Alma Mater Studiorum
University of Bologna

European Geosciences Union
General Assembly 2018

Hydrology is Important

Ten Propositions to Promote Water Science

2018 Henry Darcy Medal Lecture

Henry Philibert Gaspard Darcy
1803 – 1858

Alberto Montanari
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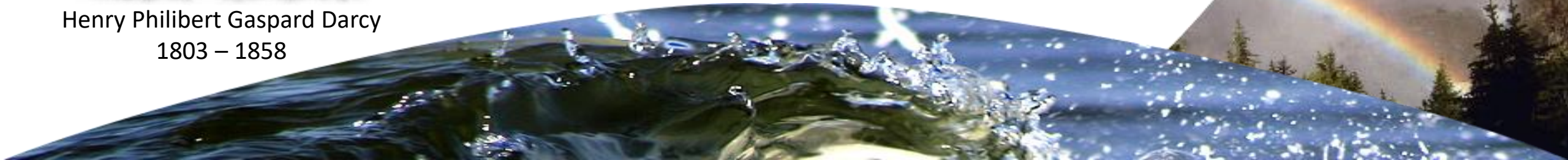


The most distinguished behaviors and ideas often look obvious

Pietra di Bismantova – Reggio Emilia – Italy

Proposition #1

Hydrology is important: a trivial statement!

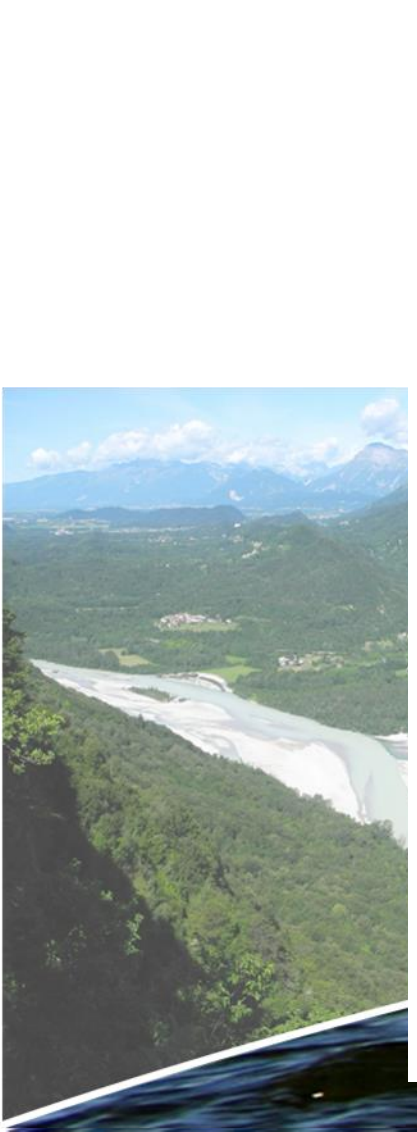
Five facts to prove the essential role of hydrology in ensuring sustainable development:

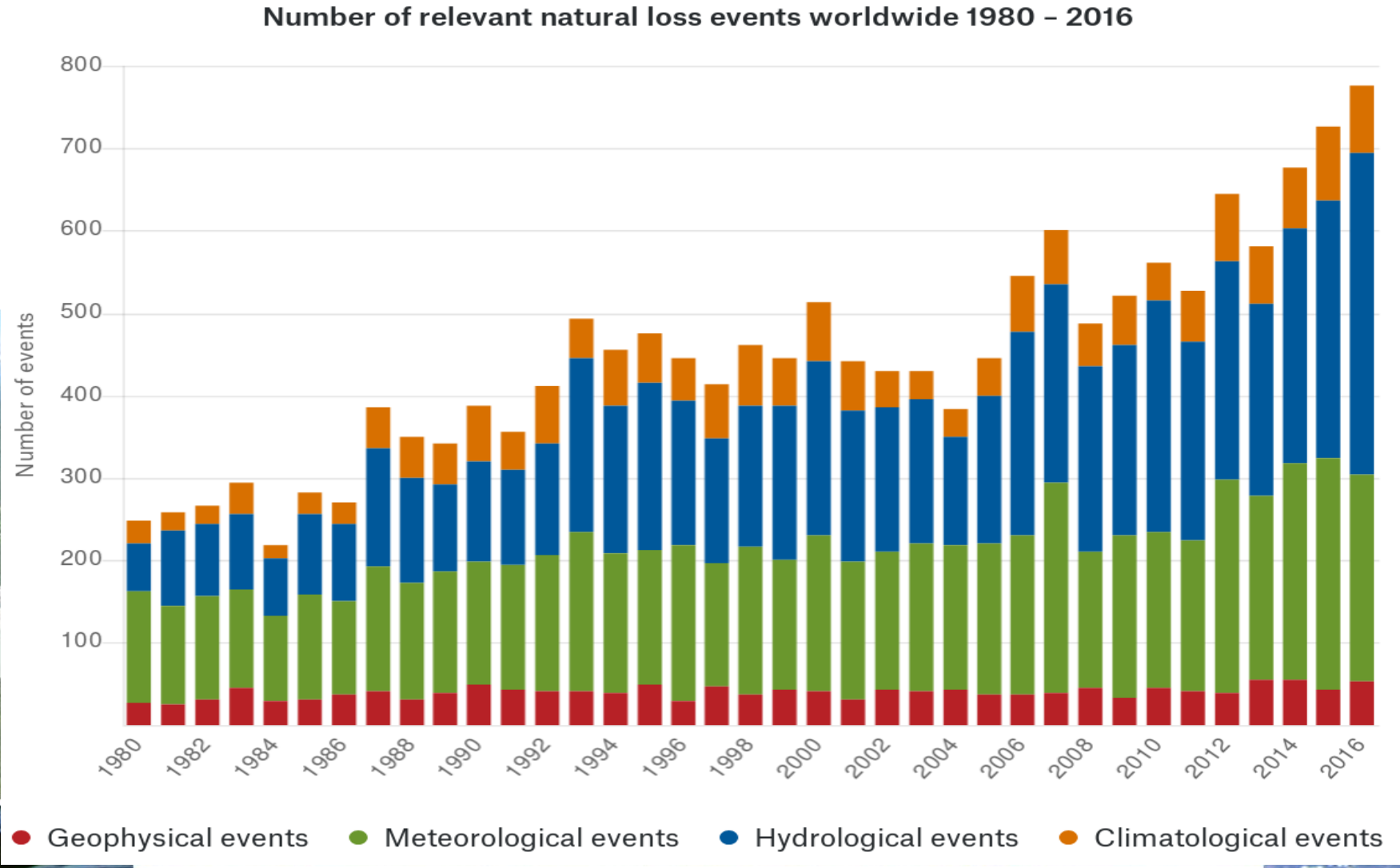
This presentation is available at the web address http://www.albertomontanari.it – E-mail: alberto.montanari@unibo.it

Hydrology is important: a trivial statement!

Five facts to prove the essential role of hydrology in ensuring sustainable development:

- Economic losses from hydrological extreme events, and the number of reported events are steadily increasing;





Data from Munich Re

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Hydrology is important: a trivial statement!

Five facts to prove the essential role of hydrology in ensuring sustainable development:

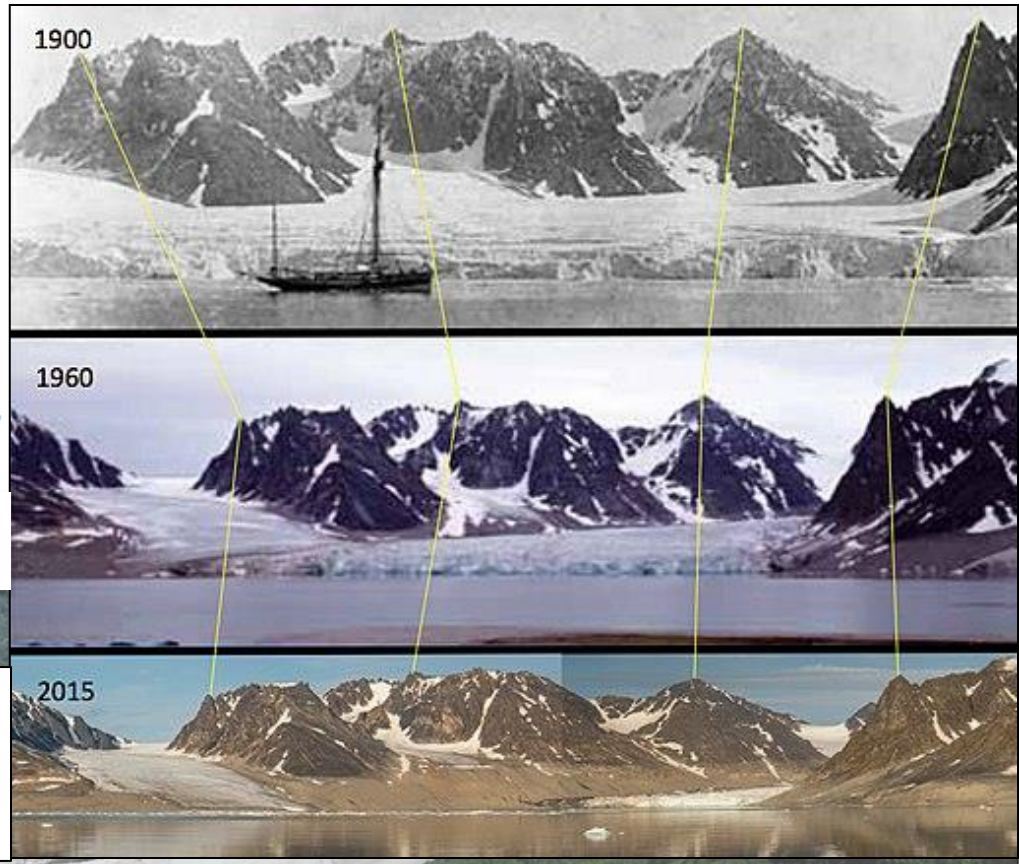
- Economic losses from hydrological extreme events, and the number of reported events are steadily increasing;
- Hydrology is the interface between humans and climate. Climate change affects humans through the filter operated by hydrology;

Hydrol. Earth Syst. Sci., 19, 379-387, 2015
https://doi.org/10.5194/hess-19-379-2015

Research article

Climate and hydrological variability: the catchment filtering role

I. Andrés-Doménech[1], R. García-Bartual[1], A. Montanari[2], and J. B. Marco[1]
[1]Instituto Universitario de Investigación de Ingeniería del Agua y Medio Ambiente, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain
[2]Facoltà di Ingegneria, Università di Bologna, Via del Risorgimento 2, 40136 Bologna, Italy



Retreat of the glacier Waggonwaybreen at Magdalenfjord on Svalbard.
By Andreas Weith (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

