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Arctic sea ice dynamics forecasting through interpretable machine learning

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Machine Learning (ML) has become an increasingly popular tool to model the evolution of sea ice in the Arctic region. ML tools produce highly accurate and computationally efficient forecasts on specific tasks. Yet, they generally lack physical interpretability and do not support the understanding of system dynamics and interdependencies among target variables and driving factors.

Here, we present a 2-step framework to model Arctic sea ice dynamics with the aim of balancing high performance and accuracy typical of ML and result interpretability. We first use time series clustering to obtain homogeneous subregions of sea ice spatiotemporal variability. Then, we run an advanced feature selection algorithm, called Wrapper for Quasi Equally Informative Subset Selection (W-QEISS), to process the sea ice time series barycentric of each cluster. W-QEISS identifies neural predictors (i.e., extreme learning machines) of the future evolution of the sea ice based on past values and returns the most relevant set of input variables to describe such evolution.

Monthly output from the Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS) from 1978 to 2020 is used for the entire Arctic region. Sea ice thickness represents the target of our analysis, while sea ice concentration, snow depth, sea surface temperature and salinity are considered as candidate drivers.

Results show that autoregressive terms have a key role in the short term (with lag time 1 and 2 months) as well as the long term (i.e., in the previous year); salinity along the Siberian coast is frequently selected as a key driver, especially with a one-year lag; the effect of sea surface temperature is stronger in the clusters with thinner ice; snow depth is relevant only in the short term.

The proposed framework is an efficient support tool to better understand the physical process driving the evolution of sea ice in the Arctic region.