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Mathematical Modelling of Ocean Circulation



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Mathematical Modelling of Ocean Circulation Guriĭ Ivanovich Marchuk, Artem Sarkisovich Sarkisyan, 1988-10-05

The problems of ocean dynamics present more and more complex tasks for investigators based on the continuously sophistication of theoretical models which are applied with the help of universal and efficient algorithms of numerical mathematics. The present level of our knowledge in the field of mathematical physics and numerical mathematics allows one to give rather complete theoretical analysis of basic statements of problems as well as numerical algorithms. Our task is to perform such analysis and also to analyze the results of calculations in order to improve our knowledge of the mechanism of large scale hydrological processes occurring in the World Ocean. The new level of numerical mathematics has essentially influenced the formation of new solution methods of ocean dynamics problems among which an important one is the splitting method which has been already widely practised in various fields of science and engineering. A number of monographs by N N Yanenko, A A Samarsky, G Marchuk, Rozhdestvensky and Yanenko 1968, Samarsky and Andreyev 1976, Marchuk 1970, 1980b and others are devoted to the description of these methods. But the methods of the splitting theory require extensive creative work for their application to concrete problems which are peculiar as a rule in problem formulation. The success of the application of these methods is related to the deep understanding of the essence of the described processes. In the last decades fundamental works of Arakawa K. *Mathematical Modelling of Ocean Circulation* G.I. Marchuk, A.S. Sarkisyan, 1988. The problems of ocean dynamics present more and more complex tasks for investigators based on the continuously sophistication of theoretical models which are applied with the help of universal and efficient algorithms of numerical mathematics. The present level of our knowledge in the field of mathematical physics and numerical mathematics allows one to give rather complete theoretical analysis of basic statements of problems as well as numerical algorithms. Our task is to perform such analysis and also to analyze the results of calculations in order to improve our knowledge of the mechanism of large scale hydrological processes occurring in the World Ocean. The new level of numerical mathematics has essentially influenced the formation of new solution methods of ocean dynamics problems among which an important one is the splitting method which has been already widely practised in various fields of science and engineering. A number of monographs by N N Yanenko, A A Samarsky, G Marchuk, Rozhdestvensky and Yanenko 1968, Samarsky and Andreyev 1976, Marchuk 1970, 1980b and others are devoted to the description of these methods. But the methods of the splitting theory require extensive creative work for their application to concrete problems which are peculiar as a rule in problem formulation. The success of the application of these methods is related to the deep understanding of the essence of the described processes. In the last decades fundamental works of Arakawa K. *Ocean Circulation and Pollution Control - A Mathematical and Numerical Investigation* Jesús I. Díaz, 2012-12-06. In the framework of the Diderot Mathematical Forum DMF of the European Mathematical Society EMS December 19-20 1997 a Videoconference was held linking three teams of specialists in Amsterdam, Madrid and Venice.

respectively The general subject of this videoconference the second one of the DMF series was Mathematics and Environment and more specifically Problems related to Water This volume contains the texts of the Madrid site contributions with important new and unpublished examples on the modeling mathematical and numerical analysis and treatment of the associated control problems of relevant questions arising in Oceanography and Environment ***Numerical Modeling of Ocean Circulation*** Robert N. Miller,2007-01-18 The modelling of ocean circulation is important not only for its own sake but also in terms of the prediction of weather patterns and the effects of climate change This 2007 book introduces the basic computational techniques necessary for all models of the ocean and atmosphere and the conditions they must satisfy It describes the workings of ocean models the problems that must be solved in their construction and how to evaluate computational results Major emphasis is placed on examining ocean models critically and determining what they do well and what they do poorly Numerical analysis is introduced as needed and exercises are included to illustrate major points Developed from notes for a course taught in physical oceanography at the College of Oceanic and Atmospheric Sciences at Oregon State University this book is ideal for graduate students of oceanography geophysics climatology and atmospheric science and researchers in oceanography and atmospheric science ***Numerical Modeling of Ocean Circulation*** Robert Naham Miller,2007