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- Economic losses from hydrological extreme events, and the number of reported events are steadily increasing;
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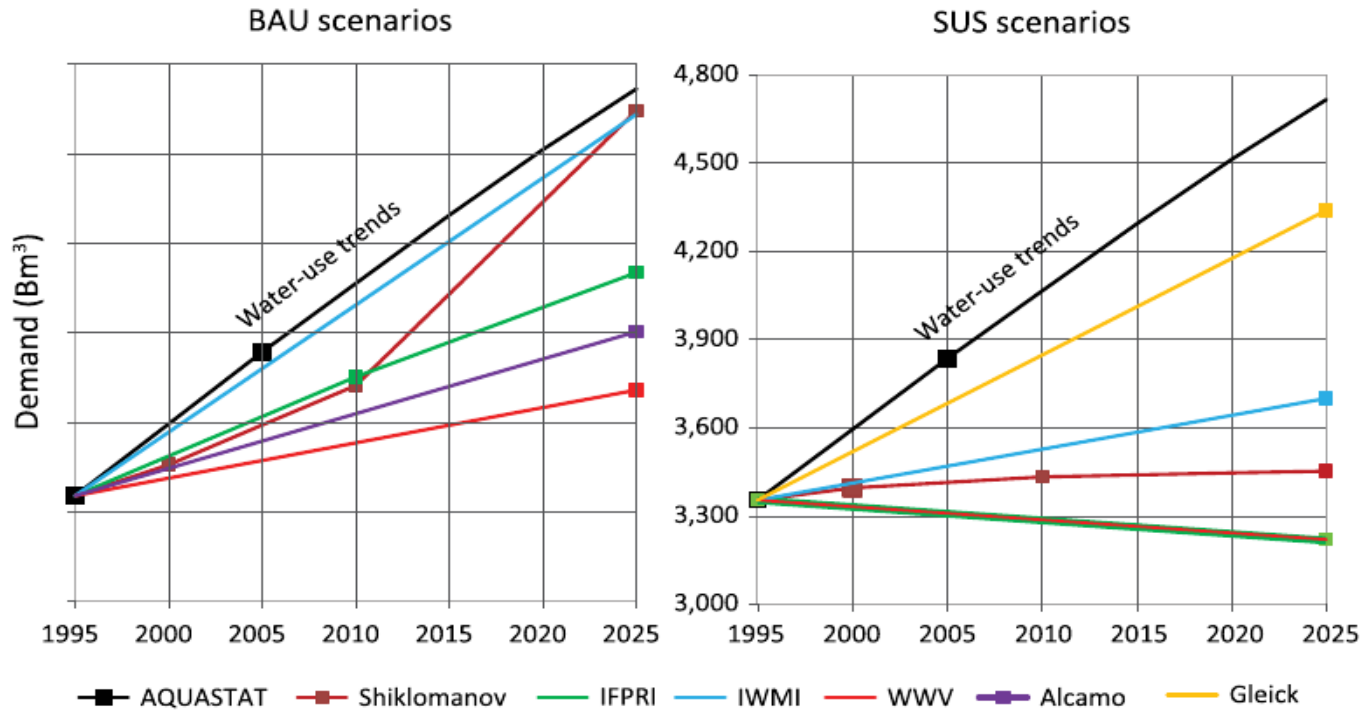
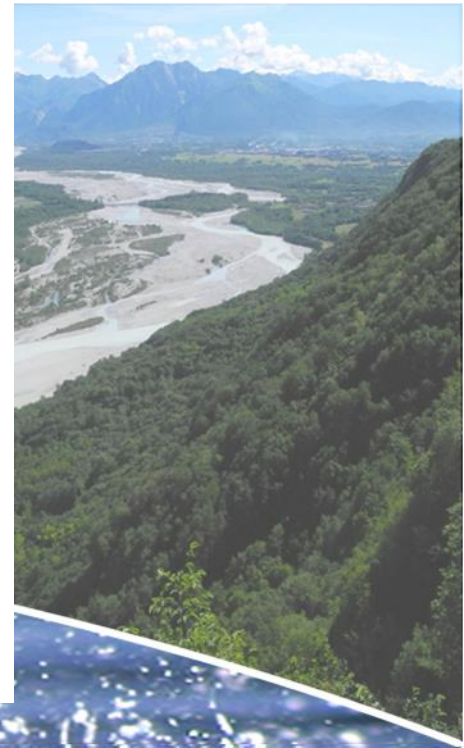
- Projections of water demands point out an uncertain future situation (Amarasinghe & Smakhtin, 2014);



Sources: AQUASTAT data for 1995 and 2005 are from FAO 2012a; AQUASTAT 2000 and 2015-2025 data are authors' estimates. BAU scenario and SUS values are based on Table 1 (with further adjustments as noted above).



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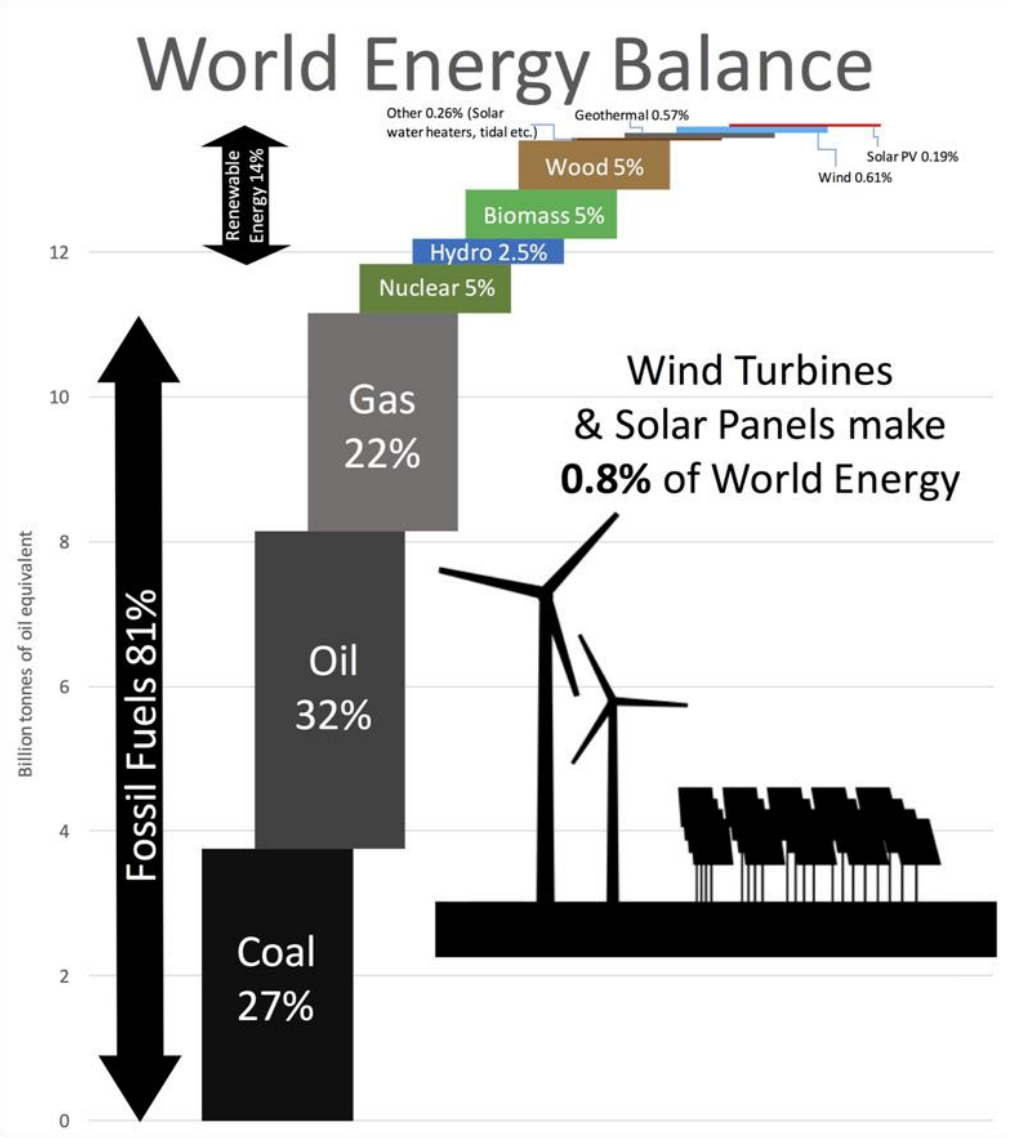
- Projections of water demands point out an alarming future situation (Amarasinghe & Smakhtin, 2014);
- Hydropower has an essential role in storing energy and covering world's energy consumption (see Koutsoyiannis et al., 2009);



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Hydrology is important: a trivial statement!

Five facts to prove the essential role of hydrology in ensuring sustainable development:

- Hydrological extreme events are steadily increasing in terms of number and economic losses;
- Hydrology is the interface between humans and climate. Climate change affects human through the filter operated by hydrology;
- Projections of water demands point out an alarming future situation (Amarasinghe & Smakhtin, 2014);
- 2.5% of world's energy consumption is covered by Hydropower (Koutsoyiannis et al., 2009);
- Increasing irrigation and groundwater depletion may impact water and food security (video by NASA's Scientific Visualization Studio, http://svs.gsfc.nasa.gov/4523; see Dalin et al., Nature 543, 2017).

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Hydrology is indeed important !

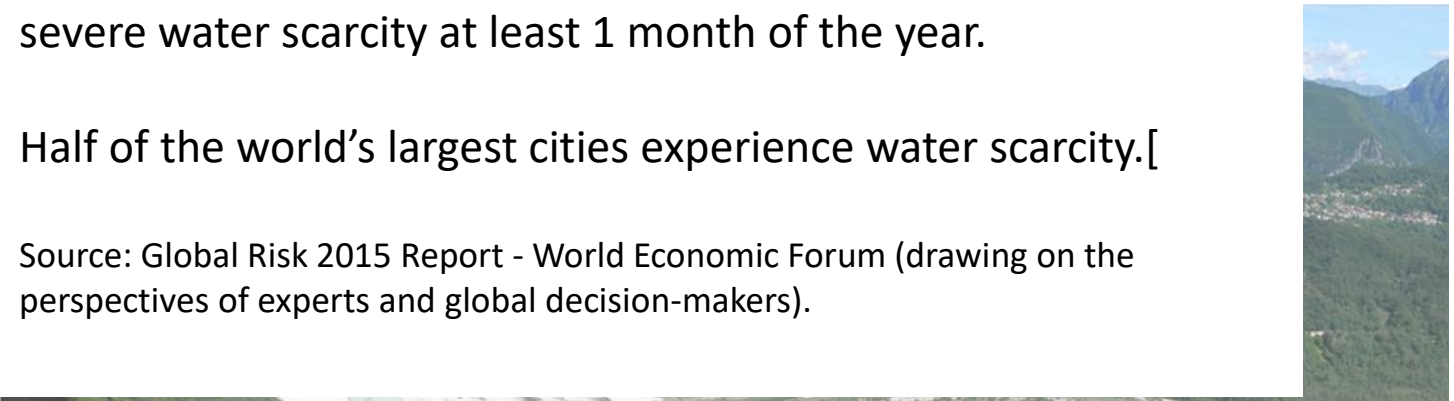
According to the Global Risk 2015 Report of the World Economic Forum, **global water crises** are the biggest threat facing the planet over the next decade.

