Atmospheric Dynamic Response to Ocean Surface Currents over the Gulf Stream

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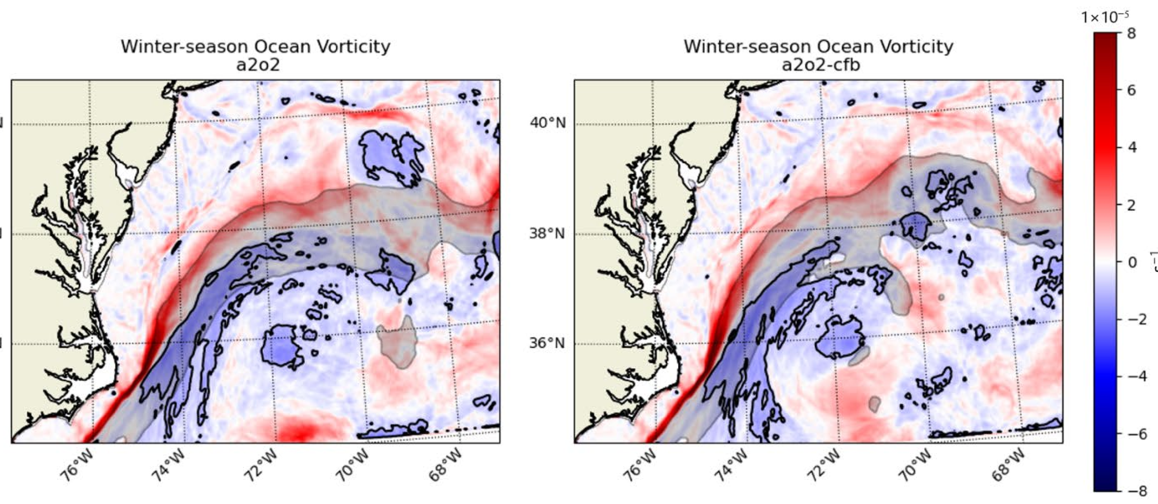
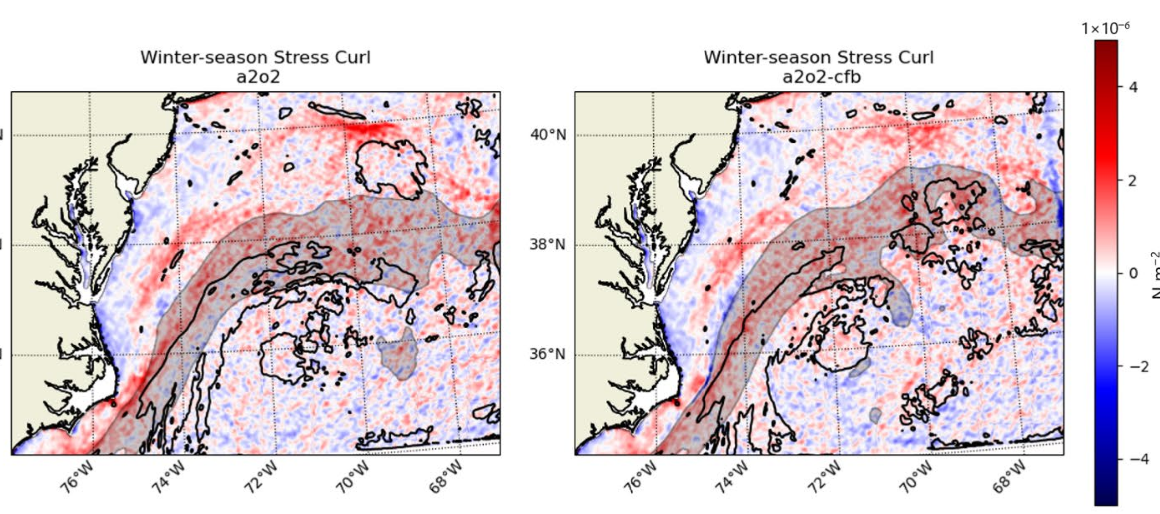
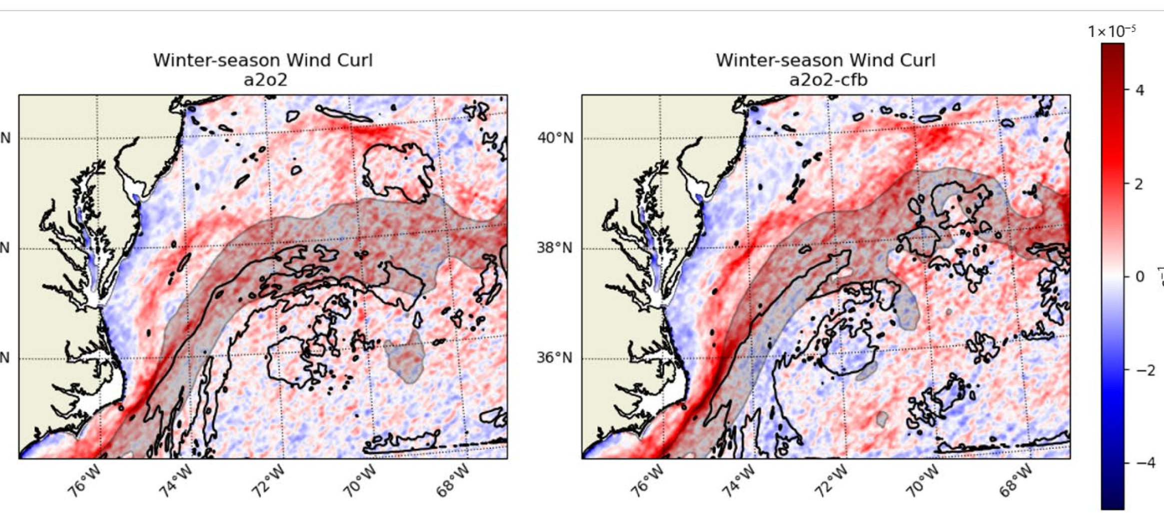
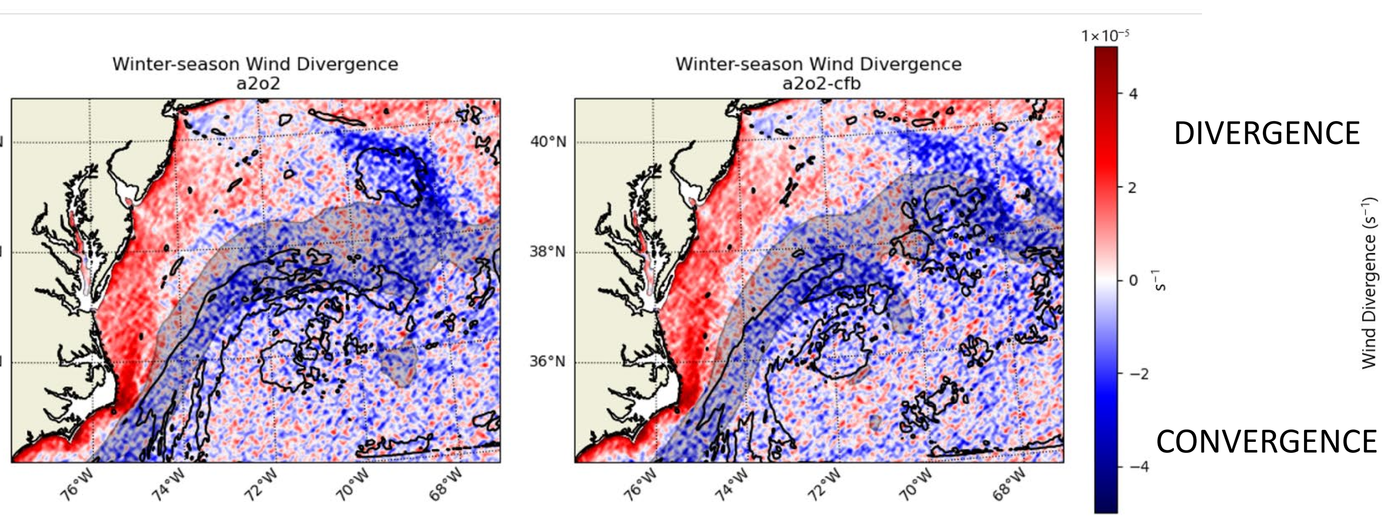
Atmospheric near-surface stress and boundary layer wind responses to surface currents are examined with high resolution coupled atmosphere-ocean models, i.e. 2km atmosphere and 2km ocean, over the Gulf Stream during a winter season. Winter-time seasonal means are shown with the ocean surface current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



