Norwegian Hydrological Reference Dataset for Climate Change Studies

Norwegian Water Resources and Energy Directorate
2013

Report no. 2 – 2013

Norwegian Hydrological Reference Dataset for Climate Change Studies

Published by: Norwegian Water Resources and Energy Directorate

Editor: Anne K. Fleig
Authors: Anne K. Fleig, Liss M. Andreassen, Emma Barfod, Jonatan Haga, Lars Egil Haugen, Hege Hisdal, Kjetil Melvold, Tuomo Saloranta

Print: Norwegian Water Resources and Energy Directorate
Number printed: 50
Cover photo: Femundsenden, spring 2000, Photo: Vidar Raubakken and Gunnar Haugen, NVE.
ISSN: 1501-2832
ISBN: 978-82-410-0869-6

Abstract: Based on the Norwegian hydrological measurement network, NVE has selected a Hydrological Reference Dataset for studies of hydrological change. The dataset meets international standards with high data quality. It is suitable for monitoring and studying the effects of climate change on the hydrosphere and cryosphere in Norway. The dataset includes streamflow, groundwater, snow, glacier mass balance and length change, lake ice and water temperature in rivers and lakes.

Key words: Reference data, hydrology, climate change

Norwegian Water Resources and Energy Directorate
Middelthunsgate 29
P.O. Box 5091 Majorstua
N 0301 OSLO
NORWAY

Telephone: +47 22 95 95 95
Fax: +47 22 95 90 00
E-mail: nve@nve.no
Internet: www.nve.no

January 2013

Contents

Preface

The climate change adaptation strategy of the Norwegian Water Resources and Energy Directorate is a part of the Norwegian Government's climate change adaptation strategy. Through its hydrological network, NVE is responsible for monitoring, registering and documenting the effects of climate change on hydrology. NVE has a central role in the management of Norwegian water resources, including national flood contingency planning. The directorate also has responsibility for reducing damage caused by landslides and overall responsibility for maintaining national power supplies.

Improving knowledge about the impacts of climate change is one of the main requirements to help facilitate adaptation to climate change in NVE's Strategy for climate change adaption (NVE, 2010). To achieve this, a high quality dataset suitable for studying hydrological variability and change is required. These data should not be influenced by human activities, which may have caused non-climate related variability or change. Such a dataset has now been established. NVE's Hydrological Reference Dataset for studies of the effect of climate change on hydrology in Norway comprises streamflow, groundwater, snow, glacier mass balance and length changes, lake and river ice and water temperature in rivers and lakes.

Oslo, January 2013

Morten Johnsrud
Director

Hege Hisdal
Head of Section

Summary

This report presents an action undertaken according to NVE’s Strategy for Climate Change Adaption. There it is stated that a Norwegian Hydrological Reference Dataset suitable to study climate change effects on hydrology needs to be established as a basis to fulfil NVE’s responsibility to monitor the effects of climate change and to improve knowledge about climate change related processes and impacts. Such a Hydrological Reference Dataset (HRD) needs to consist of long, high quality data series that are not affected by human activity causing non-climate related variability or change. The here presented HRD for Norway is selected from NVE’s existing station network for the hydrosphere and cryosphere, including streamflow, soil moisture, groundwater, snow, glacier mass balance and length, lake and river ice and water temperature in rivers and lakes. The selection criteria follow international standards and cover the degree of basin development and water usage, record length, data accuracy and available metadata. Depending on the fulfilment of these criteria some stations are assigned limited usability for certain kind of studies. The total resulting HRD consists of 189 streamflow series, 28 groundwater series, 68 snow water equivalent series, 9 series of glacier mass balance and 11 of glacier length, 22 lake ice and 2 river ice duration series as well as 9 water temperature series for rivers and 37 for lakes. Currently none of the existing soil moisture series are long enough to meet the requirements. For most of the variables, however, some parts of the country are underrepresented or not covered.

1 Introduction

In recent decades, changes in climate, and in particular increased temperatures, have been observed (Solomon et al., 2007). In Norway, temperatures have increased and there have been regional changes in precipitation and annual runoff, as well as increased winter and spring runoff and earlier snowmelt (Wilson et al., 2010). A continued increase in temperature and precipitation (except for the summer season) is predicted (Hanssen-Bauer et al., 2009). More frequent episodes of extreme rainfall are also anticipated. Changes in climate are expected to lead to changes in hydrology, with increasing annual runoff, and greater runoff in the autumn and winter and less during summer (Beldring et al., 2008). Increased floods are expected in all rivers except for large inland rivers currently dominated by snowmelt floods under the present climate (Lawrence and Hisdal, 2011). Observed and predicted future changes in hydrology require adaptation, as the changes can have major economic, societal, political, and ecological impacts. For example, increased floods will have implications for land use planning and could change dam construction requirements. In order to predict and prepare for changes in hydrological characteristics under a changing climate, good knowledge about observed hydrological changes and their causes is necessary. This includes not only improved knowledge about changes in the mean hydrological characteristics, but also changes in annual and seasonal variability as well as in the frequency and magnitude of extreme events. In NVE's Strategy for climate change adaption (NVE, 2010) improved knowledge about climate change, related processes and its impacts are identified as some of the main requirements to facilitate adaption to climate change. A high quality dataset suitable to study hydrological variability and change is required. As hydrological variability is driven by climate and modified by catchment characteristics and changes in land cover, it is difficult to attribute hydrological change to the different driving forces. In addition, human influences such as river regulations may change streamflow. Even in Norway where many long term series of hydrological measurements exist, the selection of an adequate dataset can be challenging due to the multiplicity of influences on hydrology. A Hydrological Reference Dataset (HRD) should consist of good-quality long-term series not influenced by human activities.

The need for adequate and high quality data to study climate change effects is internationally regarded as a pressing issue. Identifying regional patterns of hydrological change has been suggested as one of the most important challenges in contemporary hydrology (e.g. Stahl et al., 2010; Whitfield et al., 2012). In 2006, the World Meteorological Organization (WMO) requested its members to identify "Stream gauging stations appropriate for climate studies (Whitfield et al., 2012). A number of countries have or are in processes of establishing "Reference Hydrological Networks" consisting of good-quality, long-term series of observed streamflow from natural or near-natural catchments. In general, such networks should be representative for all hydrological regions in the country and provide a good regional coverage. Norway has a long and rugged coastline, spans 13 degrees of latitude, and has large seasonal and regional variations in climate and hydrology. A good regional coverage of hydrological stations is needed to capture this variability and also for the detection of future changes. Several studies have shown that climate predictions vary considerably between different parts of the country (Hanssen-Bauer et al., 2009). In NVE's Strategy for climate change adaption (NVE, 2010) it is stated that the Norwegian reference dataset should represent all elevations and special focus should be given to regions where large changes in streamflow (including floods and droughts), soil moisture, groundwater, snow, glaciers, period with lake/river ice, sediment transport and location of riverbeds are expected, as well as on regions with particularly high uncertainty in climate predictions.

Data from HRDs are not only necessary for studies of climate change related processes, trends and changes in hydrological characteristics, but also for improving climate models, as hydrological conditions provide feedback to the climatic system, for instance through the variability in snow cover and albedo or evapotranspiration. In general, HRDs are essential for research and good water management (Whitfield et al., 2012).

The aim of this report is to present a Hydrological Reference Dataset suitable for the study of the effects of climate variability and change on the hydrology and cryosphere in Norway. The reference dataset includes streamflow, soil moisture, groundwater, snow, glacier, lake and river ice and water temperature in rivers and lakes.

The necessary requirements for reference stations are specified in Chapter 2 in terms of six general selection criteria. In Chapter 3, these criteria are used, where applicable, to identify data series of each of the different variables. The resulting HRD is presented in Chapter 4, with strategies for maintaining and further improving the Norwegian Hydrological Reference Dataset suggested in Chapter 5.

2 Selection criteria for a Hydrological Reference Dataset

The six following selection criteria were used for identification of suitable reference stations (Whitfield et al., 2012):

Criteria:

1. Degree of basin development: Pristine or stable land-use conditions (<10% of the area is affected);
2. Absence of significant regulations, diversions, or water use. Only natural catchments. When regulation is present in a basin some gauging stations may be appropriate for analyzing high flows and average flows, but not low flows;
3. Record length: Minimum 20 years and some stations with > 50 years.
   This length ensures that underrepresented climatic or geographic areas, which are characterized by minimal data availability, are also included. However, record lengths should also be as long as possible to allow decadal variability to be distinguished from long-term trends; due to multi-decadal oscillations in streamflow.
4. Active data collection: Currently active and is expected to continue operation;
5. Data accuracy: Good quality data.
6. Adequate metadata: Adequate metadata should be available to support the previous five conditions.

These criteria are partly subjective and subject to interpretation, but they are identical to the WMO requirements in its request in 2006 for its members to identify “Stream gauging stations appropriate for climate studies” (Whitfield et al., 2012). These criteria were therefore chosen as the basis for the development of the Norwegian reference dataset, comprising data on streamflow, soil moisture, groundwater, snow, glaciers, lake/river ice and water temperature in rivers and lakes.

3 Data and criteria for the Norwegian HRD

3.1 Streamflow

3.1.1 Available data

All the daily streamflow records stored in NVE’s Hydra II database classified as active and unregulated were chosen as the basis for the selection of reference stations. This list of potential reference streamflow stations comprised data from 249 stations. A subset of these stations have previously been included in studies of trends in streamflow both in Europe (Hisdal et al. 2001, Stahl et al., 2010) and the Nordic countries (Wilson et al., 2010).

3.1.2 Selection of streamflow stations

The criteria for HRDs presented in Chapter 2 were applied to the Norwegian streamflow data as described in the following paragraphs. According to the evaluation of the Norwegian data, the streamflow series were categorized into the following seven categories:

A series can be used for all kind of climate change related studies:

1. *based on daily data (since...),*
2. *but not for high flows / flood studies (before...),*
3. *but not for spring high flows (autumn floods ok to use),*
4. *but not for low flow studies (before...),*
5. *but not for winter low flows,*
6. *based on monthly data,*
7. *based on seasonal data,*
8. *based on annual data only.*

Furthermore, a shorter record length than the existing is recommended to be used for some stations. The reference *start date* can either be applied for all or only selected categories. The resulting streamflow reference series are presented in Chapter 4.1 and Appendix 1.

<u>1. Degree of river basin development</u>

The land use classes for the individual catchments can be obtained from NVE’s Hydra II database. The specified classes have been derived in a GIS analysis of Norwegian topographic 1:50000 maps produced between 2004 and 2011. The following seven classes were defined: agriculture, bog, lake, forest, glacier, mountain (i.e. bare rock above the tree line) and urban area. However, no class exists for open area below the tree line. As a consequence, for half of the stations the land use conditions are specified for less than 90% of the area. In most cases, the unspecified area is probably grass or grazing land. Using the above classification, the area defined as urban or agriculture can be considered as developed land.

No information exists on changes in local land use conditions. In general, the amount of agricultural and grazing land has decreased in Norway within the last 60 years, in particular in remote and mountainous areas. The amount of forest has in turn increased (Bryn, 2008). It is also known that draining of bogs has taken place as well as some changes in agricultural practices that affect runoff conditions. For example, the dominating ploughing direction has changed and more drain pipes are used.

It was decided to exclude stations from the list of potential reference stations, only if they have an urban area of more than 10%, irrespective of the amount of agricultural land. This was decided due to the lack of information on changes in local land use conditions and the proportion of grazing land within the undefined area. None of the 250 potential reference stations have an urban area proportion as high as 10%. For one station (21.49 Sømskleiva) no information is available. However, in Pettersson (2004) this station has been classified as “urban”, and it is therefore assumed that urban land covers more than 10% of the catchment area.

2. Absence of significant regulations, diversions, or water use

The 250 potential reference stations are classified as “unregulated” in the Hydra II database (March 2012; based on Pettersson, 2003). Further background information was obtained from previous reports on NVE’s network of streamflow stations (Pettersson, 2004; Pettersson, 2005; Kleivane, 2006; Pettersson & Astrup, 2007) and the station comments in Hydra II. The comments included information about earlier regulations such as small hydropower reservoirs or timber floating, minor water abstractions for local drinking water supply, water transfers of a certain part of the catchment and short term regulations for instance related to the construction of a bridge or street. However, not all of the comments were easy to interpret and the impact on streamflow could be difficult to judge. Personal contact with the responsible hydrometrist and people at NVE with long experience in using the streamflow series, helped to clarify most of the uncertainties. The information about existing regulations and water transfers was cross- checked with an ongoing station network project at NVE, where water transfers and power stations of at least 1 MWh are retrieved by GIS analysis. The maps applied for this analysis are produced between 2004 and 2011 depending on the station.

The degree of detail in this available information varies between stations, and it is likely that not all intervening activity is documented, in particular not older ones. The data series are therefore further checked for possible unnatural influences based on an earlier homogeneity tests and explorative analysis as described under 5 Data accuracy.

Based on this information and analyses, usability classes are assigned to all potential reference series, and new start dates are suggested where necessary. In case the regulations affect only parts of the hydrological regime, the recommended starting year is given in the respective usability category. For instance, station 133.7 Krinsvatn has streamflow observations since 1915. However, until 1965 there was timber floating activity during the spring. For studies considering low flow, spring floods or monthly data, it is therefore recommend using data only from 1965 onwards. Studies of annual data or particularly looking at autumn floods could still use the complete record.

The water transfers are all constant, i.e. all water from a certain part of the natural catchment is permanently transferred into a neighbouring catchment. The water flow at these stations can therefore be considered as natural, however coming from a catchment area smaller than the natural one. The catchment area given in the table of catchment characteristics in Hydra II is the natural area. In the table of recommended reference data series (Appendix 1), the area change is therefore specified in km^2.

Some catchments were described as little or insignificantly regulated in the reports, often, however, lacking information about the type of regulation. The missing information was obtained by personal communication with the authors and the impact of these regulations was evaluated for the different water levels. Usability categories were assigned, but in general it was decided to keep all of the catchments in the list of potential reference stations. Catchments not reported as regulated but with minor water abstractions, e.g. for local drinking water supply, are documented, were evaluated by the same approach. Also catchments with so called mini- or micro-power-stations are usually registered in Hydra II as unregulated. These power stations operate only with the naturally available water in a river at any time without retaining or abstracting any water. The streamflow at stations further downstream is considered as unregulated and meeting the requirements of a reference series.

3. Record length

Due to the natural multi-year and decadal variability in the climate system, climate change related studies and studies of trends should in general use records with at least 30 years of data. Here, also series with 20 and more years (until 2011) of good quality data are listed in the HRD, as these series have the potential to soon reach at least 30 years with data. It is therefore important that data collection at the respective stations is maintained and that high quality of the data is ensured. The selection of stations with long enough series was made based on the time period with good data quality series rather than on the complete record length. However, series with shorter periods of missing data are included in the reference dataset. Longer periods of missing data (>1 year) are accepted only for stations with very long records or when there are few stations with good data records in the region. Figure 1 shows the data completeness per year for all selected reference stations.

Three stations with relatively short data records (since the late 1970s) and several years of missing data are not finally excluded from the list of reference series, as they all belong to the same river system, the Skienvassdraget, and there are few other stations in the area. These three stations are: 16.127 Viertjern, 16.128 Austbygdåi and 16.193 Hørte.

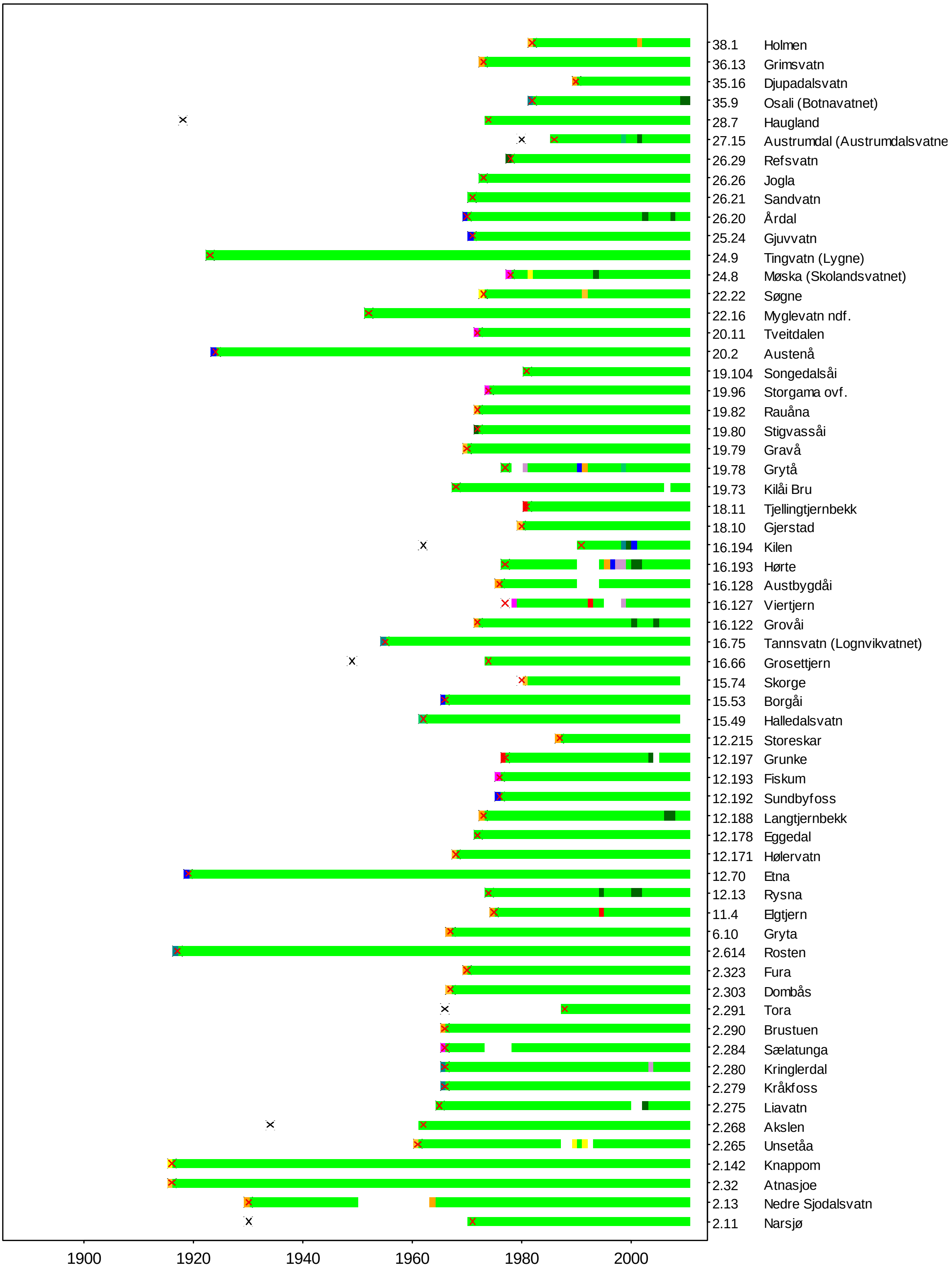

Figure 1 Annual data completeness for all series in the final reference dataset for streamflow.