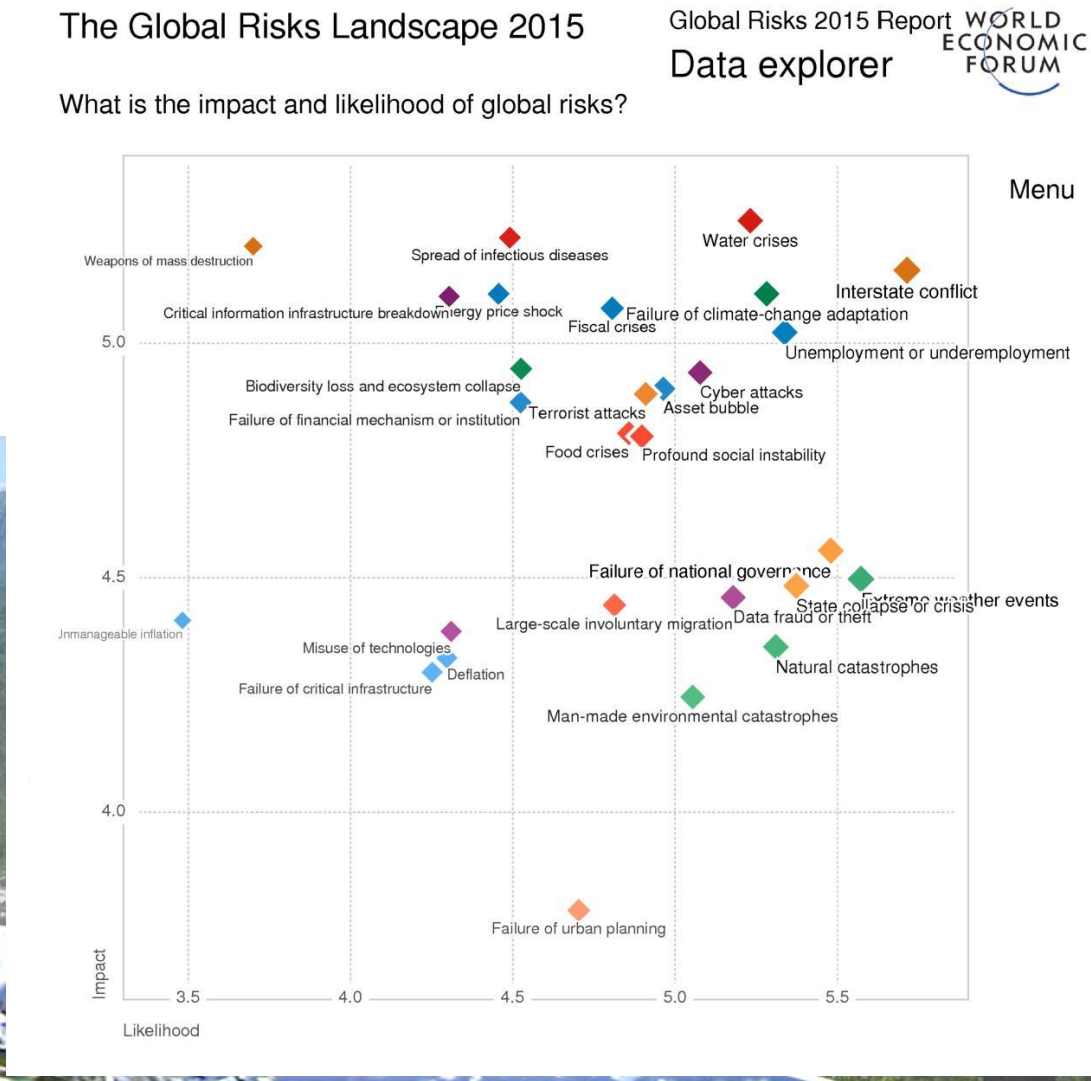
For the first time water is at the top position for impact.

Two-thirds of the global population live under conditions of severe water scarcity at least 1 month of the year.

Half of the world's largest cities experience water scarcity.[

Source: Global Risk 2015 Report - World Economic Forum (drawing on the perspectives of experts and global decision-makers).



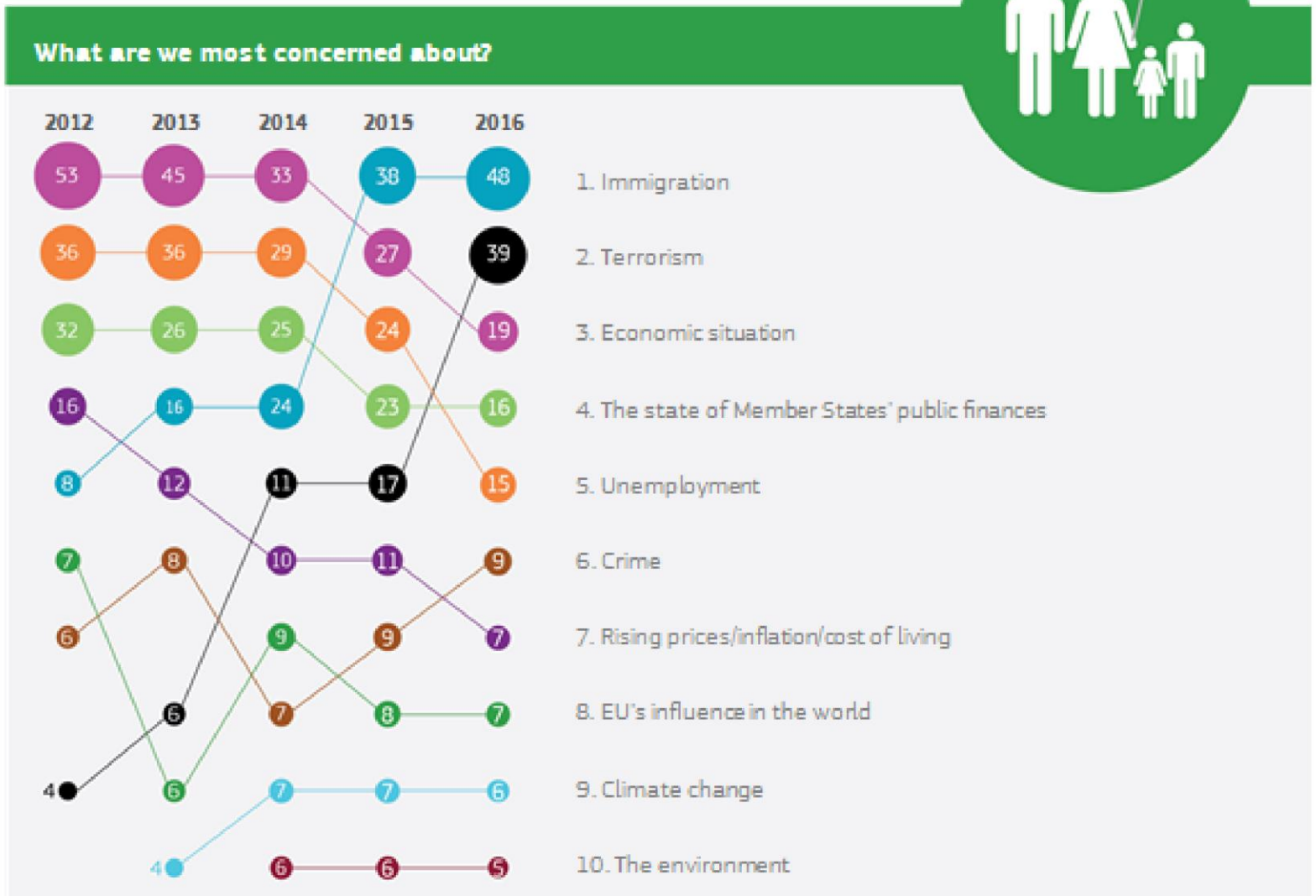


Is hydrology perceived as important by the public?

It seems not, basing on The Chapman University Survey of American Fears 2017 (https://blogs.chapman.edu/wilkinson/2017/10/11/americas-top-fears-2017/).

There is concern about water pollution, but there are no fears at all regarding water security, drought and flood risk, and associated social tensions.

A similar situation is highlighted by the "Reflection paper on the future of European defence" (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52017DC0315) published by the European Commission. (Katainen & Mogherini, 2017).

