

## From the Section President

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(University of California Irvine)

### Passing the gavel: Thank you for your support and dedication to our section



On January 1, 2017 my term as the President of the Hydrology section comes to an end. It has been a true pleasure and honor to serve our membership -- two years passed rather quickly but a lot was accomplished.

The best part of the job was to get to know “the people” who make our section work – those behind the scenes at AGU, colleagues who dedicate their time to serve on technical and award committees, special session organizers who make the Fall meeting a rich experience, nominators and letter writers, students whose innovative engagement is inspiring, supporters, donors, critical eyes of our web site, and many more.

Special thanks go to our section secretary Terri Hogue who has worked tirelessly as chair of the OSPA committee and the Student Travel Grant committee to honor the excellent work of our young rising stars. Please read her article in this newsletter and volunteer to be an OSPA judge. Our FM program chair Bart Nijssen has done an excellent job in leading a meeting improvement initiative this year (see more below). Many thanks to our past-president Eric Wood who chaired the ad-hoc nominating committee over the past two years and who was always there to brainstorm ideas. Finally, many thanks to Anthony Longjas in my group who has graciously maintained our Hydrology web site and has been the editor of our Hydrology newsletter. Our section is in great hands with our incoming president Jeff McDonnell and our newly

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elected president-elect Scott Tyler and section secretary Charles Luce. I look forward to their leadership and I stand by to help during the transition period.

**2014-2016 accomplishments of our section:** I take pride that our section has led the establishment of the first mid-career award for hydrologists (the [Paul Witherspoon mid-career Lecture award](#), established in 2016) which bridges the gap between our Early Career HS award and the HS award. Please read the article of the inaugural awardee Paolo D’Odorico in this newsletter and plan to attend his lecture on Thursday December 15 at 11:20 am Moscone West 2022/2024.

Our young hydrologists thrive and lead AGU. They established the first [pre-AGU conference for students and early career scientists](#) (a concept adopted now

AGU-wide) and have introduced spirited and exciting new initiatives to enhance the experience of our students and early career members during the AGU meeting and beyond. Please read a summary in the article of the chair of the [Hydrologic Sciences Student Subcommittee \(H3S\)](#) Evan Kipnis in this newsletter.

I am honored to have launched a cross-generational science initiative for our community by creating a digital library of the publications of prominent hydrologists who defined our field (the [Virtual Hydrologists Project](#)), which is an ongoing project. Steve Burges has been instrumental in guiding AGU to locate and restore the 80's-90's recorded award lectures of our section, which are now available at the [Hydrology web site](#). Keith Beven has initiated a [History of Hydrology wiki](#), to which the community is asked to contribute.

As an elected member of the [Council Leadership Team](#) (meeting virtually once per month) I cherished the opportunity to look after and promote the interests of our members in policy setting and Union decisions.

**Beyond 2016:** In the years that follow, I see the following main challenges and opportunities for our Hydrology section: (1) as one of the largest sections of the Union we have the ability to influence AGU directions and initiatives and we should make sure our voice is heard -- from journal publisher decisions, to subsidizing student and section activities, to privacy issues, to corporate sponsorship; (2) we must take the time to nominate deserving colleagues, maintaining a strong pool of nominees, promoting excellence and building an even stronger, diverse and influential community (for your information I show below some interesting statistics on awards per age for AGU and our section); and (3) water issues are not going away – they are at the center of the 21<sup>st</sup> century environmental challenges and our section should strive to strengthen its reach both in fundamental and translational science at the international, multi-society, inter-governmental, and institutional levels.

I would recommend that our section re-institutes the *Hydrology Liaison* standing committee which is in our [bylaws](#) but has not been called to action for several years. This committee will bring together academia and agencies to discuss research trends and foster an open dialogue on actionable science.

**Thank you for your continuous financial support:** Our section depends on your contributions (even small)

to support events that build community and promote leadership in the young members of our section. I want to thank you for your generous support over the past year, which placed our budget in much better order than previous years (see budget in this newsletter). The Paul Witherspoon award fundraising committee has done an incredible job in just one year to raise funds to permanently establish and sustain this new award by creating a separate fund – the overwhelming contributions speak volumes for the friends and colleagues of Paul and their support for science and our AGU community.

This year, our students via the Hydrology Student Section Subcommittee (H3S) have proposed establishing a “watershed science-to-service activity” on the Saturday after the AGU meeting to increase the engagement of young hydrologists in lending their expertise to society-serving institutions (see the article of H3S in this newsletter for more details). The estimated cost of this activity is \$900, for the transportation of the students and an after-event discussion meeting, and this year it was my personal present to them for all the great things they do! Please [contribute](#) if you can and note that AGU offers some new incentives worth taking advantage of (see Table 1).

**Opportunities for Hydrology Students:** The Hydrology Section (HS) is looking for a new generation of student leaders to join technical committees and the student subcommittee (H3S). To find out more information about these opportunities visit the HS website (<http://hydrology.agu.org/student/>) or reach out to the 2017 Student Representative Niels Claes ([nclaes@uwyo.edu](mailto:nclaes@uwyo.edu)). To learn more about the activities and goals of the Hydrology Section student leadership join us in San Francisco on Wednesday, 12/14 at 6:45 PM in San Francisco Marriott Marquis Sierra E. Follow us on twitter (@AGU\_H3S) or reach out to Evan Kipnis ([evan.kipnis@utah.edu](mailto:evan.kipnis@utah.edu)) for more information on this meeting.

**Fall Meeting Highlights:** This year we tried a new model for proposing and merging special sessions and as a result we expect an enhanced Fall meeting experience with less “running around.” Please read the article of Bart Nijssen who explains how the process worked and reports that from the 165 sessions originally proposed we have consolidated the Hydrology program to 85 sessions to avoid fragmentation and keep most of us on the same floor or in the same room for longer periods of time.

Please plan to attend the “Awards and Langbein lecture” session on Tuesday December 13 at 10:20 am – 12:30 pm. All awardees will be honored: Gabriele Villarini for the James Macelwane award, Ciaran Harman for the Early Career Hydrologic Sciences award, Amilcare Porporato for the Hydrologic Sciences award, Paolo D’Odorico for the Paul Witherspoon Lecture award (please read their articles in this newsletter), and Tom Dunne for the Robert Horton Medal. Then the Langbein lecture will be delivered by James Kirchner. The Hydrology section Luncheon will follow the Langbein lecture (400 tickets sold out very quickly – sorry if you did not get one). Our students have volunteered to help monitor luncheon attendance and are committed to not let any unoccupied seat go to waste by allowing last minute entries up to capacity – *thank you Hydrology students!*

Finally, please honor and congratulate our awardees by attending the Honors ceremony on the evening of Wednesday Dec 14 at 6 pm (it is free for guests). Other highlights of the FM are given in the newsletter, including Union sessions, Townhall meetings, and the schedule of the Technical Committee meetings and the Executive Committee meeting.

**Read in this newsletter:** In our series “A Fellow speaks” please enjoy the articles of Mary Hill, Paolo D’Odorico, Martyn Clark, Mark Bierkens, Anthony Jakeman, and Gordon Grant. Also congratulate our students Horton Research Grant recipients – Katalyn Voss, Noah Jemison, and Hadley McIntosh – their pictures clearly show the spirited field work these grants support. Finally, please read the report of the WRR Editorial team (Alberto Montanari, EIC, and Editors Jean Bahr, Günter Blöschl, Ximing Cai, D. Scott Mackay, Anna Michalak, Harihar Rajaram, and Xavier Sanchez-Vila) – this is their last contribution to the newsletter as their term ends on March 31, 2017. I

take the opportunity to thank all and each one of them for the tremendous service they have done to our science and community in keeping WRR the best journal in the field.

***Celebrating David Dawdy’s 90<sup>th</sup> birthdate:*** There will be a reception, hosted at San Francisco State University on Monday Dec. 12 at 6 pm, in honor of David Dawdy’s distinguished career – please see details at the end of this newsletter and please join if you can. David began his career at the USGS surface water branch in 1951, working with Luna Leopold and Walter Langbein. He made fundamental contributions to hydrology, including in flood frequency analysis, characterizing resistance to flow in sand-bedded channels, and modeling urban surface runoff. He authored more than 100 papers (now posted in the [VHP](#) section of our Hydrology web site), and received numerous honors. Most importantly, David’s endless curiosity and enthusiasm for science is contagious and as strong as ever in his 90’s. *Happy birthday David!*

***Some interesting statistics:*** The median age of becoming a Fellow is 56 with a singular peak at age 35-36 (Fig. 1). Women are almost half (43%) of the membership under age 30 for both AGU and the Hydrology section but drop precipitously with age (19% at age 45-59) (Table 2). Our Hydrology Fellow statistics with age/gender lack behind compared to the AGU statistics but we are catching up in recent years (Table 3). Please keep the strong nominations coming.

Thank you for trusting me with our section and I hope I have contributed to its growth and success.

I look forward to seeing all of you in SF.

Efi  
President, Hydrology section of AGU

**Table 1.** AGU Section and Focus group incentive program for participation of \$50+ donors

| <i>Participation from primary affiliated members</i> | <i>Contribution from AGU to Section or Focus Group</i> |
|------------------------------------------------------|--------------------------------------------------------|
| 5%                                                   | \$1000                                                 |
| 7%                                                   | \$2000                                                 |
| 10%                                                  | \$3000                                                 |
| 12%                                                  | \$4000                                                 |
| 15% or greater                                       | \$5000                                                 |

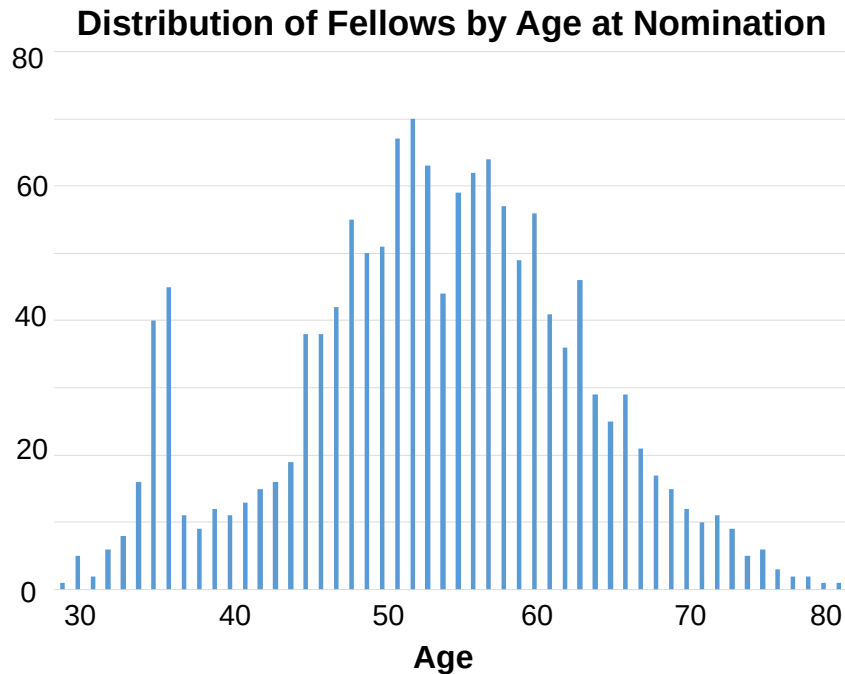


**Fig. 1.** The median age of nomination for AGU Fellows is 54. The distribution is almost Gaussian with a peculiar spike at the age of 35-36.

**Table 2.** Changing demographics: A snapshot of the age profile of 2016 members of AGU and those with Hydrology as primary affiliation. Almost half of the members under the age of 30 are women but drop to 17% (Hydrology) - 21% (AGU) by the age of 45-59.

#### Total AGU Membership for 2016

| Age Group    | Male         | Female       | No Data    | Total        |
|--------------|--------------|--------------|------------|--------------|
| Under 30     | 6440         | 5198         | 89         | 11727        |
| 30-44        | 13462        | 6920         | 169        | 20551        |
| 45-59        | 10792        | 2968         | 83         | 13843        |
| 60-74        | 7274         | 1045         | 44         | 8363         |
| 75+          | 2200         | 97           | 9          | 2306         |
| No Data      | 1393         | 958          | 397        | 2748         |
| <b>Total</b> | <b>41561</b> | <b>17186</b> | <b>791</b> | <b>59538</b> |

| Percentage of Females |
|-----------------------|
| 44%                   |
| 34%                   |
| 21%                   |
| 12%                   |
| 4%                    |
| 35%                   |
| <b>29%</b>            |

#### Total Hydrology Membership for 2016

| Age Group    | Male        | Female      | No Data   | Total       |
|--------------|-------------|-------------|-----------|-------------|
| Under 30     | 759         | 576         | 4         | 1339        |
| 30-44        | 1819        | 681         | 24        | 2524        |
| 45-59        | 1278        | 263         | 8         | 1549        |
| 60-74        | 776         | 77          | 6         | 859         |
| 75+          | 233         | 7           | 3         | 243         |
| No Data      | 156         | 79          | 10        | 245         |
| <b>Total</b> | <b>5021</b> | <b>1683</b> | <b>55</b> | <b>6759</b> |

| Percentage of Females |
|-----------------------|
| 43%                   |
| 27%                   |
| 17%                   |
| 9%                    |
| 3%                    |
| 32%                   |
| <b>25%</b>            |

**Table 3.** Statistics of female fellows in Hydrology and especially at younger age are lacking behind those of AGU, but we are doing much better in recent years. For 2015-2016 the statistics (not shown here) are: 99 Fellows (23 women) in AGU and 13 Fellows (3 women) in Hydrology, same ratio of 19%.

