Simulating the effect of the Tehuantepec Jet on the ecosystem in the northeast tropical Pacific

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Abstract

The global Navy Coastal Ocean Model (NCOM) is used as input to a medium complexity, nitrate based ecosystem model in the northeast Tropical Pacific. The model is validated using SeaWiFS and reproduces the observed patterns of chlorophyll reasonably well. Here, the model was used to study the impact on the ecosystem by eddies generated by intense wind jets at the Gulf of Tehuantepec. During the period of the wind jet nutrient rich water is brought to the surface by mixing and Ekman pumping. When the eddy forms, organic material is caught in the eddy and advected offshore, the eddy also maintains some primary productivity by upwelling around the edge.

Introduction

The Gulf of Tehuantepec is located about 15° N and 95° W. During winter the Tehuantepec jet (a strong northerly wind over the Gulf of Tehuantepec) develops when cold fronts travel down through the United States and create a pressure gradient between the Gulf of Mexico and the Pacific Ocean. As the jet comes through the mountain gap it is not in geostrophic equilibrium and comes directly from the north, further offshore it turns inertially to the right before it adjusts to geostrophic equilibrium (Chelton et al., 2000). These intense wind jets mix up cold, nutrient rich water below the axis of the jet and are responsible for the large plume of high chlorophyll concentration that can be seen in SeaWiFS satellite images (Fiedler, 2002). The winds can also generate large anticyclonic eddies that advect organic matter offshore.

Here, and advanced physical ocean model is used as input to a medium complexity ecosystem model in order to simulate the impact on the ecosystem by the wind jets and the subsequent eddy formation.

Methods

A hindcast of the Global NCOM was used as input to a seven-component nitrate based ecosystem model. The global NCOM assimilates MODAS temperature and salinity profiles and sea surface height, and has a realistic representation of both mesoscale variability and coastal processes. The ecosystem model includes two nutrients; nitrate and ammonium, two size classes of phytoplankton, two size classes of zooplankton, and detritus. The model also includes a parameterization of denitrification, because the water in the northeast tropical pacific is oxygen depleted below the thermocline. The event reported here is an eddy that was generated in November of 2001.

Results

The model simulation compares well with the SeaWiFS data, although it overestimates open ocean chlorophyll concentration and somewhat underestimates the concentration along the coast (Fig. 1).

When an eddy is generated, first a large amount of nitrate is upwelled to the south of the gulf of Tehuantepec. There is also an increased phytoplankton population in response to the increased nutrients (Fig. 2). Eventually, when the eddy starts to detach from the coast, it transports the nutrients and plankton, that have been wrapped around the eddy, offshore.

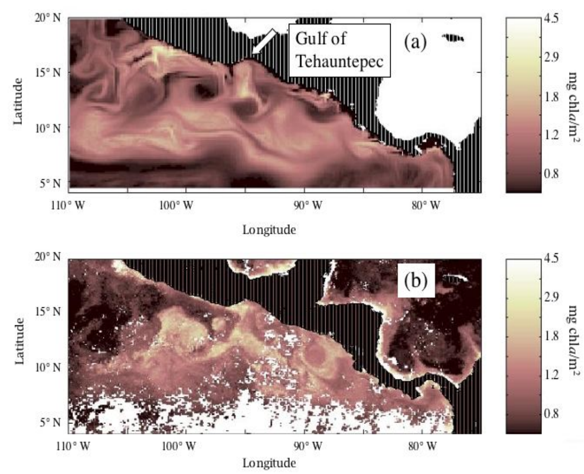

Figure 1. Comparison between model results (a) and SeaWiFS data (b) for the period October 25 to November 1 2001. The spatial means for both field have been subtracted. Note the patch of high chlorophyll concentration south of the Gulf of Tehuantepec (15° N, 95° W) and that the eddy that is located to the west of the Gulf of Tehuantepec has high chlorophyll concentration in the SeaWiFS data and low concentration in the model data.

