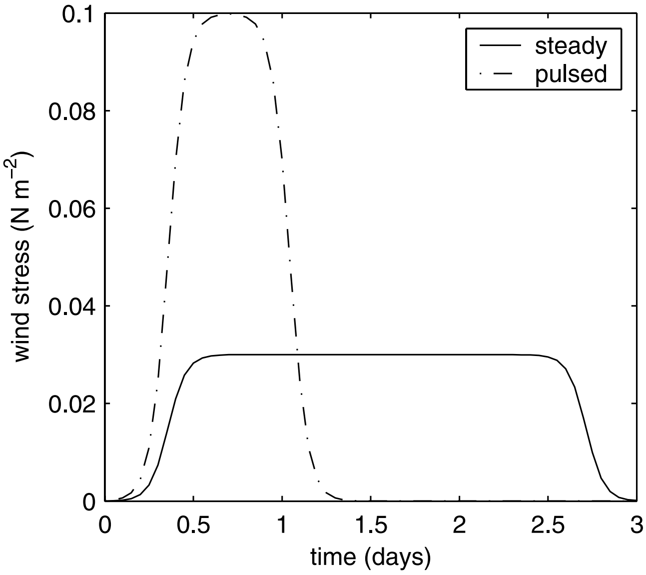

Figure 2. Wind forcing for the sustained and pulsed wind events used in the single boundary layer response experiments.

bottom boundary layer can be calculated as was done for the case of a full bottom boundary layer interacting with the interior. The only difference here is that an attempt is made to match the shape function variable G smoothly into the profile determined for the surface boundary layer rather than the interior. Vertical mixing in the surface boundary layer is calculated first using the interior estimates for vertical mixing at the boundary layer depth. Then the bottom boundary layer depth is calculated and final vertical mixing coefficients over the water column depth are determined. It is possible for the slope in viscosity coefficient predicted by the surface boundary layer scheme at h_{bbl} to be positive. In this case the slopes of the mixing coefficients at h_{bbl} are set to zero to avoid the possibility of negative estimates within the bottom boundary layer. We consider this approach an adequate method of superimposing the effect of the turbulence generated at the two boundaries.

3. Model Setup

[33] The two vertical mixing schemes are compared as implemented in ROMS [*Haidvogel et al.*, 2000], a hydrostatic, primitive equation, generalized sigma coordinate model. For these experiments a single prognostic equation for potential density is used rather than separate equations for temperature and salinity. A third-order upwind scheme is used for horizontal advection and a fourth-ordered-centered scheme is used for vertical advection of all fields. A small amount of "horizontal" Laplacian-diffusion (along sigma levels) is also utilized (2.0 m^2 s^{-1}) for momentum and potential density. Three model setups are explored which emphasize different aspects of vertical mixing in the coastal ocean.

3.1. Case 1: Surface Boundary Layer Response to a Wind Stress

[34] The first setup examines the surface boundary layer response to a wind deepening event (at midlatitude). Model simulations are performed in a one-dimensional, 20 m deep domain with uniform 0.5 m vertical resolution. A moderate wind stress is applied in the y direction which is spun up over the first inertial period of the simulation. It is sustained for 1.6 days then ramped back down to zero by day 3 as displayed in Figure 2. A wind "pulse" experiment is also briefly examined (Figure 2). It has the same integrated wind stress over the three day period but is applied as a forcing 3.33 times as strong for one-third the duration. The bottom stress is set to zero in these simulations to isolate the surface boundary layer response as if in an infinitely deep ocean.

[35] The stratification on a continental shelf can vary from completely well mixed because of convective cooling or during strong wind events to very highly stratified because of surface heating and/or riverine input of fresh water. Here we want to compare the surface boundary layer response over a broad range of stratification. The water column is initially at rest with no stratification in the top 7.5 m and uniform stratification beneath this depth. Four initializations are considered in which the interior stratification is varied. The highest stratification, N^2 = 0.0098 s^{-2} (or 1 kg/m^3/m) we label N_o. The lower three are $N_o/10$, $N_o/100$ and $N_o/500$.

3.2. Case 2: Surface/Bottom Boundary Layer Interaction

[36] The second setting again uses a one-dimensional, wind-forced, stratified water column. Here the net transport of mass over the water column in the across-wind direction is forced to equal zero. This specification drives the development of bottom currents opposing the surface Ekman flux. In shallow enough water a bottom boundary layer forms which may interact with the surface wind forced one. In many ways this setup is analogous to the circulation that develops in two-dimensional upwelling in which an alongshore wind drives offshore transport which is balanced by onshore flow in a bottom boundary layer.

[37] A moderate wind stress is spun up over the first inertial period as in the case 1 experiment, but here it is sustained until the end of the experiment at day 6. Bottom stress is calculated following a quadratic drag law as,

$$\left(\tau_b^x, \tau_b^y\right) = \rho_o C_d\left(\sqrt{u_b^2 + v_b^2}\right)(u_b, v_b) \tag{27}$$

where τ_b denotes bottom stress, u_b and v_b are model velocities components at the bottom grid point and C_d is a drag coefficient specified as,

$$C_d = \kappa^2\left(\ln\frac{z_b}{z_o}\right)^{-2} \tag{28}$$

where κ is vonKarman's constant, z_b is the distance the bottom u or v grid point is from the seafloor and z_o is a roughness height specified as 1 cm.

[38] The density field is initialized again with a 7.5 m thick well-mixed surface layer above a uniformly stratified interior. Initial stratification of the pycnocline is varied from 0.02 kg/m^3/m to 1 kg/m^3/m ($N_o/50$, $N_o/10$ and N_o) in sensitivity studies. To vary the degree of interaction