Numerical Ocean Circulation Modeling Aike Beckmann,Dale B Haidvogel,1999-04-29 This book offers a comprehensive overview of the models and methods employed in the rapidly advancing field of numerical ocean circulation modeling For those new to the field concise reviews of the equations of oceanic motion sub grid scale parameterization and numerical approximation techniques are presented and four specific numerical models chosen to span the range of current practice are described in detail For more advanced users a suite of model test problems is developed to illustrate the differences among models and to serve as a first stage in the quantitative evaluation of future algorithms The extensive list of references makes this book a valuable text for both graduate students and postdoctoral researchers in the marine sciences and in related fields such as meteorology and climate and coupled biogeochemical modeling

Modelling Ocean Climate Variability Artem S. Sarkisyan,Jürgen Sündermann,2009-05-13 In this wide ranging and comprehensive review of the historical development and current status of ocean circulation models the analysis extends from simple analytical approaches to the latest high resolution numerical models with data assimilation The authors both of whom are pioneer scientists in ocean and shelf sea modelling look back at the evolution of Western and Eastern modelling methodologies during the second half of the last century They also present the very latest information on ocean climate modelling and offer examples for a number of oceans and shelf seas The book includes a critical analysis of literature on ocean climate variability modelling as well as assessing the strengths and weaknesses of the best known modelling techniques It also anticipates future developments in the field focusing on models based on a synthesis of numerical simulation and field observation and on nonlinear thermodynamic model data synthesis ***Oceanic Circulation Models***

D.L.T. Anderson,J. Willebrand,1989-08-31 Proceedings of the NATO Advanced Study Institute on Modelling the Ocean General Circulation and Geochemical Tracer Transport Les Houches France February 15 26 1988 *Mathematical Study of Degenerate Boundary Layers: A Large Scale Ocean Circulation Problem* Anne-Laure Dalibard,Laure

Saint-Raymond,2018-05-29 This paper is concerned with a complete asymptotic analysis as ϵ to 0 of the Munk equation $\partial_x \psi \epsilon \Delta^2 \psi \tau$ in a domain Ω subset \mathbf{R}^2 supplemented with boundary conditions for ψ and $\partial_n \psi$. This equation is a simple model for the circulation of currents in closed basins the variables x and y being respectively the longitude and the latitude. A crude analysis shows that as ϵ to 0 the weak limit of ψ satisfies the so called Sverdrup transport equation inside the domain namely $\partial_x \psi \epsilon 0 \tau$ while boundary layers appear in the vicinity of the boundary Mathematical Modeling in Studies of Arctic Ocean Circulation N. Yu Doronin,A. Yu Proshutinsky,ARCTIC AND ANTARCTIC RESEARCH INST LENINGRAD (Soviet Union),1992 A hierarchy of mathematical models adapted to certain physical phenomena of the Arctic Ocean has been developed. The density structure of the Arctic Ocean water is characterized by a well marked stratification. This allows us to describe it by means of models with a discrete stratification. In this context a two dimensional model of the upper 200 m of the ocean can be considered as the lowest level of a hierarchy of models. With the help of this model coupled with the ice drift model seasonal oscillations of sea level and variability of barotropic water circulation in the annual cycle affected by wind atmospheric pressure and river runoff were studied. The same model is used to successfully predict level oscillations and ice drift up to 6 days in advance. The multi layer models are suggested as models of the second level. For example energy concentration in the upper layer of the ocean the main property of baroclinicity is well simulated in the two layer version. The advantage of these models as compared with those of the first level is that the depth of the interface is given as a solution. The diagnostic two layer model is quite simple to use on small computers. The prognostic two layer model allows one to estimate the time when the water circulation becomes stationary in the ocean of real depth. The diagnostic three dimensional ocean model with a continuous stratification is suggested as the third level model. The elliptical equation relative to denivelation of the free surface is the governing equation of the model. The estimation of the terms of the motion and continuity equations indicates the need to introduce geostrophic corrections for non linear effects and a horizontal turbulent exchange when calculating vertical current velocity

