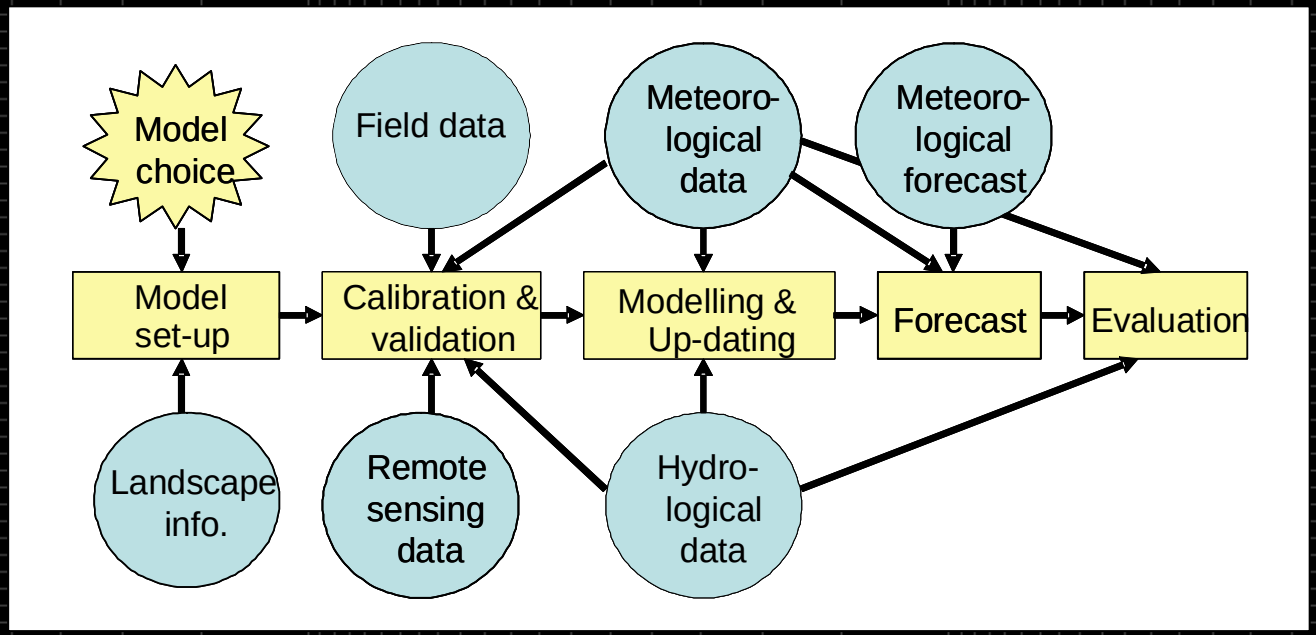
A SYSTEMATIC REVIEW OF SENSITIVITIES IN THE SWEDISH FLOOD-FORECASTING SYSTEM

2011-01-27

Göran Lindström/SMHI



Outline

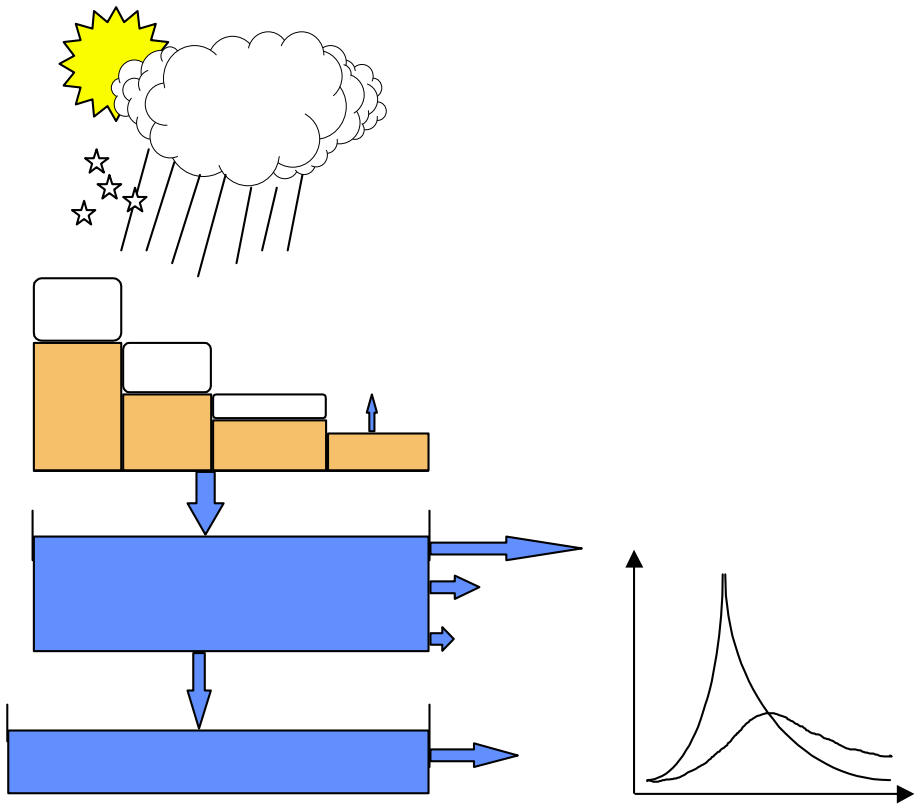
- A SYSTEMATIC REVIEW OF SENSITIVITIES IN THE SWEDISH FLOOD-FORECASTING SYSTEM
- Berit Arheimer, Göran Lindström and Jonas Olsson
- Atmospheric Research, in press

- Project financed by SVC (Svensk Vattekraftcentrum)

