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Wind Error and Strategies for Mitigation in Modeling Coastal Dynamics

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The wind is very often either the primary driving force or an important modifier to the underlying circulation in coastal ocean waters. Commonly, operationally available wind products are coarse in spatial and/or temporal resolution relative to the geometric and dynamical scales of the coastal zone. These inadequacies not only produce error in the forecast wind fields but also in the predicted coastal currents that are subject to forcing by these winds. The study presented quantifies errors in both the wind field itself and in the coastal currents resulting from the application of these winds to ocean models. A triple-nested atmospheric model containing grids of 27km, 9km and 3km spatial resolution and an unstructured grid coastal ocean model resolving scales at 10-100 meters are applied to two diverse coastal regions for the purpose of quantifying the role of wind error in the prediction of coastal ocean dynamics. The two coastal regions considered in the analysis are the Turkish Strait System, a two-strait region of complex coastal geometry and topography, and the region outside of Chesapeake Bay, MD that also has convoluted coastlines subject to numerous frontal passages. At each of these locations varied spatial and temporal resolution of the winds are evaluated through direct comparison to meteorological station measurements and indirectly via comparisons of current observations to predicted coastal ocean currents. In both locations, increased spatial resolution generally results in improved wind and current predictions but enhanced temporal resolution is especially critical for capturing frontal events that bring sharp gradients of strong winds which maximally impact the modification of coastal current patterns. The analysis presented also demonstrates the importance of resolving the coastal outline for accuracy of the wind vectors and the nearby coastal ocean dynamics. Mitigation strategies for wind errors are considered including the modification of surface wind drag considering marine vs. terrestrial friction as well as canopy and directional effects in addition to localized increases in spatial resolution.