



The Motion of Water—Modeling Nature’s Power

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If you ask a grade school science class what makes water, you’ll get a range of answers. Hidden amongst the funny ones and the “ums” and “ahs” will be many of the properties that fascinate the physical scientist: water is sort of see-through, water dissolves things, water wets when splashed onto a surface, water changes from liquid to vapour and back again, and most of all, water flows.

This ever-present motion of water is my primary professional interest, and I find myself quite privileged to be associated with computational fluid mechanics. Nevertheless, my recent summer vacation in the Calgary area certainly put my professional efforts in perspective. While the clean up in the city has largely effaced the images of this spring’s floods that splashed across newspapers and television screens, the same could not be said for the mountains. Here a major bridge was missing a third of its span; a road disappeared into a river that had suddenly shifted its course by a hundred meters; a ski trail I had skied dozens of times was replaced

by a new creek bed; a forest floor covered Pompeii-like by fine silt and clay left behind by the flood waters for the full two kilometer extent of a hiking trail. I have purposefully avoided the human tragedies, the washed out backyards and flooded basements, though their presence should be acknowledged. This was nature at its most potent, and quite possibly Mankind at its most foolish as the billboard advertisements for great deals on houses sticking up out of a flooded field outside the town of High River seemed to call out to us.

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water's motion is relatively young. Yet in a world moving at the speed of data, the mathematics behind the motion of water is actually quite old. The generally accepted equations of fluid motion date back to the early 19th century, paying intellectual debts to Euler (18th century) and Newton and Leibniz (17th century). Even the modern study of fluid mechanics, which uses computational algorithms to study approximate solutions to the governing equations, dates back to the earliest digital computers of the 1940s and 1950s. These clunky, slow, and limited mechanical beasts, that filled entire wings of US government buildings seem as unreal today as city streets filled with horses and wagons.

Indeed, the quantitative science of fluid mechanics has come a long way. We can predict weather for the next few days with amazing accuracy, especially when one considers the disparity in size between a human wondering whether to grab an umbrella for the walk to work and a weather system that may range over several hundred kilometers. We can model the flow of water over a submarine, or air over a fighter jet, thereby increasing the efficiency of the design. For almost any task there is a chorus of "we can". And yet, the natural motion of water still trumps our best computational efforts. Why is this so? The same properties of water that make it the wondrous, life giving liquid that it is, allow it to execute motions on an almost unimaginable number of scales: From the thousands of kilometers associated with the Gulf Stream, to tens of kilometers associated with ocean eddies, to kilometer scales associated with warm and cold fronts, to ten to hundred meter scales associated with waves in the ocean interior, to meter scales associated with patches of overturning and turbulence, all the way down to the sub-millimeter scales on which mechanical energy is converted to heat.

So we strive. We design better algorithms that exploit the latest computational architecture, and we use these algorithms as virtual laboratories to create terabytes of data, which in turn requires ever more sophisticated techniques to analyze and visually present. Though this is merely half of the story. The second half of the story is the battle waged by the human intellect to try to understand the motion of water, to tame its complexity with mathematics, to construct models that contain the essence of the motion without its full complexity. As the connoisseurs of the profession would tell you, "what good is a model that is as complex as the object to be modeled?"

We are a long way from a flood model that could predict how a creek bed is remolded, nor do we understand all the mechanisms by which nature accomplishes this act. With luck though, by the next World Water Day we will have uncovered a few more pieces of the puzzle.

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Marek Stastna: <http://math.uwaterloo.ca/applied-mathematics/people-profiles/marek-stastna>



The washed out highway 66 bridge in Kananaskis Country, near Bragg Creek. Photo by Marek Stastna

Water Researchers in the News

Josh Neufeld Receives the CSM 2013 Fisher Scientific Award

Dr. Josh Neufeld, a Water Institute member in the Department of Biology, is the 2013 recipient of the Canadian Society of Microbiologists' 2013 Fisher Scientific Award. This award is given "in recognition of outstanding contributions to Microbiology as a profession". The award included a sum of \$1500, a framed plaque, and a 50 minute talk at the Canadian Society of Microbiologists meeting held in Ottawa this past summer. Dr. Neufeld's masterful talk was titled: *Beyond the black stump of microbial ecology*.

Congratulations Josh!

