VIIRS and ABI Land Surface Emissivity Product Evaluation

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Introduction

Emissivity is a key parameter for determining land surface temperature (LST) from thermal remote sensed data. NOAA LST team at STAR is developing a new emissivity product that enhances LST product of JPSS and GOES-R missions as well as to support forecasting models. It is proposed to combine historic emissivity product (ASTER GED mean emissivity and MODIS LSE product) and VIIRS near-real-time vegetation and snow observations for a dynamic emissivity production. Global gridded LSE product including VIIRS and ABI split window channels as well as a 8-13.5um broadband was generated each day at 0.009 degree resolution. The new product could well depict the seasonal variation of surface emissivity. In order to evaluate the LSE product, a series of evaluation efforts were performed, both *in-situ* and *ex-situ* measurements over bare sites was carried out for arid and semi-arid area evaluation where emissivity is lower and has large spatial variation. Time series analysis over vegetation area was carried out to investigate the emissivity evolution, meanwhile, a cropland site was selected for emissivity evaluation at three different growing stages. Finally, LSE was incorporated into LST retrieval and evaluated at SURFRAD stations.

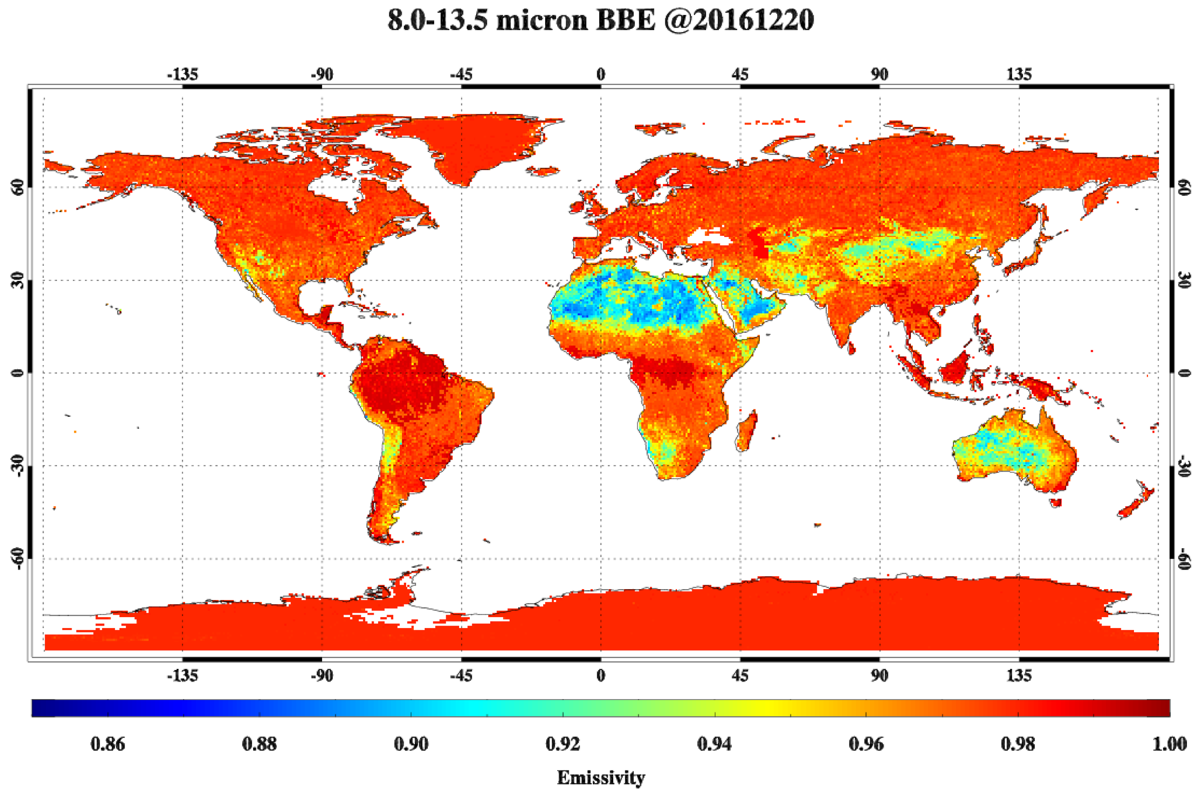
LSE product and uncertainty

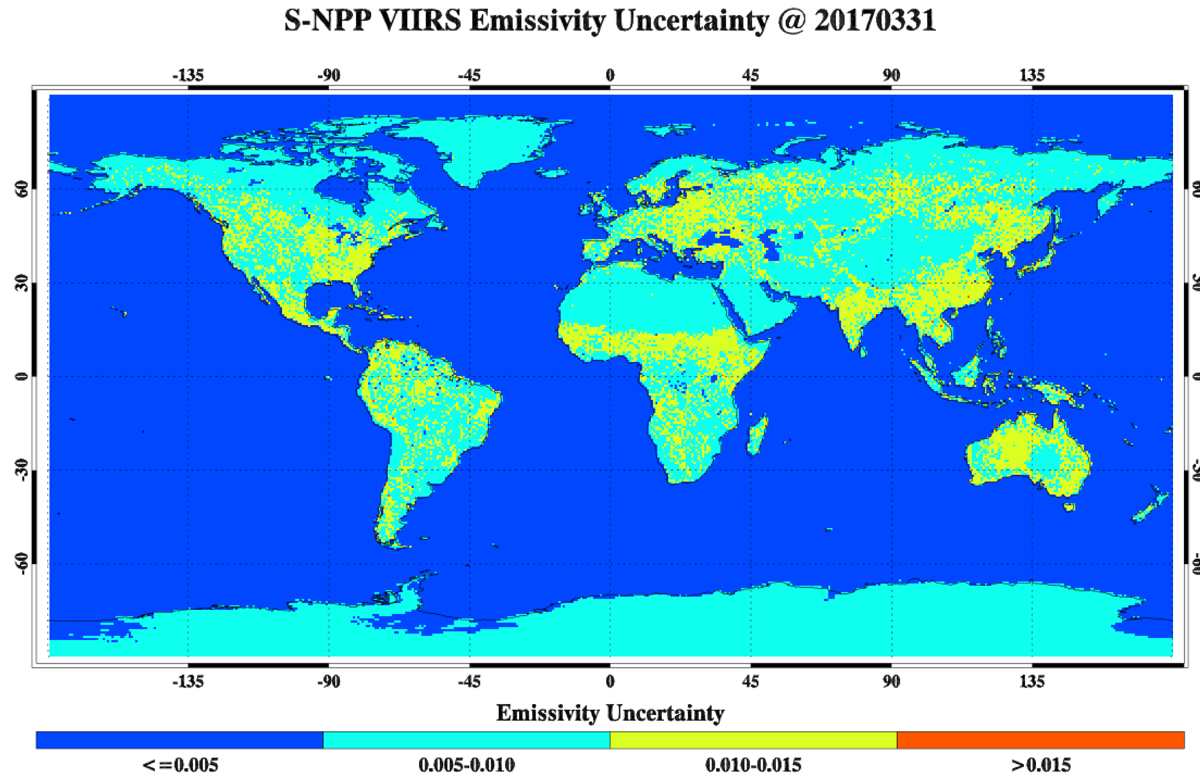
- Principal algorithm: Vegetation Cover Method

A. Using mean background (bare soil and snow ice) emissivity from over 9 years ASTER & MOIDS LSE Products.
B. Accounting for the dynamic change by VIIRS Near-Real-Time green vegetation fraction and snow fraction data.

- Main features:

