

Preface

The Institute for Mathematics and Its Applications (IMA) at the University of Minnesota held a special year on “Simulating Our Complex World: Modeling, Computation and Analysis” in 2010–2011, co-chaired by Susanne Brenner of Louisiana State University and Clint Dawson of the University of Texas at Austin. As part of this special year a workshop was held April 11–15, 2011 on “Societally Relevant Computing,” co-organized by Michael P. Brenner of Harvard University; Clint Dawson; Margot Gerritsen of Stanford University; and Anna M. Michalak of the University of Michigan. This volume presents and summarizes some of the cutting-edge research problems specific to geoscience applications that were discussed at this workshop.

Simulation and computation play a critical role in geoscience problems. Examples include the role of anthropogenic emissions on climate and ocean circulation; the prediction of earthquakes and tsunamis; the prediction of paths and storm surges of hurricanes; and designing infrastructure that is capable of withstanding disasters, such as floods and terrorist attacks. These systems exhibit extreme complexity, and there are myriad critical issues that must be accurately addressed. Models need to encompass large numbers of physical effects. All of these problems represent grand challenge computer problems that require pushing the limits of technology, with regard to algorithms and machines and to the development of the physical models themselves.

Critical issues include the development and coupling of algorithms for multiphysics, multiscale applications, verification and validation of these computer models, and quantifying their predictive reliability given potentially large uncertainty in numerical accuracy, code reliability and ultimately the models themselves. How good is good enough? For any complex phenomenon, more and more physical effects can always be included as data and computing power increase, and larger computations can always be designed. However there will always be substantial uncertainty and numerical error to overcome.

While no single volume could address all of these complexities, the contributors to this volume represent a cross-section of geoscience research. Specifically the topics addressed herein include mathematical and numerical complexities of ocean

modeling, fast algorithms for Bayesian inversion in geostatistical applications, the modeling of complex multiphase fluids in porous media, real-time storm surge forecasting in the coastal ocean, and modeling and software development for geophysical fluid dynamics applications ranging from tsunamis to debris flows.

We thank the authors for their important contributions to the workshop and to this volume. We thank all who attended the workshop for their participation in the lively discussions that were held. We also thank the IMA for hosting this workshop and for the important work they do in supporting and promoting mathematical research.

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