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Decision tree for choosing an uncertainty analysis methodology: a wiki experiment http://www.floodrisknet.org.uk/methods http://www.floodrisk.net

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Introduction

Uncertainty analysis has received ever-increasing attention over recent decades in hydrological and hydraulic modelling. This growth has lately begun to accelerate, fuelled by an interest in the use of risk and decision analysis techniques to support decision making (Defra/Environment Agency, 2003).

A wide range of technique exist to handle of uncertainty. All every techniques, as well as the tools which implement them, has an associated learning curve. Surmounting any one of these curves requires the investment of considerable time and effort. Surmounting sufficiently many of these curves to understand the nuances and different areas of applicability of a range of methods is a major barrier to their more widespread use.

The would-be uncertainty analyst is faced with a difficult, even intimidating decision. We describe an attempt to address this problem in a scalable, extensible way, making use of a *wiki*, a type of web site that allows and encourages editing by its readers. This effort contributes something quite unique and complementary to the Working Group on Uncertainty and Parameter Estimation of the US Federal Interagency Steering Committee on Multimedia Environmental Modeling[1] and the IAHS PUB Working Group on Uncertainty Analyses and Model Diagnostics.[2] It provides a *brief discussion of risk and uncertainty* in the context of hydrological and hydraulic modelling, a *glossary of terminology*, a *catalogue of uncertainty analysis methods*, some *worked examples*, and a *decision tree*, helping users choose a method by answering a small set of questions.

The Wiki Concept

The abbreviated 'wiki' is used to describe a tool allowing the collaborative development of densely linked set of web pages. Recently,

[1] **See http://www.iscmem.org/WorkGroup_02.htm**
[2] **See http://cee.uiuc.edu/research/pub/htmlStorage/WorkingGroups/Uncertainty_PUB_WG7.pdf**

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the concept has been brought to a larger audience in the form of Wikipedia,[3] the collaboratively edited encyclopaedia.

The pages of a wiki can be added to or edited very easily. A single mouse click is needed to move from viewing to editing a page. Rather than asking the user to learn an arcane markup language like HTML, or requiring them to install a particular editing tool, editing takes place in plain text in a browser window, with text formatting achieved through a few simple rules. Thus, it is easy not only to add and edit pages, but also to connect them in a densely hyperlinked network.

The notion of a web site in which any page can be edited by any visitor at any time strikes most people not already familiar with it as odd. Many go further, and insist that the lack of editorial oversight and quality control must lead to a rapid degeneration of quality. There are many wiki instances that stand as concrete evidence that this is not necessarily the case.

This apparently paradoxical situation arises because a wiki instance is not a piece of software but a sociotechnical system comprising software and a user community. Rather than requiring the *a priori* allocation of editor, contributor, and reader roles to members of the community, wiki software provides tools that allow any member to play any role at any time. By making these tools simple to learn and fast to use, the diffuse expertise of the community is effectively mobilized, providing robustness as an emergent property of the socio-technical system rather than through the constant exercise of oversight by a few editors.

One feature of the wiki, which is of particularly important in this context, is that a complete history of edits to pages is retained. Using this history, edits can be reverted, which alleviates the problems of wanton vandalism and well-intentioned but erroneous contributions alike. Furthermore, the availability of this history allows the reader to see at a glance how rapidly a page is changing, and thus to gain an impression of how stable and, by implication, uncontroversial the content of that page is.

[3] See http://www.wikipedia.org/

The Methods Wiki

Uncertainty, risk, and decision analysis are evolving fields. More methods already exist than can be collected and documented by a small number of editors, and the number of methods available is added to regularly by active research communities. The methods are founded in a variety of general approaches and philosophies that may be the subject of debate and even controversy. Application of methods in practice generates valuable case studies that can only be documented effectively by those involved.

We have established a wiki on uncertainty, risk and decision analysis methods, taking as a starting point a recent review of uncertainty analysis methods by the authors (Pappenberger *et al*., 2005). Our hope is that the power of the wiki in mobilizing and concentrating expertise that is diffusely distributed across a community of practice will lead to the creation of a resource of great benefit to researchers and practitioners in flood risk management. In time, this resource may provide the basis of a code of practice in risk and uncertainty estimation as advocated by Pappenberger and Beven (2006).

Wiki Structure

Background information

The nature of the wiki is that structure as well as content can change over time. In order to provide a useful resource from the outset, we have provided a structured information resource with a number of well-defined sections.

