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Empirical approach to hydrological modelling: a historical perspective in the case of the GR models

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1. Why an empirical approach?

- Much research over the past decades on modelling the hydrological response of a catchment to climate variables
- Additional difficulty in the context of environmental change
- No single approach appears best in all cases
- Different modelling approaches have various advantages and drawbacks in different contexts
- Empirical modelling approach: a modelling approach among others
- Main idea: **building model structures by testing a large number of hypotheses and options without a priori**
- Keep only those which prove useful to improve the predictive power of models
- Resulting models: good compromise between data requirements, complexity, modelling efficiency and ease of use

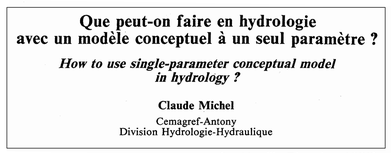
2. Start of the GR models

This empirical approach was followed by the Catchment Hydrology research group at Irstea (Antony, France). At the beginning of the 1980's, Claude Michel started to develop a family of storage-type hydrological models, called GR (standing for '*Génie rural*').



Main objectives:

- To represent as efficiently as possible the main features of the rainfall-runoff transformation
- To robustly model flows at gauged and ungauged locations
- To enhance model applications for decision-making on risk anticipation and water management



Que peut-on faire en hydrologie avec un modèle conceptuel à un seul paramètre ?

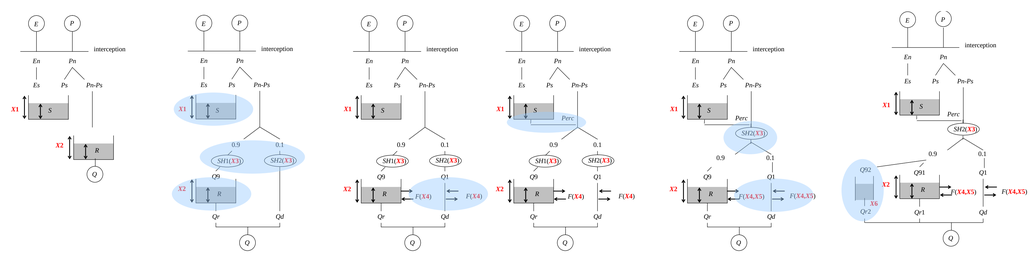
How to use single-parameter conceptual model in hydrology ?

Claude Michel
Cemagref-Antony
Division Hydrologie-Hydraulique

(La Houille Blanche, 1983)

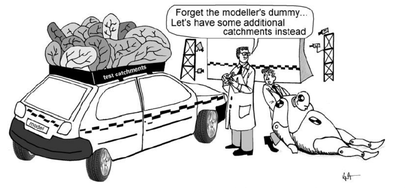
Result : suite of models running at various time steps ranging from sub-hourly to annual

3. Example of evolution of the daily model structure



4. A few guidelines for empirical model development

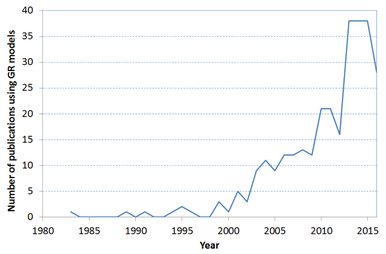
- Using large sample of catchments to make models more general, i.e. improve their transposability in space
- "Crash-testing" models with generalized split sample tests to detect problems of robustness (transposability in time)
- Accepting additional complexity only if it brings significant additional predictive power (Occam's razor principle)
- Searching for better models rather than good models (which do not exist by nature) through systematic comparisons
- Searching for flexible structures while avoiding mis- and over-calibration
- Searching for improved model consistency in time (across time steps) and space (with semi-distributed schemes)



(Andréassian et al., HESS, 2009)

5. On the use of GR models

- More than 350 published studies using the GR models
- Gradual increase in the applications of the models over the last 30 years
- GR models applied over a wide range of conditions on all the continents
- Models included in various software, operational tools and decision-making systems



6. Conclusion and perspectives

- Empirically developing models provides efficient and versatile model structures.
- But this approach also has limitations (dependency to the testing scheme options, very close competing model structures, difficult to define structure realism, etc.).
- GR models may be seen as an attempt to produce "one-size-fits-all" structures. We know this is not a realistic goal. These models should rather be seen as robust elementary building blocks from which more complex models can be designed.
- Community of end-users provides much valuable feedbacks to detect model failures.

6. References

- See our webiste for detailed references on the GR models: http://wegr.irstea.fr
- Implementation of the GR models in the airGR and airGRTeaching R packages: https://webgr.irstea.fr/modeles/airgr/
- See also tomorrow (HS2.1.1, Fri, 13 Apr, 17:30–19:00, Poster session, Hall A, A.13) on GR models: Santos et al., On the use of a Nash cascade to improve the lag parameter transposability at different time-steps in hydrological modelling