Baroclinic Tides Theoretical Modeling And Observational Evidence

Rapid development of Earth observation satellite using remote sensing techniques enables observations of the oceanic processes by sea and airborne study to be carried out over vast areas in a short time. This first book written by Russian and Norwegian scientists is an analysis of studies of the Kara Sea and presents a unique catalogue of environmental and pollution data of the joint Norwegian and Russian oceanographic expedition studies of the Kara Sea spanning three decades.

This book covers the areas of fundamentals in energy conservation and its applications in selected industries. There are nine chapters in this book which have been written by leading experts in energy from all over the world. The topics range from energy fundamentals from cosmic radiation, tidal waves and dams. The chapters examine the potential of utilizing energy from sustainable resources and how energy consumption may be conserved from various new technologies. The contents of this book include space energy, barotropic and baroclinic tidal energy, understanding energy conservation in biological context, Earth shelters, hydro power, biofuel from groundnut oil and low energy consumption in industrial production. This book is suitable as a reference for students, educators, researchers, scientists, engineers and energy practitioners. It will also be a useful for the understanding of energy fundamentals, design and applications.

Covers the traditional range of topics in regional oceanography. An important aspect of work is its novel approach to a description of the features which give each ocean region its character. The two core principles are the use of the most modern database for all maps of regional distributions of properties and a discussion of all observed features within a frame of reference developed from ocean dynamics, rather than based on the simple geographical approach. The ocean's role in climate variability and climate change is described in detail. The book also includes an evaluation of all major international research projects such as FGGE, IIOE and TOGA. The SI system is used throughout. The use of modern data and inclusion of the oceanographic literature up to 1992 and early 1993 make it a useful reference text.

This book commemorates the 70th birthday of Eugene Morozov, the noted Russian observational oceanographer. It contains many contributions reflecting his fields of interest, including but not limited to tidal internal waves, ocean circulation, deep ocean currents, and Arctic oceanography. Special attention is paid to studies on internal waves and especially those on tidal internal waves in the Global Ocean. These papers describe the most important open problems concerning experimental studies of internal waves and their theoretical, numerical, and laboratory modeling. Further contributions investigate the physics of surface waves and their interaction with internal waves. Here, the focus is on describing interaction processes between internal waves and deep currents in the ocean, especially currents of Antarctic Bottom Water in abyssal fractures. They also touch on the problem of oceanic circulation and related processes in fjords, including those occurring under sea ice. Given its breadth of coverage, the book will appeal to anyone interested in a survey of ocean dynamics, ranging from historic perspectives to modern research topics.

Internal wave dynamics in lakes (and oceans) is an important physical component of geophysical fluid mechanics of ‘quiescent’ water bodies of the Globe. The formation of internal waves requires seasonal stratification of the water bodies and generation by (primarily) wind forces. Because they propagate in basins of variable depth, a generated wave field often experiences transformation from large basin-wide scales to smaller scales. As long as this fission is hydrodynamically stable, nothing dramatic will happen. However, if vertical density gradients and shearing of the horizontal currents in the metalimnion combine to a Richardson number sufficiently small (

"Understanding Tides, Surges, Tsunamis and Mean Sea-Level Changes Sea levels change for many reasons and on many timescales, and extreme sea levels can result in catastrophic coastal flooding, such as the Katrina storm surge in 2005 or the Sumatra tsunami in 2004. As global sea level rises, and coastal populations increase, understanding sea-level processes becomes key to plan future coastal defence effectively"--