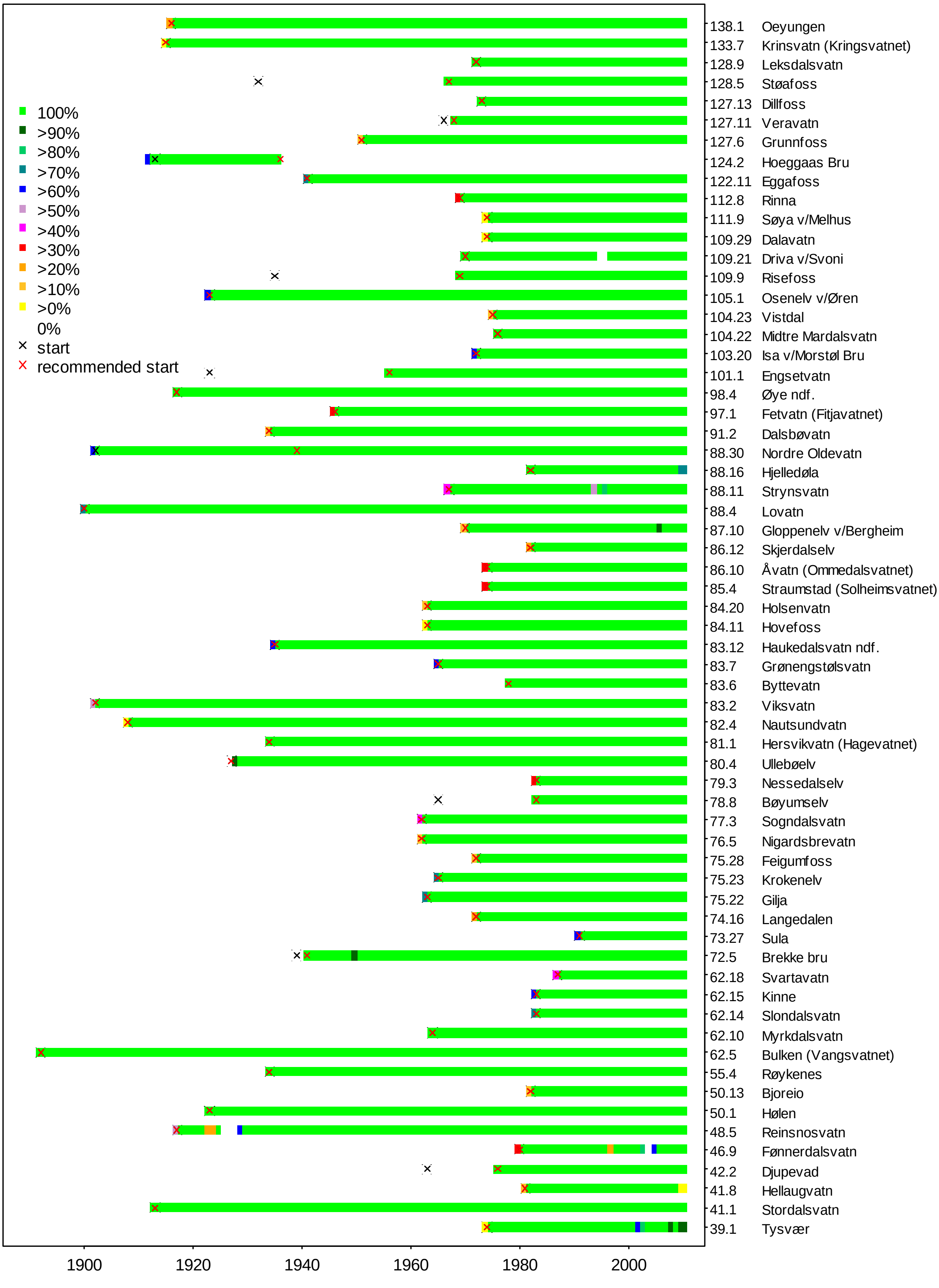

Figure 1 continued.

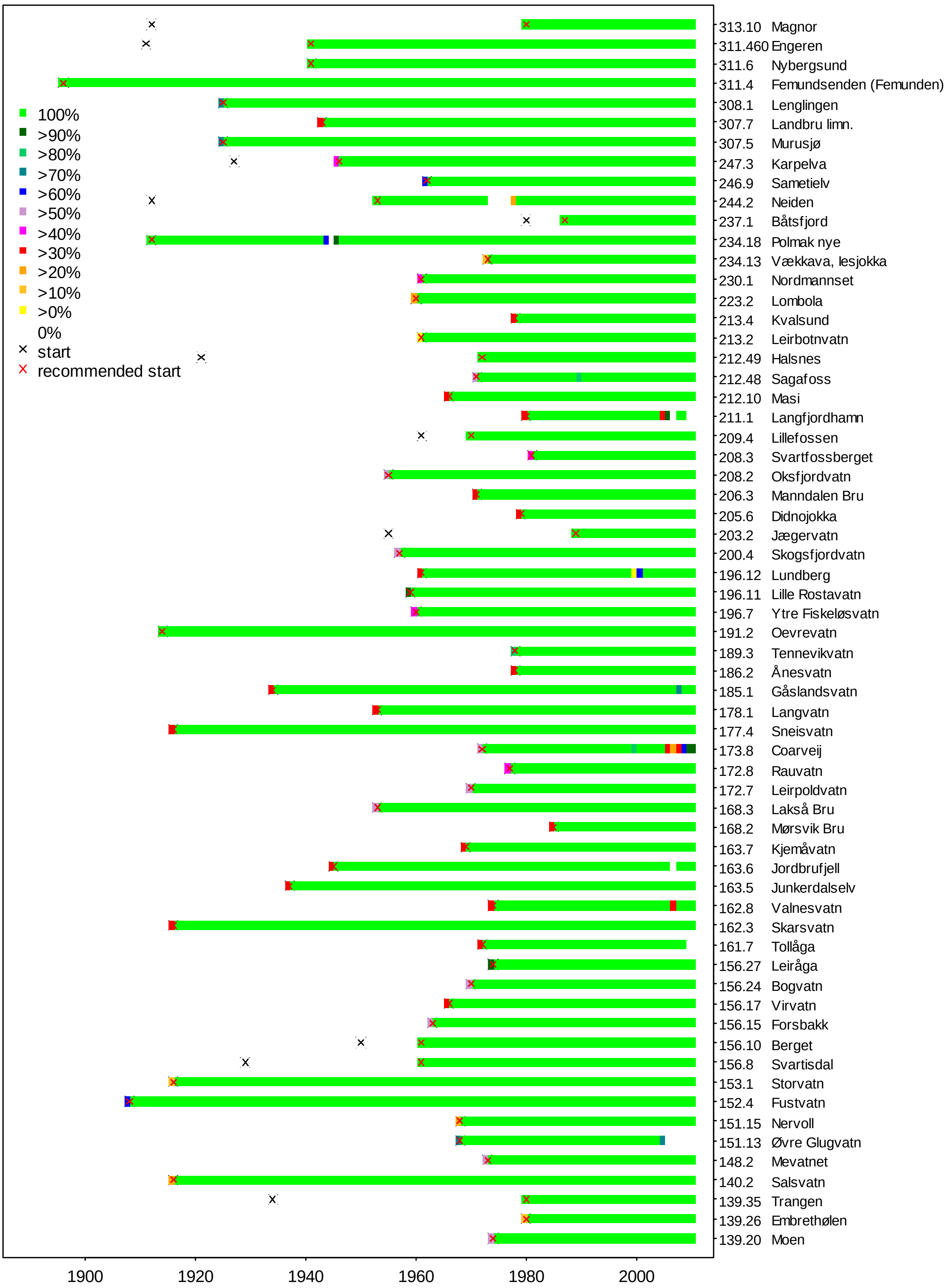

Figure 1 continued.

4. Active data collection

All stations that are currently active (2012) are considered as potential reference stations. Two stations (68.1 Kløvtveitvatn, 111.8 Ålvundelva) had to be excluded from the list, as they are not operating anymore.

5. Data accuracy

Information about data accuracy was obtained from the station comments in Hydra II and personal communication. Comments about the data quality were also found in the stored information about the rating curve quality and in a report about homogeneity tests (Astrup, 2000). Furthermore, the data quality was checked by an explorative analysis. Special focus was given to the periods where an inhomogeneity had been found by Astrup (2000) as well as on the periods when a station had been moved or the series had been extended, as indicated by a new version number for the time series.

The reports and station comments contained information about general data quality, changes in the riverbed profile, river-ice and possible ice jams during winter, difficult measuring conditions in general or during summer due to vegetation and particularly high uncertainty in the rating curve due to few streamflow measurements. The written comments are subjective as is the interpretation of them to assess the consequences on data quality. The amount of detail in the available information varies between stations and there is no guarantee of completeness.

A statistical quality analysis of the rating curves exist for the rating curves established during the last years. As such, this information is only available for some series and rating curve periods. Excluding streamflow series from the list of potential reference series based on this information would therefore be misleading, because the rating curve quality of most of the series remaining in the list would still be unknown. For most of the series the rating curve quality also varies from low to high flows and between periods. Therefore only the written comments from this analysis are considered, e.g. when they refer to changes in the riverbed profile or other reasons for reduced data quality.

Series with reported changes in the riverbed profile have either been excluded as a whole, if the profile changes take place slowly over a longer time period, or a new starting date is recommended if the change is related to one particular event and the profile can be considered stable after that. Series with difficult measuring conditions due to vegetation should not be used for low flow studies. For series with river-ice during winter, the winter low flows cannot be used. In none of the series ice jams were found to cause high flows that could disturb flood studies.

The homogeneity test was performed in 2000 with series having at least 15 years of data during the period 1961 – 1990. This means that not all the stations were tested. Series with identified homogeneity breaks were excluded only, if:

- the inhomogeneity could be attributed to a known change in the catchment or events causing insufficient data quality;
- the inhomogeneity is clearly visible in the series of daily or annual mean values or in the annual minimum or maximum series and cannot be explained by climatic changes or glacier extension or decline.

Hence, series with suggested homogeneity breaks that could not be explained or were visible in the exploratory data analysis were included in the list of potential reference series. Series with non-accepted inhomogeneities were either excluded completely or a shorter time period was recommend as reference series, depending on the kind of inhomogeneity.

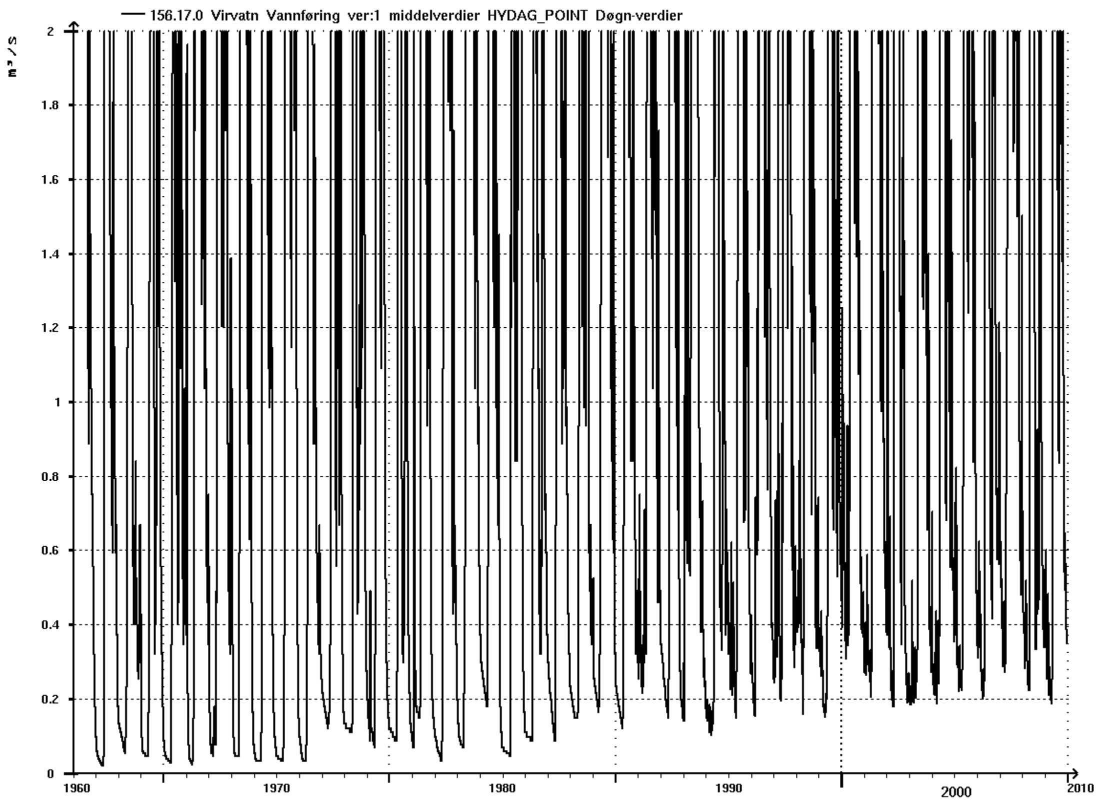

Figure 2 The low flow part of the daily streamflow series at 156.17 Virvatn (1966 – 2010).

If the explorative analysis revealed possible errors, the usability categories of the respective series were further adjusted. For instance, for the station 156.17 Virvatn no homogeneity break was identified by Astrup (2000), however, the explorative analysis suggested an inhomogeneity in the low flow values around 1990 (Figure 2). As Virvatn has winter low flow, the change could be due to warmer winters. It is quite likely, however, that the change is caused by varying praxis in correcting for river-ice. This series is therefore categorized as not being usable for studies of winter low flow. Also, for the streamflow series at 62.10 Myrkdalsvatn, no homogeneity break had been identified. The commonly used data series, version 0, is, however, a combination of two series. During the period where the two series overlap, in 1971, they have different streamflow values, in particular for high flows (Figure 3). It is therefore recommended only to use data of the newer series (since 1971) for flood studies. For other studies, the complete data record is considered acceptable.

In general, there is a higher uncertainty related to the streamflow data of earlier periods, e.g. due to manual water level measurement once a day as opposed to automatically registering loggers used today. Both measurement types are considered to represent the daily mean. However, the deviations between measurements once a day and an automatically registered daily mean can vary considerably. Most of the streamflow stations were equipped with automatic measuring devices during the early 1960s. Around 1980 all stations were recording continuously. Higher uncertainty in older streamflow data is also introduced by the higher uncertainty in older rating curves. This increase in uncertainty with record length extending further back in time is, however, no reason for excluding earlier series from the HRD, because long data series are particularly valuable for long term climate change studies. However, it is important to be aware of possible inconsistencies.

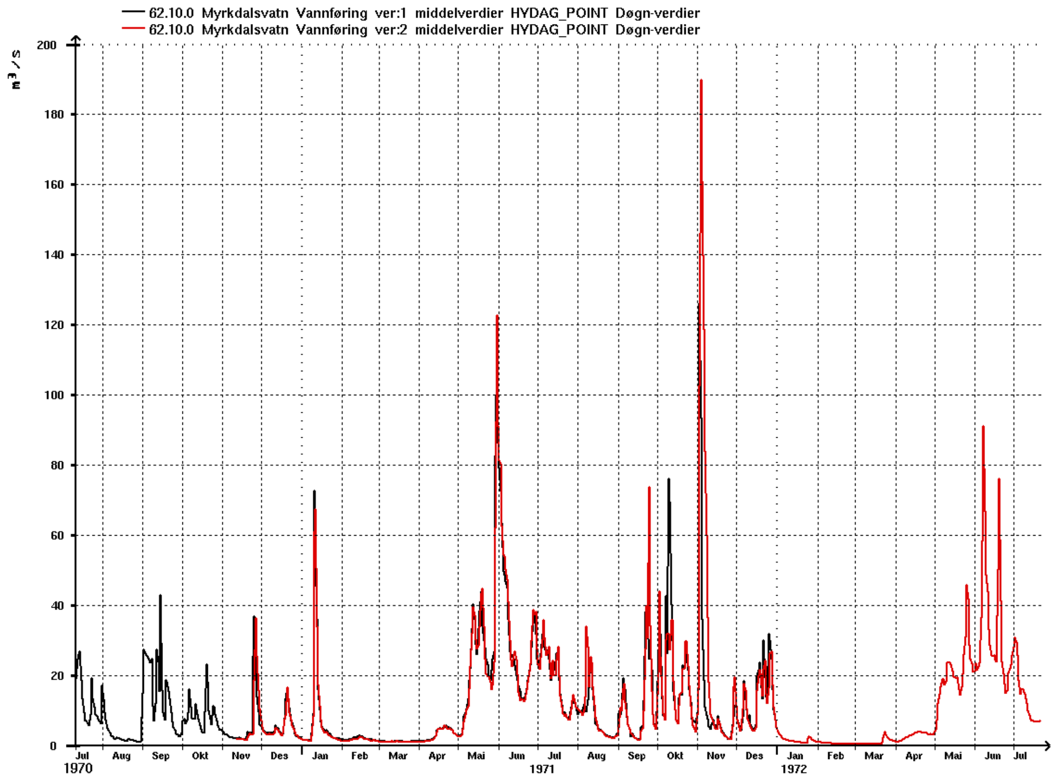

Figure 3 Streamflow series at 62.10 Myrkdalsvatn during the period of series extension (1970 –1972).

<u>6. Adequate metadata</u>

Valuable metadata include both catchment characteristics and background information about the complete record history, anthropogenic disturbances in the catchment and special events. All of these are also deemed relevant and valuable by Whitfield et al. (2012). The metadata available vary considerably between stations and periods and is not found in one source. The metadata covering catchment characteristics is, however, excellent. Included are information about station and catchment location, elevation (the hypsographic curve), area, catchment and river length and gradient as well as land cover (see above). What is missing is information about *changes* in the land cover.

Hydra II contains information about how the stations have been operated, including instrumentation, measurement location (river / lake) and profile (natural / artificial), control streamflow measurements, rating curves etc. However, not everything is stored in the same place and is easy to find for the user. For instance, in case a station has been moved or replaced by a new one, all of the control streamflow measurements from both stations are registered under the newest station without specifying where the single measurements were taken. The rating curves and instrumentation history, on the other hand, are registered under the station, where they actually have been used. In particular for the discontinued stations, information can also be missing.

The station description in Hydra II further specifies station type (i.e. the purpose for streamflow observations and that location), which other variables are measured at the station and what the data series are applied for. The application areas of the streamflow series is currently updated in the ongoing station network project mentioned above.

Relevant information is also available through personal communication and in reports. This is particularly the case for information about special events or varying catchment area, e.g. due the varying extension of glaciers or a lake with two outlets in the catchment. Whenever such information was found this has been included in the list of reference stations in Appendix 1.

3.2 Soil moisture

3.2.1 Available data

The existing soil moisture monitoring network at NVE includes 18 stations. In addition to groundwater monitoring, soil moisture at different depths is routinely measured.

Soil moisture potential (kPa) at every 15 cm depth, down to around 1 m, is measured with soil water resistance blocks (Watermark sensors, Irrometer Co, Riverside, California). The measurement range is from -20 kPa to -200 kPa. The sensors are mostly used for evaluation of soil frost depth and not soil water content. Therefore the measurements are discarded from the reference dataset.

Soil moisture is measured at the following depths: 0-10, 10-20, 20-30, 30-40, 40-60 and 60-100 cm with a PR2 Profile Probe from Delta-T mounted in an access tube. Measurement accuracy with soil calibration is ± 0.04 m^3/m^3. It is an indirect measurement of the soil moisture content by measuring the permittivity of the soil (Frequency domain reflectometry). The series are less than 10 years and a proper site calibration has to be performed before the data can be used as a reference dataset.

3.3 Groundwater

3.3.1 Available data

All daily groundwater series stored in NVE’s Hydra II database classified as active were chosen as basis for the selection of reference stations, totally 63 stations.

3.3.2 Selection of groundwater stations

The criteria for HRNs presented in Chapter 2 are adjusted for groundwater and commented shortly below

Criteria groundwater stations:

1. Stable land use conditions including absence of significant regulations, diversions or water use. Includes both natural and agricultural sites.

2. Record length. Minimum 20 years in total and more than 10 years of daily groundwater measurements.
   This length ensures that underrepresented climatic or geographic areas, which are characterized by minimal data availability, are also included. However, record lengths should also be as long as possible to allow decadal variability to be distinguished from long-term trends; due to multi-decadal oscillations in groundwater depth.

3. Active data collection. Currently active and is expected to continue operation;

4. Data accuracy. Good quality data.

5. Adequate metadata. Adequate metadata should be available to support the previous five conditions.

According to the evaluation of the Norwegian data, the groundwater data series were categorized into the following usability categories:

A series can be used for all kind of climate change related studies (comments for groundwater in bold):

1. *based on daily data (since...),*
2. *based on weekly or monthly data (from – to), but not for* ***max or min groundwater levels***

1. <u>Degree of basin development</u>

The main land cover unit according to the European Environment Agency (EEA) “Coordination of information on the environment”-programme (CORINE) are included in the metadata. For Norway, maps for 2000 and 2006 are published by The Norwegian Forest and Landscape Institute, UMB. Comparison of changes now and in the future will therefore be possible. Data from 2006 are given for the site of the groundwater measurement in the metadata. Descriptions of the classes are shown in Table 1.

Table 1 CORINE Land Units for groundwater measurement sites.

CORINE Land Unit	Label 1	Label 2	Label 3	Number of stations
112	Artificial surfaces	Urban fabric	Discontinuous urban fabric	3
211	Agricultural areas	Arable land	Non-irrigated arable land	8
243	Agricultural areas	Heterogeneous agricultural areas	Land principally occupied by agriculture, with significant areas of natural vegetation	9
311	Forest and semi natural areas	Forests	Broad-leaved forest	10
312	Forest and semi natural areas	Forests	Coniferous forest	20
313	Forest and semi natural areas	Forests	Mixed forest	3
322	Forest and semi natural areas	Scrub and/or herbaceous vegetation associations	Moors and heath land	3
333	Forest and semi natural areas	Open spaces with little or no vegetation	Sparsely vegetated areas	2
412	Wetlands	Inland wetlands	Peat bogs	2
	Sum			60

It was decided to exclude stations from the list of potential reference stations if they fall in Land Unit 112 and 412.

