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MODIS, LANDSAT VE NOAA AVHRR VERİLERİNİ ENTEGRE EDEREK AKYATAN LAGÜNÜ'NDE (ADANA) SU YÜZEYİ SICAKLIKLARININ (SST) İNCELENMESİ (2001-2015)

THE EXAMINING IN THE SEA SURFACE TEMPERATURES (SST) OF AKYATAN LAGOON (ADANA) INTEGRATING NOAA AVHRR, LANDSAT AND MODIS DATAS (2001-2015)

Mehmet Ali ÇELIK•
Mehmet Tahir KAVAK**
Ali Ekber GÜLERSOY***

Abstract

Sea Surface Temperatures (SST) can provide significant data about the climate of a certain place. Sea surface temperatures can vary at short distances with the effect of air masses. Variations in the climate can be well understood by examining the SST data. In this context, the SST values are considered as an important parameter in global climate modelling. The reactions of the oceans and seas to the global climate change can be understood by examining the SST values. Studies show that the water surface of the world's oceans has been increasing with the global climate change.

In this study MODIS, Landsat and NOAA AVHRR platform is used. 8-day data for the summer months of the years 2001-2015 were obtained. Finally, after various image processing techniques applied to this data, the ST maps have been obtained. At the same time, statistical methods were used to determine the relationship between SST values and air temperatures. The Akyatan Lagoon located on the southern coast of Turkey, which is expected to be significantly affected by global climate change, has been selected as the investigation field. In this study, the average air temperatures and sea surface temperature of the summer season were investigated.

Akyatan Lagoon reaches the highest temperatures during the year in August. The results of the study show that there is a statistically significant relationship between air temperatures and SST values in the Akyatan Lagoon. In particular, a strong relationship was found between air temperatures and SST values for the months of July and August.

Keywords: Akyatan Lagoon, SST, NOAA AVHRR, Climate.

1. Introduction

Sea Surface Temperature (SST) is an important parameter used to estimate the temperature variation between air and water surface. In particular, it is important to study the sea surface temperatures in terms of revealing the heat balance of the earth and explaining the atmospheric and ocean circulations and anomalies, which are required for the global climate models (Kavak and Karadoğan, 2012: 1). Sea surface temperatures can vary at short distances with the effect of air masses. Sea surface temperatures and weather conditions are closely related. Studies show that the water surface of the world's oceans has been increasing with the global climate change (Vörösmarty et al., 2000; Winter et al., 2000, Poff et al., 2002). In this context, it is possible to understand the fluctuations and changes occurring in atmospheric conditions by looking at the surface temperatures of the water. Sea surface temperatures are the base data for climate studies. The analysis of these data is important to better understand the global climate system.

In this study, the temperature changes of the Akyatan Lagoon in the south of Adana during the summer of 2001-2015 were analyzed through remote sensing data. Remote sensing data are frequently used in Turkey and in the world due to its availability, its wide coverage as well as its generation of uninterrupted data (Kawabata et al., 2001; Mao et al., 2011; Bahadır and Özdemir, 2012; Çelik and Karabulut, 2013; Şekertekin et al., 2013: 1). By using remote sensing methodology, variation in the sea surface temperatures, stemming from human or natural effects, have been shown in many studies.

Thomas et al. (2002) examined the variation in sea surface temperatures in the Maine Gulf of America which overlooks the Atlantic Ocean. Using sets of Landsat TM data in the study, the temperature variation in the 10 years-period between 1986-1996 was observed. One of the results of the study shows that air masses are important in the variation of the gulf water temperatures. Water or ground surface temperatures do not vary only with air masses and natural conditions. Küçükönder et al. (2014) studied the

