A study on the interaction between a horizontal shear flow and thermal convection

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The interaction among a shear flow, eddies and thermal convection often causes interesting features in geophysical fluids: For instance, zonal structure such as belts and zones in Jovian and Saturn's atmosphere and eddies such as Great Red Spot may affect the characteristics of convection, while the convection may play an important role in maintaining the shear flow and/or the eddies.

In this study, we investigate, by means of a linear stability analysis and a nonlinear numerical calculation, the interaction among the

convection, a large scale horizontal shear flow, and eddies embedded.

Firstly, thermal convection in a plane Couette flow was examined by alinear analysis for various combinations of Taylor number Ta and Reynolds number Re.

It is found that the most preferred mode is roll convection which runs along the direction of the flow for allmost all cases.When Ta is smaller than Re squared, the critical Rayleigh number becomes small since an inertial instability contributes to increase the growth rate of the thermal convection. In addition, it turned out that, for large Taylor numbers, cellular convection trapped near the horizontal boundaries becomes the most preferred mode.

Secondly, a numerical model is used to study the time evolution of nonlinear convection. It is confirmed that roll convection which has the largest growth rate in the linear analysis, or roll convection which is having its axis in the north east-south west tends to intensify the zonal shear flow.

Also performed is the calculation to study the interaction between convection and a zonal jet which has sinusoidal profile in meridional direction.It is found that a decaying normal mode for the sinusoidal shear flow is excited at the expense of the kinetic energy of the thermal convection. The mechanism for the excitation of the decaying normal mode is discussed.