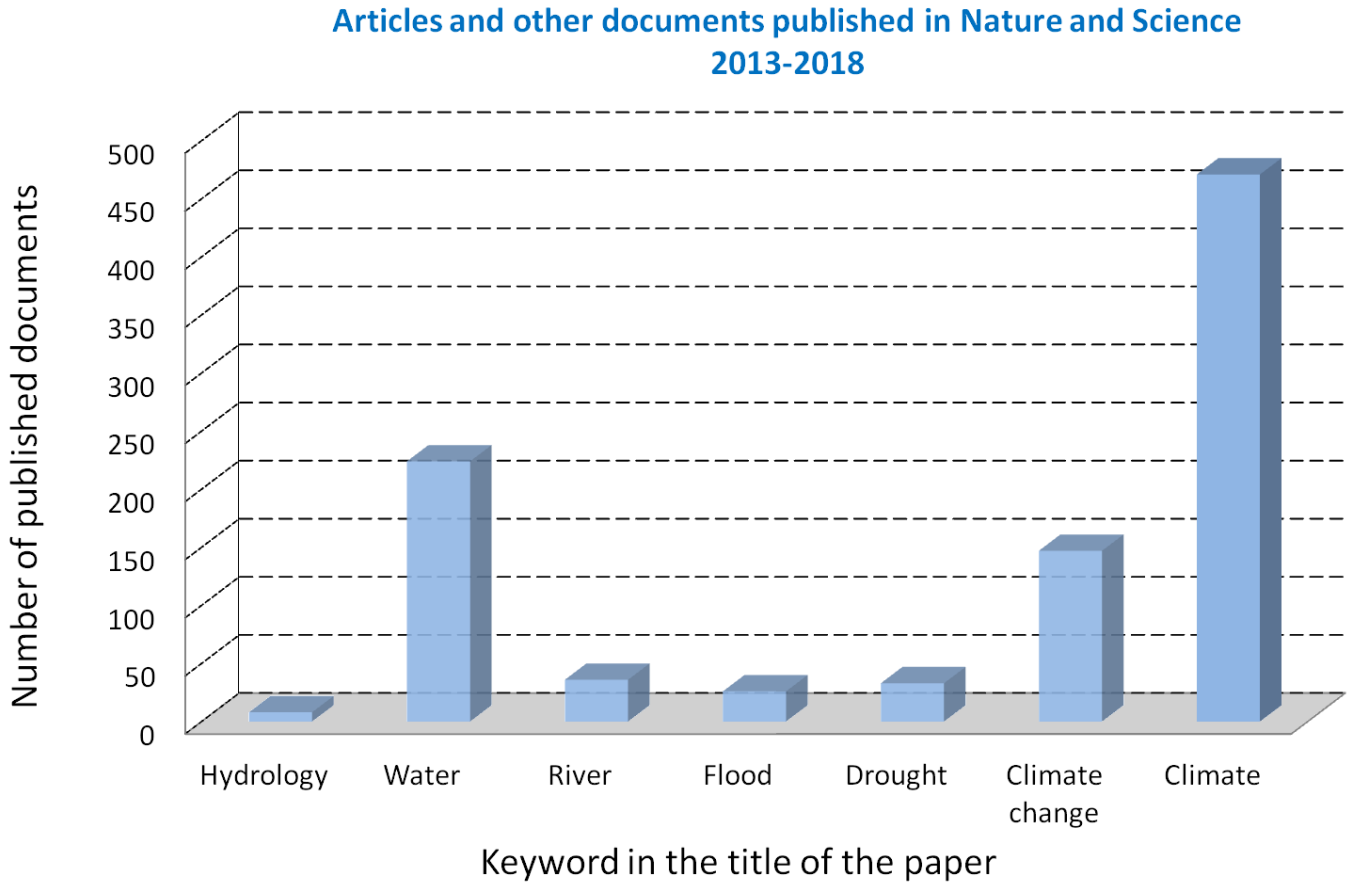


Is hydrology perceived as important by the public?

Search for keywords in the title of articles and other documents published in Nature and Science, during the period 2013-2018
(search performed on March 1st, 2018)

Hydrology:	8 papers, H index = 4
Water:	224 papers, H index = 50
River:	36 papers, H index = 9
Flood:	26 papers, H index = 7
Drought:	33 papers, H index = 13
Climate change:	147 papers, H index = 34
Climate:	471 papers, H index = 54

Climate: 9730 citations, 8450 citing articles;
Water: 10904 citations, 9788 citing articles.



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It is not yet clear what the research priorities are for ensuring environmentally sustainable human development. Science needs to seek credibility through objectivity.

Passo Sella – Dolomites – Italy

Proposition #2

Why is the importance of hydrology underperceived?

Four reasons why the role of hydrology is underestimated by the public and administrations:

The hydrological community is not unified enough;

- ✓Is there too much competition within the hydrological community?
- ✓Competition may be beneficial to science, but nowadays scientists work in an environment of relentless stress, time pressure, and insecurity, factors that are counterproductive to good science.
- ✓We need to make an effort to unify the community. Earth Science is not an individual effort. Most science today would benefit from a radically different structure that promotes cooperation, collaboration, and creativity.
- ✓Useful measures may include changing the criteria for professional advancement, with an emphasis on common rather than individual goals and a reduced emphasis on publication in prestigious venues.

Adapted from Cieresek - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=50150253

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An interesting example where community made the difference

Hydrological Sciences Journal – Journal des Sciences Hydrologiques, 2013
http://dx.doi.org/10.1080/02626667.2013.809088

"Panta Rhei—Everything Flows": Change in hydrology and society—The IAHS Scientific Decade 2013–2022

A. Montanari[1], G. Young[2], H. H. G. Savenije[3], D. Hughes[4], T. Wagener[5], L. L. Ren[6], D. Koutsoyiannis[7], C. Cudennec[8], E. Toth[1], S. Grimaldi[9], G. Blöschl[10], M. Sivapalan[11], K. Beven[12], H. Gupta[13], M. Hipsey[14], B. Schaefli[15], B. Arheimer[16], E. Boegh[17], S. J. Schymanski[18], G. Di Baldassarre[19], B. Yu[20], P. Hubert[21], Y. Huang[22], A. Schumann[23], D. A. Post[24], V. Srinivasan[25], C. Harman[26], S. Thompson[27], M. Rogger[10], A. Viglione[10], H. McMillan[28], G. Characklis[29], Z. Pang[30] and V. Belyaev[31]

Fig. 2 Examples of interaction between environmental and human systems.

Why is the importance of hydrology underperceived?

Four reasons why the role of hydrology is underestimated by the public and administrations:

- The hydrological community is not unified enough;

✓Is there too much competition within the hydrological community?

✓Competition may be beneficial to science, but nowadays scientists work in an environment of relentless stress, time pressure, and insecurity, factors that are counterproductive to good science.

✓We need to make an effort to unify the community. Earth Science is not an individual effort. Most science today would benefit from a radically different structure that promotes cooperation, collaboration, and creativity.

✓Useful measures may include changing the criteria for professional advancement, with an emphasis on common rather than individual goals and a reduced emphasis on publication in prestigious venues.

✓Unselfish scientific acts such as mentoring and making useful reagents and information available to the community should be recognized.

✓Defining joint goals promotes cohesion in the community, just as Hilbert's definition of 23 unsolved problems in 1900 helped to galvanize the efforts of mathematicians.

See: Explorable.com (Aug 11, 2009). Competition in Science. Retrieved Mar 05, 2018 from Explorable.com: https://explorable.com/competition-in-science
Fang, F. C., & Casadevall, A. (2015). Competitive science: is competition ruining science?, Infect. Immun. April 2015 vol. 83 no. 4 1229-1233.

IAHS initiatives: PUB, Panta Rhei and Unsolved Problems in Hydrology

What are the 23 unsolved problems in Hydrology that would revolutionise research in the 21st century?

Published on November 15, 2017

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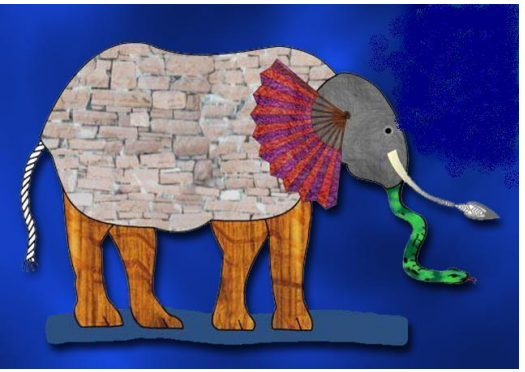

Panta Rhei
IAHS AISH
Everything Flows
Change in Hydrology and Society

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Unsolved Problems in Hydrology - Join the Conversation

In November 2017 IAHS launched the new initiative to generate the 23 unsolved problems in Hydrology that would revolutionise research in the 21st century with a YouTube video.

The generation of questions is open to everyone and will be distilled through discussion on the IAHS LinkedIn group https://www.linkedin.com/groups/13552921 We aim to finalise the questions in Spring 2018.

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Why is the importance of hydrology underperceived?

Four reasons why the role of hydrology is underestimated by the public and administrations:

- The hydrological community is not unified enough;
- Hydrologists do not disseminate and communicate well;

✓Scientific journals for hydrology have limited impact – They are too specific;

✓No convincing alternative to journal publishing has appeared so far in Hydrology; (Koutsoyiannis & Kundzewicz, 2007)

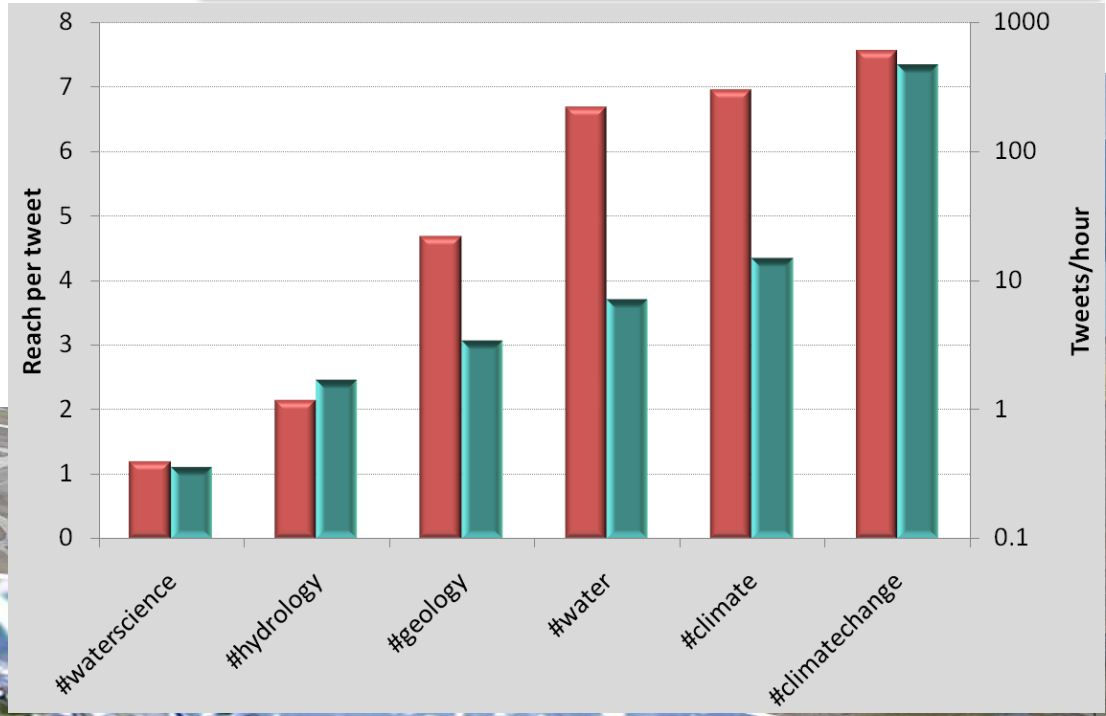
✓Use of blogs and "modern" communication means (socials, etc) is limited;

✓The dialog with stakeholders and administrations is not developed as the importance of our research would need and deserve;

✓We need to make hydrology more "social". This is one challenge where the cooperation of social scientists is essential.

