Probability spring flood forecasts in Northern Sweden

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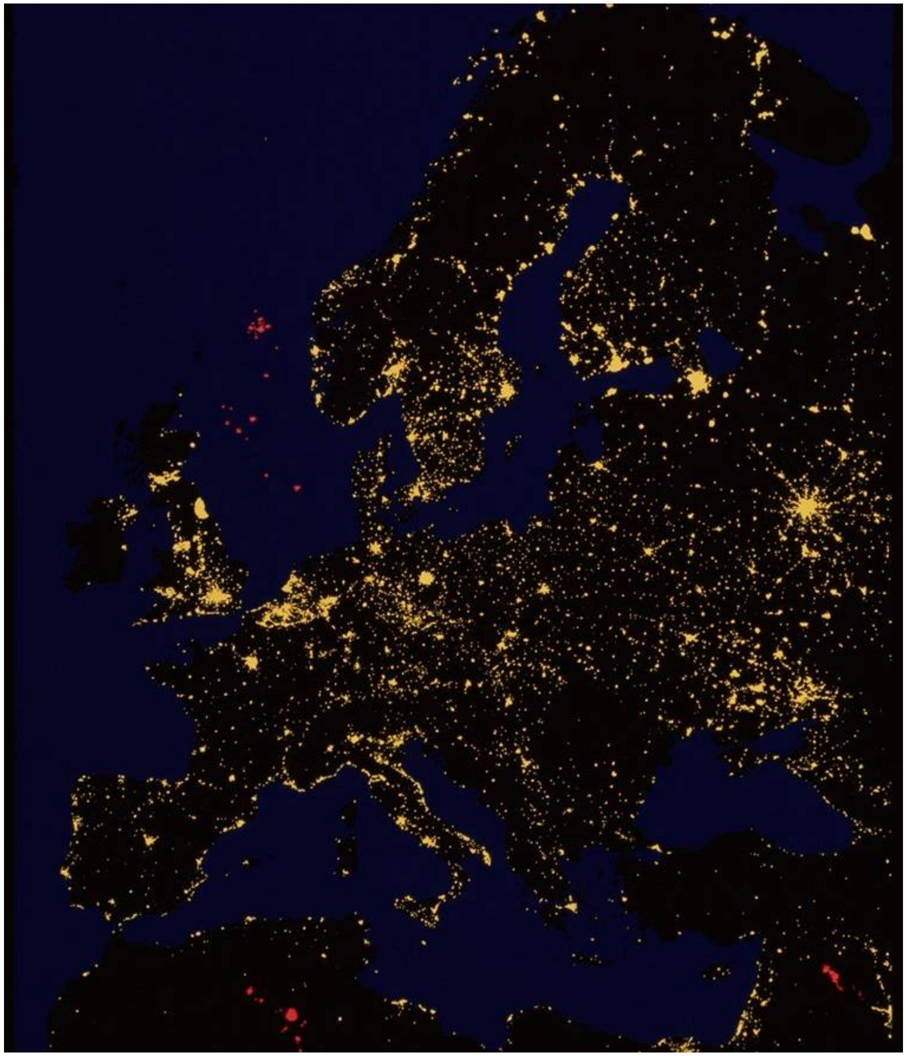
Agenda

- Vattenfall in brief
- Hydrological forecasting in Lule River
- Snow measurement
- SMHI in brief
- Long range forecast – possibilities for improvement

