A multi-model system for spring flood forecasts

Elforsk report 11:72

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Preface

Since 1980 the hydropower industry has carried out joint development activities in the hydrology field. Since 2003 the work has been organized in three year frame work programmes. The programme phase 2009-2011 included four R&D projects, the arrangement of an annual HUVA seminar as well as hydrology training courses for power industry personnel. The programme has been administrated by Elforsk and managed by a steering group with the following members:

Peter Calla, Vattenregleringsföretagen (chair.)
Sigrid Eliasson, E.ON Vattenkraft
Jesper Nyberg/ Lars Skymberg, Fortum
Emma Wikner, Statkraft
Susanne Nyström, Vattenfall
Dan Roupe, Vattenfall
Mikael Sundby, Vattenfall
Lars Pettersson/Peter Lindström, Skellefteälvens vattenregleringsföretag
Björn Norell, Vattenregleringsföretagen
Cristian Andersson, Elforsk (adj.)

HUVA (2009-2011) was financed by E.ON Vattenkraft Sverige AB, Edsbyns Elverk AB, Fortum Generation AB, Gävle Energi AB, Holmen Energi AB, Jämtkraft AB, Karlstads Energi AB, Mälarenergi AB, Skellefteå Kraft AB, Sollefteåforsens AB, Statkraft Sverige AB, Tekniska Verken i Linköping AB, Umeå Energi AB and Vattenfall Vattenkraft AB.

This report covers a project that was carried out 2009-2011. The idea behind the project was to try different approaches to predict either the development of the weather or the actual spring flood in the very forecasting period ahead, i.e. not in a year with a normal weather development. The approaches used reflect the latest developments with respect to analysis and modelling of climate on seasonal time scales.

Stockholm, February 2012

Cristian Andersson
Program are Hydropower
Elforsk

Sammanfattning

Projektmål

Projektets mål har varit att utvärdera ett antal nya angrepp för att förbättra vårflödesprognoserna. Den procedur som används som standard idag, och som finns implementerad i det hydrologiska modellsystemet IHMS, går ut på att först köra fram HBV-modellen med observerad temperatur och nederbörd fram till prognostillfället och på samma sätt erhålla en optimal beskrivning av det hydro-meteorologiska tillståndet i avrinningsområdet. Temperatur och nederbörd under prognosperioden från samtliga historiska år antas därefter utgöra möjliga utvecklingar under den kommande perioden. Resultaten från alla historiska år utgör en ensemble av vårflödesprognoser som kan uttryckas i termer av sannolikhet för överskridande av olika flöden. Normalt används enbart medianvärdet av ackumulerad vattenföring under vårflödesperioden.

Eftersom samtliga historiska år används är (median-)prognosen klimatologisk, d.v.s. den förutsäger vårflödet under förutsättningen att väderutvecklingen under prognosperioden blir normal. Prognosfelet kommer således att bli större ifall väderutvecklingen är ovanlig, förutsatt att det initiella HBV-tillståndet väl beskriver verkligheten.

Tanken bakom projektet är att via olika ansatser försöka förutsäga antingen väderutvecklingen eller själva vårflödet under just den kommande perioden, d.v.s. inte under ett år med normal väderutveckling. De angrepp som används ska avspegla den senaste utvecklingen vad gäller analys och modellering av klimatet på årstidsskala.

Genomförande

Tre olika ansatser har testats och utvärderats:

- Reducerad historisk ensemble. Två olika metoder för att identifiera de historiska år vars väderutveckling är mest sannolikt representativ för den kommande perioden (s.k. analoga år) utvärderades. Båda utgår från väder-utvecklingen närmast före prognostillfället. (1) Klimatindex (*TeleConnection Index;* TCI): utvecklingen av olika index som förenklat beskriver regionalt klimat. (2) Cirkulations-mönster (*Circulation Pattern;* CP): frekvensen av olika vädertyper, klassificerade i grupper.

- Meteorologiska säsongsprognoser från ECMWF i HBV (EH). Temperatur och nederbörd i meteorologiska säsongsprognoser från *European Centre for Medium-range Weather Forecasts* (ECMWF) omvandlades till indata till HBV modellen. Därefter kördes HBV-modellen från samma uppdaterade initialtillstånd som används i dagens procedur.

- Statistisk nedskalning av ackumulerat vårflöde (*Statistical Downscaling;* SD). Statistiska samband mellan storskalig atmosfärisk cirkulation och ackumulerat vårflöde identifierades och kalibrerades för varje älv.

Ansatserna utvärderades för prognoser gjorda 1/1, 1/3 och 1/5 för vårflödena 2000-2010 i älvarna Vindelälven, Ångermanälven och Ljusnan. Utvärderingen gjordes främst i termer av genomsnittligt absolut fel av ackumulerat vårflöde med IHMS-prognosen som referens. Träffsäkerheten hos de nya ansatserna uttrycktes som relativ minskning av prognosfelet (%) jämfört med IHMS.

Efter att ha utvärderat de olika ansatserna separat testades att på olika sätt kombinera de olika prognoserna i ett optimalt multi-modell system.

Resultat

	Vindelälven			Ljusnan			Ångermanälven		
	1/1	1/3	1/5	1/1	1/3	1/5	1/1	1/3	1/5
TCI	-7.8	-5.8	-13.8	-13.3	-9.0	-4.3	-3.5	-2.0	**8.0**
CP	**11.5**	**21.6**	-20.9	-7.0	-20.6	-1.5	**2.2**	**4.3**	**24.8**
EH	-2.8	-18.0	-4.9	-38.6	-4.2	-2.7			
SD	**23.7**	-16.7	-75.2	-13.1	-13.1	-36.4	**35.1**	-0.4	-25.9
M-M	**19.4**	**11.9**	**9.7**	**11.6**	-0.3	**4.2**	-8.9	**8.9**	**17.2**

I tabellen ovan visas minskningen av felet för de olika älvarna, prognostillfällena och ansatserna (M-M betyder multi-modell). Positivt värde (fet stil) betyder att prognosfelet i den nya ansatsen är mindre än IHMS.

Vad gäller de enskilda ansatserna ledde ingen av dem till någon tydlig förbättring jämfört med IHMS för Ljusnan, men viss minskning av prognosfelet verkar möjlig för Vindelälven och Ångermanälven. Den största förbättringen erhölls för 1/1-prognoserna med SD-ansatsen, där felet minskade med upp till 35%. Den ansats som gav den största förbättringen sett över alla prognostillfällen var CP, för vilket felet minskade med upp till 25%. Prognoserna från TCI- och EH-ansatserna hade överlag ett större fel än IHMS-prognosen.

Den kombinerade multi-modellen gav viss förbättring även i Ljusnan. Sett över alla älvar och prognostillfällen minskar prognosfelet med knappt 10% jämfört med IHMS.

Projektets huvudsakliga slutsatser är följande: (1) det är idag (2011) svårt att göra vårflödesprognoser som totalt sett är markant bättre än dagens klimat-baserade från IHMS, (2) för enskilda älvar och prognostillfällen kan en minsking av prognosfelet med upp till 30% erhållas genom analys av dominerande vädertyper eller statistisk nedskalning, (3) med en kombinerad multi-modell kan en generell minskning av prognosfelet med ~10% uppnås.

Framtida studier

- Generellt finns behov av fortsatta studier för att öka förståelsen för de bakomliggande hydro-meteorologiska processerna. Denna studie har visat på intressanta och användbara samband men mera djupgående analyser behövs för att bättre förstå och beskriva de olika beroenden som finns i tid och rum.

- Metoden att identifiera analoga historiska år på basis av cirkulationsmönster visade lovande resultat trots icke-optimala data. Ytterligare förbättring kan vara möjlig med en optimal klassificering, bättre anpassad till specifika älvar/regioner och datakällor.

- En orsak till EH-prognosernas begränsade träffsäkerhet är troligen skillnaden i rumslig skala mellan prognoser och avrinningsområde. Genom statistisk nedskalning bör en bättre representation av klimatet i avrinningsområdet kunna erhållas och därmed bättre prognoser.

Summary

Objective

The objective of the project has been to evaluate a number of new approaches to improve spring flood forecasts. In today's standard procedure, which is implemented in IHMS, the HBV model is firstly run using observed temperature and precipitation up until the time of the forecast, that way producing an optimal description of the hydro-meteorological conditions. Temperature and precipitation in the forecasting period from all historical years are considered as representing possible evolutions in the coming period. The results from all historical years comprise an ensemble of spring flood forecasts that may be expressed in terms of exceedance probabilities of different discharges or volumes. Normally only the median value of accumulated discharge during the spring flood period is used.

Since all historical years are used, the (median) forecast is climatological, i.e. it predicts the spring flood under the assumption that the development of the weather in the forecasting period will be normal. The forecast error will thus be larger the more unusual the weather develops, provided that the initial HBV-condition well represents reality.

The idea behind the project is to try different approaches to predict either the development of the weather or the actual spring flood in the very forecasting period ahead, i.e. not in a year with a normal weather development. The approaches used will reflect the latest developments with respect to analysis and modelling of climate on seasonal time scales.

Implementation

Three different approaches have been tested and evaluated:

- <u>Reduced historical ensemble.</u> Two methods for identifying the historical years that are most likely representative for the coming period (analogue years) were evaluated. Both are based on analyses of the weather development just before the forecast time. (1) Teleconnection indices (TCI): the evolution of different indices that describes regional climate in a simplified way. (2) Circulation patterns (CP): frequency of different weather types, classified into groups.

- <u>Meteorological seasonal forecasts from ECMWF in HBV (EH).</u> Temperature and precipitation in seasonal ensemble forecasts from European Centre for Medium-range Weather Forecasts (ECMWF) were converted into HBV model input. Then the HBV model was run from the same updated initial condition as the one used in today's procedure.

- <u>Statistical downscaling of accumulated discharge (SD).</u> Statistical relationships between large-scale circulation variables and accumulated discharge were identified and calibrated for each river.

The approaches were evaluated for the spring floood forecasts 2000-2010 issued on 1/1, 1/3 and 1/5 in rivers Vindelälven, Ångermanälven and Ljusnan. The evaluation was made in terms of mean absolute error of accumulated discharge. The perfomance of the new approaches was expressed as a relative reduction of the forecast error (%) as compared with IHMS.

After separate evaluations of the differnent approaches, different ways to combine the forecasts in an optimal multi-model system were investigated.

Results

	Vindelälven			Ljusnan			Ångermanälven		
	1/1	1/3	1/5	1/1	1/3	1/5	1/1	1/3	1/5
TCI	-7.8	-5.8	-13.8	-13.3	-9.0	-4.3	-3.5	-2.0	**8.0**
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The above table shows the error reduction for the different rivers, forecast dates and approaches (MM denotes multi-model). A positive value (boldface) means that the forecast error in the new approach is less than that in IHMS.

Concerning the single approaches, none of them generated any clear improvement compared with IHMS for Ljusnan, but some reduction of the forecast error seems attainable for Vindelälven and Ångermanälven. The largest improvement was found for the 1/1-forecasts with the SD approach, with an error reduction of up to 35%. The largest improvement considering all forecast dates was found for the CP approach, with an error reduction of up to 25%. The forecast error in the TCI- and EC-forecasts were generally larger than in IHMS.

The combined multi-model gave some improvement also in Ljusnan. On average over all rivers and forecast dates, the error is reduced by almost 10% as compared with IHMS.

The main conclusions from the project are the following: (1) it is today (2011) difficult to make spring flood forecasts that in total are markedly better than today's climataology-based ones from IHMS, (2) for single rivers and forecast dates, a reduced forecast error by up to 30% is attanable by weather type analysis or statistical downscaling, (3) a general reduction of the forecast error by up to 10% can be reached by a combined multi-model.

Future studies

- Generally there is a need for future studies to increase the understanding of the hydro-meteorological processes involved. This study has revealed interesting and useful relationships but more in-depth investigations are required to better understand and describe the dependencies in time/space.

- The method to identify analogue historical years on the basis of circulation patterns showed promising results despite non-optimal data (different sources before/after 2003, tuning for Vindelälven). Further improvement may be possible if using an optimal classification, tuned to regions and data sources.

- One reason for the limited accuracy of the EH-forecasts is probably the difference in spatial scale between forecasts and catchment. A better representation of the catchment climate, and thus better forecasts, should be attainable using statistical downscaling.

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1 Introduction

Seasonal (or long-term) discharge forecasts are used primarily by the hydropower industry for dam regulation and production planning. The forecasts may be used to optimise the balance between on one hand a sufficiently large water volume for optimal power production and on the other hand a sufficient remaining capacity to handle sudden inflows in a safe way. In northern Sweden, the most important seasonal forecast is the spring flood forecast which covers the main snow-melt period in May, June and July.

The current spring flood forecasting practice in Sweden is a procedure based on the HBV model (e.g. Bergström, 1976; Lindström et al., 1997; Carlsson and Lindström, 2001; Carlsson and Sjögren, 2003). In the first step of this procedure, a well-calibrated set-up of the HBV model is run using observed meteorological inputs (temperature, precipitation) for a historical period up until the forecast date, typically sometime in February. The final state of the HBV model will thus reflect the current hydro-meteorological conditions in the catchment, with respect to snow pack, soil moisture, etc. In the second step, this final HBV state from the simulation period is used as initial state in forecast runs. Historical time series of temperature and precipitation, covering the period from the forecast date until the end of the spring flood period, are extracted from the catchment data base. The time series of each historical year are used as input in the HBV model to simulate one possible evolution of the spring flood to come. The results from all historical years make up a forecast ensemble, which may be expressed in terms of percentiles with different probabilities of exceedance. Normally, the main result used in practice is the median value of the total accumulated discharge in the spring flood period.

While overall sound and generally useful, this current practice has the obvious limitation that it is based on the climatology, i.e. the normal climate. Thus, if the weather in the spring flood period evolves in a close-to-normal way the median forecast is likely to have a small error. But if the weather deviates from the climatology, the forecast error will be larger. One potential way to improve the current practice is therefore to include information of the most likely evolution of the weather in the spring flood period to be forecasted, to which degree it is expected to deviate from the climatology.

Recently, substantial progress has been made in the field of seasonal climate forecasting. It may be distinguished between dynamical and statistical approaches. In the dynamical approach, numerical atmospheric models (global circulation models - GCM) have been developed to predict seasonal climate, i.e., the average climate for 3 consecutive months, several months ahead (Goddard et al., 2001). The scientific basis of such predictions is that the sea surface temperature (SST), that characteristically evolves slowly, drives the predictable part of the climate. Consequently, providing to a GCM model the information about the variations in SST makes possible the forecast of seasonal climate. The SST information may be provided to the GCM either by providing the SST field as a boundary condition or by coupling the GCM to an ocean model that will then provide the necessary SST information (this coupled system is then named Global Climate Model). The most common use for seasonal climate forecast is to support decision making to improve management and thus reducing risks and costs or improving production and profit (Goddard et al., 2001; Troccoli, 2010; and references therein).

In the statistical approach, teleconnections between climate phenomena that affects the large-scale atmospheric circulation and the subsequent hydro-meteorological development in specific locations are identified and utilised (e.g. Jónsdótir and Uvo, 2009). The impacts of the El Niño-Southern Oscillation on the tropical climate are the most common use of such teleconnections in seasonal forecast (Troccoli, 2010). Teleconnections can be also the basis for seasonal forecast in high latitudes such as the impacts of the North Atlantic Oscillation if the winter climate in Scandinavia (e.g. Uvo, 2003) and the recently identified impact of the Scandinavian Pattern on summer climate in southern Sweden (Engström, 2011).

The objective of this project has been to test and evaluate three different approaches to use seasonal climate forecasts to obtain more accurate spring flood forecasts. Two of the approaches aim at improving the current HBV-based procedure, whereas the third approach does not involve hydrological modelling. The main focus is on statistical climate forecasting but also dynamical forecasts are evaluated. Finally, an attempt is made to combine the different new approaches with the current procedure in a multi-model spring flood forecasting system.

2 Material

2.1 Study area and HBV simulations

The basins of rivers Vindelälven, Ångermanälven and Ljusnan have been used for testing the spring flood forecasts (Figure 1). Vindelälven is unregulated, whereas both Ångermanälven and Ljusnan are regulated.

Figure 1 Locations of the three study basins

In all rivers two stations have been used in the evaluation, one located in the upstream part of the basin and one in the basin outlet (Table 1). In all rivers obervations of temperature, precipitation and discharge are avilable since 1961 and in the forecasting experiments we focus on the spring flood period May-July in years 2000-2010. The mean accumulated discharge in the spring flood period, ΣQ, given in Table 1 is calculated as the average over these 11 years.

Table 1 Basin and station characteristics including performance of the HBV model.

River	Station	Area (km²)	Mean ΣQ (m^3*10^6)	HBV R^2	RVE (%)
Vindelälven	Sorsele	6054	2302	0.89	3.2
	Vindeln*	11846	3178	0.91	1.5
Ångerman-älven	Kultsjön	1705	883	0.82	3.6
	Sollefteå*	30979	7896	0.92	1.7
Ljusnan	Svegsjön	8484	1658	0.87	-0.6
	Dönje*	14743	2312	0.85	0.5

*Basin outlet

Updated set-ups of the HBV model were available for all rivers. For Vindelälven and Ljusnan, grid-based input of temperature and precipitation is used, whereas the Ångermanälven set-up uses station-based input. The overall accuracy in terms of the Nash-Sutcliffe efficiency R^2 and the relative volume error RVE in period Oct 1999 - Sep 2010 are given in Table 1. The numbers indicate that the HBV model parameters are well calibrated.

2.2 Meteorological data

The meteorological and climate data used in this work were obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF). The data are from the system 3 data sets; the system consists of an ocean analysis to estimate the initial state of the ocean, a global coupled ocean-atmosphere general circulation model to calculate the evolution of the ocean and atmosphere, and a post-processing suite to create forecast products from the raw numerical output.

The ECMWF model is the Cy31r1 version of ECMWF IFS (Integrated Forecast System) coupled with a 1° version of the HOPE ocean model, and the Météo France model used is the Arpege atmospheric model coupled with the ORCA ocean model.

The seasonal forecasts were used in two different forms; a seasonal forecast average was used in the statistical downscaling method and daily seasonal forecast data were used in the ECMWF forecasts in HBV method.

- Seasonal forecast average – these data are the ensemble means of the different predictors which had a domain covering 75°W to 75°E and 80°N to 20°N with a 2°x2° resolution. Each predictor has 11 ensemble members for the period 1982-2006 and 41 ensemble members for the period 2007-2010. The predictors considered in this part of the work were the following predictors forecasted by both the ECMWF and MF models: 2m temperature, 10m meridional wind velocity, meridional wind stress, 10m zonal wind velocity, zonal wind stress, surface sensible heat flux, surface latent heat flux, total precipitation, 850mb temperature, 850mb specific humidity, 850mb meridional wind velocity, 850mb zonal wind velocity, and 850mb geopotential height.

