



The Unsolved Problems in Hydrology Initiative

14 April, Vienna

In 1900 David Hilbert set out
23 problems to foster mathematical research
He presented 10 of them at the Paris Congress



Mathematische Probleme.

gehalten auf dem internationalen Mathematiker-Kongreß
zu Paris 1900.

Von

D. Hilbert.

Wer von uns würde nicht gern den Schleier lüften, unter dem die Zukunft verborgen liegt, um einen Blick zu werfen auf die bevorstehenden Fortschritte unsrer Wissenschaft und in die Geheimnisse ihrer Entwicklung während der künftigen Jahrhunderte! Welche besonderen Ziele werden es sein, denen die führenden mathematischen Geister der kommenden Geschlechter nach-

Hilbert's unsolved problems invigorated 20th century mathematics

9th	Find the most general law of the reciprocity theorem in any algebraic number field.	Partially resolved. ^[n 3]	–
10th	Find an algorithm to determine whether a given polynomial Diophantine equation with integer coefficients has an integer solution.	Resolved. Result: impossible, Matiyasevich's theorem implies that there is no such algorithm.	1970
11th	Solving quadratic forms with algebraic numerical coefficients .	Partially resolved. ^[15]	–
12th	Extend the Kronecker–Weber theorem on abelian extensions of the rational numbers to any base number field.	Unresolved.	–
13th	Solve 7-th degree equation using algebraic (variant: continuous) functions of two parameters.	The problem was partially solved by Vladimir Arnold based on work by Andrei Kolmogorov . ^[n 4]	1957
14th	Is the ring of invariants of an algebraic group acting on a polynomial ring always finitely generated ?	Resolved. Result: no, a counterexample was constructed by Masayoshi Nagata .	1959
15th	Rigorous foundation of Schubert's enumerative calculus .	Partially resolved.	–

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

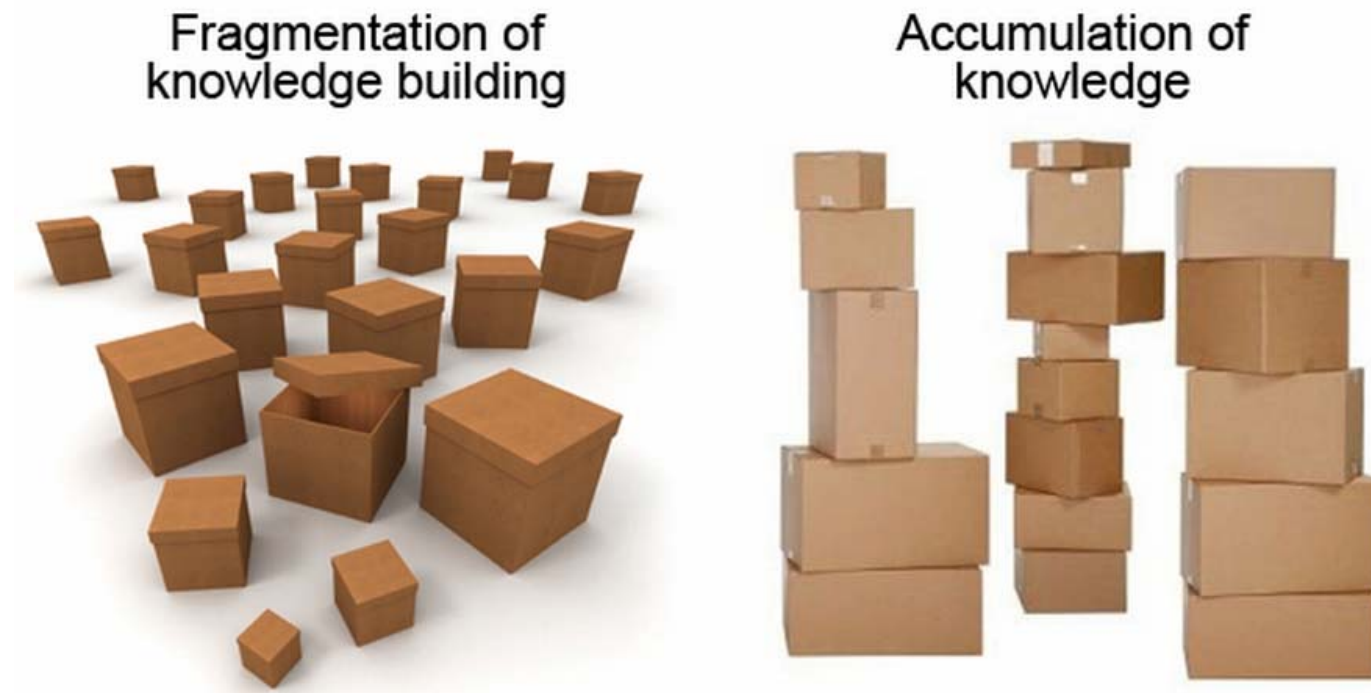
Problems should be

- **universal** (not only apply to one region)
- ideally relate to **phenomena** (Why does this happen?)
- be **specific** (alas, not as specific as those of Hilbert)

