

# Climatology and Variability of Sea Surface Temperature in the Region of Turkish Straits System, 1982-2021

Erdal TOKAT, Şükrü BEŞİKTEPE

Dokuz Eylul University, Institute of Marine Sciences & Technology, Inciralti, 35340 Izmir-Turkey

erdal.tokat@deu.edu.tr

## Abstract

This study focuses on spatiotemporal climatology and long-term variability of sea surface temperature (SST) in the region of Turkish Straits System for the period 1980-2021. For this purpose, daily SST data from the Advanced Very High-Resolution Radiometer (AVHRR) version 5.3 were used. From this dataset, 40 years of monthly, seasonal, and yearly mean SST time series and spatial fields and their descriptive statistics were calculated. In addition, daily air temperature and sea temperature data that obtained from the Turkish State Meteorological Service (TSMS) for the period 1980-2021 were analysed and compared with AVHRR SST data. Interannual and interdecadal variability of the SST was investigated by using linear trend analysis. The results of this study showed that all regions are experiencing a steady warming trend. In comparison to the north Aegean Sea ( $0.050\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ) and the western Black Sea ( $0.060\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ), the Sea of Marmara shows the largest positive SST annual mean trend ( $0.064\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ). The basin-averaged yearly mean SST anomalies exhibits a similar variability and pattern across all regions: From 1982 to 1998, negative anomalies dominant, from 1999 to 2006, anomalies generally fluctuate around normal, and from 2007 onward, positive anomalies predominant. The seasonal cycle is strong for all regions, with lower SST values in the winter months (January, February, and March) and higher SST values in the summer (July, August and September). From one decade to the next, the SST values in the seasonal cycle gradually increasing. According to the monthly mean climatic SST fields, due to the seasonal upwelling, the eastern Aegean Sea coast experiences lower SST values in the summer compared to all other regions. These results imply that the SST values for all regions have been consistently increasing over the 40-year study period.

## Acknowledgments

This publication has been produced benefiting from the 2236 Co-Funded Brain Circulation Scheme2 (CoCirculation2) of TÜBİTAK Project No: 121C366. The entire responsibility of the publication belongs to the owner of the publication. The financial support received from TÜBİTAK does not mean that the content of the publication is approved in a scientific sense by TÜBİTAK.

## Dataset Used In This Study

### AVHRR Pathfinder Version 5.3 SST

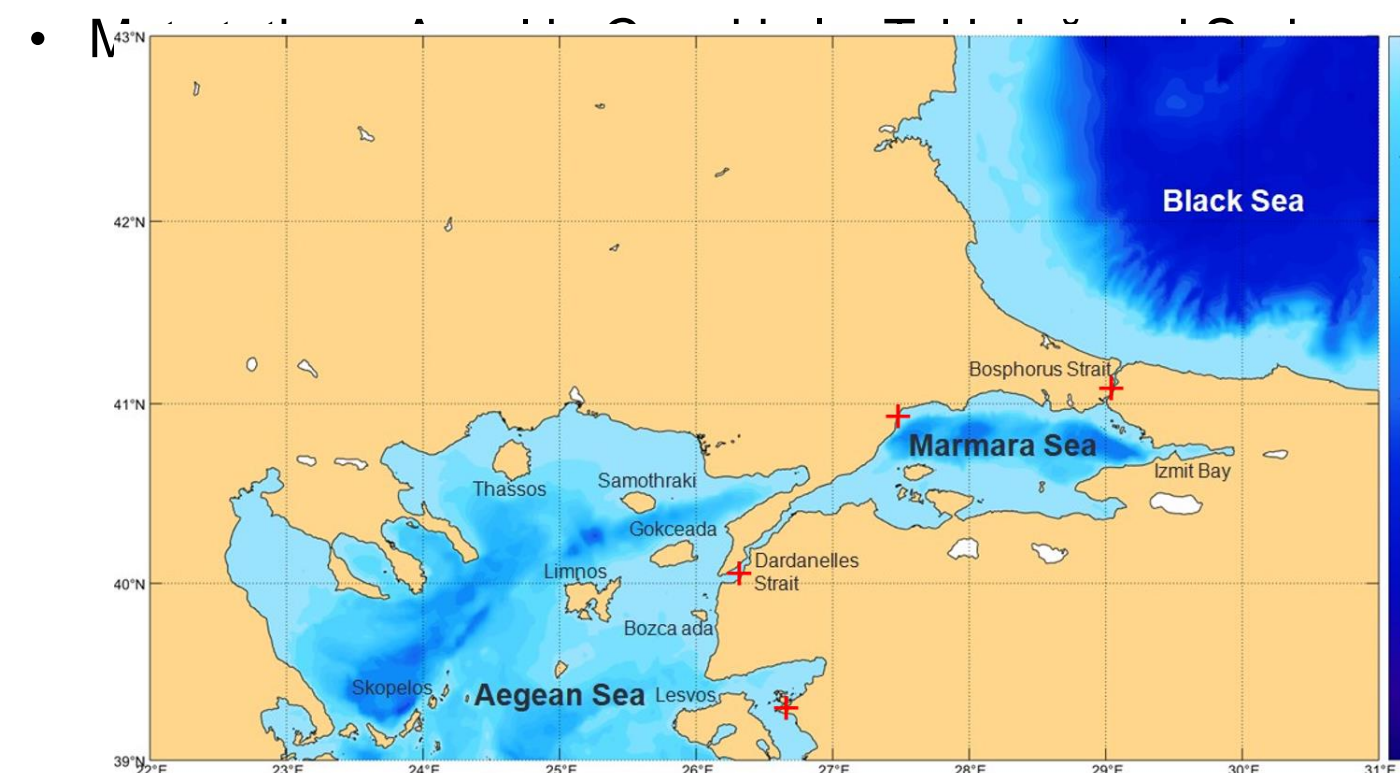
- For this study we used: Advanced Very High Resolution Radiometer (AVHRR) Pathfinder version 5.3, Sea Surface Temperature (SST) dataset. This dataset is the most recent version of the AVHRR Pathfinder data
- We extracted the data from: US National Oceanic and Atmospheric Administration data server, <https://data.nodc.noaa.gov>
- The dataset is daily and has four-kilometre resolution from 1982 to 2021
- To eliminate day-time solar heating effect, we only used night time SST data
- In our analyses, we only used data that have quality level 4 (acceptable) and quality level 5 (best)

