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On a theory of large-scale intrusions generation in the Arctic fronts at stable-stable stratification

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The instability of geostrophic currents with a linear vertical velocity shear is analyzed taking into account diffusion of buoyancy. The model is applied to describe stable and unstable disturbances of geostrophic currents in the Arctic basin. Relevance of the investigation is based on the following statements: a) dissipative processes can cause a significant effect on the instability of geostrophic currents; b) in some cases (in particular, when the current carries water with T, S-indices that differ from the T, S-indices of the surrounding waters), it is important to take into account the linear vertical shear of the geostrophic current. In the papers (Kuzmina, 2016 a, b) it is shown that a geostrophic flow with a linear vertical velocity shear accounting for vertical diffusion of buoyancy can be unstable at length-scales of interleaving (the long-wave approximation). A distinctive feature of this kind of instability is that the phase velocity of unstable perturbations is directed along the flow and exceeds the maximum velocity of the mean flow. Thus, the instability considered cannot be attributed to the baroclinic instability or the critical layer instability.

In this work, new results on instability of a geostrophic flow with a linear velocity shear in a vertically bounded layer are presented. In contrast to the previously considered problem (Kuzmina, 2016a), the model includes small but finite vertical circulations due to the friction effect, the beta effect, and the temporal variability of the relative vorticity. A detailed derivation of the model problem is presented in (Kuzmina et al., 2018). The problem was solved by a numerical high-precision method (Skorokhodov, 2007) under boundary conditions typical for the ocean. Eigenvalue spectra for various dimensionless parameters of the problem are presented. It is found that there is an eigenvalue in the eigenvalue spectrum that corresponds to unstable disturbances, which are characterized by phase velocity exceeding the maximum velocity of geostrophic flow. These results validate a new type of instability described in (Kuzmina, 2016 a, b). The unstainable (growing with time) solutions are used to describe generation of large-scale intrusions that are observed in the Arctic basin under thermohaline stable-stable stratification.

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