### All Fellows

| Age Group    | Male Fellows | Female Fellows | No Data  | Total       | Percentage of Female Fellows |
|--------------|--------------|----------------|----------|-------------|------------------------------|
| Under 30     | 0            | 0              | 0        | 0           | 0%                           |
| 30-44        | 19           | 12             | 1        | 32          | 38%                          |
| 45-59        | 219          | 60             | 0        | 279         | 22%                          |
| 60-74        | 640          | 85             | 3        | 728         | 12%                          |
| 75+          | 376          | 9              | 0        | 385         | 2%                           |
| No Data      | 13           | 1              | 4        | 18          | 6%                           |
| <b>Total</b> | <b>1267</b>  | <b>167</b>     | <b>8</b> | <b>1442</b> | <b>12%</b>                   |

### Fellows with Hydrology as primary section (All years)

| Age Group    | Male Fellows | Female Fellows | No Data  | Total      | Percentage of Female Fellows |
|--------------|--------------|----------------|----------|------------|------------------------------|
| Under 30     | 0            | 0              | 0        | 0          | 0%                           |
| 30-44        | 1            | 0              | 1        | 2          | 0%                           |
| 45-59        | 33           | 5              | 0        | 38         | 13%                          |
| 60-74        | 65           | 5              | 0        | 70         | 7%                           |
| 75+          | 32           | 1              | 0        | 33         | 3%                           |
| No Data      | 1            | 0              | 0        | 1          | 0%                           |
| <b>Total</b> | <b>132</b>   | <b>11</b>      | <b>1</b> | <b>144</b> | <b>8%</b>                    |

### Hydrology Section Budget (1/15 to 12/16)

|                                                                              | <i>Actuals</i><br>1/15-12/15 | <i>Actuals</i><br>1/16-10/16 | <i>Projected</i><br>11/16 – 12/16 |
|------------------------------------------------------------------------------|------------------------------|------------------------------|-----------------------------------|
| <b>Revenue</b>                                                               |                              |                              |                                   |
| Donations                                                                    | \$20,092                     | \$6,437                      | \$14,902                          |
| Sponsorship                                                                  | 0                            | \$0                          | \$0                               |
| <b>Total Revenue</b>                                                         | <b>\$20,092</b>              | <b>\$6,437</b>               | <b>\$14,902</b>                   |
| <b>Expenses</b>                                                              |                              |                              |                                   |
| Support for CUAHSI reception                                                 | \$500                        | \$0                          | \$0                               |
| Hydrology Business Luncheon (including expenses related to section awardees) | \$31,056                     | \$0                          | \$29,484                          |
| Ticketed Events                                                              | (\$4,700)                    | \$0                          | (\$6,500)                         |
| AGU Subsidies of Hydrology Luncheon                                          | (\$20,000)                   | \$0                          | (\$20,000)                        |
| FM Travel Awards                                                             | \$2,470                      | \$0                          | \$2,500                           |
| OSPA winners                                                                 | \$3,000                      | \$0                          | \$3,000                           |
| Favorable Expense Correction                                                 | (\$150)                      | \$0                          | \$0                               |
| <b>Total Expenses</b>                                                        | <b>\$12,176</b>              | <b>\$0</b>                   | <b>\$8,484</b>                    |
| <b>Net Revenue (Deficit)</b>                                                 | <b>\$7,916</b>               | <b>\$6,437</b>               | <b>\$6,418</b>                    |

| <b>Fall Meeting Highlights</b>  |                         |                                                                      |                                           |
|---------------------------------|-------------------------|----------------------------------------------------------------------|-------------------------------------------|
| <b>Hydrology Section Events</b> |                         |                                                                      |                                           |
| <b>Date</b>                     | <b>Time</b>             | <b>Event/Function</b>                                                | <b>Location</b>                           |
| Sunday<br>Dec. 11               | 8:00 A.M. – 6:00 P.M.   | Student and Early Career Scientist Conference                        | San Francisco Marriott Marquis Salon 9    |
| Monday<br>Dec. 12               | 4:00 – 6:00 P.M.        | Social Dimensions of Geoscience Pop-Up Session                       | Moscone West 2001A                        |
| Tuesday<br>Dec. 13              | 10:20 A.M. – 12:20 P.M. | <b>H22A: Hydrology Section Awards and Walter B. Langbein Lecture</b> | Moscone West 2022–2024                    |
| Tuesday<br>Dec. 13              | 12:30 – 1:30 P.M.       | <b>Hydrology Section Business Meeting and Luncheon</b>               | San Francisco Marriott Marquis, Salon 7   |
| Tuesday<br>Dec. 13              | 4:00 – 6:00 P.M.        | Water Sciences Pop-Up Session                                        | Moscone West 2001A                        |
| Wednesday<br>Dec. 14            | 7:00 – 9:00 P.M.        | CUAHSI Water Science Mixer                                           | Jillian's at the Metreon, San Francisco   |
| Wednesday<br>Dec. 14            | 6:00 – 8:00 P.M.        | AGU Honors Ceremony                                                  | Moscone North Hall E                      |
| Wednesday<br>Dec. 14            | 8:30 – 11:55 P.M.       | AGU Honors Banquet                                                   | San Francisco Marriott Marquis, Salon 7-9 |
| Thursday<br>Dec. 15             | 11:20 A.M. – 12:20 P.M. | <b>H42H: The Paul A. Witherspoon Midcareer Lecture</b>               | Moscone West 2022–2024                    |
| Saturday<br>Dec. 17             | 7:00 A.M.–2:00 P.M.     | H3S Watershed Monitoring Service Event                               | Palo Alto, California                     |

| <b>Hydrology Section Meetings (Executive, Technical Committees, Student)</b> |                   |                                                                              |                                          |
|------------------------------------------------------------------------------|-------------------|------------------------------------------------------------------------------|------------------------------------------|
| Monday<br>Dec. 12                                                            | 6:45 – 7:45 A.M.  | Biogeosciences/Hydrology-Soil Systems and Critical Zone Processes TC Meeting | San Francisco Marriott Marquis, Salon 4  |
| Monday<br>Dec. 12                                                            | 6:45 – 7:45 A.M.  | Hydrology-Hydrogeophysics TC Meeting                                         | San Francisco Marriott Marquis, Salon 10 |
| Monday<br>Dec. 12                                                            | 6:45 – 7:45 A.M.  | Hydrology-Ground Water TC Meeting                                            | San Francisco Marriott Marquis, Salon 2  |
| Monday<br>Dec. 12                                                            | 6:45 – 7:45 A.M.  | Hydrology-Ecohydrology TC Meeting                                            | San Francisco Marriott Marquis, Salon 3  |
| Monday<br>Dec. 12                                                            | 6:45 – 7:45 A.M.  | Hydrology-Large-Scale Field Experimentation TC Meeting                       | San Francisco Marriott Marquis, Salon 11 |
| Monday<br>Dec. 12                                                            | 6:45 – 7:45 A.M.  | Hydrology-Remote Sensing TC Meeting                                          | San Francisco Marriott Marquis, Salon 13 |
| Monday<br>Dec. 12                                                            | 12:30 – 1:30 P.M. | Hydrology/Societal Impacts and Policy Sciences-Water and Society TC Meeting  | San Francisco Marriott Marquis, Salon 10 |
| Monday<br>Dec. 12                                                            | 12:30 – 1:30 P.M. | Hydrology - Hydrological Uncertainty TC Meeting                              | San Francisco Marriott Marquis, Salon 13 |
| Tuesday<br>Dec. 13                                                           | 6:45 – 7:45 A.M.  | Hydrology-Precipitation TC Meeting                                           | San Francisco Marriott Marquis, Salon 10 |
| Tuesday<br>Dec. 13                                                           | 6:45 – 7:45 A.M.  | Hydrology-Surface Water TC Meeting                                           | San Francisco Marriott Marquis, Salon 11 |
| Tuesday<br>Dec. 13                                                           | 6:45 – 7:45 A.M.  | Hydrology-Unsaturated Zone TC Meeting                                        | San Francisco Marriott Marquis, Salon 12 |
| Tuesday<br>Dec. 13                                                           | 6:45 – 7:45 A.M.  | Hydrology-Water Quality TC Meeting                                           | San Francisco Marriott Marquis, Salon 2  |
| Wednesday<br>Dec. 14                                                         | 6:45 – 7:45 A.M.  | Hydrology Technical Committee Chairs Meeting                                 | San Francisco Marriott Marquis, Salon 11 |
| Wednesday<br>Dec. 14                                                         | 9:00 – 10:00 A.M. | Hydrology Section Finances Meeting                                           | San Francisco Marriott Marquis, Sierra G |
| Wednesday<br>Dec. 14                                                         | 12:30 – 1:30 P.M. | Hydrology Section Executive Committee Meeting                                | San Francisco Marriott Marquis, Salon 6  |

|                      |                  |                                                         |                                             |
|----------------------|------------------|---------------------------------------------------------|---------------------------------------------|
| Wednesday<br>Dec. 14 | 6:45 – 7:45 P.M. | Hydrology Section Student Subcommittee<br>(H3S) Meeting | San Francisco Marriott<br>Marquis, Sierra E |
|----------------------|------------------|---------------------------------------------------------|---------------------------------------------|

### Union Lectures of Interest

|                      |                            |                                                                                                                                          |                           |
|----------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Monday<br>Dec. 12    | 10:20A.M. – 12:20<br>P.M.  | U12A Observing Earth's Water from Space:<br>Scientific Opportunities and<br>Societal Applications                                        | Moscone West<br>2022/2024 |
| Monday<br>Dec. 12    | 12:30 – 1:15 P.M.          | <b>AGU Presidential Forum: H.S.H. Prince<br/>Albert II of Monaco</b>                                                                     | Moscone North Hall E      |
| Monday<br>Dec. 12    | 1:40 – 3:40 P.M.           | U13A Earth's Future: The Food-Water-Energy<br>Nexus                                                                                      | Moscone West<br>2022/2024 |
| Wednesday<br>Dec. 14 | 10:20–12:20 P.M.           | U32A Collaborative Research Infrastructures to<br>Support Current and Future Global Challenges<br>in Earth and Space Sciences            | Moscone West 2020         |
| Thursday<br>Dec. 15  | 10:20 A.M. – 12:20<br>P.M. | U42A Integration of Climate, Hydrology, Social<br>Science, and Water Management: Connecting<br>Hydroclimate Models with Stakeholder Need | Moscone South 102         |
| Thursday<br>Dec. 15  | 12:30–1:30 P.M.            | <b>Union Agency Lecture: Marcia McNutt<br/>(Geophysicist and the 22<sup>nd</sup> President of the<br/>National Academy of Sciences)</b>  | Moscone North Hall E      |
| Friday<br>Dec. 16    | 1:40–3:40 P.M.             | U53A The Critical Zone: Revealing the<br>Structure, Function, and Evolution of<br>Earth's Living Skin                                    | Moscone South 102         |

### Town Hall Meetings of interest to Hydrology Section Members

|                      |                   |                                                                                                                                                                                     |                           |
|----------------------|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|
| Monday<br>Dec. 12    | 12:30 – 1:30 P.M. | TH13F NASA SnowEx - Enhancing new<br>sensing technologies to retrieve snow<br>water equivalent in forested and other lands                                                          | Moscone West 2002         |
| Monday<br>Dec. 12    | 6:15 – 7:15 P.M.  | TH15B Kickoff Conversation on the Importance<br>of Data in the Earth and Space Sciences: A<br>Conversation with Rebecca Moore, Director of<br>Google Earth, Earth Engine & Outreach | Moscone West<br>2022/2024 |
| Monday<br>Dec. 12    | 6:15 – 7:15 P.M.  | TH15D NASA Earth Science Division Town<br>Hall                                                                                                                                      | Moscone West 2016         |
| Tuesday<br>Dec. 13   | 12:30 – 1:30 P.M. | TH23A AGU Data Fair: Data Skills<br>Recommended for Researchers and Scientists                                                                                                      | Moscone West 2002         |
| Tuesday<br>Dec. 13   | 12:30 – 1:30 P.M. | TH23D Critical Zone Observatories: Platforms<br>for Collaborative Science                                                                                                           | Moscone West 2003         |
| Tuesday<br>Dec. 13   | 12:30 – 1:30 P.M. | TH23E Future Earth – Research Agenda and<br>Opportunities for Global Sustainability                                                                                                 | Moscone West 2020         |
| Tuesday<br>Dec. 13   | 12:30 – 1:30 P.M. | TH23G NASA Sea Level Change Team Town<br>Hall                                                                                                                                       | Moscone West 2018         |
| Tuesday<br>Dec. 13   | 12:30 – 1:30 P.M. | TH23L Study Update: ESAS 2017, The 2017-<br>2027 Decadal Survey for Earth Science and<br>Applications from Space                                                                    | Moscone West 2007         |
| Tuesday<br>Dec. 13   | 6:15 – 7:15 P.M.  | TH25A Advancing Global Water Sustainability                                                                                                                                         | Moscone West 2003         |
| Tuesday<br>Dec. 13   | 6:15 – 7:15 P.M.  | TH25D Latest News on NSF Geosciences                                                                                                                                                | Moscone West 2011         |
| Tuesday<br>Dec. 13   | 6:15 – 7:15 P.M.  | TH25H The European Research<br>Council: Attractive Funding Opportunities<br>for Individual Scientists                                                                               | Moscone West 2005         |
| Wednesday<br>Dec. 14 | 12:30 – 1:30 P.M. | TH33A AGU Data Fair: Data Management Plan<br>Development and Management Best Practices                                                                                              | Moscone West 2003         |
| Wednesday<br>Dec. 14 | 12:30 – 1:30 P.M. | TH33B EarthScope Science and Synthesis                                                                                                                                              | Moscone West 2007         |