2. Absence of significant regulations, diversions, or water use

Stations on agricultural land are insignificantly influenced and probably small changes in water use can be expected in the future. Forest and woodcutting will affect water use more. Increased elevation of the timber line will also change the water use.

3. Record length

Due to the natural multi-year and decadal variability in the climate system, climate change related studies and studies on trends should in general use records with at least 30 years of data. Here, also series with a minimum of 20 years (until 2012) of good quality data are listed in the HRD, as these series have the potential to soon be at least 30 years long. It is therefore important that data collection at the respective stations is maintained and that high quality of the data is ensured. The selection of stations was made based on the time period with good data quality rather than on the complete record length. However, series with shorter periods of missing data are included in the reference dataset. Longer periods of missing data (>1 year) are accepted only for stations with very long records or when there are few stations with good data records in the region.

Users of the reference dataset are advised to use a subset of the dataset according to the required record length.

4. Active data collection

All stations which currently are active (2012) are considered as potential reference stations. However, several stations were lacking data or quality controlled data for the most recent period. For most of these, the lacking data could easily be retrieved.

5. Data accuracy

The data quality was checked by an explorative graphical analysis. Special focus was given to the periods for which an inhomogeneity seems to occur, periods of changes in measurement frequency and method, and peaks which look unnatural.

The reports and station comments contained information about general data quality and changes in the measurement equipment (manual → automatic) or change of groundwater pipe. The amount of detail in the available information varies between stations and there is no guarantee of completeness. It is for instance rarely commented on good data quality. Some series have occurrence of ice in the groundwater pipe during winter. These stations should not be used to evaluate changes in the winter climate.

If the explorative analysis revealed possible errors, the usability categories of the respective series were further evaluated. This was performed by a visual graphical check of estimated recharge and groundwater response (rain and snowmelt) from a conceptual precipitation-runoff model (HBV-model, 1x1 km^2 grid).

In general, there is a higher uncertainty related to peak groundwater measurements in earlier periods, e.g. due to manual measurement weekly or monthly as opposed to the automatically registering loggers used today. Most of the groundwater stations were equipped with automatic measuring devices around 2000. From 2012 all stations were recording continuously.

6. Adequate metadata

Hydra II contains metadata about how the stations have been operated, including instrumentation, measurement location and elevation and control measurements. The station description in Hydra II further specifies station type and other variables measured at the station.

3.4 Snow

3.4.1 Available data

Snow water equivalent (*SWE*) has been recorded by the hydropower companies since 1914, with the aim to obtain information about available water resources for hydropower production and to estimate the risk of flooding. This data (hereinafter referred as HPC-data) is managed by NVE and contains over 40000 measurements of snow depth and density (*SWE* = snow depth · density) from over 1300 stations. Most of the measurements are taken at the time of the annual snow maximum around the beginning of April. However, only a handful of stations have continuous data since the 1920s.

The measurements in the HPC-data are normally based on a snow course (~1 km) or a point swarm. Common for all measurements is that a "station" is a fixed coordinate along the snow course/in the point swarm, and that the reported *SWE* at the station is a mean of several snow depth measurements, combined with one or more density measurements.

The HPC-data set has recently been used to analyze long-term trends in snow depth (Dyrrdal et al., 2013) and snow water equivalent (Skaugen et al., 2012) in Norway, as well as to evaluate the seNorge snow model simulating snow maps for Norway (Saloranta, 2012).

In addition to the extensive HPC-data set, NVE has recorded time series from over 30 snow pillows around Norway measuring *SWE* directly by weighing the snow pack over the snow pillow. Some of these time series date back to 1967, but many of the snow pillow stations were established 10-15 years ago. NVE also operates a few snow courses, but the length of these time series is still relatively short (except for the Atna snow course dating back to the 1980s).

In the following, we focus on selecting representative time series of the HPC-data for the climate reference data set. We also briefly mention reference station candidates from the NVEs snow pillow and snow course data archives.

3.4.2 Selection of snow stations

The following criteria were used to select a subset of the HPC-stations for the climate reference data set:

1. Observations taken at the approximate time of the annual snow maximum. This time window was selected to be 15. March - 15. April.

2. Continuous time series of at least 20 annual observations (by "continuous" we mean that missing data gaps of up to three years are tolerated).

3. The continuous time series must end within the last three years (2009-2011). Note that newer measurements, i.e. 2012, are not yet included in the analyzed data set.

In total 68 stations passed these selection criteria. All these stations are situated in southern Norway, and as Figure 9 shows, many are clustered to certain areas. Therefore, additional binning of the data was done in order to find out how many different station regions and elevation classes that were included. Figure 9 shows the visually selected horizontal bin limits. The elevation bin limits were selected every 300 m from 0 to 1800 m a.s.l.

This simple bin-analysis showed that 12 different station bins could be distinguished from the HPC-stations passing the above selection criteria. Figure 9 shows the location of the horizontal bins, as well as the elevation classes of the stations in these bins. Table 6 lists the station numbers and other information about the 68 selected stations. The number of stations in each bin varies from 1 to 18 (see Table 6).

Other issues, which can be important selection criteria e.g. regarding streamflow data (such as basin development, significant water regulation and flow levels) are not relevant for the selection of the snow stations.

3.5 Glaciers

The glacier series we considered for this report were mass balance and length change observations. Whereas the mass balance reflects annual weather directly, records of length change (also termed front-position change) are considered as proxies for climate change on a decadal-to-century time scale (Oerlemans, 2005).

3.5.1 Available data

We used criteria 3 (record length) and 4 (active data collection) as a first criteria for selecting the possible reference stations for glaciers. Thus, all annual glacier mass balance and length change series stored in NVE's Hydra II database that are longer than 20 years and classified as active were chosen as basis for the selection of reference stations. Overviews of all the monitored glaciers as well as description of methods are found in Andreassen et al. (2005) with updates in Kjøllmoen et al. (2011).

Mass balance

NVE's glacier surface mass-balance series contain annual (net), winter and summer balances. The annual balance is the sum of winter balance and summer balance. Area-averaged values for winter and summer balances are calculated by inter- and extrapolating point measurements of snow density, snow depths and ablation. In 2012 mass balance are measured at 16 glaciers. Ten glaciers have been measured for 20 years or longer and were used as basis for the selection for reference stations (Table 2).

Table 2 Long term mass-balance glaciers in Norway being active today and with series longer than 20 years. H-ID refers to ID in NVE's database Hydra II. Atlas-ID refers to ID in the glacier inventory of Norway (Andreassen et al., 2012b).

H-id	A-ID	Name	Period
2084	54	Langfjordjøkelen	1989-93, 1996-
1220	1135	Engabreen	1970-
543	2085	Ålfotbreen	1963-
545	2145	Hansebreen	1986-
413	2301	Nigardsbreen	1962-
425	2480	Austdalsbreen	1988-
115	2638	Storbreen	1949-
68	2743	Gråsubreen	1962-
81	2768	Hellstugubreen	1962-
279	2968	Rembesdalskåka	1963-

Length change

Glacier length change is derived from annual, repeated measurements of distance between the glacier terminus and fixed landmarks. In 2012 length change are measured at about 30 glaciers. Totally 12 glaciers have been measured for the past 20 years or longer and were used as basis for the selection for reference stations (Table 3). It should be noted that length change must not be measured every year to have a continuous series such as mass balance. If one year is missing one get a length change of two years instead of one, thus losing the annual signal, but keeping the cumulative signal.

Table 3 Long term length-change glaciers in Norway being active today and with series longer than 20 years. H-ID refers to ID in NVE's database Hydra III. Atlas-ID refers to ID in the glacier inventory of Norway (Andreassen et al., 2012b).

H-ID	Atlas-ID	Name	Period
1220	1135	Engabreen	1903-
414	2297	Fåbergstølsbreen	1899-
413	2301	Nigardsbreen	1899-
612	2320	Briksdalsbreen	1900-
512	2349	Austerdalsbreen	1905-20, 1933-
464	2474	Supphellebreen	1899-1958, 1977-83, 1992-
420	2480	Stigaholtbreen	1903-
115	2636	Storbreen	1902-
121	2638	Leirbreen	1909-
375	2680	Styggedalsbreen	1901-
81	2768	Hellstugubreen	1901-
200	2964	Midtdalsbreen	1982-

3.5.2 Selection of glacier stations

When selecting reference glaciers the general criteria listed in chapter 2 were considered. Criteria 3 (record length) and 4 (active data collection) were already used to select the available glaciers for the reference dataset. Below we briefly discuss the criteria for the mass balance and length change glaciers.

1. Degree of basin development

We have not considered this criterion for the glacier measurements, as it is not considered relevant for the glacier mass balance and length change studies.

2. Absence of significant regulations, diversions, or water use

Mass balance: One glacier in the sample, Austdalsbreen (Figure 4), is calving into a regulated lake. Part of the ablation is formed by calving from the glacier (3-18% of the summer balance). Since the mass balance of this glacier is influenced to some extent by this regulation, this glacier should not be used as reference station.

Figure 4 Austdalsbreen is calving into the regulated lake Austdalsvatnet, which has been part of the hydropower reservoir Styggevatnet since 1988. Photo: Hallgeir Elvehøy, October 2011.

Length change: None of the glaciers are directly influenced by regulations or water use**.**

3. Record length

Mass balance: All series are continuous, except Langfjordjøkelen where data were not measured for two years (1994, 1995). Modelled data using climate data as input are available to fill the gap for this glacier, but they will be dependent on climate data that cannot be assured to be completely representative (e.g. Kjøllmoen and Olsen, 2002: Andreassen et al., 2012a). All data series are longer than 30 years, except Langfjordjøkelen and Austdalsbreen where the number of observed years up to and including 2012 are 22 and 25, respectively. Engabreen has 43 years of observations, whereas the 7 other glaciers have more than 50 years of observations. The longest series is Storbreen having 64 years of continuous measurements. According to the record length all glaciers from our sample should be included.

Length change: Length change measurements were initiated around 1900 at many glaciers in Norway. The size of the monitoring programme has varied according to levels of funding and dedication. Eleven glaciers have a relatively continuous record since initiation around 1900. In addition, we also include Midtdalsbreen where measurements began in 1982. A complete record of annual measurements exists from Briksdalsbreen. According to the record length all glaciers from our sample should be included.

4. Active data collection

All glaciers presented in Table 2 and 3 are active stations measured today. We have no information on planned termination of any of the mass balance or length change series. It might of course occur that a glacier is no longer suited for length change measurements, such as for Bergesetbreen where the lower tongue became completely separated from the rest of the glacier in 2006. The new, active terminus was inaccessible for glacier length observations and the last year of observation was 2006. This glacier was not included in our selection due to too short record length.

5. Data accuracy

Mass balance: The accuracy of mass-balance measurements depends on both the accuracy of the point observations and the inter- and extrapolation of point values to spatially distributed values. Systematic errors may cause large cumulative errors in long term mass balance series.

To control the results of the direct mass balance observations, cumulative balance can be calculated from glacier surface elevations measured in different years by differencing digital terrain models (DTMs) and by converting the volume change to mass using density estimate, this is called the *geodetic method*. Since 2008 all the mass-balance glaciers in Table 2 have been mapped by highly accurate airborne laser scanning. The collected data are now compared with previous maps of surface elevations to calculate geodetic mass balance and to compare this with the cumulative measured mass balance. Preliminary results reveal larger discrepancies between the methods for four of the glaciers: Nigardsbreen, Ålfotbreen, Hansebreen and Engabreen, whereas the other glaciers have better or acceptable agreement (e.g. Andreassen et al., 2012a). The results of these analyses will be used to correct and revise the direct measurements where necessary.

Long series of measurements will seldom be perfectly homogeneous because of changes in personnel and procedure, and as there will be changes in glacier area (and elevation) when averaging the data (Braithwaite, 2002). To isolate the effects of climate from the effects of changing glacier topography one can create reference-surface mass-balance series (Elsberg et al., 2001). All the mass-balance glaciers referred to here have multiple maps which have been used in the calculations; they are thus not based on reference surface topography, so care must be taken when using long mass-balance series for extracting a climate signal.

It might be worthwhile to calculate (or if already available use such) reference-surface mass-balance series for climate studies, especially when changes in glacier geometry are large over the studied period.

Length change: The accuracy of the distance meter should be within 1-2 m. However, where access was limited or dangerous or line of sight has been changed, the accuracy could be considerably poorer. In general, glaciers have different response times because of different steepness, length, and mass balance gradients. Glacier retreat can also be enhanced significantly when calving into a lake. Monitoring a number of glaciers in an area is useful for filtering the influence of different glacier dynamics and geometries, and local meteorological conditions. Just using one glacier for extracting a climate change signal is not recommended.

6. Adequate metadata

All mass balance and length change data are stored in NVEs database Hydra II and published annually or biannually since 1963 in the report series ‘Glaciological investigations in Norway’ (e.g., Kjøllmoen, 2011).The data are also reported to the World Glacier Monitoring Service and published in their series Fluctuations of Glaciers (e.g., WGMS, 2008) and Glacier Mass Balance Bulletin (e.g., WGMS, 2011). Although the reporting might be less detailed for some years/periods and some glaciers, the available metadata is found to be satisfactory for using the glaciers as reference stations.

3.6 Lake and river ice

3.6.1 Available data

Available data on ice conditions in NVEs Hydra II database are freeze-up and break-up dates code=5100, ice thickness code=1005, ice map code=5101 and ice notes code=5102. Only active stations with code=5100 (lake ice 23 stations and river ice 3 stations) will be considered in this report. Data for the other codes are sparse and sporadic in Hydra II.

3.6.2 Selection of lake and river stations

When selecting reference stations the general criteria in chapter 2 were considered. Criteria 2 (Absence of significant regulation that could affect freeze-up and break-up dates) 3 (record length) and 4 (active data collection) were used to select the available reference dataset for ice duration. According to the evaluation of the Norwegian data, the ice duration series were categorized into the following two usability categories:

A series can be used for all kind of climate change related studies:

1. *based on freeze-up, break-up data*
2. *based on season (ice duration) data,*

<u>1. Absence of significant regulations, diversions, or water use</u>

The 23 (lake) and 3 (river) potential reference stations are classified as “unregulated” or regulated rivers or lakes with insignificant or small impact on freeze-up and break-up dates. Personal contact with the responsible group leader and people at NVE with long experience in using the ice data, helped to clarify most of the uncertainties. Further background information was obtained from previous reports on NVE’s network of hydrological stations in Norway (Pettersson, 2003) and the station comments. The effect of regulations is assumed to decrease when the distance increase between ice station and point where water are transferred or added to the river/lake or lakes. However, the degree of detail in this available information varies between stations, and it is likely that not all intervening activity is documented, in particular not older ones.

<u>2. Record length</u>

Due to the natural multi-year and decadal variability in the climate system, climate change related studies and studies on trends should in general use records with at least 20 years of data.

The selection of stations with sufficiently long series was made based on the time period with expected good data quality rather than on the complete record. Series with short periods of missing data are included in the reference dataset. Long periods of missing data (>1 year) are accepted only if there are few stations with good quality records in the region or for stations where it is possibility to fill in missing data.

3. Active data collection

All stations which are currently active (2011) are considered as potential reference stations. However, several stations were lacking data or quality control in recent years.

3.7 River and lake temperature

3.7.1 Available data

All daily or sub daily river water temperature series stored in NVEs Hydra II database that are classified as active and unregulated (85 stations) or regulated rivers with insignificant impact on water temperature (18 stations) or regulated with small effect on water temperature (53 stations) were chosen as basis for the selection of reference station.

Similarly were all lake water temperature profiles in NVEs Hydra II database that are classified as active and not considered effected by regulations chosen as basis for selection of reference station (73 stations)

River water temperature

River water temperature before 1982-85 has been monitored by manual measurements mostly at a daily basis. Gradually, manual measurements have been replaced by automatic loggers, recording 4–12 times a day, most frequently in recent years as the logger memory has increased. If the loggers were deployed on the bottom, a bias towards more groundwater dominance on stream temperatures could be expected. However, all loggers were located in relatively shallow and turbulent rapids where significant temperature layering is unlikely. Also, great care was taken to avoid locations where the logger could be stranded during low flows, buried by bedload transport or embedded in ice during winter. However, such problems were not completely eliminated.

Lake water temperature

Lake water temperatures have been measured for most lakes twice a year. The temperature measurements consist of vertical lake temperature profiles where measurements are carried out at 1 m interval down to 10 m, at 2 m interval between 10 and 20 m, at 25 and 30 m depth, and for every 10 m deeper than 30 m to a maximum of 100 m (or to the bottom if the lakes are shallower). The first measurement was taken close to the temperature minimum, when most lakes were ice covered (February–May), the other around the temperature maximum in August/early September. In most years, and for most lakes the measurement site was located where the lake is deepest, but not all measurements were carried out to this depth due to difficulties in locating the exact position. However, in later years, GPS technology has significantly eased the task of finding the same location every year.

3.7.2 Selection of river and lake temperature stations

When selecting reference stations the general criteria in chapter 2 were considered. Criteria 2 (Absence of significant regulation that could affect water temperature) 3 (record length) and 4 (active data collection) were used to select the available reference dataset for water temperature. According to the evaluation of the Norwegian data, the river water temperature series were categorized into the following two usability categories:

A series can be used for all kind of climate change related studies:

1. *based on daily data (since...),*
2. *but not during winter (since only summer measurements have been carried out),*

For the lake water temperature series the date could only be used for climate change related studies

1. *based on maximum summer temperature and minimum winter temperature*

The resulting river and lake water temperature reference series are presented in Chapter 4.

<u>1. Absence of significant regulations, diversions, or water use</u>

The 156 (river) and 72 (lake) potential reference stations are classified as “unregulated” or regulated rivers or lakes with insignificant impact on water temperature or with small effect on water temperature in our water temperature logger scheme. Personal contact with the responsible group leader and people at NVE with long experience in using the water temperature series, helped to clarify most of the uncertainties. Further background information was obtained from previous reports about the network of hydrological stations in Norway (Pettersson, 2003) and the station comments. The effect of regulations is assumed to decrease when the distance increase between water temperature station and point where water are transferred or added to the river/stream or lakes. However, the degree of detail in this available information varies between stations, and it is likely that not all intervening activity is documented, in particular not older ones.

In some rivers the documented water transfers are constant, i.e. all water from a certain part of the natural catchment is permanently transferred into a neighbouring catchment. The water flow in the remaining part can therefore be considered as natural, however, coming from a catchment area smaller than the natural one. In such cases the water temperature series after regulation could be used.

Catchments with so called mini- or micro-power-stations are usually registered in Hydra II as unregulated. These power stations operate only with the naturally available water in a river at any time without retaining or abstracting any water. The streamflow at stations further downstream is considered as unregulated but water temperature could be significant altered and thus not meeting the requirements of a reference series.

2. Record length

Due to the natural multi-year and decadal variability in the climate system, climate change related studies and studies on trends should in general use records with at least 30 years of data. Since most of the water temperature stations are shorter also series with 20 and more years (until 2011) of good quality data are listed in the HRD, as these series have the potential to soon reach at least 20 years with data.

The selection of stations with sufficiently long series was made based on the time period with good quality rather than on the complete record length. Series with shorter periods of missing data are included in the reference dataset. Longer periods of missing data (>1 year) are accepted only for stations when there are few stations in the region or for stations where it is possible to fill in missing data (by using other stations belonging to the same river system or stations situated under the same temperature conditions).

3. Active data collection

All stations which are currently active (2011) are considered as potential reference stations.

4 Final reference datasets

4.1 Streamflow

According to the criteria for the Hydrological Reference Dataset stations described in Chapter 2, 188 of the 249 active and unregulated streamflow stations in Norway are included in the HRD. The types of analyses are limited for some of the series as specified by the assigned usability categories. 128 series have at least 30 years of data and no restrictions. The complete streamflow RD including usability categories and data quality comments is presented in Section 4.1.1 and listed in Appendix 1. The spatial coverage of the dataset across Norway is shown in Section 4.1.2, and in Section 4.1.3 the diversity in catchment characteristics in the dataset is described. Sections 4.1.2 and 4.1.3 includes a description of how the selected streamflow RD meets the demands of a HRD of being representative of a country's hydrological, physiographic and climatic variability.

