American Geophysical Union | Hydrology Section | July 2017 Newsletter

July 2017

Newsletter

Hydrology Section

In this Issue

AGU American Geophysical Union

From the Section President

Jeffrey J. McDonnell (University of Saskatchewan)

It's a pleasure to welcome everyone to the Hydrology Section! This is my first newsletter as President. I'm very aware of the shoes I am filling. The section has been guided by terrific leadership previously and I appreciate the continued wise counsel of Efi, Eric and Dennis. I hope to continue the tradition to the best of my ability. It requires a light touch given how well the AGU structures and systems work. However, in the spirit of constant improvement I hope to make some small inroads of progress in a few key areas over the next 18 months.

Some words of appreciation: I first want to thank some key people who have been working hard these past 6 months: Scott Tyler (President-Elect), Charlie Luce (Secretary), Casey Brown (Program Committee Chair), Niels Claes (Student Chair) and the Technical Committee Chairs (Holly Michael, Joseph Alfieri, Marc G. Kramer, Kaveh Madani, Shirley Papuga, Sander Huismann, Pierre-Emmanuel Kirstetter, Theresa Blume, Ming Ye, Teamrat Ghezzehei and Nandita Basu). In addition, the past six months has seen much work by the members of the various awards committees. While space limits me from thanking each individually, I do want to thank each of these Committee Chairs: Scott Tyler (Fellows Section Committee), Peter Kitanidis (Hydrological Sciences Award), Sally Thompson (Early Career Award Committee), Rina Schumer (Horton Research Grant Committee), Sally Benson (Witherspoon Lecture Committee), Efi Foufoula-Georgiou (Nominations Committee), Laurel Larsen (Langbein Lecture Committee, Charlie Luce (Outstanding Student Paper Award Committee).. You can see that it 'takes a village' to raise a section. We have over 500 volunteers helping our section in one way or another. Thank-you all!

Congratulations: Congratulations to the newly announced winners of the 2017 Hydrology Section Awards! (with awards listed alphabetically): *Early Career Hydrologic Science Award*, Amir Agakouchak; *Hydrologic Science Award*, Elfatih Eltahir; *Langbein Lecture*, Bob Hirsch; *Horton Research Grants*, Ravindra Dwivedi, James Knighton and Michael O'Connor; *Witherspoon Lecture*, Thorsten Wagner. You will hear much more about the Fellows and Union level award winners in the coming weeks when AGU makes its announcements and at the Fall meeting where we will celebrate all of the award and medal winners.

Union Updates: Our union is in some very good

hands. Over the past six months, I've been attending related geophysical union meetings (EGU, JpGU and CGU) in order to conduct espionage and see what ideas AGU could steal from these other organizations and incorporate into our union and Fall Meeting structure. While I have certainly seen some things we may try to emulate, I've come away from this first six months of my presidency realizing how well run our union is. Some of the reasons for this are the guiding principles that govern how our union works. The chart below is an example and guides each and every meeting at the union level.

I'd like to propose the adoption of this chart as a discussion 'placemat' for our section—at our Exec meetings, as well as our Technical and award Committee discussions. It will help to keep us focused on our shared values at all levels of the organization.

The main thing that the Union and AGU Council are working on now is planning for the Centennial Celebration. This will commence December 2018 in Washington, DC and end in December 2019 in San Francisco. For members of our section, it's important to start thinking now about what we might want to accomplish in this period. AGU will be funding initiatives proposed by sections and its members. I encourage you all to start thinking along these lines now and to be ready for announcements made by the AGU leadership in the coming months. I hope that you can work with your Technical Committee(s) in the Hydrology Section to develop short proposals and be ready when opportunity knocks.

New Developments within the Hydrology Section: Our section is in great shape given the past leadership. But there are a few small things we have started in order to improve things further. I've initiated quarterly meetings with the Technical Chairs (TC) and Exec Committee. Previously, this group would meet once per year at the Fall AGU. But given the flow of information and activities that we are planning, this frequency has been very helpful with the coordinating effort. My main objective with this structure is to better engage the TCs and by association, each of our HS members, by integrating TCs more into Fall session planning. This was a key recommendation from the Ad Hoc Committee on 'Fall Meeting planning', that I led two years ago.

AGU New Orleans: The next two Fall Meetings offer the possibility to 'try out' some things that would otherwise be difficult within the normal San Francisco Fall Meeting. Consider this the hydrology version of Naomi Kline's 'shock doctrine'! Changes will be measured and below is a list of a few things to anticipate:

1. An all-day event for our section. It is tough to build intimacy among members during a week with 20,000+ participants and ~100 HS sessions. One thing we will try out this year is an all-day 'Catchment Science Symposium' on the Wednesday of AGU week. This will be an opportunity for a large number of our section members to spend a day, within the Fall Meeting, in the same room with a larger-than-normal group of colleagues. The goal of the symposium is to be as broad as possible and link to as many of the Technical Committee themes as possible. Jim Kirchner will lead this, fashioned largely on his very successful Catchment Science Symposium, held in previous years at UC Berkeley on the Sunday before AGU. Planning for this is now proceeding in earnest.

2. A change to our Awards Lectures and Hydrology Section business luncheon. We will shift the Langbein and Witherspoon Lectures to commence at 2pm on the Tuesday of AGU week. This is a very well attended event by our members. We'll then proceed as a group to our Hydrology Section Business meeting from 4-7pm. This event will be co-sponsored with CUASHI and will be the main networking event of the week. We will have beer and finger food on hand and after our business meeting (with presentation of the Horton Research Grants, WRR Editors Reports etc). We'll then segue into mixing and mingling. We will encourage the graduate students and post docs to bring their advisors to the gathering with the hope of using the event as a speed-dating activity for PhD students, post docs, and potential advisors to find each other and to get to know one another. Planning for this event is now proceeding in earnest.

3. A meeting room devoted to the Hydrology Section for mingling and meeting-up. We will have a room at the Fall Meeting dedicated to the Hydrology Section; it will be a place to meet-up, have discussions, hang out and socialize, and connect with other section members.

Communications Task Force: A Communications Task Force committee has been struck. I've asked Jay Famiglietti to Chair it. The committee's charge will be to consider how to develop and improve our communications within the Hydrology Section, focused both inside and outside our organization. They will also link to the new 'AGU Connect' initiative that is working to think these issues through at the Union level. Jay and his committee will report back to us later this Fall.

Gender issues in our section: In my statement for standing as President, now some years back, I stated that while the Hydrology Section has good gender balance at the student level, the number of women in senior positions is low. I promised, as President, to initiate a goal of gender balance on all award committees. This has now been done. But as any reader of this newsletter will pick up on, all our award winners this year were male. Clearly, we still have some ways to go.

I'll start this discussion of gender balance, within our section, with a story. It dates back to 1993 when George Hornberger received the Hydrologic Sciences Award (then the Robert E Horton Award). He used his acceptance speech to highlight a number of young colleagues and their work which gave him great optimism for the future of hydrology. Not until shortly after the speech did I realize that every colleague that he mentioned was a woman. It was a subtle yet powerful reminder to a then male-dominated field about gender and gender bias.

That was 1993 when the proportion of women members in AGU was less than 15%. Fast forward almost 25 years and some things have changed. Women make up 27% of the AGU membership with a breakdown across age groups of: 43% women 20-29 years old; 31% women 30-39 years old; 23% 40-49 years old; 18% 50-59 years old; 10% 60 years and older. Overall representation has improved somewhat over the last quarter-century, and driving that change is increasing gender diversity in the early career age group, where we are beginning to approach parity. Gender and gender bias issues are out in the open and discussed at AGU Fall meeting workshops and in the pages of EOS. Implicit gender bias is something that is now recognized and openly discussed. AGU has compiled very useful resources for the all the membership (http://honors.agu.org/diversity-resources/).

In the Hydrology Section we've made strides in many areas of gender diversity. Our Technical and Awards Committees are diverse. Four out of five of our major awards committees are now chaired by women. Our student body and student awards are diverse. This reflected in the award stats for the Horton Research Grant (47% to women in the previous 5 years) and Outstanding Student Paper awardees (58% to women in the previous 5 years). Another area where some strides have been made is with our Fellows section. Changes in recent years is the result of the hard work by others within the Union some years ago. The Druffel (1994) EOS piece "Looking at gender distribution among AGU Fellows" (Eos Trans. AGU, 75(37), 429, doi:10.1029/94EO01062) began changes across the union where today our Hydrology Section Fellows are in keeping with our senior level gender diversity.

But stubbornly, our various Hydrology Section awards have not kept pace with the other positive gender developments. And it is this discrepancy that I feel compelled, as President, to address head on. It is a fraught issue, but exposing and discussing it, I think, is critical to making progress on awards gender balance more in keeping with our membership's diversity (there are other diversity issues that also need attention, but that is material for another newsletter).

So what might be the cause of the awards gender imbalance within the Hydrology Section? **I think it mostly stems from the low number of nominations.** For instance, the Hydrological Science Early Career (HSEC) award should be roughly 50:50 with respect to gender based on demographics, and this is the case with the Horton Research Grant and Outstanding Student Paper awards. However, in the 8 years of the HSEC award's existence, we've awarded seven men and only one woman. This year, we had eight total nominations; but, only one was a female hydrologist. This must change.

At the senior awards level, things get even more problematic , with little progress made in the past 5 years (I am omitting from this analysis the new Witherspoon award as there is only 1 year of data, also the Macelwane and Bowie Award stats as these are somewhat out of the hands directly of our Hydrology Section). The Langbein award has been awarded to one woman in the past 5 years (3 in the award's history dating to 1993); a woman has never been awarded the Horton Medal and one woman has won the Hydrological Sciences Award in the past 5 years (2 in the award's history dating to 1956). One critical point that we have not previously made public, is that the nomination numbers for all three of these major awards average less than 5 per year each for the past 5 years. There have been no females nominated for the Horton Medal in the past five years; no female nominations for Langbein in the past two years; and only one female nomination for Hydrologic Sciences Award in the past two years.

So what can be done?

The first thing is to give visibility to our gender imbalance. The second thing is to formulate an action plan to address and resolve it. Why do we need to do this? Because it is 2017 (to paraphrase Justin Trudeau).

To that end, I am proposing a 6 step action plan to implement over the next year. It is aimed specifically at the nomination issue. These ideas have developed in consultation with my Executive team, my counterparts at EGU, JpGU and CGU and through discussions with our past presidents. Note also that the stats discussed above are for only our section awards---the Fellows process and that for the Horton Medal, Macelwane and Bowie remain the purview of the Union.

1. Change the nomination process for Hydrology Section Awards. To make the nomination process easy for everyone, I am proposing that we shift the work of the nomination process to the various selection committees. People wishing to nominate a deserving candidate (male or female) would simply send a 1-pg letter to the Committee Chair for that award with their reasons why a person may be deserving. They would include their nominee's CV, Web of Science stats and a list of 5 potential support letter writers.

2. Change the Award Committee tasks: The particular award committee would take those nominations and create a shortlist and then contact the reference letter writers. While this process means more work for the Committees, it would greatly simplify the nomination process and will, I hope, stimulate more, and more diverse, nominations.

3. Change the focus of the Nominations Committee: Our section has a Nominations Committee that is chaired by the Past President of the Hydrology Section. That committee helps drum up nominations for our various awards. I propose that we change the focus of the Nominations Committee from one that tries to stimulate nominations by others to one that writes nominations. And, to identify and write diverse nominations for deserving candidates at all award levels.

4. Create new expectations for the Technical Committees: I want to empower all of our Technical Committees to do more. I propose that we task each Technical Committee to submit a nomination from their membership for each Hydrology Section award. Committee chairs would work with their committees to identify who they think—from their membership within their disciplinary area—deserves to be the TC's pick for awards that year. The success of TC-nominated award winners will be noted and celebrated through TC web sites and on their promotional material.

5. Create new expectations for the past recipients of AGU Fellowship and Hydrology Section awards: To whom much has been given, much is expected. Fellows and Awardees should accept an unwritten contract of such distinction that henceforth, they should themselves submit at least one nomination for someone, for an award or fellowship each year. We have such an unwritten cultural arrangement when we publish (we should be expected to review 3 papers for each one we submit). Why not something similar with awards?

6. Use AGU staff to generate data for our section and to help facilitate steps 1-5. I am now working with AGU staff to develop databases to help in all this. I think that transparency in our nomination data is key to progress. Therefore, I hope that nomination stats can be tracked and published each year; so that we see how progress is being made.

While these steps should help to move the dial, I hope that section members at all levels (especially senior members of the Hydrology Section) can do their part to recognize a deserving award nominee and make a (now-easy) nomination.

