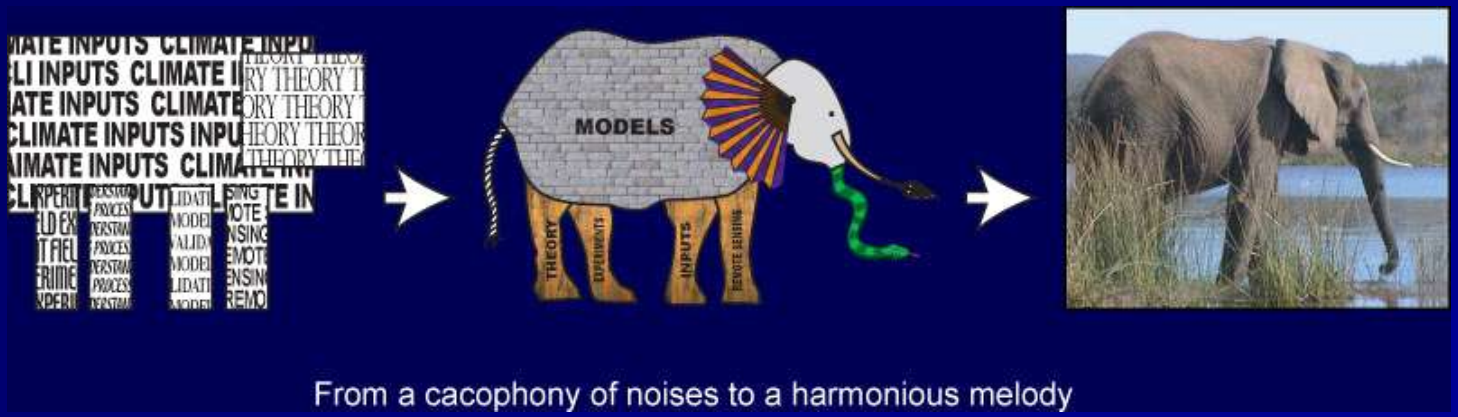
IAHS Decade for Predictions in Ungauged Basins, PUB – Advances and Prospects