Nonlinear Physical Oceanography Henk A. Dijkstra,2007-07-16 Taken from a review of the first edition in SIAM This text is different from most others in that it combines several different disciplines and draws on many scientific studies in order to deduce mechanisms of ocean circulation. Therefore it cannot be substituted and it meets its unique goals with clarity and thoroughness *Some Aspects of the New York University Mathematical Model of the Ocean for Oceanographic Forecasting* Akira Ōkubo,1970 A working numerical model for oceanographic forecasting is being developed at the Department of Meteorology and Oceanography New York University In this paper we discuss a few aspects of physical problems in the basic model equations

and boundary conditions These are 1 realistic initial conditions which enable the forecasting model to track rapidly variable wind stresses and water properties imposed at the sea surface 2 nonlinear eddy fluxes in the vertical direction and 3 boundary mixing at lateral and bottom walls In Problem 1 use is made of the results on theoretical models for the thermohaline circulation of the oceans to construct the realistic initial conditions Thus the velocity and density fields are expressed by similarity forms that are valid in the interior of the ocean In Problem 2 the dependence of the vertical eddy conductivity on water stratification is taken into account in the vertical flux of heat The resultant diffusion process may describe realistic temperature profiles in the surface layer for a warming period In Problem 3 two kinds of boundary mixing processes are studied Author **The Ocean Circulation Inverse Problem** Carl Wunsch,1996-06-13 This book addresses the problem of inferring the state of the ocean circulation from a mathematical perspective

Ocean Modeling and Parameterization Eric P. Chassignet,Jacques Verron,2012-12-06 The realism of large scale numerical ocean models has improved dramatically in recent years in part because modern computers permit a more faithful representation of the differential equations by their algebraic analogs Equally significant if not more so has been the improved understanding of physical processes on space and time scales smaller than those that can be represented in such models Today some of the most challenging issues remaining in ocean modeling are associated with parameterizing the effects of these high frequency small space scale processes Accurate parameterizations are especially needed in long term integrations of coarse resolution ocean models that are designed to understand the ocean variability within the climate system on seasonal to decadal time scales Traditionally parameterizations of subgrid scale high frequency motions in ocean modeling have been based on simple formulations such as the Reynolds decomposition with constant diffusivity values Until recently modelers were concerned with first order issues such as a correct representation of the basic features of the ocean circulation As the numerical simulations become better and less dependent on the discretization choices the focus is turning to the physics of the needed parameterizations and their numerical implementation At the present time the success of any large scale numerical simulation is directly dependent upon the choices that are made for the parameterization of various subgrid processes

Nonlinear Physical Oceanography Henk A. Dijkstra,2005-05-04 Taken from a review of the first edition in SIAM This text is different from most others in that it combines several different disciplines and draws on many scientific studies in order to deduce mechanisms of ocean circulation Therefore it cannot be substituted and it meets its unique goals with clarity and thoroughness

Mathematical Models of the Ocean Circulation Keith Richard Thompson,University of Manchester,1974

Dynamical Oceanography Henk A. Dijkstra,2008-10-01 This textbook provides a mathematical introduction to the theory of large scale ocean circulation It is accessible for readers with an elementary knowledge of mathematics and physics including continuum mechanics and solution methods for ordinary differential equations At the end of each chapter several exercises are formulated Many of these are aimed to further develop methodological skills and to get familiar with the

physical concepts New material is introduced in only a few of these exercises Fully worked out answers to all exercises can be downloaded from the book s web site NBS Special Publication ,1973 *Mathematical Modelling of Tides and Estuarine Circulation* P. B. Crean,Tadepalli Satyanarayana Murty,J. A. Stronach,1988 *Hydraulic Research in the United States and Canada* ,1972

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