



Improvement of regional early-warning for landslides in Norway by using local instrumentation

Klima 2050 Lunsjpresentasjon

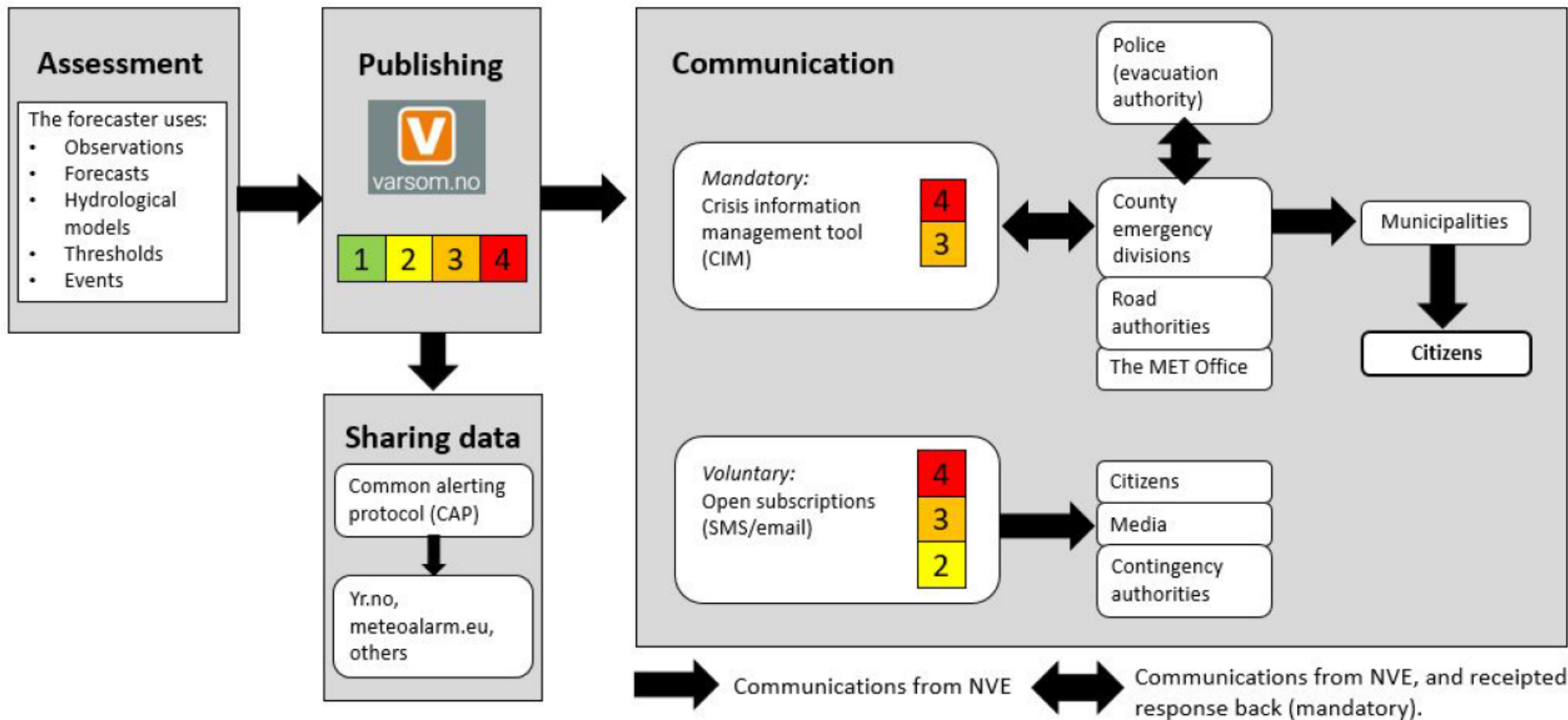
José Cepeda (NGI)

