Application for computational resources at DKRZ

Dragos B. Chirila

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**Project Title:** LBOM (Lattice Boltzmann Ocean Model) || **Period:** 01.01.2010-31.12.2010

**Project Description**

Lattice Boltzmann Methods (henceforth LBM) represent relatively new techniques for fluid dynamics simulations, which have been extensively used for smaller-scale simulations. They emerged out of statistical mechanics, in contrast to more traditional methods, which are based on direct discretization of macroscopic conservation laws. The basic idea is to discretize both time and phase space, and also to separate the dynamics of the fluid particles into multiple scales, expressed through a collision and a streaming step. The streaming step involves only nearest neighbours, while the collision step is local and consists of a relaxation towards the local Maxwell-Boltzmann distribution, as required by Boltzmann’s H-theorem. This leads to a conceptually simple but very powerful paradigm, which can be proved to effectively approximate the Navier-Stokes equations under the assumption of a low Mach number. From a computational point of view, the locality of the algorithm leads to greater benefits from parallel computing compared to traditional Computational Fluid Dynamics (henceforth CFD), where an expensive global pressure correction step is usually required. Another benefit of the method relevant for the present project is the simplicity of implementing proper boundary conditions, which is of crucial importance in real-world oceanographic simulations, where the effects due to the coastline have to be resolved. Also, the method allows efficient inclusion of time-dependent fluid geometries (varying ocean level).

The aim of the present work is to extend the range of applicability of LBM to include problems in numerical oceanography. The computer time at DKRZ would be used to test some of the theoretical advances achieved within the project, which now allow realistic turbulence parameterizations to be incorporated into the LBM methodology. We will evaluate the new model through several simulations of the global ocean over decadal and centennial timescales. To our knowledge, this would be the first application of the method to a large-scale, three-dimensional, geophysical fluid dynamics problem.

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1This assumption holds for the applications in geophysical fluid dynamics.
2Especially on cache-based architectures as the new Blizzard system at DKRZ.