IAHS Decade on Predictions in Ungauged Basins (PUB): 2003–2012

PUB Science and Implementation Plan

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Motivation for PUB

- …human activities have disrupted the natural hydrological and ecological regimes … water supplies are no longer secure, flood risk is increasing, and biodiversity is steadily decreasing due to destruction of riparian ecosystems…. we need predictive tools for sustainable management

Current Prediction Methods and the Role of Gauging

- the most widely used predictive tools are data-driven, estimated from hydrometric (gauged) data.
- application of these for predictions is based on the premise that

  1) past is a reasonable guide to future, and

  2) data from one basin is a useful guide to the response at another basin.

Difficulties with Predictions in Ungauged Basins

- spatial heterogeneity of climatic and landscape properties, …
- multi-annual and multi-decadal fluctuations in climatic inputs, …
- human-induced changes in climate and land use, …..
- decline of gauging networks in areas where the land use impacts are also strongest!

Overall Goal of PUB

- To formulate and implement appropriate science programmes to engage and energize the scientific community, in a coordinated and effective manner, towards achieving major advances in the capacity to make predictions in ungauged basins

Broad Community Objectives ..

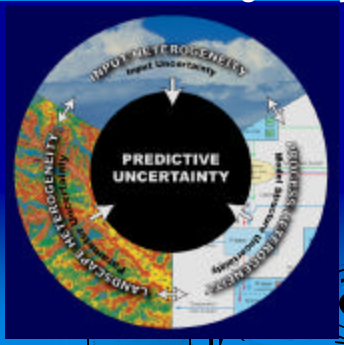
1. Advance the ability of hydrologists worldwide to predict the fluxes of water and associated constituents from ungauged basins, along with estimates of the uncertainty of predictions;
2. Advance the knowledge and understanding of climatic and landscape controls on hydrologic processes occurring at all scales, in order to constrain the uncertainty in hydrologic predictions;

continued …

Broad Community Objectives

3. Demonstrate the value of data for hydrologic predictions, and provide a rational basis for future data acquisitions, by quantifying the links between data and predictive uncertainty;
4. Advance the scientific foundations of hydrology, and provide a scientific basis for sustainable river basin management.
5. Actively promote capacity building activities in the development of appropriate scientific knowledge and technology to areas and communities where they are needed.

Predictive Uncertainty: Links to Heterogeneity



PUB Science Plan

- Research Targets
- Key Science Questions
- Enabling Research

Specific Targets

- **Target 1**
  - examine and improve existing models in terms of their ability to predict in ungauged basins through appropriate measures of predictive uncertainty

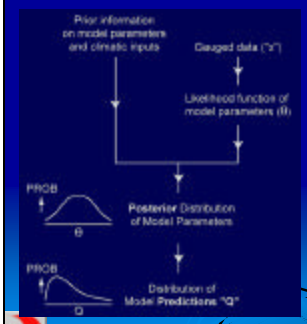
Research Targets

- Overall target:
  - Focus on *reduction of predictive uncertainty*

Specific Targets

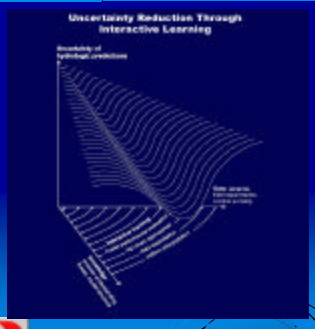
- **Target 2**
  - develop new, innovative models to capture space-time variability for making improved predictions in ungauged basins, with a concomitant reduction of predictive uncertainty

