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The Courant Institute of Mathematical Sciences at New York University

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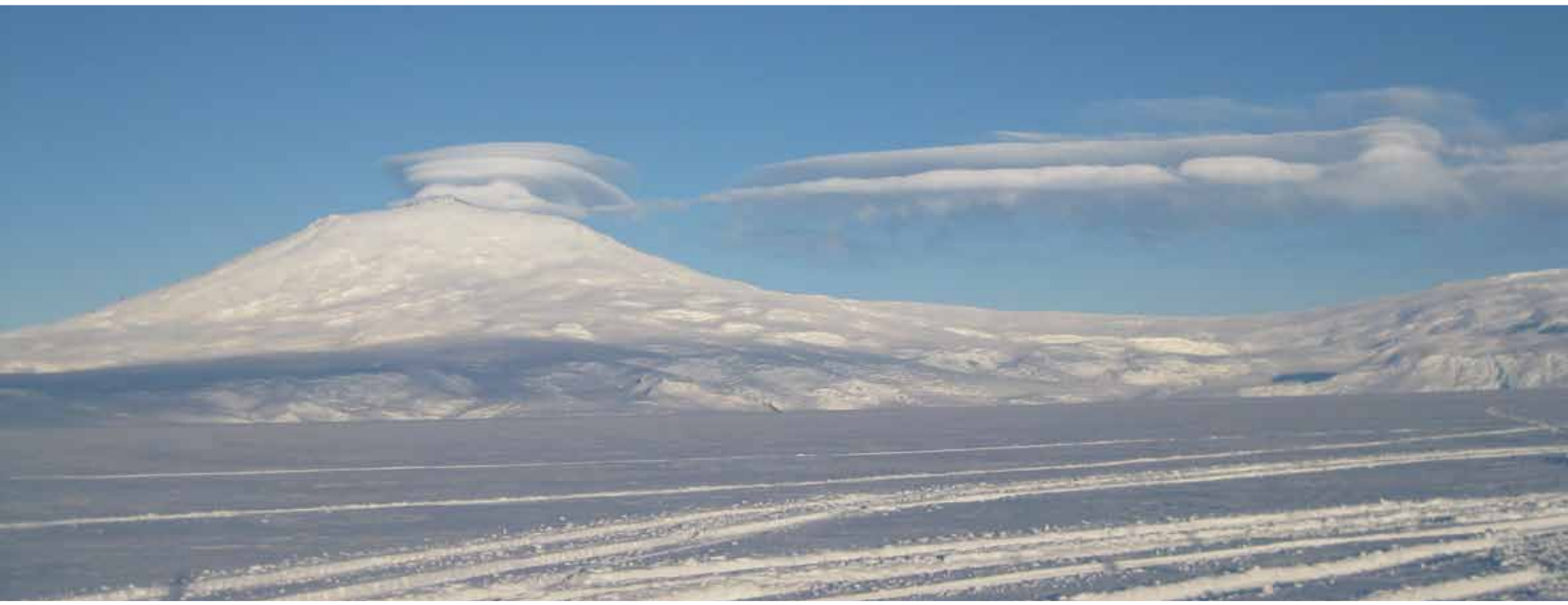


In this Issue:

The Iceman Cometh: **David Holland** Studies Polar Ice Sheets to Predict Rising Sea Levels by M.L. Ball

A disassembled helicopter is loaded on board an Air National Guard Hercules aircraft en route to McMurdo Station. The helicopters were used at the remote Pine Island Glacier base camp where Holland and his graduate student installed an autonomous weather station and geophysical surface instrumentation in Jan. 2013.

David Holland, Courant Institute Mathematics Professor and past Director of the Center for Atmosphere Ocean Science (CAOS), recently returned from two months on Antarctica's Pine Island Glacier conducting field observations and installing ice measurement instrumentation. Professor Holland specializes in ice-ocean interaction, physical oceanography and climate system dynamics.

Growing up playing ice hockey in St. John's in Newfoundland and Labrador, Canada, David Holland always thought he would study something having to do with ice. His boyhood hunch came to pass, as he now spends his time studying ice thickness, observing melting ice flows and collecting data from the frozen fjords of Greenland and Antarctica in hopes that scientists, today and in generations to come, will be able to predict the rate at which sea levels are rising.

Global sea level: A key focus of the CAOS group

One of the most pressing issues currently being studied by the Courant Institute's CAOS group is global sea level. "Specifically, why it is changing and how much might it change in the next hundred years or so," explains Professor Holland. "To try to determine that, we look at two ice sheets, one in Greenland and the other in Antarctica. These are huge mountains of ice, well above present-day sea level, that are equal to sixty feet of ocean height, in the case of Greenland alone.