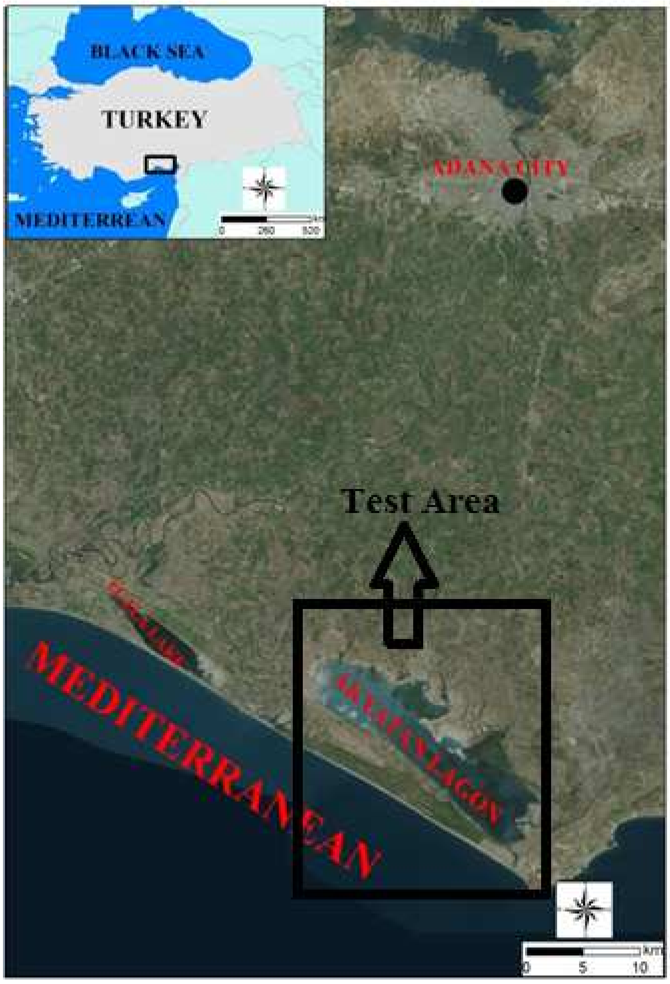
• Dr., Faculty of Arts and Sciences, Kilis 7 Aralık University, mehmet.ali.celikk@gmail.com
**Assistan Prof. Dr., Faculty of Education, Department of Physics, Dicle University mtkavak@gmail.com
***Assoc. Prof. Dr., Buca Faculty of Education, Dokuz Eylül University, gulersoy74@gmail.com

effect of thermal power plants on the ground surface temperature. Landsat Land Surface Temperature (LST) data is used for this. The surface temperature was examined before and after the construction of the thermal power plant. The findings show that the thermal power plants have significantly increased ground surface temperatures. Variation in water and surface temperatures are also being studied by using MODIS, Landsat and NOAA AVHRR data in addition to Landsat data. MODIS and NOAA AVHRR are mostly preferred because it covers a wider area than Landsat.

Reinart and Reinhold (2008) studied two of Europe's largest lakes in Sweden. In the study, data covering 2001 and 2003 belonging to NOAA AVHRR platform were used. It has been found that the surface of the lake shows considerable oscillations during the year. Both lakes were found to have reached the highest temperatures in July and August.

In this study, the average air temperatures and sea surface temperature of the summer season were investigated. The relationship between these two variables has been tried to be revealed. The basic data of the study belongs to the NOAA AVHRR platform. The NOAA AVHRR data used in our work provides data at various scales and accuracy about the atmosphere, hydrosphere, biosphere, ice sphere and ground surface. The Landsat and NOAA AVHRR data has been used in many studies (Zhan et al., 2002; Wardlow et al., 2008, Çelik and Karabulut, 2014).

Akyatan Lagoon located in the south of Adana was chosen as the study area (Figure 1). This area is one of the major impact areas of climate change. Many studies report that Turkey's southern regions will be significantly affected by global climate change (Kimura et al., 2006, Turkes et al., 2000, Kum and Çelik, 2014; Cook et al., 2016). In this context, the study of Akyatan Lagoon is important.



