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### **The Norwegian landslide early warning service turns 10 years old.**

*It has been 10 years since the landslide and slushflow early warning service was established in Norway. It has played an important role in increasing awareness and knowledge about landslides (i.e., debris flows, debris avalanches) and slushflows.*

On the 21<sup>st</sup> of October 2013, the national landslide early warning service (“Jordskredvarslingen” in Norwegian) was officially launched during the Technology Days in Trondheim. Representatives from the Norwegian Water Resources and Energy Directorate (NVE), the Norwegian Public Roads Administration (NPRA), the Meteorological Institute (MET) and the Norwegian Railway Authority proudly launched and presented the coloured rubber boots that would illustrate the warning levels for both flood and landslide warnings. Ten years later, the wellies are still a symbol of flood and landslide danger, and a popular photo motif for external visitors.



*The rubber boots that illustrate the warning levels used in the Norwegian flood and landslide early warning system. Photo: Hervé Colleuille/NVE.*

### **One of the first countries in the world with a nationwide landslide warning**

Before 2013, there was limited national knowledge on temporal and spatial occurrence of debris flows, debris avalanches and slushflows. It was, therefore, an important step to establish a system that could warn these types of mass movements.

- The organization of the landslide warning has been a pioneering work. In 2013, Norway was one of the first countries in the world to develop a nationwide operational landslide early warning service, says Hege Hisdal, director of the Hydrology department at NVE.

### **National cooperation at its best**

The landslide early warning service is currently operated as a collaboration between the Norwegian Water Resources and Energy Directorate (NVE), the Meteorological Institute (MET) and the Norwegian Public Roads Administration (NPRA). The group of landslide forecasters consists of hydrologists and geologists, with 15 employees from NVE and three from the Norwegian Public Roads Administration.

- We are both a contributor and a user of the landslide early warning service. We contribute directly to the service with some of our geologists and geotechnical engineers as landslide forecasters. In



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In addition, we contribute to the further development of several Varsom products, says Viggo Aronsen, section leader at the Norwegian Public Roads Administration.

Warning notifications are important in the daily assessment of the level of emergency response to be issued by NPRA's natural hazards response unit, road managers and builders, responsible for the road maintenance. This is important so that they can carry out preventive measures in case of increased emergency and, they can be prepared to handle possible landslide or slushflow incidents.

Weather observations and forecasts from the Norwegian Meteorological Institute (MET) are input data for models used to assess landslide and slushflow hazards. The landslide forecasters have a daily morning briefing with a meteorologist from MET. The representatives of NPRA's natural hazards response unit are also taking part to the daily morning briefing.

- The start in 2013 of the landslides and snow avalanches warning and forecasting services, the creation of [varsom.no](http://varsom.no) and the subscription solution to get warning notifications through e-mail and SMS, is an example of a common desire to offer useful and coordinated warning services to emergency authorities and the general public, says Bård Fjukstad, director of the forecasting division at MET. Through the creation of these warning services, we have also been able to expand our network of weather stations, through a collaboration with the three agencies. This contributes to better weather forecasts, adds Fjukstad.

### **Model-based notification service**

The landslide warning service covers the mainland Norway and publishes daily hazard assessments for debris avalanches, debris flows and/or slushflows at regional level, for the current day and the next two days. Much of the basis for the hazard assessment is model based, i.e. the service uses mathematical models that reproduce the physical processes from precipitation that falls, snow that melts, water that infiltrates into the ground or evaporates, groundwater reservoirs that are filled with water, and water that flows into streams and rivers. The hazard assessment is based, among other things, on calculations of water supply, from rain and snowmelt, and water soil saturation for the coming days. Information from real-time observations of groundwater levels, past landslide and slushflow events, acquired experience and knowledge of both past weather conditions that have triggered landslides, and regional landslide susceptibility is also used in the assessment.