Bill Taylor and Philippe Van Cappellen Participate in Opening of the China-Canada Three Gorges Water Science Centre

The China-Canada Three Gorges Water Science Centre (CCTW) was officially opened on August 13, 2013 with a workshop at Southwest University, Chongqing, China, focused on current research and upcoming research needs in the Three Gorges Reservoir (TGR) area. Dr. Bill Taylor, biology, and Dr. Philippe Van Cappellen, earth and environmental sciences, were on hand for the opening and both researchers participated in the workshop. The workshop included presentations on innovative monitoring and prediction of non-point source pollution and water quality in the TGR catchment area. Dis-

cussion of plans for future collaborative research endeavours followed.

The CCTW is a collaboration of multiple researchers from academia, industry and government agencies in Canada and China. There is a great need for research into the myriad of conditions arising from the creation of the TGR. The cooperation arising from this new Centre should produce new knowledge that can be applied not only in the context of the TGR area but also for emerging water issues in Canada.

The Canadian involvement began with the Great Lakes Institute for Environmental Research (GLIER) at the University of Windsor, and now involves researchers at Agriculture Canada, Laurier, McMaster, and Guelph in addition to Waterloo.

The Centre's website is: www.cctwcq.com

Doctoral Candidate and Postdoctoral Fellow Selected for National Awards

Timothy Leshuk, doctoral candidate in chemical engineering, was selected to receive the prestigious NSERC Vanier Canada Graduate Scholarship. These scholarships recognize top academic achievement and leadership skills. Recipients receive \$50,000 for three years. Tim's proposed research involves the application of nanotechnology for water purification.

Dr. Igor Lehnerr, a post doctoral researcher in earth and environmental sciences, was awarded the W. Garfield Weston Postdoctoral Fellowship in Northern Research for the second year in a row. The \$50,000 award is funded through the Association of Canadian Universities for Northern Studies and the W. Garfield Weston Foundation. The fellowship will support Dr. Lehnerr's continued research in examining how climate change is impacting water quality and ecosystem productivity in Arctic lakes and ponds.



Attendees at the opening ceremonies for the CCTW

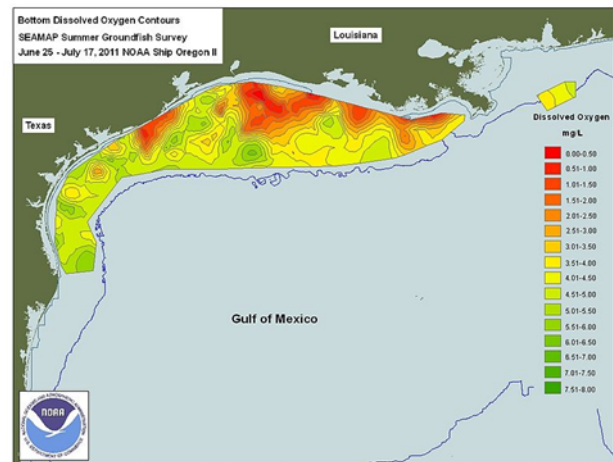
Technology and Innovation

Where does all the fertilizer go?

With a current world population of more than 7 billion, and with human impacts being seen in nearly every corner of the globe, some say that we have entered the age of the anthropocene. Dr. Nandita Basu (Department of Earth and Environmental Sciences and Department of Civil and Environmental Engineering) says that with more than 133 billion kilograms of nitrogen fertilizer being applied to cropland each year, and another 25 billion kilograms being generated via fossil fuel combustion, nowhere are human impacts more visible than in our manipulation of the nitrogen cycle. Dr. Basu and her students are working to better our understanding of the transport of nitrogen and other nutrients across watersheds.

Having recently moved from the University of Iowa in US, a particular focus of Dr. Basu's work has been nitrogen accumulation in the Mississippi River basin. The Mississippi River is the longest and largest river in North America and the basin covers more than 40% of the land area of the U.S. Intensive agriculture throughout the Mississippi watershed has led to consistently high levels of nutrients such as nitrogen and phosphorus. The delivery of these pollutants to the Gulf of Mexico, which gets 90% of its fresh water from the Mississippi, has led to the development of a large Dead Zone within the gulf. This Dead Zone, which is characterized by a critical lack of the dissolved oxygen necessary to support marine life, is one of many such hypoxic zones in coastal areas throughout the world that has, in recent years, covered an area of approximately 17,000 km².

Although there has recently been a strong focus on implementing best management practices to reduce fertilizer inputs, Dr. Basu's work has shown that in human-dominated landscapes, stream nutrient concentrations are only loosely related to changes in yearly inputs. In fact, it appears that legacy stores of nitrogen



Gulf of Mexico Dead Zone (NOAA Image – public domain)

and phosphorus have been building up in soils and stream sediments over decades of fertilizer application, and these act as long term sources. As such, even if fertilizer application was stopped altogether, there would be a *lag time* of decades before stream water quality will improve.

