Agulhas ring formation as a barotropic instability of the retroflection

Weijer, Wilbert; Zharkov, Volodymyr; Nof, Doron; Dijkstra, Henk A.; Ruijter, Wilhelmus P.M. de; Terwisscha van Scheltinga, Arjen; Wubs, Fred

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Supplementary Information to: Agulhas ring formation as a barotropic instability of the retroflection

Wilbert Weijer, Volodymyr Zharkov, Doron Nof,

Henk A. Dijkstra, Wilhelmus P. M. de Ruijter,

Arjen Terwisscha van Scheltinga, and Fred Wubs

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1. The length scale of the barotropic instability

To investigate whether the zonal length scale is consistent with theoretical predictions, we compare our results to Talley (1983), who studied the stability of a shear layer $U(y)$ with discontinuities in dU/dy. Fitting her Eq. (22) to our velocity profile ($U_T(y)$; Fig. S1a, dashed black line) suggests a shear layer of only 0.5° wide, or a half-width $L = 2.8 \cdot 10^4\,\mathrm{m}$. Our maximum westward and eastward velocities of $-0.4\,\mathrm{m\,s^{-1}}$ and $0.2\,\mathrm{m\,s^{-1}}$ suggest a velocity scale $U_0 = 0.3\,\mathrm{m\,s^{-1}}$, in addition to a net westward translation of $-0.1\,\mathrm{m\,s^{-1}}$. With $\beta_0 = 1.8 \cdot 10^{-11}\,\mathrm{m^{-1}\,s^{-1}}$, this yields a dimensionless $\beta = \beta_0 L^2/U = 0.05$. Figure S1b shows the (dimensionless) real (c_r; solid gray) and imaginary (c_i; dashed gray) parts of the dispersion relation for $\beta = 0.05$ as function of (dimensionless) zonal wavenumber k (cf. Fig. 4 of Talley (1983)), while the curve kc_i (black) shows the (dimensionless) growth rate. The growth rate is optimal for $k = 0.4$; the corresponding wave length $\lambda = 4.4 \cdot 10^5\,\mathrm{m}$ (about 5°) is consistent with that of the Retroflection Mode (7°). In addition, the (dimensionless) propagation speed for this wavenumber is $c_r = -0.14$, which corresponds to $-0.04\,\mathrm{m\,s^{-1}}$. Taking into account the additional translation speed of $-0.1\,\mathrm{m\,s^{-1}}$, this corresponds well with the $-0.13\,\mathrm{m\,s^{-1}}$ speed diagnosed from the Hovmüller diagrams.

REFERENCES

Talley, L. D., 1983: Radiating barotropic instability. *J. Phys. Oceanogr.*, **13**, 972–987.

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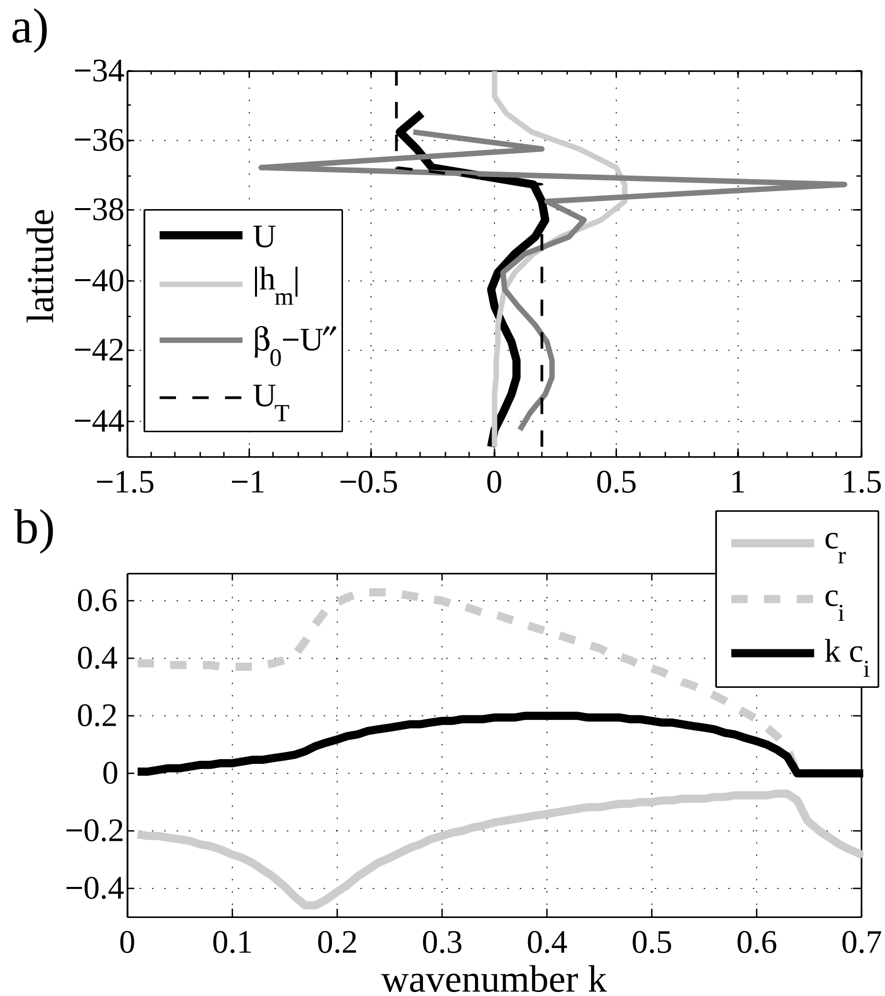

FIG. 1. a) Profiles along 25°E of mean zonal velocity of our standard solution (U in $\mathrm{m\,s^{-1}}$; solid black); the norm of h_m (light gray; arbitrary amplitude); the gradient of potential vorticity (dark gray; $10^{-10}\mathrm{m}^{-1}\,\mathrm{s}^{-1}$); and the fitted velocity profile $U_T(y)$ according to Eq. (22) of Talley (1983) (dashed black). b) Real (c_r; solid gray) and imaginary (c_i; dashed gray) parts of the dispersion relation for $\beta = 0.05$ as function of zonal wavenumber k. Growth rate is given by kc_i (black).