SMEX02 Landsat 5 and 7 Thematic Mapper Land Surface Brightness Temperatures, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Jackson, T., F. Li, and W. Kustas. 2004. *SMEX02 Landsat 5 and 7 Thematic Mapper Land Surface Brightness Temperatures, Version 1* [Indicate subset used]. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. https://doi.org/10.5067/SFENVFY5CSE5. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/NSIDC-0241

National Snow and Ice Data Center

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1 DETAILED DATA DESCRIPTION

Land surface temperatures (Ts) and brightness temperatures (TBs) are key boundary conditions in many remote sensing-based land surface modeling schemes. Currently available satellite thermal infrared sensors provide data with different spatial resolutions and temporal coverage to estimate land surface temperature. The Geostationary Operational Environmental Satellite (GOES) has 4 km spatial resolution in the thermal infrared channel, while the NOAA-Advanced Very High Resolution Radiometer (AVHRR) and the NASA Terra- and Aqua-Moderate Resolution Imaging Spectroradiometer (MODIS) sensors have 1 km spatial resolution. The Terra-Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) provides significantly higher spatial resolution at 90 m. The Landsat 5 TM has 30 m resolution, and Landsat 7 ETM+, which has 60 m resolution. However, these instruments have a repeat cycle of 16 days. Some Ts standard products are available from NOAA AVHRR and MODIS data with a 1 km resolution. These low-resolution data are limited in some applications.

As part of the SMEX02 campaign, two Landsat 5 TM scenes and three Landsat 7 ETM+ scenes were acquired during the primary study period. These data were used to produce high-resolution (30 m to 60 m) TB data sets. Users should be aware that these satellite data represent a single point in time, while ground-based estimates were taken before, during, and after the SMEX02 campaign.

The following table summarizes characteristics of the five images in this data set.

File name	062302_btemp.bil	070102_btemp.bil	070802_btemp.bil	071602_btemp.bil	071702_btemp.bil
Date	2002-06-23	2002-07-01	2002-07-08	2002-07-16	2002-07-17
Time (Fractional hours in GMT)	16.4943	16.7013	16.8083	16.5887	16.694
Landsat No.	5	7	7	5	7
Path	26	26	27	27	26
Row	31	31	31	31	31
Upper-left corner (UTM, meters)	431085.000 E 4731115.000 N	431064.092 E 4731115.913 N	431085.000 E 4731115.000 N	431085.000 E 4731115.000 N	431097.084 E 4731095.389 N
Upper-right corner (UTM, meters)	486616.000 E 4731115.000 N	486624.092 E 4731115.913 N	484450.871 E 4731102.466 N	486615.000 E 4731115.000 N	486657.084 E 4731095.389 N

Lower-left corner (UTM, meters)	431085.000 E 4616185.000 N	431064.092 E 4616155.913 N	431050.871 E 4616142.466 N	431085.000 E 4616185.000 N	431097.084 E 4616195.389 N
Lower-right corner (UTM, meters)	486615.000 E 4616185.000 N	486624.092 E 4616155.913 N	484450.871 E 4616142.466 N	486615.000 E 4616185.000 N	486657.084 E 4616195.389 N
Pixel size (meters)	30	60	60	30	60
Rows	3831	1916	1916	3831	1915
Columns	1851	926	890	1851	926

1.1 Format

Brightness temperature data are unsigned integer, band-interleaved-by-line (BIL), binary values, scaled by 100. Pixel values of "0" indicate missing data. Data are in a PC byte order (little endian). SGI and Sun users should byte-swap these data before using them.

1.2 File and Directory Structure

The HTTPS site contains five files. See the Image Specifications table above for characteristics of each file.

1.3 File Naming Convention

File names are "ddmmyy_btemp.bil", where "dd" is the two-digit day, "mm" is the two-digit month, "yy" is the two-digit year, and "btemp" is T_B.

1.4 Spatial Coverage

The Landsat data coincided with the SMEX02 experiment and were acquired over the Walnut Creek watershed in the Iowa study region. The data collectively cover the following area:

Southernmost Latitude: 41.69° N

Northernmost Latitude: 42.73° N

Westernmost Longitude: 93.84° W

Easternmost Longitude: 93.16° W

1.4.1 Spatial Resolution

Landsat ETM+ data have 60 m pixel resolution. The original Landsat 5 TM Level-1G data from the United States Geological Survey (USGS) have a 120 m footprint, but the USGS resampled the data to 30 m spatial resolution.

1.4.2 Projection and Grid Description

These Landsat data are in a Universal Transverse Mercator (UTM) Zone 15 projection and North America (NAD83) datum.

1.5 Temporal Coverage

The Landsat scenes in this data set were acquired on 23 June, 1 July, 8 July, 16 July, and 17 July 2002.

1.6 Parameter or Variable

1.6.1 Parameter Description

Pixel values represent TBs in Kelvins, scaled by 100.

1.6.2 Parameter Range

Data values range from 23044 (230.44 K) to 33553 (335.33 K).

