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UNIVERSITY OF MIAMI
FROST INSTITUTE
for DATA SCIENCE
& COMPUTING



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IDSC

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Data science holds the key to tackling society's greatest challenges. From the advancement of AI to smart cities, social justice, or the global environment, a leading-edge computational approach can extract hidden knowledge and generate fresh insights from large and complex datasets across many different sectors.

Leveraging the University of Miami's state-of-the-art technology platforms, including an AI-ready supercomputer and expertise in Advanced Computing and Systems & Data Engineering, the Frost Institute for Data Science and Computing (IDSC) supports basic and applied research initiatives University-wide, and shares ideas, insights, and resources.

As a member of the University's Frost Institutes of Science and Engineering, IDSC is launching new programs in data science and building close ties with academic institutions worldwide to develop educational, research, and community partnerships. IDSC's focus on collaboration also extends to industry, government, and nonprofit partners who recognize the University's ability to provide valuable support.

Explore how the U's powerful resources in data science and computing can help you achieve your research, training, and business goals.

Nick Tsinoremas | FOUNDING DIRECTOR
Ben Kirtman | DEPUTY DIRECTOR



- › AI + Machine Learning
- › Data Ethics + Society
- › Digital Health + Life Sciences Informatics
- › Earth Systems Science
- › Human Centered Design + Computing
- › Smart Cities + Smart Environments
- › Partnerships
- › Workforce Development



AI + Machine Learning

Artificial intelligence (AI) and machine learning (ML) are powerful tools for uncovering fresh insights, trends, and opportunities in a wide range of fields from the sciences to the humanities.

Algorithms developed through AI and ML systems could accelerate the R&D process for new vaccines and therapies. In business, AI applications can help companies deliver a better customer experience and facilitate targeted marketing initiatives. In the social sciences, AI can help researchers identify disparities within communities and point the way toward potential solutions.

IDSC's professionals support research in AI and ML, including natural language understanding (spoken and written), computer vision, data mining, human-computer interfaces, data visualization, and deep learning.

As the world's data grows in volume, velocity, variety, and veracity, the need for powerful, unbiased AI and ML tools will increase exponentially. IDSC can streamline the development of algorithms and applications that assist in decision making and solving complex problems.

From chemical manufacturing to cosmetics, AI is set to unleash an era of rapid innovation and transformative solutions in product formulation. By leveraging the power of AI, companies can streamline their development processes and quickly identify promising formulations. This not only speeds up the product development timeline, but also reduces costs and increases the likelihood of success. AI-driven formulation tools also have the potential to revolutionize data analysis of large amounts of data from lab experiments to customer feedback, enabling continuous improvement of existing products and aiding in the development of new ones that better meet consumer needs and preferences. The integration of AI in product formulation holds great promise for disrupting traditional methods and accelerating the introduction of innovative products to market.



Yelena Yesha, PhD
DIRECTOR





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A visualization of NASA's GPM (Global Precipitation Measurement) Core Observatory flying above the Earth and partner satellites in the background (by Ellen Gray).

NASA Looks to IDSC AI + Machine Learning to Address Satellite Security

Blockchain Technology will help secure all the data collected by satellites, making it much more difficult for adversaries to gain illicit access.

Five years ago, representatives from telecommunications companies approached Dr. Yelena Yesha in a panic. As they sent more and more satellites into orbit around the Earth, the potential risks for hacking grew with each launch and they wanted guidance from Yesha, a world-renowned computer scientist who has worked extensively in cybersecurity. Fast forward to 2023, and Dr. Yelena Yesha was approached by NASA. The government space agency was looking for ways to protect its growing constellation of satellites and signed a contract with Yesha's team at the University of Miami's Frost Institute for Data Science and Computing (IDSC) to help mitigate cyber risks.

Yesha, who runs the AI +Machine Learning unit at IDSC, describes the response as a monumental task, especially to address concerns for smaller craft (commonly referred to as nanosatellites or microsatellites), with limited hardware, software, and power budgets. And given that satellites mostly communicate with the ground through basic radio signals, or network between satellites, "anybody can mess with the data, corrupt it, put something that doesn't belong there"

Yesha said. "We need to protect intersatellite inter-communication in space."