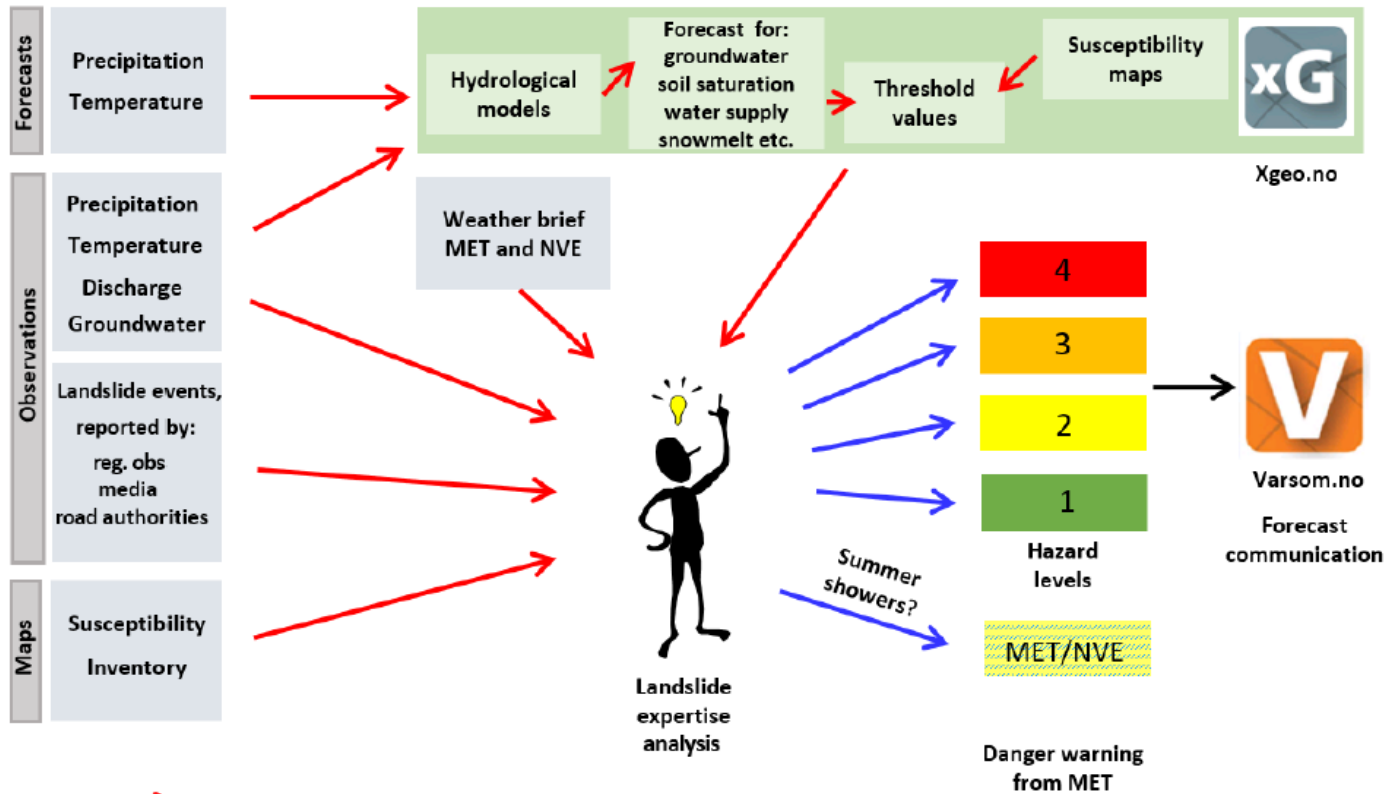
SINTEF, Oslo, 17 October 2019



Background

- Regional warning system for landslides in Norway is based on a national interpolated 1 km grid of hydrometeorological variables
- It is important to explore improvements in the system (i.e., make it more useful for the Norwegian society)
- Can one use locally measured variables to improve the system?
- Pecoraro, Calvello, Cepeda (2019) Using local monitoring data for regional forecasting of weather-induced landslides in Norway. Proceedings of the XVII European Conference on Soil Mechanics and Geotechnical Engineering. doi: 10.32075/17ECSMGE-2019-0141



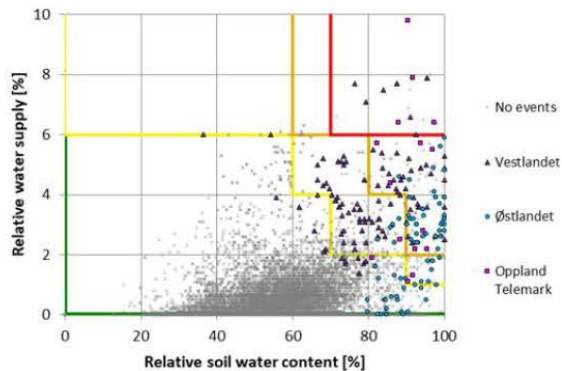


→ Quantitative processes

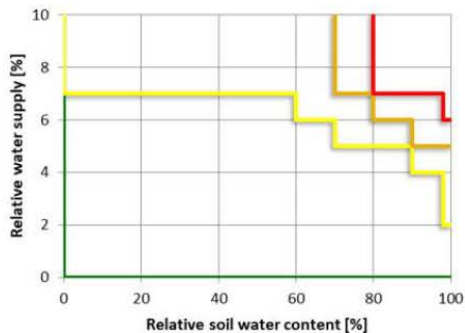
→ Qualitative processes



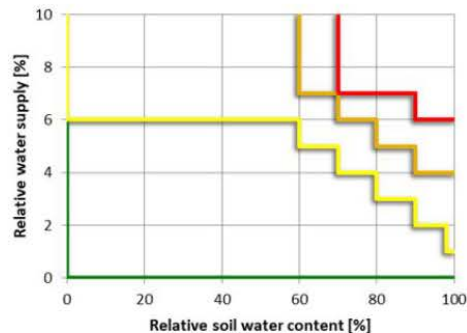
Thresholds for landslide hazard (a)

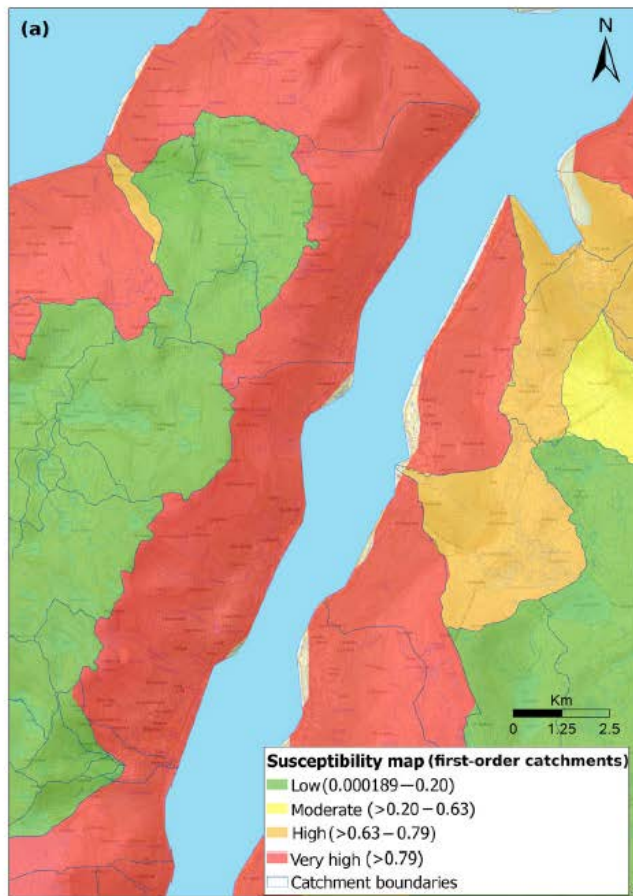


Thresholds for landslide hazard for Southern Norway



Thresholds for landslide hazard (c) for Eastern Norway





Significance of the awareness levels

Red awareness level Very high landslide hazard. Many landslides and several large ones may occur; their long runout and extent may result in damage to settlements and infrastructures. Red awareness level is an extreme situation that occurs very rarely. Safety measures such as closed roads and evacuations can occur on short notice. Emergency response authorities should have implemented emergency plans and mitigation measures for carrying out evacuations and other contingency responses. Pay attention to the media and follow recommendations from the authorities.