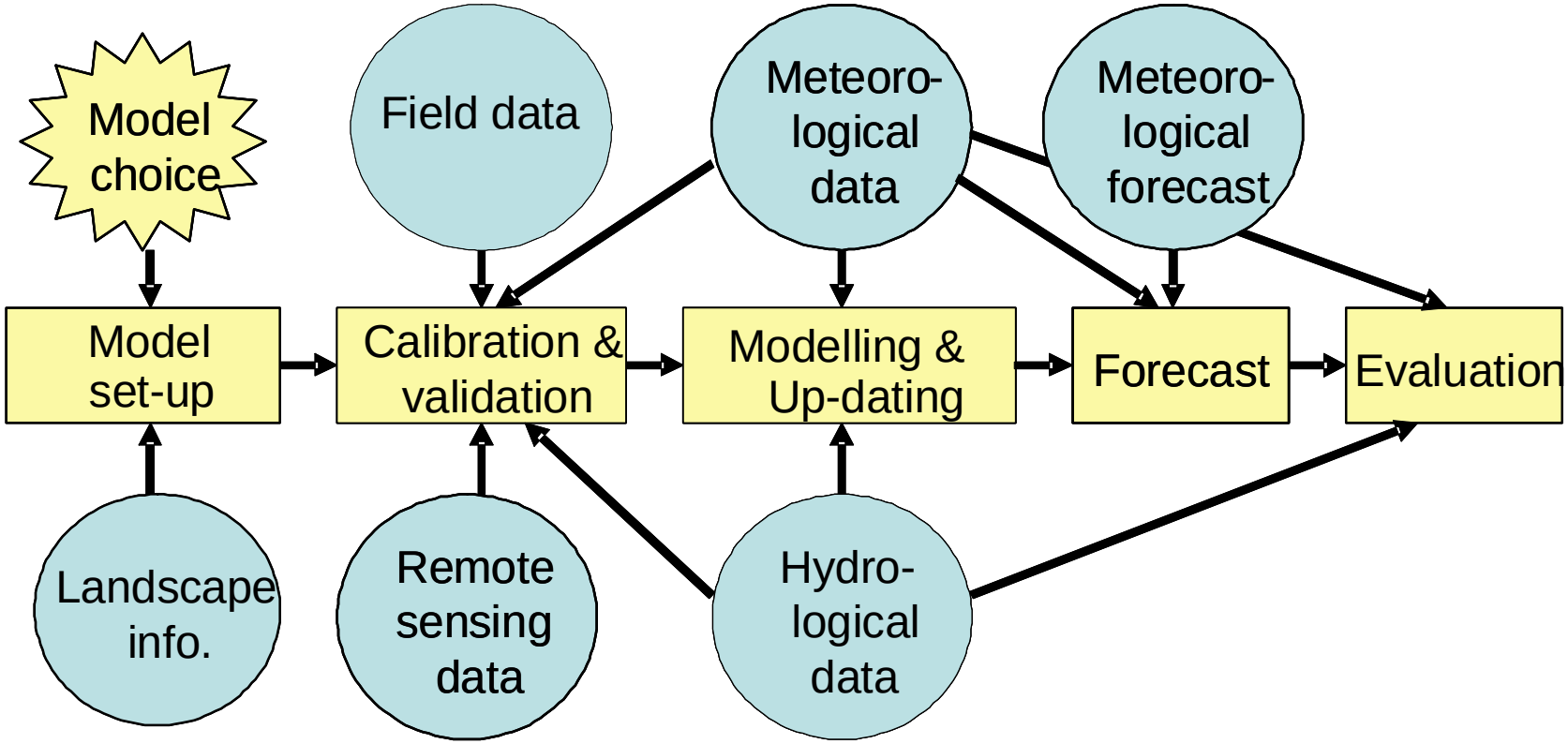
- New S-HYPE version

Background

- HBV model was developed in the 1970s
- Large number of studies aiming at improving the model and forecasts
- Large amount of experience from model applications and use at the SMHI
- A quantitative synthesis of the knowledge was needed



The forecast chain



- Forecast quality is influenced by many factors
- Forecast chain at SMHI is quite complex

Questions

- What are the most sensitive steps in the forecast chain?
- What errors should we avoid in model applications?
- In what fields could there be room for further improvements?

Three categories

1. General runoff simulations
2. Spring flood forecasts
3. Short term forecasts

Comparing evaluation criteria

- Different numerical evaluation criteria have been used in different studies (e.g. NSE, mse, rms, mean absolute error,...

- For each alternative model test an improvement compared to the reference was computed

$$I = (E_{REF} - E_{ALT}) / E_{REF}$$

- Ex) From NSE = 0.80 to 0.90 means an improvement by 50%
  (NSE is based on mse)