The streamflow reference dataset includes only series applicable for climate variability and change related studies as specified by the usability categories. Users might want to use only a sub-set of the complete dataset for their studies based on specific criteria, such as record length and completeness or catchment characteristics. For instance, for many climate change related studies it might be sensible to analyse catchments with and without glaciers separately.

4.1.1 Reference series

The streamflow reference series are presented in the maps in Section 4.1.2 with their catchments (Figure 5), the assigned usability categories (shown as limitations of usability, Figure 6) and series length (Figure 7). The streamflow reference series are listed in Appendix 1. The table in Appendix 1 includes the following information:

Regine no	Regine number (River basin number)
Main no	Main number
Station name	Station name
Record start	Record start date
Reference series start	Start date of the series usable as reference series
Homogeneity break	Indicated breaks as identified by Astrup (2000), until 2000
Connection year	The junction year, if a data series has been extended with data from another/previous station.
Area change (km^2)	The change in area due to water transfer or a lake with several outlets. The change is given in km^2 with respect to the natural catchment area as specified in Hydra II, i.e. it is negative when water is transferred out of the natural catchment.
Varying area	1 catchment area varies between different flow amounts, e.g. in case of bifurcation or a lake in the catchment with two outlets; 2 catchment area varies slowly over time, e.g. due to glaciers; 3 catchment area changed at a certain point in time, e.g. due to a constant transfer of water; 23 catchment area varied slowly over time up to a certain point in time and is constant from then onwards, e.g. changes in glaciers do not influence that catchment anymore.
Usability categories	If the usability of a series is restricted, this is marked in the respective column with “x”. If the usability is restricted only for part of the data record, the year from where on the data can be used is given instead.
Comment	Information which is considered relevant for data quality.

4.1.2 Map

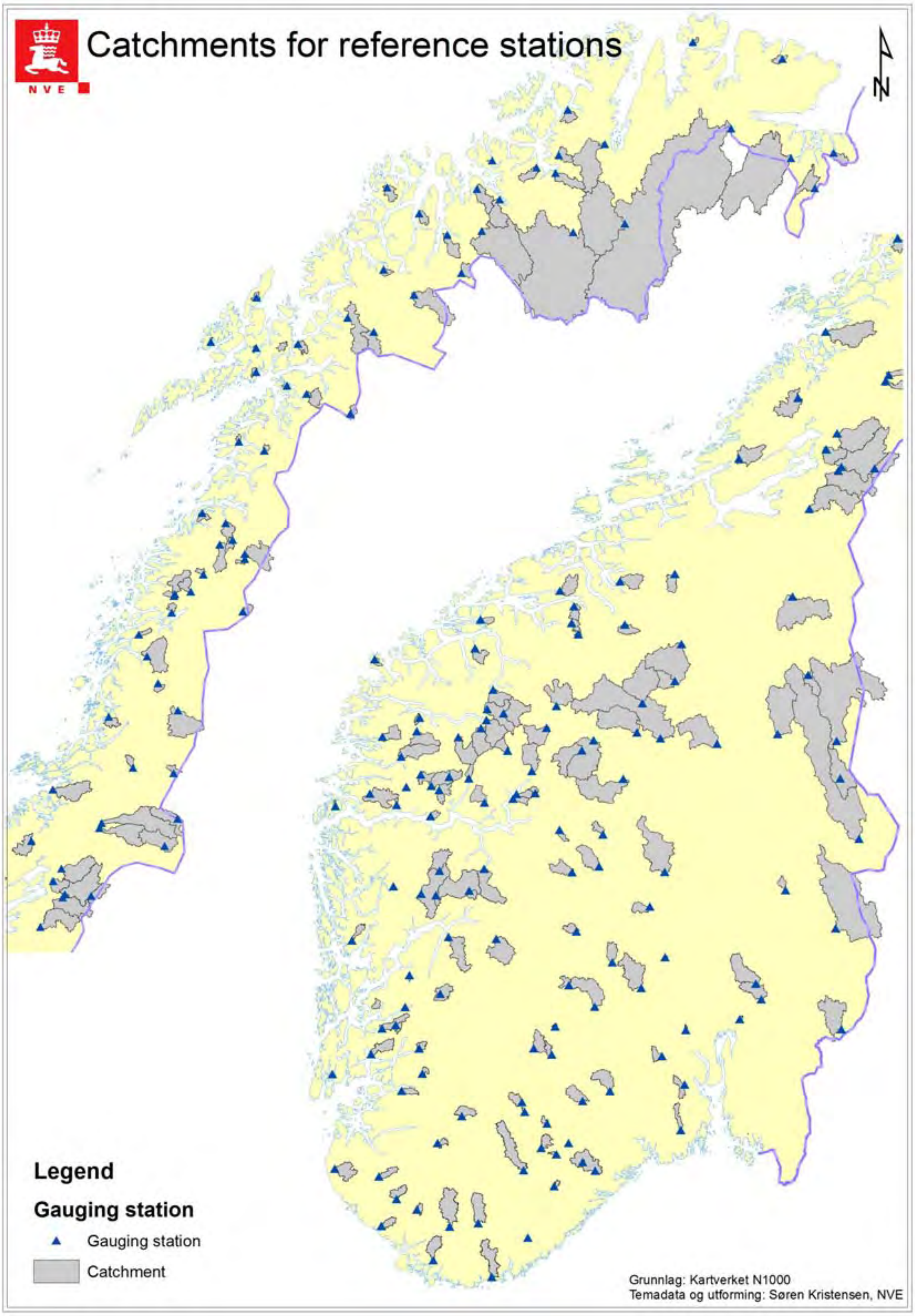

Figure 5 Streamflow stations and catchments in the reference dataset.

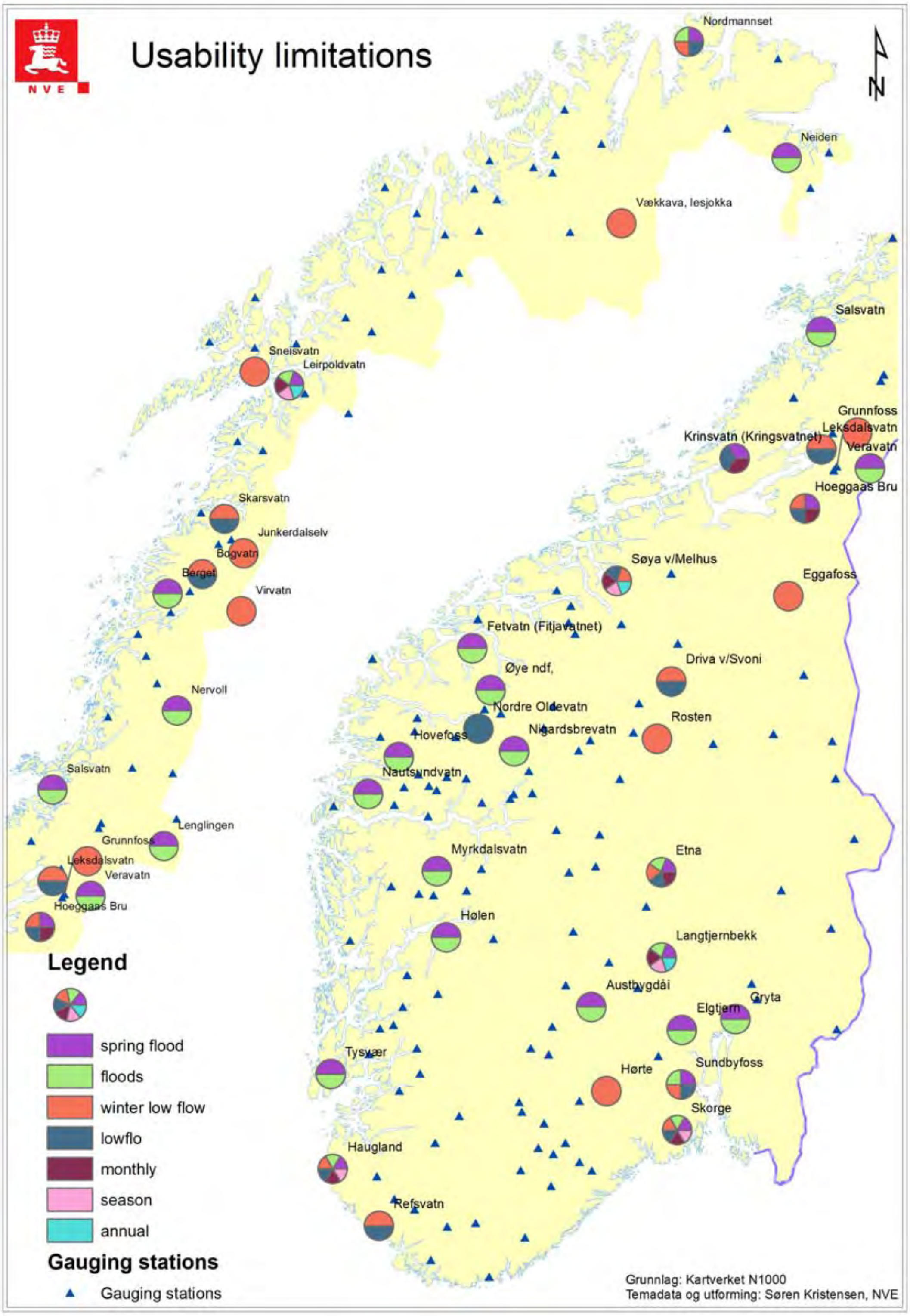

Figure 6 Streamflow reference stations showing for which kind of studies a series should not be used for.

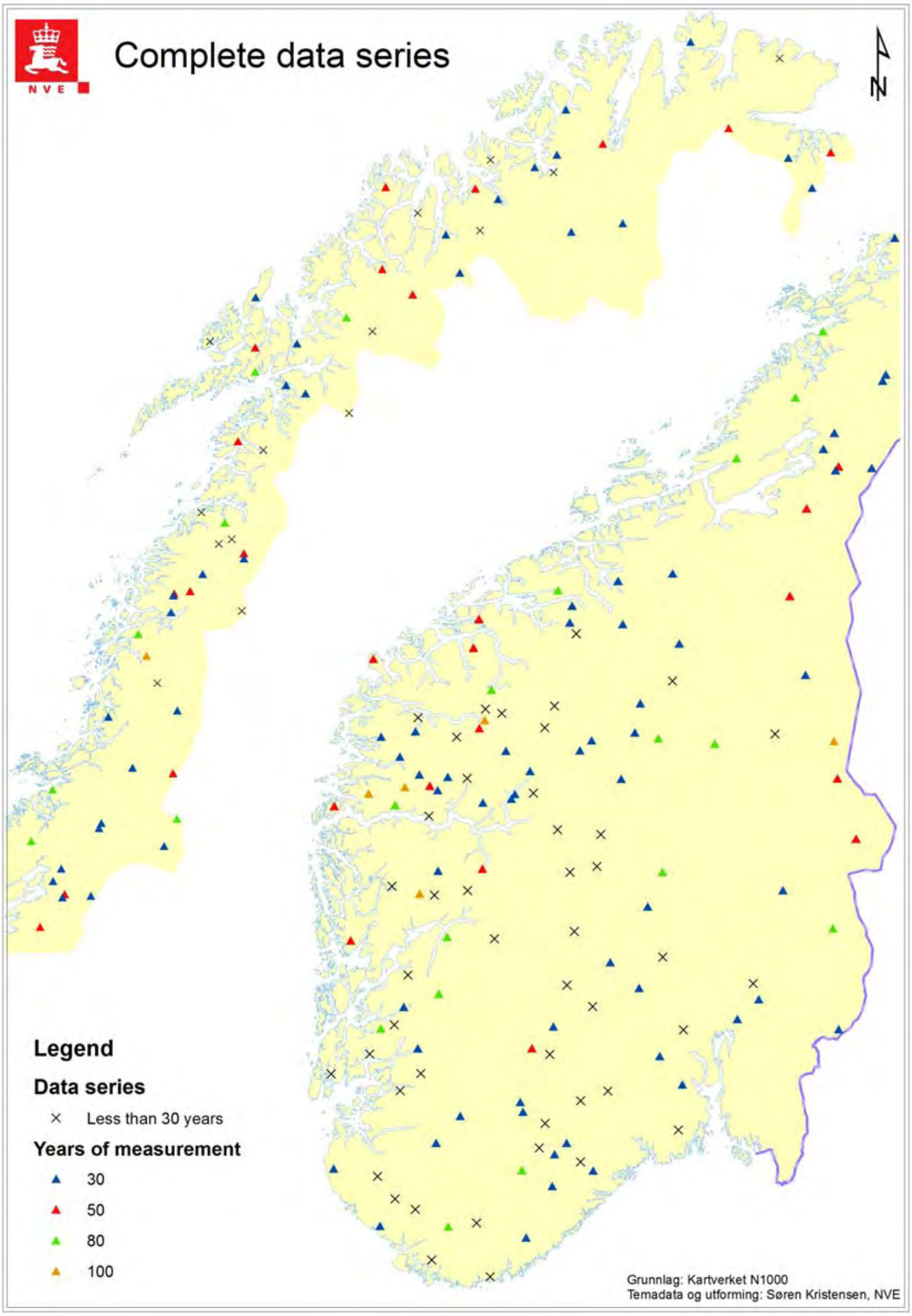

Figure 7 Streamflow stations in the reference dataset and record length of complete daily data until 2010.

4.1.3 Catchment characteristics

The stations included in the streamflow RD are distributed over the whole country (Figure 5-7). This ensures that the different climatic and hydrological regions of Norway are represented. However, the quality of the series in terms of record length, data completeness and usability varies. In particular, in the eastern part of southern Norway mostly shorter and incomplete or imperfect series are available. Most of the reference series are from small catchments (50% are <120 km^2 and 86% <500 km^2). This can be expected as most large catchments in Norway are affected by regulations. The largest catchments with reference series are all in located in northern Norway and along the Swedish border in the south-east. Most of the selected catchments are dominated by mountains or forest. Only four catchments are covered by more than 10% agricultural land and none has more than 1% of urban area. 19 catchments have more than 10% glacier cover, with up to 75% in 76.5 Nigardsbreevatn. The streamflow RD also covers catchments from different elevation zones, with station elevation varying from 0 to 1100 m a.s.l. and the maximum catchment elevation reaching up to 2462 m, which is almost as high as Galdhøpiggen (2469 m), the highest mountain in Norway.

4.2 Groundwater

Using the criteria for HRD stations described in Chapter 2 for the 63 active groundwater stations, resulted in a groundwater reference dataset (RD) including 28 series. All the series are longer than 20 years and 8 of the series have daily values for 10 years or more. Before automatisation, measurements were performed weekly or monthly. The other 20 series have daily values for a shorter time period than 10 years.

The criteria for discarding 25 of the series were:

a. shorter than 20 years

b. large gaps in the time series (several months/years)

c. probably errors/trends in the series not possible to verify or correct

The rest of the series, 10, are set on hold because further evaluations of e.g. large gaps and short periods of trends are necessary before they can be included.

4.2.1 Reference series

Tables 4 and 5 show the proposed reference stations with more than 20 years of good quality data. Table 4 includes stations with more than 10 years of daily values and Table 5 includes stations with less than 10 years of daily values.

Table 4 Reference stations with more than 10 years of daily values.

Hydra-Id	Station name	Start	Daily values from	Comments
2.725.1	Abrahamsvoll	1969	1999	Missing 11.2007-03.2008
20.34.4	Birkenes	1979	2002	
2.718.2	Dombås	1981	2002	Missing 02.2002-05.2002
2.727.0	Kise	1991	2000	
12.343.12	Modum	1979	2001	
173.28.1	Skjomen	1983	2001	
19.144.6	Stigvassåi	1971	2002	
124.33.0	Værnes	1992	1999	

Table 5 Reference stations with less than 10 years of daily values.

Hydra-Id	Station name	Start	Daily values from	Comments
16.231.9	Bø	1979	2010	
21.80.1	Evje	1982	2011	Measurements taken at varying time intervals before 1997
56.3.2	Fana	1978	2003	
2.722.1	Finnbølseter	1977	2010	
84.25.3	Førde	1979	2007	Missing 01.1996-04.1996
16.232.1	Groset	1949	2004	Missing 06.2003-09.2003
2.724.9	Haslemoen	1981	2005	Missing several periods up to 4 months -80`s and 01.2007-05.2007
2.713.3	Hauerseter	1967	2011	
28.14.2	Jæren	1979	2010	
209.9.2	Kvænangen	1979	2010	
111.14.2	Kårvatn	1981	2011	
23.17.4	Lindesnes	1980	2010	
2.721.1	Lykkjestølane	1977	2010	
313.12.7	Magnor	1977	2008	
89.3.1	Nordfjordeid	1979	2008	
2.723.4	Settalbekken	1975	2010	Missing 02.1995-11.1996
2.716.6	Stenerseter	1969	2011	Missing winter data in 1971 and 1972
12.334.1	Storruste	1972	2012	
196.47.2	Øverbygd	1979	2004	
2.719.2	Øyangen	1977	2010	Missing 01.2007-06.2007

4.2.2 Map

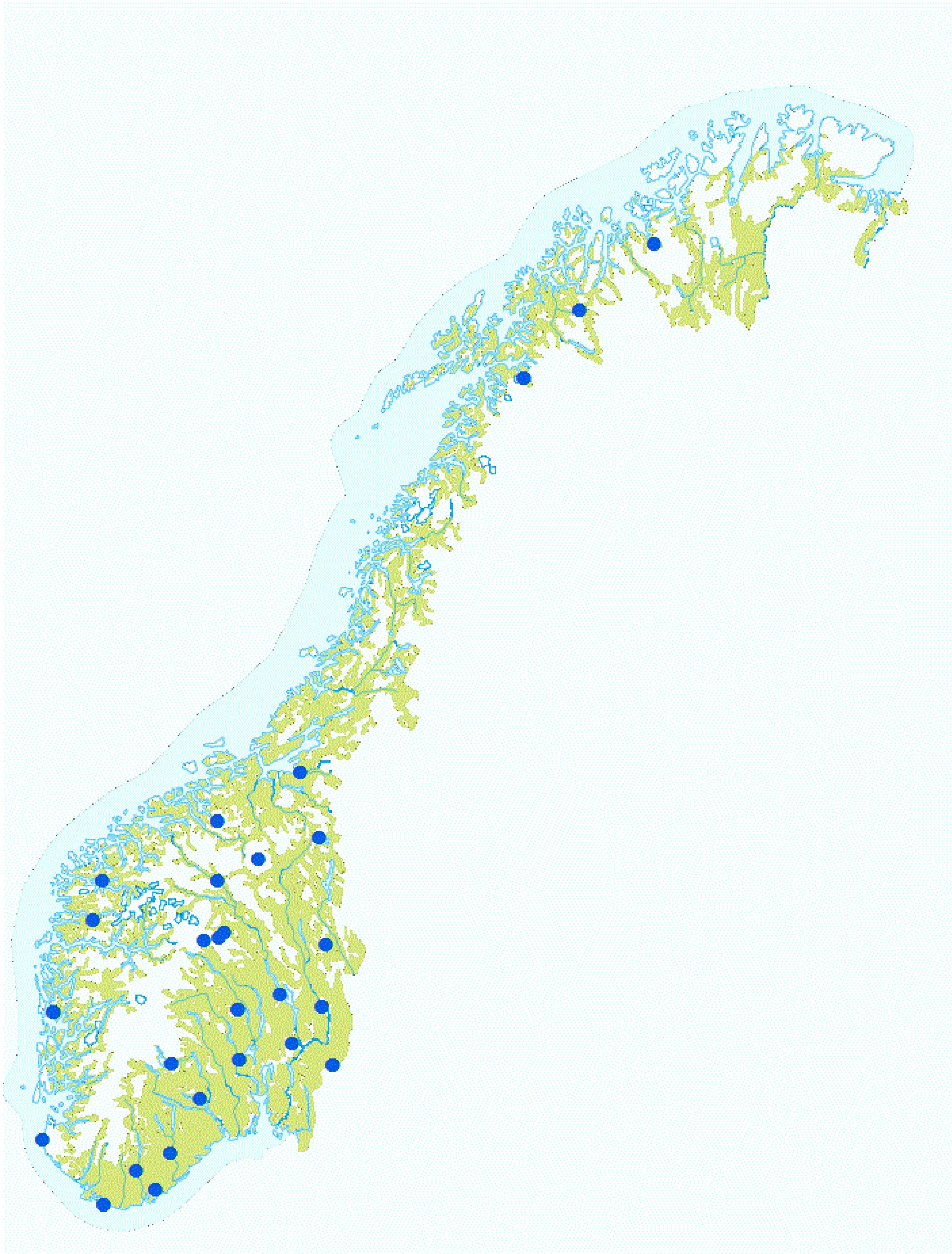

Figure 8 Location of groundwater reference stations

4.3 Snow

4.3.1 Reference series

Table 6 List of selected stations from the HPC-data

Regine nr.	Main nr.	Elevation	Total nr. years in the last continuous period	Last obs. year in the last continuous period	Bin ID
19	199	291	33	2011	2021
19	214	259	32	2011	2021
19	200	429	34	2011	2022
19	212	321	33	2011	2022
19	213	377	28	2011	2022
19	215	431	32	2011	2022
19	101	660	35	2011	2023
19	195	611	37	2011	2023
19	196	614	31	2011	2023
19	204	690	37	2011	2023
19	206	661	36	2011	2023
19	216	670	38	2011	2023
19	217	739	37	2011	2023
19	224	681	35	2010	2023
19	231	812	28	2011	2023
19	233	761	29	2011	2023
21	107	891	26	2011	2023
21	108	857	25	2011	2023
25	40	875	38	2011	2023
25	41	780	39	2011	2023
25	43	640	38	2011	2023
26	83	760	37	2011	2023
26	85	630	37	2011	2023
26	86	730	37	2011	2023
21	98	1136	26	2011	2024
21	104	1063	26	2011	2024
21	119	916	26	2011	2024
21	120	998	25	2011	2024
21	123	950	22	2011	2024
25	44	930	33	2011	2024
26	68	1130	20	2011	2024
16	290	938	70	2011	3024
16	292	1115	72	2011	3024
16	293	940	73	2011	3024
16	294	931	72	2011	3024

Table 6 continued.