- Daily seasonal forecast - these data are the forecasted daily values of 2 meter temperature and the accumulated total precipitation since the forecast date. These data spanned a period from 2000-2010 and had a domain covering 11°E to 23°E and 55°N to 70°N with a 1°x1° resolution. There were 11 ensemble members for each variable for the period 2000-2006 and 41 ensemble members for 1997-2007. Figure 2 shows this 1ºx1º grid in relation to Sweden.

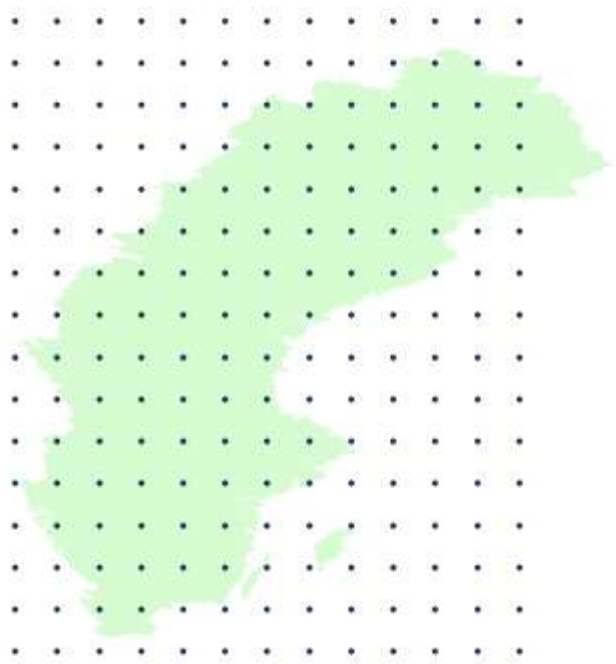


Figure 2 Sweden with the 1ºx1º ECMWF grid.

For the approach based on circulation patterns (section 3.1.2), data from two meteorological reanalyses were used: ERA40 and ERAINTERIM (REF). ERA40 data used was for the period 1961-2002 and had a 1ºx1º resolution while the ERAINTERIM data used was from 1976-2010 and had a 0.75ºx0.75º resolution.

3 Methodology

Three different approaches to improve the spring flood forecasts are tested and evaluated. In the first approach, two ways to obtain a reduced ensemble of historical years are investigated. In the second approach, dynamical climate forecasts are used as input in the HBV model. In the third approach, statistical relationships directly coupling spring flood volume to large-scale circulation are identified.

3.1 Reduced historical ensemble

As described in section 2.1, meteorological data from a large number of historical years are avalable for each catchment. These data thus constitute a historical ensemble of which each year is a member. Because of the large number of members available, it is likely that one or some of them will well represent the weather in the spring flood period to come.

In this approach, we try to identify historically analogue years, i.e. the historical years in which the weather is most likely to represent the evaluation from the forecast date. Then only data from these years are extracted from the catchment data base and fed into the HBV model to generate the spring flood forecasts. Two sub-approaches are used, one based on climate indices and one on circulation patterns.

3.1.1 Climate indices – TCI

Teleconnection i are recurring pressure and circulation anomalies that have been identified using a Rotated Principle Component Analysis of standardised height anomalies (Barnston and Livezey, 1987). The Climate Prediction Center, part of the National Oceanic and Atmospheric Administration (NOAA), calculate indices for ten teleconnection patterns in the Northern Hemisphere.

From these ten teleconnection patterns the following three were selected for this work:

- North Atlantic Ocillation (NAO) – The positive phases of the NAO is associated with above average temperatures and precipitation over Scandinavia, while the negative phases tend to be associated with below average temperatures and precipitation
- East Atlantic pattern (EA) - The positive phase of the EA pattern is associated with above average temperatures and precipitation over Scandinavia.
- Scandinavia pattern (SCAND) – the positive phase of the SCAND pattern is associated with below average precipitation over scandinavia.

The method looks at the persistence of the different TCI for different periods in the forecast year, namely 1, 2, 3, 4, 5 and 6 months prior to the forecast date. The TCI are classified as either normal (indices within one standard deviation of the mean value), above normal (indices above one standard deviation of the mean value) and below normal (indices below one standard deviation of the mean value). Then the same is done for corresponding periods in the historical years and if the classification of the three different TCI are in agreement with the year being forecasted then that historical year is selected as an analogue year to run the HBV model. If there are no analogue years selected using the three TCI then analogue years are selected using a an agreement between two of them, NAO–EA and NAO-SCAND.

3.1.2 Circulation patterns – CP

Circulation-pattern (CP) analysis is a commonly used tool in climatological and meteorological studies (Hay et al., 1991; Wilby and Wigley 1994). It was initially applied to explain climate variability at a large scale (Barry and Perry, 1973), later on widely developed for decades to scale down coarse general circulation model (GCM) output into local climate in e.g. climate change studies (Wetterhall et al., 2006; Yang et al., 2010).

The method normally works with reliable upper-air data at multi-grid, i.e., sea level pressure, to explain recorded events in observations such as temperature and precipitation. By differentiating the long-term historical observations into several representative patterns, each pattern is supposed to describe certain climate condition in the study area. The patterns are defined based on either professional knowledge of atmospheric motions (subjective classification) or statistical characteristics derived from the observations (objective classification). The objective classification is a semi-automated or automated technique that pertains to mathematical approaches, e.g., hierarchical methods (Johnson, 1967), k-means methods (Mac-Queen, 1967), cluster analysis (Kysel and Huth, 2003) and correlation methods (Yarnal, 1984). The method that is proposed and investigated here is based on fuzzy-rule logic.

Fuzzy-rule-based classification is one of the objective classifications. It works on the concept of fuzzy sets (Zadeh, 1965), using imprecise statements to describe a certain system, in this case the climate system. The classification scheme for circulation patterns (CPs) follows four steps: the transformation of large-scale data, the definition of the fuzzy rules, the optimization of the fuzzy rules and the classification of circulation patterns. A detailed description of the methodology can be found in Bárdossy et al., 2002.

In this work, the anomalies of daily mean sea level pressure (MSLP), g(i,t), from reanalysis data, ERA40 (1ºx1º) or ERAINTERIM (0.75ºx0.75º), serves as a predictor according to

$$g(i,t) = \frac{h(i,t) - \mu(i,t')}{\sigma(i,t')} \qquad (1)$$

where h(i,t) is daily MSLP at grid i and time t. $\mu(i,t')$ and $\sigma(i,t')$ stand for climatological mean and standard deviation of MSLP over an enough long period at grid i and Julian date t´. The anomaly g(i,t) indicates the deviation of daily MSLP away from long-term climatology at certain location i and time t.

Precipitation records, p(t), measured in the Vindelälven basin during 1961-1990 are used as local observations to define fuzzy rules that describe main characteristics of local climate. Two measures are used to evaluate the performance of the optimization process for explaining the heavy rainfall events seasonally. They are the differences in frequency and magnitude of local variables between the weather state under specific CP and no specific CP, calculated in the following equations

$$\frac{\qquad}{} - \tag{2}$$

$$- \quad \frac{\qquad}{} \tag{3}$$

where, T is the number of days used for the CP optimization. P(CP(t)) is the probability of precipitation exceeding the threshold occurring with a given CP. P is the probability of a day being wet without consideration of CP classification. Z(CP(t)) indicates the mean precipitation amount or frequency of rainy days with a given CP. Z is the mean value over all days.

The classified CPs are thus able to explain variability in frequency and the amount of precipitation in study area. Next, the statistic properties such as frequency occurrence and persistence of individual CPs are calculated per month for both historical and forecasting years. The two most frequently occurred CPs within periods of 1 up to 6 months before forecasting date are used to select historical years that are similar to the years to be forecasted.

3.2 ECMWF forecasts in HBV - EH

Temperature and precipitation from the daily ECMWF forecasts were converted into HBV input format (sub-basin averages). Within the resources of this project, this conversion was only attainable for the two rivers with HBV model set-ups using grid-based input (Vindelälven and Ljusnan). Further method development is required for downscaling the ECMWF forecasts to represent station-based HBV input, thus this approach was in this study not evaluated for Ångermanälven. After conversion, the forecasts were used to feed the HBV model from the same initial state as used in the current IHMS procedure.

3.3 Statistical spring flood downscaling – SD

Statistical downscaling is a common method used to connect course scaled climate data, typically large scale circulation variables, to finer scaled data, in this case accumulated discharge (e.g. Landman et al., 2001; Foster and Uvo, 2010). The method employed in this work was to use a singular value decomposition (SVD) analysis; SVD analysis is a technique that identifies linear combinations of variables from two data fields. SVD is similar to a canonical correlation analysis (CCA) except instead of maximising the temporal correlation between two data fields SVD maximises the temporal covariance between the two fields (Cheng and Dunkerton, 1995). The connection made by the SVD analysis is then used in combination with new predictor data to make forecasts.

The method uses historical time series for both the predictors and the predictand to train the model then uses present predictor data to make a forecast. As there is generally more than one climate signal affecting discharge, each predictor will only be able to explain some of the variation. To maximise the robustness of the forecast multiple forecasts are made with different predictors resulting in an ensemble forecast.

In this work the predictors are the 90 day forecast means of the large scale circulation variable being used. The mean of the predictors is calculated for the 90 days following the forecast date, i.e. if the forecast date were 1 January then the mean of the predictor is calculated for 1 January to 31 March. The predictors were chosen by first consulting the literature to narrow the selection and then by performing an analysis on these to select those that performed the best. The predictors used were large scale circulation variables with a 2ºx2º resolution from both the ECMWF seasonal forecast model and the Meteo France climate model. The training period used was from 1982 until the year prior to the year being forecasted, thus the training period increased in length with each step forward through the study period.Due to the relatively large distances between the different gauging stations it is expected that there will be differences in the dominant climate signals that affect the hydrology in each area, therefore different GCM predictor combinations were used to forecast each station.

The predictors used in the final forecasts are 2m temperature, 10m meridional wind velocity, meridional wind stress, 10m zonal wind velocity, zonal wind stress, surface sensible heat flux, surface latent heat flux, total precipitation, 850mb temperature, 850mb specific humidity, 850mb meridional wind velocity, 850mb zonal wind velocity, and 850mb geopotential height.

3.4 Experimental set-up and evaluation

A key issue in seasonal forecasting is the lead time, i.e. the period between the forecast date and the start of the forecasting period (in our case, the forecasting period is May-July). It may be expected that the relative skill of the different approaches depends on the lead time. Generally, the main gain of statistical approaches is expected for long lead times. When approaching the forecasting period, the representation of the hydro-meteorological state in the HBV model becomes gradually more important and the relative skill of the current procedure is likely to increase. To assess the relative skill for different lead times, we evaluate hindcasts issued on the 1st of January (1/1), 1st of March (1/3) and 1st of May (1/5) for the spring floods 2000-2010.

The evaluation of performance is done mainly in terms of how well the accumulated discharge in the spring flood period, ΣQ, is forecasted. This is assessed by MAE_{FC}, the mean absolute error of a certain forecast FC, defined as

$$MAE_{FC} = \frac{1}{11}\sum_{y=2000}^{2010} AE^{y} \qquad (4)$$

where y denotes year and AE_{FC}^{y} the absolute error

$$AE_{FC}^{y} = \left| \Sigma Q_{OBS}^{y} - \Sigma Q_{FC}^{y} \right| \tag{5}$$

where OBS denotes observation.

To quantify the gain of the new forecast approaches (sections 3.1-3.3), their MAE-values (MAE_{FCN}) are compared with the MAE obtained using the current IHMS procedure (MAE_{IHMS}) by calculating the relative improvement RI (%) according to

$$RI_{FCN} = 100 * \left(\frac{MAE_{IHMS} - MAE_{FCN}}{MAE_{IHMS}} \right) \tag{6}$$

where MAE_{FCN} denotes the MAE of a certain new forecast approach. A positive RI indicates that the error of the new approach is smaller than the error in the IHMS procedure, and vice versa. The following abbreviations are used instead of FCN in the Results section (section 4): TCI – teleconnection indices (section 3.1.1); CP – cirulation patterns (3.1.2); EH – ECMWF forecasts in HBV (section 0); SD – statistical downscaling (section 3.3).

As an additional performance measure, we also calculate the frequency of years in which the new approach performs better than the IHMS procedure, FY^{+} (%). This may be expressed as

$$FY_{FCN}^{+} = 100 * \left(\frac{1}{11} \sum_{y=2000}^{2010} H^{y} \right) \tag{7}$$

where H is the Heaviside function defined by

$$H^{y} = \begin{cases} 0, AE_{IHMS}^{y} < AE_{FCN}^{y} \\ 1, AE_{IHMS}^{y} > AE_{FCN}^{y} \end{cases} \tag{8}$$

All of the forecast methods in this report may be used to generate ensemble forecasts, but with a different number of ensemble members N:

- IHMS: N equals the total number of historical years available N_{TOT}
- TCI, CP: N equals the number of analogue historical years found, which may vary between 0 and N_{TOT}
- EH: N equals 11 in 2000-2006 and 41 in 2007-2010
- SD: N equals the number of large scale circulation predictors used

The methods with a large and stable number of ensemble forecasts are thus IHMS and EH. For these methods, a limited probabilistic evaluation was performed. Figure 3 illustrates an ensemble forecast of accumulated discharge ΣQ (normal denotes the climatological evolution). From the values of ΣQ in the end of the forecasting period (31/7), statistical percentiles may be calculated that represent different probabilities of exceedance.

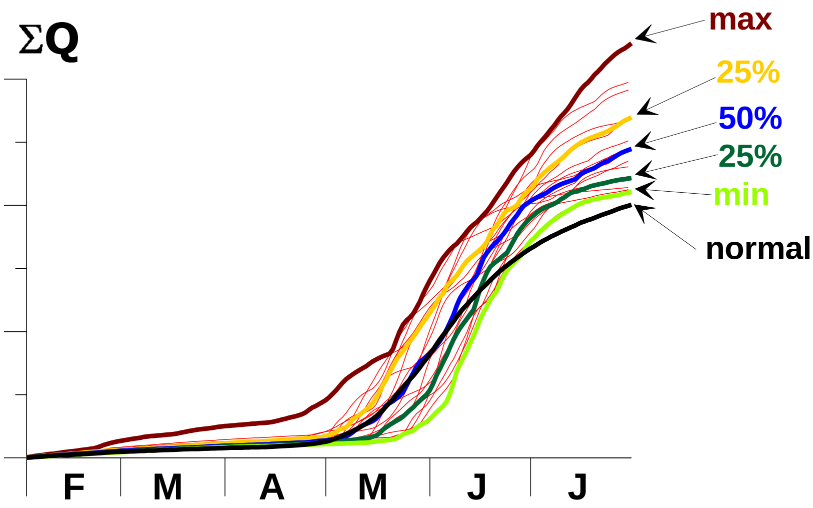


Figure 3 Ensemble forecasts.

If the ensemble forecasts are accurate in a probabilistic sense, the frequency of ΣQ-values that are actually observed should correspond to the percentiles. For example, in half of all years (50%) ΣQ should be above the 50th percentile and in half of the years below. In 1 year out of 4 ΣQ should fall above the 25th percentile and in 1 year out of 4 below the 75th percentile, and so on. If this is the case, the percentiles are well calibrated and do reflect the true exceedance probabilities. If the actual outcome does not correspond to the percentiles, the ensemble forecasts are biased and the percentiles do not reflect the true probabilities.

Ths may be graphically evaluated using frequency diagrams such as the one shown in Figure 4, which corresponds to the Talagrand diagram used in meteorology(e.g. Persson, 2001). The diagram shows the frequencies of ΣQ-values falling in the percentile-intervals given on the x-axis. If the forecasts are accurate, the observed frequencies match the theoretical distribution.

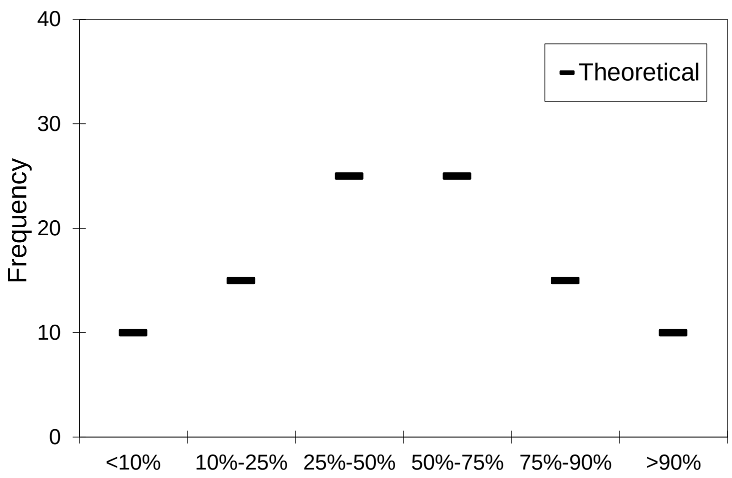


Figure 4 Frequency diagram for probabilistic evaluation of ensemble forecasts.

4 Results

A complete overview of the forecast experiments are given in Appendices 1 and 2.

4.1 Standard IHMS procedure

Before testing the new forecasting approaches, the performance of the current IHMS procedure was assessed (Table 2). In simulation mode, i.e. using observed values of temperature and precipitation, MAE is on average 7.7% with limited variation among the rivers. This quantifies the HBV model error and corresponds to having a perfect meteorological forecast.

Table 2 MAE of IHMS simulations (SIM) and forecasts (FC) in period 2000-2010.

River	Station	MAE_{IHMS} (%)			
		SIM	FC 1/1	FC 1/3	FC 1/5
Vindelälven	Sorsele	6.8	19.2	11.6	9.5
	Vindeln	8.2	20.0	13.2	9.0
Ångerman-älven	Kultsjön	4.1	18.6	12.8	10.8
	Sollefteå	7.6	21.0	18.4	16.3
Ljusnan	Svegsjön	9.5	25.1	25.3	16.0
	Dönje	10.3	27.7	30.6	18.8
Average		7.7	21.9	18.7	13.4

In forecast mode, the average MAE decreases from 21.9% for 1/1 to 13.4% on 1/5. Overall, the forecast accuracy decreases from north to south. This reflects the fact that in the north the spring flood is entirely dominated by the snowmelt whereas further south the snowmelt is mixed with precipitation falling as rain. The latter situation is more complex and difficult to forecast.