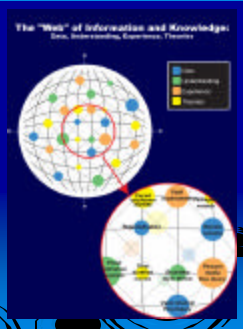
A Framework for Uncertainty Estimation



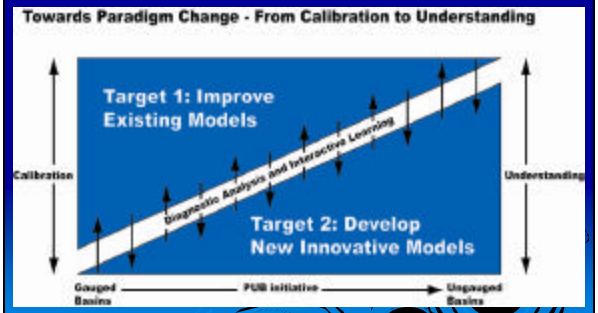
- **The Bayesian approach to estimating predictive uncertainty is only one of many alternative approaches that will be explored during PUB.**
- **Other methods include Monte Carlo procedures, application of fuzzy logic, the use informational entropy, and the generalised likelihood uncertainty estimator (GLUE).**

A Framework for Reduction of Predictive Uncertainty





Research Targets



Key Science Questions, and Enabling Research

- **Question 1: What are the key gaps in our knowledge that limit our capacity to generate reliable predictions in ungauged catchments?**

Enabling Research: Investigate the connection between heterogeneity and predictive uncertainty, by addressing:

(i) Lack of concurrent datasets at multiple space-time scales limiting development of tools and approaches that are capable of dealing with extreme multi-scale variability.

(ii) Lack of understanding of (a) hydrological functioning at a multiplicity of scales within basins and (b) nonlinear coupling and feedback that exist between vegetation, land forms, water and energy at these scales.

(iii) Limitations of existing theoretical and modelling approaches to satisfactorily deal with the above.

Key Science Questions, and Enabling Research

- **Question 2: What are the information requirements to reduce predictive uncertainty in the future?**

Enabling Research: Advance theories, data and models relating to the heterogeneity of climatic inputs, landscape properties and hydrological processes.

(i) Develop appropriate multi-scale theories of climatic inputs, landscape properties and resulting hydrological processes that can be tested

(ii) Assemble suitable datasets for testing of the theories developed in (i) above.

(iii) Develop suitable approaches to evaluate predictability limits and compare the prediction performances of models in ungauged and poorly gauged basins to these limits

Key Science Questions, and Enabling Research

- **Question 3: What experimentation is needed to underpin the new knowledge required?**

Enabling Research: Process studies and field experiments worldwide for theory development and model improvement

(i) Concurrent measurements over a wide range of time-space scales in nested river channel networks and within associated hillslope and landscape elements.

(ii) Well-defined space-time resolution of new data acquisition systems for the testing of theories of hydrological processes, and improving process descriptions in models.

Key Science Questions, and Enabling Research

- **Question 4: How can we employ new observational technologies in improved predictive methods?**

  Enabling Research: Advance the use and development of remote sensing and other novel observational technologies

  (i) Development of new instruments and models for data acquisition as needed.

  (ii) The fusion of data collected with the help of multiple sensors, both remote and on-ground.

Key Science Questions, and Enabling Research

- ***Conclusion:***

  "The steps outlined above will undoubtedly lead to new predictive approaches based on existing and potentially new data sets that are as yet unimaginable at the present time."

Key Science Questions, and Enabling Research

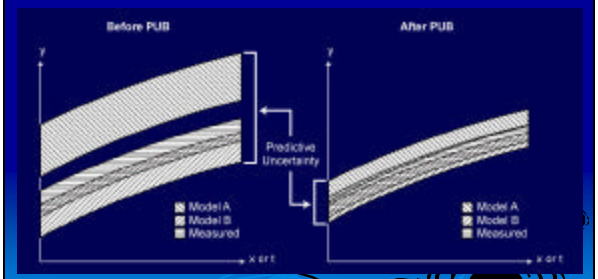
- **Question 5: How can we improve the hydrological process descriptions that address key knowledge elements to reduce uncertainty**

  Enabling Research: Advance process descriptions through field experiments and comparative evaluation of models in selected basins in a variety of environments

  (i) Advance process descriptions through field experiments and comparative evaluation of existing models, conditioned upon data in selected basins in a variety of environments.

