Supplementary material
Atmospheric boundary layers over an oceanic eddy

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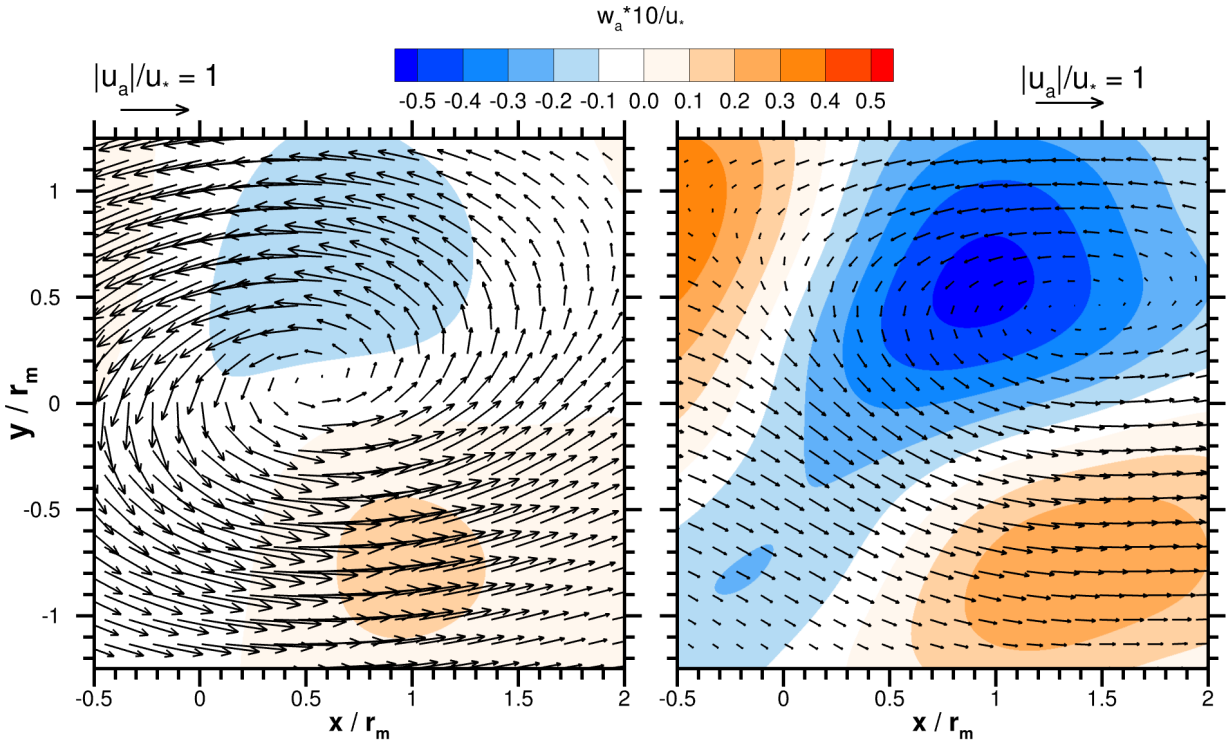

Fig. S1: Horizontal vector anomalies $\mathbf{u}_a/u_*$ at $z = (7.5, 59)$ m, (left, right) panels overlaying contours of vertical velocity anomaly $w_a \cdot 10/u_*$ for simulation $k03$.