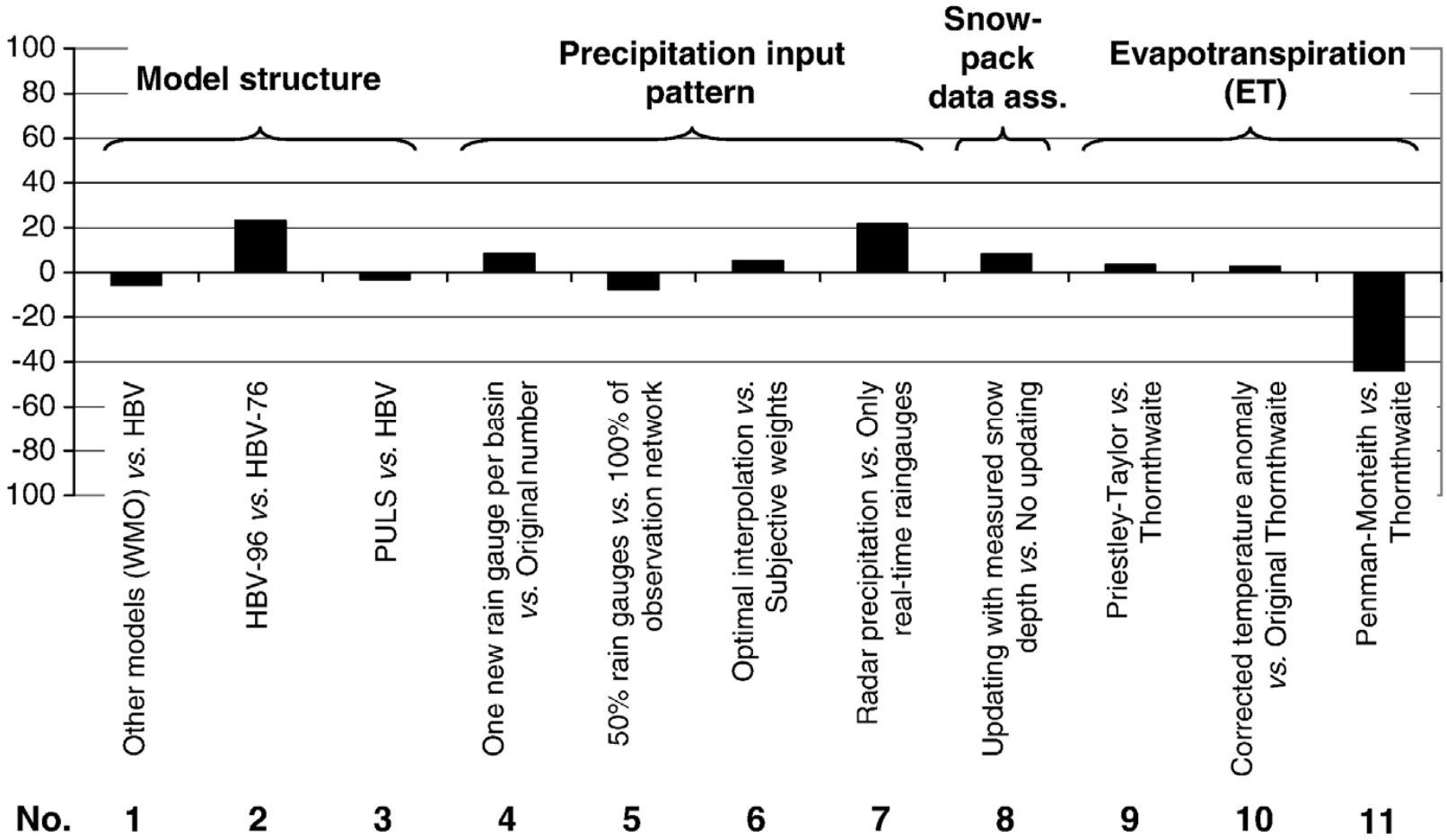
- Some tests give poorer results (negative improvement)

- Improvements can not be added

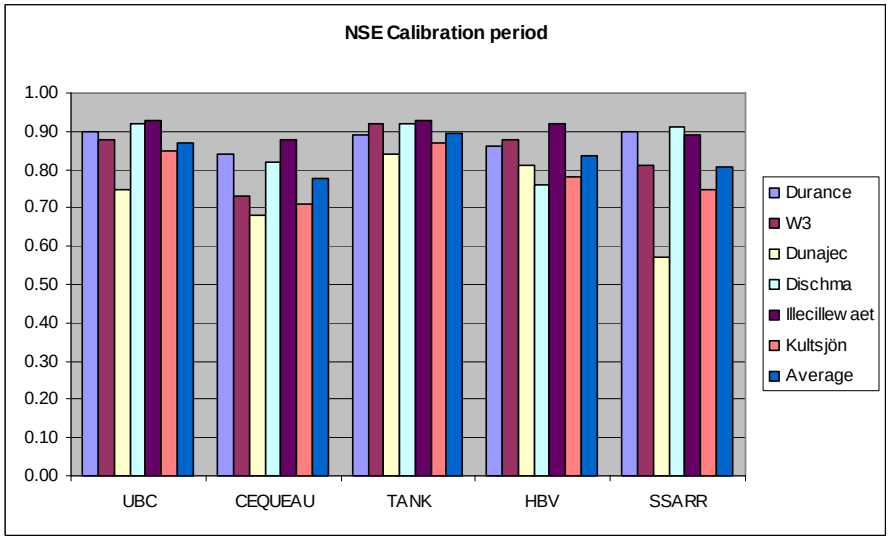
Reviewed Studies

Type of hydrological forecast	Studied components in the production system	No	References
General runoff simulations and predictions	Model structure	1 2 3	WMO, 1986; Lindström et al., 1996; Brandt, 1987a.
	Precipitation input pattern	4 5 6 7	Larsson and Lidén, 1996; Brandt, 1987b; Johansson, 2000; Johansson et al., 2007
	Snow-pack data assimilation	8	Lindström and Ottosson-Löfvenius, 2000
	Evapotranspiration equations	9 10 11	Gardelin and Lindström (1997) Gardelin and Lindström (1997) Unpublished
Annual spring-flood forecasts	Up-dated precipitation & temperature	12 13	Unpublished; Carlsson and Sjögren, 2003
	Meteorological forecasts	14 15	Unpublished; Carlsson and Sjögren, 2003
	Model calibration	16	Unpublished
	Data assimilation of snow distribution (remote sensing)	17 18 19 20	Brandt 1991; Andréasson et al., 2001; Bergström and Brandt, 1984; Johansson et al., 2003
Short-term forecasts	Up-dated discharge	22 23	Unpublished; Carlsson and Lindström, 2001
	Precipitation input Ensembles of meteorological forecasts	24 25 26	Unpublished Olsson et al., 2006; Unpublished

