DEAN'S RESEARCH VENTURE INITIATIVE

2025-26 Report

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Dear friend,

Thank you for your support of the Dean's Research Venture Initiative (DRVI), a bold and forward-looking program at the Nicholas School designed to catalyze transformative research that addresses some of the most urgent environmental challenges of our time.

I'd like to introduce you to our 2025 DRVI recipients, and give you a sneak peek into some of the innovative research they are launching with your support. Notably, all of these initiatives take advantage of new AI technologies to move the needle in areas ranging from sea-level rise to human health to climate-resilient food production. In addition, all of the projects involve collaborations with faculty from the Pratt School of Engineering or the departments of math, statistics, or computer science in the Trinity College of Arts and Sciences.

This initiative also invests in the next generation of environmental leaders by providing graduate and PhD students with hands-on research opportunities. These emerging scholars work alongside faculty mentors to solve complex environmental issues through interdisciplinary collaboration and evidence-based action.

We extend our deepest gratitude to you for making this possible. Your generous support not only fuels the advancement of critical research, but also nurtures the talent and vision needed to meet the environmental challenges ahead.

Sincerely,

Duke | NICHOLAS SCHOOL *of the* ENVIRONMENT

AN AI-ASSISTED FRAMEWORK FOR ENVIRONMENTAL HEALTH ASSESSMENT

"Our goal is to demonstrate an approach to discovery of mechanisms of toxicity that is both much faster and more accurate than traditional approaches."

– Dr. Joel Meyer

THE ISSUE

As new chemicals and classes of chemicals are produced, it is critical to understand their toxicity to assess the trade-offs between their benefits and risks. Because of the regulatory shift away from traditional vertebrate animal-based testing, today's methods for toxicology testing are becoming less able to meet modern challenges. At the same time, environmental scientists are faced with the challenging task of manually synthesizing the immense and rapidly growing amount of scientific literature on the subject.

THE RESEARCH

Dr. Joel Meyer of the Nicholas School of the Environment has teamed with Dr. Matthew Hirschey of the Duke Department of Medicine to integrate AI-assisted data analysis tools with traditional toxicological expertise to produce a new model for environmental health assessment.

The AI-assisted tools developed by Dr. Hirschey can comprehensively query databases and integrate that knowledge to produce data-informed hypotheses in hours. By applying these tools to environmental toxicology, they can develop hypotheses to lay the groundwork for training students in this approach. They can also test these hypotheses in non-vertebrate roundworms (Caenorhabditis elegans), in Dr. Meyer's laboratory.

These new methods and techniques will equip the next generation of environmental health leaders with skills that dramatically accelerate discovery.

THE IMPACT

Funds from the Dean's Research Venture Initiative is allowing the team to apply AI to environmental health challenges, combining computer models and simulations with real-world experiments to verify findings. It will also result in a database of computer models and experiments to train students how to use AI to determine whether and how substances cause harmful effects in living organisms.

** There were two categories of awards this year. This work was funded with a traditional research seed award that will enable future external funding if the project is successful.*

EXPLORING ICE SHEET SURFACES TO FORECAST SEA-LEVEL RISE

> *"By using AI to determine sampling locations, our rover will provide an opportunity to develop algorithms that will allow a robot scientist to assist humans with environmental exploration and sampling."*
>
> – Dr. Jonathan Ryan

THE ISSUE

Measuring the mass of the Earth's ice sheets is essential in determining causes of sea-level rise and forecasting future global sea levels. The current method is to measure the changes in ice sheet elevation, but converting elevation change to mass change requires knowledge of the density of the ice layer and the amount of firn (an intermediary stage between compacted snow and glacier ice).

Firn densification, the process by which snow transforms into glacial ice, is complex and requires measurement of hand-drilled ice cores. These ice cores are time-consuming, laborious, and expensive to collect.

THE RESEARCH

Dr. Jonathan Ryan of the Nicholas School teamed with Dr. Boyuan Chen of the Pratt School of Engineering to develop:

- An experimental AI scientist, "FirnBot," that is capable of physically collecting shallow ice and snow density measurements as well as autonomously selecting sample sites without human intervention
- A theoretical AI scientist, "DeepFirn," that will use deep learning to predict the shallow ice and snow density directly from climate data, for converting volume change to mass change

This collaboration will lead to the design of a rover that is capable of traveling long distances in extreme cold (as low as -40˚C) to sample and measure ice cores.