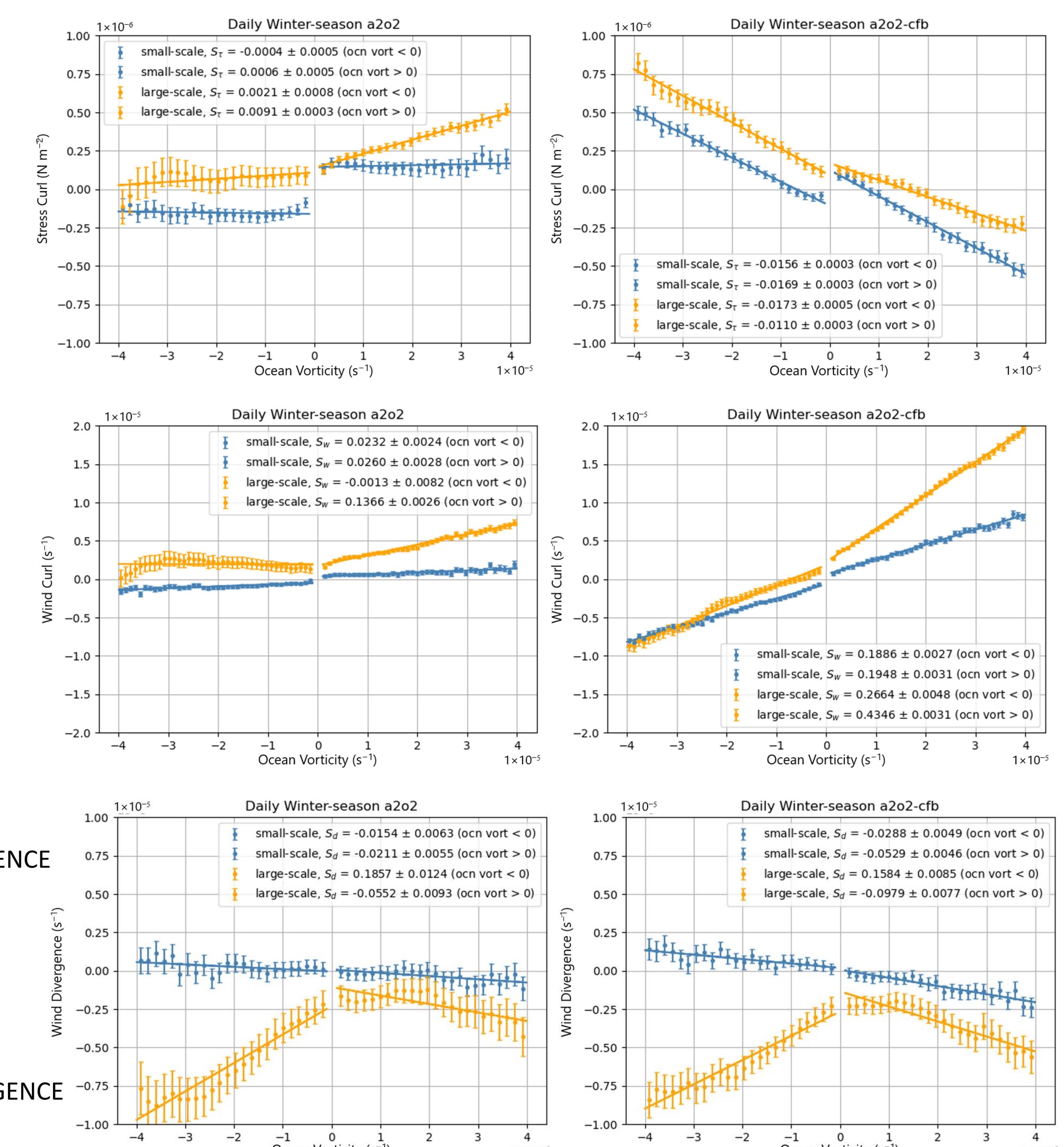




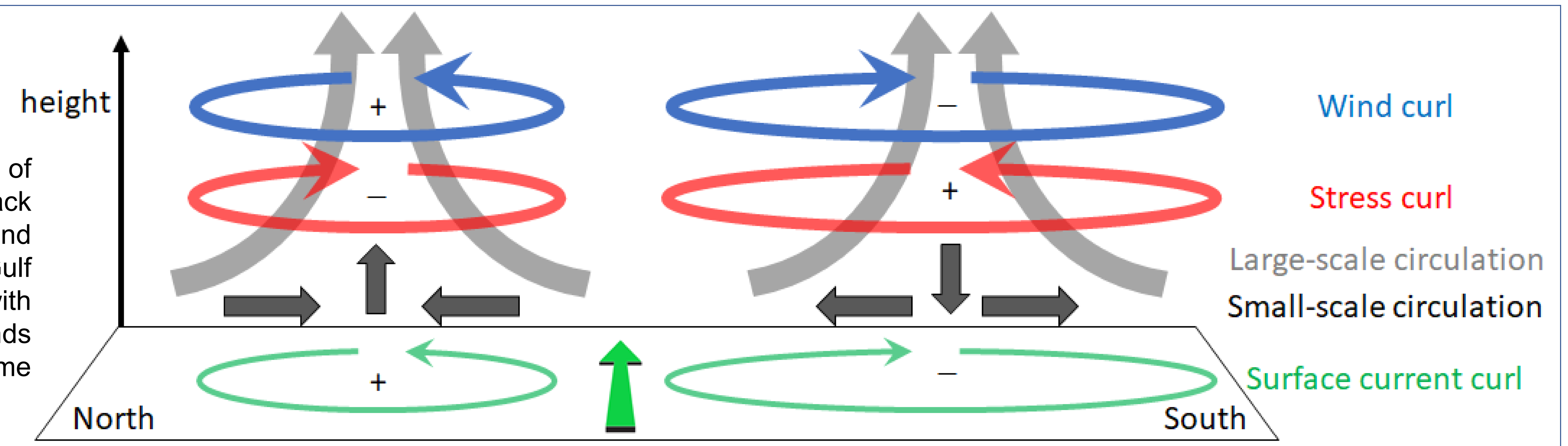


The stress curl and wind curl patterns with respect to the ocean-relative vorticity pattern are found to be depended on the current feedback. Conversely, The seasonal means of the wind divergence pattern are similar regardless of the inclusion of the current feedback, indicating a thermodynamic dependence.