Even a casual review of past work on risk and uncertainty reveals that even these fundamental concepts are understood differently by different people. The wiki provides a discussion of these and related concepts and their use in the context of hydrological and hydraulic applications, in particular in flood risk management.

Risk. Some of the many definitions of 'risk' of relevance in flood risk management are listed. In most definitions, risk estimation requires the quantification of both the probability or possibility of certain situations occurring (such as inundation to some depth) and of the consequences of those

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occurrences (such as the economic loss resulting from that inundation). Both are discussed, taking into consideration the contested meaning and meaningfulness and the difficulties of quantification.

Uncertainty. These difficulties in quantification are the source of the need for improved uncertainty analysis. The wiki site outlines with examples the various sources of uncertainty in risk analysis. In terms of process simulation, model structure, scaling and resolution issues, model parameterization, topography, and boundary conditions are proposed as particularly significant sources of uncertainty. Contributions to the wiki to discuss this typology are invited. The ranking of uncertainties and the cascading of risk and uncertainties are also discussed. Two important and closely linked issues in any uncertainty analysis are the measure of model performance to use and the quality and quantity of data available, which are discussed in depth in the current wiki.

Catalogue of methods

A huge number of uncertainty handling and risk and decision analysis methods exist, and there is an urgent need for guidance in understanding and applying them. The wiki currently contains a page for each of a small but significant set of uncertainty handling methods. Each page contains a description of the method, lists strengths and weaknesses, and provides pointers to supporting material and software implementing the method (Figure 1).

The methods currently included are placed within one or more of four categories:

