Experimental study on flows driven by pressure gradient force due to horizontal temperature difference

*Tomomi Terada[1], Daisuke Noto[1], Yuji Tasaka[2], Takatoshi Yanagisawa[3,2], Takehiro Miyagoshi[3], Yuichi Murai[2]

1. Graduate School of Engineering, Hokkaido University , 2. Faculty of Engineering, Hokkaido University, 3. Japan Agency for Marine-Earth Science and Technology

Convection in which both heating and cooling are applied at the same horizontal plane is called horizontal convection and plays important roles in various fluid motions on the Earth, e.g. oceanic flows, atmospheric flows, liquid metal flows inside the outer core. It is necessary to elucidate the pressure gradient force, which is considered as the main driving force of horizontal convection, however, literature on this is less even up to now. This is because the thermal buoyancy generated at the heating or cooling plates could be the driving force in most previous studies, and care for the relatively weak pressure gradient force has not been taken so far.

For detailed investigations on the pressure gradient force in horizontal convection, we have conducted visualization experiments. The test fluid is sealed in a rectangular container so as to be a stable temperature stratification, and subsequently the top of the fluid layer starts to be heated unevenly. At the time, temperature at any parts of the heating plates are higher than the initial temperature of the fluid, and thanks to this, no buoyancy sources drive the flow in the system. We observed horizontally driven fluid flows in this configuration, which may be caused by pressure gradient force originated in the horizontal temperature gradient of the uneven heating plates at the top of fluid layer. By means of particle tracking velocimetry and direct temperature measurement using horizontally aligned multiple thermistors, we quantified the horizontal acceleration of the flow and the temperature gradient at corresponding points. Pressure gradient force acting on the fluid was then evaluated through equation of motion dominating horizontal fluid motion.

Keywords: Horizontal convection, Pressure gradient force, Velocity measurement

