

“Mathematics of Planet Earth 2013”: An Invitation

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In 2000 the World Mathematical Year offered the occasion for a collective reflection on the great challenges of the 21st Century, on the role of mathematics as a key for development and on the importance of the image of mathematics in the public understanding. The countless repeated phrase “the Universe is written in the language of mathematics”, written by Galileo in 1614, is now truer than ever but it raises new challenges in the current age of data-intensive science driven, in particular, by the information and communication technologies, as identified in a recent report to the European Commission [1].

The “rising tide of scientific data” created by the digital revolution provides new possibilities of facing some of society’s great challenges of energy and water supply, global warming and healthcare. Over the last few centuries, mathematics has developed a “universal method for the study of the systems”. In particular, for the Planet Earth System the mathematician Jacques-Louis Lions has synthesised in his book *El planeta Tierra* that universal method in three parts: the mathematical modelling; the analysis and the simulation; and the control of the systems [2].

In 2007 a scientific workshop on “Climate Change: From Global Models to Local Action”, organised by the Mathematical Sciences Research Institute in Berkeley, identified several mathematical research topics that might contribute to resolving problems whose solutions would have a large societal impact [3]: from high dimensional systems to model reduction, from multiscale computations to data assimilation and from uncertainty quantification to economics and societal aspects. The areas of mathematics that might have a significant role in those problems vary from dynamical systems and non-linear differential equations to asymptotic and numerical analysis, from computational science to statistics and operations research and from stochastic processes to game and control theories.

“Mathematics of Planet Earth 2013” (MPE2013) is an initiative proposed by the North American (Canadian and U.S.) Mathematical Institutes that now has many partners in Europe and around the world. MPE2013 aims to increase the engagement of mathematicians (researchers, teachers and students), as well as the public, with the role of mathematics in issues affecting our Planet Earth and its future.

It is expected to be a year full of scientific research programmes and activities for the public, media and schools. The *mission statement* of this worldwide endeavour consists of:

- Increase the engagement of mathematicians – researchers, teachers, students – as well as the public, with the role of mathematics in issues affecting our Planet Earth and its future.
- Encourage research to identify and address fundamental questions that have to do with our planet to which mathematics can contribute to a solution, including understanding its climate and environment, and addressing its sustainability.
- Encourage mathematics teachers at all levels to communicate issues related to our Planet Earth through their instruction and their curriculum development.
- Encourage mathematics students and beginning researchers to pursue research areas related to our Planet Earth.
- Inform the public about roles that mathematics can play in addressing questions related to our Planet Earth.

A special aspect of MPE2013: a competition for modules of a virtual exhibition, was described in some detail in the last issue of this newsletter [4]. Last month the UNESCO granted its patronage for the international launching of the MPE Open Source Exhibition, proposed to take place in February 2013. With the present article we hope to motivate you to realise your MPE2013 project in *your* city and in *your* country.

A list of MPE topics

It is not hard to identify a number of topics that are important when we try to master the problems of our contemporary world where mathematics plays a crucial role (see for instance [5]). Here are some examples:

- Network Science in Ecology, Environment, Society and Finance
- Climate Change
- Finance and Sustainability
- Biological Processes
- Environmental Management (nuclear waste disposal, contaminant transports and water quality, transportation emissions)
- Uncertainty Quantification (geostatics and stochastic modelling)
- Renewable and Sustainable Energy (batteries, biofuels, nuclear, natural gas)
- Disease
- Genetics

- Catastrophic Events (seismic modelling, storm surge modelling, tsunami modelling, severe weather prediction)
- Internet and Communications
- Computational and Theoretical Fluid Dynamics
- Materials Sciences (polymers, microstructure and interfacial phenomena, phase transitions, optical and photonic materials)
- Imaging (compression, inverse problems, applications in biomedicine, geophysics, etc.)
- Celestial mechanics

It is very likely that your special subject is close or at least related to one of these topics. Then you are the right person to realise an MPE2013 project!

Of course, if you are an applied mathematician, you may have already written a research paper concerned with one of these topics. But you may wish to write an expository version of a popular mathematical lecture on the global change, as in [6], or a survey article, as, for instance, in [7], that deals with different analytical and numerical models for climate dynamics and presents the interesting contention “that the greatest challenges as well as the greatest promise for novel and innovative mathematical thinking is at this interface between data and models”. Or else you may wish to discuss and develop concrete models concerning any topic on human wellbeing and the natural or societal environment, as suggested in [8], for instance. But even if you are not a mathematician directly involved with any of these topics you may well find other ways to relate mathematics to the MPE2013 project.

