JPSS LAND SURFACE TEMPERATURE

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UMD/ESSIC

Outline

- Cal/Val Team Members
- JPSS LST Production Overview
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  - Performance Overview
  - New Development
    - ✓ Enterprise LST Algorithm
    - ✓ Emissivity Development
  - Reprocessing Status
  - Long Term Monitoring
  - Issues
- JPSS-1 Readiness
- Summary and Path Forward

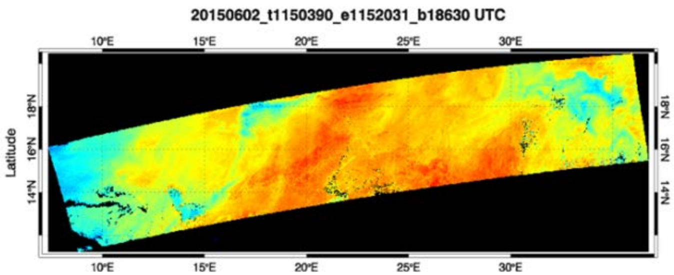
Cal/Val Team Members

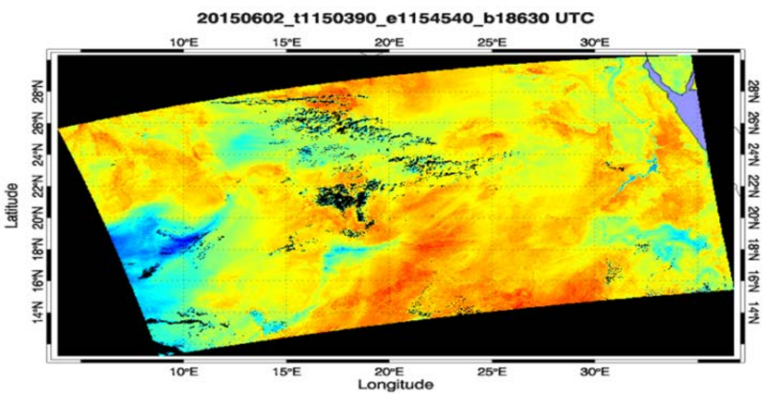
PI	Organization	Team Members	Roles and Responsibilities
Ivan Csiszar	NOAA/NESDIS/SATR		Land Lead, Project Management
Yunyue Yu	NOAA/NESDIS/SATR		EDR Lead, algorithm development, validation, team management
		Yuling Liu	product monitoring and validation ; algorithm development
		Heshun Wang	algorithm improvement, emissivity development
		Peng Yu	product validation tool, monitoring, applications
Walter Wolf	NOAA/NESDIS/SATR		System Integration, Transition
		Valerie Mikles	System Integration, Transition
		Marina Tsidulko	STAR IT support
Michael EK	NOAA/EMC/NCEP		User readiness
		Weizhong Zheng	User readiness : Model LST verification
		Yihua Wu	User readiness : Model LST verification
Miguel Roman	NSAS/GSFC		NASA Land Science Investigator-led Processing System Lead
		Sadashiva Devadiga	System support, product monitoring

Current VIIRS LST Algorithm Overview

$$LST_{i,j} = a_0(i,j) + a_1(i,j)T_{15} + a_2(i,j)(T_{15} - T_{16}) + a_3(i,j)(\sec\theta - 1) + a_4(i,j)(T_{15} - T_{16})^2$$

Where a_k (with k=0 to 4) are coefficients depending on surface type (with i =0 to 16 for 17 IGBP surface types) and day/night condition (with j=0 to 1), and θ is satellite viewing zenith angle.





- Operational Products
  - Single 1.5 min granule data
  - Combined 4 x 1.5 min granule data
- Production team
  - STAR Science Team : Scientific development and validation
  - JPSS DPE (Data Product Engineering) : Production

Name	Type	Description	Dimension	Unit
Input				
Primary Sensor Data(SDR)				
Brightness temperature at 11μm	input	brightness temperature at 11μm	grid (xsize, ysize)	K
Brightness temperature at 12μm	input	brightness temperature at 12μm	grid (xsize, ysize)	K
Geolocation file	input	It includes solar zenith angles and Satellite view zenith angle	grid (xsize, ysize)	Degree
Derived Sensor Data				
Cloud mask	Input	Cloud mask data	grid (xsize, ysize)	unitless
Surface Type EDR	Input	Level 2 surface type data which includes Snow/ice, and IGBP types	grid (xsize, ysize)	unitless
AOT	Input	Level2 AOT data	grid (xsize, ysize)	unitless
LUT and Configuration File				
Coefficients LUT	Input	Algorithm coefficient file	2(day/night)*17(IGBP)*9(coef items)	Unitless
Parameter control	Input	Configuration value file		Unitless
Output				
LST	Output	LST value	grid (xsize, ysize)	K
QF	Output	Associated pixel quality flags	grid (xsize, ysize)	Unitless

Product Performance Overview

Attribute Analyzed	Performance	Description
L1RD APU Threshold	1.4K (2.5K)	
In-situ Validation	**-0.41(2.35)**	Results are based on the VIIRS data over six **SURFRAD** sites for over 3 years . The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data error.
	-0.68(1.79) **-0.41(2.09)**	Results are based on the VIIRS data over two sites from **BSRN**. One site is in Gobabeb, Namibia and the other one is located in Cabauw, Netherland. The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data error.
	0.19(2.13) **-001(2.24)**	Results are based on the VIIRS data over the **ARM** site in South Great Plain in Oklahoma; over **GMD** site in Summit, Greenland The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data error.
R-based Validation	**0.47(1.12)**	A forward radiative transfer model is used, over 9 regions in globe, representing all 17-IGBP types over the seasons. The error budget estimation is limited by profile quality, cloud screening procedure and sampling procedure.
Cross satellite Comparison	**0.59(1.93): day** **0.99(2.02): night**	The results are based on comparisons to **MODIS** LST, over 100 scenes, over low latitude, polar area and CONUS. The error budget estimation is limited by the spatial and temporal difference, sensor difference, angle difference etc.
	Winter: -0.15(2.16):night **-2.02(2.81):day** **Summer:** **0.2(1.55):night** **-2.95(4.76):day**	The results are based on comparisons to **SEVIRI** LST in summer and winter seasons over Iberian Peninsula. The error budget estimation is limited by the spatial and temporal difference, sensor difference, angle difference etc.