Change will not happen overnight. And success will be defined by a gender balance in our awards consistent with our membership gender balance across age groups. While George Hornberger got us started down this path with his important subtle comments, the time has now come to act.

I welcome your critical comments and feedback.

From the Section President-Elect

Scott Tyler (University of Nevada, Reno)

My first installment in the Hydrology Section newsletter must start off with a heartfelt "thank you" to the membership for putting your trust in me to serve as your President-elect. It is a tremendous honor, and one that I never expected, but also carries significant responsibilities. When the AGU elections were held, I imagined the President's duties to be significant, but somewhat predictable in what the parameters of the job would be. But the parameters of the job have shifted significantly as our science has come under attack for its relevance and in questioning our contributions to our society. There is now a need for a larger role of our professional organizations to go beyond our traditions and stand up for what we honestly know to be true, whether its human-derived climate change or the value of an educated electorate. I have been very impressed with how AGU has "stood itself up" in defense of earth and space sciences, and as your president-elect, I have been working closely with AGU to mobilize our members to help make their voices heard in a variety of ways.

As many of you know, AGU was a proud supporting organization of the DC March for Science. AGU was also approached by many of the "Satellite" marches, and I am proud to say that AGU and our membership were instrumental in making many of the satellite marches "Earth and Space Science" focused. I had the pleasure of working the Louise Pellerin, a member of the AGU Board and Petra Dekens, a fellow AGU section president to organize the San Francisco March for Science, where we had a large group of our members marching together, followed by an AGU booth at the March finish. Many other members came by the booth that afternoon, but so many more San Francisscan's stopped by to say "Hey, are you the geologists who come here every year before Christmas; we love having you here!!"

My duties have not only been reliving my days as a hippy from the sixties and seventies, but also working within the AGU organization. The Hydrology Section has long had a presence on the AGU Council Leadership Team or CLT as it is known. With Efi's term finishing, I was asked to run and, to my somewhat surprise, was elected by the AGU Council members to serve on the leadership team under our new AGU president, Robin Bell. We meet monthly by conference call, and I will be reporting out to our membership about a few significant changes/additions and decisions that impact our section in our next newsletter.

And finally, our Section's president-elect serves as the chair of our Section level Fellows committee, and we have just completed our review of nominations. It was a pleasure working with committee members Larry Band, Gia Destouni, Praveen Kumar, Bridget Scanlon, and Harry Veereken reviewing a tremendously talented pool of Fellows applicants. This year, we reviewed 39 nominations, including 8 candidates from other sections or focus groups. It was a very challenging task given how deserving all of the candidates were, but we are limited by AGU to a total of 20 nominations that we can forward to the Union Committee. Our committee worked closely with other sections and focus group committees to support our joint nominees and we will continue that process next year. I want to congratulate all who were nominated this year, and while the competition at the Union level is intense, you should all take pride in being recognized by your Section.

As I grow into this job, I look forward to hearing from all of you about your thoughts, desires and goals for the Section. Jeff, Charley and I have already built a close working relationship, and I look forward to the next few years working with them and with the membership.

Have a great summer!

"...our science has come under attack for its relevance and in questioning our contributions to our society."

From the Section Secretary

Charlie Luce (United States Forest Service, Boise)

Quite a bit of the Secretary's focus is on supporting student participation in meetings. The most notable activity is chairing the Outstanding Student Paper Award (OSPA) Committee, but the Secretary also organizes selection of travel grant awards, and participates in other efforts engaging students in the meeting with the rest of the hydrology section leaders. OSPA and travel grant review require help from volunteers; if you have an interest, please contact me.

Last year's OSPA committee concluded their duties in January by awarding Outstanding Presentations from 20 students (http://hydrology.agu.org/awards/outstanding-paper-award-winners/). The committee was led by the Secretary, Terri Hogue (Colorado School of Mines), and included four members: Kolja Rotzoll (University of Hawaii), Laurel Saito (University of Nevada, Reno), Rolf Hut (Delft University), and Alicia Kinoshita (San Diego State University). Two of these members, Rolf and Alicia, will continue this year, and two new members, Heidi Asbjornsen (University of New Hampshire) and Matthew Weingarten (Stanford University), will join the committee along with me.

There were 428 student presentations at the Fall 2016 meeting. The 20 winning presentations had high scores, in the neighborhood of 95%, consistent with the scores for 2015's winners. Not all high scoring presentations, though, were offered awards. As always, comments were critical to the judging. The winning students not only need a high score, they need comments about how their presentation stood out from among the others. A high score without supporting comments from any of the judges could not be offered an award. If you see a great presentations, tell us (and the presenter) why it was great! Comments are also critical to the rest of the student presenters, as a numerical score alone is not particularly useful feedback, and specific written feedback can more effectively help them improve. Remember that the OSPA judging not only has value for recognizing outstanding work; it is a part of how we let students know they are welcome at the meeting, that we are interested in what they came to say, and that we care about their professional development.

The 2016 Committee carefully tracked the progress of judging sign-up and reporting. In particular, Kolja sent the committee (and their member-in-training) frequent colorful, graphic-filled updates of progress before, during, and after the meeting to make sure that all presentations were being judged (see Figure 1 for example). There were 412 judges involved in judging Hydrology Section presentations. By January 3rd, 98% had submitted all of their scores (note that some of these were "judge could not make it" or "student was not present"). This yielded 94.6% of students having all three score sheets, 4.9% with just two, 1 student with one, and no judging for 1 presentation. Counting only numerical scores, 65% had 3 evaluations,

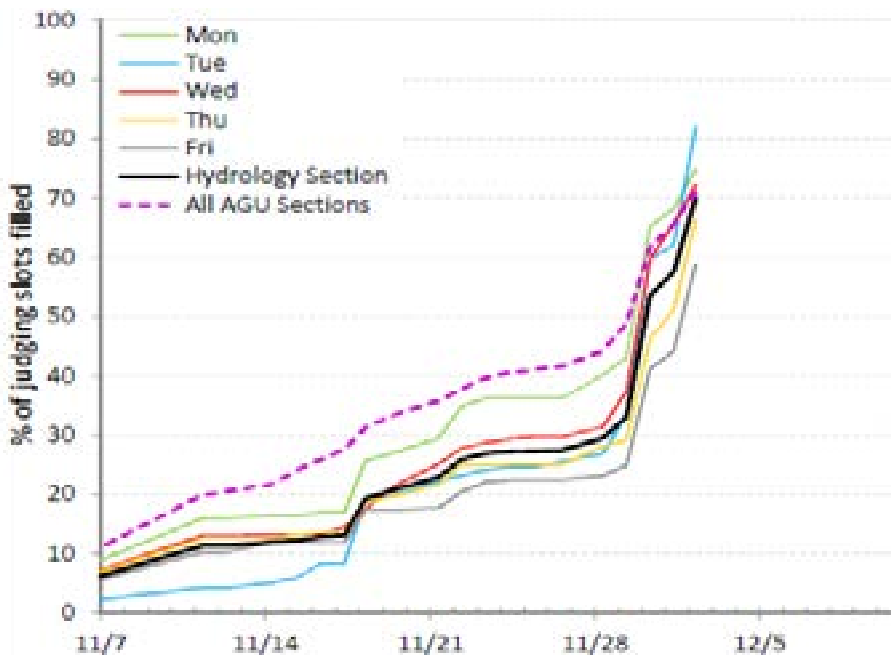

Figure 1: Progress on judge recruitment December 2, 2016. Progress is charted for the individual days of the meeting because it is harder to find judges on some days than others. If you plan to be there Friday, we will need your help! Hydrology Section President, Efi Foufoula-Georgiou, sent an email calling for more judges on 11/29.

25% had 2, 7% had one, and 3% had none. Thoughtful commentary can help when numerical scores are missing, too, and 5 of the 20 winners received only 2 score sheets. These response levels represent an improvement, but the goal is still 100%. We encourage more judges to look at 3 or more presentations; so that they can have, and potentially offer comments about, contrast among multiple presentations. Last year, 26% of Hydrology judges signed up for only one presentation, and 17% only two, yielding only a weak majority with the recommended three or more presentations.

There will be calls for judges in the Fall. There is also an opportunity to indicate an interest in judging during abstract submission. We encourage all members with an interest in the health and vibrancy of hydrologic science to sign up for OSPA judging. Remember early career and postdoctoral scientists are eligible to judge. Student travel grant applications will be submitted shortly, and I am seeking volunteers to evaluate them. We expect on the order of 150 applications, with 1-2 weeks to review them. The workload is a little more reasonable with a relatively large team. Please contact me at cluce@fs.fed.us if you are interested in helping! I will start asking specific people shortly, but it is better to start with volunteers.

I have also participated in a few phone calls and meetings with our student representatives, Neils Claes, Megan Brown, and Akhil Kumar, brainstorming activities with Jeff McDonnell, Scott Tyler, and Martyn Clark for improving connections with the section and Water Resources Research (WRR). Several integrated activities affording the students more opportunities to visit with established scientists and journal editors. There is more information in the individual reports from the other teams.

“OSPA and travel grant review require help from volunteers; if you have an interest, please contact me.”

Fall Meeting Updates

Casey Brown (Hydrology Section Fall Meeting Committee Chair)

The Hydrology Program Committee (HPC) represents Hydrologic Sciences (HS) Section on the Fall Meeting Program Committee. In this role, the HPC develops the scientific program of Fall Meeting, including the review and approval of sessions proposed for the HS, allocation of oral and poster sessions, and scheduling every oral and poster session. The HPC also provides input on other aspects of the Fall Meeting, including new session formats, participation of junior scientists and other matters brought to us by AGU Meetings. It adds up to a very busy three years for those of us lucky enough to serve on this committee!

This year we’re very excited about the 2017 Fall Meeting in New Orleans, December 11-15. It’s a brand new venue and with it we’re rolling out some exciting variations to the traditional meeting. One interesting example is the eLightning session format. These sessions will use iPoster technology, which enables interactive features and videos in a poster format, and include a brief presentation by each poster presenter followed by traditional poster interactions. There will be a dedicated space specially designed for these sessions. So I encourage you to consider these sessions (but note that there is an extra fee): H053, H058, H099, H125.

Lookout for announcements this summer of additional new twists for our New Orleans Fall Meeting. Finally, the numbers. We received 167 session proposals for the Hydrology Section, successfully reduced that number through proactive mergers and will whittle that down to the allocation we receive from AGU in August (based on total abstracts submitted), usually around 100 oral sessions. Abstracts are due August 2 and if you submit by July 26 you get a chance to win $100. Submit abstracts early and often here. We look forward to seeing you in New Orleans.

Laissez les bon temps rouler!

2017 Fall Meeting Hydrology Program Committee: Casey Brown (UMass), Megan Smith (LLNL), Laura Bowling (Purdue)

From the Section Student Subcommittee Chair

Niels Claes (University of Wyoming)

The Hydrology Section Student Subcommittee, H3S, is dedicated to a number of ideas and issues within the geosciences complementary to those highlighted by the larger Hydrology Section. We strive to provide student members with opportunities for professional development as well as social interaction and networking within the broader geosciences community. We structured this effort in 2016 around the following events and themes as detailed below.

We held a student conference on the Sunday before the 2016 AGU Fall meeting in San Francisco. This conference provided hydrology students and early career scientists the opportunity to network in between sessions that addressed useful skills such as data visualization and modeling approaches. The afternoon panel discussion gave conference participants opportunities to discuss challenges involved within the Food-Energy-Water Nexus.

At the 2016 AGU Fall Meeting, we organized the popular Pop-Up sessions that showcased fresh ideas about the future of the hydrological community, water sciences, and geosciences.

For 2017, we will hold a similar series of workshops and panel discussions at the AGU Fall Meeting in New Orleans. We will be addressing the question about differences in the hydrology community between students' and early career scientists' needs and challenges. We invite the hydrology community to submit an abstract for a 5 minute TED-style presentations at our 2017 Pop-Up sessions. This year we have Pop-Up sessions on the topics of (1) future directions in water sciences (H001), (2) growth mindset in graduate research (H096), (3) redefining the role of science in society (PA003), and (4) cultural responses to global change (GC024).

A closer collaboration and exchange of ideas, visions, and experiences between the Young Hydrology Society, H3S, and other groups (e.g. GEWEX), will improve our ability to answer questions from our AGU hydrology student base and address their needs.

We have seen steady growth in the number of members we reach through our social media channels and are committed to growing our online community. We share research and professional development opportunities through our twitter account, @AGU_H3S. We highlight our student and early career members in profile features on the AGU Tumblr site (https://americangeophysicalunion.tumblr.com/tagged/profile). Join us online to meet our many fantastic members!

Join the Splash!! Let Your Hydrology Voice be Heard!

