New Refinements in the V5 Daily MODIS LST PGE Code (PGE16)

Zhengming Wan, ICESS, University of California, Santa Barbara, CA
(wan@icess.ucsb.edu)

Institute for Computational Earth System Science
University of California, Santa Barbara

1. Major Changes Made in V5 PGE16 Code for Collection 5 Reprocessing

(1) The grid size for LST/emissivity results from the day/night algorithm is changed to 6km x 6km (exactly 5.56km) from 5km x 5km (exactly 4.63km in V4) so that it has the same 0.05° size of climate model grids in latitude for most CMG land products.

(2) Increase the number of sub-ranges of viewing angles to 16 from 5 (in V4) in the interim data file for the day/night algorithm so that a maximum of 16 pairs of daytime and nighttime data can be stored for each 6km grid without significantly increasing the file size by changing the data structure (replacing float32 with uint16 or uint8).

(3) Add an option for combined use of Terra and Aqua MODIS data in the day/night LST algorithm so that it is possible for the day/night algorithm to use pairs of day and night observations at nearly equal zenith angles in the same azimuth plane.

(4) The effect of slopes in the 6km grids is considered in the QA of the LST/emissivity results from the day/night algorithm.

(5) Fully incorporate the split-window method into the day/night algorithm by using the values of emissivities, column water and surface air temperature in the iterations of solution for the day/night algorithm.

(6) Do not make temporal averages in the generation of the 1km LST product (MOD11A1 and MYD11A1) per request of the user community. After this change, LSTs in 1km and 6km products are all from instant MODIS observations.

(7) Use the surface air temperature (as in v3.0.0 PGE16) interpolated from the atmospheric temperature profile in MOD07 because the Surface_Temperature SDS in new MOD07 has been changed to regression-based retrieval of skin temperature from the GDAS surface temperature in the old MOD07.

2. Test Results of V5.0.2 PGE16

2.1, Comparison between LSTs retrieved by the day/night and incorporated split-window methods

The v5.0.2 PGE16 code has been tested with Terra and Aqua MODIS data in July and August 2002 in two tiles, h08v05 mostly in dry weather condition, and h09v05 partly in dry in the west portion and in wet weather condition in the east portion. Fig. 1 shows the daytime LSTs retrieved from Terra MODIS data on 25 August 2002 (h08v05 in the left and h09v05 in the right).

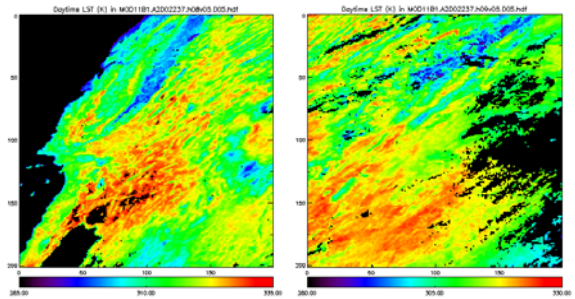


Fig. 1, daytime LSTs in mod11b1 in tiles h08v05 (left) and h09v05 (right).

Fig. 2 shows the comparison between daytime (in red) and nighttime (in green) LSTs retrieved from the day/night method and the incorporated split-window method with MODIS data collected on 4th July 2002 (Julian day 185) in tiles h08v05 and h09v05. The mean and standard deviation of the differences are -0.02K and 0.15K for daytime LSTs, -0.05K and 0.23K for nighttime LSTs in tile h08v05. These numbers are -0.01K and 0.20K, -0.07K and 0.34K in tile h09v05. The maximum standard deviation is less than 0.4K for all days in these two months. This indicates that the refined day/night algorithm consistently gives reliable results.

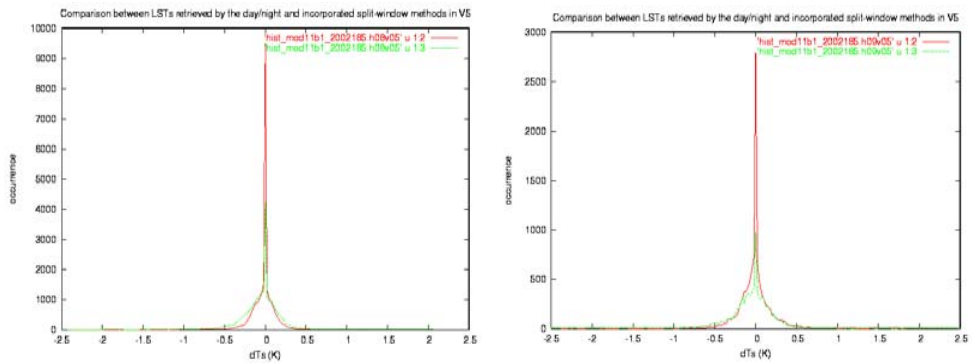


Fig. 2, comparisons of LSTs retrieved from the day/night and incorporated split-window methods in tiles h08v05 (left) and h09v05 (right).