Concrete projects

In Europe several European Research Centres of Mathematics belonging to ERCOM have already prepared and/or announced initiatives associated explicitly with MPE2013 (see <http://www.ercom.org/centres.htm>). For instance, the Mathematisches Forschungsinstitut Oberwolfach (this institute also hosts the open source platform for the competition of modules for a virtual exhibition [4]) announced at least two workshops directly related with MPE2013, one on “Geophysical Fluid Dynamics” (W#1308) and another on “Design and Analysis of Infectious Disease Studies” (W#1346). Some centres have already associated their initiatives to a topic, like the Centre de Recerca Matemàtica in Spain, which has a research programme on “The Mathematics of Biodiversity” and has announced for 2013 a conference on “New Trends in Regularization Theory and Methods for Geomathematical Problems”.

The Institut Henri Poincaré in Paris will host a trimester at the Center Emile Borel on “Mathematics of Bio-Economics” from January till April 2013 and the Centro Internacional de Matemática is organising in Lisbon, Portugal, two international conferences, one on “Mathematics of Energy and Climate Change” in March 2013 and another one on “Dynamics, Games and Science” in September 2013.

The Newton Institute in Cambridge, UK, has in 2012 a programme on “Multiscale Numerics for the Atmos-

phere and Ocean” with three workshops. For 2013 their announcements use the MPE2013 logo and three programmes have relations with it, namely “Mathematical Modelling and Analysis of Complex Fluids and Active Media in Evolving Domains”, “Infectious Disease Dynamics” and “Infectious Disease Dynamics”.

At the individual or group level, there are many additional possibilities for being active in 2013. Here are some examples:

- Write a research or survey article!
- Initiate a research project!
- Organise a workshop!
- Present a contribution to the competition of virtual modules!
- Write an article for the general public to be published in a newspaper in your city/country! (In Germany, for example, there will be a series of MPE2013 articles in the nationwide newspaper WELT. Each month there will appear a contribution written by a specialist of one of the MPE2013 topics.)
- Invite a speaker to give a talk for the general public!
- Organise an exhibition!
- Prepare a summer school for the students of your department!

A list of MPE topics already announced in various institutions around the world can be found at <http://www.crm.umontreal.ca/Math2013/en/theme.php>.

Also, you are invited to be an active partner for this worldwide project. If you make up your mind to realise something then don't forget to send an email to the MPE2013 organisers: info@mpe2013.org. They are very interested to learn what's going on in the world.

References

- [1] “Riding the wave. How Europe can gain from the rising tide of scientific data”, final report of the HLG on Scientific Data to the European Commission, 2010.
- [2] J.-L. Lions, *El planeta Tierra. El papel de las matemáticas y de los superordenadores*, Instituto de España, Madrid, 1990.
- [3] *Mathematics of Climate Change, A new discipline for an uncertain century*, Mathematical Sciences Research Institute, Berkeley, CA, 2008.
- [4] E. Behrends, A. Matt, J. F. Rodrigues, “A Competition in Connection with Mathematics of Planet Earth 2013: Modules for a Virtual Exhibition”, *EMS Newsletter* 83, March 2012, 12–13.
- [5] C. Rousseau, “Four themes with potential examples of modules for a virtual exhibition on the “Mathematics of Planet Earth”, *Centro Internacional de Matemática Bulletin* #30 July 2011, 31–32.
- [6] R. Klein, “Mathematics in the Climate of Global Change”, Chap. 15 of *Mathematics Everywhere*, edited by M. Aigner, E. Behrends, American Mathematical Society, Providence, R.I. 2010, 197–216.
- [7] C. K. T. Jones, “Will climate change mathematics (?)” *IMA J. Appl. Math.* 76 (2011), no. 3, 353–370.
- [8] A. Friedman, “Human Well-being and the Natural Environment: Research Challenges in Mathematical Sciences”, Report to a Workshop on Mathematical Challenges for Sustainability held at DIMACS, Rutgers University, 15–17 November 2010. Available online at <http://dimacs.rutgers.edu/SustainabilityReport/friedman8-26-10.pdf>.