### Air Temperature and Sea Temperature Data

- Daily air temperature and sea temperature data that collected from the Turkish State Meteorological Service (TSMS) for the period 1980-2021 were used and compared with the AVHRR SST data

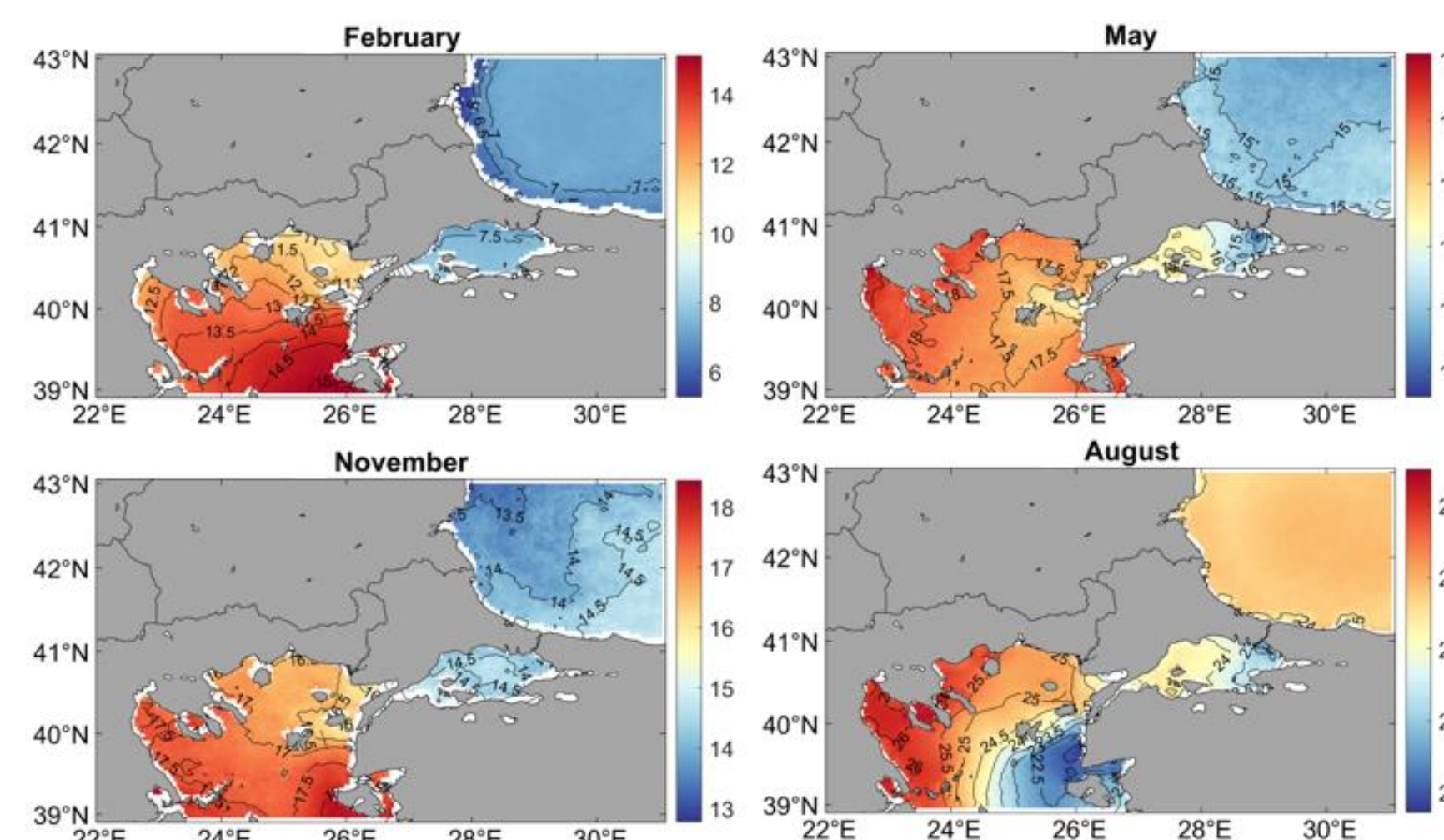
## Study Area

- The study area covers the western Black Sea, the Bosphorus Strait, the Sea of Marmara, the Dardanelles Strait and the Northern Aegean Sea



