# A Metamodel-Based Analysis of the Sensitivity and Uncertainty of the Response of Chesapeake Bay Salinity and Circulation to Projected Climate Change

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**Abstract:** Numerical models are commonly used to project how salinity, circulation, and water quality in estuaries will respond to climate change. However, these models are often computationally expensive, and fully representing the wide range of uncertainty about future climate would require an infeasible number of model simulations. In this talk, we develop a computationally inexpensive statistical model, or metamodel, as a surrogate for a computationally expensive model of Chesapeake Bay. The metamodel is fit using a small number of numerical model simulations conducted at varying levels of three input factors: winter-spring river discharge, mean sea level rise, and tidal amplitude at the mouth of the bay. After evaluating the metamodel fit and its out-of-sample ability to predict the actual numerical model projections of four metrics (summer mean salinity, estuarine circulation, and vertical and horizontal salinity gradients), the metamodel is used to generate projections of future conditions in Chesapeake Bay by sampling from probability distributions of the three input factors. These simulations show that future stratification, mean salinity, and estuarine circulation are all likely to be higher than present-day conditions as a result of a nearly certain increase in mean sea level and a likely increase in winter-spring river discharge. However, after using the metamodel to conduct a sensitivity and uncertainty analysis, which identifies how uncertainty in the input factors translates to uncertainty in the outputs, we find that the projections of mean salinity, stratification, and exchange velocity are all highly sensitive to uncertainty about changes in the amplitudes of tides at the mouth of the bay. Although several observational studies have found that changes in tidal amplitudes are occurring in Chesapeake Bay and worldwide, nearly all studies that project future conditions have neglected the possibility of changes in tidal amplitude, which highlights the importance of conducting a rigorous sensitivity and uncertainty analysis. We also analyze the individual sensitivities identified by the metamodel, such as the response of mean salinity to a change in sea level or tidal amplitude, to compare with other idealized solutions and numerical models and to understand the physics behind the projected changes and identified sensitivities.