When this ice melts and flows into the ocean, it causes the sea level to rise, but not just in one place. Similar to an ice cube being put into and then melting in a glass of water, when marine ice melts, the sea level rises everywhere, really fast," he says.

In Antarctica, Holland's group is studying not only the thickness of the ice but also the movement of water flowing out to the ocean and back in to land again. The group's focus is the same in Greenland except that there, the ice is not as big a threat as in Antarctica. It is also much easier to get to. "Greenland is largely trapped on a piece of land, while part of Antarctica is actually in the ocean," says Holland. "That's the difference and that's the key."

Warm ocean water flowing through fjords will determine the next 100 years of sea level change

Scientists recognize that for the past millions of years, melted ice has been traveling to the ocean by way of fjords, which are canal-like passageways. To study this, Holland's group of researchers, numbering around ten people, makes camp every summer on the Jakobshavn Glacier in Greenland, "which is just ridiculously beautiful, amazing and impressive," he says.

"We're dealing with a massive amount of ice that's been grounded onto rock and is extremely thick," he explains. "When warm water from the ocean flows through the fjord to the ice-covered land, this causes the ice to melt and come back out. Our goal is to place a temperature sensor into the ocean so we can see whether or not warm water is

coming into the fjords and ice is flowing out, which is the issue affecting global sea level change for this century and the next."

Future sea levels cannot yet be predicted

Surprisingly, even with today's technology, instrumentation, and data analysis capabilities, Holland says that scientists cannot predict the sea level over the next century because the mathematical and physical constructions to simulate what will happen to the Greenland ice sheet, and far more importantly, the larger Antarctica one, do not exist.

"We have mathematical tools, numerical methods and computers," Holland explains. "But when you attempt to write your equation down, you realize you don't know what to write because you haven't studied the details of what you're trying to describe. That's why for the last five years, I've done field observation, collecting data that will hopefully bring some insight into what we're trying to describe."

Collecting this data will take at least 100 years, he predicts. "Generations will be doing this. We're just trying to make moderate progress and meaningful contributions, so that future researchers will find our data set really useful, and can then go off and develop some theory based on it."

Collecting data in one of the harshest, most remote places on earth

Think you're up for a challenge? Think again before joining Professor Holland on one of his annual expeditions, financed by the National Science Foundation, NASA, and the NYU Abu Dhabi Research Institute ("at staggering cost," he says). To reach the Pine Island Glacier in Antarctica and make a measurement took his group seven years from start to finish. "One measurement, seven years," says Holland. "We went every year and finally this year, after many, many failures, we got in."

This particular area of West Antarctica is the most important location for sea level study on earth, according to Holland, because of its marine ice — ocean water into which ice has spilled. Getting there, however, is more than a little tricky.

"You can't get there by boat because the icebergs will kill you," he says. "They make waves that will roll over on you and swamp your boat. And you have to go in summer, because in winter you'd freeze to death. Then once you get to Pine Island Glacier, which is where you want to drill a hole through the ice, you need lots of equipment and a camp, all the while trying not to fall into any of the crevices and die."

Next, you need a base, but the nearest one is 1,400 miles away at McMurdo. To get onto the ice, you need helicopters which must be transported by Air Force jets. This requires a runway to be built so that the jets can land next to the glacier, plus large amounts of fuel which must be hauled across Antarctica by sled, along with food and shelters. "That's why it takes seven years," says Holland.

Lured to Courant by Andy Majda and the CAOS group

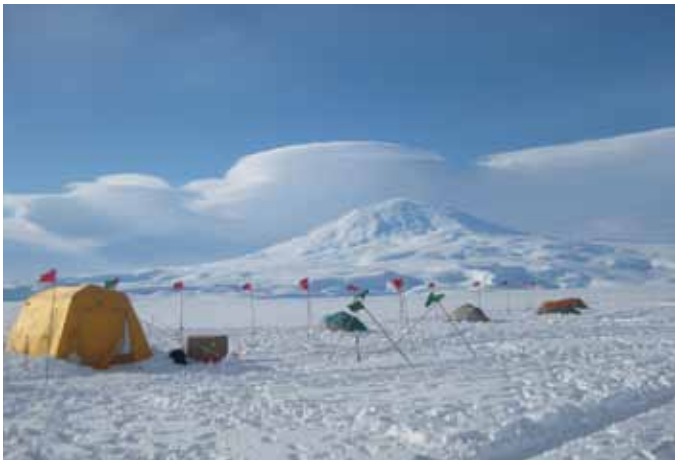
Professor Holland joined the Courant Institute from Columbia University. "I met Andy Majda of CAOS who said he had started a new group and had positions here, and so I came," he says. Warmly describing Courant as "a wonderful spot," Holland says that he likes "the idea that here, observations by themselves are not the game. It's observations plus math and theory."