Twitter search for (last 100 tweets):

#hydrology:	1.2	tweet/h;	2.47 reach per tweet;
#waterscience:	0.4	tweet/h;	1.11 reach per tweet;
#water:	222.2	tweet/h;	3.71 reach per tweet;
#geology:	22.2	tweet/h;	3.07 reach per tweet;
#climate:	303.0	tweet/h;	4.35 reach per tweet;
#climatechange:	606.6	tweet/h;	7.34 reach per tweet;



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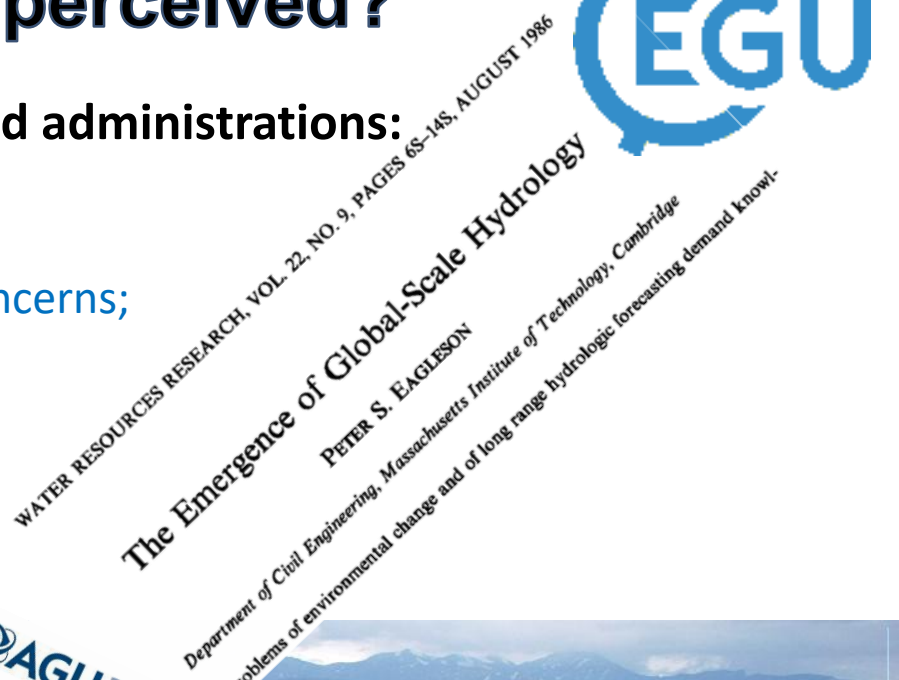
- The hydrological community is not unified enough;
- Hydrologists do not disseminate and communicate well;
- The research agenda of hydrology is not convincingly addressing current global concerns;

✓Classical hydrology focuses on local problems; global scale hydrology was introduced 30 years go, but most contributions still focus on the catchment scale;

✓While there are good reasons for solving technical problems at the local level, an effort need to be made to better model the global water cycle and water resources;

✓While enlarging the modeling scale, hydrology should maintain a rigorous approach to model validation. Hydrologists have a consolidated experience in rigorously benchmarking models with observations;

✓Humans need to be informed; when managing water there cannot be room for sensationalism, distortion, and overstatement.



Hydrology implies uncertainty which we do not convincingly deal with and communicate.

Monte Cusna, Appennines, Italy

Proposition #3

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- The hydrological community is not unified enough;
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- The research agenda of hydrology is not convincingly addressing current global concerns;
- Hydrology implies uncertainty which we do not convincingly deal with and communicate.

✓Hydrologists know well what uncertainty is; in the context of geosciences, we have a unique experience of benchmarking simulations and predictions with the real world (Gupta et al., 2008);

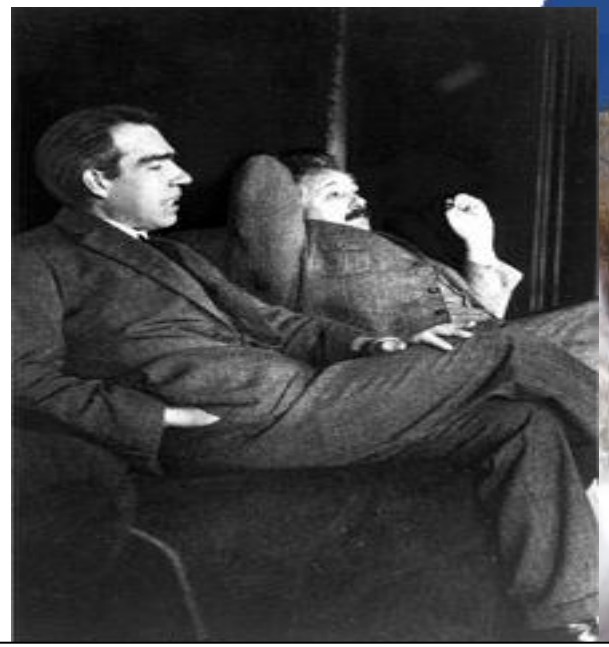
✓However, is uncertainty in hydrology epistemic (related to lack of knowledge) or intrinsic? Will uncertainty be eliminated in the future? Uncertainty is often presented as a limitation, rather than an intrinsic property.

✓"Hydrology…must move towards …. by radically rethinking its fundamentals, which are unjustifiably trapped in the 19th-century myths of deterministic theories and the zeal to eliminate uncertainty"(Koutsoyiannis, 2009).

On the nature of uncertainty

An interesting reading: the Bohr-Einstein debates on quantum mechanics (https://en.wikipedia.org/wiki/Bohr-Einstein_debates).

- ✓In 1926 Max Born proposed that a particle's position in quantum mechanics was to be understood as a probability without any causal explanation.
- ✓In a 1926 letter to Max Born, Einstein wrote: "I, at any rate, am convinced that He [God] does not throw dice."
- ✓Einstein did not reject the idea that positions in space-time could never be completely known but did not want to allow the uncertainty principle to necessitate a seemingly random, non-deterministic mechanism by which the laws of physics operated.
- ✓Can we locate a drop of water in a catchment through a deterministic law? Or should we better describe it through probability?

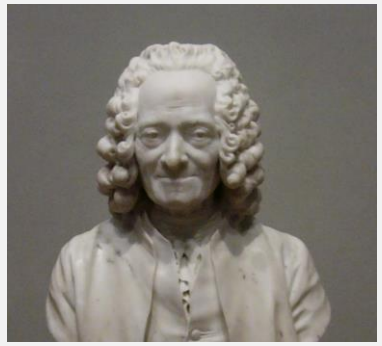


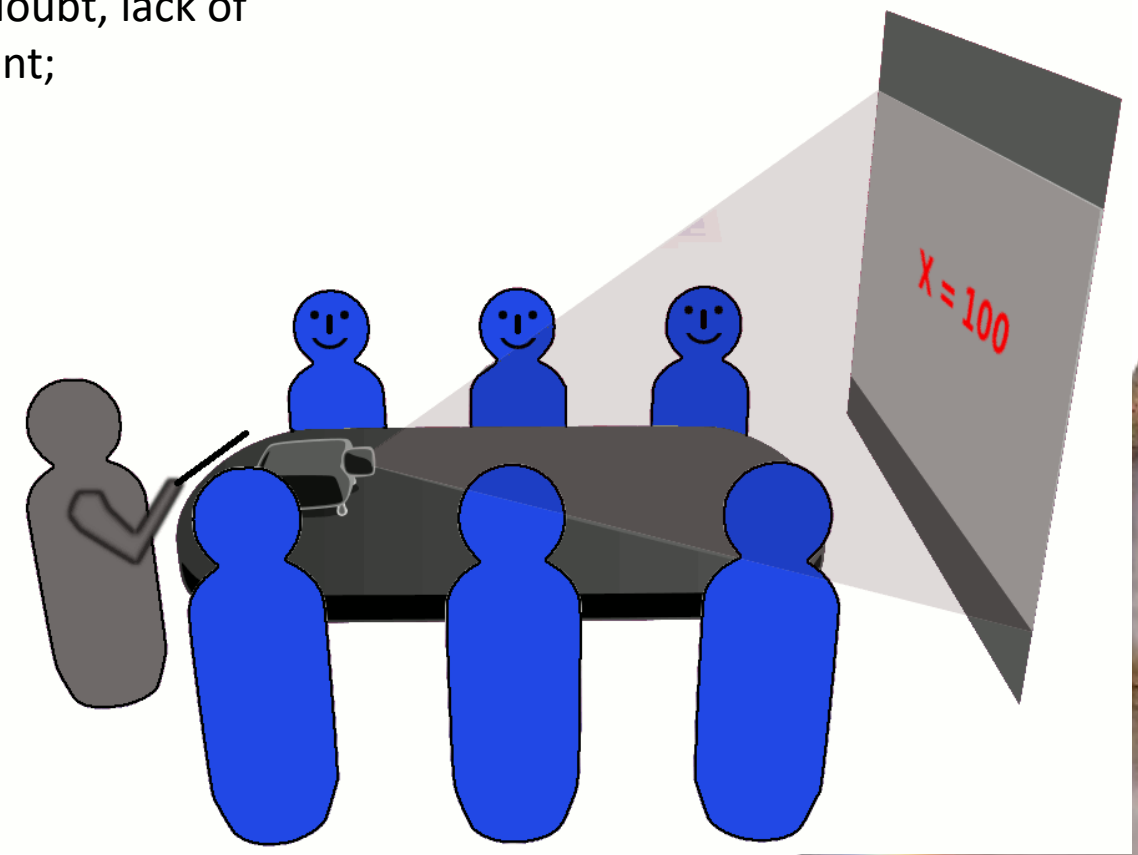
Niels Bohr with Albert Einstein at Paul Ehrenfest's home in Leiden (December 1925; https://en.wikipedia.org/wiki/Bohr%E2%80%93Einstein_debates)

Why hydrology needs to get to the top of uncertainty

- ✓Public does not like uncertainty. Public likes crystal clear predictions;
- ✓Uncertainty (and probability) is associated to insecurity, doubt, lack of understanding, failure of science, possible mismanagement;

"Uncertainty is an uncomfortable position. But certainty is an absurd one"
Voltaire, 1694 - 1778



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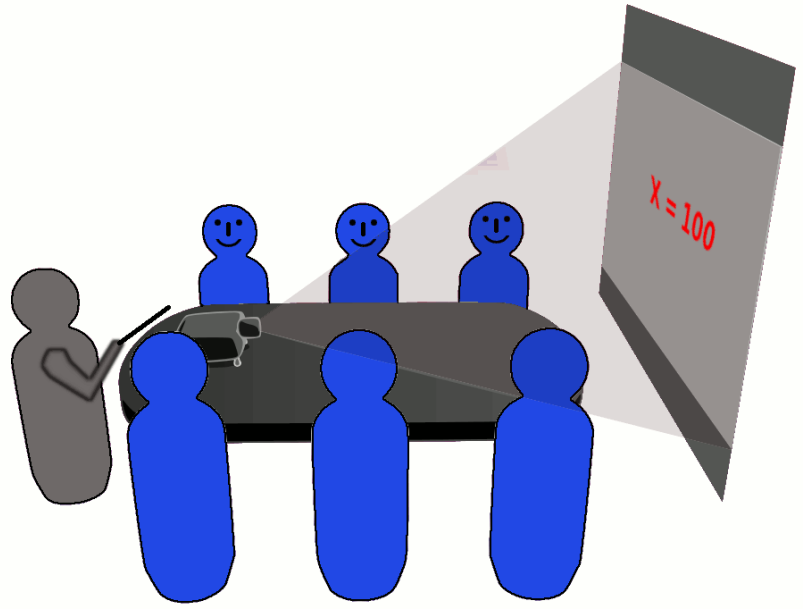
Why hydrology needs to get to the top of uncertainty

- ✓Public does not like uncertainty. Public likes crystal clear predictions;
- ✓Uncertainty (and probability) is associated to insecurity, doubt, lack of understanding, possible mismanagement;
- ✓Hydrologists generally second this interpretation by admitting that predictions are imprecise. Actually, our predictions are among the most reliable in the geosciences;
- ✓Uncertainty is an inherent behaviour of hydrology. While hydrology is driven by dynamical systems that may be known in detail, they cannot be described deterministically for the presence of chaos, unobservability of control volume and boundary conditions etc. Uncertainty is an attribute of information (Zadeh, 2005); neglecting uncertainty implies discarding part of the information;
- ✓Deterministic predictions are not merely stochastic predictions without uncertainty bounds. If a system is affected by randomness, deterministic predictions are wrong;
- ✓ Beven, K. (2008). On doing better hydrological science. Hydrological processes, 22(17), 3549-3553.