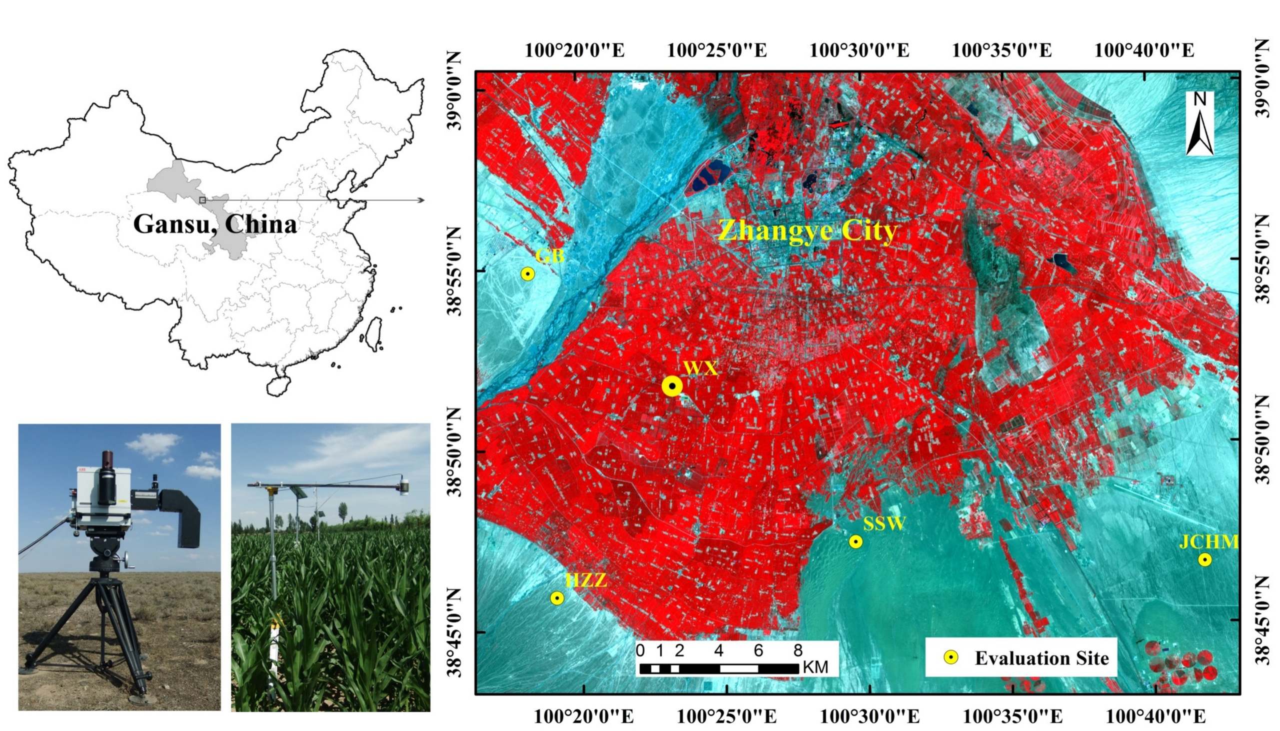
A. Daily product with global coverage at 0.009 degree grid.
B. Including 5 bands: VIIRS and ABI split window channels and 8-15um broadband.
C. Pixel by pixel quality flag, grouping LSE uncertainty into four level and vast majority with an error of less than 1.5%.