Exploring the mechanisms of such time lags as well as the extent to which nutrients may be accumulating within watersheds is a particular focus of Dr. Basu's current students. Their most recent analysis of historical soil data from the Mississippi River Basin for the first time provides evidence of a long-term, accumulation of organic nitrogen in soils under intensive agriculture. In addition, she and her students have extended their analysis beyond soil to surface waters, working to develop a low-cost water sampler to test for nitrate and phosphorus in streams.

Dr. Basu looks forward to continuing this work in Ontario's Grand River Basin, where both nitrogen and phosphorus are major sources of concern. Bettering our understanding of nutrient dynamics in agricultural watersheds will continue to enhance our ability to improve management practices and preserve water quality.

Nandita Basu: <https://uwaterloo.ca/earth-environmental-sciences/people-profiles/nandita-basu>

Water Institute News

Water Among Top Research Priorities in uWaterloo's New Strategic Plan

It is an exciting time to be a water researcher at the University of Waterloo. The University of Waterloo Strategic Plan 2013, "*A Distinguished Past - a Distinctive Future*" was recently approved by the Board of Governors. Of particular note, the report states that "Waterloo will allocate current resources and align future resources to support areas of research where we have the **greatest potential for world leadership, including quantum science, water and aging.**" Inclusion of "water" as one of only three areas of intensified research focus is a testament to the strength, vision and excellence of our past and present water researchers.

Though the decision of the university represents an exceptional opportunity for water researchers, we are also challenged to develop and implement a vision and a strategy that will significantly elevate the international profile of water research at Waterloo.

Development of a strategy to gain greater international profile and the resources necessary to implement the strategy will be included as major considerations in the Water Institute strategic planning process that is already in progress. This will facilitate input from the entire faculty membership and our external partners, and should result in a strategy that has broad support across the university faculties. To have your views considered, it is necessary to participate as the planning process unfolds.

Water Institute Graduate Scholarships

The Water Institute is pleased to announce that applications are now being accepted for the

AECOM Graduate Scholarships and Golder Associates Graduate Scholarships. These scholarships are open to graduate students conducting water research at Waterloo. Each scholarship is valued at \$5,000. The deadline for applications is **November 1, 2013.**

Water Institute - Sponsored Workshops

The competition for the 2013 WI-sponsored workshops will be commencing shortly. The WI provides up to \$15,000 in support to each of two workshops selected from those proposed by the membership. The workshops provide an excellent opportunity to bring national / international experts to Waterloo, to develop new collaborations and to enrich and broaden research areas. As in past years, there will be a strong requirement for multidisciplinary in the proposals.

Water Institute Supports Museum Exhibit and Children's Water Festivals

The Water Institute is sponsoring the WWF exhibit, *River Runs Through it*, a component of the exhibition SURFACE TENSION | The Future of Water showing this fall at THE MUSEUM. PhD students Cailey McCutcheon and Lorenzo Brignoli and Dr. Bill Annable of Civil and Environmental Engineering were involved in the design and creation of a water swing and an immiscible fluid cascade for the exhibition.

www.themuseum.ca/exhibition/surface-tension-future-water

The Water Institute is also pleased to be supporting the Halton Children's Water Festival and the Children's Source Water Festival in Sault Ste. Marie this fall. The WI also supported the Waterloo Wellington Children's Groundwater Festival that took place this past spring.

Annual Report 2012/2013 Now Available

The Water Institute's 2012/2013 Annual Report is now available on our website and hard copies have been circulated to WI members, external partners and other friends of the Water Institute. If you would like additional copies, please contact Mary Anne Hardy (mahardy@uwaterloo.ca).

Integrated Water Management Graduate Program

The Water Institute is pleased to announce that Waterloo's new Integrated Water Management (IWM) graduate program will launch in the Winter 2014 term. The program, jointly offered by seven departments across the Faculties of Engineering, Environment, Mathematics and Science, is intended to promote multi- and interdisciplinary perspectives related to water. The goal of the program is to supplement disciplinary (specialist) training offered in individual departments with perspectives from a variety of water-related disciplines. Students graduating from the collaborative program will be better equipped to work in multi-disciplinary teams to solve increasingly complex water issues. The collaborative program in IWM represents a tremendous opportunity for graduate students to train within their chosen disciplines while being exposed to perspectives of water research, innovation and management from other fields.

Full-time or part-time Masters or PhD students i) enrolled in a participating department, ii) pursuing a thesis- or major paper-based research degree, and iii) whose program of study has a substantial focus on water are eligible to apply to the IWM program. Participating departments currently include:

- Applied Mathematics;
- Biology;
- Civil and Environmental Engineering;
- Earth and Environmental Sciences;
- Environment and Resource Studies;
- Environment, Enterprise and Development;
- Geography and Environmental Management.

