On Sea Ice

This book presents the fundamental laws of sea ice drift, as derived from the material properties of sea ice, the basic laws of mechanics, and the latest modeling techniques. Topics covered include the science of sea ice drift, forecasting velocity based on volume, size and shape, sea ice ridging and remote sensing, modelling of ice conditions, and the role of sea ice drift in oceanography, marine ecology and engineering.

Sea ice is a major component of polar environments, especially in the Arctic where it covers the entire Arctic Ocean throughout most of the year. However, in the context of climate change, the Arctic sea ice cover has been declining significantly over the last decades, either in terms of its concentration or thickness. The sea ice cover evolution and climate change are strongly coupled through the albedo positive feedback, thus possibly explaining the Arctic amplification of climate warming. In addition to thermodynamics, sea ice kinematics (drift, deformation) appears as an essential factor in the evolution of the ice cover through a reduction of the average ice age (and consequently of the cover's thickness), or ice export out of the Arctic. This is a first motivation for a better understanding of the kinematical and mechanical processes of sea ice. A more upstream, theoretical motivation is a better understanding of the brittle deformation of geophysical objects across a wide range of scales. Indeed, owing to its very strong kinematics, compared e.g. to the Earth's crust, an unrivaled kinematical data set is available for sea ice from in situ (e.g. drifting buoys) or satellite observations. Here, we review the recent advances in the understanding of sea ice drift, deformation and fracturing obtained from these data. We focus particularly on the scaling properties in time and scale that characterize these processes, and we emphasize the analogies that can be drawn from the deformation of the Earth's crust. These scaling properties, which are the signature of long-range elastic interactions within the cover, constrain future developments in the modeling of sea ice mechanics. We also show that kinematical and rheological variables such as average velocity, average strain-rate or strength have significantly changed over the last decades, accompanying and actually accelerating the Arctic sea ice decline.

This book provides an advanced introduction to the science behind automated prediction systems, focusing on sea ice analysis and forecasting. Starting from basic principles, fundamental concepts in sea ice physics, remote sensing, numerical methods, and statistics are explained at an accessible level. Existing operational automated prediction systems are described and their impacts on information providers and end clients are discussed. The book also provides insight into the likely future development of sea ice services and how they will evolve from mainly manual processes to increasing automation, with a consequent increase in the diversity and information content of new ice products. With contributions from world-leading experts in the fields of sea ice remote sensing, data assimilation, numerical modelling, and verification and operational prediction, this comprehensive reference is ideal for students, sea ice analysts, and researchers, as well as decision-makers and professionals working in the ice service industry.

At a time when the polar regions are undergoing rapid and unprecedented change, understanding exchanges of momentum, heat and salt at the ice-ocean interface is critical for realistically predicting the future state of sea ice. By offering a measurement platform largely unaffected by surface waves, drifting sea ice provides a unique laboratory for studying aspects of geophysical boundary layer flows that are extremely difficult to measure elsewhere. This book draws on both extensive observations and theoretical principles to develop a concise description of the impact of stress, rotation, and buoyancy on the turbulence scales that control exchanges between the atmosphere and underlying ocean when sea ice is present. Several interesting and unique observational data sets are used to illustrate different aspects of ice-ocean interaction ranging from the impact of salt on melting in the Greenland Sea marginal ice zone, to how nonlinearities in the equation of state for seawater affect mixing in the Weddell Sea. The book's content, developed from a series of lectures, may be appropriate additional material for upper-level undergraduates and first-year graduate students studying the geophysics of sea ice and planetary boundary layers.