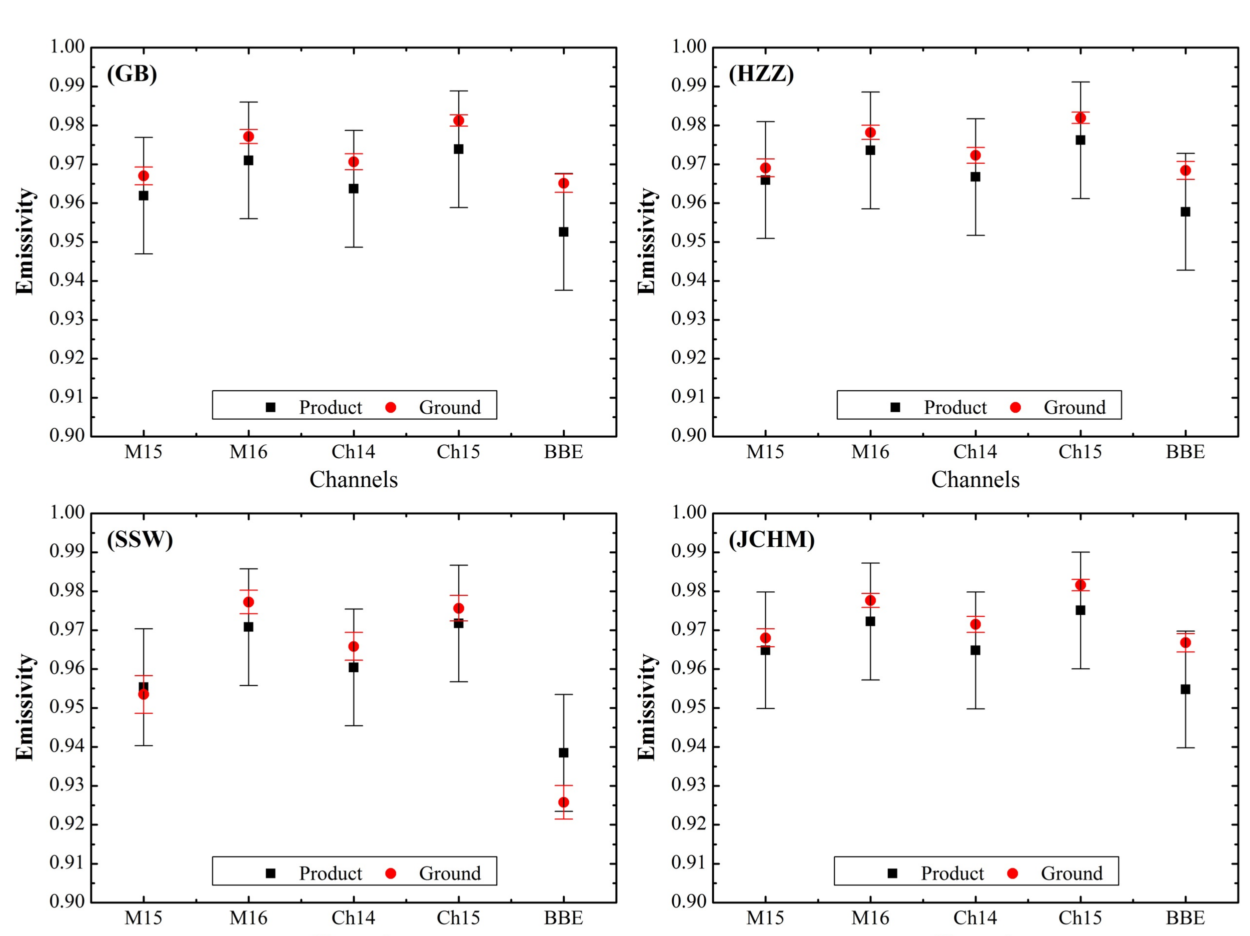


LSE evaluation

Bare sites *in-situ* emissivity evaluation

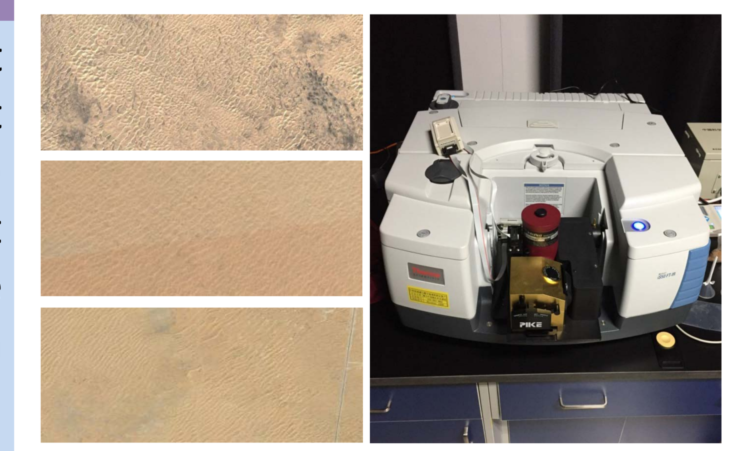


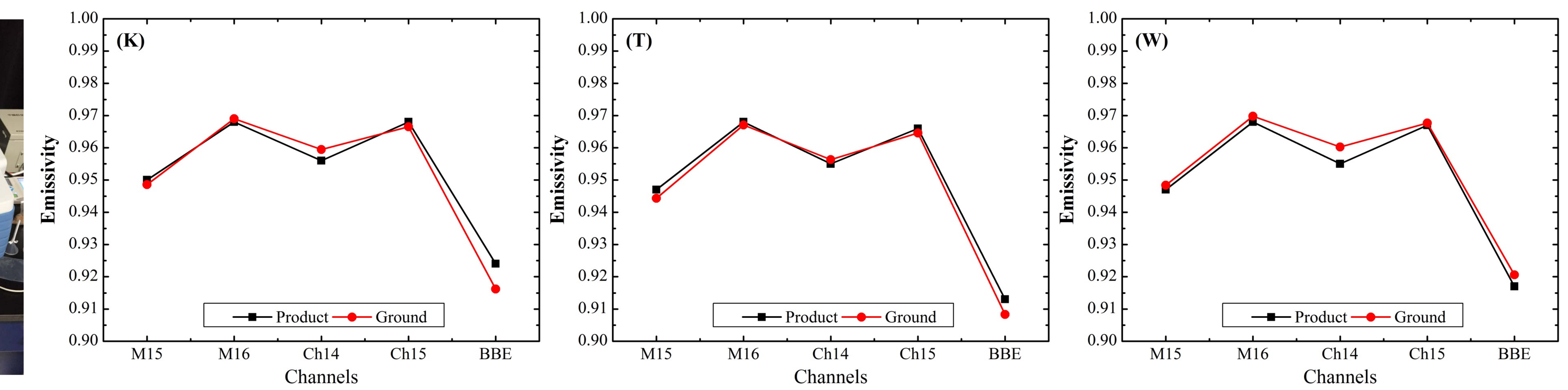
- 4 bare surface sites (GB, HZZ, SSW and JCHM) and a cropland site (WX) at Northwest of China were selected for emissivity evaluation.
- A BOMEM MR304 FTIR was employed to determine 4 bare sites emissivity under clear sky condition. Ground emissivity was retrieved by the Iterative Spectrally Smooth Temperature and Emissivity Separation algorithm with an accuracy better than 1%.
- A CE312-2B was used to measure canopy emissivity at three growing stages with different vegetation fraction and emissivity retrieved using Temperature and Emissivity Separation algorithm.