The AGU Hydrology Section Student Subcommittee (H3S) will organize an online town hall meeting for students and early career members on Wednesday July 12th at 2 PM MDT (GMT-6). This virtual meeting will give students and early career members a platform to voice their ideas, raise questions and provide input for future activities, workshops and events that are organized by the hydrology section. More details about the platform and meeting format will be communicated through our twitter account (@AGU_H3S).

2016 Hydrology Section Student Subcommittee

From Water Resources Research Editorial Board

Martyn Clark (Editor-in-Chief), Jean Bahr, Marc Bierkens, Ximing Cai, Terri Hogue, Charles Luce, Jessica Lundquist, Scott Mackay, Ilja van Meerveld, Harihar Rajaram, Xavier Sanchez-Vila, and Peter Troch (Editors)

As we begin our four-year term of service as WRR Editors, we'd like to introduce ourselves and provide an update on our efforts to meet the growing demands of science and society.

The WRR Editorial team, most pictured in the photo below, includes:

- **Martyn Clark** is a Senior Scientist at the National Center for Atmospheric Research (Boulder, Colorado, USA). Martyn's research on the numerical modeling and prediction of hydrologic processes includes developing new approaches for large-domain hydrologic modeling, improving the representation of hydrologic processes in Earth System models, and understanding how climate variability and change shapes regional water resources.

- **Jean Bahr** is a hydrogeologist and Professor of Geoscience at the University of Wisconsin – Madison. Her research interests include physical and biogeochemical processes affecting solute transport in groundwater systems, groundwater-surface water interactions, and the role of groundwater in geologic processes.

The WRR editorial team includes (left to right) Martyn Clark, Harihar Rajaram, Ximing Cai, Scott Mackay, Jean Bahr, Ilja van Meerveld, Charlie Luce, Peter Troch, Terri Hogue, Jessica Lundquist, and Xavier Sanchez-Vila. Credit: Erin Syring.

From Water Resources Research Editorial Board (continued)

- **Marc Bierkens** is a Professor of hydrology at Utrecht University (Utrecht, The Netherlands). Marc's research mostly involves global-scale hydrological modelling with the aim to analyze the effects of global environmental change on water resources. Occasional excursions include ecohydrology, groundwater hydrology, glacio-hydrology, hyper-resolution modeling, and hydrological forecasting.

- **Ximing Cai** is the Lovell Endowed Professor of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign. His current research topics include coupled human-natural system analysis, environmental impact of biofuel development, and application of hydroclimatic forecasts for water resources systems operation and planning.

- **Terri Hogue** is a Professor in the Civil and Environmental Engineering Department at the Colorado School of Mines (Golden, Colorado, USA) and is Director of the Hydrologic Science and Engineering graduate program. Her research focuses on the management and sustainability of water resources, including urban systems and stormwater capture, climate variability and watershed response, catchment response to wildfire, modeling and optimization of watershed processes, and development and application of remote sensing products. More recent work includes assessment of water sustainability related to oil and gas production in the western U.S.

- **Charles Luce** is a Research Hydrologist with the U.S. Forest Service (Boise, Idaho, USA). Charles' research addresses effects of land management and of climate variability and change on forest and stream ecosystems. His research focuses on physical hydrologic processes affecting snowpack, stream temperature, erosion and mass wasting, streambed water and energy exchanges, and drought; and the interactions of these processes with aquatic and terrestrial ecology.

- **Jessica Lundquist** is a Professor of Civil and Environmental Engineering at the University of Washington (Seattle, Washington, USA). Her research focuses on spatial and temporal patterns of snow and weather in the mountains, and how these patterns impact basin-scale hydrology and ecology.

- **Scott Mackay** is an Ecohydrologist, Professor of Geography, and Associate Dean at the University at Buffalo (Buffalo, New York, USA). Scott's research addresses how changes in temperature and precipitation affect drought-induced mortality of forests and increase pressure on water resources for crop production. His research focuses on biophysical processes, emphasizing the integrated roles of hydrology and plant hydraulics on nutrient, carbon, and energy exchange.
- **Ilja van Meerveld** is a research and teaching associate at the Department of Geography at the University of Zurich (Zurich, Switzerland). Her research focuses on hillslope and catchment hydrology, particularly how runoff generation mechanisms are affected by land use change and the hillslope-riparian-stream connectivity.

- **Harihar Rajaram** is a Professor and President's Teaching Scholar at the University of Colorado Boulder. Hari's research on fluid mechanics and transport phenomena in earth and environmental systems focuses specifically on porous media, fractured rock, and glaciers and ice sheets. His prior research also covers stochastic subsurface hydrology, reactive transport, and coupled processes.

- **Xavier Sanchez-Vila** is a Professor at the Universitat Politecnica de Catalunya in Barcelona, and member of the Hydrogeology Group. Xavi's research interests include flow and reactive transport in complex subsurface media, stochastic hydrogeology, and in general water resources management, from quantitative aspects, such as managed recharge, to qualitative ones, such as fate of inorganic and organic pollutants.

- **Peter Troch** is a Professor at the Department of Hydrology and Atmospheric Sciences of the University of Arizona. He is also Science Director of Biosphere 2 and the lead Principal Investigator of the Landscape Evolution Observatory (LEO). Peter's research focuses on hillslope and catchment hydrology, including the geochemical, microbiological and ecological evolution of the critical zone. His research aims to contribute to a better understanding of hydrological change in a changing environment.

Our editorial term of service occurs at an interesting point in world history. Key external trends include changes in the perceived value of science to address societal problems, the explosive global growth in science over the past decade, and the transition to a more diffuse publishing landscape. Each of these trends affects WRR, both directly and indirectly, meaning that WRR must evolve to meet the growing demands of science and society (see our introductory editorial, Clark et al. [2017a]).

Changes in the perceived value of science dictates that WRR provides clear and compelling illustrations of the value of hydrologic science for society. WRR published nine commentaries in the AGU "science is essential" collection [Belmont and Foufoula-Georgia, 2017; Celia, 2017; Grant and Dietrich, 2017; Kirchner, 2017; Lettenmaier, 2017; Michael et al., 2017; Scanlon et al., 2017; Sturm et al., 2017; Tetzlaff et al., 2017], released on Earth Day (22 April 2017). Every one of these commentaries is brief, accessible, and packed with content. These commentaries, in different ways, emphasize the need for rigorous interdisciplinary science, the need to effectively communicate science advances, and the need for science to objectively inform the policy process [Clark et al., 2017b]. At a time when many in the science community are adopting a defensive posture, these commentaries celebrate hydrologic science, they show how hydrologic science is essential for society, and they illustrate how hydrologic science has had a positive influence on policies.

"The explosive global growth in science over the past decade creates a stronger need for WRR to unify currently fragmented research efforts."

The explosive global growth in science over the past decade creates a stronger need for WRR to unify currently fragmented research efforts. WRR is continuing the "debates" series to explore competing perspectives on hydrologic science. Some popular recent debates include stochastic subsurface hydrology [Sanchez-Vila and Fernandez-Garcia, 2016; Cirpka and Valocchi, 2016; Fogg and Zhang, 2016; Fiori et al., 2016] and hypothesis testing in hydrology [Pfister and Kirchner, 2017; Baker, 2017; McKnight, 2017; Neuweiler and Helmig, 2017]. Moreover, WRR has a number of interesting special sections, including a special section on concentration-discharge relations in the critical zone (papers published already), a special section on socio-hydrology (submissions just closed) and a new special section on global energy, water, and carbon cycles. We'd like to increase the number of debates and special sections over the next four years, so please share with us ideas for topics that you think deserve more attention.

The transition to a more diffuse publishing landscape makes it more important than ever to strengthen the relationship between WRR and the AGU Hydrology section. Plans are already underway for the AGU Fall meeting. First, we'll have a new invitation-only session at the AGU Fall meeting focused on recent advances in hydrologic science. The intent is to showcase the major advances published in WRR over the last year – to come together as a community, celebrate what we have learned, and discuss key research challenges and potential solutions. Second, we're planning interactions between WRR Editors and young hydrologists, to discuss challenges in publishing, the responsibility of reviewing, and the diffusion of scientific knowledge in the modern era. Third, we'd like to reverse the current trend where papers from popular sessions at the AGU Fall meeting are scattered across journals. We're very interested in special sections on popular topics at the AGU Fall meeting in order to create greater synergy among papers on emerging topics in hydrology.

As we move forward in these next four years, we appreciate the very strong connection between WRR and the hydrologic science community. We value the strong WRR tradition where reviewers go out of their way to provide constructive advice to authors, and where Editors and Associate Editors provide meaningful guidance to authors on ways to improve their papers. As we noted in our introductory editorial, we're most interested in helping authors increase the quality and impact of their papers, hence increasing the value of hydrologic science investments. Please feel free to share your ideas, your opinions, your concerns, and your experiences, so that we can improve the extent that WRR advances hydrologic science.

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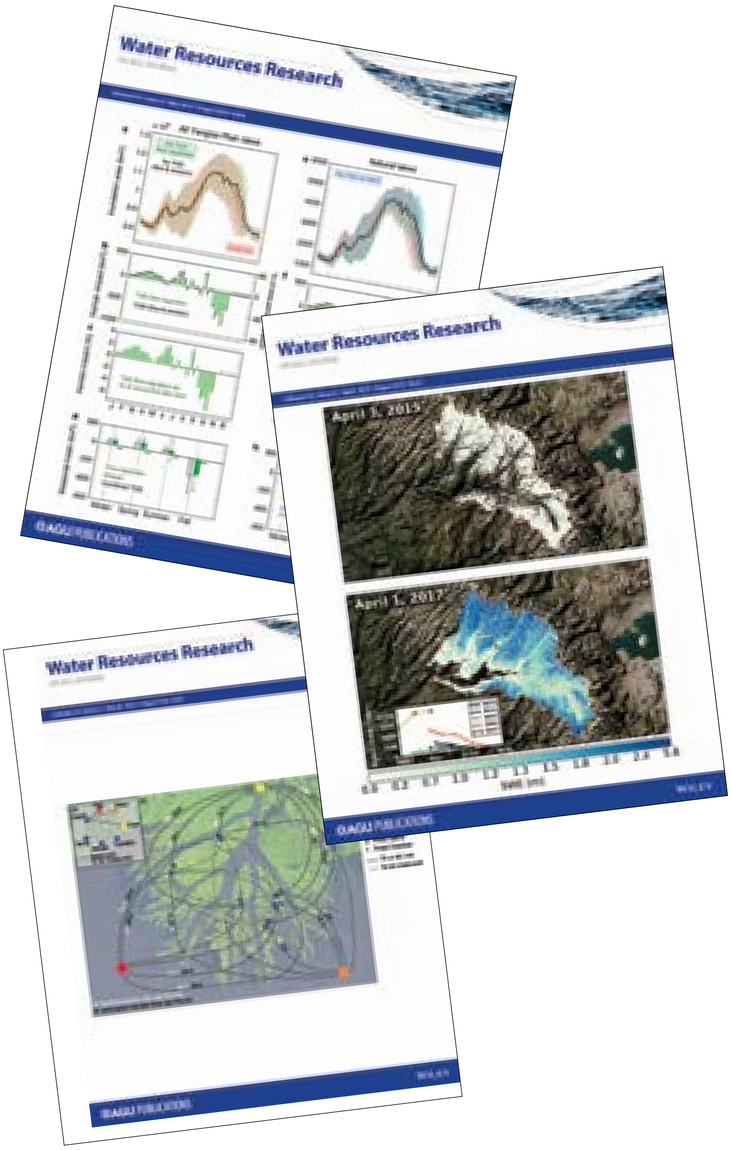

From Section Technical Committee Chairs

Ecohydrology

Shirley A. Papuga
University of Arizona

Ecohydrology is an actively growing part of the AGU Community. This evolving interdisciplinary field was initially conceived to enable an improved understanding and quantification of relationships between hydrological processes and biotic dynamics at the catchment scale, with a special focus on sustainable water resource management. Since those early days, the field of ecohydrology has grown considerably. In 1998 less than 10 publications used the term ecohydrology. However, in 2002, a formative Chapman Conference "Ecohydrology of Semiarid Landscapes: Interactions and Processes" was held in Taos, New Mexico and by 2004, over 80 peer-reviewed ecohydrology publications were available to the community. In 2008, Wiley began a new journal "Ecohydrology", capitalizing on a growing interest. And just last year, a Chapman Conference on "Emerging Issues in Tropical Ecohydrology" was held in Cuenca, Ecuador, highlighting the importance of ecohydrological studies in tropical regions. This year, only 20 years after the concept was developed, at least 1100 peer-reviewed publications are available to the ecohydrology community and the scope of research has become much richer both in scale and in subject matter.

