MONITORING WATER SURFACE TEMPERATURE BY SATELLITE REMOTE SENSING: A CASE STUDY ON RIVER KARNAPHULI

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ABSTRACT

Passive microwave radiometry from satellites provides more precise atmospheric temperature information than that obtained from relative the relatively sparse distribution of thermometers over the earth's surface. Satellite remote sensing is the easiest way to monitor surface temperature of land cover and water bodies for several years. The aim of this research is to find out of temperature distribution over the water surface of the river Karnaphuli in the years 2000, 2007 and 2015 and to make necessary comparisons among them. LANDSAT satellite images have been used for remote sensing measurement of water surface temperature. The 2000 LANDSAT data used is ETM+, 2007 is TM and 2015 data is OLI_TIRS data. Surface temperature for three months (March, July, and November) has been calculated for each distinct year. The numeric value of temperature was observed at 15 different stations. It has seen that average temperature for March was 21.84°C in 2000 and 22.48°C in 2015, for November was 23.56°C in 2000 and 25.28°C in 2015 and for July it was 14.67°C in 2000 and 13.58°C. Being monsoon period of year can be attributable to the reason of behaving odd for July.

Keywords: Remote Sensing, LANDSAT, TM, ETM+, OLI_TIRS

INTRODUCTION

Water quality is the key environmental concern because of its important provision of water for drinking and domestic purpose, irrigation and aquatic life including fish and fisheries, (Ahmed et al, 2013). In case of river, surface temperature is a major factor to be considered. According to United States Geological Survey temperature governs kind of organism that can live in rivers. Water temperature is a physical property expressing how hot or cold water is. As hot and cold are both arbitrary terms, temperature can both further be defined as a measurement of the average thermal energy of a substance, (Brown, 1999). Satellite image data sensed by the optical and thermal sensors on various remote sensing platforms has been widely used for water quality measurement studies, (Alparslan et al, 2007). The use of monitoring has evolved to help determine trends in the quality of aquatic environment and hoe the quality is affected by release of the contaminants, other anthropogenic activities or by waste treatment operations. The principal benefit of satellite remote sensing for inland water quality monitoring is the production of synoptic views without the need of costly in situ sampling, (Hadjimitsis et al, 2010). Karnaphuli is the largest river in Chittagong and Chittagong hill tracts which is 2188 ft. wide, originating from the Lushai hills in Mizoram, India, it flows 270 kilometers, (Saleheen, 2014).The objective of the study is to compare the temperature over the river at the target years both by distribution from map and numerical values obtained from 15 particular stations.

METHODOLOGY

Temperature for each data is calculated using the thermal band. LANDSAT TM and ETM+ data requires same method to find out brightness temperature and OLI_TIRS data requires a distinguished method for calculation of temperature. All procedures are obtained from LANDSAT data users' handbook.

Temperature derivation from TM and ETM+

Calculating land surface temperature for TM & ETM+ is a three step methodology. First the raw image is needed to convert into spectral radiance image.

$$L_{\lambda} = ((LMAX_{\lambda} - LMIN_{\lambda})/(QCALMAX - QCALMIN)) \times (QCAL - QCALMIN) + LMIN_{\lambda} \quad (1)$$

The radiance values are converted to reflectance by using following equation

$$\rho_{\lambda} = \pi \times L_{\lambda} \times d^2 / ESUN_{\lambda} \times \cos\Theta_s \quad (2)$$

Then the reflectance images are converted into brightness temperature

$$T = \frac{K2}{Ln(\frac{k1}{L\lambda}) + 1} \quad (3)$$

Temperature derivation from OLI_TIRS

For OLI_TIRS the DN values are converted to surface reflectance

$$\rho\lambda' = M_{\rho} Q_{cal} + A_{\rho} \quad (4)$$

Then a sun angle correction is done for the reflectance values

$$L_{\lambda} = \frac{\rho\lambda'}{\sin(\theta sE)} \quad (5)$$

From reflectance to brightness temperature conversion is done by using the Eq. (3)

