

Neural Networks and You: Using Satellite Data and Machine Learning for Ecological and Earth System Models

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Project Location:

Brown University

Project Description:

Climate and ecosystem models operate on a discretized grid, and so are only explicitly "correct" at simulating physical processes above the spacing of that grid, which in many cases may be kilometers or higher. All of the physical processes active on smaller scales than the model grid are "parameterized", which means their bulk effect on larger-scale things is captured within a simple set of equations that influence the larger-scale physics. Yet as computing power has increased, the climate model grid scale has been pushed to higher and higher resolutions (lower and lower grid spacings). Now, some of these physical processes are resolved.

As an example: consider the iceberg. Some icebergs might be 10 kilometers wide. In the past, climate models with grid spacings of 1 degree (roughly 100 kilometers) would not be able to simulate individual icebergs, and all of the effects of icebergs on the ocean were parameterized. As computing power has increased, climate models are frequently run with spacings of 10 km or less. Now, some of these icebergs should be clearly visible!

For many types of scientific problems, called multi-scale or fractal problems (like iceberg size), increasing the resolution of our models can cause issues: some of the physics now is larger than the scale of the model but some of it is not! Models must now parameterize the sub-grid-scale physics at the same time as they explicitly model the larger scales. Successfully creating a model parameterization that does this is a real challenge!

Enter machine learning. Neural networks are a growing and increasingly useful way of taking a physical system that is complex, multi-scale, and crosses the grid scale and developing parameterizations of those physics. The SURF student will be tasked with learning about neural network approaches to climate models and model parameterization, and then employing them in one of several potential areas. Two are listed below, but with an interested student we can come up with many more!

(1) Blooms in the Narragansett Bay (with Baylor Fox-Kemper, Aakash Sane) - from space, we can observe highly complex ecological patterns that span many scales. By combining the satellite measurements with simple models of nitrogen and carbon uptake, and comparing to high-resolution model runs, we will create a simple regional model parameterization that describes the influence of these localized multi-scale events on hypoxia within the Bay.

(2) Sea ice in the Arctic Ocean (with Johnny Ryan, Sarah Cooley) - sea ice is a composite material made of individual pieces, called floes. Yet the bulk impact of the size of these floes is unknown because floes

can range from millimeters to hundreds of kilometers across. Our project will involve creating a neural net that takes low-resolution satellite data (as in a climate model) and parameterizes sea ice melting and loss.

*This project involves **both field & lab/computer work***

Required/preferred skills for student applicant:

A desire to learn new things!

General scientific computing skills - familiarity with a common scientific programming language will be necessary (MATLAB, for example).

Optional but not necessary - some experience with machine learning - a course, a youtube tutorial, etc.

Student transportation needed for project?

No