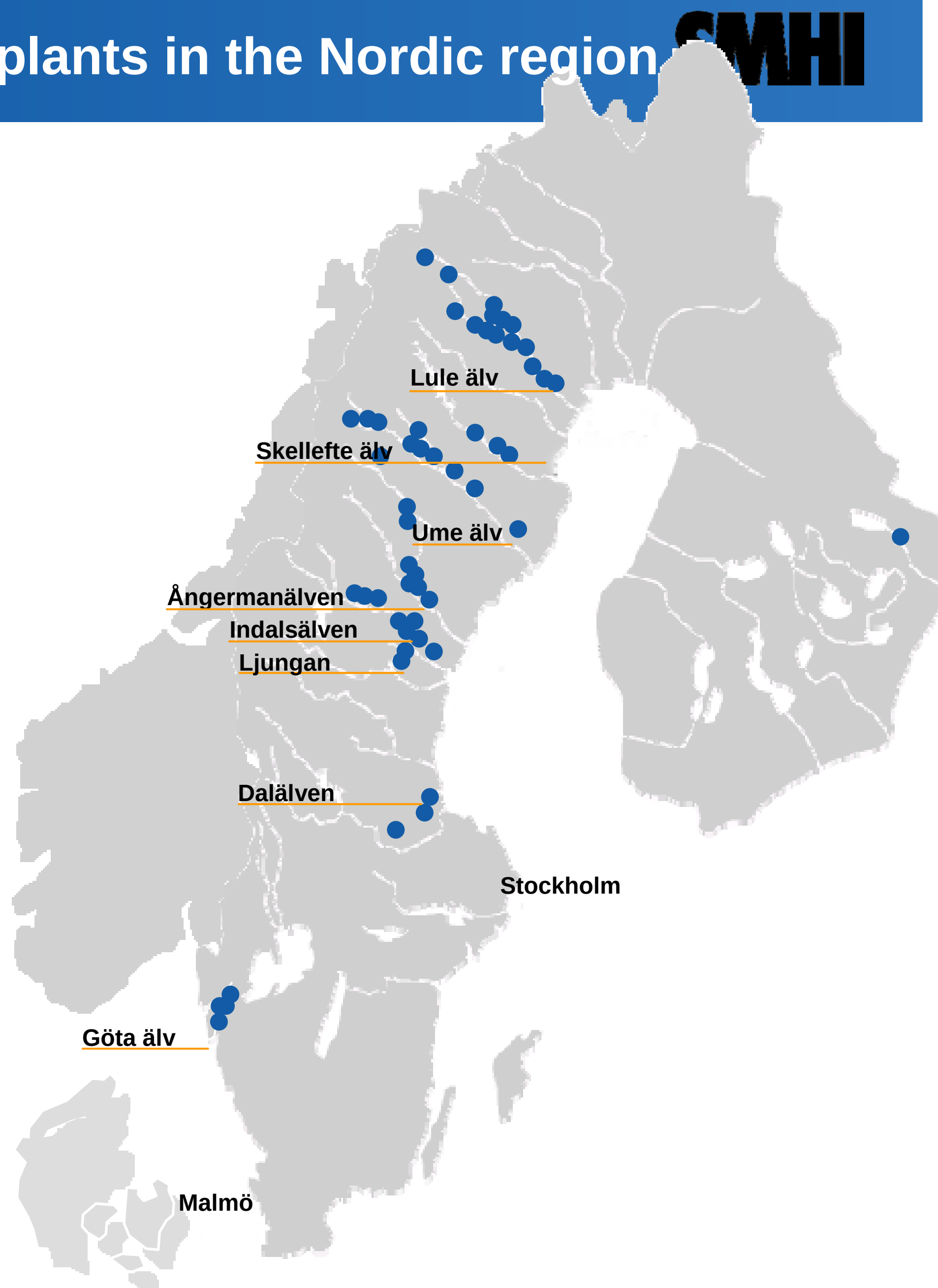
Vattenfall in brief

- The 4th largest electricity producer in Europe
- Production, transmission, distribution, trade and sales of electricity
- Production, distribution and sales of heat
- About 33 000 employees
- Wholly owned by the Swedish State
- One of the leading producers of hydropower in the Nordic region



Vattenfall large scale hydropower plants in the Nordic region

- Power is generated in 53 large scale hydropower plants in Sweden and in Finland
- Average yearly energy output: 33,5 TWh
- Maximum power output: 8,400 MW
- Total reservoir capacity 20TWh
- Half of the installed output is located in the Lule river in the northen part of Sweden