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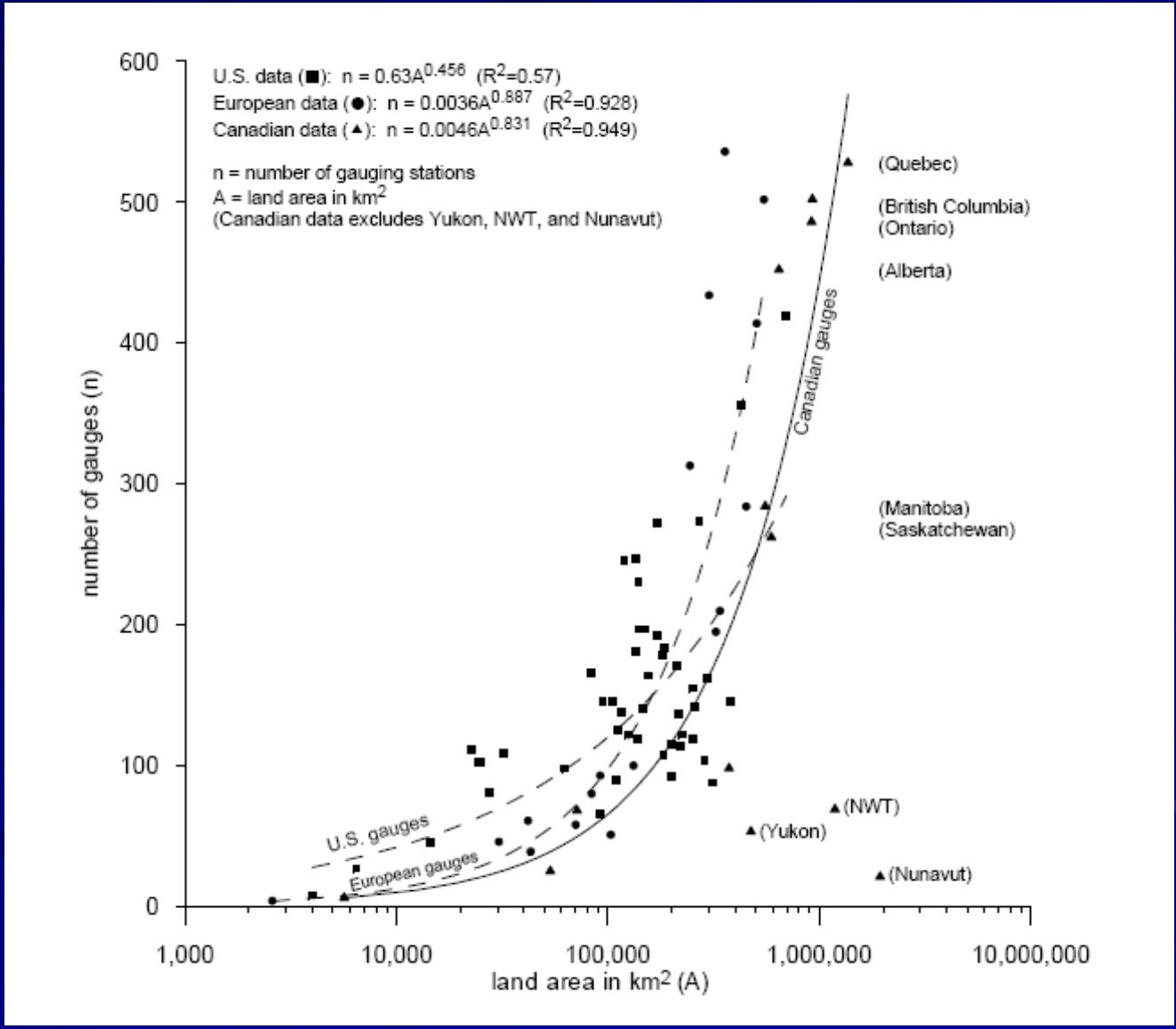
Why PUB?

Canada lost 725 out of ~3500 hydrometric stations in the 1990s.

Northern Canada remains sparsely gauged



Pyrce, 2004

Streamflow can be Difficult to Measure

Meteorological Inputs can be difficult to measure

Climate Change is making water management infrastructure inadequate

Water Governance is Changing

PUB Approach

- PUB is a *revolutionary scientific movement* to improve hydrological prediction in regions where streamflow measurements
  - do not exist, or
  - are sparse, or
  - are becoming difficult to interpret due to rapidly changing climate/weather, land use, or water management.
- PUB was developed not only to compensate for the lack of streamflow gauges and address situations where other measurements are also lacking, but to
  - Demonstrate the value of observations
  - Reduce the reliance of prediction on calibration
  - Enhance the capability to predict based on understanding

PUB, Science, Technology & Society

- PUB is a vehicle to transform hydrology by:
  - improving the scientific basis of hydrology
  - providing a dialogue and feedback between applied and theoretical hydrology
  - making coordinated international efforts in hydrology relevant to local needs, especially in the under-developed world.
- PUB is desperately needed to better manage water resources as we deal with hydrological change due to the world water crisis, climate change, deforestation and resource development.

PUB Progress to Date

- Substantial progress on many PUB themes
- Some early examples of success in prediction in ungauged basins
- Expansion of PUB activities through working groups and national groups
- Work on compilation of progress in PUB Benchmark Report

Strengths of Current Progress

- PUB Streamflow Benchmark Report
- Scientific rigour
- Development of new methods for comparisons, classification, and diagnostics
- Development of new theory
- Consideration of regionalisation approaches
- Parameter estimation
- Uncertainty quantification
- Consideration of issues relevant to well gauged regions
- Improvement of application of existing models and methods

Difficulties

- Defining the appropriate use of sparse gauge observations
- Integration of inductive and deductive methods in practice
- Limitations of the usefulness of regionalisation efforts in ungauged regions