|                      |                   |                                                                                                                   |                   |
|----------------------|-------------------|-------------------------------------------------------------------------------------------------------------------|-------------------|
| Wednesday<br>Dec. 14 | 12:30 – 1:30 P.M. | TH33D Earthcube: A Community-Driven<br>Cyberinfrastructure for the Geosciences                                    | Moscone West 2002 |
| Wednesday<br>Dec. 14 | 12:30 – 1:30 P.M. | TH33I U.S. Group on Earth Observations<br>(USGEO) Town Hall                                                       | Moscone West 2006 |
| Thursday<br>Dec. 15  | 12:30 – 1:30 P.M. | TH43A AGU Data Fair: Research<br>Reproducibility Techniques                                                       | Moscone West 2009 |
| Thursday<br>Dec. 15  | 12:30 – 1:30 P.M. | TH43B Atmospheric Rivers - A Discussion of<br>the Definition Under Development for<br>the Glossary of Meteorology | Moscone West 2016 |
| Thursday<br>Dec. 15  | 12:30 – 1:30 P.M. | TH43H The AmeriFlux Network: Celebrating<br>Its 20th Anniversary                                                  | Moscone West 2004 |
| Thursday<br>Dec. 15  | 6:15 – 7:15 P.M.  | TH45A Awards & Grants Advancing Your<br>Early Earth Science Career: Multi-<br>agency Perspectives                 | Moscone West 2020 |
| Thursday<br>Dec. 15  | 6:15 – 7:15 P.M.  | TH45D GeoPolicy Connect - A New Initiative<br>to Bridge the Science and Policy Divide                             | Moscone West 2011 |

## From the Section President-Elect

*Jeff McDonnell, University of Saskatchewan*



I would like to start my newsletter remarks by thanking Efi Foufoula-Georgiou for her leadership and tremendous service to the section these past two years. She has worked tirelessly to represent the Hydrology Section (HS) and led several new initiatives, including the Paul A. Witherspoon Mid-

career Lecture in Hydrologic Sciences. Hers will be difficult shoes for me to fill.

Time races on and the AGU Fall meeting is almost upon us. My last act as President-Elect is chairing the search for new Editor-in-Chief of Water Resources Research (WRR). My committee is comprised of Marc Parlange, Hoshin Gupta, Fu-Chun Wu, Alberto Bellin, Doerthe Tetzlaff and Ciaran Harman. We've received several applications for the post and we will be conducting "interviews" in the coming weeks. We're very happy with the slate of candidates and hope to announce the new Editor-in-Chief in early 2017. Of course, we owe a huge thanks to Alberto Montanari, outgoing Editor-in-Chief WRR for his leadership and outstanding guidance of the journal. The many new innovations he has developed including the ongoing "Debates Articles" and "50<sup>th</sup> Anniversary Issue" will be a lastly legacy of his period of leadership. I'd also like to his team of Editors, Jean Bahr, Günter Blöschl,

Ximing Cai, D. Scott Mackay, Anna Michalak, Harihar Rajaram, and Xavier Sanchez for their hard work and exemplary service.

When I take over as President of the section January 1<sup>st</sup>, my transition team will include Scott Tyler as President Elect and Charlie Luce as Secretary. My plan is to formalize things further within the section and host a quarterly Executive Committee meeting via WebEx. Our current once-per-year formal meetings of the Executive Committee during the Fall meeting seems now unworkable with so much going on. In addition, I hope to hold quarterly meetings with the Technical Committee (TC) Chairs so that we can tackle the many items of business leading up to the 2017 Fall meeting in New Orleans. Our section is one of the few within AGU with such a TC structure. I hope to further exploit this structure and to continue to follow-up on the recent Task Force findings aimed at Fall meeting improvements. My goal is to further engage the TC Chairs with the Program Committee Chair in helping to define and curate sessions for Fall 2017 and beyond.

We will be living in interesting times (!) these next two years as we take the AGU Fall meeting 'on the road'. I hope that we can all embrace this opportunity to try out new things during these next two Fall meetings: new ways of socializing, new types of sessions, new ways of developing and curating sessions within the TCs, etc. One item that I'm keen to push forward, from the bully pulpit of my HS President role, is the recognition

of ‘fieldwork’ in our section. Fieldwork activities continue to decline throughout our discipline and this desperately needs attention and recognition. I’ll be setting up a new task force to explore how to counter this decline. I hope that we can recognize fieldwork, especially among our HS graduate students, post docs and early career scientists. I am also reaching out on this topic to WRR and to the Presidents of the EGU Hydrology Section and IAHS. I’ll have more to report on this in the next newsletter.

Lastly, a word on volunteering within the Hydrology section. Our bylaws state that “the (Section) President

shall appoint members to Section committees and task groups whose terms coincide with the biennial term of the President”. I am now populating these committees for 2017. If called upon to serve, I hope you will do so. For those new to the section, note that becoming involved with a TC is a great way to become involved beyond just attending the Fall meeting. Please see our committee information at <http://hydrology.agu.org/committees/>.

I look forward to suggestions by the membership. If you have ideas, please feel free to contact me ([Jeffrey.McDonnell@usask.ca](mailto:Jeffrey.McDonnell@usask.ca)).

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## From the Section Secretary

*Terri Hogue, Colorado School of Mines (Hydrology Section Secretary)*



The Hydrology Section Outstanding Student Paper Awards (OSPA) committee is working on our fall meeting charge of assuring all of the participating students in our section are judged. This year we have 428 presentations, resulting in the need for 1284 judging slots or assessments by our attending members. As of this newsletter we are behind in our goals of securing judges prior to the start of the meeting – we had just under 30% of these slots filled with over 900 remaining! All liaisons should have been notified and we have also emailed all potential judges to ask for help. If you are attending the fall meeting, please sign up to judge and provide feedback to our hydrology section students. In addition to your numerical scores, winning students must also have outstanding comments specific to their presentation. Your comments are weighed heavily, so please add some remarks reflective of your scores and what stood out during your review of the presentation. Our OSPA team has two new members this year – Alicia Kinoshita (San Diego State University) and Rolf Hut (TU Delft) – who have joined Kolja Rotzoll (USGS) and myself (who serves as chair) to steer the OSPA this last year. If you see them at the fall meeting this year – please thank them for taking on this time-consuming and important task.

As the fall meeting expands, the Hydrology Section Fall Planning Committee’s workload grows. As section secretary, I worked with Bart, Casey and Megan to

help organize the fall meeting last September in Washington, DC. Our virtual program is also growing and improving; please encourage colleagues and students to access the online virtual program: AGU On-Demand (<http://fallmeeting.agu.org/2016/virtual-options>). This year’s channels include Union, Climate, Geohealth, Earth Processes, Science & Society, Planetary Discovery, Extreme Events & Hazards, and Data & Emerging Technologies.

We will use the technical chairs and executive committee meetings in San Francisco to discuss the fall meeting planning process and other items within the committees. If you have suggestions or feedback, please get in touch with your technical committee chairs, the fall program committee or the executive leadership team (<http://hydrology.agu.org>). As always, it is not a simple job organizing hundreds of presentations with significant space constraints and fast turnaround times.

I will soon be turning over the reins into the very capable hands of Charlie Luce who will serve as your new Hydrology Section Secretary. As I depart I want to say thank you to Laurel Saito, Newsha Ajami, Tara Troy and Kolja Rotzoll for their commitment to the Hydrology OSPA committee and to our students – it has been a pleasure working with you the last four years. It has also been my privilege to work with the outstanding and dedicated hydrology section leadership, including Efi, Eric and Jeff. Finally, thanks for all you do as members and helping ensure that the annual fall meeting and the section’s OSPA continue to be successful.

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## Fall Meeting Updates

*Bart Nijssen, University of Washington (Hydrology Section Fall Meeting Committee Chair)*



The 2016 AGU Fall Meeting is right around the corner and it promises once again to be an excellent meeting. To provide some numbers: Hydrology has about the same number of abstracts as last year. We have nearly 2800 abstracts in 85 individual sessions. As mentioned in the June newsletter, about two-thirds of the presentations are posters (just over 1900). Following abstract submission, the AGU allocated just over 110 2-hour oral blocks to Hydrology. To ensure that most sessions would have at least one oral block, the Hydrology Section Fall Meeting Committee worked hard with the Technical Committees and the session conveners to reduce the overall number of sessions. The original number of proposed sessions was 165, which was reduced to 119 before abstract submission opened and further reduced to 85 after abstract submission closed. The result is that we have fewer poster-only sessions this year. A few of these sessions stated a preference for poster-only, while the remainder did not meet the minimum number of abstracts for an oral allocation and was not able to find a merge partner.

While I understand that the merge process can be difficult and frustrating at times, it results in a stronger program for meeting attendees and is the best way to accommodate the fact that we have far more session proposals than oral blocks. Consequently, this merger process will be required in the coming years as well. Given the success of entraining the Technical Committees in the merger process, it is likely that they will play a similar role in upcoming meetings.

One consequence of having fewer but larger sessions is that we had to schedule the poster block (4 hours) and oral block (2 hours) for some sessions during the same day segment (morning or afternoon). We tried, to the extent possible, to schedule oral and poster sessions on the same day and to have poster blocks follow the first oral block, so that session conveners can advertise their poster blocks. If you are a session convener for a session for which there is a partial overlap between an oral block and the poster block, I strongly recommend that you contact your poster presenters and ask them to be present at their posters during the 2-hour period that does not overlap with the oral block. Similarly, if you

are a poster presenter for a poster block that partly overlaps with an oral block, please be present at your poster during the non-overlapping 2-hour period. As is customary at the AGU Fall Meeting, posters should still be hung early in the morning and will remain for the entire day.

The Hydrology Awards and Walter B. Langbein Lecture will be held on Tuesday from 10:20AM to 12:20PM in Moscone West 2022/2024. This year's Walter B. Langbein Lecture will be given by James W. Kirchner with the topic "Exploring landscapes and ecosystems by studying their streams". The inaugural Paul A. Witherspoon Midcareer Lecture Award in Hydrologic Sciences will be presented on Thursday from 11:20AM to 12:20PM also in Moscone West 2022/2024. The lecture will be given by Paolo D'Odorico and is entitled "Drivers and effects of virtual water cycling".

The Hydrology Section Business Meeting and Luncheon will be held in the San Francisco Marriott Marquis - Salon 7 on Tuesday from 12:30PM to 13:30PM (ticket required). The AGU Honors Ceremony is on Wednesday from 6PM to 8PM in Moscone North – Hall E (open to all), followed by the Honors Banquet in San Francisco Marriott Marquis - Salons 7-9 at 8:30PM (ticket required). These events provide an opportunity to network with your hydrology colleagues and to celebrate the newly elected Fellows and other prize recipients and medalists.

As you are probably already aware, changes are afoot for the AGU Fall Meeting for the next few years. Perhaps the biggest change for the Fall Meeting will be a temporary relocation in 2017 and 2018. After nearly 50 years in San Francisco, the meeting will move to New Orleans in 2017 and Washington DC in 2018 to accommodate renovation plans in the Moscone Center. The meeting will return to an expanded Moscone Center in 2019, just in time to celebrate AGU's Centennial. These moves will also make it easier to try some other innovations in the meeting organization, but that will be for the next Hydrology Section Fall Meeting Committee. My tenure on the committee ends with this year's Fall Meeting and Casey Brown will chair the committee in 2017. It has been my pleasure to participate in meeting organization these past three years and I look forward to seeing you in San Francisco this December.

## Hydrology Section Student Subcommittee (H3S)

*Evan Kipnis, University of Utah (Chair)*



The 2016 Hydrology Section Student Subcommittee (H3S) has been hard at work to expand programs for AGU student members at the Fall Meeting and beyond. Partnering with Hydrology Section leadership and AGU staff we have made opportunities available that include building professional and scientific skill sets, addressing issues within or related to research, and networking with expert scientists! Below is a short list of events to look forward to in December.

- AGU Student and Early Career Conference (SECC)** - For the third year in a row the SECC has SOLD OUT! This conference all day Sunday, 12/11, focuses on concepts important to scientists earlier in their career and includes two tracks-- professional development and interdisciplinary science. Sessions to look forward to include a sharing science activity, the Food-Water-Energy Nexus panel discussion, and a keynote lecture from David Harwell, Assistant Director of Talent Pool at AGU. To learn more about the SECC check out the website: <http://fallmeeting.agu.org/2016/students/events/student-early-career-scientist-conference>
- Pop - Up Talks** - For four years the students of the Hydrology Section have organized short-format talks. Students and experts alike can share information on a scientific topic that excite and inspire AGU membership at all stages of their careers. Please join us once again for the Social Dimensions of Geosciences on Monday, 12/12 and the Water Science Pop-Ups on Tuesday, 12/13, from 4 - 6 pm in Moscone West 2001A. For more information on this year's speakers please visit this website: <http://fallmeeting.agu.org/2016/students/events/pop-up-talks/>
- Hydrologist Bingo** - Don't miss the opportunity to engage expert hydrologists in conversation! Experienced members of the Hydrology Section

have volunteered to interact with students throughout the Fall Meeting. Further, prizes will be available to participating student members. Bingo cards can be picked up at the SECC, Pop-Up Talks, the Hydrology Section business luncheon, and the CUAHSI evening mixer. Reach out to Harsh Beria ([harsh.beria93@gmail.com](mailto:harsh.beria93@gmail.com)) with questions concerning this event.