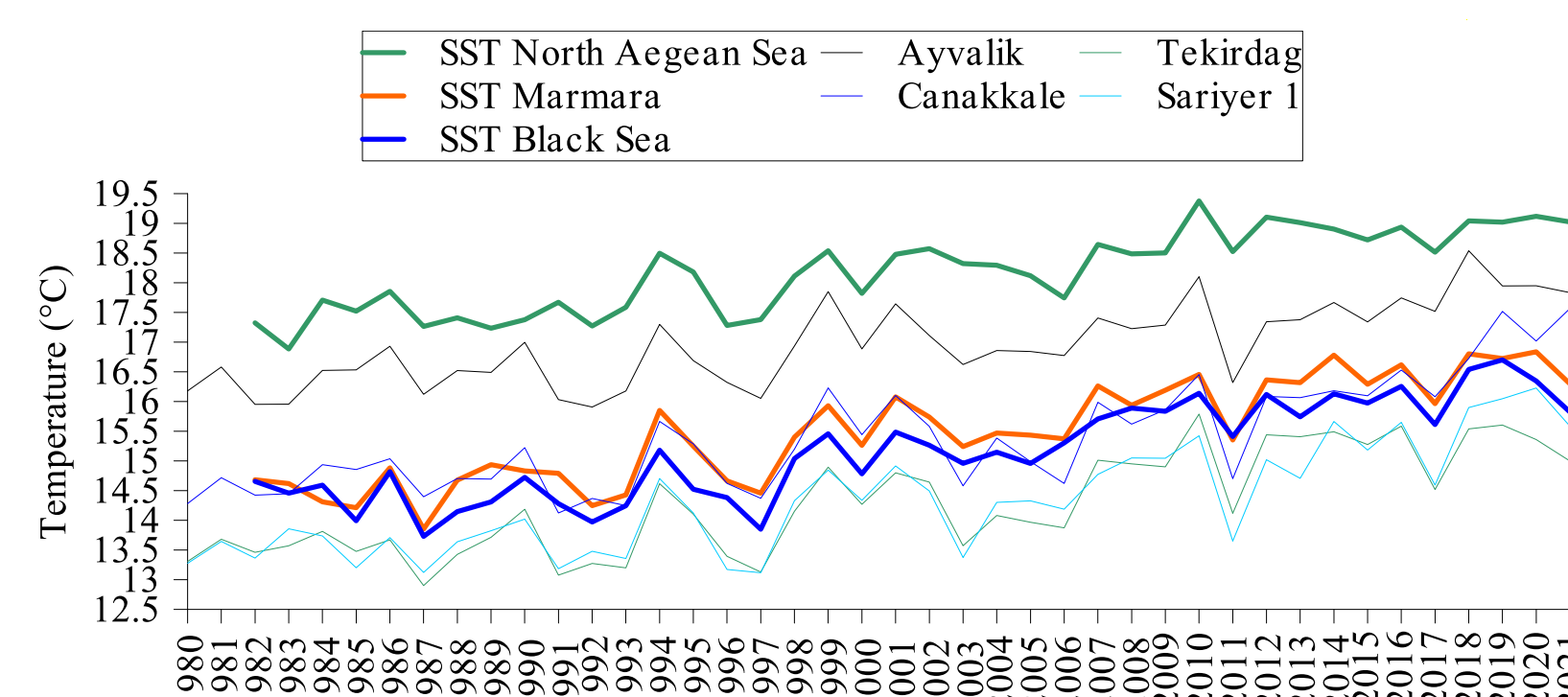
## Monthly Mean Climatology

- Monthly mean climatic SST fields showed that due to the seasonal upwelling, the eastern Aegean Sea coast experiences low SST values in the summer compared to all other regions
