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The effect of a new drag-law parameterization on ice shelf water plume dynamics

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Abstract

A drag law accounting for Ekman rotation adjacent to a flat, horizontal boundary is proposed for use in a plume model that is written in terms of the depth-mean velocity. The drag law contains a variable turning angle between the mean velocity and the drag imposed by the turbulent boundary layer. The effect of the variable turning angle in the drag law is studied for a plume of ice shelf water (ISW) ascending and turning beneath an Antarctic ice shelf with draft decreasing away from the grounding line. As the ISW plume ascends the sloping ice shelf-ocean boundary, it can melt the ice shelf, which alters the buoyancy forcing driving the plume motion. Under these conditions, the typical turning angle is of order -10° over most of the plume area for a range of drag coefficients (the minus sign arises for the Southern Hemisphere). The rotation of the drag with respect to the mean velocity is found to be significant if the drag coefficient exceeds 0.003; in this case the plume body propagates farther along and across the base of the ice shelf than a plume with the standard quadratic drag law with no turning angle.

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