Diagnosing eddy-to-small scale transfers in eNATL60

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Abstract

Current climate models partially resolve oceanic eddies. However, the interaction of ocean eddies with smaller scale flows (scales of ∼10 km) remains crudely represented, which may yield inaccurate eddy-to-small scale transfers of energy and tracers. The goal of the CONTaCTS project is to study these eddy-to-small scale transfers in the submesoscale permitting (1/60°) eNATL60 ocean simulation, and to seek ways to represent their effects in coarser horizontal resolution ocean models (typically 1/12°) where otherwise resolved eddy feedbacks can be critical. To achieve this task, we are:

- Diagnosing eddy-to-small scale energy transfers in eNATL60 from an offline version of the Kinetic Energy (KE) budget (Jamet, Q.)
- Evaluating the mixed-layer eddy (MLE) parametrization developed by Fox-Kemper et al. (2008; hereon FFH) from eNATL60 outputs. (Uchida, T.)

Introduction (Momentum/KE budget)

Forming an offline Kinetic Energy (KE=$\frac{u^2}{2}+\frac{v^2}{2}$) budget (3) from the momentum equations ((1) and (2)) to apply coarse-graining approach and diagnose eddy-to-small scale energy transfers.

$$\partial_t u = -\partial_x p + fv - \nabla.\mathbf{u}u - \nabla A_u \nabla u \qquad (1)$$

$$\partial_t v = -\partial_y p - fu - \nabla.\mathbf{u}v - \nabla A_v \nabla v \qquad (2)$$

$$\longrightarrow \partial_t KE = -\nabla.\mathbf{u}p + wb - \nabla.\mathbf{u}KE - Dissip. \qquad (3)$$

Results

Although weaker, the vertical forcing/dissipation tendency (Fig. 1**F**) exhibits both large and small scale horizontal structures. At large scale, this might well reflect the action of atmospheric winds, but might also reflect a large scale organisation of small scale vertical dissipative processes.

