

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

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

All photos: NVE

Norwegian Water Resources and Energy Directorate



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Hydrological models

Hydrometeorological
observations

Decision-making tools

Human resources

Management / economy

Warning levels

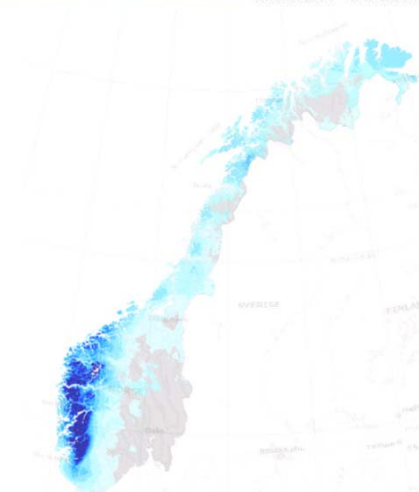
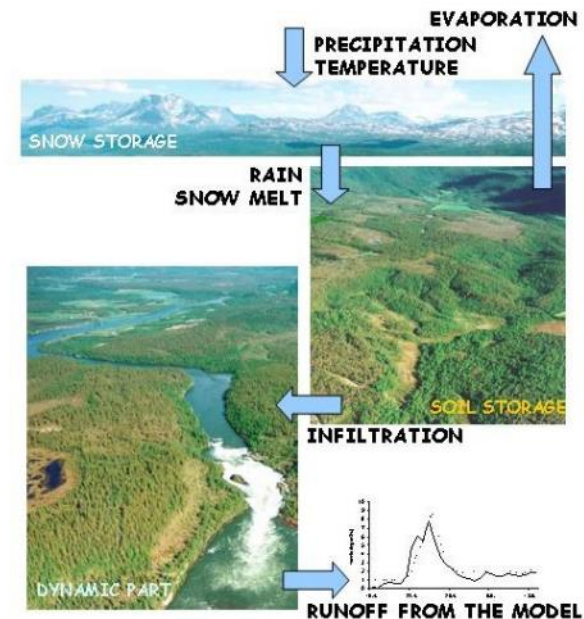
Communication

