Geophysical Research Abstracts, Vol. 7, 01189, 2005
SRef-ID: 1607-7962/gra/EGU05-A-01189

Linear stability of thermoviscous ice-sheet flow using the Stokes equations.

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Linear stability analysis of the thermoviscous flow of ice using the shallow ice approximation (HIndmarsh, 2004a) has shown that while there is a flow-direction wavelength at which thermoviscous instabilities grow most rapidly, there is no such counterpart in the transverse wavelength. In particular, at short transverse wavelengths, the system is unstable down to very short wavelengths. The preferred transverse wavelength is infinite, meaning that thermoviscous instabilities should develop a roll/ribbing instability, and not the streams seen both in the current ice-sheet of models as well as in nature. Consistent results between ice-sheet are difficult to obtain, meaning that the process by which the streaming instability is developed in models needs to be investigated more closely.

Since the instability persists down to very short wavelengths, one factor that will influence the instability are mechanical effects not represented in the shallow ice approximation. This paper extends the analyses of Hindmarsh (2004a) and (2004b) to investigate how the full mechanical system affects the instability. A perturbation approach is adopted, which considers the free-surface flow of a thermoviscous fluid down the infinite plane. Spectra are computed as a function of the four independent parameters ice thickness, slope, geothermal heat flux and surface temperature, and compared with those obtained for the shallow ice approximation. Differences at short wavelength are highlighted.

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