Because of growing interest in ecohydrology, the AGU TC to develop a larger engaged community. You can join our listserv and tell us how you might like to become involved at our website: www.aguecohydrology.org. Our goal is make a big impact in the AGU community through collective dissemination of information and participation in the AGU Meetings. We encourage you to follow us on Twitter @AGUecohydro and share relevant ecohydrology material using the hashtag #ecohydro.

AGU Fall Meeting 2017 Deadlines

July 26 — Early Abstract Submissions

August 2 — Final Abstract Submissions

Hydrogeophysics

Sander Huismann
Forschungszentrum Jülich

Hydrogeophysics is the use of geophysical measurements to estimate parameters and monitor processes important for hydrological studies, such as those associated with water resources, contaminant transport, ecological, and climate investigations. The mission of the AGU Hydrogeophysics Technical Committee is to provide a bridge between the near-surface geophysics and the hydrological communities. These two communities have not historically been tightly linked despite that the emergence of the field of hydrogeophysics in the past two decades has resulted in a generation of scientists that feel equally at home in both communities. A key activity of this TC is organizing and directing activities at AGU meetings, often in collaboration with other TCs, to inform the broader hydrological community about the possibilities and limitations of hydrogeophysical investigations. We also collaborate with the Near-Surface Geophysics Focus Group of AGU to interface with other professional organizations that focus on the use of geophysics for near-surface investigations. To engage and inform our members we operate a mailing list (AGU-HGP@psu.edu). For more information, to join the mailing list, or to become involved in the Hydrogeophysics TC, please check out our website: www.hydrogeophysics.org.

Precipitation

Pierre-Emmanuel Kirstetter
University of Oklahoma

Precipitation is a major component of the water and energy cycles, a primary source of freshwater, and a driver of natural hazards. It is directly or indirectly the source of various effects of hydrology, and among the largest uncertainties in weather predictions and climate projections. Knowing where, when, and how much it rains or snows is paramount for understanding current and future water challenges. The AGU Precipitation Technical Committee brings together hydrologists, atmospheric scientists and mathematicians to collectively formulate and address key questions in precipitation science, including: i) physical processes that produce various forms of precipitation; ii) observing and modeling precipitation variability; iii) increasing needs in the hydrologic community for hydrological, weather, climate, and societal applications; iv) required interdisciplinary research and education. Observations are needed both at global scales to assess changes in large scale patterns, and at the finest possible scales to capture its intermittent and dynamic nature. Challenges are: i) to attain high accuracy in precipitation estimates; ii) capture their temporal and spatial distribution, specifically at ungauged locations (e.g. sea, desert, and complex terrain); iii) quantify their uncertainty and impact on simulated hydrologic processes. Recent activities have emphasized synergy between sensors through international efforts with space-borne missions (TRMM[1] and GPM[2]), reanalysis like APHRODITE[3] in Asia or the global-scale GPCP[4], field campaigns like AMMA[5] in Africa and CHUVA[6] in South America, and validation initiatives such as developed by the IPWG[7]. The AGU Precipitation Technical Committee promotes these topics and more for AGU sessions, AGU publications, and AGU award nominations.

[1] Tropical Rainfall Measuring Mission (https://trmm.gsfc.nasa.gov/)
[2] Global Precipitation Measurement (https://www.nasa.gov/mission_pages/GPM/main/index.html)
[3] Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources (https://climatedataguide.ucar.edu/climate-data/aphrodite-asian-precipitation-highly-resolved-observational-data-integration-towards)
[4] Global Precipitation Climatology Project (https://precip.gsfc.nasa.gov/)
5 African Monsoon Multidisciplinary Analyses (http://amma-international.org/)
[6] Cloud Processes of the Main Precipitation Systems in Brazil: A Contribution to Cloud-Resolving Modeling and to the Global Precipitation Measurement (http://chuvaproject.cptec.inpe.br/portal/noticia.ultimas.logic)
[7] International Precipitation Working Group (http://www.isac.cnr.it/~ipwg/)

Catchment Hydrology

Theresa Blume
GFZ German Research Center for Geosciences

The Surface Water Technical Committee was recently renamed to Catchment Hydrology. The term "surface water" was historically used to distinguish the topic from groundwater. However, the study of surface water requires an integrative approach, including consideration of subsurface processes, which is better reflected in the term "catchment hydrology". Because of the integrative nature of Catchment Hydrology, we cooperate with other Technical Committees, including Groundwater, Ecohydrology, Water Quality, and Uncertainty.

Committee members represent the broader AGU membership in terms of career stage, geography and gender. A major task of the committee is to help plan and execute the AGU Fall Meeting. During the session proposal stage the committee helps the Program Committee to identify potential mergers of proposed sessions to reduce overlap and the number of poster-only sessions. Each year, the committee identifies sessions of special importance to Catchment Hydrology and ensures that these are proposed. Recurring sessions proposed by the committee in the past years include Disturbance Hydrology, General Surface Hydrology, the MacGyver Session on novel sensing methods and sessions on Runoff Generation Processes. Each year, the committee discusses potential improvements to the Fall Meeting organization and suggestions are then taken to the Hydrology Section Executive Committee. We thus hope to contribute to making the Fall Meeting an even better experience by being "communication facilitators", and fostering both interdisciplinary collaboration and community building. Other committee activities include brainstorming and developing ideas for Chapman Conferences and identifying topics for articles to be submitted to the Hydrology Section newsletter.

From Section Technical Committee Chairs

Uncertainty

Ming Ye
Florida State University

The Technical Committee on Hydrologic Uncertainty seeks to improve how uncertainty is evaluated and measured by scientists, and to improve how uncertainty is communicated within and beyond the hydrology section. The technical committee maintains a log site at http://aguhu.blogspot.com/ for communication and evolution of scientific sessions. Hydrologists use uncertainty concepts and measures in many ways, from testing theories against data to providing regulators with defensible quantification of uncertainties associated with sometimes controversial environmental problems (e.g., sustainability, integrated water resources management, climate impacts, carbon sequestration, hydrofracking, and waste disposition). Issues of interest include how uncertainties (in data and model structures, parameters, and driving forces) are represented, evaluated, and reduced; uncertainty quantification in risk analysis and decision support; and how legal structures do and do not integrate the reality of uncertainty. Of interest are probabilistic and non-probabilistic metrics used to evaluate model responses, judge models against data, rank alternative models and test hypotheses; sensitivity analyses used to unravel sources of uncertainty; data collection strategies optimized for uncertainty reduction; and novel ideas not yet considered. As uncertainty is a cross-cutting issue, the Hydrology Section Uncertainty Technical Committee coordinates with other sections of AGU to include the notion of uncertainty in their research fields. This interdisciplinary and quantitative focus provides fruitful opportunities for conducting collaborative research with broader funding opportunities. It is one of the critical missions of the committee to foster interdisciplinary research for uncertainty analysis and to use uncertainty analysis as a vital tool for advanced understanding and bridging multiple disciplines.

Unsaturated Zone

Teamrat A. Ghezzehei
University of California, Merced

The Unsaturated Zone group brings together a diverse community of scientists and engineers who study multi-phase flow and transport processes between the Earth's surface and the groundwater table and related critical hydrologic phenomena including infiltration, evapotranspiration, and groundwater recharge and pollution. Many of the problems that we encounter in the unsaturated zone (also known as vadose zone) are inherently complex because of heterogeneities across spatial and temporal scales and involve interactions among physical, chemical and biological processes. The unsaturated zone community has been at the forefront in advancing approaches of quantifying and monitoring these processes. The community is also active in advancing mathematical modeling and simulation of hydro-bio-geochemical and -physical processes that occur in the vadose zone. One of the primary missions of the Unsaturated Zone technical committee is to foster interaction with sister technical committees in areas of common interest, particularly in soils, surface and ground-water, and critical zone processes. We invite interested members of the community to get involved by visiting our website: aguvadosezone.org

Water Quality

Nandita Basu
University of Waterloo

Water quality research covers a broad spectrum of concerns, from the dynamics of coupled nutrient cycles, to groundwater-surface water interactions, to the downstream fate of agricultural and industrial contaminants. A specific goal of AGU's Water Quality Technical Committee (WQTC) is to provide opportunities for connection among this diversity of interests and to serve as a bridge between the AGU Hydrology Section and the AGU Biogeosciences Section. The WQTC seeks to better understand the interactions between water flow and chemical and biological processes at all scales, and to use such understanding to protect and improve water quality in streams and groundwater under rapidly changing climate, land use and land management practices. The WQTC is committed to bringing together researchers working at the intersections of chemistry, biology, and hydrology from the scale of the global landscape down to that a single soil particle, and to facilitate research and discussion across disciplines regarding the major issues currently facing the water quality community, including but not limited to urbanization, eutrophication, plastic pollution, acidification, and the growing use of nanomaterials. The WQTC invites both senior and early-career/student members of the Hydrology Section who are interested in water quality issues to follow us on twitter @AGUwaterqual and to share information and items of interest using the hashtag #AGUWQ.

Groundwater

Holly Michael
University of Delaware

The Groundwater Section encompasses fields within hydrology that deal with subsurface water, including physical, chemical, biological, and geological aspects. The science and its applications are diverse and include the quantity and quality of groundwater supply and its sustainability, maintenance of ecosystems, geologic processes such as heat flow, oil and gas production, and geochemical cycles. The research methods deal with the special challenge of access to the subsurface and an always-incomplete knowledge of its properties. As such, we are closely linked to the Hydrologic Uncertainty Section. The many connections between groundwater and other aspects of hydrologic and environmental systems promote interdisciplinary interactions with other AGU sections within Hydrology, including Ecohydrology, Hydrogeophysics, Water Quality, Surface Water, and Water and Society. We also interact across AGU disciplines, with linkages to Biogeosciences, Global Environmental Change, Cryosphere, and Atmospheric Sciences. The Groundwater Technical Committee maintains a website (http://agugroundwater.nmsu.edu/) with information on activities and contact information for those interested in learning more. Our goal is to foster a collaborative exchange of ideas and promote the development of our understanding of groundwater processes.

Large Scale Field Experimentation

Joseph Alfieri
USDA-ARS

Whether the goal is to understand physical processes and interactions, develop and evaluate numerical modeling schemes, or address practical questions posed by industry or society as a whole, field experimentation is critical to all scientific endeavors. Moreover, as these research goals become more complex, so does the necessity and importance of large collaborative field campaigns that bring together scientists from a broad range of disciplines and institutions. The Large Scale Field Experimentation (LSFE) technical committee acts to promote interdisciplinary observational research and, in conjunction with other AGU sections, provides a forum for scientists to discuss both the outcomes and application of those research activities. Examples of topics that have been the focus of Chapman Conferences and meeting sessions in recent years include the development and application of data analysis tools and techniques to large datasets, measuring and modeling evapotranspiration, and improving our ability to monitor the terrestrial water cycle. Because of the cross-cutting nature of the research it fosters, the Large Scale Field Experimentation technical committee needs to be engaged with both the hydrological and larger AGU community. Although, the committee does not yet have a website, anyone interested in field experimentation and the application of observational data to address scientific and practical questions should contact either the Committee Chair, Joseph Alfieri (joe.alfieri@ars.usda.gov), or any of the members of the committee.

From Section Technical Committee Chairs

Remote Sensing

Alejandro Flores
Boise State University

The purpose of our technical committee is to promote discovery in theory and application of remote sensing of water resources. RSTC curates and promotes a forward-looking snapshot of the remote sensing of hydrology area each year.

Remote sensing enables us to extend field- and process-level understanding to large spatial scales, and to provide constraints on physically-based models run at large scale. It enables us to see the big picture. However, remote sensing rarely gives us exactly the quantity of interest. For that reason, it is vital that the RSTC contributes to collaboration across diverse disciplinary and methodological traditions that advance fundamental understanding of how to infer hydrologic quantities from remote sensing measurements, techniques to use existing products to better understand hydrologic processes, and enhance the use of remote sensing data in hydrological applications.

Please keep a lookout for our sessions in the AGU program: if you are new to remote sensing, consider emailing one of the RSTC chairs to ask how you could learn more. Not all RSTC-promoted sessions are equally accessible! If you are interested in becoming part of the RSTC, we invite you to email us, as members are regularly rotating off.

Water and Society

Kaveh Madani
Imperial College London

The Water and Society Technical Committee seeks to promote future directions for research at the interface of water and society, including its natural, physical and human dimensions. The science of water management is increasingly challenged to tackle complex and interdisciplinary research questions. Critical research questions for our group include: What are the research needs to solve future water sustainability challenges? Can we predict, influence, or manage the future direction of coupled human-hydrologic systems? How should the competition for freshwater resources be best managed? Within these questions, how can we bridge the gap between science and policy?