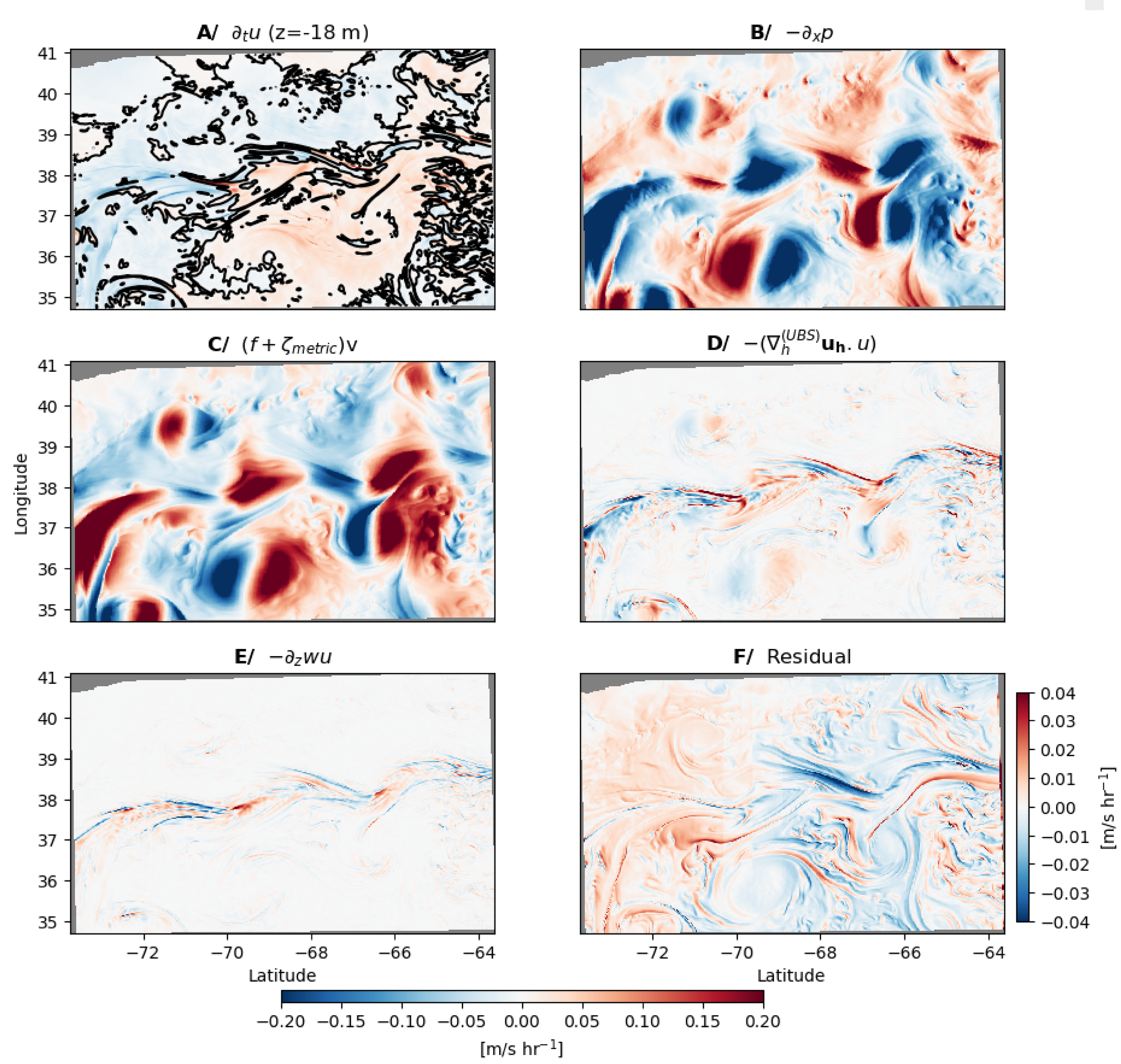

Figure 1: Zonal momentum budget downstream of Cape Hatteras at -18 m depth on January 1, 2010. The residual **F** (computed as the sum of **B**-**E** minus the time rate of change **A**) reflects the vertical forcing/dissipation tendency $\partial_z A_u^{vm} \partial_z u$.

Introduction (MLE parametrization)

Submesoscale vertical buoyancy fluxes have been shown to be first-order importance for mixed-layer restratification and air-sea interaction. We evaluate the submesoscale fluxes by filtering w' and b' with a Hanning window and calculate the parametrized equivalent via FFH's formulation by taking the horizontal gradients of coarse grained fields of buoyancy ($\langle b \rangle$), i.e.

$$\langle w'b' \rangle \sim \frac{H_{\mathrm{ML}}^2 |\overline{\nabla_{\mathrm{H}} \langle b \rangle}^z|^2}{f} \mu(z).$$