Committed to making informed projections rather than jumping to conclusions

The fact that global sea level has risen and fallen throughout the ages is a given, says Professor Holland, but to jump to the conclusion that it will continue to increase is unfounded, he adds. "I feel strongly that the scientists who make observations and gather data should not also be the ones analyzing it and determining what it means," he says. "My goal is for the data that I gather or model that I construct to be accurately communicated so that other independent brains can then sift through it and draw conclusions.

NYU's new Center for Data Science is well-timed, coinciding with the data Holland's group is collecting

"There are vast amounts of data coming from satellites flying over the ice sheets daily, generating vast data sets over decades," Holland states. "The ability to sift through this requires data science. This is becoming so important and sophisticated, and it's allowing us to learn amazing things," he adds. "I can see only more of it coming." ■



Base camp, with Mt. Erebus in the background, for Holland's field research at Windless Bight, Antarctica, Dec. 2011 where Holland and his team installed a one kilometer long fiber optic cable through the ice shelf into the ocean beneath. This cable monitors the melting of the ice shelf.

An ice core from Windless Bight.

In the Field of Computational Medicine, Isidore Rigoutsos Trusts the Data Rather than the Books

Director of the Computational Medicine Center at Thomas Jefferson University in Philadelphia, PA, Computational Biologist Isidore Rigoutsos has joint appointments in the Department of Pathology, Anatomy and Cell Biology; the Department of Cancer Biology; and the Department of Biochemistry and Molecular Biology. He is also a member of the Kimmel Cancer Center at Jefferson Medical College.

Dr. Rigoutsos initially trained as a physicist, earning his B.S. from the National and Kapodistrian University of Athens, Greece. He then pursued a master's degree in Computer Science from the University of Rochester, followed by a Ph.D. in Computer Science from the Courant Institute. Prior to joining TJU, Dr. Rigoutsos spent almost 18 years at IBM's Thomas J. Watson Research Center where he co-founded the Computational Biology Center in 1992. He also founded the Bioinformatics and Pattern Discovery group in 1998 and managed it until his departure for Jefferson. For a decade, while with IBM, he was also a Visiting Faculty in MIT's Department of Chemical Engineering.

A leader in computational biology with roots in physics and computer science

A computational biologist in the emerging field of computational medicine, Dr. Isidore Rigoutsos came to his present line of work by way of physics and computer science. "I began my career as a physicist," he explains, "but, before long, computer science lured me away, and I found myself studying it at Courant. Originally, I set out to do my thesis on the calculus of variations but ended up working on geometric hashing and computer vision. When I joined IBM Research," he says, "I applied the Ph.D. thesis work I had done at Courant to problems involving biological sequences. I knew how to analyze data, biology was beginning to generate data in an automated manner, and I loved organic chemistry. As I got deeper into biology, I was attracted by specific biological questions, and over time, was transformed into a molecular biologist."

At odds: Two opposing schools of thought in biology and medicine

A current situation which Dr. Rigoutsos finds both fascinating and confounding are the two contrasting ways of thinking concerning, on the one hand, historically-accepted bodies of knowledge, and on the other, today's overwhelming abundance of data. "In April 2010, there were two one-page articles in the journal *Nature* that are very representative of the two schools of thought that exist in biology and medicine right now," he notes. "The first takes the traditional approach where someone understands a domain intimately well, such as a gene or disease. This person thinks hard and long and comes up with a hypothesis, then says, 'Let's do a test in the lab.' This is how we practiced science for quite a few years."

The second approach, he says, is the result of advances in computational sciences and technology. "We now have the ability to generate tons of data in a guided way from a cell, a tissue, or an organism. So the question is, can we figure out what the data is telling us? How can we exploit this unprecedented capability to answer existing questions, as well as break new ground and advance knowledge?"

In the first approach, Rigoutsos explains, the scientist is limited by his or her imagination. In the second, one is limited by technology, and technology has been making great strides. "This is where it gets interesting," he says, "because we can now generate information about individual cells that we could not have fathomed ten years ago. It challenges you to think in ways you wouldn't have done if you followed what the books say."

Learning to leave behind the constraints of education, training and what's in the book

Commonly, in situations where data says one thing and the books say another, Rigoutsos and his colleagues are faced with a choice: Which one to believe? "My position has always been, believe the data," he states firmly. "It doesn't matter what your personal beliefs are, it doesn't matter what the books say. If the result is repeatable and the experiment has been done correctly, you have to believe the data. You have to learn to liberate yourself from the constraints that come with formal education. As scientists, we are trained to think differently but when it comes to practicing it, it's not always easy," he says.

