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Automated Detection and Categorization of Hydrograph Errors for Updating Operational Hydrologic Models

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Background

- The Norwegian hydropower system is complex and its operation heavily depends on hydrological models
- Hydropower companies employ hydrological models for inflow prognosis, reservoir operation planning and optimization of production
- Challenges:
  - degree of mismatches between simulated and measured hydrographs
  - forecasting the unknown future using hydrological models
- Developing a new updating algorithms is one of the on going collaborative hydrological projects

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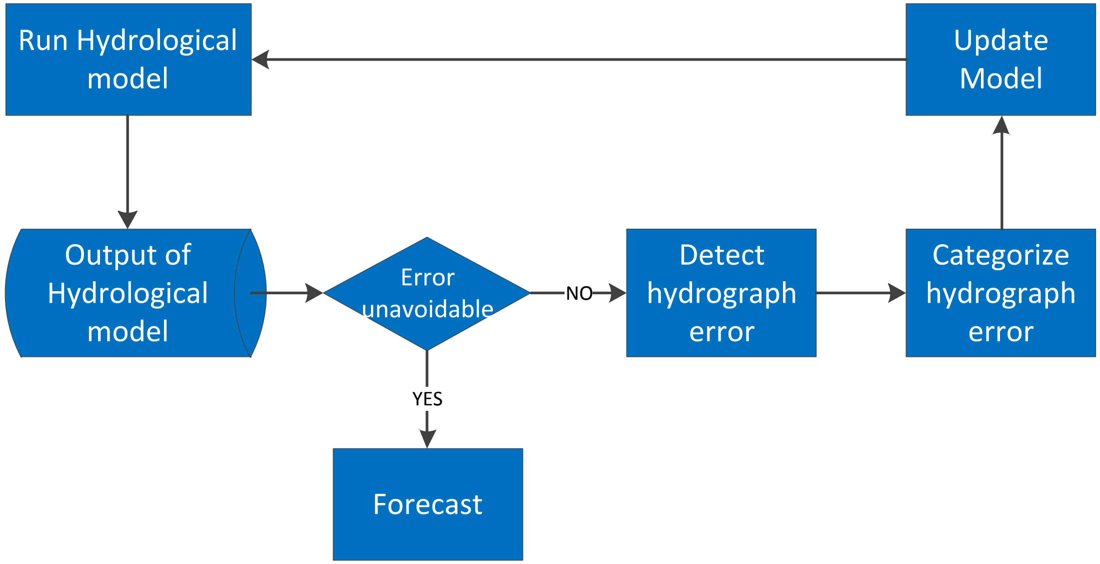
Objective

- Main objectives of this study are to:
  - formulate a methodology for automated detection and categorization of hydrograph errors, and
  - apply and test the method.
- Goal: to utilize quantitative analysis of model uncertainties for improving operational hydrologic forecasts through model updating.



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Error detection algorithm

Algorithm for detection of hydrograph errors

i. **Compute** mismatches: between observed, $Q_O(t_i)$ and simulated, $Q_s(t_i)$ flows over the entire simulation period *(t)*, at a discrete time step, t_i

$$e(t_i) = Q_o(t_i) - Q_s(t_i)$$

ii. **Classify** mismatches: overestimation $(e(t_i)<0)$; underestimation $(e(t_i)>0)$

iii. **Aggregate** mismatches: of similar classes over a hydrological year of maximum *N* discrete time steps

$$E_O = \sum_{\substack{t_i=1 \\ e(ti)<0}}^{N} e(t_i) \times \Delta t_i \qquad E_U = \sum_{\substack{t_i=1 \\ e(ti)>0}}^{N} e(t_i) \times \Delta t_i$$

iv. **Cluster** adjacent mismatches (of same class)

$$E_{CO}(j) = \sum_{\substack{t_i=l_j \\ e\left(t_{(l_j-1)}\right),e\left(t_{(r_j+1)}\right)>0 \\ e(t_i)<0\ \forall\ t_i\in[l_j,r_j]}}^{r_j} e(t_i) \times \Delta t_i \qquad E_{CU}(j) = \sum_{\substack{t_i=l_j \\ e\left(t_{(l_j-1)}\right),e\left(t_{(r_j+1)}\right)<0 \\ e(t_i)>0\ \forall\ t_i\in[l_j,r_j]}}^{r_j} e(t_i) \times \Delta t_i$$

