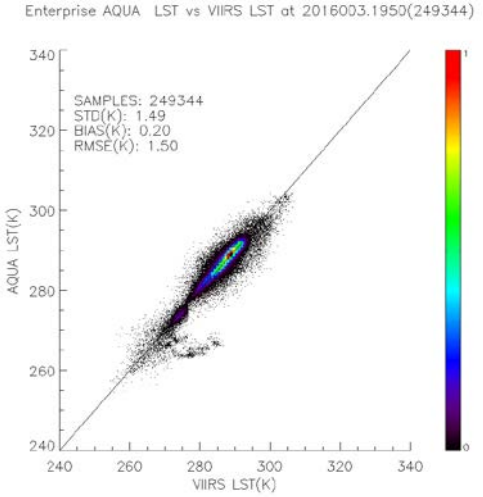


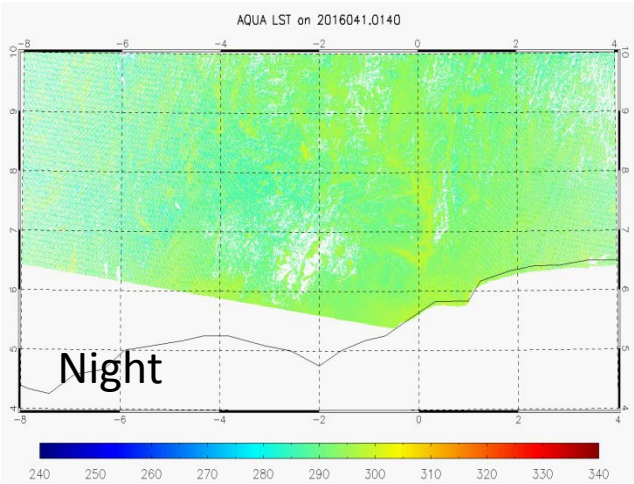
VIIRS vs SEVIRI

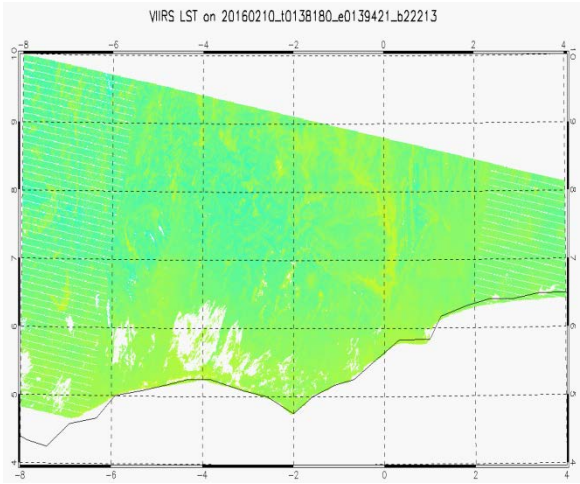
Algorithm Evaluation
Cross Satellite Comparison