Regine nr.	Main nr.	Elevation	Total nr. years in the last continuous period	Last obs. year in the last continuous period	Bin ID
16	295	919	69	2010	3024
16	297	969	72	2010	3024
16	305	941	64	2010	3024
16	311	1178	74	2011	3024
16	314	1083	74	2011	3024
16	319	1137	73	2011	3024
16	321	1136	76	2011	3024
16	327	1159	74	2011	3024
16	298	1456	74	2011	3025
16	304	1220	74	2011	3025
16	307	1214	74	2011	3025
16	316	1206	76	2011	3025
16	317	1339	75	2011	3025
16	323	1273	74	2011	3025
16	324	1320	71	2011	3025
49	30	1300	37	2010	3025
49	41	1308	35	2010	3025
49	57	1329	36	2010	3025
6	37	290	20	2011	3031
2	321	470	22	2011	3032
2	325	350	20	2011	3032
6	31	390	21	2011	3032
6	32	360	21	2011	3032
6	33	470	21	2011	3032
6	36	550	20	2010	3032
12	423	1193	43	2011	4024
12	425	1217	44	2011	4025
12	398	820	21	2011	4033
12	399	806	20	2011	4033
2	277	970	36	2011	4034
12	405	995	20	2011	4034
12	408	925	20	2011	4034
12	409	903	20	2011	4034

Other potential snow time series for the climate reference data set

The *SWE* data from the snow pillows was downloaded from NVEs HYDAG data archive, and tested for time series length. Six of the over 30 snow pillow stations had *SWE* data from more than 20 years, and last archived years between 2009 and 2011. These six stations (length of time series in parentheses) were: Kyrkjestølane (40 years), Groset (40 years), Svarttjørnbekken (39 years), Lybekkbråten (36 years), Vauldalen (27 years) and Brunkollen (22 years). All these stations are situated in the southern part of Norway (Svarttjørnbekken, situated close to Trondheim, is the northernmost station). However, the data from these snow pillow station candidates should first be thoroughly quality-checked before including them in the HRD.

In addition, the Atna snow course, measured annually by NVE since 1983, could be included in the climate reference data set. However, Atna has not been quality-checked or transferred to the official NVE data base.

4.3.2 Map

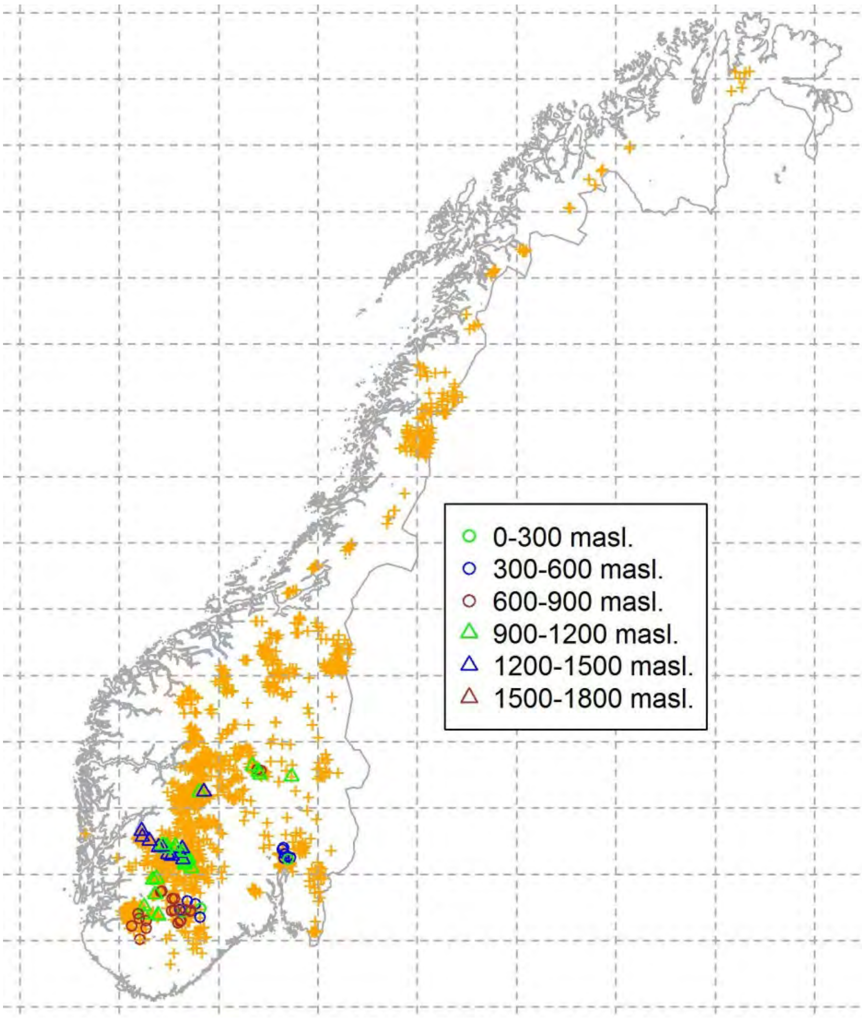

Figure 9 Location of the over 1300 HPC-stations in Norway (orange crosses). The 68 stations meeting the criteria for climate reference data (see text) are indicated by colored markers, where the colors and symbols denote the different elevation bins (see legend). The dashed grid lines denote the horizontal bins dividing the data into different regional station clusters.

4.4 Glaciers

4.4.1 Reference series

Mass balance

In total nine glaciers are selected as climate stations (Table 7), thus, all glaciers in Table 2 except for Austdalsbreen. Four of the glaciers series needs to be revised, due to significant deviations between geodetic and direct observations. Homogenization may be useful for all series.

Table 7 Mass-balance glaciers in Norway selected as reference stations. Code refers to abbreviation of name in Figure 10.

H-id	A-ID	Code	Name	Period	Remarks
2084	54	L	Langfjordjøkelen	1989-93, 1996-	
1220	1135	E	Engabreen	1970-	Needs revision
543	2085	Å	Ålfotbreen	1963-	Needs revision
545	2145	H	Hansebreen	1986-	Needs revision
413	2301	N	Nigardsbreen	1962-	Needs revision
115	2638	S	Storbreen	1949-	
68	2743	G	Gråsubreen	1962-	
81	2768	He	Hellstugubreen	1962-	
279	2968	R	Rembesdalskåka	1963-	

Length change

In total 11 glaciers are selected as climate stations (Table 8), thus, all glaciers in Table 3 except for Supphellebreen. The series of Fåbergstølsbreen and Stigaholtbreen needs to be homogenized due to differences between length changes measured on maps and the field observations. Styggedalsbreen are discontinuous between 1989 and 1993. Although the change in this period for Styggedalsbreen is assumed to be small, this gap will be filled from maps or other information to have a continuous series.

Table 8 Length-change glaciers in Norway selected as reference stations. Code refers to abbreviation of name in Figure 10.

H-ID	A-ID	Code	Name	Period	Remarks
1220	1135	E	Engabreen	1903-	Terminating in proglacial lake 1931-1942
414	2297	F	Fåbergstølsbreen	1899-	Needs revision
413	2301	N	Nigardsbreen	1899-	
612	2320	B	Briksdalsbreen	1900-	Terminating i proglacial lake in periods, lower tongue separated in 2011
512	2349	A	Austerdalsbreen	1905-20, 1933-	Tongue covered in rock debris
420	2480	St	Stigaholtbreen	1903-	Needs revision
115	2636	S	Storbreen	1902-	
121	2638	Le	Leirbreen	1909-	Proglacial lake since 1987

Table 8 continued.

H-ID	A-ID	Code	Name	Period	Remarks
375	2680	Sy	Styggedalsbreen	1901-1989, 1993-	Not continuous series
81	2768	He	Hellstugubrean	1901-	
200	2964	M	Midtdalsbreen	1982-	

4.4.2 Map

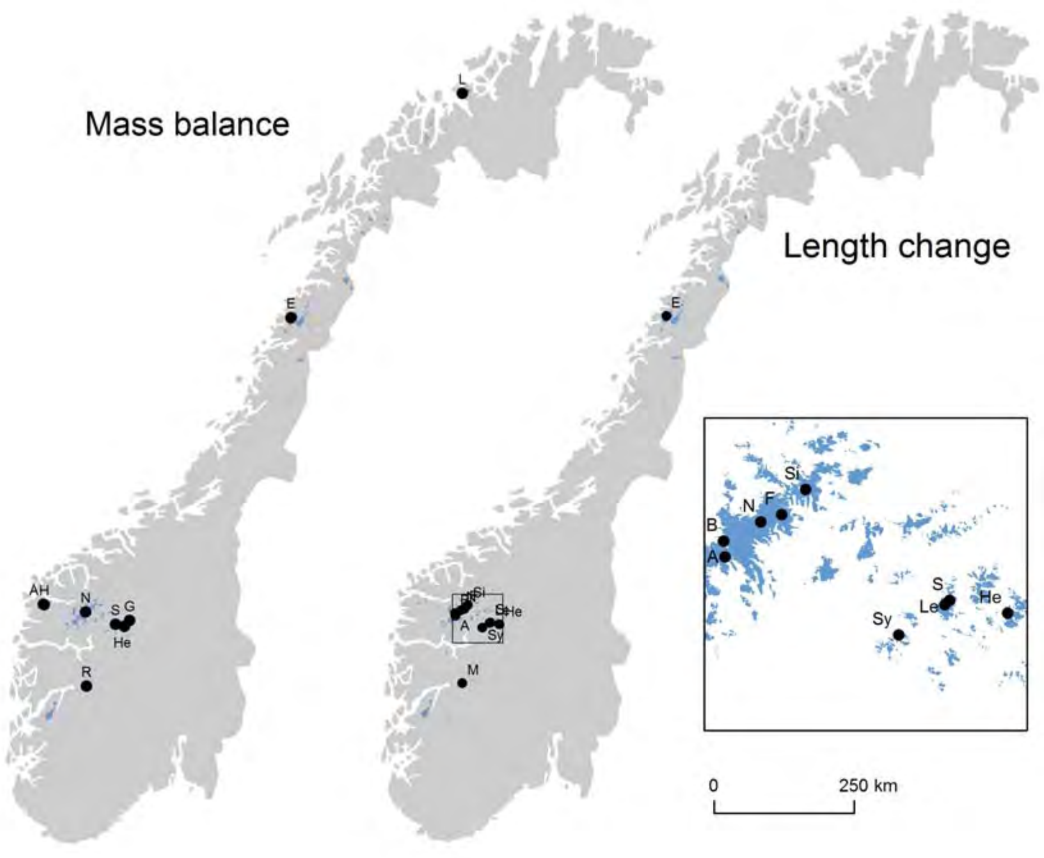

Figure 10 The mass balance and length-change glaciers selected as reference stations. The glaciers are shaded in blue. The inset shows the length-change reference glaciers from Jostedalsbreen (to the left) and in Jotunheimen (to the right). See Table 7 and 8 for further information.

4.4.3 Station characteristics

Mass balance

The selected stations include both small valley glaciers (e.g. Hellstugubreen, Figure 11) and small to large outlet glaciers from ice caps. The most typical glacier types in Norway are thus well presented in the sample, except for cirque glaciers. The glaciers range in size from 2.2 km^2 (Gråsubreen) to 47.2 km^2 (Nigardsbreen) (Kjøllmoen et al., 2011). The nine selected glaciers cover in total an area of 124 km^2, which represents nearly 5% of the present total glacier area in Norway of 2692 km^2 (Andreassen et al., 2012). The mass-balance reference glaciers are biased towards southern Norway where 7 out of 9 are located, whereas only 2 are located in northern Norway. It would be beneficial to have more glaciers in northern part, e.g. Lyngen or Blåmannsisen, but no or few, and then only short term, records exist. Also, reference glaciers from the third largest glacier in Norway, Søndre Folgefonna in the southwestern part of Norway would be good to have included in the sample.

Figure 11 Hellstugubreen in Jotunheimen. Annual length-change measurements began in 1901 and mass balance measurements in 1962. The glacier was connected with the small glacier to the right earlier. The glaciers became detached in the 1960s. Photo: Liss M. Andreassen, 2011.

Length change

The selected stations include both small valley glaciers and small to large outlet glaciers from ice caps. The glaciers range in size from 1.8 (Styggedalsbreen) to 47.2 km^2

(Nigardsbreen). The 11 selected glaciers cover in total an area of 178 km^2, which represents about 6 % of the present total glacier area. Also length-change glaciers are biased towards southern Norway, only one of eleven glaciers is located in northern Norway (Engabreen).

4.5 Lake and river ice

4.5.1 Reference series

Applying the HRD stations criteria to active lake and river ice stations in Norway resulted in a Norwegian reference dataset (RD) including 23 (lake ice duration) and 2 (river ice duration) series (Table 9). All the series are longer than 20 years.

Table 9 Lake and river ice reference series.

Reg no	Main no	Point no	Station name	Start	Ref start	Reg Grad	Lake/ river
2	15	0	Breiddalsvatn ndf.	1950		2	R
2	79	0	Tessevatn	1908		1	L
2	82	0	Osen	1967		0	L
2	89	0	Savalen	1919		1	L
2	98	0	Olstappen	1967		1	L
2	111	0	Aursunden	1902		1	L
2	162	0	Bygdin	1967		1	L
2	167	0	Vinsteren	1950		2	L
2	257	0	Heimdalsvatn	1975		1	L
2	260	0	Øyangen	1971		0	L
2	342	0	Fundin	1970		0	L
2	395	0	Elgsjø	1976		0	L
2	397	0	Marsjø	1976		0	L
2	824	4	Hurdalssjøen v/Haraldvangen (14)	1981	1990	0	L
2	825	39	Mjøsa, Kise-Kapp	1865		1	L
2	831	2	Øvre Heimdalsvatnet v/Osbui (11)	1969	1995	0	L
2	836	0	Rauddalsvatnet	1967		1/2	L
2	841	0	Storsjøen	1968		2	L
2	843	10	Atnsjøen v/Sør-Neset (12)	1950		0	L
2	1108	0	Kaldefjorden	1967		1	L
24	13	13	Lygne, sørenden	1925		0	L
75	13	0	Breidalsvatn	1967		1	L
104	3	0	Aursjø	1967		1	L
311	9	0	Nybergsund	1972		2	R

4.5.2 Map

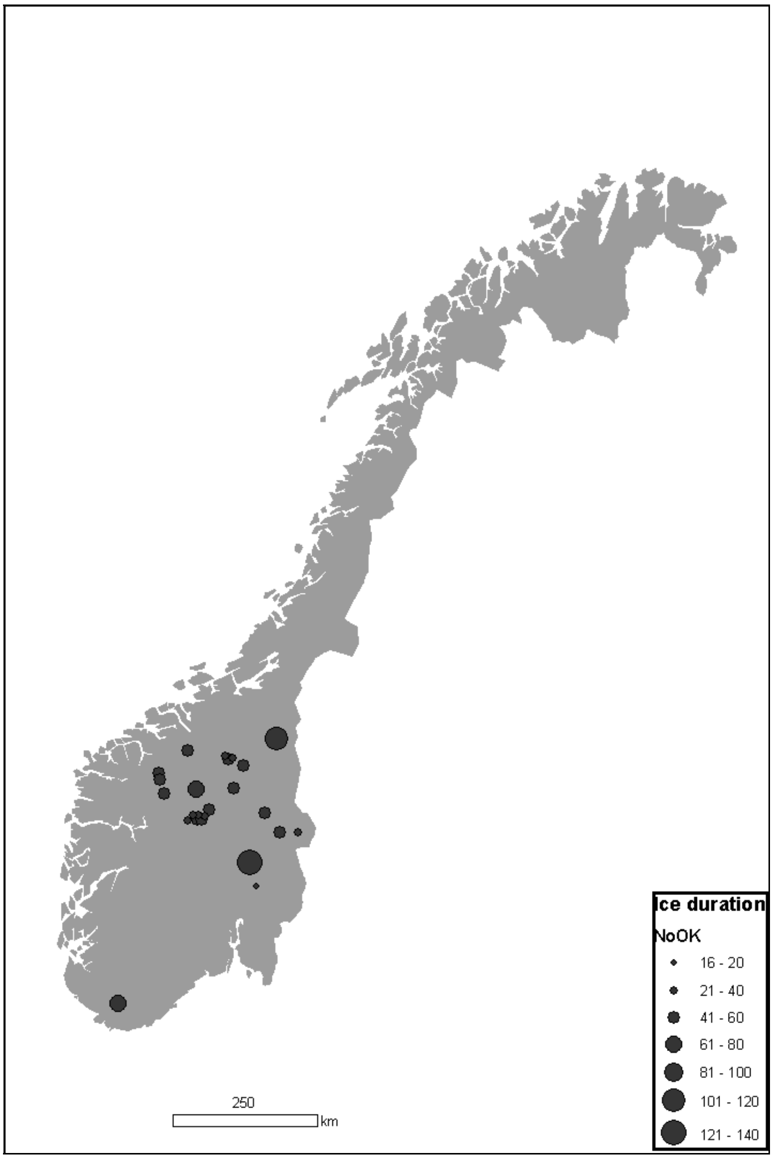

Figure 12 The ice duration series selected as reference stations. The size of the circles indicates the length of series.

4.5.3 Station characteristics

The spatial coverage of the dataset across Norway is shown in Figure 12. From the map it is clear that the ice duration series do not meet the overall demands of an HRD of representing a country's hydrological, physiographic and climatic variability and the requirements to the Norwegian HRD as stated in NVE's Strategy for climate change adaption (NVE, 2010). Most of the stations are situated in the south-eastern part of Norway.

4.6 River and lake temperature

4.6.1 Reference series

Application of the criteria for HRD stations to active stations in Norway resulted in a Norwegian reference dataset (RD) including 37 (lake water temperature, Table 10), and 91 (river water temperature, Table 11) series. All the series are longer than 20 years. The 91 RD stations for river water temperature have been divided into to two suitability classes (class 1 (with 51 stations) and 2 (with 40 stations) respectively. In class 1 only one or two years of missing data are accepted. The series are therefore more complete than class 2 and less estimation is required to obtain a continuous RD data series. The complete lake water temperature and river water temperature RD including station comments can be found in Tables 10 and 11, respectively. One should remember that the individual series may have some missing data.

Table 10 Lake temperature reference series.