Arctic Sea Ice Ecosystem

Proceedings of a Workshop

Springtime Melt Onset on Arctic Sea Ice from Satellite Observations and Related Atmospheric Conditions

Introduction to the Physics of the Cryosphere

Antarctic Sea Ice Variability in the Southern Ocean-Climate System

Sea of Ice

The Inuit relationship with sea ice told through stories, artwork and photographs

The book on sea ice ecology is the ecology of sea ice algae and other microorganism as bacteria, meiofauna, and viruses residing inside or at the bottom of the sea ice, called the sympagic biota. Organisms as seals, fish, birds, and Polar bears relies on sea ice but are not part of this biota. A distinct feature of this ecosystem, is the disappearance (melt) every summer and re-establishing in autumn and winter. The book is organized seasonally describing the physical, optical, biological, and geochemical conditions typical of the seasons: autumn, winter, and spring. These are exemplified with case studies based on author's fieldwork in Greenland, the Arctic Ocean, and Antarctica but focused on Arctic conditions. The sea ice ecosystem is described in the context of climate change, interests, and effects of a decreasing summer ice extent in the Arctic Ocean. The book contains an up to date description of most relevant methods and techniques applied in sea ice ecology research. This book will appeal to university students at Masters or PhD levels reading biology, geosciences, and chemistry.

Ice, the magic crystal -- A brief history of ice on planet Earth -- The modern cycle of ice ages -- The greenhouse effect -- Sea ice meltback begins -- The future of Arctic sea ice the death spiral -- The accelerating effects of Arctic feedbacks -- Arctic methane, a catastrophe in the making -- Strange weather -- The secret life of chimneys -- What's happening to the Antarctic? -- The state of the planet -- A call to arms

When leading mountaineer Sir Chris Bonington was researching Quest for Adventure, his study of post-war adventure, he contacted Sir Robin Knox-Johnston, the first person to sail single-handed and non-stop around the world, for an interview. This simple request turned into an exchange of skills, which then grew into a joint expedition to Greenland's unexplored Lemon Mountains. Sea, Ice and Rock is the story of this epic journey. With both Bonington and Knox-Johnston having little experience in the other's craft, their expedition was not without difficulty. But through one another's support, the two men and their team sailed from Britain to Greenland, going on to twice attempt the Lemon Mountain's forbidding highest peak, the Cathedral. Though their attempts ended in a dramatic descent, this could not dampen the unfailing optimism with which the two approached their task. They recount their experiences not only with appreciation for the awe-inspiring nature that surrounded them, but also for one another. Layers of alternate narration between Bonington and Knox-Johnston make this a truly collaborative memoir. In the same way they exchanged skills on their expedition, the two authors rely on one another's recollections to fill the gaps in their own. Full of ambition and perseverance, anyone wondering why Bonington and Knox-Johnston are masters in their fields need only read Sea, Ice and Rock.

Sea Ice in the Arctic

People and Sea Ice in Three Arctic Communities

Research in Sea Ice Mechanics

Ice in the Ocean

Microwave Remote Sensing of Sea Ice

Field Techniques for Sea-Ice Research

As much as one-tenth of the world's oceans are covered with sea ice, or frozen ocean water, at some point during the annual cycle. Sea ice thus plays an important, often defining, role in the natural environment and the global climate system. This book is a global look at the changes in sea ice and the tools and techniques used to measure and record those changes. The first comprehensive research done on sea-ice field techniques, this volume will be indispensable for the study of northern sea ice and a must-have for scientists in the field of climate change research.

A true account of Sir Ernest Shackleton and his attempted journey to Antarctica chronicles what happens when his ship became caught in a vast sea of ice 100 miles from the South Pole. Simultaneous.

This book provides in-depth information about the sea ice in the Arctic at scales from paleoenvironmental variability to more contemporary changes during the past and present centuries. The book is based on several decades of research related to sea ice in the Arctic and its variability, sea ice process studies as well as implications of the sea ice variability on human activities. The chapters provide an extensive overview of the research results related to sea ice in the Arctic at paleo-scales to more resent scales of variations as well as projections for changes during the 21st century. The authors have pioneered the satellite remote sensing monitoring of sea ice and used other monitoring data in order to study, monitor and model sea ice and its processes.

