LETTER TO THE EDITOR

Comments on N. J. MacDonald's "The evidence for the existence of Rossby-like waves in the hurricane vortex"

MacDonald's article was useful in pointing out yet another possible example of the characteristic tendency of disturbances in quasi-two-dimensional flow to transfer momentum against the gradient. Besides the well-known case of the atmospheric general circulation, examples of similar behavior have been reported in ocean currents (Webster, 1965) and the solar general circulation (Gilman, 1968) as well as in numerical simulation of two-dimensional convective elements in a mean shear (Asai, 1964). In fact this behavior is clearly one aspect of the general tendency of two-dimensional turbulence to "cascade" energy to larger, rather than smaller scales, as explained by Fjortoft (1953) and in more detail by Kraichnan (1967).

I think, however, that the article is to an extent incorrect and misleading in attempting to equate the spiral rain bands of tropical cyclones to Rossby waves. Aside from the poorly chosen title (are the waves like Rossby?) I fail to see where the author has shown any dynamic similarity at all between the rain bands, which are probably driven by convective instability, possibly augmented by Ekman layer instability, and the quasistationary waves of the large scale atmosphere. Rossby (1939) deduced that the waves now named after him owe their characteristic upstream propagation speeds to the latitudinal variation of the Coriolis parameter. In the absence of the β-effect the waves would still exist (as they do in dishpan or annulus experiments) since they are produced either directly or indirectly from baroclinic energy sources. Whether they should still be called Rossby-waves without the β-effect is doubtful, but in any case they seem to have little in common with hurricane rain bands except for being active disturbances in a quasi-two-dimensional, rotationally constrained fluid.

MacDonald's argument that both phenomena involve transformation from potential to kinetic energy is not convincing, since most active disturbances of the atmosphere share this property. Finally, in contrast to the importance of Rossby waves in the maintenance of the general circulation, the spiral rain bands of hurricanes seem to be a noncrucial element of the storm system, since both diagnostic studies (Riehl and Malkus, 1961) and a complete theoretical model (Ooyama, 1967) have produced internally self-consistent and realistic results with the assumption of radial symmetry. The low-level frictional inflow appears to be both necessary and sufficient for producing the observed distribution of angular momentum.

D. K. Lilly
National Center for Atmospheric Research
Laboratory of Atmospheric Sciences
Boulder, Colorado, 80302

REFERENCES

Asai, T., 1964. Cumulus convection in the atmosphere with vertical wind shear: numerical experiment. *J. Meteor. Soc. Japan 42*, Ser. II, 245–259.

Fjørtoft, Ragnar, 1953. On the changes in the spectral distribution of kinetic energy for two-dimensional, non-divergent flow. *Quart. J. Geophys 3*, Vol. 5, 225–230.

Gilman, Peter A., 1968. Thermally driven Rossby-mode dynamo for solar magnetic field reversals. *Science 160*, 760–763.

Kraichnan, R. H., 1967. Inertial ranges in two-dimensional turbulence. *Phys. Fluids 7*, Vol. 10, 1417–1423.

Ooyama, 1967. *Numerical simulation of the life cycle of tropical cyclones.* Report from New York University School of Engineering and Science, Department of Meteorology and Oceanography, dated Dec., 1967.

Riehl, H. & J. Malkus, 1961. Some aspects of Hurricane Daisy, 1958. *Tellus 13*, 181–213.

Rossby, C.-G. & Collaborators, 1939. Relation between variations in the intensity of the zonal circulation of the atmosphere and the displacements of the semi-permanent centers of action. *J. Marine Res. 2*, 38–55.

Webster, Ferris, 1965. Measurements of eddy fluxes of momentum in the surface layer of the Gulf Stream. *Tellus 2*, 239–245.