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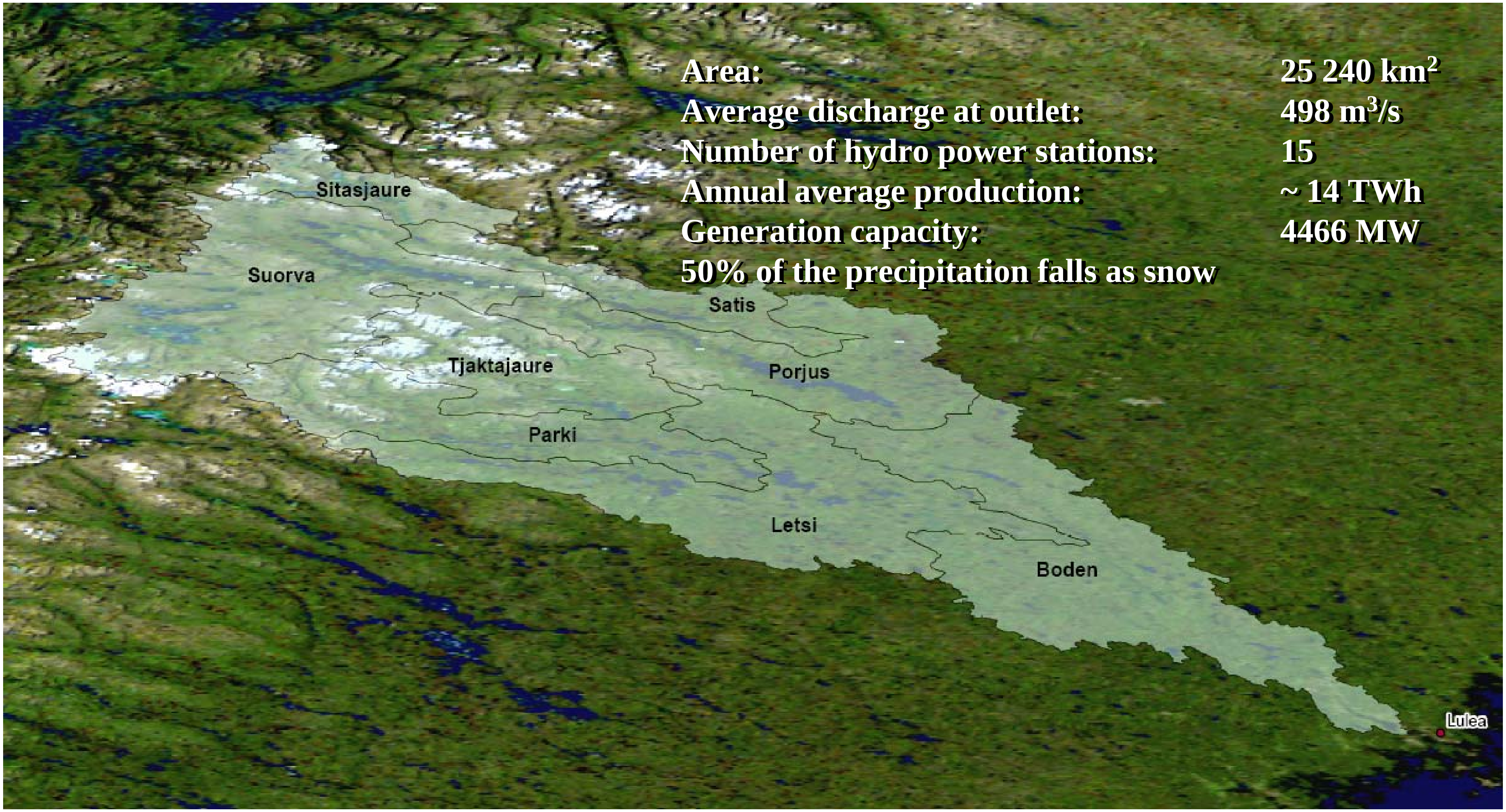
The Lule River Basin



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Hydrological forcasting in Lule River

Hydrological forecasts are very important for planning and optimation of avaiable hydropower

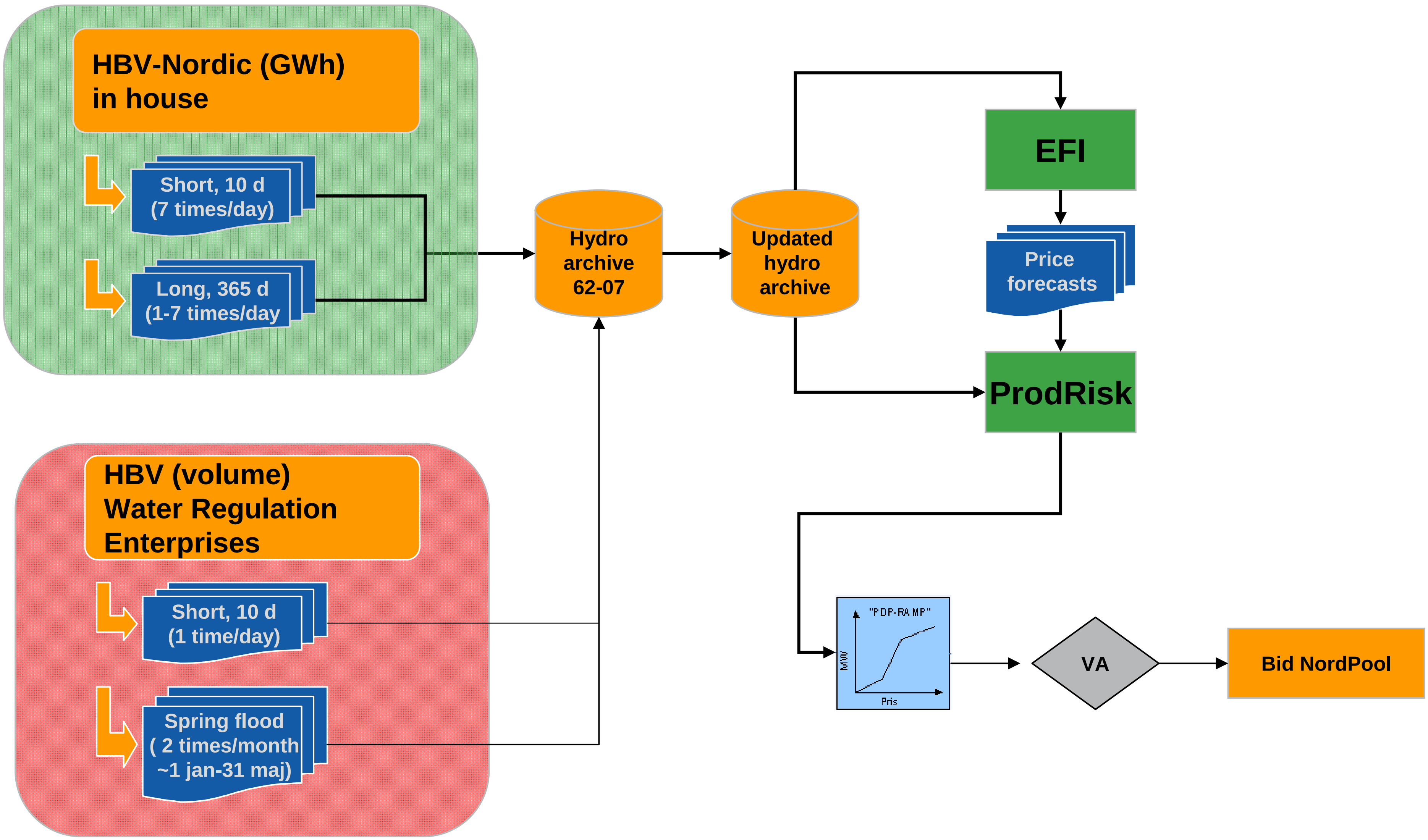
Both springflood and shortrange forcasting are performed with the HBV-model*