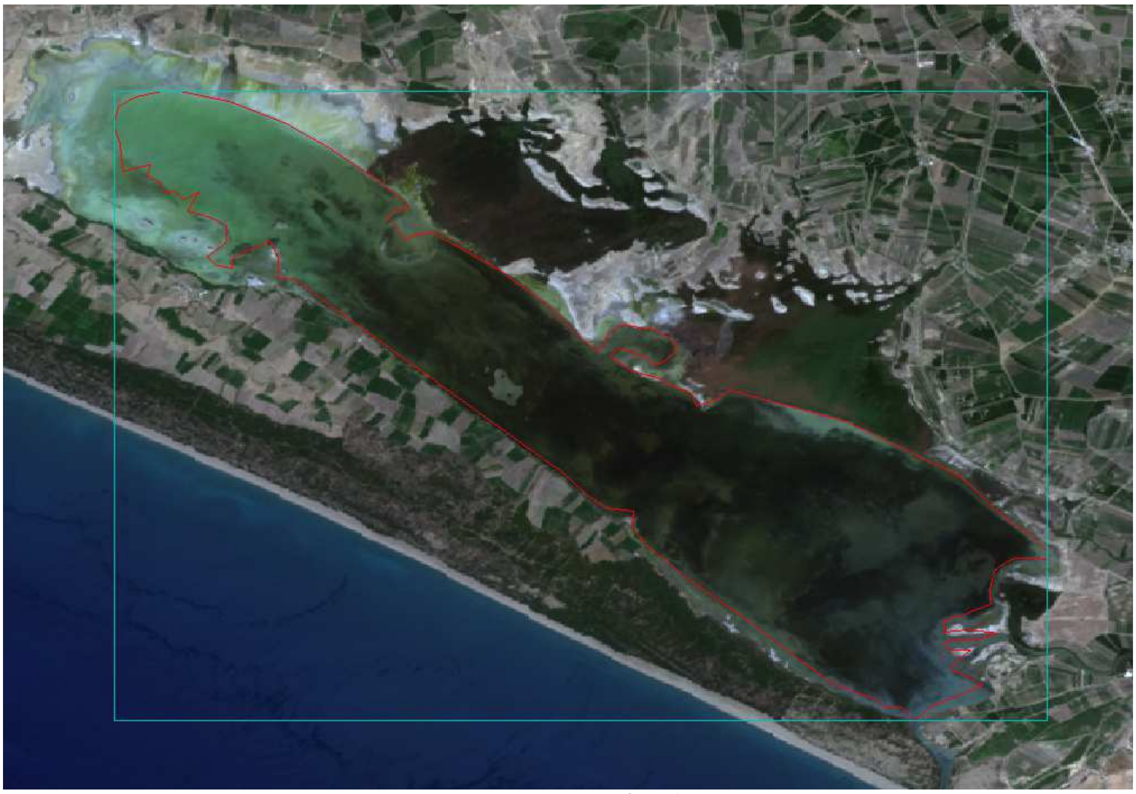


Figure 1. Location Map of Study Area.

2. Material and Method

In this study, MODIS, NOAA AVHRR and Landsat platforms are used. The data used have a temporal resolution of 8 days and a spatial resolution of 1 km (Figure 2).

In this study, 11 NOAA AVHRR images belonging each year were used. In total, 165 data have been worked on. SST calculation was performed from these data. Various methods such as the RTE-radiative transfer equation, the mono-window algorithm (Qin et al., 2001) and the single-channel algorithm (Jiménez et. al., 2006) were used in the SST calculations by thermal sensors.

Atmospheric variables such as aerosols and other gas absorbers, surface emissions from land cover, sensor features like noise, angular effects and wavelength uncertainties are considered to be important sources of error in calculating surface temperatures (Jiménez et al., 2006). In this study, SST calculations were performed using a mono-window algorithm that takes into account atmospheric effects and surface emissions corrections. Obtaining the SST values with the one-window algorithm begins with the transformation of the sensor raw images to the spectral radiance values and then to the sensor brightness temperature. The most important steps of the algorithm are the calculation of surface emissions and atmospheric diffusion. The atmospheric permeability, which is effective on surface temperatures, is calculated by modelling over atmospheric temperature and relative humidity conditions (Table 1). Temperature and relative humidity values, obtained from meteorological stations which are compatible with the satellite passage time close to the region, are used (Li et al., 2013).

Table 1. Water vapour and atmospheric permeability (wi: water vapour content g/cm3).

Profiles	Water Vapour	Atmospheric Permeability
High Air Temperature	0,4-1,6	0,974-0,800³wj
	1,6-3	1,031-0,115³wj
Low Air Temperature	0,4-1,6	0,982-0,096³wj
	1,6-3	1,053-0,141³wj

Another variable used in the one-window algorithm is the average atmospheric temperature (Ta). The average atmospheric temperature is calculated based on the location of the investigated zone (Qin et al., 2001).

Table 2. The relationship between the average atmospheric temperature and the investigated zone (To: Meteorological station temperature (K)).