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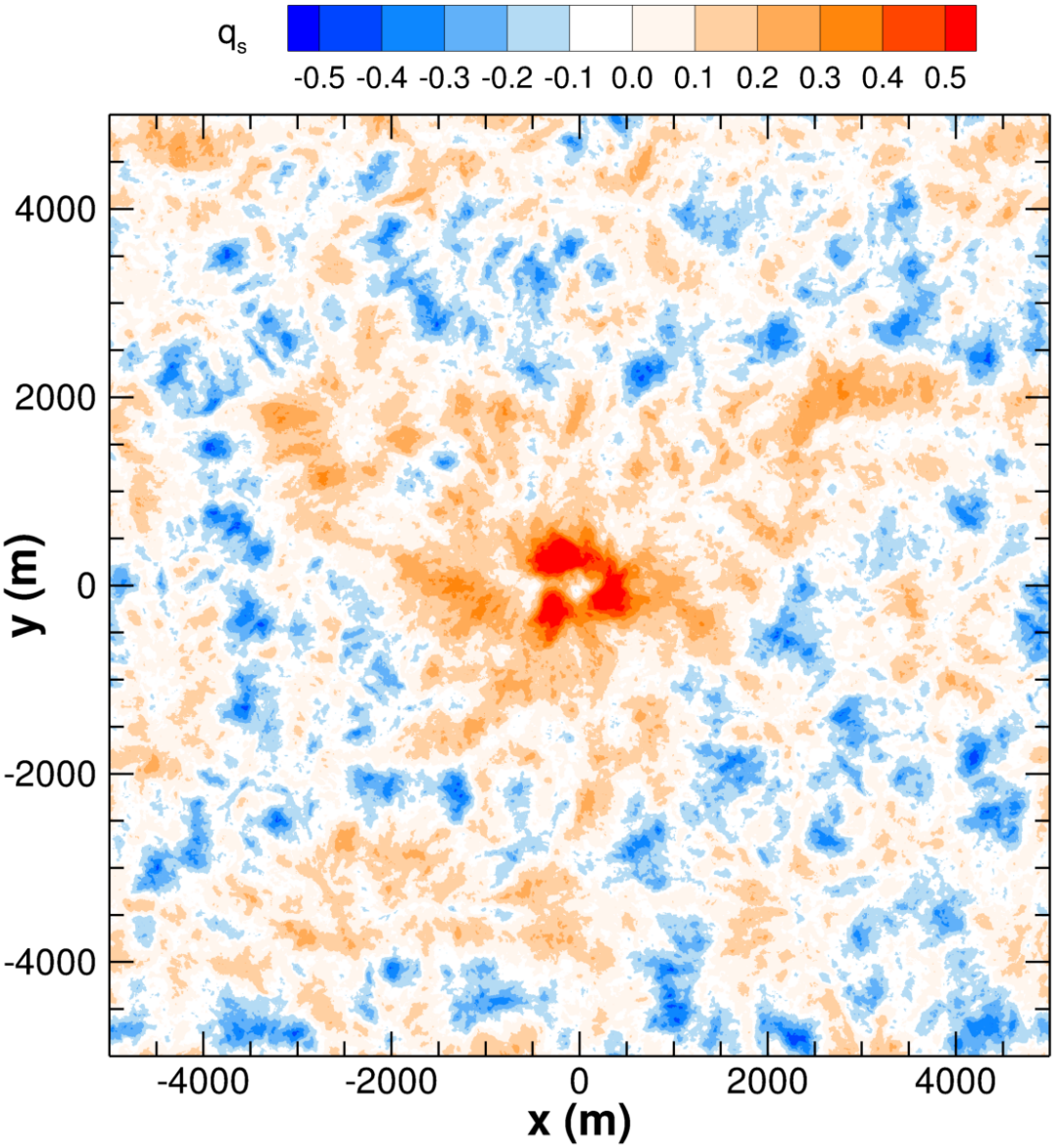

Fig. S2: Average point-by-point surface temperature flux anomaly $\overline{q_s(x,y)}^t$ computed from simulation $f01$ over a time period of 6200 s. This flux distribution is used as the boundary condition in simulation $f05$ with no currents.