2.2, Comparison between LSTs retrieved by the day/night and independent generalized split-window methods

Fig. 3 shows the cumulative histograms of the differences between daytime (in red) and nighttime (in green) LSTs retrieved from the day/night method and the independent generalized split-window method with MODIS data in August 2002 in tiles h08v05 and h09v05 based on all V5 MOD11B1 products in the month. The mean and standard deviation of differences are less than 0.1K and 0.5K. This means that the LSTs retrieved by the split-window method using the classification-based emissivities in bands 31 and 32 dependent on land cover types are not too far from the LSTs retrieved by the day/night algorithm using pairs of day and night MODIS data in seven TIR bands plus the information provided in MOD07, MOD10, MOD35 and MOD43 products. Therefore, validated LSTs in 1km LST products (MOD11A1 and MYD11A1) can be used in-directly validate the LSTs in 6km LST products (MOD11B1 and MYD11B1) thru the Aggregated_from_1km SDS in the B1's in relatively homogeneous areas. But it is not always possible to use this approach in V4 due to the temporal average in the generation of M*D11A1 products.

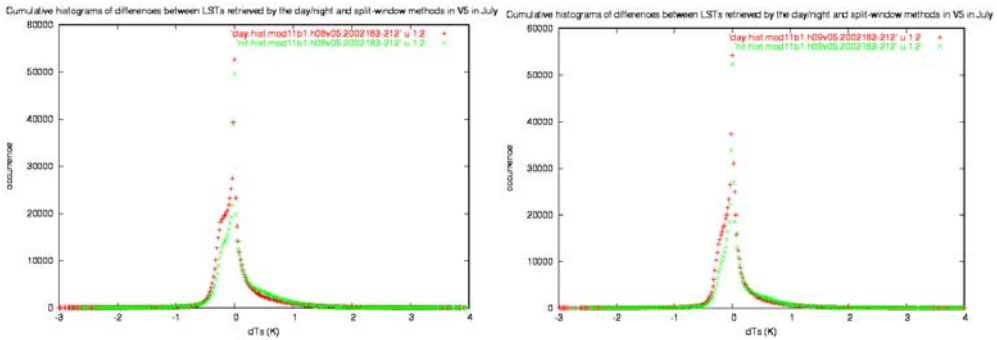
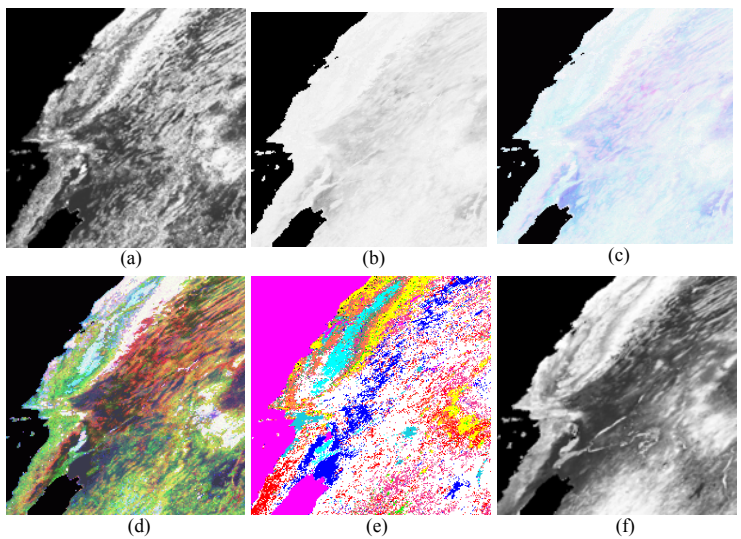


Fig. 3, cumulative histograms of differences in LSTs in MOD11B1 in August 2002 in tiles h08v05 (left) and h09v05 (right).

2.3, Surface emissivities in bands 20, 22, 23, 29, 31 and 32 retrieved by the day/night algorithm



As shown in Fig. 4, the emissivities retrieved in V5 PGE16 are more reliable and well correlated with landcover and NDVI although NDVI is not used as input of PGE16.

Lab measurements show that ε_{20}, ε_{22}, ε_{23} are more sensitive to the moisture in vegetation leaves.

Simulations show that $\varepsilon 2_9$, ε_{31}, ε_{32} are all important in the narrow-to-broad band conversion to calculate the broadband emissivity.

Fig. 4, retrieved ε_{22} (a) and ε_{29} (b) from MODIS data in August 2002, in scale 0.492-1.0, color composite of ε_{22} ε_{29} ε_{31} as RGB components (c) in the same scale, another color composite of the same components enhanced by the histogram equalization method (d), landcover from MOD12Q1 (e), and NDVI from MOD13A2 (f).

3. Plans for the Future

In the MODIS LST PGE, LST is retrieved for pixels in clear-sky conditions at the 99% confidence defined by cloudmask MOD35 or MYD35 over land, and 66% and higher in lakes in V4. It was found that cloud-contaminated LSTs exist in both MOD11A1 and MOD11B1 LST products, e.g., LSTs below freezing point in Lake Tahoe that is open around the year. Cloud-screen schemes using landcover-dependent constraints on temporal variations in LSTs will be implemented in V5. A few more validation field campaigns will be conducted. More temporal analysis of LSTs and emissivities will be made at global and regional scales.

Wan, Z. and Z.-L. Li, "A physics-based algorithm for retrieving land-surface emissivity and temperature from EOS/MODIS data", IEEE Trans. Geosci. Remote Sens., vol. 35, 980-996, 1997.
Wan, Z., Y. Zhang, Q. Zhang, and Z.-L. Li, "Validation of the land-surface temperature products retrieved from Terra Moderate Resolution Imaging Spectroradiometer data", Remote Sens. Environ., vol. 83, 163-180, 2002.
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