Consortium on cross comparison of satellite land surface temperature retrievals, a case study between VIIRS and MODIS LST product
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Introduction
LST is a key parameter in the physics of land surface processes on regional and global scales, combining the results of all surface atmosphere interactions and energy fluxes between the atmosphere and the ground. The cross-comparison of LST products from different satellites or sensors is widely used to evaluate one LST product with reference to the other, particularly between heritage satellite products. This method is not a real validation but allows identifying weakness in a product. As the VIIRS LST is expected to replace MODIS LST in the future, the inter-comparison between VIIRS LST and MODIS LST will provide for the evaluation of VIIRS LST performance with respect to difference characterization, i.e. spatial pattern, systematic error budget, which may reflect the algorithm difference, limitations or errors. Some researchers have evaluated the VIIRS LST product after Suomi NPP launch mostly based on the temperature based approach and the cross comparisons between MODIS and VIIRS is mostly around the ground sites over time series. Cautions need to be taken in the whole chain of cross-comparisons, i.e. data selection for comparison, data processing procedures and results analysis. This study will focus on concerns regarding temporal differences, composite process, and angular differences. Some comparison cases are discussed and a guideline is provided for each of them in the cross satellite LST comparison.

VIIRS LST and MODIS LST Algorithms

- **VIIRS LST algorithm**
  
  Establish the 2-band 10.76\um(M15) and 12.01\um(M16) split window algorithm for both day and night based on regression equation for each of the 17 IGBP surface types.
  
  \[ LST_j = a_0 + a_1 T_{\text{d}j} + a_2 T_{\text{n}j} - (T_{\text{d}j} - T_{\text{n}j}) \]

  Where \( a_i \) (with \( i = 0 \) 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 \( \theta \) is satellite viewing zenith angle.

- **MODIS LST algorithm**
  
  The generalized split window algorithm
  
  \[ T_j = A + A_1 \frac{1 - \epsilon}{e} + A_2 \frac{\Delta v}{e} (T_o + T_{\text{d}j}) + (A + A_1 \frac{1 - \epsilon}{e} + A_2 \frac{\Delta v}{e}) (T_o - T_{\text{n}j}) \]

  Where \( \epsilon = 0.5 \) (\( \epsilon_1 \) and \( \epsilon_2 \)) and \( \Delta v = (\epsilon_1 + \epsilon_2) \), the coefficients \( A_k \) (\( k = 0, 1-6 \)) depend on viewing zenith angle, atmospheric surface temperature and water vapor.

Cross comparison over ground sites

Corresponding matchups for VIIRS and MODIS Aqua:
- Suggested for matchup:
  - VIIRS LST and MODIS LST overall presents a similar performance over ground sites in SURFRAD, CRN and Africa.
  - Cross comparison at granule level shows the difference from the implementation of quality control procedures and criteria selections particularly the spatial variation. A proper threshold for the spatial tests needs further investigation, which is set as 1.5 in this study. The difference between VIIRS LST and AQUA LST is much smaller when VIIRS LST is calculated using the MODIS sensor data as input and VIIRS algorithm. This indicates the algorithm difference is not the main cause for the large LST difference.
  - The composite procedure makes difference particularly for global comparison which is usually conducted at coarse resolution.