- Watershed Monitoring Service Event** - H3S is proud to be partnering with Grassroots Ecology for a service event in Palo Alto, CA on Saturday, 12/17 following the completion of the Fall Meeting. This half day event will connect members with non-profit monitoring and data collection occurring locally in the Bay Area. Roundtrip transportation from San Francisco and lunch will both be provided. For more information please check out the sign-up page at: <https://goo.gl/forms/UGBT0ZTPcRzGVyH3>

### Call for Student Leaders

The Hydrology Section is looking for a new generation of student leaders for a continued legacy of excellence within the Union. H3S aims to represent all AGU Hydrology Section early career members and we encourage all to apply for a committee position. Calls will be going out in December for new students members of each technical committee, as well as H3S. To submit an application or for more information, reference the H3S webpage (<http://hydrology.agu.org/student/>) or contact the 2017 Hydrology Section Student Representative Niels Claes ([nclaes@uwoyo.edu](mailto:nclaes@uwoyo.edu)).

H3S is looking forward this year's Fall Meeting program and we encourage you to seek us out. We will be holding a meeting for any members to come discuss student activities and goals with us on the morning of Wednesday, 12/14 at 6:45 PM in San Francisco Marriott Marquis Sierra E. Follow us on twitter (@AGU\_H3S) or reach out to Evan Kipnis ([evan.kipnis@utah.edu](mailto:evan.kipnis@utah.edu)) for more information on this morning meeting.

We look forward to meeting many of you this year in San Francisco!

## Towards a new era for Water Resources Research

Alberto Montanari (Editor in Chief), Jean Bahr, Günter Blöschl, Ximing Cai, D. Scott Mackay, Anna Michalak, Harihar Rajaram, and Xavier Sanchez-Vila (Editors)



The Italian actor Pino Caruso (born 1934) once said that, “Time flows slowly with an impressive speed.” Indeed, when looking back at the period since April 1<sup>st</sup> 2013, when our term as Editors of Water Resources Research started, time has slipped by amazingly quickly. Our term will end on March 31<sup>st</sup>, 2017,

and so this is our last contribution to the newsletter of the Hydrology Section.

This has been a busy period for us and there was probably not a single day without accessing the WRR web site. The statistics say that we assessed about 5.500 submissions, which means that we interacted with more than 10.000 authors and even more reviewers. About 2200 manuscripts were ultimately published, and these have already garnered 12600 ISI citations. Figure 1 shows the number of submissions and publications by article type from April 1<sup>st</sup>, 2013 to November 18, 2016 (we aggregated some categories for clarity). The vast majority of manuscripts are research articles and technical notes, as expected, but 27 review articles were also published.

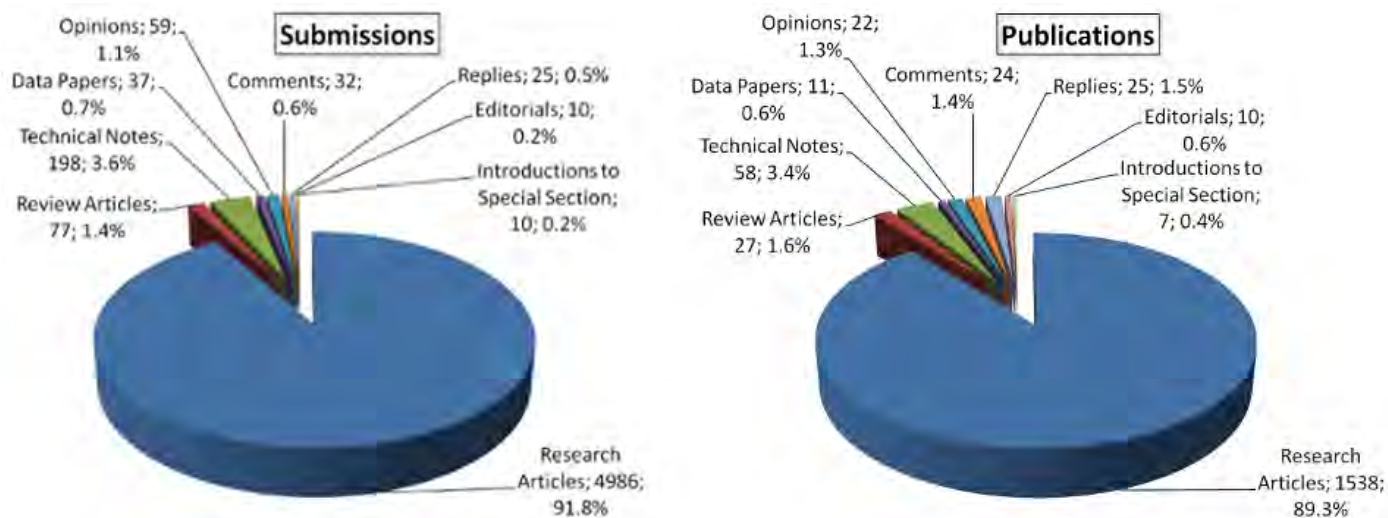


**Figure 1.** Distribution over article types of WRR submissions (left) and publications (right) from April 1<sup>st</sup>, 2013 to November 18, 2016.

We also received 32 comments, 24 of which were published. During our term we promoted 17 special sections, some of which are still open for submission.

The most significant editorial effort we undertook was the special section dedicated to the 50<sup>th</sup> Anniversary of Water Resources Research, entitled “*Legacy and perspectives for the science of hydrology*”. It includes a total of 57 papers, divided into three chapters and 8 subjects, and totals more than 1200 pages! These papers have already received 365 ISI citations. They provide an excellent summary of the past 5 decades of

research in hydrology, and give exciting perspectives for the future. In our opinion, the 50<sup>th</sup> Anniversary special section is a valuable reference for young students, which further strengthens the role of WRR for modern hydrology.

During our term we introduced the series of Debates on Water Resources, a WRR forum that discusses timely, contentious issues within the international research community. Three debates have been published: “*The future of hydrological sciences: A (common) path forward?*”, “*Perspectives on Socio-Hydrology*”, and “*Stochastic Subsurface Hydrology from Theory to*

Practice”. One more debate is under way: “*Hypothesis testing in Hydrology*”. We found the contrasting views of the debaters, and the mutual responses, extremely insightful and are therefore convinced that the Debates will stimulate the synthesis of research and thus foster progresses.

We believe that an important contribution provided by WRR during our term was also given by two joint

editorials: “*On the future of journal publications in hydrology*” (Blöschl et al., 2014) and “*Fostering innovation and improving impact assessment for journal publications in hydrology*” (Koutsoyiannis et al., 2016). These editorials were jointly published by a number of major hydrology journals. Since they address future perspectives and issues of scientific publishing in general, they have gained significant visibility in other disciplines as well.



**Figure 2.** Average time from submission to the first decision for WRR manuscripts submitted from April 1<sup>st</sup>, 2013 to November 18, 2016, for different article types. Statistics include papers for which a decision was reached without review.

Finally, during our term WRR introduced the article type “Commentary”, to substitute the “Opinion paper”. The commentary is more than an opportunity to present a scientific opinion: in fact, it aims to stimulate the publication of personal views on concepts and results presented by WRR papers. WRR reviewers are stimulated to write commentaries on the papers they assessed, in order to provide an additional opportunity for discussion.

An interesting question is whether we noticed any trends in the WRR contributions during our term, but this is difficult to say since our term was short as compared with the time scale of research innovation. To get a longer term perspective, it is interesting to

compare the two anniversary special sections published so far in WRR, namely, the above mentioned “*Legacy and perspectives for the science of hydrology*”, and “*Trends and Directions in Hydrology*”, that was edited by Steven Burges in 1986 to celebrate the 20<sup>th</sup> anniversary of the journal (Burges, 1986). The differences in the main focus, perspectives and writing style are striking. In particular, **the traditional break-up of hydrology into sub-disciplines, each focusing on separate components of the water cycle, has given way to a more interconnected, interdisciplinary research on a wide range of spatial and temporal scales, and interactions between water, society, earth and biological systems. These trends are confirmed by what we observed during our term. There is an increasing interest in large**

**spatial and temporal scales, interdisciplinarity, links and feedbacks. The number of submissions dealing with water economics, virtual water trade, coupling of different modeling techniques and philosophies is clearly increasing, and international cooperation is increasing as well. The future is headed towards teamwork, which is consistent with the increasing need for sustainably managing research infrastructures. More details on emerging trends are given by Rajaram et al. (2015).**

During our service we could count on the excellent and prompt support of the AGU Staff, the Hydrology Section of AGU and, above all, the relentless work of Associate Editors and Reviewers. For 4 years, we could really feel the immense culture, knowledge and dedication of the hydrological community. The commitment of our colleagues to ensure that science is promoted in the best possible way is impressive. It is a clear demonstration that in research, as with other human activities, each individual is of incalculable value. We were enriched by the relationships we established with the thousands of people during these 4 years and are genuinely grateful for their thoughtfulness, patience and creativity.

A huge effort has been made to ensure timeliness in manuscript management. The average time to first decision of all manuscripts during our term has been 48 days. Figure 2 provides a distribution by article type. We believe that the WRR timeliness is rather competitive in our field.

What about the future? We are heading towards significant changes. Emerging forms of publishing, based on social networks, will become increasingly important and new methods of scientific assessment will emerge. WRR, like any other scientific journal, will evolve. We believe that building on its tradition will continue to be important for WRR, and at the same

time adjustments will be needed to align the journal to changing publication and scientific environments. The community perceives WRR as a high quality publication outlet where highly competent feedback is obtained from peers. A publication in WRR is very well rated by international assessment committees, and WRR is considered a reliable and professional journal, with a robust track record and an open mind for innovation. Our prediction is that the above standards will be raised further. This will not be straightforward, but we have no doubt that the future editorial boards, and our community, will do their best to succeed. As Winston Churchill said, “The empires of the future are the empires of the mind”!

Our heartfelt thanks to WRR, to AGU and the entire hydrologic community!

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## 2016 James B. Macelwane Medal Recipient

Gabriele Villarini, *The University of Iowa*



The Macelwane Medal arguably represents the highest honor for an early career scientist in the geophysical sciences, and I am thrilled to have been selected to receive it; it is also very humbling given the caliber of scientists who have received it before me. I wish to thank my nominator, Manu Lall, the colleagues who supported my nomination, and the American Geophysical Union.

The focus of this newsletter article is on the influence of different flood-generating mechanisms on flood frequency. The topic is not new, but it is one that I believe has received less attention that it deserves. Today, most flood frequency analyses employ relatively standard statistical methods and software for computing return periods, fitting flood distributions, or modeling inundation extents. Resources like Coles' excellent *Introduction to statistical modeling of extreme values* (2001) and the *R* software environment have made non-statisticians more comfortable than before with the statistical modeling of extremes. However, the standardization of statistical procedures for flood frequency analysis has perhaps led us to forget the underlying physical processes producing the observed discharge records.

In some respects, the science of flood frequency has changed relatively little in over forty years. In 1974, Klemeš wrote that "The main emphasis in stochastic analysis of hydrological processes (...) has been on the fitting of various preconceived mathematical models to empirical data rather than on arriving at a proper model from the physical nature of the process itself." He further noted that, to improve flood modeling, we must "find the ways in which the physical features of a phenomenon can be introduced into the analysis." As I see it, the main issue with flood frequency analysis today is that we oftentimes try to identify the "best" parametric distributions to fit the observed flood

records, while forgetting what the numbers really mean. In other words, we assume that all flood events are "created equal," i.e., that they belong to the same population. This may well be the case at locations where just one flood "agent" is responsible for the observed flood events. However, in many locations there are multiple flood-generating mechanisms, often affecting different parts of the flood distribution. As an example, consider the locations where flooding may be caused by snowmelt and/or heavy precipitation, or by either tropical or extratropical storms (e.g., Smith et al. 2011). Although our understanding of the hydrological processes accompanying flood events is better than ever, we have done little to incorporate these physical insights into flood frequency analyses.

In many cases, fitting a single distribution to an observed flood record is inadequate. What if we take a step back, and try to examine which flood agents might be responsible for the observed flood events? Can we bring hydrology back into flood frequency analyses? In doing so, we would improve our fitting of the observational records, which in turn would lead to a more accurate estimation of flood quantiles. These models may indeed be more complex, but the increased complexity would be justified by our understanding of the physical processes at play. I do not believe that accounting for mixed populations in flood frequency analysis will be an easy task to accomplish, but it is one that may have large payouts from a scientific and engineering perspective.

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## 2016 Hydrologic Sciences Award

*Amilcare Porporato, Duke University*



I am very honored by this award, and I would like to thank once again the colleagues who nominated me, the hydrologic community for their support and the numerous collaborators with whom I share it. Our Hydrology President, Efi Foufoula-Georgiou, has kindly invited me to present here some

thoughts on my research. I am grateful for this opportunity, which allows me to briefly describe three main areas that I currently find most exciting. After more than twenty years of research in academia, this also made me reflect on how research paths often follow unpredictable directions, driven by a mixture of internal interests and external forcings, linked to both funding and research trends.

