How are weather and snow data produced for seNorge.no and XGEO.no?

How MET produces weather data and NVE snow data for XGEO.no og seNorge.no.
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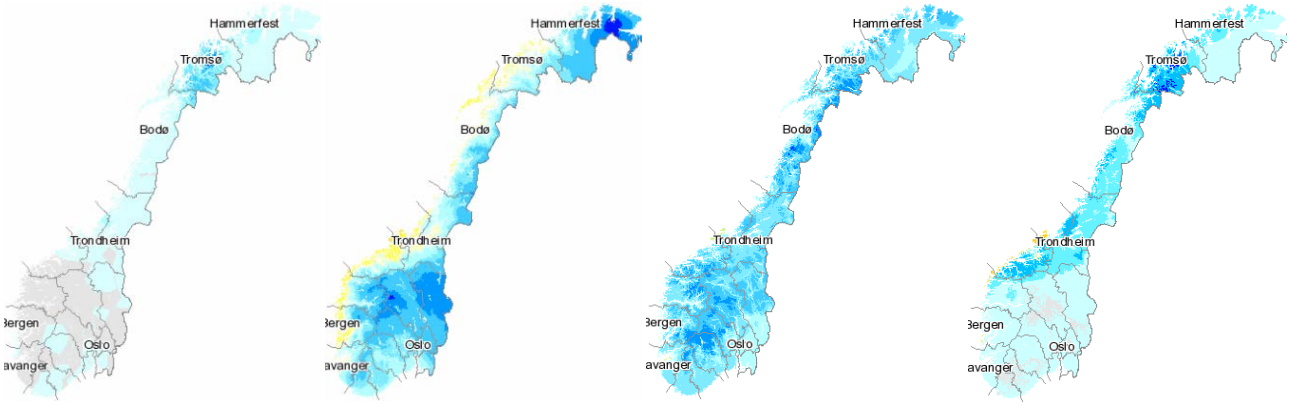
INTRODUCTION

General information about the data sets

The data sets consist of values for precipitation, air temperature and several snow properties with spatial resolution of one kilometre and one day (24 h) time resolution, see the example below. The data sets cover the period from 1957 to 9 days in to the future.

Weather data (daily precipitation and temperature) is calculated by spatial interpolation of point observations. Snow data (quantity, depth, condition, fresh snow, melting, age, etc.) is calculated by snow models run with weather data.

Tuesdays and Thursdays maps for the past 18 days are updated in order to include delayed observations.



Precipitation | Air temperature | Snow amount | Change in snow amount previous week

Examples of data for 15 February 2010.

Observation-based and forecast-based maps

Observation-based maps with daily data are calculated from observations of the day until 7 am (8 am DST) for the given date. Observation-based maps are produced until the current date.

Forecast-based maps are produced for a period of 9 days. Maps for the next two days are calculated with precipitation data from Arome and temperature data from elevation-adjusted and kalman-filtered Hirlam8 (same as on YR), as well as snow models. Maps for the next 7 days are based on 9-days prognosis from EC.

Daily updates of weather and snow maps at around 0, 6, 8, 9, 12, 18, 19 and 21 Norwegian standard time:

- at about 00 by new Arome (18H the day before) precipitation forecast
- at about 06 by new Arome (00H) precipitation forecast and YR (00H) temperature forecast
- at about 08 by new observations
- at about 09 by more new observations and EC (00H) forecast
- at about 12 by new Arome (06H) precipitation forecast
- at about 18 by new Arome (12H) precipitation forecast and YR (12H) temperature forecast
- at about 19 by new observations
- at about 21 by new EC (12H) forecast

Numerical weather prediction models: Arome (Application of Research to Operations at MEsoscale) with 2.5 km resolution, EC (European Centre for Medium Range Weather Forecasting), Hirlam (High Resolution Layered Atmospheric Model) with 8 km.

00H is the model run starting at midnight, 06H at 06, 12H at 12 and 18H at 18.