Region	Average Atmospheric Temperature
For US 1976	25,93+0,880
For Tropical Regions	17,97+0,917
For Medium Latitude Summer	16,01+0,926
For Medium Latitude Winter	19,27+0,911

The final step is applying one-window algorithm (Equation 1) and obtaining the YYS image whose resultant surface emission and atmospheric diffusion correction is made.

$$T_s=\{a*(1-C-D)+[b*(1-C-D)+C+D]*T_i-D*T_a\}/C$$

As a result of the above processes histograms were generated (Figure 2). Erdas imagine software was used to creating histograms.

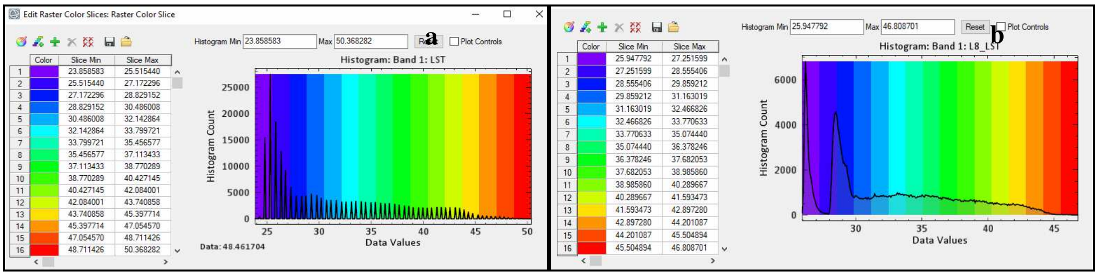


Figure 2. Histogram of SST maps of 2012 (a) and 2014 (b) years.

For this study, 5 Landsat OLI and ETM+ (see Table 3) scenes, from 2012 to 2017 that covering the region was selected. The data were downloaded from USGS EROS (United States Geological Survey's Earth Resources Observation and Science data Centre) via the Internet. To process and evaluate the Landsat ETM+ and OLI images, standard commercial ENVI (www.exelis.com) software which can run on a personal computer was used. From the scenes ROI (region of interest) extracted a subsection to cover only Akayatan lagoon. One scene was belong to 2012 was Landsat ETM+ SLC-off (Scan line Corrector off) which contain strip lines due to detector failure, this caused an estimated about 22% of any given scene is lost (Zhang et al, 2007: 5103–5122). Fortunately ROI was free of strip lines.

For the most effective comparison, all images captured at the same time of the year in order to eliminate any seasonal variations that my cause different spectral responses. Spectral variations may also occur owning to atmospheric factors. If one image was captured on a day when atmosphere was full of smog or smoke, the pixel values will be affected.

To overcome this problem we have used subtracting the pixel value of the darkest pixel over water from all pixel values in the same image Richards (1995), and Schowengerdt (1983). LST This technique is made easier by opening up two windows in ERMapper one with each dataset, and geolinking them so that, at all times, they show the same ground area. It is best to select area relatively uniform such as water body then LST calculated according to NASA (https://landsat.usgs.gov/landsat-8-l8-data-users-handbook-section-5) algorithm.

Table 3. Using Landsat data in this study.

2012	LE07_L1TP_175035_20120630_20161130_01_T1
2013	Not used due to cloud cover
2014	LC08_L1TP_175035_20140628_20170421_01_T1
2015	LC08_L1TP_175035_20150615_20170407_01_T1

3. Findings And Discussion

The Akyatan Lagoon, which is the southernmost end of the Çukurova Delta, is also one of the largest wetlands of the Mediterranean shore. According to SST data, the point where the Akyatan Lagoon meets the sea has the lowest water temperature. The water temperature decreases from the northwest to the southeast along the lagoon. The places where the lake level of the lagoon falls in the north have the highest temperature (Figure 3).

