The good, the bad or the ugly? Under what conditions can we trust our models for impact studies?

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1. Rationale

Hydrological models (HMs) are simplifications of the real world. This is all the more true in climate change (CC) impact studies, where models are run under unknown conditions, which may generate substantial errors and limit their transposability in time.
Here some of the shortcomings of HMs in this perspective are shown. Methods to overcome (or at least to diagnose) these limitations are proposed, based on various modelling experiments.

2. The common pathologies of hydrological models (*Coron et al., 2011*)

- Models are simplifications of the real world ⇨ their conceptualization is modeller-dependent and this impacts simulations.
- Input quality and availability can be limited ⇨ e.g. PE is a poorly-known variable.
- Model parameters depend on the hydroclimatic conditions of the calibration period.
- Identifiability of parameters can be low.

3. Diagnosis

In our past works, we identified model deficiencies through several diagnosis approaches to answer the following questions:

- Is HM performance expected to decrease when the climatic contrast (P or T) between calibration and simulation periods increases? (see Fig. 1)

- Is the long term pattern of HM bias much dependent on the calibration period? (see Fig. 2)

- To which extent do the sign and intensity of flow evolution in CC impact studies depend on the calibration strategy (typically the objective function)? (see Fig. 3)

Fig. 1: 10-yr mean flow volume errors from 10-yr calibrated HM. High dependency to T (left) and to P (right). (Coron, 2013)

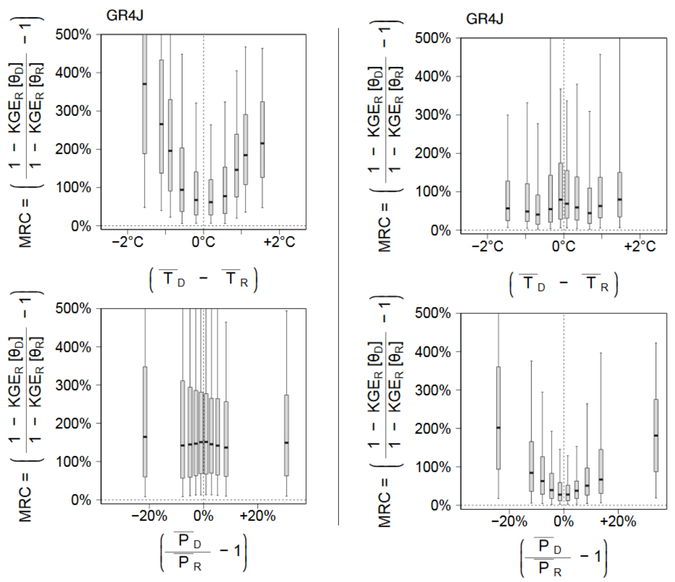


Fig. 2: 10-yr mean flow volume errors from 10-yr calibrated HM (Coron et al., 2014).

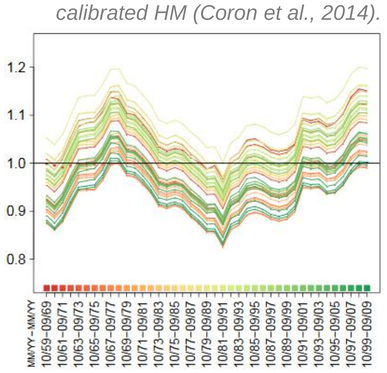
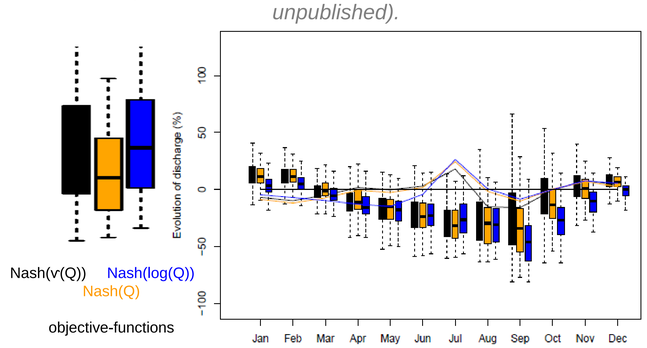


Fig. 3: Evolution of monthly discharge when HM is calibrated with different objective functions. Oct.-Nov. is the flood season (Thirel, unpublished).



4. Tools to evaluate the models robustness and establish more robust solutions

- Model intercomparison: there is no good model, only better models. Better or more robust HM results may indicate ways to improve other HMs (see in Thirel at al., 2015b, a summary of the 2013 IAHS GA workshop).

- Advanced testing: Calibration / validation of HMs through differential/generalized split sample tests (SST, DSST or GSST) (Figs. 4&5).

- Large sample hydrology: generalizing the catchments (i.e. conditions) to which HMs can be applied: transposability in space tends to improve transposability in time.

Fig. 4: An example of a DSST to be applied for examining the capacity of a HM to deal with a change.

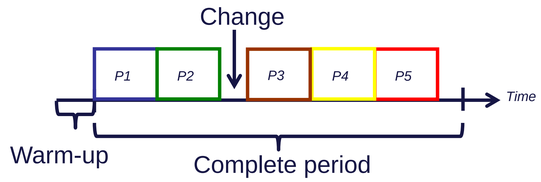
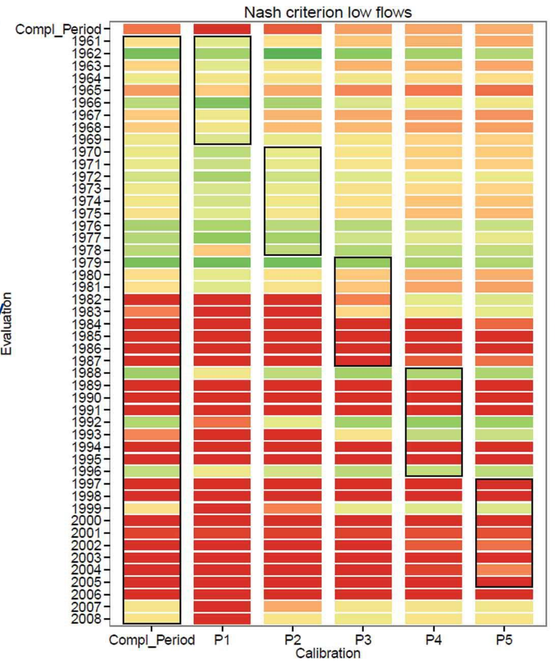


Fig. 5: Evolution of Nash on log of flows when the HM is calibrated on different periods (Thirel et al., 2015a).



5. Conclusions and perspectives

A good model for CC impact studies should not show poor behaviour in the diagnosing phase. This may not be a sufficient condition to trust the HM in all cases, but this may be a good safeguard to avoid first-order errors.
A HM failing the test described above may not be definitely bad or ugly. Different approaches may be followed to better understand its pathologies.
Potential ways to advance our capacity of proposing 'good' models for impact studies are:

- Setting up a dataset of catchments with well-known and documented changes of different types as well as high-quality meteorological and hydrological data.
- Defining and following proper HM setting up protocols for every impact study. Can hydrological modellers agree on the most adequate one?
- Process description must be adapted to the expected catchment changes.

Whatever good or bad a model may be, the quantification of uncertainties associated to the modelling phase remains an essential step in CC impact studies.

6. References

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