Yesha's team is developing a new computational platform that will be used to explore the security of satellite operations using a simulation environment. Jacqueline Le Moigne, Advanced Information Systems Technology (AIST) Program Manager for NASA's Earth Science Technology Office (ESTO) said "NASA is developing revolutionary capabilities in terms of Intelligent and Collaborative Constellations of Smallsats communicating seamlessly with ground and airborne sensors. Dr. Yesha's work will provide NASA with zero trust cybersecurity technologies that will ensure that all of these various observing nodes will be able to securely communicate and interact to form the future 'Internet of Earth-Things'."

Project Collaborators

Steven Dennis, Jacqueline Le Moigne, Phuong Nguyen, Yusen Wu, Yelena Yesha

Data Ethics + Society

Who controls—and who should control—an individual's personal data and information? How ought we balance privacy rights with public safety and the common good? Who should review the assumptions, research, and policies that shape artificial intelligence (AI) and machine-learning systems? IDSC is committed to identifying, addressing, and resolving these ethical, legal, and social challenges in collaboration with the University of Miami's Ethics Programs and Institute for Bioethics and Health Policy.

IDSC recognizes that data ethics and social issues underlie all aspects of information technology, includ-

ing computational science, software engineering, AI, and deep learning. This opens the door to a wide range of research projects with immediate relevance to contemporary social issues, as well as to challenges whose resolution will have long-term implications.

IDSC's collaborations include across-the-curriculum contributions to teaching and learning, innovations in incorporating data ethics into UM's Responsible Conduct of Research training, and the use of intelligent machines in hospital care. These relationships have stimulated research on topics ranging from appropriate uses and users of intelligent machines to privacy challenges raised by data collection and analysis and surveillance to strategies for AI governance and oversight.



Ken Goodman, PhD FACMI FACE
DIRECTOR





Digital Health + Life Sciences Informatics

Digital health care has entered an era of major data transformation spurred by the use of advanced analytics and related technologies. Data-driven translational research, population health management, and precision medicine have served as the catalyst. IDSC Digital Health and Life Sciences Informatics encompasses Digital Drug Discovery, Population Health Informatics, and Social and Behavioral Data Science.

The University of Miami Miller School of Medicine, as a learning health care system—one in which knowledge-generation processes are embedded in daily practice to produce continual improvement in care—affords availability to millions of UHealth patient records.

Access to extensive patient data from diverse sources, including structured, semi-structured, and unstructured data, enables data science to enhance precision medicine by improving diagnosis accuracy, tailoring treatments, and predicting disease risk. This data-driven approach allows us to identify patterns in patient profiles, responses to medications, and health outcomes, ultimately advancing personalized healthcare.

IDSC's technology platforms allow physicians and researchers to analyze vast data sets across different systems, informing healthcare decisions, and transforming basic and translational biomedical research.

Stephan Schürer, PhD

DIRECTOR, DIGITAL DRUG DISCOVERY



Azizi Seixas, PhD

DIRECTOR, POPULATION HEALTH INFORMATICS



Daniel Messinger, PhD

DIRECTOR, SOCIAL AND
BEHAVIORAL DATA SCIENCE



Sylvester Comprehensive Cancer Center's Data Portal to Accelerate Cancer Research

Florida has the nation's second-highest cancer burden. Extensive, well-organized, harmonized, and deeply annotated data is needed for cutting-edge cancer research strategies.

A new state grant will build on the foundation of the Sylvester Data Portal (SDP) to accelerate cancer research throughout Florida. In addition, Sylvester's membership in the American Association for Cancer Research's Project GENIE (Project Genomics Evidence Neoplasia Information Exchange) will enhance national data collaboration. "We plan to establish the 'Florida Cancer Research (CARES)' computational research network to facilitate access and sharing of cancer-related data and bioinformatics resources," said Stephan Schürer, Ph.D., Sylvester's associate director of data science, professor of pharmacology at the UM Miller School of Medicine.