As a collaborative program, students must fulfill all of the requirements of their home department, including any specific courses, thesis or seminar milestones, and all of the requirements of the IWM program. Specific IWM program requirements are two core courses (WATER 601, WATER 602) and a research seminar. These

are designed to provide fundamental multi-disciplinary knowledge and experience to complement the student's specialist courses and water-related research in the home department. The degree conferred will be that of the home department, with an adjunct IWM program qualification to the degree.

Dr. Mark Servos, Canada Research Chair in Water Quality Protection and Professor in the Department of Biology, is the inaugural IWM Program Director and chairs a committee with representatives from each participating department, the graduate students, and the Water Institute who are responsible for developing and delivering the program.

In June 2013, it was announced that RBC had donated \$1.75M over eight years to the University and the Water Institute to support the IWM graduate program. The majority of these funds are designated for student scholarships, with additional funds being available to support program fellows and various enrichment activities.

For more information on the IWM program, please contact the Water Institute.



RBC's Donation: Jane Black (RBC), Maricor Arlos, Marie-Claire Brisbois, Mark Servos

Students of the Water Institute, Graduate Section (SWIGS)

Welcome New SWIGS Members

The SWIGS executive committee would like to extend a very warm welcome to all the new SWIGS members. We look forward to meeting each and every one of you at this year's events, and we hope that some of you will also join our committees. SWIGS continuously strives to improve, and would love to hear from you with any suggestions or comments you may have on how we could improve our events and activities.

Welcome to UW, we hope your time as graduate students here is very rewarding.

Summer 2013

SWIGS had a really great summer, attending a Blue Jays Game with the Earth Science Graduate Association (ESGA) and taking part in a brewery tour. Screening of the movie "Into the Gyre" also brought out many people to the July **Blue Drinks** event.

Thank you to Drs. Hans Dürr, Fereidoun Rezanezhad, and Kristen Mitchell who presented at the July **Student Lecture Series**.

Looking forward to Fall 2013

SWIGS kicked off the Fall 2013 term with their annual SWIGS Welcome BBQ. We were happy to see many new faces at the BBQ and we look forward to a great year.



The SWIGS committees have been wracking their brains all summer, and have planned many activities for the fall term.

Below is a sneak peak at some of the great activities coming your way this term:

Speaker Series: International Water Cooperation (Outreach);

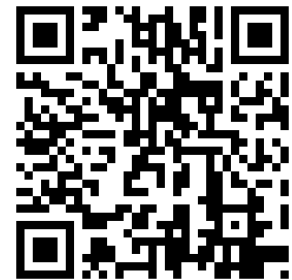
Community Planting Event (Outreach);

Victoria Park Improvements Tour (Outreach);

SWIGS Student Lecture Series (Academic);

Laser Tag, and many more...

Stay connected! To ensure you don't miss any of these great events, please join our **Facebook** group, follow us on Twitter **@UW_SWIGS** and take a look at our website -



www.swigs.uwaterloo.ca. Join our **mailing list** by scanning the QR code.

Remember, the success of SWIGS depends on the people involved! If you are a faculty member who participates in water related research, please encourage your graduate students to get involved with SWIGS. There are many ways to learn more about the world of water through SWIGS, from volunteering on committees to leading event planning as an executive!



Platinum Partners



Gold Partners



a BluMetric™ company

Silver Partners



engineers | scientists | innovators

External Partners Program

The External Partners Program provides the opportunity to connect business, industry and government with University of Waterloo researchers and students. We are here to identify and promote new opportunities for Water Institute researchers and students.

Recently, we met with several of our External Partners to discuss how the External Partner relationship can be shaped to provide additional value. We also sought feedback from our Platinum, Gold and Silver level External Partners in our strategic planning process, providing a voice to potential stakeholders in University of Waterloo research programs.

We are developing a Career Fair and Employer Information Sessions which will provide access to the University of Waterloo's talented pool of graduates. The annual Water Institute Research Symposium is one of the benefits of membership in our External Partners Program and we are already starting to prepare the 2014 event. Mark your calendars now for **May 1st 2014** when we'll bring you another stimulating research symposium and distinguished lecture.

Through events like these and other face-to-face meetings, our External Partners gain access to our broad "water community". If you have any questions about the Water Institute External Partners Program, please do not hesitate to contact Grant Murphy at g3murphy@uwaterloo.ca or at 519 888 4567 ex. 31883.

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