Hydrology should understand uncertainty through physical reasoning. Uncertainty is part of Nature (not a weakness of Science).

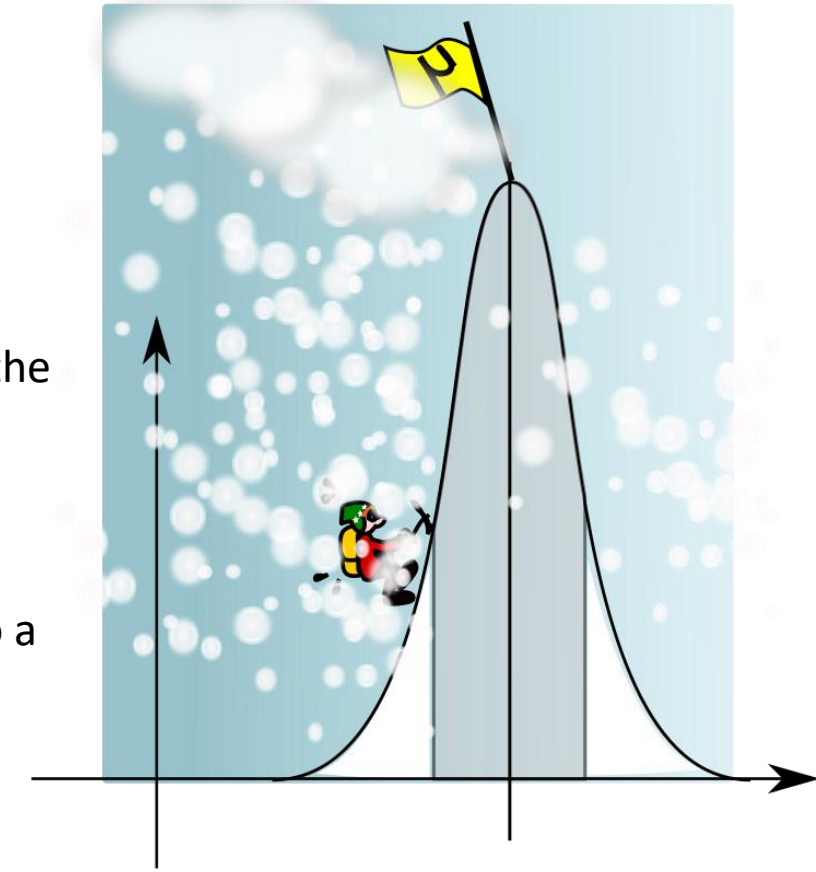
Cima 11, Fassa Valley, Dolomites, Italy

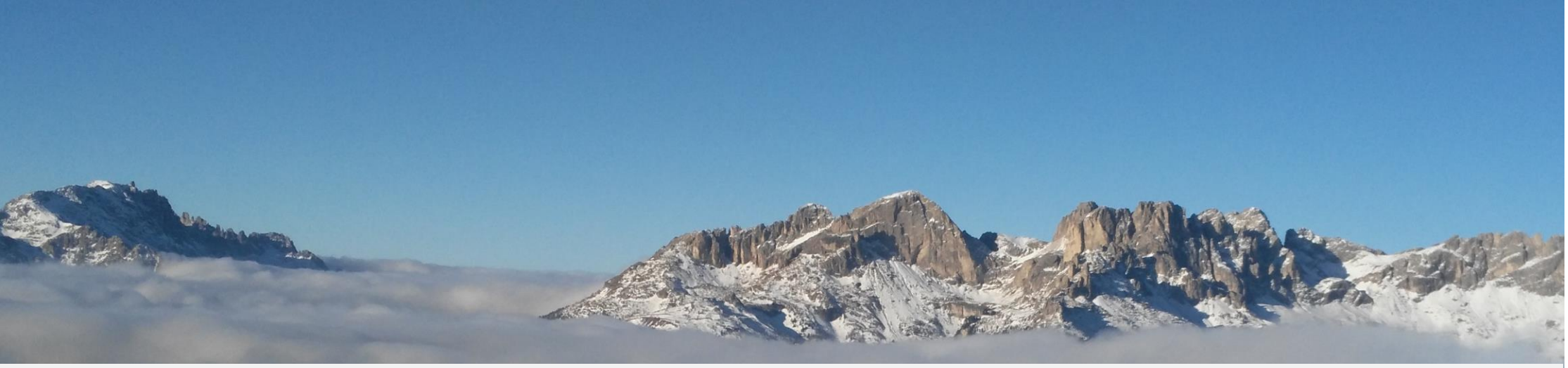
Proposition #4

A climbing route to the top

Positive premises:

- ✓Predictions are uncertain by definition;
- ✓Uncertainty is an intrinsic feature of water science; it means awareness and understanding of the system;
- ✓Uncertainty assessment needs to be process (physical chemical, ecologic) based; assessing the physical basis of uncertainty is an exciting research endeavor. It opens the door to several avenues of new and unexplored research!
- ✓The theoretical basis for uncertainty assessment in hydrology are fully established. Several options are available.
- ✓Uncertainty assessment is a distinguishing feature of hydrological research: thanks to a long experience in model benchmarking, we have a unique capability to present predictions along with their reliability. This is an immensely valuable asset.





Objective and transparent uncertainty assessment and communication is the way forward to cope with change.

Roda di Vael, Fassa Valley, Dolomites, Italy

Proposition #5

A theoretical blueprint
Physically-Based Stochastic Modelling

A blueprint for process-based modeling of uncertain hydrological systems

Alberto Montanari[1] and Demetris Koutsoyiannis[2]

Received 16 September 2011; revised 19 August 2012; accepted 20 August 2012; published 29 September 2012.

Hydrological model in a deterministic framework:

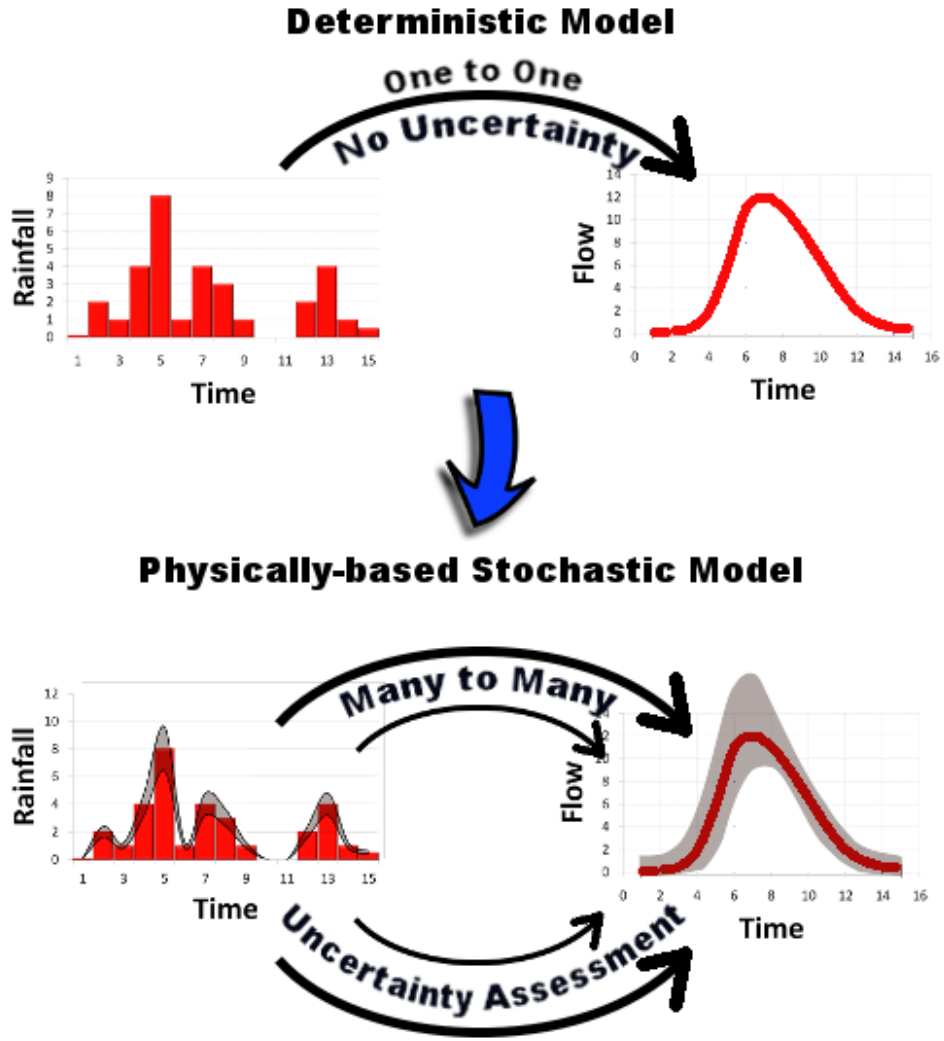
$$Q_p = S(\Theta, \mathbf{X})$$

Q_p model prediction;
S model structure
X input data vector
Θ parameter vector.

Hydrological model in a stochastic framework:

$$f_{Qp}(Q_p) = K\, f_{\Theta, \mathbf{X}}(\Theta, \mathbf{X})$$

where f indicates the probability density function, and K is a transfer operator that depends on model *S*.



A theoretical blueprint
Physically-Based Stochastic Modelling

Symbols:

- Q_p Predicted value of the true hydrological variable
- $S(\Theta,\mathbf{X})$ Deterministic hydrological model
- $e = Q_p - S(\Theta, \mathbf{X})$ Model error
- Θ Model parameter vector
- $\mathbf{X}$ Input data vector
- $f_e(Q_p - S(\Theta, \mathbf{X}))$ Probability distribution of model uncertainty ;

From the deterministic formulation:

$$Q_p = S(\Theta, \mathbf{X})$$

to the physically-based stochastic formulation:

$$f_{Q_p}(Q_p) = \iint_{\Theta,\mathbf{X}} f_e(Q_p - S(\Theta, \mathbf{X}))\, f_\Theta(\Theta)\, f_X(\mathbf{X})\, d\Theta\, d\mathbf{X}$$

Assumptions:

1) Model uncertainty independent of input/output data and parameters.
2) Prediction with additive form.
3) Other assumptions are necessary to compute f_e.

