Estimation of Surface Air Temperature from MODIS 1km Resolution
Land Surface Temperature over Northern China

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Abstract:
Surface air temperature is a critical variable to describe the energy and water cycle of the Earth-atmosphere system and is a key input element for hydrology and land surface models. It is a very important variable in agricultural applications and climate change studies. This is a preliminary study to examine statistical relationships between ground meteorological station measured surface daily maximum/minimum air temperature and satellite remotely sensed land surface temperature from MODIS over the dry and semiarid regions of northern China. In this paper, air and land temperature data for year 2008 have been used. The relationships between surface air temperature and remotely sensed land surface temperature are statistically significant. The relationships between the maximum air temperature and daytime land surface temperature depends significantly on land surface types and vegetation index, but the minimum air temperature and nighttime land surface temperature has little dependence on the surface conditions. Based on linear regression relationship between surface air temperature and MODIS land surface temperature, surface maximum and minimum air temperatures are estimated from 1 km MODIS land surface temperature under clear sky conditions. The statistical errors (sigma) of the estimated daily maximum (minimum) air temperature is about 3.8°C (3.7°C).

I. Motivation:
Traditionally, surface air temperatures (Tmax and Tmin) are obtained from meteorological stations at 2 meters above the ground. In general, meteorological stations are distributed sparsely that is not enough for higher resolution regional model. Recent studies [1-3] have shown that estimated minimum air temperatures (Tmin) from MODIS Land Surface Temperature (Tsurf) are statistically meaningful over Africa, US Mississippi, and in Alpine areas, but the estimated maximum air temperature (Tmax) has large errors at some regions. In supporting research of Monsoon Asia Integrated Regional Study (MAIRS) project, NASA GEOS DISC has processed standard 8-day 1 km MODIS land surface temperature by mosaic-ing and re-projecting 10x10 degree tiled data files (MOD11A2.005 and MYD11A2.005) over the entire Monsoon Asia region (50°N-150°E, 0-60°N) and made data accessible easily for any region through the online visualization and analysis system, Giovanni. The question is how accurate Tmax and Tmin are over the Monsoon Asia region. This work is to examine that over the dry and semiarid regions of northern China.

http://disc.gsfc.nasa.gov/mairs/visualization/

II. Data and Processing:

Location of Stations:

Four datasets of year 2009 are used in this study. MODIS data are downloaded from USGS Land Processes Distributed Active Archive Center (https://lpdaac.usgs.gov)

1) MODIS daily land surface temperatures (Tsurf) at 1 km resolution of Collection-5 from Terra (MOD11A1.005) and Aqua (MYD11A1.005).

2) Daily surface air maximum and minimum temperatures from 75 meteorology stations over northern China are downloaded from China Meteorological Data Sharing Service System (http://cdec.cma.gov.cn/)

3) MODIS yearly land cover type at 500m resolution (MCD12Q1.005) of 2008.

4) MODIS monthly vegetation index at 1 km resolution from Terra (MOD13A2.005) and Aqua (MYD13A2.005).

Each station:
1) Daily MODIS Tsurf and monthly MODIS NDVI from Terra and Aqua are extracted at the nearest points to the station location for daytime and nighttime, respectively
2) MODIS yearly land cover type are extracted from 9 points centered by the station for identifying the environment of a station. Land cover type is classified as the one that appears most within the 9 points. Most stations are located in the suburban areas. Since no year 2009 data are available yet, the data from 2008 are used by assuming that the environment has no significant change from year 2008 to 2009.

III. Statistical Relations between Tsurf and Tsurf / Tmax:

Daytime Tsurf and Maximum Air Temperature

Nighttime Tsurf and Minimum Air Temperature

IV. Estimation of Tmin and Tmax from MODIS Tsurf:

For each station, calculate estimated air temperature by applying linear regression equation: Tsurf = a + b(Tsurf - Tsurf). Where, a and b depend on surface types:

Barren 0.7792508372 0.2718366542 0.0000104644 2.5673050000 1.4673133182 0.5871571137
Grassland 0.7731317569 0.0091163-1.49477 0.0000170611 0.24632024 0.6564402655
Woody-savanna 0.7800320391 0.2293404613 0.0000170611 0.2590413823 0.6564402655
Terra 0.7780576347 0.154619513 0.0000170611 0.2590413823 0.6564402655
Aqua 0.8333601621 0.1059170504 0.0000157994 0.5871571137 0.6564402655

Minimum Temperature

V. Summary:
Statistical relationships are investigated between MODIS Tsurf and surface air temperature (Tsurf) and minimum (Tsurf) by using 2009 data for 75 stations over dry and semiarid region of northern China. Results are summarized as follows:

- MODIS land surface temperature of daytime (Tsurf) and nighttime (Tsurf) from both Terra and Aqua are correlated significantly (p<0.001) with air temperatures Tsurf and Tsurf.
- The correlation between Tsurf and Tsurf is slightly higher than that between Tsurf and Tsurf.
- The slope of the linear regression equation of Tsurf and Tsurf depends on land surface type and vegetation index;
- Combining estimated temperatures from both Terra and Aqua reduces the estimation error;
- Estimated air temperatures have errors of about 3.7°C for Tsurf and 3.8°C for Tsurf.

References:

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