	VIIRS-M15	VIIRS-M16	ABI-Ch14	ABI-Ch15	BBE
Mean LSE Difference	0.004	0.006	0.006	0.006	0.012

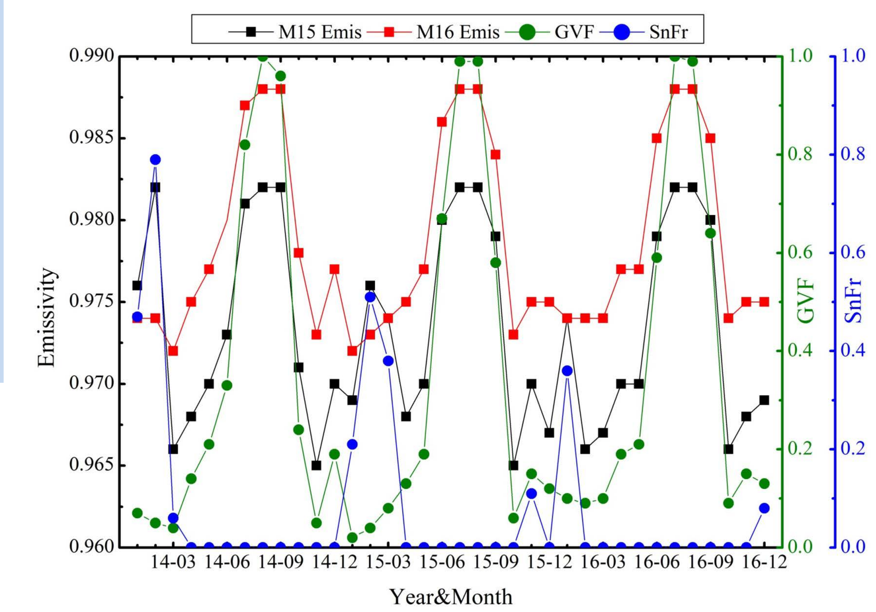
Bare sites *ex-situ* emissivity evaluation





- A dozen of sand samples were collected from three big deserts in China: K (40.308°N, 108.615°E), T (37.482°N, 104.974°E), W (39.720°N, 106.672°E), and emissivity were measured in laboratory (RADI, CAS) using a Nicolet iS50 Fourier transform infrared spectroscopy. The validation results as demonstrated reveal a high accuracy of less than 0.3% error over desert sites.

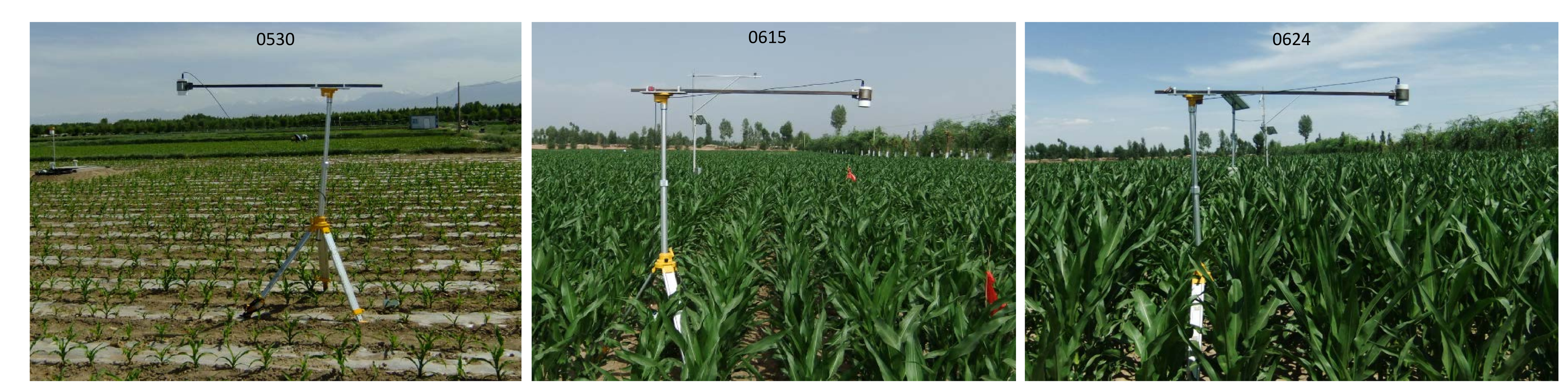
Time series evaluation over vegetation area