Unquestionably, it was his time at Courant that broadened his thinking

Rigoutsos describes the Courant Institute during his years there, 1987-1992, as a crossroads of people doing hundreds of different things. "That's when I began learning to think out of the box," he recalls. "Originally, my thesis was supposed to be on a problem from the calculus of variations. It was basically applied math, in an area that my advisor, Bob Hummel, a mathematician, knew intimately well. It was after I had passed my thesis proposal that I happened to attend a presentation by Haim Wolfson, a post doc at the time, who was working with Jack Schwartz on geometric hashing," he says. "It was love at first sight and I said to myself, 'This is it. I know what I'm going to do my thesis on.'"

The resulting thesis, "*Massively Parallel Bayesian Object Recognition,*" focuses on computer vision, using a probabilistic variant of geometric hashing that Rigoutsos developed. Rigoutsos' work eventually connected him to Marsha Berger, Courant Institute Silver Professor of Computer Science and Mathematics, with whom he worked for several summers, culminating in the Berger-Rigoutsos algorithm, a grid-generating technique used in solving partial differential equations with the adaptive mesh refinement method.

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Rigoutsos describes the Courant Institute as an environment that exposes students to a world of diverse ideas all at the same time, resulting in immeasurable benefits. "I had a roommate from the math department who was working on the heat equation with Robert Kohn," he recalls. "Allan Gottlieb was working on the NYU Ultracomputer. When I changed my thesis topic to airplane recognition, I got access to the Connection Machine, one of the very first massively-parallel supercomputers. This was 1990 and I had the opportunity to work on a 32,000-processor machine," he explains. "My office was near Ken Perlin's and Jack Schwartz's and Bob Hummel's. You'd walk out of your office and bump into people who were doing something different, and you'd have coffee with them and learn something new. It was a very interesting time. I really enjoyed every minute there."

The impact of big data on the practice of medicine

According to Dr. Rigoutsos, there is an increasing realization by the medical community that the new way of doing science, namely, smart processing of big data, will shape our scientific activities for years to come. This, he says, will likely be a long process but will happen. "You need to train new people while also convincing the practitioners who have been doing it a different way that they have more to gain if they open themselves to this new possibility," he states. "Biology and information science took about 20 years to converge, so we're probably looking at 20 years if not more for medicine, with the end result that medicine will be practiced in a radically different way."

Rigoutsos adds that similarly, fewer than thirty years after the Courant Institute's founding, "Jack Schwartz came along and said, 'I think computer science is the future,' and, of course, we know he was right. In the same way, Courant is charging ahead with this new data science center because they can see the future coming. There aren't that many places around the United States at the moment that have embraced this. The Center for Data Science," he says, "is the natural evolution of things that started fifty years ago with Jack." ■

Puzzle | SPRING 2013

No Change for the Holidays

by Dennis E. Shasha, Professor of Computer Science

Have you ever noticed that if a teenager has been given $50 to buy a $20 item, no money comes back? Some other item was just so essential ...

In this puzzle, we provide the teenager with a good excuse. Artiste and street vendor Claude sells beautiful handmade items for $100 or less but refuses to give change.

You have no cash, but you have three checks. You will make them out to Claude in whole dollar amounts. Your teenager is to give Claude a combination of checks which covers the purchase price and among all such choices has the smallest total value. For example, if you give your child a $50 check, a $30 check and a $20 check and the item costs $53, your child will give Claude the $50 and $20 checks and Claude will keep the $17 in change in addition to the purchase price.

You like Claude's stuff, but you very much begrudge him his "I keep the change" attitude. So you'd like to minimize the amount he keeps beyond the purchase price.

Warm-up: If you knew that the item in question cost either $20, $40, $50, or $60, which combination of three check amounts could you give in order to leave no change for Claude?

Solution to Warm-up: $20, $40, and $50 is one among many solutions. Claude will not be able to keep anything in change.

1. If you did not know how much the purchase price would be except that it is a whole number amount between $1 and $100 inclusive, which amounts would you write on your three checks in order to minimize Claude's change?

2. Suppose Claude publishes his four whole number prices in an advertisement that you see. Can you show how he can guarantee to do so in such a way that at least one item will yield him non-zero change no matter which check amounts you write? What is the largest amount you might have to overpay; i.e. identify 4 prices so that if these are the prices Claude chooses, whatever checks amounts you select, for one of the items you will overpay by $x, and make x as large as possible.

3. Suppose Claude knows you want to minimize the maximum change he can receive. Are there four prices that Claude could publish to guarantee that on average his prices will require you to overpay by $9, no matter which check amounts you subsequently choose? (Assume that each item is purchased with equal probability). If so, what are these prices?

We will publish the name of the proposer of the best solution (from Claude's point of view) in the next issue. As of now, I don't know the answer. Solutions should be sent to alumni@cims.nyu.edu.

