Status of Land Surface Temperature production from the JPSS Mission

Yunyue Yu, Yuling Liu, Peng Yu, Heshun Wang

NOAA/NESDIS, Center for Satellite Applications and Research

Outline

- ✓ VIIRS LST Basics
- ✓ Current Operational Products
- ✓ Validation Status
- ✓ Issues and improvement Needs
- ✓ International Cooperation
- ✓ Long-term Monitoring
- ✓ J1 CalVal Plan

VIIRS LST Basics

Definition: Land Surface Temperature (LST) is the mean radiative skin temperature derived from thermal radiation of all objects comprising the surface, as measured by remote sensing ground-viewing or satellite instruments.

VIIRS LST EDR: Granule Product, moderate resolution, Split-window/Surface-type (17 IGBP) Dependent Regression Algorithm

Benefits:

- plays a key role in describing the physics of land-surface processes on regional and global scales
- provides a globally consistent record from satellite of clear-sky, radiative temperatures of the Earth's surface
- provides a crucial constraint on surface energy balances, particularly in moisture-limited states
- provides a metric of surface state when combined with vegetation parameters and soil moisture, and is related to the driving of vegetation phenology
- an important source of information for deriving surface air temperature in regions with sparse measurement stations

Target Requirement: Horizontal resolution – 1 km, Temporal resolution – 1 h, Accuracy – 1 K

Current VIIRS* : H = 1 km, T = Daily, A = 1.4 K, Uncertainty = 2.4 K

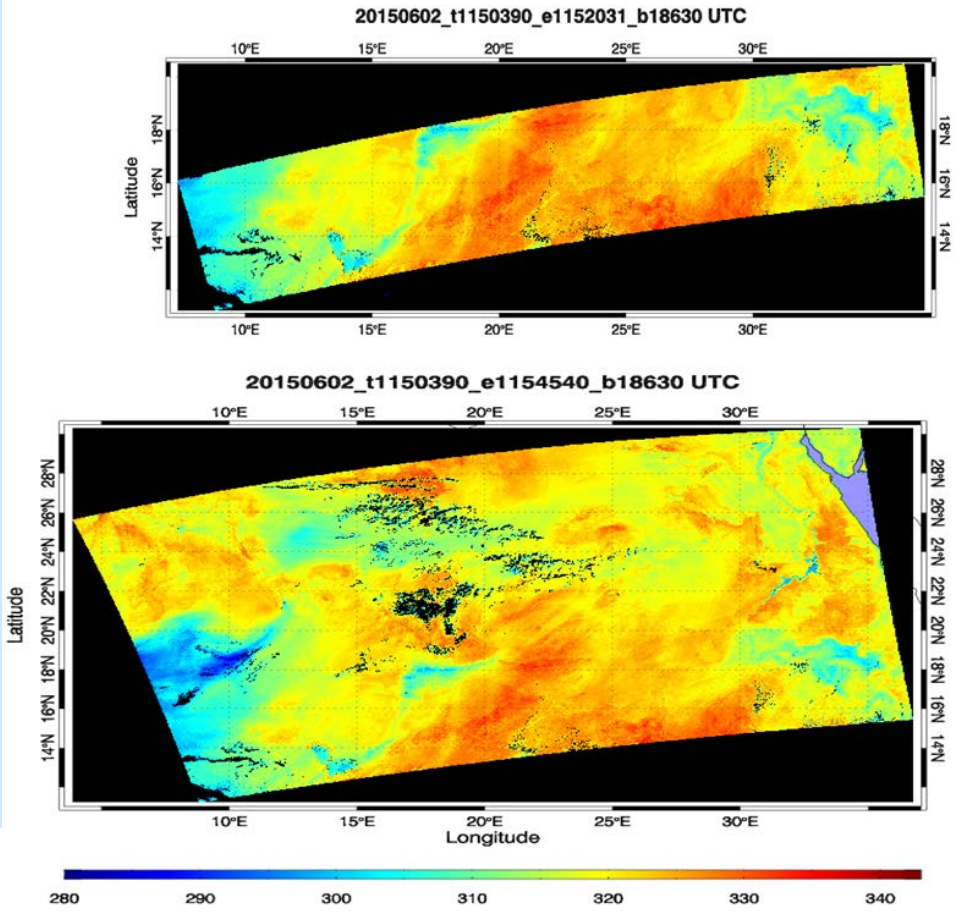
* with limited in-site estimates and cross-satellite validation

Basics: LST EDR and Cal/Val Team

	Name	Institute	Function
JPSS-STAR	Ivan Csiszar	NOAA/NESDIS/SATR	Land Lead, Project Management
	Yunyue YU	NOAA/NESDIS/SATR	EDR Lead, algorithm development/improvement, calibration/validation, team management
	Yuling Liu	*NOAA Affiliate, UMD/ESSIC*	*product monitoring and validation ; algorithm development/improvement*
	Heshun Wang	*NOAA Affiliate, UMD/ESSIC*	*algorithm improvement, product calibration/validation*
	Peng Yu	*NOAA Affiliate, UMD/ESSIC*	*product validation tool, monitoring, applications*
	Marina Tsidulko	*NOAA Affiliate, SciTech/IMSG*	*STAR AIT*
	Michael EK	NOAA/EMC/NCEP	user readiness ,
	Yihua Wu	NOAA/EMC/NCEP	user readiness
JPSS/DPA			
	Leslie Belsma	Aerospace Corp	algorithm Manager (JAM) for Land
NASA S-NPP Science Team			
	Miguel Roman	NSAS/GSFC	*Validation data support, product monitoring*
	Sadashiva Devadiga	NASA/GSFC Affiliate, SSC	*Validation data support, product monitoring*