Recent events



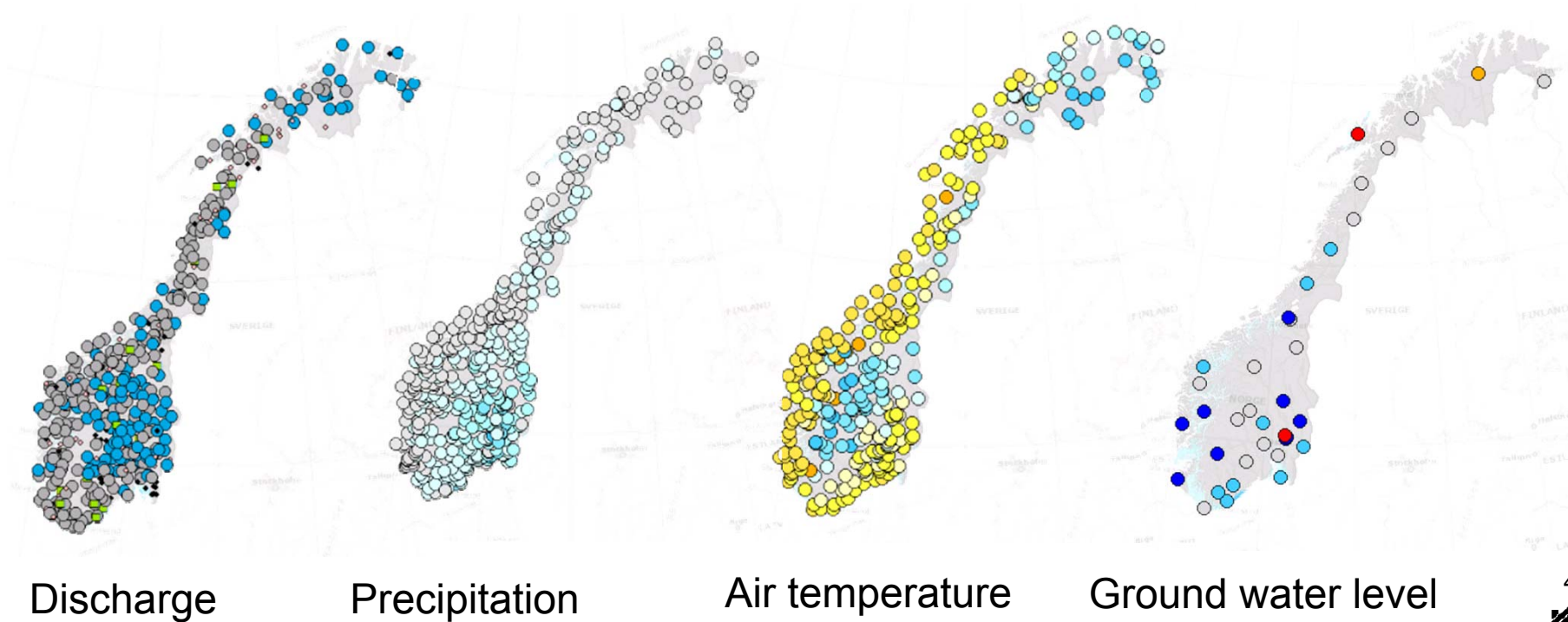
Hydrological models

- Distributed HBV-model. 1 km² 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.