I will call the first research area '*paleo ecohydrology*'. Up until few years ago my main interest about hydrological processes focused predominantly on relatively short time scales around a growing season (from turbulent timescales of seconds to interannual rainfall variability), aimed at describing and predicting current and future hydrologic conditions. Recently, however, I have been lucky to be involved in two very special research projects, funded by NSF, that have helped me expand my time horizons. In this new light, the present hydrologic conditions appear as the results—so to speak—of hundreds of millions of growing seasons! In a fascinating project with Paul Baker, Sheri Fritz and several others, we have been working on the interactions between the formation of the Andes, global circulation, hydrological processes and biodiversity in tropical South America. With Dan Richter and the other colleagues of the Critical Zone Observatories (CZOs) we have similarly turned our attention to the impact of  $\sim 10^{15}$  hydrologic fluctuations that, over millions of years, have shaped the current soil conditions at the Calhoun CZO, in the foothills of the Appalachians. It has been extremely interesting to explore how the complex geochemistry of soil formation is intimately intertwined with the history of deep water fluxes, which in turn are controlled by the variability of surface ecohydrological processes. This expansion in timescales has spurred me and my group

to start thinking of questions about the stability of the water cycle over geological time scales, the origin of land atmosphere interaction (which arguably can be traced back to after the step change – geologically speaking! – of the Devonian expansion of terrestrial plants) and of the long-term role of surface hydrology on the world we see now around us (Bonetti et al. 2016; Bonetti and Porporato 2016; Calabrese et al. 2016). How different must hydrology have been before terrestrial plants and serious soils had developed! Looking at the past may also be useful to revisit our views of the future, especially in face of the rapid changes we are causing globally (e.g., Feng et al. 2013).

The second area of current research in my group represents a natural evolution of some previous work on ecohydrology and has to do with the current focus on the food-water-energy nexus and the linkages between '*ecohydrology and sustainability*'. The very complex and nonlinear interactions that are so interesting in ecohydrology between biogeochemistry are also underlying the sensitivity and far-reaching consequences of the alterations to the soil-plant water system and the energy and the water cycles that we are inducing. For these reasons, we are particularly interested in problems of optimal management to make sure our soil, plant and water resources are used not only profitably but also sustainably (e.g., Porporato et al. 2015; Mau and Porporato 2016; Pelak and Porporato 2016; Parolari and Porporato 2016). What are the optimal combinations of soil, water and plant management practices in current and future climate and socio political conditions that allow us to maintain a healthy environment and achieve food water and energy security? Can low-input agriculture be profitable and sustainable in the long term? I believe that these are some of the most important research areas that span hydrology, ecology, and environmental engineering. In order to make progress in this direction, one needs to account for the uncertainties in future conditions, the presence of hydrological fluctuations and the (in part unknown) multi physics and multi-scale interactions. Towards this goal we are beginning to employ the interesting tools of control theory, non-equilibrium thermodynamics and stochastic theory.

Finally, I would like to mention some of our recent efforts on aspects of '*theoretical hydrology*' aimed at

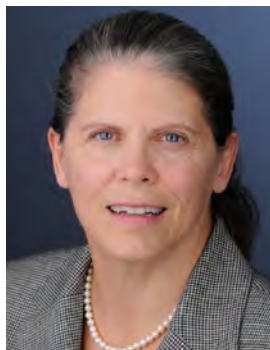
unifying and extending existing models and theories. While on the one hand hydrology is very exciting for the variety of phenomena and the complexity of interactions it encompasses, on the other hand these also may hinder a description of hydrological processes based on first principles. Hydrology does have several very elegant results and theories as well as useful empirical or semi-empirical formulations, but in general we suffer from lack of unified descriptions. It is typical that, on comparing hydrological research to the one in sister disciplines, such as theoretical meteorology and fluid mechanics, which have long benefited from the theoretical structure provided by their fundamental equations (also in their numerical approaches), a theoretically inclined student may initially feel a bit disoriented or frustrated. This not only calls for improved and well-designed numerical methods and field experiments, but should also warn us against a proliferation of conceptual models, brute-force simulations and unnecessary experiments. When possible, unified descriptions of physical phenomena, even if in simplified form, have proven extremely beneficial and rewarding, allowing the revision of fundamental results and their extension beyond their original formulations. Our recent attempts to work along these lines on co-spectral theory of near-wall turbulence (Katul et al. 2011, 2015), the theoretical justification of (mean) runoff curves and semi-distributed hydrological models (Bartlett et al. 2016), age theory (Calabrese and Porporato 2015), a general soil-plant model coupled with environmental conditions that covers all photosynthetic pathways (Bartlett et al. 2014; Hartzell et al. 2015), and land-atmosphere interaction (Yin et al. 2015, 2016), have been very instructive for us in this respect.

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## A Fellow Speaks: A future vision

Mary Hill, University of Kansas



Curiosity. Wonder. A desire for people to live gracefully on Earth. These have been wonderful guideposts for my life as an Earth scientist. The budding development of scientific computing in the 1970's was irresistible to me. It provided an alternative universe that could be prodded, poked, and fully understood -- a window into the world around me, a window to the future. At Hope College, Michigan State University, Princeton University, the U.S. Geological Survey, and now at the University of Kansas, I spent most of my professional life working with data and models of environmental systems (mostly hydrologic, and mostly subsurface). MODFLOW came out in 1984 and provided a disciplined Fortran programming framework that was fast (even now, no language is faster). Because it was connected to MODFLOW, my PCG program became the most used solver in groundwater hydrology worldwide for decades – an amazing feat of endurance in the fast-moving world of computers.

Having a community model like MODFLOW helped develop a realization rather early on that the model predictive abilities hoped for in the heady days of the 1980's was not happening. Finer grids, smaller time steps, more processes, more geology, and more parameters were not leading to the imagined advances in accuracy and increased impact of models. Only now, when farmers are starting to pump air, are the limits of the Ogallala aquifer, which were predicted with 1970's models, being accepted enough to promote change. Only now, when we bake in the summer heat and see birds that were previously far to the south, is global warming, predicted by science and models since the 1950's, being accepted enough to promote change. Models have largely been relegated to limited impact roles, with results that were accepted mostly by the scientists who created them. Even now, model results are presented in ways that are often distant and indecipherable even to other scientists, let alone people asking practical questions. Something is very wrong.

Popper and Oreskes had warned us of problems, and we found them. Even models of designed engineered

systems like the space shuttle and bridges have had difficulties. What is to be made of modeling natural systems in which so much is unobservable, unknowable? People may get ill from 30 parts per billion TCE and 25 millirems, but it does not mean that subsurface transport models can or will ever be able to simulate their occurrence accurately.

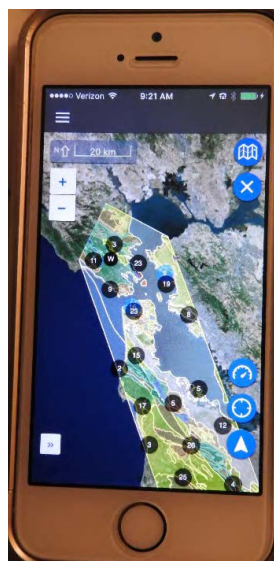


**Figure 1.** Image of my cell phone screen showing San Francisco Bay using the NSF-sponsored application FlyOver Country. Colored shading shows the geologic map. Dots locate geologic and hydrologic sites of interest and can be clicked to reveal descriptions obtained from Wikipedia. Performance is fast enough to be fun. Expansion to richer data sources and model results visualized in engaging and scientifically informative ways is nearly possible. (inspired by <http://fc.umn.edu/>)

Perhaps we are limited to predicting large signals with models. Perhaps small signals will remain elusive. And yet, perhaps there is substantial utility even if this limited situation is the destiny of modeling environmental systems. Knowledge of large signals and known limited knowledge of small signals are insights that can and are providing important scientific input for what needs to be momentous societal shifts. Perhaps this is enough for models to play a more important role in achieving a sustainable future for people on Earth. How is this to be done? Consider the possibility of using models to bring scientific knowledge to classrooms, to cell phones, to Pokémon Go, to endeavors yet to be imagined. This kind of evolution requires three things.

(1) As our fellow AGU member Katharine Hayhoe has suggested so eloquently in her YouTube videos and elsewhere, real change requires approaching people from the perspective of values. Carefully pick what to communicate and seek to understand what others see as important. We as scientists are, I think, starting to learn

the needed words, the needed patterns (see Günther Blöchl's work), the methods of engagement using cyber infrastructure (Figure 1) and interactive visualizations of data and model results (being pursued by my group and others).

(2) To be part of the communication future envisioned by (1), models need to be reconsidered. They need to be made transparent and nimble. Being transparent and nimble enables models to address questions faced by real people in real time. That is, if models are transparent and nimble, they can be used to enable our scientific knowledge to play an everyday role in addressing everyday questions as people build houses, tend gardens, and plant crops.

For models to be transparent and nimble, nonlinearities need to be managed carefully. Models need to **include** important nonlinearities representative of significant real world processes, and **exclude** nuisance nonlinearities that cause trouble for no advantage. Nuisance nonlinearities -- "numerical daemons" -- bog things down. They require behemoth computational demands to do even basic tasks. There are some recent models that are nimble -- such as some versions of MODFLOW (Figure 2), and surface water models like TOPKAPI (see Foglia et al. 2009) and SUMMA (Clark et al 2015). There is still much to learn about taking advantage of these models, as noted by Rakovec et al. (2014).

(3) While there is a dizzying array of methods for analyzing variability and uncertainty, today many popular methods were developed to deal with numerical daemons. In figure 2 the very expensive uncertainty intervals (1.5 million model runs!!) were developed largely to cope with numerical daemons. For models without daemons, there is a world of methods to be explored (Hill et al 2015, 2016; Ye and Hill 2016). To help advance scientific progress in this field, I started the AGU Hydrology Section Technical Committee on Hydrologic Uncertainty. It brings together people concerned with a range of uncertainty and other model analysis methods, and attempts to reach across section boundaries. Like all Technical Committees, meetings are open to all. Come join us!

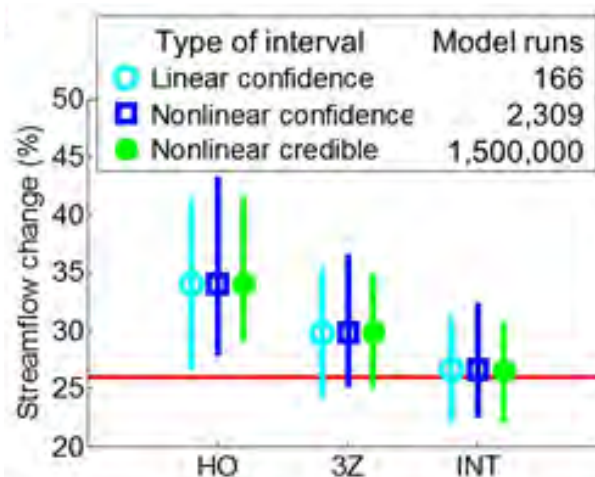


**Figure 2.** Uncertainty intervals calculated in three ways, as listed, for three MODFLOW-simulated groundwater hydraulic-conductivity distributions: HO is homogeneous, 3Z uses three zones of constant value, and INT uses interpolation. The number of model runs listed is for all three. The nonlinear credible intervals are calculated using Markov Chain Monte Carlo (MCMC). (modified from Lu et al. 2012; Hill et al. 2015; Hill et al. 2015).

We have an increasingly technology savvy population already exploring new imaginary worlds full of Aliens, Predators, and other scary things. They could be exploring imaginary worlds that are scientifically rich in ways that inform their everyday decisions.

I end with the thought that permeates the words above. Moving toward living gracefully on Earth takes science, and more than science. Wise change requires engagement of people -- of their hearts, their souls, and their imaginations.

### Words of thanks and gratitude

I have been blessed with wonderful mentors and colleagues on what has been an exciting scientific journey. Mary Anderson, Keith Beven, Tissa Illangasekare, William W.-G. Yeh, George Pinder and Leonard Konikow shepherded my nomination through AGU. Linda Abriola worked on a previous attempt. I am honored beyond expression. Colleagues Martyn Clark and Tony Jakeman are also celebrating as new fellows this year, and Tom Dunne was awarded the Horton Medal. My husband, J. Dungan Smith, taught me to think more deeply as a scientist as we hiked and back-packed through some of the most glorious scenery on Earth. And so many others. You know who you are. Thank-you.

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## A Fellow Speaks: Hydrological implications of the ongoing agricultural transition

Paolo D'Odorico, University of Virginia

2016 Paul A. Witherspoon Midcareer Lecture Award



It is a great honor to have been elected a *Fellow of the American Geophysical Union*, and I am grateful to those colleagues who have nominated me and to those who have supported this election. I am also honored to have been selected to deliver the *Inaugural Witherspoon Lecture*. I am

really overwhelmed by both recognitions. I owe them to my mentors, students, collaborators, and the support of our community. Indeed, I have always been extremely fortunate to work with a very creative group of colleagues and interact with an outstanding community of scholars.