Basics: Current Operational Product

- 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



- Archive site
  - CLASS: http://www.nsof.class.noaa.gov/saa/products/welcome (search for JPSS VIIRS EDR)
  - Team site : http://www.star.nesdis.noaa.gov/jpss/lst.php
  - NASA site: http://viirsland.gsfc.nasa.gov/Products/LSTEDR.html
- Monitoring: http://www.star.nesdis.noaa.gov/jpss/EDRs/products_LST.php

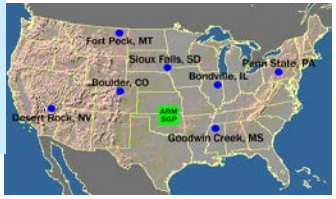
Validation Status

- **Provisional Review – May 2014**
- **Validated V1 review – December, 2014**

Validation summaries of the LST EDR are shown in Table (**right**); validated 1 maturity approval in Dec. 2014. Marginally meet the requirement with limited "in-situ" data

Validation details of the VIIRS LST comparisons against the SURFRAD station data are shown in the plots (**bottom-left**) and in the tables (**bottom-middle, bottom-right**).

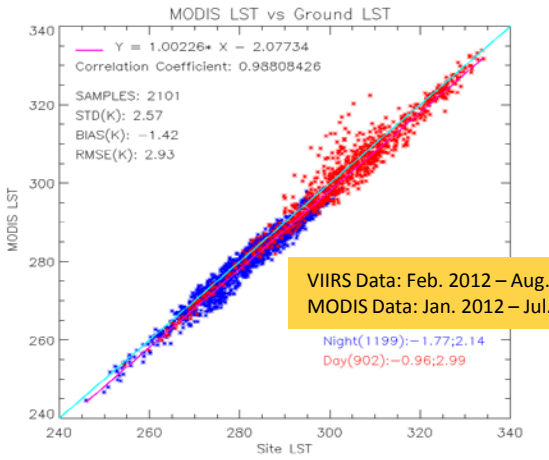
Attribute Analyzed	L1RD Threshold	Validation Result	Description
In-situ Validation	1.4K (2.5K)	**-0.37 (2.35)**	Results are based on the VIIRS data over SURFRAD sites for over 2.5 years . The error budget estimation is limited by ground data quality control, cloud filtering procedure and upstream data error.
R-based Validation	1.4K (2.5K)	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): daytime 0.99(2.02): nighttime	The results are based on comparisons to MODIS LST, over 100 scenes, over low latitude, polar area and CONUSThe error budget estimation is limited by the spatial and temporal difference, sensor difference, angle difference etc.



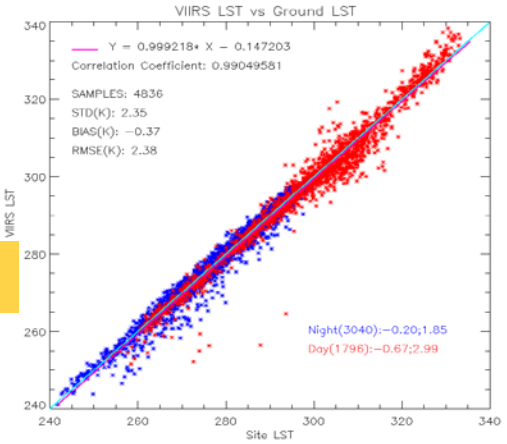
U.S. SURFRAD stations

Season	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
Spring	1297	-0.54	2.78	-0.69	3.82	-0.46	1.97
Summer	1403	-0.1	2.43	-0.87	3.68	0.26	1.39
Fall	1160	-0.28	1.9	-0.32	2.04	-0.24	1.79
Winter	976	-0.65	2.01	-0.83	1.65	-0.53	2.21

IGBP type	Samples	Overall		Day		Night	
		Bias	STD	Bias	STD	Bias	STD
4	18	-1.41	3.01	-1.82	2.66	-1.26	3.22
6	96	-0.98	1.41	-0.5	1.88	-1.32	0.84
7	955	-0.2	1.59	0.24	2.06	-0.61	0.79
8	286	0.19	2.56	-1.7	2.6	1.38	1.66
10	1048	-0.49	1.81	-0.85	2.3	-0.37	1.59
12	1238	-0.35	2.68	-0.63	3.8	-0.22	1.91
14	857	-0.28	2.54	-1.28	2.4	0.19	2.47
15*	189	-1.72	4.31	-1.72	4.31		
16	149	-0.23	1.55	0.87	1.67	-1.04	0.75



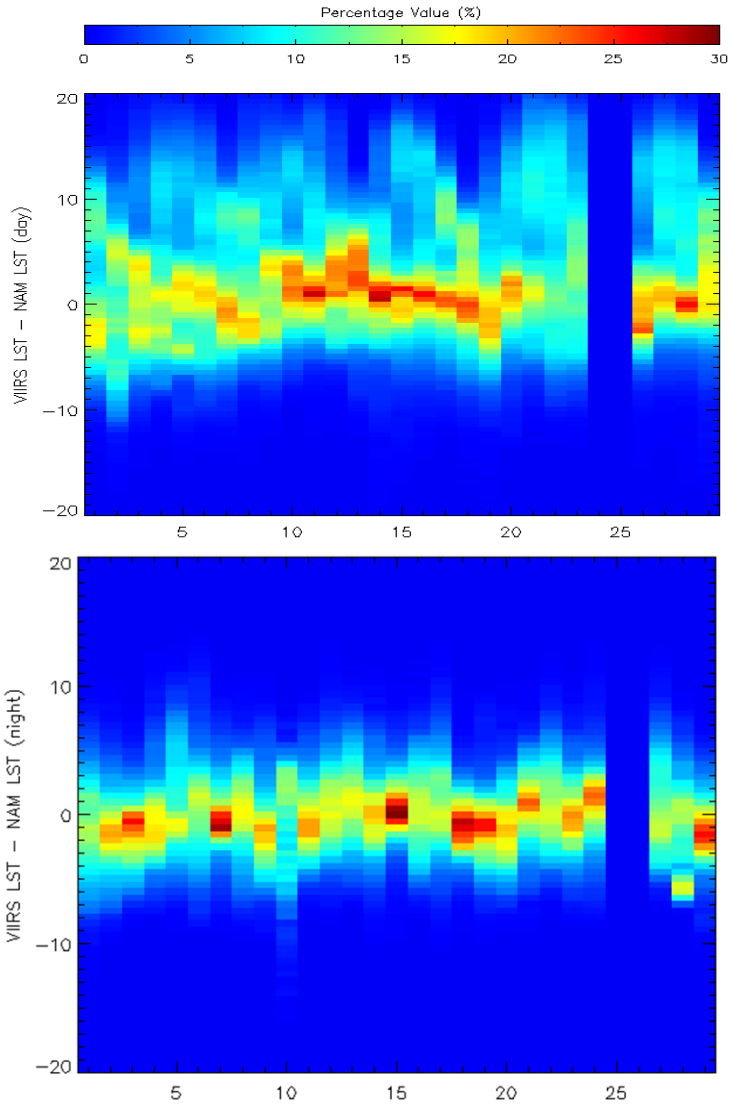
VIIRS Data: Feb. 2012 – Aug. 2014
MODIS Data: Jan. 2012 – Jul. 2013