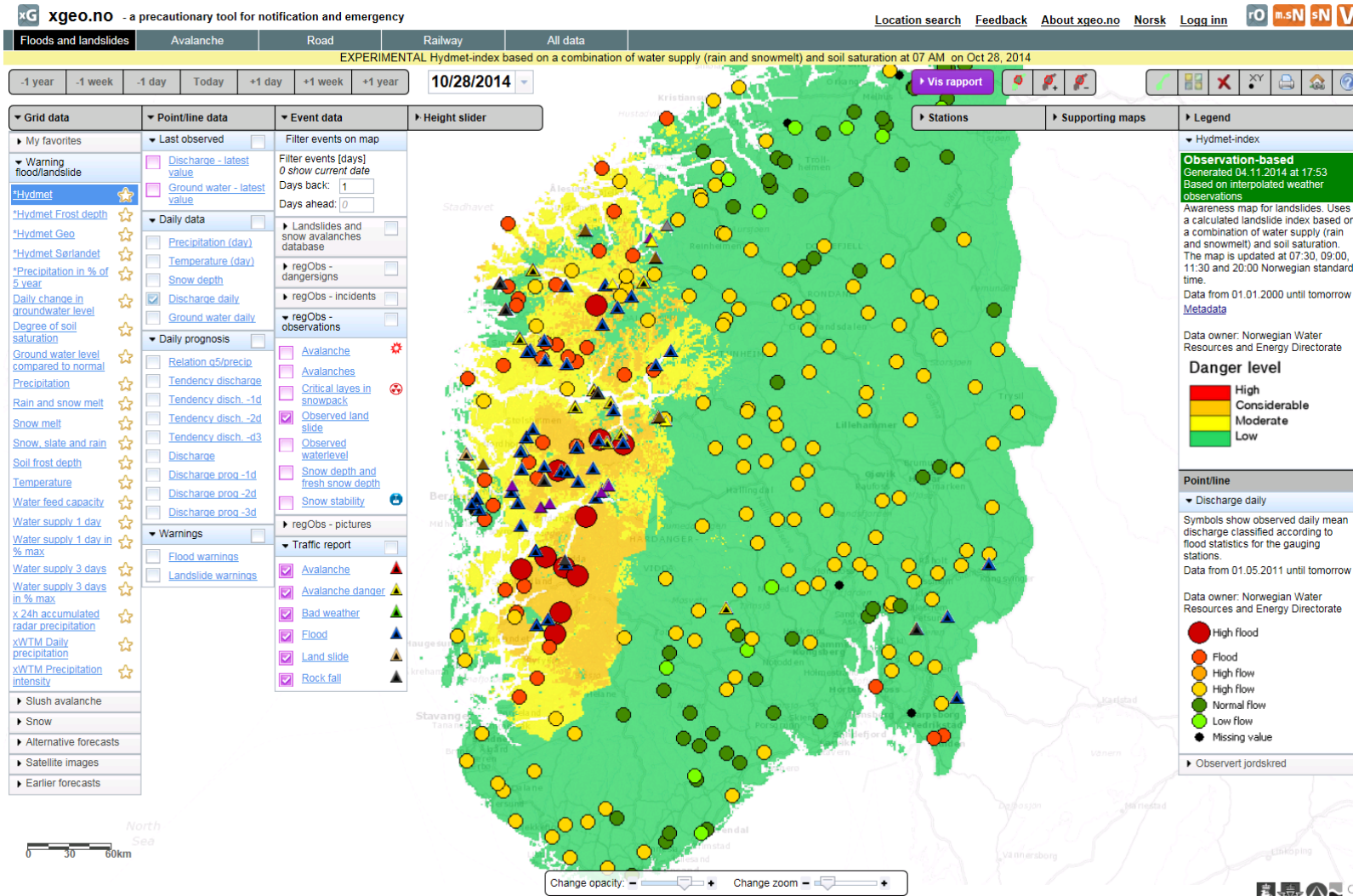
Hydrometeorological observations

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



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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.

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Human resources



- Multidisciplinary teams
 - 23 hydrologists and geoscientists
 - 12 women and 11 men
 - Age from 30 to 59 years
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- Flood warning: 14 persons, landslide warning: 12 persons
 - Both flood and landslide warning: 5 persons
 - Flood/landslide and snow avalanche warning: 3 persons