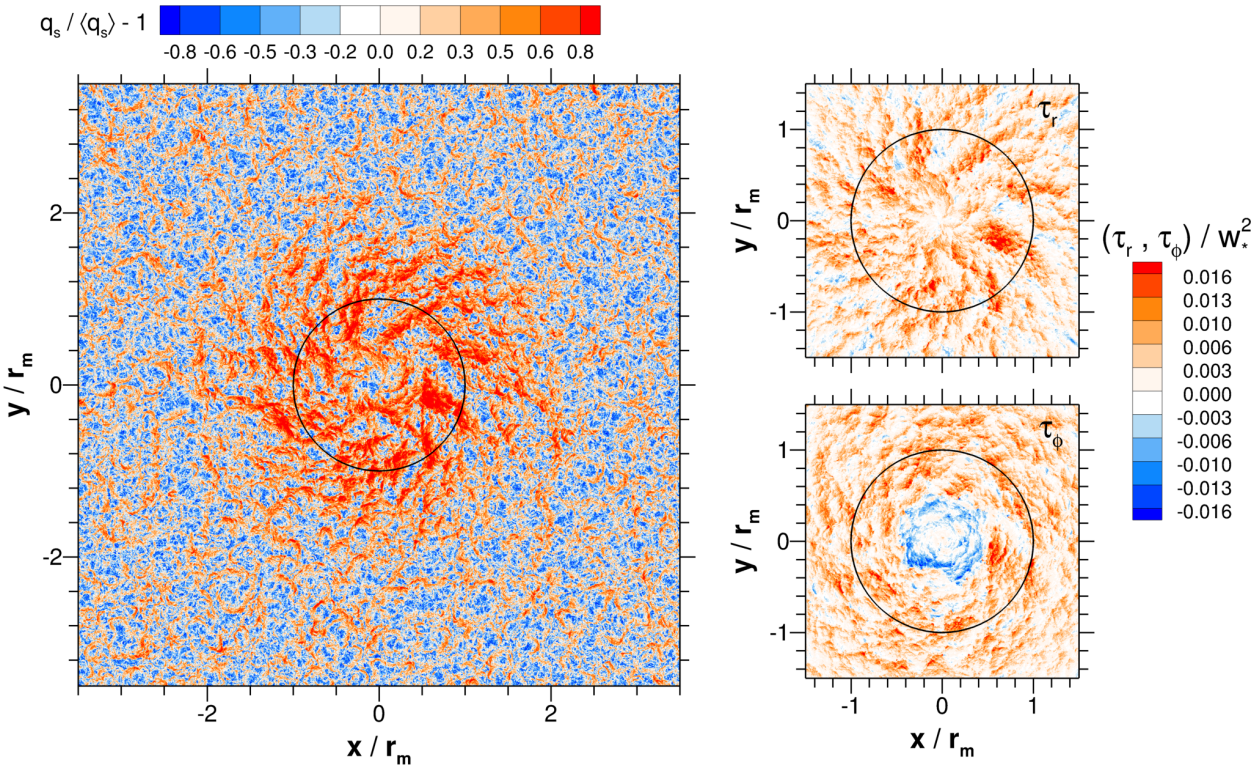

Fig. S3: Variation of surface fluxes in free convection coupled to a cyclonic oceanic eddy with $r_m = 4\,\mathrm{km}$. Surface temperature flux q_s normalized by $\langle q_s \rangle$, left panel, and a zoom of the (radial, azimuthal) momentum fluxes (τ_r, τ_ϕ) normalized by w_*^2, right panels. The black circle has radius $r/r_m = 1$.