2 SOFTWARE AND TOOLS

Users can read these data with any remote sensing or image processing software.

3 DATA ACQUISITION AND PROCESSING

3.1 Data Acquisition Methods

The original TM and ETM+ radiance data from the USGS were Level-1G products, partly georegistered and radiometrically corrected. However, the data were not corrected for atmospheric effects.

3.2 Derivation Techniques and Algorithms

Atmospheric Correction

Radiance from a satellite platform is strongly affected by the presence of the atmosphere. So, atmospheric correction is needed to convert satellite-based radiance to an estimated surface TB. The MODTRAN 4.1 radiative transfer model (Berk et al. 1998) was used to correct for atmospheric effects. See Li et al. (2004) for details of how the investigators derived land surface TBs and surface temperature data during SMEX02.

The sensor radiance ($I\lambda$) is expressed as follows (Schmugge, Hook, and Col 1998):

$$I\lambda = t\lambda I\lambda(0) + d\lambda$$

Where,

$t\lambda$ is atmospheric transmittance

$I\lambda(0)$ is the surface-leaving radiance

$d\lambda$ is the spectral radiance added by the atmosphere

A TB is simply the temperature corresponding to a blackbody radiator emitting the same radiance. Radiance data can be converted into equivalent TBs as the following equation shows. The surface-leaving radiance, $I\lambda(0)$, can be expressed in terms of surface temperature in the following manner:

$$I\lambda(0) = I\lambda B(TB) = \varepsilon\lambda I\lambda B(Ts) + (1 - \varepsilon\lambda)Id\lambda$$

Where,

$\varepsilon\lambda$ is the wavelength-dependent surface emmisivity

$I\lambda B(Ts)$ is the spectral radiance from a blackbody at surface temperature Ts

$Id\lambda$ is the downwelling sky radiance due to the atmosphere

Using MODTRAN, $t\lambda$, $d\lambda$, and $Id\lambda$ can be obtained from Landsat band response functions and radiosonde data.

Brightness Temperature Calculation

For Landsat thermal data, the investigators computed surface TBs in Kelvins for each pixel using the following equation:

$T_B = (k2 / \ln[k1 / I\lambda(0) + 1])$

Where,

$I\lambda(0)$ is the integrated band radiance (Wm-2 sr-1 µm-1) from the first atmospheric correction equation above

k1 and k2 are calibration constants chosen to optimize the approximation for the band pass of the sensor. For Landsat 7, k1 is 666.09 Wm-2 sr-1 µm-1 and k2 is 1282.71 K (GSFC 2005). For Landsat 5, k1 is 607.76 Wm-2 sr-1 µm-1 and k2 is 1260.56 K (Schneider and Mauser 1996). When emissivity is known, all of the above equations can be used to estimate Ts.

3.2.1 Error Sources

Converting radiances to Ts and TBs involves a number of assumptions and approximations. Sensor properties represent one source of error. The calibration error is within ±0.6 K for ETM+ data obtained after December 2000, while the calibration error from TM is difficult to quantify; past studies indicate it is quite significant and requires recalibration with in situ data (Li et al. 2004).

A second source of error arises from the accuracy of water vapor measurements while using the MODTRAN atmospheric correction model. Schmugge, Hook, and Call (1998)estimate this as nominally 10%. If the target T_B is 300 K, this could lead to a T_B error of about 0.5 K for ETM+ data (Li et al. 2004).

A third source of error comes from estimating surface emissivity. The emissivity of the soil is relatively high at the Iowa study site, and the site is also vegetated. The investigators assumed a general emissivity of about 0.98. The emissivity error for this site should be less than 0.005, which could lead to a change of 0.2 K (ETM+ data) in the Ts when the target TB is 300 K (Li et al. 2004).

The estimated overall accuracy of the TBs is approximately 1° K when comparing tower and satellite measurements. The TM TBs were recalibrated using low-altitude aircraft measurements (Li et al. 2004). Analysis revealed that the post-calibrated TBs from ETM+ still have a 0.98° C bias when compared to tower measurements. The TBs from TM have a bias of 1.47° C when compared to tower measurements (Li et al. 2004).

3.3 Sensor or Instrument Description

TM is a multispectral scanning radiometer carried on Landsats 4 and 5. The TM has seven spectral bands, with a spatial resolution of 30 m for most bands.

ETM+, an improved version of TM, is carried on Landsat 7. The ETM+ has eight spectral bands with a spatial resolution of 60 m for most bands.

4 REFERENCES AND RELATED PUBLICATIONS

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5 CONTACTS AND ACKNOWLEDGMENTS

Tom Jackson, **Fuqin Li**, and **William Kustas**
United States Department of Agriculture
Agricultural Research Service
Hydrology and Remote Sensing Laboratory
Beltsville, MD 20705-0000

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6 DOCUMENT INFORMATION

6.1 Publication Date

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6.2 Date Last Updated

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