- A positive SST gradient is observed in Marmara from East to West during spring and summer



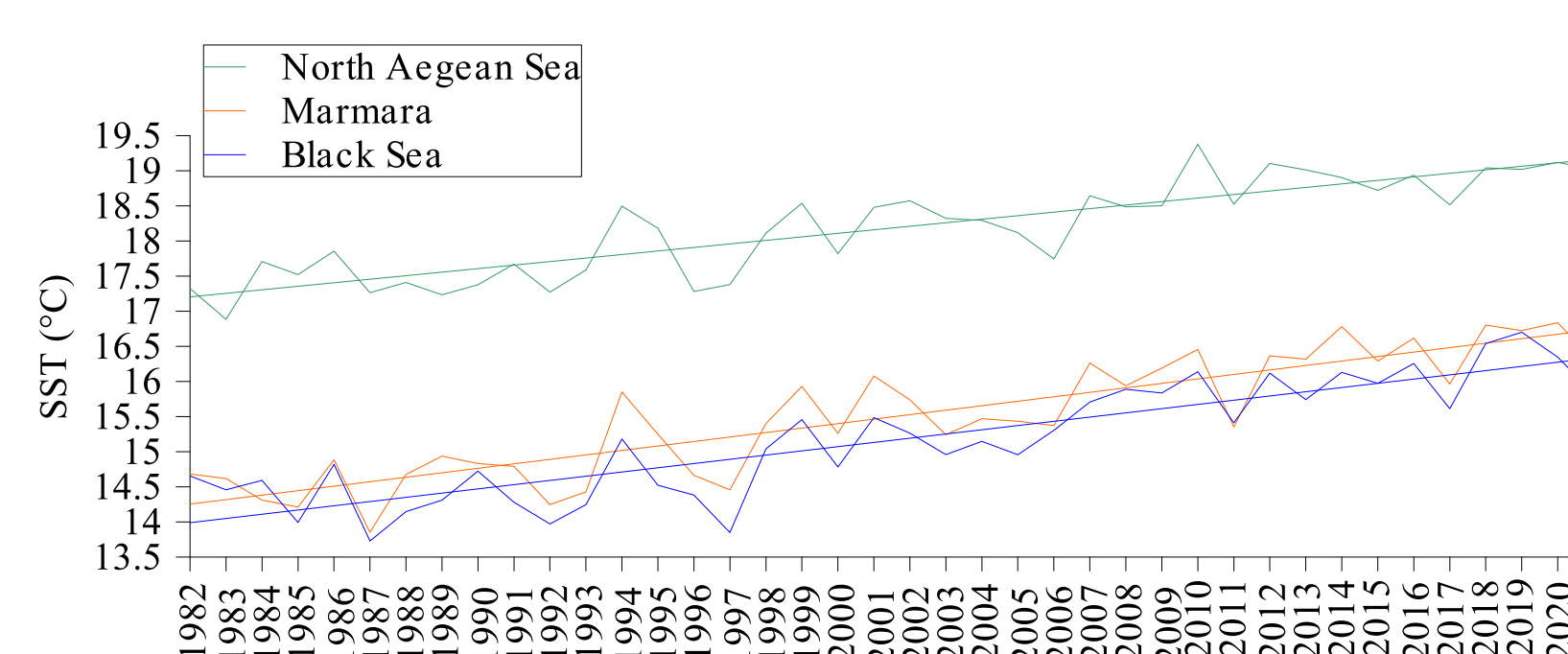
## Comparison of AVHRR SST with Air Temperature