JPSS LST for EMC model validation

Project on-going: Incorporation of near-real-time S-NPP JPSS Land Surface Temperature data into the NCEP Land modeling suite

- Performed comparison of VIIRS Granule LST data and NAM model data
  - Period: March 2012
  - Resolution: 0.05 deg
- Results
  - ✓ VIIRS LST and NAM LST agree with each other better in nighttime.
  - ✓ The monthly mean biases are 0.47 and 3.76 during nighttime and daytime, respectively.
  - ✓ Granule level comparisons show that the VIIRS-NAM difference over west region is higher than that over east region.
- Current effort: new data format needed
  - Gridded 1 km data
  - Projection and data format matches to the EMC model run needs
  - Time label and QFs for each grid
  - Tools to convert a popular L3 LST data format into a rather specific EMC requested data format
  - Analysis of the JPSS and Model LST differences



Day and night, March 2012

Issues and Improvement Needs

Issues encountered through the Cal/Val activities

- *Lack of high quality validation data set.* The CalVal performed only with limited data, mostly with SURFRAD data. Global and seasonal representativeness of the validation is needed
- impacts of ST misclassification and cloud contamination are significant (will rely on annual ST data).
- *Cloud contamination impact is significant*
- over 50% error sources of the LST derivation can not be identified, due to quantitative and qualitative limitations of in-situ measurement.
- Practical uncertain is significantly larger than the theoretical analysis.

New Development (1)

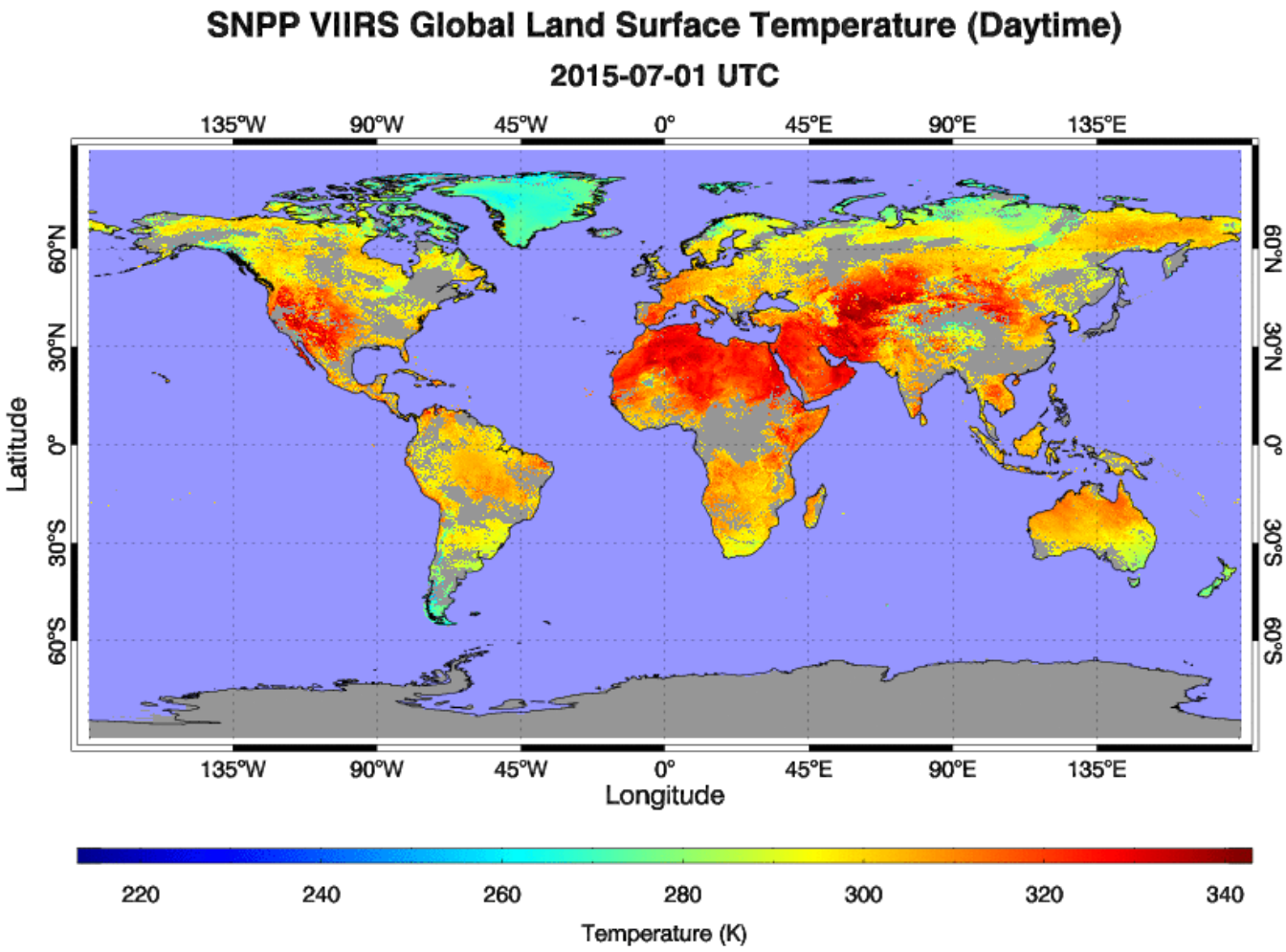
Rational

User-friendly dataset needs
replacement of the ST-dependent algorithm
Enterprise System Requ
Emissivity Development