Goals for the Water and Society TC include promoting AGU sessions, fostering an environment to allow for new interdisciplinary collaborations, and promoting increased dialogue and the exchange of ideas. Please join our Google Group and share your ideas with us: https://groups.google.com/d/forum/agu-water-and-society. We seek to galvanize a community of scholars who work at the interface of science and practice to achieve advancement in both, with a goal of generating scientific insights and seeing them translated into improved management of and fundamental understanding of water resources and their interface with society.

Soils and Critical Zone Processes

Marc G. Kramer
University of California, Santa Cruz

Soils of the Earth's Critical Zone (CZ) are both responders and drivers of critical environmental changes facing the Earth. The purpose of our technical committee is to foster sessions addressing the Earth's Critical Zone which address all aspects of the complexity of the soil system including erosion; dust production; soils in water, transport, and chemistry; isotopic analyses; pedogenic processes affected by volcanism; physical, chemical, and biological composition; fertility; greenhouse gas production; and weathering. Our technical committee fosters interdisciplinary sessions and communication across the AGU membership to characterize and quantify soil / critical zone processes from microbial to tectonic scales. We also work to facilitate the growth of international critical zone science networks through town halls, sessions and supporting cross-society activities with the Geological Society of America and the Ecological Society of America.

Thomas Dunne: 2016 Robert E. Horton Medal

The Robert E. Horton Medal is for Outstanding contribution to the geophysical aspects of hydrology. The Medal has been awarded biennially since 1976 and awarded annually starting in 1995.

Discovery and Consolidation in Hydrology

Throughout most of its history, hydrology has been overwhelmingly concerned with practical matters, such as flood peak prediction, water availability and its relation to weather patterns, environmental impact assessment, etc. Even its newer focus on the implications of global change respond to perceived needs for urgent decision-making in the face of whatever knowledge limitations exist about hydrology itself, current or future environmental conditions, or the anticipated drivers. I appreciate why we take this approach -- I am currently using it in investigations of snowmelt and of mountain streamflow regimes. We usually do so because our goal is to get an answer that is sufficient for some purpose outside of hydrological science. We are grateful when we can develop a useful answer, and so long as we think the answer is reliable we are less concerned about detailed and validated representations of the hydrology itself. We acknowledge the potentials for "uncertainty"; we hope for the best, and this pragmatic approach to placing our hydrological knowledge at the service of humanity is something that we all value and hope to expand. It has not yet been demonstrated that anything more than fairly crude representation of hydrology improves predictions, although constraining predictions with more observational data does improve predictions somewhat.

"Field studies need to be designed from the outset in a (probably stochastic) framework for converting measurements into quantified explanations rather than simply descriptions."

Hydrologists usually provide this societal service of estimating future conditions by developing or using predictive models of varying complexity. When Beven [2001, p. 1] answered the self-imposed question, "Why model?", he gave as two of three reasons: "a means of extrapolating from the few available measurements in space and time, particularly in ungauged catchments", and "the ultimate aim of prediction using models must be to improve decision-making about a hydrologic problem." Faced with these pragmatic challenges, Beven [2001, p.3] explains that a necessary first step in hydrological modeling is to construct "the perceptual model of the rainfall-runoff processes in a catchment". He elaborates that, "A perceptual model is necessarily personal. It will depend on the training that hydrologists have had, the books and articles they have read, the data sets they have analyzed and particularly the field sites they have had experience of in different environments. Thus, it is to be expected that one hydrologist's perceptual model will differ from that of another…."

Even if one acknowledges Kant's argument that personal imagination, along with experience, "is a necessary ingredient for perception" [Matherine, 2015], the idiosyncratic situation Keith describes as the required first step in model construction, though it reflects the current state of hydrology, seems unsatisfactory to me. Hydrological systems are mysterious and hard to comprehend, and conversations about how they function at any chosen scale often seem to dissolve into an impasse somewhere between confusion, unknowability, and doubt. Beyond the most coarse-grained level, we simply don't seem to be able to agree about what is going on, or at least about what critical features need to be accurately defined, represented, and quantified. Even though there is an impressive and growing number of hydrological prediction models (or software packages combining several models), that number is much smaller than the number of hydrologists' perceptions of hydrological functioning in various geographic domains of model application, suggesting a considerable amount of compromise. So, we often use a strategy in hydrological computation that a friend of mine calls, “Bash to fit, and paste over the cracks”.

The convenience, societal value, fundability, adequacy, and urgency of this pragmatic use of hydrological knowledge can obscure the question of how much we really understand about Earth’s hydrologic system at all its scales and in all its geographic variety. Of course, we could simply admit there is so much complexity in hydrological processes that operate mainly underground, or “in the remote mountains”, or during inconvenient and uncomfortable events that it is unlikely that we will ever consolidate our tenuous perceptual models into a more systematized, agreed upon, and reproducibly quantified form. Perhaps we will never be able to improve on our mechanistic understanding to explain what is going on to create a flood wave on the Mississippi River or the recharge pattern of a ground water basin unless the problem of data sparseness improves dramatically. And society may not need very precise predictions, founded on detailed mechanistic representations, so long as the predictions are robust and unlikely to mislead. But as a scientific challenge, we are surprised so often in hydrology when we try to make a ‘first principles’, uncalibrated prediction of the behavior of water that surely we are intrigued to expand our explorations of the mechanisms and properties which surprise us.

Fortunately, the scientific study of water behavior at locality, landscape and planetary scales, -- though always a minority activity, poorly represented in textbooks, in the training of most hydrological practitioners, and in communications with the public – has flourished in recent decades because of technical and organizational advances. This branch of hydrologic research emphasizes discovery and the consolidation of empirical studies into deeper forms of understanding. I will not try to summarize these empirical advances here because they are represented widely across many hydrological fields and journals. Suffice it to say that many aspects of hydrology have recently been transformed by technological innovation, and have yielded surprises --- the hallmark of a science with legs. Some opportunities for discovery arise from unplanned sources, so it is useful to have curiosity and unanswered scientific questions at the ready for those serendipitous situations when one hears from a colleague about a novel technology developed for some other purpose [Borsa et al., 2014]. We need to be on the lookout for such opportunities to promote hydrologic discovery and expand its geographical coverage. The various technical and meeting program committees within the Hydrology and neighboring sections of AGU have demonstrated remarkable creativity in developing formal and informal ways of promoting cross-fertilization along these lines.

Of course, this emphasis on empiricism is not meant to suggest that we should not be formalizing and generalizing these burgeoning new results as exactly as possible. Keith Beven’s third reason for modeling was “a means of formalizing knowledge about hydrological systems.” Highlighting the need for studies that are empirical, exploratory, inductive, and not yet ready for predictive modeling but only for modeling to explore mechanism could encourage early-career hydrologists to pursue discovery, innovation, and geographic expansion of understanding. In some branches of hydrology, defining what actually happens, what is connected to what, and what is a large effect or small effect, are more interesting issues at this point than evaluating “effective parameters” for prediction tools. Empirical investigations might uncover, for example, undiscovered effects of the rooting habits of different plant systems on ET, or how water-modulated seasonal differences of microbial behavior affect soil structure and water-holding properties. Discovery might also define under-appreciated ranges of environmental conditions affecting runoff processes, such as when studies of subsurface flow with novel technology were extended into extremely wet regions with exceptionally steep slopes and shallow soils disrupted by aggressive bioturbation over irregular bedrock (summarized by Seibert and McDonnell [2002]). Whatever the difficulties, extensive instrumental field studies and visualization techniques are still needed to define how water travels over scales of $10\text{-}10^3$ m and how to express the results in stochastic form to define how microscale effects propagate to larger scales of interest. Field studies need to be designed from the outset in a (probably stochastic) framework for converting measurements into quantified explanations rather than simply descriptions.

On the other hand, an appetite for discovery needs to be combined with consolidation of discoveries to explain the workings of the hydrologic cycle in connected, more satisfying, and more credible ways. Findings based on the dazzling array of new technology sometimes seem only to expand our sense of complexity, confusion, and resignation to statistical studies of variability. New discoveries are often recorded in summaries of "the state of the science" as lists rather than as connected narratives. Consolidated narratives are needed, for example, about how a single process works under the entire range of environmental conditions across continents (which, after all, will still be represented in global flood prediction, water balance or sediment production models). Better narratives are also needed of how multiple hydrological processes interact in a single location or region. In order to describe Nature realistically, such explanations will have to be formulated in terms of distributions of energy states, material characteristics, timing, intersections of events, etc. Progress is being made (again with new technologies and lengthening data records) to define the nature of these distributions. It is becoming clearer (if not surprising) that the distributions are not all random, because they are created by processes obeying natural rules, even if the patterns must often be treated as random in data-sparse prediction models. The separation of patterns from irreducible randomness can reveal mechanisms creating both.

Consolidation of knowledge is also needed to connect new findings. Many of the new tools allow measurements of correlations between (say) rates, concentrations, or residence times and some assumed control over large scales of time and space that were unavailable until recently. Examples include: correlations between erosion rates and average landscape gradients; runoff and rainfall volumes; groundwater age and mean annual precipitation. These statistical associations are satisfying when in some general way they meet our expectations, and even more so, when they contradict our expectations. They can also be usefully employed in predictive models for satisfying societal needs. But, in the spirit of discovery, they provoke curiosity about how Nature creates those relationships, presumably through neglected interactions between hydrologic and other mechanisms.

One sometimes hears (I will refrain from attributions to informal publications or seminar and workshop discussions) that breakthrough discovery is no longer likely in hydrology; that computing the consequences of an adequate base of physical understanding with better remotely sensed data products is now the most useful career strategy; and that hydrology is "an inexact science". All of those terms seem to me like the end of aspiration, and not something one hears about other Earth and environmental sciences that also confront variety, complexity, and logistical challenges in measurement and theory construction. Those other sciences are able to continually create rigorous but motivational stories about how Nature works at many intricate scales, to earn the affection and trust of the public about their credibility, and to attract young scientists to combine their esthetic and analytical passions. With the hydrologic cycle as a study object that creates beauty and supports life, we should be able to transmit to young scientists (and supporting funding agencies) the vision that this science is only just beginning to get a handle on mysterious and wonderful processes and relationships that extend over an infinitely variable planet. Perhaps we need a hydrological analog of Darwin's last sentence in On the Origin of Species: "There is grandeur in this view of [life …]".

"All of those terms seem to me like the end of aspiration, and not something one hears about other Earth and environmental sciences that also confront variety, complexity, and logistical challenges in measurement and theory construction."

Much of what I am supporting here could be described as waving to a train full of travelers while they are accelerating out of the station. But it never hurts to emphasize to early-stage researchers the value of finding ways to jump on that train, even if it might lead to more uncertainties and physical discomfort than sitting in the station's package receiving facility. You will be at the center of scientific investigation.

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A Fellow Speaks: The Outsized Influence of River Corridors

Jud Harvey, U.S. Geological Survey

Rivers comprise a small part of the landscape, less than a percent, yet they have outsized transformative power as regulators of biogeochemical reactions, aquatic metabolism and energetics, food webs, biodiversity, and overall aquatic system health.

The functional values of rivers depend on more than just wetted channels. Valuable services such as water purification and provision of habitat are supported by wet connections with riparian and hyporheic zones, floodplains, and ponded surface waters adjacent to the main channel, all together comprising the larger functional unit known as the river corridor. Carbon and nutrients are stored and processed in these off-channel waters, and habitat is provided for rearing and refuge of aquatic organisms. Additionally, contaminants are filtered from the terrestrial runoff as it traverses the corridor, back-and-forth between the main channel and the adjoining waters, where the increased contact and residence time triggers geochemically and microbially-activated reactions. This article outlines progress in linking fine-scale controls of river corridor processing with consequences for river basin water quality and aquatic ecology.

A parcel of water passes not once, but thousands of times across the river corridor interface in its journey from the mountains to the sea (Figure 1). Despite today's integrated curricula, a typical hydrology student still may not encounter this basic concept, although a broad view of river functions is incomplete without it. Even interdisciplinary approaches such as the science of environmental flows that ask questions like "how much water do rivers need?" still tend to be overly focused on discharge (Poff et al., 1997), overlooking key information about the off-axis exchanges of water and materials between aquatic and terrestrial landscapes (Stanford and Ward, 1993; Dunne et al., 1998). The lateral and vertical exchanges in the river corridor often may be the most ecologically relevant fluxes for assessing nutrient cycling and river habitat functional values.