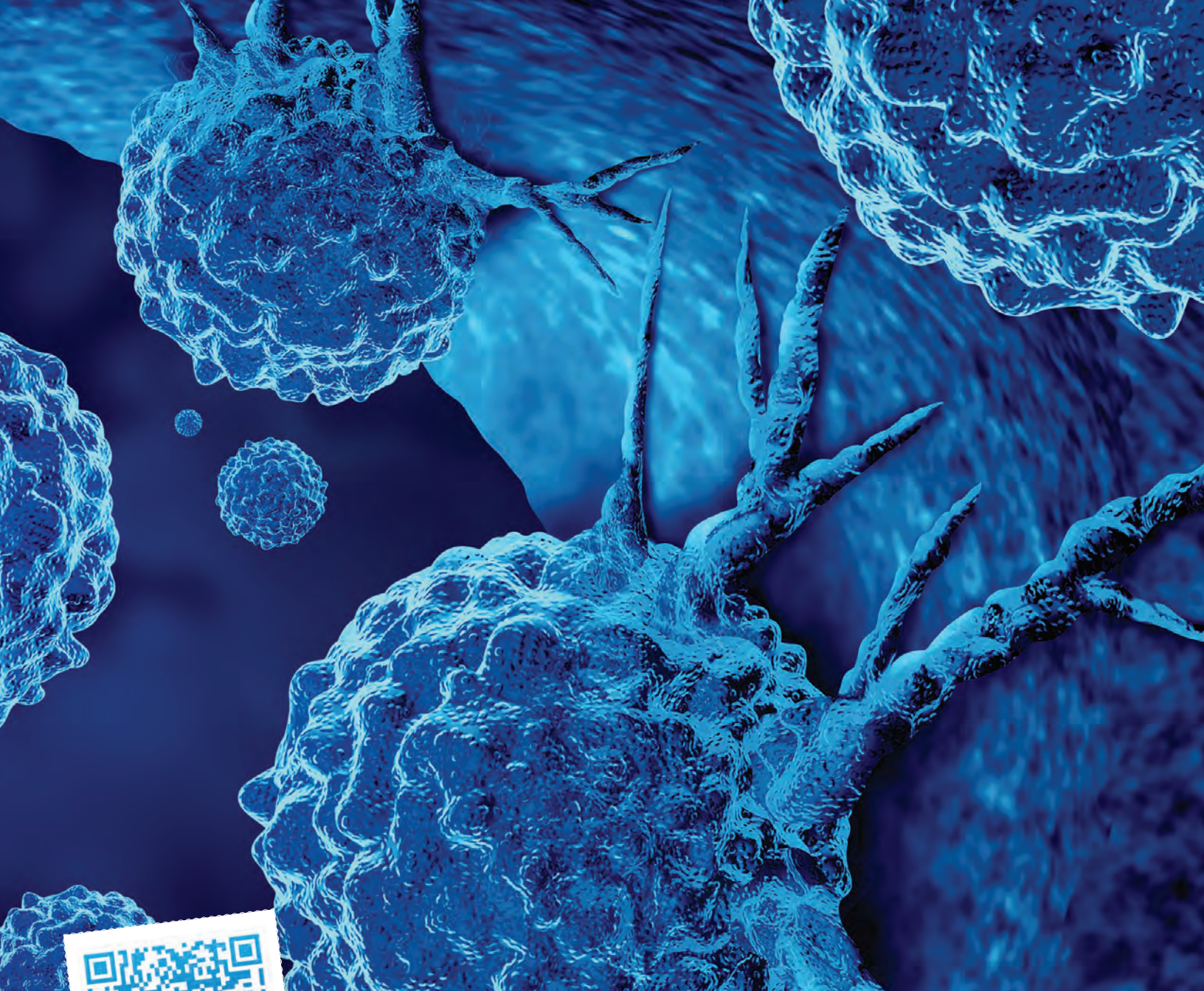
With the \$1.5 million Bankhead-Coley Cancer Research Program Florida Infrastructure Grant, SDP will provide the foundation for the Florida "Platform for Accelerating Collaborative Computational Cancer Research" (PAC3R—pronounced "pacer"), which will connect the University of Miami with five other Florida research institutions in the CARES network.