Optical Remote Sensing is one of the main technologies used in sea surface monitoring. Optical Remote Sensing of Ocean Hydrodynamics investigates and demonstrates capabilities of optical remote sensing technology for enhanced observations and detection of ocean environments. It provides extensive knowledge of physical principles and capabilities of optical observations of the oceans at high spatial resolution, 1-4m, and on the observations of surface wave hydrodynamic processes. It also describes the implementation of spectral-statistical and fusion algorithms for analyses of multispectral optical databases and establishes physics-based criteria for detection of complex wave phenomena and hydrodynamic disturbances including assessment and management of optical databases. This book explains the physical principles of high-resolution optical imagery of the ocean surface, discusses for the first time the capabilities of observing hydrodynamic processes and events, and emphasizes the integration of optical measurements and enhanced data analysis. It also covers both the assessment and the interpretation of dynamic multispectral optical databases and includes applications for advanced studies and nonacoustic detection. This book is an invaluable resource for researches, industry professionals, engineers, and students working on cross-disciplinary problems in ocean hydrodynamics, optical remote sensing of the ocean and sea surface remote sensing. Readers in the fields of geosciences and remote sensing, applied physics, oceanography, satellite observation technology, and optical engineering will learn the theory and practice of optical interactions with the ocean.

This book offers a unique multidisciplinary integration of the physics of turbulence and remote sensing technology. Remote Sensing of Turbulence provides a new vision on the research of turbulence and summarizes the current and future challenges of monitoring turbulence remotely. The book emphasizes sophisticated geophysical applications, detection, and recognition of complex turbulent flows in oceans and the atmosphere. Through several techniques based on microwave and optical/IR observations, the text explores the technological capabilities and tools for the detection of turbulence, their signatures, and variability. FEATURES Covers the fundamental aspects of turbulence problems with a broad geophysical scope for a wide audience of readers Provides a complete description of remote-sensing capabilities for observing turbulence in the earth’s environment Establishes the state-of-the-art remote-sensing techniques and methods of data analysis for turbulence detection Investigates and evaluates turbulence detection signatures, their properties, and variability Provides cutting-edge remote-sensing applications for space-based monitoring and forecasts of turbulence in oceans and the atmosphere This book is a great resource for applied physicists, the professional remote sensing community, ecologists, geophysicists, and earth scientists.

Published by the American Geophysical Union as part of the Coastal and Estuarine Sciences, Volume 3. The AGU Monograph Series on Coastal and Estuarine Regimes provides timely summaries and reviews of major process and regional studies, both observational and theoretical, and of theoretical and numerical models. It grew out of an IAPSO/SCOR/ECOR working group initiative several years ago intended to enhance scientific communications on this topic. The series' authors and editors are drawn from the international community. The ultimate goal is to stimulate bringing the theory, observations, and modeling of coastal and estuarine regimes together on the global scale.

Shipboard ADCP and CTD measurements were conducted in Monterey Submarine Canyon in April and October 1994 to determine the

propagation characteristics and energy levels of the semidiurnal internal tide. The measurements reveal a bottom intensified internal tide propagating energy up canyon. The region of strongest motion is in a beam 150-200 m thick, centered approximately 150 m above the Canyon floor. Along canyon baroclinic M2 currents are typically 15-20 cm/s, an order of magnitude larger than the estimated barotropic tidal currents. In April 1994, the internal tidal beam is well described by a progressive wave, while in October 1994, the signal is standing along and perpendicular to the beam. The Princeton Ocean Model was used to study the generation and propagation of semidiurnal internal tides in submarine canyons and to investigate their sensitivity to canyon shape.

This book was first published in 2005. When an oceanic tidal wave that is primarily active on the water surface passes an ocean shelf or a region with a seamount, it is split into a less energetic surface wave and other internal modes with different wavelengths and propagation speeds. This cascading process, from the barotropic tides to the baroclinic components, leads to the transformation of tidal energy into turbulence and heat, an important process for the dynamics of the lower ocean. Baroclinic Tides demonstrates the analytical and numerical methods used to study the generation and evolution of baroclinic tides and, by comparison with experiments and observational data, shows how to distinguish and interpret internal waves. Strongly non-linear solitary internal waves, which are generated by internal tidal waves at the final stage of their evolution, are investigated in detail. This book is intended for researchers and graduate students of physical oceanography, geophysical fluid dynamics and hydroacoustics.

