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How to write a (benchmark) scientific paper in hydrology

Keith Beven
(k.beven@lancaster.ac.uk)

How to write a scientific paper in hydrology?

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- First session in 2009 with Jeff McDonnell
- Past presentations on How to write a paper

  http://younghs.com/readings/writing
- Focus today on writing a highly cited / benchmark paper

What makes a benchmark paper?

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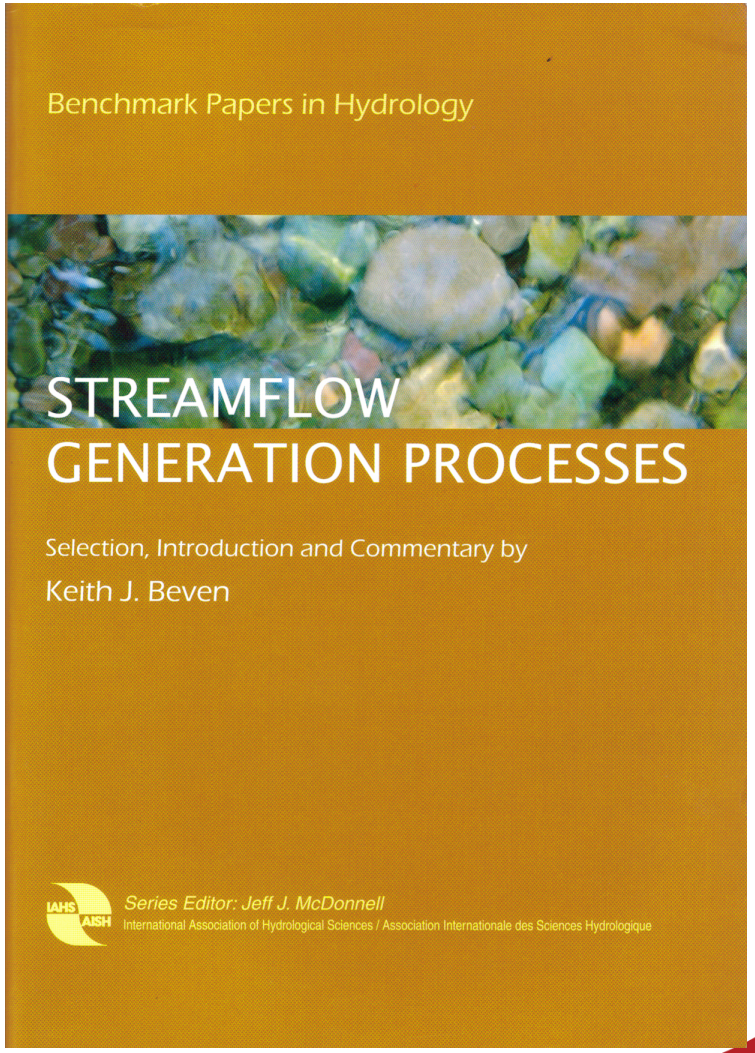
Introductory essay about the relationship between processes, perceptions and models

Classic benchmark papers about hydrological processes from Horton (1933) on…



What makes a benchmark paper?

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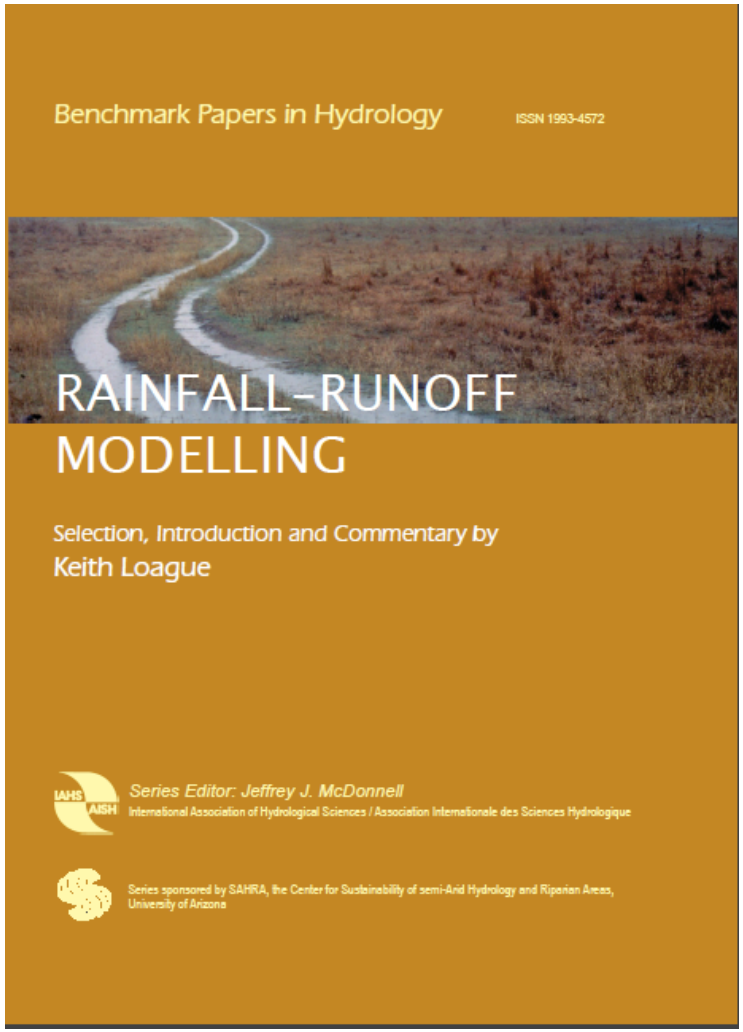
Rainfall-runoff models edited by Keith Loague