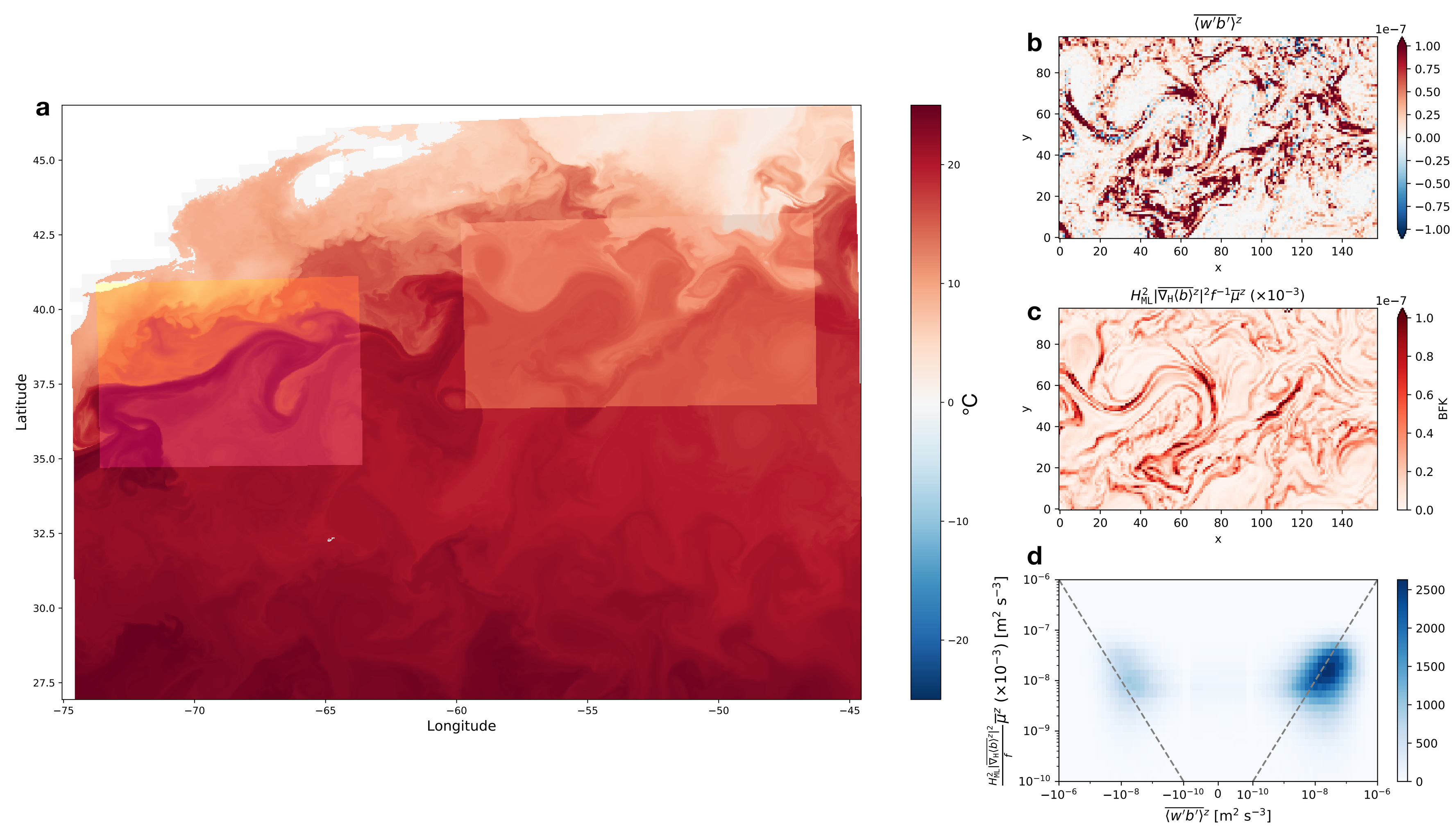

Figure 2: Snapshot of SST on January 1, 2010 in the Gulf Stream region **a**. **b**,**c** Diagnosed submesoscale buoyancy flux and its parametrized equivalent depth averaged over the mixed layer. **d** Histogram between the two.

Results

The parametrization captures the submesoscale fluxes well except during late spring (February-April) when we would expect vigorous air-sea heat exchange.

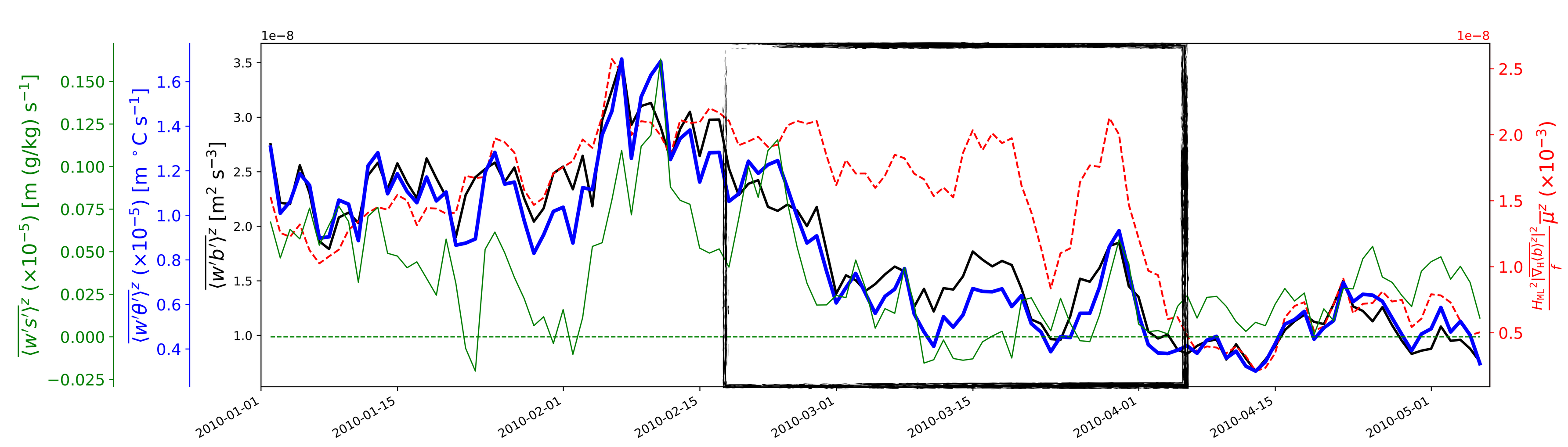

Figure 3: Vertical flux of buoyancy (black), heat (blue), salinity (green), and the parametrized buoyancy flux (red) all depth averaged over the mixed layer.

Considering that the strength of parametrized restratification stays relatively constant during this time, we are looking into possibility that $\langle w'b' \rangle$ is the net effect of restratification and air-sea interaction:

$$\langle w'b' \rangle \sim \frac{H_{\mathrm{ML}}^2 |\overline{\nabla_{\mathrm{H}} \langle b \rangle}^z|^2}{f} \mu(z) + \frac{\alpha g \dot{Q}}{\rho_0 c_P}.$$

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