Opportunities for PUB

- Approaches relevant to the full range of regional PUB conditions in the world
  - Regionalisation not always possible or appropriate in ungauged regions
  - Cold regions, arid regions, mountains, droughts receive scant attention and require coupled water and energy balance approaches
- Rapid climate, land use and consumption change the requirements for hydrological prediction
  - Non-stationarity can require changing model structure and parameter requirements, changes regional parameter estimation
- Prediction of the Hydrological Cycle – multiple endpoints to prediction
  - Snow, hydrochemistry, soil moisture, ecohydrology, wetlands groundwater, glaciers
- Sharing approaches with global hydrological models and hydrological land surface schemes.
- Develop methods to estimate parameters and model structure using new types of information and basin classification.
  - Incorporate better understanding of process behaviour, patterns and scale emergence in model development
  - Develop innovative methods to parameterise physically based models

Challenges for PUB

- Difficulties with a universal hydrological theory – substantial differences in runoff formation with hydroclimatic region,
  - but this does not preclude comprehensive models that can work well in many regions.
- Uncertainty estimation is important but does not by itself improve prediction or achieve PUB.
- Over-reliance on single objectives for assessment of prediction – do not forget the wonderful variety of catchment processes and state variables.
- Do not assume that we have adequate basin input information on rainfall, snowfall, and groundwater to predict streamflow.

PUB 4th Biennium

- Follow the plan!
- Renewal and Consolidation of Themes
  - Benchmark Report completion
  - New inputs
- Putting PUB into Practice
  - Assess progress
  - Develop solutions for various hydroclimate zones and data availability situations
- Contribute to International Hydrology
  - Elevate hydrological practice to science
  - Strengthen IAHS and link to Commissions
  - Apply PUB to real world problems

Goals of 4th Biennium of PUB

- Enhance communication within the scientific community and dialogue with applications community.
- Inclusion and analysis of regional efforts and varying perspectives.
- Maximise the predictive value of available data.
- Incorporation of process structure, variability and emergence into predictive approaches.
- Improvement of realism in conceptual approaches.
- Utilisation and assessment of new measurement and information technologies for basin inputs and characterization.
- Development of improved models that reflect recently improved hydrological understanding.