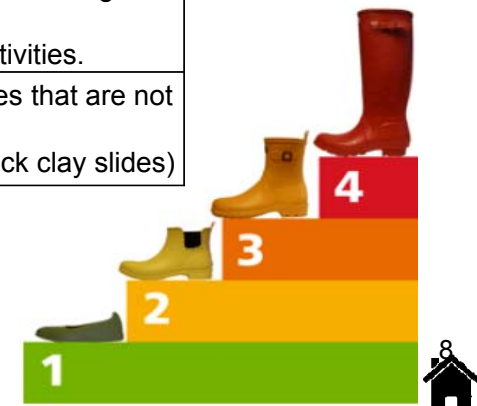


Management and economy

- 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

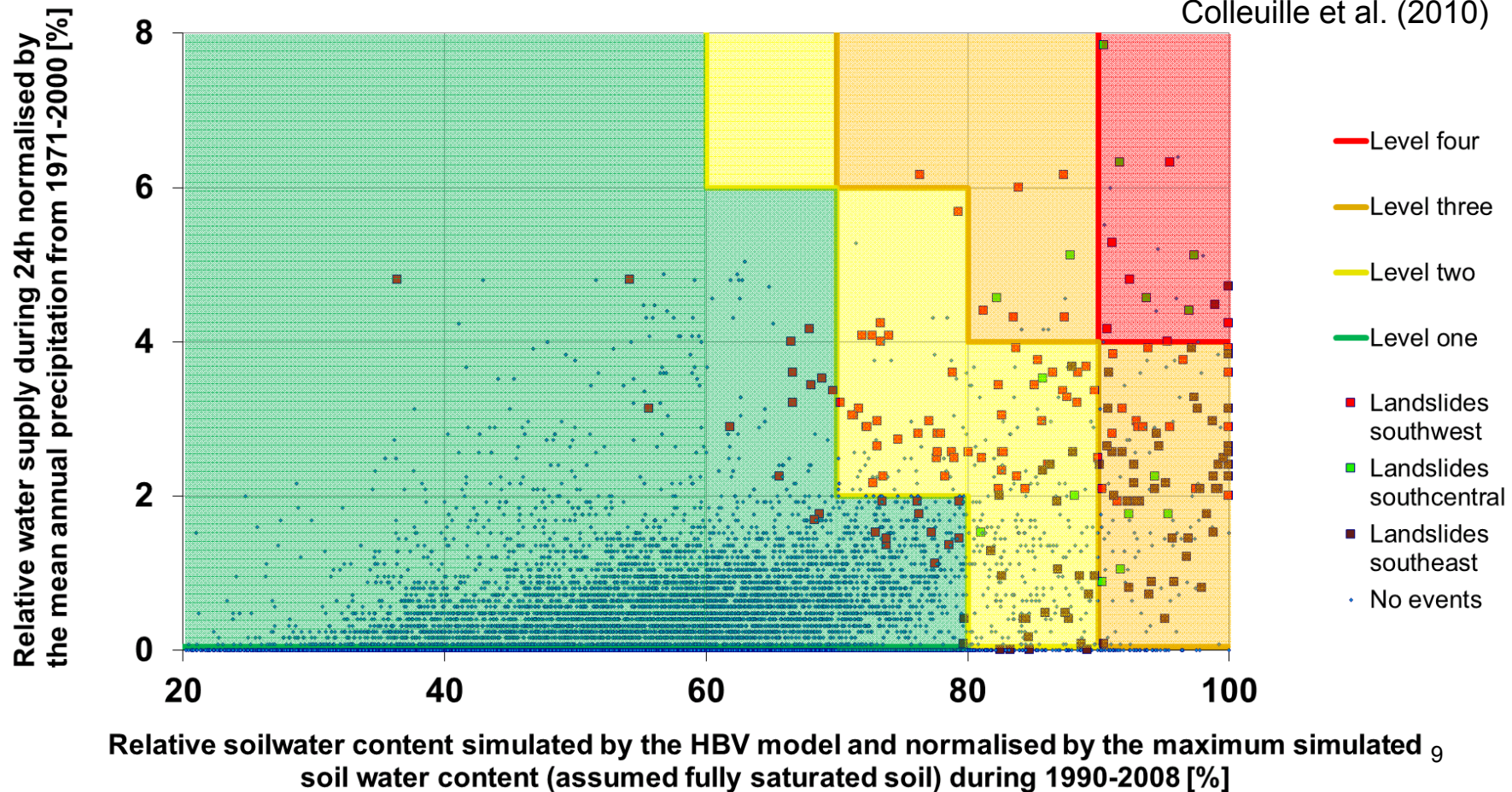
| Level | Flood – Probability and extent | Landslide – Extent and damages |
|-------|---|---|
| 4 | Runoff larger than 50 year flood Severe flooding and damages. Risk for lifes. | Large and smaller landslides are expected, in many numbers and with in a large geographical area. Dangerous situation threatening 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



VAR SOM.NO

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

Varsom = vigilance, cautious, careful

The screenshot displays the Varsom.NO website interface. At the top, there's a navigation bar with links like 'varsom.no', 'regiOs', 'Til nedlasting', 'Kontaktinformasjon', and 'Bulletins in english'. Below this is a search bar and a menu with categories: FLOM, JORDSKRED, SNØSKRED, IS, KART, OM VARSOM.NO, and ENGLISH. The main content area is divided into several sections:

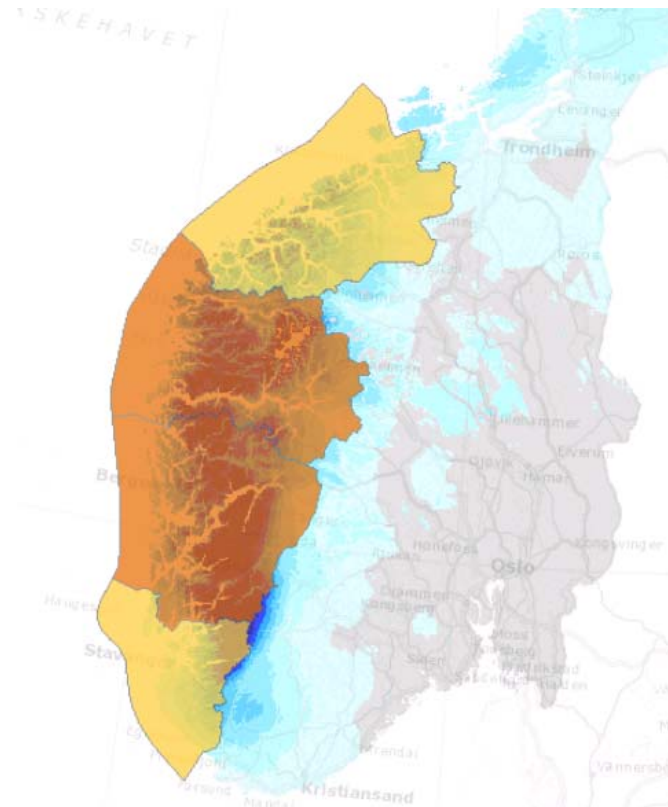
- Høyeste varsel i dag:** A table showing the highest warnings for the day. It includes columns for 'Fr', 'Lø', and 'Sø'. The data is as follows:

| | Fr | Lø | Sø |
|-----------|----|----|----|
| Snøskred | 3 | 2 | ? |
| Jordskred | 1 | 1 | 1 |
| Flom | 1 | 1 | 1 |
- Sist oppdaterte isvarsel:** A section for the latest ice warnings, with a link to 'Isvarsel for påske utarbeidet 26. mars'.
- Varslingen:** A section for the 'varslingen' (warning) with a link to 'varslingen'.
- Gyldighetsperiode:** A section for the validity period of the warnings, with a link to 'Gyldighetsperiode'.
- Gjeldende varsel - klikk i kartet:** A section for the current warning, with a link to 'Gjeldende varsel - klikk i kartet'.
- Regn og snøsmelting (modell):** A section for rain and snow melt (model), with a link to 'Regn og snøsmelting (modell)'.
- Sanntidsdata og hendelser:** A section for real-time data and events, with a link to 'Sanntidsdata og hendelser'.
- Vannføringsprognoser:** A section for water flow forecasts, with a link to 'Vannføringsprognoser'.
- Nedbørradar:** A section for precipitation radar, with a link to 'Nedbørradar'.

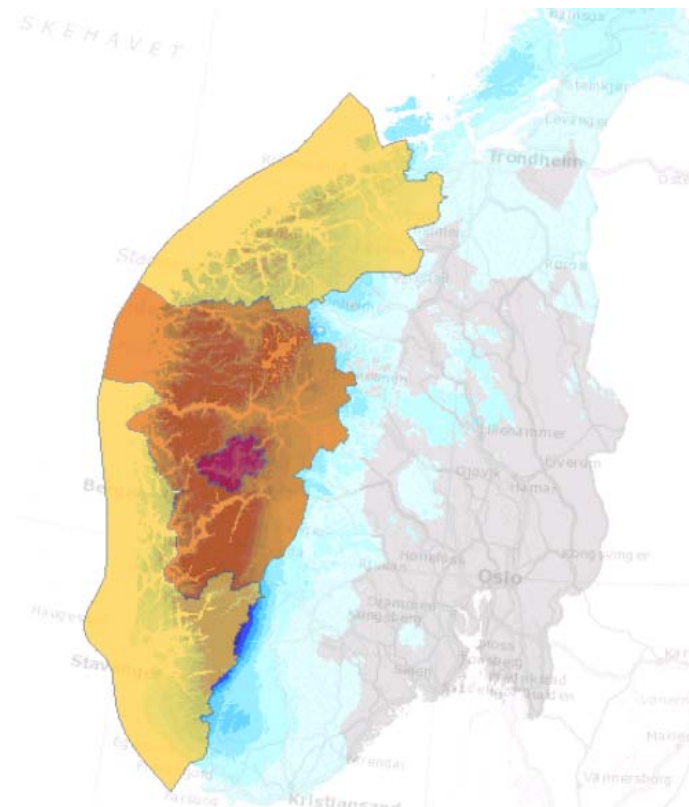
The website also features a map of Norway showing the current warning status, with a 'BETA TESTING' badge. The bottom right corner of the screenshot shows a home icon and the number '10'.