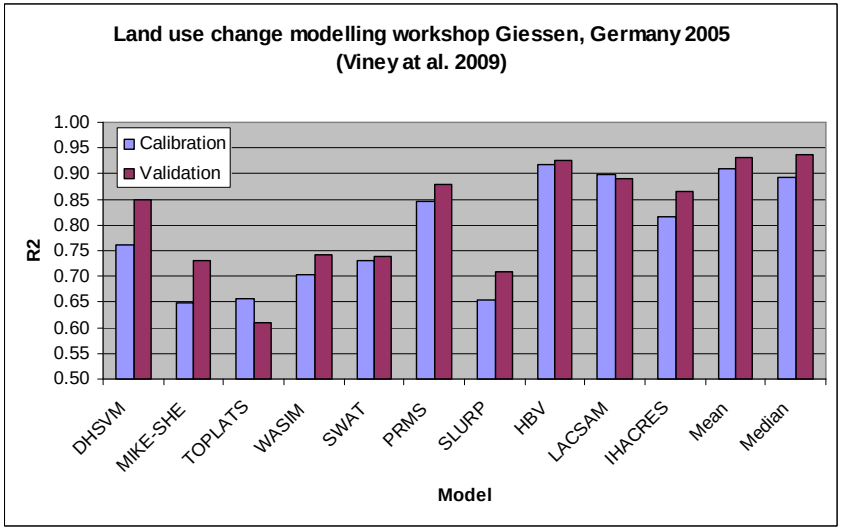
1. General runoff simulations



The choice of model is important

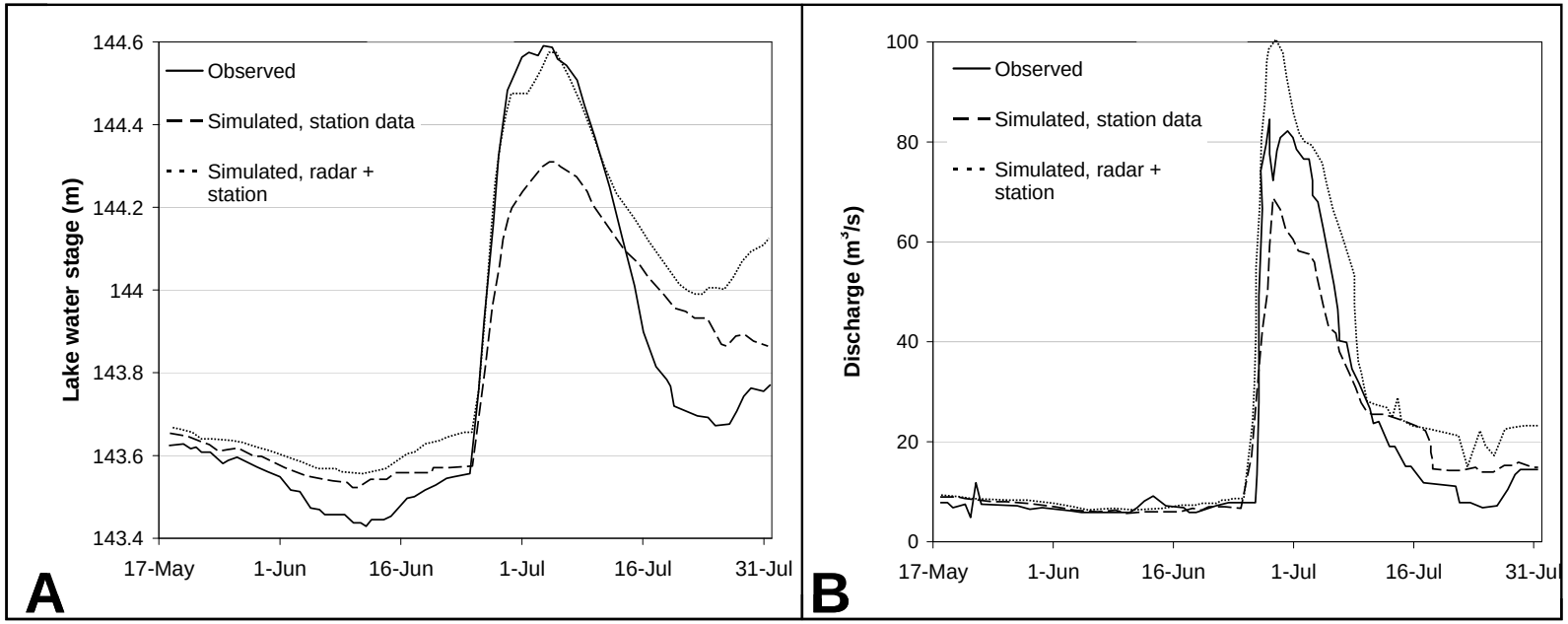


WMO (1986)
Short term forecasting/ updating



LUCHEM
Land use changes

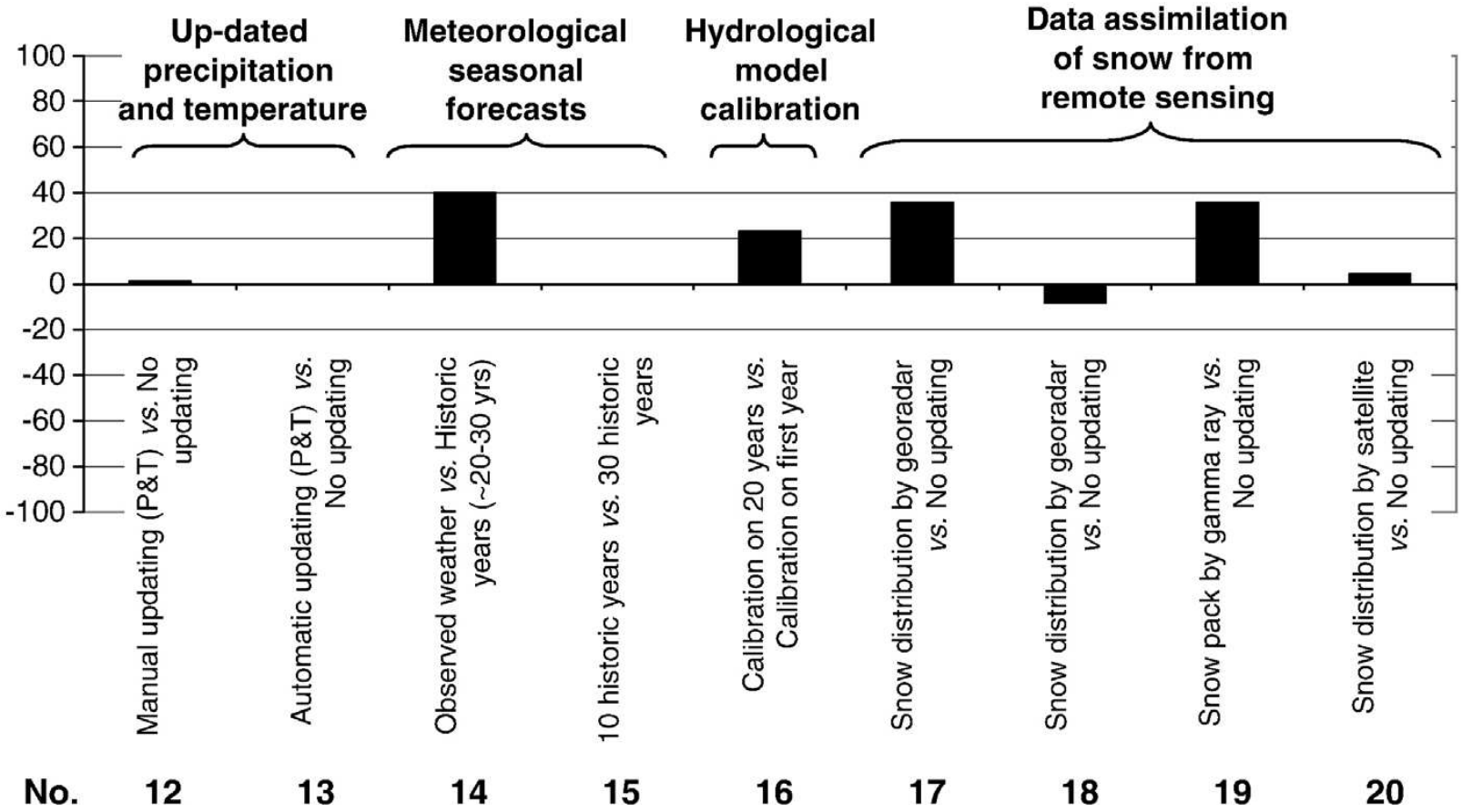
