A Comparison of Implicitly Parallel Multithreaded and Data Parallel Implementations of an Ocean Model based on the Navier-Stokes Equations

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Abstract

We present a state-of-the-art general circulation model (GCM), which has been used to model oceans, and develop and compare two implementations of it. One implementation is written in the implicitly parallel functional language Id for the multithreaded Monsoon dataflow machine, while the other is written in a data parallel Fortran dialect for the CM-5. The multithreading model is more expressive than the data parallel model, so a goal of this study is to understand the performance penalties of multithreaded execution, if any. In order to avoid technology and machine configuration issues, the two implementations are compared in terms of overhead cycles per required floating point operation. The static nature of the data might be expected to favor the data parallel implementation. However, it turns out that both implementations have similar efficiency in geometries typical of ocean basins at spatial resolutions employed in ocean modeling. The inefficiency in the data parallel approach arises from unnecessary calculations done on land zones, while the inefficiency in the multithreaded approach arises from overhead due to the exploitation of asynchronous fine-grain parallelism.

List of Symbols

- $\vec{v}$ – vector arrow superscript
- ρ – rho
- ∇ – del
- $\triangle$ – triangle
- ϵ – epsilon
- ε – Epsilon
- τ – tau
- γ – gamma
- α – alpha
- β – beta
- ξ – xi
- $*$ – star
- δ – delta