# On the physics of millenial thermohaline oscillations

## A. Colin de Verdiere

Laboratoire de Physique des Oceans, Universite de Bretagne Occidentale
(email:acolindv@univ-brest.fr, fax:33 (0)2 98 01 64 68)

The physics of the millenial oscillations of the thermohaline circulation remains obscure in spite of the potential for applications to the paleoclimates of the last glacial period. Stochastic and/or periodic forcing, ocean-ice coupling, nonlinearity of the equation of state of seawater are often considered important to generate them but none of these are necessary as some recent work has shown. Under mixed boundary conditions (and salt conservation), the oscillations occur through global bifurcations in a window of freshwater flux intensity which favors reduced precipitation in polar regions. The period of the oscillations is a weak function of the mixing coefficients but becomes infinite near the edge of the window. This behavior observed in box and two-dimensional models can be reproduced with a two degree of freedom dynamical system which can be analyzed theoretically. Two kinds of steady regimes are possible: the thermal and haline Stommel states and a convective state when polar stratification is unstable. Under certain environmental conditions, additional periodic regimes are found in a freshwater window nearby the saddle-node bifurcation of Stommel model. A solution, possibly relevant to the Dansgaard-Oeschger millenial oscillations, oscillates between the Stommel haline, low circulation state which is convectively unstable and a convective, high circulation state which is dynamically unstable. The physics of these free oscillations is an alternative to stochastic resonance mechanisms which require external forcing action to generate transitions between stable steady states.