Determining (seasonal) periodic orbits in global ocean models using continuation methods

Utku Erdogan[*], **Jonas Thies**[†], **Fred Wubs**[*], **Henk Dijkstra**[‡]

[*] Johann Bernoulli Institute for Mathematics and Computing Science
University of Groningen, P.O.Box 407, 9700 AK Groningen, The Netherlands
e-mail: f.w.wubs@rug.nl - Web page: http://www.math.rug.nl/cmnm

[†] Centre for Interdisciplinary Mathematics
Uppsala University, P.O. Box 480, 75106 Uppsala, Sweden
e-mail: jonas@math.uu.se - Web page: http://www2.math.uu.se/cim/

[‡] Institute for Marine and Atmospheric Research Utrecht
Utrecht University, Princetonplein 5, 3584 CC Utrecht, The Netherlands
e-mail: dijkstra@phys.uu.nl - Web page: http://www.phys.uu.nl/∼dijkstra

ABSTRACT

In traditional explicit time-stepping ocean-climate models an equilibrium seasonal cycle is usually obtained after a long ($\mathcal{O}(1000)$ years) spin-up simulation. It is desirable to have more efficient methods to compute these seasonal cycles, for example to study their dependence on parameters. Over the years, we have developed methods to determine steady states (and their linear stability) of global ocean models, e.g. the ThermoHaline Circulation Model (THCM), versus parameters using continuation methods [1,2]. Recently, these methods have been extended to also compute seasonal cycles of the THCM versus parameters in a global intermediate resolution configuration. Thereto, the THCM (a finite volume discretization of the ocean model equations giving a dynamical system of a few million degrees of freedom at intermediate resolution) is coupled to the LOCA and Trilinos [3] software as in [2], in which the tailored solver of [1] is implemented. Until now LOCA's feature to perform bifurcation analysis on periodically driven problems is hardly applied to realistic problems of this scale, since they lead to 4D systems. We were however able to parallelize in both the spatial and temporal directions, which makes the computations tractable. We will present results of seasonal cycles of the global ocean model in which the seasonal density and wind-forcing of the ocean is prescribed and focus on the performance of the numerical methods.

REFERENCES

[1] A.C. de Niet, F.W. Wubs, H.A. Dijkstra and A. Terwisscha van Scheltinga, *A tailored solver for bifurcations analysis of ocean-climate models*, J. Comput. Phys., **227(1)**, 654-679, 2007.

[2] J. Thies, F. W. Wubs and H.A. Dijkstra, *Bifurcation analysis of 3D ocean flows using a parallel fully implicit ocean model*, Ocean Modelling, 287-297, **30**, 2009.

[3] M.A. Heroux and J.M. Willenbring, *Trilinos Users Guide*, Techn. Report SAND2003-2952, Sandia National Laboratories, 2003.