Experiences from coordinated national-level landslide and flood forecasting in Norway

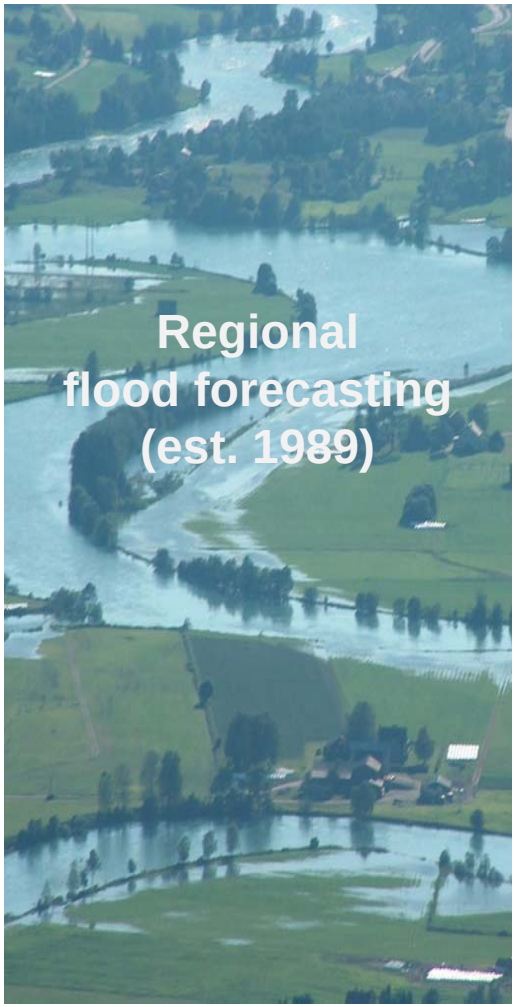
I. K. Krøgli, A. Fleig, P. A. Glad, M.-P.J. Dahl, G. Devoli, H. Colleuille, EGU general assembly 2015

Landslides = Debris slides, debris flows, debris avalanches and slush flows

All photos: NVE

Experiences from coordinated national-level landslide and flood forecasting in Norway,

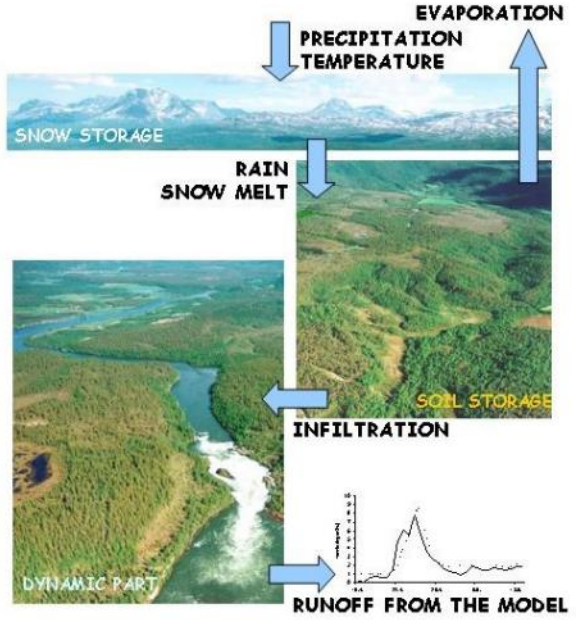
I. K. Krøgli *et al.*

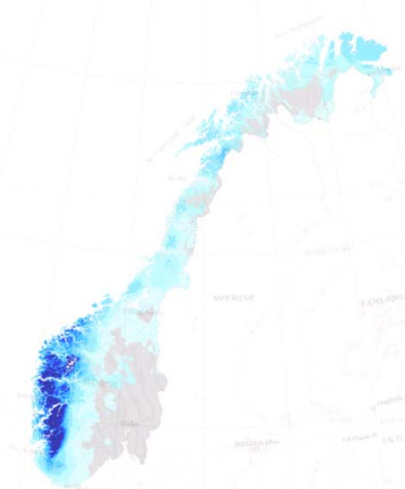


- Hydrological models
- Hydrometeorolgical observations
- Decision-making tools
- Human resources
- Management / economy
- Warning levels
- Communication
- Recent events

Hydrological models

- Distributed HBV-model. 1 km^2 grid cells.
- Input:
  - Observation on discharge, temperature and precipitation
  - Prognosis on temperature and precipitation.
- Output:
  - Discharge, snow water equivalence and snow depth, soil water content, ground water content, soil frost depth and more.