Orange awareness level High landslide hazard. Many landslides and some large ones that can damage infrastructure and roads may occur. Exposed roads may be closed off. Emergency response authorities should be prepared to implement emergency plans and mitigation measures and evaluate the need for evacuations and other contingency responses. Mitigation measures such as clearing water channels should be carried out. Pay attention to the media and follow recommendations from the authorities.

Yellow awareness level Moderate landslide hazard, primarily shallow slides on artificial slopes that may affect roads, railways or river embankments. Isolated debris avalanches or debris flows can occur and could cause damages to infrastructure and people. At this level emergency authorities should increase vigilance related to landslides and pay attention to weather forecasts and landslide forecasts and information at <http://www.varsom.no/>. Preventive measures are recommended, such as clearing water channels in exposed areas.

Green awareness level Generally safe conditions. Debris avalanches, debris flows, shallow slides, and slushflows are not expected at this level; however other landslide types (like rock falls, clay slides, and quick-clay slides) may occur, caused by slow response processes, such as erosion, freeze–thaw weathering or human activity, such as deposition, digging or blasting. These incidents may occur at all awareness levels.

Flood and landslide forecast

En > Flood and landslide forecast

3

Debris avalanches and debris flows warning on orange level for Agder. (NVE)

Valid for: 2017-10-01. Published: 01.10.2017 12:07 PM. Next forecast before: 02.10.2017 11:00 AM

Type

 Landslide

It has been raining a lot the last days, and it is expected a further 120 mm precipitation, as rain, from sunday evening to monday.

The groundwater level and the soil water saturation are very high. Steep slopes, as well as streams and river with high discharge are particularly exposed for landslides.

Details

Consequence

Along the watercourses in the flood areas: High discharge can lead to excavation of masses at the foot of slopes. Rapid lowering of water levels after flood can also cause local landslides.

Advice

Cleaning of drainage roads and culverts are recommended to let water drain away. Municipalities, counties and other emergency operators should continuously evaluate the need for preparedness and prevention measures. Pay particular attention in areas were quick clays are mapped, and in areas with marine deposits. Notify the emergency response in your municipality if you observe such incidents.

Warning level meaning

Severe situation that occurs rarely, requires contingency preparedness and may cause severe damages within some extent of the warning area. Orange level is the second highest of our alert levels.

Causes

 Rain

Varsellets gyldighetspriode

Varslene gjelder fra kl. 07 til kl. 07 normaltid (kl. 08 til 08 sommertid).

Oppdateres: Man-fre før kl 11 og 15.30, og lør-søn før kl 11.