Enterprise Algorithm Development

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

- Better Cross-satellite evaluation
- Better global validation effort
- Engineering and maintenance easiness

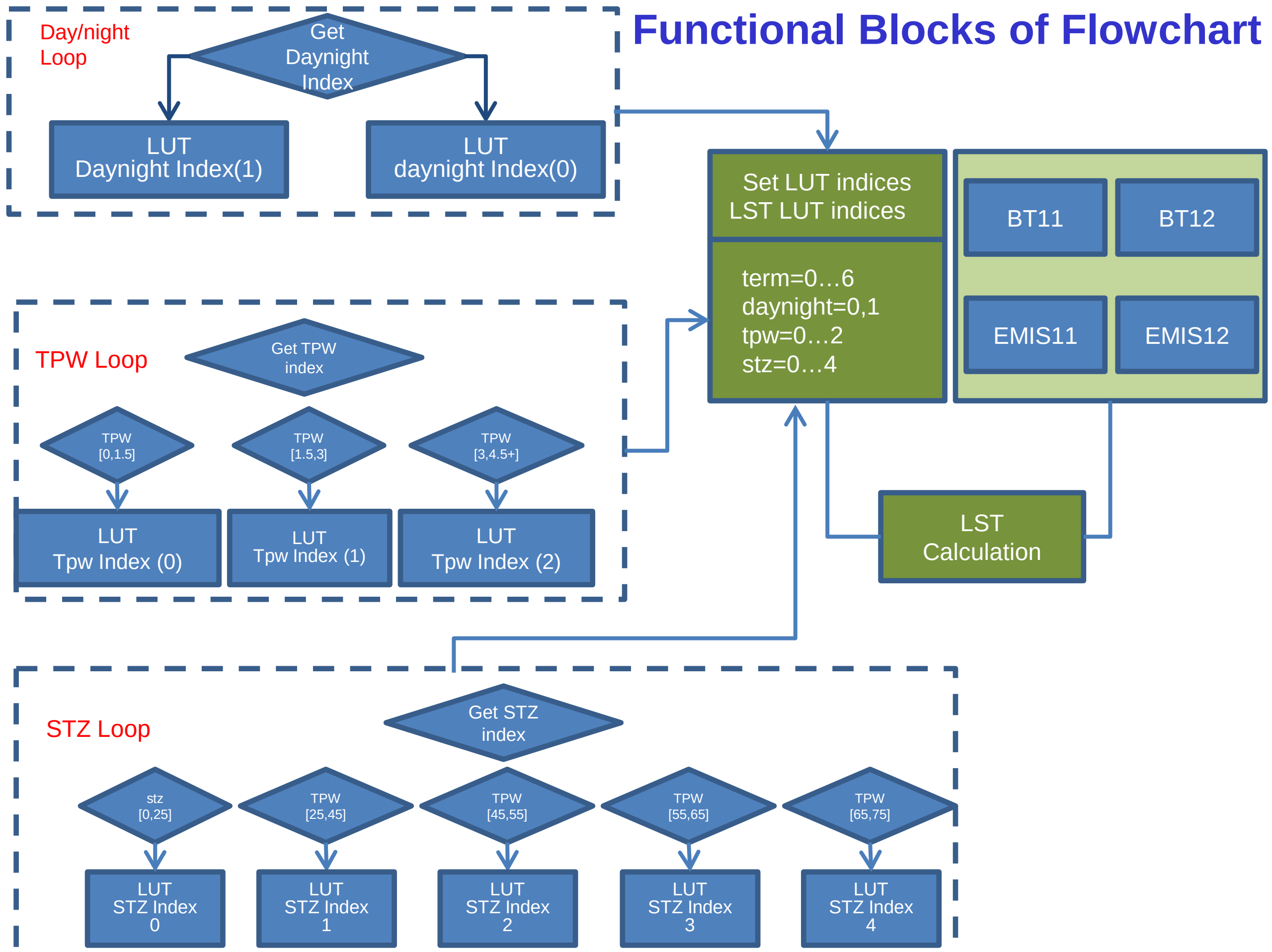
Consideration of enterprise algorithm development

- Simplify
- Robustness
- Applicable to both LEO and GEO satellite missions
- Consistent quality flags for users and for evaluation analysis
- Rely on thermal split window for best accuracy

Practical algorithm determination

- Over 20 algorithms being tested
- Simulation study for Coeffs dimension
- ATBD is in writing