PUB SSG 2009-2011

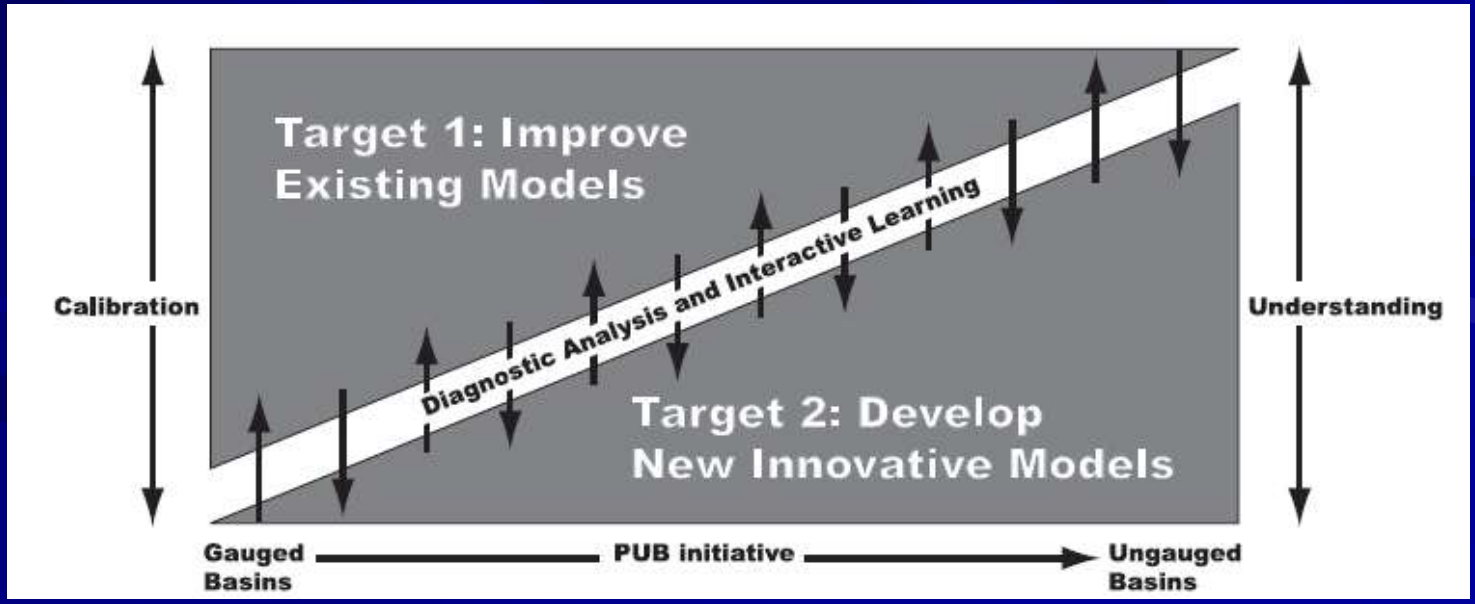
- Chair — John Pomeroy, Canada
- Communications — Vladimir Smakhtin, Sri Lanka
- Theme 1 Catchment Classification — Ross Woods, New Zealand
- Theme 2 Conceptualization of process heterogeneity — Doerthe Tetzlaff, Scotland
- Theme 3 Uncertainty analyses and model diagnostics — Thorsten Wagener, USA
- Theme 4 New data collection approaches — Danny Marks, USA
- Theme 5 New hydrological theory — Alexander Gelfan, Russia
- Theme 6 New model approaches — Hubert Savenije, Netherlands
- Theme 7 Working groups — Denis Hughes, South Africa
- Theme 8 Integration and Demonstration projects — Berit Arheimer, Sweden
- Young Hydrologists — Yukiko Hirabayashi, Japan; Olga Semenova, Russia
- Advisors: Guenter Bloschl, Austria; Jeff McDonnell, USA; Siva Sivapalan, USA; Kuni Takeuchi, Japan
- Secretariat/Webmaster — Michael Allchin, Canada

PUB Working Groups

- WG1 Top-Down Modelling Working Group
- WG2 MOPEX Working Group
- WG3 Orographic Precipitation, Surface & Ground Water Interactions and their Impact on Water Resources
- WG4-Japan Working Group - Suimon Adventure for Knowledge Evolution (SAKE)
  - WG4-1/2 Basin Inter-comparison and Classification Relating Hydrologic Diversity to Landscape Elements to Establish a Realistic PUB Model
  - WG4-3 Establishment of a Guideline for Selecting Hydrologic Models through Development of Uncertainty Evaluation Indices
  - WG4-4 Dam Reservoir Operation Monitoring with Remote Sensing for Large Scale Hydrologic Modeling
  - WG4-5 Estimating Frequencies of Hydrologic Extreme Events in Ungauged Basins using Scaling, Regionalization, and Historical Record Analysis
  - WG4-6a Global-Scale Hydrological Modeling, Considering Interaction between Natural Variation and Anthropogenic Activities
  - WG4-6b Downscaling of Global Hydrologic Information for Local-Scale Watershed Management in Ungauged Basins
- WG5 Design Flood Flows for Ungauged Basins
- WG6 China Working Group
  - WG6-1 Hydrological modeling and water resources assessment in Northern China under high water-stress
  - WG6-2 Evaluation and prediction of groundwater in northern China
  - WG6-3 Flood forecast and damage estimation in southern China
  - WG6-4 Prediction of Water Resources and Consumption in the Arid Region of Northwest China
  - WG6-5 Study of ecologically vulnerable basins in China
  - WG6-6 Development of coupled hydrological and water-quality models in urbanized river basins
  - WG6-7 Application of new technologies, theories and methods to hydrological prediction in ungauged basins in China
- WG 7 Uncertainty Estimation for Hydrological Modelling
- WG8 Remote Sensing and Data Assimilation
- WG9 Mediterranean Working Group
- WG 10 Drought and Flood Risk: Hydrology and Sediment Transport in Mountain Catchments
- WG 11 Andean Catchment Flow Estimation
- WG 12 Slope Inter-Comparison Experiment (SLICE)
- WG13 United Kingdom Working Group
- WG14 The Waternet of Southern Africa
- WG15 Canadian National Working Group
- WG 16 IP3: Improved Processes and Parameterisation for Prediction in Cold Regions
- WG 17 Low Stream Flows And Hydrologic Drought
- WG 18 Extreme flood assessment and prediction in the monsoon climate zone of North-East Asia