Papers from Mulvaney (1851) onwards



Choosing a benchmark paper

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- Can a paper be a benchmark and not be highly cited? Most important criterion is that it be interesting and move the field on in some way
- In the past, no citation statistics but selective choice of materials included in text books (and then citation trail of papers cited in those papers based on title)
- Citations are clearly a guide, but there may be neglected areas or small communities where it is quite possible to produce a benchmark paper that is innovative (e.g. runoff from field drains)

My background

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- Wrote first hydrological model as an undergraduate at Bristol University in 1970
- Did a PhD at University of East Anglia on distributed physically-based models using the Freeze and Harlan 1968 blueprint – *almost* the first application of finite element models in hydrology (made it into Benchmark papers volume but not very highly cited). Applied using only measured parameters and failed miserably (see Beven, HESS, 2001)
- Developed Topmodel at Leeds University with Mike Kirkby
- One of the team at Institute of Hydrology developing the SHE model

My background

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- Started doing Monte Carlo experiments on models at the University of Virginia in 1980 (start of GLUE and equifinality concepts) – discouraged by statisticians and statistical hydrologists
- Mid-80s - Used Monte Carlo in continuous simulation for flood frequency estimation
- Moved to Lancaster 1985, continued GLUE work (first paper 1992), developed Dynamic Topmodel, + work on dispersion in soils and rivers, water quality, flood inundation, flood frequency, flood forecasting
- Gradually learning more about the epistemic uncertainty problem……

Quick Summary of my papers

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Time/Volume: 300+ Papers on WoS

- 1 > 2500 citations (but 1979 Topmodel paper which was in HSB and does not appear in WoS)
- 2(3) > 1000 citations
- 7(8) > 500 citations
- 43(44) > 100 citations
- H-index 65 (Higher values in Google Scholar / Publish or Perish)
- 6 in Loague Benchmark volume (not all highly cited)
- and 19 papers with 0 citations (though some are quite recent!!)

My Benchmark papers

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From Loague, Benchmark Papers in Rainfall-Runoff Modelling

- 1977 Beven, Hillslope hydrographs by the finite element method. *Earth Surface Processes* (44 WoS citations)
- 1979 Beven and Kirkby, A physically based, variable contributing area model of basin hydrology. *Hydrological Sciences Bulletin* (not listed on WoS, ~2500?)
- 1982 Beven, On subsurface stormflow: predictions with simple kinematic theory for saturated and unsaturated flow. *Water Resources Research* (92 WoS citations)
- 1987 Sivapalan et al., On hydrologic similarity. 2. A scaled model of storm runoff production. *Water Resources Research* (243 WoS citations)
- 1989 Binley et al., A physically based model of heterogeneous hillslopes. 2. Effective hydraulic conductivities. *Water Resources Research* (74 WoS citations)
- 1989 Beven, Changing ideas in hydrology – the case of physically-based models. *Journal of Hydrology* (758 WoS citations)