SNOW MAPS

Snow amount, conditions and melt

The maps showing snow amount as snow water equivalent (in millimetres), the quantity of liquid water in the snow (in percent moisture), and runoff from the snow (in millimetres) for the specified date. Data are calculated with a snow model, which uses day precipitation and temperature as input, (see figure below) by the following procedure:

1. The snow model is based on the HBV-model and calculates the snow water equivalent, liquid water content and runoff from the snow pack based on the weather data described above. The model calculates values for each square kilometre of Norway.
2. The snow model considers precipitation as snow accumulation if the air temperature is below a prescribed threshold value. If the air temperature is higher, it considers precipitation as rain, which either moistens the snow pack (and thus becomes part of it) or drains to the ground as runoff.
3. The snow model has four state variables, which are updated daily: snow water equivalent (in millimetres), fraction of snow-covered area (in percent), proportion of liquid water in the snow (in percent) and runoff from the snow (in millimetres). In addition, the amount of fresh snow is calculated in millimetres. If the air temperature is higher than a predetermined threshold value, the snow melts. The melting water will either remain in the snow (and snow will become wetter) or drain to the ground (runoff). If the snow is wet and the air temperature is below a fixed threshold value, liquid water in the snow freezes to ice and becomes part of the frozen snow pack. In this case, the proportion of liquid water in the snow is reduced or eliminated (this is called refreezing).

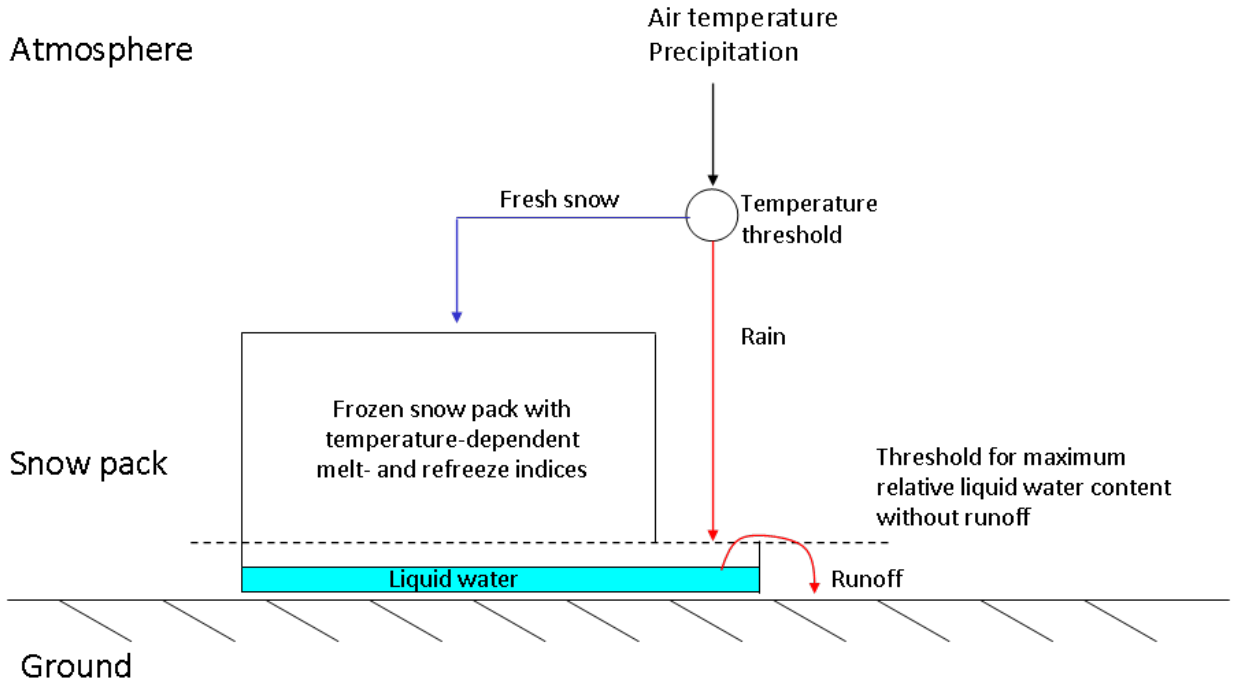


Illustration of the Snow map model that simulates the amount of snow, liquid water and snow melt.

