The expert tool XGEO and its applications in the Norwegian Avalanche Forecasting Service

Emma Barfod[1], Karsten Müller[1], Tuomo Saloranta[1], Jess Andersen[1], Nils Kristian Orthe[1], Anders Wartianien[1], Tore Humstad[2], Steinar Myrabø[3] and Rune Engeset[1]
[1] Norwegian Water Resources and Energy Directorate, Middelthunsgate 29, 0301 Oslo, Norway.
[2]Norwegian Public Road Administration, Brynsengfaret 6A, 0667 Oslo
[3]Norwegian National Rail Administration, Stortorvet 7, Oslo

ABSTRACT: Norway is highly dependent on tracking the changing snow cover, not only for the avalanche forecasting but also for hydropower production planning, flood forecasting, climate change monitoring and ski tourism.
The web portal XGEO is a map centric tool for visualizing temporal and spatial data. Based on interpolated temperature and precipitation observations, a snow model produces various maps indicating the condition of the snow pack. All maps can be combined with other geographical information, such as roads and county borders. Observational data from weather stations, webcams, or field observations by avalanche observers can be viewed, thus making XGEO an invaluable tool for the Norwegian Avalanche Forecasting Service.

KEYWORDS: Map centric tool, observations, snow model, avalanche forecasting

1 INTRODUCTION

Norway stretches over 13 degrees of latitude and sees significant differences in landscape and weather conditions. Accordingly, snow conditions and the avalanche danger can vary significantly from North to South and from coast to inland. The Norwegian Avalanche Forecasting Service (Engeset, 2013) assesses the avalanche danger in the country daily during the winter season. It is essential for the forecasters to get a full overview of the current conditions and important events. XGEO provides such an overview and easy access to detailed information from various data sources, thus making the avalanche danger assessment more efficient.

2 THE WEB PORTAL XGEO

The web portal XGEO is a map centric tool for visualizing temporal and spatial data (Figure 1). XGEO has been developed and maintained by the Norwegian Water Resources and Energy Directorate (NVE) since 2004, in collaboration with the Norwegian Meteorological Institute, the National Public Road Administration and the National Rail Administration. XGEO is an expert tool used for preparedness, monitoring and forecasting avalanches, but with support of open data policy, i.e., data is freely available to everyone (citizens, scientists, authorities, etc.)

Profiles are used to customize the tool for different user groups, such as floods and landslides, avalanches, climate, and road and rail. The profile geared towards the general public is available at www.senorge.no and m.senorge.no (mobile version).

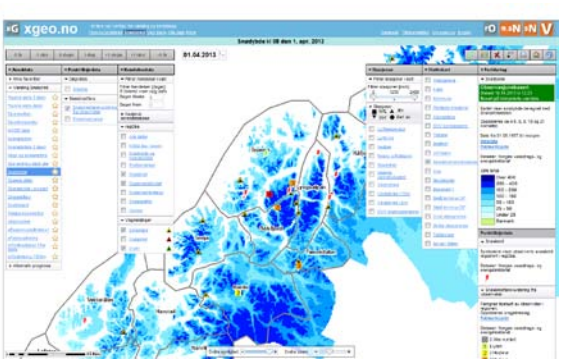

Figure 1: The web portal XGEO. The current map shows the snow depth distribution in parts of Northern Norway. The triangles indicate roads closed due to avalanches. The drop-down menus allow the user to combine various data sets.

XGEO shows daily maps of the snow conditions, interpolated weather observations and numerical predictions, gridded water balance and climate means and anomalies. In addition XGEO presents real-time weather point observations from around 300 stations together with available webcams harvested from webcams.travel). Observations from NVEs professional avalanche observers, public observers and observers from the rail and road authorities, which contribute to regobs.no (Ekker, 2013) are accessible via XGEO.

XGEO also displays administrative data, such as forecast regions, the existing infrastructure of rails and roads and other static map layers, such as steepness or tree line.

XGEO has an easy temporal navigation that makes it efficient to analyze historical events.

The chart service in XGEO can combine virtually any time series from different data sources. These include hydrological and meteorological data, both forecast and observation, and all available grid cells (1x1 km) from our grid models.

Often used charts are provided as templates in order to give fast access to commonly used data sets. For example, a customized meteogram provides a comprehensive overview over current meteorological conditions at a weather station (Figure 2).