My highly cited papers

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- 1979 Beven and Kirkby, A physically based, variable contributing area model of basin hydrology. *Hydrological Sciences Bulletin* (not listed on WoS, ~2500?)
- 1992 Beven and Binley, The future of distributed models: model calibration and uncertainty prediction, *Hydrological Processes* (1600 WoS citations)
- 1982 Beven and Germann, Macropores and water flow in soils, *Water Resources Research* (1345 WoS citations)
- 1989 Beven, Changing ideas in hydrology – the case of physically-based models. *Journal of Hydrology* (758 WoS citations)
- 2001 Beven and Freer, Equifinality, data assimilation, and uncertainty estimation in mechanistic modelling of complex environmental systems using the GLUE methodology (738 WoS citations)
- 1991 Quinn et al., The prediction of hillslope flow paths for distributed hydrological modelling using digital terrain models, *Hydrological* Processes (657 WoS citations)
- 1996 Beven, A manifesto for the equifinality thesis (630 WoS citations)

Analysis (1)

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Beven and Kirkby (HSB 1979)

Hydrological Sciences–Bulletin–des Sciences Hydrologiques, **24**, 1, 3/1979

A physically based, variable contributing area model of basin hydrology

K. J. BEVEN Institute of Hydrology, Wallingford, Oxfordshire
M. J. KIRKBY School of Geography, University of Leeds, Leeds, Yorkshire

Received 14 April 1978, revised 17 August 1978

Abstract. A hydrological forecasting model is presented that attempts to combine the important distributed effects of channel network topology and dynamic contributing areas with the advantages of simple lumped parameter basin models. Quick response flow is predicted from a storage/contributing area relationship derived analytically from the topographic structure of a unit within a

Analysis (1)

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Beven and Kirkby (HSB 1979)

- Novelty - new type of model based on topography (Kirkby topographic index)
- Rejection by Journal of Hydrology – "of too local an interest" (topographic analysis too demanding to be of any practical use) - Accepted later by HSB
- Generality - Water flows downhill so topography must be useful
- Technological advance - DTMs became more readily available (Dave Wolock – whole of US at 30m)
- Wrong - approximate assumptions not valid everywhere

Analysis (2)

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Beven and Binley (HP 1992)

HYDROLOGICAL PROCESSES, VOL. 6, 279–298 (1992)

THE FUTURE OF DISTRIBUTED MODELS: MODEL CALIBRATION AND UNCERTAINTY PREDICTION

KEITH BEVEN AND ANDREW BINLEY
Centre for Research on Environmental Systems, Lancaster University, Lancaster, LA1 4YQ, U.K.

ABSTRACT

This paper describes a methodology for calibration and uncertainty estimation of distributed models based on generalized likelihood measures. The GLUE procedure works with multiple sets of parameter values and allows that, within the limitations of a given model structure and errors in boundary conditions and field observations, different sets of values may be equally likely as simulators of a catchment. Procedures for incorporating different types of observations into the calibration; Bayesian updating of likelihood values and evaluating the value of additional observations to the calibration process are described. The procedure is computationally intensive but has been implemented on a local parallel processing computer. The methodology is illustrated by an application of the Institute of Hydrology Distributed Model to data from the Gwy experimental catchment at Plynlimon, mid-Wales.

KEY WORDS Distributed models Calibration uncertainty Likelihood

Analysis (2)

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Beven and Binley (HP 1992)

- First GLUE methodology paper
- Novelty - new way of looking at model calibration and uncertainty estimation
- Generality - large number of papers using GLUE in different domains
- Wrong – large number of papers suggesting it is a misguided or incoherent methodology that was undermining the science

Analysis (2)

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Beven and Binley (HP 1992)

- So additional papers justifying GLUE
    - On undermining the science (HP Commentary, 2006)
    - On doing better hydrological science (HP Commentary, 2008)
    - Manifesto for the equifinality thesis (JH 2006)
    - So why would a modeller chose to be incoherent? (JH 2008)
    - GLUE 20 years on (HP 2013)
- Titles

Analysis (3)

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Beven and Germann (WRR 1982)

WATER RESOURCES RESEARCH, VOL. 18, NO. 5, PAGES 1311–1325, OCTOBER 1982

Macropores and Water Flow in Soils

KEITH BEVEN AND PETER GERMANN

Department of Environmental Sciences, University of Virginia, Charlottesville, Virginia 22903

This paper reviews the importance of large continuous openings (macropores) on water flow in soils. The presence of macropores may lead to spatial concentrations of water flow through unsaturated soil that will not be described well by a Darcy approach to flow through porous media. This has important implications for the rapid movement of solutes and pollutants through soils. Difficulties in defining what constitutes a macropore and the limitations of current nomenclature are reviewed. The influence of macropores on infiltration and subsurface storm flow is discussed on the basis of both experimental evidence and theoretical studies. The limitations of models that treat macropores and matrix porosity as separate flow domains is stressed. Little-understood areas are discussed as promising lines for future research. In particular, there is a need for a coherent theory of flow through structured soils that would make the macropore domain concept redundant.