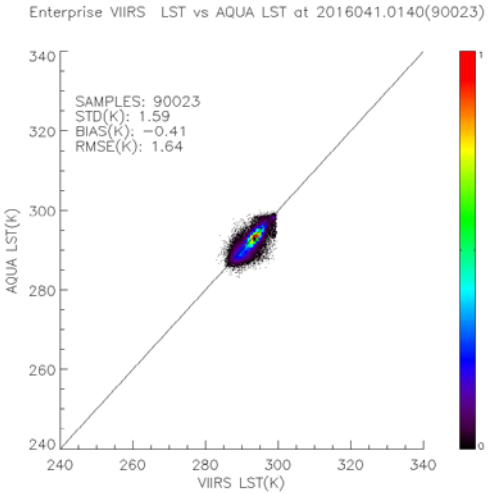






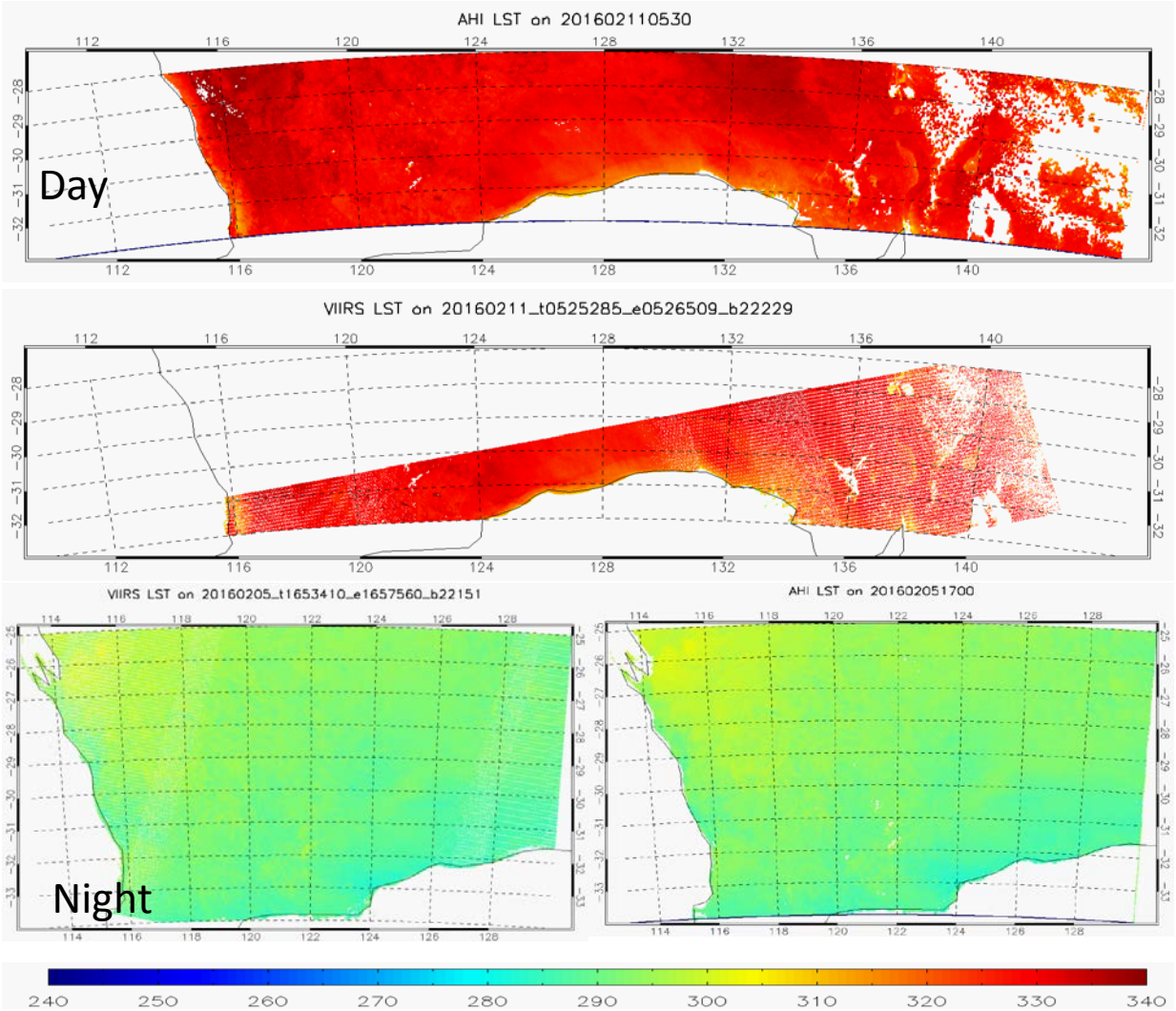




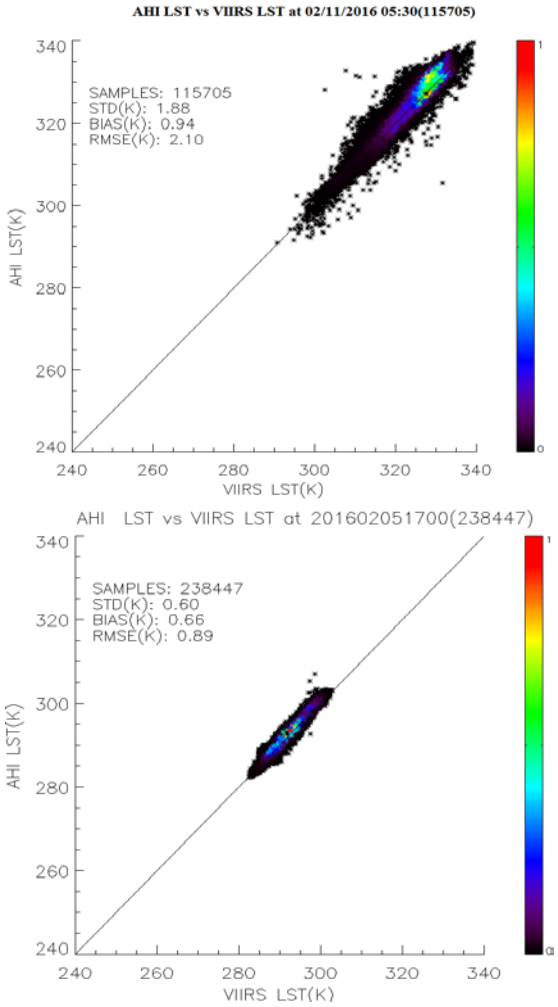


VIIRS vs AQUA

Algorithm Evaluation
Cross Satellite Comparison

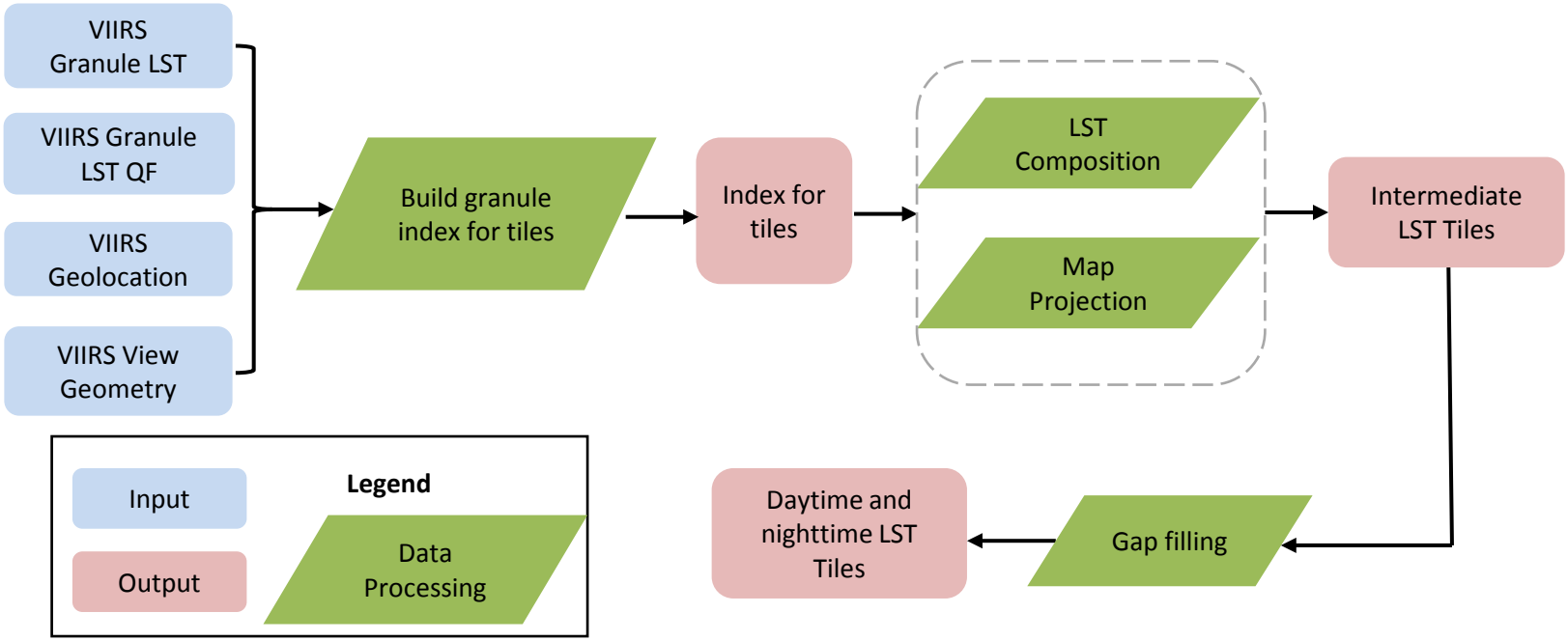


VIIRS vs AHI



Gridded LST Development

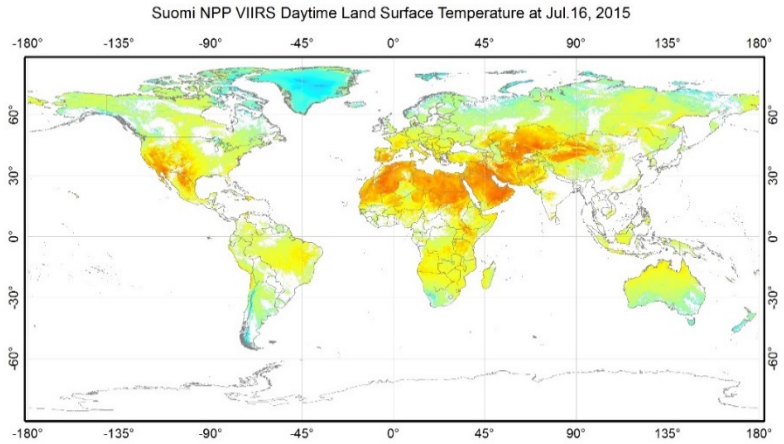
- Based on the current granule LST product, our Level-3 VIIRS Gridded LST was designed with the following features:
  - Global coverage with two spatial resolutions provided: 0.009 degree and 0.036 degree
  - Gridded with tile system management
  - Gap-filled at invalid pixel
  - Daily product at daytime and nighttime



