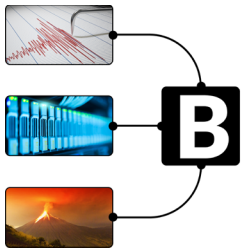
Committee on SEISMOLOGY AND GEODYNAMICS

The National Academies of SCIENCES ENGINEERING MEDICINE

Fall Meeting **October 28, 2019**



BEYOND THE BLACK BOX

The Future of Machine Learning and Data-Intensive Computing in the Solid Earth Geosciences

Register for online attendance here. To attend in person, contact Courtney DeVane (cdevane@nas.edu).

The application of computational algorithms such as neural networks that underpin machine learning (ML) have grown within geophysics over the past several decades. In recent years, the increasing power of computing systems when combined with exponentially growing data holdings is leading to exciting new results and tremendous interest in ML and its application in the geophysical sciences. The solid Earth geosciences have large datasets and are developing the expertise to make major contributions to the ML discipline as a scientific discovery tool.

This meeting reviews progress and future investments needed for a concerted, long term effort to organize the datasets and combine them with appropriate data-intensive computing resources in solid Earth geoscience. This is the natural laboratory necessary for scientists across disciplines to most effectively work together, and we seek to discuss how those workflows and student training can be combined with approaches that provide insights into the physics of earth systems. ML in general is well suited for problems that require interpolation – looking for signals like those for which training data is available - and usually do much more poorly at extrapolation - looking for new signals where similar training data is not available. Many recent geophysical applications fall into three interconnected areas:

- Automation (e.g. seismic phase picking, template detection, data processing, QC)
- Modeling (e.g. ground motion prediction, interpolation of numerical calculations)
- Discovery (e.g. new patterns, structure and relationships)

Speakers will focus on all three of these areas with a special emphasis on emerging opportunities to move beyond automation into modeling and discovery, with a deeper understanding of ML beyond using it as a "black box". As Kong et al. 2019 write: "It would be transformative if we could develop a hybrid modeling framework that combines data driven ML methods with explicit physical models. … Although ML provides…new tools to extract novel insights directly from data, combining classical [geophysical] techniques with ML in a hybrid approach might lead to radically new discoveries". A focus of this meeting is to discuss these ideas and practical next steps.

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Monday, October 28, 2019
Keck Center
Room 206

AGENDA

9:15 AM	**Welcome and Introductions** • Bill Walter

Panel 1: Review of Recent Applications of Machine Learning in Geophysics

Moderator: Cindy Ebinger

Guiding questions:

- *How are ML and deep learning (DL) being used in solid Earth geosciences across the range of subdisciplines? What is the state-of-the-art?*
- *What are the contributions to date of ML and DL to automation, modeling and discovery across the solid Earth Geosciences?*

9:30 AM	**Overview of Machine Learning for Data Driven Discovery in Solid Earth Geoscience** • Karianne Bergen, Harvard University
10:00 AM	**Searching for Hidden Earthquakes in Southern California** • Zachary Ross, California Institute of Technology
10:30 AM	**Rapid Forecasts of Earthquake Hazards from Crustal Deformation Patterns** • Diego Melgar, University of Oregon
11:00 AM	**Panel Discussion**
11:30 AM	**Break**

Panel 2: Next Practical Steps to Accelerate and Broaden Use of ML in the Geosciences

Moderator: Thorsten Becker

Guiding questions:

- *What are the opportunities and challenges for ML and DL for the next 5-10 years in the solid Earth geosciences?*
- *ML and DL are often being used as a black box -- how do we move beyond the current situation into a deeper understanding of the techniques and into physical insight?*
- *What steps do we need to take as a community to move ML and DL forward?*

11:45 AM	**Machine Learning in Seismology: Turning Data into Insights** • Qingkai Kong, University of California, Berkeley (remote)
12:15 PM	**Discussion**

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12:45 PM	**Lunch**

Panel 3: Machine Learning Lessons Learned in Related Fields: Remote Sensing, Physics and Astrophysics

Moderator: Matt Pritchard

Guiding questions:

- *How are ML and deep learning being used in related fields?*
- *What are the opportunities for cross-fertilization with the solid Earth geosciences in terms of techniques and inter-disciplinary workforce education?*

1:45 PM	**Machine Learning in Remote Sensing Applications** • Hannah Kerner, University of Maryland
2:15 PM	**Statistics, Machine Learning, and Astrophysics** • Brice Ménard, Johns Hopkins University
2:45 PM	**Panel Discussion**
3:15 PM	**Break**

Panel 4: Lessons Learned and Next Steps to Advance the Science

Moderator: Bill Walter

3:30 PM	**Summary of Current Status and Opportunities of Machine Learning and Data Intensive Computing in the Geosciences** • Greg Beroza, Stanford University
4:00 PM	**Open Discussion and Q&A with Panelists and Audience**
4:30 PM	**Adjourn**