### **Climate change requires continuous development of the service**

Although the landslide warning has been a success story, our users want more precise and local warning. Climate change can lead to increased and more intense precipitation and changed snow conditions, which will increase the risk of debris avalanches, debris flows and slushflows in the future. It is therefore necessary to be at the forefront, and to continuously develop and adapt the forecasting and warning service to meet these challenges.

- Over the past 10 years, the landslide early warning service in Norway has contributed to better social security. The service is an important tool for raising awareness of the risk of debris avalanches, debris flows and slushflows, and gives emergency responders and people more time and a better opportunity to take the necessary preventive actions. We can be proud of the work that has been done in the past 10 years, while at the same time we look forward to a continued development of landslide warning in the years to come, says Hege Hisdal, director of the Hydrology department at NVE.



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### **Sharing experience internationally**

In these 10 years, the Norwegian landslide early warning service has been promoting the close collaboration among researchers and practitioners all around the world, through the establishment of the [LandAware – the international network on LEWS](#), that was a follow-up initiative of two workshops on territorial/geographical LEWSs, held in Oslo, Norway, in 2016 and in Perugia, Italy, in 2020. The Norwegian landslide early warning service is an active associate and always willing to share knowledge and experiences through workshops and meetings organized as part of the international network.

-The managers of this system must be praised for their “openness” and their ability to engage, continuously during the last 10 years, with a wide international community of people and institutions that deal with warnings for landslides, at different levels and from different viewpoints, says Michele Calvello, President of the LandAware network and Professor at the Civil Engineering Department of University of Salerno, Italy.

The development of landslide warning in Norway is often used as inspiration and reference for other countries that want to build a similar warning service.

-NVE quickly became a reference in the community of researchers and professionals in the field of operational warning systems for landslides, avalanches, and floods. The combined implementation of meteorological, hydrological, and hydrogeological stations and numerical models constitutes a significant strength in the “Jordskredvarslingen” system. The willingness of NVE professionals to check the performance of the system, and to promote the exchange of information with other colleagues from all over the world is also noteworthy, says Stefano Gariano, Researcher at the Italian National Research Council - Research Institute for the Geo-Hydrological Protection CNR-Irpi, Italy.

-The inspiration from the Varsom Xgeo system has been invaluable for the advancement of landslide forecasting and management in Malaysia. We congratulate NVE and wish for it to continue excelling and become a leading institution in landslide research, says Mohd Farid Bin Abdul Kadir, Geoscience Officer at the Department of Mineral and Geoscience, Malaysia.

-As part of our work exploring the development of landslide early warning and awareness tools for deep-seated landslides across North America, we undertook an extensive review of the international state-of-the-art. The Norwegian landslide early warning system provides the best example of a fully operational data-driven approach that on which we use to demonstrate the desired end-state for our development in terms of analytical approach and operational delivery, says Corey Froese, Principal at Wavelength Advisory Services, Canada.

### **Fact: Large regional variation in the issued warnings**

The first warning was sent on the 22<sup>nd</sup> and 23<sup>rd</sup> of October for western Norway on a yellow level. Over the past decade, the landslide early warning service has issued over 800 landslide warnings, averaging 30 and 120 per year. These warnings primarily fell under the yellow level (92%), with orange (7%) and red level (1%) being less common. The regions that have received most of the warnings and often at the most severe levels, are Trøndelag, Innlandet, Viken and Vestlandet. Conversely, Oslo, Agder, Rogaland and inner parts of Finnmark regions have received the fewest warnings. The years, 2020, 2014 and 2013, have been the years with the major number of issued warnings.



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The 1st forecasted weather condition that could cause landslides!

**Nedbør tirsdag**

The 1st landslide index prognosis!

**Faregrad**

The 1st published landslide warning message!

Moderat fare for jordskred, flomskred og utglidinger grunnet mye regn

**Beskrivelse**  
Det ventes opp mot 50 mm regn frem til onsdag morgen. Nedbørstetningen og mengden er noe usikker. Bratte skråninger, samt bekker og elveløp med stor vannføring er spesielt utsatt. Rensing av dreneringsrør og utskjærner anbefales. Se mer informasjon for "Trek av varsel" - beredskap!