Examples of using radar data



Lake water level, Vidöstern Discharge, Lagan

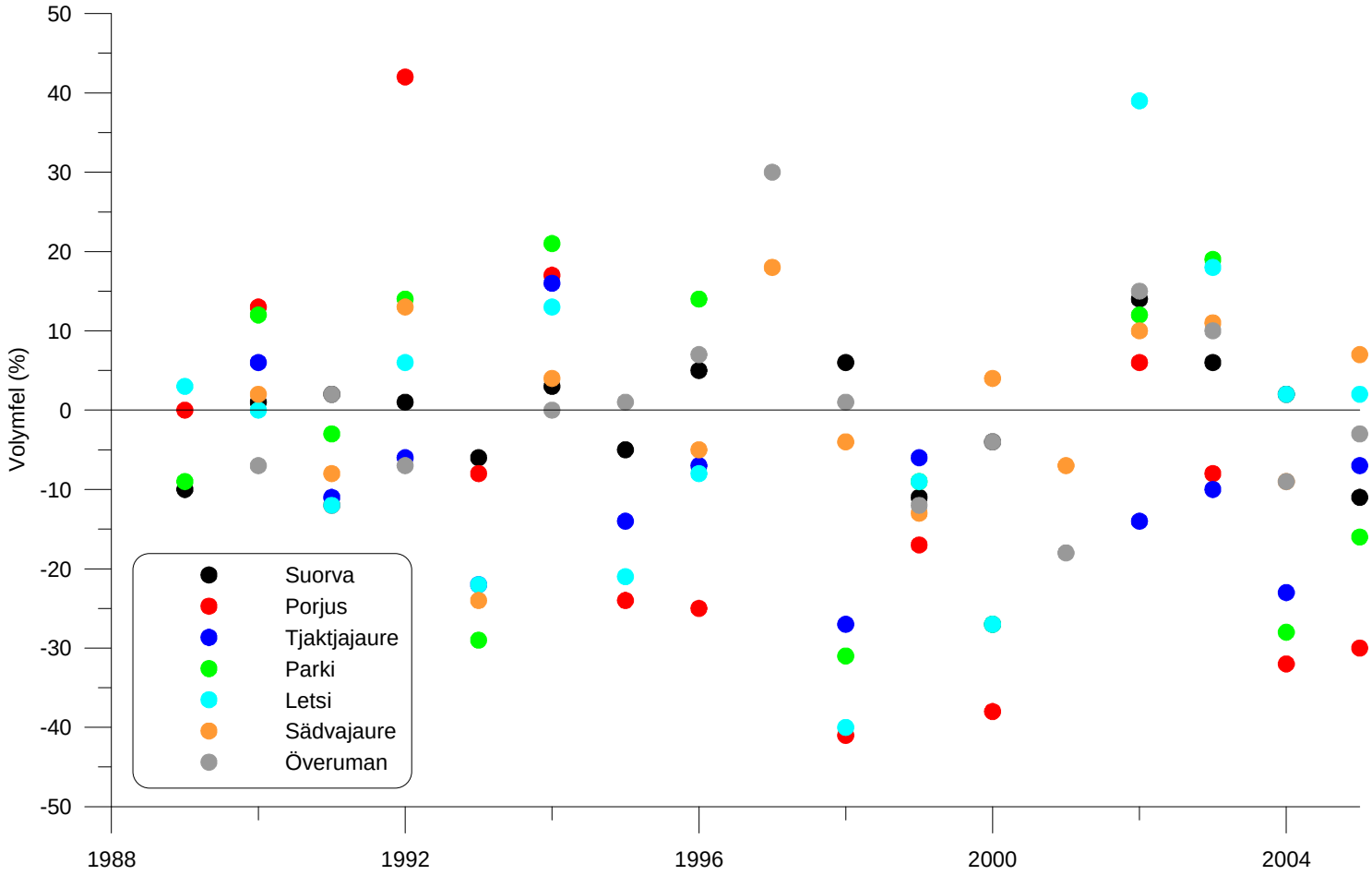
Flood event 2004

2. Spring Flood Forecasts

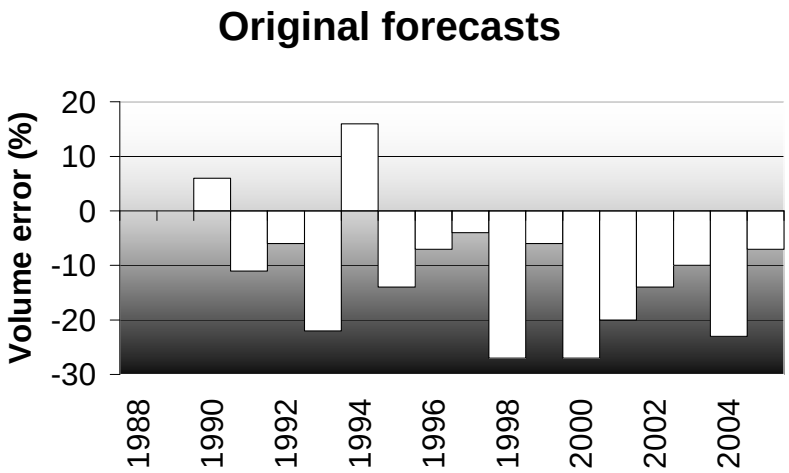


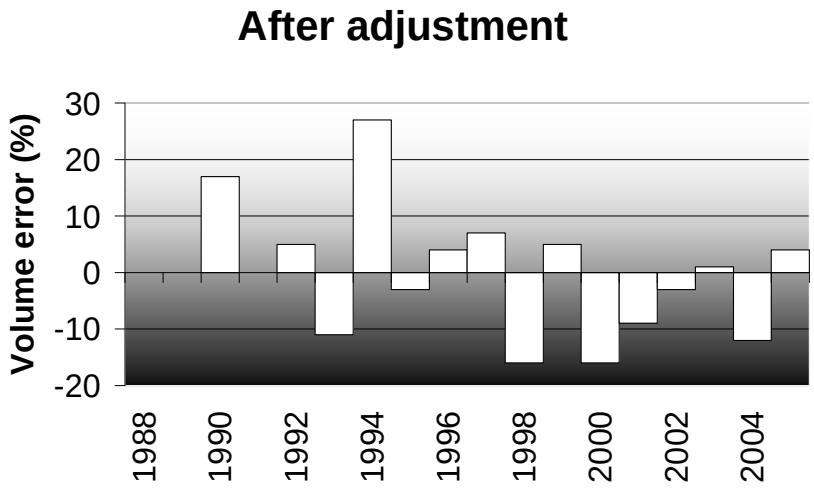
Rather insensitive!