Abonner på jordskred- og flomvarslert

Kart

Kartinfo

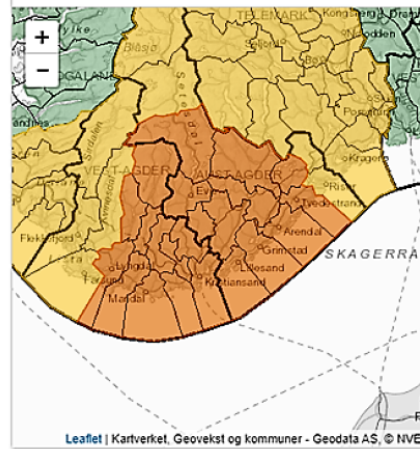
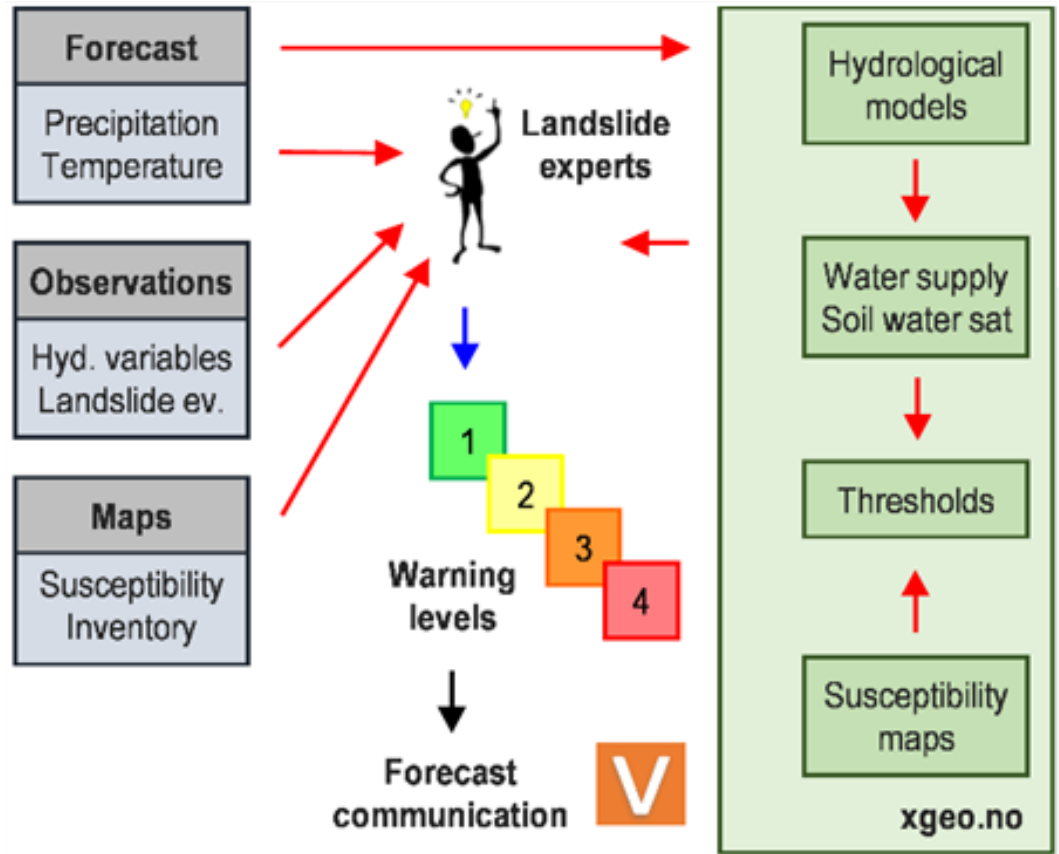
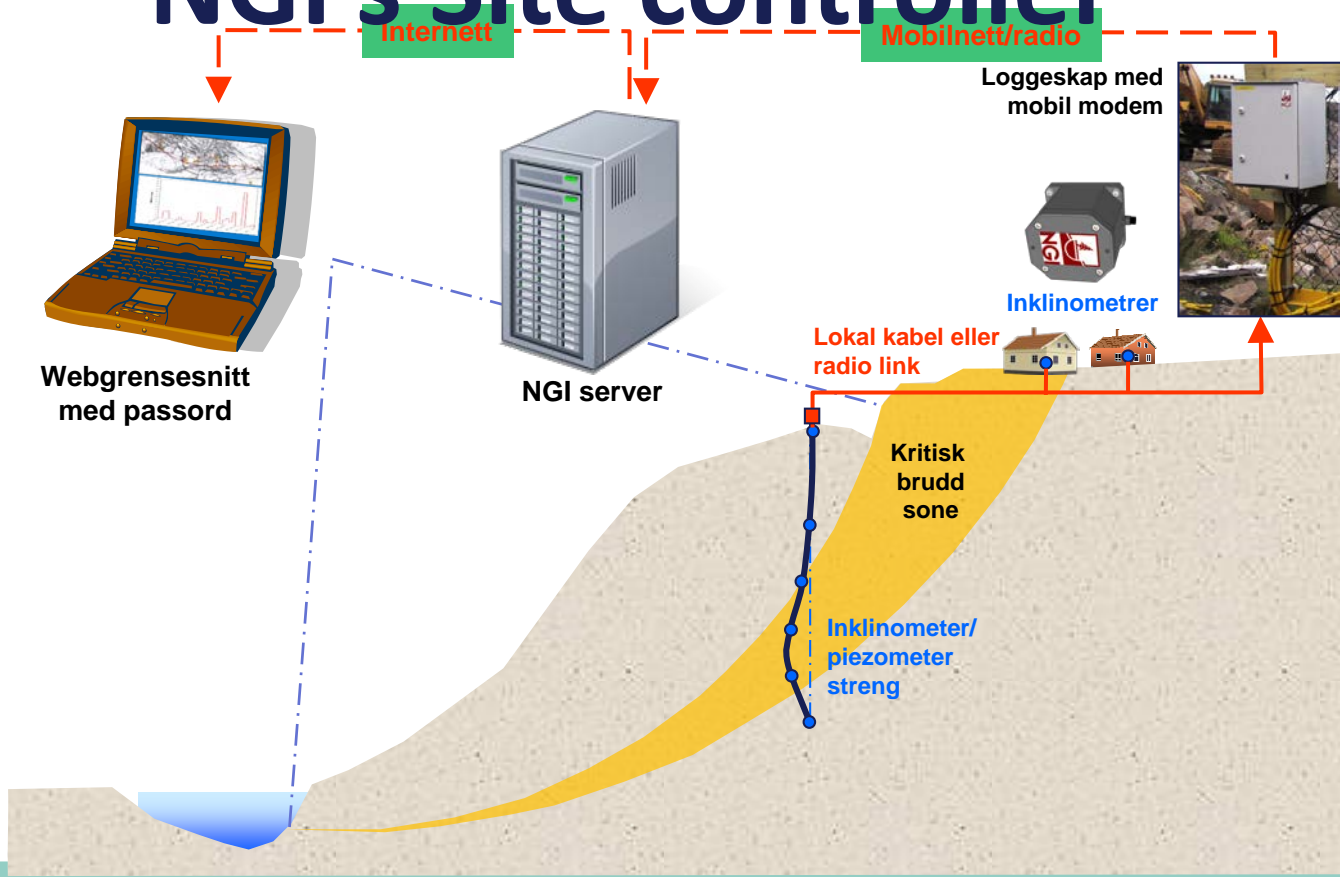


Figure 4. Example of landslide warning bulletin, as viewed on <http://www.varsom.no/>. The example presented is for the bulletin issued on 1 October 2017, the same case study as in Sect. 6.

Conceptual framework of the national LEWS (red arrows indicate quantitative processes; blue arrow indicates a qualitative process)