Example 1

L3 Global Gridded Daily LST

- 2 datasets each day (i.e. day and night)
- 1 km resolution
- Time label and QF for each grid

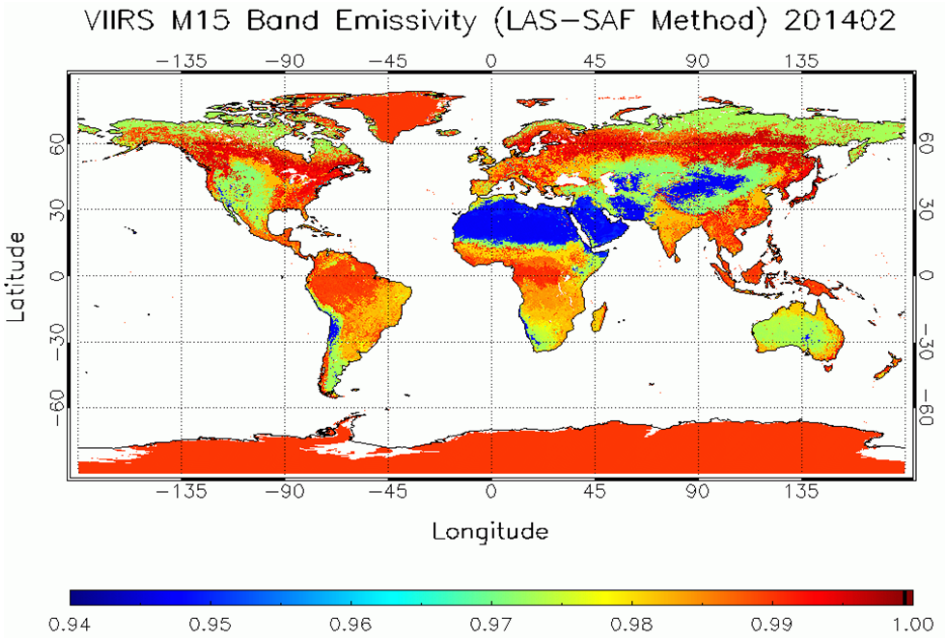


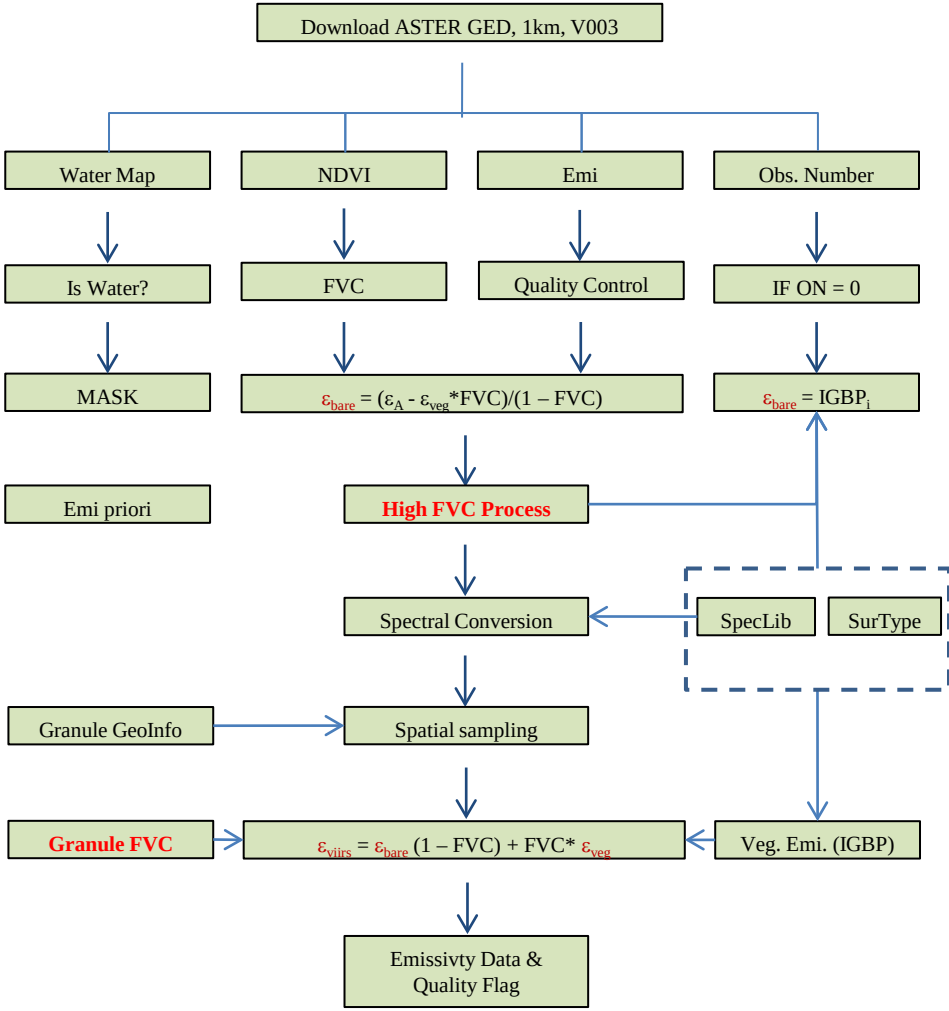
New Development (2)