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

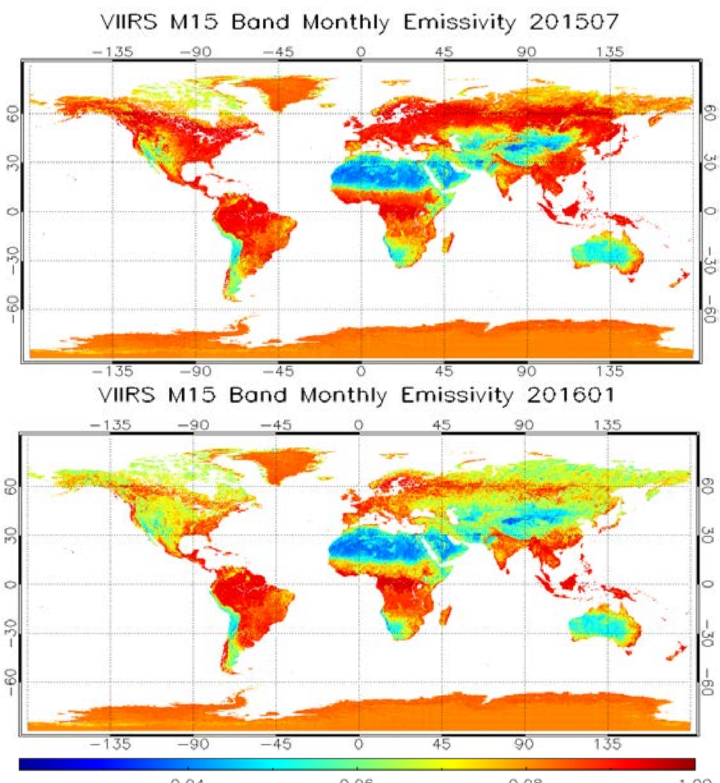


Enterprise Algorithm Status

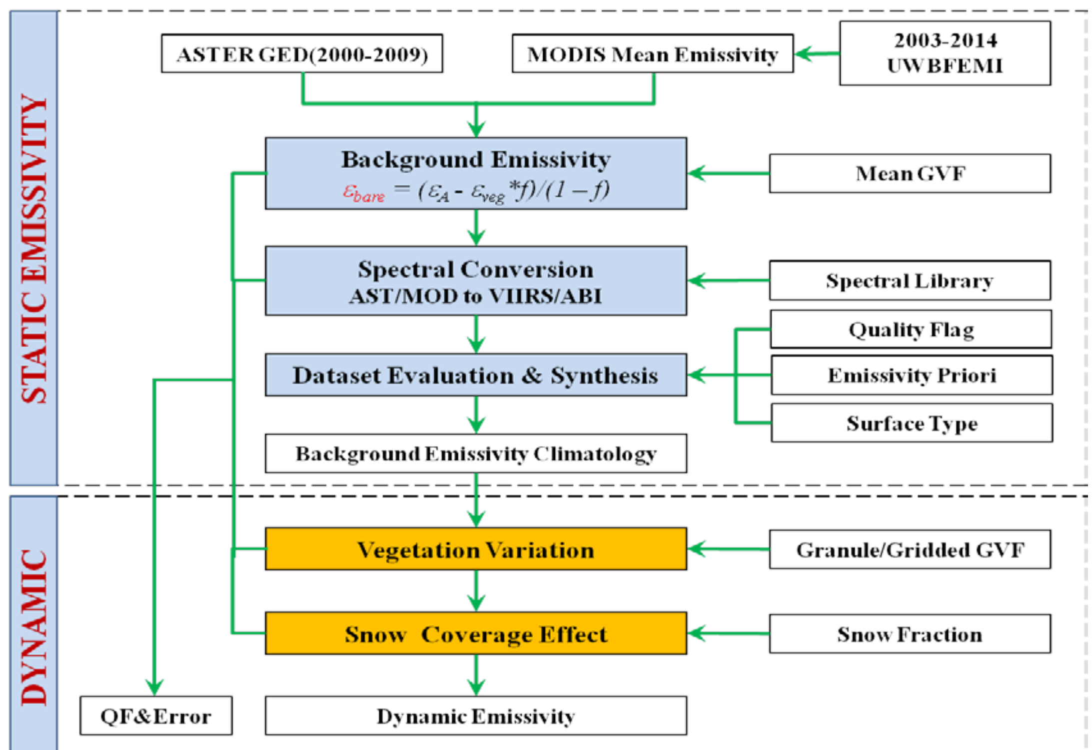
- Simulation study of algorithm test, uncertainty and sensitivity analysis have been performed.
- Real satellite data tests using VIIRS, MODIS, AHI and SEVIRI have been conducted.
- Evaluation of the algorithm is performed using 1) in-situ observations from SURFRAD, BSRN, ARM and GMD, and 2) cross satellite comparisons.
- A consistent pixel level quality flag set are determined for different satellite platform.
- Concurrently, land surface emissivity (LSE) algorithm has been developed; a daily global LSE data will be available for the LST production.
- The core part of the science code has been finished.
- The detailed design of the software architecture is on-going, with the AIT team.
- Draft version of enterprise LST ATBD and ppt slides for the coming critical design review is on-going.

Emissivity Data Development

- **Developed a new emissivity algorithm**
  - Using historical emissivity products to generate background emissivity climatology.
  - Employing a relationship between emissivity and GVF & Snow fraction to account for dynamic change.
  - Produce high resolution (0.009 degree) daily emissivity product for JPSS and GOES-R missions.
- **Advantages**
  - The dynamic emissivity provides more accurate surface emission property than static emissivity
  - High resolution GVF & Snow data gives the dynamic emissivity change information.
- **Limitations**
  - The new emissivity product only include thermal infrared channels



Flowchart of Emissivity Production Process



Reprocessing Plans/Status

- Reprocess Necessity has been proposed
  - SDR data corrections (Cal/Val, Strips, etc.)
  - LUT corrections (three times)
  - Surface Type Update
  - Cloud Mask update
- Reprocessing is planned: *after the Enterprise Algorithm development; covering the entire SNPP period (i.e. from 11/19/2012 to present)*
- Upstream data check for the reprocessing: *SDR, cloud mask and AOT and the availability of the ancillary data such as total precipitable water and snow/ice information*
- The input/output data structure and QC flags are generally determined for the enterprise LST algorithm
- Concern: data storage need