Coral reefs are the largest landforms built by plants and animals. Their study therefore incorporates a wide range of disciplines. This encyclopedia approaches coral reefs from an earth science perspective, concentrating especially on modern reefs. Currently coral reefs are under high stress, most prominently from climate change with changes to water temperature, sea level and ocean acidification particularly damaging. Modern reefs have evolved through the massive environmental changes of the Quaternary with long periods of exposure during glacially lowered sea level periods and short periods of interglacial growth. The entries in this encyclopedia condense the large amount of work carried out since Charles Darwin first attempted to understand reef evolution. Leading authorities from many countries have contributed to the entries covering areas of geology, geography and ecology, providing comprehensive access to the most up-to-date research on the structure, form and processes operating on Quaternary coral reefs.

A history of the study of the tides over two millennia, from Ancient Greeks to present sophisticated space-age techniques.

This textbook is a self-contained introduction to tides that will be useful for courses on tides in oceans and coastal seas at an advanced undergraduate and postgraduate level, and will also serve as the go-to book for researchers and coastal engineers needing information about tides. The material covered includes: a derivation of the tide-generating potential; a systematic overview of the main lunar periodicities; an intuitive explanation of the origin of the main tidal constituents; basic wave models for tidal propagation (e.g. Kelvin waves, the Taylor problem); shallow-water constituents; co-oscillation and resonance; frictional and radiation damping; the vertical structure of tidal currents; and a separate chapter on internal tides, which deals with ocean stratification, propagation of internal tides (vertical modes and characteristics) and their generation. Exercises are provided in each chapter.

Ocean Mixing: Drivers, Mechanisms and Impacts presents a broad panorama of one of the most rapidly-developing areas of marine science. It highlights the state-of-the-art concerning knowledge of the causes of ocean mixing, and a perspective on the implications for ocean circulation, climate, biogeochemistry and the marine ecosystem. This edited volume places a particular emphasis on elucidating the key future questions relating to ocean mixing, and emerging ideas and activities to address them, including innovative technology developments and advances in methodology. Ocean Mixing is a key reference for those entering the field, and for those seeking a comprehensive overview of how the key current issues are being addressed and what the priorities for future research are. Each chapter is written by established leaders in ocean mixing research; the volume is thus suitable for those seeking specific detailed information on sub-topics, as well as those seeking a broad synopsis of current understanding. It provides useful ammunition for those pursuing funding for specific future research campaigns, by being an authoritative source concerning key scientific goals in the short, medium and long term. Additionally, the chapters contain bespoke and informative graphics that can be used in teaching and science communication to convey the complex concepts and phenomena in easily accessible ways. • Presents a coherent overview of the state-of-the-art research concerning ocean mixing • Provides an in-depth discussion of how ocean mixing impacts all scales of the planetary system • Includes elucidation of the grand challenges in ocean mixing, and how they might be addressed

This book presents a detailed study of the structure and variability of internal tides and their geographical distribution in the ocean. Based on experimental analysis of oceanic measurements combined with numerical modeling, it offers a comprehensive overview of the internal wave processes around the globe. In particular, it is based on moored buoys observations in many regions in all oceans (Atlantic, Pacific, Indian, Arctic, and Southern) that have been carried out by researchers from different countries for more than 40 years as part of various oceanographic programs, including WOCE and CLIVAR. However, a significant portion of the data was collected by the author, who is a field oceanographer. The data was processed and interpreted on the basis of the latest knowledge of internal wave motion. The properties of internal waves were analyzed in relation to the bottom topography and mean state of the ocean in specific regions. Internal waves play a major role in the formation of seawater stratification and are responsible for the main processes of ocean dynamics, such as energy transfer and mixing. One of the most significant ideas presented in this book is the generation of internal tides over submarine ridges. Energy fluxes from submarine ridges related to tidal internal waves greatly exceed the fluxes from continental slopes. Submarine ridges form an obstacle to the propagation of tidal currents, which can cause the creation of large amplitude internal tides. Energy fluxes from submarine ridges account for approximately one fourth of the total energy dissipation of the barotropic tides. Model simulations and moored measurements have been combined to generate a map of global distribution of internal tide amplitudes. This book is of interest to oceanographers, marine biologists, civil engineers, and scientists working in climate research, fluid mechanics, acoustics, and underwater navigation.