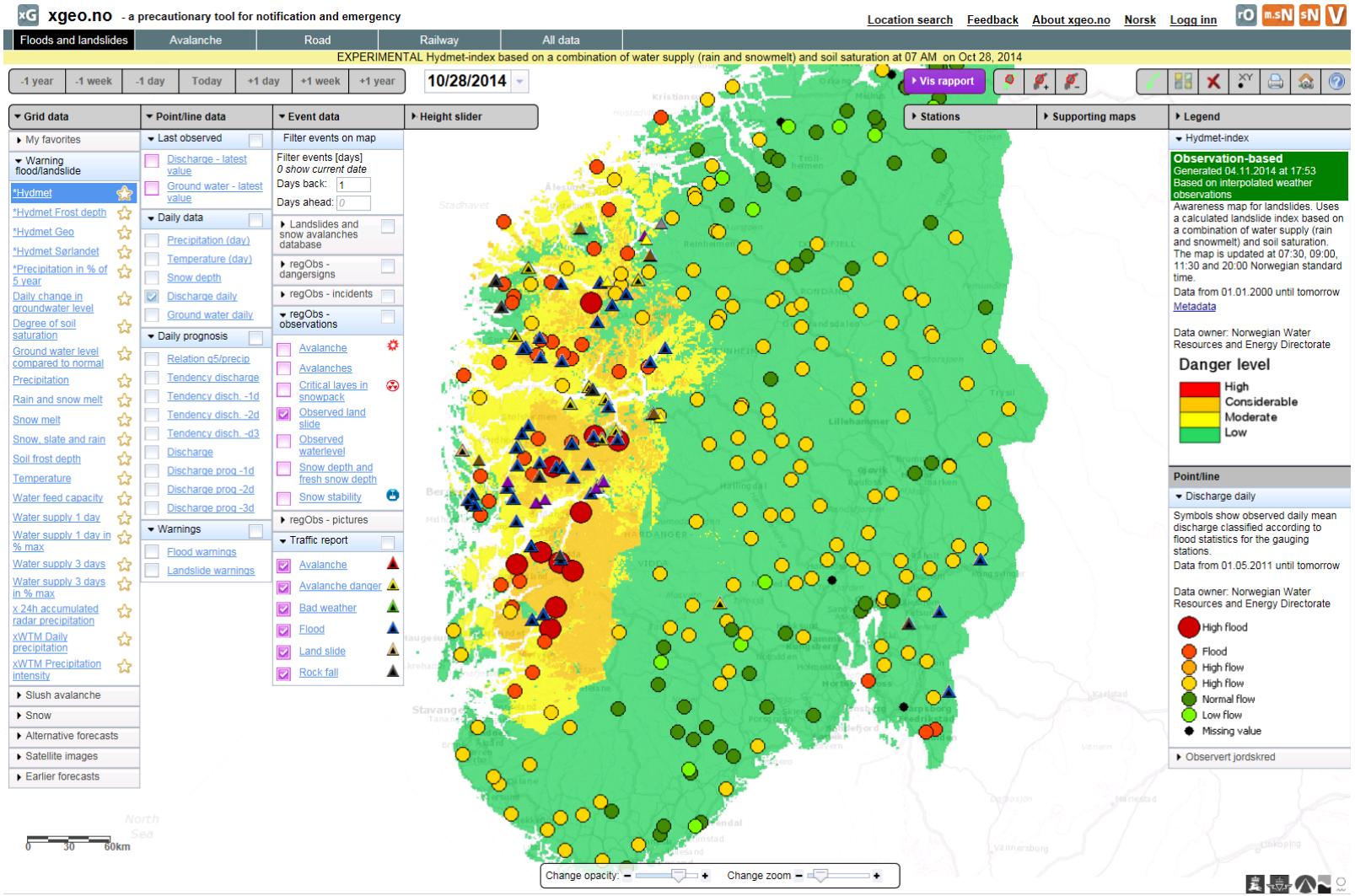
Hydrometeorological observations

- Provided by Norwegian Water Resources and Energy Directorate, Norwegian Meteorological Institute, railway and road authorities.