This Sylvester-led initiative will include instituting an administrative and policy framework to govern data and metadata standards, data sharing, privacy, security, access to resources, reporting requirements, membership, outreach, and collaborative opportunities. The PAC3R technology platform will be a foundation for data-driven, collaborative cancer research.

"We will demonstrate the potential of PAC3R by integrating, coordinating, and sharing relevant cancer datasets and deploying bioinformatics tools across the Florida research network," said Dr. Schürer. "We will also develop and share a collection of bioinformatics resources to mitigate existing health disparities in cancer treatment and outcomes."

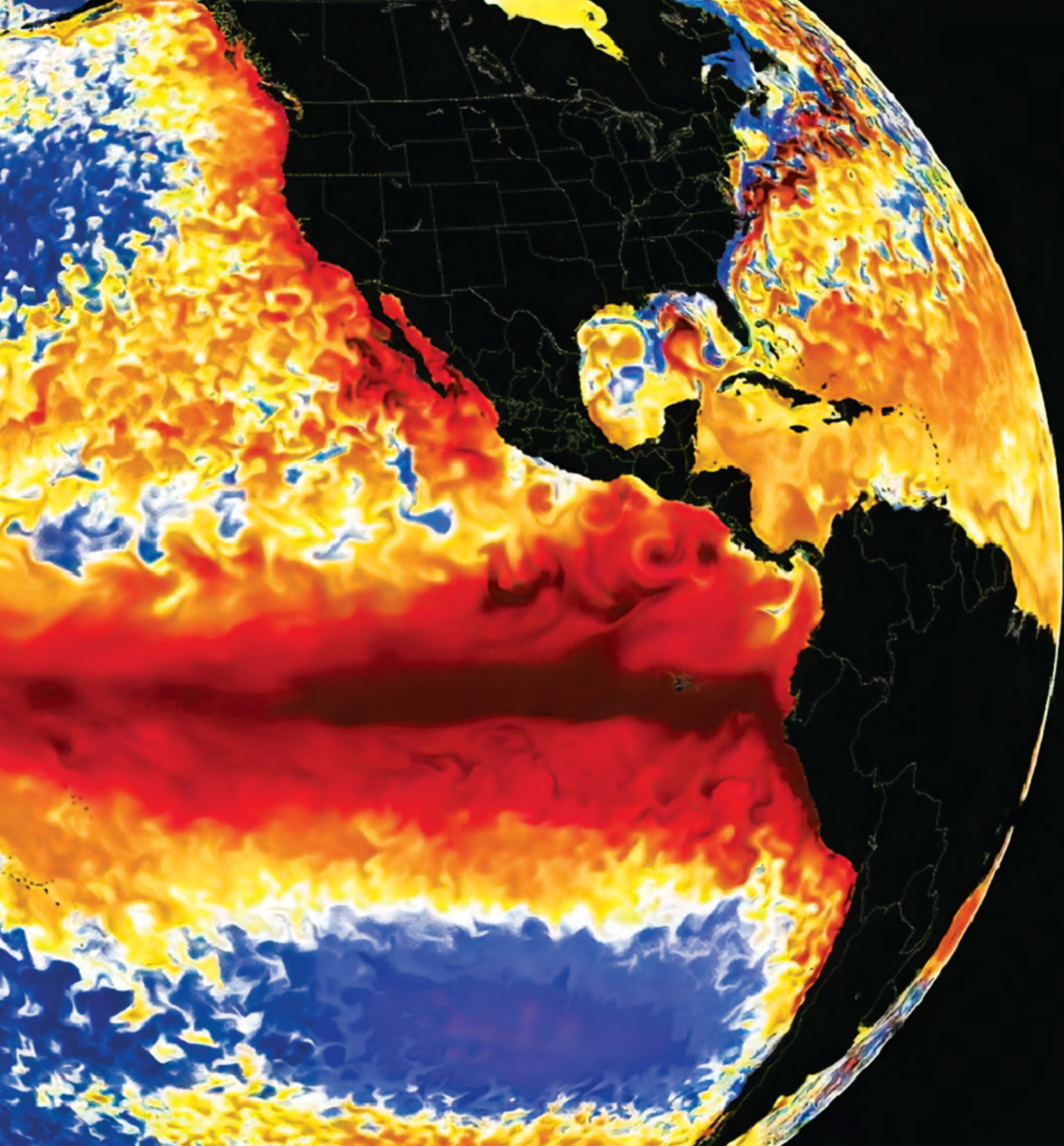
Project Collaborators

Stephan Schürer, Vasileios Stathias



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Sylvester researchers will develop predictive models while contributing clinic-genomic data that will “enable impactful discoveries transcending race, ethnicity and geography.” -VASILIEOS STATHIAS, PHD, Assistant Director for Data Science



Earth Systems Science

Vast quantities of data and powerful analytic tools are needed to analyze complex weather patterns, track ocean currents, or predict seismic events. IDSC's computational power and analytic platforms can help researchers develop sophisticated models based on highly diverse datasets with abundant information, as well as those with sparse data and high uncertainty.

Machine learning (ML) techniques can detect rare but extremely dangerous events such as tsunamis, submarine earthquakes, and volcanoes, and aid

in life-saving early warning systems. By pairing ML with Bayesian statistics, researchers have access to multiple prediction tools for more reliable forecasts, and a detailed understanding of the ever-present uncertainties.

IDCS Earth Systems Science researchers are using these resources to address atmospheric, oceanic, and earth science problems—particularly in areas where direct observations are difficult, such as the deep ocean, polar ice caps, and upper atmospheric wind currents. One example is the North American Multi-Model Ensemble (NMME) for climate prediction, developed at the University of Miami and adopted by the National Oceanic and Atmospheric Administration (NOAA), which provides guidance to the Federal government.