- The results showed that the Basin averaged yearly mean AVHRR SST data showed good agreement with the air temperature data from the Met stations



## Yearly Mean Trend Analysis of AVHRR SST

- For the 40-year study period, the Sea of Marmara experiences the highest positive SST annual mean trend ( $0.064\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ) compared to the western Black Sea ( $0.060\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ) and the North Aegean Sea ( $0.050\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ )



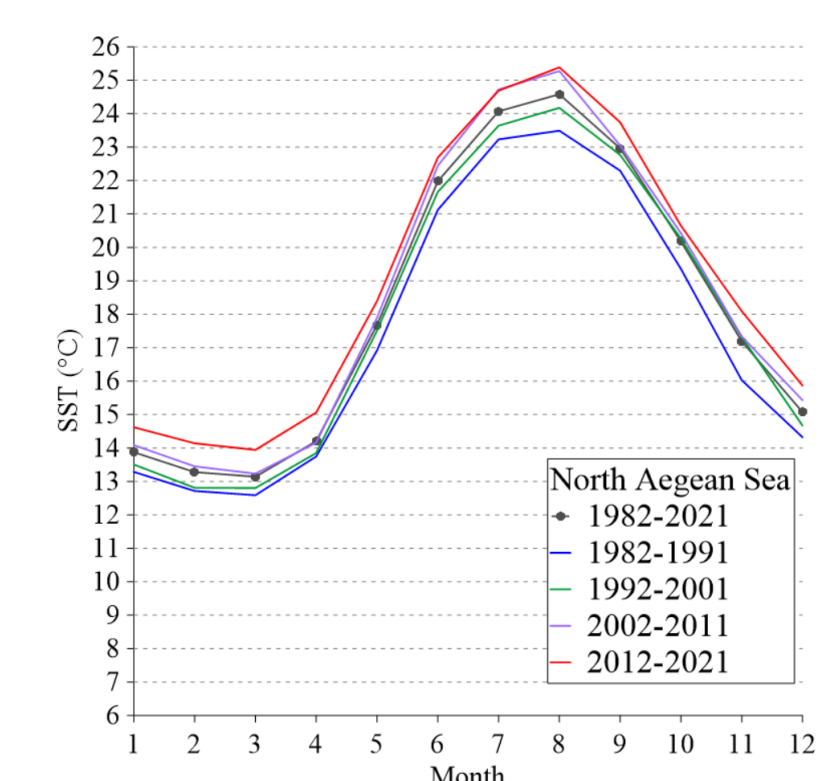
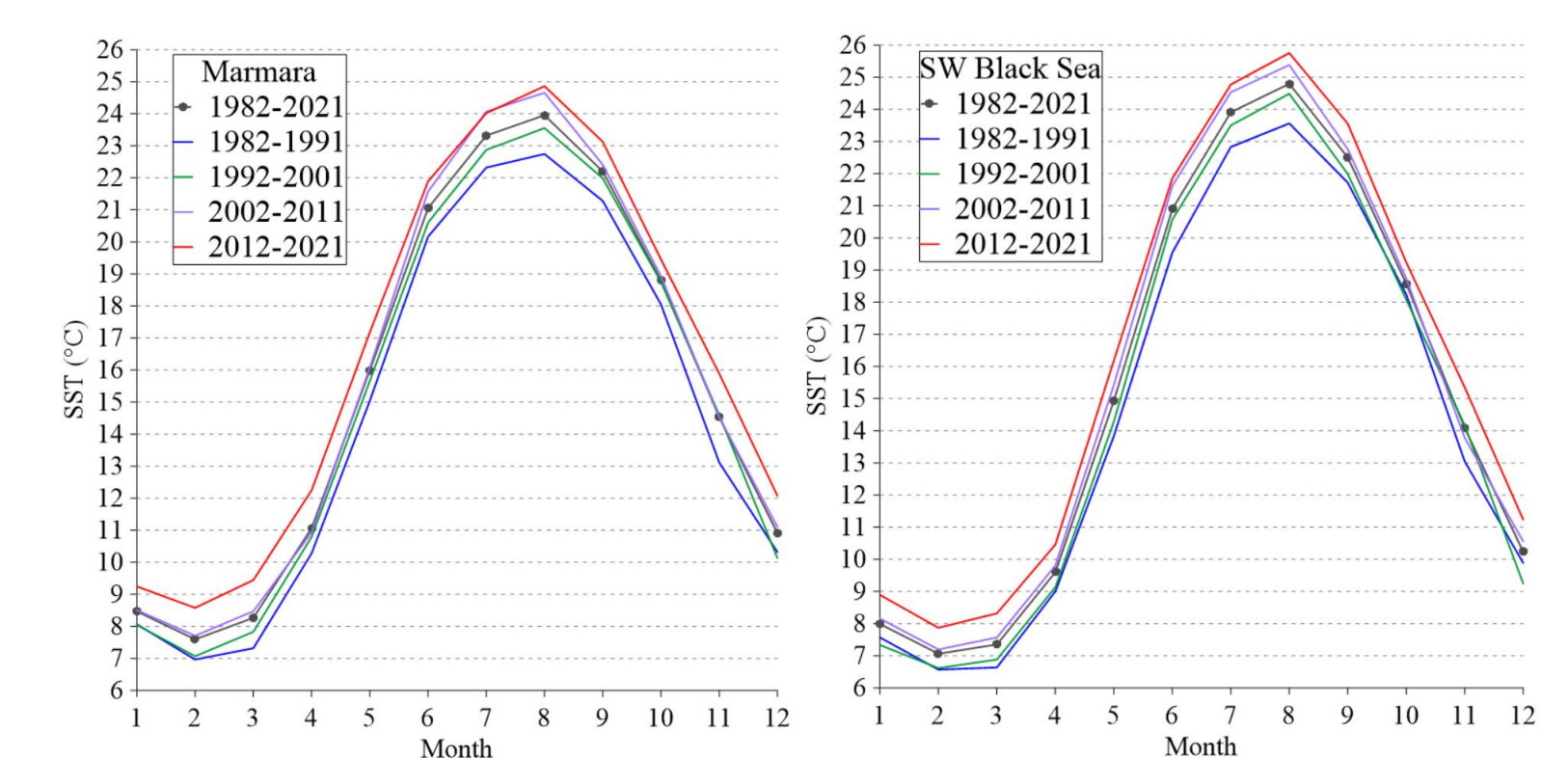
## Comparison of Yearly and Seasonal Trends