Published by the American Geophysical Union as part of the Geophysical Monograph Series, Volume 68. Human activities in the polar regions have undergone incredible changes in this century. Among these changes is the revolution that satellites have brought about in obtaining information concerning polar geophysical processes. Satellites have flown for about three decades, and the polar regions have been the subject of their routine surveillance for more than half that time. Our observations of polar regions have evolved from happenstance ship sightings and isolated harbor icing records to routine global records obtained by those satellites. Thanks to such abundant data, we now know a great deal about the ice-covered seas, which constitute about 10% of the Earth's surface. This explosion of information about sea ice has fascinated scientists for some 20 years. We are now at a point of transition in sea ice studies; we are concerned less about ice itself and more about its role in the climate system. This change in emphasis has been the prime stimulus for this book.

Air-Ice-Ocean Interaction

Summer 1958

A Farewell to Ice

Beyond the Sea of Ice

The Meaning of Ice

An Introduction to its Physics, Chemistry, Biology and Geology

In addition to observations and lab experiments, the scientific investigation of the Arctic and Antarctic sea ice is conducted through the employment of geophysical models. These models describe in a numerical framework the physical behavior of sea ice and its interactions with the atmosphere, ocean, and polar biogeochemical systems. Sea-ice models find application in the quantification of the past, present, and future sea-ice evolution, which becomes particularly relevant in the context of a warming climate system that causes the reduction of the Arctic sea ice cover. Because of the sea-ice decline, the navigation in the Arctic ocean increased substantially in the recent past, a trend that is expected to continue in the next decades and that requires the formulation of reliable sea-ice predictions at various timescales. Sea-ice predictions can be delivered by modern forecast systems that feature dynamical sea-ice models. The simulation of sea ice is at the center of this thesis: A coupled climate model with a simple sea-ice component is used to quantify potential impacts of a geoengineering approach termed "Arctic Ice Management"; the skill of current operational subseasonal-to-seasonal sea-ice forecasts, based on global models with a varying degree of sea-ice model complexity, is evaluated; and, lastly, an unstructured-grid ocean model is equipped with state-of-the-art sea-ice thermodynamics to study the impact of sea-ice model complexity on model performance. In chapter 2, I examine the potential of a geoengineering strategy to restore the Arctic sea ice and to mitigate the warming of the Arctic and global climate throughout the 21st century. The results, obtained with a fully coupled climate model, indicate that it is theoretically possible to delay the melting of the Arctic sea ice by ~60 years, but that this does not reduce global warming. In chapters 3 and 4, I assess the skill of global operational ensemble prediction systems in forecasting the evolution of the Arctic and Antarctic sea-ice edge position at subseasonal timescales. I find that some systems produce skillful forecasts more than 1.5 months ahead, but I also find evidence of substantial model biases and issues concerning data assimilation and model formulation. Chapter 5 deals with the impact of sea-ice model complexity on model performance. I present a new formulation of the FESOM2 sea-ice/ocean model with a revised description of the sea-ice thermodynamics, including various parameterizations of physical processes at the subgrid-scale. The model formulation grants substantial modularity in terms of sea-ice physics and resolution. The new system is used for assessing the impact of the sea-ice model complexity on the FESOM2 performance in different atmosphere-forced setups with a specific parameter-tuning approach and a special focus on sea-ice related variables. The results evidence that a more sophisticated model formulation is beneficial for the model representation of the sea-ice concentration and snow thickness, while less relevant for sea-ice thickness and drift. I also highlight a dependence of the model performance on the atmospheric forcing product used as boundary conditions. In the final part of this thesis, I formulate recommendations for future developments in the field of sea-ice modeling, with particular emphasis on FESOM2 and, more generally, on the modeling infrastructure under development at the Alfred Wegener Institute.