ANALYSIS AND DISCUSSION

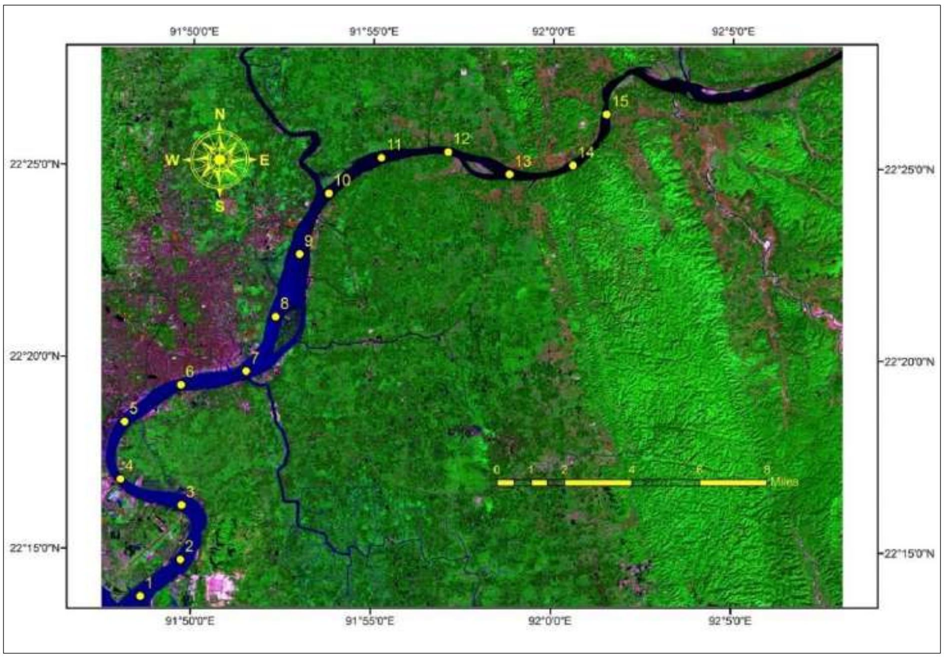


Figure 1: River Karnaphuli with observing stations

The observed stations are visible in Fig 1 which are arranged serially keeping an approxiamte distance of 3000m between two points. For analysis and to facilitate comparison temperature has been classified into four categories which are Very high (24-28 °C), High (21-24 °C), Medium (19-21 °C) and Low (<19 °C). There are islands on the river which are omitted during analysis.

Temperature in the month of March

In fig: 02 for the derived temperature of March is seen. At the year 2000 the river is almost occupied by high range of temperature values though in some areas low and medium level of temperature exists. In 2007 the river is occupied by high to very high range of temperature and in case of 2015 it is high range of temperature values. From the observing stations the same scenerio has found. Temperature at all of the points are within 20°C to 25°C except for one. At station 14 the year 2000 has a temperature value of below 20°C. The years 2000 and 2015 almost overlapped at most of the stations.