*developed by Swedish Meteorological and Hydrological Institute

For the operational daily planning short range forecasts runs everty day using a meteorological forecast as input

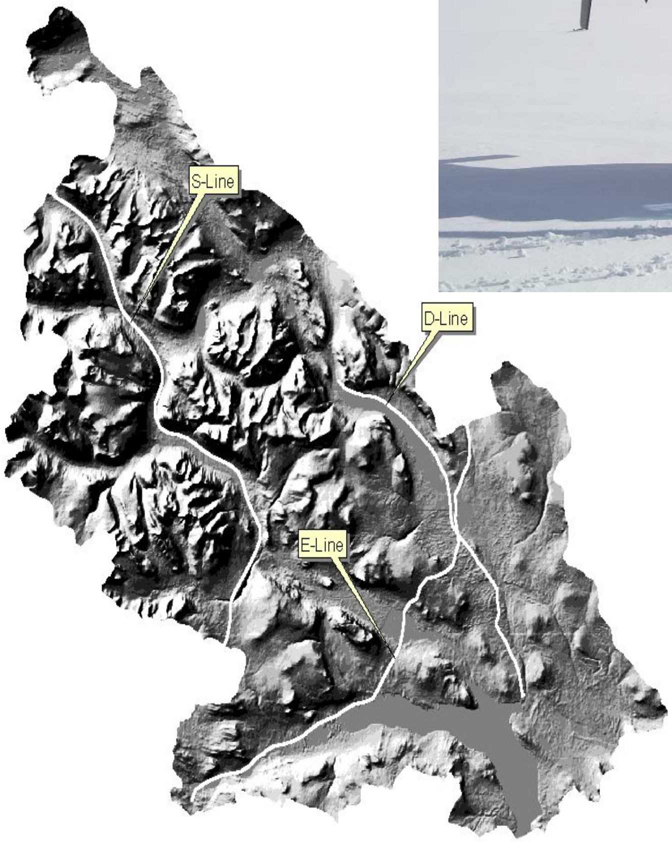
- Long range forecasts runs every week from January until July and is until today based on statistical P and T values for the last 40 years

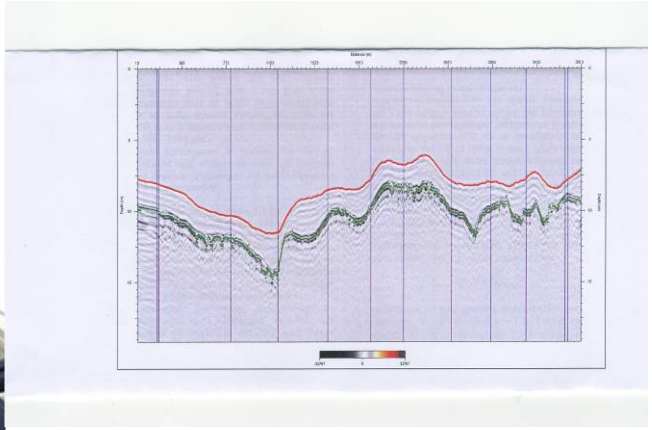
Hydro forecasts – process overview



Snow measurement

- To verify the HBV model measurements of snow and calculation of SWE is done once a year in the beginning of April.