For the solution, email: courant.alumni@nyu.edu

NYU Launches Initiative in Data Science and Statistics: a Great Leap Forward by M.L. Ball


Gérard Ben Arous

On February 11, 2013, New York University officially launched the Initiative in Data Science and Statistics (http://bit.ly/12WUna7). Spearheaded by Gérard Ben Arous, Director of the Courant Institute, this major university-wide effort had its origins last year within a working group of leaders throughout the university, led by Yann LeCun, Courant Institute Silver Professor of Computer Science, Neural Science, and Electrical and Computer Engineering. LeCun will serve as the inaugural Director of the Center for Data Science, part of the new initiative.

Seeking to propel NYU to the forefront of the rapidly developing field of data science, the Initiative in Data Science and Statistics will build on the university's strength in many fields of knowledge at schools across its academic spectrum, including the Leonard N. Stern School of Business; the Polytechnic Institute of NYU; the Center for the Promotion of Research Involving Innovative Statistical Methodology (PRIISM) at the Steinhardt School of Culture, Education, and Human Development; the Center for Health Informatics and Bioinformatics at NYU Langone Medical Center; the College of Arts and Sciences; and the newly created Center for Urban Science and Progress (CUSP).

The initiative includes two separate but complementary components: education (Master of Science in Data Science program), and research (Center for Data Science). Both are essential because as massive data sets are constantly being generated, seemingly in every field of human endeavor, it has become increasingly important to extract valuable knowledge from them, requiring both the teaching and utilization of advanced analytic methods.

"Once you have data," says Ben Arous, "how do you squeeze information out of it? How do we know that we have extracted the signal of a large data set which could be in a very large, very complex form? It's much harder, much more complex than in the usual context of traditional statistics. That will be the focus of this new initiative."

Starting this fall, a Master of Science in Data Science will be offered

A key part of the Initiative in Data Science and Statistics is the Master of Science in Data Science (MSDS) program, the first of its kind in the United States. The two-year degree program is accepting applications until April 1, 2013, with classes commencing in the fall. A doctoral program is planned to follow next year.

The initiative's degree program is both significant and timely, as individuals familiar with techniques for extracting knowledge from data are in increasingly high demand. "You can't find these people anywhere because they need a combination of expertise in applied mathematics, statistics, and computer science, particularly machine learning," explains Yann LeCun. "There is no program anywhere in the country that educates people with this combination of expertise. Some students manage to acquire the right set of skills by taking courses from various programs, but it's not easy. The MSDS is designed to cover the right set of topics for a well-rounded data scientist," he says.

Local guest lecturers will not be hard to find

Fortunately for the MSDS program, New York is well-placed within the world of data science. "There are so many people in New York who are involved day in and day out with big data problems, and so many companies here do this as their core business," observes LeCun. "This means that there are a lot of people with practical expertise who can guest lecture or teach courses for us on this subject, from large companies such as IBM, AT&T, Google, Facebook, and Microsoft, to smaller ones like Foursquare, bit.ly and Etsy," he says.

Center for Data Science: a hub for cutting-edge research

Hosted by NYU's Courant Institute of Mathematical Sciences, the Center for Data Science will focus on the enormous research possibilities inherent in the field of data science. The center will be composed of a number of core faculty, co-located in the center alongside their students and postdocs, as well as a number of associated and affiliated faculty from across the university who will participate in the center's research and teaching activities.

Corporate sponsors recognizing the Center for Data Science's potential

Several companies heavily involved with large data are taking note of the new Center for Data Science and its research objectives, and want to get on board. Says LeCun, "Some are interested in the whole enterprise, some in methods in which they don't have expertise, some in collaborating with faculty and students, some in hiring our graduates, and some in sponsoring projects for students to work on in collaboration with a research lab within NYU." One of the founding sponsors is Yahoo! Labs, which donated a 100-node computer cluster and is presenting a seminar series at NYU this spring.

Offering the unique ability to share data

As well as focusing on highly advanced research, the Center for Data Science will also be a key place where companies can share data. According to LeCun, "There are companies that don't want to share their data with competitors but would like to know what those competitors are doing with *their own* data. They would also like to see if people in academia, our students included, can come up with better ideas than what they've done in-house. One way to do this is to give their data to a repository in academia, thereby creating a pool from industry where people can share their data."

Center for Data Science and CUSP: a symbiotic relationship

One of the goals of the Center for Data Science is to have ongoing

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interaction with its Brooklyn neighbor, CUSP. "There are people within CUSP whom we already know will have a prominent role in the Center for Data Science," says LeCun. "And CUSP will be one of the big 'customers,' if you will, of the Center for Data Science. You can't develop new methods in the abstract. Very often the best methods arise because there's a new problem in the world you need to solve and this makes you think about new ideas. That is in fact one of the goals of the Center for Data Science: to bring together people who have data that might spur new ideas about methods," he says.