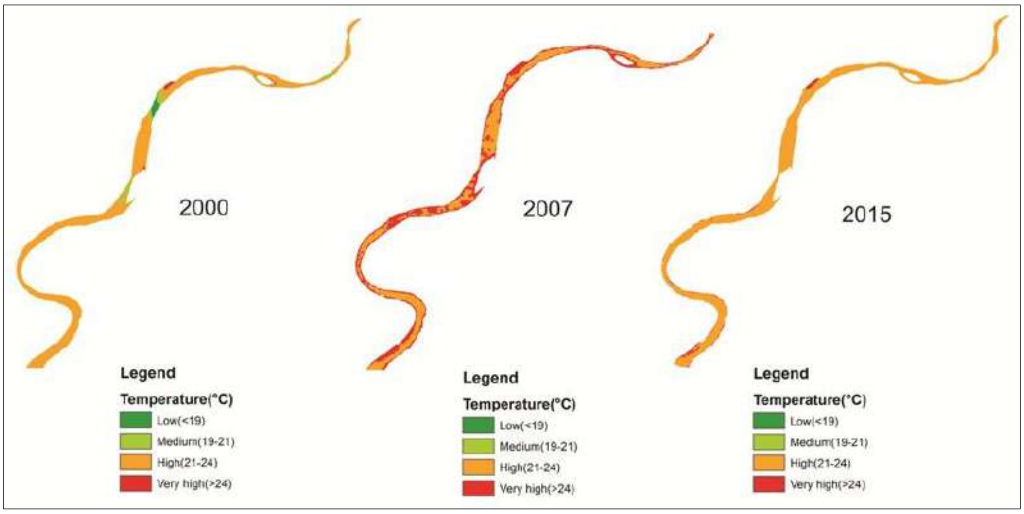


Figure 02: Temperature distribution at March

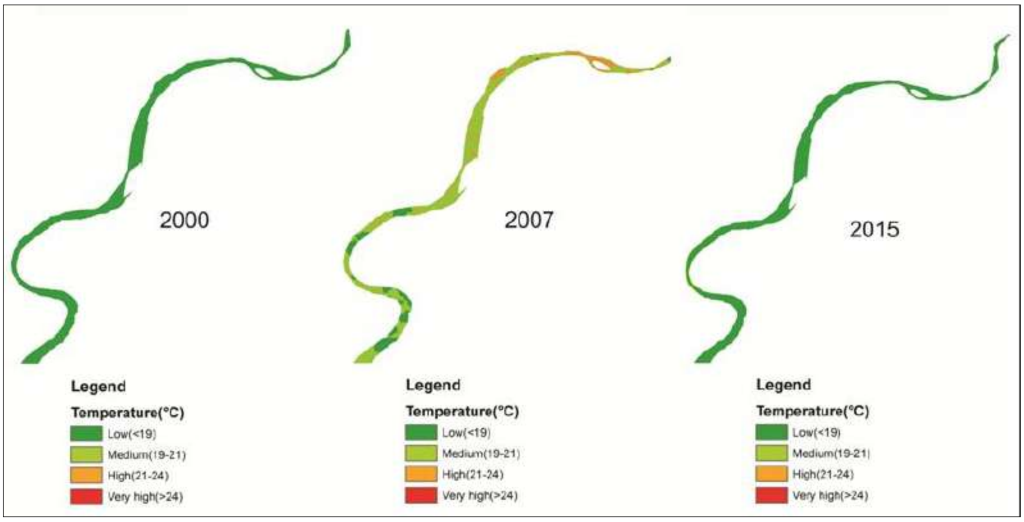


Figure 03: Temperature distribution at July

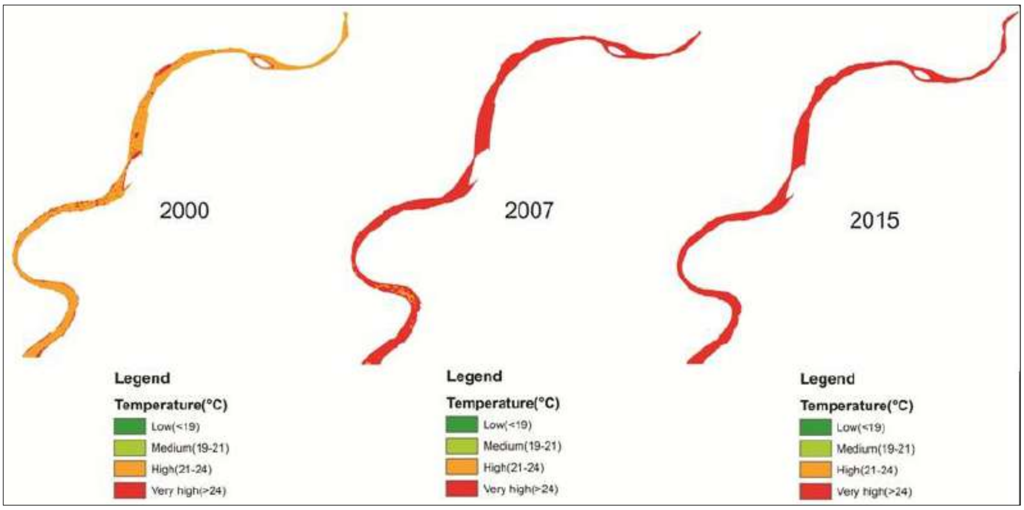


Figure 04: Temperature distribution at November.