THE IMPACT

This funding will support the innovative use of autonomous vehicles for glacier and ice sheet research. This research will demonstrate the potential for a swarm of robots to collect shallow density measurements across large expanses where it would be too difficult and time-consuming for humans. The data provided by FirnBot will be used to calibrate data for DeepFirn, providing opportunities to use deep learning approaches to predict shallow densities.

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LINKING OCEAN TEMPERATURE VARIABILITY TO GLOBAL CROP YIELDS

"Our goal is to identify key climate drivers, develop predictive early warning systems, and inform adaptive management strategies to reduce climate risks in cropping systems."

– Dr. Liyin He

THE ISSUE

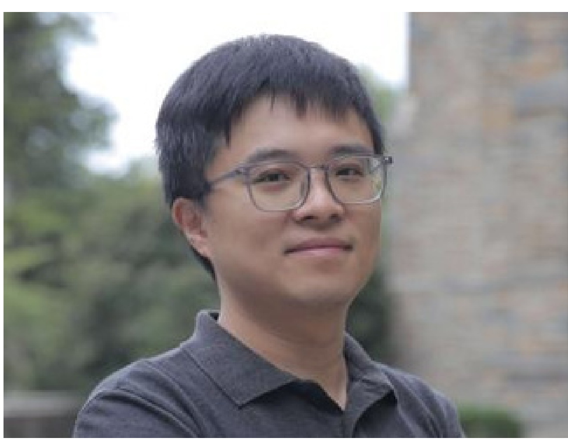
Feeding a growing global population will require sustained increases in crop productivity and resilience. Agricultural production remains highly vulnerable to climate variability from year to year, particularly to extreme events such as droughts, flood, and heatwaves. The pan-tropical ocean temperature variability, which includes El Niño and other climate patterns, is a major driver of this kind of variability in key agricultural regions.

THE RESEARCH

Dr. Liyin He and Dr. Shineng Hu of the Nicholas School aim to develop an AI approach to quantify the impact of climate variability on food production. Crop and climate datasets will be used to explore AI-based methods to identify key predictors of pan-tropical ocean temperature variability. The focus will be on major breadbaskets such as the U.S. Midwest, the Indo-Gangetic Plain, and South America.

THE IMPACT

This funding enables the team to identify methodological gaps and opportunities for collaboration, which will ultimately lead to better systems for agricultural risk management in a rapidly changing climate. These may include early warning systems, improved irrigation practices, or adjusted planting schedules. This work has the potential to enhance food security as well as economic and environmental sustainability.



"This interdisciplinary project leverages Dr. He's expertise in terrestrial ecosystems and my expertise in ocean and climate variability. Both are critical elements to building ocean-informed early warning systems for global crop yields."

– Dr. Shineng Hu

** There were two categories of awards this year. This work was funded with a small intellectual planning grant that allows faculty to collaborate on a nascent research issue that could develop into a new research collaboration for future funding.*

HOW BEHAVIORAL SCIENCE CAN INFORM RIVER FLOW MODELING

"An important emphasis of this work is 'centering' environmental managers as individuals and entities for research. We may be able to empirically test whether they are adopting tendencies well-known from behavioral science, which may have significant environmental impacts."

– Dr. Martin Doyle

THE ISSUE

Traditionally, when operating upstream reservoirs to control downstream river flow, environmental managers use "guide curves." These engineering-based regulatory guidelines represent target elevations or storage levels for a reservoir over time, helping achieve desired water levels and manage water resources more effectively. Insights from behavioral science tell us that reservoir operators are making decisions independently and are not consistently operating using guide curves.

THE RESEARCH

Dr. Martin Doyle and his team are developing a large-scale database on U.S. Army Corps of Engineers reservoir operations. This database would use AI-based analytic approaches to identify patterns of behavior among different reservoir operators.

THE IMPACT

Research on environmental decision-making has often focused on consumers rather than environmental managers – those individuals who make environmental decisions on behalf of others. Funding through the Dean's Research Venture Initiative will help Doyle's team demonstrate how scholars can more appropriately consider environmental managers – such as reservoir operators – as relevant to research, and how individuals' decisions can influence environmental outcomes.

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