The difference between big data and data science

Big data and data science may seem similar—even identical—to some, but there is an important distinction between the two. Ben Arous emphasizes: "We are not doing big data. This is crucial. The difference between the two is the word *science*. I am, we are, *scientists*."

He continues, "Big data is more concerned with the engineering components of data and in answering the following questions: how do you store it, how do you manipulate it, how do you do parallelized computations on it, how do you access it, how do you mine it? That is more of what CUSP will be interested in and we will collaborate. But we will do more science, looking at the algorithmic and mathematical aspects of extracting knowledge from data."

Organic growth within the Courant Institute

"Within Courant, within math," Ben Arous says, "my colleagues are pleased to see us going into statistics. That's why it's called the Initiative in Data Science and Statistics. In particular, many in CAOS, the Center for Atmosphere Ocean Science, see this as very important. A lot of the applied efforts at Courant are using stochastic modeling more and more, and doing more with data, so they are pleased as well."

And within Courant's computer science department, "the machine learning community will benefit, as well as other areas that are close to data, like visual computing," he adds. "This is widely seen as a domain in which we can have more interaction between math and computer science, which is very good. It's organic growth, not a revolution."

Andy Majda of CAOS anticipates cross-fertilization of ideas

"I think there's an incredible future in climate change science for data-driven methods of various sorts," says Courant Professor of Mathematics and The Samuel F.B. Morse Professor of Arts and Science Andy Majda, who will also serve as an affiliated faculty member of the Center for Data Science. "This is a very exciting new research direction in which we hope there will be a lot of serendipity between our work at CAOS and the new data science initiative."

Majda adds, "We're really looking forward to having all these new activities in data science so that we can have cross-fertilization of ideas, ideas from one discipline that might apply in another discipline so that we can develop other ambitious new methods for complex data."

Mathematician Raghu Varadhan praises NYU's commitment to data science

Courant Institute Professor of Mathematics and Abel Prize Winner Raghu Varadhan is also glad that the Center for Data Science has come to pass. "Because of advances in communications, much more data is available, so much that we're all drowning in it," he says. "And it's not so easy to make sense out of it. So if you have a scientific way of comprehending the data, analyzing it and getting information from it, that's a very useful thing to do. Data science as a science then becomes very important. It's also important to have a center where people from different disciplines can come, see what kind of data is available, what kinds of questions they want to ask, and exchange ideas. There will be a whole new set of ideas that will emerge that will be useful," he says.

A major addition that will substantially further the standard of excellence of NYU and the Courant Institute

"If this university-wide Initiative in Data Science and Statistics is successful," states Gérard Ben Arous, "if we have success at the master's level and the Ph.D. level and the research level, and if the collaboration with the rest of the university is as strong as I expect it to be, then we could move into undergrad territory. But that is for the very long-term future. For the moment we will be concentrating on getting something done on the scientific level."

Even with this great leap forward, for both NYU and the Courant Institute, Ben Arous asserts that this is no time for resting on laurels. "We still must be careful to maintain excellence in all of our endeavors," he says. "But that's not the job of the Director of Courant alone. Courant, and NYU at large, is a family and everybody takes care of that part of the business." ■

PhD student Pierre Sermanet and Yann LeCun, Director of the Center for Data Science.

Data Science at NYU

For more information about NYU's new University-Wide Initiative in Data Science and Statistics see **http://nyu.edu/datascience**

After Nearly Four Decades at the Courant Institute, Sylvain Cappell has a Long-Term Perspective on Scientific Progress

Born in Brussels, Belgium and brought to New York by his parents in 1950, Courant Institute Silver Professor of Mathematics Sylvain Cappell, a topologist, is best known for his codimension one splitting theorem, his discovery with research collaborator Julius Shaneson of non-linear similarity, and his works on geometrical symmetries, singularities, and invariants of spaces.

In 1963, while a senior at the Bronx High School of Science, Professor Cappell won first place in the Westinghouse National Science Talent Search (now the Intel National Science Talent Search) for his work on "The Theory of Semi-cyclical Groups with Special Reference to Non-Aristotelian Logic." This early achievement led to Cappell's career-long mentoring of math-talented youths in the tri-state area, including several extraordinary high school students in his first-year graduate classes at the Courant Institute.

Professor Cappell currently serves on the Courant Institute Appointments and Promotions Committee and the NYU Faculty Senators Council (former Chair), and is a past Vice President of the American Mathematical Society.

Having spent most of his professional career at the Courant Institute, Mathematics Professor Sylvain Cappell is uniquely qualified to offer a long view of where the Institute has been, and also where it is headed.