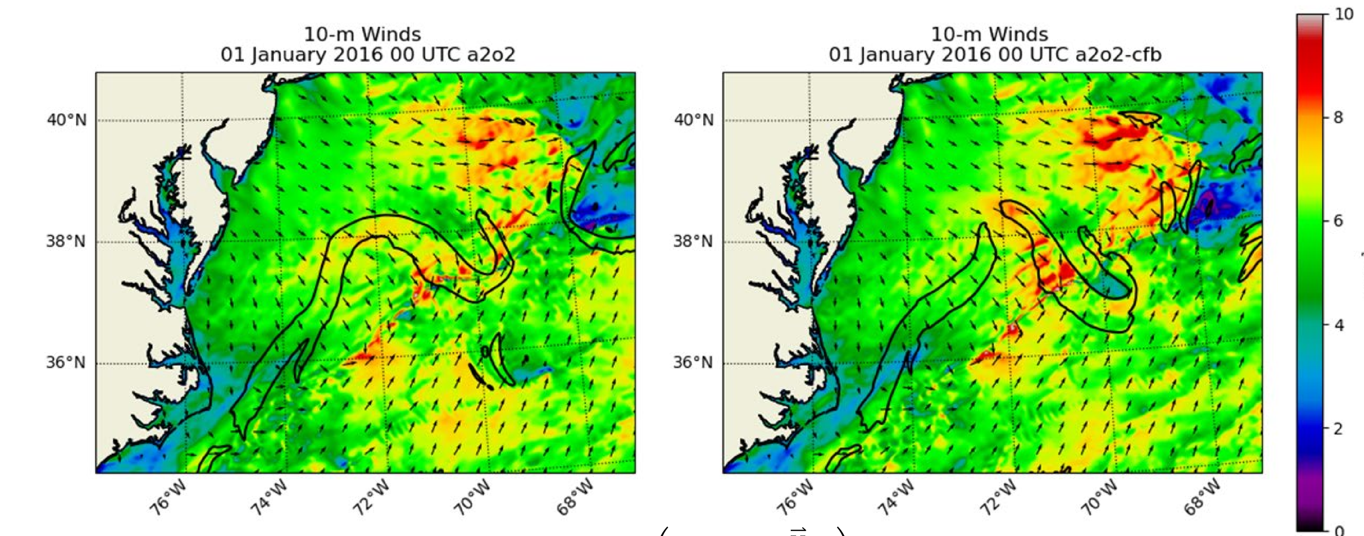
Coupling coefficients are used to show the linear relationship between two variables. The surface stress and surface wind response to including vs neglecting the current feedback is determined with coupling coefficients between ocean surface current relative vorticity and stress curl (s_τ), 10 m wind curl (s_w), and 10 m wind divergence (s_d). Separate coupling coefficients are calculated for positive vs negative ocean relative vorticity values. The hourly output fields have first been temporally averaged using a 1-day running mean. Then a 30 km high-pass Gaussian spatial filter is applied to separate the small-scale (submesoscale) impact vs the large-scale impact.



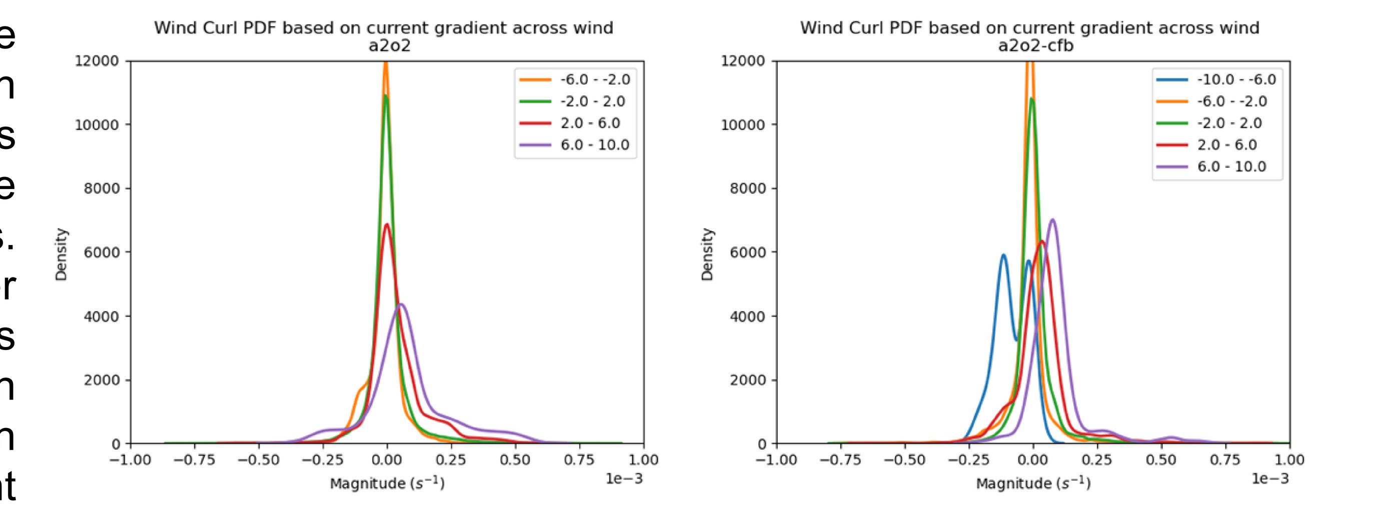
Conceptual diagram of the current feedback impacts (primary and secondary) over the Gulf Stream extension with currents and winds moving in the same direction.



