

Combining machine learning with data assimilation to improve the quality of phytoplankton forecasting in a shelf sea environment

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Abstract

We demonstrate that assimilating neural network (NN) predicted surface nitrate leads to a major improvement in phytoplankton short-range (1–5 day) dynamical model forecasts for the Northwest European Shelf (NWES) seas. We show that assimilation of only ocean-colour chlorophyll-a in the current Met Office NWES operational system can lead to excess surface nitrate concentrations in the post-spring bloom period and these are a major reason behind some known, fast-growing biases in NWES phytoplankton forecasts during late spring and summer. Assimilating observations of nitrate would potentially help to address this, but NWES nitrate data are typically not available in sufficient abundance to be assimilated effectively. We have therefore used a recently developed and validated NN model predicting surface nitrate concentrations from a range of observable variables and assimilated the NN-predicted nitrate within a research and development version of the Met Office's NWES operational forecasting system. As a result of nitrate assimilation, the phytoplankton five-day forecast skill improves by up to 30%. We show that, although much of this improvement can be achieved by using a weekly nitrate climatology predicted by the NN model, there is a clear advantage in using flow-dependent nitrate data. We discuss the impacts of this improvement on a range of additional eutrophication indicators, such as dissolved inorganic phosphorus and sea-bottom oxygen. We argue that it should be feasible to upgrade this approach to a fully hybrid machine-learning–data assimilation within the near-real-time NWES operational forecasting system.

Reference: Banerjee, D.S., Skákala, J. and Ford, D., 2026. Assimilation of machine-learning-predicted nitrate to improve the quality of phytoplankton forecasting in the shelf-sea environment. *Quarterly Journal of the Royal Meteorological Society*, p.e70156., <https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.70156>