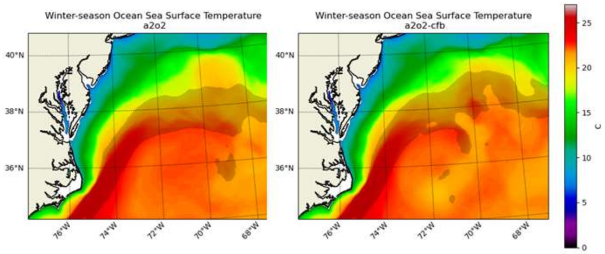
Upper Ocean Response to Coupling Currents to Wind Stress over the Gulf Stream

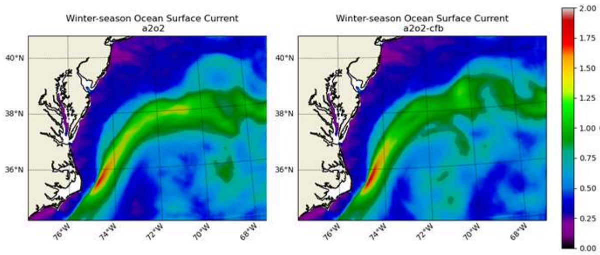
Jackie C. May[1] and Mark A. Bourassa[2,3]

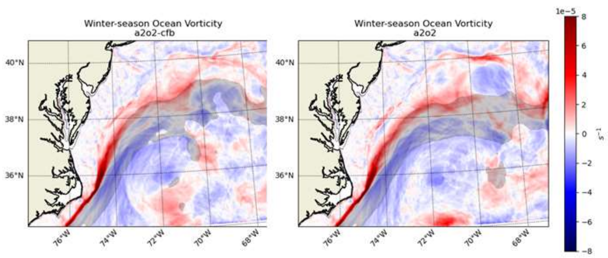
1. Naval Research Laboratory, Code 7321, Stennis Space Center, MS
2. Department of Earth, Ocean and Atmospheric Science, Florida State University, Tallahassee, FL
3. Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL

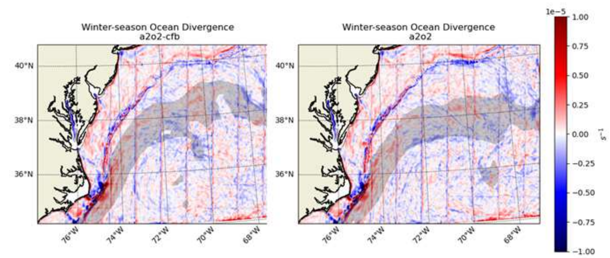
The upper ocean responses to coupling surface currents to wind stress are examined with high resolution coupled atmosphere-ocean models, i.e. 2km atmosphere and 2km ocean, over the Gulf Stream during a winter season. Winter-time seasonal means are shown with the ocean surface current velocity greater than 0.8 m s^{-1} shaded in grey.

The ocean surface patterns with respect to the Gulf Stream extension location are found regardless of the current feedback, indicating a thermodynamic dependence. However, including the current feedback acts to enhance the surface patterns.







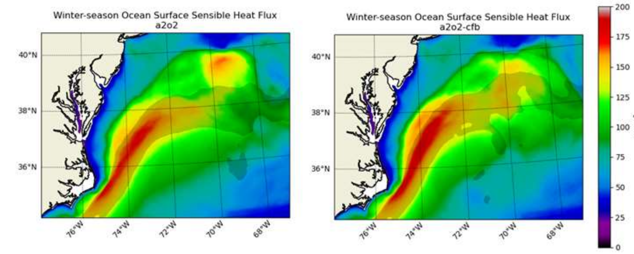


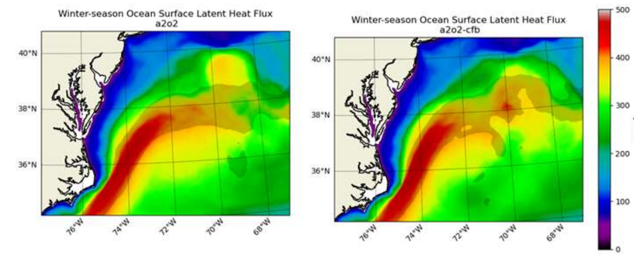
The submesoscale vertical heat flux (SVHF) is used to determine the small-scale vertical heat transport within the upper ocean. The SVHF impacts the heat transport between the mixed layer and deep ocean, as well as between the surface and mixed layer. Heat and variability within the ocean mixed layer is also influenced by surface forcing, such as from turbulent heat fluxes (i.e. sensible and latent heat flux), solar radiation, and longwave radiation.