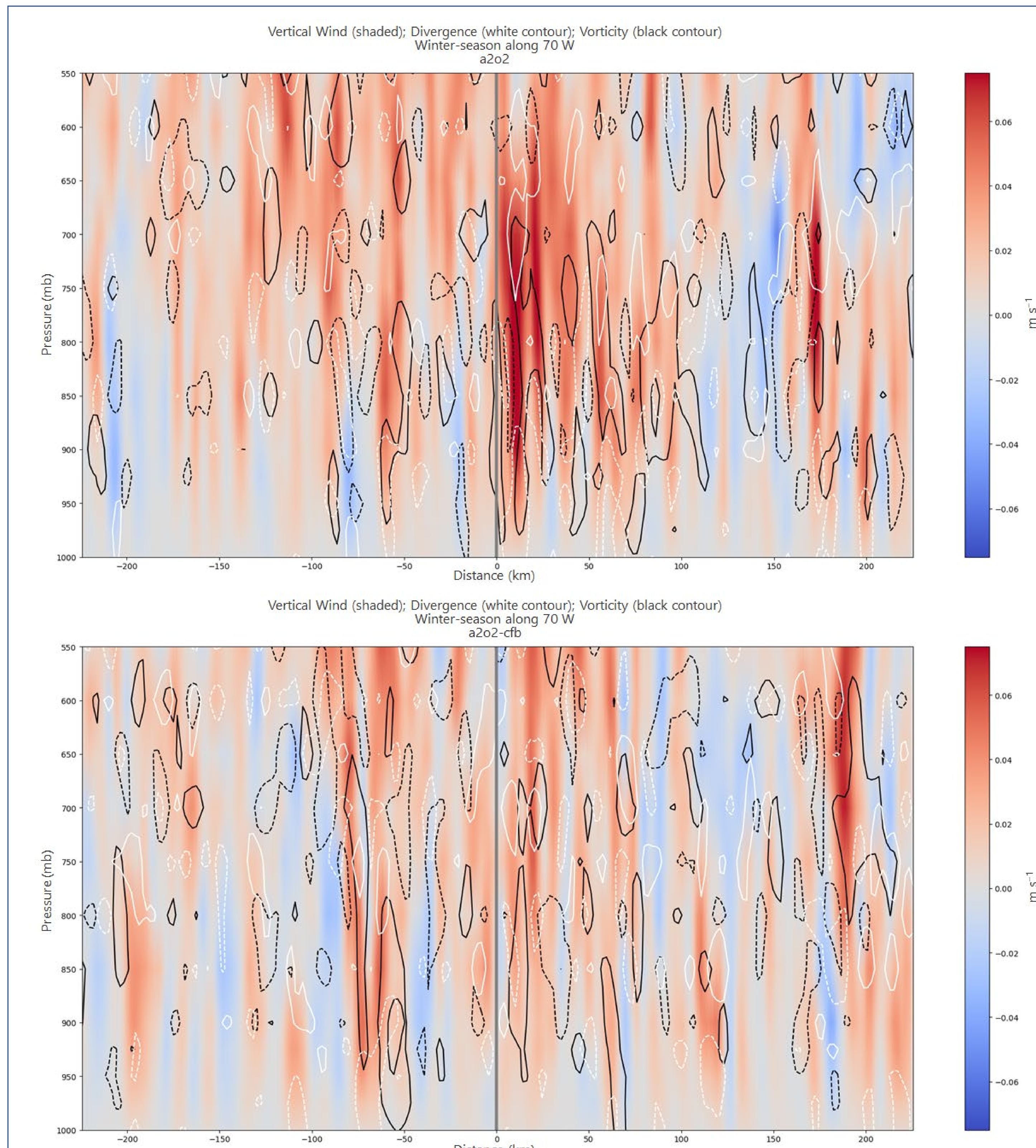
Because the current feedback has its largest impacts when there is a large change in stress, areas associated with higher winds (i.e., atmospheric fronts) and stronger currents (i.e., Gulf Stream) are ideal for investigating responses. We found the cross-wind component of the current gradient (CWCG) to be a primary contributing factor driving the horizontal advection in the momentum budget, as well as the wind curl.