v. **Identify** the significant clustered adjacent mismatches ($I(j) \geq 1$)

$$I(j) = 100\frac{E_{CO}(j)}{E_O} \qquad I(j) = 100\frac{E_{CU}(j)}{E_U}$$

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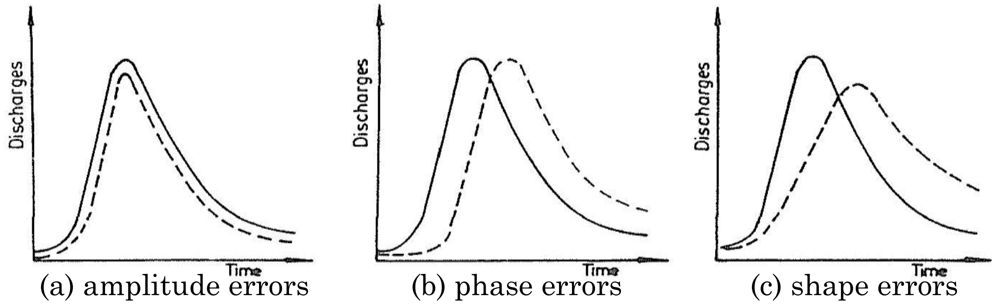
Error categorization

a. Types of hydrograph errors



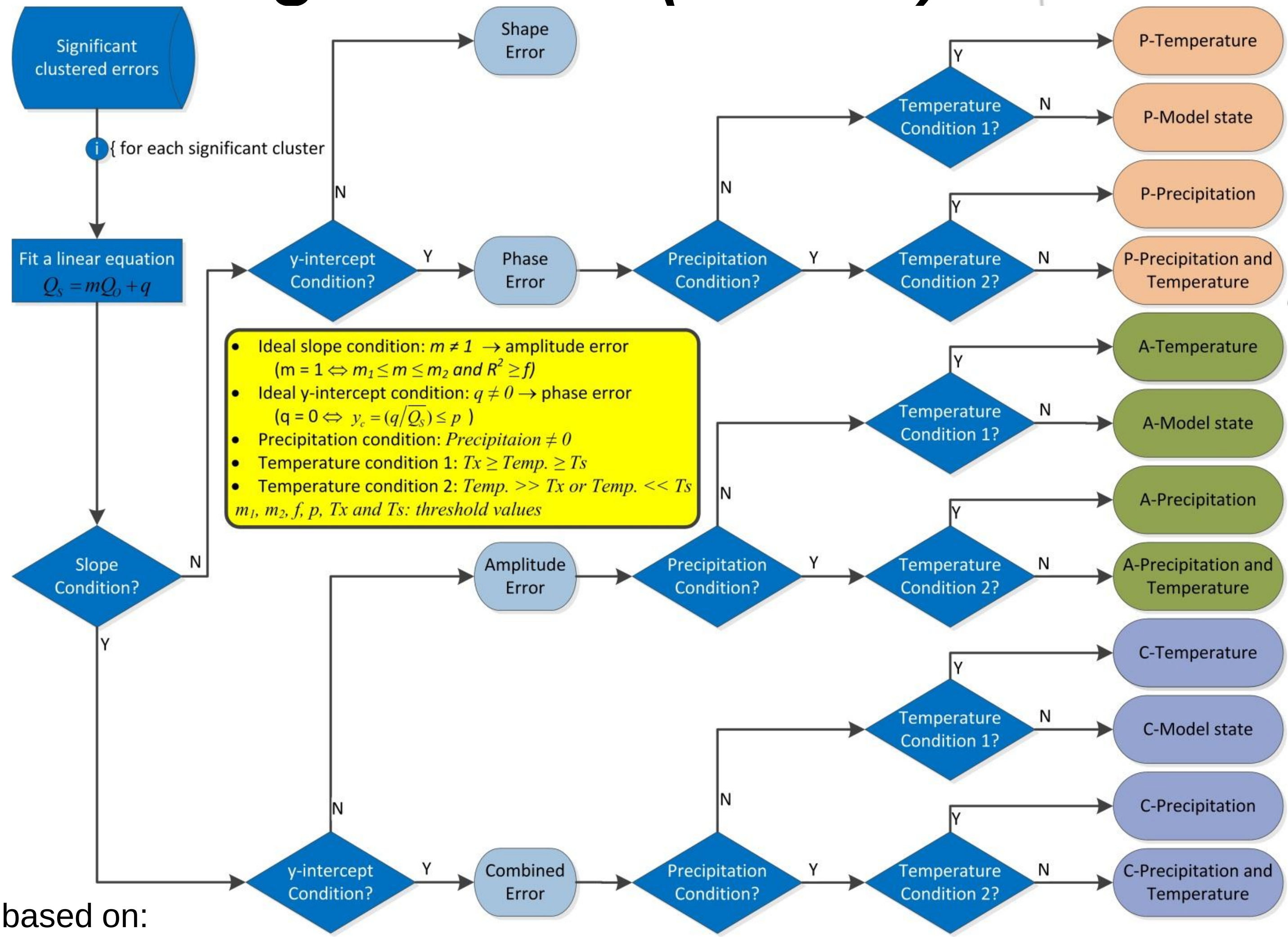
Definition of types of errors between measured (—) and simulated (---) hydrographs [Source: *adopted from Serban and Askew (1991)*]

