

Springer INdAM Series 6

Alessandra Celletti  
Ugo Locatelli  
Tommaso Ruggeri  
Elisabetta Strickland *Editors*

# Mathematical Models and Methods for Planet Earth

 Springer

# Preface

More than a hundred scientific societies, universities, research institutes and organizations from around the world have banded together to dedicate 2013 as a special year for the Mathematics of Planet Earth. The Italian partner which endorsed the MPE2013 initiative is INdAM, the National Institute of Advanced Mathematics. First founded in 1939 by the noted mathematician Francesco Severi, the aims of INdAM are the training of researchers in mathematics, especially in the emerging branches, in order to foster the transfer of knowledge to technological applications and promote contact between Italian and international mathematical research. In order to achieve its objectives in training researchers and in supporting excellence programs, INdAM offers fellowships from undergraduate level to experienced researchers, as well as organizing workshops, meetings and schools.

INdAM has decided to share in and support the mission of the MPE2013, as it shares the desire of the world's mathematical community to learn more about the challenges faced by our planet and the underlying mathematical problems. The MPE2013 initiative organized by INdAM took place in Rome, Italy, on May 27–29, 2013, and consisted in the Workshop “Mathematical models and methods for Planet Earth”, organized by Alessandra Celletti (Università di Roma Tor Vergata), Ugo Locatelli (Università di Roma Tor Vergata), Tommaso Ruggeri (Università di Bologna) and Elisabetta Strickland (Università di Roma Tor Vergata).

Over the course of the workshop an international group of mathematicians (namely all corresponding authors of the following chapters and other outstanding invited speakers) with a very wide range of expertise in various branches presented findings on several themes related to the MPE2013: Earth as a planet to discover, a planet supporting life, a planet organized by humans, and a planet at risk from celestial threats. The topics of the talks concerned social, biological, medical, geological and astronomical problems related to our planet. Mathematical methods for studying complex systems arising in the fields of social prevention and socio-economic problems were presented with the aim, for example, to understand emerging collective behaviours of a high number of interacting units. In particular, stochastic models can be used to investigate complex social and biological behaviours. In biology and medicine, mathematics plays a pivotal role through modelling and simulations in a

diverse range of contexts: from the behaviour of cells and tissues to the description of tumour growths. The leading role of mathematics in supporting our planet is also witnessed by the authorship attribution of literature texts and by models for future internet information dissemination.

Beyond the investigation of human-related aspects, mathematics allows us to study the physical characteristics of our planet. Most notably, some talks were devoted to the calibration of the geological time scales (a crucial aspect which allows us to retrieve specific events in Earth history), to the investigation of boundary layers associated with large-scale ocean circulation and, farther up in the atmosphere, to studying the Earth's climate variability and changes using the theory of dynamical systems.

Safeguarding the Earth is not limited to our planet and its atmosphere but - as we are only one part of the solar system - one really needs to investigate the interaction of the Earth with the other bodies populating the neighbouring sky. Indeed, the investigation of the so-called N-body problem allows us to study the stability of the Earth's dynamics as well as to identify new interplanetary trajectories. The recent impact of the meteorite in Chelyabinsk (Russia) alerted mankind to the necessity of protecting the planet from near-Earth asteroid hazards and of developing mitigation strategies. Finally, we are also definitely worried by the thousands of pieces of space debris from defunct satellites and fragments, which now surround the Earth and form a dangerous envelope: a mathematical investigation of the dynamics of space debris has now become vital.

In addition to the talks devoted to the investigation of the above topics, a special event of the Workshop was the public lecture by Christiane Rousseau (Université de Montréal), vice-president of the International Mathematical Union. Her talk dealt with the complexity of the Earth as a whole and outlined the role of mathematics in protecting and discovering our planet.

One interesting aspect that came out of this meeting is that the amount of data involved in some scientific problems has become overwhelmingly large, so that there is an apparent loss of simplicity between mathematics and its applications. Today no one could so deeply master as many mathematical arguments as Poincaré or Hilbert were able to do a century ago; but all the speakers at the workshop clearly showed that mathematicians are now also challenged in the opposite direction: more and more research topics require deep mathematical knowledge, often to tackle problems in the context of network teams. Though abstraction can allow mathematics to remain pure, mathematicians are called upon to more intensively work together with the rest of the scientific community.

INdAM believes that the collaborations and efforts of all scientists who participated in the workshop pointed out that our planet is home to dynamic processes of all sorts. The challenges facing our planet and our civilization are multidisciplinary and multifaceted, and the mathematical sciences play a central role in scientific efforts to understand and effectively address those challenges. INdAM sincerely believes that MPE2013 will also help us to motivate students and young researchers by providing stimulating answers to questions like: "What is mathematics good for?". We conclude by quoting Marta Sanz-Solé, President of the European Mathematical

Society; at the UNESCO Headquarters in Paris during the MPE Day on 5 March 2013, she stated that “The MPE2013 initiative will expose mathematicians to the whole world, by showing their usefulness and stimulating research. From now on, mathematics can no longer be associated with a pure intellectual exercise without connection to the most important problems of mankind”. We hope that the INdAM Workshop has contributed to pursuing those goals.

Roma, 2013

Alessandra Celletti  
Ugo Locatelli  
Tommaso Ruggeri  
Elisabetta Strickland



<http://www.springer.com/978-3-319-02656-5>

Mathematical Models and Methods for Planet Earth

Celletti, A.; Locatelli, U.; Ruggeri, T.; Strickland, E. (Eds.)

2014, X, 174 p., Hardcover

ISBN: 978-3-319-02656-5