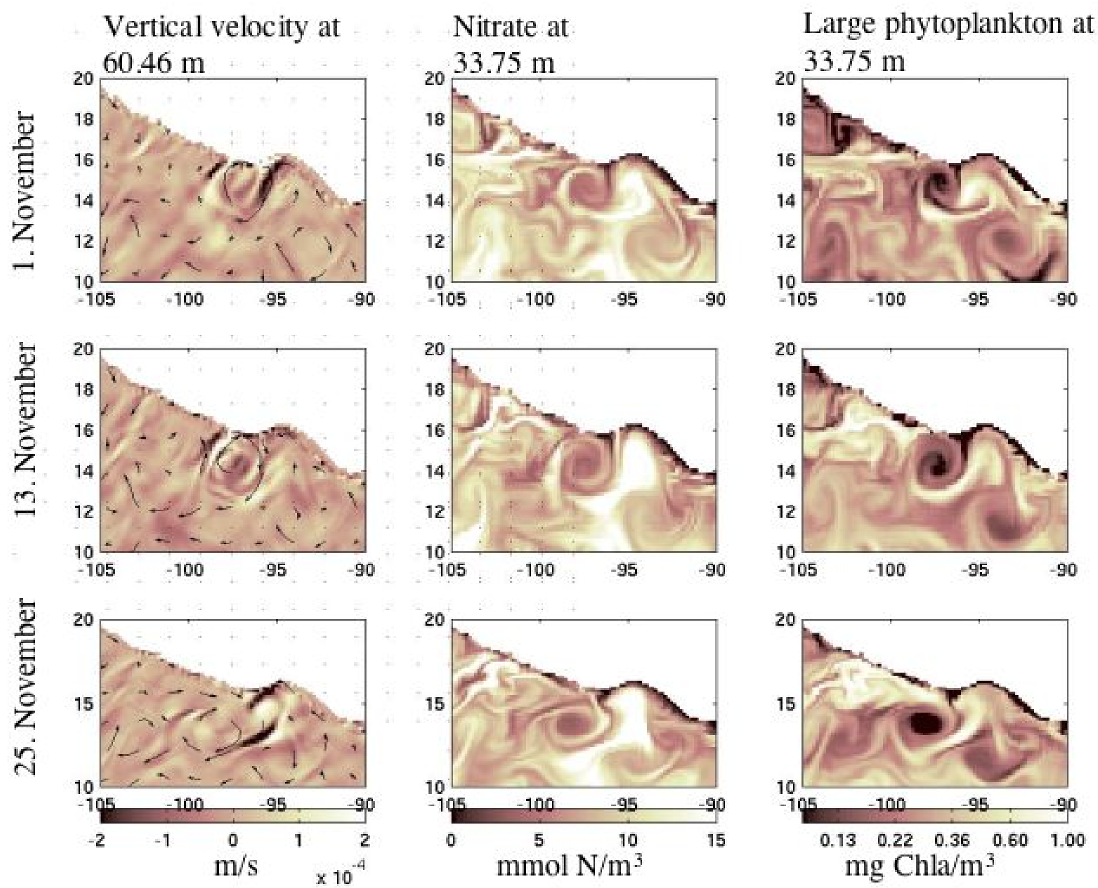

Figure 2. Generation and detachment from the coast of a eddy at the gulf of Tehuantepec. The first column displays horizontal velocity, represented by arrows, and the vertical velocity, represented by color. After the eddy is detached from the coast (25. November), it has patches of upward velocity along the edge. The second and third column show the nitrate and large phytoplankton corresponding to the eddy. Both components get caught in the eddy velocity field and are transported offshore.

Discussion

The model simulated the ecosystem response to eddy generation fairly realistically and it is clear that these eddies contribute to transporting a considerable amount of organic matter offshore. Although, as the eddy propagates further offshore, the simulated data show low concentration of chlorophyll at the center of the eddy, while the satellite data show the chlorophyll is more evenly distributed across the eddy. The reason for this discrepancy is unclear, but it may be that the model overestimates the vertical velocity at the center of the eddy or the lack of horizontal diffusivity in the ecosystem model prevents the ecosystem components from spreading across the eddy.

References

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Acknowledgement

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