Snow amount as percent of normal and ranked

The maps shows the amount of snow (snow water equivalent) for the specified date, in percent of normal (median for the given date in the period 1981-2010) and ranked the same day in all winters in the period from 1957 until this winter.

Snow depth and fresh snow depth

The maps show snow depth (total depth of snow pack) and fresh snow depth (depth of fresh snow which has come last 24 hours) in centimetres for the specified date. Snow depth is derived on the basis of the simulated snow water equivalent and snow pack bulk density. Both the density of fresh snow and snow pack compaction under varying weather conditions are taken into account in the simulations.

Maps of amount and type of precipitation shows snow, sleet and rain based on air temperature thresholds at -0.5 and 2.0 °C.

Snow transport

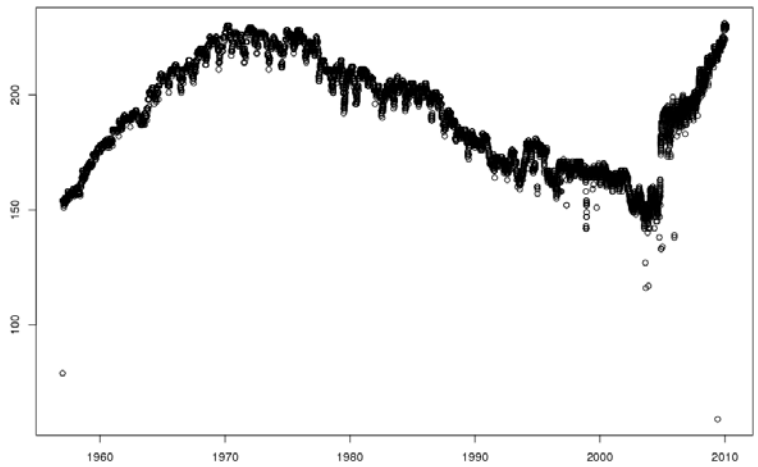
The map shows the amount of wind-transported snow during previous 24-hour period until 7 a.m. The map is a combination of a model for snow storms (Föhn, 1980) and snow transport depending on snow age and wetness. Snow is moved from windy areas to lee slopes leaving the total snow amount unchanged. Based on data from Arome.

WEATHER MAPS

Air temperature

The map shows the daily average temperature (in °C) based on observations from the past 24 hours. It is calculated by the following procedure:

1. Daily temperature is calculated for each station based on observations of air temperature at about 230 measurement sites in Norway. Number of stations has varied over time (see figure below).
2. Air temperature is interpolated in a grid with 1 km point distance, which gives a value for each square kilometre route in Norway based on observations from all measurement locations. The spatial interpolation is based on a Bayesian method in which the prior information (i.e. the background field) is meant to include the atmospheric large-scale effects on temperature, which determine the vertical lapse rate for example.



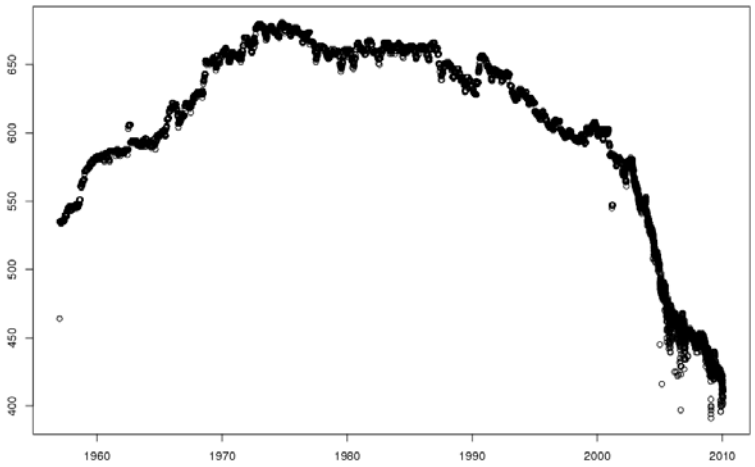
Number of stations used for interpolation of air temperature.