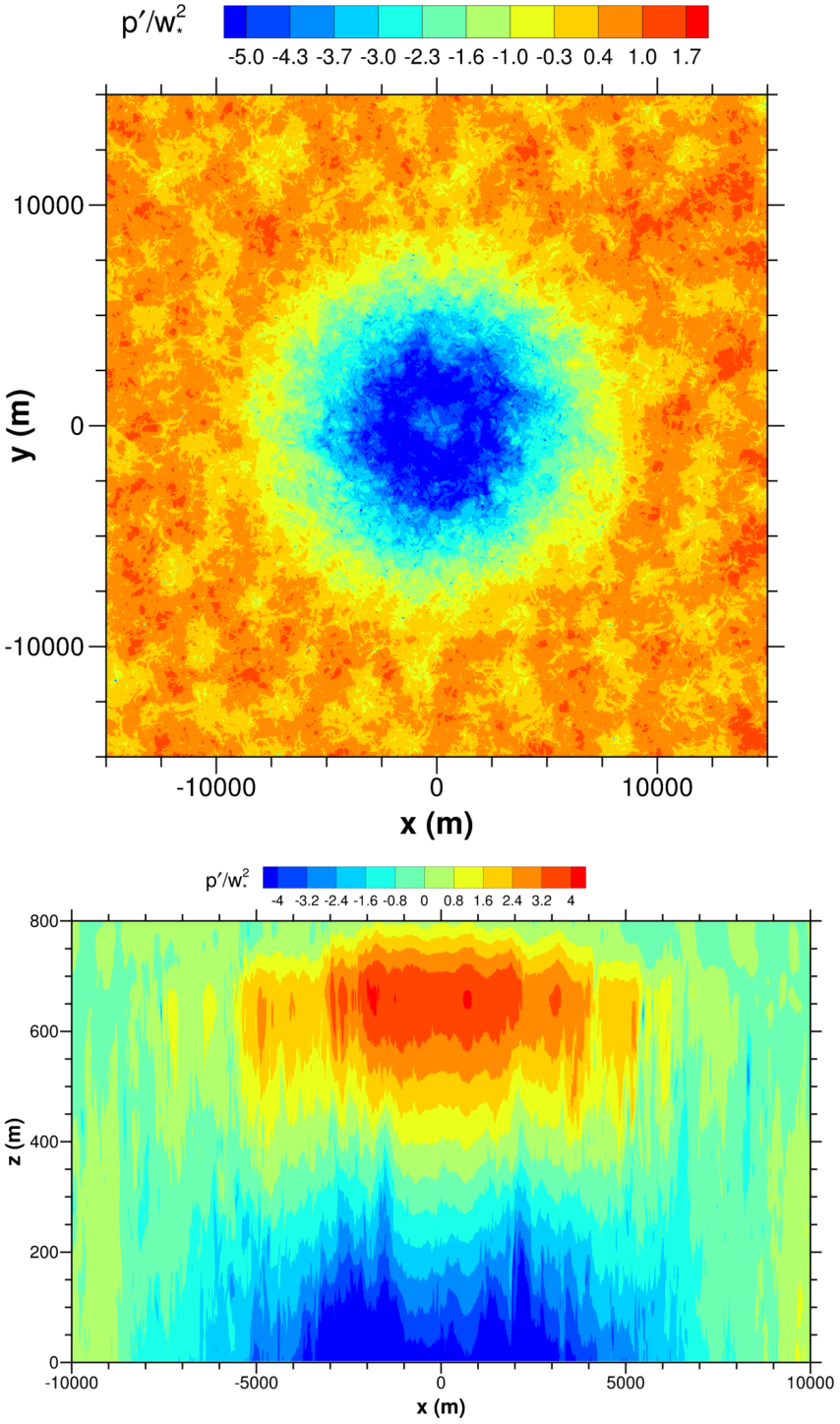

Fig. S4: Fluctuating pressure $p' = p - \langle p \rangle$ normalized by w_*^2 in an x-y plane near the surface $z = 6.0\,\mathrm{m}$ (top panel), and in an x-z plane at $y = 0\,\mathrm{m}$ (lower panel) from simulation $f08$ with eddy radius $r_m = 4\,\mathrm{km}$.

