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High-resolution simulations of biophysical processes associated with the Florida Current circulation: implications for regional ecosystem dynamics and ocean observing system design

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While coastal upwelling events are typically related to strong wind-driven events along eastern ocean basin margins, the intense circulation associated with western boundary currents along shelf breaks has the potential to generate significant inputs of cool, nutrient-rich water into the coastal zone. Observational studies suggest that the presence of the Florida Current (FC) along the East Florida Shelf (EFS) (from ca. 83 W to 31 N) is linked to several upwelling mechanisms, such as FC frontal eddy (FCFE) passages and onshore bottom Ekman transport, modulated by periods of upwelling-favorable winds in the summer months. However, there is still uncertainty about the exact magnitude and duration of these different upwelling events, as well as their overall contributions to the net primary production and cross-shelf fluxes of nutrients, plankton, etc. The rapid translation speed (40 km/day), short recurrence period (4 to 7 days), and relatively small along and cross-shelf dimensions (ca. 80 km and 30 km, resp.) of the FCFE poses an aliasing problem for in-situ quasi-synoptic observations and prohibits the use of composite satellite ocean color imagery. Since the EFS region suffers from significant cloud contamination, daily images are only marginally useful to calibrate ecosystem model parameters or perform data assimilation.

Simulation results from a high-resolution, three-dimensional coastal ocean model (EFS-POM, developed within the Southeast Atlantic Coastal Ocean Observing System (SEACOOS) program), coupled to a 4-component (NPZD) ecosystem model, provide a new basis to estimate the frequency, intensity, duration, and property transport of

upwelling events along the EFS, as well as to identify their underlying mechanisms. While there exists more evolved ecosystem models (i.e., inclusive of several phytoplankton and zooplankton size classes and other nutrient sources, such as ammonium, silicate, etc), the NPZD model is well suited to study the lower trophic level response to rapid, episodic nutrient input at the shelf break (i.e., phytoplankton and zooplankton populations controlled by one dominant species and primary production supported mainly by nitrate), while minimizing parameterization complexity. Furthermore, the NPZD model is complex enough to determine the impact of environmental parameters and sinking rates on primary production estimates. For instance, in an outer shelf circulation regime where clear oceanic water mixes with more turbid coastal water, the spatial variance of the light attenuation coefficient may affect phytoplankton growth more significantly than other biological parameters.

Overall, the simulation results compare favorably with available in-situ and remotely-sensed observations and illustrate the dramatic spatial and temporal variability associated with episodic shelf-break upwelling events and primary production response along the EFS. As such, the coupled biophysical model significantly advances the ability to characterize the lower trophic level response to the FC mesoscale and seasonal circulation and represents a necessary step toward the implementation of more elaborate ecosystem models. Finally, the model provides a framework for future ecological forecasting efforts and ocean observing system design in the region.