Benjamin Kirtman, PhD

DIRECTOR

Trio of Grants Awarded to Study El Niño and its Role in Wildfire and Flooding Prediction

Two grants from NOAA fund work with first responders while simultaneously developing a real-time prediction model and one from NSF looks at predicting El Niño's intensity.

When Ben Kirtman started researching the meteorological phenomenon known as "El Niño" in 1993, few knew what it was and even fewer foresaw what that research could lead to. Now, 30 years later, Kirtman and an ever-growing team of collaborators have not only helped make El Niño a household name, but they're starting to use the lessons they've learned along the way. Kirtman recently secured three grants totaling more than \$3 million. The results, Kirtman said, can influence how governments prepare for disasters, help firefighters prepare for wildfire season, and have profound effects on the day-to-day lives of people living in the shadows of fires and floods. "Everything is connected," Kirtman said. "In my mind, it's all one thing."

Kirtman is most excited that the new projects were driven by his current and former students. In fact, former students are his co-principal investigators on two of the new projects. After spending decades focusing on theoretical and predictive research, Kirtman's students have pushed him to conduct more practical meteorological research that can improve

current-day weather forecasts, and save lives in the process. "People I'm working with really want to do things that matter," he said. "I want to keep the theoretical and prediction work going because it fascinates me, but translate that to something that helps the world. My students really care, my post-docs really care, so I want to support that."

Project Collaborators

Emily Becker, Ben Kirtman, Samantha Kramer, Sarah Larson, Brian McNoldy, Brian Potter, Brian Soden

"The way we think about this is the co-production of science. The use case is going to drive how the science is done."