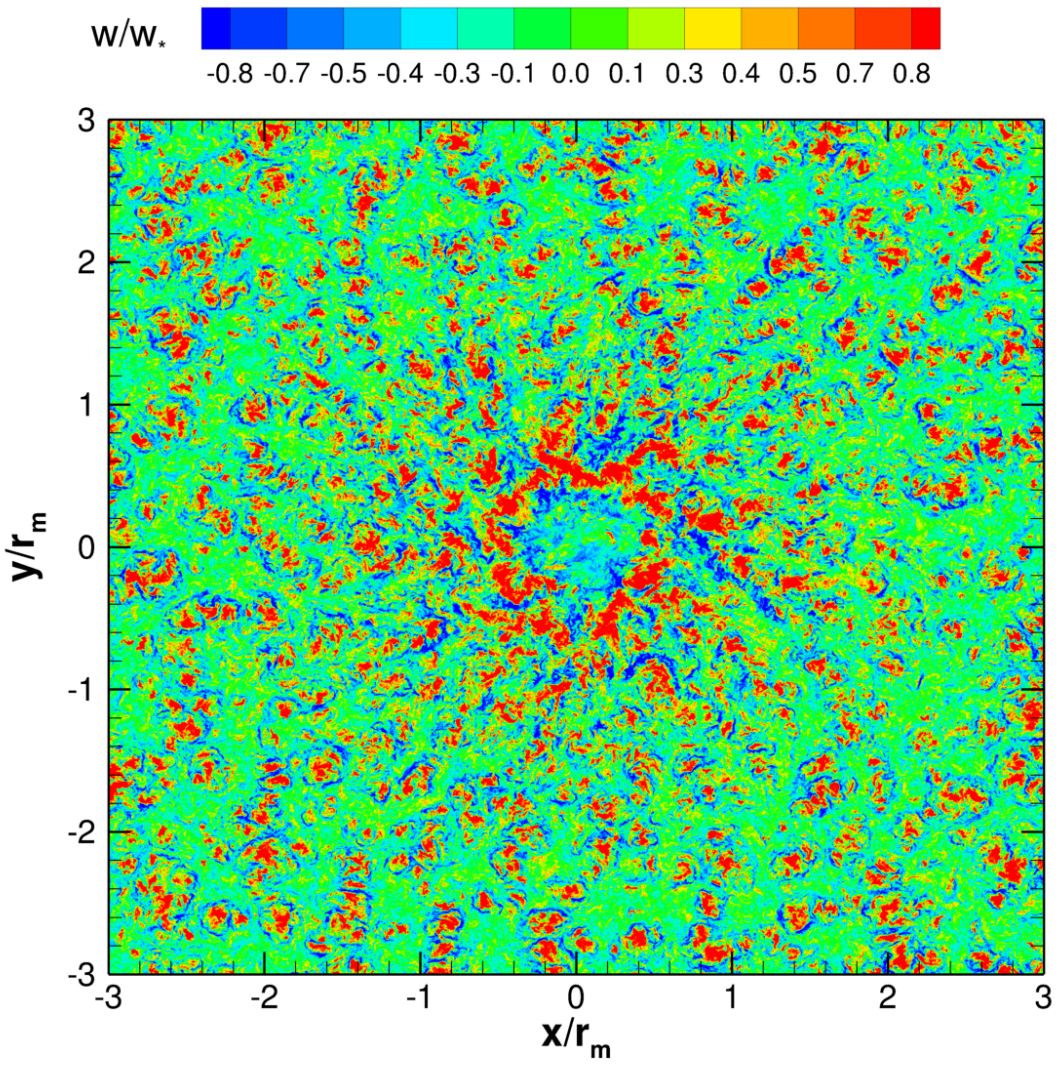

Fig. S5: Fluctuating vertical velocity w/w_*^2 in an x-y plane near the boundary-layer top $z = 530\,\mathrm{m}$ from simulation $f08$ with eddy radius $r_m = 4\,\mathrm{km}$. The horizontal domain $L_x = L_y = 36.9\,\mathrm{km}$, or in terms of the eddy radius $r/r_m = \pm 4.608$. The LES captures many individual convective plumes in the farfield and also the large convective ring near the eddy center. The eddy radius is much larger than the boundary-layer depth $z_i/r_m = 0.163$.