Discharge Precipitation Air temperature Ground water level

Experiences from coordinated national-level landslide and flood forecasting in Norway,
I. K. Krøgli *et al.*

Xgeo.no – our decision-making tool

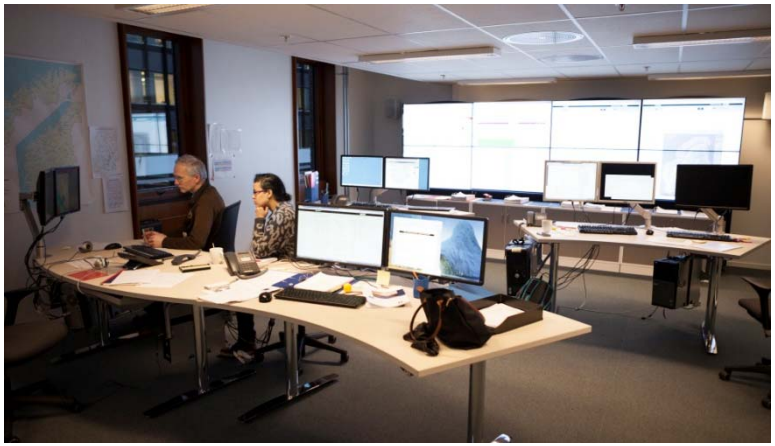


Custom made, at NVE.

Combines observations, model results and threshold values.

Development in cooperation with road and railway authorities.

Human resources



- Multidisciplinary teams
- 23 hydrologists and geoscientists
- 12 women and 11 men
- Age from 30 to 59 years

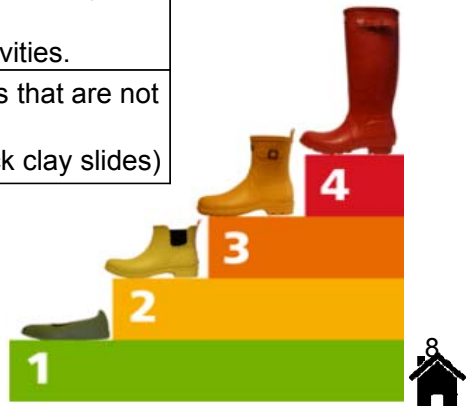
- Flood warning:14 persons, landslide warning:12 persons
- Both flood and landslide warning: 5 persons
- Flood/landslide and snow avalanche warning: 3 persons

Management and economy

- Cost, total for flood and landslide services: € 1.4 mill
  - Includes forecasters compensation, research & development, management, etc.
- Both flood and landslide forecasting are organized under Hydrology department, section for Flood and Landslide forecasting.
- Early warning systems share economy.
  - Since regional landslide forecasting is a new service, some funding is earmarked for development on landslide forecasting methods.
  - **Mutual spin-off effects are considerable for both services!**