	Main no	Point no	Navn	Start	Ref start	Degree of regulation	Comments
2	817	1	Aursunden v/Evavollen (11)	1985		1	Sommer fra 1987 vinter fra 1987
2	833	1	Bessvatnet v/Besshøbreen (12)	1982		0	Bare vintermålinger før 1987
2	838	1	Tesse v/Langodden (23)	1969	1982	1	Sporadiske målinger før 1982
2	839	1	Lemonsjøen v/Nordigard (11)	1976	1982	0	Sporadiske målinger før 1982
2	834	1	Øvre Sjodalsvatnet v/Mobesstrond (11)	1986		0	
2	829	2	Bygdin v/Dyrnesodden (11)	1985		0	Bare sommer målinger
2	818	2	Savalen v/Sandvika (22)	1991		1	
2	832	4	Gjende v/Leirungsholet (11)	1969	1984	0	Sporadiske målinger før 1984
2	843	5	Atnsjøen v/Grasskardbekken (23)	1980		0	Mer eller mindre sammenhengende data mangler enkeltmålinger
2	841	8	Storsjøen v/Burua (23)	1984		1	En måling i 1959,60,mange målinger i 1967-1973, Uregelmessig før 1984. Vintermåling påvirket av gjennom-strømning
2	837	11	Vågåvatnet v/Grev (23)	1969	1980	2	Målinger i hele perioden tidspunkt varierer før 1980. Måling påvirket av gjennomstrømning
2	825	17	Mjøsa v/Hol-Kapp (34)	1963	1984	0	Sporadiske målinger før 1973-1978 ingen målinger før 1984
12	390	2	Sperillen v/Rambergsodden (23)	1958	1984	2	Noen data før 1984 men ikke tilstrekkelig
12	394	2	Volbufjorden v/Rogne (11)	1961	1984	1	Sporadiske målinger før 1984
12	387	3	Vangsmjøsi v/Leine (23)	1957	1987	1	Noen data før 1987
12	383	8	Randsfjorden v/Fall (23)	1978	1988	1	Sporadiske målinger før 1988
12	389	8	Strondafjorden v/Gausåk (23)	1958	1986	1-2	Noen data før 1986

Table 10 continued.

	Main no	Point no	Navn	Start	Ref start	Degree of regulation	Comments
12	389	8	Strondafjorden v/Gausåk (23)	1958	1986	1-2	Noen data før 1986
12	377	9	Krøderen v/Veikåker (11)	1959	1988	2	Ingen data mellom 1959-60 og 1988
12	377	17	Krøderen v/Herbrandsbråtan (23)	1961	1988	2	Sporadiske målinger før 1988
16	267	1	Follsjå v/Jonrud (13)	1980	1987	0	Sporadiske målinger før 1987
16	251	2	Norsjø v/Dollvika (13)	1985	1990	2	Sporadiske målinger før 1990
16	260	2	Totak v/Vå (23)	1961	1982	1	Sporadiske målinger før 1982
16	261	3	Lognvikvatn v/Hamarsnes (22)	1987	1991	0	Sporadiske målinger før 1991
19	145	9	Nisser v/Torsholmen (11)	1987	1989	1	Sporadiske målinger før 1989
20	43	1	Høvringsvatnet v/Gautestad (11)	1986		1	
21	83	2	Breidvatn v/Flottestølen (11)	1974	1985	1	Sporadiske målinger før 1985
21	86	2	Store Bjørnevatn v/Strandestølen (11)	1984	1985	0	Vintermåling fra 1985 sommer fra 1989
21	88	21	Byglandsfjorden v/Eikjåknodden (23)	1971	1985	1	Sporadiske målinger før 1985
22	38	1	Bjørndalsvatn, midten (11)	1981		0	Bare vintermåling før 1985
26	56	7	Sirdalsvatnet v/Haughom (11)	1968	1987	2	Sporadiske målinger før 1987
48	9	2	Reinsnosvatnet v/Austdalen (11)	1983	1990	0	Sporadiske målinger før 1990
212	94	1	Trangdalsvatnet v/Gukkesjokka (11)	1972	1980	0	En måling for 1980
311	464	1	Sølensjøen v/Fiskevollen (11)	1959	1985	0	Ingen data mellom 1959 og 1985 bare sommer målinger
311	467	1	Engeren v/Storsneset (11)	1984		0	En måling i 1953, nest måling i 1964, Uregelmessig før 1984
311	463	4	Femunden v/Sorkodden (11)	1958	1986	0	Noen data før 1986

Table 11 River temperature reference series.

Reg no	Main no	Station name	Start	Ref start	Usability categories	Degree of regulation	Suitability classes	Comment
2	590	Vikka	12.03.1992		Y	0	1	GOD bare små hull
2	639	Glåma v/Strandfossen kraftstasjon	01.11.1980		Y	2	1	Mangler 2-3 år med data
2	650	Lågen v/Hunderfossen kraftstasjon	20.05.1971		Y	2	1	Mangler 1-2år med data
2	651	Lågen v/Harpefoss kraftstasjon	07.04.1972		Y	2	1	Mangle 1-2 år med data

Table 11 continued.

Reg no	Main no	Station name	Start	Ref start	Usability categories	Degree of regulation	Suitability classes	Comment
2	653	Lågen ovf. Otta	09.05.1974		Y	0	2	Mangler 3 år med data god overlapp med manuelle målinger
2	656	Lågen v/Hovdefossen	10.05.1983		Y	2	2	Bare sommer fram til 1994/95 Noen brudd i seriene
2	658	Lågen ndf. Lora	17.10.1990		Y	0	1	Mangle et drøyt år med data 2000-2001
2	660	Hinøgla ndf. Øvre Heimdalsvatnet	27.09.1984		Y	0	1	To store hull i serien på ca 2 år og 1,5 år
2	661	Sjoa ovf. Lågen	26.06.1971		Y	0	1	Ikke vinter data for 2002, hull 1988-1990
2	666	Otta ovf. Skim v/Marlo bru	15.09.1970		S/Y	1	1	Bare sommer data på 80 tallet, bra manuelle målinger
2	674	Otta v/Eidefoss kraftstasjon	01.03.1963		Y	1	2	Mangler 3 år med data, manuelle målinger ok?
2	677	Bøvre ovf. Otta	10.05.1974		S	0	1	Sommer data mangler sommer 1988 og 1991 og 1993, hull også i manuell serie
2	683	Otta v/Pollfoss	11.05.1983		Y	1	1	Mangler 4 år med data
2	685	Otta ndf. Vågåvatnet	01.12.1992		Y	1	2	Små brudd ellers OK
2	700	Atna ndf. Atnsjøen	15.06.1981		Y	0	1	En del hull i data før juni 1985. Finne noe døgndata i perioden
2	704	Atna v/Fossum	03.09.1986		Y	0	1	Mangler data for vinter 1994/95
12	308	Hallingdalselva v/Bergheim	20.06.1985		Y	2	1	Mangler et år med data
15	109	Numedalslågen v/Mykstufoss kraftstasjon	27.04.1974		Y	2	1	Mangler 2 år med data og noe manuelle målinger
15	115	Numedalslågen v/Brufoss	14.11.1984		S/Y	1	2	Bare sommer før 203/2004, Mangler 4 år med data
16	212	Kjela ndf. Eivindbuvatn	28.08.1984		Y	2	1	Bare små hull
16	217	Straumen ovf. Hogga kraftstasjon	20.12.1984		Y	2	1	Mangler ca 2 år med data
16	222	Bøelva v/Sanda bru	03.01.1972		Y	2	1	Bare små hull god manuelle målinger
16	228	Hjartdøla ndf. Hanefossen	19.05.1988		Y	2	2	Mangler data for1991 og deler av 1992 så små hull
18	13	Storelva v/Fosstveit	02.10.1989		Y	0	2	En del hull i data serien opp mot 3 år
20	29	Tovdalselva ovf. Flaksvatnet	13.11.1978	1991	Y	1	1	Mangler data mellom 1986 og 1991 Eller god data før og etter

Table 11 continued.

Reg no	Main no	Station name	Start	Ref start	Usability categories	Degree of regulation	Suitability classes	Comment
21	79	Otra v/Mosby	02.01.1986		Y	2	1	Små brudd ellers OK
22	25	Mandalselva v/Kjølemo	28.11.1983	28.11.1983	Y	2	1	Mangler 2-3 år med data
23	14	Audna ndf. Øvre Øydnavatnet	13.05.1988		Y	0	2	En god del hull på noen mnd mangler to sommere
23	15	Audna v/Melhusfossen	13.05.1988		Y	2	2	mangler data for 1989 og 2010-2011
24	5	Lygna ndf. Lygne	02.05.1980		Y	0	1	Mangler et år med data men ellers bra kan for lenges med manuelle målinger
26	52	Mydlandselva	06.11.1981		Y	0	1	Mangler et år med data men ellers bra kan for lenges med manuelle målinger
26	53	Sokndalselva ovf. Mydlandselva	06.11.1981		Y	2	1	Mangler 2 år med data kan forlenges med manuelle målinger
27	29	Bjerkreimselvi v/Bjerkreim	23.04.1986		Y	0	1	Noen mindre hull god serie
28	12	Figgjo ndf. Øksna bruk	13.06.1987		Y	0	2	Sporadisk med data før 1992 etter det noen hull opp mot et år.
33	12	Årdalselva v/Soppeland	25.10.1988		Y	1	2	Mangler 3 år med data
38	2	Vikedalselva utløp	12.10.1985		Y	0	1	Mangler to sommere ellers grei
41	9	Stordalsvatnet utløp	04.06.1969		Y	0	1	God bare små hull
55	18	Oselva v/Røykenes	14.10.1985		Y	0	1	Mangler i perioder mindre enn 1 et år med data men ellers bra kan for lenges med manuelle målinger
62	30	Vosso ovf. Evangervatnet	03.06.1987	02.09.1988	Y	1	2	Mangler 4 år med data, ikke overlapp med manuell målinger
62	33	Strondaelvi ovf. Raundalselvi	01.10.1975		Y	1	1	Mangler ca 2 år med data ellers god manuelle målinger
62	34	Raundalselvi ovf. Strondaelvi	06.10.1975		Y	0	2	Lang serie et større hull på opp mot 2 år
76	37	Jostedøla v/Myklemyr	27.05.1981		Y	2	1	Mangler 2 år med data kan forlenges med manuelle målinger
78	10	Vetlefjordelva ovf. Mel kraftstasjon	29.11.1990		Y	2	1	Mangler 1 år med data
83	16	Gaula ndf. Eikelandsvatnet	12.10.1971		Y	0	1	God serie kan forlenges med manuelle målinger. Manuell serie 1 mest komplett

Table 11 continued.

Reg no	Main no	Station name	Start	Ref start	Usability categories	Degree of regulation	Suitability classes	Comment
83	17	Gaula utløp	01.10.1971		Y	0	1	Noen hull på noen mnd ellers god manuelle målinger delvis
83	18	Gaula ndf. Haukedalsvatnet	11.10.1971		Y	0	2	En og del hull opp mott 2 år ellers lang
84	22	Jølstra ndf. Jølstravatnet	05.07.1989		Y	2	1	Mangler noen mnd med data
85	8	Oselva ndf. Endestadvatnet	18.06.1983		Y	2	1	Mangler 1 år med data
87	4	Gloppenelva utløp	15.03.1974		Y	1	2	Mangler 3 år med data
88	31	Loelva ndf. Lovatnet	07.07.1970		Y	0	2	Stor hull rundt tusenårsskifte eller god lang manuell serie
88	32	Strynselva v/Stauri	12.10.1968		Y	0	2	Mangler to år med data 1996/97 og 1998/99 eller god lang manuell serie mangler et år for overlapp
88	33	Hjelledøla ovf. Strynsvatnet	15.06.1974		Y	0	2	En del hull i første del av loggerserien
88	35	Erdalselva	16.06.1974		Y	0	1	Noen hull på none mnd ellers god manuelle målinger delvis
89	2	Eidselva ndf. Hornindalsvatnet	06.07.1989		Y	1	1	Kun små brudd
103	42	Rauma ovf. Grytten kraftstasjon	08.09.1974		S/Y	1	2	Bare sommer før 1992/1992, mangler 3 år med data
103	46	Rauma ndf. Lesjaskogvatnet	11.06.1983		Y/S	0	1	Bare sommer mangler ca 2 år med data
103	48	Rauma v/Raudstøl bru	11.06.1983		S/Y	0	2	Bare sommer mangler ca 2 to 3 år med data
112	35	Surna ovf. Trollheim kraftstasjon	04.06.1987		Y	2	2	Mangler 3 år med data
112	40	Vinddølva ovf. Surna	16.10.1993		Y	0	2	Mangler et år med data
122	28	Gaula v/Haga bru	21.09.1984		Y	0	2	Mangler enn god del data
123	56	Homla utløp	04.04.1986		Y	0	2	Mangler ca 3 år med data
124	27	Stjørdalselva v/Hegra bru	20.12.1990		Y	2	2	Mangler 3 år med data kort
127	14	Verdalselva v/Grunnfossen	01.01.1971		Y	0	1	Mangler et år med data men ellers bra kan for lenges med manuelle målinger
133	9	Nordelva ndf. Kringsvatnet	03.12.1986		Y	0	1	Mangler ca 3 år med data

Table 11 continued.

Reg no	Main no	Station name	Start	Ref start	Usability categories	Degree of regulation	Suitability classes	Comment
151	29	Unkerelva	04.06.1972		Y	0	2	Mangler ca 4 år med loggerdata, manuellserie god
151	32	Vefsna v/Laksfors	01.09.1972		S	0	2	Bare sommer data enn del hul, lang manuell måleserie OK
151	35	Susna v/Ivarrud	01.05.1975	1975	S	0	1	Bare sommer mangler ca 2 år med data, lang manuell måling
156	52	Ranaelva v/Messingslett bru	31.05.1988		Y	0	2	Mangler 2 år med data tynt med data manuell målinger
161	30	Tollåga ovf. Beiarelva	01.05.1975		S/Y	0	2	Sommer data mangler ca 2 til 3 år med data
163	19	Saltelva ovf. Eneneselva	01.05.1975		S/Y	0	2	Bare sommer data enn del hul, lang manuell måleserie OK
163	23	Lønselva ndf. Kjemåga	15.06.1979		Y/S	0	1	Bare sommer mangler 3 år med data
163	24	Junkerdalselva ovf. Lønselva	15.06.1979		Y/S	0	1	Bare sommer mangler 3 år med data
166	15	Laksåga ovf. Sleipa	29.05.1990		S/Y	0	2	Bare sommer mangler 2 år med data
167	35	Kobbelva ndf. Kobbvatnet	03.05.1975	1983	Y	2	1	Mangler 2 år med data kan kobles med manuelle målinger
173	24	Elvegårdselva v/Stiberg bru	16.11.1983		Y	2	1	Mangler 1 år + noen mnd med data noen år mellom manuell og loggerdata
191	3	Salangselva ndf. Nervatnet	20.05.1987		Y	0	1	Mangler 1,5 år med data, 3 år hull mellom manuelle målinger og logger data
212	62	Halselva ndf. Storvatnet	07.04.1994		Y	0	2	Litt kort mangler ca 1 år med data
212	65	Kautokeinoelva v/Virdneguoika	01.07.1980		Y	0	1	God noen hull
212	66	Altaelva v/Savco	02.07.1979	1983	Y	2	1	Mer eller mindre sammenhengende data fra 1991 til 2008 før dette mange brudd
212	68	Altaelva v/Gargia	14.09.1980		Y	2	1	Mangler 1 år med data fram til 2008
212	69	Cabardasjokka ndf. Stuorajavri	07.10.1980	1989	Y	0	1	God fra 1989, mangelfull manuelle data
212	74	Kautokeinoelva v/Gjevdneguoika	02.07.1981		Y	0	1	Mangler ca 2 år med data
212	80	Eibyelva v/Eiby	02.07.1981		S/Y	0	2	Sommer data fram til 1996 mangler ca 3 år med data
234	19	Tana ovf. Polmakelva	06.07.1990		Y	0	2	Mangler noe data i starten brudd på 1,5 år

Table 11 continued.

Reg no	Main no	Station name	Start	Ref start	Usability categories	Degree of regulation	Suitability classes	Comment
234	21	Karasjokka ovf. Iesjokka	04.09.1974		Y	0	2	Mangler 1,5 år med data, manuelle målinger ok
246	11	Pasvikelva v/Skogfoss kraftstasjon	13.03.1991		Y	1	2	Mangler 2 år med data
311	461	Femundselva ndf. Femunden	04.10.1972		Y	0	1	Mangler ca 2 år med data ellers god manuelle målinger ligger lavt
400	1	Bayelva	17.06.1991		S	0	2	Sommer mangler 2 år
400	4	Londonelva	23.06.1992		S	0	2	Sommer mangler 1 år
400	5	De Geerdalen	18.06.1991		S	0	2	Sommer mangler 1 år

4.6.2 Map

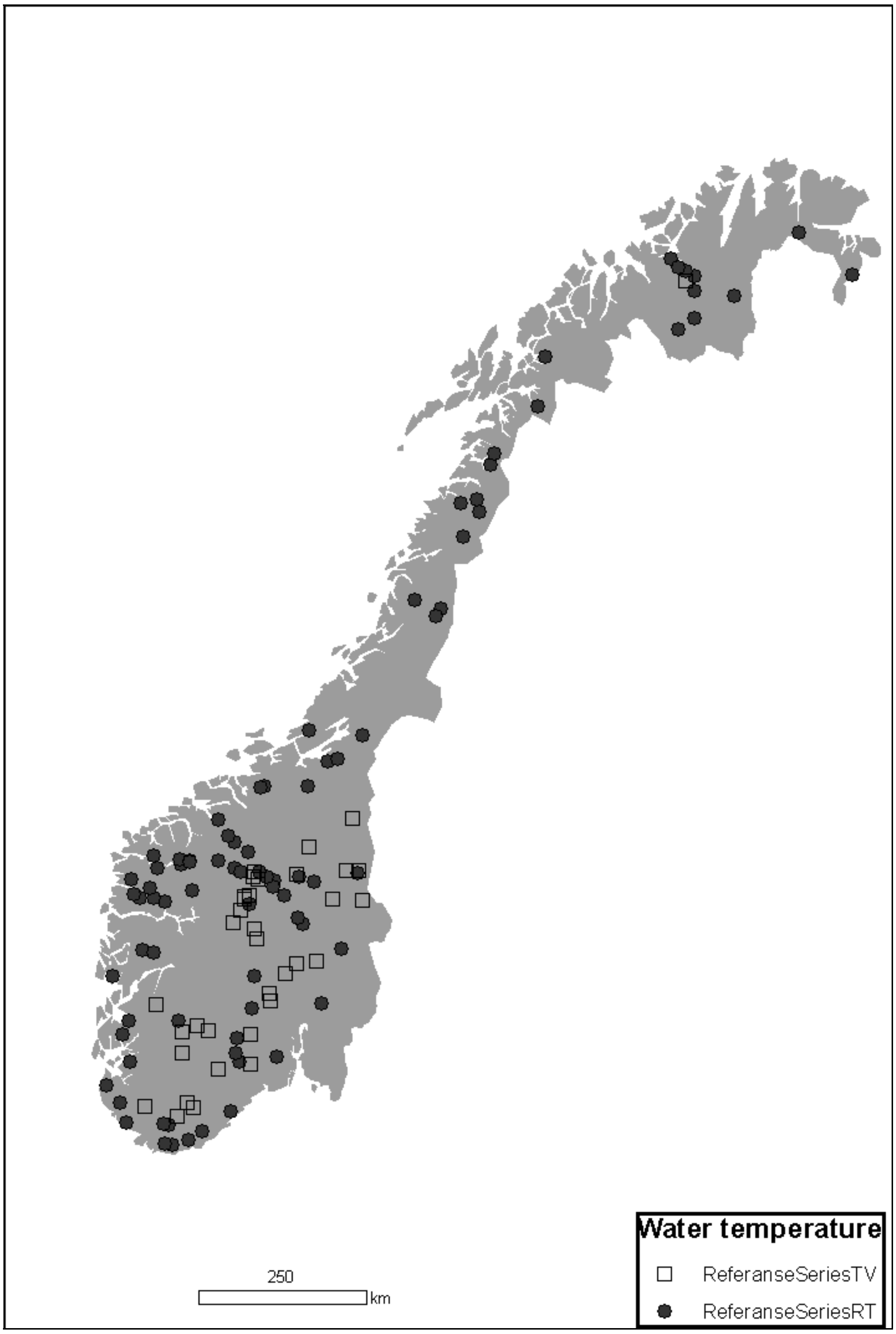

Figure 13 The river (circle) and lake (square) water temperature series selected as reference stations.

