The flow generated by the rotation of a horizontal disk in a stratified fluid

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Results are presented from a series of laboratory experiments in which a flow has been generated in a linearly-stratified fluid (initially at rest in a cylindrical container of radius RT) by the impulsive steady azimuthal rotation of a flat, smooth, horizontal circular disk of radius Rd. Experiments have been conducted for a range of disk sizes Rd, disk rotation rates ω, and buoyancy frequencies N0, and the spatial and temporal development of the motion and density fields (and mixing associated therewith) have been shown to be critically dependent on the ratio Rd/RT. For cases in which this ratio is close to unity, the principal mixing mechanisms affecting the flow development are shown to be (i) the localised overturning of fluid forced by the disk Ekman layers and confining sidewalls and (ii) shear-induced billow entrainment along the outer edge of the so-called primary interface between the upper, unmixed fluid and the lower, partially-mixed fluid regions adjacent to the disk. For the large disk case, for sufficiently high values of ω/N0, density gradients develop sequentially with time within the partially-mixed region and the forms of the associated density interfaces also change with time as the primary interface migrates vertically. At the other extreme, for small values of the ratio Rd/RT but otherwise identical external conditions, the container walls play a negligible role in the flow development and the initial mixing is achieved primarily by shear-induced billow overturning at the primary interface. A scaling analysis is advanced to predict the growth rate of the primary interface and the experimental data are shown to be in good agreement with the analysis.

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