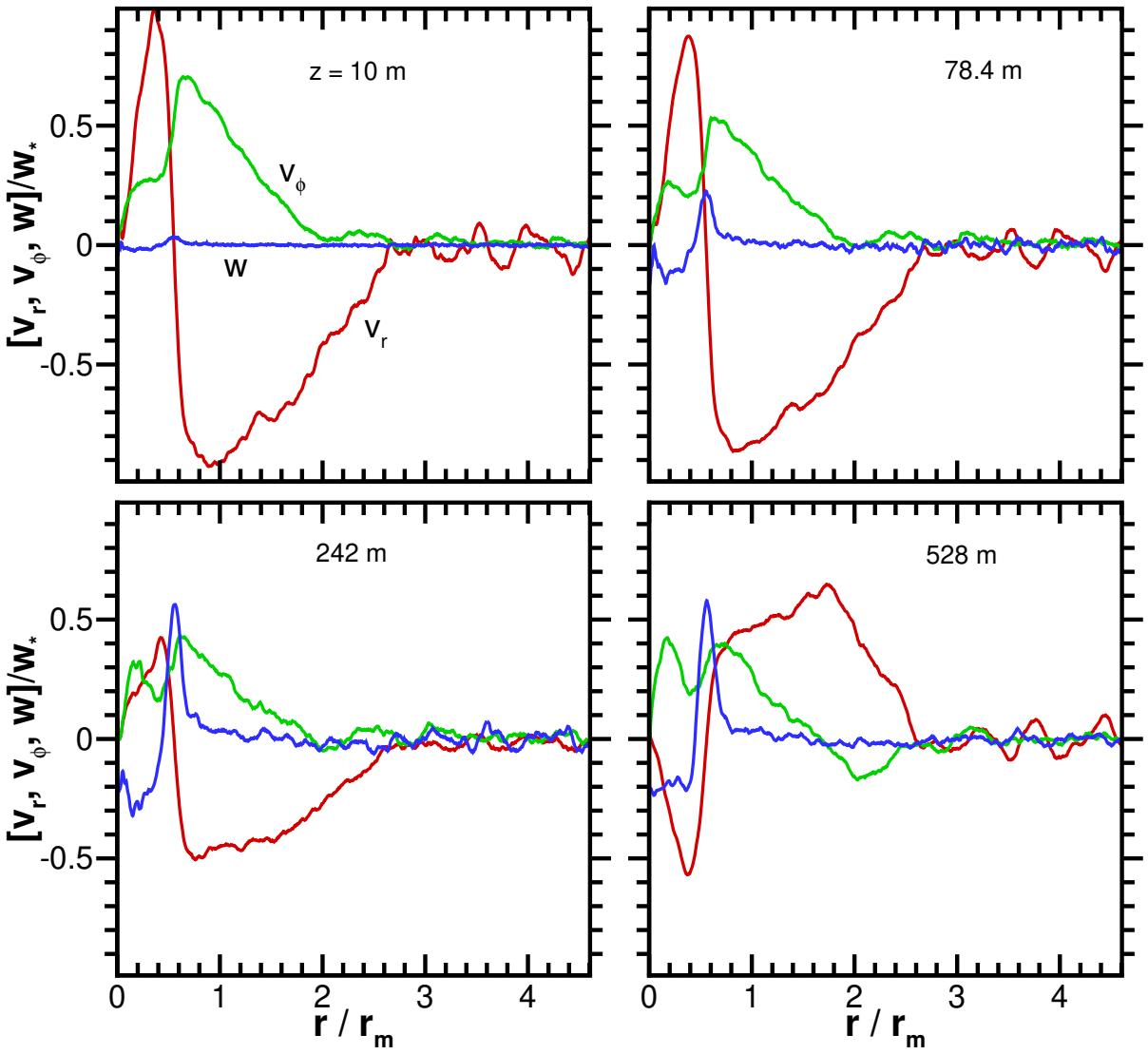

Fig. S6: Average radial v_r, azimuthal v_ϕ, and vertical w velocities (red, green, blue) colors, respectively, for simulation $f08$ of free convection above a cyclonic eddy with $r_m = 4\,\mathrm{km}$. The vertical levels are $z = (10, 78.4, 242, 528)\,\mathrm{m}$. For comparison with smaller radius $r_m = 0.4\,\mathrm{km}$ see Fig. 11.