Sea Ice: Physics and Remote Sensing addresses experiences acquired mainly in Canada by researchers in the fields of ice physics and growth history in relation to its polycrystalline structure as well as ice parameters retrieval from remote sensing observations. The volume describes processes operating at the macro- and microscale (e.g., brine entrapment in sea ice, crystallographic texture of ice types, brine drainage mechanisms, etc.). The information is supported by high-quality photographs of ice thin-sections prepared from cores of different ice types, all obtained by leading experts during field experiments in the 1970s through the 1990s, using photographic cameras and scanning microscopy. In addition, this volume presents techniques to retrieve a suite of sea ice parameters (e.g. ice type, concentration, extent, thickness, surface temperature, surface deformation, etc.) from space-borne and airborne sensor data. The breadth of the material on this subject is designed to appeal to researchers and users of remote sensing data who want to develop quick familiarity with the capabilities of this technology or detailed knowledge about major techniques for retrieval of key ice parameters. Volume highlights include: Detailed crystallographic classification of natural sea ice, the key information from which information about ice growth conditions can be inferred. Many examples are presented with material to support qualitative and quantitative interpretation of the data. Methods developed for revealing microstructural characteristics of sea ice and performing forensic investigations. Data sets on radiative properties and satellite observations of sea ice, its snow cover, and surrounding open water. Methods of retrieval of ice surface features and geophysical parameters from remote sensing observations with a focus on critical issues such as the suitability of different sensors for different tasks and data synergism. Sea Ice: Physics and Remote Sensing is intended for a variety of sea ice audiences interested in different aspects of ice related to physics, geophysics, remote sensing, operational monitoring, mechanics, and cryospheric sciences.

The Arctic sea ice is characterized by profound changes caused by surface melting processes and the formation of melt ponds in summer. Melt ponds contribute to the ice-albedo feedback as they reduce the surface albedo of sea ice, and hence accelerate the decay of Arctic sea ice. To quantify the melting of the entire Arctic sea ice, satellite based observations are necessary. Due to different spectral properties of snow, ice, and water, theoretically, multi-spectral optical sensors are necessary for the analysis of these distinct surface types. This study demonstrates the potential of optical sensors to detect melt ponds on Arctic sea ice. For the first time, an Arctic-wide, multi-annual melt pond data set for the years 2000-2011 has been created and analyzed.

The sea ice surrounding Antarctica has increased in extent and concentration from the late 1970s, when satellite-based measurements began, until 2015. Although this increasing trend is modest, it is surprising given the overall warming of the global climate and the region. Indeed, climate models, which incorporate our best understanding of the processes affecting the region, generally simulate a decrease in sea ice. Moreover, sea ice in the Arctic has exhibited pronounced declines over the same period, consistent with global climate model simulations. For these reasons, the behavior of Antarctic sea ice has presented a conundrum for global climate change science. The National Academies of Sciences, Engineering, and Medicine held a workshop in January 2016, to bring together scientists with different sets of expertise and perspectives to further explore potential mechanisms driving the evolution of recent Antarctic sea ice variability and to discuss ways to advance understanding of Antarctic sea ice and its relationship to the broader ocean-climate system. This publication summarizes the presentations and discussions from the workshop.

Sea, Ice and Rock

Sea-ice Prediction Across Timescales and the Role of Model Complexity

Sea Ice Analysis and Forecasting

Towards an Increased Reliance on Automated Prediction Systems

A Report from the Arctic

Sea Ice Observation and Modelling

By exploring indigenous people's knowledge and use of sea ice, the SIKU project has demonstrated the power of multiple perspectives and introduced a new field of interdisciplinary research, the study of social (socio-cultural) aspects of the natural world, or what we call the social life of sea ice. It incorporates local terminologies and classifications, place names, personal stories, teachings, safety rules, historic narratives, and explanations of the empirical and spiritual connections that people create with the natural world. In opening the social life of sea ice and the value of indigenous perspectives we make a novel contribution to IPY, to science, and to the public

When humans first walked the world and learn to live in an exotic new world of mystery and danger.

Presents conclusions made by Joint Steering Committee under headings of polar cloud and radiation, atmospheric forcing fields for sea-ice models, sea-ice climatology data, Arctic projects, and Antarctic projects. Appendix includes 11 individual reports.

