Applications of PUB in practice in southern Africa

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Models have been used for water resources assessments for many years:

- Pitman monthly rainfall-runoff model for estimating natural hydrology and some changes (e.g. land use change effects).
- Water Resources Yield Model (WRYM) to simulate development impacts (reservoirs, abstractions & return flows) and operating rules under different scenarios.
Traditional approach

- Observed data
- Calibration
- Hydrological model
- Regional parameters
- Stochastic streamflow model
- Systems yield model
- Historical, present day and future water use data
- Decision making and water allocations
Problems

► Stream flow gauging data rarely represent natural conditions:
  ♣ Naturalisation process confused by inadequate historical data on upstream development & patterns of water use.
  ♣ Impacts on calibration results

► Poor rainfall data in some areas (mainly mountainous regions).
  ♣ Parameter sets could be biased to input errors.

► Use of ‘catchment similarity’ approach has been largely subjective:
  ♣ No real basis for establishing similarity & no independent tests.
  ♣ Regional parameter sets uncertain, but not quantified.
Is there an alternative approach?

► That includes:
   ♦ Recent international developments in the concepts of uncertainty in hydrological modelling.
   ♦ Principles and developments of PUB.

► And is:
   ♦ Practical to apply under SA conditions.
   ♦ Does not require a complete change to existing approaches to water resources assessment (there would be a lot of resistance to a major change).
   ♦ Can be applied with existing models.
An uncertainty framework

- Prior parameter distributions
- Parameter sampling scheme (with options to include sensitivity analysis and optimisation)
- Hydrological model
- Stochastic rainfall model including climate change impacts
- Water use data with uncertainty
- Decision making based on yield probability curve including all sources of uncertainty
- System yield Model (including stochastic flow generation)
- Accepted hydrologically behavioural solutions
- Ensembles of flow predictions
- Regional or observed constraints on indices of hydrological response

Contributions from PUB
How can PUB support the practical application of the framework

► Parameter estimation procedures:
  • Understanding processes as the catchment scale.
  • Understanding distributions of hydrological processes across complex landscapes.
  • Scaling rules across different size catchments.
  • Estimation of residence times and flow paths using isotope data, etc.
  • Characterisation of storage & fluxes.
  • Transfer of parameters from donor catchments with parameter likelihoods.
  • Similarity weighting.
  • Non-stationary parameter values linked to climate.
How can PUB support the practical application of the framework

- **Constraints on model ensemble outputs:**
  - Hydrological indices used to condition model ensemble outputs (SCS curve number & others).
  - Using hydrological state variables as well as output stream flow (information obtained from remote sensing or other sources).
  - Regional signatures of catchment response (residence times, storage-discharge relationships, GW contributions, etc.).
  - Use data rich information to help in data poor situations.
  - Use focused, short-term field observations.
How can PUB support the practical application of the framework

►► Feedback loop from constraint analysis to parameter estimation:

♣ Using model outputs to assess process understanding.
♣ Identifying critical processes/parameters that generate most output uncertainty (sensitivity analyses).
♣ Reducing the uncertainty in model parameters.
♣ Identifying parameter redundancy.
How can PUB support the practical application of the framework

- Others
  - Parameter sampling schemes across different model complexities to achieve realistic expressions of output uncertainty (given huge sampling space).
  - Identifying model structural inadequacies and needs for improved models.
  - Using satellite or NCM data to substitute for inadequate model forcing data.
  - Proving to practitioners that uncertainty assessments are possible, practical and essential.
Some of the PUB contributions are research areas that could improve techniques that can be applied in practice.
- e.g. develop better parameter estimation procedures.

Others are contributions that can be applied directly in practice.
- e.g. ensemble outputs to generate yield probabilities to inform water resource decision making risk.