Swedish Meteorological and Hydrological Institute

SMHI

- **Government agency**
  - Responsible for the national meteorological, hydrological and oceanograpical networks as well as for forecasts and warnings to the public.
  - Provides services to other government agencies.
- **Research department** (100 scientists)
  - Hydrology, Oceanography, Air Environment, Atmospheric Research, Forecasts and Analysis, Climate Research
- **Consultancy services**, e.g. to Vattenfall
  - Provides the hydrological model. Calibrate, maintain, evaluate, develop.
  - Delivers input data for model simulations

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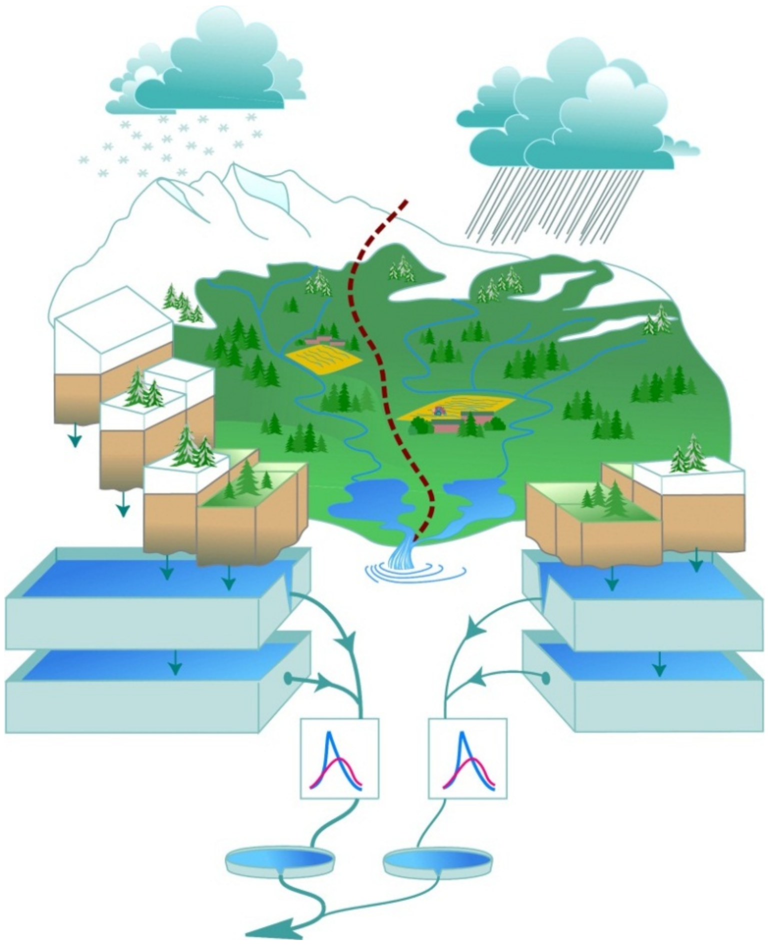
HBV Model

Developed at SMHI in co-operation with the Swedish hydro power companies

First version in 1972.



Long-range forecasts

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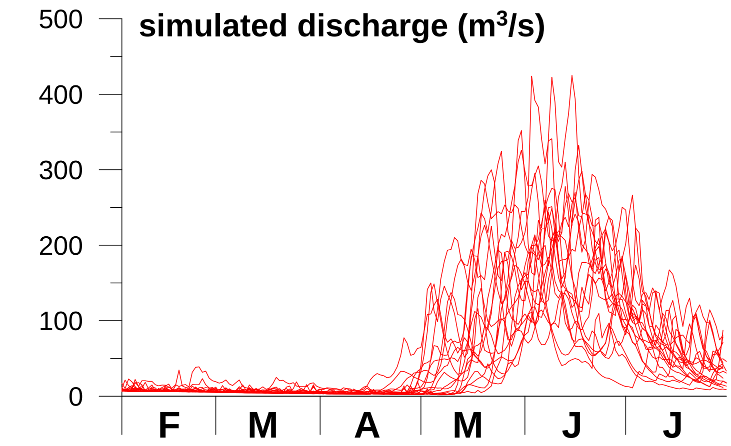
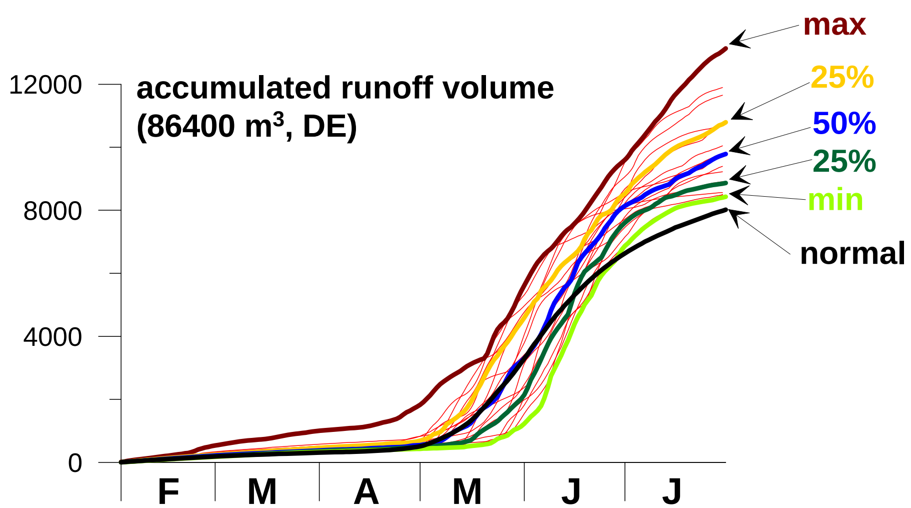
Probability forecasts based on historic time series of precipitation and temperature