Sea Ice Image Processing with MATLAB addresses the topic of image processing for the extraction of key sea ice characteristics from digital photography, which is of great relevance for Artic remote sensing and marine operations. This valuable guide provides tools for quantifying the ice environment that needs to be identified and reproduced for such testing. This includes fit-for-purpose studies of existing vessels, new-build conceptual design and detailed engineering design studies for new developments, and studies of demanding marine operations involving multiple vessels and operational scenarios in sea ice. A major contribution of this work is the development of automated computer algorithms for efficient image analysis. These are used to process individual sea-ice images and video streams of images to extract parameters such as ice floe size distribution, and ice types. Readers are supplied with Matlab source codes of the algorithms for the image processing methods discussed in the book made available as online material. Features Presents the first systematic work using image processing techniques to identify ice floe size distribution from aerial images Helps identify individual ice floe and obtain floe size distributions for Arctic offshore operations and transportation Explains specific algorithms that can be combined to solve various problems during polar sea ice investigations Includes MATLAB® codes useful not only for academics, but for ice engineers and scientists to develop tools applicable in different areas such as sustainable arctic marine and coastal technology research Provides image processing techniques applicable to other fields like biomedicine, material science, etc

Turbulent Ocean Boundary Layer Exchange Processes

Documenting Inuit Sea Ice Knowledge and Use

Arctic Sea Ice Ecology

Seasonal Dynamics in Algal and Bacterial Productivity

Past, Present and Future

Sailing and Climbing Above the Arctic Circle

The cryosphere encompasses all regions of the planet that experiences water in ice form for some portion of the year. In this book, authors Melody Sandells and Daniela Flocco deliver an introduction to the physics of the cryosphere. This includes the Arcti

As the Arctic perennial sea ice continues to disappear at an alarming rate, a full understanding of sea ice as a crucial global ecosystem, and the effects of its loss is vital for all those working with and studying global climate change. Building on the success of the previous edition, the second edition of Sea Ice, now much expanded and in full colour throughout, includes six completely new chapters with complete revisions of all the chapters included from the first edition. The Editors, Professor David Thomas and Dr Gerhard Dieckmann have once again drawn together an extremely impressive group of internationally respected contributing authors, ensuring a comprehensive worldwide coverage of this incredibly important topic. Sea Ice, second edition, is an essential purchase for oceanographers and marine scientists, environmental scientists, biologists, geochemists and geologists. All those involved in the study of global climate change will find this book to contain a wealth of important information. All libraries in universities and research establishments where these subjects are studied and taught will need multiple copies of this book on their shelves. truly multidisciplinary approach world leading authors and editors international in scope, covering both Arctic and Antarctic work of vital interest to all those involved in global warming and climate change research highly illustrated full colour book with colour images throughout

ICe in the Ocean examines sea ice and icebergs and their role in the global climate system. It is comprehensive textbook suitablefor students, pure and applied researchers, and anyone interested in the polar oceans; the distribution of sea ice; the mechanisms of growth, development and decay; the thermodynamics and dynamics of sea ice; sea ice defo

Covering more than seven percent of the earth's surface, sea ice is crucial to the functioning of the biosphere and is a key component in our attempts to understand and combat climate change. With On Sea Ice, geophysicist W. F. Weeks delivers a natural history of sea ice, a fully comprehensive and up-to-date account of our knowledge of its creation, change, and function. The volume begins with the earliest recorded observations of sea ice, from 350 BC, but the majority of its information is drawn from the period after 1950, when detailed study of sea ice became widespread. Weeks delves into both micro-level characteristics internal structure, component properties, and phase relations and the macro-level nature of sea ice, such as salinity, growth, and decay. He also explains the mechanics of ice pack drift and the recently observed changes in ice extent and thickness. An unparalleled account of a natural phenomenon that will be of increasing importance as the earth's temperature rises, On Sea Ice will unquestionably be the standard for years to come.

Report of the Third Session of the JSC Working Group on Sea Ice and Climate : (Oslo, Norway, 31 May - 3 June 1988).

