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Volume 9

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Editors

The Mathematics of Marine Modelling

Water, Solute and Particle Dynamics in Estuaries and Shallow Seas

MPE

Springer

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Preface

Coastal regions are strongly impacted by human interventions and climate change. Sea level rise and increased storminess threaten coastal safety; changes in intensity and duration of rainfall strongly impact intrusion of salt which may endanger the availability of fresh water. Examples of human interventions are the measures to mitigate these adverse climate effects, but also interventions are driven by, for example, economic (e.g., deepening of shipping channels, sand mining) and environmental (e.g., construction of large-scale wind parks) reasons. Unfortunately, such interventions may have unintended negative impacts due to the many conflicting interests in these regions: for example, channel deepening may be an excellent choice from an economic point of view, but it may result in a deterioration of the coastal safety and ecological values of the system under consideration. To oversee the multi-faceted impact of interventions and climate change, the dynamics of coastal seas, estuaries, and tidal inlets have to be well-understood. Only with such understanding, coastal managers can make well-balanced decisions that take all aspects into account. Mathematical modeling of marine systems becomes increasingly important to provide the insights necessary for decision making.

Over the past few decades, the mathematical modeling cycle has become instrumental in understanding the dynamics of coastal seas, estuaries, and tidal inlet systems. In this cycle, new mathematical models are developed or existing models are improved upon, advanced solution techniques are developed and employed to solve these highly complex nonlinear models, and the model outcomes are analyzed using state-of-the-art mathematical techniques and, if possible, compared to field and laboratory observations.

In this contribution, we focus on mathematical techniques available to study various topics from marine sciences in estuaries and coastal seas. Since only a limited number of topics can be treated, we restrict ourselves to the discussion of mathematical models on water motion and transport of pollutants and sediments by the water motion. In the first chapter, the basic mathematical concepts to obtain the governing equations are summarized and the final system of equations to model the water motion in coastal regions is given. In the next chapters, specific aspects of water motion are discussed: water waves in isotropic and anisotropic media, (near-shore) waves, and barotropic tides. This is followed by a detailed review of 2D-turbulence modeling and parameterization of turbulent dispersion. In the final chapters, river plumes, mathematical techniques to model transport phenomena, morphodynamic modeling of the bathymetry and geometry, and accurately model drying and flooding are discussed.

The prerequisite mathematical knowledge varies, but most of the material should be accessible to advanced graduate students and early-stage researchers. In most chapters, there is a clear link with observations and practical challenges, allowing professionals outside academia and decision-makers to get a good insight into the various techniques underpinning the models often used and other methodologies that can be employed to tackle their real-world problems. In each chapter, there is an extensive list of references, ranging from general to highly specialized, allowing the interested reader to further explore these topics independently.

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