Reflecting on NYU's new Initiative in Data Science and Statistics, Cappell states, "That's a great initiative. Things have continued to develop in a number of areas that will benefit from this, within Courant, NYU, and society at large. Human society is overwhelmed by vast amounts of data that need to be organized, understood, and made into the basis of new knowledge," he says. "Climate science data, economic data, biomedical data, genetic data and others are now available because of new ways of measuring phenomena."

The combination of greater instrumentation and greater computerization, says Cappell, means that "in every direction, we are producing reams of data and they need to be comprehended. I think it's really good that NYU has an exciting initiative in this direction."

Cappell asserts that in many ways, the role of mathematical thinking and mathematical sciences is continuing to grow. "The data science story is one aspect of that but there are others, such as mathematical thinking and mathematical modeling, including numerical work but not restricted to that," he emphasizes. "In fact, mathematical modeling is nowadays as large as any other way of approaching science. People in engineering schools are spending much of their time doing mathematical modeling or numerical modeling. So the roles for a distinctive place like the Courant Institute have grown."

Professor Cappell notes that he and Charles (Chuck) Newman were early advocates of New York University joining with the Polytechnic Institute, foreseeing this as a grand opportunity to create a broader science and high-tech basis in New York. "We're gratified that Poly is soon becoming an NYU school," he says. "I have long had close relations to math colleagues there, such as Professor Edward Miller of Polytech Math, one of my research collaborators."

Having spent decades in the field of mathematics, Professor Cappell describes the current climate as one which is not only developing rapidly, but developing on all fronts. "All of science and many areas of mathematics are developing at extraordinary speed, considerably greater than when I was young," he says. "Historically, there were certain areas of science that were advancing rapidly, and then there were others where you could go to sleep and wake up a generation later and you wouldn't have missed much. That's not true anymore."

In mathematics, Cappell says, as in science more broadly, the number of new areas and the speed of their development has picked up amazingly, partially fed by the ways in which areas create tools that in turn, get used by other areas of mathematics. "My field of topology, for example, has created tools and methods and basic foundational results that have spun off into other fields," he explains. "This has enabled rapid growth and development in ways that couldn't have been anticipated."

Adept at directing a number of research projects simultaneously, Cappell routinely works on a number of diverse projects with several groups of collaborators. "I've been blessed with wonderful collaborators and brilliant students, so I've been able to work on many different kinds of problems concurrently in collaboration with them," he says. "I like having short-term, medium-term, and long-term goals. Long-term goals should be hard and challenging and you can't be sure you'll ever get there, so you want to have goals of different scales."

Currently, Cappell is working on several projects focused on singularities of spaces, specifically, the way they vary at different points. "One wants to understand the relationship between numerical invariants, the whole big space, and how those are affected by singularities," he describes. "That's something I've been interested in, as have some of my distinguished colleagues at Courant who have made important contributions. I'm interested in aspects of those questions in algebraic geometry, symplectic geometry, geometric topology and applications to other areas of mathematics."

According to Cappell, his most renowned former student is Shmuel Weinberger, now Chairman of the Mathematics Department at the University of Chicago. Cappell is collaborating with Weinberger and one of Weinberger's former students, Min Yan, a Chinese researcher

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based in Hong Kong, on several projects having to do with symmetry of spaces. Additionally, Cappell is working on the algebraic geometric invariants of spaces, and is possibly the only current researcher of both low and high dimensional topology of manifolds.

Jürgen Moser

"It's been a fantastic privilege to be here," says Cappell of his 39 years at the Courant Institute. "I thought I understood how terrific it would be but it's been even better than I anticipated. The amount I've learned from colleagues has been astounding, particularly Jürgen Moser, one of the great figures here, who came from Germany after the war. He was a great mathematician and a great mentor, along with Peter Lax, Louis Nirenberg, Joe Keller, Cathleen Morawetz, Martin Davis and Jack Schwartz. The school still benefits from that rich tradition," he says. "We pursue somewhat different scientific programs but we're in good relationships with each other. People get along better than at any other place I know of."

The reason for this rare combination of scientific rigor and genuine camaraderie? "There's an element of both selection and self-selection involved," Cappell contends. "We look for people who combine scientific distinction with an interest in interacting with colleagues and the larger community, and in exchanging ideas."

Before narrating a story about his mother's regard for his life's work, Professor Cappell states, "Being a mathematics researcher requires intense dedication but its work schedule allows for a lot of flexibility and freedom as to how you structure your life."

He then goes on to say, "When my parents got old, I had to help them with paperwork and such. So one day, while I was helping my mother with paperwork—and I am not a lover of paperwork—she complained that I'd fallen behind on some of it. I said to her, 'You know, you could ask my very smart siblings to help you with this.' I have a brother who's a school administrator, a sister who's a very well-known cognitive psychologist, and another brother who's a physician-researcher. And my mother looked at me in horror and said, 'But they have jobs!'" ■

Faculty Honors

Andrew J. Mada

Andrew J. Mada has received the 2013 Norbert Wiener Prize in Applied Mathematics for "his groundbreaking work in theoretical fluid mechanics and its applicatio n to problems in atmospheric science and oceanography."