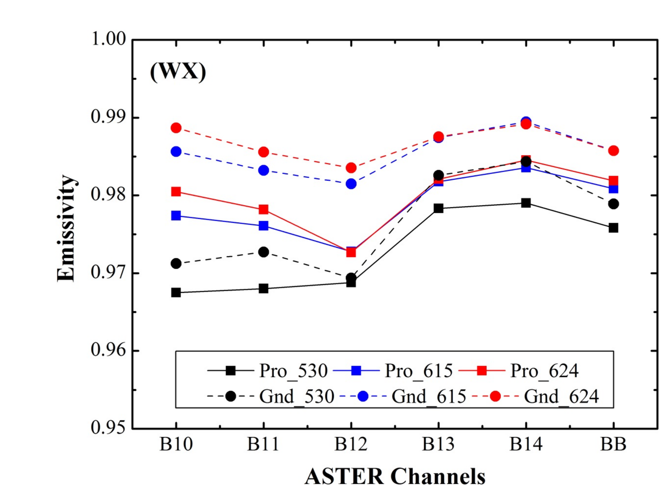


To investigate LSE temporal variation, monthly product were generated from 2014 to 2016. In this case study, WX is a cropland site with dramatic vegetation fraction change and snowfall in the winter time. The emissivity increases start from May and reach highest value in August as GVF, decreasing subsequently until October when it is harvested. During the winter time, snow fraction will bring significant impact on LSE. The biggest emissivity difference for VIIRS M15 and M16 channel could up to 0.017 and 0.014, respectively.

Ground measurements were carried out three times on May 30, June 15 and 24 in 2012.

Date	GVF	Mean Emissivity Diff.
20120530	0.06	0.005
20120615	0.34	0.007
20120624	0.56	0.007





Incorporate LSE into LST retrieval

- Incorporating LSE product into the emissivity-explicit split-window algorithm to implement VIIRS LST retrieval.
- Evaluate the LST accuracy via long-term (From February 2012 to June 2015) observations at 7 sites of SURFRAD
- Evaluate the quality of the LSE product through VIIRS LST results.

NOAA/STAR Enterprise Algorithm for VIIRS: $T_s = C + A_1 T_{11} + A_2 (T_{11} - T_{12}) + A_3 \varepsilon + A_4 \varepsilon (T_{11} - T_{12}) + A_5 \Delta\varepsilon$

	Bondville	Boulder	Desert Rock	Fort Peck	Goodwin Creek	Penn State	Sioux Falls
Matchup Number	541	460	959	558	519	252	594
Bias (K)	0.44	-0.42	-0.81	0.32	0.84	0.34	0.36
STD (K)	2.13	1.54	1.78	2.00	2.05	2.21	1.75
RMSE (K)	2.17	1.60	1.95	2.02	2.21	2.23	1.78

Summary

- LSE product provides pixel-by-pixel theoretical uncertainty estimation and stores in the quality flag, more than 99.9% pixels have uncertainty within 1.5%.
- Bare sites *in-situ* measurements have a good agreement with the product with less than 0.6% mean difference at narrow bands and 1.2% for broadband.
- *Ex-situ* results show product has pretty high accuracy at desert area, where the gap could be as small as 0.3% and 0.5% for narrow bands and broadband, respectively.
- This new product highly related to the vegetation and snow fraction, it works well at vegetated areas with a difference of less than 0.7%.
- LSE have a good performance in the LST retrieval according to the SURFRAD validation, satisfying LST accuracy requirement.