Snow on Sea Ice

Impacts of Storm on Sea Ice

The Geophysics of Sea Ice

On Sea Ice

Recent studies have shown that intense and long-lasting storms potentially facilitate sea ice melting. Under the background of extratropical storm tracks poleward shift, significant reductions of Arctic sea ice coverage, and thinning of sea ice thickness over the last several decades, a better understanding on how storms impact sea ice mass balance is obviously of great importance to better predict future sea ice and the Arctic climate changes. This thesis presents a multi-scale study on how storms impact sea ice, consisting of three different parts of the effort. In the first part, we examined the impacts of the 2016 summer intense storm on sea ice changes over the Chukchi Sea using ship-borne observations. The results show that the intense storm can accelerate ice melt through enhanced upper-ocean mixing and upward heat transport. The satellite-observed long-term sea ice variations potentially can be impacted by many factors. In the second part, we first explore key physical processes controlling sea ice changes under no-storm condition. We examined and compared results from 25 sensitivity experiments using the NCAR's Community Earth System Model (CESM). We found that sea ice volume, velocity, and thickness are highly sensitive to perturbed air-ice momentum flux and sea ice strength. Increased sea ice strength or decreased air-ice momentum flux causes counter-clockwise rotation of the transpolar drift, resulting in an increase in sea ice export through Fram Strait and therefore reduction of the pan-Arctic sea ice thickness. Following four tracers released over the Arctic, we found the sea ice thickness distributions following those tracers are broader over the western Arctic and becomes narrower over the eastern Arctic. Additionally, thermodynamic processes are more dominant controlling sea ice thickness variations, especially over periphery seas. Over the eastern Arctic, dynamic processes play a more important role in controlling sea ice thickness variation. Previous studies show that thin ice responds to external perturbations much faster than the thick ice. Therefore, the impacts of storms on sea ice are expected to be different compared with the western/eastern Arctic and the entral/periphery seas. In the third part, we conduct a new composite analysis to investigate the storm impact on sea ice over seven regions for all storms spanning from 1979 to 2018. We focused on sea ice and storm changes over seven regions and found storms tend to have different short-term (two days before and after storm passage), mid-term (one-two weeks after storm passage), and long-term (from 1979 to 2018) impact on sea ice area over those regions. Over periphery seas (Chukchi, East Siberian, Laptev, Kara, and Barents Seas), storms lead to a short-term sea ice area decrease below the climatology, and a mid-term sea ice increase above the climatology. This behavior causes sea ice area to have a small correlation with the storm counts from 1979 to 2018, which suggest that storms have a limited long-term impact on sea ice area over periphery seas. Both the short term and mid-term storm impacts on sea ice area are confined within a 400 km radius circle with maximum impacts shown within a 200 km radius circle. Storms over the western Arctic (Chukchi, East Siberian, and Laptev Seas) have a stronger short-term and mid-term impact on sea ice area compared with the Eastern Arctic (Barents and Kara Seas). Storms over both Atlantic and Pacific entrance regions have a small impact on sea ice area, and storms over the Norwegian, Iceland, and Greenland Seas have the smallest impact on the sea ice area. Compared to the periphery seas, storms tend to have a stronger long-term impact on sea ice area over the central Arctic. The correlation coefficients between the storm count and sea ice area exceed 0.75.

This book is dedicated to the study of the composition, structure and dynamics of the Arctic sea ice ecosystem. It considers the permanent Arctic sea ice cover as an integral steady-state ecological system. Detailed descriptions are given of time-scale characteristics, physical and chemical sea ice properties, and the species composition of sea ice biota. The ecological mechanisms which govern the ecosystem on both the vertical and lateral scales are discussed, including the function of microcommunities during seasonal sea ice evolution. The Arctic Sea Ice Ecosystem will be an invaluable reference source for all researchers and students of polar ecology.

