Generative Models For Spatial-Based Bottom Hypoxia Forecasting In The Black Sea

Hypoxia phenomena are worldwide issues that affect the bottom of many coastal zones and pose severe threats to marine life. Accurately forecasting marine hypoxia is essential for the preservation of benthic life. As part of the ESA MultIple Threats on Ocean Health (MITHO) project, we explore neural network solutions for spatial-observation based forecasting. To compare against a classical and still overly relied upon regression method, we build a simple generative neural network model that produces a probabilistic forecast of oxygen on the northwestern continental shelf of the Black sea. Our results demonstrate the superiority of generative models and show that a deterministic method fails to accurately detect rare and sparse spatio-temporal events such as hypoxia. By estimating a full distribution of forecasts, we capture scenarios where these events occur that would be missed with a single-point estimate. We also demonstrate the efficiency of using a generative neural network, which is capable of generating multiple forecasts more efficiently than a numerical physical-biogeochemical sea model. The performances are assessed by comparing predicted oxygen levels and hypoxic events using various key metrics. With this work, we aim to further motivate the use of generative models as a versatile solution beyond our current problem. These models can be applied to various climate modeling challenges that require efficient and accurate forecasts to detect sparse spatio-temporal events.

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