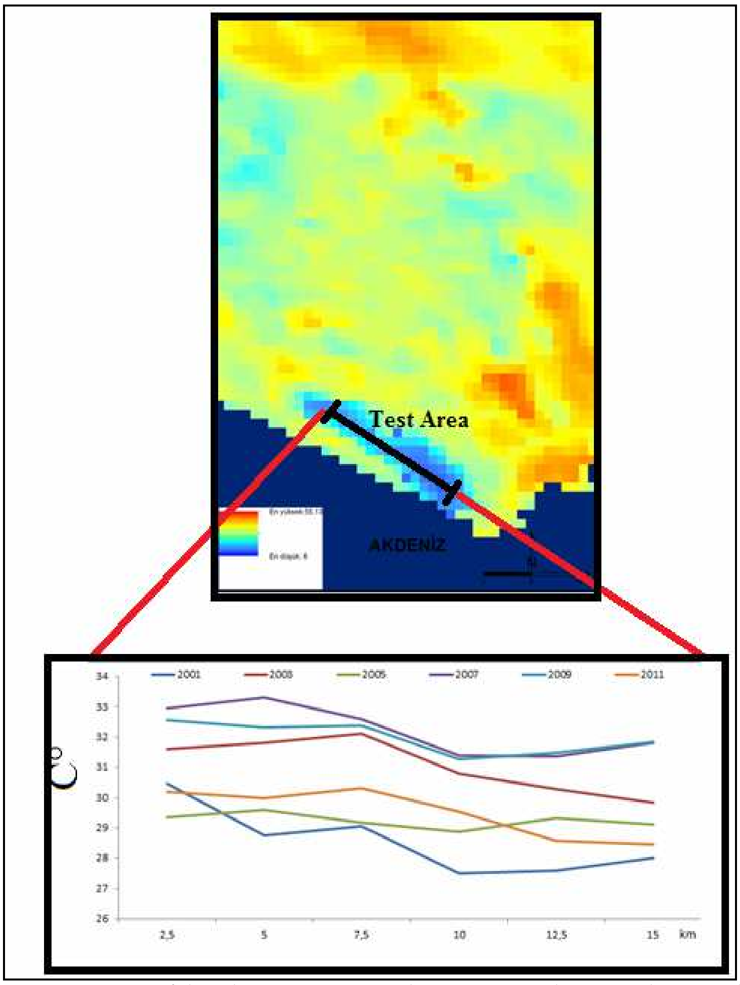


Figure 3. Temperature map of the Akyatan Lagoon and its vicinity and NW-SE directional SST values

The surface temperature of the lagoon has increased from June to August. The same increase is also valid at air temperatures. The increase in sea surface temperatures is lower than the air temperatures.

Since the shallow sections of the lagoon waters are rapidly affected by the temperature variation, it is seen that the standard deviations of maximum temperatures are higher. Deep lake water surfaces generally have minimum values. As a matter of fact, the standard deviation of minimum temperatures is relatively low. This indicates that the minimum temperatures do not vary much over the course of the year.

June 30, 2014 The minimum temperature for June is the highest. The minimum air temperature during this period is 23 ° C. The period when the lake surface temperature is the hottest, end of June and the beginning of July, also corresponds to the period when the maximum temperature reaches to 38 ° C. June 27 is the day when the maximum temperatures are highest in June. This extreme air temperature, which is seen on June 27, is also the hottest day of the year 2014. While the sea surface temperatures in the lagoon are 28.11 ° C in June, the air temperatures are 25.27 ° C. By July, water temperatures in the Lagoon increased by about 1.5 ° C and reached 29.59 ° C. There is also an increase in air temperatures during the same period. According to Karatas District General Directorate of Meteorology data, the air temperatures in July were measured as 27.88 ° C. When it comes to August, there is an increase of 0.5 ° C in sea surface temperatures, while a rise in air temperatures is about 1 ° C. In this period, sea surface temperatures are 30.1 ° C while air temperatures are 28.72 ° C. The sea surface temperatures of the lagoon are higher than the Karataş district air temperature, which is the closest meteorological station. (Table 3 and Figure 4).

Table 3. SST values for summer months and Karataş Meteorological Station air temperature.

Months	SST (°C)	Temperature (°C)
June	28,11	25,27
July	29,59	27,88
August	30,10	28,72
Std. Dvt.	1,03	1,80