The difference between MAE for forecasts (FC) and MAE for simulations (SIM) represents the part of the total error that is related to the meteorological input. On average, this part decreases from 14.2 percentage points in the 1/1-forecasts (which corresponds to 65% of the total error) to 5.7 in the 1/5-forecasts (43%). It should be emphasised that three out of the four new forecast approaches tested here (CP, TCI, EH) aim at improving the meteorological input. They can thus only improve the forecasts in that respect; the HBV model error will remain. The fourth method (SD), however, aims at improving total performance.

The relative impact of the HBV model error thus increases with decreasing lead time, which implies that the scope for improving the IHMS forecasts decreases the closer we get to the forecasting period. It is remarkable that MAE for the 1/5-forecasts in Vindelälven are only slightly higher than the HBV model error. This may be interpreted as that with a proper representation of the hydro-meteorological state in the HBV model for Vindelälven on 1/5, the exact evolution of the weather in the forecasting period has only a minor impact.

Some analysis of HBV model bias was also perfomed, i.e. the tendency to systematically over- or underestimate ΣQ. In simulation mode, a small positive bias (~5%) was found with little difference between rivers. In forecast mode, when averaged over all rivers and forecast dates, only a negligible negative bias (~1%) was found, with some tendency to go from slightly positive on 1/1 to slightly negative on 1/5.

4.2 Overall results of new approaches

Generally, the resuts for different stations in the same river are similar. Therefore, the results in the following represent averages over the two stations in each river. An overview of the results is given in Table 3. The numbers after approaches TCI and CP correspond to the best performing version of each approach, see further sections 3.1.1 and 3.1.2. Numbers marked in boldface indicate that the new approach performs better than the IHMS procedure.

Table 3 Performance in terms of relative improvement (RI) and frequency of years with a lower MAE than IHMS (FY+) of the new forecasting approaches. Boldface indicates better performance than IHMS.

		TCI6		CP3		EH		SD	
		RI	FY^+	RI	FY^+	RI	FY^+	RI	FY^+
1/1	V-älven	-7.8	50	**11.5**	**75**	-2.8	45	**23.7**	**55**
	Ljusnan	-13.3	36	-7.0	38	-38.6	50	-13.1	50
	Å-älven	-3.5	**55**	**2.2**	50			**35.1**	**68**
1/3	V-älven	-5.8	**55**	**21.6**	**75**	-18.0	45	-16.7	50
	Ljusnan	-9.0	45	-20.6	35	-4.2	50	-13.1	27
	Å-älven	-2.0	41	**4.3**	**70**			-0.4	50
1/5	V-älven	-13.8	50	-20.9	39	-4.9	45	-75.2	45
	Ljusnan	-4.3	45	-1.5	44	-2.7	**55**	-36.4	**55**
	Å-älven	**8.0**	50	**24.8**	**56**			-25.9	50

It is evident that in most cases the error in the IHMS forecast is smaller than in the new approach. For two methods, TCI6 and EH, RI is essentially always negative, i.e. their MAE is always higher than the MAE of IHMS. The only exception is the TCI6 forecast for Ångermanälven on 1/5, which has 8% lower MAE than IHMS. In a few cases FY+ is slightly higher than 50, indicating that the new approach performs better than IHMS in more than half of the forecasts used in the testing. In total, however, neither TCI6 nor EH seems able to improve the spring flood forecasts as compared with the IHMS procedure.

Except in Ljusnan, the CP3 approach outperforms IHMS on essentially all forecast dates. The only exception is the 1/5-forecast for Vindelälven, which was previously shown very difficult to improve by a different meteorological input (see discussion in connection with Table 2). The most notable improvement is found for the 1/1- and 1/3-forecasts in Vindelälven, for which the MAE is reduced by 10-25% compared with IHMS and the CP3-forecast is better for 75% of the forecasts used in the testing. Also for Ångermanälven, the CP6 forecast is generally better than IHMS with a MAE reduction of up to 25%. In terms of only the meteorological input error, the average improvement by CP3 is ~30%.

On 1/3 and 1/5, the SD forecasts have a larger error than the IHMS forecasts. On 1/1, however, except in Ljusnan the SD approach seems able to reduce MAE by 25-35% as compared with IHMS.

To summarise, distinct improvements compared with the IHMS procedure were found for rivers Vindelälven and Ångermanälven using the CP3 approach (forecast dates 1/1 and 1/3) and SD (forecast date 1/1).

All observations and hindcasts by IHMS and the new approaches are given in Appendix 1.

4.3 Reduced historical ensemble

As mentioned in section 3.1, both the TCI and the CP approach are based on analyses of the climate a number of months before the forecast date. The number of months tested ranges from 1 to 6. The intention was to identify the number of months that performed best overall, i.e. when averaged over all forecast dates and rivers, to ensure that the selected approach is optimally robust. For a specific forecast date and river another number of months may perform better than the selected approach but this likely mainly reflects statistical varibility in light of the rather limited sample available.

4.3.1 Climate indices – CI

As shown in Table 4, the TCI approach performs better than IHMS in only a few cases. The accuracy of the TCI forecasts in Vindelälven and Ljusnan is generally low. In Ångermanälven, however, the TCI forecasts are notably better and even slightly better than IHMS when averaged over all dates and TCI versions (i.e. number of months used). In particular the 1/5-forecasts are clearly better than the IHMS forecasts. The main reason for this difference lies in the physics that support the TCI method. This method is based on the effect of different climate phenomena on the precipitation, temperature and consequently discharge and this effect varies depending on the location of the river basin (see Uvo, 2003). In particular, Ångermanälven is located in a region that is more affected by natural climate phenomena than Vindelälven and Ljusnan. It may be remarked that the different TCI versions often identify approximately the same analogue years, therefore the performance is generally rather similar for a certain forecast date and river.

Table 4 Relative improvement (RI) for the climate indices approach TCI with a different number of months used. Boldface indicates better performance than IHMS.

		TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
1/1	V-älven	-45.2	-26.3	-16.4	-10.3	-20.4	-7.7
	Ljusnan	-29.9	-5.4	**6.1**	-15.9	-9.8	-13.2
	Å-älven	-19.1	**0.5**	-4.7	**8.0**	**2.9**	-3.6
1/3	V-älven	-22.5	-5.5	-40.5	-44.4	-43.0	-5.8
	Ljusnan	-12.0	-29.5	-38.8	-33.6	-33.6	-9.0
	Å-älven	-6.6	-10.5	**3.4**	-1.8	-4.2	-2.0
1/5	V-älven	**2.0**	-6.3	-66.9	-73.4	-63.8	-13.8
	Ljusnan	**1.6**	-4.7	-20.7	-17.1	-28.9	-4.3
	Å-älven	**21.7**	**11.7**	**15.0**	**5.6**	**9.8**	**8.0**
Avg		-12.2	-8.4	-18.2	-20.3	-21.2	-5.7

On average, the TCI forecasts generally have a 10-20% larger MAE than IHMS. The best overall perfomance is found for TCI6, with a 5.7% larger MAE than IHMS. It outperforms IHMS in only one case but is always close to the IHMS accuracy. The other versions outperfom IHMS (generally only slightly) in two-three cases, but also in many cases have a substantially larger error than IHMS.

4.3.2 Circulation patterns – CP

Similarly to TCI, the CP approach performs better than IHMS in only a limited number of cases (Table 5). Also similarly to TCI, the best performance is found for Ångermanälven but for the CP approach the difference in performance between the rivers is smaller.

Comparing the different versions, using a period of three months before the forecast date to characterise the climate stands out as the superior choice. The MAE of the CP3 forecasts are on average 1.6% lower then in IHMS and the performance gradually decreases for both shorter and longer periods. On average in Vindelälven and Ångermanälven, CP3 performs 7.3% better than IHMS.

Table 5 Relative improvement (RI) for the circulation pattern approach CP with a different number of months used. Boldface indicates better performance than IHMS.

		CP1	CP2	CP3	CP4	CP5	CP6
1/1	V-älven	-26.6	-34.1	**11.5**	-11.0	-14.4	**4.0**
	Ljusnan	-8.4	-27.6	-7.0	-0.8	**7.1**	**3.7**
	Å-älven	-48.1	-41.4	**2.2**	-3.2	-2.6	**7.6**
1/3	V-älven	-15.4	-49.6	**21.6**	-0.1	-12.3	-24.2
	Ljusnan	-13.4	-52.2	-20.6	-14.9	-13.5	-8.2
	Å-älven	-34.7	-55.7	**4.3**	-15.9	-15.1	-16.9
1/5	V-älven	-111	**16.2**	-20.9	0.0	-5.6	-21.6
	Ljusnan	-55.3	-26.3	-1.5	**0.6**	-1.1	-9.9
	Å-älven	-33.5	**4.6**	**24.8**	**6.6**	**7.3**	-1.8
Avg		-38.5	-29.6	**1.6**	-4.3	-5.6	-7.5

As mentioned above (section 3.1.2), the circulation patterns were defined using the ERA40 analysis and then applied to the ERAinterim analysis to obtain results for 2003-2010. This implies a higher uncertainty in the results for 2003-2010. If considering only the results for 2000-2002, in which the selection of analogue years is fully consistent with the CP classification, the accuracy of the CP3 forecasts improves by 10-20% as compared with the results in Table 5. This result should be interpreted with care in light of the very limited sample used, but it indicates that improved performance is attainable if using a consistent data set for the CP classification.

4.3.3 Using the number of historical analogue years

The TCI and CP approaches are based on identifying a number N of historical analogue years, and a minor analysis was performed aimed as assessing the potential to use N in a qualitative way. It may be speculated that if N is large, i.e. many analogue years are found, then the climate in the spring flood period is likely to become close to the climatology. In this case the climatology-based IHMS procedure is likely to perform well. On the other hand, a small value of N means that only a few analogue years were found. Then deviations from the climatology may be expected and consequently a poorer performance of the IHMS procedure.

The relationship, however, turned out to be weak. From visual inspection, the strongest correlation was found for the CP3 approach, where a high MAE in IHMS is generally associated with a low value of N (Figure 5). However, also low MAE-values are often found for low N-values, and sometimes a high MAE is associated with a high value of N. It does not appear possible to use N for any practical purpose.

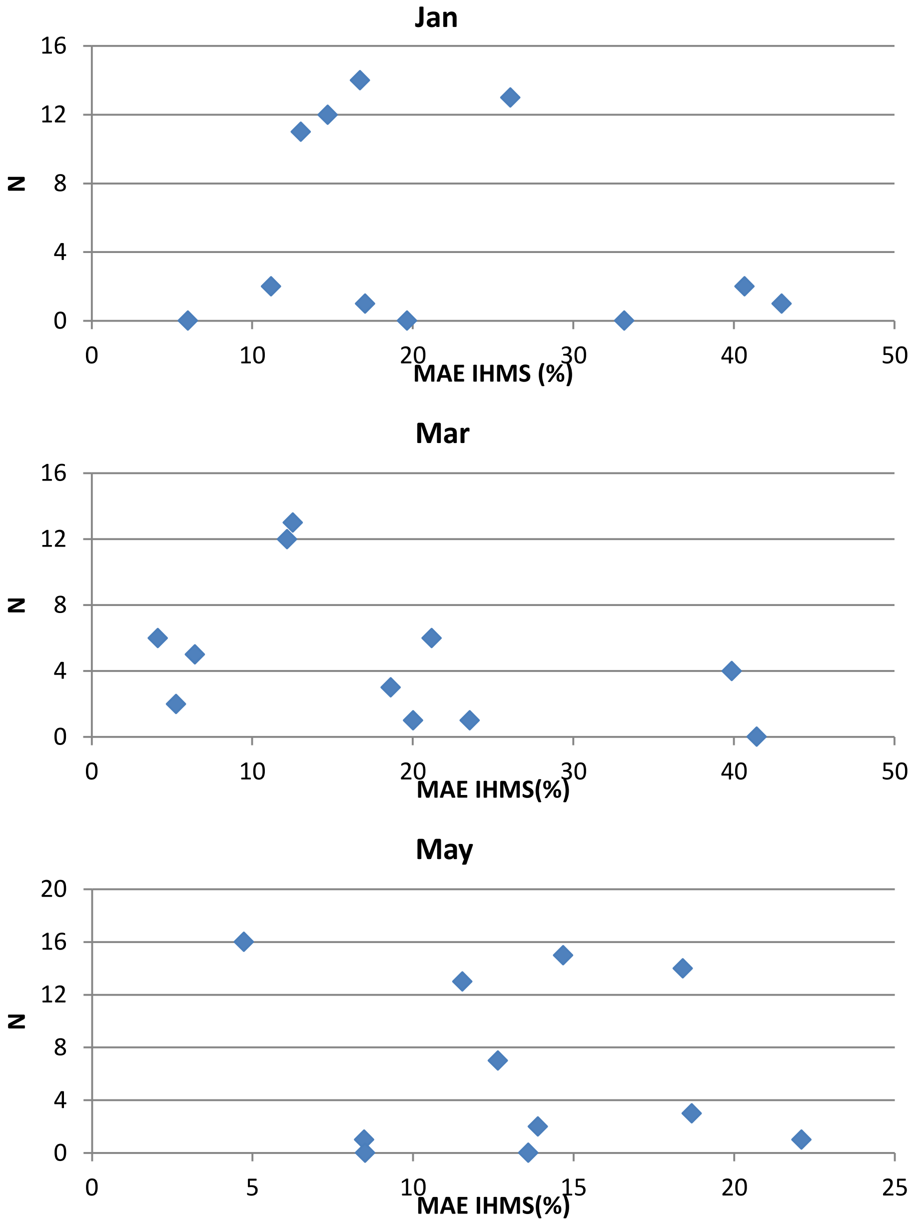


Figure 5 MAE of IHMS as a function of the number of analogue years N found in the CP3 approach.

4.4 ECMWF forecasts in HBV – EH

As shown in Table 3, using ECMWF forecasts in the HBV model did not improve performance as compared with the IHMS procedure. Even though the EH forecasts do outperform IHMS in about half of the cases, on average their MAE is higher than in IHMS for all forecast dates and rivers.

4.4.1 Analysis of temperature and precipitation

To understand why better performance was not attained, temperature and precipitation in the ECMWF forecasts were compared with observations from the river basins. In Table 6, the result is expressed in terms of monthly biases. For temperature, the bias is absolute (°C) but for precipitation it is relative, expressed as percentage of the observed precipitation (%).

Table 6 Bias in ECMWF forecasts as compared with observations.

			Jan	Feb	Mar	Apr	May	Jun	Jul
V-älven	P (%)	1/1	+23	+46	+74	+67	+9	-8	-29
		1/3			+43	+51	+5	0	-33
		1/5					+32	+3	-20
	T (°C)	1/1	+1.9	+0.8	-1.3	-1.5	-1.7	+1.1	+3.6
		1/3			+1.3	-0.8	-1.3	+2.3	+3.8
		1/5					+0.3	+4.1	+4.4
Ljusnan	P (%)	1/1	+22	+66	+75	+54	+11	-4	-26
		1/3			+75	+51	+10	+6	-20
		1/5					+40	+8	-6
	T (°C)	1/1	+0.3	-0.2	-1.9	-1.5	-0.7	+2.6	+4.8
		1/3			+0.6	-0.9	+0.5	+4.0	+5.0
		1/5					+2.4	+5.4	+5.8

The results are overall similar for Vindelälven and Ljusnan. A substantial positive bias is evident for precipitation in late winter and early spring (Feb-Apr), up to 75%, in both the 1/1- and the 1/3-forecasts. In the 1/5-forecasts, also the May precipitation is clearly overestimated. In July, a clear negative bias is found in all forecasts. The temperature bias is generally small in the period Jan-May, but a distinct positive bias is found in summer (Jun-Jul). Further, the forecasts become consistently warmer the closer to the spring flood period they are issued.

It may be mentioned that a new version of the ECMWF seasonal forecasting system has recently been released. A quick look data from the new system, that became available by the time of writing this report, indicated a similar precipitation bias but distinctly improved temperatures with only a small bias also in summer.

A main reason for the biases found is likely the coarse resolution of the ECMWF forecasts. It is not surprising that these large-scale average values may differ from basin-scale observations. Some form of statistical downscaling appears required to convert the raw ECMWF forecasts into input suitable for basin-scale hydrological modelling.

In addition to the bias analysis, a minor analysis was made to assess the potential gain of combining the seasonal forecast with a shorter, 15-day forecast for the first part of the period into a composite forecast. For this purpose, a sample test was made in which temperature and precipitation during May 2009 from the short-term and the seasonal forecasts were compared. The results showed that in terms of ensemble means, the difference was 1.2°C for temperature and 3 mm (corresponding to 0.2%) for precipitation. Also the maximum differences between ensemble members were small. The results indicate only a small difference between the short-term forecasts and the corresponding period in the seasonal forecasts.

Based on these results, it was decided not to pursue the development of composite forecasts. It may be remarked that the meteorological forecasts are becoming more and more 'seamless'. Instead of separate models for different time horizons, consistent systems covering all horizons are being developed and seamless forecasts are expected in a near future.

4.4.2 Probabilistic evaluation

Frequency diagrams for the IHMS and EH forecasts on 1/1, 1/3 and 1/5 are shown in Figure 6. Forecasts from both rivers were pooled in this analysis.

Looking first at the results for IHMS, it is clear that the spread in the forecast ensemble is too large. In the 1/1-forecasts, the actually observed spring flood volume ΣQ is never smaller than the 10^{th} percentile or larger than the 90^{th}. It sometimes falls within the 10-25%- and 75-90%-intervals but too seldom. Instead the actual ΣQ falls between the 25^{th} and 75^{th} percentile in more than 80% of the forecasts, in contrast to the theoretical 50%. These results indicate that when using all available historical years to generate a spring flood forecast ensemble, the ensemble becomes too wide and the percentile values will not represent the actual probabilities. For example, in the case of the IHMS forecasts on 1/1, the 75^{th} percentile does not represent a 25% probability of exceedance but rather a 10% probability.

In the 1/3- and 1/5-forecasts of IHMS the performance improves slightly and some ΣQ-observations fall outside the 10^{th} and 90^{th} percentiles, although still far too few. As mainly the median value is used for practical purposes, it may be remarked that although the spread is overestimated, generally the bias of the median is rather limited, i.e. approximately half of the ΣQ-observations fall above/below it.

The ECMWF forecasts on 1/1 have a clear positive bias. For 70% of the forecasts, the actual ΣQ falls below the median (50^{th} percentile) and an analysis of the forecasts revealed a bias of +23%. This is likely caused by the overestimated Feb-Apr precipitation in the 1/1-forecasts (section 4.4.1). A similar but less pronounced tendency is found for the 1/3-forecasts. The 1/5-forecasts have a slight positive bias but overall the distribution is rather close to the theoretical one. Thus, despite the clear positive temperature bias in the 1/5-forecasts (section 4.4.1), in a probabilistic sense the EH forecasts outperform IHMS on this forecast date. This indicates that despite the slightly higher MAE in the EH 1/5-forecasts (Table 3), the generated forecast ensemble represents the evolution during the spring flood period better than the climatology-based IHMS procedure.