The timing of snowmelt onset (MO) on Arctic sea ice derived from passive microwave satellite data is examined by determining the melting area (in km 2) on a daily basis for the spring and summer melt season months over the 1979 -- 2012 data record. The date of MO on Arctic sea ice has important implications for the amount of total solar energy absorbed by the ice-ocean system in a given year. Increasingly early mean MO dates have been recorded over the 34-year data record. Statistically significant trends indicate that MO is occurring 6.6 days decade-1 earlier in the year over all Arctic sea ice extent. Larger trends exist in sub-regions of the Arctic Ocean including the Barents, Kara, Laptev, East Siberian, Chukchi, and Beaufort Seas and in the Central Arctic region. The Bering Sea is the only sub-region of the Arctic that has a positive trend in mean MO date indicating that melting is occurring later in the year. Temporal and spatial variability in melting events are examined in the time series of daily MO areas via the identification of several types of melting events. These melting events are characterized based on the magnitude of area melted and duration of the event. Daily maps of MO during melting events are compared with the atmospheric conditions from reanalysis data to investigate the nature of spatial variability in melting area. The occurrence of transient cyclones tends to produce large, contiguous areas of melting on sea ice located in the warm sector of the cyclone. By contrast, high pressure and attendant clear sky conditions tend to produce sporadic, discontinuous areas of melting area. Interannual variability in daily MO area is assessed using an annual accumulation of daily MO area for each melt season. Trends in mean MO dates are evident in the annual accumulations, however, regional variability is high and outlier events can occur. This work illustrates the need for a better understanding of the synoptic weather conditions leading to specific patterns in MO area to improve the predictability of early season Arctic sea ice response to a changing climate.

The Second Edition of The Drift of Sea Ice presents the fundamental laws of sea ice drift which come from the material properties of sea ice and the basic laws of mechanics. The resulting system of equations is analysed for the general properties of sea ice drift, the free drift model and analytical models for ice drift in the presence of internal friction, and the construction of numerical ice drift models is detailed. This second edition of a much lauded work, unique on this topic in the English language, has been revised, updated and expanded with much new information and outlines recent results, in particular in relation to the climate problem, mathematical modelling and ice engineering applications. The current book presents the theory, observations, mathematical modelling techniques, and applications of sea ice drift science. The theory is presented from the beginning on a graduate student level, so that students and researchers coming from other fields such as physical oceanography, meteorology, physics, engineering, environmental sciences or geography can use the book as a source book or self-study material. First the drift ice material is presented ending with the concept of 'ice state' – the relevant properties in sea ice dynamics. Ice kinematics observations are widely presented with the mathematical analysis methods, and thereafter come drift ice rheology – to close the triangle material – kinematics – stress. The momentum equation of sea ice is derived in detail and its general properties are carefully analysed. Then follow two chapters on analytical models: free drift and drift in the presence of internal friction: These are very important tools in understanding the dynamical behaviour of sea ice. The last topical chapter is numerical models, which are the modern tool to solve ice dynamics problem in short term and long term problems. The closing chapter summarises sea ice dynamics applications and the need of sea ice dynamic knowledge and gives some final remarks on the future of this branch of science.

The Drift of Sea Ice

Microwave Remote Sensing and Its Impact on Antarctic Sea Ice

A Perspective Across Scales

Proceedings of 93's International Symposium on Sea Ice, Beijing

The Wreck of the Endurance

Sea Ice and Climate

Based on the proceedings of the NATO Advanced Study Institute on Air-Sea-Ice Interaction held September 28-October 10, 1981 in Acquafredda di maratea, Italy. Intent is to present the topic of sea ice in the broad and interdisciplinary context of atmospheric and oceanographic science.

On Sea IceUniversity of Alaska Press

Panel appointed in 1979 to investigate available information and research needs in field of sea ice mechanics, referring especially to engineering activities in and under ice of polar oceans.

Describes the latest remote sensing technologies used to detect ice hazards in the marine environment; map surface currents, sea-state and surface winds; study ice dynamics, over ice transportation, oil spill countermeasures, climate changes and ice reconnaisance. Includes such technologies as acoustic sensing, ice-thickness measurement, passive microwave remote sensing, ground wave and surface-based radars.