NGI's Site controller



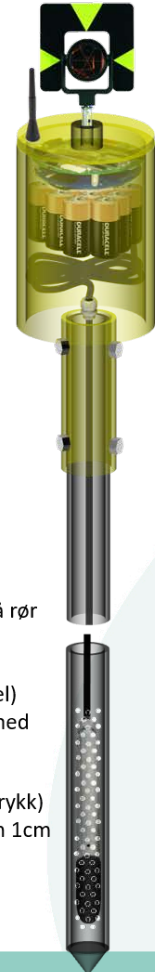
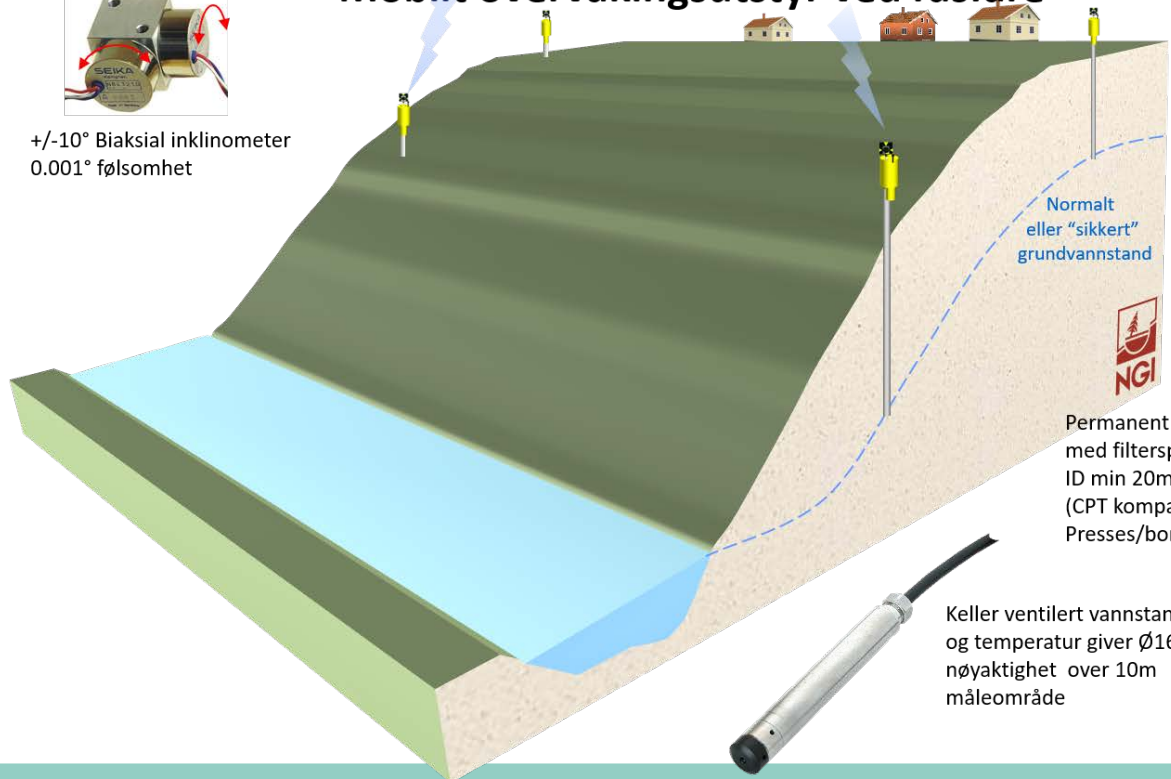
”Skråsikker”

Mobilt overvåkingsutstyr ved rasfare

Mobilt målehode:
Biaksial inklinometer
Datalogger/batteri
Radio/mobil modem
Feste for måleprisme



+/-10° Biaksial inklinometer
0.001° følsomhet



Permanent nivå rør
med filterspiss
ID min 20mm,
(CPT kompatibel)
Presses/bores ned

Keller ventilt vannstand (trykk)
og temperatur giver Ø16mm 1cm
nøyaktighet over 10m
måleområde

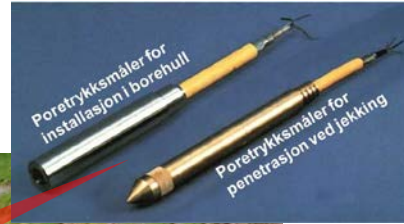
Skråning/Rasfare



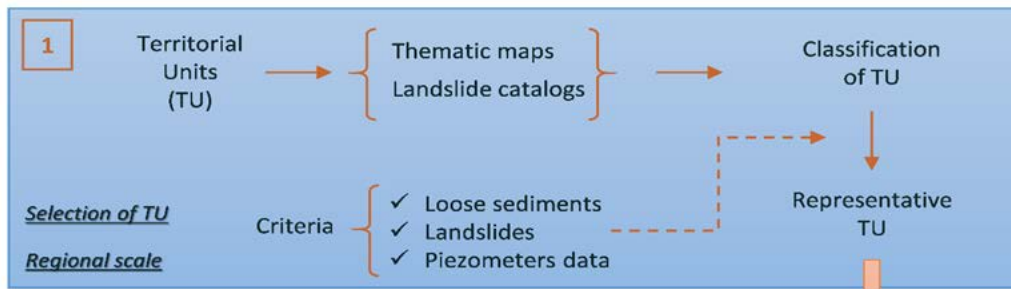
Laser scanner
Geophones
Taut wires
Inclinometers



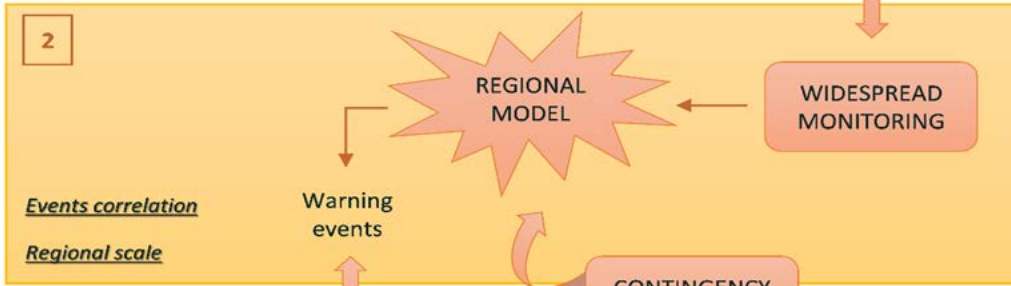
Piezometer/poretrykk



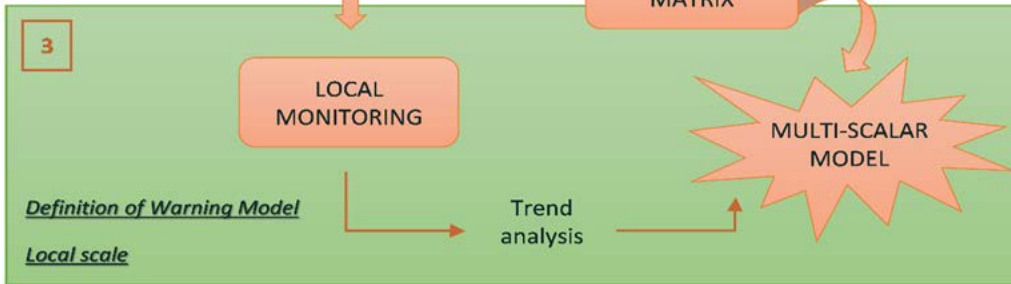
1st PHASE



2nd PHASE



3rd PHASE



Methodology adopted for integrating local and regional monitoring data within a warning model at regional scale

Contingency table and performance criteria adopted to relate the presence of landslides with the warning levels (W1 to W4). Legend: MA=missed alerts; TN=true negatives; CA=correct alerts; FA=false alerts