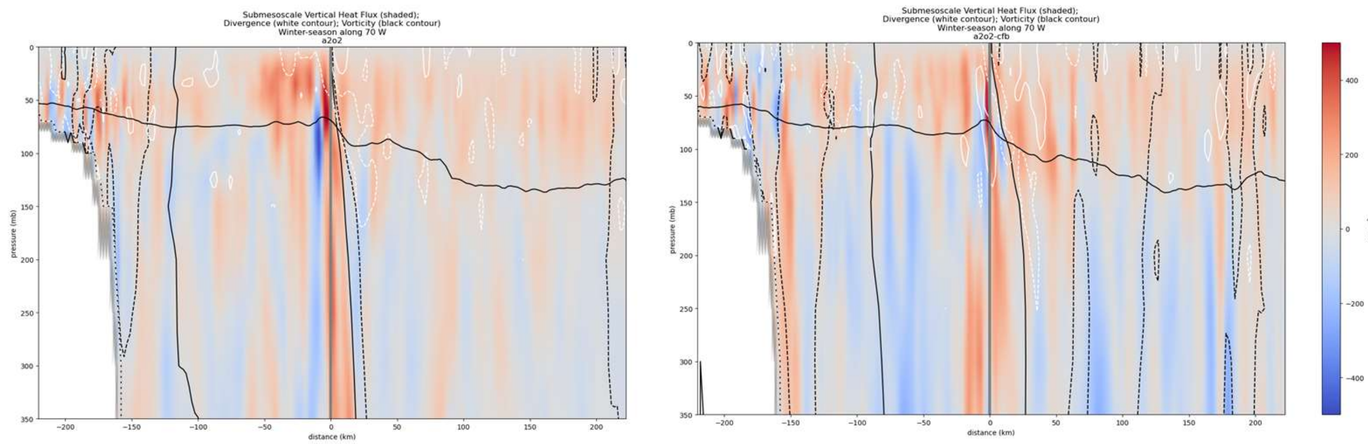
Regardless of the current feedback, the SVHF is found to have an upward transport (from cold to warm) within the mixed layer, in agreement with previous studies. Including the current feedback leads to enhanced SVHF throughout the upper ocean. This enhancement is not restricted to the mixed layer. However, there is a general notable change in direction of the SVHF at the mixed layer. Additionally, the SVHF magnitudes are comparable to those from surface latent and sensible heat fluxes.

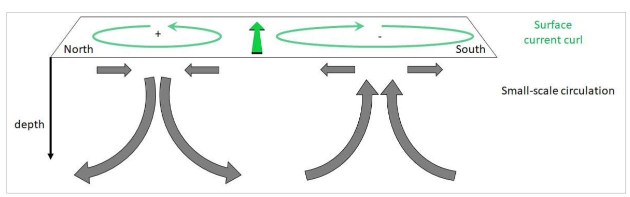
$$SVHF = C_p \rho w'T'$$

Where C_p is the specific heat capacity, ρ is the density of sea water, w' and T' are the submesoscale components of vertical velocity and temperature, respectively. The submesoscale components of a given quantity are calculated as the anomaly of the given hourly quantity from its daily 0.5° x 0.5° spatial mean.









Conceptual diagram of the current feedback impacts within the ocean over the Gulf Stream extension with currents and winds moving in the same direction.

To the right (south) of the maximum current in the Gulf Stream extension there is generally negative ocean relative vorticity
- Including the current feedback leads to increased low-level divergence (or decreased surface convergence), and increased small-scale upward vertical motion

To the left (north) of the maximum current in the Gulf Stream extension there is generally positive ocean relative vorticity
- Including the current feedback leads to increased low-level divergence, and enhanced small-scale downward vertical motion

IOVWST meeting
Virtual | 4 October 2023

Abstract for: IOVWST 2023 Meeting
virtual
October 4, 2023

Upper Ocean Response to Coupling Currents to Wind Stress over the Gulf Stream

Jackie May[1] and Mark Bourassa[2]
[1]Oceanography Division, U.S. Naval Research Laboratory, Stennis Space Center, MS
[2]Center for Ocean-Atmospheric Prediction Studies (COAPS), Florida State University, Tallahassee, FL

Coupling ocean surface currents with atmospheric wind stress has impacts on the primary and secondary circulations within both the upper ocean and throughout the atmosphere. With high resolution, coupled ocean-atmosphere model simulations over the Gulf Stream region, we are able to examine these impacts with respect to the Gulf Stream current. For this study, we focus on the response within the ocean mixed layer. In agreement with previous studies, we find there is a negative ocean relative vorticity pattern, corresponding to surface divergence and upward vertical motion, to the right of the maximum current in the Gulf Stream extension. To the left of the maximum current in the Gulf Stream extension, there is a positive ocean relative vorticity pattern, corresponding to surface convergence and downward vertical motion. Of further interest in this study is the impact on the vertical heat fluxes when the current feedback is included. The submesoscale vertical heat flux within the ocean is found to have enhanced upward motion to the right of the maximum current in the Gulf Stream extension and enhanced downward motion to the left of the maximum current in the Gulf Stream extension. Additionally, the magnitude of the submesoscale vertical heat flux daily average is shown to be comparable to the magnitude of the surface latent heat flux daily average. These results will have further implications on vertical mixing and weather.