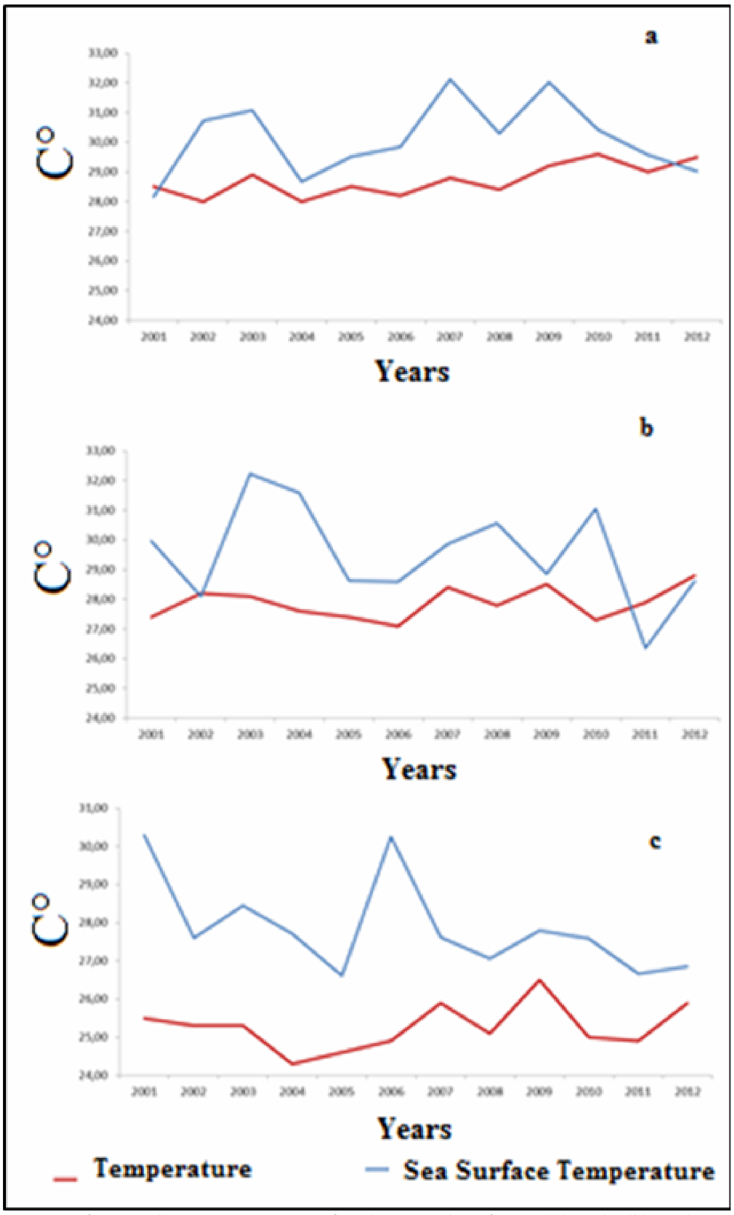


Figure 4. Average water surface and air temperatures for the months of June (a), July (b) and August (c) (2001-2012).

What is the relationship of the Akyatan Lagoon with the air temperatures? Statistically, which month of the summer is more strongly associated with the SST values of the lagoon? Regression analysis has been made to answer of these questions. Regression analyzes were conducted over a 15-year period covering the years 2001-2015. Regression analyzes were made for the summer months. Thus, the effect of air temperature in the summer months on the Akyatan Lagoon SST values was determined. The findings show that the relationship between SST values and summer temperatures is statistically significant. The strongest relationship is between August SST and air temperature (Table 4).

Table 4. Regression analysis results are showing the relationship between the June, July and August SST values with the air temperatures.