Precipitation

The map shows precipitation (in millimeters) past 24 hours. It is calculated by the following procedure:

1. Precipitation sum last 24 hours is calculated for each station based on observations at about 400 measurement points. Number of stations has varied over time (see figure below).

2. Precipitation is interpolated in a grid with 1 km point distance. The spatial interpolation is based on a Bayesian method in which the prior information is estimated from the data. Furthermore, the information is propagated from the coarser to the finer scales by means of an iterative Optimal Interpolation (OI) procedure. No catch-correction of the precipitation observations is applied at this stage.

1. 

Number of stations used for interpolation of precipitation.

IMPROVED DATA SETS

20.09.2006: Version 1.0 was released on www.seNorge.no, when the portal was opened by the former minster of petroleum and energy, Odd Roger Enoksen.

18.02.2010: Version 1.1 was released with these improvements from version 1.0 from 20.09.2006:

- The data set goes back to 1957 (version 1.0 went back to 1961)
- The terrain is calculated from a better digital elevation model with 1 km resolution (in version 1.0 was GTOPO30 resampled to 1 km was used)
- Set of stations used in the calculation of precipitation and air temperature is always updated (in version 1.0 until 1 April 2008, the selection of stations was based on semi-static station lists)
- Air temperature and precipitation are calculated using the same time period, from 6 until 6 UTC (Version 1.0 used 06-06 UTC for precipitation and 18-18 UTC for air temperature until 01.06.2006)

Comparison of versions 1.0 and 1.1 are documented in reports both for weather data (M. Mohr, met.no-note # 19/2009 on http://met.no/Forskning/Publikasjoner) and snow data (Heidi B. Stranden, NVE Dokument 04-2010 on http://www.nve.no/snokart).

23.02.2012: Forecast maps were now produced using UM4 precipitation and YR temperature. Previously, Hirlam10 and Hirlam8 were used. Furthermore, the forecasts are updated twice a day, rather than once a day. This change affects the forecasts only, and not the historical data archive. Thus, the version numbering was not incremented.

14.01.2013: The web site xgeo.no was launched as a decision support tool for warning and preparedness when the Avalanche Warning Service for Norway was established and started publishing bulletins on www.varsom.no. XGEO.no provides all data sets from seNorge.no in addition to several data more relevant to warning and preparedness.

01.09.2013: Version 1.1.1 of the snow maps released (1957- present). The new snow maps are based on a revised and calibrated snow model, now also simulating the fraction of snow-covered area in the square-kilometer pixels. Evaluation of the new snow model against snow observations shows, that it simulates the snow conditions generally more accurately than the previous model version. Furthermore, the Arome

model replaced UM4 on 15 October, thus the precipitation two-day forecasts are from this date from the Norwegian version of the Arome model (named Arome-Norway). The snow model and new data sets are described in “Saloranta, T. M. 2012: Simulating snow maps for Norway: description and statistical evaluation of the seNorge snow model. The Cryosphere 6, 1323-1337” and “Saloranta, T. M. 2013: Calibration and uncertainty analysis of the seNorge snow model (v.1.1.1) and the snow maps for Norway. Manuscript in prep.”.

20.112015: Version 2.0 for the precipitation, air temperature and snow maps released (1957- present). New Bayesian interpolation methods are used in interpolation of precipitation and air temperature. Available observations from Sweden and Finland are now also included in this interpolation. The new snow maps are based on the same v.1.1.1 snow model as previously, but with new input data (v.2.0 of precipitation and air temperature) and revised correction factors for precipitation (+5 % for rain, +10 % for snow, based on evaluation against snow observations). (Manuscript in prep.)