Wave breaking represents one of the most interesting and challenging problems for fluid mechanics and physical oceanography. Over the last 15 years our understanding has undergone a dramatic leap forward, and wave breaking has emerged as a process whose physics is clarified and quantified. Ocean wave breaking plays the primary role in the air-sea exchange of momentum, mass and heat, and it is of significant importance for ocean remote sensing, coastal and ocean engineering, navigation and other practical applications. This book outlines the state of the art in our understanding of wave breaking and presents the main outstanding problems. It is a valuable resource for anyone interested in this topic: researchers, modellers, forecasters, engineers and graduate students in physical oceanography, meteorology and ocean engineering.

Edited by R.H.J. Grimshaw, this book covers the topic of solitary waves in fluids.

The new level of precision and global coverage provided by satellite altimetry is rapidly advancing studies of ocean circulation. It allows for new insights into marine geodesy, ice sheet movements, plate tectonics, and for the first time provides high-resolution bathymetry for previously unmapped regions of our watery planet and crucial information on the large-scale ocean features on intra-season to interannual time scales. Satellite Altimetry and Earth Sciences has integrated the expertise of the leading international researchers to demonstrate the techniques, missions, and accuracy of satellite altimetry, including altimeter measurements, orbit determination, and ocean circulation models. Satellite altimetry is helping to advance studies of ocean circulation, tides, sea level, surface waves and allowing new insights into marine geodesy. Satellite Altimetry and Earth Sciences provides high resolution bathymetry for previously unmapped regions of our watery planet. Satellite Altimetry and Earth Sciences is for a very broad spectrum of academics, graduate students, and researchers in geophysics, oceanography, and the space and earth sciences. International agencies that fund satellite-based research will also appreciate the handy reference on the applications of satellite altimetry.

This book contains a comprehensive study of the internal ocean waves, which play a very important role in ocean physics providing mechanisms for ocean water mixing and circulation, as well as the transportation of gases, nutrients, and a very large number of marine organisms in the ocean body. In contrast to surface waves, the literature on internal waves is not so numerous, mainly due to the difficulties in experimental data collection and in the mathematical description of internal wave propagation. In this book, the basic mathematical principles, a physical description of the observed phenomena, and practical theoretical methods of determination of wave parameters as well as the original method of observation using moving sensors are presented. Special attention is paid to internal wave propagation over changing bottom topographies in shallow seas such as the Baltic Sea. The book is supplemented with an extended list of relevant and extended bibliographies, a subject index, and an author index.

Oceans play a pivotal role in our weather and climate. Ocean-borne commerce is vital to our increasingly close-knit global community. Yet we do not fully understand the intricate details of how they function, how they interact with the atmosphere, and what the limits are to their biological productivity and their tolerance to wastes. While satellites are helping us to fill in the gaps, numerical ocean models are playing an important role in increasing our ability to comprehend oceanic processes, monitor the current state of the oceans, and to a limited extent, even predict their future state. Numerical Models of Oceans and Oceanic Processes is a survey of the current state of knowledge in this field. It brings together a discussion of salient oceanic dynamics and processes, numerical solution methods, and ocean models to provide a comprehensive treatment of the topic. Starting with elementary concepts in ocean dynamics, it deals with equatorial, mid-latitude, high latitude, and coastal dynamics from the perspective of a modeler. A comprehensive and up-to-date chapter on tides is also included. This is followed by a discussion of different kinds of numerical ocean models and the pre- and post-processing requirements and techniques. Air-sea and ice-ocean coupled models are described, as well as data assimilation and nowcast/forecasts. Comprehensive appendices on wavelet transforms and empirical orthogonal functions are also included. This comprehensive and up-to-date survey of the field should be of interest to oceanographers, atmospheric scientists, and climatologists. While some prior knowledge of oceans and numerical modeling is helpful, the book includes an overview of enough elementary material so that along with its companion volume, Small Scale Processes in Geophysical Flows, it should be useful to both students new to the field and practicing professionals. * Comprehensive and up-to-date review * Useful for a two-semester (or one-semester on selected topics) graduate level course * Valuable reference on the topic * Essential for a better understanding of weather and climate

