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Integrated GIS/Machine-Learning Workflows for Modeling Spatiotemporal Variations in Potential Seagrass Habitats within a Changing Climate

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Coastal marine plant habitats are impacted by changes in ocean conditions and the resulting changes in plant populations can produce positive climate feedbacks which exasperate warming. (Waycott et al., 2009). One such example is seagrasses, marine plants that can sequester vast amounts of carbon. When compared to tropical terrestrial forests, seagrasses can store up to 100 times more CO_2 at a rate that is 12 times faster (Mcleod et al., 2011). Understanding the future of an important biologic carbon sink such as seagrass can shed some light into future carbon balance. Modeling the relationships between seagrass occurrence and ocean conditions, current and future, can aid in quantifying the impacts on future carbon balance. In this work, we use an integrated GIS and machine learning approach to build a data-driven model of seagrass presence-absence in a changing climate. We quantify the relationships between observed seagrass occurrence and ocean conditions. This relationship allows us to delineate patterns in current ocean conditions that promote favorable seagrass habitats. We pose this relationship as a binary classification problem and utilize Random Forest to establish a relationship for seagrass occurrence. This relationship is projected into the future under changing ocean conditions. We use deep-learning methods, recurrent neural networks, to forecast ocean conditions as the oceans get warmer and use these conditions in conjunction with the Random Forest model to predict the abundance of future seagrass habitats. We integrate multiple data sources including fine-scale seagrass data from MarineCadastre.gov and the recently available, globally extensive publicly available Ecological Marine Units (EMU) dataset. In addition, we use global ocean models from NOAA to calibrate our ocean forecasts. Our analysis includes a sensitivity study which investigates the vulnerability of seagrass to changes in specific ocean variables. We use the proposed model to provide an upper bound of the amount of carbon that can be stored in seagrasses as ocean conditions change. Finally, we use a Getis-Ord Gi* statistic within a space-time window to quantify the temporal changes in potential seagrass habitats.

References:

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