Warning levels

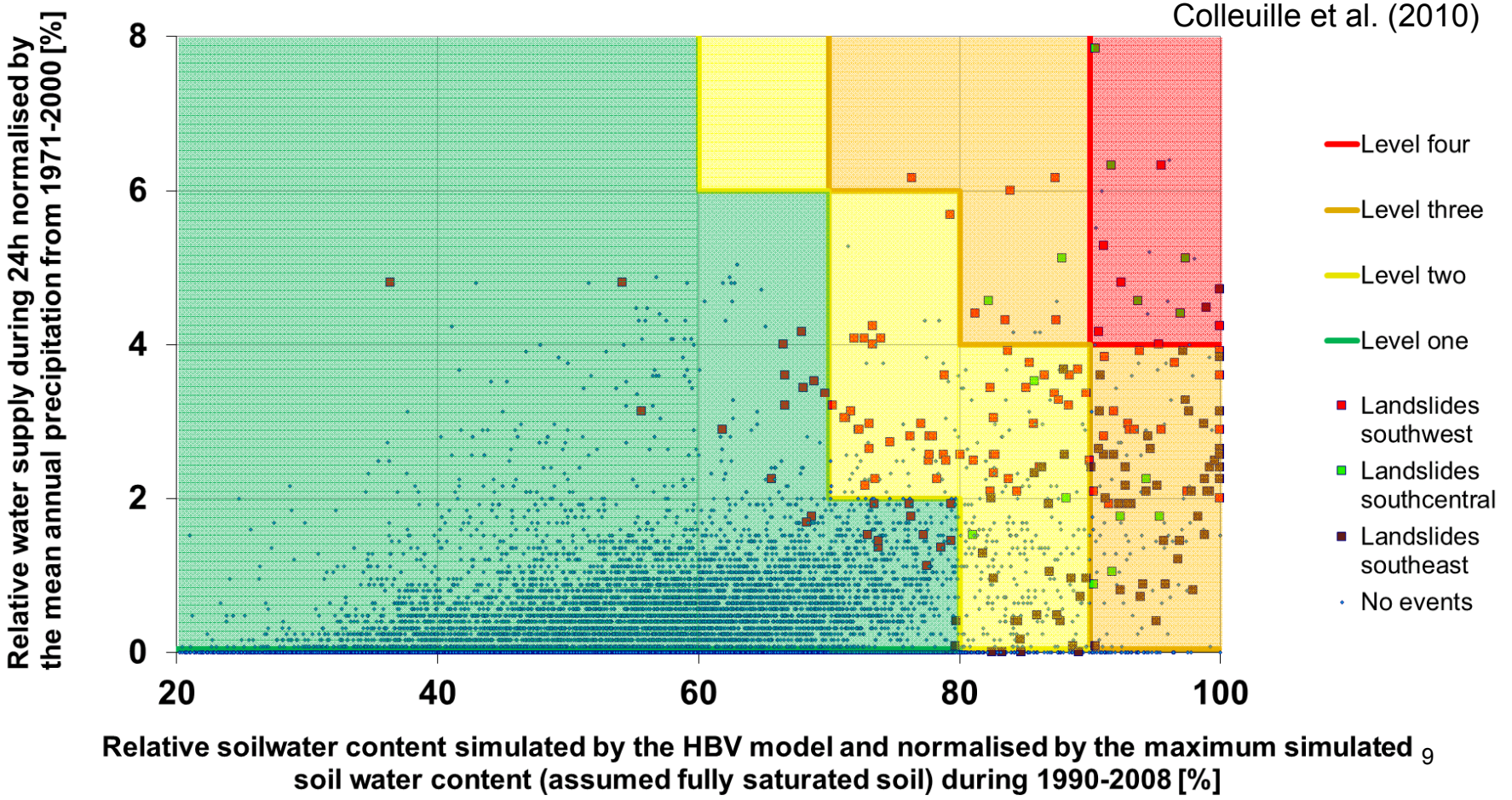
Level	Flood – Probability and extent	Landslide – Extent and damages
4	Runoff larger than 50 year flood Severe flooding and damages. Risk for lifes.	Large and smaller landslides are expected, in many numbers and with in a large geographical area. Dangerous situation threatening lifes, valuables and infrastructure.
3	Runoff larger than 5 year flood Extensive flooding, local damages.	Some large and smaller landslides are expected. Accidents and damage on valuables are expected.
2	Unusually large runoff, risk of ice-jam, local flooding due to local heavy rainstorm.	Landslides possible, mainly shallow debris slides along roads, railways and rivers. Landslides may happen locally due to high intensity rainfall /snowmelt and /or human activities.
1	Generally safe conditions.	Generally safe conditions. Landslides that are not related to water may happen (rock fall and quick clay slides)



Hazard thresholds in landslide warning system

- Empirical tree-classification analysis of 206 landslide events

Colleuille et al. (2010)