4.6.3 Station characteristics

The spatial coverage of the dataset across Norway is shown in Figure 13. From the map it is clear that the RD for lake water temperature series does not meet the overall requirements of an HRD to represent a country's hydrological, physiographic and climatic variability and the requirements of the Norwegian HRD as stated in NVE's

Strategy for climate change adaption (NVE, 2010). Most of the stations are situated in southern Norway.

The RD for river water temperature is less biased covering a larger part of Norway, but there are regions with few data series. It would be beneficial to have more stations in Nord Trøndelag, Troms and along the coast, but no or few, and then only short term, records exist in these regions.

5 Further work

The Hydrological Reference dataset for Norway can be used to study climate variability and change. The list of stations is found in this report (Chapter 4 and Appendix 1) and on www.nve.no. The data records can be retrieved from Hydra II or ordered from NVE. There is potential for further improvement of the dataset, since it is important that the quality of the selected series is maintained and the stations continue to meet the requirements of the HRD. Possibilities for improving and requirements for maintaining the HRD are discussed below:

5.1 Improving the streamflow RD

Long data series are of special importance in climate change studies due to multi-year and decadal variability, e.g. in large-scale climate patterns such as NAO or ENSO. When currently only part of a series is recommended for use, it would be valuable to improve and extend the series back in time where possible.

There is potential for correcting parts of a record, so that the complete data record meets the HRD requirements. For example, series from catchments with constant water transfer from a fixed area during part of the observation period could be homogenized, and inhomogenities caused by incorrect reference heights or rating curves could be corrected, although these tasks may require substantial work.

There is a need for a better and more systematic approach to the identification and correction of poor quality data. Possible improvements could be made by, for example, using recent software to check the quality of a rating curve for an earlier period. An up-to-date homogeneity assessment of all selected series could also be considered. Regular updates of the metadata according to identification and correction of errors is important.

Information about data quality should be collated in one place, for example, linked to the station and data series comments in the NVE software (Finut, Dagut). Comments currently only available in reports or together with the rating-curve quality assessment should also be included.

Limited data quality comments in a stations metadata could give the impression that data quality is very good, whereas the real reason may be that information is unknown or undocumented. This suggests that including comments about good quality data could also be beneficial.

To increase objectivity of the data quality evaluation, criteria need to be established for when specific comments are to be used. A standard list of factors that may influence data quality could be identified, including for example, regulation, profile stability and observations of land use changes in the catchment. Also, the introduction of some “standard formulations”, describing different data issues could be considered. For example, a percentage regulation could be defined for the comment “little regulation”. More easily available and understandable metadata would facilitate choosing appropriate series for a particular study and possibly improve the quality of a study.

5.2 Improving the soil moisture RD

Site calibration of soil water measured by the PR2 Profile Probe is the first step necessary for further improvement of the data-series. Site calibration requires the direct measurement of soil water content (gravimetric method) on at least two separate occasions, one dry and one wet. This is therefore a labor-intensive and costly task. Further evaluation of the existing data-series, including model simulations, could also aid selection of the most representative sites. In addition, the soil moisture dataset would profit considerably from pumping well tests as described for the groundwater RD (Section 5.3).

5.3 Improving the groundwater RD

Automatically recorded groundwater levels are validated against manual measurements of the groundwater level up to 12 times a year. However, for most stations manual measurements are only performed once or twice a year. As a minimum, performing quarterly manual measurements for all stations would enable deviations to be detected more quickly and therefore considerably increase data quality. Routines for regularly removing mud in the groundwater pipe should also be established.

Pumping well tests can provide a better description and understanding of hydrogeological characteristics and offer the possibility of detecting and correcting deviations. The test provides information about effective porosity and hydraulic conductivity which can be used to check measurement levels against model simulations of groundwater level and soil moisture content, thereby also improving the soil moisture dataset.

5.4 Improving the snow RD

The HPC-data have undergone a preliminary quality control (see unpublished note by Tuomo Saloranta, 2012), but a final quality control is planned for spring 2013. This final quality control will be better documented, include some previously hidden data, and will result in the uploading of the final data set onto the HYDRA II data base (HYKVAL archive).

The two main challenges concerning the future of HRD stations for *SWE* (HPC-data) are:

- to ensure measurements taken by hydropower companies are continued on an annual basis. This could be achieved either by: (i) encouraging the hydropower companies to continue taking measurements as is required in their hydropower concessions, and following-up to check this is undertaken; or, (ii) NVE taking over measurement. In either case, it is preferable to continue taking measurements in the same way, using the same method in order to avoid inhomogeneities in the series.
- to identify stations in northern Norway, with more than 10-15 years of data, which could be included in the HRD. Presently, no stations from mid- or northern Norway passed the HRD selection criteria.

An unpublished note by Heidi Stranden (NVE) suggests a partly overlapping, alternative set of approximately 10 climate reference stations of HPC-data, where some additional factors (not considered here), such as the location and easy access to the stations, are taken into account. This note also details risks to the continued recording of *SWE* data. It can thus provide useful information regarding, for example, on which stations to focus measurement efforts in the future.

5.5 Improving the glacier RD

Where needed, the mass-balance and length-change reference glacier datasets should be homogenised. The length-change record for Briksdalsbreen has been compared with maps and photos (Kjøllmoen et al., 2006) and has resulted in an updated and homogenised data record.

Information regarding both data quality and homogeneity issues should be well documented and stored in NVE’s Hydra II database.

5.6 Improving the lake and river ice RD

Surface based observations have provided much of the information regarding lake and river ice response to climate (Magnuson, et al, 2000; AMAP, 2011). The declining state of our network in recent years has led to serious geographical and temporal gaps in several regions of Norway. Consideration should therefore be given to the reactivation of some of the longest series in order to improve the geographical distribution.

5.7 Improving the river and lake temperature RD

It is preferable to have longer records of river and lake temperature. It should therefore be checked whether existing series could be further improved in order to decrease the amount of missing data. One possibility is to install extra loggers to duplicate measurements.

5.8 Maintaining the Hydrological Reference Dataset

To maintain the Hydrological Reference Dataset, the data series need to be regularly updated and new data must meet the HRD criteria. Adequate metadata need to be continuously collected and stored, with routines and standards for regular updates of the HRD set up. For instance, catchment alterations may require that the station needs to be deleted from the HRD.

Whitfield et al. (2012) suggest reference datasets are reviewed annually, to keep the data, data quality and metadata up to date, with a more general review performed on a decadal basis. In the more general review, major changes (such as basin development) should be investigated and the effectiveness of the dataset assessed. It has to be decided whether a general HRD update every ten years as suggested by Whitfield et al. is sufficient in Norway and for NVE, or whether it should be routinely undertaken on a more frequent basis. In the general review of the HRD, the inclusion of stations which have reached 20 years of data should be considered, and the spatial coverage and the representativeness of the HRD with respect to hydrological and geophysical variability in Norway should be assessed.

In addition to the annual and general updates, identified quality issues should be followed up. For example, analyses involving HRD time series may reveal inhomogeneities or trends, and it should be investigated whether these are natural, artificial or caused by measurement errors. Appropriate action must be taken, e.g. correction of data, update of metadata or even deletion of the series from the HRD. Each time a new rating-curve is established for only part of a series, homogeneity checks of the complete streamflow record should take place.

A good way of storing, disseminating and maintaining the HRD (including the list of stations, data and metadata) needs to be established and followed up by NVE.

Acknowledgements

We would like to thank all the field hydrologists at NVE, who helped in obtaining more metadata on the streamflow stations and their history, as well as Lars-Evan Pettersson and Lars Roald at NVE whose extensive knowledge on the regional climate history and different streamflow series helped identifying reason of observed changes.

References

AMAP (2011) Snow, water, ice and permafrost in the Arctic (SWIPA).Oslo: Arctic Monitoring and Assessment Programme (AMAP). www.amap.no

Andreassen, L.M., H. Elvehøy, B. Kjøllmoen, R.V. Engeset and N. Haakensen. (2005) Glacier mass balance and length variations in Norway. *Annals of Glaciology*, 42, 317–325, doi: 10.3189/172756405781812826

Andreassen, L.M., B. Kjøllmoen, A. Rasmussen, K. Melvold and Ø. Nordli. (2012a) Langfjordjøkelen, a rapidly shrinking glacier in northern Norway. *Journal of Glaciology*, 58 (209), 581–593, DOI: 10.3189/2012JoG11J014

Andreassen, L.M., S.H. Winsvold (eds.), F. Paul and J.E. Hausberg. (2012b) Inventory of Norwegian glaciers. NVE Rapport 38:2012

Astrup, M. (2000) Homogenitetstest av hydrologiske data. (In Norwegian: Homogeneity testing of hydrological data) NVE Rapport 7:2000

Beldring, S., T. Engen-Skaugen, E. Førland, L.A. Roald (2008) Climate change impacts on hydrological processes in Norway based on two methods for transferring regional climate model results to meteorological station sites. *Tellus* 60A, 439–450, doi: 10.1111/j.1600-0870.2008.00306.x

Braithwaite (2002) Glacier mass balance: the first 50 years of international monitoring. *Progress in Physical Geography*, 26 (1), 76–95, doi: 10.1191/0309133302pp326ra

Bryn, A. (2008) Recent forest limit changes in south-east Norway: Effects of climate change or regrowth after abandoned utilisation? *Norwegian Journal of Geography*, 62(4), 251–270, doi: 10.1080/00291950802517551

Dyrrdal, A.V, T. Saloranta, T. Skaugen and H.B. Stranden (2013) Changes in snow depth in Norway during the period 1961-2010. *Hydrology Research*, 44 (1), 169–179, doi:10.2166/nh.2012.064

Elsberg D.H., W.D. Harrison, K.A. Echelmeyer and R.M. Krimmel (2001) Quantifying the effects of climate and surface change on glacier mass balance. *Journal of Glaciology*, 47(159), 649–658, doi: 10.3189/172756501781831783

Hanssen-Bauer, I., H. Drange, E.J. Førland, L.A. Roald, K.Y. Børsheim, H. Hisdal, D. Lawrence, A. Nesje, S. Sandven, A. Sorteberg, S. Sundby, K. Vasskog and B. Ådlandsvik (2009) Klima i Norge 2100 (In Norwegain: Climate in Norway in 2100) Bakgrunnsmateriale til NOU Klimatilpassing. Norsk klimasenter, September 2009

Hisdal, H., K. Stahl, L.M. Tallaksen, and S. Demuth (2001) Have droughts in Europe become more severe or frequent? *International Journal of Climatology*, 21, 317-333, doi: 10.1002:joc.619

Kjøllmoen, B. and H.C. Olsen (2002) Langfjordjøkelen i Vest-Finnmark, Glasiohydologiske undersøkelser, NVE Dokument 4. Kjøllmoen, B. (Ed.), L.M. Andreassen, R.V. Engeset, H. Elvehøy, M. Jackson and R.H. Giesen, (2006) Glaciological investigations in Norway in 2005. NVE Report 2:2006

Kjøllmoen, B. (ed.), L.M. Andreassen, H. Elvehøy, M. Jackson and R.H. Giesen (2011) Glaciological investigations in Norway in 2010. NVE Report 3:1010

Kleivane, I. (2006) Vassføringsstasjonar på Vestlandet. NVE Rapport 17:2006

Lawrence, D. and H. Hisdal (2011) Hydrological projections for floods in Norway under a future climate. NVE Report 2011:5

Magnuson, J.J., D.M. Robertson, B.J. Benson, R.H. Wynne, D.M. Livingstone, T. Arai, R.A. Assel, R.G. Barry, V. Card, E. Kuusisto, N.G. Granin, T.D. Prowse, K.M. Stewart and V.S. Vuglinski (2000) Historical trends in lake and river ice cover in the Northern Hemisphere. *Science*, 289,1743-1746, doi: 10.1126/science.289.5485.1743

NVE (2010) Klimatilpasning innen NVEs ansvarsområder – Strategi 2010-2014, NVE Rapport 15:2010

Oerlemans, J. (2005) Extracting a climate signal from 169 glacier records. *Science*, 308, 675-677, doi: 10.1126/science.1107046

Pettersson, L.-E. (2003) Norges hydrologiske stasjonsnett, NVE Rapport 7:2003

Pettersson, L.-E. (2004) Aktive vannføringsstasjoner i Norge, NVE Rapport 16:2004

Pettersson, L.-E. (2005) Vannføringsstasjoner i Midt- og Nord-Norge, NVE Rapport 18:2005

Pettersson, L.-E. & Astrup, M. (2007) Vannføringsstasjoner på Østlandet og Sørlandet, NVE Rapport 2:2007

Saloranta, T. M. (2012) Simulating snow maps for Norway: description and statistical evaluation of the seNorge snow model. *The Cryosphere 6*, 1323-1337, doi:10.5194/tc-6-1323-2012

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.) (2007) Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change**,** Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA

Skaugen, T., H.B. Stranden, and T. Saloranta (2012) Trends in snow water equivalent in Norway (1931-2009). *Hydrology Research 43*, 489-499, doi:10.2166/nh.2012.109

Stahl, K., H. Hisdal, J. Hannaford, L.M. Tallaksen, H.A.J. van Lanen, E. Sauquet, S. Demuth, M. Fendekova, and J. Jódar (2010) Streamflow trends in Europe: evidence from a dataset of near-natural catchments, *HESS*, **14**, 2367-2382, doi:10.5194/hess-14-2367-2010

WGMS (2008) Fluctuations of Glaciers 2000–2005, Volume IX. W. Haeberli, M Zemp, A. Kääb, F. Paul and M. Hoelzle (eds.) ICSU(FAGS)/IUGG(IACS)/UNEP/UNESCO/ WMO, World Glacier Monitoring Service, Zurich, Switzerland

WGMS (2011) Glacier Mass Balance Bulletin No. 11 (2008–2009). M. Zemp, S.U. Nussbaumer, I. Gärtner-Roer, M. Hoelzle, F. Paul and W. Haeberli (eds.) ICSU(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, Zurich, Switzerland

Whitfield, P.H., D.H. Burn, J. Hannaford, H. Higgins, G.A. Hodgkins, T. Marsh and U. Looser, U. (2012) Reference hydrologic networks I. The status and potential future directions of national reference hydrologic networks for detecting trends. *Hydrological Sciences Journal*, 57 (8), 1562-1579, doi: 10.1080/02626667. 2012.728706

Wilson, D., H. Hisdal and D. Lawrence (2010) Has streamflow changed in the Nordic countries? – Recent trends and comparisons to hydrological projections. *Journal of Hydrology*, 394, 334-346, doi:10.1016/j.jhydrol.2010.09.010.

Appendix 1: Streamflow reference dataset

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
2	11	Narsjø	1930	1970?	1971	1971										
2	13	Nedre Sjodalsvatn	1930	OK	1981	1930										Ingen data 1957-1963! Gammelt vm 2.220.0. og 2.12.0. NB! Vst.reg. t.o.m. 8/9-2010 kl. 09:00 er i kum med meget dårlig kommunikasjon. F.o.m. 8/9-2010 12:00 er vst1 fra trykkcelle ute i sjøen, mens vst2 fortsatt er i kummen.
2	32	Atnasjø	1916	OK	1985	1916										
2	142	Knappom	1916	OK		1916										
2	265	Unsetåa	1961	OK		1961										
2	268	Akslen	1934	1955	1962	1962										
2	275	Liavatn	1965	OK		1965										
2	279	Kråkfoss	1966	OK		1966										
2	280	Kringlerdal	1966	OK		1966										
2	284	Sælatunga	1966	OK		1966										mangler 1974-79

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
2	290	Brustuen	1966	OK		1966										
2	291	Tora	1966	1988		1988	-7.4									En ny vf-kurve gjelder f.o.m. 1986 som gir betydelig lavere vannføringer for høye vannstander enn kurver som gjelder tom 1985. Homogenitetsbruddet i flomverdiene kan evt. skyldes dette. Men årsvannføringen virker også større etter ca 1986/88. Usikker om dette kan skyldes ny vf-kurve.
2	303	Dombås	1967	OK		1967										
2	323	Fura	1970	OK		1970										
2	614	Rosten	1917	OK	1917, 1945	1917	-41	x			x					Arealet bør reduseres med 41 km^2, siden det et vann med to utløp i feltet. Men utløpsandel av vannet fordeles forskjellig mellom lavvann og flom. Om få år blir det nok byggestart på Rosten kraftverk. Da havner inntaksdammen oppstrøms dagens 2.614 Rosten, og utslippet fra kraftverket nedstrøms.
2	616	Kuggerud	1968	OK		2001										
6	10	Gryta	1967	OK		1967			x	x						Ikke bruk data for vannstander >0,8 m (tilsvarer ca vannføringer >1,34 m^3/s)!
11	4	Elgtjern	1975	OK		1975			x	x						Vannføringsserie versjon 1 har data ut 2007 og versjon 2 f.o.m. 2007-2009, men de er ikke satt sammen til en serie ennå. De går fint å bruke data fra begge versjoner som en tidsserie, men ikke for flom.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
12	13	Rysna	1974			1974	-10.1									Som uregulert men med mindre areal. Overføring ut av 10.1 km^2 areal siden starten
12	70	Etna	1919	1955		1919			1968	1968	1968	1968	1968			1968 siste år for fløterdamslipp i mai mnd. Ingen målinger i øvre segment av kurven. Derfor intet grunnlag for statistikk for flomverdier.
12	171	Hølervatn	1968	OK		1968										
12	178	Eggedal	1972	OK		1972										
12	188	Langtjernbekk	1973	OK		1973			x	x			x	x	x	Loggerproblemer sommer 2009: Komplettert ved sammenligningsserie. Loggersvikt sommer/høst 2008: Komplettering av vst-serie innenfor 2-3 cm usikkerhet. Kvalitetsvurdering 2005 med hjelp fra Kval. gr. HH: - Flomtopper blir dempet pga av steinbru/fløtningsdam oppstrøms - Meget usikre vannføringer for vannstander over v-overløp (> 0,33 m) pga manglende målinger. Vannstrømmen treffer også overbygget/lokket på vst ca 0,5-0,7 m
12	192	Sundbyfoss	1976	ikke testet		1976			x	x	x	x				vannstander over 2.4m før 1.1.2009 er usikre pga store svingninger i vannstand (bølger)og for sjelden logging (1time). Etter 1.1.2009: Hver loggede halvtimesverdi er middel over ca 1min. Døgndata for flomtopper før 2009 er simulerte data. Litt lenger opp i vassdraget er det en liten, privat dam, Rønneberg. Rare dropp i data på stasjonen skyldes at dammen av og til blir fylt opp for så å tømmes helt. Dette gjøres antageligvis for å bli kvitt bever i elva.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
12	193	Fiskum	1976	ikke testet		1976										
12	197	Grunke	1977	ikke testet		1977										
12	215	Storeskar	1987	ikke testet		1987										
15	49	Halledalsvatn	1962	1979		1962										
15	53	Borgåi	1966	OK		1966										
15	74	Skorge	1980	ikke testet		1980			x	x	x	x	x	x		Mangler data 2010. Juni 2010 ble et tre med røtter inntil terskelen fjernet. Dette gjør at vannet nå har gravd ut venstre bredd og ødelagt profilet! Kurven, spesielt lavvann er derfor feil. Vannføringskurven er svært usikker for vst > ca. 1,8 m og stasjonen bør ikke benyttes til flomanalyser. Problemet skyldes at profilet druknes og vannstanden blir oppstuet ved høy vannstand i Goksjø. Påvirket av oppstuvning fra sjø nedstrøms på høyere vannføringer.
16	66	Grosettjern	1949	1972		1974										
16	75	Tannsvatn (Lognvikvatnet)	1955	OK		1955										Nye og gamle målinger gir forskjellig vannføring for samme vannstand, men det kan også knytes til forskjellige målemetoder (flygel fra båt vs ADCP). I kurvegenerasjonen er det lagt mer vekt på de nye målingene og kurven passer også ganske bra til dem.
16	122	Grovåi	1972	OK		1972										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
16	127	Viertjern	1977	ikke testet		1977	-0.36									Flom topp mai 2004 er beregnet v.h.a. 16.66 Grosettjern. Is hadde stuet opp profilet. Forskjellen i "Feltareal" og "Feltareal fra GIS" skyldes at et vann i øvre del av nedbørsfeltet, Gryvletjønn, har naturlig utløp i to retninger. I 1920 ble utløpet mot Viertjern stengt med en dam. Denne står fortsatt. Gryvletjønn er derfor ikke en del av nedbørfeltet til Viertjern. Riktig feltareal derfor 46,4 km^2, dvs. 0,4 km^2 mindre enn angitt i GIS. 16.127, 16.128, 16.193 mangler alle flere år med data, men det er ellers ikke så veldig mange stasjoner i området.
16	128	Austbygdåi	1976	ikke testet		1976			x	x						Usikker for vannføringer > 100 m^3/s. ingen data 1986-1990. 16.127, 16.128, 16.193 mangler alle flere år med data, men ellers ikke så veldig mange stasjoner i området.
16	193	Hørte	1977	OK		1977					x					Mangler 6 år med data mellom 1992-2000. 16.127, 16.128, 16.193 mangler alle flere år med data, men det er ellers ikke så veldig mange stasjoner i området.
16	194	Kilen	1962	1972	1988	1991										
18	10	Gjerstad	1980	ikke testet		1980										
18	11	Tjellingtjernbekk	1981	ikke testet		1981										
19	73	Kilåi Bru	1968	OK		1968										Mangler data for 2007.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
19	78	Grytå	1977	ikke testet		1977										Vannstandsverdier f.o.m. september 2011 i perioder med høy vannføring er preget av oppstuvning. Om vinteren er det oppstuvning selv på lave vst. Data er svært usikre i denne perioden. Dette skyldes utbygging av småkraft og inntaksdam nedstrøms vannmerket. Midlertidig konstruksjon for å lede vann bort mens dam bygges forårsaker oppstuvning. Konstruksjonen ble fjernet sensommer 2012 har blitt nevnt. Vannføringsdata f.o.m. denne dato ser foreløpig riktig ut, men det må fortsatt måles på høye vannstander for å se om det er påvirkning fra dam nedstrøms. Data i denne perioden må brukes forsiktig.
19	79	Gravå	1970	OK		1970										
19	80	Stigvassåi	1972	OK		1972										
19	82	Rauåna	1972	OK		1972										
19	96	Storgama ovf.	1974	ikke testet		1974										
19	104	Songedalsåi	1981	ikke testet		1981										
20	2	Austenå	1924	OK		1924										
20	11	Tveitdalen	1972	OK		1972										
22	16	Myglevatn ndf.	1952	OK		1952										
22	22	Søgne	1973	ikke testet		1973										Mangler 1992.
24	8	Møska (Skolandsvatnet)	1978	ikke testet	1994	1978										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
24	9	Tingvatn (Lygne)	1923	OK	1940, 1994	1923										
25	24	Gjuvvatn	1971	ikke testet		1971										
26	20	Årdal	1970	OK		1970										
26	21	Sandvatn	1971	OK		1971										
26	26	Jogla	1973	OK	1999	1973										
26	29	Refsvatn	1978	ikke testet		1978					x	x				Usikre lavvannsdata pga vannuttak i Guddalsvann til vannforsyningen i Sokndal.
27	15	Austrumdal (Austrumdalsvatnet)	1980	ikke testet		1986										
28	7	Haugland	1918	1980		1974			x	x	x	x	x	ikke sommer		Lavvannsdata er noe usikre grunnet sesongavhengige forandringer i vegetasjonen langs elvekanalen. Uttak av vann til jordbruksvanning, særlig i tørrperioder. Kurvekvalitet: Det antas en viss fare for systematiske feil i det ekstrapolerte området (vst. > 1,56 m).
35	9	Osali (Botnavatnet)	1982	ikke testet		1982										
35	16	Djupadalsvatn	1990	ikke testet		1990										
36	13	Grimsvatn	1973	OK		1973										
38	1	Holmen	1982	ikke testet		1982										Mangler nesten hele 2002
39	1	Tysvær	1974	OK		1974			x	x						