- The Sea of Marmara and the Western Black Sea region show always higher annual and seasonal trend values compared to the North Aegean Sea
- Pisano et al. found that a mean warming trend of  $0.041\text{ }^{\circ}\text{C}/\text{year}$  over the whole Mediterranean Sea using satellite-based data from 1982 to 2018. They reported mean warming trend for different basins:  $0.036\text{ }^{\circ}\text{C}/\text{year}$  in the Western Basin,  $0.048\text{ }^{\circ}\text{C}/\text{year}$  in the Levantine-Aegean Basin and  $0.027\text{ }^{\circ}\text{C}/\text{year}$  in the North-Eastern Atlantic Area (west of Gibraltar). [Pisano, A., Marullo, S., Artale, V., Falcini, F., Yang, C., Leonelli, F., Santoleri R Nardelli, B. (2020). New evidence of Mediterranean climate change and variability from Sea Surface Temperature observations. Remote Sensing, 12]

	Annual	Winter	Spring	Summer	Autumn
<b>Black Sea</b>	0.060	0.054	0.067	0.069	0.051
<b>Sea of Marmara</b>	0.064	0.060	0.061	0.064	0.060
<b>North Aegean Sea</b>	0.050	0.049	0.047	0.056	0.049

## Seasonal Cycle and Decadal Variations

- It is observed that for all regions the seasonal cycle is strong, with lower SST values in the winter months (January, February and March) and higher in the summer (July, August and September)
- The SST values in the seasonal cycle are gradually increasing from one decade to the next



## Conclusions

These findings imply a general warming of SST values across all regions during the 40-year study period

- Comparing the western Black Sea ( $0.060\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ) with the north Aegean Sea ( $0.050\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ ) over the 40-year study period, the Sea of Marmara has the strongest positive SST annual mean trend ( $0.064\text{ }^{\circ}\text{C}\cdot\text{yr}^{-1}$ )
- Comparing annual and seasonal trend values with the north Aegean Sea, the Sea of Marmara and the western Black Sea region always display higher values
- The SST values in the seasonal cycle are gradually increasing from one decade to the next for all regions
- Monthly mean climatic SST fields revealed that, due to seasonal upwelling, the eastern Aegean Sea coast had lower SST values in the summer than all other regions
- During the spring and summer, a positive SST gradient is recorded in Marmara from east to west