Year	June	July	Agust
2001	y = -0,5103x + 32,246 **R² = 0,64**	y = -0,1151x + 30,145 R² = 0,31	y = -0,49x + 30,313 **R² = 0,68**
2002	y = -0,308x + 28,998 R² = 0,48	y = -0,3617x + 28,686 **R² = 0,55**	y = -0,10x + 30,854 R² = 0,15
2003	y = -0,2866x + 29,138 R² = 0,29	y = -0,4514x + 29,17 **R² = 0,68**	y = -0,41x + 32,533 **R² = 0,74**
2004	y = -0,2909x + 33,178 R² = 0,47	y = -0,2526x + 32,394 R² = 0,30	y = -0,15x + 29,482 R² = 0,16
2005	y = 0,0214x + 26,64 R² = 0,00	y = 0,5091x + 25,958 R² = 0,66	y = -0,06x + 29,484 R² = 0,27
2006	y = -0,5557x + 32,527 R² = 0,39	y = -0,4286x + 28,219 R² = 0,12	y = -0,66x + 32,595 **R² = 0,70**
2007	y = -0,3191x + 28,635 R² = 0,33	y = -0,2589x + 27,696 R² = 0,15	y = -0,36x + 33,515 **R² = 0,67**
2008	y = -0,4031x + 28,239 **R² = 0,74**	y = -0,6766x + 33,611 R² = 0,52	y = -0,004x + 29,599 R² = 0,00
2009	y = -0,5926x + 30,117 **R² = 0,64**	y = -0,2634x + 28,765 **R² = 0,71**	y = -0,203x + 32,68 **R² = 0,53**
2010	y = -0,2131x + 28,166 R² = 0,38	y = -0,3774x + 32,479 **R² = 0,92**	y = -0,408x + 31,897 R² = 0,39
2011	y = -0,4286x + 28,219 R² = 0,12	y = -0,6606x + 32,595 **R² = 0,70**	y = -0,39x + 30,9 **R² = 0,81**
2012	y = -0,2589x + 27,696 R² = 0,15	y = -0,104x + 30,854 R² = 0,15	y = 0,22x + 27,823 **R² = 0,64**
2013	y = -0,2634x + 28,765 **R² = 0,71**	y = -0,4986x + 30,313 **R² = 0,68**	y = -0,33x + 32,673 **R² = 0,81**
2014	y = -0,3329x + 31,96 R² = 0,36	y = -0,4514x + 29,17 **R² = 0,68**	y = 0,228x + 24,83 **R² = 0,65**
2015	y = -0,1591x + 29,152 R² = 0,17	y = 0,0214x + 26,64 R² = 0,00	y = -0,229x + 33,289 R² = 0,30

The highest values of SST belonging to Akyatan Lagoon are reached in July and August. The July months of 2003, 2004, 2010 and 2014 have the hottest lagoon surface temperatures of the summer period. The highest sea surface temperatures recorded in 2002, 2005, 2007, 2009, 2011, 2012, 2013 and 2015 are in August. In general, Akyatan Lagoon reaches its highest temperatures of the year in August. Another noteworthy point is that the SST values of June in 2006 are higher than they are in July and August (Figure 5 and 6).

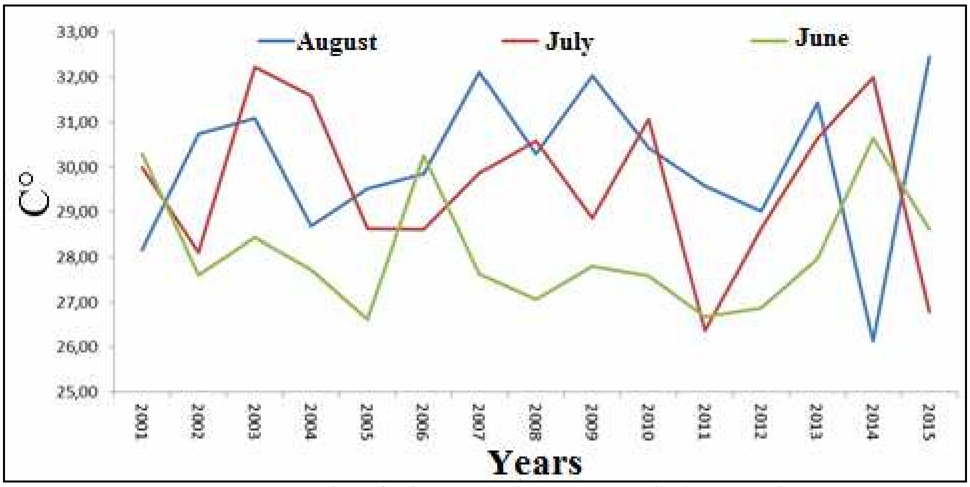


Figure 5. SST value of July, June and August months (2001-2015).

