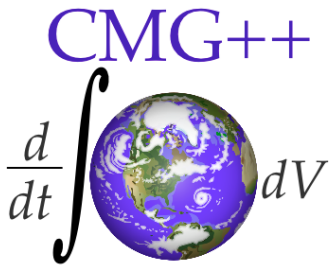

Consortium for Mathematics in the Geosciences (CMG++)

Promoting the development and application of mathematics, statistics, and computational sciences to the geosciences

The Consortium for Mathematics in the Geosciences is a group of researchers interested in promoting the development and application of mathematics, statistics, and computational sciences to the geosciences. Discussions at two workshops and the writing of a white paper have identified four broad research themes in which significant advances in both the geosciences and mathematical sciences can result from accelerating the traditional interaction between geoscientists, mathematicians, statisticians, and computer scientists involved in understanding and predicting the behavior of the planetary environment in which humans thrive, or by which we are threatened. All involve both significant challenges in the geosciences and the development and application of relevant mathematical, statistical, and computational techniques.

I. Assessing and Mitigating Natural Hazards and Climate Change

Although natural hazards, including those associated with climate change, can be enormously destructive, our ability to assess these hazards and develop strategies to adapt to and mitigate their consequences is far from adequate. One key need is to improve the analytical and computational methods used to model the chaotic and complex nonlinear systems involved. A second is to improve our ability to assess the hazards involved, including quantifying the uncertainties in estimating the occurrence of such extreme events and the resulting losses, both from a social and economic perspective. A third is to evaluate the costs and benefits of alternative adaptation and mitigation approaches and thus help society formulate strategies to address these problems.

II. Exploring and Observing Earth Structure and Processes

Understanding earth structure and processes is a fundamental scientific goal with important consequences for studying many of the natural resources on which societal sustainability relies. The Earth system involves the interaction of many physical processes operating through a myriad of scales in a heterogeneous, complex environment Describing these processes and their interactions require descriptions of great complexity and detail. At the same time, certain aspects of the system are observable only indirectly or not at all, even with powerful new observing tools coming on line. Hence progress requires major innovative advances in data assimilation and experimental design,

harnessing heterogeneous data types to improve and validate predictions, and computationally scalable solutions for massive inverse problems. These topics are at the intersection of data acquisition, inverse theory, uncertainty analysis, and optimization and thus offer the opportunity for significant advances in mathematics, statistics, and computational science.

III. Modeling and Simulating Earth Structure and Processes

The crucial task of better predicting the behavior of the earth system will require advances in both the models for earth processes and structure, and the numerical techniques for simulating these models. The models will involve novel combinations of both deterministic and stochastic mechanisms, and integration of multiple spatial and temporal scales. Reliable simulations of these models will demand novel developments in both hardware technology and in numerical methods that can leverage such architectures. These methods must be highly accurate, cost-efficient, feature algorithmic simplicity while allowing for non-uniform spatial and temporal resolution. Concurrently, software libraries must be developed for geoscientists to easily implement such advances in computational mathematics on modern hardware platforms.

IV. Developing & Strengthening Cross-Disciplinary Expertise

These tasks involve integrating the expertise of geoscientists together with that of mathematicians, statisticians and computer scientists. This requires a process in which different groups learn the others' methods, including both strengths and limitations, to develop important insights and solve key challenges. Toward this end, we seek to promote both avenues for collaborative research and interdisciplinary education. The first involves approaches including educating and enabling software users, and developing libraries and community codes for reproducible research. The second involves both interdisciplinary graduate and postdoctoral training, and developing undergraduate curricula, with the goal of training a new generation of researchers with both the breadth and depth of expertise to make major advances.

Implementation

The CMG Consortium is coming together, building on two scientific workshops (http://www.earth.northwestern.edu/Mathgeo and SECOND MEETING URL). Our long-term goal, discussed in a white paper "Fostering Interactions Between the Geosciences and Mathematics, Statistics, and Computer Science", (https://www.cs.uchicago.edu/research/publications/techreports/TR-2012-02) is establishing a geographically distributed but well-focused institute with a novel operational, educational and training structure that can foster and promote these valuable interactions. In the short term, we plan to continue organizing a community and seeking funding for various aspects of our goals.

Achieving the Goals of CMG++: A Framework for Collaboration in Geosciences, Mathematics, Statistics, and Computational Science