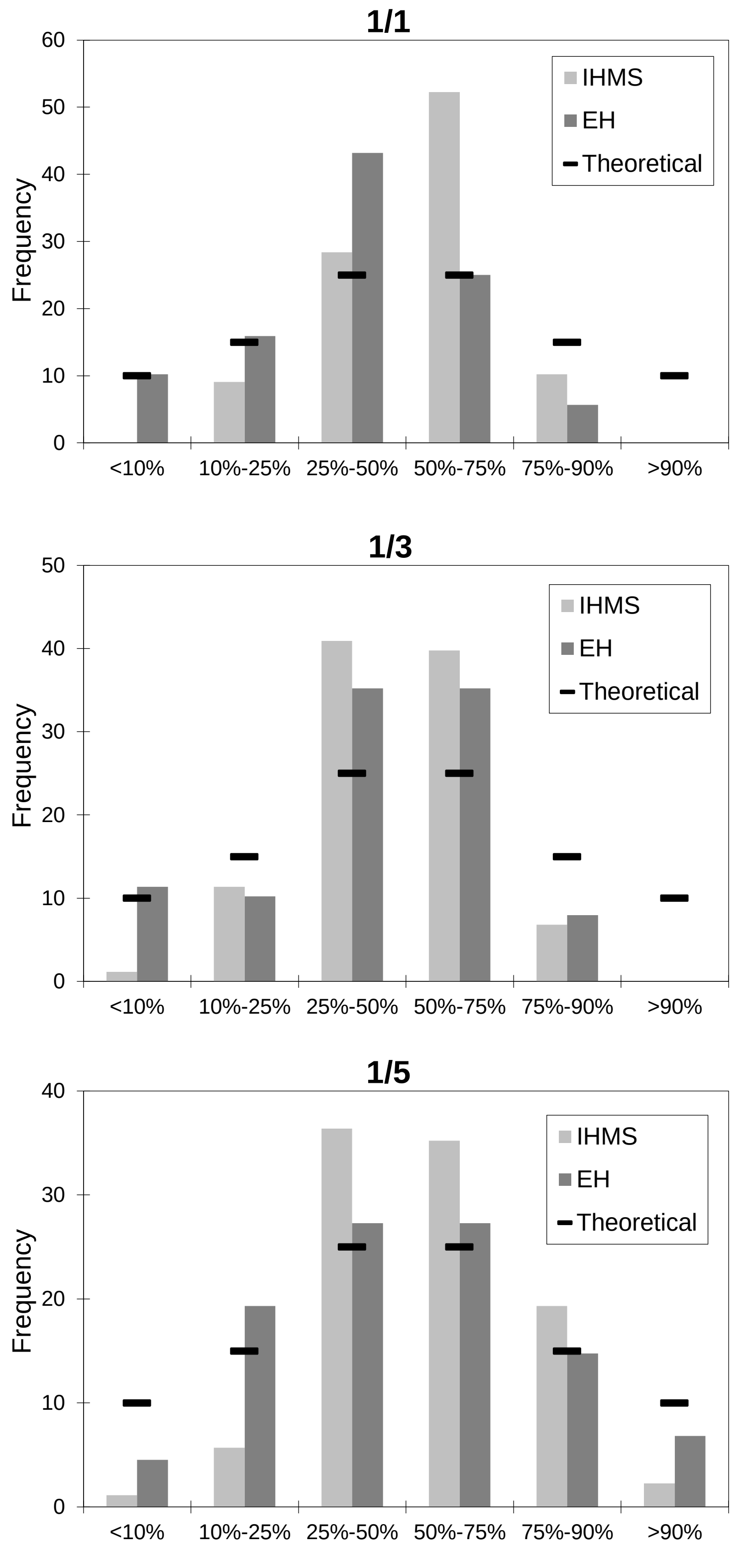


Figure 6 Frequency diagrams for the IHMS and EH forecasts on 1/1, 1/3 and 1/5.

4.5 Statistical spring flood downscaling – SD

The SD method is such that it only forecasts the accumulated volume of the spring flood; the forecasts from the SD method would be of most interest early on and of less interest the closer to the spring flood period as it does not provide information about the flood profile.

As shown in Table 3, the SD method only performs better than IHMS in a limited number of occasions, notably for the 1/1-forecasts where the SD method performs significantly better than IHMS on average for Vindelälven and Ångermanälven. The likely reason for the SD method not improving on the 1/1-forecasts for Ljusnan is that Ljusnan is located further south than the other catchments and thus the physical factors that affect the spring flood are different and thus harder to forecast with this method. Even though the SD method does sporadically perform better than IHMS for the other forecast dates (see Appendix 1), these are intermingled with forecasts where the SD method performs notably worse than IHMS.

The performance of the SD method is heavily affected by whether the climatic setups in the forecasting data were encountered in the training period dataset. If the climatic conditions are outside the scope in the training period the SD method has a tendency to make forecasts that differ drastically from the observations (see Appendix 2). This can be dealt with by either increasing the length of the training dataset or by analysing the year in question and determining if there were similar years in the training period which would give an indication as to how the method might perform.

5 Multi-model system

The definition of a multi-model system is some sort of combination of the different forecasts resulting in one single forecast. By combining the forecasts in a good way, this multi-model forecast may become more robust and reliable than any single forecast. The forecasts that make up the multi-model forecast are the accumulated volumes from each forecast simulation.

Two principal ways of combining the forecasts were investigated: (1) taking the median of all forecasts (section 5.1) and (2) applying weights to the forecasts and adding them together (section 5.2). The five forecasts considered in the multi-model approach are IHMS and the new approaches that were found most accurate (section 4.2), i.e. TCI6, CP3, EH and SD. If one of the methods had missing data, this value was replaced by the IHMS-value. Missing data appeared, for example, in the CP approach for years when the selection algorithm could nott find any analogue years.

5.1 Median multi-model

The motivation behind using the median of all forecast methods is that some of the forecasts are likely to overestimate the observed volume, while other forecasts will underestimate it. The median of the forecasts should in this case be close to the observed value. As five forecast are available, a median approach amounts to using the third value when the forecasts are ranked in decreasing (or increasing) order.

The results are presented in Table 7. Overall, the median approach worked relatively well, with an average RI of 3.6%. Interestingly, especially for the 1/1- but also for the 1/5-forecasts the performance in Ljusnan is consistently better than any single forecast (for the 1/3-forecast IHMS and EH are slightly better). This demonstrates the potential gain in combining forecasts.

Table 7 Relative improvement (RI) for the median approach. Boldface indicates better performance than IHMS.

	RI		
	1/1	1/3	1/5
V-älven	**4.9**	**3.9**	-2.7
Ljusnan	**7.9**	-4.3	**0.5**
Å-älven	**5.9**	**10.9**	**5.7**

Also for the 1/3-forecasts in Ångermanälven the median outperforms all single forecasts. Generally for Vindelälven and Ångermanälven, one of the single forecasts ouperforms the median.

It may be concluded that the potential improvement from the median multi-model approach is rather limited in size, up to ~10% compared with IHMS, but rather stable over all rivers and forecast dates.

5.2 Weighted multi-model

This approach consists of applying weights between 0 and 1 to the five different forecasts and then adding them together. The sum of all weights must be 1, and all weights must be non-negative.

The weighted volume is defined as

, where and (9)

where the index i refers to the five different forecasts.

One set of weights are chosen for each river and forecast date. The weighted volume is then calculated for the selected years and lakes, and averaged over these entries.

The objective now is to find the set of weights that gets as close to the observed volume as possible. There are several algorithms that can find a set of weights that get close to the observed volume. Two different approaches have been tested:

1. Fixed weights: apply fixed weight values to the five forecasts in line with their ranking found in the evaluation (section 4.2).
2. Optimal weights: find the best set of weights down to a certain decimal accuracy, in this case 2 decimals.

5.2.1 Fixed weights

The first step is to choose weight values. This analysis used the weight values 5/15 (0.33), 4/15 (0.27), 3/15 (0.2), 2/15 (0.13) and 1/15 (0.07) for in Ljusnan and Vindelälven with five forecasts available. As the EH-forecasts were not available in Ångermanälven, here the weight values 4/10 (0.4), 3/10 (0.3), 2/10 (0.2) and 1/10 (0.1) were used. Note that the weights add up to 1. The weights were placed based on the results shown in Table 3 – the method with the highest RI was assigned the highest weight, 5/15, the method with the second best RI was assigned the second highest weight, 4/15, and so on.

The results are presented in Table 8 below. In total the performance is rather good with an average relative improvement of almost 10%. In four out of the nine cases, the combined forecast is better than any single forecast and in four cases it is outperformed by one single forecast, but only slightly. For the 1/1-forwcast in Ångermanälven, however, the combined forecast is worse than all single forecasts.

Table 8 Weights used and performance in terms of relative improvement (RI) for the fixed weights approach. Boldface indicates better performance than IHMS.

		Weights					
		IHMS	CP	TCI	EH	SD	RI
1/1	V-älven	0.2	0.27	0.07	0.13	0.33	**19.4**
	Ljusnan	0.33	0.27	0.13	0.07	0.2	**11.6**
	Å-älven	0.2	0.3	0.1	-	0.4	-8.9
1/3	V-älven	0.27	0.33	0.2	0.07	0.13	**11.9**
	Ljusnan	0.33	0.07	0.2	0.27	0.13	-0.3
	Å-älven	0.3	0.4	0.1	-	0.2	**8.9**
1/5	V-älven	0.33	0.13	0.2	0.27	0.07	**9.7**
	Ljusnan	0.33	0.27	0.13	0.2	0.07	**4.2**
	Å-älven	0.2	0.4	0.3	-	0.1	**17.2**
						Avg	8.2

5.2.2 Optimal weights

A script was made that simply looped through all possible ways of selecting the five weights down to two decimals of accuracy. For each set of weights the script calculated the RI, and selected the set of weights that resulted in the highest RI value. In this calculation, the total period 2000-2010 was divided into one calibration period (2000-2006), which was used to optimise the weights, and one validation period (2007-2010), in which the optimised weights were only applied to generate weighted forecasts.

The results are presented in Table 9. It is clear that when optimising the weights, very good performance can be obtained in the calibration period, reaching an error reduction with up to 50% as compared with IHMS. Also for Ljusnan a substantial improvement is obtained. However, with the exception of the 1/1- and 1/5-forecasts in Ångermanälven the results in the validation period are poor. This indicates that the weights are overfitted to suit the calibration period and are not meaningfully applicable outside of it.

However, looking at the weight values may give some insight into how well the different models performed for the particular forecast. For example, for the January forecast in Vindelälven, the ECMWF forecast got a high weight, 0.81, indicating that ECMWF is good at predicting the observed volume. However, a high weight on a forecast method does not necessarily mean that this model is good at predicting the observed volume. Consider for example the situation where one forecast method always underestimates the observed volume greatly, and another method always overestimates the observed volume greatly. If one takes the mean of these two, i.e. applying the weights 0.5 to both of them, one might get the volume very close to the observed volume. Basically, when adding optimally weighted volumes the errors can cancel each other out.

Table 9 Weights used and performance in terms of relative improvement in calibration period (RIcal) and validation period (Rival) the optimal weights approach. Boldface indicates better performance than IHMS.

		Weights						
		IHMS	CP	TCI	ECMWF	SD	RIcal	RIval
1/1	V-älven	0	0.05	0	0.81	0.14	**41.4**	-25.7
	Ljusnan	0	0.49	0.51	0	0	**21.5**	-11.9
	Å-älven	0.39	0.29	0	-	0.32	**22.0**	**30.8**
1/3	V-älven	0	0.84	0	0.16	0	**47.0**	-26.2
	Ljusnan	0	0	0.31	0.66	0.03	**8.7**	-14.8
	Å-älven	0.23	0.62	0.15	-	0	**20.1**	-16.7
1/5	V-älven	0	0.26	0	0.74	0	**14.8**	-27.6
	Ljusnan	0	0	0.29	0.71	0	**16.2**	-12.8
	Å-älven	0	0.22	0.46	-	0.32	**30.0**	**27.2**
						Avg	24.6	-8.6

6 Operational aspects

One operational aspects concerns modification of IHMS/HBV to include only selecvted years in the long-term forecasts. In the current version of IHMS/HBV it is only possible to select the number of years in the ensemble. If the user selects to base the forecast on N years, the most recent N years will be chosen automatically. It is fairly simple to develop the system to enable the use of N disparate historic years, assuming that a list of the selected years is available. The list could be provided as a text file from the TCI/CP analysis, or it could be entered via the IHMS user interface.

Another aspects concerns the 'real-time' availability of the meteorological data needed. The seasonal forecast and meteorological data from the ECMWF database, that are used for the EH and SD approaches (sections 3.2 and 3.3), are updated on the 1st of each month. Thus these approaches may in principle be put into operational use directly.

The teleconnection indices from the Climate Prediction Center used in the TCI approach (section 3.1.1) are calculated using 500mb standardised geopotential height anomalies. For a certain month, the indices are calculated using the anomalies in this month, the month before and the month after (i.e. in total a 3-month period). The indices for a certain month can thus not be calculated until after the following month, which means that there is a 1-month delay in data availability. This would mean that the TCI approach used in this work would need to be modified to accommodate this delay. For example, the December indices will not be available for the 1/1-forecasts but these forecasts must be based on indices from November (calculated using anomalies in Oct-Dec), October (Sep-Nov), September (Aug-Oct), etc.

The meteorological reanalysis ERAINTERIM, used in the circulation-pattern approach CP (section 3.1.2), is updated with a 3-month delay which limits the operational implementation of this method. It needs to be investigated whether other, updated meteorological fields are available that can be used to substitute ERAINTERIM. There are further onging efforts to generate new reanalyses with a higher spatial resolution than the existing ones, which are likely to have a better representation of in particular precipitation fields.

7 Conclusions

None of the single approaches generated any clear improvement for Ljusnan, but some reduction of the forecast error seems attainable for Vindelälven and Ångermanälven. This is probably because the spring flood in the two latter rivers are more clearly related to snow melt, whereas in Ljusnan it is mixed with rain and therefore more difficult to forecast.

The largest improvement was found for the 1/1-forecasts with the SD approach, with an error reduction of ~30%. The largest improvement considering all forecast dates was found for the CP approach, with an error reduction of up to 25% and with up to ¾ of the forecasts outperforming IHMS. In total, the TCI- and EH-forecasts outperformed IHMS in almost half of the cases, but generally the MAE was larger. An analysis of the ECWMF forecasts indicated clearly overestimated precipitation in Feb-Apr and temperature in Jun-Jul, as compared with catchment observations.

Concerning the IHMS forecasts, the results showed that the share of the total MAE which is related to the meteorological input decreases from 65% in the 1/1-forecasts to 43% in the 1/5-forecasts. The spread of the IHMS climatological ensemble proved too wide, therefore the outer percentiles (e.g. 10% and 90%) do not reflect their actual probability of exceedance. The ensemble forecasts on 1/1 and 1/3 from the EH-approach were systematically overestimated, in line with the overestimated precipitation, but the frequencies of the 1/5-forecasts were close to the theoretical distribution.

Different ways to combine the forecasts in a multi-model system appear possible. One would be to simply use the best performing method for each lead time. If considering only Vindelälven and Ångermanälven, this would imply using SD for the 1/1-forecasts, CP3 for the 1/3-forecasts and IHMS (or possibly) CP3 for the 1/5-forecasts. Better performance for Ljusnan seems attainable using either a median or, in particular, a (fixed) weighted approach to combine the forecasts. This approach also generally improves the 1/5-forecasts. It is, however, at the expense of substantially lower performance of the 1/1-forecasts in Vindelälven and Ångermanälven.

Generally there is a need for future studies to increase the understanding of the hydro-meteorological processes involved. This study has revealed interesting and useful relationships but more in-depth investigations are required to better unterstand, describe and generalise the different temporal and regional dependencies. Concerning the methods used, further improvement may be possible e.g. by using an optimal CP classification, tuned to regions and data sources, and by statistically downscaling the ECMWF forecasts to catchment scale.

References

Bárdossy, A., Stehlík, J., Caspary, H. (2002) Automated objective classification of daily circulation patterns for precipitation and temperature downscaling based on optimized fuzzy rules, *Climate Research* 23:11–22.

Barnston, G., Livezey, R.E (1987) Classification, seasonality and low-frequency atmospheric circulation patterns, *Monthly Weather Review* 115:1083-1126.

Barry, R. G., Perry, A. H., (1973) *Synoptic climatology, methods and applications*, Methuen, London, UK.

Bergström, S., (1976) *Development and application of a conceptual runoff model for Scandinavian catchments*, SMHI Reports RHO, No. 7, Norrköping.

Carlsson, B., Lindström, G. (2001) *HBV-modellen och flödesprognoser*, SMHI Reports Hydrology No. 85 (in Swedish).

Carlsson, B., Sjögren, J. (2003) *Uppdatering och hydrologiska långtidsprognoser — en jämförelse mellan olika metoder*, Report No. 43, SMHI, Norrköping (in Swedish).

Cheng, X., Dunkerton, T.J. (1995) Orthogonal rotation of spatial patterns derived from singular value decomposition analysis, *Journal of Climate* 8:2631-2643.

Engström, J. (2011) *The effect of Northern Hemisphere teleconnections on the hydropower production in southern Sweden*, Master Thesis at Department of Earth and Ecosystem Sciences, Physical Geography and Ecosystems Analysis, Lund University.

Foster, K.L., Uvo, C.B. (2010) Seasonal streamflow forecast: a GCM multi-model downscaling approach, *Hydrology Research* 41:503-507.

Goddard, L., Mason, S.J., Zebiak, S.E., Ropelewski, C.F, Basher, R., Cane, M.A. (2001) Current approaches to seasonal-to-interannual climate predictions, *International Journal of Climatology* 21:1111–1152.

Hay, L., McCabe, G., Wolock, D., Ayers, M. (1991) Simulation of precipitation by weather type analysis, *Water Resource Research*, 27:493–501.

Johnson, S. (1967) Hierarchical clustering schemes, *Psychometrika* 32:141–154.

Jónsdóttir, J. F., Uvo, C.B (2009) Long term variability in Icelandic hydrological series and its relation to variability in atmospheric circulation over the North Atlantic Ocean, *International Journal of Climatology*, 29:1369-1380.