Example 2

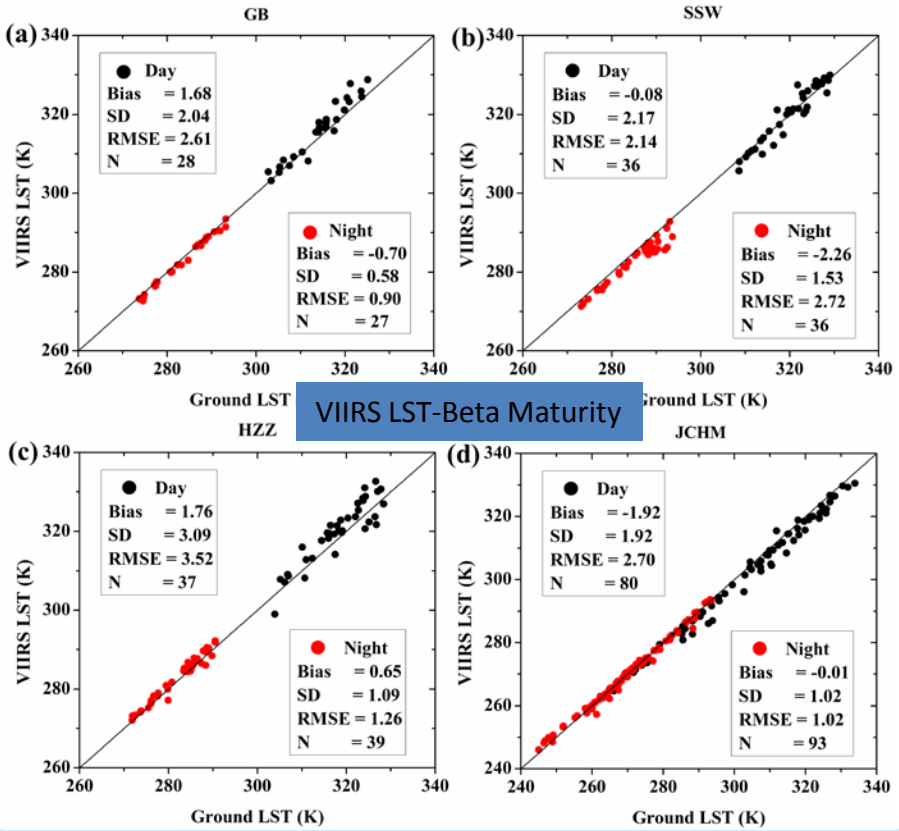
Land Surface Emissivity

- Spectral emissivity at M15 (10.76 μm) and M16 (12.01 μm)
- Daily global gridded dataset
- 1 km resolution
- QF for each grid

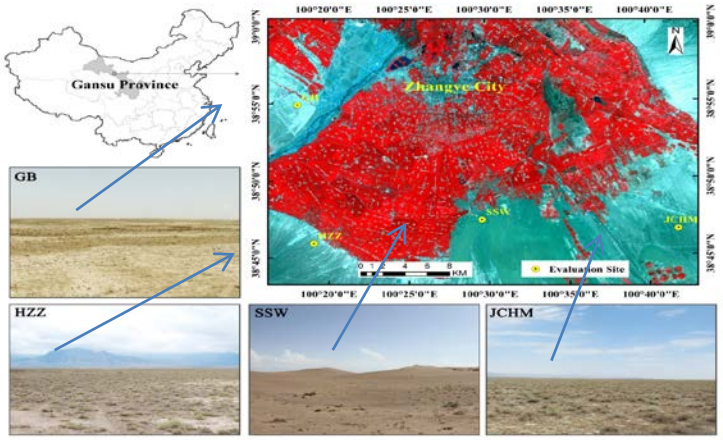


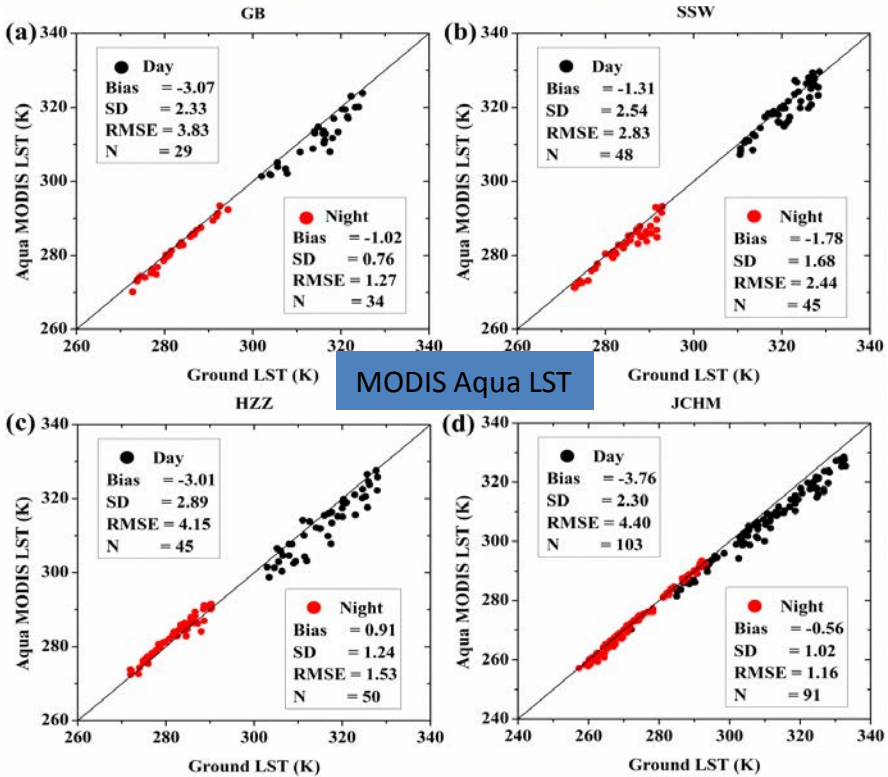


International cooperation
-- with CAS



VIIRS LST-Beta Maturity





MODIS Aqua LST

Data collection: arid area of northwest China (Heihe Watershed Allied Telemetry Experimental Research), from June 2012 to April 2013. Four barren surface sites were chosen for the evaluation.