I started my research career intrigued by the idea of investigating the hydrological and biotic processes

underlying organization and patterns in nature. I initially focused on the interaction between soil moisture dynamics and vegetation. This work soon led to new research in *ecohydrology* with a focus on plant water stress, nitrogen cycling, root dynamics, and vegetation-atmosphere interactions (e.g., D'Odorico et al., 2010a). Field research added an empirical component to my modeling work through campaigns in the Kalahari, the Yucatan, and the Southwestern United States. This work clarified the role of ecohydrologic feedbacks in the dynamics of dryland ecosystems with the emergence of bifurcations, alternative stable states, and spatial patterns in arid and semiarid vegetation (e.g., Ridolfi et al., 2011). Field experiments and theoretical frameworks shed light on mechanisms of 'desertification' associated with state shifts in dryland vegetation and feedbacks with the physical environment mediated by both aeolian and hydrological processes (e.g., Bhattachan et al., 2014).

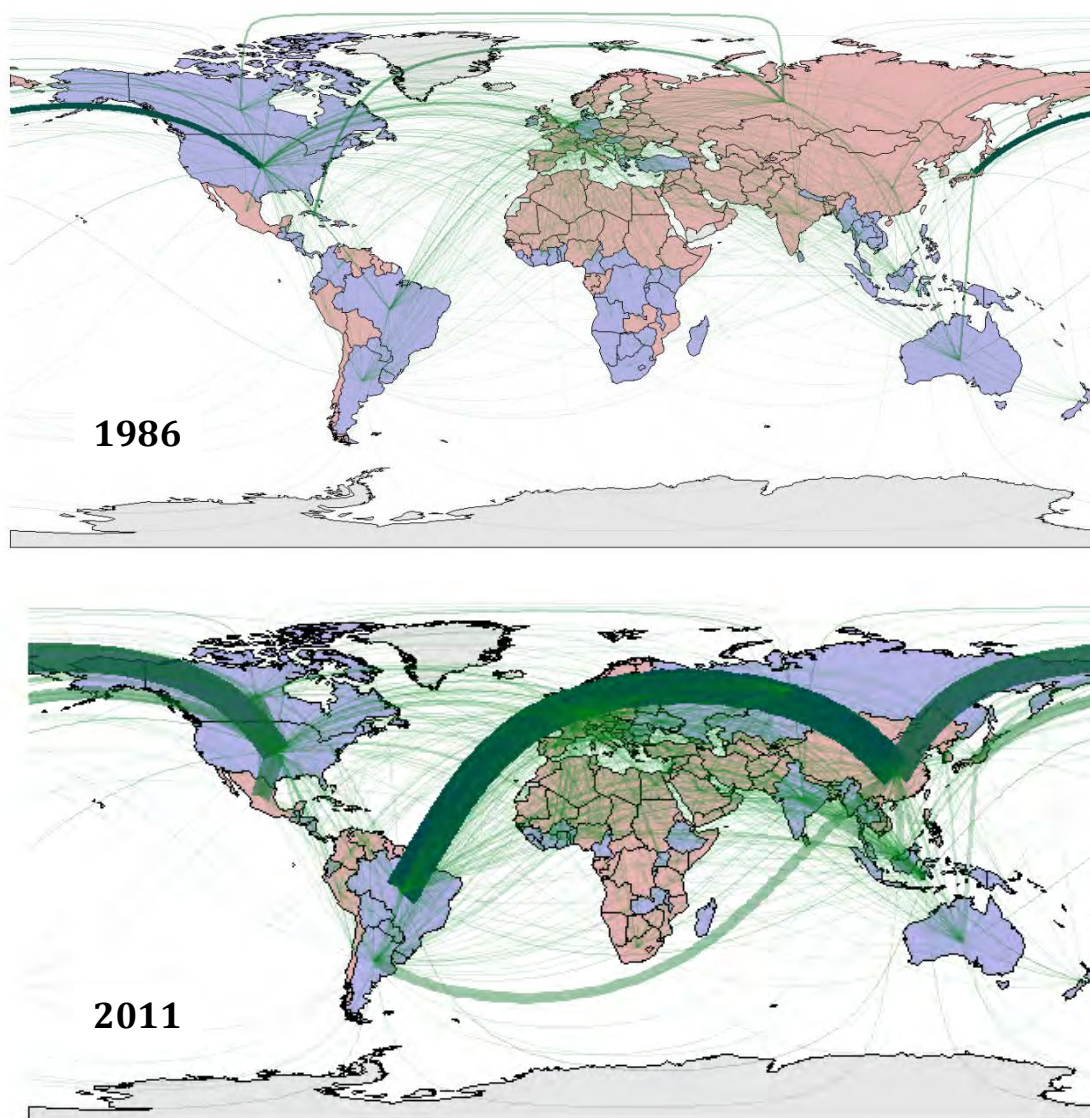


**Figure 1.** Global virtual water trade in 1986 and 2011. Net exporters are shown in blue; net importers in pink, and trade flows in green with width proportional to the volumes of traded virtual water (courtesy of Joel A. Carr)

In recent years, part of our community has become increasingly interested in understanding how human societies interact with the environment and its water resources. The focus has often been on water use by crop and livestock production because agriculture accounts for the majority of human appropriation of freshwater. It has been observed that the import and export of agricultural commodities virtually transfers water around the globe, a process that contributes to the *globalization of water resources* (Hoekstra and Chapagain, 2008). These virtual water transfers do not

entail a physical transport of water but the flow of commodities that were produced using water, often in great amounts (Allan, 1998). Recent work has quantified the globalization of water associated with global trade and international investments in agricultural land (Hoekstra and Chapagain, 2008; Carr et al., 2012; Rulli and D'Odorico, 2013). This research has shown that virtual water trade has increased dramatically in the last few decades (Figure 1). Presently, about one fourth of the water used by agriculture is accessed through virtual water trade or

international land investments. We can highlight some of the pros and cons of such a globalization of water. Its main merit is that it limits the societal vulnerability to crop failure resulting from local droughts, thereby limiting the occurrence of famine and conflict (Allan, 1998). It also allows for water savings and an overall improvement of the water use efficiency of global food production (Dalin et al., 2012). On the other hand, the globalization of land and water may enhance environmental degradation, reduce social resilience to drought, and lead to loss of environmental stewardship (D'Odorico et al., 2010b; Davis et al., 2015). The globalization of water allows societies to rely on water resources they do not control, thereby exposing them to the uncertainties of a global trade market that has proven to be unreliable in periods of water and food scarcity and escalating food prices (e.g., Suweis et al., 2013). Interestingly, while there is a relatively large number of virtual water exporters, more than 50% of net exports is contributed (and controlled) by few countries: Brazil, the USA, Argentina, and Indonesia.

By modifying the distribution of virtual water resources, international trade may increase or decrease (virtual) water availability in water scarce regions of the world. Even though virtual water trade *on average* reduces inequality and improves food availability in water stressed countries (Carr et al., 2015), its impact on the economic access to water and the fulfillment of human rights remains poorly understood. By showing how virtual water trade is reshaping the global distribution of water resources, we can connect research in hydrology to studies in water ethics and environmental justice (Seekell et al., 2011).

With water remaining a major factor constraining crop production and many developing economies relying on agriculture as a primary income source, water will likely play a critical role in determining food security, economic development, and the sustainability of rural livelihoods. Thus changes in agriculture in response to the escalating needs of the growing and increasingly demanding global population may have profound impacts on hydrological processes and the dynamics of water resources. A major transformation in agricultural production is indeed taking place around the developing world. It entails a transition from small scale farming to large scale commercial agriculture with the displacement of semi-subsistence, small-holder farmers and traditional users of natural common-pool resources by large-scale commercial production (e.g., D'Odorico and Rulli, 2013; Dell'Angelo et al., 2016). Such a transition is partly

induced by the increasing demand for agricultural products and the consequent need for investments in agriculture; but it is also the result of market drivers, new investment opportunities and development of new technologies. Because most of the cultivated land worldwide is still managed by small-scale farmers, this ongoing shift in systems of production is strongly reshaping the agrarian landscape around the world with important impacts on the environment, the rural populations and their livelihoods. While the societal implications of such an agricultural transition have been fairly well understood, the environmental effects have often been overlooked. The transition typically involves an intensification of agriculture, with an increase in fertilizer use, mechanization, and irrigation. The impact on the water system resulting from changes in water stocks, timing and magnitude of environmental flows and land-atmosphere interactions has only started to be investigated. Ecohydrological models and observations can quantify these processes and inform institutional analyses aiming at the development of water governance approaches that could reconcile the competing water needs of commercial farmers, small-holder agriculture, and the environment. Such efforts will lead to new advances in the study of the social-environmental implications of this major transformation of our time and the associated changes in land use.

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## A Fellow Speaks: Advancing large-domain hydrologic simulation and prediction

Martyn Clark, National Center for Atmospheric Research, USA

I am delighted to be elected a Fellow of AGU. It is a tremendous honor, and I sincerely thank my colleagues for their efforts to nominate and support me. I am also very grateful to my colleagues for sharing in this scientific adventure – it's truly been an exciting ride over the years, where I've had the opportunity to work with influential and provocative colleagues across many different disciplines to advance the science of large-domain hydrologic simulation and prediction.



It all really started for me in my graduate work in snow hydrology in the early 1990s at the University of Canterbury in New Zealand. I had a wonderful opportunity to conduct the research for my Masters thesis at the Broken River ski field in Craigieburn Range. I started my research during winter, learned to ski, and the managers of the ski field gave me the keys to the lodges and rope tows after the field had closed for the season. Now, Broken River was a club field run by volunteers. The four-wheel drive road to the field was only open in the summertime, requiring a 30-minute walk up a steep trail (fun times with car batteries and data loggers in your backpack). And the rope tows were a single rope going from the bottom to

the top of the mountain, powered by a tractor in the shed at the bottom. You rode the rope tows by attaching a nutcracker to your climbing harness, flicking the nutcracker over the rope as you careened up the hillside, and hung on for dear life as the nutcracker rattled through the pulleys. The research was also thrilling – I got to study snowpack energetics during large melt events in warm and windy conditions when both the sensible and latent heat fluxes were directed toward the snow surface, and I got to study the heterogeneity of melt water through snow using spatial surveys of volumetric liquid water in snow, dye tracing experiments, and a "thick section cutter" to extract and photograph sections of the snowpack.

My research over the years has focused on advances in large-scale hydrologic simulation and prediction. I've worked on developing models and methods to simulate hydrologic processes, to portray the potential impacts of climate change on water resources, and predict streamflow on time scales ranging from days to seasons. This work has included developments in process-based hydrologic modeling, ensemble data assimilation, probabilistic quantitative precipitation estimation, model evaluation, climate dynamics, and optimization. I've had the benefit of working at the interface between science and applications; for example, developing a streamflow prediction system

for New Zealand, and contributing to water security assessments in the USA.

Nowadays there is a problem that gets me especially excited – improving physically motivated hydrologic model simulations over large geographical domains. I'm excited about this problem, in part, due to its difficulty, since developing realistic hydrologic simulations across large domains has arguably been one of the greatest challenges in modern hydrology. The thing that really gets me excited, to be honest, is that the juxtaposition of several synergistic advances in hydrologic science provides us with the necessary tools to substantially accelerate modeling improvements.

The advances that interest me here cut across all areas of hydrologic model development, application, and evaluation. One advance is the development of multiple hypothesis modeling frameworks, now used by numerous modeling groups. These frameworks enable decomposing a model into the individual decisions made as part of model development, evaluating each modeling decision in isolation, and identifying key model weaknesses and model development needs. Another advance is the effort to improve the theoretical underpinnings of hydrologic models by bridging the gap between model algorithms and the process explanations emerging from research watersheds. Important model improvements gained from research watersheds include better representation of small-scale variability and hydrologic connectivity for multiple processes across a range of space and time scales. Still another advance is the development of multi-scale methods to relate geophysical attributes to model parameters, improving estimates of the spatial variability in the storage and transmission properties of the landscape. In addition, we now have better spatial information on climate, topography, vegetation, soils, and the human impacts on the terrestrial water cycle, including probabilistic information necessary to characterize hydrologic model uncertainty. And, perhaps most important, through applications of information theory we have advanced our ability to quantify how effectively models use the available information, providing an estimate of system predictability and identifying opportunities to improve models. Taken together, these advances provide the ingredients to improve model fidelity, to improve the extent to which models faithfully represent dominant processes; and to improve estimates of model uncertainty and information use, in order to better define tractable paths toward model improvement.

I expect that the hydrologic modeling community will undergo a remarkable transformation over the next five years. First, I expect that the current calls for a community hydrologic model will result in concrete efforts to unify hydrologic modeling activities. This will result in greater engagement of field scientists in model development and greater collaboration across diverse modeling groups, resulting in substantial improvements in the physical realism and predictive capabilities of hydrologic models. I expect that the community will be much more effective and efficient in sharing data and model source code, not just by making models and data publicly available, but, critically, integrating models and data in widely-used analysis frameworks and developing model standards to simplify the sharing of source code in models developed by different groups. Second, I expect that many in the hydrologic modeling community will focus attention on advancing process-oriented approaches to estimate spatial fields of model parameters. Such focus will give the parameter estimation problem the scientific attention that it deserves, rather than the far-too-common approach where parameter estimation is simply a “tuning exercise” in model applications. This focus on parameter estimation is necessary to improve the physical realism and applicability of process-based models. Third, I expect that the community will substantially advance capabilities in model analysis, providing important insights on why models behave badly and what can be done to address model inadequacies. Fourth, I expect that hydrologic modeling advances will be used much more rapidly in applications. The modeling advances on the horizon will substantially improve the skill of drought monitoring and prediction, flood and water supply forecasting, coupled environmental prediction, and a broad variety of hydrological and ecological impact assessments. My colleagues often tell me that I have unrealistic expectations – I hope that they are wrong in this case, since I believe that the modeling transformation defined here is critical for the vitality of hydrologic science.

