Rainfall-runoff model to estimate low-flow indices

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Objectives: To develop a daily rainfall-runoff model, with few parameters to simulate low-flow indices at gauged and ungauged sites and under different climate conditions.

1. Introduction

- Low flows are characterized by different indices that are needed to manage water resources at gauged and ungauged sites.
- Low-flow indices are statistics derived from measured or simulated discharges.
- A monthly regionalized rainfall-runoff model (LoiEauM) was developed by Irstea to estimate monthly indices at ungauged sites.
- Needs to adapt the model structure and regionalize its parameters to estimate daily indices at ungauged sites.

2. Dataset and methods

**Dataset**
- Daily meteorological data come from the SAFRAN reanalysis of Météo-France and daily streamflow data from the French database HYDRO.
- Set of 691 catchments throughout France, natural or with small human influences, with various hydro-meteorological behaviors.

**Low-flow indices**
- MAR: mean annual runoff.
- QMM: seasonality (mean monthly runoff).
- MAM3(5) and MAM10(5): mean annual 3-d and 10-d minimum flow at the recurrence interval of 5 years.
- QMNA(5): annual mean monthly flow at the recurrence interval of 5 years.
- Q95 and Q75: discharge equaled or exceeded 95% and 75% of the time, come from the flow duration curve.

**Methods**
- Daily model structure (LoiEauJ) derived from the monthly model LoiEauM, which has 2 parameters.
- 2 structures: one with 3 parameters and one with 2 parameters (parameter A regionalized).
- Objective function: \( \frac{1}{2} KGE(Q) + \frac{1}{2} KGE(Q^2) \).
- Evaluation of the low-flow index simulations.
- Evaluation of the robustness of the model.
- Comparison with the low-flow indices simulated with the daily models GR4J (4 parameters) and GR3J (3 parameters) and the monthly model LoiEauM.

3. Results

**Comparison for one catchment**
- Better simulations of MAM3 and QA (annual runoff), in validation with the model LoiEauJ with 2 parameters for the Loir River at Durtal.
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**Legends of the models**
- LoiEauJ (2 parameters)
- GR3J (3 parameters)
- LoiEauM (2 parameters)
- LoiEauJ (3 parameters)
- GR4J (4 parameters)

**Comparison of the models for the catchment set**
- Good simulations of the low-flow indices with the two LoiEauJ models.
- Better simulations of high flows, C2M(Q), and intermediary flows, C2M(sqrt(Q)), with the model LoiEauJ with 3 parameters. (C2M = \( \frac{x_{10}}{x_{95}} \)).
- No differences between the two LoiEauJ for the low-flow simulations, C2M(1/Q).
- The performances of the two LoiEauJ are as good as the ones with GR3J and GR4J.

4. Conclusions, Perspectives

**Robustness of the models**
- Calibration on the 22 driest years and validation on the 22 wettest ones, then the periods are exchanged.
- The LoiEauJ model with 2 parameters is more robust for the low-flow index simulations.
- The LoiEauJ models are more robust for the high-flow and intermediary-flow simulations.
- Evaluation of the low-flow simulations.

**Comparison with the monthly model**
- The QMNA(5) and the monthly hydrographs are better simulated with the daily models, the 2 LoiEauJ, GR4J and GR3J, than with the monthly model, LoiEauM.
- The monthly indices are better simulated with the daily models than with the monthly one, at gauged sites.
- The parameters of these models will be regionalized, with spatial proximity interpolations or regressions, and the simulations will be compared at ungauged sites.

References