- mismatches between observation and simulation are regarded as deterministic hydrograph errors

b. Process chart

Serban, P., & Askew, A. J. (1991). Hydrological Forecasting and Updating Procedures. IAHS Publ. no. 201: 357-369

Error categorization *(cont…)*



Condition based on:

i. "Slope and y-intercept" approach of model evaluation (Moriasi et al., 2007) and
ii. approximate expert system evaluation (multiple-criteria).

Moriasi et al. (2007). Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Transactions of the ASABE, 50(3), 885-900

Results from applications

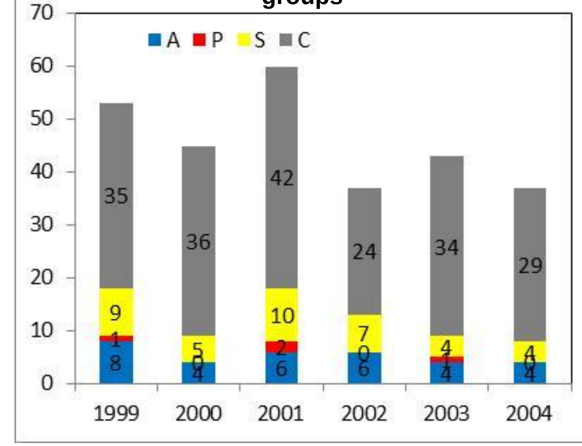
Catchment: Votna

Hydrological Model: HBV

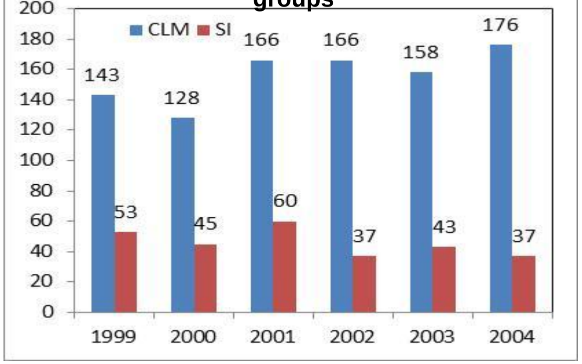
Simulation interval: Hourly

Threshold values: m_1=0.5, m_2=1.5, f=0.7, p=30, Tx=1°c and Ts= -1°c

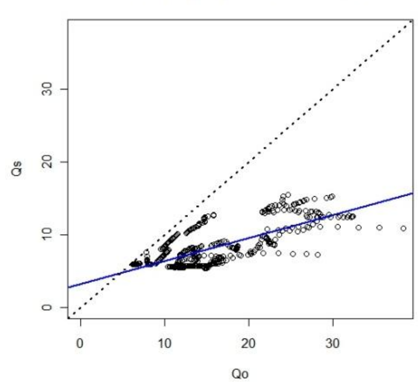
Category of identified clustered adjacent error groups