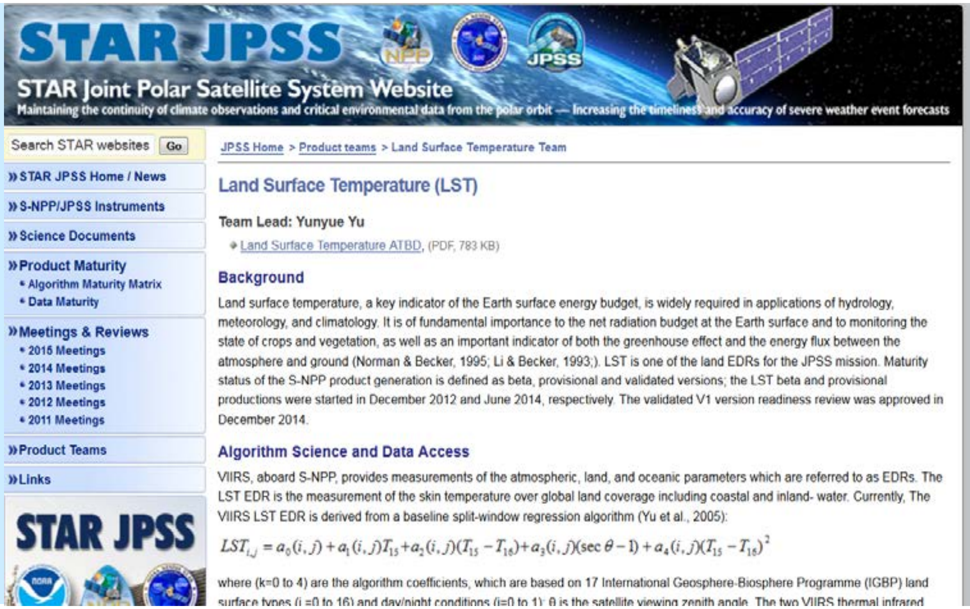
Long-term monitoring

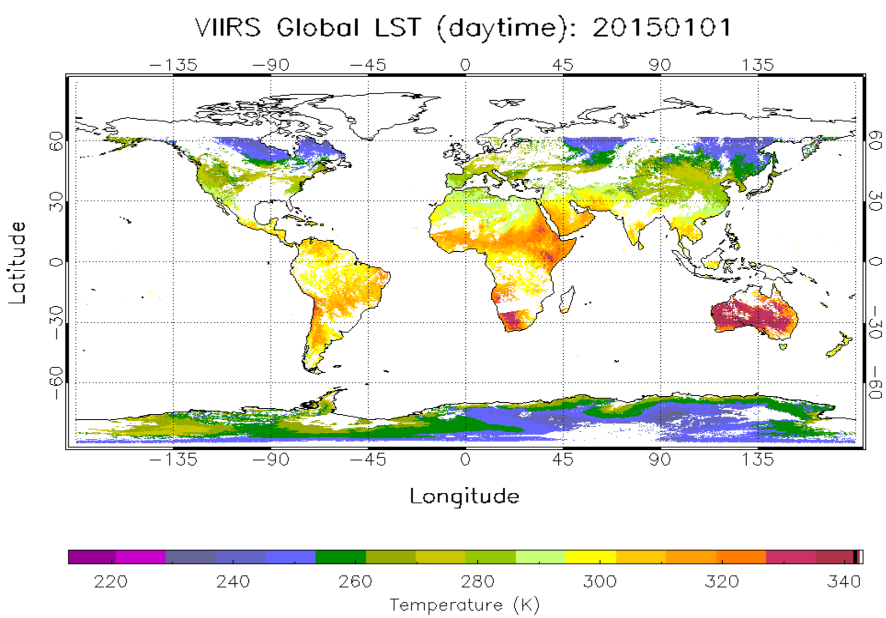
- **Monitoring/Validation tool drafted**
- **Webpage development**

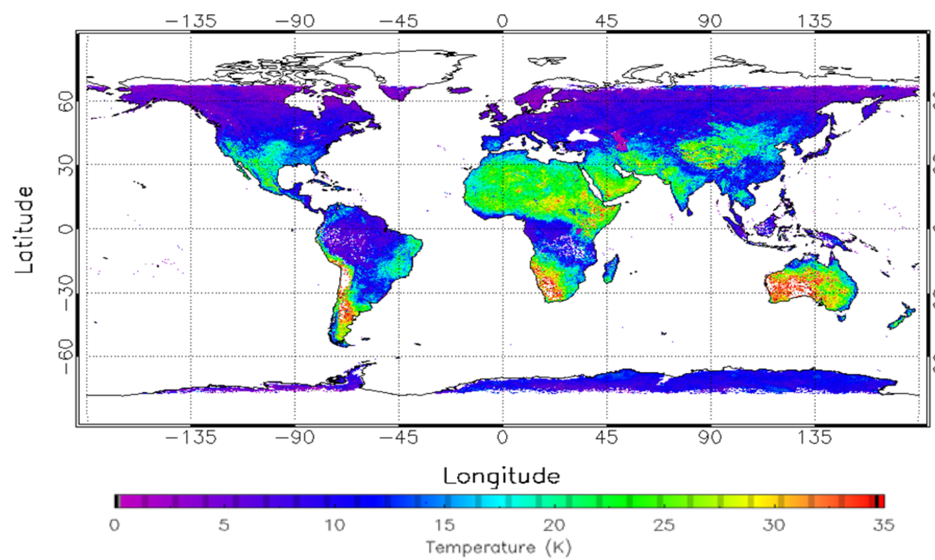
✓ A monitoring tool has been developed, which generates daily global VIIRS LST maps, and the diurnal temperature range (DTR) from the operational VIIRS LST EDR data and routinely validate with SURFRAD data.

✓ An ftp site and notification system has been setup for the monitoring, which runs the daily global LST, the monthly DTR, and the routine validation automatically. ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/.

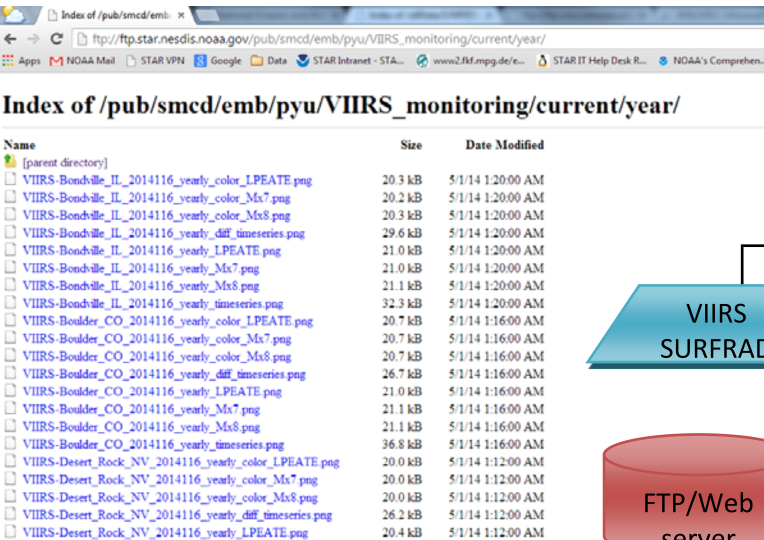
✓ A webpage development is on-going for public to review and download the global daily LST and the monthly DTR maps.







Long-term monitoring - 2



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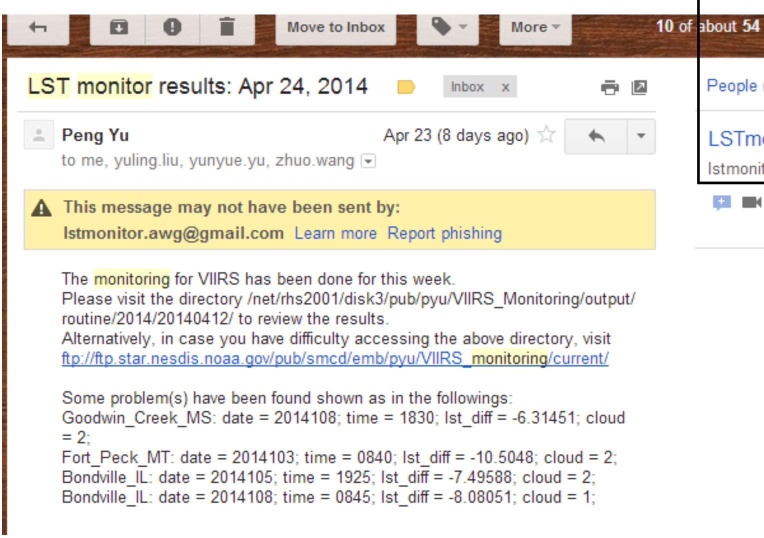


