Review of Hydrodynamics and Water Quality: Modeling Rivers, Lakes, and Estuaries by Zhen-Gang Ji. Second edition.

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Overview

There are very few good hydrodynamic texts on the market today and fewer still that combine hydrodynamics and water quality for the range of surface water system applications addressed by this book “Hydrodynamics and Water Quality: Modeling Rivers, Lakes, and Estuaries” by Zhen-Gang Ji. The first edition of the book was reviewed by V.J. Singh (Singh, 2008) who commended the book for its integrated approach and treatment of processes such as hydrodynamics, sediment transport and processes, toxic fate and transport, water quality, and eutrophication in surface water systems. This second edition, published eight years after the first, has added additional chapters dealing with topical areas such as risk analysis, water quality modeling of shallow estuaries and on the effect of wind waves on sediment transport. Of particular note is the new chapter on wetlands. This is a welcome addition and addresses an oversight that has been evident in wetland texts and other hydrodynamic texts for many years.

Content and Coverage

This well written and easy-to-follow, new edition of the book has twelve chapters and four appendices. The first two chapters after the introduction cover the basic principles of hydrodynamics and sediment transport that are covered in most popular texts. The discussion of surface water hydrodynamic theory starts with the laws governing conservation of mass and momentum that lead to the governing equations and their approximations for 1-D, 2-D and 3-D equations expressed in both Cartesian, Sigma and Curvilinear coordinates. This is followed by a detailed description of the various processes and associated theory covering heat flux that forms the basis for all water quality processes that follow in the text. In Chapter 2 the author introduces two case study sites in Florida that are among those referred to throughout the text in subsequent chapters. In Chapters 3-5 the author introduces theory covering sediment transport, pathogens and toxics and water quality and eutrophication introducing additional case study sites in Florida to provide practical examples of the theoretical principles covered in each chapter. The water quality section is particularly comprehensive covering algae and phytoplankton, nutrients and dissolved oxygen and is a particular strength of this text. For each of these constituents the author provides relevant example case studies that are designed to show how the basic theory and technical approaches can be incorporated into real-world problem solving. Chapter 6 provides a brief though highly relevant description on watershed processes and how they are considered in the development of TMDLs. TMDLs are becoming an increasingly important tool for implementing water quality control policy nationwide and we hope the author considers expanding this chapter in subsequent editions of this textbook.

The textbook transitions to coverage of mathematical modeling and hydrodynamic processes in various aquatic environments including rivers, lakes, reservoirs, estuaries and coastlines and wetlands in Chapters 7-11. Chapter 7 reviews statistical tests and methodologies for analyzing and summarizing model performance – an evolving discipline that is critically important as models become more complex and new visualization techniques are introduced. This chapter also includes a discussion of model calibration, validation and verification with illustrative examples to distinguish between these procedures.

The chapter on Estuaries and Coastal Processes treats discusses hydrodynamic, sediment and water quality processes in estuaries and presents topical examples in Morro Bay in California and the St. Lucie Estuary and Indian River Lagoon in Florida. In the Morro Bay example the author introduces the well-documented Environmental Fluid Dynamics Code (EFDC – Tetra-Tech, 2007) numerical modeling code that has become popular for this types of application. The process of walking the reader through the various model development and setup steps using a well-regarded code is a useful addition to this textbook.

Discussion

Wetlands can take many forms ranging from the natural waterbodies that can be permanent or seasonal depending on local hydrology to highly manipulated impoundments that can be used for wastewater treatment purposes to seasonal

wetlands used to provide waterfowl habitat. Few textbooks consider the hydrodynamics of these waterbodies worthy of inclusion – hence the author does a great service to the water resources community by including a chapter on this topic. The estimation of wetland ET and the development of wetland water budgets is covered in some detail – both subjects are becoming areas of active research and available data remains hard to come by. We believe that the author has done sterling work summarizing seminal studies and recent literature.