Follow the Plan

- **TARGET 1: Examine and improve existing models in terms of their ability to predict in ungauged basins.**
- **TARGET 2: Develop new, innovative models for making predictions in ungauged basins.**



New Initiatives to Address the Science Plan

- Comprehensive efforts on
  - i) improved process, basin behaviour and predictive understanding,
  - ii) incorporation of understanding into new innovative model structures
    - development of new modelling schemes based on i) and ii)
  - iii) Input uncertainty

Renewal of Themes

Major Conclusions of Themes to be Consolidated and Articulated

- Benchmark Report – completed 2011 (Bloschl & chapter leads)
- PUB International Workshop, P3: Putting PUB into Practice, Canada, May 10-14 2011.
- Kovacs Colloquium, Paris 2012
  - Completion of PUB.
  - Plenary session to review the Decade

Contribute to International Hydrology

- Elevate hydrological practice to science, even “Art”.
- Recognise National Working Group Progress
- Strengthen IAHS and link to Commissions
  - Joint events with commissions
  - Special Issues
- Enhanced communication strategy
  - Website, list-serve emails to community
- Putting PUB into Practice, Canmore 2011
  - Major Report from P3 Workshop on How to Predict in Ungauged Basins for various hydroclimate regimes and levels of data availability.
- IUGG, Melbourne 2011
  - Townhall Meeting for Development of Plan to Complete PUB in 2012.
  - Union Symposium, several IAHS workshops and symposia

Putting PUB into Practice, P3
Canmore, Alberta, Canada 10-14 May 2011

- 3 days of science lectures, discussion and breakout discussions
- Involvement of researchers and practitioners
- Policy implications discussed
- Field trip to Canadian Rocky Mountains

P3 Scientific Advisory Committee

Canadian Group	PUB Theme Leads	Other PUB Leaders
John Pomeroy – Chair of IAHS Decade for PUB 4th Biennium	Berit Arheimer - Sweden	Keith Beven – UK
Howard Wheater, Director, Global Institute for Water Security, Univ Saskatchewan	Alexander Gelfan - Russia	Günter Blöschl -Austria
Al Pietroniro, Government of Canada, Director, Water Survey of Canada	Denis Hughes – South Africa	Robin Clarke – Brazil
Chris Spence - CNC-PUB	Danny Marks – USA	Barry Croke – Australia
Paul Whitfield -CNC PUB	Hubert Savenije - Netherlands	Carmen de Jong - France
Taha Ouarda –CNC PUB	Doerthe Tetzlaff - UK	Yuikio Hirabayashi - Japan
Bob Metcalfe – CNC PUB	Thorsten Wagner - USA	Ian Littlewood - UK
Dan Moore, IAHS Nat. Rep.	Ross Woods - NZ	Suxia Liu - China
		Alberto Montenari – Italy
		Jeff McDonnell - USA
		Siva Sivapalan - USA
		Kuniyoshi Takeuchi – Japan
		Eric Wood – USA
		Olga Semenova - Russia
		Gordon Young – IAHS President

P3 L mmittee

- Paul
- Mich versity of Sask
- Joni , University of Sa
- John ogy, Univ
- Rob sheds Clim