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.

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Western Norway 27th – 29th
Oct. 2014



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

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.



Photo: NVE

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

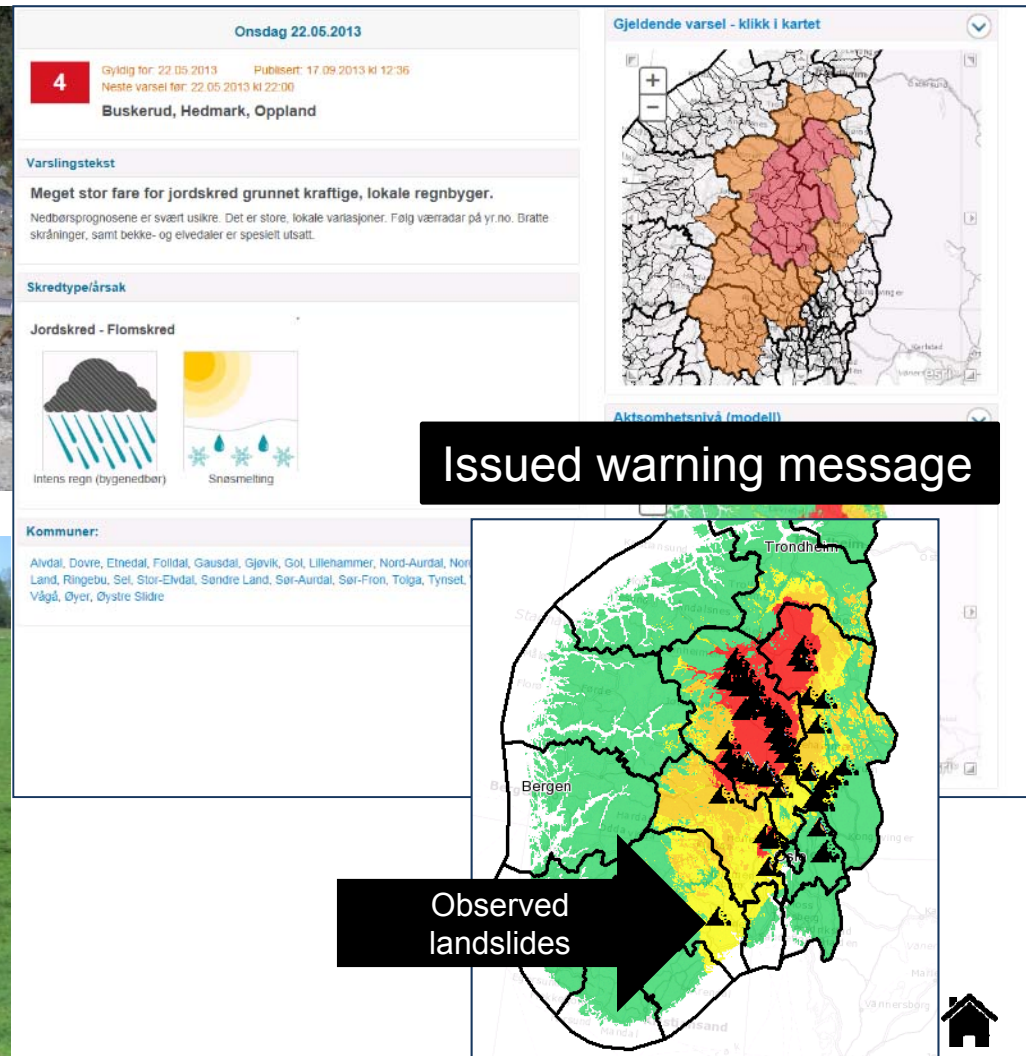
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Landslides, Eastern Norway May 2013



Photo: RØ, NVE



Issued warning message

Observed
landslides

References / literature

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- 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.
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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

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