Model uncertainty: resembles the random component of the process. It depends on model S

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A theoretical blueprint
Physically-Based Stochastic Modelling

An example of application: model is generic and possibly physically-based. Let us assume that probability distributions of model input, model uncertainty and parameters are known.

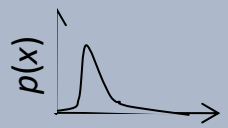
Repeat j times

Pick up a parameter vector Θ from the model parameter space according to probability $f_{\Theta}(\Theta)$

Pick up an input vector **X** from the input space according to probability $f_{\Xi}(\mathbf{X})$

Compute model output and add n realisation of model error from probability distribution $f_e(Q_p - S(\Theta, \mathbf{X}))$

Obtain n • j points lying on $f_{Qp}(Q_p)$ and infer the probability distribution



Key issue: to estimate $f_e(Q_p - S(\Theta, \mathbf{X}))$

A blueprint for process-based modeling of uncertain hydrological systems

Alberto Montanari[1] and Demetris Koutsoyiannis[2]

Received 16 September 2011; revised 19 August 2012; accepted 20 August 2012; published 29 September 2012.

Model uncertainty: the key to decipher process randomness

- ✓Model uncertainty can be viewed as the probability distribution of the discrepancy between simulation and Nature. It may be non-stationary;
- ✓Model uncertainty can be physically explained. Finding such physical explanation is a challenging task and an exciting research endeavor;
- ✓What may condition model uncertainty?
  - Catchment morphology, geology and hydrology (aridity, imperviousness, etc.);
  - Climate and climate change;
  - Anthropogenic effects and human impact.
- ✓Exploring the physical basis for model uncertainty is relatively easy, through **model validation** and deep learning (Quilty et al., 2016).

Random walk. By László Németh (Own work) [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)], via Wikimedia Commons

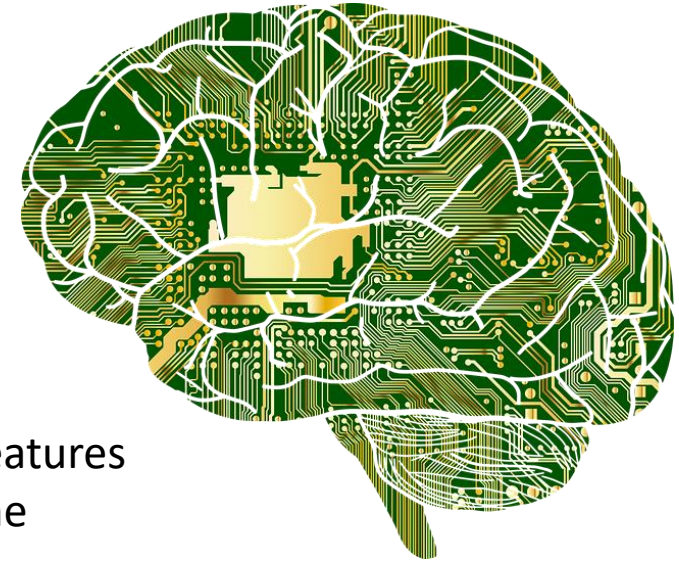
Estimating the Uncertainty of Hydrological Predictions through Data-Driven Resampling Techniques

Anna E. Sikorska[1]; Alberto Montanari[2]; and Demetris Koutsoyiannis[3]

Abstract: Estimating the uncertainty of hydrological models remains a relevant challenge in applied hydrology, mostly because it is not easy

Exploring the physical basis of model uncertainty

- ✓Recognizing randomness and its physical basis paves the way to an efficient and revolutionary communication of predictability in hydrology and environmental sustainability in the 21st century.
- ✓Deep learning is an opportunity to decipher to what extent a signal can be explained by a deterministic relationship. Deep learning may help to assess when a model (and a hydrologist) has fulfilled its task. An interesting example is the Gamma Test (Elshorbagy et al., 2010). See also Shen et al., under discussion in HESSD, 2018.
- ✓Recognizing randomness is especially relevant to decipher the feedbacks between hydrology and society. They cannot be described deterministically.
- ✓There is an upper limit to model performances that is determined by the hydrological features of the catchment (including climate and human impact). No matter the complexity of the model, uncertainty cannot be reduced beyond a limit that is dictated by the considered process.
- ✓The very reason why performances of hydrological models in some cases do not improve despite increasing information and model complexity is that randomness cannot be explained deterministically.



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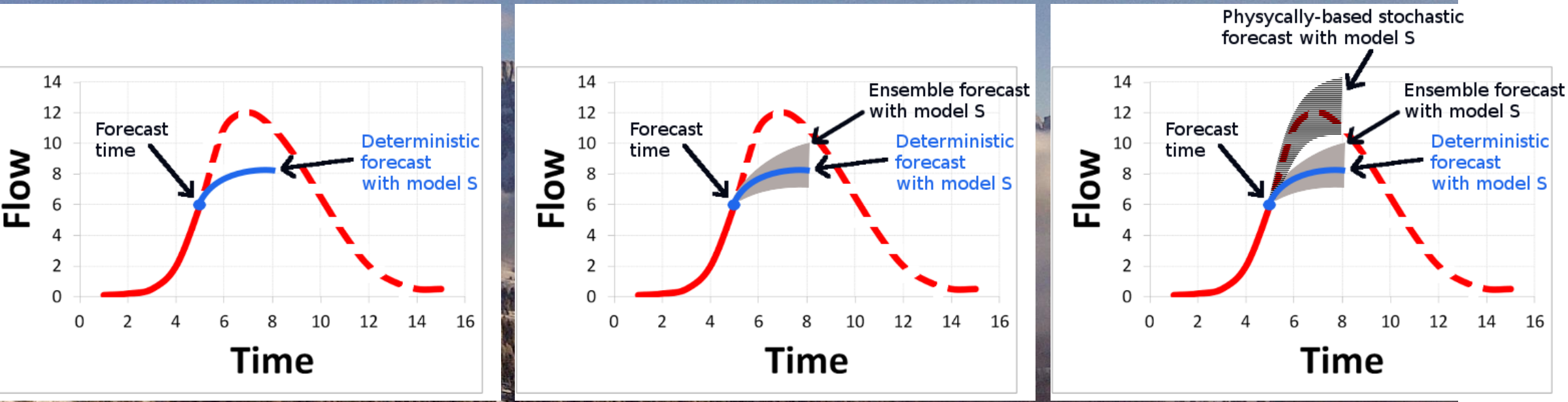
Attempts to explain randomness through deterministic relationships lead to misintepretation, overfitting, and eventually mistaken predictions.

Ensemble predictions by deterministic models may not provide a consistent estimate of prediction uncertainty.

A sketch derived from a case study:



Pale di San Martino, Dolomites, Italy

Proposition #6

Communication is essential!

- ✓We need a new approach to communicate our science, uncertainty and findings: we urgently need a paradigm change to convey that we do have clear ideas, methods and predictions.
- ✓We need to recognize the efforts of early career and established scientists that are successful in public engagement.
- ✓Communication is where we need the support of social sciences: we need new ideas for interacting with the public, administrations and stakeholders in general. We need to make the best use of modern communication means.
- ✓EGU pioneered innovative forms of scientific publishing: let's continue along this way. We need to take the lead to stimulate a transformation of the peer review process. We cannot use the same peer review model that was introduced 300 years ago. Peer review is biased and not responding to increasing need of efficiency and objectivity.
- ✓"Online scientific interaction outside the traditional journal space is becoming more and more important to academic communication" (Hendler, 2008).
- ✓We need to take a clear position.

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Quarta Torre di Sella, Gluck route,
Dolomites, Italy

Proposition #7

Hydrologists should take a clear position within the debate on global change and sustainability.

Is water cycle affected by global warming and how? Is extreme rainfall increasing under climate change? What are the main reasons why water scarcity and flood risk are globally increasing? Is global warming more important with respect to demographic expansion and land use change? What is the uncertainty of our conclusions?

We need to present a coherent assessment and scientific position, rather than adhering to mainstream opinions. A consistent identification of priorities is the key to developing strategies to ensure sustainability.

Conclusion: 10 propositions to promote Water Science

#1 –The most distinguishing behaviors and ideas often look obvious.

#2 –It is not yet clear what are the research priorities for ensuring environmentally sustainable human development. Science needs to seek credibility through objectivity.

#3 –Hydrology implies uncertainty which we do not convincingly deal with and communicate.

#4 –Hydrology should understand uncertainty through physical reasoning. Uncertainty is part of Nature (not a weakness

#5 –Objective d to cope with change.

#6 –Attempts tion, overfitting, and eventually mistaken predictions.

....and now the second part
(much shorter!)

#7 –Hydrologists should take a clear position within the debate on global change and sustainability.

#8 –Hydrology needs to develop an agreed and unified research agenda, rather than following the agenda dictated by other disciplines. Hydrology needs to take the lead in science communication.

#9 –Hydrology has a unique capability to draw reliable projections of future climate and water resources sustainability, along with a unique experience in model validation and uncertainty assessment.

#10–We need to objectively pursue and present the truth rather than serving political strategies. Presenting the truth is our duty and a huge service of science to society.

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Alma Mater Studiorum
University of Bologna

European Geosciences Union General Assembly 2018

I learned from Tim Cohn that life is *naturally trendy.*

Cohn, T. A., & Lins, H. F. (2005). Nature's style: Naturally trendy. Geophysical Research Letters, 32(23).

Tim proved that the passion for research can lead to lifetime friendship.

The way Tim fought against his challenging illness is an example that I will never forget.

