

## **NVE's snow reference datasets for climate change studies**

*last updated in December 2021 by Heidi Stranden and Tuomo Saloranta (HB/NVE)*

### **Available data basis**

Snow depth (SD) and/or snow water equivalent (SWE) have been recorded by both NVE and various hydropower companies since 1914. NVE and the hydropower companies need information about available water resources for hydropower production and to estimate the risk of flooding. Both data recorded by NVE and data recorded by the different hydropower companies (hereinafter referred as HPC-data) is managed by NVE. Most of the HPC-measurements are taken at the time of the annual snow maximum around the beginning of April, while automatic snow stations (like snow pillow stations) give continuous measurements of SWE during the whole winter season. At some locations manual measurements are performed once a month or biweekly. A handful of the stations have continuous data since the 1920s, while the first automatic station, a snow pillow station, was established at Filefjell in 1967. During the 1970s and in the beginning of the 1980s more stations were established.

The measurements in the HPC-dataset and a few of the NVE stations are normally based on a snow course (~1 km) or a point swarm. Common for all measurements of this type is that a "station" is a fixed coordinate along the snow course/in 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.

Previously, the HPC-data set has been used to analyze long-term trends in snow depth (Dyrørdal 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). The network of automatic registrations of SWE has been thoroughly evaluated and analyzed by Ree et.al. (2011), Stranden et al. (2015) and Stranden & Ree (2016), with respect to data quality and locations.

In Fleig (2013) only HPC-data was included as reference stations. However, in the updated reference stations list (Tables 1-2), also other snow measurement time series are included.

### **The HPC-dataset**

In Fleig (2013) 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.

In Fleig (2013) totally 68 stations passed these selection criteria. An updated check on the database revealed that most of these stations have had continued measurements after 2013 and until now. For ten of the 68 stations in Fleig (2013) data has not been recorded in the database since 2010/2011.

Consequently, 58 of the HPC-stations listed and shown in Fleig et al (2013) still qualify as reference stations, even though data from 19 of the stations are missing since 2018.

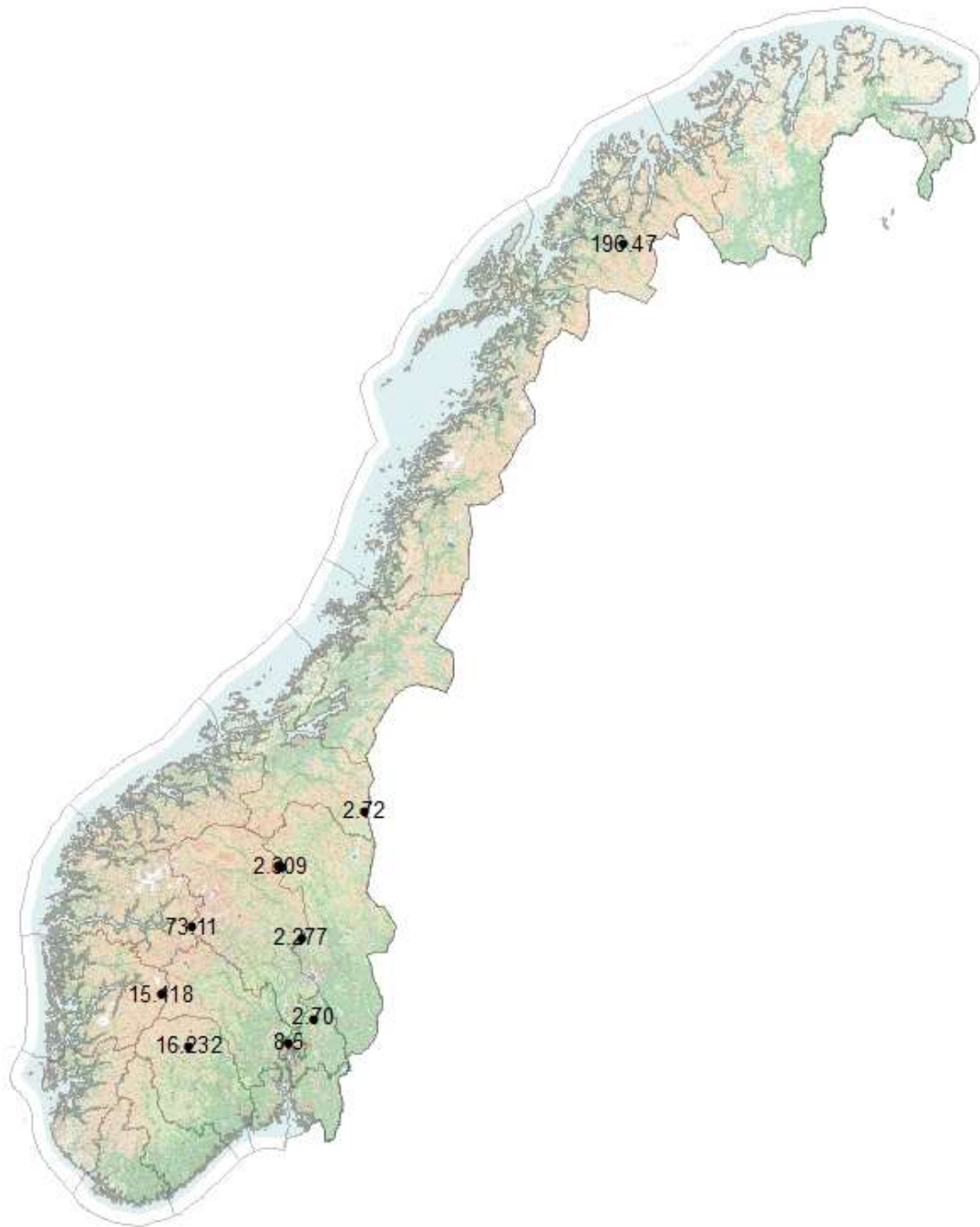


Figure 1. Map of stations in Tables 1 and 2.