I very much look forward to the future. I believe that the convergence of synergistic research advances places us on the cusp of a new era in hydrologic modeling, and, as a community, we will rapidly transform what hydrologic science can offer to society.

Onward!

## A Fellow Speaks: Challenges in Global Hydrology and Water Resources

Marc F.P. Bierkens, Utrecht University



It is a great honor to be elected fellow of the American Geophysical Union. I would like to thank the people that were kind enough to nominate and support me. I also like to thank all those hydrologists that I have met and cooperated with throughout my career and who have influenced and stimulated me tremendously.

The last decade or so I have been part of the community involved in global hydrological modeling.

The field has grown dramatically since its inception by Peter Eagleson in 1986 (Eagleson, 1986). More than 30 different global hydrological models saw the light since then. Many of these are land surface models in GCMs, but there are also a considerable number of global hydrology and water resources models (GHWs) meant to also simulate the human factor in terrestrial water resources (Bierkens, 2015). New applications of global hydrology are manifold and will continue to develop. Obviously, these new applications will bring about their own challenges, some of which have been briefly described in the above-mentioned review paper. Here I would like to focus on two of these challenges that are (still) the focus of our group's current research.

### Environmental flow requirements (1960-2014 at 5 arcminutes) Estimated by Y. Wada with PCR-GLOBWB 2.0

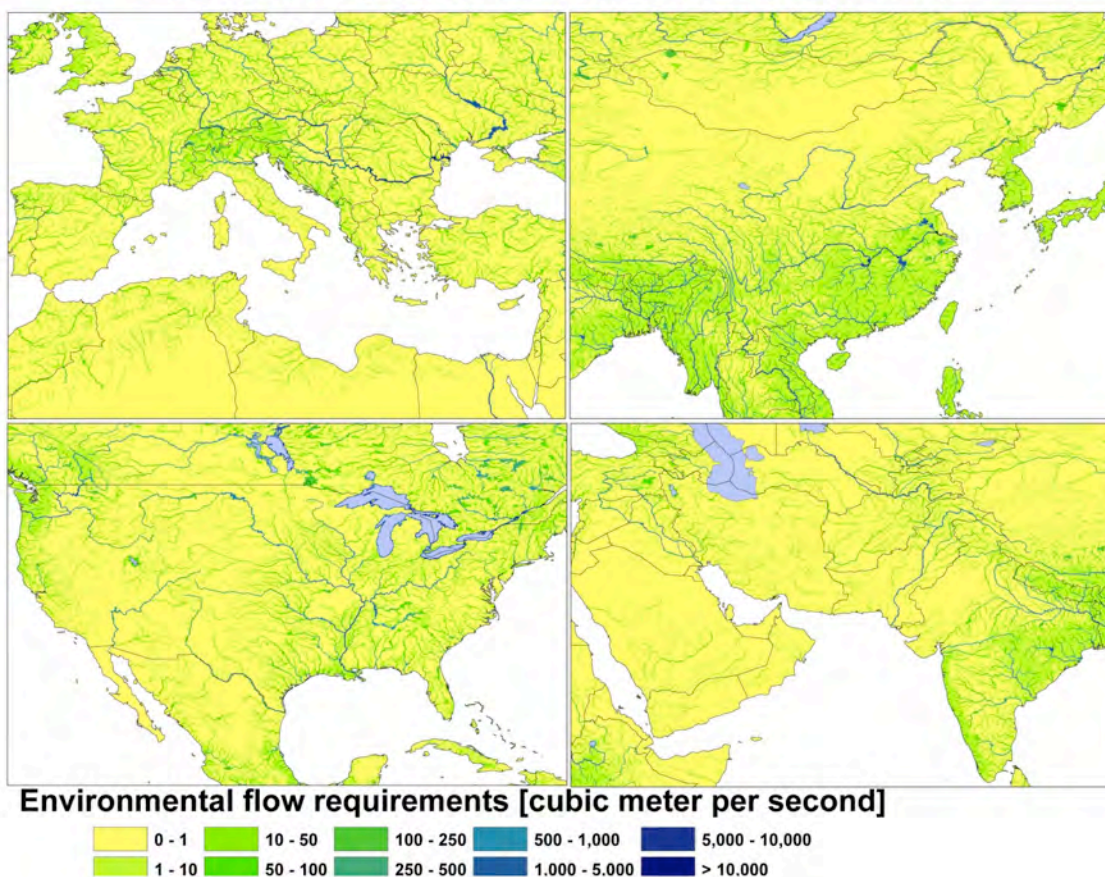


**Figure 1.** Environmental flows simulated by a 5-arcminute (10 km at the equator) global hydrology and water resources model

The challenge of trying to be “everywhere and locally relevant, i.e. using global models to provide hydrological predictions at high enough resolution to be useful for local water managers, in areas that are not always monitored or modeled, is an ongoing one; and so is the discussion about the use and feasibility of this **hyper-resolution global hydrological modeling** (Wood et al., 2011; Beven and Cloke, 2012). Bierkens et al (2014) mention three key challenges that come with the ambition of hyper-resolution global hydrological modeling: 1) the breakdown of subgrid concepts; 2) lack of data and epistemic uncertainty; 3) computational challenges. Note that these challenges are actually the ones already named by Freeze and Harlan (1969) in their Blueprint paper: processes, parameters and computation; in hindsight it was quite an omission of Bierkens et al. (2014) not to see the resemblance.

Challenges 2 and 3 are generally well tackled by the community. There are groups working on seamless parameterizations across scales (Samaniego et al., 2010) and groups that use massive parallelization to meet computational challenges (Kollet et al., 2010; Maxwell, 2013). Recent attempts to apply Sameniego et al.’s algorithm to our own GHWM PCR-GLOBWB show very promising results indeed. However, challenge 1, although somewhat related to the parameterization problem, is far from resolved. It is not at all clear what process representations, if known at all, are necessary and/or sufficient to describe the hydrological states and fluxes satisfactorily at hyper-resolution. Here, formal multi-process frameworks such as proposed by Clark et al. (2015) are a possible way forward.

Notwithstanding these challenges, applied research institutes are already using the results of global hydrological models as first-order estimates for regional and local studies (e.g. Trambauer et al., 2015), after which local data are added when available. The ambition here is the so-called “3 clicks to a model” procedure (personal communication Jaap Schellekens of Deltares): Global hydrological models parameterized at multiple scales, or a combination of a flexible distributed model-code (e.g. HBV, SWAT, WFLOW) and high-resolution datasets, are used to create a regional- or local-scale model through a web-interface by a few clicks. These clicks only involve the choice of model extent and model resolution and what processes to include or not. Such applications are currently under development and the scientific

hydrological modeling community better be on board to be part of this game.

The second challenge involves our efforts in **global groundwater modeling**. Inge de Graaf (2015) developed a two-layer transient groundwater model coupled to PCR-GLOBWB in order to assess current and future groundwater depletion. A one-layer steady state version has been published (De Graaf et al., 2015) and the two-layer transient version is currently under review. Despite the importance of groundwater and the explicit treatment of groundwater recharge and pumping in global studies (Wada et al., 2010; Döll et al., 2014), most global-scale hydrological models do not include a groundwater flow component. The obvious reason for this missing component is the lack of consistent global-scale hydrogeological information. Such data is needed to obtain a correct physical representation of the groundwater system, allowing for a more realistic simulation of groundwater head dynamics and lateral flows (e.g. Schaller and Fan, 2009). Another reason is that at the usual time scales considered (season to years), the amount of lateral flow across cell boundaries is likely to be small compared to the vertical exchange between groundwater and the overlying soil through recharge, evaporation and capillary rise (Lam et al., 2011).

However, there are a number of applications that do require lateral flow to be explicitly modeled. First, even though the volumes of groundwater traveling across cells is limited currently, it becomes more and more important if one moves to ever higher resolutions (Wood et al., 2001; Bierkens et al., 2014), and certainly in case of groundwater abstractions. Second, particularly below megacities in deltas and under irrigated agriculture in developed countries such as the U.S., groundwater abstractions are often from (semi-) confined aquifers. In confined aquifers the spatial influence of abstractions is much larger than in unconfined aquifer, likely exceeding cell boundaries. Third, there is considerable interaction between surface water and groundwater, even in confined aquifers, with the larger rivers. Failure to take this into account may overestimate groundwater depletion due to the neglect of increased capture (see e.g. Konikow (2011) for a critique on our initial flux-based approach). This groundwater-surface water interaction is difficult to parameterize in a land-surface model without lateral flow. Fourth, it is important to eventually surpass the mere estimation of depletion volumes and move to estimating head declines if one aims to estimate by what time in the future groundwater becomes

## Groundwater depletion 1960-2010 in 4 major exploited aquifers simulated with a global groundwater model; Inge de Graaf (2015)

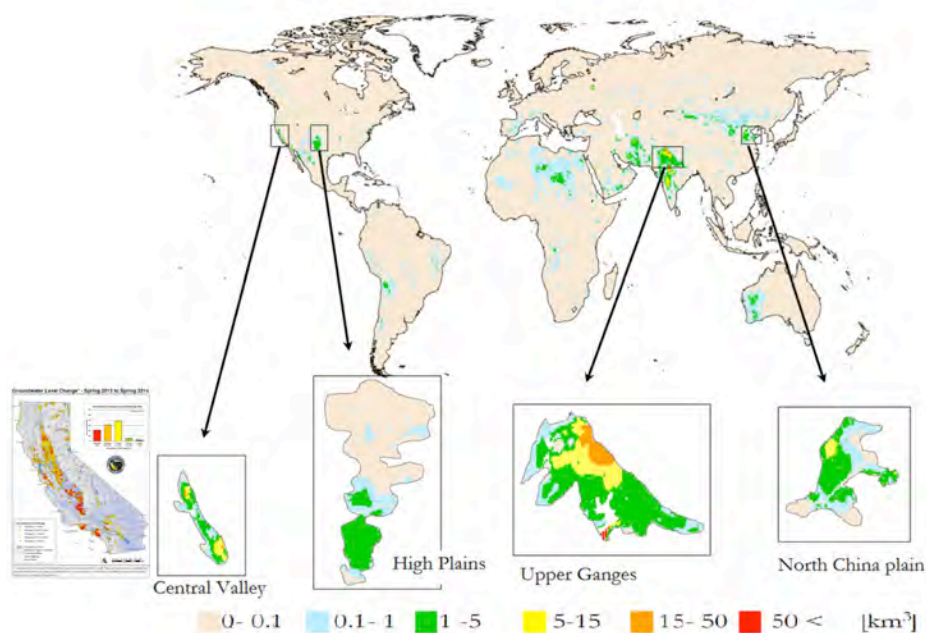


**Figure 2.** Groundwater depletion in major aquifers simulated with a global two-layer groundwater model coupled to PCR-GLOBWB (5 arcminutes spatial resolution).

unattainable or when falling heads will result in rivers running dry during low flow periods.

Our most recent work with the global coupled groundwater-surface water framework revolves around two efforts. One involves calculating economically accessible global groundwater volumes (here defined as heads within 300 m below the surface) and ecological boundaries to groundwater abstraction (maintaining environmental flows) and more importantly, projecting the times at which these economic and ecological boundaries of groundwater depletion will be reached for different aquifers around the world. The other effort is trying to estimate terrestrial water storage (TWS) change and its contribution to sea-level variations over the period 1900-2010. For our simulations we detect an interesting correspondence between TWS-anomalies and ENSO and with major volcanic eruptions (a significant difference in TWS change between la Niña and El Niño years:  $p < 0.005$ ; a non-significant difference in TWS change between years with and without eruptions;  $p = 0.07$ ). We also find a general increase of TWS over the 20<sup>th</sup> century. How real this trend really is, is currently being checked.

Our global groundwater modeling work rests on a first-order global hydrogeological model that was developed using global maps of surface lithology and hydrogeological properties (Gleeson et al., 2014), elevation characteristics and coastal bathymetry. Obviously there is enormous room for improvement here. I call for the hydro(geo)logical community to follow the soil scientists and start compiling a global hydrogeological multilayer model based on national geological maps and archives and local- and regional scale groundwater modeling studies.

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## A Fellow Speaks

*Anthony John Jakeman, Australia National University*



I feel enormously honoured to be made a Fellow of the AGU and thank my nominators and supporters for putting my name forward. The AGU is such a wonderful institution in the ever-improving way that it globally services the geophysical sciences and their societal interactions. The AGU provides such thoughtful opportunities for its members and is underpinned by a magnificent spirit of generosity from its volunteers. It has always stood out like a beacon to me in the way a Society can best function. Its inherent collegiality has been especially valuable to me, having benefitted immensely from members' comments on my work and

presentations, often leading to very productive collaborations.