Analysis of evaluation of long range forecasts



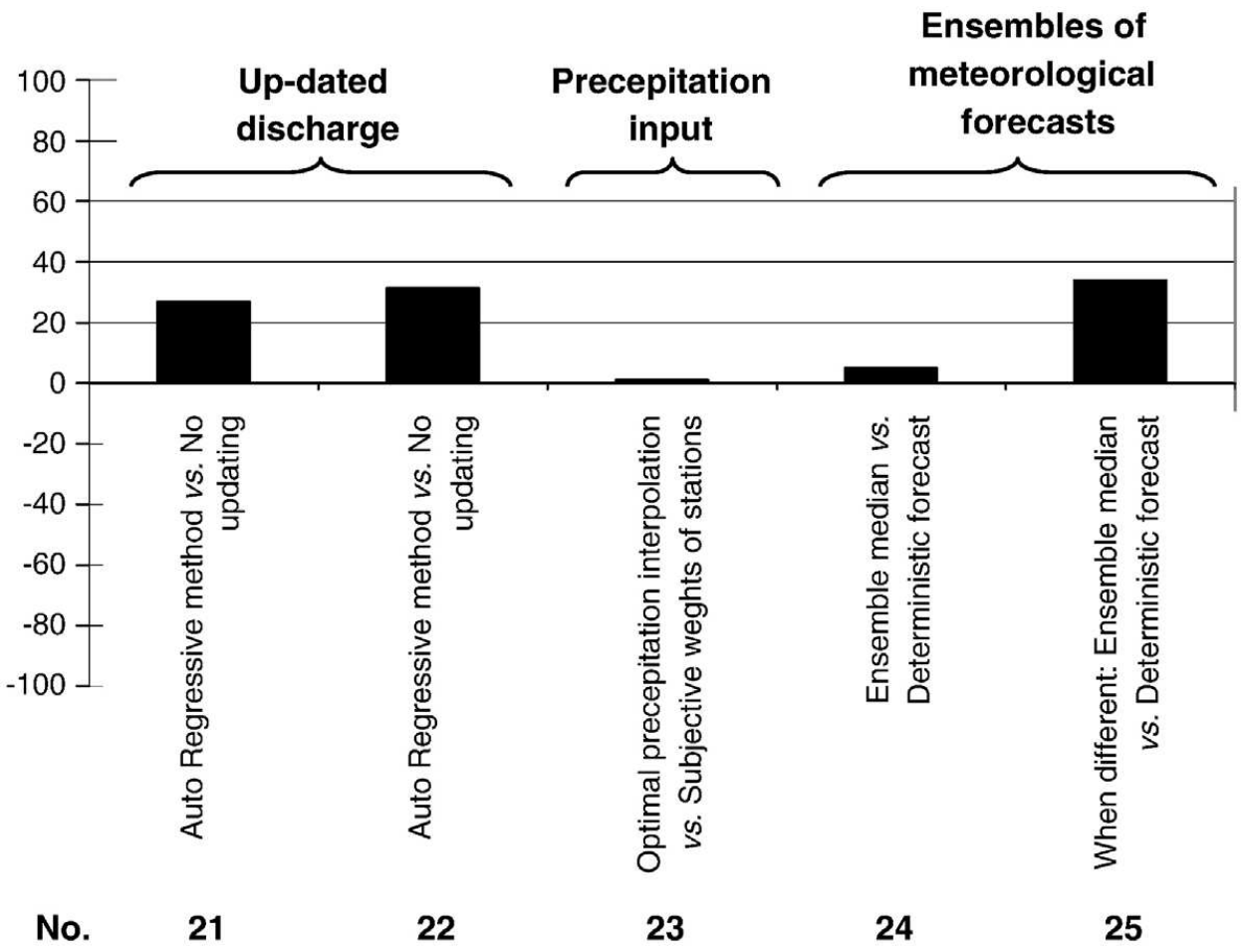
Recalibration sometimes appropriate



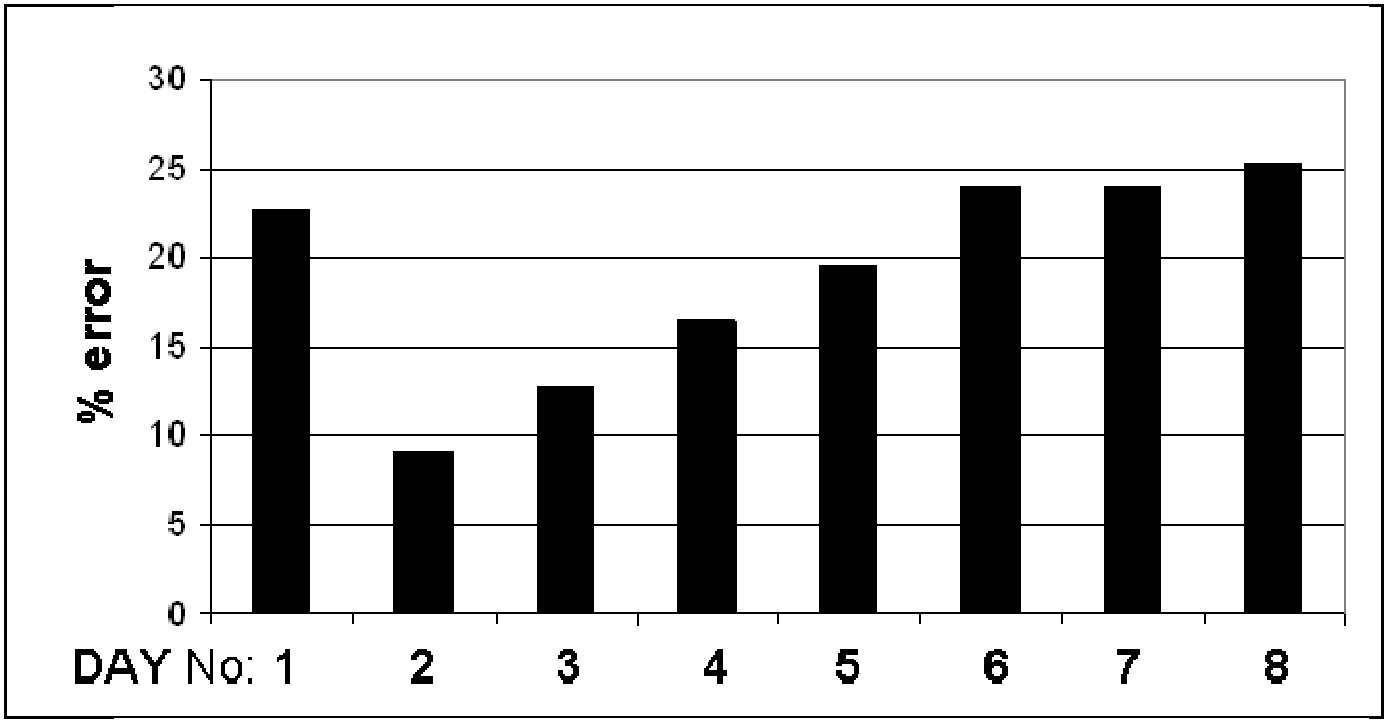