Mixing processes in the ocean play a key role in controlling the large-scale circulation and energy distribution of the ocean. Internal tide-driven mixing is most important among the processes to mix the ocean interior. In the past decade, significant efforts have been made to understand tidal mixing processes. However, more details and better understanding are still required for some fundamental problems, such as the mechanisms that govern internal tide generation, radiation, and dissipation processes and the associated energy partitioning. This research aims to understand the energetics and dynamics of tidal mixing processes through both theoretical analysis and numerical simulations. The complete form of barotropic and baroclinic energy equations are derived and employed as the theoretical framework for analyzing the tidal energy budget. These equations provide a more accurate and detailed energy analysis because they include the full nonlinear and nonhydrostatic energy flux contributions as well as an improved evaluation of the available potential energy. This approach has been implemented in the hydrodynamic SUNTANS model, which is being employed to study the energetics of barotropic-to-baroclinic tidal conversion over complex bathymetry in the real ocean. Three-dimensional, high-resolution simulations of the barotropic and baroclinic tides in the Monterey Bay area are conducted using the SUNTANS model. A detailed analysis of the energy budget is performed to address the question of how the barotropic tidal energy is partitioned between local barotropic dissipation and local generation of baroclinic energy. After that, we then assess how much of this generated baroclinic energy is lost locally versus how much is radiated away and made available for open-ocean mixing. The mechanism of internal tide generation is investigated by examining the dependence of barotropic-to-baroclinic energy conversion on three nondimensional parameters, namely the steepness parameter, the tidal excursion parameter, and the Froude number. Finally, a simple parametric model is presented to estimate the barotropic-to-baroclinic energy conversion.

This first volume in the treatise on the Physics of Lakes deals with the formulation of the mathematical and physical background. A large number of lakes on Earth are described, presenting their morphology as well as the causes of their response to the driving environment. Because the physics of lakes cannot be described without the language used in mathematics, these subjects are introduced first by using the simplest approach and with utmost care, assuming only a limited college knowledge of classical Newtonian physics, and continues with increasing complexity and elegance, starting with the fundamental equations of Lake Hydrodynamics in the form of ‘primitive equations’ and leading to a detailed treatment of angular momentum and vorticity. Following the presentation of these fundamentals turbulence modeling is introduced with Reynolds, Favre and other non-ergodic filters. The derivation of averaged field equations is presented with different closure schemes, including the k-? model for a Boussinesq fluid and early anisotropic closure schemes. This is followed by expositions of surface gravity waves without rotation and an analysis of the role played by the distribution of mass within water bodies on the Earth, leading to a study of internal waves. The vertical structure of wind-induced currents in homogeneous and stratified waters and the Ekman theory and some of its extensions close this first volume of Physics of Lakes. The last chapter collects formulas for the phenomenological coefficients of water.

Baroclinic tides result from the interaction of barotropic tides with topography in stratified oceans. They play an important role in