Kysel, J., Huth, R. (2003) Recent changes in atmospheric circulation over europe detected by objective and subjective methods, *Americal Meteorological Society*, page 31.

Landman, W.A., Mason, S.J., Tyson, P.D., Tennant, W.J. (2001) Statistical downscaling of GCM simulations to Streamflow, *Journal of Hydrology* 252:221-236.

Lindström, G., Johansson, B., Persson, M., Gardelin, M., Bergström, S., (1997) Development and test of the distributed HBV-96 hydrological model, *Journal of Hydrology* 201:272–288.

MacQueen, J. (1967) Some methods for classification and analysis of multivariate observations, In: *Proceedings of 5th Berkeley Symposium on Mathematical Statistics and Probability Berkeley*, pages 281–297.

Persson, A. (2001) *User guide to ECMWF forecast products*, Meteorological Bulletin M3.2, ECMWF.

Troccoli, A. (2010) Review of easonal climate forecast, *Meteorological Applications* 17:251–268, DOI: 10.1002/met.184.

Uvo, C.B. (2003) Analysis and Regionalization of Northern European Winter Precipitation based on its Relationship with the North Atlantic Oscillation, *International Journal of Climatology*, 23:1185–1194.

Wetterhall, F., Bárdossy, A., Chen, D., Halldin, S., Xu, C. (2006) Daily precipitation-downscaling techniques in three Chinese regions, *Water Resources Research* 42:W11423.

Wilby, R., Wigley, T. (1994) Stochastic weather type simulation for regional climate change impact assessment, *Water Resources Research*, 30:3395–3403.

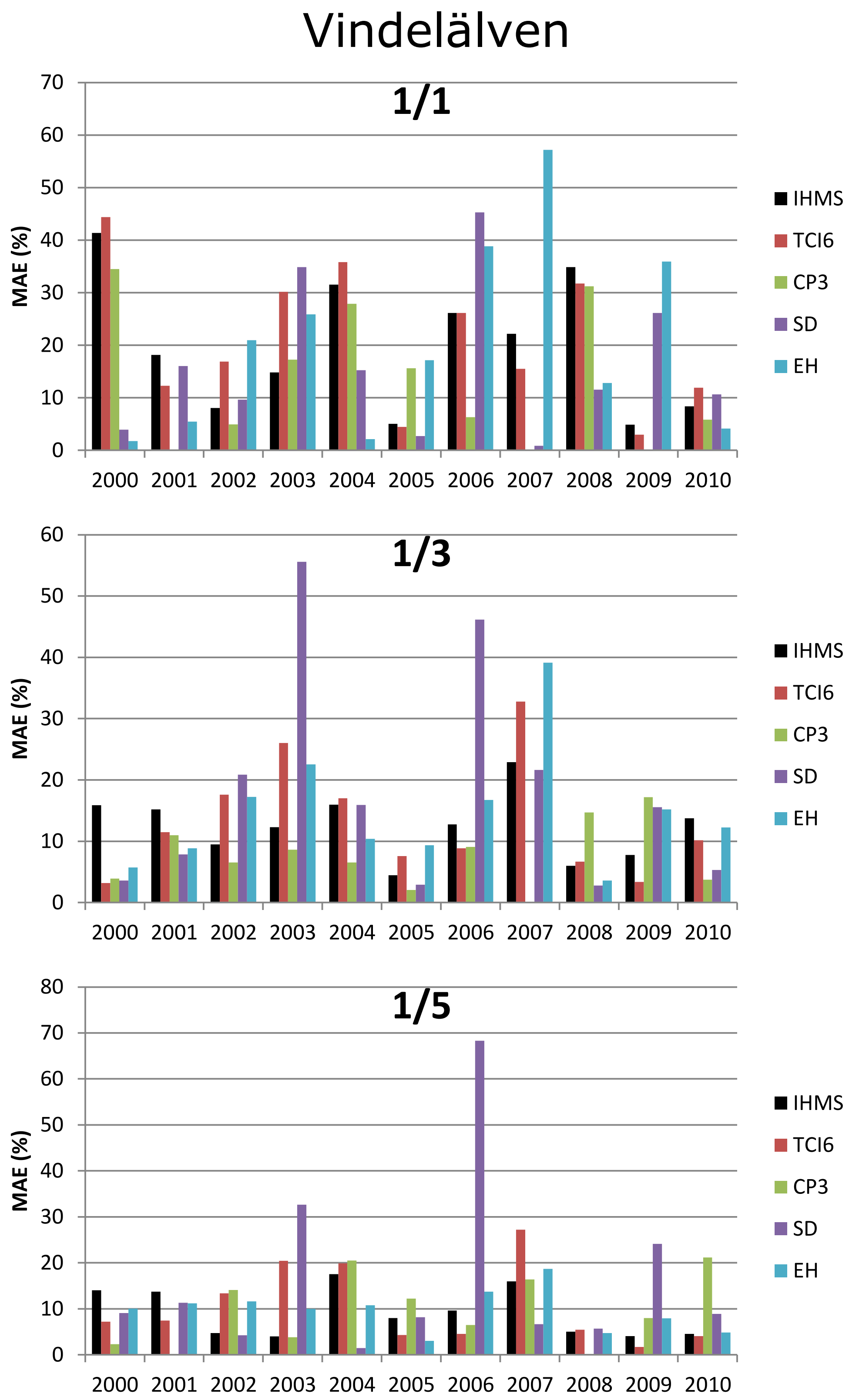
Yang, W., Bárdossy, A., Caspary, H.-J. (2010) Downscaling daily precipitation time series using a combined circulation- and regression-based approach, *Theoretical and Applied Climatology* 102:439-454, DOI: 10.1007/s00704-010-0272-0.

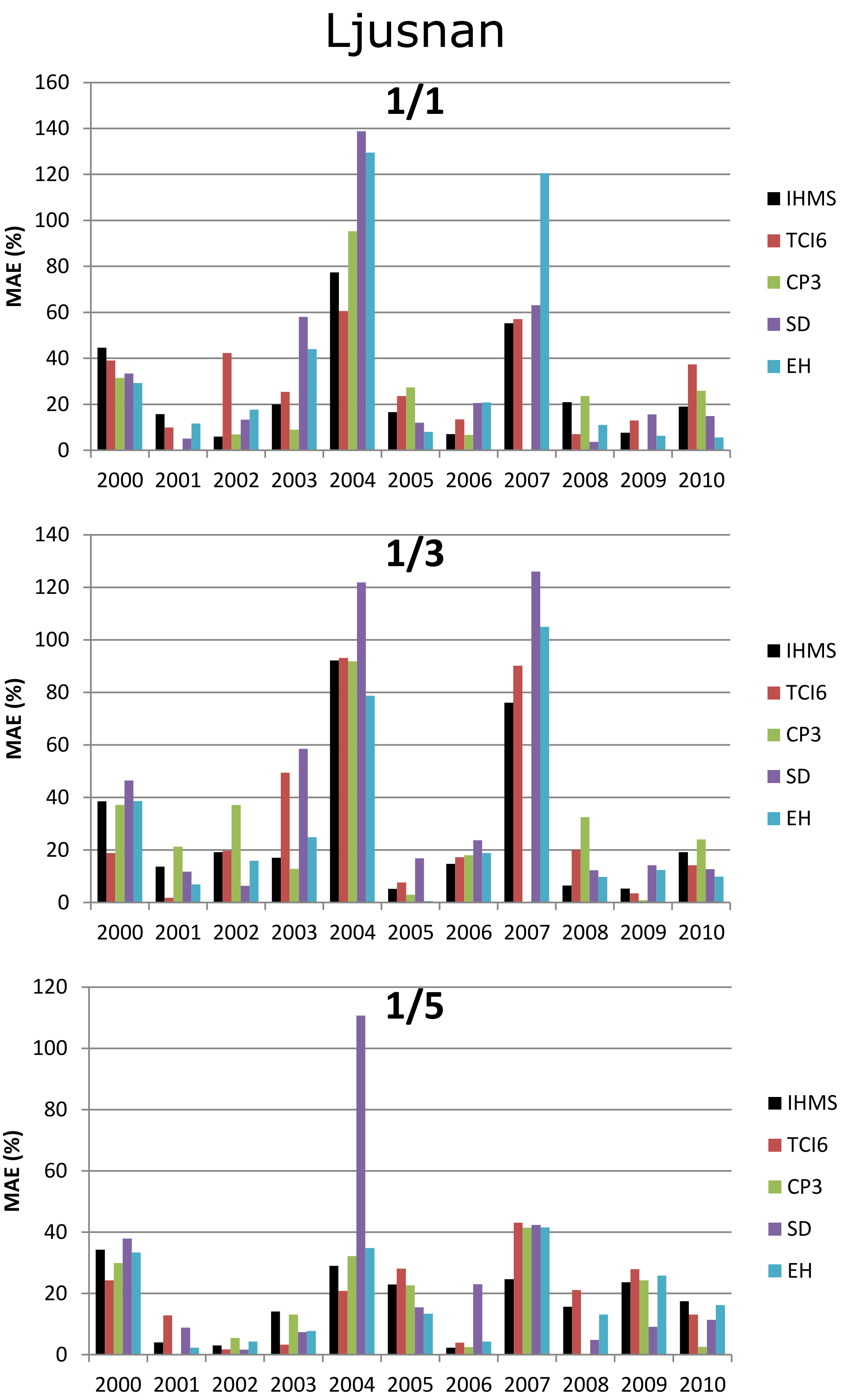
Yarnal, B. (1984) A procedure for the classification of synoptic weather maps from gridded atmospheric pressure data, *Computer Geoscience* 10:397–410.

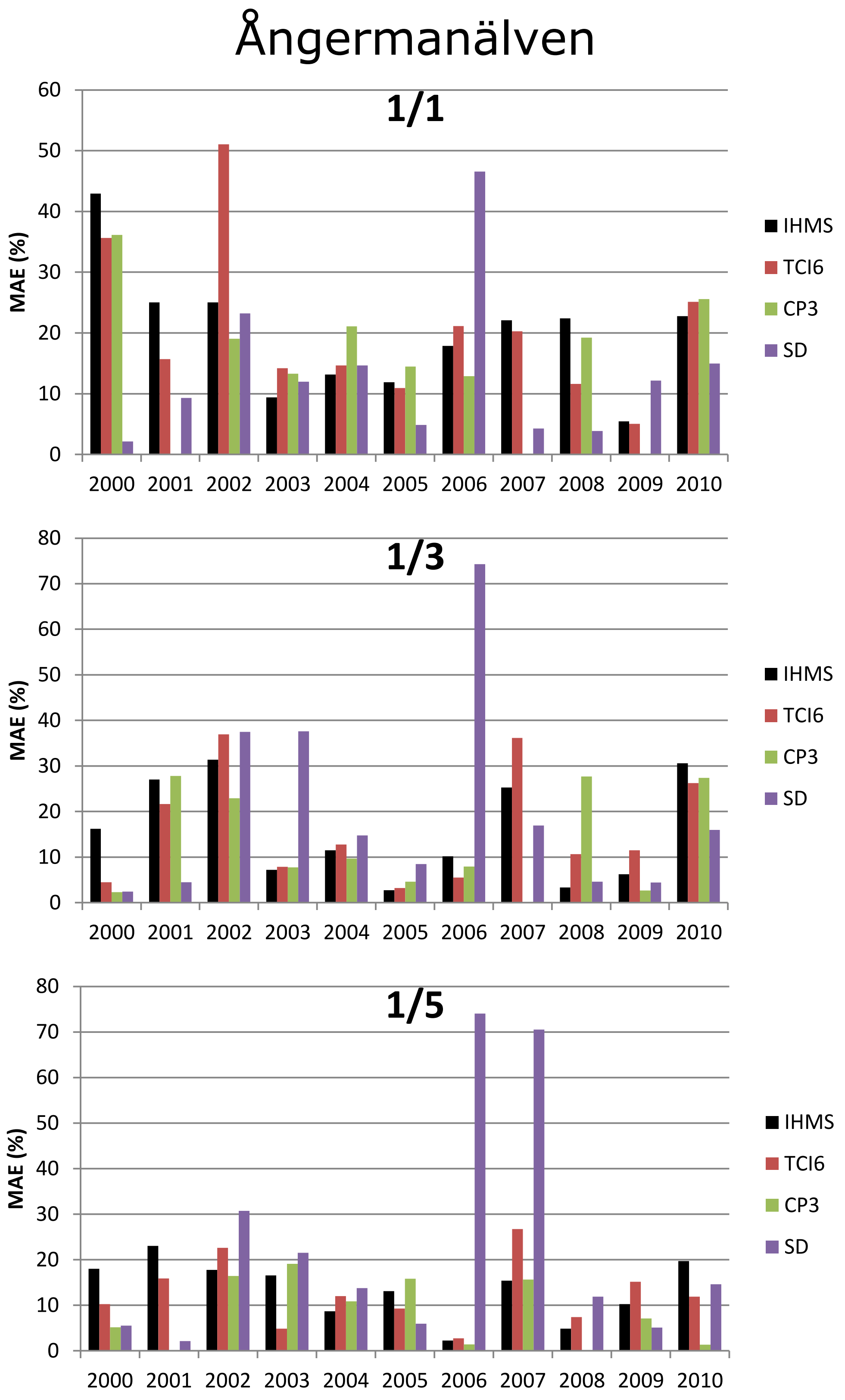
Zadeh, L. (1965) Fuzzy sets, *Information and Control* 8:338–353.

Appendix 1

Time series plots of MAE for each method, forecast date and river (averaged over the two stations used).


Vindelälven
1/1
MAE (%)
70
60
50
40
30
20
10
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
IHMS
TCI6
CP3
SD
EH
1/3
MAE (%)
60
50
40
30
20
10
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
IHMS
TCI6
CP3
SD
EH
1/5
MAE (%)
80
70
60
50
40
30
20
10
0
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
IHMS
TCI6
CP3
SD
EH


Ljusnan
1/1
1/3
1/5
MAE (%)
IHMS
TCI6
CP3
SD
EH
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010


Ångermanälven
1/1
MAE (%)
0
10
20
30
40
50
60
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
IHMS
TCI6
CP3
SD
1/3
MAE (%)
0
10
20
30
40
50
60
70
80
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
IHMS
TCI6
CP3
SD
1/5
MAE (%)
0
10
20
30
40
50
60
70
80
2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
IHMS
TCI6
CP3
SD

Appendix 2

Tables with observed and forecasted values of ΣQ (m^3*10^6) for the different methods, rivers and forecast dates. The number in parahtheses after the TCI and CP forecasts indicate the number of analogue years found.

TCI forecasts 1(6)

Observations and forecasts in Sorsele issued 1/1 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	2630	1470	**1602** (2)	**1740** (4)	1379 (7)	1280 (3)	1233 (1)	1402 (3)
2001	2721	2243	**2459** (1)	**2459** (1)	3710 (1)	**2357** (5)	**2347** (9)	**2396** (6)
2002	2262	2316	2657 (1)	2358 (9)	**2215** (4)	2426 (1)	2423 (10)	2426 (1)
2003	1739	1967	2112 (2)	2168 (4)	2215 (3)	3401 (1)	2226 (4)	2249 (1)
2004	2748	1818	1543 (11)	1803 (10)	1783 (10)	**1887** (12)	**1899** (11)	1736 (13)
2005	2438	2301	**2484** (9)	2154 (3)	**2314** (7)	**2374** (9)	2629 (2)	**2341** (14)
2006	1607	2034	**1765** (1)	2165 (2)	2234 (2)	2054 (3)	2068 (12)	2049 (15)
2007	2489	2851	3074 (8)	3730 (1)	3033 (14)	2918 (2)	3241 (2)	**2810** (6)
2008	2356	1446	1290 (12)	1401 (11)	1431 (11)	**1536** (4)	1300 (3)	**1518** (4)
2009	1968	2047	1760 (3)	**2016** (12)	2123 (12)	2106 (13)	**2016** (13)	**2035** (16)
2010	2361	2114	**2495** (1)	**2172** (6)	2639 (4)	2749 (2)	**2177** (10)	**2137** (1)

Observations and forecasts in Sorsele issued 1/3 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	2630	2212	**2750** (1)	**2669** (2)	**2444** (3)	**2367** (1)	1740 (2)	**2669** (2)
2001	2721	2307	**2580** (1)	**2319** (12)	3205 (1)	3205 (1)	**2459** (5)	**2437** (9)
2002	2262	2398	2491 (10)	2571 (2)	2600 (1)	2564 (8)	**2358** (6)	2575 (10)
2003	1739	1914	2156 (2)	2000 (13)	2610 (2)	2610 (2)	2168 (1)	2150 (4)
2004	2748	2251	**2393** (3)	**2634** (3)	**2272** (15)	**2266** (14)	1803 (15)	**2256** (13)
2005	2438	2498	2940 (2)	**2463** (2)	2515 (16)	2516 (15)	2154 (1)	2633 (3)
2006	1607	1821	1823 (2)	1832 (3)	1856 (17)	**1808** (16)	2165 (16)	**1771** (14)
2007	2489	2825	2861 (3)	3269 (4)	3509 (3)	3509 (3)	3730 (2)	3030 (5)
2008	2356	2133	2655 (2)	2459 (2)	**2142** (18)	2105 (17)	1401 (17)	**2180** (3)
2009	1968	2082	2386 (3)	2344 (2)	2090 (19)	**2070** (18)	**2016** (18)	**2010** (16)
2010	2361	1937	**2017** (3)	**1945** (10)	**2343** (1)	**2343** (1)	**2172** (1)	**2071** (10)

Observations and forecasts in Sorsele issued 1/5 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	2630	2299	**2684** (1)	**2473** (2)	2258 (3)	2103 (1)	**2519** (2)	**2473** (2)
2001	2721	2318	**2567** (1)	**2365** (12)	**3104** (1)	**3104** (1)	**2622** (5)	**2505** (9)
2002	2262	2372	2479 (10)	**2283** (2)	2423 (1)	2431 (7)	2506 (6)	2569 (10)
2003	1739	1875	2062 (2)	1975 (13)	2500 (2)	2500 (2)	2605 (1)	2173 (4)
2004	2748	2283	2429 (3)	**2621** (3)	2251 (15)	**2304** (14)	**2313** (15)	2223 (13)
2005	2438	2276	2668 (2)	2265 (2)	2249 (16)	**2288** (15)	1880 (1)	**2407** (3)
2006	1607	1753	**1696** (2)	1840 (3)	**1738** (17)	**1751** (16)	1762 (16)	**1668** (14)
2007	2489	2837	**2712** (3)	3145 (4)	3431 (3)	3431 (3)	3194 (2)	3112 (5)
2008	2356	2207	2625 (2)	**2356** (2)	2178 (18)	2172 (17)	**2228** (17)	**2234** (3)
2009	1968	2018	2128 (3)	2209 (2)	**1992** (19)	2022 (18)	2037 (18)	1901 (15)
2010	2361	2162	**2266** (3)	**2235** (10)	**2462** (1)	**2462** (1)	**2462** (1)	**2346** (10)