The 1st landslides forecasted and their location!

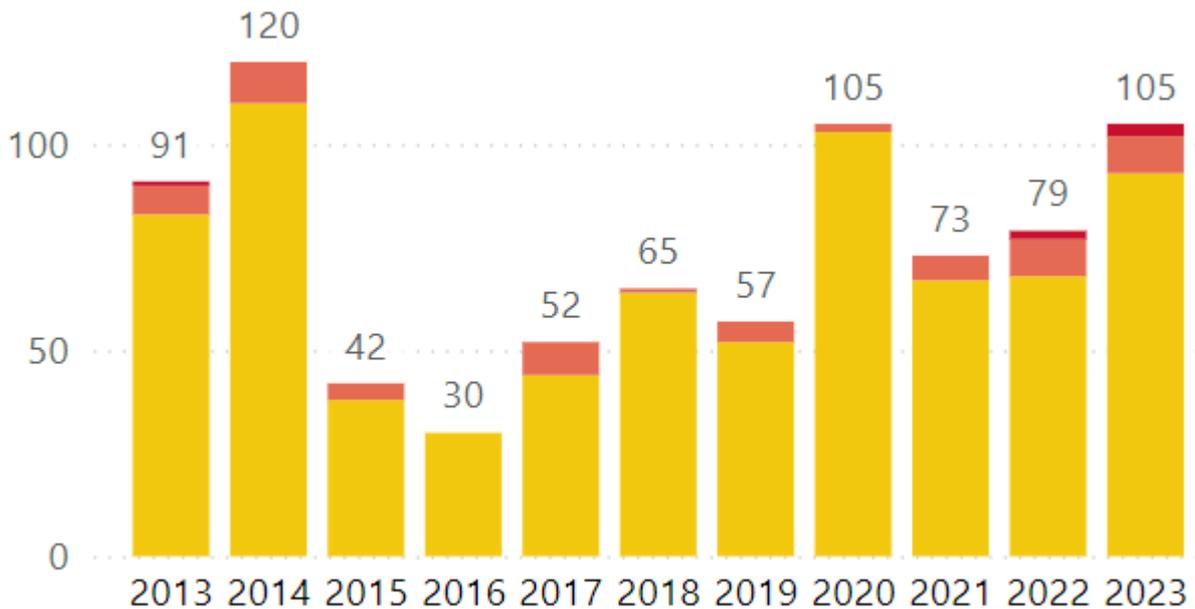
**Happy 10y anniversary!**  
22nd and 23rd of October 2013

E 16 ved Romslo (Bergen), ID: 17645  
22.10.2013, 09:20

Bergen, ID: 17642  
23.10.2013, 09:25

**\*Hydret Geotirsdag**

Summary of the first warning, sent on the 22<sup>nd</sup> and 23<sup>rd</sup> of October 2013. Illustration: NVE.



Number of landslide warnings sent annually between October 2013 and September 2023. Illustration: NVE.



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### **Useful tools developed by NVE in collaboration with MET and NPRA:**

- [Varsom.no](https://varsom.no) is your main source for warning notifications and knowledge about natural hazards in Norway.
- At [Abonner.varsom.no](https://abonner.varsom.no) you can subscribe to receive land-based natural hazard warnings from NVE and MET by e-mail and SMS, as soon as they are published. The service is free.
- On [Regobs.no](https://regobs.no) you can register, share observations and/or read about events related to snow avalanches, floods, landslides, and ice conditions. The information can also be found in the Varsom app, which can be downloaded from the [App Store](https://apps.apple.com/norway/app/varsom) or [Google Play](https://play.google.com/store/apps/details?id=no.nve.varsom).
- [Xgeo.no](https://xgeo.no) is our experts' source of data used for the daily hazard assessment of flood, snow avalanche and landslides.
- At [Naturhendelser \(varsom.no\)](https://naturhendelser.varsom.no) we publish digital reports that describe significant weather-related events that have caused past floods, landslides, and other natural hazards in Norway.