Appreciation of the river corridor's importance has been tempered by the difficulty of measuring the hydrologic exchange flows. Much of the focus in past few decades has been on developing field methods, many of them tracer based, to detect main channel exchanges with adjoining surface and subsurface waters (Jones and Stanley, 2016). Oxygen-rich main channel waters mix with off-channel waters with longer storage times that are often devoid of oxygen. Further interactions occur with a sediment biolayer, a granular surface layer with high concentrations of algal cells and microbes that filters fine particulates from flowing water and supplies substantial quantities of reduced, energy-rich organic compounds. The hydrologic mixing between

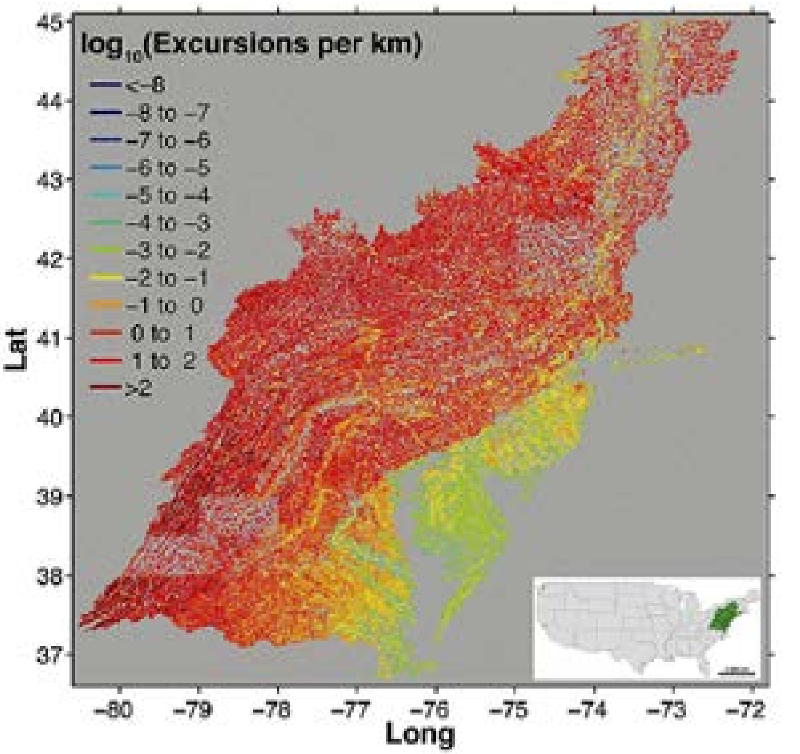

Figure 1. River water is exchanged numerous times with hyporheic zones, particularly in headwaters, where excursions may exceed 100 times per kilometer. Not all headwaters are equivalent, as exemplified in this figure of the United States Mid-Atlantic region by comparing mountainous regions in the west with the Atlantic coastal plain.

these systems drives high rates of organic matter decomposition, mineralization of nutrients, and a cascade of redox, precipitation-dissolution, and sorption-desorption reactions that, depending on specific circumstances, may sequester in the sediments or transform riverine contaminants.

An important goal of river corridor science is to assess and prioritize best management practices to enhance contaminant filtration from flowing waters. A necessary step is to understand and identify which flow paths significantly alter downstream water chemistry, especially those controlling the removal or transformation of nutrients and metals as well as organic contaminants associated with waste disposal, mining, and unconventional oil and gas extraction. But how can the relative importance of the many types of river corridor flow paths be compared? In other words, is it reaction in groundwater discharging through riparian sediments or is it reaction in hyporheic flow paths that is most important in removing contaminants from flowing waters, or is it bank storage or overbank flow driven by river-stage? Lacking that understanding diminishes the hydrologist's ability to assess the effectiveness of best management practices such as riparian setbacks or in-stream or floodplain engineering to enhance contaminant filtration and degradation.


Maple Creek, Nebraska (Image source: U.S. Geological Survey)

Reaction efficiency in the river corridor can be characterized by contrasting the transport time available for a reaction with the intrinsic reaction timescale. The Damköhler number, the ratio of the hydrologic residence time to the reaction timescale, is a fundamental metric of importance, with values larger than 1 indicating a transport limitation compared with values less than 1 indicating a reaction limitation. In transport limited flow paths the reaction rate slows and then ceases before transport is completed (99% removal for Damköhler number above 4). Transport-limited flow paths are generally inefficient because storage capacity is "wasted" long after the reaction has ceased. In contrast, reaction limited flow paths remain active throughout transport (albeit at a lower reaction rate) because the reactant concentration remains relatively high.

Because of fundamental differences between flow paths, I have argued for modifying the Damköhler number by adding a flow weighting term for application in complex hydrologic settings like the river corridor. Flow weighting reveals that reaction significance either can be high because of the high intrinsic reaction rate or because of the large volume of water that is processed, with significance being greatest when both the intrinsic rate and the volume of processed water are high. Flow weighting also enables comparisons between various types of flow paths, e.g. vertical hyporheic flow beneath small bedforms compared with lateral hyporheic flow through banks, or groundwater discharge through riparian areas, or bank storage and overbank flow onto floodplains operating only during spates and floods.

To implement flow weighting we developed RSF, a dimensionless, flow-weighted reaction significance factor. RSF scales the Damköhler number by multiplying it by the flux across the river corridor interface as a proportion of the river discharge in a reach of specified length (Harvey and Fuller, 1998; Harvey et al., 2013). Examples of quantifying reaction efficiency in river corridors include denitrification in a Midwestern agricultural landscape, and precipitation of manganese oxides and sorption of trace metals in a semi-arid, mine-drainage affected landscape (Harvey et al., 2013; Fuller and Harvey, 2000). In both situations the contaminants were sourced from groundwater, but removal by riparian processing during groundwater discharge was either transport limited or subject to bypassing with little reaction. The stream's hyporheic flow paths were only centimeters deep, but they had a moderate intrinsic reaction rate and most important, they were fast-exchanging and processed much more water than did groundwater flow paths (that only crossed the interface once). As a result, the reaction significance in these very different river corridors with contrasting contaminants was dominated by contaminant removal in the hyporheic zone, which exceeded the removal that occurred in discharging groundwater by more than an order of magnitude in some cases.

Recently the flow-weighted Damköhler approach has been incorporated in river corridor models for large river basins. The purpose of these models is to provide the terrestrial-aquatic model linkages that are often poorly specified by standard watershed, groundwater basin, and open channel models. To develop this link, a river corridor model must be physically based, but to be effective at large scales, the model also must be parsimonious and take advantage of widely available data sets on channel slope, hydraulic geometry, riverbed grain size, and groundwater inflow, as well as increasingly widespread data sets acquired by chemical sensors. Emerging river corridor models (e.g., Mazardri et al., 2017; Gomez-Velez et al., 2015) potentially can bridge the gap between highly refined models useful for specific locales, and regional water quality models that, because they often are based entirely in statistical measures, tend to be less useful for forecasting future water quality outcomes.

One example of a river corridor model is NEXSS, a multi-scale model that captures centimeter-scale hyporheic flow through small bedforms all the way up to kilometer-scale hyporheic flow through river meanders (Gomez-Velez et al., 2015). NEXSS makes these computations for the 3 million georeferenced river reaches of the United States in the National Hydrography Dataset (NHD). Early progress with NEXSS quantified the relative importance of vertical exchange flows with riverbeds and lateral exchange flows with banks in the upper Mississippi River drainage basin. The model distinguishes the relative capacities of vertical and lateral zones in exchanging the main channel's entire volume through reactive sediments where biogeochemical opportunities for nutrient processing, sediment redistribution, and attenuation of contaminants are increased.

A preliminary conclusion from NEXSS was that variation in the hydrogeomorphic factors, e.g., river slope, river bed grain size, and types and sizes of bedforms, rather than the intrinsic reaction rates, may dominate outcomes for nitrate removal and downstream loading of nitrogen to estuaries. The dominance of hydrogeomorphic factors arises because the water exchange fluxes, and reaction opportunities, are so much more variable compared with the intrinsic reaction rate of denitrification in various sediments. Furthermore, in the Upper Mississippi River basin, it was found that vertical exchanges with small river bedforms dominated over lateral exchanges through banks in their potential for removing nitrate, suggesting that managing rivers to protect permeable bedforms will be more productive than restoring large-scale bar and meander features to filter contaminants. The preliminary results also suggested that riparian buffers, although important, may not always do the primary work in removing nitrate within river corridors. While those results are preliminary, representing only mean flow conditions, they can be reexamined after including monthly river flow variation and bank storage and floodplain processing. Also needed is more examination of basin controlling factors (e.g., network position, surficial geology, slope, grain-size, etc.) compared with instream features such as bank height, channel edge complexity, bedform type and other distinctions that promote water quality functions. These and others advancements are necessary to scientifically assess management practices in terms of their effectiveness in protecting water quality functions and river health.

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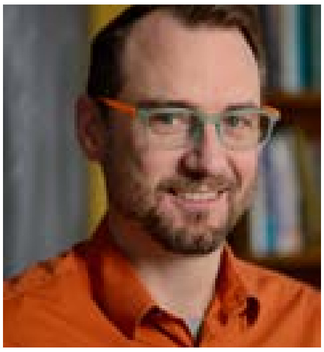
Interview with Early Career Awardee

Ciaran Harman (Johns Hopkins University)



We recently interviewed Ciaran Harman, 2016 ***Hydrologic Sciences Early Career Awardee***. The Award recognizes outstanding contributions to the Science of Hydrology, education, or societal impacts by a scientist at his or her early career stage. This prestigious award acknowledges early career prominence and promise of continued contributions to hydrologic science.

1. Tell us a little bit about yourself

I grew up in Perth, Western Australia, which is a city on a river of sorts. The Swan River is really a broad estuary stretching into the sandy coastal plain. As a kid I learned to swim in its brackish waters. Toward the end of my undergraduate studies in Environmental Engineering at the University of Western Australia I had to pick something to focus on, and decided that rivers were the thing for me. I loved the way they were self-made, arising from feedbacks between the fast dynamics of fluid mechanics, intermediate dynamics of streamflow variability, and slow(er) dynamics of channel formation and migration, with a hefty dose of anthropogenic influence.

This led me first to a brief and unimpressive career as a consulting engineer, then to two golden years working as a research scientist at the University of Melbourne, and eventually to the University of Illinois for graduate school. I planned to study fluvial geomorphology, but was drawn over into hydrology by Siva Sivapalan. Siva had been my undergraduate professor, and moved to Illinois at the same time as me. He showed me that hydrology could be mysterious and exciting too – feedbacks across time-scales and space-scales lurk in hydrology too, but are harder to see.

Siva also introduced me to the problem of scale and variability/heterogeneity in hydrology, which to me is a beautiful problem at the heart of the science, and central to why it exists. Hydrology is not just fluid mechanics writ large, though there are obviously many useful results that can be derived from pretending it is. Ultimately hydrologic science is about the interaction of landscape, climate, life – us in particular – and the behavior that emerges at scales that matter for human decision-making. That means it must be deeply rooted in the reality of landscapes.

Today I am an Assistant Professor at Johns Hopkins University in the department of Environmental Health and Engineering. My graduate students and I work on various pieces of both of these broad problems – co-evolution and process upscaling. One day I hope we will really understand how these two are linked together in the landscape, and put that understanding to good use.

2. *Highlights*: What would you consider to be the highlights of your young scientific career prior to receiving the prestigious 2016 Hydrologic Sciences Early Career Award?

> "Go out and learn a new technique, and think about how it might be applied to an important problem in hydrology."

It's hard to pick one thing, but I should probably talk about the work on rank storage selection functions, which has definitely been the highlight of the last 5 years, and has been enormous fun.

In September of 2012 (just after I arrived at Hopkins) my graduate student Minseok Kim and I started thinking about the new time-variable transit time models that Gianluca Botter and Ype van der Velde had (concurrently) been developing. These boil down to age-structured demographics models for 'populations' of parcels of water stored in a catchment. Parcels are born when they enter (e.g. as rain) and die when they leave (e.g. as ET or discharge). If the timeseries of births is known (the hyetograph) as well as that of total deaths (the hydrograph and ET timeseries), the trick is to have a function that characterizes how those deaths are distributed amongst the different age groups. That function is the 'storage selection function'. Once you have a SAS function you can predict how the age structure of the population (and the recently departed) changes in time.

While Gianluca's work had laid a lot of foundations very comprehensively, it was clear that there was a basic problem with their framework. It wasn't really useable! The 'age function' (as they initially called the SAS function) that they defined in 2011 is certainly the heart of the problem, but their formulation couldn't be directly parameterized in a way that will guarantee mass conservation. Ype's formulation (which he developed independently I believe, but published later) solved this problem, and was a crucial breakthrough. Without it this line of work would not have been able to get very far.