John Rinzel

John Rinzel was named a SIAM Fellow for his contributions to Mathematical Neuroscience and Physiology along with 32 other fellows this year.

Bruce Kleiner

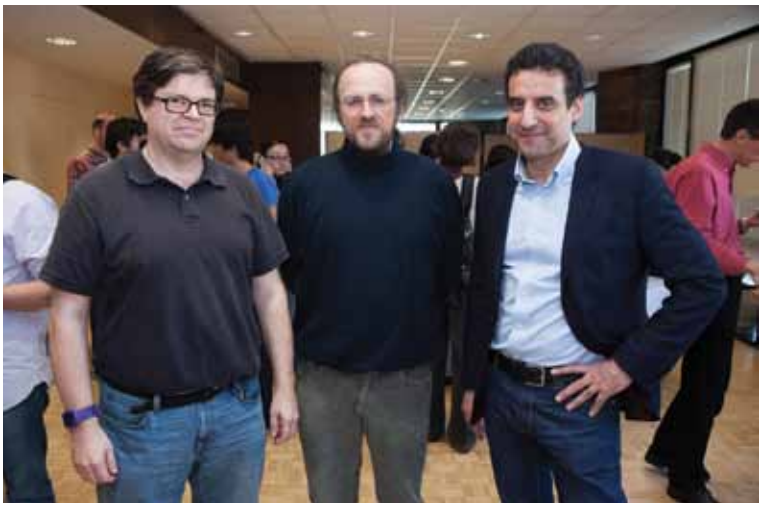
Bruce Kleiner has received an NAS Award for Scientific Reviewing jointly with John Lott for their "explication of Perelman's celebrated solution of the Poincaré Conjecture."

Zvi Kedem

Zvi Kedem has received the Outstanding Contribution to ACM award for his leadership in rebuilding the ACM Computing Classification System (CCS) as a modern cognitive map of the computing field for the worldwide computing community.

19 Courant Faculty were elected as Fellows of the American Mathematical Society in an inaugural class of 1119 from over 600 Institutions. The Courant Honorees are: Sylvain Cappell, Jeff Cheeger, Martin Davis, Percy Deift, Harold Edwards, Bob Kohn, Andy Majda, Henry McKean, David McLaughlin, Cathleen Morawetz, Assaf Naor, Charles Newman, Louis Nirenberg, Charles Peskin, Ricky Pollack, Joel Spencer, Yuri Tschinkel, Raghu Varadhan, Margaret Wright.

The 28th Courant Lectures presented by Bernhard Schoelkopf



Yann LeCun, Bernhard Schoelkopf, and Gérard Ben Arous

Bernhard Schoelkopf presented this year's Courant Lectures. Schoelkopf heads the Department of Empirical Inference at the Max Planck Institute of Intelligent Systems in Tuebingen, Germany, where he is managing director. Schoelkopf is widely credited for popularizing the use of support vector machines, one of the most influential techniques in machine learning today. His other research interests include causality, computational photography and its applications to astronomy. The lectures, "Statistical and Causal Learning" and "Inference of Cause and Effect" were presented to packed audiences on April 25 and 26, respectively.

Student Honors

Bella Manel Prize
Xiao Xiao

Matthew Smosna Prize
Lin Shi

Henning Biermann Award
Adriana López-Alt

Sandra Bleistein Prize
Sandra May

Hollis Cooley Prize
Jing Ye

Janet Fabri Prize
Y-Lan Boureau and Dejan Jovanović

Kurt O. Friedrichs Prize
Mert Gürbüzbalaban and Lingjiong Zhu

Max Goldstein Prize
Juan Felipe Beltrán

Harold Grad Memorial Prize
Andres Muñoz *(Math)* and Sunandan Chakraborty *(Computer Science)*

Moses A. Greenfield Research Award
Samu Alanko and Xichen Li

Wilhelm Magnus Memorial Prize
Dorian Goldman and Adam Stinchcombe

Math Master's Thesis Prize
Eliot Brenner

Computer Science Master's Thesis Prize
Emily Morton-Owens

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Your donations to the Courant Annual Fund are more important than ever. This unrestricted income supports students and their conference travel, enhances the activities of our student clubs, and helps fund the cSplash and WinC outreach programs. The Annual Fund provides matching funds to secure grants from other sources, enables the Institute to invite distinguished speakers for both technical and public lectures, and assists in creating improved public spaces in both Warren Weaver Hall and the Broadway building.

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Cover image: A view from Holland's field camp at Windless Bight where clouds envelop the peak of Mt. Erebus.

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