Simulations made for February to July with precipitation and temperature series from many different years

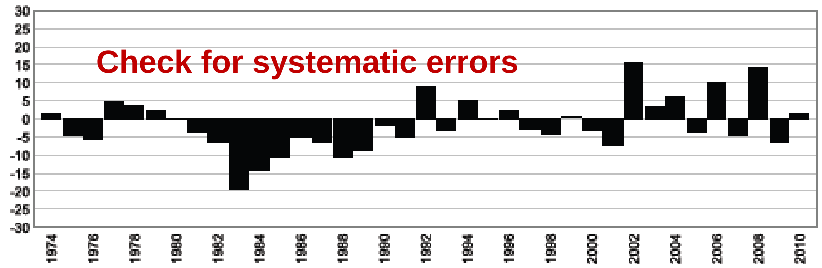


A statistical analysis is made to estimate the probable runoff volume over the forecast period

Annual evaluation for 75 catchments

Catchments where forecasts are made for hydropower production

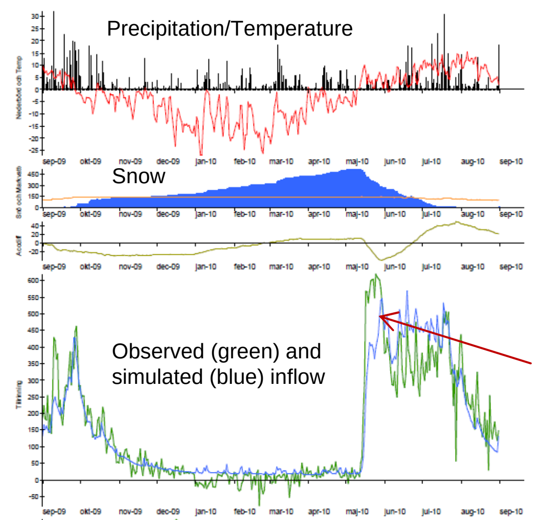
Model error for the melt season (%), 1974-2010



Values for 2010

Catchment	Period	Forecast error (%)	Model error (%)	Observed inflow (% of normal)
Suorva	0501-0831	-7	2	90

Model simulation for September 2009 – August 2010



Same type of error in all mountain catchments 2010

Unusual weather conditions – less reliable forecasts?

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Typical winter weather: Strong westerly winds resulting in high precipitation on the western side of the mountain range along the Swedish/Norwegian border.

How to identify the unusual patterns?

- In January-March for forecasts with 5-7 months lead time?
  - Is it possible to predict weather anomalies?
- In May for for forecasts with 2-3 months lead time?
  - Use snow observations?

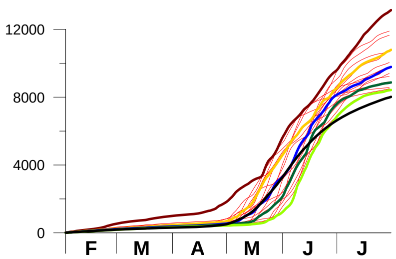
Approaches to predict winter weather anomalies

- **Reduced climatological ensemble**

  Identification of analogue historical years based on:

  1. Values of Climate Indices (CI)

  2. Persistence of Circulation Patterns (CP)



- **ECMWF seasonal ensemble forecasts**

  (European Centre for Medium Range Weather Forecasts)

  Using daily P and T as input to the HBV model (E+H)

- **Statistical Downscaling**

  Relationships between atmospheric variables and spring flood volume (SD). No hydrological model

Research project funded by the Hydrological development group (HUVA)
Participants: Jonas Olsson, Kean Foster, Jonas German , Johan Södling, Wei Yang

Long range forecasts with traditional method

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- Test period was 2000-2010
- Forecasts were made on the first of January, March and May up to the end of August.
- The resulting runoff volume for May to August was computed for all time series, and the mean was compared to the observed runoff volume.
- The forecast error was determined for each of the years 2000-2010.