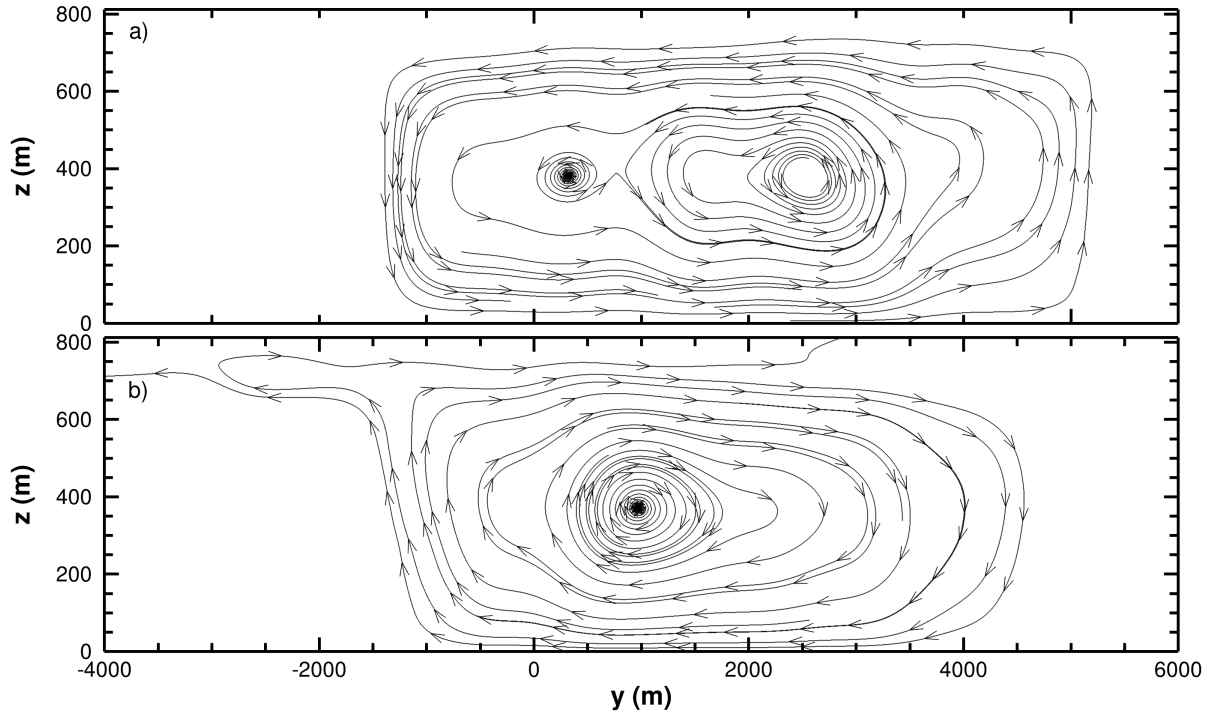

Fig. S7: Streamtraces in a y-z plane at $x/r_m = 4.375$ above the cyclonic and anticyclonic eddies in Figs. 14 and 15 panels a) and b), respectively. The streamtraces highlight the secondary circulation (SC) downstream of the eddy center. Note the rotation of the SC changes direction depending on the eddy rotation, and the horizontal extent of the SC matches the eddy radius $r_m = 4\,\mathrm{km}$. The spacing between the lines has no quantitative significance.

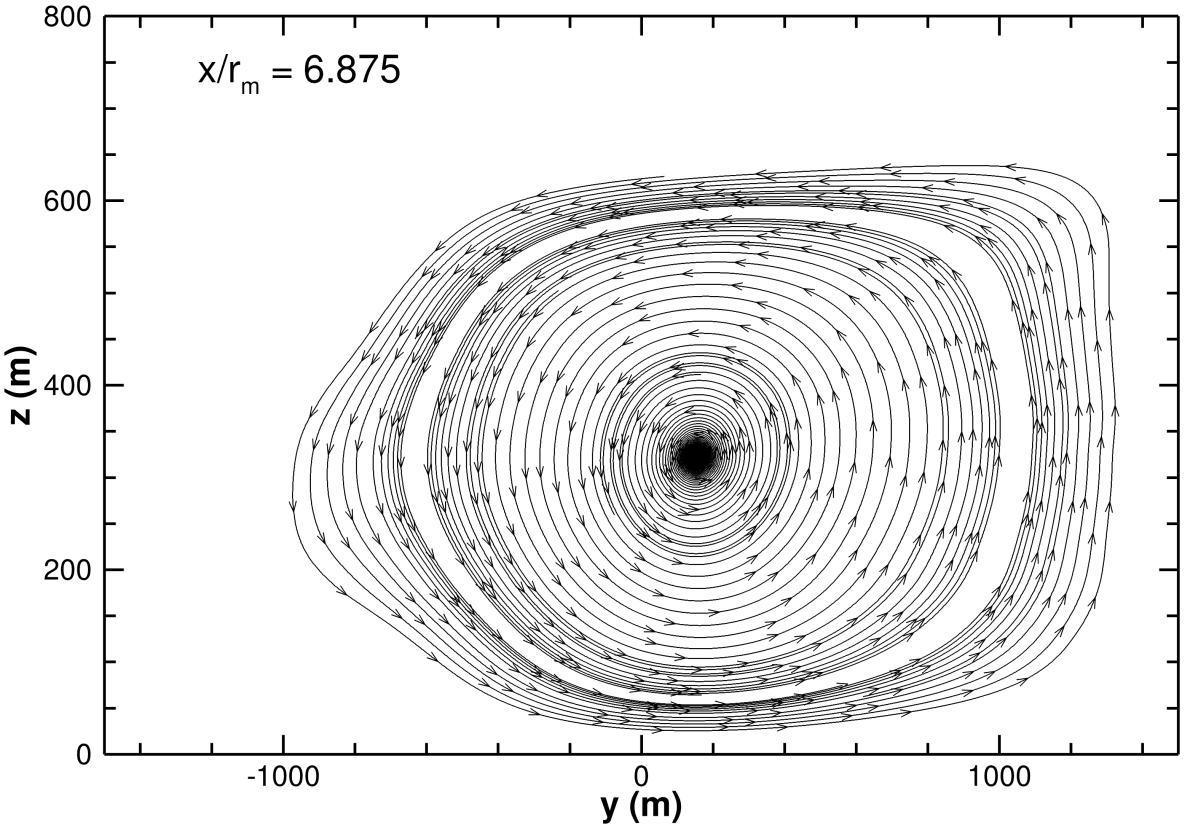

Fig. S8: Streamtraces computed from the anomaly vector $(v, w)_a$ in simulation $i08$ as in Fig. 16. The streamtraces trace the counter-clockwise secondary circulation in a y-z plane in the eddy wake at $x/r_m = 6.875$. The spacing between the lines has no quantitative significance.