Teaching modelling and hydrological concepts

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Undergraduate courses

- Data analysis techniques – spectral and time-series analysis (Captain toolbox)
- ODE and PDE based models
- Model development techniques, and analysis of models
  - 10 steps paper
- Uncertainty propagation – and model evaluation in presence of uncertainty
- Models from different disciplines
- Integration of different disciplines
  - Coupled complex models
  - Bayesian network models
Introduction

Development of teaching tools

- Tamborine (written in Java)
  - Introduction to modelling for less mathematical students
  - Hands on “play-with-model” tool
- Hydrosanility (written in R)
  - Tool for exploring data to spot errors, assist with filling missing data
- Rainflowlab (written in R)
  - Future development version of IHACRES
    - Integration of model with Hydrosanility
    - Multiple calibration techniques
    - New model structures – e.g. influence of event magnitude on UH
Model development

- Preference for data-based model development
  - E.g. Captain toolbox
- Need good understanding of the data, and correction of known problems
  - Tools to find problems in datasets, and assist in correcting them
- In absence of suitable data, then resort to processes
  - Constraints on model formulation
  - Use uncertainty analysis to indicate future research
Data analysis

- auto-correlation of rainfall

Correlation coefficient

Normalized response function

Lag
Constraints on model formulation

CMD module drainage equation

\[ \frac{\partial U}{\partial P} = 1 - f(M) \]

\[ \frac{dM}{dP} = -f(M) \]

- Constraints
  - Analytic solution

\[ \frac{\partial U}{\partial P} = 1 \quad \text{when } M = 0 \]

\[ \frac{\partial U}{\partial P} \text{ is a monotonically decreasing function of } M \]

\[ \int_{M_1}^{0} \frac{dM}{f(M)} = \infty \]
Possible functional forms

- linear
- power law
- bilinear
- trig
- hyperbolic
- tanh
Simulation version of IHACRES

Demonstrates, interactively:
- effect of changing parameter values
- non-uniqueness of calibrated parameter set: “equifinality”.
- tradeoff between fitting different features of the observed data.
- fit statistics vs graphical displays of results.
- the difficulties of manual calibration!
- Start with a catchment dataset and the initial parameter values
  - Investigate goodness of fit
  - Investigate data anomalies
- Play with parameter values
  - Compare models
- Export data and do your own analysis
2. Hydrosanity

- R package with Graphical User Interface
- For managing, plotting and manipulating multiple time series of rainfall and streamflow
- Focus is on understanding the data, and assisting in locating errors in the data
### Summary table (click cells to edit)

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<thead>
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<th>ID</th>
<th>Name</th>
<th>Start</th>
<th>End</th>
<th>Length</th>
<th>Timestep</th>
<th>Location X.Y.Z</th>
<th>Qual</th>
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<td>(good/sus)</td>
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</table>
$o =$ sufficient data in chosen time frame;
$x =$ too little data available.
qqmath(~data, data = tmp.groups, type = "b", cex = 0.5, groups = which, distribution = qnorm, panel = function(x, ...)::

Click or drag to identify points, Ctrl-drag to zoom, Ctrl-click to zoom out, Right-click for more
Rolling cross-correlation Q vs. P for lags 0,1,-1
3. Rainflowlab (R package)

- Framework for specifying, calibrating and comparing hydrological models.
- Soil Moisture Accounting (SMA) and Routing modules can be specified.
  - e.g. IHACRES CWI and CMD models for SMA
  - Typically transfer function for routing
- Calibration routines for
  - All parameters jointly;
  - SMA parameters, with routing calibration nested inside;
    - SRIV algorithm
  - Separate calibration of routing (independent of SMA, not nested). May use a DBM-like approach, or an iterative inverse scheme.
Summary

- **Model development**
  - Understanding data
  - Data-based versus processed-based formulation
  - Model testing

- **Tools**
  - Teaching behaviour of models
  - Importance of data evaluation
  - Calibration techniques