	Mean total volume (m^3*10^6)	Mean absolute error (%)			
		Simulated (Observed P and T)	Forecast January 1	Forecast March 1	Forecast May 1
Vindeln	3178	**8.2**	**20.0**	**13.2**	**9.0**
Ångermanälven	7896	**7.6**	**21.0**	**18.4**	**16.3**
Ljusnan	2312	**10.3**	**27.7**	**30.6**	**18.8**

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Evaluation of new approaches

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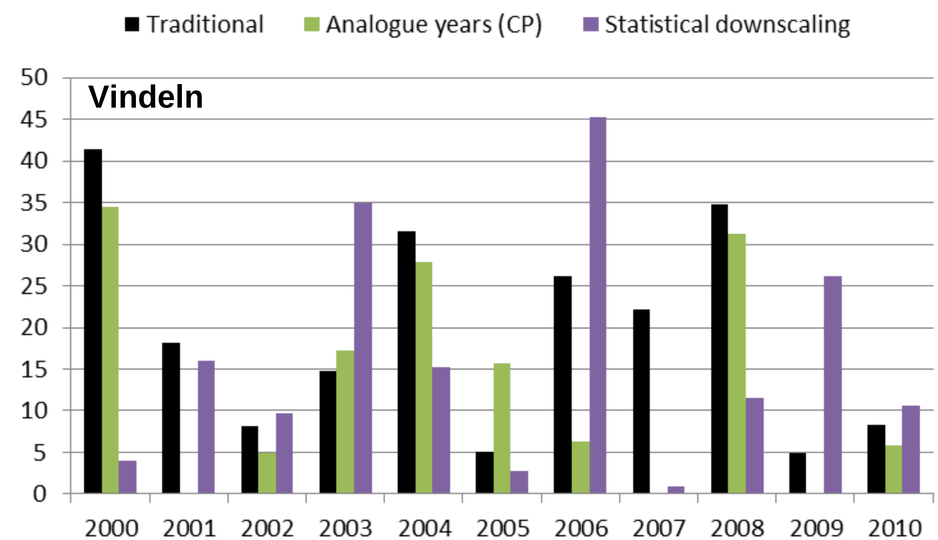
		Change in forecast error (percentage points) / percentage of years with smaller forecast error	
Forecast date		Reduced ensemble (CP)	Statistical downscaling (SD)
January 1	Vindeln	**-2.4 / 75**	**-3.5 / 55**
	Ångermanälven	**-0.5** / 50	**-6.4 / 68**
	Ljusnan	1.8 / 38	8.0 / 50
March 1	Vindeln	**-2.8 / 75**	5.6 / 50
	Ångermanälven	**-0.6 / 70**	4.5 / 50
	Ljusnan	4.7 / 35	13.0 / 27
May 1	Vindeln	1.9 / 39	7.2 / 45
	Ångermanälven	**-3.2 / 56**	9.7 / 50
	Ljusnan	0.3 / 44	7.4 / **55**

Improvement for the methods:

- **Reduced ensemble from persistence of circulation patterns (CP)**
- **Statistical downscaling (SD)**

- Test period was 2000-2010
- Forecasts were made on the first of January, March and May up to the end of August.
- The forecast error was determined for each of the years 2000-2010.



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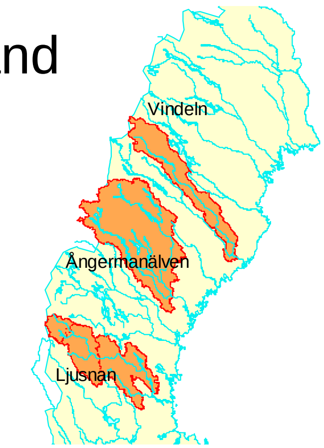
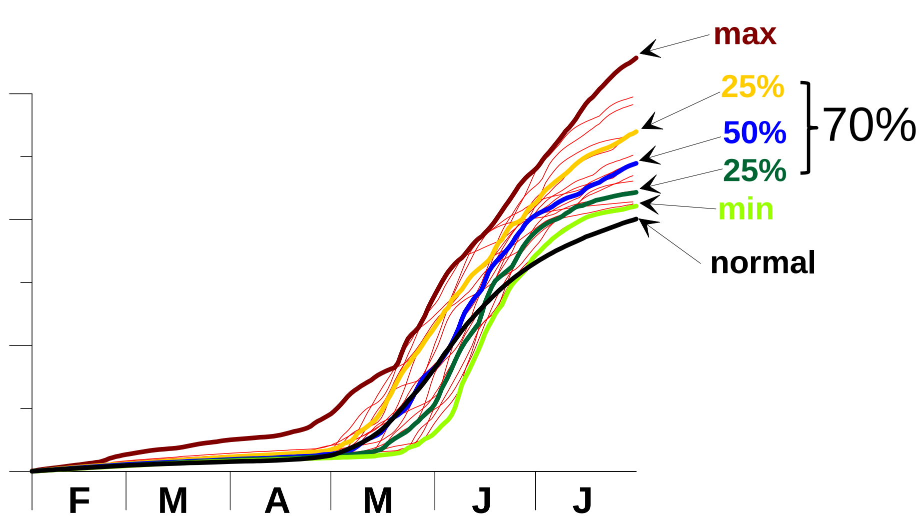
Discussion