The next problem was that no one really knew what these functions looked like in typical hydrologic systems, let alone how to parameterize them in real landscapes. Minseok and I wondered whether it would be possible to directly observe them using active tracer injections. It was immediately clear that this was difficult in a field setting (for reasons beyond the mere logistics), but it might be possible in the lab if a physical model of a hydrologic system could be driven to a periodic steady state. This led to the development of the PERTH method, which has now been successfully run on a few different systems (including the three LEO experimental hillslopes at Biosphere2) and has helped us start to see how SAS functions are related to the internal organization and mobilization of water in storage.

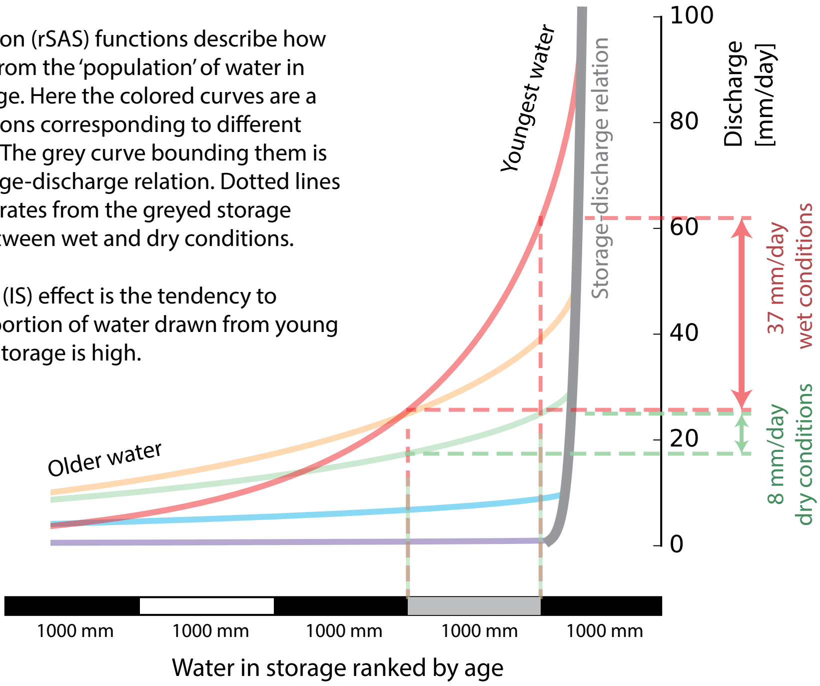
The other contribution we made back then was to bring the role of storage more clearly into the picture. Ype's approach expresses the SAS function in terms of the probability distribution of water parcel ages in storage (the residence time distribution), which means you have to know the 'total' storage so that you can normalize the distribution. I don't know how to define the 'total' storage of catchment, let alone estimate it!

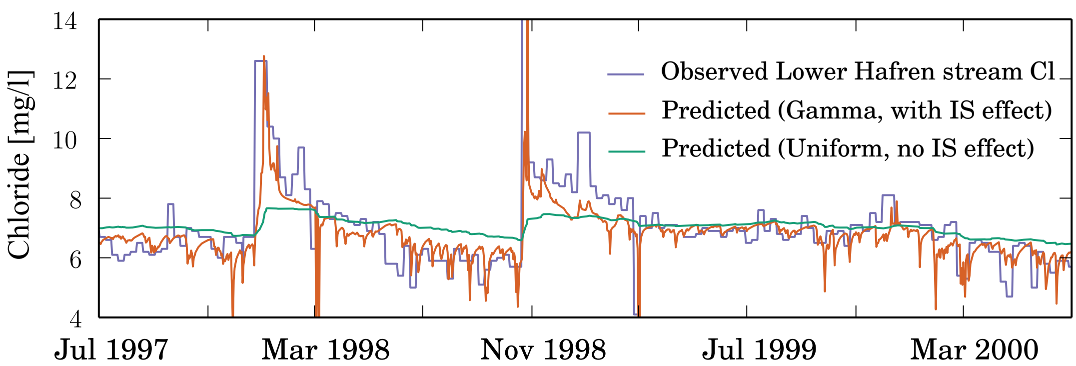
This seemed like a bad idea for two reasons. First, it would mean that functionally identical SAS functions would 'look different' depending on how you chose to define total storage. That would surely get in the way of being able to find patterns between places – which are essential if we are to find a way to predict SAS functions across the landscape. Second, it 'baked in' a sensitivity to storage that seemed to go in the wrong direction. Under wet conditions (when total storage was high) you end up dividing by a larger number, so the most recent rain would (all else being equal) make up a smaller proportion of the discharge compared to when storage was low. I don't believe this is the way most catchments work!

I spent much of the

rank StorAge Selection (rSAS) functions describe how discharge is drawn from the 'population' of water in storage ranked by age. Here the colored curves are a family of rSAS functions corresponding to different wetness conditions. The grey curve bounding them is the catchment storage-discharge relation. Dotted lines show how dicharge rates from the greyed storage volume changes between wet and dry conditions.

The 'inverse storage' (IS) effect is the tendency to release a larger proportion of water drawn from young storage when total storage is high.





2013/14 winter break developing a way to modify Ype's approach that avoided having to define a 'total' storage, and allowed the SAS function's sensitivity to storage to be directly parameterized. After my theory-heavy paper describing the approach was rejected without review from WRR, I applied the model to data from the Lower Hafren stream, demonstrating that the method worked. The results showed that under high storage more of the discharge was indeed drawn from the youngest water in storage, rather than less – a behavior now commonly referred 'inverse storage effect'. I think the resulting paper is still the most highly cited paper published by WRR in 2015.

"But mistakes and blind alleys are necessary and instructive in research"

We've put out a few different papers on SAS functions now, and today Minseok and my other students (particularly Dano Wilusz and Shane Putnam) are continuing this line of work in a number of exciting directions (several of which will be submitted for publication in the next few months).

3. *Hindsight*: What would you have done differently, if anything, in pursuing the research questions that you and/or your community have been interested in?

On a personal level: I would have made more mistakes. I mean, over the last 10 years I have made plenty of mistakes and wasted more days (months) than I can count on efforts that were ultimately fruitless. But mistakes and blind alleys are necessary and instructive in research. Experiments that don't give the result you expected, field observations that don't make sense, theory that seems to miss something important – these are the muddy ground that new knowledge springs from (even if it's only new to you). I must confess (if only so others might be encouraged) I was too often timid, or paralyzed because I didn't have a perfect plan. I would be bolder.

4. *Foresight*: Where do you (or would like to) see water resources research is headed in the next 10 years?

Advances in science are often made when new observations drive better theory, and new theory drives better (more targeted) observations. I think one area where the observations are racing ahead is hydrogeophysics. Within the critical zone community in the US, geophysical observations have been having a profound impact, transforming our understanding of the structure of the subsurface. This is naturally leading the CZ community to develop new theories about the evolution of the subsurface, which must be tested with new observations. I think it is likely that critical zone science's improved understanding will lead to improved approaches for characterizing watersheds and parameterizing hydrologic models. This is particularly likely if airborne or drone geophysics tools can one day effectively characterize details of the subsurface at sub-hillslope scales, illuminating controls on ridge-to-valley flow paths. This will naturally require us to develop new and better theory to connect these observations to hydrologic prediction (I doubt there will be a drone that can measure a permeability field or preferential flow pathways), so there is much work to be done.

5. With *hindsight* and *foresight* comes insight. What insights about water resources research would you like to share with aspiring students and early career scientists?

I think hydrologic science needs young scientists to be critical about what kinds of questions are important, and to forge new connections to other disciplines, bringing in new methods and tools to solve the most important fundamental and 'use-inspired' problems. Some of hydrology's emphasis on modeling over the recent decades, and the veil of equifinality that calibration draws over our vision might mean that there are basic processes that we think we understand, but perhaps we really don't. Critical thinking is needed. Many of those processes are important in our allied disciplines, like geochemistry and ecology, and the observational capacity that is being opened up by geophysics gives us the chance to see them with new eyes. There are so many opportunities out there that will enrich the discipline, but a typical hydrology PhD student's advisor may not even know what they are, let alone be able to provide their students training in them (this is often how I feel). Go out and learn a new technique, and think about how it might be applied to an important problem in hydrology. And play and have fun doing it, even when you fall in a heap and everything is going wrong! Better to try ten things and have one work, than to try nothing at all.

2016 Outstanding Student Paper Award Winners

Theodore C. Lim
University of Pennsylvania
Title: Beyond imperviousness: A statistical approach to identifying functional differences between development morphologies on variable source area-type response in urbanized watersheds

Kimberly Manago
Colorado School of Mines
Title: Evaluating relationships between urban land cover composition and evapotranspiration in semi-arid regions

Danielle Boshers
University of Connecticut
Title: Oxygen Isotope Composition of Nitrate Produced by Freshwater Nitrification

Lidiia Iavorivska
The Pennsylvania State University
Title: Inputs of Organic Carbon to Watersheds via Atmospheric Deposition: Variation Across Spatial and Temporal Scales

Sarah Fletcher
Massachusetts Institute of Technology
Title: Uncertainty Categorization, Modeling, and Management for Water Supply Planning

Margaret Garcia
Tufts University
Title: Modelling Per Capita Water Demand Change to Support System Planning

Margaret Zimmer
Duke University
Title: Shallow and Deep Groundwater Contributions to Ephemeral Streamflow Generation

Rachel Baum
University of North Carolina Chapel Hill
Title: Tradeoffs in Risk and Return of Financial Hedging Solutions to Mitigate Drought-Related Financial Risks for Water Utilities

Christopher Marsh
University of Saskatchewan
Title: The Canadian Hydrological Model (CHM): A multi-scale, variable-complexity hydrological model for cold regions

Cyndi Kelly
Stanford University
Title: Back-Projection Imaging of extended pre-, co-, and post-eruptive seismic sources through multiple eruption cycles at Jefe Geyser, El Tatio Geyesr Field, Chile

Daniel Wilusz
Johns Hopkins University
Title: Can a simple lumped parameter model simulate complex transit time distributions? Benchmarking experiments in a virtual watershed.

Levon Demirdjian
University of California Los Angeles
Title: Improving the Statistical Modeling of the TRMM Extreme Precipitation Monitoring System

Preston Pound
Georgia Southern University
Title: Bacterial Flux by Net Precipitation from the Phyllosphere to the Forest Floor.

Johanna Engstrom
University of Florida
Title: Hydropower in Southeastern United States, -a Hydroclimatological Perspective

Xiuyuan Li
Lehigh University
Title: Assessing the Influence of Climate Variables on the Past Floods in Continental USA

Nathaniel Looker
University of Minnesota Twin Cities
Title: Effects of land use/cover and landform on upper soil physical properties in the highlands of Veracruz, Mexico

Jane Barlow
University of Arizona
Title: Assessing Hydrologic Impacts of Future Land Cover Change Scenarios in the South Platte River Basin (CO, WY, & NE) and the San Pedro River Basin (U.S./Mexico) [Link to e-poster]

Bernardo Carvalho Trindade
Cornell University
Title: Time evolving multi-city dependencies and robustness tradeoffs for risk-based portfolios of conservation, transfers, and cooperative water supply infrastructure development pathways

Natalie Nelson
University of Florida
Title: Uncovering cyanobacteria ecological networks from long-term monitoring data using Granger causality analysis

Stephen Maples
University of California Davis
Ttile: How to Recharge a Confined Alluvial Aquifer System

The NASA SnowEx Campaign 2017: new datasets to advance snow remote sensing

Jeff Deems[1], Michael Durand[2], and Alejandro Flores[3]

The spatial distribution of the seasonal snow cover exerts a dominant control on land surface energy and water budgets, with critical importance to hydrologic science and water management practice. Yet measurement of snow cover properties remains a substantial challenge. Recent advances point to a new paradigm where quantification of spatial and temporal variation in seasonal snow mass and energy states and fluxes is accomplished widely and accurately.

Fig 1: Grand Mesa, CO field site as seen from the Airborne Snow Observatory aircraft during the February, 2017 campaign. Photo: Dan Berisford, NASA JPL Airborne Snow Observatory.

Air- and space-borne remote sensing provide the necessary perspectives to capture variation in snow cover properties across the landscape and in complex and vegetated terrain. Building on recent successes in retrospective and near-real time snow water equivalent (SWE) and albedo mapping, and on a legacy of field experiment and mission design, the NASA SnowEx campaign, sponsored by the Terrestrial Hydrology Program and fostering international participation, was created to provide coincident field, in situ, and airborne measurements in support of a multisensor approach to measuring and monitoring seasonal snow cover evolution.

Decades of hydrologic research in snow-dominated watersheds provides a foundation for science question definition, a process rapidly achieved by the International Snow Working Group on Remote Sensing, building on the strong legacy provided by the NASA Cold Lands Processes Working Group and the subsequent Cold Lands Processes Mission Concept – a Tier 3 2007 Decadal Survey selection.