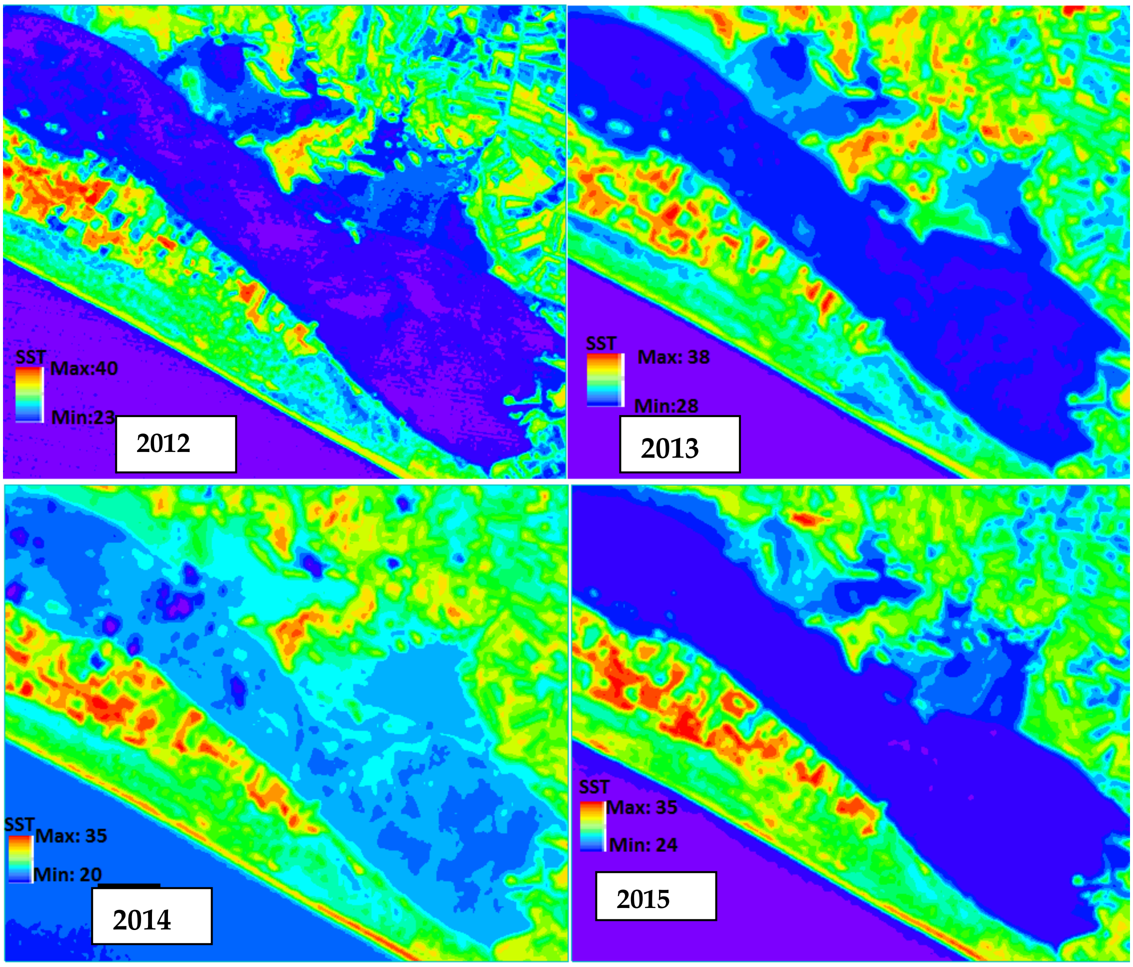


Figure 6. Landsat OLI SST maps of study area in august (2012-2015).

4. Conclusion

Akyatan Lagoon, which was selected as the zone of investigation in our study, is one of the sensitive places of Turkey in terms of climate change. Climate studies for such areas should be made more often. These studies should be carried out not by a single method but by developing various and new methods. This study, indeed, applied various methods while calculating the sea surface temperatures and examining its relationship with air temperatures for the Akyatan Lagoon which is one of the important wetlands of Turkey located on the Mediterranean. In this study, the variation of SST values of Akyatan Lagoon was investigated with the remote sensing methodology. For this purpose, 165 MODIS data were used. SST calculation was performed by mono-window method from these data. The data used covers the summer months of 15 years from 2001 to 2015.

The results show that SST values are important parameters in climate modelling. Accordingly, the SST values of Akyatan Lagoon reach the hottest period of the year at the end of July and at the beginning of August, similar to the weather temperatures. The study also investigates which summer months were statistically more strongly related to SST values. Accordingly, SST values of Akyatan Lagoon in July and August are in a significant relationship with the air temperatures of the same period. The relationship between the air temperatures of June and SST values is relatively statistically insignificant. Another result reached in this study is that the increase in SST values is relatively lower than the air temperatures.

According to another important result obtained in our study, the point where the Akyatan Lagoon meets to the sea at the south has lowest value of SST. The sea surface temperature decreases from the northwest to the southeast along the lagoon. At the same time, the north of the lagoon where the lake level falls is the place where the temperature is the highest.

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