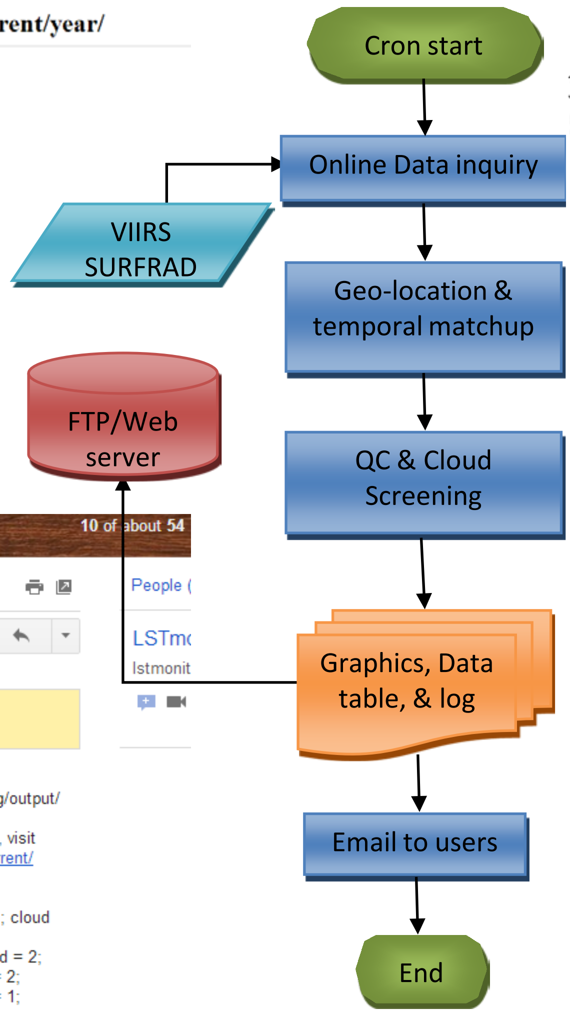
LST monitor results: Apr 24, 2014

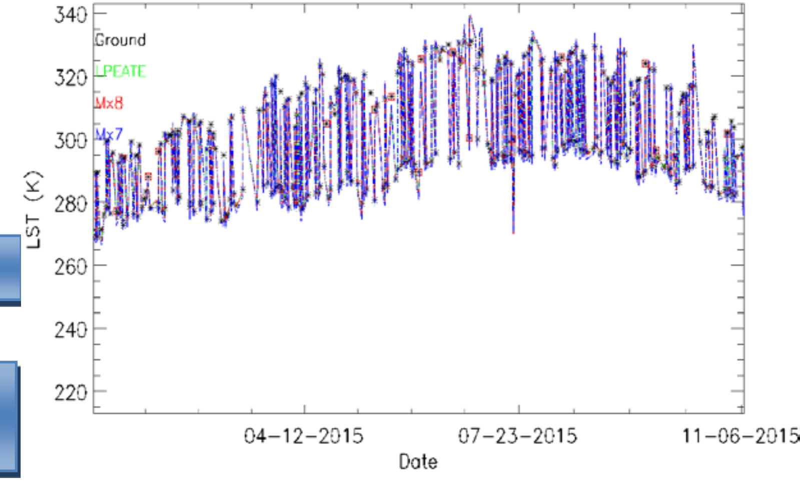
Peng Yu — Apr 23 (8 days ago)
to me, yuling.liu, yunyue.yu, zhuo.wang

This message may not have been sent by: lstmonitor.awg@gmail.com Learn more Report phishing

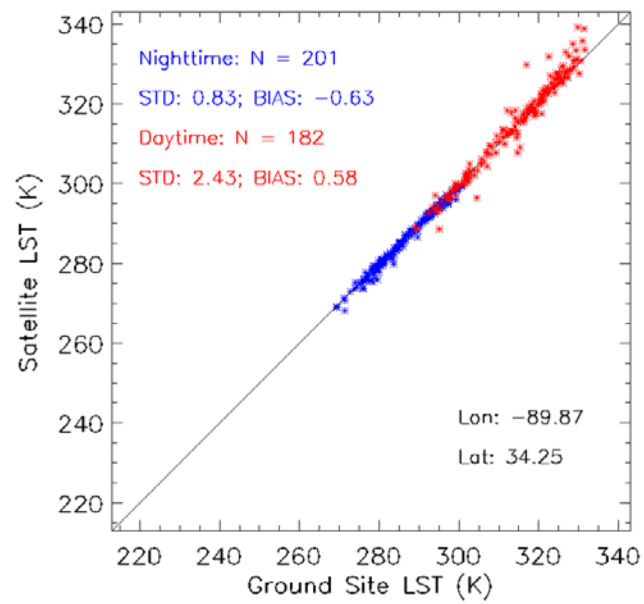
The monitoring for VIIRS has been done for this week.
Please visit the directory /net/rhs2001/disk3/pub/pyu/VIIRS_Monitoring/output/routine/2014/20140412/ to review the results.
Alternatively, in case you have difficulty accessing the above directory, visit ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/current/

Some problem(s) have been found shown as in the followings:
Goodwin_Creek_MS: date = 2014108; time = 1830; lst_diff = -6.31451; cloud = 2;
Fort_Peck_MT: date = 2014103; time = 0840; lst_diff = -10.5048; cloud = 2;
Bondville_IL: date = 2014105; time = 1925; lst_diff = -7.49588; cloud = 2;
Bondville_IL: date = 2014108; time = 0845; lst_diff = -8.08051; cloud = 1;