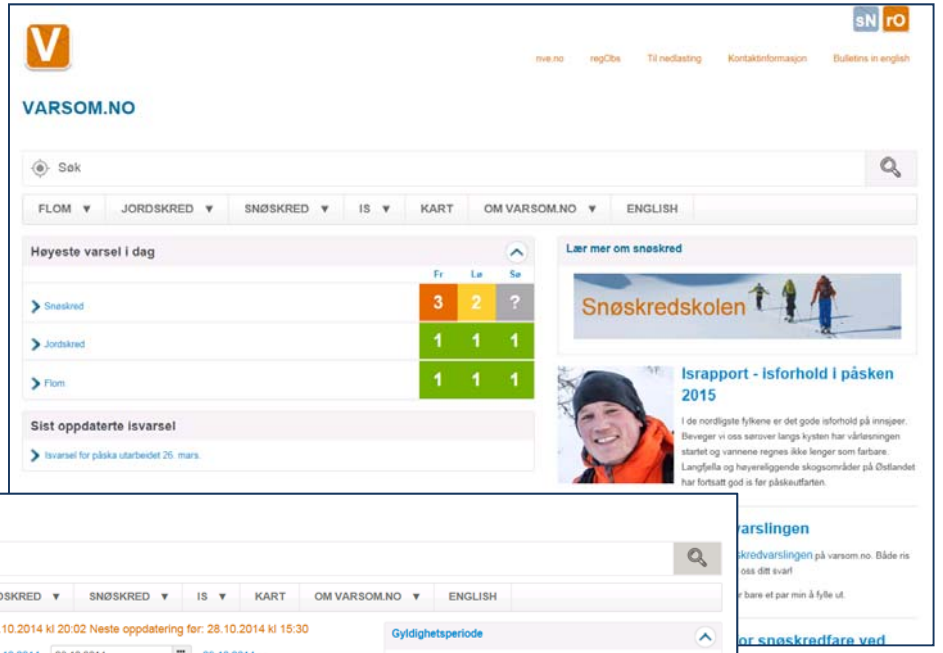


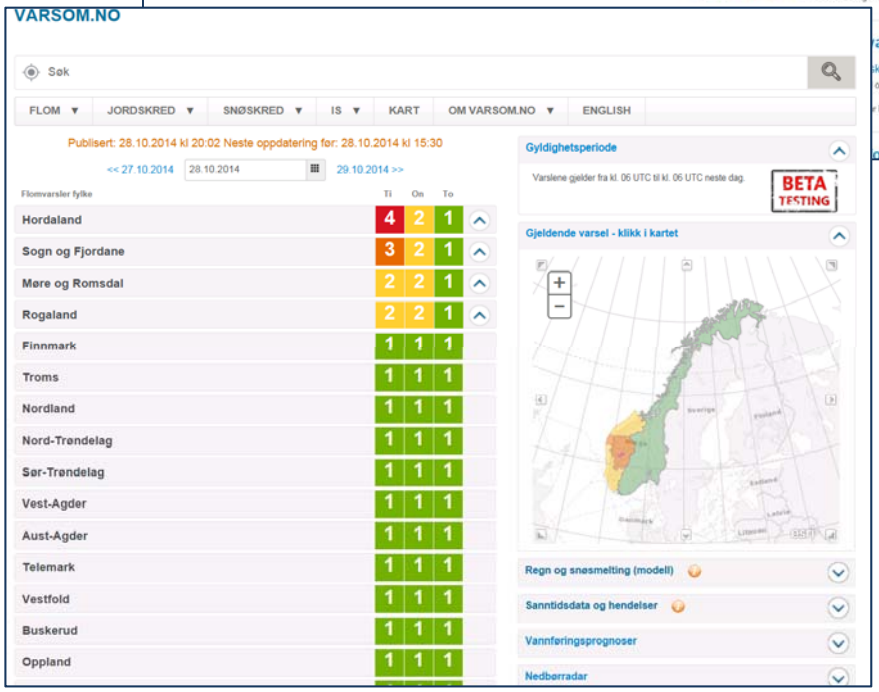
Communication

VARSOM.NO

Web site for forecasts on floods, landslides, snow avalanches and reports on safety on ice

