Geophysical Research Abstracts
Vol. 17, EGU2015-15560, 2015
EGU General Assembly 2015

Instability of water-ice interface under turbulent flow

Norihiro Izumi (1), Kensuke Naito (2), and Miwa Yokokawa (3)

(1) Faculty of Engineering, Hokkaido Univ., Sapporo 060-8628, Japan (nizumi@eng.hokudai.ac.jp), (2) Ven Te Chow Hydrosystems Laboratory Dept. of Civil and Environmental Engineering University of Illinois at Urbana-Champaign, U.S.A. (kensuke.g.naito@gmail.com), (3) Lab. of Geoenvironment., Fac. Info. Sci. & Tech., Osaka Institute of Technology, Hirakata, Osaka 573-0196, Japan (miwa@is.oit.ac.jp)

It is known that plane water-ice interface becomes unstable to evolve into a train of waves. The underside of ice formed on the water surface of rivers are often observed to be covered with ice ripples. Relatively steep channels which discharge melting water from glaciers are characterized by beds covered with a series of steps. Though the flowing agent inducing instability is not water but gas including water vapor, a similar train of steps have been recently observed on the Polar Ice Caps on Mars (Spiral Troughs). They are expected to be caused by the instability of water-ice interface induced by flowing fluid on ice. There have been some studies on this instability in terms of linear stability analysis. Recently, Caporeale and Ridolfi (2012) have proposed a complete linear stability analysis in the case of laminar flow, and found that plane water-ice interface is unstable in the range of sufficiently large Reynolds numbers, and that the important parameters are the Reynolds number, the slope angle, and the water surface temperature. However, the flow inducing instability on water-ice interface in the field should be in the turbulent regime. Extension of the analysis to the case of fully developed turbulent flow with larger Reynolds numbers is needed. We have performed a linear stability analysis on the instability of water-ice interface under turbulent flow conditions with the use of the Reynolds-averaged Navier-Stokes equations with the mixing length turbulent model, the continuity equation of flow, the diffusion/dispersion equation of heat, and the Stefan equation. In order to reproduce the accurate velocity distribution and the heat transfer in the vicinity of smooth walls with the use of the mixing length model, it is important to take into account of the rapid decrease in the mixing length in the viscous sublayer. We employ the Driest model (1956) to the formulation. In addition, as the thermal boundary condition at the water surface, we describe the continuity of the heat fluxes from inside of water to the water surface and from the water surface to the surrounding air with the use of the heat transfer coefficient. The boundary condition then becomes the Robin boundary condition. It is found from the analysis, that the instability takes place in the range of large Froude numbers and small wavenumbers in the wavenumber-Froude number plane. It is also found that the unstable region does not show a significant difference when the Reynolds number is larger than somewhere around 5,000.