A forecast analysis tool for extreme hydrological conditions in Norway

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Flow Regime from International Experimental and Network Data
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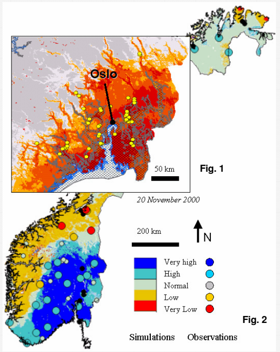
BACKGROUND: The Norwegian Water Resources and Energy Directorate is responsible for the administration of Norway's water and energy resources. Since 2009, NVE's responsibilities include prevention of damage caused by landslides, avalanches and rock falls. NVE has since 1989 had a 24 hour flood forecasting service for the entire country and is now developing an early warning system for landslides at regional level. It is expected to be operational from 2013. NVE provides forecasts and analyses of inflow to hydropower plant reservoirs and supervises hydropower production.

OBJECTIVES: Analyse, follow and forecast extreme hydrological conditions. Develop an integrated awareness system at regional scale with regard to flood, landslide and drought.

EXAMPLE: Floods and landslides

Landslides and debris flows: Shallow landslides and debris flows in Norway mostly occur as a combination of high-intensity precipitation or snowmelt and high groundwater level. Information of simulated soil water conditions and precipitation based on weather forecast have proved to be useful indicator variables. Forecasts of runoff and freezing-thawing are also valuable information.



✹ Autumn 2000: weeks with low-intensity rainfall lead slowly to soil saturation and high groundwater levels in Southeast Norway causing over 90 landslides and prolonged floods in November/December 2000.

Figure 1: Simulated (HBV) soil water capacity and registered landslides (yellow circles). The red color indicates soil water saturation and extreme high groundwater level.

Figure 2: Simulated (HBV) and observed groundwater conditions (deviation from average)

✹ Spring 2008:

Intensive snowmelt on wet soil caused several landslides and debris flows during one week in the Southeast Norway.

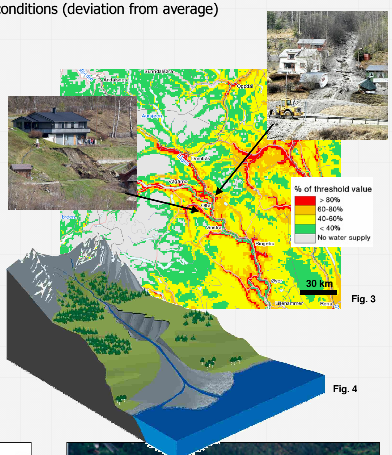


Figure 3: Map shows 3-day precipitation and snow melt in percent of a threshold value (red pixels indicate values close to 16 % of annual precipitation).

Figure 4: Sketch of a typical debris flow

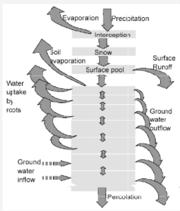
• Beldring S, Engeland K, Roald LA, Sælthun NR, Voksø A (2003). Estimating of parameters in a distributed precipitation-runoff model for Norway. Hydrology and Earth System Sciences, 7.
• Engeset R. Tveito OED, Mengistu Z, Udnæs HC, Isaksen K, Førland EJ (2004). Snow Map System for Norway. XXIII Nordic Hydrological Conference. Tallin. NHP Report 48. Tartu.
• Jansson PE, Karlberg L, (2004). Coupled heat and mass transfer model for soil-plant-atmosphere systems. Royal Institute of Technology. Dept. of Civil and Environmental Engineering, Stockholm.

Analytical tool

Measurements in real-time:

- ✹ Discharge (350)
- ✹ Groundwater level (80)
- ✹ Soil water content and temperature (17)
- ✹ Snow water equivalent (25)
- ✹ Meteorological data (met.no)

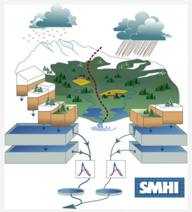
Model simulations:



✹ An adapted version of 1-D soil water and energy balance model COUP (Jansson & Karlberg, 2004)

Input: Daily values of air temperature, precipitation, relative humidity, wind speed, cloudiness or global radiation. Soil and plant characteristics.

Output: Soil water content and flow, soil temperature, snow depth, soil frost …



✹ A spatially distributed version of the conceptual precipitation-runoff HBV-model (Beldring et al., 2003)

Input: Daily resolution of air temperature and precipitation on 1*1 km² grid generated by met.no. Indirect description of soil and vegetation by a 5-level classification for each grid-cell.

Output: runoff, groundwater (mm), subsurface storage capacity, soil frost, snow depth.

Analysis:

✹ Web- and GIS-based systems with daily nationwide maps showing the meteorological and hydrological conditions for the present and the near future from quantitative weather prognosis

seNorge.no (Engeset et al., 2004)

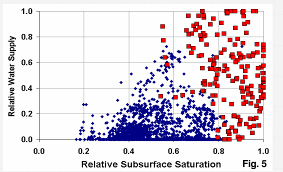


Figure 5: Relationship between simulated relative water supply (rain & snow melt) and relative subsurface saturation (soil water & groundwater). Red dots: over 200 days with landslides events. Blue dots: over 4000 normal days with no events

✹ The warning of potential hydrological-hazards is based on an analysis of spatial and point information on forecasted precipitation and snowmelt with simulated and observed information on runoff, groundwater and soil water conditions. **Threshold-levels are estimated from the statistical analyses of historical geo-hazards events.**

EXAMPLE: Drought

Winter drought:
In headwater catchment, the lack of recharge in winter (snow and soil frost), combined with constant groundwater discharge, lead to a fall of groundwater level through soil drainage resulting in soil deficit up to 250 mm, especially in mountainous areas. When snow quantity is too small to replenish the soil water deficit from the winter, drought may persist to next autumn.

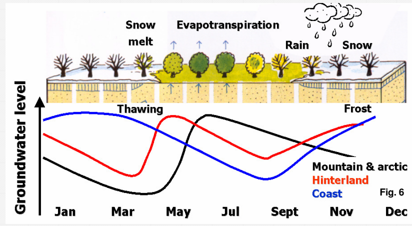


Figure 6: Groundwater variation in Norway

Consequences:
- Decrease water inflow to hydro-power plants (electricity prices)
- Decrease in groundwater level (problems with water supply, frost damages..)
- Decrease in water availability for plants in summer season (reduced yield)

Winter drought 2009-2010 Southwest Norway:

Water supply for both surface and groundwater sources was affected due to a dry autumn (locally along the coast 100-year precipitation drought) and cold winter: precipitation came early as snow, even along the coast. The drought last until september 2010 in southern Norway.

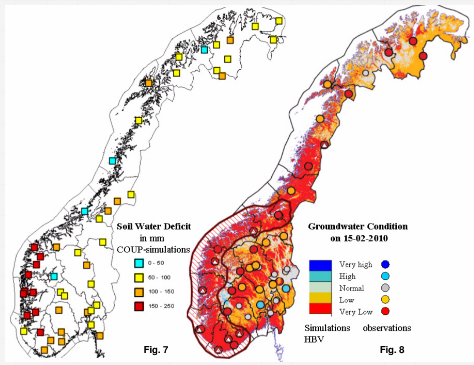


Figure 7: Simulated (COUP) soil water deficit

Figure 8: Simulated (HBV) and observed groundwater conditions (deviation from average) The shaded area indicate the most affected area with extreme low groundwater (lowest measured groundwater level ever >30 years with data)

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