  (ii) Couple hydrological processes and conservation equations with patterns and statistics at multiple scales

Reduction of Uncertainty through Improved Process Descriptions



Key Science Questions, and Enabling Research

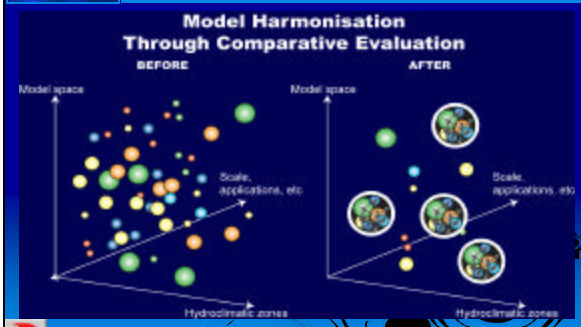
- **Question 6: How can we maximise the scientific value of available hard and soft data in generating improved predictions?**

  Enabling Research: Interpret existing hard and soft data, and patterns in such data, through assimilation with dynamic models

  (i) Advance the theoretical framework for interpreting patterns in data through tests of hypotheses involving the use of simple models of basin responses, and the discovery of new laws governing those responses;

  (ii) Develop new uncertainty criteria to detect, evaluate and interpret patterns caused by nonlinear interacting, and/or threshold processes, including new uncertainty bounds required to deal with the resulting pattern dynamics.

Model Harmonisation



Core Science Themes: Science to Implementation

- **Target 1: Improve existing models …**
  - **Theme 1.** Advance new approaches to learning from existing data: data mining and re-analysis, basin inter-comparisons and global hydrology
  - **Theme 2.** Advance existing theories regarding process heterogeneities, and improve their descriptions through detailed process studies
  - **Theme 3.** Advance learning from the application of existing models, through uncertainty analyses and model diagnostics

Core Science Themes: Science to Implementation

- **Target 2: Develop new, innovative models**
  - **Theme 4.** Use of new data collection approaches for large-scale process understanding, model development and improved predictions
  - **Theme 5.** Develop new hydrologic theories based on scaling, multi-scaling and complex systems approaches, nonlinear pattern dynamics and ecohydrological relationships
  - **Theme 6.** Develop new, multi-scale spatially distributed modelling approaches with a focus on model falsification over a wide range of basin scales

PUB Implementation Plan

- PUB Organisational Principles
- Structure of PUB Organisation and Activities
- Links to IAHS and IAHS Commissions
- Links to Other Global Programmes

Organising Principles of PUB: *"Design the process, not the product"*

- **PUB is inclusive of the diverse range of research interests within the hydrological scientific community, and a similarly wide range of applications;**
- **PUB is amenable to the adoption of uncertainty estimation on a routine basis;**
- **PUB enables comparability of performance of a plurality of approaches with regard to specific objectives;**

Organising Principles of PUB

- PUB encourages integration of different areas of expertise towards common objectives;
- PUB emphasizes merging or assimilation of theoretical advances, process understanding, new data technologies and evaluation of model performances in different contexts (scales, applications, hydro-climatic zones etc.) towards the reduction of predictive uncertainty.

Organising Principles of PUB

- Plurality of applications, approaches, models, basins, and enabling research programmes towards the single common objective: *"Reduce Predictive Uncertainty"*

Current prediction methods …

- extrapolate from gauged basins
- remote sensing
- hydrological model simulation
- integrated meteorological and hydrological model

Possible regions of interest …

- arid to semi-arid regions
- humid regions
- tropical
- cold regions
- mediterranean regions
- karstic regions
- monsoon Asia

Potential applications …

- flood estimation
- climate variability and droughts
- erosion and sedimentation
- snow and ice and snowmelt
- nutrients and eutrophication
- land use and salinity

Plurality of interests and approaches

- Is there a particular order in which we do these?
- Is one method better than the other?
- Is one application more important than another?
- Is one region more important than the other?

NO! Plurality is chosen ….

- because comparability models/approaches/basins/-applications will enrich the learning process, and
- because additional information/knowledge/data/-experience are used,

reduction of uncertainty will be faster.