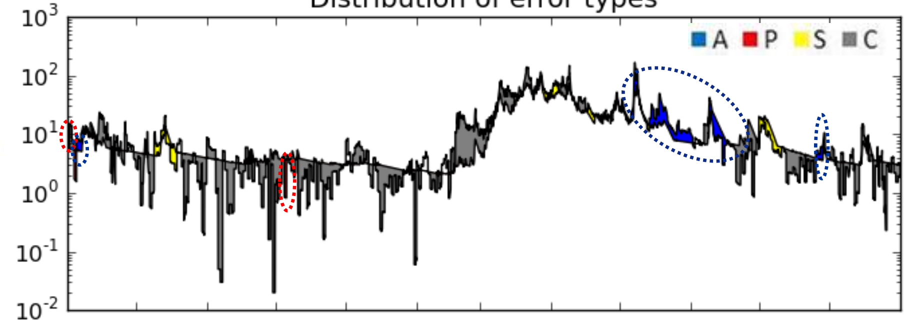
No. of total vs. significant clustered adjacent error groups



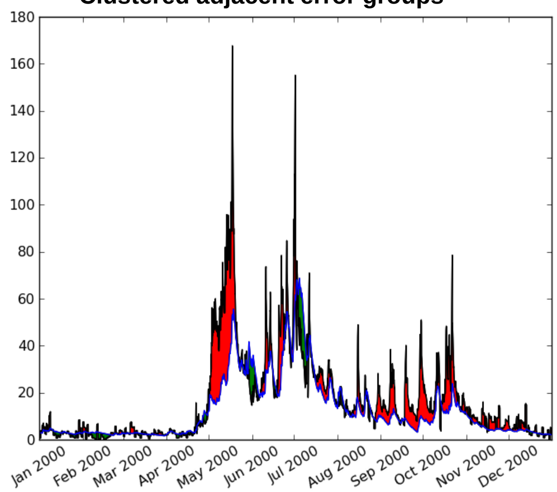
Qs vs. Qo plot (Cluster #142, 1999)



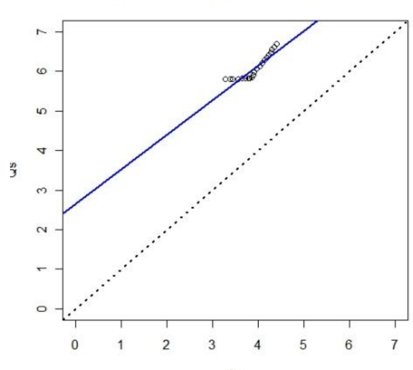
Distribution of error types



Clustered adjacent error groups

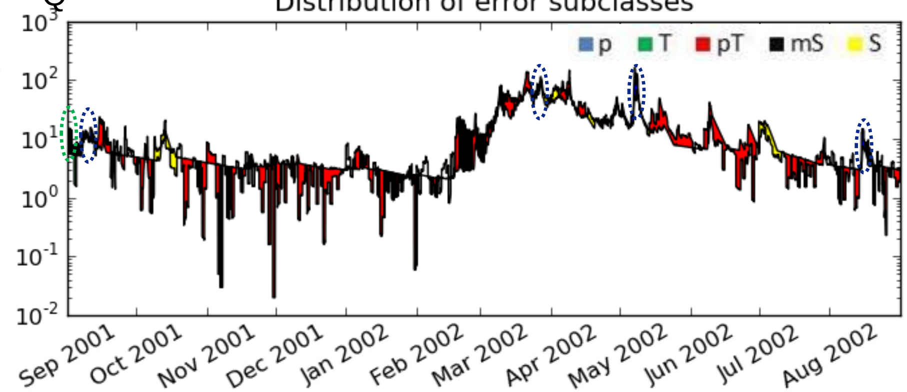


Qs vs. Qo plot (Cluster #31, 1999)



Q

Distribution of error subclasses



Discussions and future work

Discussions

- Threshold values
  - only *Tx* and *Ts* are determined through sensitivity analysis of the model
- Obtaining a better estimate of the actual (initial) state of a basin is important aspect of flow forecasting
  - can be achieved by linking the error detection and categorization (EDC) algorithm with updating procedure

Future work

- setting up updating procedures for each error category
- evaluating effect and validity of each threshold value
- testing efficiency of the EDC algorithm by implementing updating procedure

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Thanks for your attention!

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