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
41	1	Stordalsvatn	1913	OK		1913										
41	8	Hellaugvatn	1981	ikke testet		1981										
42	2	Djupevad	1963	1975		1976										
46	9	Fønnerdalsvatn	1980	ikke testet		1980										Mangler mye data 1997 og 2003-05. 47% bre.
48	5	Reinsnosvatn	1917	1957		1917										Homogenitetsbruddet skyldes sannsynligvis økt nedbør.
50	1	Hølen	1923	OK		1923			2004	2004						Lite regulering siden 1916, men ubetydelig også for flom og lavvann. Homogenitetsbrudd i 1970 mot 41.1 og 41.4 kan skyldes ulikt klima. I perioden 11.06.1997 - 31.08.2003 er flomvannføringer opp mot 10 % underestimert pga uheldig plassering av midlertidig stasjon
50	13	Bjoreio	1982	ikke testet		1982										
55	4	Røykenes	1934	1982		1934										Det lages en ny vf-kurve vinteren 2012/13.
62	5	Bulken (Vangsvatnet)	1892	OK		1892										Ubetydelig regulering siden 1919.
62	10	Myrkdalsvatn	1964	OK	1971	1964			1971	1971						Skjøting ikke homogen for høye vannføringer.
62	14	Slondalsvatn	1983	ikke testet		1983										
62	15	Kinne	1983	ikke testet		1983										
62	18	Svartavatn	1987	ikke testet		1987										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
72	5	Brekke bru	1939	OK		1941										Det lages en ny vf-kurve vinteren 2012/13.
73	27	Sula	1991	ikke testet		1991										kontinuerlig f.o.m. mai 1991
74	16	Langedalen	1972	OK		1972										
75	22	Gilja	1963	OK		1963										
75	23	Krokenelv	1965	OK		1965										
75	28	Feigumfoss	1972	OK		1972										
76	5	Nigardsbrevatn	1962	OK		1962			2002	2002						Det lages en ny vf-kurve vinteren 2012/13. Fram til ny kurve er laget kan serien kun brukes for flomstudier f.o.m. 2002. 75% bre
77	3	Sogndalsvatn	1962	OK		1962										
78	8	Bøyumselv	1965	1982?	1982	1983										Årsvannføringen i 1986 og 1987 var veldig lav, men sammenlikning med P og T fra seNorge, antyder at det kan skyldes år med lite nedbør og lave temperaturer om sommeren og derfor lite smelting fra breen. 43% bre.
79	3	Nessedalselv	1983	ikke testet		1983										
80	4	Ullebøelv	1927	1970?		1927										
81	1	Hersvikvatn (Hagevatnet)	1934	OK		1934										
82	4	Nautsundvatn	1908	1973?	1983	1908			x	x						Det lages en ny vf-kurve vinteren 2012/13.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
83	2	Viksvatn	1902	OK		1902										Vann overføres ut siden starten av 60-åra fra et ca. 1 km^2 stort delfelt. Opprinnelig areal 507 km^2.
83	6	Byttevatn		OK		1978										
83	7	Grønengstølsvatn	1965	OK		1965										30% bre.
83	12	Haukedalsvatn ndf.	1935	1966?	1984	1935										
84	11	Hovefoss	1963	OK	1998	1963			x	x						Skjøting ikke bra, men ved slutten av overlappingsperioden passer ny og gammel versjon bra overens for lavvann men ikke flom.
84	20	Holsenvatn	1963	OK	1983	1963										
85	4	Straumstad (Solheimsvatnet)	1974	OK		1974										Flere perioder med manglende data (opp til ca ett år). Solheimsvatnet har to utløp, søndre og nordre. Alle målinger på stasjon er en sum av målinger fra begge utløpene.
86	10	Åvatn (Ommedalsvatnet)	1974	OK		1974										
86	12	Skjerdalselv	1982	ikke testet		1982										21% bre.
87	10	Gloppenelv v/Bergheim	1970	ikke testet 87.3 OK		1970										19% bre.
88	4	Lovatn	1900	1912?		1900										39% bre.
88	11	Strynsvatn	1967	OK		1967										18% bre.
88	16	Hjelledøla	1982	ikke testet		1982										20% bre.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
88	30	Nordre Oldevatn	1902	1912, 1940	1938, 1987	1939						1988				40% bre. Se også 88.2. Norde Oldevatn (Data frå 1902 - 1984). Reguleringsdato 11.11.1938. Det blir tatt ut vann til vannforsynig i Olden, men det er sannsynligvis ikke så mye siden feltet er angitt som uregulert. Ikke lavvann før 1988 pga inhomogenitet ved skjøtingen.
91	2	Dalsbøvatn	1934	OK		1934										
97	1	Fetvatn (Fitjavatnet)	1946	OK		1946			x	x						Flommer kan være påvirket av stormflo når det er lavtrykk kombinert med sterk vind.
98	4	Øye ndf.	1917	1940	1991	1917			1991	1991						
101	1	Engsetvatn	1923	1955		1956										
103	20	Isa v/Morstøl Bru	1972	ikke testet		1972										Svært vanskelige måleforhold (vf-måling/vst. registrering) på middels og høye vannstander. Ok på lavvann.
104	22	Midtre Mardalsvatn	1976	OK		1976										
104	23	Vistdal	1975	ikke testet		1975										
105	1	Osenelv v/Øren	1923	1960		1923										
109	9	Risefoss	1935	1968		1969										
109	21	Driva v/Svoni	1970	OK		1970					x	x				I praksis uregulert (lite reguleringsmagasin i en sidebekk øverst i feltet). Sannsynlig at kurven underestimerer vannføring på middels vannstand.
109	29	Dalavatn	1974	OK		1974										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
111	9	Søya v/Melhus	1974	OK		1974					x	x	x	x	x	Det er en liten regulering her. Stasjonen er brukt som vannkilde for vassforsyning. Vi har ikke fått noe svar fra kommunen, og det anbefales derfor til å bruke stasjonen kun for flomstudier, hvor antatt uttaksmengde ikke har noe betydning, siden vi heller ikke vet, når reguleringen startet, d.v.s. om måneds- og årsverdier kan være påvirket.
112	8	Rinna	1969	OK		1969										
122	11	Eggafoss	1941	OK		1941					x					
124	2	Høggås Bru	1913	1933, 1935		1936			1965		1965	1965	1965			Tømmerfløtning om våren fram til 1995 med kunstige flomtopper. Stabilt fjellprofil.
127	6	Grunnfoss	1951	1965		1951					x					Liten regulering siden 1.11.1951. Stor flom jan 2006 sannsynligvis korrekt.
127	11	Veravatn	1966	OK		1968			1968	1968						Riving av gammel dam, delvis tatt av flom før 1970 (antakelig allerede 27.5.1967), et stykke nedenfor Veravatn.
127	13	Dillfoss	1973	OK		1973										
128	5	Støafoss	1932			1967										Nå uregulert etter slutt tømmerfløting 15.6.1966.
128	9	Leksdalsvatn	1972	OK		1972					x	x				Drikkevannskilde for Verdal kommune. Opplysninger fra teknisk avd i Verdal kommune tilsier et snitt vannuttak på 70 l/s, noe som påvirker lavvann.
133	7	Krinsvatn (Kringsvatnet)	1915	OK	1965	1915			1965			1965	1965			Uregulert, men vær obs på tømmerfløtningsaktivitet inntil ca 1965, spes merkbart ved å gi kunstig lave perioder.
138	1	Oeyungen	1916	1983?		1916										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
139	20	Moen	1974	OK		1974										
139	26	Embrethølen	1980	ikke testet		1980										
139	35	Trangen	1934	1959	1979	1980										
140	2	Salsvatn	1916	OK, men perioden med ny bro ikke testet		1916			x	x						Ny bru i utløpet i 1946. Ytterligere ny bru (utvidelse) i 1989 - medfører fare for profilendring etter ca 20.08.1989. Byggeperiode med utfylling (innsnevring 2/3) fra ca 20.06.1989. Utfyllingen ble fjernet ca 20.08.1989, men sannsynligvis ikke alt. Den hadde liten effekt på små vannføringer - økende effekt med økende vannføring.
148	2	Mevatnet	1973	OK		1973										
151	13	Øvre Glugvatn	1968	1977		1968										Nedbørfelt ved utløp av nedre Glugvatn: 63,3 km². Historiske vannføringsmålinger er utført på både øvre og nedre Glugvatnet uten å ta hensyn til skalering. Målinger både for øvre og nedre Glugvatn ligger bra på kurven. Forskjell i areal er 4%. Stasjonen ble flyttet i 1971.
151	15	Nervoll	1968	OK		1968			x	x						
152	4	Fustvatn	1908	1978?	1916, 1928, 1951, 1970	1908										
153	1	Storvatn	1916	1965		1916										Bruddet synes evt. på lavvann, men det passer også til tendensen hos 138.1 og 140.2

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
156	8	Svartisdal	1929	1945, men ikke testet bare f.o.m. 1961		1961		23								Nå 46% bre. Hele serien bra for virkninger av klima på brefelt men evt. separate analyser fra andre felt. Forandringer i areal pga bresmelting, stabil siden 1961. Statistikken gjelder fra 1961. Feltarealet har variert som følge av påvirkning av bretunge fra Østerdalsisen: 5. juli 1929 - aug. 1941 Feltareal: ca 35 km². aug. 1941 - 9. mai 1959 Feltareal ustabilt 35 - 122 km². 9.mai 1959 - mai/juni 1961 Feltareal 111 km². mai/juni 1961 - d.d. Feltareal: 122 km².
156	10	Berget	1950	OK		1961	-20	23	x	x						Konstant overføring ut på ca 20km2 siden 1955. Nå 35% bre. Hele serien (f.o.m. 1956) bra for virkninger av klima på brefelt men evt. separate analyser fra andre felt. Forandringer i areal pga bresmelting, stabil siden 1961. Statistikken gjelder fra 1961. Feltarealet har variert som følge av påvirkning av bretunge fra Østerdalsisen: 25. mars 1950 - 24. mai 1955 Feltareal: 222 el. ca 297 km². 24. mai 1955 - 9. mai 1959 Feltareal ustabilt: 197 el. ca 272 km². 9. mai 1959 - mai/juni 1961 Feltareal: 197 km². mai/juni 1961 - d.d. Feltareal: 187 km².
156	15	Forsbakk	1963	OK		1963										
156	17	Virvatn	1966	OK		1966					x					
156	24	Bogvatn	1970	ikke testet		1970					x	x				20% bre. Usikker kurve på lavvann.
156	27	Leiråga	1974	OK		1974										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
161	7	Tollåga	1972	OK		1972										
162	3	Skarsvatn	1916	OK		1916					x	x				Usikker vannføringskurve for vannstander under 0,75 m.
162	8	Valnesvatn	1974	ikke testet	2008	1974										Data også f.o.m. 1912, men ingen data 1952-73 og 2007.
163	5	Junkerdalselv	1937	OK		1937					x					Brudd i lavvann rund 1989? Stasjonen ble flyttet ca 20m og ny vf-kurve ble laget. Både den gamle og den nye kurven er usikker ved lavvann pga få målinger. Men vannstanden er bare så lavt om vinteren.
163	6	Jordbrufjell	1945	OK		1945										Ingen data 2007.
163	7	Kjemåvatn	1969	OK		1969										
168	2	Mørsvik Bru	1985	ikke testet		1985										
168	3	Lakså Bru	1953	OK		1953										Vf-kurve trolig feil på vst >0,7 m. Kurven gir for stor vannføring. Høyeste vannføringsmåling ble utført ved 0,765m i 2010. Så det mangler bare målinger for flommene. Men da er kurven ikke mer usikker enn kurver for andre stasjoner.
172	7	Leirpoldvatn	1970	OK		1970			x	x			x	x	x	Vf-kurven gir for høy vannføring på høye vannstander.
172	8	Rauvatn	1977	ikke testet		1977										
173	8	Coarveij	1972	OK		1972										Mangler data 2006-start 2009
177	4	Sneisvatn	1916	1972/ 73		1916					x					Ikke korrigert for tidligere isreduksjoner.
178	1	Langvatn	1953	OK		1953										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
185	1	Gåslandsvatn	1934	OK		1934										
186	2	Ånesvatn	1978	ikke testet	1998	1978										
189	3	Tennevikvatn	1978	ikke testet		1978										
191	2	Oevrevatn	1914	OK		1914										Det mangler data i 1985-1987.
196	7	Ytre Fiskeløsvatn	1960	OK, men ikke testet etter flytting av stasjon		1960										
196	11	Lille Rostavatn	1959	OK		1959	-127									Utløp fra en innsjø med to utløp. Det er estimert at vann som tilsvarer et areal av 127 km^2 drenerer til det andre utløpet.
196	12	Lundberg	1961	OK		1961										
200	4	Skogsfjordvatn	1957	OK, men nåværende stasjon ikke testet	1989	1957										
203	2	Jægervatn	1955	1988		1989										Den sammensatte serien ser bedre ut nå. Men i perioden 1978-87 ble hele serien forandret mye ved datakorreksjoner; usikkert hvorfor det ble gjort
205	6	Didnojokka	1979	OK		1979										
206	3	Manndalen Bru	1971	OK		1971										

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km^2)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
208	2	Oksfjordvatn	1955	1981		1955										
208	3	Svartfossberget	1981	ikke testet		1981	-46									Overføring ut siden 1967 av 45,8 km^2.
209	4	Lillefossen	1961	1970		1970	-14.6									Overføring ut siden 1969 av 14,6 km^2 areal.
211	1	Langfjordhamn	1980	ikke testet		1980										28% bre.
212	10	Masi	1966	OK		1966										
212	48	Sagafoss	1971	OK	1990	1971										
212	49	Halsnes	1921	1950, 1970?	1955, 1966	1972										Datafeil på 60-tallet. Mangler data for en del år mellom 1944 og 1972.
213	2	Leirbotnvatn	1961	OK		1961										
213	4	Kvalsund	1978	ikke testet		1978										
223	2	Lombola	1960	OK		1960										
230	1	Nordmannset	1961	1976		1961			x	x	x	x				Det er ikke målt vannføring over 1,4 m (4 m^3/s). Derfor usikre data på høy vannstand. Sensorene har vært lagt i en steinsatt kum som ikke er stabil fram til 2008. Ved lave vannstander har kummen gått tørr, og noen problemer med is i kommunikasjonsrøret. Begge sensorene ligger nå i vannet.
234	13	Vækkava, Lesjokka	1973	OK	1990	1973					x					Brudd i vinterlavvann pga forkjellige måter å isredusere på.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
234	18	Polmak nye	1912	ikke testet, 234.1 OK	1991	1912										
237	1	Båtsfjord	1980			1987										1986 er fjernet pga dårlig kvalitet.1985 heller er ikke ok.
244	2	Neiden	1912	1900/91	1978	1953			x	x						Overføring ut på 64,2 km² begynte etter 1952, men usikkert når. I praksis uregulert. Sporadiske flomtap.
246	9	Sametielv	1962	1976?		1962										
247	3	Karpelva	1927	1942/43		1946										Mangler data høst 1944 til sommer 1946.
307	5	Murusjø	1925	1945		1925										
307	7	Landbru limn.	1943	OK		1943										Avløp fra karstområde, kalkfjell med mange forsenkninger og grotter. Målestasjonen ligger nedenfor utløpet "Landbru" som er en grotte (tunnel) på ca 150m. Vannet går ned i undergrunnen innerst i grotten for å komme opp i kulpen hvor målestasjonen ligger.
308	1	Lenglingen	1925	1971		1925			x	x						
311	4	Femundsenden (Femunden)	1896	1983/84		1896										Brukbar også for flom. Overføring ut fra nordenden av Femunden. Overføringen er av liten betydning. 1896-1916 ble det utført målinger av overføringen. Det ble anslått at overføringen var 27 millioner m3 i året i gjennomsnitt, hvilket tilsvarer en årlig middelvannføring på 0.86m3/s. Det er tvilsomt om overføringen har vært så stor i senere tid. Kanalen er ombygget i flere omganger, senest i 1996. Fløting av tømmer frem til ca. 1970.

Regine no	Main no	Station name	Record start	Homogenity break	Connection year	Reference series start	Area change (km²)	Varying area	Not spring flood	Not floods	Not winter lowflow	Not lowflows	Not monthly flow	Not seasonal flow	Not annual fow	Comment
311	6	Nybergsund		OK	1973, 2000											Overføringen ut i hele perioden, men ubetydelig også for lavvann. 1896-1916 i middel 0,86 m²/s, sannsynligvis mindre etterpå.
311	460	Engeren	1911	OK for stasjoner i samme vassdrag. Ellers evt. 1933, 58, 69?		1941										Magasinering f.o.m. 1941, men ubetydelig.
313	10	Magnor	1912	1958, 1980	1969, 1972, 1981	1980		x								Påvirket av "Glommas bifurkasjon ved Kongsvinger" (NVE-rapport 1-2001) ved Q > middleflom.

Denne serien utgis av Norges vassdrags- og energidirektorat (NVE)

Utgitt i Rapportserien i 2013