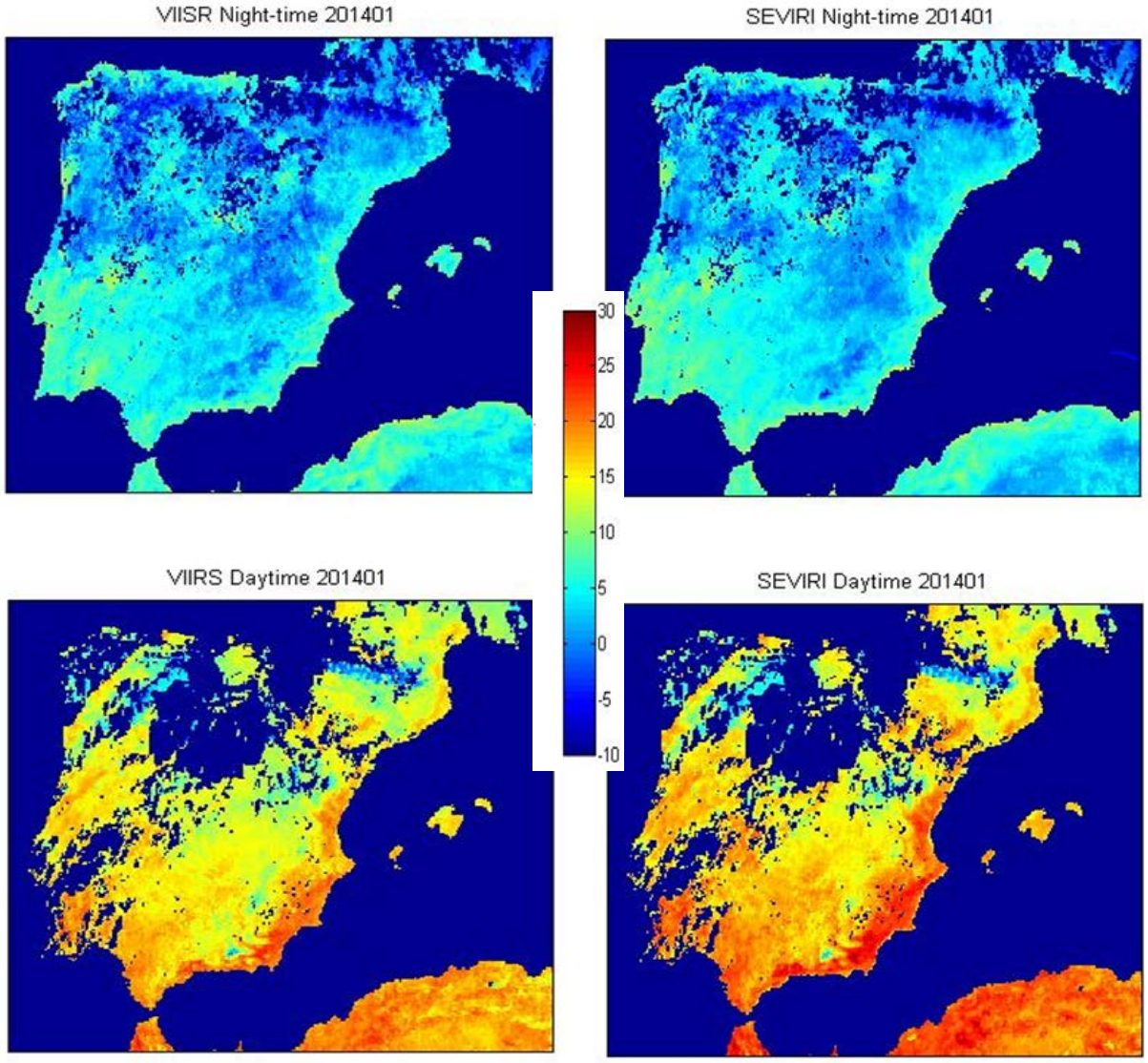
The result generally shows a better agreement for VIIRS LST than that for MODIS LST.

***China site data was obtained through a collaborative effort with Dr. Hua Li at Institute of Digital Earth and Remote Sensing, China Academy of Science**

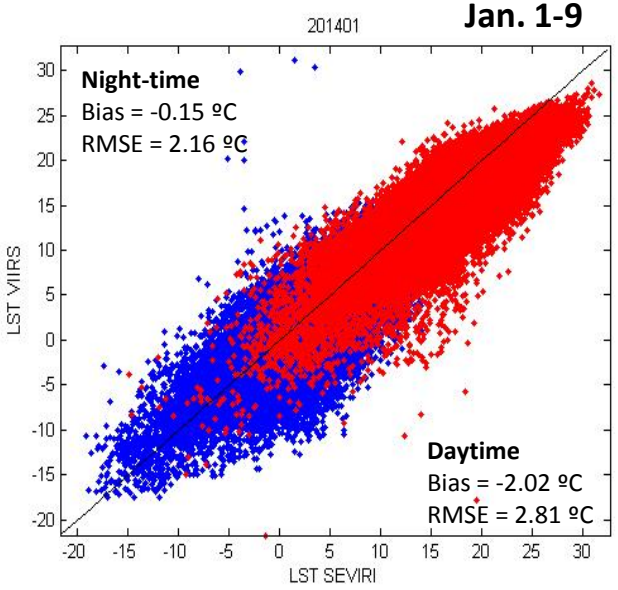
Reference: *H. Li, D. Sun, Y. Yu, H. Wang, Y. Liu, Q. Liu, Y. Du, H. Wang and B. Cao(2014), Evaluation of the VIIRS and MODIS LST products in an arid area of Northwest China Remote Sensing of Environment 02/2014; 142:111–121.*