-BENJAMIN KIRTMAN, PHD

William R. Middelthorn III Endowed Chair in Earth Sciences



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Until now, fire first responders have been relying mostly on generic, short-term weather forecasts and basic prediction tools like the Hot Dry Windy Index (HDWI) that are erratic and can predict weather conditions for up to only two weeks.



Human Centered Design + Computing

Visualization and Creative Technologies

It can be challenging to convey the meaning of complex models and data sets clearly and accurately to journalists and the public. Visualization is an effective strategy for presenting scientific findings in an understandable manner, as well as for identifying significant patterns hidden within the data.

“Unrivaled at teaching data visualization, UM has deep coursework in infographics, visualization, cartography, 3D modeling, and advanced programming—all related to journalism.”

The University of Miami has taken the leap into the Metaverse and IDSC researchers are at the forefront of Creative Technologies, using code and design to shape our world. Students use AR, VR, and XR immersive technologies to coalesce computing and shape the Metaverse in the new Digital Twins Lab.

“Faculty and students will now have access to educational materials, job search platforms, online training, research, and a network of companies working in the immersive space.”



Alberto Cairo, PhD

DIRECTOR, VISUALIZATION

Kim Grinfeder
DIRECTOR, CREATIVE TECHNOLOGIES



“Mangrove City” Collaborative VR Project wins Educate Category at AWE 2023 Awards

Geared toward middle school and high school students, the Mangrove City Virtual Reality app lets students experience potential options for cities to adapt to sea-level rise.

With sea levels rising at increasing rates worldwide, IDSC Creative Technologies Director Kim Grinfeder wondered: could he create a virtual experience that teaches students how they might navigate a coastal city like Miami 100 years from now? “It is expected that 243,000 square miles in the U.S. will be impacted by sea level rise in 2100, and several large cities are within that area, including Miami. Building walls isn’t going to be enough; we need to learn how to adapt.” said Grinfeder. “Understanding mangrove ecology and how to leverage this ecosystem to build urban resilience will be critical to our survival.”

To address sea-level rise, Grinfeder formed a small interdisciplinary group of students, faculty, and staff with expertise in virtual reality, mangrove ecology, coastal management, and architecture. And this summer, they unveiled their immersive application, called “Mangrove City.” The group’s efforts did not go unnoticed. The Mangrove City team recently placed first in the education category at an XR Prize Climate Change Challenge as part of AWE, the Augmented World Expo in California.

Project Collaborators

Rafael Araujo—Rosenstiel School of Marine, Atmospheric, and Earth Science, Ashay Dave and Sourav Pande—Frost School of Music, Ruth Ron—School of Architecture, Kim Grinfeder, Kumani Riley, Bryson Rudolph, and Cassandra Swilley—School of Communication, and K. “Ren” Rende—University of Nebraska

“Often the most effective learning is experiential, and virtual reality offers a unique opportunity to transport students into mangroves and to consider alternative realities. I see applications like this as the future of education.”

-KIM GRINFEDER
Director, Creative Technologies

IND AWE
VERYWHERE



Mangrove City
by University of Miami

WINNER
XR Prize Challenge
Educate Category



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Accepting the award, from left to right: Kim Grinfeder, Kumani Riley, Bryson Rudolph, and Ashay Dave, onstage at the Augmented World Expo (AWE) 2023 Awards ceremony in Santa Clara, California.



Smart Cities + Smart Environments

A smart city utilizes information derived from diverse datasets to design and manage sustainable and resilient communities. Integrating data from devices and sensors connected to the Internet of Things (IoT), as well as other applications and platforms, can optimize municipal operations and service delivery, while creating new kinds of experiences and engagement opportunities with residents.

IDSC's powerful resources empower researchers to exponentially expand the reach, diversity, and magnitude of that municipal data in real time to deepen their understanding of the urban ecosystem.

Smart cities research includes data collecting technology as well as data analytics and advanced hardware and software applications. IDSC builds on this research to provide design services for the planning and implementation of smart cities in the region and around the world. Today, IDSC is in a unique position to leverage its computational resources, along with its expertise in physical computing and data analytics, to design the next generation of smart cities and environments.