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and Global Institute for Water Security

Western Watersheds Climate Research Collaborative

columbia icefield glacier adventure

Centre for Hydrology
University of Saskatchewan

Putting PUB into Practice: P3

- *By examining a gradient from data rich to data poor regions and considering the needs of various hydroclimatic regions, we seek to share and consolidate between and across:*
  - *PUB themes and working groups,*
  - *the variety of regional efforts and perspectives,*
  - *approaches that maximise the predictive value of streamflow data and their use,*
  - *approaches that maximise the use of physically based theory - process structure, process variability and their emergence into predictive approaches, and*
  - *the inclusion of new measurement and information technologies for meteorological inputs, process verification, and catchment characterization*
- *And continue the exploration of improved models and tools that reflect improved hydrological understanding and their use in practice.*

P3 Synthesis Lecture Topics

- ***How to maximize the predictive value of available information (basin parameter transfer, statistical approaches, hydroclimate classification, proxy data)?***
- ***How to improve process realism in physically-based predictive approaches (parameter identification)?***
- ***How to apply process understanding in predictive approaches (parameterisation and structure)?***
- ***How to predict using physical principles (implementing hydrological land surface scheme)?***
- ***How to reduce uncertainty when land use or climate change is creating non-stationarity (integrated)?***
- ***How to chose and assimilate data for hydrological prediction (data assimilation)?***
- ***How to access measurement and information technology for prediction (satellite, atmospheric models)?***
- ***How to use new information technologies for prediction (ensemble forecasts)?***
- ***How to combine inductive and deductive approaches to prediction (integrated solutions)?***

P3: Hydroclimate and Data Availability Regional Approach

- TODAY: How can the various approaches for hydrological prediction in your hydroclimatic region be implemented given the availability of meteorological and catchment data and current understanding of hydrology.
  - small spatial scales, short time scales
  - large scales, longer time scales
- THURSDAY:
  - How can predictive approaches be improved? (Additional process understanding, additional data)
  - How can information gleaned from data rich regions be applied to data sparse regions
- FRIDAY:
  - How can available hydrological tools be made usable by practitioners?
  - How can information gleaned from data rich regions be applied to more data poor regions.

Breakout Groups

Group 1: Semi-arid and Arid Regions Squirrel Room
Chair: Anil Gupta (Canada)
Rapporteur: James McPhee (Chile)

Group 2: High Mountains Wolverine Room
Chair: Ross Woods (New Zealand)
Rapporteur: Dan Moore (Canada)

Group 3: Temperate Forest Regions Cougar/Grizzly Room
Chair: Tim Link (USA)
Rapporteur: Carmen de Jong (France)

Group 4: Temperature Agriculture Regions Vic's Private Room
Chair: Ian Littlewood (United Kingdom)
Rapporteur: Kevin Shook (Canada)

Group 5: Boreal-Arctic Regions Caribou Room
Chair: Sarah Boon (Canada)
Rapporteur: Chris Spence (Canada)

Group 6: Tropical and Sub-Tropical Regions Crocus/Arnica Ballroom
Chair: Julie Kiang (United States)
Rapporteur: Dennis Hughes (South Africa

Poster Session

- PUB Café in Ladyslipper/Orchid Ballroom
  - Coffee/tea/snacks for morning and afternoon breaks
  - PUB opens 5:30 pm daily (6 pm Friday)
- Posters up and attended in the PUB Café 5:30 pm Today and Thursday
  - Can also be viewed at coffee break, lunch

P3 Outcomes

- Better understanding of needs of applied hydrology and capabilities of theoretical hydrology
- Regional solutions to PUB identified, reviewed, outlined and issues in implementation discussed
- P3 Book – Proceedings, inclusive, publication by CWRA
- P3 Special Issue – key presentations, regional solutions, international journal

Field Trip

Michael Allchin, Robert Sandford and Joni Onclin for meeting planning and logistics.
Speakers and poster presenters.
Session and breakout group chairs, discussion leaders and rapportuers.
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