Whereas the majority of the textbook through Chapter 11 is focused on deterministic methods and models – the remaining chapter introduces and provides useful detail on stochastic methods and statistical tools relevant to water resource hydrodynamics and water quality management. The author covers elementary statistics and probability theory before moving on to extreme value theory with examples of catastrophic events and how mathematical models can inform both pre-event and post-event management. The chapter concludes with a primer on environmental risk management, again illustrated with a number of well-publicized recent environmental disasters such as the Deep Water Horizon Macondo well blowout in the Gulf of Mexico in 2010. The book is appended with the EFDC code in Appendix A, conversion factors in Appendix B, electronic files in Appendix C and an introduction to EFDC Explorer in Appendix D.

As scientists specializing in the area of developing and evaluating land surface models for earth system models, we found this comprehensive book extraordinarily refreshing and resourceful. The state-of-the-art land surface models have included sophisticated mathematical representations for terrestrial biogeophysical and biogeochemical processes, but the treatments of many surface water systems such as estuaries and coastal lines are still in an early stage, despite some initial effort (Sun et al., 2017). Sediment transport and water quality have been neglected in these earth system models. Therefore, this book provides a useful reference for land surface and earth system modelers to understand the relevant theories, processes, and modeling of these processes.

In both the weather forecasting community and the operational water modeling community, an integrated modeling of the atmosphere, land surface, and river flow has made rapid progress, especially in the case of flood modeling (Lin et al., 2018). The US National Water Model (Souffront Alcantara et al, 2017) is predicting river flows in real time for 2.67 million river reaches in the continental United States using the National Hydrography Dataset Plus vector flowline network. Future efforts to couple chemical processes with hydrological processes can benefit from the excellent coverage of related topics in Chapter 3 (Sediment Transport), Chapter 4 (Pathogens and Toxics), and Chapter 5 (Water Quality and Eutrophication) of the book.

Chapter 9 on Lakes and Reservoirs is useful for augmenting the framework used in many operational hydrological models. The book does have helpful sections on model calibration and parameter estimation, but more advanced materials can be found in the papers by Keith Beven and Hoshin Gupta.

Summary

This textbook by Professor Zhen-Gang Ji is a long overdue and welcome addition to the water resources and water quality modeling and analysis literature. We believe the textbook would be well suited for a senior undergraduate or beginning graduate course on applied hydrodynamics and water quality modeling. The lack of solved examples and end-of-chapter problems is not a significant oversight in our estimation. There are sufficient real-world examples and case studies in the textbook on which to develop homework problems – although this will demand a bit more thought and preparation by the instructor. The wealth of knowledge and experience that Professor Zhen-Gang Ji brings to this topic will be helpful to student and instructor alike. In summary, given the integrated coverage of hydrodynamics, sediment processes, toxic fate and transport, and water quality and eutrophication in surface waters, including rivers, lakes, estuaries, coastal waters and wetlands, we strongly recommend this book to environmental, land surface, water, and earth system modelers with some cautions for instructors who may require ready-to-use homework problems.

References

Souffront Alcantara, M.A., Kesler, C., Stealey, M.J., Nelson, E.J., Ames, D.P., Jones, N.L., 2017, Cyberinfrastructure and Web Apps for Managing and Disseminating the National Water Model. J. of the American Water Resources Association (JAWRA), 54, pp 859-871.

Singh V.J., 2008. Review of Hydrodynamics and Water Quality: Modeling Rivers, Lakes, and Estuaries by Zhen-Gang Ji. Wiley Interscience, John Wiley & Sons, Inc., 111 Rivers Street, Hoboken, NJ 07030; 2008; 676 pp. ISBN: 978-0-470-13543-3.

Tetra-Tech Inc. 2007. *The Environmental Fluid Dynamics Code, User Manual*. US EPA Version 1.01. Tetra-Tech Inc., Fairfax, VA.

Lin, P. R., L. J. Hopper, Jr., Z.-L. Yang, M. Lenz, and J. W. Zeitler, 2018: Insights into hydrometeorological factors constraining flood prediction skill during the May and October 2015 Texas Hill Country flood events, *J. Hydrometeorology,* **9** (8), 1339–1361.

Sun, Q., M. M. Whitney, F. O. Bryan, and Y.-H. Tseng, 2017. A box model for representing estuarine physical processes in Earth system models, *Ocean Modelling*, **112**, 139–153.