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Supplementary Materials for

Atmospheric and Offshore Forcing of Temperature Variability at the Shelf Break

Observations from the OOI Pioneer Array

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Heat Balance

Neglecting horizontal diffusion, the heat balance for the depth-averaged temperature can be written as

$$\frac{1}{H} \int_{-h}^{\eta} \left(\frac{\partial T}{\partial t} \right) dz + \frac{1}{H} \left(\int_{-h}^{\eta} (\mathbf{u} \cdot \nabla T) dz + \int_{-h}^{\eta} w \frac{\partial T}{\partial z} dz \right) = \frac{Q}{\rho C_p H} \quad (1)$$

where T is 4-dimensional temperature, \mathbf{u} is the horizontal velocity vector, w is the vertical velocity, $H = h + \eta$ is the total local water depth (while h is bottom depth and η is surface elevation), Q is the net air-sea heat flux, ρ is water density and C_p is the specific heat capacity.

Equation (1) can be expressed as

$$\bar{T}_{rate} = Q_{air} + Q_{hadv} + Q_{vadv} \quad (2)$$

and then temporal integration of (2) gives

$$d\bar{T} = Q_{airT} + Q_{hadvT} + Q_{vadvT} \quad (3)$$

or

$$T = T_0 + Q_{airT} + Q_{hadvT} + Q_{vadvT} \quad (4)$$

where \bar{T} is the depth-averaged temperature, $Q_{airT} = \int_0^t Q_{air} dt' = \int_0^t \frac{Q}{\rho C_p H} dt'$,

$$Q_{hadvT} = \int_0^t Q_{hadv} dt' = -\frac{1}{H} \int_0^t \int_{-h}^{\eta} (\mathbf{u} \cdot \nabla T) dz dt', \text{ and } Q_{vadvT} = \int_0^t Q_{vadv} dt' = -\frac{1}{H} \int_0^t \int_{-h}^{\eta} w \frac{\partial T}{\partial z} dz dt'$$

For the proof of concept, here we only estimate the depth-averaged temperature, and the first two terms on the right hand side of (4), which is the initial depth-averaged temperature and cumulative air-sea heat flux.

For the inshore site, the heat flux is measured at the inshore surface mooring, and the depth-averaged temperature is derived by combining the profiling temperature at the upstream inshore mooring and sea surface temperature at the inshore surface mooring. Similarly, for the central site, the heat flux is taken from the central surface mooring, and the depth-averaged temperature is a combination of profiling temperature at the central offshore mooring and sea surface temperature at the central surface mooring. The bottom 20 m of the water column at the profiling mooring is assumed to be equal to the lowest valid measurement from the wired profiler. Each term is calculated using hourly data before a 48 hr low pass filter was applied.