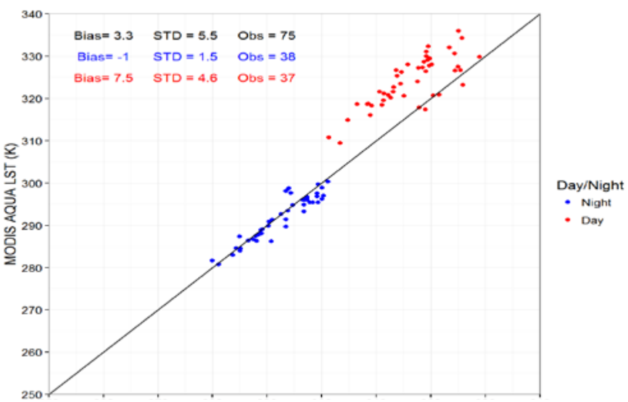
Desert Rock: 2015001-2015311

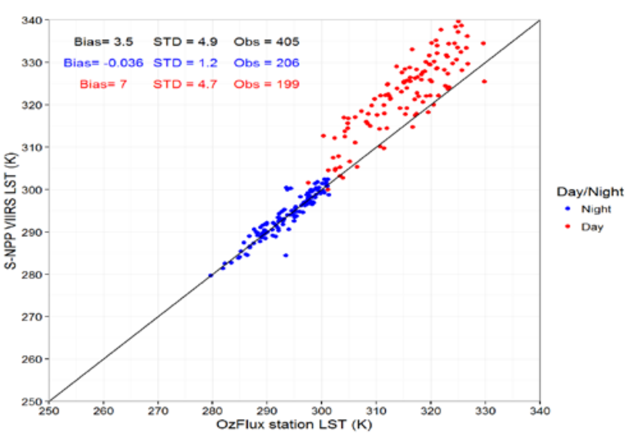


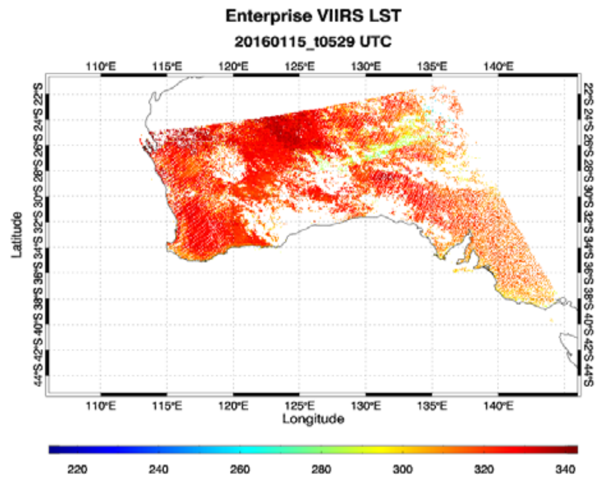
ftp://ftp.star.nesdis.noaa.gov/pub/smcd/emb/pyu/VIIRS_monitoring/current/year/

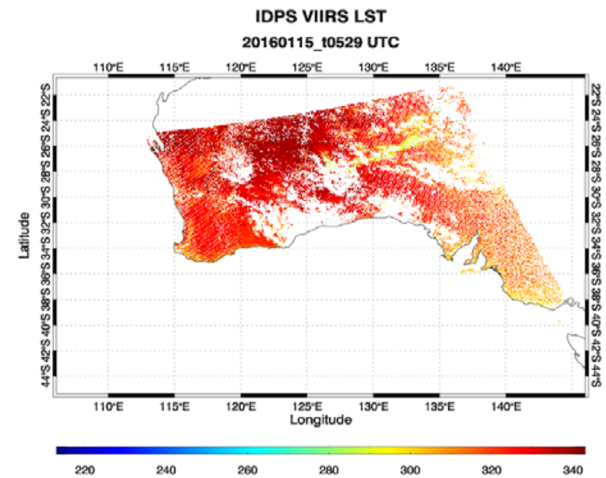
Issues In Australia region

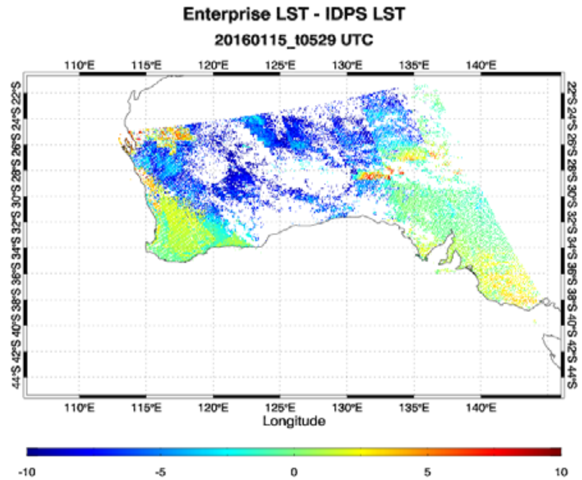
Suspicious High IDPS LST values observed in Australia Region in Summer.

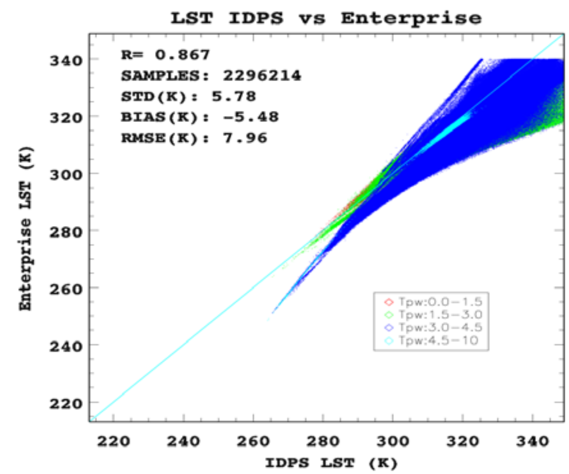












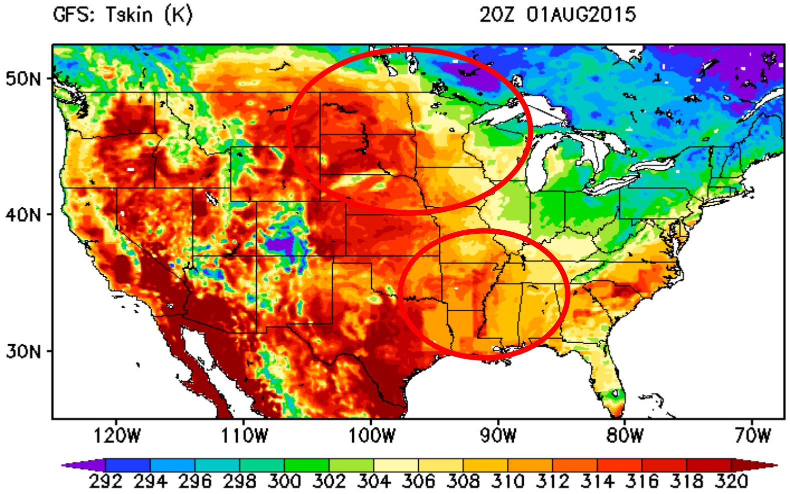
Left: The MODIS LSTs (top) and VIIRS IDPS LSTs (bottom) against ground station LST estimates
Right: VIIRS Enterprise LSTs and the IDPS LSTs

External Users of LST product

- USDA Agricultural Research Services(Martha Anderson)
- USDA Forest Service (Brad Quayle)
- Academy – Univ. of Maryland (Konstantin Vinnikov, Shunlin Liang, Cezar Kongoli)
- Army Research Lab (Kurt Preston)
- EUMETSAT LSA SAF LST group (Isabel Trigo, Project Manager)
- ESA/ESRIN, Italy (Simon Pinnock & Olivier Arino)
- Univ. Of Edinburgh, UK (Chris Merchant)
- OBSPM, and LSCE, France (Catherine Prigent & Carlos Jimenez, and Catherine Ottlé)
- Universitat de les Illes Balears, Spain (Maria Antonia Jimenez Cortes)
- eLEAF, The Netherlands (Henk Pelgrum & Wim Bastiaanssen)
- Centre for Ecology and Hydrology, UK (Rich Ellis)
- Institute of Geodesy and Cartography, Poland (Katarzyna Dabrowska-Zielinska)