- No improvement for Ljusnan may be due to less snow melt and more rain in May-July.
- A strong bias in the seasonal forecasts from ECMWF
  - Possibilities for improvement
- The traditional forecasts predicts a too wide statistical range





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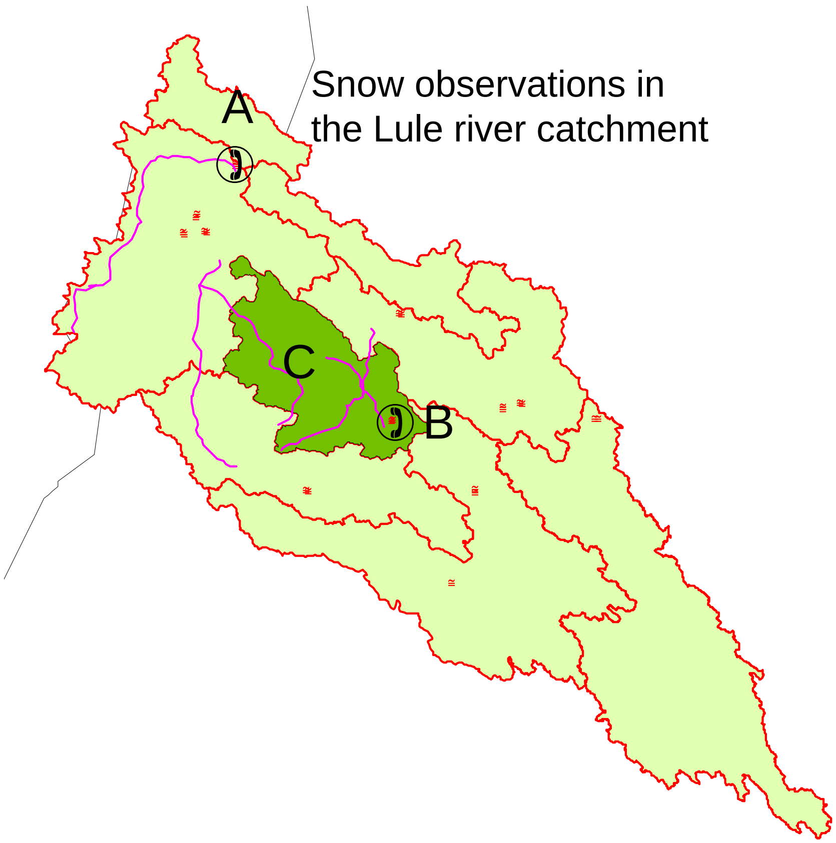
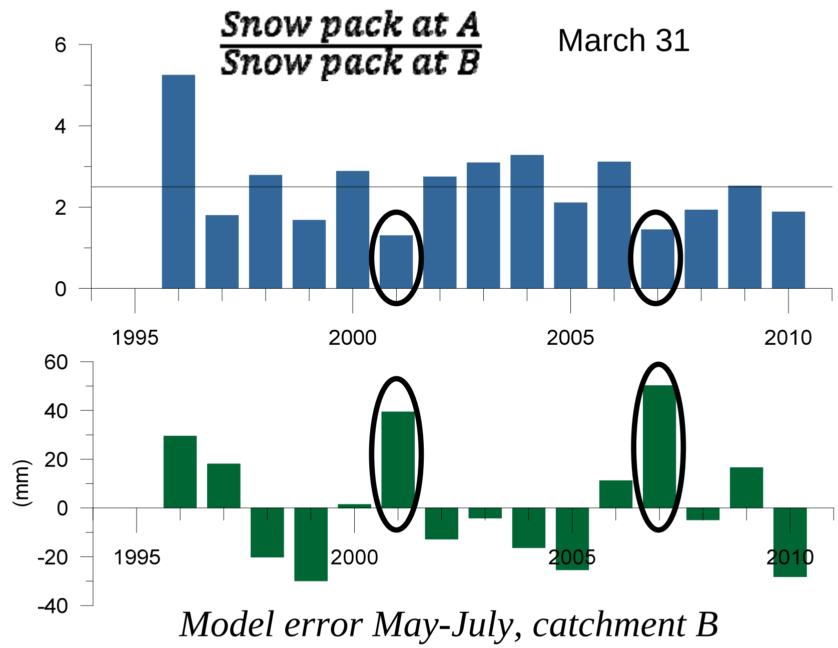
How to use snow observations to assess/improve forecast accuracy?





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Thank you!

We have presented some preliminary results.

We would like to learn from your experiences.