	Lowest Warning Level (safest)			Highest Warning Level (most dangerous)
	W1	W2	W3	W4
Landslides	MA	CA	CA	CA
No landslides	TN	FA	FA	FA



Good performance of EWS



Bad performance of EWS

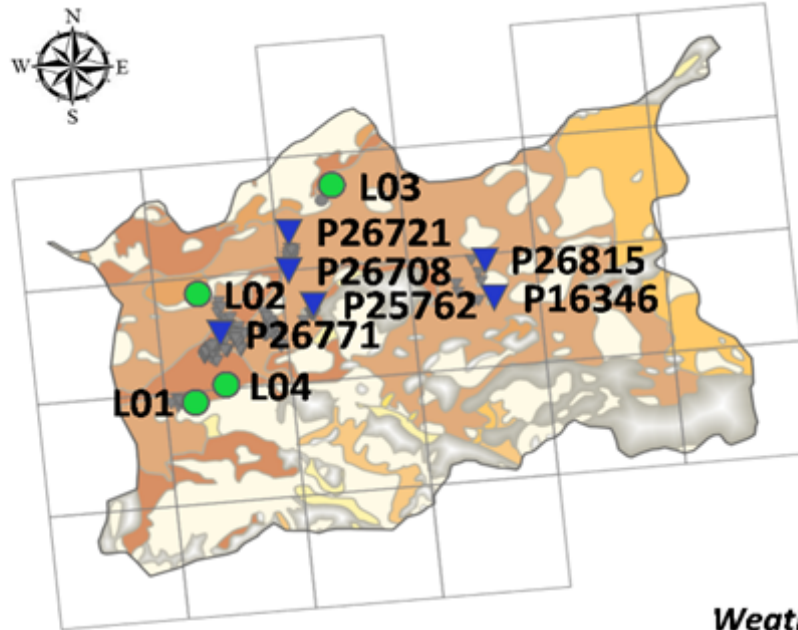
Quaternary deposit map, landslides and piezometers in the case study area (Horvereidelva basin)

Quaternary deposits map

- Moraine material, thick
- Moraine material, thin
- Terminal moraine
- Marine and fjord deposits, thick
- Marine and fjord deposits, continuous
- Marine and fjord deposits, thin
- Glaciofluvial deposits
- Anthropogenic and organic material
- Bare rocks

Legend

- Xgeo grid
- Weather-induced landslides
- Available piezometers
- Other landslides
- Other NGI boreholes