Users feedback

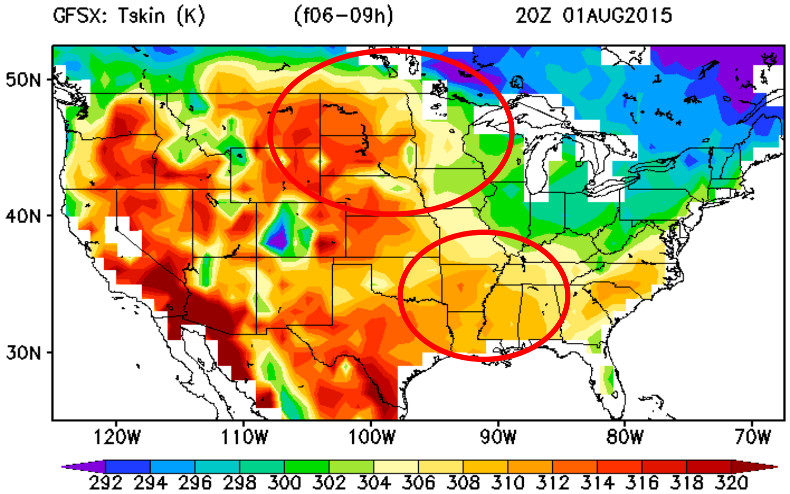
Operational GFS LST



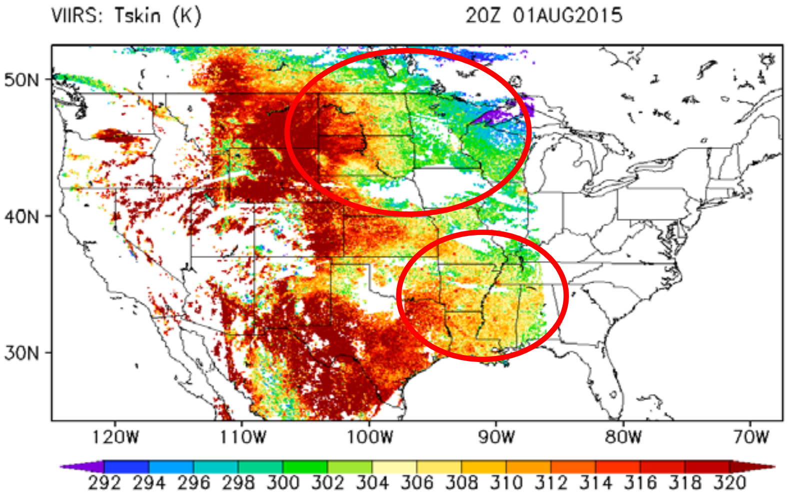
Gridded VIIRS LST data has been sampled over CONUS for verification of NCEP GFS model LST output.

EMC/NCEP requested daily gridded VIIRS LST product. The VIIRS LST team is developing a spatial and temporal gridding model for the production

Adjusted GFS model LST



VIIRS LST



VIIRS LST used to verify GFS with updated land model physics.

JPSS-1 Readiness

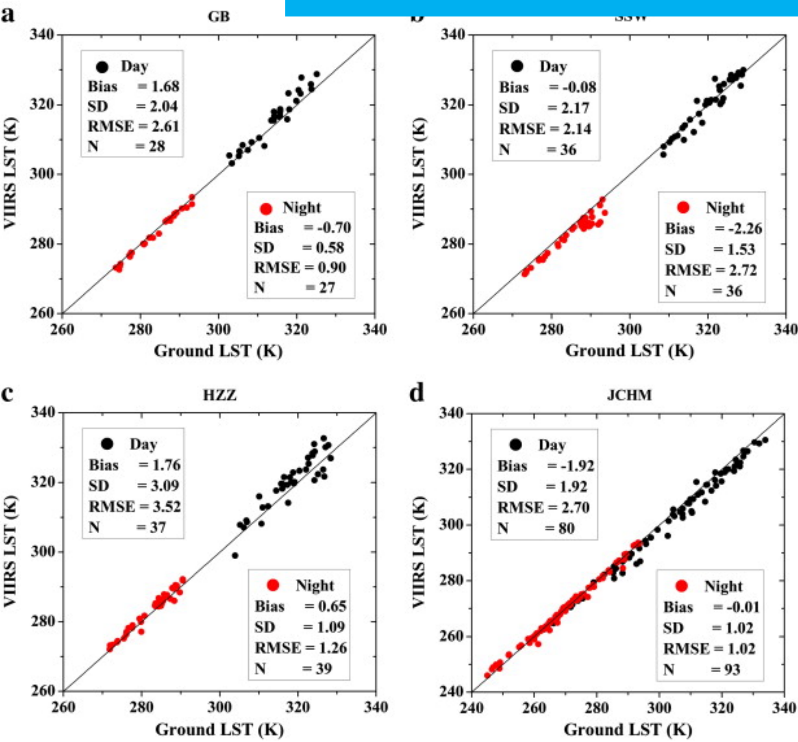
- ❑ Enterprise LST algorithm will be run at NOAA NDE system to replace the IDPS LST algorithm
  - Emissivity explicit algorithm
  - Consistent QC flags
  - Detail LUT dimension
    - Better clarification of atmospheric conditions
    - Better clarification of view geometry
  - Comprehensive evaluation and calibration
- ❑ Pre-launch Characterization
  - SNPP data serves as proxy for JPSS-1.
  - Simulation software package and database are updated for J-1 LST LUT generation
  - Calibration/validation/monitoring tools developed for SNPP are applicable for J1 mission
- ❑ Post-Launch Cal/Val Plans
  - GOES-R Field Campaign data will used for J1 mission as well
  - In-situ validation: existing + new site data; domestic + international
  - Cross comparisons: S-NPP, MODIS, +Sentinel-3
  - Schedules and Milestones: based on the mission requirement

