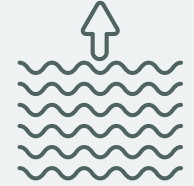


SPATIAL AND TEMPORAL ANALYSIS OF SEA SURFACE HEIGHT VARIATIONS IN THE MEDITERRANEAN SEA USING NEURAL GAS AND THEIR LINK TO BIOLOGICAL PARAMETERS

Master's thesis

Ivona Siber

University Department of Marine Studies, University of Split



Introduction

- The Bimodal Oscillating System (BiOS) of the Ionian Sea has a periodic oscillation of 12-13 years.
- BiOS is linked to the upper circulation of the North Ionian Gyre and deep-water formation.
- Influences surface air-sea interactions and biogeochemical properties of the sea.
- Affects Adriatic Sea biodiversity and water mass exchanges from the Levantine and Atlantic origins.
- Changes in surface circulation impact the vertical dynamics of the nutricline.
- Modulates convection intensity in the southern Adriatic, influencing thermohaline properties.

Objective

- Determining climatological averages of environmental parameters.
- Applying machine learning methods to spatio-temporal series of sea level data.
- Identifying key factors that influence changes in sea level and other biological parameters, including phosphate, nitrate, ammonia, and chlorophyll.
- Investigating regional differences in spatial and temporal patterns.
- Analyzing the relationship between sea level and biological parameters, as well as their fluctuations over time.

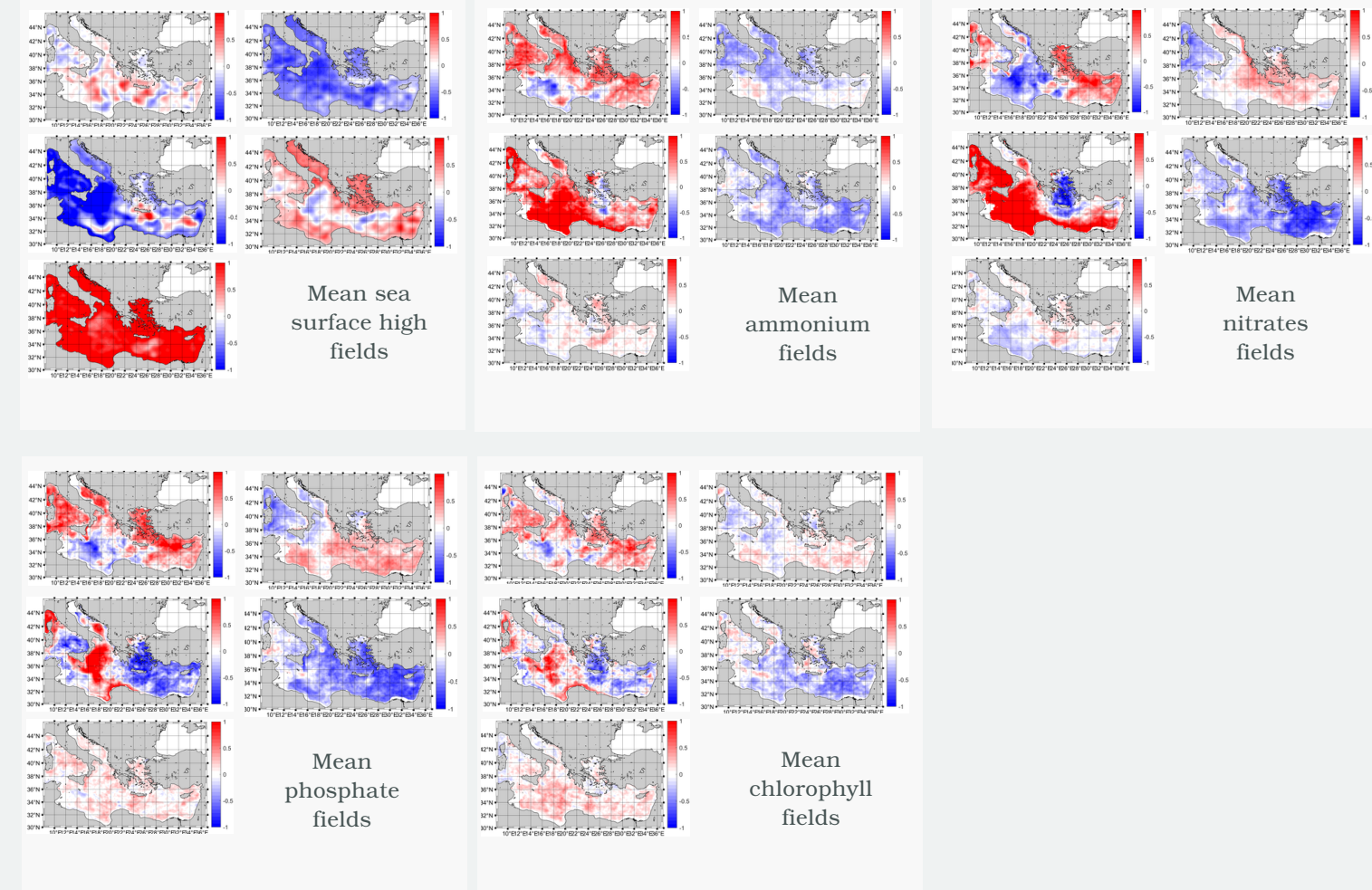
Methodology

- Data related to sea level, chlorophyll, phosphates, nitrates, and ammonia were sourced from the Copernicus Marine Service database.
- The processing and analysis of this data were conducted using MATLAB, where we employed neural networks to model and predict trends for each parameter. This methodology facilitated the efficient management of large datasets and enhanced the accuracy of our analysis of oceanographic variables.
- Neural Gas (NG): An unsupervised learning algorithm utilized in this study to identify patterns in sea level, nutrient concentrations, and chlorophyll levels.
- Hebbian Learning Rule: This principle was applied to improve the adaptation of neurons to incoming data inputs.

Results

- Significant spatial-temporal changes in environmental parameters of the Mediterranean Sea were observed over 30 years (1988.-2020.).
- Neural networks (Neural Gas algorithm) detected changes in sea level, nutrient concentrations (phosphates, nitrates, ammonia), and chlorophyll.
- The eastern Mediterranean showed the most pronounced sea level rise, linked to thermal expansion and local currents.
- Sea level displayed seasonal fluctuations, with lower levels in winter and peaks in summer.
- Nutrient concentrations were higher in coastal areas, particularly in the Adriatic, due to anthropogenic impacts like agriculture and river nutrient input.
- Neural network analysis highlighted spatial anomalies, with the Bimodal Oscillating System (BiOS) affecting circulation in the Ionian Sea.
- High nutrient levels in the northern Adriatic correlated with elevated biological activity.

Analysis - Best matching unit for sea high, ammonium, nitrates, phosphate and chlorophyll



Conclusion

- Significant seasonal and long-term fluctuations in environmental parameters observed, especially in the eastern Mediterranean.
- The sea level rise in the eastern Mediterranean, particularly in the Levantine and Aegean Seas, suggests a potential influence of thermal expansion and strengthening of local currents transporting warmer water from the Atlantic Ocean, while the western Mediterranean exhibited less variability.
- High biological activity in the northern Adriatic linked to eutrophication.
- Oligotrophic areas in the eastern Mediterranean have lower productivity due to low nutrient levels.
- Seasonal fluctuations in chlorophyll, with lowest levels in winter and highest in spring/summer.
- BiOS plays a key role in the Ionian Sea's current dynamics and impact on environmental parameters.