Detection of Melt Ponds on Arctic Sea Ice with Optical Satellite Data

Sea Ice

A Report on Sea Ice Conditions in the Eastern Arctic

Remote Sensing of Sea Ice and Icebergs

Sea Ice Image Processing with MATLAB®

Physics and Remote Sensing

Sea ice, which covers up to 7% of the planet's surface, is a major component of the world's oceans, partly driving ocean circulation and global climate patterns. It provides a habitat for a rich diversity of marine organisms, and is an extremely valuable source of information in studies of global climate change and the evolution of present day life forms. Increasingly sea ice is being used as a proxy for extraterrestrial ice covered systems. Sea Ice provides a comprehensive review of our current available knowledge of polar pack ice, the study of which is severely constrained by the logistic difficulties of working in such harsh and remote regions of the earth. The book's editors, Drs Thomas and Dieckmann have drawn together an impressive group of international contributing authors, providing a well-edited and integrated volume, which will stand for many years as the standard work on the subject. Contents of the book include details of the growth, microstructure and properties of sea ice, large-scale variations in thickness and characteristics, its primary production, micro-and macrobiology, sea ice as a habitat for birds and mammals, sea ice biogeochemistry, particulate flux, and the distribution and significance of palaeo sea ice. Sea Ice is an essential purchase for oceanographers and marine scientists, environmental scientists, biologists, geochemists and geologists. All those involved in the study of global climate change will find this book to contain a wealth of important information. All libraries in universities and research establishments where these subjects are studied and taught will need multiple copies on their shelves. David Thomas is at the School of Ocean Sciences, University of Wales, Bangor, UK. Gerhard Dieckmann is at the Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

Overview of sea ice growth and properties / Chris Petrich & Hajo Eicken -- Sea ice thickness distribution / Christian Haas -- Snow in the sea-ice system : friend or foe? / Matthew Sturm & Robert A. Massom -- Sea ice and sunlight / Donald K. Perovich -- The sea ice-ocean boundary layer / Miles G. McPhee -- The atmosphere over sea ice / Ola Persson & Timo Vihma -- Sea ice and arctic ocean oceanography / Finlo Cottier, Mike Steele & Frank Nielsen -- Oceanography and sea ice in the southern ocean / Michael P. Meredith & Mark A. Brandon -- Methods of satellite remote sensing of sea ice / Gunnar Spreen & Stefan Kern -- Gaining (and losing) antarctic sea ice : variability, trends and mechanisms / Sharon Stammerjohn & Ted Maksym -- Losing arctic sea ice : observations of the recent decline and the long-term context / Walt N. Meier -- Sea ice in earth system models / Dirk Notz & Cecilia M. Bitz -- Sea ice as a habitat for bacteria, archaea and viruses / Jody W. Deming & R. Eric Collins -- Sea ice as a habitat for primary producers / Kevin R. Arrigo -- Sea ice as a habitat for micrograzers / David A. Caron, Rebecca J. Gast & Marie-Eve Garneau -- Sea ice as a habitat for macrograzers / Bodil A. Bluhm, Kerrie M. Swadling & Rolf Gradinger -- Nutrients, dissolved organic matter and exopolymers in sea ice / Klaus M. Meiners & Christine Michel -- Gases in sea ice / Jean-Louis Tison, Bruno Delille & Stathys Papadimitriou -- Transport and transformation of contaminants in sea ice / Feiyue Wang, Monika Pucko & Gary Stern -- Numerical models of sea ice biogeochemistry / Martin Vancoppenolla & Letizia Tedesco -- Arctic marine mammals and sea ice / Kristin L. Laidre & Eric V. Regehr -- Antarctic marine mammals and sea ice / Marthán N. Bester, Horst Bornemann & Trevor McIntyre -- A feathered perspective : the influence of sea ice on arctic marine birds / Nina J. Karnovsky & Maria V. Gavrilo -- Birds and antarctic sea ice / David Ainley, Eric J. Woehler & Amelie Lescroel -- Sea ice is our beautiful garden : indigenous perspectives on sea ice of sea ice in the arctic / Henry P. Huntington, Shari Gearheard, Lene Kielsen Holm, George Noongwook, Margaret Opie & Joelie Sanguya -- Advances in palaeo sea-ice estimation / Leanne Armand, Alexander Ferry & Amy Leventer -- Ice in subarctic seas / Hermanni Kaartokallio, Mats A. Granskog, Harri Kuosa & Jouni Vainio

From Case Study to Climate Scale Analysis

Drift, Deformation, and Fracture of Sea Ice

SIKU: Knowing Our Ice