Proposal: **3 questions** per IAHS Commission

Purpose

- Link research groups around the world
- Link IAHS Commissions with each other (and Commissions with Panta Rhei)
- Make tangible progress



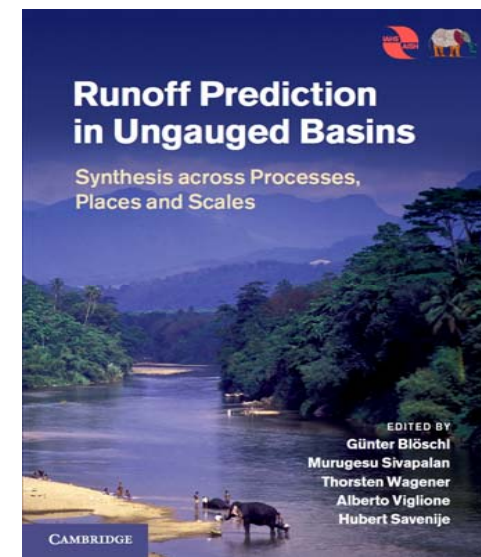
Nature of the questions

- **Why** questions – processes/phenomena
- **What** questions – processes/estimation
- **How** questions – methods

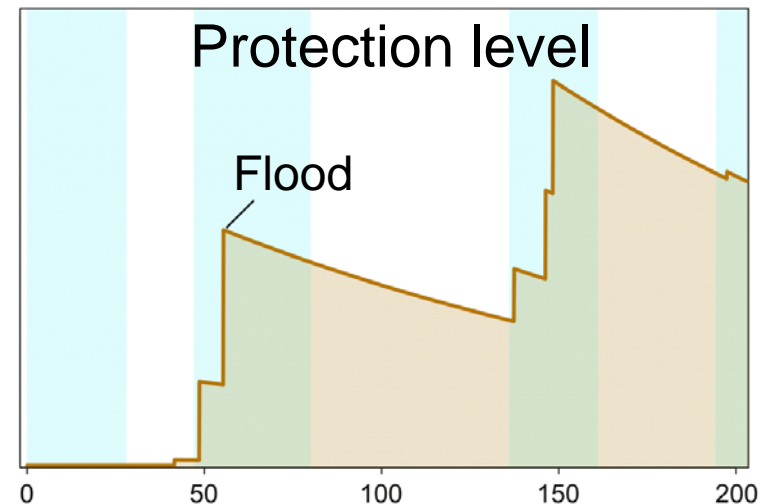
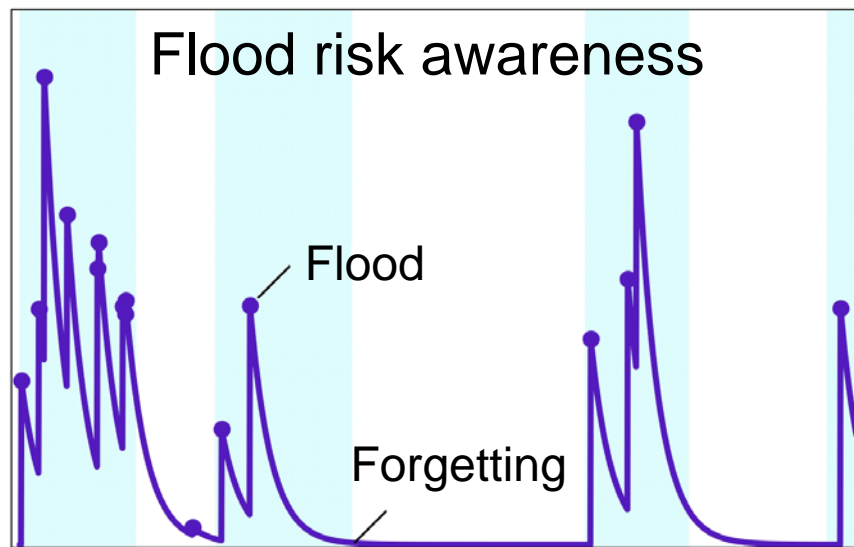
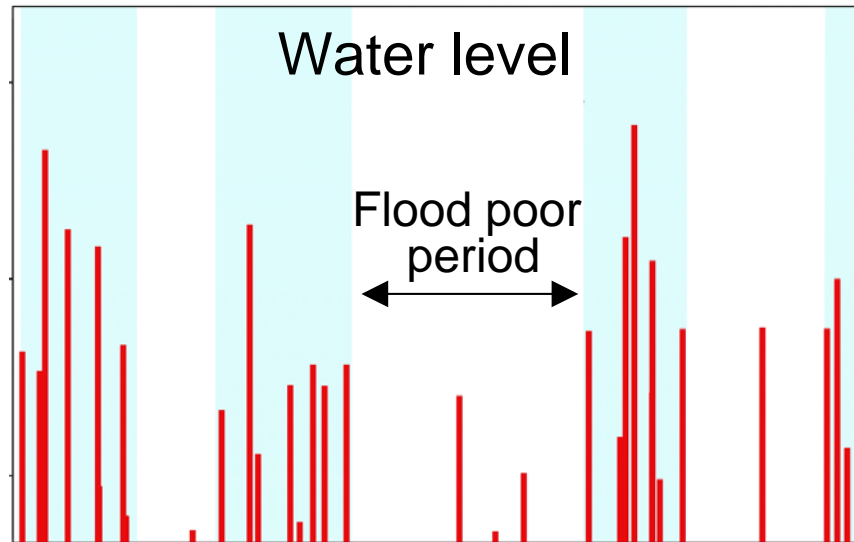