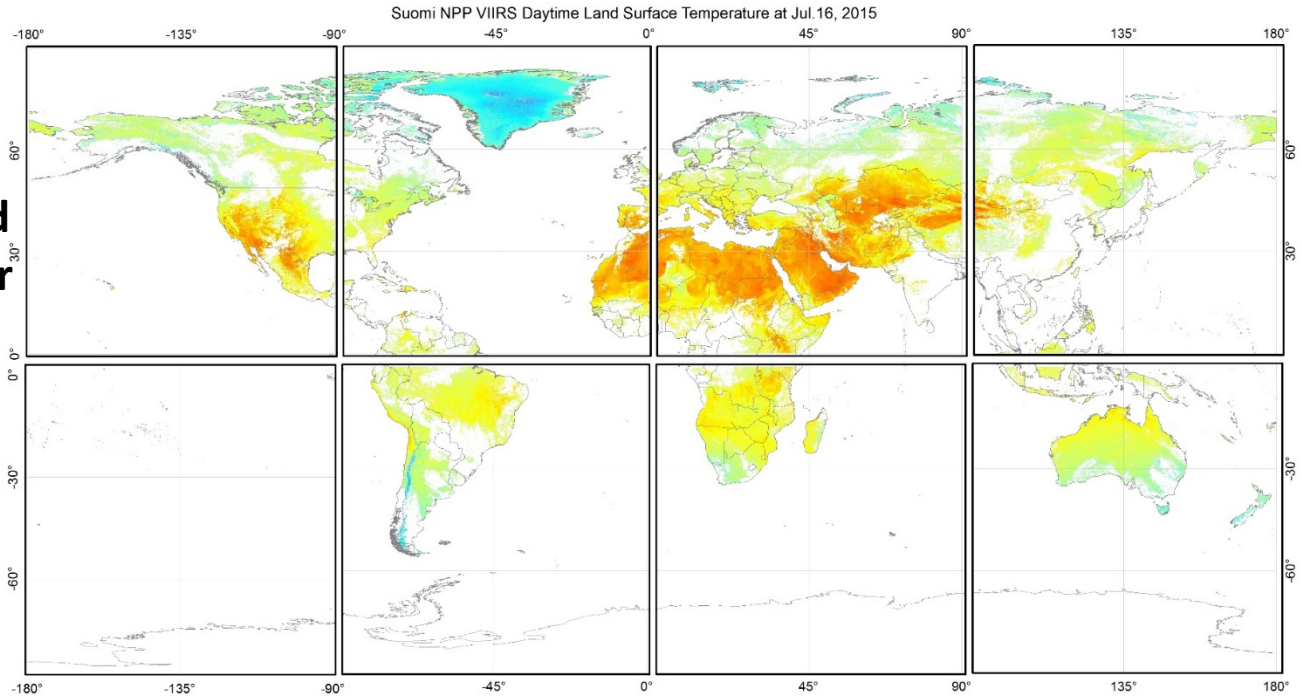
Flow chart of the gridded LST product

Gridded LST Development

4km Gridded VIIRS Land Surface Temperature for daytime

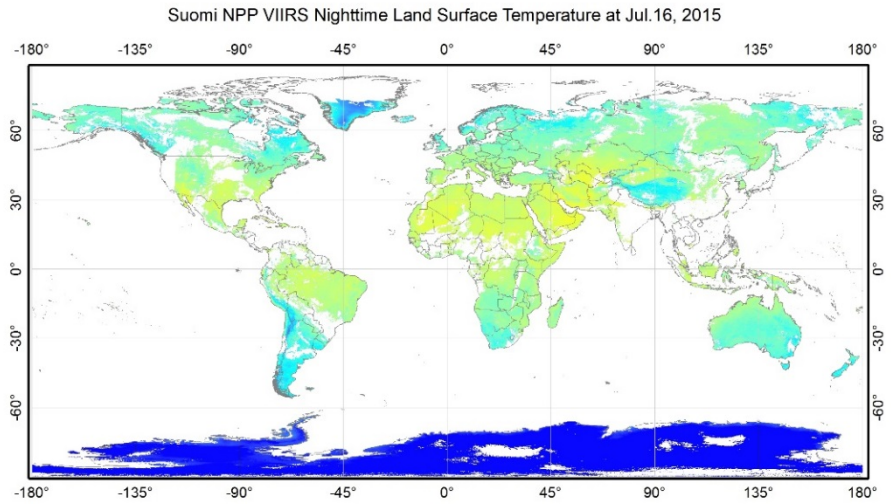


1km Gridded VIIRS Land Surface Temperature for daytime
(4×2 tiles for globe)

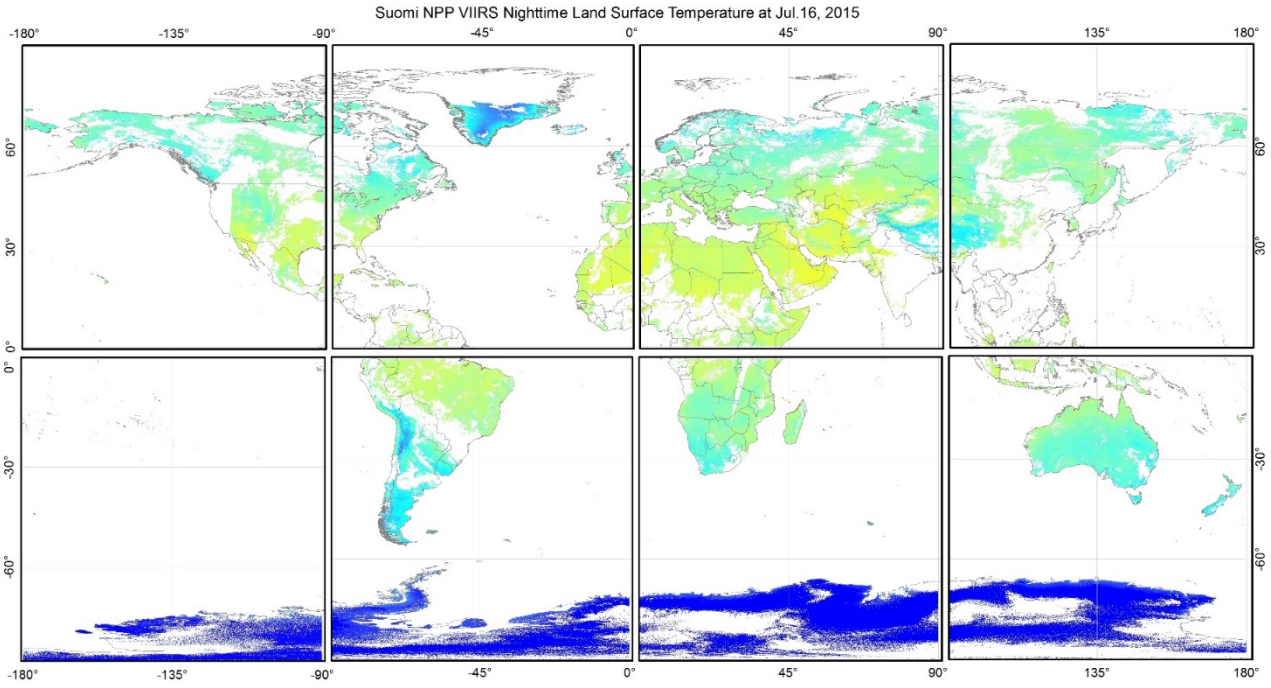


Gridded LST Development

4km Gridded VIIRS Land Surface Temperature for nighttime



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



Issues and Concerns

- Validation protocol
  - Validation against ground measurements
    - Ground data quality control
    - Cloud residue effect: cloud mask definition difference between satellite LST products
    - Viewing geometry effect
    - Upscaling effect
  - Cross satellite comparison
    - Composition method
    - Minimize temporal difference
    - Minimize the angular difference
    - Difference interpretation
      - Sensor difference can not be ignored
      - Simulation and regression procedures
      - Algorithm difference
      - Upstream input data difference

Summary

- The enterprise algorithm is currently under integration and expected to be operational at early 2018. It is expected to be used for J-1 LST product generation. At the early stage of J1, the IDPS algorithm will be used for LST retrieval.

- 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.