0 0,5 1 2 3 4 km

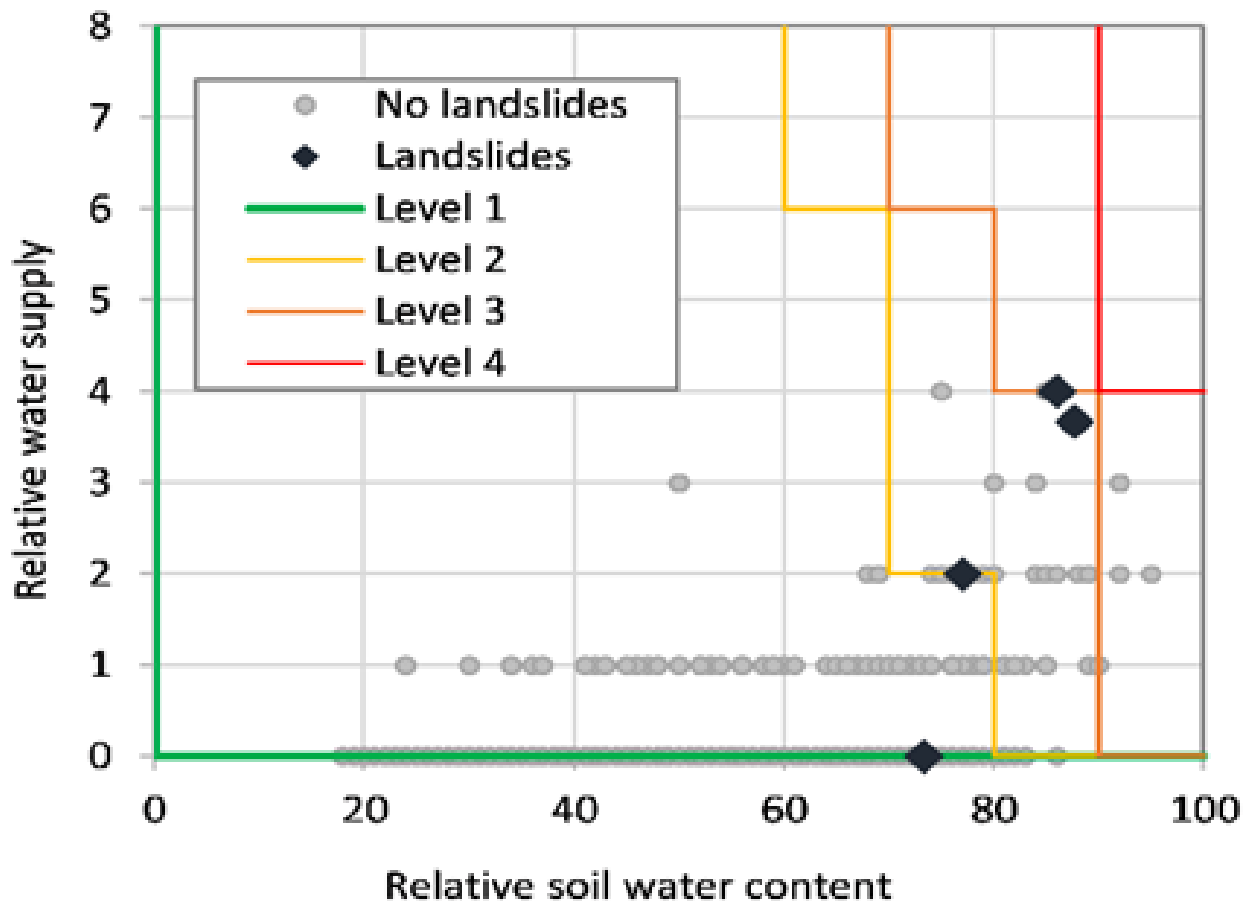


Weather-induced landslides

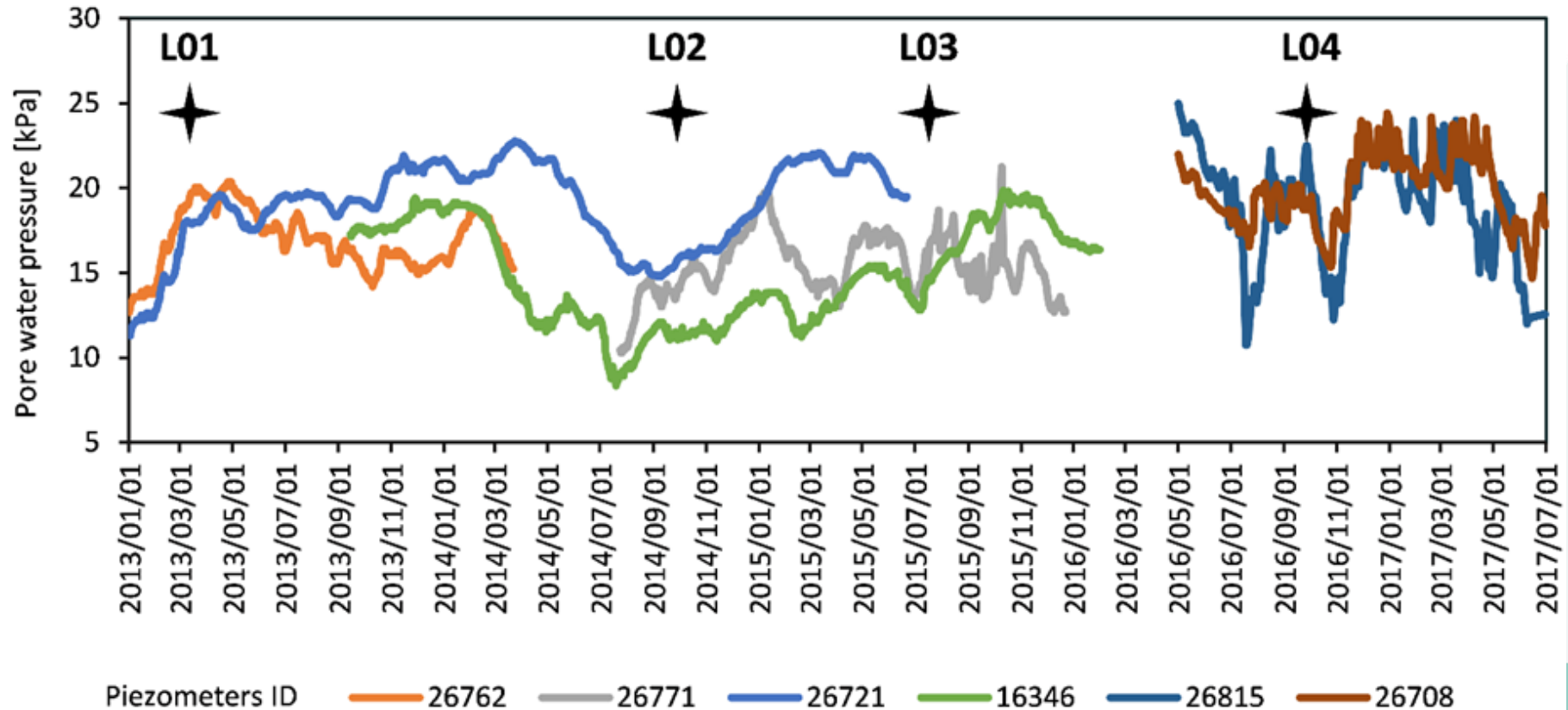
- L01 – 26/02/2013
- L02 – 30/10/2014
- L03 – 03/10/2015
- L04 – 04/12/2016



Results obtained applying the current regional warning model employed in the national LEWS



Pore-water pressures recorded in the 6 considered piezometers in the period of analysis. Dates with landslides are shown with cross marks.

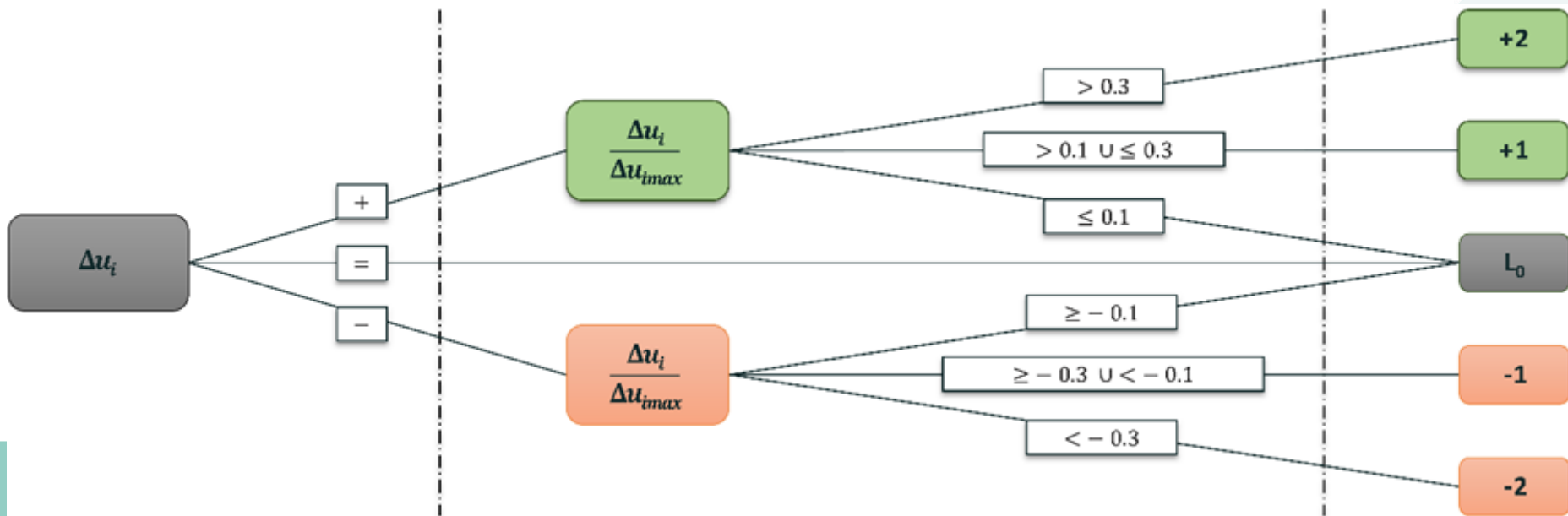


Scheme of the adopted multi-scalar warning model. The numbers on the right indicate the change in the original warning level (L_0) after updating with the pore-water pressure (pwp) data.