International cooperation
-- with Land SAF

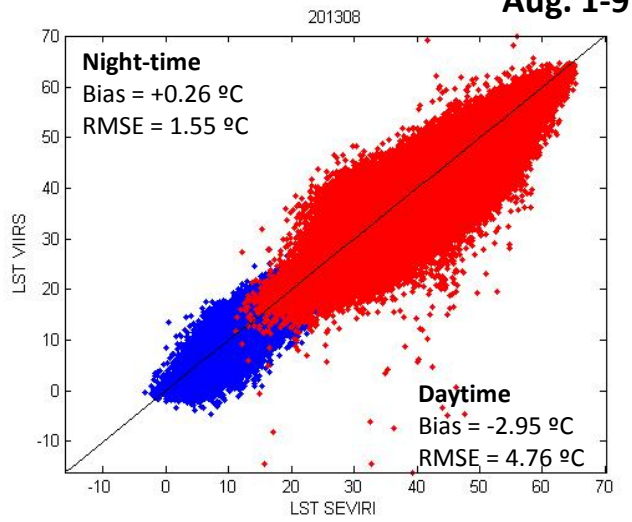
VIIRS **1-9 Jan 2014** **SEVIRI**



Jan. 1-9



Aug. 1-9

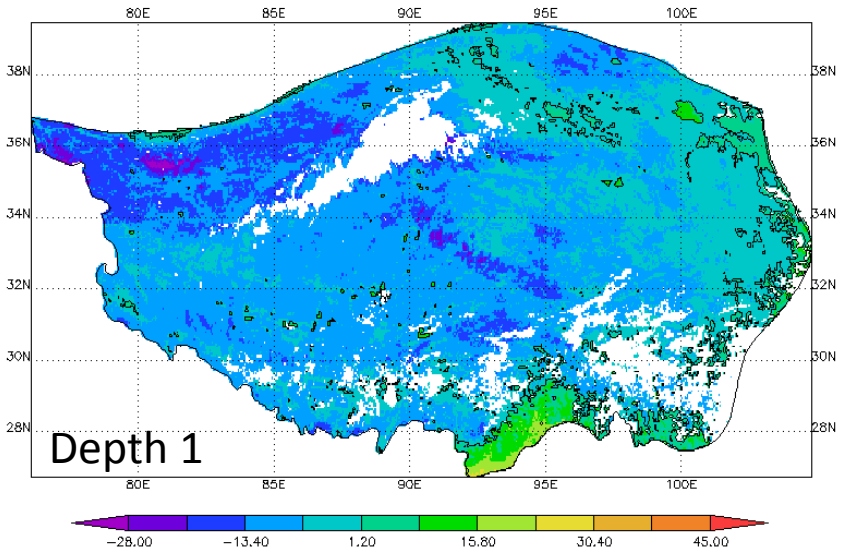


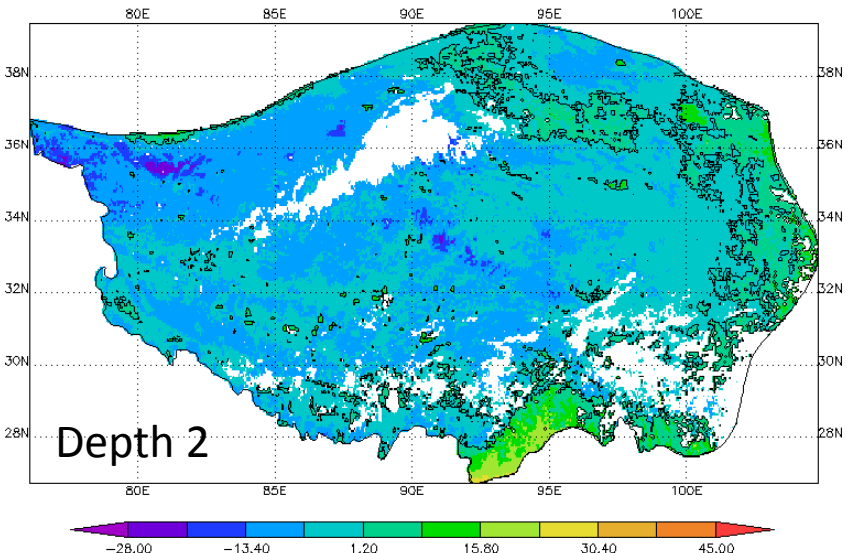
Courtesy of Isabel F. Trigo , through US-Portugal Bilateral cooperation program (on remote Sensing)

International cooperation
-- with CMA

VIIRS LST Application in Soil Freeze-Thaw in Tibet

- Monitoring spatial distribution of freeze-thaw in whole Tibet with high spatial resolution (1 km)
- Monitoring seasonal dynamics of freeze-thaw in Tibet (daily)
- Monitoring changes of freeze-thaw in different soil depth