I am indebted to the scores of PhD students that I have supervised, as well as cohorts of early career researchers in my group at ANU. Students and postdocs continue to be the most exciting and rewarding part of my job and their unselfish collaboration is very much appreciated. Three individuals who have strongly influenced my career in science cannot go without a mention. Bob Anderssen, now at CSIRO, was a great mentor in my early days as a PhD student in numerical methods at the Australian National University and remains a constant industrious colleague to this day. Being one of Australia's leading applied mathematicians, he is one of the most versatile scientists I know and brings great insights into every new problem he attacks. He uses mathematics

creatively as an enabler to resolve practical problems (e.g. Anderssen and Stuart 2007). As a postdoc, Peter Young at Lancaster invested generously in me, and instilled in me the value of data based analysis in generating insights. He influenced much of my thinking on system identification (Young and Jakeman 1980), and he continues to show how wonderfully suited it is to building models that are fit for purpose. George Hornberger, now at Vanderbilt, has also influenced my research in so many ways, perhaps most of all around exploring uncertainty of process-based modeling. His work with Bob Spear at Berkeley on regionalised sensitivity analysis (Spear and Hornberger 1980) has instigated so many methodological developments in the last three or more decades. And it is pleasing that my most heavily-cited paper and arguably most useful was written with George (Jakeman and Hornberger 1993). All three of these esteemed people are inspiring exemplars of how one can continue to grow and take on new scientific challenges and at the same time be outstanding mentors of younger researchers.

There are two major areas where I am focussing my present research, both with a usefully common thread around the issue of uncertainty. The first is a generic methods one. While much of our modeling in hydrology and water resources is useful, it can be more so. The overwhelming proportion of our models are non-identifiable, being over-parameterized in structure or calibrated with insufficiently informative data. Keith Beven has done a good service here in promoting the ensuing concept of equifinality (Beven 2006). Whilst such models can still be useful for prediction and with some additional work provide a measure of uncertainty, they are not so often employed to test hypotheses, and move towards a more applicable representation that captures just those processes that are relevant for the modeling purpose. Of course one can go bottom-up or top-down to develop representations that are more suited to the purpose and faithful to the dominant processes. Top-down means starting simple and building up complexity and requires great care and insights. Bottom-up can be easier as we have loads of complex model representations whose processes can be mined and whose scales interrogated for their faithfulness. And we now have a wealth of foundational (see Shin et al. 2015) and new techniques to test the structure of models. Sensitivity analysis and response surface methods have had much development as have Bayesian techniques for ranking or quantifying uncertainty and seeing where the weaknesses are in our models. Model emulation (Asher et al. 2015), through

polynomial chaos (Sudret 2008) and Gaussian processes (Rasmussen and Williams 2006), and Active Subspace methods (Constantine 2015) are relatively new kids on the block and offer some additional advantages by coming up with surrogate models with potentially nicer properties. Even if these surrogates don't have physically acceptable representations, they do provide valuable information on, and smart sampling schemes for, parameter sensitivities and interactions. The challenge is to use these techniques eclectically to revise our models and make them more identifiable.

The other major area of interest to me is how we as a science community can progress and help resolve complex scientific, management and water policy problems where results are contested and uncertainty is rife. Here the emerging discipline of socio-hydrology is an exciting opportunity to move research forward. But serious attention must involve a model-based process to systematically manage the integration of knowledge for assessing policy options, but with links through the process to identify and manage uncertainties. The involvement of interest groups is essential to: get the appropriate problem framing and to generate the ensuing conceptual modeling; understand the social, policy and institutional settings, constraints and opportunities; and integrate the model components rigorously, focusing the science components on the identified questions, attributes and scales of interest. Often the components are best integrated into more computational models so that the effects of policy drivers can be gauged along with non-controllable forces like climate and commodity prices on outcomes. Outcomes of a triple bottom line nature will also need to be identified as trade-offs, and their uncertainty managed so that one can more confidently decide among alternative courses of action. An overriding process theme should always be appropriate engagement and targeted best science in all stages of the process so that knowledge is integrated and shared, trust is engendered and adoption of good outcomes more likely. The more wicked the problem the more one needs such a process. Process is as important as the science and takes as much time. It is "an adaptive process that incorporates many dimensions and stakeholders. The process itself requires a level of validation that often warrants being given the same priority as may be attached to the outcomes produced. In maintaining this perspective, the words of Robert Louis Stevenson are apposite. i.e. to travel hopefully is a better thing than to arrive" (Jakeman and Letcher 2003).

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## A Fellow Speaks: Go deep, young hydrologist, go deep

Gordon Grant, Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture



"Not since Moses was discovered among the bulrushes of the Nile has there been such a propitious moment for hydrology as the present: a rare conjunction of interest in both the science of water and the management of water." So began M. Gordon (Reds) Wolman's acceptance speech for the Robert Horton medal in

the year 2000. Since then Reds' point has only been sharpened by ever more frequent and intense floods and droughts, mounting evidence of global human impacts on the climatic and hydrologic cycles, and an ever-heightened awareness that water, and its abundance, scarcity, quality, and cost, will be defining issues for centuries.

But addressing these issues will not be easy. Both studying and writing about water are difficult, reflecting the nebulous properties of the substance itself. Water is ubiquitous and therefore not easily

circumscribed; it runs across geographical, political, and disciplinary boundaries with impunity; it assumes many forms and is therefore simultaneously everywhere and nowhere. It is a shape- and phase-shifter of the first rank, conforms to whatever seeks to contain it and is therefore not easily characterized. It is a precursor and precondition of life, and intimately intertwined in all things biological, yet we often measure and talk about it as if it were an inert, independent substance. But these very properties are the ones that make it so fascinating. As a hydrologist it is all too easy to be distracted by its sparkling reflection or lost in its mesmerizing depths.

This leads me to offer some modest heuristic reflections on navigating the currents of this discipline. There is no lack of exciting research directions that this and future generations of young hydrologists have to look forward to. We are poised to make real progress towards transformative scientific ideas, questions, and perspectives that are not yet within our grasp.

For example, the emergence of “critical zone science” is a potential game-changer. I say this as someone who was originally quite skeptical of the concept; to me it seemed like a rebranding of soil science. Years of close engagement with the program proved me wrong, and now I serve as the chair of the Science Steering Committee for the U.S. NSF-funded Critical Zone Observatory program. The critical zone is the thin, dynamic, and life-sustaining skin of the terrestrial earth, extending from the top of the vegetation canopy to the top of the unweathered bedrock that never sees groundwater. Studying the states, fluxes, feedbacks and evolution of the critical zone in different lithologic, climatic, and land use environments is now an international effort, bringing together hydrologists, geomorphologists, biogeochemists, ecologists, and climatologists to focus on critical and scientifically rich questions. How deep is the critical zone and how did it get that way? Does the vegetation know what kind of bedrock lies beneath the root zone, and does the bedrock know what’s growing on top of it? How will a climatically changed atmosphere and a land surface modified by human activities affect the deeper critical zone and vice versa? Can the critical zone be managed to better sustain human health and well-being? In a real sense, the term “critical zone” occupies the same place as an organizing principle for both the earth and biological sciences as “ecosystem” did for ecology half a century ago.

One of the lessons we’re learning from critical zone science is that we don’t understand trees very well: why they grow where they do, why they experience water stress and die, what strategies they have for obtaining and using water, and how these strategies vary by species, setting, and climate. For example, we’re learning that different tree species growing right next to each other use isotopically dissimilar water (Moreno-Gutiérrez et al, 2012). Why? We don’t know yet, but suspect it relates to species-specific survival strategies. These observations underscore an urgent need to better understand the interactions among roots, vegetation, soil moisture, and groundwater in different climatic settings (e.g., Fan, 2015). Understanding these dynamics are critical if we want to predict water stress on vegetation and its consequences at the landscape level, a societally critical question in the face of massive droughts and widespread forest mortality. The same isotopes used to reveal differences in water use by vegetation point to a deeper set of questions. What controls the chemical evolution of water – in the atmosphere, vegetation, ground, and rivers? What does the chemical “flavor” of water in the river tell us about

what’s happening on the hillslopes. Even more broadly, how does the chemistry together with measurements of storage and fluxes inform our understanding of hydrologic partitioning? Despite the lovely pictures of the hydrologic cycle that grace every entry-level textbook, our understanding of the specifics and dynamics of these fundamental processes is rudimentary at best. New measurement and sensing techniques and instrumentation, including remote sensing and distributed sensor networks, are going to provide dramatically new perspectives on these key processes in the near future.

What intriguing possibilities might lie just beyond our current abilities? Going way out on an unsupported limb, perhaps we will tag and follow individual “packets” of water as they move through the hydrological cycle over continental scales. Emerging observations and modeling studies show how air passage over dense tropical forests results in greater precipitation downwind and, conversely, how air masses are depleted of moisture when deforestation occurs (e.g., Spracklen et. al., 2012). Imagine if we could calculate water budgets, not just for watersheds, but for large-scale atmospheric rivers and fluxes. Consider the societal and legal implications of an expanded conception of everyone living both down- and upwind from somebody else.

These thoughts are primarily intended for students and early-career scientists who have chosen to make hydrology their disciplinary home. I find myself enviously thinking that never before has there been such a good time to be a student of water in its myriad, captivating forms. Hydrology sits at a fortuitous confluence of insight, interest, and tools, and, above all else, critical questions that must be answered if the global community is to survive and prosper in the years ahead.

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**2016 Horton Research Grant Recipients:****1. Katalyn Voss**

(University of California, Santa Barbara)

*"Contributions of Glacial Melt, Snowmelt, and Groundwater to Streamflow During Low Flow Periods: A Paired Catchment Approach in the Arun Watershed, Eastern Nepal"*

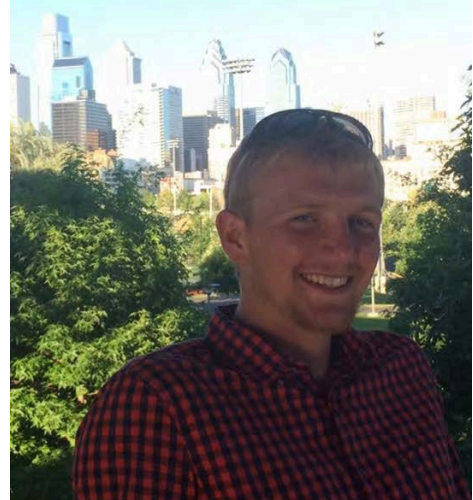
Advisor: Oliver Chadwick

**2. Noah Jemison**

(University of Illinois, Urbana-Champaign)

*"Using  $^{238}\text{U}/^{235}\text{U}$  ratios to Track Oxidation of U(IV) from Biostimulated and Naturally Reduced Sediments"*

Advisor: Prof. Thomas M. Johnson

**3. Hadley McIntosh**

(University of Maryland)

*"Source and age variability of methane in lakes in the Mackenzie River Delta"*

Advisor: Dr. Laura Lapham



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**Reception in honor of David Dawdy***Leonard Sklar and Stephen Burges*

David Dawdy is a distinguished hydrologist, with over 60 years of experience in research, teaching and consulting. He began his career at the USGS surface water branch in 1951, working with Luna Leopold and Walter Langbein. He has made fundamental contributions to many topics in hydrology, including flood frequency analysis, hydrologic modeling, worth of hydrologic data and data network design for various water resource inventory purposes as well as scientific hypothesis testing, characterizing resistance to flow in alluvial channels, mapping flood hazard zones on alluvial fans, and urban hydrologic modeling practice. The author of over 100 papers in hydrology, he has received numerous honors, including the Ven Te Chow Award and the Arid Lands Hydraulic Engineering Award from the ASCE, and the Ray K. Linsley Award from the American Institute of Hydrology (AIH), and was named a Fellow of the AGU in 1990. He has served on the AGU committees on surface water, sedimentation and the history of hydrology, and served for 12 years on the editorial board of the AGU Water Resources Monograph Series. He was instrumental in initiating the AGU History of Hydrology Interview series starting in 1995. David Dawdy received a MS in Statistics from Stanford University and a BA in History from Trinity University, and was on the faculty of the Civil Engineering Department at Colorado State University.

*Please come to a***Reception in Honor of David Dawdy**

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On the occasion of David's 90<sup>th</sup> birthday,  
we gather to celebrate David's career in  
hydrology and his support for hydrology at  
San Francisco State University

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**When:**

Monday, Dec. 12, 2016  
6:00 – 7:30pm

**Where:**

SFSU Downtown Campus  
835 Market Street, Rm. 609  
(SW Corner @ 4<sup>th</sup> St.)

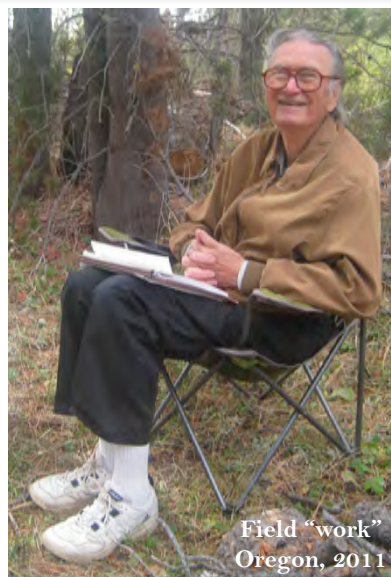
**Refreshments:**

Celebratory beverages  
Light hors d'oeuvres

**What to bring:**

Friends, stories, problems to solve

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**Host Committee:**

Leonard Sklar, Steve Burges, Bill Dietrich, Tom Dunne  
SFSU College of Science and Engineering  
Questions? Email: [leonard@sfsu.edu](mailto:leonard@sfsu.edu)