driving deep ocean mixing. In this research, investigations of the dynamics of baroclinic tides and internal solitary waves (ISWs) in the northern South China Sea (SCS) are conducted, mainly by means of the Massachusetts Institute of Technology general circulation model (MITgcm). Firstly, simulations of internal wave generation at the Luzon Strait (LS) are carried out. By conducting three-dimensional (3D), high-resolution experiments, it was found that the generated wave field features a multi-modal structure: large, pronounced ISWs of first mode (amplitude ~120 m) and second mode (amplitude ~120 m) were reproduced. The two north-south aligned ridges in the LS contribute together to the generation of the second mode ISWs, whereas the easternmost ridge of the two is responsible for the first mode ISWs. It was found that multiple generation mechanisms of internal waves could occur in this region, and overall it belongs to a mixed lee wave regime. A specific type of short internal waves arose during the 3D simulation. These ride on a second mode ISW with similar phase speed, trailing a first mode ISW. The short waves possess wavelengths of ~1.5 km and amplitudes of ~20 m, and only show up in the upper layer up to a depth of ~500 m. Scrutiny of the generation process showed that these short waves appear in two distinct regions and are produced due to two mechanisms, namely, the disintegration of an inclined baroclinic bore near the LS, and the overtaking of a second mode ISW in the deep water by a faster first mode ISW. Robust evidence has been sought from satellite imagery and by solving the theoretical Taylor-Goldstein Equation to verify their existence. The effects of superposition of multiple tidal harmonics (diurnal and semidiurnal) on the resultant ISW generation were investigated. It was first found that, by analyzing historical observational data, the occurrence of ISWs in the far-field always follow strong semidiurnal barotropic tidal peaks in the LS, regardless of whether it is the maximum for the diurnal or total tidal strength. However, modelling results of MITgcm and a linear internal tide generation model demonstrate that the diurnal tidal harmonics modulate the arrival time and amplitude of the propagating ISWs. Specifically, it leads to the emergence of the so-called A and B type ISWs and an alternation and transition between the two. Secondly, the shoaling process of ISWs in the northern SCS slope-shelf area is investigated. A series of two-dimensional (2D) experiments are set up to study the shoaling of a large-amplitude second mode concave ISW over a linear slope that resembles the SCS slope. Modelling results show that a strong transformation of the wave profile starts to take place when the wave is approaching the shelf break. A convex type wave is born at the trailing edge of the incident wave and gradually disintegrates into a group of ISWs due to the steepening of the rear wave profile. The frontal face of the wave gets flatter when travelling on the slope, but forms a steep structure right above the shelf break. However, this steep structure shows no tendency to evolve into an ISW: instead, it gets increasingly flat again while evolving on the shelf. The trailing convex wave packet travels faster and merges with the frontal concave wave. Finally, a wave packet with rank-ordered convex ISWs moves forward steadily on the shelf. Energy transfer to the ambient modes is evident, as both first mode and higher modes are clearly seen during and after the shoaling process. First mode ISW evolution is studied too by performing 3D, high-resolution experiments over the wide northern SCS slope and shelf area. It was found that the wave profiles change drastically near the shelf break and the Dongsha Atoll. In agreement with satellite imagery, the wavefront of the leading ISW becomes more spatially oblique with respect to its original orientation as it progresses westward due to the inclination of the slope in the topography. Wave disintegration is prominent in the shallow water zone, and wave polarity reverses near the turning point (at the 130 m isobath), which is consistent with the predictions of weakly nonlinear theory. A series of 2D experiments were set up to inspect the effects of rotation on the shoaling ISW. The results indicate that under the rotation, upon reaching the continental shelf, one shoaling ISW could disintegrate into one ISW packet and one secondary solibore that contains a number of rank-ordered waves with much shorter wavelength than an ISW. The secondary solibore is very pronounced in the northern portion of the northern SCS slope and shelf, but could hardly be discerned in the southern portion, which is consistent with the outcome of 3D simulations.

This book contains the written versions of invited lectures presented at the Gerhard H. Jirka Memorial Colloquium on Environmental Fluid Mechanics, held June 3-4, 2011, in Karlsruhe, Germany. Professor Jirka was widely known for his outstanding work in Environmental Fluid Mechanics, and 23 eminent world-leading experts in this field contributed to

A self-contained introduction to tides, explaining the origin of tidal constituents and their wave propagation in oceans and coastal seas.

This Special Issue is a collection of papers addressing the scientific use of data acquired in the course of the TerraSAR-X mission 10 years after launch. The articles deal with the mission itself, the accuracy of the products, with differential interferometry, and with applications in the domains cryosphere, oceans, wetlands, and urban areas.