

Marginal Stability Analysis on Salt Fingers Convection with Parabolic Temperature and Salinity Profiles

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ABSTRACT

This paper explores the influence of parabolic profiles of temperature and salinity, as might arise due to local evaporation or warming disturbance, on the marginal stability problem in a salt-fingering regime. From the results of this article, the governing equations obtained for stationary onset of salt-fingers convection of a gravity gradient due to local disturbance in parabolic temperature and salinity profiles are similar to those obtained by the small-gap Taylor-Couette problem. Detailed relationships between the effective Rayleigh number (\tilde{R}_c), the critical wave number (a_c) and the couple disturbed local depth under the stationary stability analysis are also shown in this work. From the result of overstability analysis, it shows that oscillatory motion of salt-fingers convection will be triggered under a certain definite characteristic frequency. In overstability, it provoke restoring forces so strong as to overshoot the corresponding position on the other side of equilibrium for case of coupled disturbance in the upper layer of ocean.

KEY WORDS: salt-fingers convection; parabolic profile; stationary stability; overstability; effective Rayleigh number; couple disturbed local depth.

INTRODUCTION

Salt-fingers convection is now widely recognized as an important mechanism for mixing heat and salt both vertically and laterally in the ocean dynamics. Since the discovery of double-diffusive convection by Stommel, et. al (1956), "evidence has accumulated for the widespread presence of double-diffusion throughout the ocean" and for its "significant effects on global water-mass structure and the thermohaline convection"(Schmitt,1988). The salt-fingering form of double-diffusion has particularly attracted interest because of its peculiar long narrow convecting cell structure and enhancement of the diapycnal transport of heat and salt, even when the net density gradient is stable. Furthermore, these structures are increasingly recognized as an important mechanism for oceanic mixing and salt transport (Williams

1975, Magnell 1976, Lambert and Sturges1977). Recent observations by Osborn (1991) suggested that the finger instability is also important in near-surface waters. Kluikov and Karlin (1995) suggested that two-thirds of world ocean is favorable for fingering convection. For example, in the tropics, surface evaporation exceeds precipitation and heating exceeds cooling, producing these conditions. In contrast, the diffusive convection form of double-diffusion is commonly found in polar water where cool fresh water overlies warmer saltier water.

Salt-fingers convection has been investigated both theoretically and experimentally. Theoretical analysis of salt-fingers convection was first considered by Stern(1960). A number of works have begun with a base state in which the solute concentration and the temperature are linear functions of depth (Baines and Gill 1969). Proctor and Holyer (1986) showed that rolls are preferred over square cells for conditions modeling a salt-fingers regime. Subsequent developments for theoretical analysis of salt-fingers convection were summarized by Kunze(2003). Salt-fingering laboratory experiments were first conducted by Turner and Stommel(1964). Subsequent works were summarized by Schmitt(2003) in this issue. Analytical and modeling efforts have focused on the onset and stability of salt-fingers convection, their diapycnal heat and salt transports, layer formation, and interaction with internal waves and shear-driven turbulence.

Meanwhile, the small-scale thermohaline plumes near the surface of a calm sea under the warming condition have been revealed by oceanic observations. The stratification is favorable for the double-diffusive salt finger instability. In thinking of the instability of a hydrodynamic system, it is often convenient to suppose that all parameters of the system, save one, are kept constant while the chosen one is continuously varied. Then the hydrodynamic system passing from stable to unstable states, when the particular parameter being taken to be a certain critical value. Thus we may say that instability is set in at this value of the chosen parameter when all the others have their preassigned values. If at the onset of instability a stationary pattern of motions prevails, the principle of the exchange of stabilities is set in as the stationary cellular convection, or secondary flow. On the other hand, if at the onset of instability oscillatory motion prevails, that is the case of overstability. In the former case, the transition from stability to instability takes place via