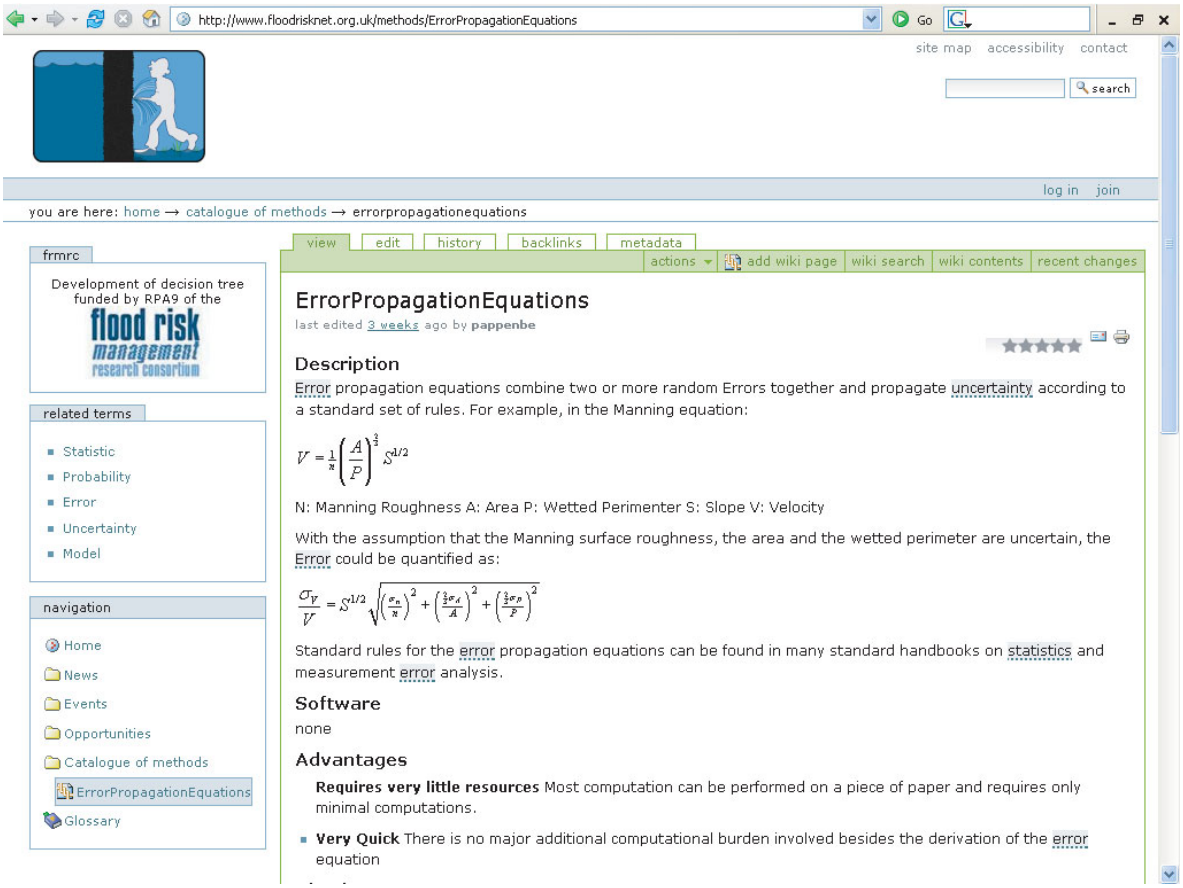

Figure 1. Sample screenshot of the description of a method (error propagation equation) taken on 26th July 2006

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- **forward propagation methods that allow the assessment of uncertainty where evaluation data are not available;**
- **methods that can be applied when such data are available;**
- **real-time data assimilation methods;**
- **qualitative methods.**

Decision tree

To choose an appropriate uncertainty analysis method for a given application currently requires a thorough understanding of the range of methods available. In particular, the assumptions made in the various methods and the choices required of the user in applying them must be understood. The catalogue section of the site provides some assistance in this regard, providing a single site to look for the needed information. This catalogue is already sizeable, however, and if this 'wiki experiment' is successful it will grow larger still. Some means are needed to constrain the space in which the potential analyst must search for appropriate methods, allowing them to focus their efforts on promising methods.

We have included a decision tree that guides the user to a small set of possibly suitable methods. This is achieved by guiding the user through a sequence of questions that encapsulate the most significant differences between methods or classes of method (Figure 2). As with the rest of the wiki, this decision tree is not claimed to be definitive, and is open for critique, modification, and extension.