“Technology is not only an instrument for construction, design, management, and workflow, we think of it as ingredient—we are embedding technology into *every* building material to see what happens.”



Rodolphe el-Khoury, PhD

DIRECTOR

Environmental Justice Clinic Partnership Develops New Tool to Combat Displacement

Moving from a paper-based spreadsheet to automating the data collection and aggregation was a tremendous step forward bringing a fresh perspective to using local data.

For many years, the school of Law's Environmental Justice Clinic has been an advocate for vulnerable minority communities facing development pressure. Now, the Frost Institute for Data Science and Computing (IDSC) has partnered with the clinic team to develop a user-friendly tool, supported by rich data sets, that empowers grassroots organizations.

Chris Mader, Senior Director, IDSC Systems + Data Engineering, led the team that developed the web-based **Displacement Vulnerability Mitigation Tool** (DVMT), which brings together approximately 50 data sets of geospatial and demographic information relating to properties and neighborhoods in the Miami area. The data is maintained with the Geospatial Digital Special Collections (GDSC), the result of a recent IDSC initiative to develop a UM resource for maintaining structured collections of geospatial datasets.

"In addition to keeping the data sets current, we record them so researchers in the future will be able to track changes," Chris said. "We use IDSC's ad-

vanced computing resources (including the TRITON supercomputer) to run these applications."

With this new tool, community organizations can select specific parcels targeted for development. The DVMT will then calculate the risk of displacement. "It's a great tool to start conversations with policy-makers about the need to protect neighborhood cultures as well as housing in historically marginalized communities."

"Greater Miami has experienced cycles of higher-density and mixed-use development that have exacerbated gentrification and displaced existing residents. This offers suggestions for mitigating that impact."

-ABIGAIL FLEMING, JD

Associate Director, Environmental Justice Clinic



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The Displacement Vulnerability Mitigation Tool can calculate the risk of displacement, then take things a step further by presenting a set of mitigation options in different categories for highly vulnerable areas.



Partnerships

Meet Justin Gammage, Director of Partnerships at IDSC. In this role, Justin leads the development of creative partnerships with stakeholders from business, industry, and the broader local and international communities. Integral to these efforts is building collaborations that leverage the University of Miami's internationally recognized faculty and research staff, along with its world-class computing infrastructure.

An expert in operational AI, Justin can connect you to the right IDSC resources that can help build, test, and validate machine-learning models, develop a proof of concept, or accelerate the commercialization process.



Justin Gammage, PhD, PEng

DIRECTOR

IDSC serves as a pipeline to the U's specialized degrees and training in data science and computing, and offers research and support services for non-experts in the field. Through Justin, IDSC brings a full set of options to potential University partners.

From elevating imaginative start-ups to helping actualize ideas for industry-shaping innovations, an IDSC partnership can help you achieve your goals.

“ As IDSC expands its reach into South Florida’s tech community, I look forward to seeing where scientific innovation will take the U.”

To collaborate with IDSC, give Justin a call:
305.243.1639 | idsc@miami.edu

Workforce Development

Currently, Miami-Dade County has hundreds of businesses, nonprofits, and government agencies that employ data science professionals. This pool of talent continues to grow as the South Florida region attracts more technology companies.

Recognizing the importance of the growing business technology workforce needs, IDSC has partnered with the Miami-Dade Beacon Council, the area's key public-private economic development organization. Working through our Industry Advisory Board, IDSC is compiling local data science job descriptions in order to analyze the requisite skills and knowledge.

The resulting insights are made available to UM and other academic institutions in our community so that curriculum and course offerings can be aligned with industry needs.

This type of workforce development initiative will support the expansion of local businesses, as well as the relocation of newcomers. It can help businesses understand the nature of the ICT (Information/Communication/Technology) talent pool in South Florida, so they can source the right talent locally. This partnership is a win-win for our community.



“IDSC is building partnerships to develop the skilled STEM workforce of the future.”

Mitsunori Ogihara, PhD

DIRECTOR





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