TCI forecasts 2(6)

Observations and forecasts in Vindeln issued 1/1 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	3692	2266	**2308** (2)	**2588** (4)	2092 (7)	1990 (3)	1896 (1)	2138 (3)
2001	4138	3362	**3739** (1)	**3739** (1)	5382 (1)	**3428** (5)	**3493** (9)	**3617** (6)
2002	2949	3355	3654 (1)	**3322** (9)	**3065** (4)	3730 (1)	3398 (10)	3730 (1)
2003	2323	2707	2743 (2)	3071 (4)	3114 (3)	4675 (1)	2964 (4)	3044 (1)
2004	3633	2573	2272 (11)	2528 (10)	2502 (10)	**2628** (12)	2529 (11)	2368 (13)
2005	3295	3148	**3375** (9)	2819 (3)	**3173** (7)	**3273** (9)	3580 (2)	3132 (14)
2006	2264	2847	**2377** (1)	2983 (2)	2898 (2)	**2725** (3)	**2834** (12)	**2825** (15)
2007	3148	4086	4301 (8)	4727 (1)	4119 (14)	4086 (2)	4819 (2)	**3718** (6)
2008	3391	2337	2076 (12)	2241 (11)	2209 (11)	**2542** (4)	2280 (3)	**2443** (4)
2009	2814	2975	2344 (3)	**2869** (12)	3105 (12)	3099 (13)	**2848** (13)	**2886** (16)
2010	3317	3110	4033 (1)	**3342** (6)	4010 (4)	3876 (2)	3107 (10)	2841 (1)

Observations and forecasts in Vindeln issued 1/3 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	3692	3105	**3477** (1)	**3872** (2)	**3508** (3)	**3477** (1)	2588 (2)	**3872** (2)
2001	4138	3511	**3690** (1)	**3523** (12)	4706 (1)	4706 (1)	**3739** (5)	**3620** (9)
2002	2949	3332	3374 (10)	**3324** (2)	**3160** (1)	3542 (8)	**3322** (6)	3580 (10)
2003	2323	2662	2947 (2)	2783 (13)	3652 (2)	3652 (2)	3071 (1)	2985 (4)
2004	3633	3129	3021 (3)	**3685** (3)	**3182** (15)	**3153** (14)	2528 (15)	3048 (13)
2005	3295	3506	4081 (2)	**3317** (2)	3534 (16)	3514 (15)	2819 (1)	3532 (3)
2006	2264	2540	**2475** (2)	**2444** (3)	2569 (17)	**2511** (16)	2983 (16)	**2435** (14)
2007	3148	4167	4184 (3)	4730 (4)	5092 (3)	5092 (3)	4727 (2)	4529 (5)
2008	3391	3304	3907 (2)	3631 (2)	**3316** (18)	3199 (17)	2241 (17)	3588 (3)
2009	2814	3088	3430 (3)	3391 (2)	3099 (19)	**3027** (18)	**2869** (18)	**2943** (16)
2010	3317	3000	**3241** (3)	2961 (10)	3636 (1)	3636 (1)	**3342** (1)	**3049** (10)

Observations and forecasts in Vindeln issued 1/5 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	3692	3118	**3512** (1)	**3379** (2)	**3133** (3)	2885 (1)	**3394** (2)	**3379** (2)
2001	4138	3612	**3826** (1)	**3652** (12)	**4680** (1)	**4680** (1)	**3994** (5)	**3849** (9)
2002	2949	3084	3150 (10)	**2959** (2)	3098 (1)	3181 (7)	3267 (6)	3337 (10)
2003	2323	2318	2522 (2)	2403 (13)	3198 (2)	3198 (2)	3307 (1)	2694 (4)
2004	3633	2971	**3046** (3)	**3395** (3)	2952 (15)	**2982** (14)	**3011** (15)	2880 (13)
2005	3295	2985	**3520** (2)	2888 (2)	2960 (16)	**2992** (15)	2385 (1)	**3054** (3)
2006	2264	2496	**2370** (2)	2550 (3)	**2487** (17)	2498 (16)	2505 (16)	**2383** (14)
2007	3148	3716	**3570** (3)	4147 (4)	4608 (3)	4608 (3)	4231 (2)	4074 (5)
2008	3391	3516	4100 (2)	3690 (2)	**3479** (18)	**3451** (17)	**3488** (17)	3582 (3)
2009	2814	2969	3036 (3)	3182 (2)	**2943** (19)	**2957** (18)	**2963** (18)	**2814** (15)
2010	3317	3336	3530 (3)	3420 (10)	3711 (1)	3711 (1)	3711 (1)	3565 (10)

TCI forecasts 3(6)

Observations and forecasts in Svegsjön issued 1/1 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	2426	1318	**1392** (2)	**1645** (4)	**1462** (7)	**1532** (3)	**1563** (1)	**1454** (3)
2001	1984	1668	**1895** (1)	**1895** (1)	2341 (1)	**2099** (5)	**1833** (9)	**2117** (6)
2002	1552	1608	1382 (1)	1482 (9)	1230 (4)	2133 (1)	1332 (10)	2133 (1)
2003	1330	1602	**1483** (2)	2188 (4)	1770 (3)	2307 (1)	1851 (4)	1684 (1)
2004	796	1360	1455 (11)	**1340** (10)	**1322** (10)	**1360** (12)	**1201** (11)	**1243** (13)
2005	1758	1512	1485 (9)	1270 (3)	**1539** (7)	**1682** (9)	**1898** (2)	1401 (14)
2006	1517	1459	897 (1)	1832 (2)	1741 (2)	1949 (3)	1188 (12)	1369 (15)
2007	1085	1605	**1587** (8)	**1092** (1)	**1588** (14)	1895 (2)	1953 (2)	1639 (6)
2008	1973	1453	**1496** (12)	1448 (11)	1369 (11)	**1794** (4)	**1965** (3)	**1792** (4)
2009	1660	1522	1219 (3)	1396 (12)	1473 (12)	1463 (13)	1262 (13)	1425 (16)
2010	2156	1747	**2519** (1)	**2066** (6)	**2175** (4)	**1986** (2)	**1801** (10)	1422 (1)

Observations and forecasts in Svegsjön issued 1/3 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	2426	1533	1419 (1)	**1939** (2)	**1756** (3)	1350 (1)	**1645** (2)	**1939** (2)
2001	1984	1695	**2194** (1)	**1945** (12)	2435 (1)	2435 (1)	**1895** (5)	**1978** (9)
2002	1552	1786	1869 (10)	**1688** (2)	1122 (1)	1969 (8)	**1482** (6)	1793 (10)
2003	1330	1558	1928 (2)	1829 (13)	2179 (2)	2179 (2)	2188 (1)	1983 (4)
2004	796	1510	**1088** (3)	1911 (3)	1643 (15)	**1436** (14)	**1340** (15)	**1505** (13)
2005	1758	1732	2260 (2)	1463 (2)	1876 (16)	1637 (15)	1270 (1)	**1734** (3)
2006	1517	1353	1181 (2)	1162 (3)	**1432** (17)	1255 (16)	1832 (16)	1308 (14)
2007	1085	1822	**1594** (3)	1939 (4)	2209 (3)	2209 (3)	**1092** (2)	1948 (5)
2008	1973	1985	2350 (2)	1803 (2)	2118 (18)	1866 (17)	1448 (17)	2195 (3)
2009	1660	1724	2206 (3)	1919 (2)	1844 (19)	**1639** (18)	1396 (18)	**1672** (16)
2010	2156	1713	**1808** (3)	1510 (10)	**2305** (1)	**2305** (1)	**2066** (1)	**1811** (10)

Observations and forecasts in Svegsjön issued 1/5 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	2426	1626	**1859** (1)	**1852** (2)	**1743** (3)	1500 (1)	**1808** (2)	**1852** (2)
2001	1984	2013	2330 (1)	2104 (12)	2545 (1)	2545 (1)	2163 (5)	2169 (9)
2002	1552	1494	**1528** (10)	1626 (2)	1409 (1)	**1568** (7)	1614 (6)	**1562** (10)
2003	1330	1162	**1214** (2)	**1216** (13)	**1469** (2)	**1469** (2)	1655 (1)	**1386** (4)
2004	796	1022	1040 (3)	1092 (3)	**1020** (15)	**974** (14)	**1017** (15)	**956** (13)
2005	1758	1457	**1662** (2)	1431 (2)	**1458** (16)	1404 (15)	1185 (1)	1380 (3)
2006	1517	1582	1414 (2)	**1553** (3)	1607 (17)	**1523** (16)	**1552** (16)	**1481** (14)
2007	1085	1338	**1175** (3)	**1296** (4)	1524 (3)	1524 (3)	1667 (2)	1520 (5)
2008	1973	2152	2589 (2)	2322 (2)	2162 (18)	**2053** (17)	**2082** (17)	2237 (3)
2009	1660	1262	**1355** (3)	**1346** (2)	**1267** (19)	1240 (18)	1257 (18)	1187 (15)
2010	2156	1755	**1852** (3)	1712 (10)	**1875** (1)	**1875** (1)	**1875** (1)	**1862** (10)

TCI forecasts 4(6)

Observations and forecasts in Dönje issued 1/1 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	3510	1980	**1996** (2)	**2454** (4)	**2154** (7)	**2406** (3)	**2331** (1)	**2172** (3)
2001	2755	2325	**2594** (1)	**2594** (1)	3326 (1)	**2937** (5)	**2539** (9)	**3120** (6)
2002	2107	2283	**2065** (1)	**2070** (9)	1726 (4)	3104 (1)	1846 (10)	3104 (1)
2003	1865	2227	**2073** (2)	3125 (4)	2541 (3)	3305 (1)	2521 (4)	2318 (1)
2004	1110	2040	2289 (11)	2129 (10)	2075 (10)	2084 (12)	**1841** (11)	**1833** (13)
2005	2558	2066	2037 (9)	1757 (3)	**2141** (7)	**2323** (9)	**2721** (2)	1868 (14)
2006	2239	2007	1287 (1)	2549 (2)	2519 (2)	2773 (3)	1611 (12)	1853 (15)
2007	1343	2182	**2132** (8)	**1370** (1)	**2149** (14)	2540 (2)	2616 (2)	2190 (6)
2008	2558	2161	**2305** (12)	**2242** (11)	**2186** (11)	**2718** (4)	**2942** (3)	**2680** (4)
2009	2363	2200	1816 (3)	1981 (12)	2131 (12)	2151 (13)	1803 (13)	2087 (16)
2010	3021	2444	3852 (1)	**3059** (6)	**3149** (4)	**2844** (2)	**2483** (10)	1791 (1)

Observations and forecasts in Dönje issued 1/3 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	3510	2096	1815 (1)	**2890** (2)	**2398** (3)	1949 (1)	**2454** (2)	**2890** (2)
2001	2755	2404	3262 (1)	**2813** (12)	3524 (1)	3524 (1)	**2594** (5)	**2847** (9)
2002	2107	2598	2738 (10)	**2233** (2)	1451 (1)	2702 (8)	**2070** (6)	2612 (10)
2003	1865	2182	2760 (2)	2572 (13)	3062 (2)	3062 (2)	3125 (1)	2795 (4)
2004	1110	2160	**1431** (3)	2746 (3)	2415 (15)	**2058** (14)	**2129** (15)	2188 (13)
2005	2558	2330	3115 (2)	1869 (2)	**2543** (16)	2162 (15)	1757 (1)	2202 (3)
2006	2239	1823	1614 (2)	1536 (3)	**1981** (17)	1695 (16)	**2549** (16)	1775 (14)
2007	1343	2472	**2164** (3)	2640 (4)	3010 (3)	3010 (3)	**1370** (2)	2693 (5)
2008	2558	2872	3458 (2)	**2553** (2)	3117 (18)	**2730** (17)	2242 (17)	3297 (3)
2009	2363	2522	3226 (3)	2735 (2)	2743 (19)	**2422** (18)	1981 (18)	**2512** (16)
2010	3021	2483	**2681** (3)	2159 (10)	**3530** (1)	**3530** (1)	**3059** (1)	**2646** (10)

Observations and forecasts in Dönje issued 1/5 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	3510	2262	**2600** (1)	**2636** (2)	**2411** (3)	2079 (1)	**2461** (2)	**2636** (2)
2001	2755	2935	3585 (1)	3016 (12)	3784 (1)	3784 (1)	3177 (5)	3206 (9)
2002	2107	2060	**2104** (10)	2193 (2)	1893 (1)	**2126** (7)	2219 (6)	2168 (10)
2003	1865	1575	**1659** (2)	**1636** (13)	**2016** (2)	**2016** (2)	2372 (1)	**1908** (4)
2004	1110	1438	**1390** (3)	1565 (3)	**1434** (15)	**1392** (14)	**1417** (15)	**1349** (13)
2005	2558	1824	**2174** (2)	1728 (2)	**1830** (16)	1758 (15)	1422 (1)	1671 (3)
2006	2239	2233	1973 (2)	2188 (3)	**2289** (17)	2196 (16)	2178 (16)	2114 (14)
2007	1343	1692	**1459** (3)	**1644** (4)	1939 (3)	1939 (3)	2211 (2)	1961 (5)
2008	2558	3128	3892 (2)	3443 (2)	3162 (18)	**3055** (17)	**3051** (17)	3294 (3)
2009	2363	1812	**1859** (3)	**1842** (2)	**1834** (19)	1787 (18)	1782 (18)	1718 (15)
2010	3021	2527	**2708** (3)	2463 (10)	**2688** (1)	**2688** (1)	**2688** (1)	**2639** (10)

TCI forecasts 5(6)

Observations and forecasts in Kultsjön issued 1/1 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	1064	565	**651** (2)	**771** (4)	**596** (7)	**638** (3)	**630** (1)	**626** (3)
2001	986	710	**879** (1)	**879** (1)	1247 (1)	**794** (5)	**777** (9)	**790** (6)
2002	896	914	963 (1)	918 (9)	**873** (4)	1142 (1)	967 (10)	1142 (1)
2003	812	716	**756** (2)	**847** (4)	**897** (3)	1266 (1)	**901** (4)	918 (1)
2004	903	706	634 (11)	**752** (10)	694 (10)	**733** (12)	**764** (11)	669 (13)
2005	1038	927	**1010** (9)	862 (3)	901 (7)	**978** (9)	**1115** (2)	**937** (14)
2006	543	678	618 (1)	811 (2)	769 (2)	728 (3)	685 (12)	693 (15)
2007	986	1014	1072 (8)	1383 (1)	1116 (14)	1135 (2)	1202 (2)	1058 (6)
2008	817	588	534 (12)	**601** (11)	553 (11)	**676** (4)	581 (3)	**646** (4)
2009	803	744	703 (3)	738 (12)	742 (12)	725 (13)	728 (13)	738 (16)
2010	865	688	**787** (1)	**740** (6)	**852** (4)	**983** (2)	**747** (10)	**741** (1)

Observations and forecasts in Kultsjön issued 1/3 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	1064	880	**1110** (1)	**1029** (2)	**947** (3)	**905** (1)	771 (2)	**1029** (2)
2001	986	677	**793** (1)	**708** (12)	**919** (1)	**919** (1)	**879** (5)	**712** (9)
2002	896	983	1029 (10)	1107 (2)	1089 (1)	1017 (8)	**918** (6)	1037 (10)
2003	812	716	**818** (2)	**763** (13)	983 (2)	983 (2)	**847** (1)	**829** (4)
2004	903	798	**872** (3)	**882** (3)	**825** (15)	**806** (14)	752 (15)	776 (13)
2005	1038	1018	1227 (2)	1015 (2)	**1032** (16)	1018 (15)	862 (1)	1065 (3)
2006	543	629	**627** (2)	**599** (3)	647 (17)	**625** (16)	811 (16)	**593** (14)
2007	986	1013	1035 (3)	1104 (4)	1187 (3)	1187 (3)	1383 (2)	1096 (5)
2008	817	819	1029 (2)	934 (2)	829 (18)	800 (17)	601 (17)	884 (3)
2009	803	731	883 (3)	**855** (2)	**747** (19)	710 (18)	**738** (18)	667 (16)
2010	865	608	**655** (3)	600 (10)	**714** (1)	**714** (1)	**740** (1)	**657** (10)

Observations and forecasts in Kultsjön issued 1/5 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	1064	907	**1026** (1)	**992** (2)	905 (3)	875 (1)	**982** (2)	**992** (2)
2001	986	703	**791** (1)	**742** (12)	**917** (1)	**917** (1)	**847** (5)	**766** (9)
2002	896	964	1013 (10)	**939** (2)	**941** (1)	968 (7)	980 (6)	1002 (10)
2003	812	713	**803** (2)	**759** (13)	945 (2)	945 (2)	926 (1)	**829** (4)
2004	903	820	**866** (3)	**938** (3)	**831** (15)	**821** (14)	**824** (15)	792 (13)
2005	1038	948	**1125** (2)	**997** (2)	**952** (16)	931 (15)	926 (1)	**1021** (3)
2006	543	565	**562** (2)	611 (3)	568 (17)	**562** (16)	570 (16)	**531** (14)
2007	986	1026	**994** (3)	1093 (4)	1173 (3)	1173 (3)	1154 (2)	1110 (5)
2008	817	818	955 (2)	854 (2)	823 (18)	800 (17)	808 (17)	854 (3)
2009	803	723	**813** (3)	**838** (2)	722 (19)	700 (18)	706 (18)	671 (15)
2010	865	692	**748** (3)	**693** (10)	**810** (1)	**810** (1)	**810** (1)	**776** (10)

TCI forecasts 6(6)

Observations and forecasts in Sollefteå issued 1/1 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	9978	6082	**6949** (2)	**8435** (4)	**6914** (7)	**6748** (3)	**6716** (1)	**6970** (3)
2001	9649	7520	**8286** (1)	**8286** (1)	12141 (1)	**8469** (5)	**8080** (9)	**8539** (6)
2002	5981	8854	9008 (1)	**8503** (9)	**8081** (4)	10446 (1)	**8689** (10)	10446 (1)
2003	7014	6524	5976 (2)	7798 (4)	7516 (3)	11188 (1)	7949 (4)	8095 (1)
2004	7040	7351	**7155** (11)	**7209** (10)	**6983** (10)	**7140** (12)	**7207** (11)	**7275** (13)
2005	9457	8225	**8553** (9)	7355 (3)	7889 (7)	**8601** (9)	**9642** (2)	**8311** (14)
2006	5902	6540	5175 (1)	7794 (2)	7179 (2)	7218 (3)	**6164** (12)	6769 (15)
2007	7519	10.6*	10.7* (8)	11.1* (1)	10.9* (14)	**10.4*** (2)	12.4* (2)	**10.0*** (6)
2008	7538	6270	5975 (12)	5956 (11)	5852 (11)	**7854** (4)	**7916** (3)	**7368** (4)
2009	7546	7276	5628 (3)	6560 (12)	7146 (12)	7201 (13)	6686 (13)	**7398** (16)
2010	9232	6925	**8739** (1)	**7647** (6)	**8781** (4)	**9086** (2)	**7279** (10)	5917 (1)