Phenomena: **Why** are there wind waves?

Methods: **How** can we estimate runoff in ungauged basins?



Levee effect: Why do people move into floodplains protected by levees thus increasing flood risk?



7 0 50 100 150 200 years

FORUM

Identification of 100 fundamental ecological questions

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Suggested procedure for identifying Unsolved scientific Problems in Hydrology (UPH)

- Inspired by Sutherland et al. (2013, J. Ecol.) the emphasis is on making the process to identify the 23 most important UPH rigorous, democratic and transparent.
- Step 1: Discussion of potential UPH on <https://www.linkedin.com/groups/13552921>. The wider hydrological community has been invited to join the discussion. Nov. 2017 - March 2018.
- Step 2: Discussion of procedures on LinkedIn. Feb. - March 2018 (this document).
- Step 3: Initial assignment of UPH to broad themes reflecting areas of hydrology defined by subject or methodological approach on LinkedIn. March 2018.

Suggested procedure for identifying Unsolved scientific Problems in Hydrology (UPH)

- **Step 4: Splinter meeting on 13 April 2018 at EGU in Vienna (1pm - 5pm).**
- Participants: Invited are all those who have proposed UPH on LinkedIn, as well as IAHS, EGU-HS and AGU-HS representatives. Attendees are encouraged to consult widely.
- Procedure: Brainstorming of additional UPH. Discussion of assignment of UPH to broad themes. Identification of duplicate UPH and merging. Discussion on which UPH are unlikely to make it on the final list, so should be excluded. Initial voting on UPH ranking them 'bronze', 'silver' and 'gold' in the order of increasing importance.

Suggested procedure for identifying Unsolved scientific Problems in Hydrology (UPH)

- **Step 5: VCS Symposium on 14 April 2018 in Vienna (8:30am - 5:30pm). Participants: Open call for participation.**
- Procedure: Brief introductory talks on UPH and procedure. Three parallel working groups on three themes. Four consecutive rounds of three parallel sessions. Discussion on specificity of UPH. Rewording of UPH as needed. Voting on UPH ranking them 'bronze', 'silver' and 'gold' in consecutive rounds. Final voting in plenary and rewording if needed.
- Step 6: Small working group to do final editing of UPH, involving representatives of IAHS, EGU-HS, AGU-HS to examine and revise overlooked ambiguities and duplications. April-June 2018.
- Step 7: Final email poll to decide the fate of the last few candidates for inclusion among authors. June 2018.
- Step 8: Publication in Hydrological Sciences Journal, co-authored by all those who were actively involved and contributed to the manuscript. Late 2018.

Suggested Agenda for Today:

- General questions regarding UPH
- Going through existing list of UPH
- Brainstorming additional UPH by broad themes
- Identification of duplicate UPH and merging
- Discussion on which UPH are unlikely to make it on the final list, so should be excluded
- Voting on UPH ranking them 'bronze', 'silver' and 'gold' in the order of increasing importance **IN MULTIPLE ROUNDS**