A Numerical Simulation for the Effect of the Uniform Flow in the Horizontal Convective motion

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I. Introduction

This study concerns with properties of a thermal convection in a stably stratified Boussinesq fluid caused by partial heating at the lower boundary.

If we don't consider effect of the uniform flow, the convection takes the form of axisymmetric with respect the Z-axis. the convective motion consists of 'two-cell' with the convergence in the lower layer at the center of the partial heating area. and the temperature perturbation is characterized by the temperature 'cross over' over the partial heating area.

In this study, we would like to deal with the effects of the uniform flows on the partial heating area.

Effects of uniform flows on a two-dimensional partial heating convection were investigated by the obtaining the steady solutions of the vorticity and thermodynamic equations.

II. The model design

We deal with a Boussinesq fluid with constant kinematic viscosity(ν) thermal diffusivity(κ) and consider a two-dimensional, incompressible, nonrotating system.

A rectangular coordinate system with the vertical Z-axis is adopted.

The effect of the stable stratification may be expressed by considering the temperature field in the basic stage, which is defined as the state where there is no partial heating the lower boundary, as

$$T = \Gamma z$$

where, Γ is a positive constant and represents the stability of the fluid layer.

A perturbation is introduced into the fluid layer by specifying the constant non-zero temperature, Th, at a part of the lower boundary. We will investigate convective motion for following lower boundary configuration

$$T = \begin{cases} Th(x,0) & at \ |x| \le l \\ 0 & otherwise \end{cases} \qquad at \ z = 0$$

where, l is the half-width of the heated area

$$Th(x,0) = \frac{A}{(1 + (\frac{\pi x}{2})^2)} + 300\,K$$

A : constant

The effect of the uniform flow, U, is incorporated by considering the general flow in the basic state

III. result

When uniform flow is strong, velocity field and temperature field consist of a single cell structure which spread upstream side of the partial heating area.

The temperature pattern for strong uniform flow takes a form of positive temperature perturbation near the ground and negative temperature perturbation aloft over partial heating area. the flow pattern shows downward motion directly over the upwind portion of the partial heating area and upward motion on the downstream side.

The downstream edge of the upstream cell is shifted in the downstream direction with the increase of uniform flow almost linearly.