Observations and forecasts in Sollefteå issued 1/3 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	9978	8465	**9439** (1)	**10553** (2)	**9940** (3)	**8970** (1)	8435 (2)	**10553** (2)
2001	9649	7451	**8192** (1)	**7692** (12)	**9620** (1)	**9620** (1)	**8286** (5)	**8147** (9)
2002	5981	9153	9314 (10)	9380 (2)	**7683** (1)	9442 (8)	**8503 (6)**	9463 (10)
2003	7014	6839	8036 (2)	7162 (13)	9274 (2)	9274 (2)	7798 (1)	7971 (4)
2004	7040	7839	**7491** (3)	9296 (3)	8436 (15)	**7722** (14)	**7209** (15)	7840 (13)
2005	9457	9119	10921 (2)	8576 (2)	**9579** (16)	8835 (15)	7355 (1)	9098 (3)
2006	5902	6167	**5729** (2)	**5705** (3)	6623 (17)	**6067** (16)	7794 (16)	**6011** (14)
2007	7519	11121	**10903** (3)	11939 (4)	12903 (3)	12903 (3)	**11073** (2)	12119 (5)
2008	7538	8017	9494 (2)	8612 (2)	8465 (18)	**7647** (17)	5956 (17)	**8520** (3)
2009	7546	7280	8865 (3)	8345 (2)	**7726** (19)	6847 (18)	6560 (18)	7090 (16)
2010	9232	6328	**7054** (3)	6101 (10)	**7798** (1)	**7798** (1)	**7647** (1)	**6600** (10)

Observations and forecasts in Sollefteå issued 1/5 using method TCI

	OBS	IHMS	TCI1	TCI2	TCI3	TCI4	TCI5	TCI6
2000	9978	7859	**8694** (1)	**8610** (2)	**8018** (3)	7502 (1)	**9084** (2)	**8610** (2)
2001	9649	7978	**8312** (1)	**8097** (12)	**9930** (1)	**9930** (1)	**9201** (5)	**8734** (9)
2002	5981	7649	7758 (10)	**7233** (2)	**6987** (1)	7674 (7)	7931 (6)	7978 (10)
2003	7014	5552	**5988** (2)	**5755** (13)	**7459** (2)	**7459** (2)	**7326** (1)	**6474** (4)
2004	7040	6465	**6610** (3)	**7299** (3)	**6510** (15)	6358 (14)	6412 (15)	6214 (13)
2005	9457	7804	**9019** (2)	**7910** (2)	**7871** (16)	7737 (15)	7040 (1)	**7865** (3)
2006	5902	5933	5541 (2)	6290 (3)	6057 (17)	**5903** (16)	5844 (16)	5711 (14)
2007	7519	9530	**9039** (3)	9942 (4)	11087 (3)	11087 (3)	10937 (2)	10590 (5)
2008	7538	8263	9799 (2)	8613 (2)	8312 (18)	**8089** (17)	**8040** (17)	8311 (3)
2009	7546	6759	**7322** (3)	**7441** (2)	6705 (19)	6643 (18)	6565 (18)	6503 (15)
2010	9232	7438	**8263** (3)	7501 (10)	**8110** (1)	**8110** (1)	**8110** (1)	**7988** (10)

CP forecasts 1(6)

Observations and forecasts in Sorsele issued 1/1 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	2630	1470	- (0)	- (0)	**1723** (1)	**1606** (3)	**1664** (1)	**1664** (1)
2001	2721	2243	**2571** (1)	- (0)	- (0)	- (0)	- (0)	- (0)
2002	2262	2316	1774 (3)	1867 (2)	**2263** (11)	2801 (2)	- (0)	**2270** (13)
2003	1739	1967	**1733** (4)	2924 (2)	2018 (12)	2088 (10)	**1912** (17)	2003 (14)
2004	2748	1818	- (0)	**1902** (3)	**1906** (2)	**1860** (11)	1744 (18)	1786 (15)
2005	2438	2301	1957 (1)	- (0)	2768 (2)	2208 (4)	2268 (3)	**2301** (7)
2006	1607	2034	- (0)	**1936** (2)	**1805** (1)	**1840** (5)	2501 (2)	**2014** (8)
2007	2489	2851	3120 (1)	**2574** (1)	- (0)	2895 (12)	**2723** (4)	**2759** (9)
2008	2356	1446	- (0)	1213 (3)	**1529** (13)	**1564** (13)	**1466** (19)	**1479** (16)
2009	1968	2047	2115 (4)	- (0)	- (0)	- (0)	- (0)	- (0)
2010	2361	2114	- (0)	- (0)	**2147** (14)	**2134** (14)	2054 (20)	**2132** (17)

Observations and forecasts in Sorsele issued 1/3 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	2630	2212	**2414** (2)	**2452** (1)	**2743** (1)	**2452** (1)	- (0)	- (0)
2001	2721	2307	- (0)	- (0)	**2475** (3)	- (0)	- (0)	- (0)
2002	2262	2398	2539 (1)	- (0)	2063 (1)	2063 (1)	2803 (7)	2869 (1)
2003	1739	1914	1918 (6)	**1907** (12)	**1867** (12)	1927 (15)	**1851** (17)	**1901** (22)
2004	2748	2251	2148 (2)	2141 (1)	2494 (4)	**2385** (3)	2173 (18)	2218 (23)
2005	2438	2498	2506 (7)	3016 (5)	**2473** (6)	2521 (16)	**2387** (19)	**2457** (24)
2006	1607	1821	1824 (8)	**1798** (13)	**1758** (13)	**1817** (4)	**1755** (20)	**1800** (25)
2007	2489	2825	- (0)	- (0)	- (0)	3407 (1)	3133 (8)	3049 (2)
2008	2356	2133	2077 (5)	2908 (1)	2658 (2)	**2412** (2)	**2193** (9)	2121 (3)
2009	1968	2082	**1854** (3)	2292 (2)	2292 (5)	**1925** (5)	**1994** (2)	**2061** (4)
2010	2361	1937	1791 (4)	**2087** (3)	**2008** (6)	**1969** (17)	**1861** (21)	**1902** (26)

Observations and forecasts in Sorsele issued 1/5 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	2630	2299	- (0)	**2667** (3)	**2719** (1)	**2719** (1)	2285 (7)	**2433** (5)
2001	2721	2318	- (0)	**2771** (1)	- (0)	- (0)	2317 (8)	**2474** (6)
2002	2262	2372	2595 (3)	**2227** (13)	2639 (1)	2566 (4)	2384 (2)	2587 (3)
2003	1739	1875	1917 (4)	**1776** (14)	**1801** (13)	**1869** (17)	1895 (19)	**1830** (20)
2004	2748	2283	- (0)	2202 (15)	2201 (14)	2267 (18)	**2296** (20)	2229 (21)
2005	2438	2276	**2317** (6)	2153 (16)	2169 (15)	2250 (19)	**2277** (21)	2218 (22)
2006	1607	1753	2013 (1)	1856 (4)	**1703** (16)	1755 (20)	1772 (22)	1937 (7)
2007	2489	2837	- (0)	**2640** (1)	2859 (0)	2951 (5)	2934 (3)	2952 (4)
2008	2356	2207	2118 (2)	2574 (4)	- (0)	- (0)	- (0)	- (0)
2009	1968	2018	2459 (1)	**1936** (2)	2110 (7)	2027 (6)	2077 (9)	2166 (8)
2010	2361	2162	**2232** (3)	- (0)	**2619** (2)	**2077** (7)	**2186** (10)	**2274** (9)

CP forecasts 2(6)

Observations and forecasts in Vindeln issued 1/1 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	3692	2266	- (0)	- (0)	**2416** (1)	2149 (3)	**2485** (1)	**2485** (1)
2001	4138	3362	**3560** (1)	- (0)	- (0)	- (0)	- (0)	- (0)
2002	2949	3355	2477 (3)	2525 (2)	**3238** (11)	3905 (2)	- (0)	**3184** (13)
2003	2323	2707	**2322** (4)	3940 (2)	2752 (12)	2745 (10)	**2604** (17)	**2672** (14)
2004	3633	2573	- (0)	**2725** (3)	**2721** (2)	**2600** (11)	2467 (18)	2538 (15)
2005	3295	3148	2528 (1)	- (0)	3878 (2)	**3180** (4)	**3235** (3)	**3250** (7)
2006	2264	2847	- (0)	**2586** (2)	**2257** (1)	**2790** (5)	3500 (2)	2923 (8)
2007	3148	4086	4369 (1)	**3560** (1)	- (0)	**4026** (12)	**3971** (4)	**3988** (9)
2008	3391	2337	- (0)	1974 (3)	**2464** (13)	**2409** (13)	2325 (19)	**2366** (16)
2009	2814	2975	3063 (4)	- (0)	- (0)	- (0)	- (0)	- (0)
2010	3317	3110	- (0)	- (0)	**3122** (14)	2994 (14)	2966 (20)	3025 (17)

Observations and forecasts in Vindeln issued 1/3 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	3692	3105	**3151** (2)	3043 (1)	**3561** (1)	3043 (1)	- (0)	- (0)
2001	4138	3511	- (0)	- (0)	**3602** (3)	- (0)	- (0)	- (0)
2002	2949	3332	3633 (1)	- (0)	**2823** (1)	**2823** (1)	3698 (7)	3784 (1)
2003	2323	2662	2670 (6)	**2649** (12)	**2552** (12)	**2633** (15)	**2542** (17)	2664 (22)
2004	3633	3129	2854 (2)	2900 (1)	**3492** (4)	**3207** (3)	3030 (18)	**3144** (23)
2005	3295	3506	3593 (7)	3847 (5)	**3384** (6)	**3493** (16)	**3367** (19)	**3480** (24)
2006	2264	2540	**2500** (8)	2592 (13)	**2463** (13)	**2514** (4)	**2447** (20)	2540 (25)
2007	3148	4167	- (0)	- (0)	- (0)	4680 (1)	4335 (8)	4210 (2)
2008	3391	3304	3302 (5)	4532 (1)	3955 (2)	**3375** (2)	3240 (9)	2947 (3)
2009	2814	3088	**2758** (3)	3392 (2)	3319 (5)	**2960** (5)	**2835** (2)	**2923** (4)
2010	3317	3000	2719 (4)	**3377** (3)	**3193** (6)	2975 (17)	2898 (21)	2951 (26)

Observations and forecasts in Vindeln issued 1/5 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	3692	3118	- (0)	**3561** (3)	**3646** (1)	**3646** (1)	3032 (7)	**3268** (5)
2001	4138	3612	- (0)	**4111** (1)	- (0)	- (0)	3566 (8)	**3764** (6)
2002	2949	3084	3263 (3)	**2923** (13)	3287 (1)	3213 (4)	**3033** (2)	3272 (3)
2003	2323	2318	2301 (4)	2186 (14)	2228 (13)	**2321** (17)	2340 (19)	2259 (20)
2004	3633	2971	- (0)	2843 (15)	2866 (14)	2956 (18)	**2985** (20)	2898 (21)
2005	3295	2985	**3056** (6)	2817 (16)	2852 (15)	2954 (19)	**2988** (21)	2911 (22)
2006	2264	2496	2822 (1)	2543 (4)	**2422** (16)	**2491** (20)	2506 (22)	2674 (7)
2007	3148	3716	- (0)	**3481** (1)	**3712** (0)	3723 (5)	**3641** (3)	3741 (4)
2008	3391	3516	**3398** (2)	4076 (4)	- (0)	- (0)	- (0)	- (0)
2009	2814	2969	3620 (1)	**2853** (2)	3060 (7)	**2936** (6)	3007 (9)	3100 (8)
2010	3317	3336	**3307** (3)	- (0)	4018 (2)	3278 (7)	3365 (10)	3452 (9)

CP forecasts 3(6)

Observations and forecasts in Svegsjön issued 1/1 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	2426	1318	- (0)	- (0)	**1673** (1)	**1358** (3)	**1397** (1)	**1397** (1)
2001	1984	1668	**2074** (1)	- (0)	- (0)	- (0)	- (0)	- (0)
2002	1552	1608	1372 (3)	**1536** (2)	1424 (11)	1786 (2)	- (0)	1449 (13)
2003	1330	1602	**1556** (4)	2165 (2)	**1461** (12)	**1451** (10)	**1574** (17)	**1472** (14)
2004	796	1360	- (0)	1661 (3)	1536 (2)	1380 (11)	**1335** (18)	**1309** (15)
2005	1758	1512	1466 (1)	- (0)	2223 (2)	**1552** (4)	**1683** (3)	**1517** (7)
2006	1517	1459	- (0)	1713 (2)	1579 (1)	1316 (5)	**1471** (2)	1431 (8)
2007	1085	1605	1753 (1)	**1383** (1)	- (0)	**1516** (12)	**1595** (4)	1635 (9)
2008	1973	1453	- (0)	**1566** (3)	1391 (13)	1405 (13)	1427 (19)	1355 (16)
2009	1660	1522	1513 (4)	- (0)	- (0)	- (0)	- (0)	- (0)
2010	2156	1747	- (0)	- (0)	1625 (14)	1585 (14)	1688 (20)	1607 (17)

Observations and forecasts in Svegsjön issued 1/3 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	2426	1533	1375 (2)	968 (1)	**1612** (1)	968 (1)	- (0)	- (0)
2001	1984	1695	- (0)	- (0)	1542 (3)	- (0)	- (0)	- (0)
2002	1552	1786	2252 (1)	- (0)	2048 (1)	2048 (1)	1883 (7)	1910 (1)
2003	1330	1558	**1375** (6)	**1531** (12)	**1530** (12)	**1514** (15)	**1516** (17)	**1517** (22)
2004	796	1510	**1104** (2)	**1483** (1)	**1496** (4)	**1372** (3)	**1460** (18)	**1452** (23)
2005	1758	1732	1632 (7)	1689 (5)	1792 (6)	1711 (16)	1659 (19)	1679 (24)
2006	1517	1353	1223 (8)	1320 (13)	1306 (13)	1173 (4)	1266 (20)	1295 (25)
2007	1085	1822	- (0)	- (0)	- (0)	1932 (1)	1958 (8)	1860 (2)
2008	1973	1985	1995 (5)	3110 (1)	2449 (2)	1746 (2)	1906 (9)	1503 (3)
2009	1660	1724	1207 (3)	1844 (2)	**1649** (5)	1559 (5)	1297 (2)	1493 (4)
2010	2156	1713	1305 (4)	1660 (3)	1600 (6)	1675 (17)	1656 (21)	1669 (26)

Observations and forecasts in Svegsjön issued 1/5 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	2426	1626	- (0)	**1677** (3)	**1770** (1)	**1770** (1)	1527 (7)	1611 (5)
2001	1984	2013	- (0)	2395 (1)	- (0)	- (0)	1919 (8)	1899 (6)
2002	1552	1494	1406 (3)	1472 (13)	1487 (1)	**1531** (4)	**1508** (2)	1631 (3)
2003	1330	1162	1127 (4)	1149 (14)	**1171** (13)	**1187** (17)	**1209** (19)	**1174** (20)
2004	796	1022	- (0)	**1014** (15)	1041 (14)	1053 (18)	1081 (20)	1041 (21)
2005	1758	1457	**1485** (6)	1424 (16)	1454 (15)	**1497** (19)	**1511** (21)	**1473** (22)
2006	1517	1582	1688 (1)	**1511** (4)	**1580** (16)	1624 (20)	1638 (22)	**1502** (7)
2007	1085	1338	- (0)	1678 (1)	1565 (0)	1365 (5)	**1281** (3)	1397 (4)
2008	1973	2152	2483 (2)	2255 (4)	- (0)	- (0)	- (0)	- (0)
2009	1660	1262	2426 (1)	**1422** (2)	1241 (7)	1216 (6)	1234 (9)	1173 (8)
2010	2156	1755	**1824** (3)	- (0)	**2144** (2)	**1787** (7)	1747 (10)	1707 (9)

CP forecasts 4(6)

Observations and forecasts in Dönje issued 1/1 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	3510	1980	- (0)	- (0)	**2393** (1)	**2233** (3)	**2197** (1)	**2197** (1)
2001	2755	2325	**3089** (1)	- (0)	- (0)	- (0)	- (0)	- (0)
2002	2107	2283	1903 (3)	**2119** (2)	**1987** (11)	2507 (2)	- (0)	**2072** (13)
2003	1865	2227	**2100** (4)	2940 (2)	**2015** (12)	**1982** (10)	**2223** (17)	**2096** (14)
2004	1110	2040	- (0)	2578 (3)	2193 (2)	**1990** (11)	**1993** (18)	**1924** (15)
2005	2558	2066	1870 (1)	- (0)	3279 (2)	**2107** (4)	**2440** (3)	**2173** (7)
2006	2239	2007	- (0)	**2326** (2)	**2034** (1)	1767 (5)	**2059** (2)	1983 (8)
2007	1343	2182	2426 (1)	**1830** (1)	- (0)	**2000** (12)	2221 (4)	2206 (9)
2008	2558	2161	- (0)	**2305** (3)	2104 (13)	2076 (13)	2130 (19)	2043 (16)
2009	2363	2200	**2370** (4)	- (0)	- (0)	- (0)	- (0)	- (0)
2010	3021	2444	- (0)	- (0)	2202 (14)	2181 (14)	2384 (20)	2227 (17)

Observations and forecasts in Dönje issued 1/3 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	3510	2096	1850 (2)	1228 (1)	2079 (1)	1228 (1)	- (0)	- (0)
2001	2755	2404	- (0)	- (0)	2194 (3)	- (0)	- (0)	- (0)
2002	2107	2598	3161 (1)	- (0)	3002 (1)	3002 (1)	2702 (7)	**2587** (1)
2003	1865	2182	**1886** (6)	**2118** (12)	**2062** (12)	**2070** (15)	**2100** (17)	**2128** (22)
2004	1110	2160	**1613** (2)	2189 (1)	2173 (4)	**1975** (3)	**2078** (18)	**2106** (23)
2005	2558	2330	2128 (7)	2245 (5)	**2454** (6)	2227 (16)	2230 (19)	2242 (24)
2006	2239	1823	1655 (8)	1783 (13)	1745 (13)	1616 (4)	1700 (20)	1762 (25)
2007	1343	2472	- (0)	- (0)	- (0)	**2468** (1)	2650 (8)	**2375** (2)
2008	2558	2872	2926 (5)	4829 (1)	3604 (2)	**2336** (2)	**2789** (9)	2019 (3)
2009	2363	2522	1669 (3)	2809 (2)	**2390** (5)	**2366** (5)	1947 (2)	**2263** (4)
2010	3021	2483	1875 (4)	2446 (3)	2348 (6)	2431 (17)	2482 (21)	2466 (26)