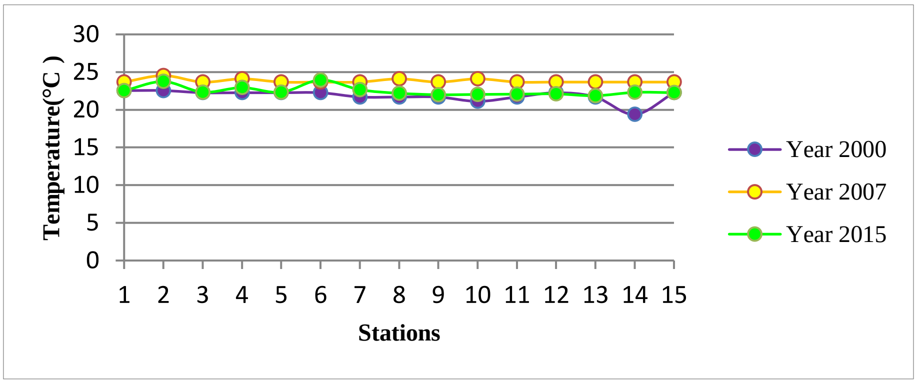
Temperature at the month of July

At the month of July (Fig: 03) the river is found in low temperature in 2000. In 2007 most of the surface area of the river was occupied by medium class of temperature though some low level of temperature

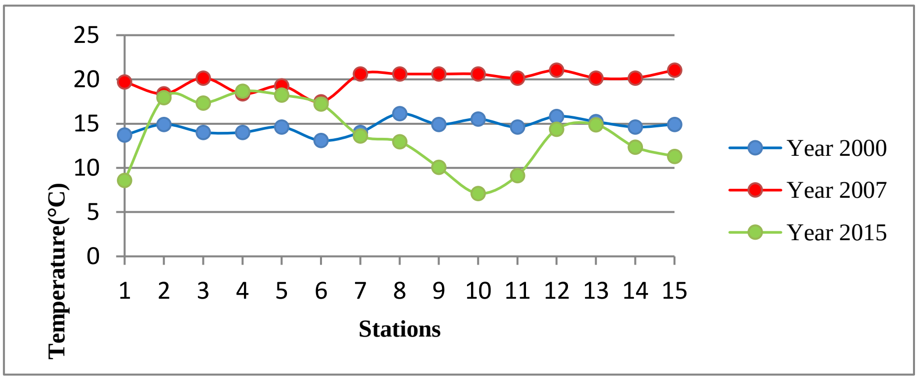
portions are seen in downstream and high range of temperature areas are visible in upstream. In case of the year 2015 the whole river is occupied by low range of temperature as like 2000.
Observed temperature values (Graph 02) show too many fluctuations and year wise variation in July. The year 2007 would lie above others in July on average. From the stations 2 to 7, 2015 got higher temperature than 2000. At the remaining stations line 2000 remains at higher then line 2015. Overall the line of 2015 showed more rise and fall then other two years.

