ROFIの力学 ーバルーニングに対する理論的・実験的アプローチ
Ocean dynamics of the ROFI regime –theoretical and experimental approach to the ballooning of river plumes

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Simpson (1997) calls the coastal region where the river plume spreads a region of freshwater influence (ROFI). In strict terms, he defines the ROFI as the region where the local input of freshwater buoyancy from the coastal source is comparable with, or exceeds the seasonal input of buoyancy as heat. In the present study, we emphasize that characteristics (the horizontal scale and freshwater transport) of ROFIs are not determined by the buoyancy-driven current alone, but by a joint effect of buoyancy-driven and transient ambient currents.
River plumes induced by a coastal freshwater source have two noticeable features. One is the formation of a coastal boundary current turning to the right (in the Northern Hemisphere) from the viewpoint of an observer at the river mouth looking seaward. Another noticeable feature of river plumes is the formation of an anticyclonic eddy (hereinafter referred to as the bulge) in front of the river mouth. It is well known that a bulge growing offshore (ballooning) hardly reaches a steady state in the absence of either ambient currents or wind forcing. This study provides a physical interpretation for the ballooning of river-plume bulges by conducting numerical experiments in which a river plume is induced by a coastal freshwater source. Part of the freshwater released to the model ocean undergoes inertial instability. Near-inertial oscillations are predominant when disturbances are not forced in ambient waters of the river plume. These isotropic disturbances are amplified by inertial instability, so that unstabilized freshwater can move in arbitrary directions. Thus, unstabilized freshwater does not need to move toward the coastal boundary current on the right-hand side of the river mouth. Freshwater unstabilized for a long time can stay in the bulge for a long time. Unstabilized freshwater accumulates gradually in the bulge, and so ballooning occurs. When the direction of disturbances is prescribed in ambient waters, unstabilized freshwater is forced to move in the same direction. Thereby, motion of unstabilized freshwater is restricted in the alongshore direction when background disturbances are induced by alongshore tidal currents. It is therefore concluded that tidal currents play a role in stabilizing the offshore growth of river-plume bulges in coastal and shelf waters.
In addition, the above argument provides us a possibility that the ballooning is potentially controlled by the curvature of the river-mouth sidewall. This is because the riverine water firstly moves along the sidewall on the rotating frame, and because the curvature affects the centrifugal force (hence, inertial instability) exerted on riverine water. In the present study, we will demonstrate the dependency of river-plume behavior on the curvature (geometry of river mouths) through a rotating tank and numerical experiments. Exploring non-linear and unsteady river plumes is a major frontline of ocean dynamics even at the present time, although the rive plume is the oceanic process nearest to the everyday life.

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