### Automatic, real-time stations

Since the first snow pillow was established in 1967, additional 32 automatic snow stations have been established at different locations in Southern and Northern Norway. Some hydropower companies are also using snow pillows for automatic recording of snow, and data from a few of them are reported to NVE. Some of the stations were established in the 1970s, while a huge launching of automatic snow stations took place in 1997/1998. By winter 2021, the NVE network of automatic snow stations (SWE and/or SD) consist of 20 real time stations. Even if most of the stations were established in 1997 or

earlier, there is just a handful of stations that has more than 30 years of reliable data. Table 1 shows these, including three NVE stations and three HPC stations with longer records. In addition, one more real time NVE snow station in South Norway has reliable data in 21 years (12.142 Bakko) and one real time snow station in the northern part of Norway has reliable data in 20 years (213.7 Øvre Leirbotn). Data from these two stations may be included as climatic series in the future.

### Other datasets

At two locations in South Norway, NVE and a local observer has performed measurements of snow depth and SWE annually and monthly/biweekly since 1987 and 1978 (Table 2). Five of the stations in Table 2 are measurements within the same catchment area (2.278 – 309 Storbekken), and the measurements are performed annually at the time of the expected snow maximum. Unpublished preliminary analysis shows that the time of snow maximum may have changed from mid –April to mid-March, and by now measurements in middle of March are the most common. At Sjusjøen-Storåsen (2.277 in Table 2), monthly and biweekly measurements of snow depth and SWE have been performed since 1978. The consequences of a changing local observer in 2014, has not been analysed in detail yet, but preliminary analysis shows that this has only a minor effect on the homogeneity.

Table 2 shows also two long time series of snow depth from one station in South Norway (15.118) and one station in North Norway (196.47). Manual measurements of snow depth were performed on monthly basis until 2006. In 2006, an automatic snow depth sensor replaced the manual measurements. Any issues regarding the homogeneity due to this shift of observation method has not been analysed yet.

Table 1: Automatic, continuously recording SWE-stations (snow pillows).

Regine nr.	Main nr.	Elevation	Total nr. years in the last continuous period	Last obs. year in the last continuous period
73	11	950	48	2021
8	5 <sup>1</sup>	370	30	2021
16	232 <sup>2</sup>	990	46	2021
123	93	285	40	2021
2	72 <sup>3</sup>	840	37	2021
2	70 <sup>4</sup>	195	29	2016

<sup>1</sup> misses 4 years in a row from 1989/1990 to 1992/1993.

<sup>2</sup> operated by HPC

<sup>3</sup> operated by HPC

<sup>4</sup> operated by HPC

Table 2. Snow measurements in Storbekken catchment area (2.278 – 309), Sjusjøen (2.277), at Skurdervikåi (15.118) and Øverbygd (196.47)

Regine nr.	Main nr.	Elevation	Total nr. years in the last continuous period	Last obs. year in the last continuous period
2	278	800	32	2020
2	286	900	32	2020
2	293	1000	32	2020
2	308	1100	32	2020,
2	309	1200	32	2020
2	277	930	46	2021
15	118	1245	40	2017
196	47	83	36	2021

Table 3. List of selected stations from the HPC-data

Regine nr.	Hoved nr.	Elevation (m a.s.l.)	Total nr. obs. years	Total nr. obs. years in the last continuous period	Last obs. year in the last continuous period
19	199	291	39	37	2021
19	214	259	38	35	2021
19	200	429	40	37	2021
19	212	321	39	37	2021
19	213	377	34	32	2021
19	215	431	38	36	2021
19	101	660	40	39	2021
19	195	611	43	41	2021
19	196	614	37	35	2021
19	204	690	43	41	2021
19	206	661	42	40	2021
19	216	670	44	42	2021
19	217	739	42	45	2021
19	224	681	40	43	2022
19	231	812	34	32	2021
19	233	761	35	33	2021
21	107	891	32	30	2021

21	108	857	31	29	2021
25	40	875	44	42	2021
25	41	780	45	43	2021
25	43	640	44	42	2021
26	83	760	43	41	2021
26	85	630	43	41	2021
26	86	730	43	41	2021
21	98	1136	32	30	2021
21	104	1063	32	30	2021
21	119	916	32	30	2021
21	120	998	31	29	2021
21	123	950	28	26	2021
25	44	930	39	37	2021
26	68	1130	26	24	2021
16	290	938	75	71	2018
16	292	1115	77	73	2018
16	293	940	78	74	2018
16	294	931	74	73	2018
16	295	919	71	70	2018
16	297	969	74	73	2018
16	305	941	65	65	2018
16	311	1178	80	75	2018
16	314	1083	80	75	2018
16	319	1137	79	74	2018
16	321	1136	82	77	2018
16	327	1159	78	75	2018
16	298	1456	80	75	2018
16	304	1220	80	75	2018
16	307	1214	80	75	2018
16	316	1206	82	77	2018
16	317	1339	81	76	2018
16	323	1273	80	75	2018
16	324	1320	77	72	2018
12	423	1193	48	47	2020
12	425	1217	50	48	2021
12	398	820	27	25	2021
12	399	806	26	24	2021
2	277	970	41	38	2021
12	405	995	26	24	2021
12	408	925	26	24	2021
12	409	903	26	24	2021

## References

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