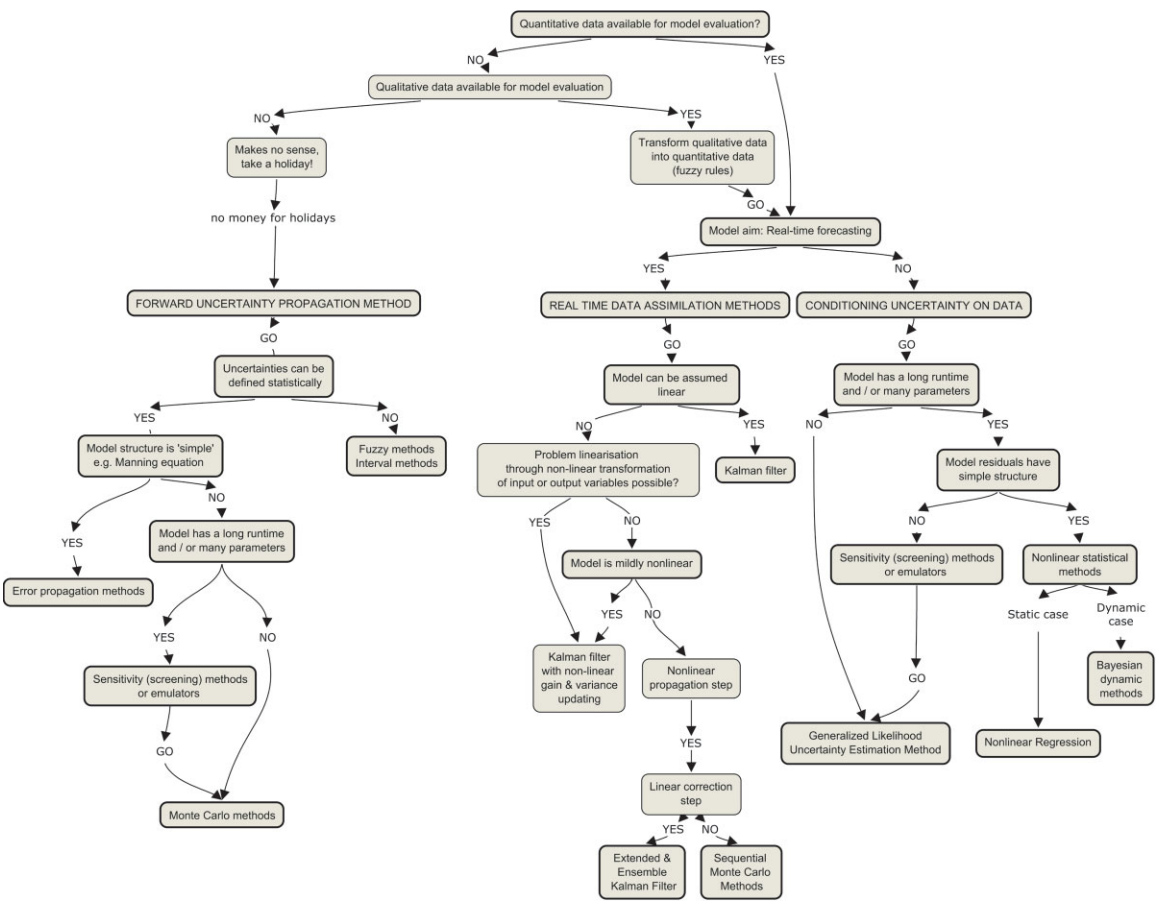

Figure 2. Decision tree to choose an uncertainty methodology (taken on 26th July 2006) as modified from the original by Renata Romanowicz (Lancaster University)

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Table I. A list of suggested contributions as a source of inspiration to the reader

Background	Extend or refine background discussion by directly editing page text or adding pages. Comment on text to suggest changes and additions or to pose questions not adequately addressed. Improve inter-linking of pages.
Catalogue	New entries for uncertainty, risk, and decision analysis methods. Improvements to existing entries, correcting errors, clarifying points, or adding additional information. Refinements to the decision tree.
Decision Tree	The decision tree is difficult to edit at present, but in principle it is just as open to improvement as the rest of the site. Propose changes using comments on the decision tree page.
Code of Practice	Proposed content for sections already suggested. Alternative or additional suggestions for useful sections.
Examples	Examples of the application of particular techniques. 'Stub' pages suggesting good examples that someone might be able to fill in. Corrections to, and questions about, existing examples. Suggestions of alternative approaches to that taken in an example.

Case studies

When it comes to understanding a particular technique sufficiently well to apply it, case studies (and particularly detailed worked examples) can be extremely valuable. A section is included in the wiki for such examples. At present this section is only sparsely populated. An example of uncertainty analysis for flood frequency estimation, based on Cameron (2006), has been added, and some additional 'stub' pages are included with suggested topics as examples. This section also contains a link to unsolved problems, which can be used to define future research projects or are supported by any experts visiting the site.

Code of practice

It is now widely recognized that the inherent uncertainty in predictions from modelling exercises—including hydrological, hydraulic, water quality, hydroecology, and risk modelling—must be addressed explicitly. The users of modelling exercise outputs are beginning to demand uncertainty estimates, and as tools for utilizing such estimates in the decision-making process become more readily available this demand will increase.

Pappenberger and Beven (2006) argue that a *code of practice* for uncertainty analysis is needed. Such a code of practice would provide guidance to the practitioner on choosing and using uncertainty analysis methods given particular applications and levels of data availability. As discussed above, the wiki provides a platform for developing and refining this sort of guidance.

A code of practice should go beyond this basic level, however. We have therefore included a section explicitly devoted to the discussion of the possible scope and content and, eventually, to the elaboration of this code.

Contributing to the Wiki

In Table I we provide suggestions for types of contribution appropriate in each area of the site and by various classes of users. This table is not complete; rather it is intended to act as a source of inspiration to the reader.

Contributions can take a number of forms, and all visitors are free to contribute in any way. The form most appropriate for a given contribution depends on the nature and status of that contribution. The types of contribution possible are as follows:

- modification of existing pages,
- addition of new pages, and
- commenting on existing pages.

Direct editing of pages is relatively 'safe' because a complete history of edits is retained. Such editing is best suited to simple changes (such as the correction of typographical errors or the addition of useful links) or to substantive modifications by experts.

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Where a contributor would like to suggest a change for consideration, but does not feel able to make the change directly, they are encouraged to use the comment facility to annotate pages. Comments can also be used to pose questions where the information provided is unclear or incomplete.

Conclusions

The wiki site described in this note is already a useful resource for those interested in uncertainty, risk, and decision analysis in flood risk management. In particular, practitioners interested in using such techniques will find the beginnings of a catalogue and guidance to help them in the process of selecting suitable methods. We hope that the ease of editing and improving the content of the site will allow it to grow and improve through the distributed efforts of the whole flood risk management community. Those who have used methods and tools are encouraged to report their experiences as case studies and examples, both to solicit feedback and for others to learn from. Researchers and experts in particular methods are also well placed to extend and refine the catalogue and decision tree sections.

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