Temperature at the month of November

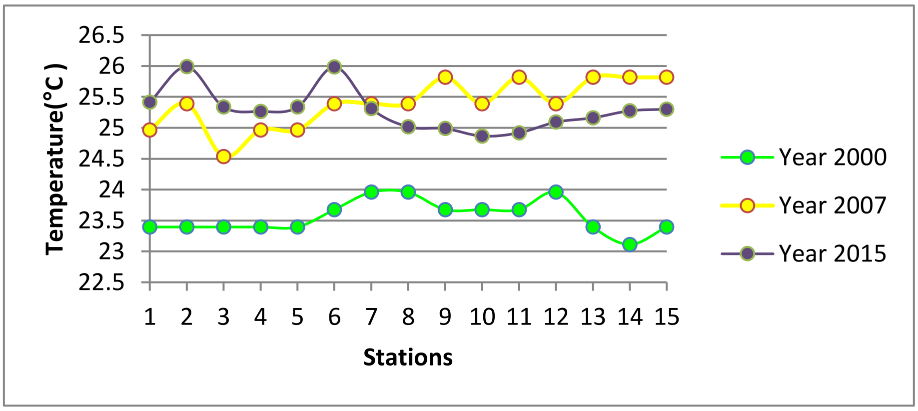
It is very clear from temperature distribution map (Fig: 04) for the month of November that in the year 2007 and 2015 the river was almost occupied by very high range of temperature values that is more than 24°C. In case of the year 2000 the river was occupied by high range of temperature values. From the extracted values at 15 stations (Graph 03) a very significant and anticipated distribution is found. For 2000 all of the stations got temperature between 23°C to 24°C and also the year lies below the other two years. From the station 1 to 6 the line of 2015 lies above 2007 and also the maximum temperature found at the station 2 which is 25.98°C at the year 2015. In case of the stations 8 to 15 the year 2007 got higher temperature than 2015.



Graph 01: Observed temperature values at 15 stations of March

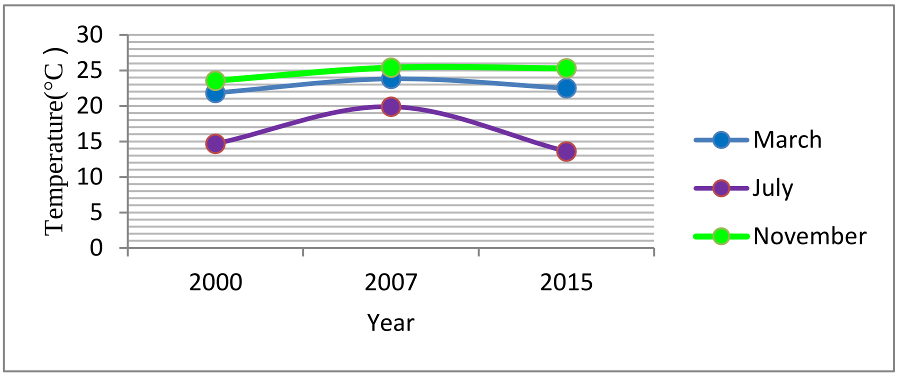


Graph 02: Observed values of temperature at July



Graph 03: Observed temperature values at November

FINDINGS AND CONCLUSION



Graph 04: Average fluctuation of temperature.

In graph no 04 average fluctuation of temperature in 2000, 2007 and 2015 has depicted. In November average temperature in 2000 was 23.56°C, in 2007 25.39°C and in 2015 it was 25.28°C. For the month of March too it represents a slight increase as in 2000 it is 21.84°C and in 2015 it is 22.48°C. But for in case of July it starts at 14.67°C in 2000 and rises to 19.89°C in 2007 and then fall to 13.58°C in 2015. As the month July is among the monsoon period it can be assumed the reason behaving different than other two months. The rainy season (June through October) accounts for 70 to 85% of the annual rainfall, which varies from 70% in the eastern part of the country to about 80% in the southeast and 85% in the northeast, (Ahmed, 2015). However for March and November there found overall increase of temperature from 2000 to 2015.

The inherent problem with this type of research is high cloud coverage of satellite data. In the monsoon period the sky almost remains covered with dense cloud and satellite images taken at that time are quite unsuitable to work with. Even though, large scale water body monitoring and observing for long period of time remote sensing based water quality assessment is an effective tool.

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