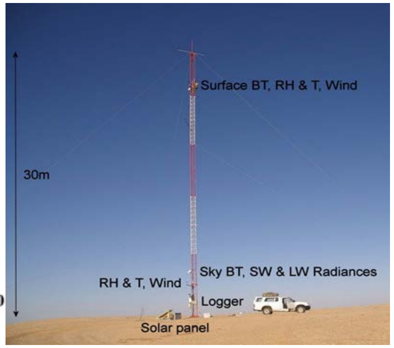
JPSS-1 Readiness -2

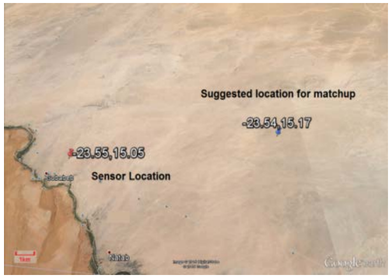
- Major Risks/Challenges/ and Mitigation
  - The enterprise algorithm run is scheduled by August 2017.
    - Mitigation: Current IDPS LST algorithm will be kept running before then
  - Availability of full resolution GVF data for the emissivity data generation
    - Mitigation: full resolution GVF product is in development
  - Emissivity data evaluation and monitoring
    - Mitigation: limited in-situ validation; LST application ; LST monitoring tool for LSE
  - Lack of high quality validation data set.
    - Mitigation: continue data collection through international cooperation; additional SURFRAD stations
  - High quality spot measurements
    - Mitigation: conduct further upscaling model study
  - Cloud contamination impact
    - Mitigation: additional cloud filtering in deep-dive validation
- Collaboration with international LST community and Stake Holders/User Agencies
  - Keep a close contact with ground data measurements providers for data quality issues and data stream anomalies
  - Provided technical support for user’s questions and difficulties in the use of the LST data
  - Actively working with EMC/NCEP users and External Users

International cooperation

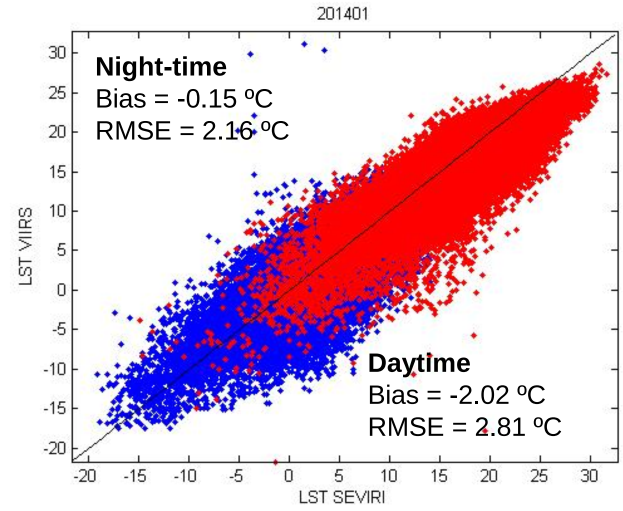
LST Validation in China

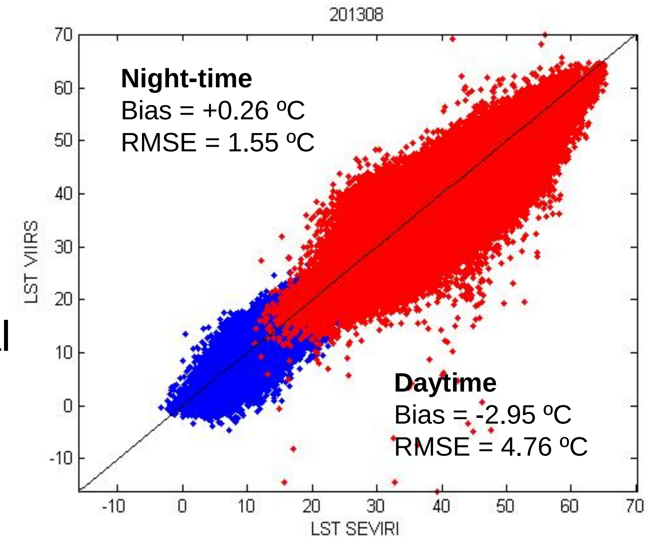




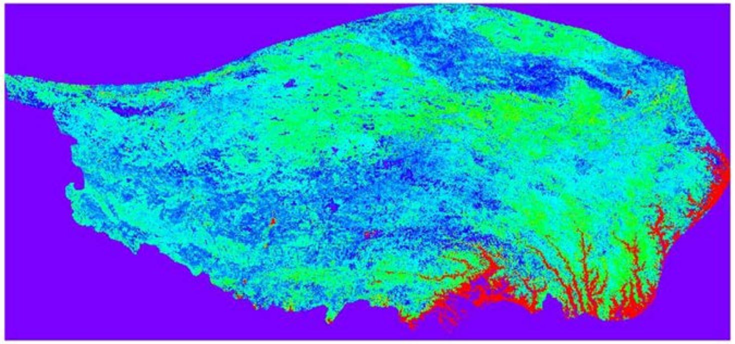


VIIRS/LST vs SEVIRI/LST comparison In Europe





Difference of Frozen days (LST-L05)



LST Applications in Tibet

VIIRS LST is used for the analysis of seasonal and diurnal cycle of freeze/thaw over Tibet Plateau area

Summary

- SNPP LST performance
  - The SNPP LST marginally meets the mission requirements based on the validation result s obtained from
    - Ground based validations(CONUS, Europe, Greenland, Australia, China)
    - Radiance based validations over global and four seasons
    - Cross satellite comparisons with MODIS, AATSR, SEVIRI etc.
  - Validation tools are run regularly for routing monitoring and web info update
  - Working with EMC/NCEP for the model verification
  - Suspicious High LSTs observed in Australia in Summer time; lack of in-situ data available for deep-dive validation
  - Cloud contamination is still the issue for accurate validation .
- Enterprise LST algorithm progress
  - Emissivity explicit algorithm developed and tested
  - Emissivity estimation algorithm is developed and tested
  - NDE LST production system is in development
- Reprocessing status
  - A reprocessing plan is proposed
  - Enterprise algorithm will be used for the reprocessing for LST consistency
- JPSS-1 readiness
  - All the validation tools and simulation tools/database are ready for the J-1 mission
  - J-1 LST production in NDE will be based on the Enterprise Algorithm
  - The J-1 Cal/Val plan has been submitted, with the schedule and milestones consistent to the mission's plan

Future Plans/Improvements

- Enterprise LST development and framework test
- Reprocessing LST data when the enterprise algorithm is ready.
- JPSS-1 LST product evaluation and monitoring
- Emissivity Data evaluation
- Level-3 gridded data production
- In-situ site upscaling model study
- LUT improvement : detail clarification of the LUT dimension
- Further interactive with EMC/NCEP model team: intensive LST model verification