Absolute change in pwp

Relative change in pwp

Change in original warning level L_0

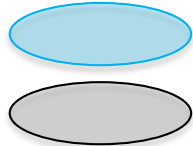


Current regional early warning system →

	Lowest Level (safest)			Highest Level (most dangerous)
	W1	W2	W3	W4
Landslides	2	2	0	0
No landslides	1525	16	7	0

Newly proposed multi-scalar early warning system →

	W1	W2	W3	W4
Landslides	2	0	1	1
No landslides	1536	7	5	0



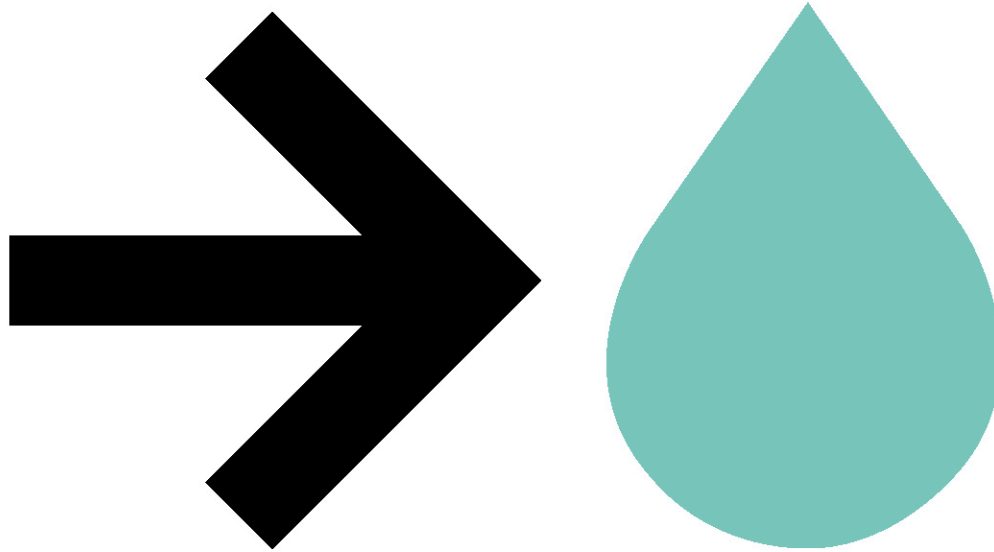
Good performance of EWS
Bad performance of EWS



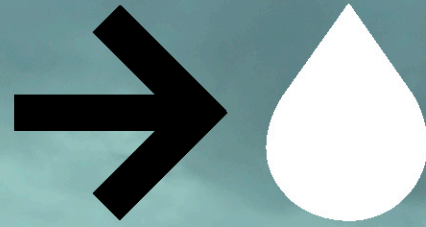
Conclusions

- Regional hydrometeorological variables (1 km interpolated national grid) and local measurements (piezometer data) can be combined in a multiscale model for early warning systems.
- The first results of the newly proposed multiscale warning model indicate the potential for improvement of the performance of the system.

Thank you for your attention



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Multiconsult **Finans Norge**

**SKJEFVELAND
GRUPPEN** **NORGESHUS**

Leca **Isola** **powel**

Public sector

Statens vegvesen **Norge
vassdrags- og
energidirektorat**

AVINOR **Jernbane-
direktoratet**

STATSBYGG **TRONDHEIM KOMMUNE**

Research & education

SINTEF

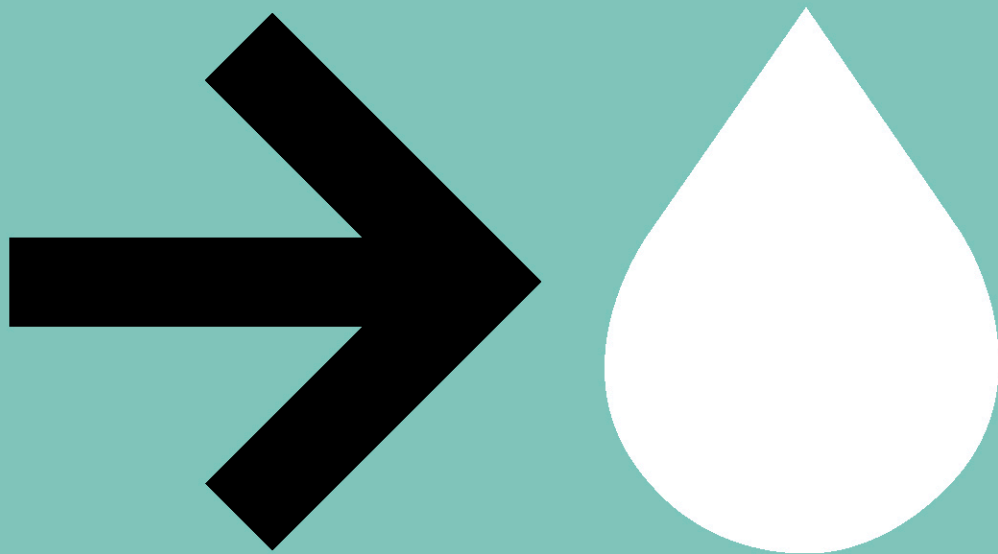
BI

NTNU

**Meteorologisk
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