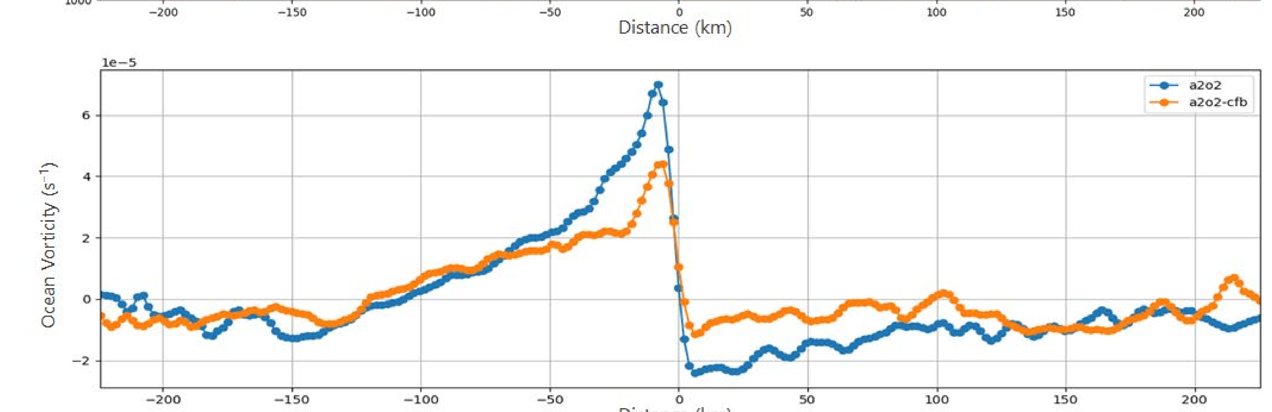


$$CWCG = \hat{k}\cdot\left(\nabla\vec{U}_{curr}\times\frac{\vec{U}_{10}}{|\vec{U}_{10}|}\right)$$



Regardless of the current feedback, the wind curl has a positive relationship with the CWCG. When the current feedback is included, there is a more systematic shift in the PDF peaks. Additionally, the PDF's have a wider distribution for stronger CWCG's. This shows that more extreme zonal advection and wind curl values are associated with stronger CWCG when the current feedback is included.





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 reduced low-level convergence (or increased surface divergence), reduced positive (or increased negative) atmospheric vorticity, and reduced upward (or increased downward) 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 there is increased low level convergence, increased positive atmospheric vorticity, and enhanced upward vertical motion

The winter-time seasonal means suggest the current feedback will impact climate, and investigating individual events, such as an atmospheric front passing over the Gulf Stream, suggests the current feedback will also impact the intensity of weather.

*** Newley published paper ***

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