INTRODUCTION

There has long been speculation that large continuous openings in field soils (which we will call macropores) may be very important in the movement of water—at least under certain conditions. Such voids are readily visible, and it is known that they may be continuous for distances of at least several meters in both vertical and lateral directions. The

even, in some cases, through a network of suncracks in the soil surface.

However, Horton suggested that such flows would be mostly turbulent, while true groundwater flow is mostly laminar, and he coined the term 'concealed surface runoff' for such rapid flows through these macropores.

There is no doubt that water will move through large voids

Analysis (3)

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Beven and Germann (WRR 1982)

- Collaboration - Arose out of a Swiss post-doc grant for Peter Germann to spend time at IH Wallingford
- Novelty - Soil Physics section was not interested in the topic of macropores and water flows
- I had a field site on cracking clay soil (and a previous PhD finite element Richards equation model that had failed – partly because of preferential flows)
- Novelty - first major review of subject (but not first review)
- Review overshadowed experimental and modelling methodological papers we produced (JSS, 1981)
- Macropores and Water Flow Revisited (WRR 2013)

What have we learned?

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- Time/Volume – stick around long enough
- Novelty – being first, seeing an opportunity (luck!)
- Generality – allowing multiple applications
- Review – being first or nearly first
- Wrong / Rejected – being honest / having belief
- Collaboration – building confidence
- Technological advance - allowing wider use
- Titles – draw the reader in

Analysis (4)

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Drawing the reader into a paper (will they read more than the title???)

Brevity

- Kinematic subsurface stormflow (WRR 1981)
- Regionalisation as a learning process (WRR, 2009)

Generality

- Generalised kinematic routing (WRR 1979)
- Changing ideas in hydrology: the case of physically-based models (JH 1989)
- Towards a coherent philosophy for environmental modelling (PTRSL 2000)

Analysis (4)

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Intriguing

- Prophecy, reality and uncertainty in distributed models (AWR, 1993)
- The Holy Grail of Scientific Hydrology: $Q_t = H(\underleftarrow{S}\underleftarrow{R})A$ as closure (HESS 2006)
- On red herrings and real herrings: disinformation and information in hydrological inference (HP Commentary 2011)

Sounds useful

- The ln(a/tanβ) index: how to calculate it and how to use it within the TOPMODEL framework (HP 1995)
- Ignorance is bliss: 7 reasons not to use uncertainty analysis (WRR 2007)

Analysis (4)

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A bit controversial?

- Does an interagency meeting near Washington imply uncertainty? (HP Commentary, 2004)
- Surface runoff at the Horton Hydrologic Laboratory (or not?). (JH 2004)
- Hyperresolution information and hyperresolution ignorance in modelling the hydrology of the land surface (Science China Geosci., 2015)

What works?

- Check out the most downloaded papers in top journals (HESS, WRR, JH, HP, ……) – what attracts the reader?

What advice can I give?

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- Look for an opportunity to be first (or is it just luck to be in right place at right time?)
- Be honest (especially about uncertainties)
- Believe in what you are doing (if not change what you are doing, or chose not to do something even if there is money and citations to be had)
- Take criticism seriously – it will make you a better scientist in trying to understand why you are being criticised – even if destructively
- And if you review other papers – be constructive. You will almost certainly learn more by doing so.

What advice can I give?

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- Find a good title
- Decide on the story you want to tell (prepare a good outline)
- Tell the story clearly
- Make sure what is important stands out
- Ensure that your conclusions are supported by the analysis
- Deal with the referee's questions before you submit (or at least those you can spot, e.g. have you cited referee's papers)

What advice can I give?

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What advice can I give?

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- REMEMBER – you are writing a paper not just to report what you have done but to try and influence people and progress hydrological science
- REMEMBER – rejection is a good thing if you believe in what you are doing (and referees do not convince you that belief is wrong). It generally either means you can make the paper better or that you are doing something novel that may lead to a Benchmark paper