Seasonal forecast of the ocean heat content of the Baltic Sea

Summary

Under global warming, exacerbated weather and ocean conditions are expected. Climate warming has resulted in a steady increase of air temperature over the world ocean. Ocean heat content of the Baltic Sea has responded to the global warming trend. Main aim of the research is to prepare seasonal forecasts of the ocean heat content in the Baltic Sea using transformer neural network models. The data used for the study consists of model reanalysis and seasonal forecast data from the Copernicus Marine Service database, ERA5 climate reanalysis database and ECMWF seasonal forecasting system's SEAS5 data.

Research field:	Earth sciences
Supervisors:	Dr. Ilja Maljutenko Prof. Dr. Urmas Raudsepp
Availability:	This position is available.
Offered by:	School of Science Department of Marine Systems
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

Ocean heat content is a key ocean climate change indicator. It accounts for the energy absorbed and stored by oceans. Ocean Heat Content in the upper 2,000 m of the World Ocean has increased with the rate of 0.35 ± 0.08 W/m2 in the period 1955–2019, while during the last decade of 2010–2019 the warming rate was 0.70 ± 0.07 W/m2. The high variability in the local climate of the Baltic Sea region is attributed to the interplay between a temperate marine zone and a subarctic continental zone. Ocean heat content of the Baltic Sea has an increasing trend of 0.3±0.1 W/m2 superimposed with multi-year oscillations. The OHC increase in the Baltic Sea is smaller than the global OHC trend and in some other marginal seas. Trend values are low due to the shallowness of the Baltic Sea, which limits the accumulation of heat in the water. The highest ocean heat content anomaly was observed in 2020. During the last two years, the heat content anomaly has decreased from its peak value.

The importance of subseasonal and seasonal weather predictions is continuously increasing worldwide. Machine learning methods are rather extensive, and the topic is evolving very rapidly, which provides a ground for the development of machine learning models suitable for seasonal prediction of the mixed layer depth and cold intermediate layer volume in the seas. Combination of convolutional neural networks, transformer neural networks and long short-term memory models have been shown to be able to predict the characteristics of the Earth system components. Therefore, these methods will be used for the seasonal forecast of the ocean heat content of the Baltic Sea.

Responsibilities and (foreseen) tasks

- Processing of the Copernicus Marine Service model reanalysis data, ERA5 climate reanalysis database and ECMWF's fifth generation seasonal forecasting system's SEAS5 data. Calculation of spatially mean monthly mixed layer depth and cold intermediate layer volume for different subregions of the Baltic Sea. Analysis of the ERA5 climate reanalysis data for net heat flux, winds and sea surface temperature. Preparation and analysis of the sea ice volume data and river runoff data for the Baltic Sea.
- Implementation, testing and validation of the machine learning clustering algorithms for the categorization of the dynamical regions of the Baltic Sea based on the mixed layer depth and cold intermediate layer volume. Analysis of the climatology of ocean freshwater content of the Baltic Sea subregions and the statistical relationships with global and local atmospheric and oceanographic drivers. Analysis of the SEAS5 seasonal forecast data as drivers of the upper mixed layer and cold intermediate layer volume of the Baltic Sea.
- Selection, testing, validation and application of deep machine learning models for the seasonal prediction of the mixed layer depth in the Baltic Sea subregions. Evaluation of the predictions, improvement and finalisation of the models. Preoperation implementation of the machine learning model for the mixed layer depth and cold intermediate layer volume predictions in the Baltic Sea.

Applicants should fulfil the following requirements:

- a master’s degree in physics, oceanography, data analysis or mathematics
- a clear interest in the topic of the position
- excellent command of English
- strong and demonstrable analytical skills
- capacity to work both as an independent researcher and as part of an international team

(The following experience is beneficial:)

- Basic knowledge of numerical modelling
- Basic knowledge of machine learning
- Programming in Matlab or Phyton
- Some experience of working with big data
- Some experience in HPC

We offer:

- 4-year PhD position in one of the leading research departments in oceanography and related numerical modelling in Estonia
- The chance to do high-level research in cooperation with European research institutes in the framework of the Copernicus Marine Service
- Opportunities for conference visits, research stays and networking with leading universities and research centers in the fields of oceanography

About the research group

Research Group on Modelling and Remote Sensing of Marine Dynamics, Tallinn University of Technology, School of Science, Department of Marine Systems.

The research group is conducting oceanographic process research based on scientific analysis to find cause-and-effect relationships. Innovative (operational) methods for monitoring the marine environment and analyzing changes are being developed, incl. weather forecasting and climate models applied to supercomputers, to elucidate the mechanisms of atmospheric and ocean interactions; and machine learning based algorithms for satellite image processing and model data analysis. The research group has a long experience in developing applications / methods of operational oceanography, the outputs of which are information provided to the public and public authorities on water level variability, ice conditions and other parameters of marine physics. The research group is making a significant contribution to the pan-European Copernicus program. In scientific process research and applied research, the strength of the research team is the use of big data (mass processing) for climate studies and statistical analysis of the properties of the marine environment, as well as for finding dynamic relationships.

(Additional information)

For further information, please contact Prof. Urmas Raudsepp,urmas.raudsepp@taltech.ee

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