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Computational Earthquake Physics
PART I: Introduction

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Large earthquakes are terrible natural disasters which usually cause massive casualties and huge property loss. In the beginning of the new century, large earthquakes violently struck the world, especially the Asia-Pacific region. Nearly 300,000 people were killed by the magnitude 9.0 Northern Sumatra earthquake and tsunami, and the magnitude 7.8 Pakistan earthquake of October 8th, 2005 resulted in 90,000 deaths. In the meantime, there has been great progress in computational earthquake physics. New understanding of earthquake processes, numerous ideas on earthquake dynamics and complexity, new numerical models and methods, higher performance super-computers, and new data and analysis methods are emerging. These include the LSM (Lattice Solid particle simulation Model) Australian Computational Earth Systems Simulator (ACcESS), Japan's Earth Simulator, GeoFEM, GeoFEST, QuakeSim, SERVO grid, iSERVO, LURR (Load-Unload Response Ratio), PI (Pattern Informatics), Critical Sensitivity, earthquake Critical Point Hypothesis, the friction law and seismicity, tremor, the Virtual California model, interaction between faults and the conversation of earthquakes, ROC (Relative Operating Characteristic), MFEM (Multiscale Finite-Element Model), etc. Most of these are the outcome of ACES-related research and activities, and will be presented in this volume.

The APEC Cooperation for Earthquake Simulation (**ACES**) [1], endorsed by APEC (Asia-Pacific Economic Cooperation) in 1997, capitalizes on this new

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opportunity and the complementary strengths of the earthquake research programs of individual APEC member economies via collaboration towards development of such models, the necessary research infrastructure to enable large-scale simulations, and to assimilate data into the models.

The inaugural workshop, the second and the third workshop of ACES were held in 1999, 2000 and 2002, respectively [2–5]. During the week of July 9–14, 2004, China hosted the 4th ACES workshop [6] in Beijing. The 4th ACES Workshop was a milestone for ACES as unanimous agreement was reached for the follow-on to ACES, the ACES-iSERVO [7] International Institute (International Solid Earth Research Virtual Observatory Institute). A colloquium on iSERVO was held at the 4th ACES Workshop leading to broad endorsement for establishment of the iSERVO Institute by the international group of over 100 scientists in attendance, and subsequent signing of a formal agreement – ''The Beijing Declaration'' [8] – to establish the institute which will be a frontier international research institute on simulating the solid earth. A special issue on Earth Systems Modelling overviewed contributions to the development of the iSERVO institute [7] by its key participants. The institute will consist of a node in each participating economy, and will build on complementary national programs, centers and facilities for solid earth simulation. The institute's focus will be development of predictive capabilities for solid earth phenomena via simulation and breakthrough science using the computational simulation capabilities aimed at understanding solid earth system complexity.

This special issue is divided into two parts. The first part (part I) incorporates Micro-Scale Simulation, Macro-Scale Simulation and Scaling Physics. Topics covered range from numerical developments, rupture and gouge studies of the particle model, Liquefied Cracks and Rayleigh Wave Physics, studies of catastrophic failure and critical sensitivity, numerical and theoretical studies of crack propagation, development in finite-difference methods for modeling faults, long time scale simulation of interacting fault systems, modeling of crustal deformation, through to mantle convection. The second part (Part II, PAGEOPH Vol 163, No 11/12 (2006)) incorporates Computational Environment and Algorithms, Data Assimilation and Understanding, Model Applications and iSERVO.

The 4th ACES workshop (2004) was planned by the ISB (International Science Board) of ACES, consisting of Peter Mora, Xiang-chu Yin, Mitsuhiro Matsuura, Andrea Donnellan and Jean-Bernard Minster, and was hosted by the Institute of Earthquake Science, China Earthquake Administration and LNM (State Key Laboratory of Nonlinear Mechanics), Institute of Mechanics, Chinese Academy of Sciences.

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Exciting developments in earthquake science have benefited from new observations, improved computational technologies, and improved modeling capabilities. Designing a realistic supercomputer simulation model for the complete earthquake generation process is a grand scientific challenge due to the complexity of phenomena and range of scales involved from microscopic to global. The APEC Cooperation for Earthquake Simulation (ACES) aims to develop such models. Since 1997 four ACES Workshops have been held in Brisbane and Noosa in Australia, Tokyo and Haoken in Japan, Maui, Hawaii in USA and Beijing, China on July 10–14, 2004, respectively. The book mainly contains the results presented in the 4th ACES Workshop in Beijing and the new outcomes from 4th ACES Workshop to the present. The book covers: Microscopic simulation of earthquake, scaling physics, macroscopic simulation, computational environment and algorithms, data assimilation and understanding, model applications and iSERVO (International Solid Earth Research Virtual Observation).

Part I of the book focuses on microscopic from numerical and physical simulation, scaling physics, dynamic rapture and wave propagation, earthquake generation, cycle and seismic pattern.