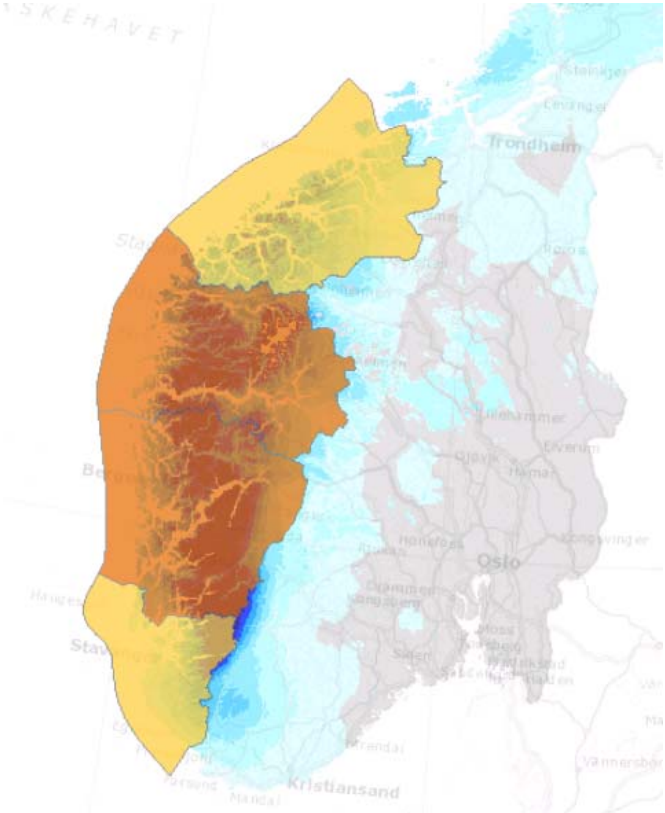
Varsom = vigilance, cautious, careful



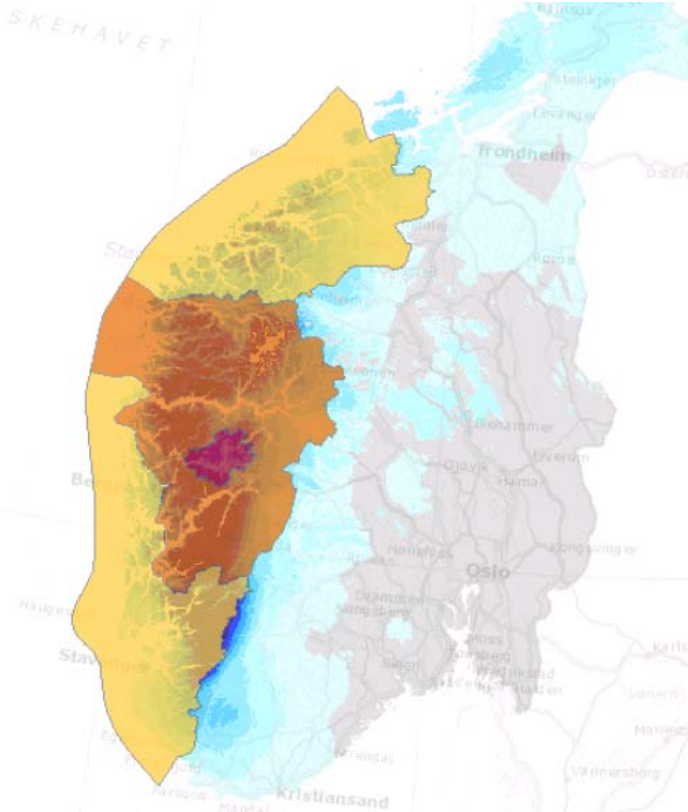


Flooding and landslides, Western Norway – 27th-29th October 2014

Landslide warnings on 28th



Flood warnings on 28th



Background map: Rain and snowmelt 24/hr, from 27th to 28th, 300 mm / 3 days.

Experiences from coordinated national-level landslide and flood forecasting in Norway,
I. K. Krøgli *et al.*

Western Norway 27th – 29th Oct. 2014

I flomrammede Odda vil det fortsette å regne til helgen. Men nedbørsmengdene vil være langt mindre enn hva de har fått tidligere denn
elven Opo som har gått langt over sine bredder. Foto: Marit Hommedal / NTB scanpix