HS7.4 Naturally trendy: natural (and non-natural) trends (and non-trends) in climate and hydrology
S. Ceola, D. Koutsoyiannis , A. Montanari , C. Cudennec , H
Orals Fri, 13 Apr, 08:30–12:00 / Room B
Posters Attendance Fri, 13 Apr, 17:30–19:00 / Hall A

A “Thank You” to my mentors…

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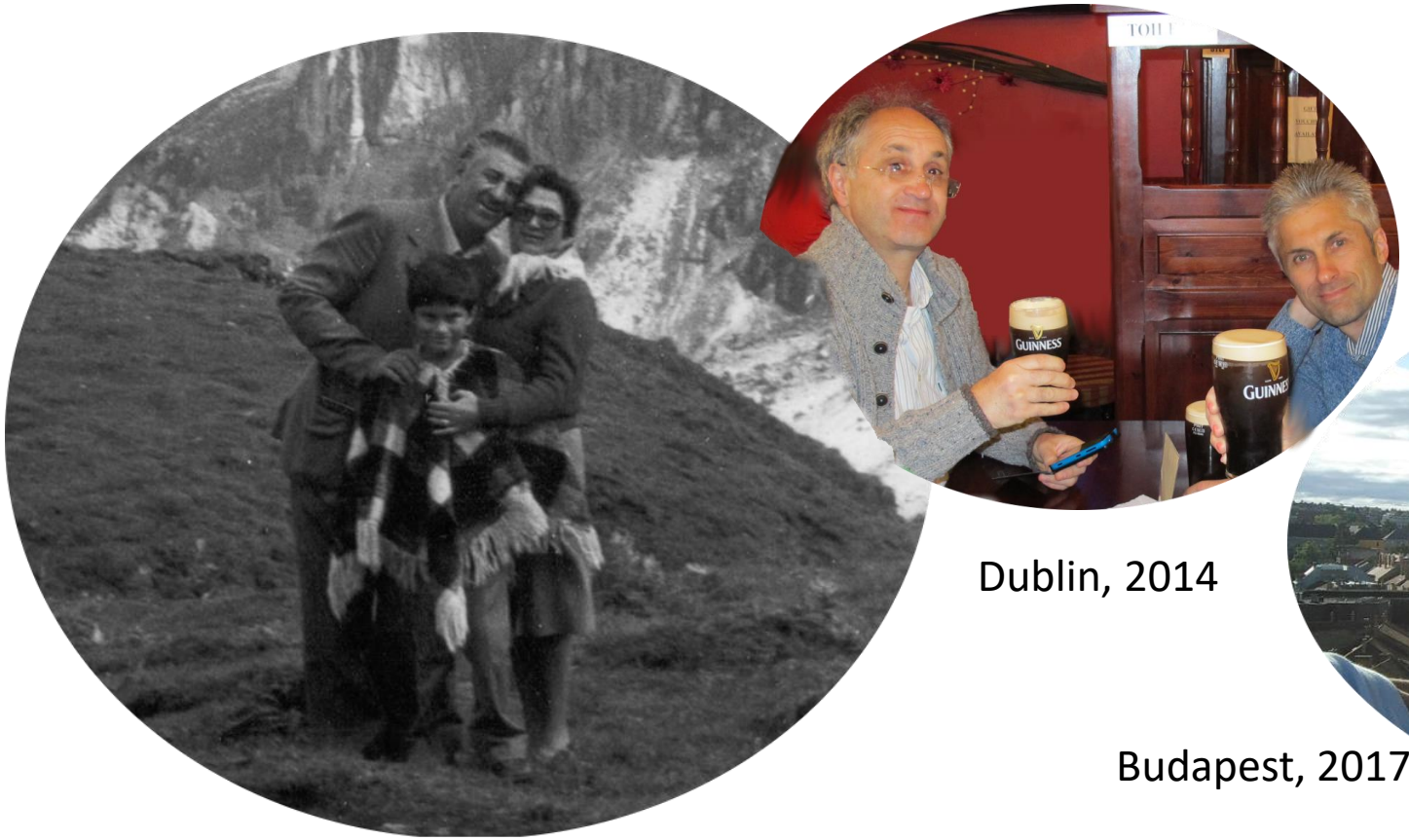
My original family…..



Baita Segantini, Dolomites, 1976

Dublin, 2014

…..and my current one!

Budapest, 2017

Pozza di Fassa, 2017

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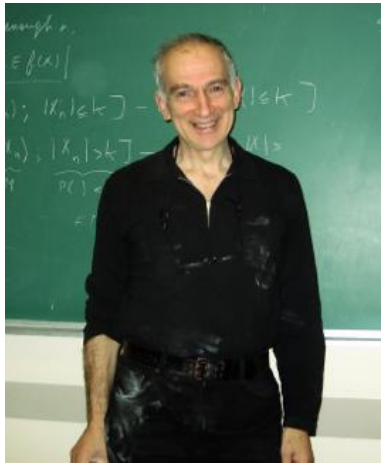
My Academic Mentors

Alberto Bianchi, Master Degree Thesis Advisor. He taught to me that studying is nothing without passion.

Renzo Rosso, Ph.D. Advisor
Paolo Burlando, Ph.D. Co-Advisor
Armando Brath, Post-doctoral Advisor.
I learned from them what Research is.



Murad Taqqu, Ph.D. Co-Advisor at Boston University.
I learned from Murad what Math and Probability are.

Thanks to my fellow PhD colleagues Roberto Ranzi, Stefano Orlandini, Giovanna Grossi, Andrea Giacomelli, Cristina Rulli, Carlo De Michele.

I am indebted to the several deep thinkers that set the basis of hydrology. Their papers are still an inestimable inspiration. I learned from their contributions that building on our past is challenging, exciting, and a necessary condition for high level research.

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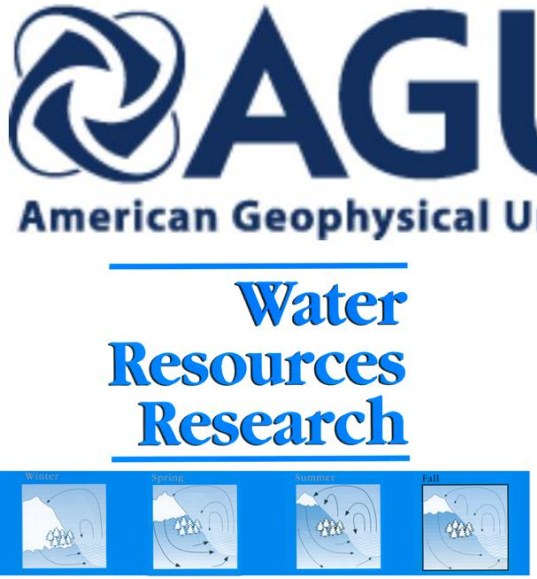
The most influencing mentors: Scientific Societies and their Members



Gordon Young

Dan Rosbjerg

Christophe Cudennec

Andreas Schumann

Efi Foufoula-Georgiou

Hoshin Gupta

Scientific societies turned out
immense source of inspiration an
ship

Hubert Savenije

Murugesu "Siva" Sivapalan

Eric Wood

Praveen Kumar

Martyn Clark

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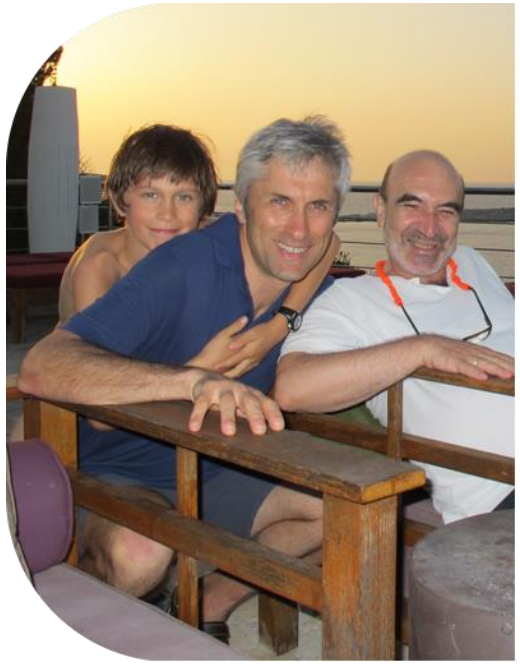
My most frequent “external” co-authors!

Demetris – He destroyed my dream to discover the perfect model….



Kefalonia, Greece, 2016

Bergamo, Italy, 2012

Günter – He asked me the most difficult scientific question….

Sicily, Italy, 2010

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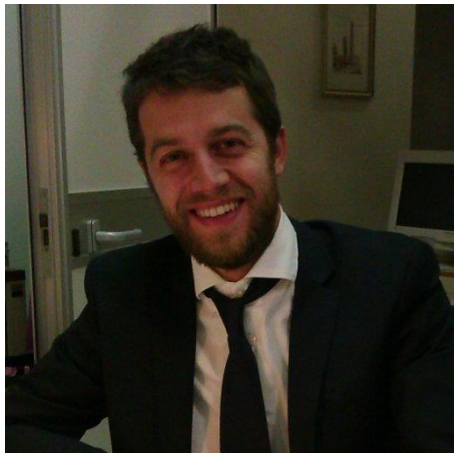
My great colleagues at Unibo!

Attilio Castellarin


Elena Toth


Serena Ceola


Alessio Domeneghetti


Alessio Pugliese


Cristiana Bragalli

...and also Marco Maglionico, Simone Persiano, Iuliia Shustikova, Mattia Neri, Francesca Carisi, Giada Molari!

Ph.D. Students and Post-Docs:

- Serena Ceola (2012-2014)
- Laura Lombardi (2008-2011)
- Alessandro Bigi (2004-2007)
- Laura Montanari (2002-2005)
- Greta Moretti (2000-2003)
- Elena Montosi (2009-2012)
- Simone Castiglioni (2007-2010)
- Giuliano Di Baldassarre (2003-2006)
- Luigia Brandimarte (2002-2005)

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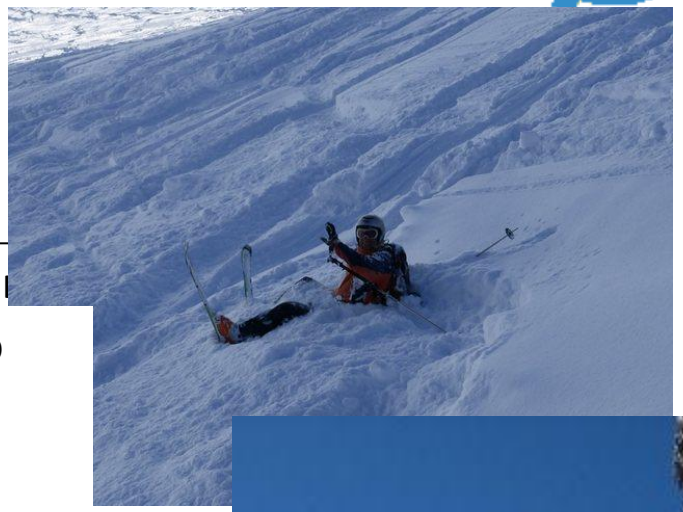
Finally…. I (selfishly) wish to acknowledge the great passions that fueled my life, besides family



"Whatever happens we should always walk over four legs, to maintain a stable equilibrium if one breaks."

Personal communication by Demetris, modified by me :-)

Mountains: hiking, climbing and off-piste skiing

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General Assembly 2018

Thanks to my Nominator, Günter, and Supporters:
Hubert Savenije, Tissa Illangasekare, Martyn Clark, Andrea Rinaldo, Amilcare Porporato, Eric Wood, Azage Gebremariam, Yilma Seleschi, Demetris Koutsoyiannis, Keith Beven

Thanks to the Italian Community of Hydrologists that always supported me.

Thanks to the Darcy Committee and

Thanks to you all !

My job gave to me the great privilege to know very interesting mentors, students, colleagues and peers. This is an immense treasure.

Thanks for being here tonight, your attendance is a great gift !

Grazie!

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Grazie!

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