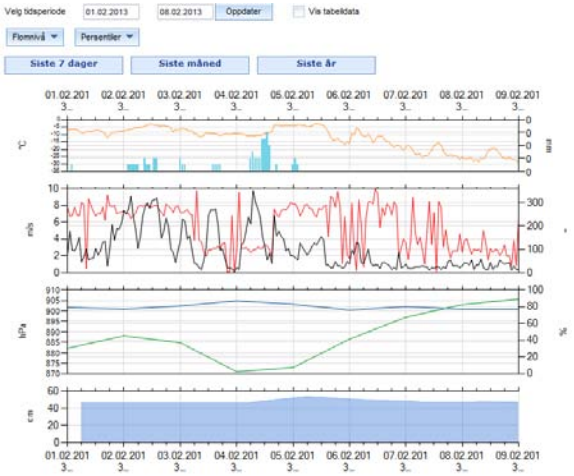

Figure 2: Meteogram showing air temperature, precipitation amounts, wind speed and direction, air pressure and rel. humidity and snow depth over the last seven days.

Grid Time Series (GTS) makes each point in the grid available as a time series. A customized binary file is produced on the fly for efficient data retrieval, all the way back to 1957. All the data is available in a REST service to be called from XGEO. The GTS data gets updated when the production workflow runs.

4 SNOW MODEL

In regards of avalanche forecasting, the most widely used application in XGEO is the single layer snow model (Figure 3). The snowpack model is based on a simple degree day factor.

The model takes interpolated observations of daily temperature and precipitations as its input forcing produced by the Norwegian Meteorological Institute (Tveito et al., 2005). The data series have daily resolution.

The snow model operates with 1x1 km resolution, resulting in 334 000 grid cells covering all of Norway. Prognosis is based on numerical weather prediction models including Unified Model (www.metoffice.gov.uk/) and ECMWF (www.ecmwf.int/).

The development in snow conditions over the last 24/72 hours is one of many outputs provided by the model that are well used in the preparation of the avalanche forecasts. The main variables are snow water equivalent (SWE) and snow depth. Additional variables are the weekly snow changes, snow wetness, snow melting and skiing conditions. A total of more than 20 different layers from the snow model are simulated back to 1957. Including the 60 additional layers from other runoff and forecast models, a total of 1.2 Million maps are available in XGEO.

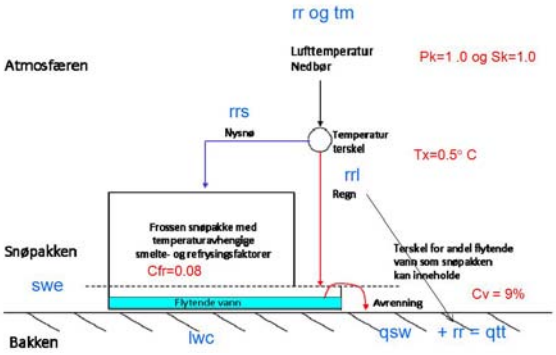

Figure 3: Sketch of the simple degree day factor model used for the snow maps on xgeo.no.

4.1 Improving the snow model

Continuous evaluation of the snow model and its uncertainties yielded a new set of snow maps with improved accuracy. A statistical evaluation in 2012 of the snow model (Saloranto, 2012) proved an overestimation of both SWE and density. The surveys resulted in the following improvements:

- Removal of significant systematic biases in SWE and density
- Better snow density routine
- New modified degree-day melt-algorithm
- Simulation of fraction of snow-covered area (SCA)

Future improvements of the snow model will focus on an energy-balance approach (with T & P still as input) and better forcing data.

5 XGEO TECHNOLOGY

XGEO is developed as a single page application in Javascript using a set of different frame works such as Dojo and the ESRI Javacscript API for map configuration and manipulation. Service layers are developed in .NET as REST services. The map technology used is the ESRI ArcGIS –server. WMS-services for grid data use custom made time parameters to handle time navigation. Configurations are stored in an MS SQL server.

6 CONCLUSION

XGEO is a comprehensive tool for forecasting various types of geohazards in Norway. It provides an overview over the hydro-meteorological conditions in the country, by combining gridded observations and model outputs with real-time observations from various sources. Given the large geographical differences and vast regions, preparing the Norwegian Regional Avalanche Forecast is a complex task. XGEO has proven to be an invaluable tool in managing this task. XGEO will continuously be evaluated and improved to serve as a highly efficient tool for the Regional Avalanche Forecast.

7 REFERENCES

Engeset, R. V., 2013. National Avalanche Warning Service for Norway – established 2013. Proceedings ISSW 2013. International Snow Science Workshop, Grenoble-Chamonix, France, 7-11 October 2013, this issue.

Saloranta, T. M.: 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, 2012.

Tveito, O. E., Bjørdal, I., Skjelvåg, A. O., and Aune, B.: A GIS-based agro-ecological decision system based on gridded clima- tology, Meteorol. Appl., 12, 57–68, 2005.