Photo: NVE

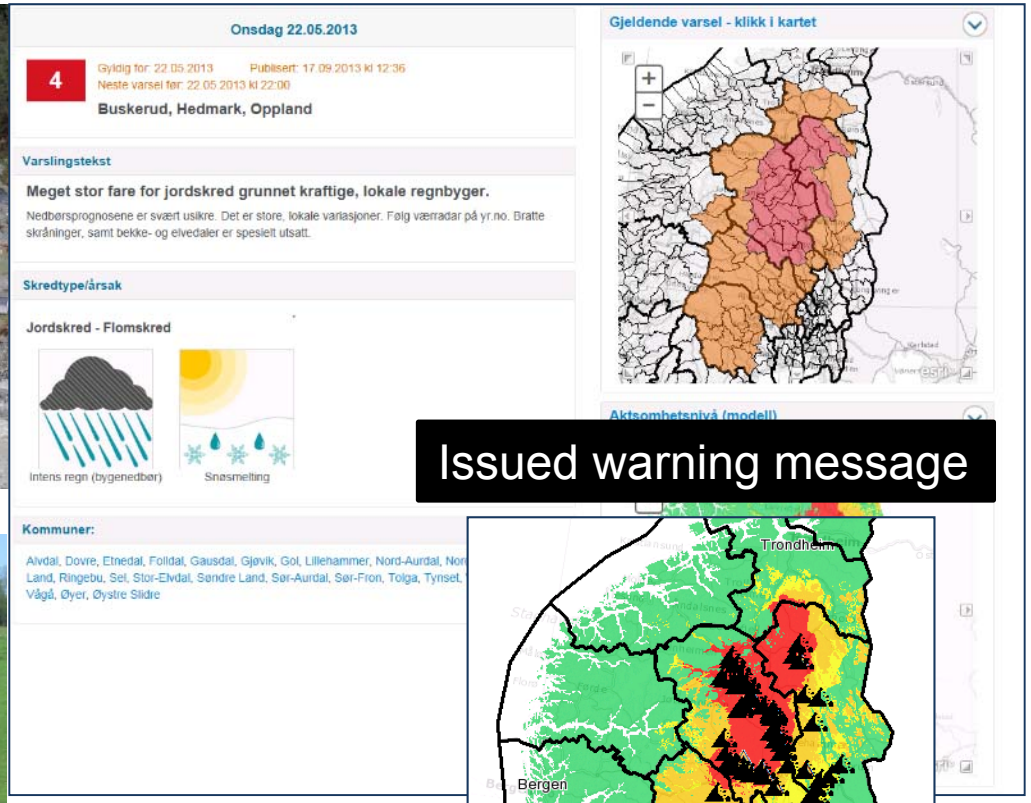
Flommen kan gi 150 millioner i erstatninger

Finans Norge anslår at flommen på Vestlandet vil ende med mellom 100 og 150 millioner kroner i naturskadeerstatninger.

«The flood may cost 150 mill NOK (€ 17 mill) in compensatory damages»

Experiences from coordinated national-level landslide and flood forecasting in Norway,
I. K. Krøgli *et al.*

Landslides, Eastern Norway May 2013



Issued warning message

Observed landslides

References / literature

- Sælthun, N.R. (1996). **The Nordic HBV model**. Norwegian Water Resources and Energy Administration Publication 7, Oslo, 26 pp.
- Beldring, S., Engeland, K., Roald, L.A., Sælthun, N.R., Voksø, A. (2003). **Estimation of parameters in a distributed precipitation-runoff model for Norway.** Hydrology and Earth System Sciences, 7, 304-316.
- Boje S, Colleuille H, Cepeda J, Devoli G (2014). **Landslide thresholds at regional scale for the early warning system in Norway**. Proceeding 3rd World Landslide Forum 3, 2-6 June 2014, Beijing.
- Devoli G., Kleivane I., Sund M., Orthe N-K., Ekker R., Johnsen E., Colleuille H. (2014). **Landslide early warning system and web tools for real-time scenarios and for distribution of warning messages in Norway.** Proceeding IAEG 2014, 15-19 September, Torino, Italy

Relevant on EGU 2015

- EOS8 – Geoethics for society: General aspects and case studies in geosciences:
  EGU2015-15395, Wed 15 Apr, 17:30 – 19:00
  Geoethical considerations in early warning of flooding and landslides: Case study from Norway
  Graziella Devoli, Ingeborg Kleivane Krøgli, Mads Peter Dahl, Hervé Colleuille, Søren Nykjær Boje, and Monica Sund

- NH3.8 – Prediction and forecasting of landslides:
  EGU2015-11282
  Operational early warning of shallow landslides in Norway: Evaluation of landslide forecasts and associated challenges
  Mads-Peter Dahl, Hervé Colleuille, Søren Boje, Monica Sund, Ingeborg Kleivane Krøgli, and Graziella Devoli