Observations and forecasts in Dönje issued 1/5 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	3510	2262	- (0)	**2414** (3)	**2358** (1)	**2358** (1)	2142 (7)	**2274** (5)
2001	2755	2935	- (0)	3358 (1)	- (0)	- (0)	**2854** (8)	**2798** (6)
2002	2107	2060	1901 (3)	2037 (13)	1965 (1)	2001 (4)	**2084** (2)	2288 (3)
2003	1865	1575	1497 (4)	1543 (14)	**1601** (13)	**1618** (17)	**1647** (19)	**1588** (20)
2004	1110	1438	- (0)	**1409** (15)	1483 (14)	1511 (18)	1527 (20)	1471 (21)
2005	2558	1824	**1860** (6)	1801 (16)	**1841** (15)	**1881** (19)	**1892** (21)	**1841** (22)
2006	2239	2233	2368 (1)	2095 (4)	2256 (16)	2290 (20)	2300 (22)	2139 (7)
2007	1343	1692	- (0)	2087 (1)	1862 (0)	**1638** (5)	**1596** (3)	1771 (4)
2008	2558	3128	3604 (2)	3317 (4)	- (0)	- (0)	- (0)	- (0)
2009	2363	1812	3595 (1)	**1990** (2)	1811 (7)	1768 (6)	1779 (9)	1706 (8)
2010	3021	2527	**2611** (3)	- (0)	**3158** (2)	**2579** (7)	**2532** (10)	2444 (9)

CP forecasts 5(6)

Observations and forecasts in Kultsjön issued 1/1 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	1064	565	- (0)	- (0)	**612** (1)	**594** (3)	**680** (1)	**680** (1)
2001	986	710	**835** (1)	- (0)	- (0)	- (0)	- (0)	- (0)
2002	896	914	738 (3)	801 (2)	858 (11)	1146 (2)	- (0)	869 (13)
2003	812	716	642 (4)	1170 (2)	683 (12)	**743** (10)	662 (17)	696 (14)
2004	903	706	- (0)	**740** (3)	**792** (2)	**783** (11)	673 (18)	671 (15)
2005	1038	927	783 (1)	- (0)	1155 (2)	**928** (4)	**1022** (3)	**937** (7)
2006	543	678	- (0)	699 (2)	**626** (1)	**621** (5)	776 (2)	**664** (8)
2007	986	1014	1219 (1)	899 (1)	- (0)	**996** (12)	1014 (4)	**1003** (9)
2008	817	588	- (0)	481 (3)	**625** (13)	**656** (13)	587 (19)	**595** (16)
2009	803	744	734 (4)	- (0)	- (0)	- (0)	- (0)	- (0)
2010	865	688	- (0)	- (0)	671 (14)	673 (14)	657 (20)	671 (17)

Observations and forecasts in Kultsjön issued 1/3 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	1064	880	**1014** (2)	**1005** (1)	**1059** (1)	**1005** (1)	- (0)	- (0)
2001	986	677	- (0)	- (0)	**683** (3)	- (0)	- (0)	- (0)
2002	896	983	1115 (1)	- (0)	**948** (1)	**948** (1)	1051 (7)	1118 (1)
2003	812	716	713 (6)	**723** (12)	706 (12)	**740** (15)	700 (17)	701 (22)
2004	903	798	749 (2)	693 (1)	**892** (4)	**807** (3)	783 (18)	784 (23)
2005	1038	1018	973 (7)	1171 (5)	**1034** (6)	**1025** (16)	999 (19)	1013 (24)
2006	543	629	**628** (8)	635 (13)	**622** (13)	**604** (4)	**616** (20)	**614** (25)
2007	986	1013	- (0)	- (0)	- (0)	1195 (1)	1070 (8)	1063 (2)
2008	817	819	895 (5)	1100 (1)	1004 (2)	929 (2)	842 (9)	801 (3)
2009	803	731	622 (3)	**853** (2)	**763** (5)	652 (5)	697 (2)	731 (4)
2010	865	608	570 (4)	**705** (3)	**647** (6)	**636** (17)	588 (21)	591 (26)

Observations and forecasts in Kultsjön issued 1/5 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	1064	907	- (0)	**1056** (3)	**1063** (1)	**1063** (1)	**929** (7)	**935** (5)
2001	986	703	- (0)	**991** (1)	- (0)	- (0)	**722** (8)	**737** (6)
2002	896	964	1048 (3)	**920** (13)	977 (1)	1062 (4)	992 (2)	1030 (3)
2003	812	713	**739** (4)	686 (14)	688 (13)	**714** (17)	712 (19)	692 (20)
2004	903	820	- (0)	807 (15)	794 (14)	**826** (18)	**826** (20)	802 (21)
2005	1038	948	926 (6)	929 (16)	909 (15)	944 (19)	**949** (21)	928 (22)
2006	543	565	676 (1)	646 (4)	**558** (16)	579 (20)	576 (22)	614 (7)
2007	986	1026	- (0)	**1000** (1)	1042 (0)	1046 (5)	1068 (3)	1045 (4)
2008	817	818	861 (2)	946 (4)	- (0)	- (0)	- (0)	- (0)
2009	803	723	**833** (1)	**736** (2)	**760** (7)	**753** (6)	**752** (9)	**761** (8)
2010	865	692	**714** (3)	- (0)	**853** (2)	**707** (7)	**731** (10)	**737** (9)

CP forecasts 6(6)

Observations and forecasts in Sollefteå issued 1/1 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	9978	6082	- (0)	- (0)	**7001** (1)	5956 (3)	**7287** (1)	**7287** (1)
2001	9649	7520	**8469** (1)	- (0)	- (0)	- (0)	- (0)	- (0)
2002	5981	8854	**7049** (3)	**7715** (2)	**8002** (11)	10792 (2)	- (0)	**8452** (13)
2003	7014	6524	5824 (4)	10225 (2)	6262 (12)	**6531** (10)	6280 (17)	**6560** (14)
2004	7040	7351	- (0)	7767 (3)	9141 (2)	7522 (11)	**6964** (18)	**7284** (15)
2005	9457	8225	6771 (1)	- (0)	11124 (2)	**8229** (4)	**9270** (3)	**8376** (7)
2006	5902	6540	- (0)	6609 (2)	**5284** (1)	**5978** (5)	7513 (2)	6557 (8)
2007	7519	10625	13.1* (1)	**9.8*** (1)	- (0)	**10.1***(12)	**10.4*** (4)	**10.5*** (9)
2008	7538	6270	- (0)	5834 (3)	**6410** (13)	**6454** (13)	6000 (19)	**6344** (16)
2009	7546	7276	6633 (4)	- (0)	- (0)	- (0)	- (0)	- (0)
2010	9232	6925	- (0)	- (0)	6580 (14)	6437 (14)	6660 (20)	6808 (17)

Observations and forecasts in Sollefteå issued 1/3 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	9978	8465	**8593** (2)	7102 (1)	**10403** (1)	7102 (1)	- (0)	- (0)
2001	9649	7451	- (0)	- (0)	7243 (3)	- (0)	- (0)	- (0)
2002	5981	9153	9964 (1)	- (0)	**8375** (1)	**8375** (1)	9240 (7)	9656 (1)
2003	7014	6839	6769 (6)	**6860** (12)	**6843** (12)	**6952** (15)	6725 (17)	6757 (22)
2004	7040	7839	**6752** (2)	**7387** (1)	8315 (4)	**7650** (3)	**7685** (18)	**7721** (23)
2005	9457	9119	9083 (7)	9808 (5)	8625 (6)	**9216** (16)	8897 (19)	9005 (24)
2006	5902	6167	**6101** (8)	**6058** (13)	**5977** (13)	**5811** (4)	**5999** (20)	**6121** (25)
2007	7519	11121	- (0)	- (0)	- (0)	13325 (1)	**10798** (8)	**10240** (2)
2008	7538	8017	8228 (5)	11875 (1)	9988 (2)	8345 (2)	**7514** (9)	6491 (3)
2009	7546	7280	5393 (3)	8281 (2)	**7525** (5)	6436 (5)	6367 (2)	6748 (4)
2010	9232	6328	5417 (4)	**6361** (3)	**6505** (6)	**6558** (17)	6143 (21)	6313 (26)

Observations and forecasts in Sollefteå issued 1/5 using method CP

	OBS	IHMS	CP1	CP2	CP3	CP4	CP5	CP6
2000	9978	7859	- (0)	**9086** (3)	**8961** (1)	**8961** (1)	7612 (7)	**8565** (5)
2001	9649	7978	- (0)	**10415** (1)	- (0)	- (0)	**7991** (8)	**8074** (6)
2002	5981	7649	8080 (3)	**7318** (13)	**7407** (1)	7823 (4)	**7333** (2)	**7545** (3)
2003	7014	5552	5354 (4)	5141 (14)	5412 (13)	**5590** (17)	**5693** (19)	5422 (20)
2004	7040	6465	- (0)	6109 (15)	6368 (14)	**6558** (18)	**6618** (20)	6347 (21)
2005	9457	7804	**7915** (6)	7393 (16)	7642 (15)	**7871** (19)	**7950** (21)	7648 (22)
2006	5902	5933	6438 (1)	6017 (4)	**5900** (16)	6049 (20)	6121 (22)	6189 (7)
2007	7519	9530	- (0)	**9523** (1)	**9444** (0)	**9319** (5)	**8829** (3)	**9112** (4)
2008	7538	8263	8799 (2)	9558 (4)	- (0)	- (0)	- (0)	- (0)
2009	7546	6759	8654 (1)	6651 (2)	**6885** (7)	**6767** (6)	**6980** (9)	**6806** (8)
2010	9232	7438	**7442** (3)	- (0)	**9119** (2)	**7476** (7)	**7658** (10)	7433 (9)

EH forecasts 1(2)

Observations and forecasts in Sorsele issued using method EH

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	EH	IHMS	EH	IHMS	EH
2000	2630	1470	**2586**	2212	**2466**	2299	**2418**
2001	2721	2243	**2927**	2307	**2477**	2318	**2417**
2002	2262	2316	2616	2398	2579	2372	2530
2003	1739	1967	2134	1914	2104	1875	1981
2004	2748	1818	**2707**	2251	**2420**	2283	**2482**
2005	2438	2301	2815	2498	2637	2276	**2533**
2006	1607	2034	2180	1821	1858	1753	1818
2007	2489	2851	3605	2825	3167	2837	2891
2008	2356	1446	**2625**	2133	**2192**	2207	**2259**
2009	1968	2047	2669	2082	2223	2018	2122
2010	2361	2114	**2298**	1937	**1966**	2162	**2294**

Observations and forecasts in Vindeln issued using method EH

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	EH	IHMS	EH	IHMS	EH
2000	3692	2266	**3758**	3105	**3500**	3118	**3246**
2001	4138	3362	**4275**	3511	**3779**	3612	**3675**
2002	2949	3355	3723	3332	3552	3084	3286
2003	2323	2707	2998	2662	2883	2318	2463
2004	3633	2573	3735	3129	**3311**	2971	**3200**
2005	3295	3148	**3917**	3506	**3642**	2985	**3366**
2006	2264	2847	3215	2540	**2668**	2496	2590
2007	3148	4086	5336	4167	4755	3716	3818
2008	3391	2337	**3871**	3304	**3400**	3516	3570
2009	2814	2975	**3833**	3088	3304	2969	3038
2010	3317	3110	**3503**	3000	**3059**	3336	3543

Observations and forecasts in Svegsjön issued using method EH

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	EH	IHMS	EH	IHMS	EH
2000	2426	1318	**1623**	1533	**1442**	1626	**1650**
2001	1984	1668	**1692**	1695	**1731**	2013	1927
2002	1552	1608	1676	1786	**1659**	1494	**1590**
2003	1330	1602	1846	1558	1600	1162	**1234**
2004	796	1360	1649	1510	**1334**	1022	1058
2005	1758	1512	**1580**	1732	**1777**	1457	**1621**
2006	1517	1459	1744	1353	**1217**	1582	1612
2007	1085	1605	2143	1822	2011	1338	1492
2008	1973	1453	**1969**	1985	**1861**	2152	**2104**
2009	1660	1522	**1533**	1724	1758	1262	1227
2010	2156	1747	**1915**	1713	**1803**	1755	**1765**

EH forecasts 1(2)

Observations and forecasts in Dönje issued using method EH

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	EH	IHMS	EH	IHMS	EH
2000	3510	1980	**2614**	2096	**2223**	2262	**2291**
2001	2755	2325	**2516**	2404	**2725**	2935	**2801**
2002	2107	2283	2686	2598	2633	2060	2238
2003	1865	2227	2785	2182	2416	1575	**1712**
2004	1110	2040	2796	2160	**2106**	1438	1516
2005	2558	2066	**2410**	2330	**2557**	1824	**2075**
2006	2239	2007	2835	1823	**1837**	2233	2289
2007	1343	2182	3270	2472	3014	1692	1953
2008	2558	2161	3118	2872	2910	3128	**3057**
2009	2363	2200	**2481**	2522	2811	1812	1757
2010	3021	2444	**3021**	2483	**2920**	2527	**2591**

SD forecasts 1(2)

Observations and forecasts in Sorsele issued using method SD

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	SD	IHMS	SD	IHMS	SD
2000	2630	1470	**2783**	2212	**2721**	2299	**2360**
2001	2721	2243	**2310**	2307	**2653**	2318	**2463**
2002	2262	2316	2360	2398	2661	2372	**2261**
2003	1739	1967	2214	1914	2678	1875	2148
2004	2748	1818	**2155**	2251	**2347**	2283	**2703**
2005	2438	2301	2503	2498	**2473**	2276	**2580**
2006	1607	2034	2493	1821	2626	1753	2661
2007	2489	2851	**2483**	2825	1734	2837	**2796**
2008	2356	1446	**2338**	2133	**2383**	2207	**2485**
2009	1968	2047	2519	2082	2244	2018	2490
2010	2361	2114	2098	1937	**2222**	2162	2666

Observations and forecasts in Vindeln issued using method SD

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	SD	IHMS	SD	IHMS	SD
2000	3692	2266	**3768**	3105	**3554**	3118	**3401**
2001	4138	3362	**3436**	3511	**3591**	3612	3591
2002	2949	3355	3389	3332	3660	3084	3198
2003	2323	2707	3309	2662	3652	2318	3295
2004	3633	2573	**3308**	3129	3005	2971	**3678**
2005	3295	3148	**3388**	3506	3149	2985	3643
2006	2264	2847	3066	2540	2919	2496	3874
2007	3148	4086	**3195**	4167	**3554**	3716	**3180**
2008	3391	2337	**2636**	3304	3240	3516	3591
2009	2814	2975	3496	3088	3293	2969	3427
2010	3317	3110	2979	3000	**3159**	3336	3479

Observations and forecasts in Svegsjön issued using method SD

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	SD	IHMS	SD	IHMS	SD
2000	2426	1318	**1609**	1533	1421	1626	1534
2001	1984	1668	**1897**	1695	**1850**	2013	1787
2002	1552	1608	1694	1786	**1664**	1494	**1508**
2003	1330	1602	2068	1558	2139	1162	**1437**
2004	796	1360	1869	1510	1817	1022	1660
2005	1758	1512	**1631**	1732	1593	1457	**1521**
2006	1517	1459	1975	1353	1931	1582	1888
2007	1085	1605	2040	1822	2600	1338	1444
2008	1973	1453	**2000**	1985	1656	2152	**1919**
2009	1660	1522	1988	1724	1870	1262	**1841**
2010	2156	1747	**1891**	1713	**1847**	1755	**1896**

SD forecasts 1(2)

Observations and forecasts in Dönje issued using method SD

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	SD	IHMS	SD	IHMS	SD
2000	3510	1980	**2345**	2096	1702	2262	2139
2001	2755	2325	**2917**	2404	2293	2935	2544
2002	2107	2283	2475	2598	**2223**	2060	**2116**
2003	1865	2227	2998	2182	2913	1575	**1991**
2004	1110	2040	2695	2160	2393	1438	2363
2005	2558	2066	**2129**	2330	1939	1824	**2113**
2006	2239	2007	2483	1823	2689	2233	2719
2007	1343	2182	**1854**	2472	2850	1692	2035
2008	2558	2161	**2408**	2872	**2337**	3128	**2733**
2009	2363	2200	2633	2522	2736	1812	**2535**
2010	3021	2444	**2491**	2483	**2685**	2527	**2696**

Observations and forecasts in Kultsjön issued using method SD

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	SD	IHMS	SD	IHMS	SD
2000	1064	565	**1082**	880	**1113**	907	**957**
2001	986	710	**891**	677	**1063**	703	**958**
2002	896	914	**909**	983	1029	964	**964**
2003	812	716	**833**	716	1115	713	911
2004	903	706	**884**	798	**951**	820	**925**
2005	1038	927	**988**	1018	949	948	921
2006	543	678	772	629	1031	565	951
2007	986	1014	**922**	1013	777	1026	394
2008	817	588	**863**	819	755	818	931
2009	803	744	939	731	**736**	723	**839**
2010	865	688	**776**	608	**757**	692	**817**

Observations and forecasts in Sollefteå issued using method SD

		Forecasts 1/1		Forecasts 1/3		Forecasts 1/5	
	OBS	IHMS	SD	IHMS	SD	IHMS	SD
2000	9978	6082	**9729**	8465	**9995**	7859	**9875**
2001	9649	7520	**8784**	7451	**9761**	7978	**9784**
2002	5981	8854	8671	9153	9580	7649	9202
2003	7014	6524	8513	6839	9676	5552	9184
2004	7040	7351	8951	7839	8742	6465	8809
2005	9457	8225	**8997**	9119	8663	7804	**9395**
2006	5902	6540	8915	6167	9367	5933	10217
2007	7519	10625	**7359**	11121	**8468**	9530	1426
2008	7538	6270	**7690**	8017	**7410**	8263	8267
2009	7546	7276	8107	7280	**7510**	6759	**7114**
2010	9232	6925	**7415**	6328	**7435**	7438	7052

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