Example: Tjaktjajaure, Luleälven

3. Short Term Forecasts



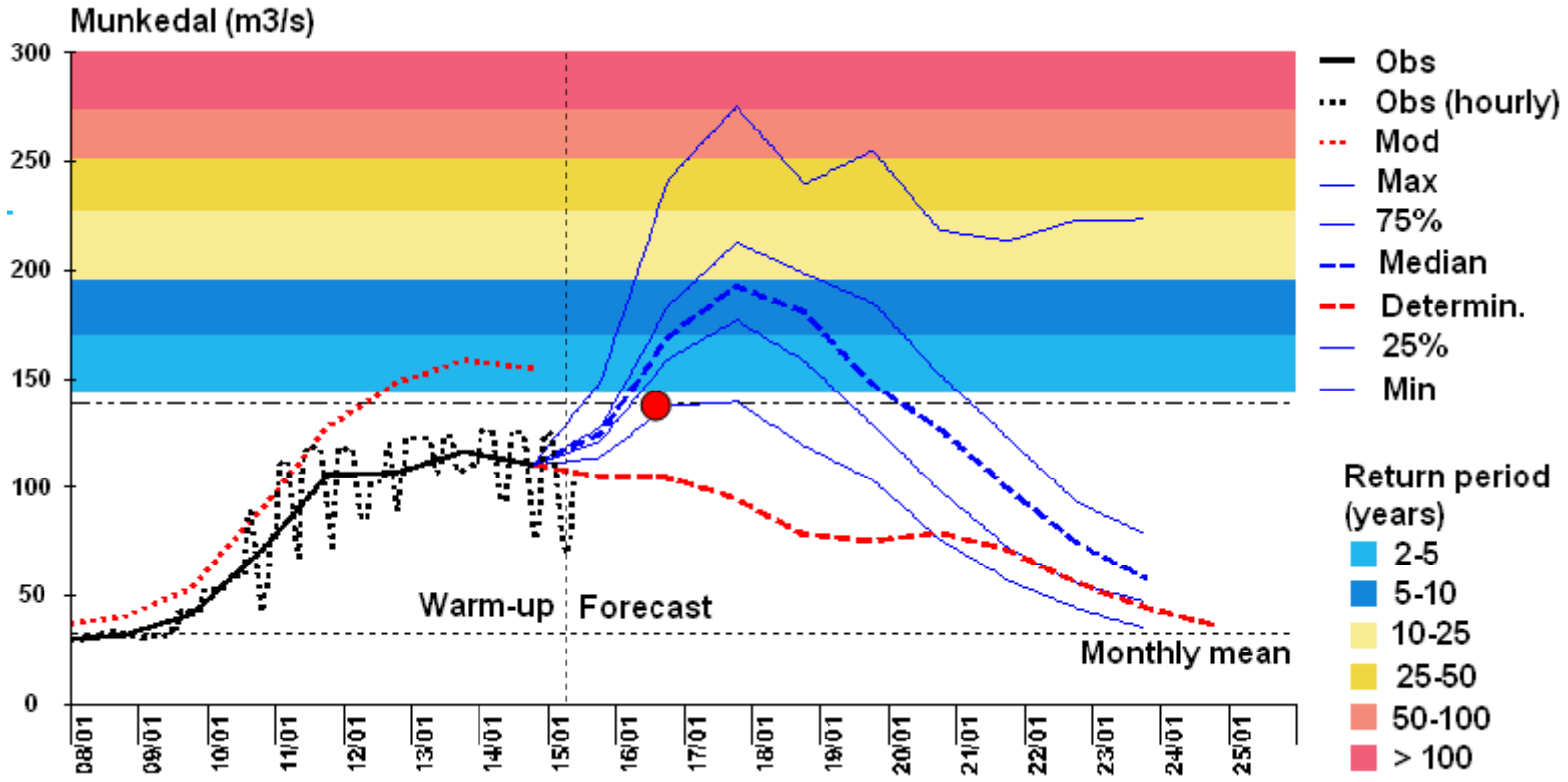
Example of evaluation of short term forecasts (Southern Sweden, 2004)



