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Satellite Datasets and there Scaling Factor for Land Surface Temperature

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Satellite remote sensing, which can continually observe various surface processes on a global scale, has explicitly facilitated such studies [1-3]. While remote sensing plays an increasingly important role in large-scale environmental monitoring, it has also been criticized for its inherently limited spatial resolution [4-6]. This limitation weakens the reliability of studies based on satellite data due to uncertainty generated from spatial heterogeneity.

Among all the land surface parameters, land surface temperature (LST) is an important factor controlling most physical, chemical, and biological processes of the Earth system. It is generally defined as the skin temperature of the Earth's surface [7]. Because the surface is generally heterogeneous and non-isothermal within an IFOV, the pixel-wise LST is an integral quantity representing the integrated effects of the whole ensemble [8].

Retrieved LST is validated with ground measurements, which are often performed over large, flat, and relatively homogeneous test sites to avoid uncertainty due to spatial heterogeneity [9,10]. However, the accuracy of LSTs retrieved from heterogeneous or mixed pixels remains questionable. Moran et al. (1997) evaluated uncertainty in LSTs due to heterogeneity. LSTs were up scaled from airborne data using two aggregation schemes for a semiarid rangeland. The average LST difference was less than 0.1 K, and the error due to emissivity differences was negligible for relatively homogeneous sites [11,12].

To explore issues related to scaling satellite-retrieved LST data, this study used data from the AMSR-2, Landsat, ASTER and AMSR-E sensors on board NASA's Earth Observation Satellites. In this research work, first take sample sites and then derive land surface temperature from satellite brightness temperature values by the help of following scaling factors for different satellite data [13,14].

The study area has six training sites on globe in different continent to compare temperature in different satellites datasets on same location. Sample sites are located on following place: (1) Karl Stefan Memorial Airport (USA); (2) Mondai, Santa Catarina (Brazil); (3) Belgrade, Serbia (Europe); (4) Khartoum, Sudan (Africa); (5) Chengdu, China; (6) Kalgoorlie, Australia.

- **AMSR-2**

For AMSR2 data scale factor is set as 0.01[K]. For instance, if brightness temperature data is stored as 28312, original value of the data is 283.12[K].

- **Aster**

ASTER surface temperatures are computed from spectral radiance so begins by converting DNs to radiance and for that equation is following:

$L_\lambda = (DN - 1) X UCC$

Where L_λ is the spectral radiance, DN are the TIR band digital numbers, and UCC are the published Unit Conversion Coefficients (0.005225 $w/m^{-2}/sr^{-1}/\mu m^{-1}$).

Temperature (measured in degrees Kelvin) is then given by:

$T = K2 / (\ln (K1/ L_\lambda + 1)$

Where K1 (641.32) and K2 (1271.22) are constants derived from Planck's radiance function.

- **Landsat**

OLI and TIRS band data can be converted to TOA spectral radiance using the radiance rescaling actors provided in the metadata file:

$L_\lambda = M_L Q_{cal} + A_L$

Where:

L_λ =TOA spectral radiance ($w/m^{-2}/sr^{-1}/\mu m^{-1}$)

M_L = Band-specific multiplicative rescaling factor from the metadata

(RADIANCE_MULT_BAND_x, where x is the band number) A_L=Band-specific additive rescaling factor from the metadata

(RADIANCE_ADD_BAND_x, where x is the band number) Q_{cal} =Quantized and calibrated standard product pixel values (DN)

TIRS band data can be converted from spectral radiance to brightness temperature using the thermal constants provided in the metadata file:

$T = K2 / (\ln (K1/ L_\lambda + 1)$

Where:

T=At-satellite brightness temperature (K)

L_λ=TOA spectral radiance ($w/m^{-2}/sr^{-1}/\mu m^{-1}$)

K_1=Band-specific thermal conversion constant from the metadata

(K1_CONSTANT_BAND_x, where x is the band number, 10 or 11) K_2=Band-specific thermal conversion constant from the metadata

(K2_CONSTANT_BAND_x, where x is the band number, 10 or 11)

- **AMSR-E**

For AMSR-E data with scale and offset values, the data values can be obtain in the specified units with the following equation:

Data value in units=(stored data value * scale factor)+offset

Example: Temperature (k)=(stored data value * 0.01)+327.68

Scaling factors and offsets are provided with the local attributes of each HDF-EOS files and should check each file to ensure correct values.

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- **Analysis**

In the following section, 1°×1° spatial subsets of the products were co-registered so that the resulting subsets cover the same area as the Landsat, ASTER, AMSR-2 and AMSR-E images. Where necessary, spatial re-sampling was performed using the nearest neighbour method [15,16]. The gravel plains are highly homogenous in space and time and outside globe two seasons (around September and June) the chances for precipitation are remote therefore, it is safe to assume that the land surface was completely dry for the results presented in this paper. The following section briefly discusses the actual land surface temperature on the same area and time from different satellite data sates.

- **AMSR-2 and AMSR-E**

AMSR-2 June 2014 data show minimum 166.67 K and highest 305.34 K temperature. In June highest temperature is present in Sahara desert, west centre of North America and northeast part of Brazil, west part of India and china. AMSR-E is showing 327.68 k highest temperatures in deserted part of the globe such as Sahara and Thar Desert. 292.34 K temperature in green vegetation part of globe. 271.02 k temperature is in high altitude and Northern hemisphere part. It's also show very cold temperature on poles.

- **Landsat**

In 2014 sample site in Europe, Landsat 8 band number 11 shows 267.11 K as lowest temperature and 312.92 highest temperatures. Maximum region show around 290 to 300 k temperatures. In North America its 287.73 to 310.57 K and in South America is 274.34 to 293.71 K but maximum region have high temperature, above than 285 k.

In 2013 in Australia temperature range is in between 271.67 to 299.53 K and this region show an average temperature. For Africa its 284 to 310 but maximum area have above than 305 K temperature, which show high temperature. In Asia it's from 267.74 to 277.58 K and maximum area has average temperature.

- **Aster**

In ASTER data on same location in 2014 in Europe, temperature range is in between 289.31 to 318.16 K and for North America is from 277.88 to 300.22 K. In both regions, maximum area is cool. In South America and Asia temperature range is 277.88 to 300.22 K and 256.85 to 300.68 K respectively. Maximum area has average temperature. In Africa and Australia it`s 275.14 to 320.80 and 285.79 to 303.80 K respectively.

- **Comparing in land surface temperature in AMSR-2, AMSR-E, Landsat and ASTER satellite data**

In North America Landsat data showing highest and AMSR-2 and AMSR-E data is showing lowest temperature in all locations. ASTER data temperature values are in between in North America. In South America ASTER show highest temperature and AMSR-2 and AMSR-E lowest and Landsat is in between. For Europe is same like South America. In Africa Landsat have highest and AMSR-2 and AMSR-E lowest temperature and ASTER data temperature is in between. In Asia ASTER is highest, than Landsat and AMSR-2 and AMSR-E is the lowest temperature. For Australia, Highest is AMSR-2 and AMSR-E than ASTER and Landsat is lowest temperature. The analysis results show that Landsat and ASTER data temperature is close to ground measurements in compare of AMSR-2 and AMSR-E data temperature due to their high resolution and scale [17].

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