2.4 VARIABILITY IN SHELF TRANSPORTS IN THE GULF OF ALASKA, PART IV: RESPONSE TO MESOSCALE FORCING USING THE REGIONAL OCEAN MODELING SYSTEM (ROMS)

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The coastal Gulf of Alaska (CGOA) is characterized by steep coastal mountains which exert strong orographic effects on the local winds. Coastal ocean currents are vigorous, and driven by alongshore winds and runoff. Therefore, trapping of the alongshore winds by the coastal orography is believed to dramatically impact the coastal ocean currents. To explore these mesoscale phenomena, we are utilizing output from a set of nested atmospheric models in conjunction with a regional, primitive equation coastal ocean model of the CGOA. The ocean model used is the Regional Ocean Modeling System (ROMS), with a mean resolution of 12 km. Here we compare the coastal ocean response to the application of two different wind products: 1) low-resolution (2-degree) daily atmospheric hindcasts from NCEP; 2) high-resolution (15-45 km) daily hindcasts from a multiply-nested implementation of MM5, where the NCEP hindcasts serve as a lateral boundary condition on the largest MM5 grid.

Figure 1 illustrates the different wind stress fields (MM5 vs. NCEP) and sea surface height (SSH, from the MM5 run) for January 31, 2001. (In this figure, x- and y-axes are labeled by ocean model gridpoint, and maximum vector lengths represent ~0.2 N/m^2). Note the enhanced wind stress along the CGOA. Such alongshore stress will lead to the generation of coastal trapped waves in the ocean; in this case, they should result in a higher coastal sea level. The ocean response will not be purely local, and higher SSH will result from enhanced alongshore winds to the southeast. Figure 2 compares time series of easterly stress at a coastal location east of Kodiak Island for both NCEP and MM5 products in 2001, and illustrates the SSH response at that same location (marked by "*" in Figure 1). The upper panel illustrates the easterly stress, the middle panel the SSH response, and the lower panel the differences between the two runs (MM5 result minus NCEP result). Highest wind stress values, and largest differences between NCEP and MM5 wind products, are evident in the winter months. The SSH responds to enhanced wind stress "events" on daily time scales throughout the year, but exhibits consistently higher SSH only in the winter months when the winds are strongest. Response to daily events appears lagged in time, reflecting the propagation of coastal trapped waves generated to the southeast.

We have also found that the MM5 product leads to 50% or greater enhancement of depth-integrated coastal currents during strong wintertime coastal wind events; typical values are 20 cm s^{-1} with NCEP to greater than 30 cm s^{-1} with MM5. This increased flow is accompanied by the enhanced SSH noted in Figure 2 (as much as 20 cm in some areas, e.g., Cook Inlet). These are major changes in the coastal circulation, and a comparison with moored current meter records demonstrate enhanced hindcast skill using the MM5 product. Together, these findings suggest that the use of enhanced wind products, which include local orographic effects, offer substantial improvements to coastal ocean simulations in regions with steep coastal mountains.

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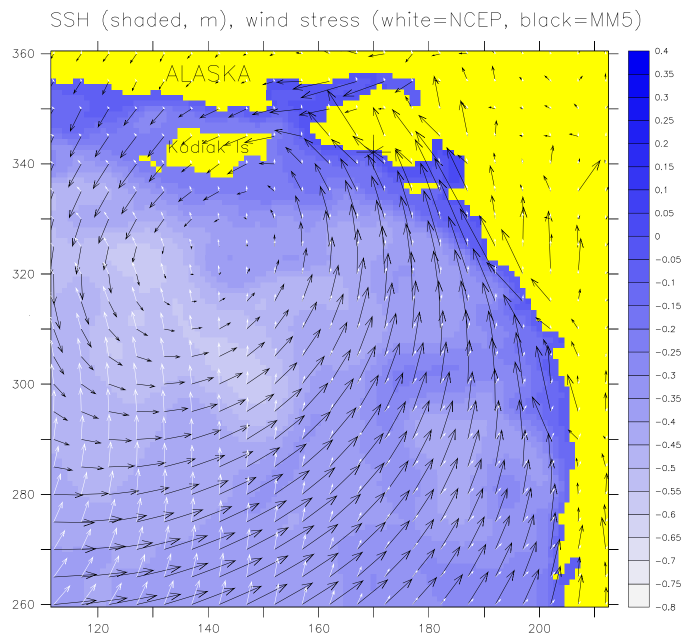

Figure 1. Wind stress fields and SSH for January 31, 2001. NCEP wind stress vectors are shown in white, MM5 winds in red. Maximum vector length is approximately 0.2 N/m^2. SSH field (shaded, in m) is from ocean model run with MM5 winds. Location of time series shown in Figure 2 is marked with "*".

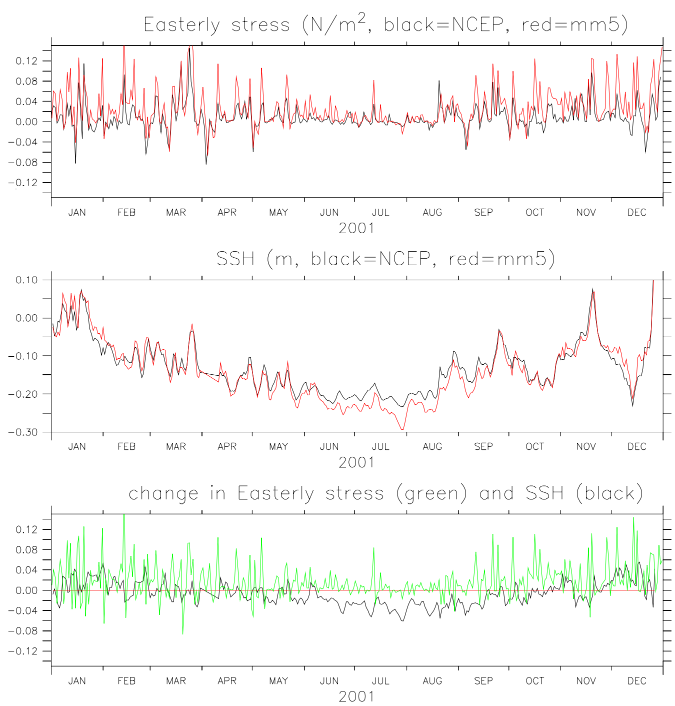

Figure 2. Time series of easterly wind stress forcing and response at the location noted in Figure 1. Upper panel: easterly stress (N/m^2) for NCEP (black line) and MM5 (red line). Middle panel: SSH (m) response to NCEP (black line) and MM5 (red line) forcing. Lower panel: differences between the two runs (MM5 result minus NCEP result), with easterly wind stress (N/m^2, green line) and SSH response (m, black line). Red line at zero for reference.