Possible types of models …

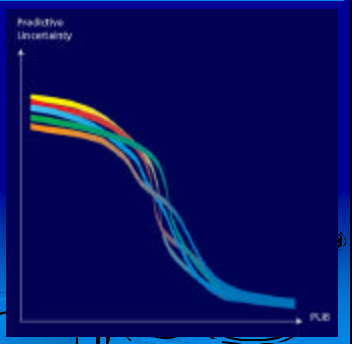
- empirical models
- stochastic models
- distributed models
- lumped models
- soil-vegetation-atmosphere-transfer (SVAT) models

Convergence of a Plurality of Approaches …

- Towards the single common objective:

"**Reduce Predictive Uncertainty**"

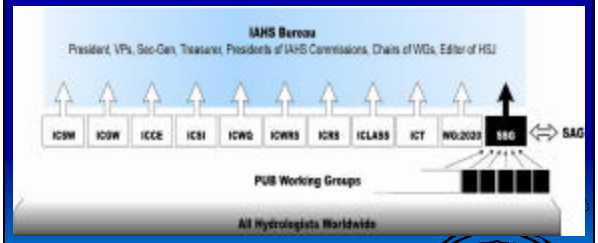
with single-minded focus and singular belief



Structure of PUB Organization and Activities

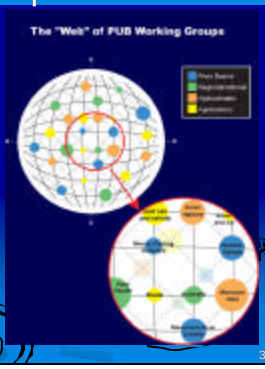
- Affiliation with PUB: networks of PUB Working Groups
- Role of and links to IAHS Commissions

Working Under the Umbrella and Guidance of IAHS



Global Network of PUB Working Groups

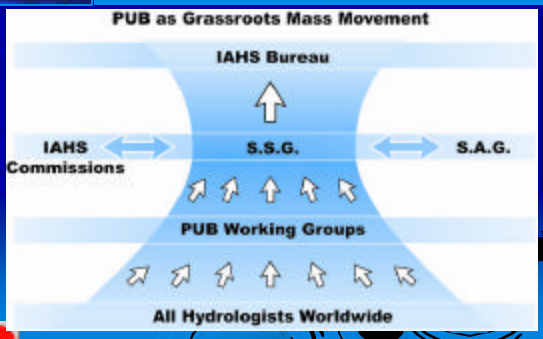
Self-organized, in a spontaneous manner around the world, consisting of collaborative groupings, ideally cutting across traditional thematic areas, and national or geographic boundaries



Links between PUB and IAHS Commissions

ICSW	International Commission on Surface Water
ICGW	International Commission on Groundwater
ICCE	International Commission on Continental Erosion
ICSI	International Commission on Snow and Ice
ICWQ	International Commission on Water Quality
ICWRS	International Commission on Water Resource Systems
ICRS	International Commission on Remote Sensing
ICCLAS	International Commission on Climate-Land-Atmosphere System
ICT	International Commission on Tracers
WG:2020	Hydrology 2020 Working Group

PUB as Grassroots Mass Movement



Links to Other International Programmes on Climate and Water

- Water and Environmental Management at Basin Scale
- Water and Energy Circulation at the Planetary Scale

Place of PUB Amongst International Programmes on Water

Water and Environmental Management at Basin Scale

- UNESCO International Hydrological Programme (IHP)
- Hydrology for the Environment, Life and Policy (IHP-HELP)
- Flow Regimes from Experimental and Network Data (IHP-FRIEND)
- WMO World Hydrological Observing System (WHYCOS)
- World Water Assessment Programme (WWAP)

Water and Energy Circulation at the Planetary Scale

- Global Energy Water Experiment (GEWEX)
- Coordinated Enhanced Observing Period (CEOP)

Synergies between PUB and Related Programmes

- PUB will provide the advanced predictive hydrological engines necessary to drive these related programmes

Network of PUB, PUB-HELP, PUB-FRIEND and PUB-CEOP Basins

- PUB Working Groups formed around selected basins in variety of hydro-climatic regimes
- Make data available through world wide web; disseminate results rapidly
- Work closely with HELP, FRIEND, CEOP, GEWEX, WWAP etc.; basins established; feed in advances in predictability
- Minimum data quality criteria to be met

Organisational Chart of SSG Activities

Coordination of ....

