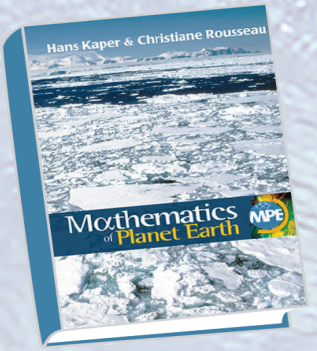
BOOK REVIEW

Mathematics of Planet Earth: Mathematicians Reflect on How to Discover, Organize, and Protect Our Planet



A Review by Christopher K. R. T. Jones

Mathematics of Planet Earth: Mathematicians Reflect on How to Discover, Organize, and Protect Our Planet
Hans Kaper and Christiane Rousseau, Editors
Society for Industrial and Applied Mathematics (SIAM), 2015
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This book is probably unlike any other reviewed in the *Notices*. It is certainly not a textbook, nor is it a popular mathematics book, although it is closer to the latter. It is a collection of blogs from the year on Mathematics of Planet Earth. As such it is largely lacking in editorial control. Despite this fact (or perhaps because of it) it is a real pleasure to read.

The contributions vary greatly in detail and depth. Some are merely short descriptions with a reference or two, while some are nuggets of information about our planet with complete mathematical explanations. A real gem along these lines is the piece by Robert Miller on the Gulf Stream. From popular expositions, you might get the impression that it was merely pure luck we have the Gulf Stream and that Europe should just enjoy it while it lasts, since a warming planet may no longer sustain such a fluke. Miller shows that there are actually intrinsic physical reasons why the Gulf Stream runs and that it will not go away without something much more drastic happening, such as the Earth no longer spinning or the sun no longer shining. There is mathematics involved in his piece, but, from the vantage point of a mathematician, it is not complicated.

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This is the kind of book you might keep on a table in your living room or by your bed and occasionally pick up to read a blog or two. Each time, you will most likely be left with a warm feeling about what mathematics does in our world. You will start to build a picture of what many different people are thinking about how mathematics is applied and why it is important to get out there and see what scientific issues can and need to be addressed using varying levels of mathematics.

A key question, however, is whether the book provides a reliable guide to the problems presented by considering our planet in its current state, or even the more modest objective of listing the mathematical issues involved. I suggest that this is where the reader should be wary. This volume has not been put together with an eye to giving complete coverage of the subject, nor does it even attempt to bring a focus on the most important issues. To people who have been working in this area, it will come across as rather haphazard in both its coverage and its focus. There are many issues of central and critical importance that are either completely omitted or only summarily touched upon. To mention just a few: ice in its many forms, both on land and sea, is not well modeled nor even understood as a material, and the problems are deeply mathematical. Cloud physics is not well represented in climate models, again in part because of our lack of understanding and lack of good models. The related issue of convection raises many mathematical questions. It would be unreasonable, however, to

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expect this book to cover all these issues in any depth, and indeed it would have lost much of its charm had the authors attempted to make a comprehensive introduction to the area out of this variety of contributions. To their enormous credit, they have smoothed out the presentation through their many individual blogs.

The authors chose not to reprint the blogs in their original chronological sequence, but rather to gather them under theme headings. The brilliance of their thinking about the subject comes out in this organization. The section titles are compelling—"A Planet to Discover," "A Planet Supporting Life," "A Planet Organized by Humans," and "A Planet at Risk"—and form a good guide to the various parts of the subject. Some of the sections are much better than others, however, and some give only cursory insight into the field. Surprisingly, the last, "A Planet at Risk," is one of the weakest. Given how much work there has been on prediction issues in climate, which is essentially a mathematical issue, it is a shame that they were not able to engage this community more.

It was pure genius to coin the term "Mathematics of Planet Earth" for the special year of 2013 organized by the various mathematics societies and interest groups worldwide. My understanding is that one of the authors here (Rousseau) deserves the credit. The phrase "Planet Earth" evokes an emotional response in each of us with an almost religious fervor. It is clearly this response and the related concern we each have for the future of our planet that is our best draw to bring people into this rich area of mathematical problems. But we probably don't know yet the boundaries of the subject nor what are its core areas.

I would argue that the issues of how our climate is changing and what we need to do to sustain the planet should frame the subject. The authors clearly go beyond the boundaries such a framing would provide. They include a chapter entitled "Beyond Planet Earth." If we take climate and sustainability as defining the area, it is hard to see the relevance of celestial mechanics and finding efficient pathways for spacecraft unless we are thinking of having to abandon the planet at some point! The problem is that there is a downside to the compelling name *Mathematics of Planet Earth* (MPE): we live on Earth and anything that happens on it or that we do as inhabitants could be viewed as concerning Planet Earth, and if it is mathematical, then it is a subject in this area. Seen this way, the area has no limits, and if so viewed, it will fail as a banner under which to organize and encourage research.

I have to admit that I go back and forth in my own mind on this point of framing this new area. There is a significant upside to its being viewed as all-encompassing, as then anybody can join in the effort and excitement. They can feel welcome under the big tent of MPE by virtue of what they are already doing. The test of success will be whether being part of this new area will redirect their work towards something that really is relevant to climate and sustainability. If that happens, the authors of this volume and the organizers of the MPE effort more generally will be fully vindicated in their big-tent approach. With the Society for Industrial and Applied Mathematics starting an Activity Group on MPE, they have an opportunity to forge a clear direction, and we shall see how well this approach works.

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Christopher K. R. T. Jones

ABOUT THE REVIEWER

The research of Christopher K. R. T. Jones focuses on the use of dynamical systems as a tool for solving problems that originate in applications, especially the use of dynamical systems methods in the study of nonlinear wave motion in neuroscience and optics, ocean dynamics, and, more recently, climate. He is currently director of the Mathematics and Climate Research Network, funded by the National Science Foundation. The network is a broad-based effort to engage the mathematical community in climate science and define the problems that will form an emerging area of "climate mathematics."