Simulation

Updated (effect decreases with time)

Ensemble forecasts vs deterministic forecasts



Which forecast should we believe in?

General runoff simulations and predictions were sensitive to

- Model structure and calibration
- Model equations (e.g. evapotranspiration expression)
- Precipitation input using radar data as a complement to station gauges.

Annual spring-flood forecasts **could be significantly improved by**

- Better seasonal meteorological forecast
- Re-calibration of the hydrological model based on long time-series
- Data assimilation of snow-pack measurements using georadar or gamma-ray technique.

Short-term (2 days) forecasts **could be significantly improved by**

- Updating using an autoregressive method for discharge
- Ensembles of meteorological forecasts using the median at occasions when the deterministic forecast is outside of the ensemble range.

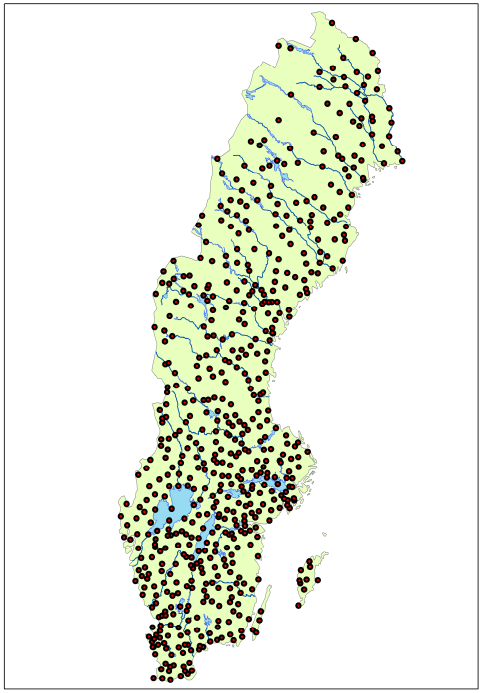
General Conclusions and comments

- It is important to continuously evaluate the entire production chain
- The presented method for harmonizing numerical performance-criteria provides a quantitative way of comparing the results from different studies.
- The study could be extended, to more models, other HBV versions etc.

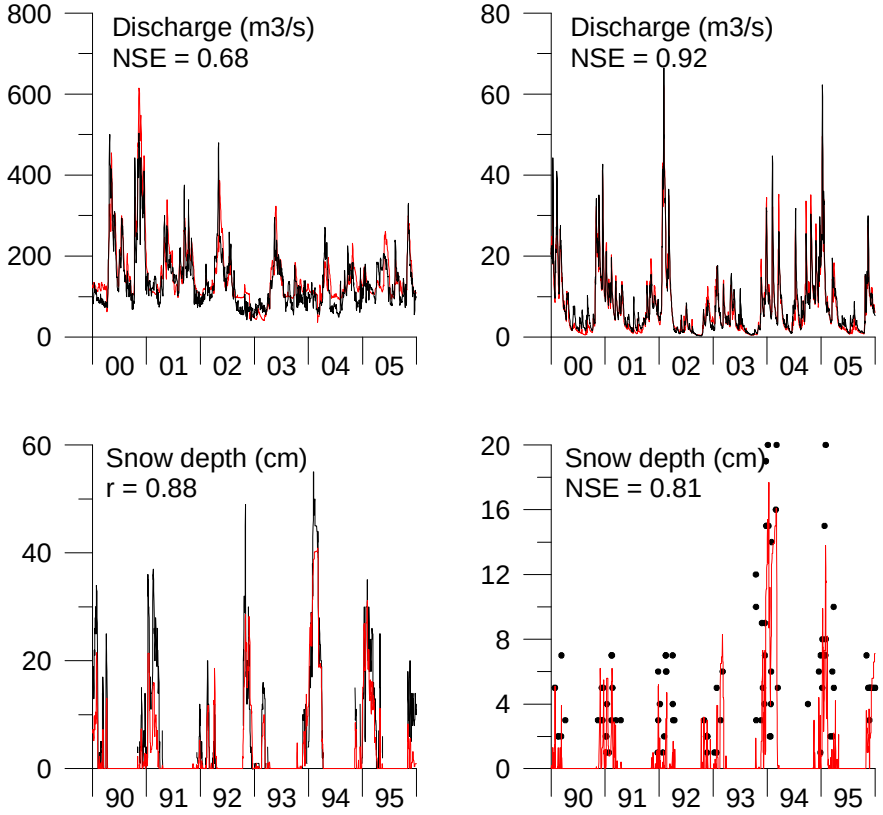
- *Complementary synthesis by Sten Bergström*

New version of S-HYPE model is being finalized right now

- 38000 subbasins for all of Sweden
- Improvements in model formulation and set-up
- Snow depth stations included for evaluation and updating



Snow stations in new S-HYPE (prel.)



Typical agreement Best agreement

Examples from evaluation of 2008 version of S-HYPE