- **PUB Working Groups**
- **PUB Activities/Conferences**
- **PUB/HELP Basins**
- **PUB Lobbying & Publicity**
- **PUB Communication - Website**
- **PUB Capacity Building**
- **Links to IAHS Commissions & User Groups**
- **Links to HELP, FRIEND etc.**
- **Links to GEWEX, CEOP, WHYCOS WWAP, etc.**
- **PUB Publications**
- **Links to SAG**

PUB Activities

As the research into PUB takes hold, the main PUB activities will be in three areas:

1. organization of meetings, workshops and congresses,
2. regular publication of progress in PUB activities, and
3. Technology Transfer through various means, but with specific focus on Web-based communication.

Meetings and Workshops

- Conferences (regular)
- Specialist Workshops (ad hoc) -
- Informal uncertainty workshops (Proactive promotion/education of uncertainty)
- International Stakeholder Conference (2008): 'The uncertainty of hydrology and the value of data'

Publications

- 1-2 IAHS Redbooks per 2 years arising from IAHS/SSG Biennial conferences
- Redbooks should integrate research/progress (focus on comparability)
- no more than 1 'special issue' or 1-2 'special sections' of HSJ
- when HSJ/Redbooks cannot accommodate volume of material, individual WGs will be encouraged to publish in the wider hydrological community (special issues)

Technology Transfer .....

- News and Views
- Science implementation plan
- Meetings - Past and Future
- List of WG's (aims, data sets employed)
- Links to PUB datasets
- Links to related activities
- Message Board
- Ongoing Call for Proposals to set up PUB Working Groups (pro forma)

Technology Transfer

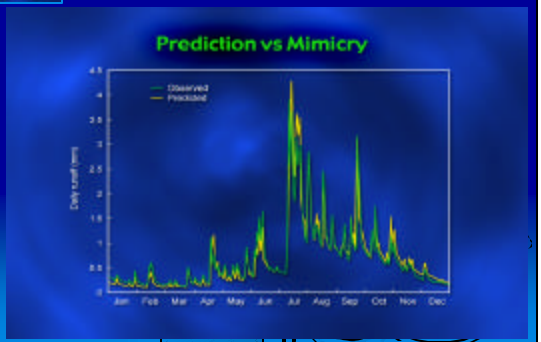
Technology Transfer (Web)

- Directory of methodologies
- Directory of expertise for consultation
- Directory of relevant data sources

Technology Transfer (workshops/short courses)

- Encourage running of workshops in Less Developed Countries
- Encourage running of short courses summarising information on lessons learnt from PUB activities

Outcomes of PUB – from "boring, mindless" calibrations .....



….. to the truly inspirational!

Why you should support PUB?

- It is highly focused and well coordinated
- It will lead to increased investment in data collection
- It will lead to improved models and prediction methods
- Its focus on predictive uncertainty will lead to better management of water resources
- It will unite the hydrologic community towards socially relevant science
- It will lead to a better funding environment for hydrologic science research

PUB Outcomes and Broader Vision

"PUB activities will undoubtedly lead to new predictive approaches based on a combination of current and new theories, and existing and potentially new data sets, that are as yet unimaginable at the present time."

A Rallying Cry for PUB …

- People support what they help to create
- None of us has all the answers
- Together we can do anything!

Why you should join PUB?

- It is challenging, exciting, rewarding
- It is practical, useful, socially relevant
- It is highly focused and well coordinated
- It is inclusive of all kinds of ideas and approaches
- It links you up with other people, reducing isolation
- It enables us to better communicate with ourselves and with the rest of the community
- It will raise the profile of hydrology in comparison with kindred sciences
- It will lead to a better funding environment for hydrologic science research