Prior efforts have sought to design and implement a single sensor to directly retrieve SWE in a diversity of environments. While some of these approaches remain promising, the community has converged on a multisensor approach in combination with process modeling to provide the most robust retrieval of snow cover properties in all environments.

In Year 1 of the SnowEx campaign, the primary focus was on snow in forested environments, and two field sites in western Colorado were selected for their physiographic characteristics as well as for existing and legacy snow system observations: Grand Mesa (primary site) and Senator Beck Basin (secondary site). The low relief environment on Grand Mesa (GM) facilitated access for a large number of field observers and instruments, while providing gradients in forest cover with minimal topographic variation. The high relief of Senator Beck Basin site (SB), a research site maintained by the Center for Snow and Avalanche Studies, allows testing of Grand Mesa retrievals in rough terrain, and will support hydrologic modeling with its 12-year energy balance and

[1]National Snow and Ice Data Center, [2]Ohio State University, [3]Boise State University

streamflow data sets.

In September 2016, snow-free data sets, micrometeorologic stations, and sample location markers were collected and installed to prepare for the snow-on campaign in February 2017. The winter campaign was very successful, with a wide array of coincident airborne, ground-based remote sensing, and manual measurements.

Ground teams included over 100 participants per week for 3 weeks at the Grand Mesa site, and 10 participants for each of two weeks at Senator Beck Basin. Full credit is due to the field organizers and leadership for managing a complex logistical effort on very short preparation time and with a perfect safety record. Over 150 snow pit measurements (density, temperature, grain size/type stratigraphy) and over 165 manual snow depth transects (~16,500 depth measurements) were conducted.

In situ instruments included 3 permanent surface energy balance towers (2 in SB, one on GM), a snow depth sensor network, snow temperature thermistor profiles, time-lapse cameras, accelerometers to measure snowfall interception, an AERONET sun photometer (SB), and a stream gage (SB).

Numerous ground-based sensors simulated or complemented the airborne measurements. GPR, FMCW, and SAR radars, Ku- and X-band scatterometers, boom-mounted and surface-based microwave radiometers, GPS receivers for snow depth retrieval, terrestrial laser scanners, field spectrometers, and thermal IR cameras were all employed, with numerous coordinated measurements. Snow grain structure and stratigraphy were characterized with snow micropenetrometer (SMP) profiles and specific surface area (SSA) from an IceCube hemispherical reflectometer.

Four aircraft participated in SnowEx 2017, with a total of 9 sensors. The Naval Research Laboratory P-3 flew 5 science sorties carrying the X- and Ku-band SnowSAR, CAR bidirectional reflectance radiometer, and KT-15/QWIP thermal IR instrument packages. The AESMIR passive microwave sensor unfortunately suffered an engineering problem that prevented its inclusion on the P-3. The JPL Airborne Snow Observatory (ASO) flew six missions on a King Air with its scanning lidar/imaging spectrometer package. The JPL GLISTIN-A (Ka-band) and UAVSAR (L-band) interferometers flew 7 days total on NASA G-III platforms. The WISM radar/radiometer suite conducted two science flights on the Twin Otter. All told, 20 science flights were achieved, with multiple coincident or consecutive overflights. Data from the 2016/17 SnowEx campaigns are in various stages of postprocessing, and all data sets will be archived and distributed at the National Snow and Ice Data Center (NSIDC).

This past year's campaigns we the beginning of a 5-year SnowEx plan. Year 2 (2017/18) is reserved for data analysis and refinement of the future field activities. Field campaigns will be conducted in each of the subsequent 3 years, with science questions, field sites, and sampling strategies to be driven by a recently-selected Science Team. Current and future Terrestrial Hydrology Program solicitations are supporting development of Algorithm Theoretical Basis Documents to help define the emerging satellite mission concept.

This is an exciting time in snow hydrology as we move toward development and deployment of new remote sensing capabilities, helping to refine measurement and understanding of seasonal snowpacks – heretofore a primary source of uncertainty in the water balance. Look for SnowEx sessions at this year's AGU Fall Meeting, and look for SnowEx and ASO data at NSIDC soon!

Fig 2: Newsletter cover photo. Credit: Photo: Jeffrey Deems, National Snow and Ice Data Center, University of Colorado.

International Workshop held on The Role of Information Theory in the Earth Sciences

Uwe Ehret[1], Hoshin Gupta[2], Grey Nearing[3], Ben Ruddell[4], Florian Wellman[5], Rohini Kumar[6], Steven Weijs[7], Beth Jackson[8] and Gab Abramowitz[9]
(Workshop Organizers)

There is a growing understanding that "*information*" is both a fundamental aspect of the *nature and workings* of reality, and also of our *understanding* of reality (Knuth, 2010, 2004). This realization has driven a resurgence of interest in the topic of Information Theory (IT) and its implementation in the Earth and Environmental Sciences (EES). Because IT analyses are essentially general in nature, they can be applied to all aspects of the scientific endeavor -- complex systems (Tononi, 2011), models of those systems (Nearing and Gupta, 2015), observational data (Datcu et al., 1998), and the synthesis of all of these (MacKay, 2003). Being rooted firmly in mathematics and statistical theory, IT provides a compelling basis for expanding upon methods that make simplifying assumptions such as linearity and Gaussianity to address problems of inference. Because of this, IT has the potential to facilitate enhanced understanding of the emergent behaviors of complex Earth Systems in ways that traditional analyses cannot (Ruddell, Brunsell, and Stoy, 2013). Additionally, IT enables the study of any and all parts of a system (real or modeled) under a common dynamical framework, so that minimal priori assumptions need be made to understand the relationships between large numbers of diverse dynamical processes (Ruddell and Kumar, 2009).

Fig 1: Ascent to the Schneefernerhaus

Fig 2: Views from the conference room

During the last week of April 2016 (24-27), an international group of 29 Earth Scientists convened at the beautiful "Schneefernerhaus" research center (http://www.schneefernerhaus.de/en/home.html) at the summit of the *Zugspitze*, the highest place in Germany, to discuss the growing role of *Information Theoretic* concepts in scientific investigations related to EES. The remote location provided the perfect opportunity for lengthy discussions, and also for an energetic and hard-fought *foosball/kicker* tournament that was, perhaps not unexpectedly, won by members of the German contingent.

The impetus to convene this workshop arose out of a series of recent AGU and EGU sessions titled "*On the Interface between Models and Data*", and "*Data & Models, Induction & Prediction, Information & Uncertainty: Towards a Common Framework for Model Building and Predictions in the Geosciences*", and the goal was to promote the innovative use of IT concepts in service of discovery, modeling and decision-making in EES. Designed around a

[1]KIT Karlsruhe Institute Of Technology, [2]University of Arizona, [3]NASA Goddard, [4]Arizona State University, [5]RWTH Aachen, [6]Helmholtz Center for Environmental Research – UFZ, [7]University of British Columbia, [8]Victoria University Wellington, [9]University of New South Wales

small number of targeted presentations, most of the workshop was devoted to moderated discussion and brainstorming, with a view to inspiring revolutionary advances in the theories of modeling/learning, inference, and diagnostic evaluation. Each participant also brought along a poster and gave a brief "*Speed Presentation*" on their current research ideas. The major topics of discussion were: What is IT and why should we care?, How can IT be used to inform the core questions in the Earth Sciences?, and How can IT help us understand the interface between models and data?

Fig 3: The foosball/kicker tournament

The targeted presentations used to stimulate the discussions included talks about:

- The relationships between IT and Physics (K Knuth), *Uncertainty* (M Branicki), and *Complexity* (S Weijs)
- The information content in *Data* (G Nearing), *Models* (W Gong), and *Networks* (B Ruddell)
- IT and the *Hydrological Sciences* (H Gupta), *Eco-Hydrological Modeling* (P Kumar and A Goodwell) and the use of *Entropy-based Metrics* to evaluate physical models (B Jackson)
- Applications of the *Maximum Entropy Approach* to EES modeling (J Wang)

Apart from the inspiring exchange of concepts and ideas, outcomes of the workshop included a jointly composed draft of a paper making the argument for why Earth System Scientists should embrace the Information Paradigm in their modeling, field work, and conceptualization of uncertainty. A follow-up workshop is in preparation.

The workshop was hosted by the ***Karlsruhe Institute of Technology*** and supported in part by the Deutsche Forschungsgemeinschaft DFG.

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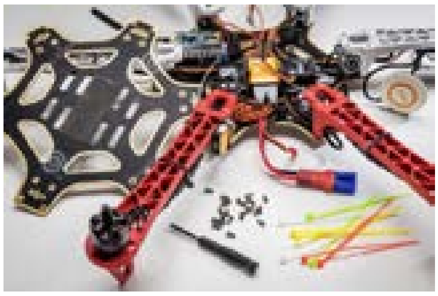
Fig 4: Workshop participants

The First UAS Hands on
Open-Format Training Session



Optimizing UAS equipment and data interpretation for environmental research applications through guided mentorship

Logistics
Dates: October 18-21, 2017; 09:00 - 17:00 daily
Location: Reno, NV
Cost: Free, first come, first served, with limit of 25 registrants each day.
Food and housing: students make arrangements.

Modality
Bring your ideas, your machines, your data, your problems. We will have a lab full of experts, hardware, software, and a place to test-fly your equipment. The CTEMPs staff and participants from across the country will help work through your issues and make sure that you find success in getting critical observational data from unmanned flying platforms. Lectures on RTK GPS, flight control systems/ mission planning, hardware specifications will be provided on an "as requested" basis. People can come or go as they need in the period of the Open Session, according to their schedules and needs.

Highlights
- Basic sUAS operations, technology progression, mission planning, and hiccups
- Selection and tuning of flight platforms, sensors, cross-validation, sensor-flight controller interfaces, and gimbal
- Post-processing, QA-QC of data collection, and rapid workflows for iterative experimental design
- Logistics and lessons learned on sUAS-delivered sensors for environmental research: from localization, quantification, to scaling processes.
- Site preparation (monument survey, optical reference targets, reference sensors)

Hands-on activities
- UAS remote sensing mission: Planning, imaging, and image processing from a half-day field data collection session
- sUAS and gimbal hardware (3-D printed components, tear down, rebuild, test)
- Sensor pre-calibration and verification.
- Flight planning with imager considerations (Mission Planner; Universal Ground Control Station)
- sUAS flying for mapping (weather permitting - a good reason to have this in Reno)
- Image stitching (visible, multispectral, thermal) and validation
- Development of DEM's based on structure from motion and LIDAR obtained from sUAS

Field data collection
Beginning on day two of the training, we will begin to plan for a UAS remote sensing image mission in a nearby area. On day three, we will visit the field site and collect imagery with a UAS. On day four, we will process and analyze the imagery. This applied field exercise should be very helpful for participants in understanding the requirementsand workflow of a UAS remote sensing operation.

Instructors: Scott Tyler, Henry Pai, Michael Wing, Jonathan Burnett, Marja Haagsma, Cara Walter, John Selker, and YOU!

Sponsors: The National Science Foundation Division of Earth Sciences Instrumentation
and Facilities Program, CTEMPs , Oregon State University ; University of Nevada Reno

Registration : To reserve a space, fill out online form:
https://goo.gl/forms/0aXD1df3MQSdRs4o2

Cost: This is a community-building, experimental participant-engaged event. CTEMPs will cover
all the on-site costs (coffee, BBQ-lunches, venue). Participants will make their own travel,
housing, breakfast, and dinner arrangements. Special consideration will be given to participants
who bring fun food etc. to share.

Accommodations, Travel, Parking: Self-organized

Fall Meeting venue: New Orleans Ernest N. Morial Convention Center, 900 Convention Center Blvd., New Orleans, Louisiana 70130

http://fallmeeting.agu.org/2017/

Abstract Deadlines

July 26 — Early Abstract Submissions

August 2 — Final Abstract Submissions

Credits for photos on this page: AGU Fall Meeting 2017 website (http://fallmeeting.agu.org/2017/)

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AGU FALL MEETING New Orleans | 11-15 December 2017

About the front cover photo

Pete Gadomski (US Army CRREL) conducts a terrestrial laser scan survey at the Swamp Angel Study Plot, Senator Beck Basin, CO during the 2017 SnowEx campaign, while Karl Rittger (NSIDC) and Ned Bair (UCSB) make field spectrometer measurements. The Swamp Angel energy balance tower, radar corner reflectors, and ski tracks from FMCW radar and manual snow depth transects are visible. Photo credits: Jeffrey Deems, National Snow and Ice Data Center, University of Colorado.

AGU Hydrology Section July 2017 Newsletter prepared and edited by Jaivime Evaristo