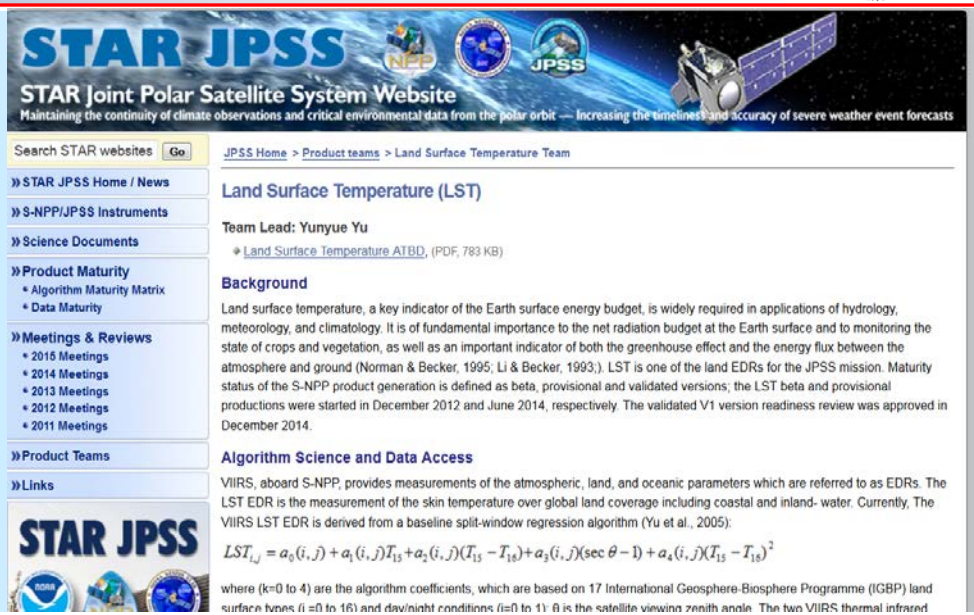
Long-term monitoring

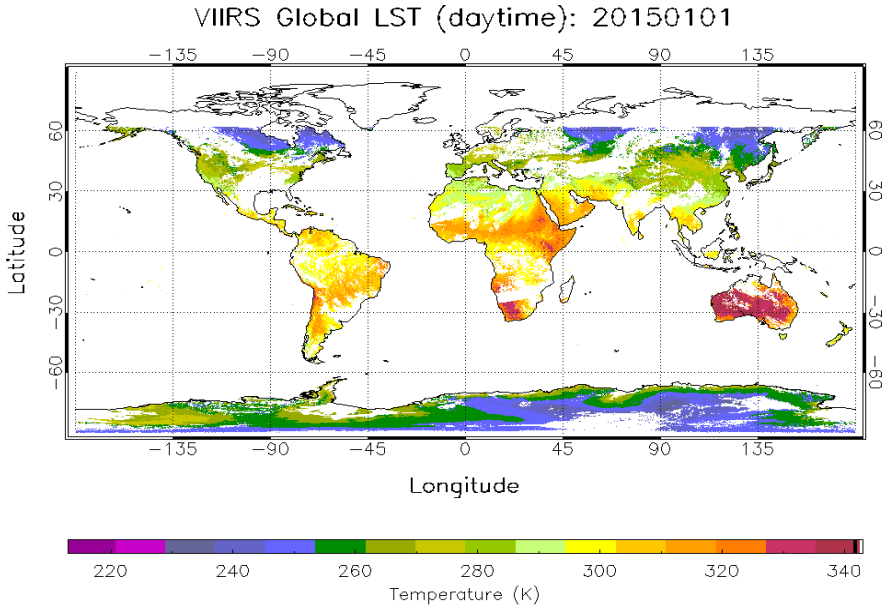
- **Monitoring/Validation tool drafted**
- **Webpage development**

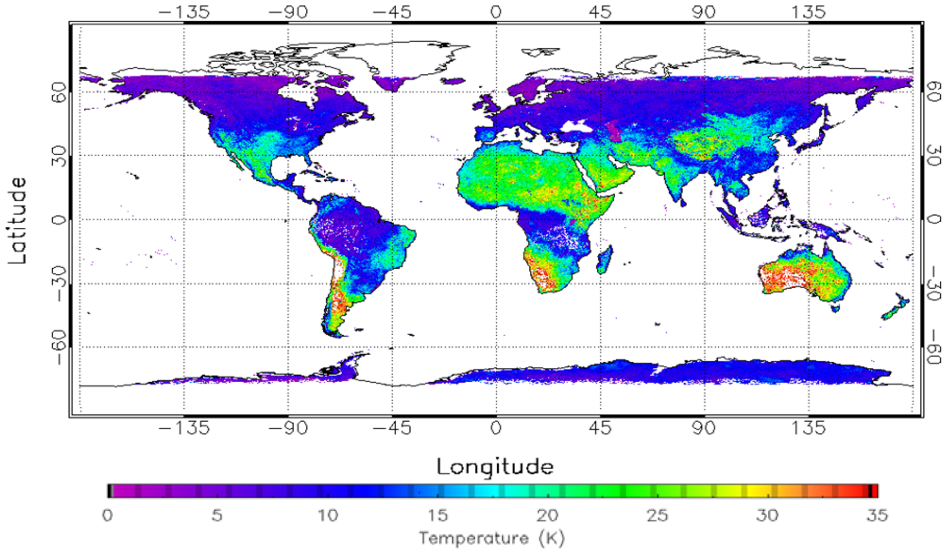
✓ A monitoring tool has been developed, which generates daily global VIIRS LST maps, and the diurnal temperature range (DTR) from the operational VIIRS LST EDR data and routinely validate with SURFRAD data.

✓ 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.







J1 Cal/Val plan

- Comprehensive Product Evaluation/validation
  - Pre-launch
    - Proxy and simulated datasets readiness
    - In-situ data readiness
    - Algorithm Evaluation and Characterization
    - Development of calibration and validation tools
  - Post-launch
    - Early orbit checkout
    - Intensive product evaluation and validation report
    - Algorithm/product calibration, coefficients update
    - Iterative in-situ data validation and calibration
    - Algorithm refinement
- Long-term monitoring
  - A web-based product monitoring interface
  - In-situ validation alerting/notification
- Correlative Data Sources
  - In-situ data collection
  - S-NPP LST data, and other satellite LST data
  - Field Campaign data (international cooperation)
- Development of CalVal tools