Mt. Kazbegi / Tergi Valley Early Warning System Report

EUCP Mission to Georgia 2014 (Landslide / Debris flow) Recommendations

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Content

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1. Introduction & Mission background

This report has been compiled by the European Civil Protection Team (EUCPT) deployed through the (European) Union Civil Protection Mechanism in response to the Government of Georgia request for assistance. Georgia has been currently affected by a **large landslide** (**debris flow**) which occurred on 17 May.

The mission objective was to undertake a rapid assessment of the situation in the area. The above considerations should be combined into an overall assessment identifying any possible immediate or potential threats to local population and the environment. Recommendations for appropriate immediate and mid-term action were provided on 2nd of June 2014 as well as recommendations to the national authorities, including disaster management and environmental authorities.

1.1.EU CP Mission (Georgia Landslide May/June 2014)

The first mission results (including first recommendations) were presented in Tbilisi (Ministry of Environment) on Monday 2 June. After the presentation the minister (Mrs. Khatuna Gogaladze) asked for an additional support in:

1) Written mission report (the Georgian authorities have expressed interest in the use of Early Warning Systems (EWS)).

2) A draft of terms of references for technical experts (for potential implementing partners).

1.2.Background

A rock/ice/snow mass collapsed in the Dariali Gorge on 17 May, blocking the Tergi River. The disaster was a result of intensive movement of the Devdoraki glacier located at the 5047 meter-high peak. The collapsed material blocked the river Tergi and created a temporary dam flooding the surrounding area. According to the Emergency Management Department of the Ministry of Internal Affairs (as of 28 May), seven people are reported missing and one dead; about 200 people were evacuated by helicopter from the border crossing checkpoint and its nearby areas. The landslide caused substantial damage to the infrastructure; North-South Pipeline, running through the area, has been affected, suspending transit of Russian gas to Armenia via Georgia.

Catastrophic, glacier related events at Devdoraki glacier have been reported during the last 120 years.

Mt. Kazbegi has a long record of extreme ice-rock avalanches. The largest ice-rock avalanche recorded, occurred in 2002 on the Russian side of the mountain. On the north-eastern face of Mt. Kazbegi, 10-200 million cubic meters of rock and ice failed and fell onto Kolka glacier, triggering an ice-rock-debris flow down the valley with speeds up to 80m/second. More than 100 people were killed (source: EOS, Vol. 89, Nr. 47, Nov. 2008).

Debris flow warning systems can be classified into two main classes: *advance warning* and *event warning*. *Advance warning systems* predict the possible occurrence of a debris flow event before its occurrence by monitoring predisposing conditions (M. Arattano and L. Marchi, 2008).

Event warning systems or *event-triggered warning systems* detect a debris flow while it is already in progress and provides an alarm; eventually a public warning is issued.

Current event early warning system

The Emergency Management Department (EMD) in cooperation with National Environment Agency (NEA) and others (e.g. Georgian Border Police) are currently running an event warning system by monitoring the situation via two observation posts (highest at 2.284m (former met/glaciological station), lowest at 1.7715m). The observation points are connected with different communication systems (radio) to alert specialists and working personal on-site (reconstruction, measurements, etc.). Alerting is done via sirens, special rocket lights and radio within approx. 4min 50 sec maximum (average landslide conditions) – see “time map” below.

This first non-automatic early warning and alert system is running 7/24. Specialists from NEA (Geologists, Hydrologist, and Glaciologists) are watching the glacier constantly (during daylight and visible weather condition, noise/sound at night or bad weather).

This staff intensive warning system has to be replaced by a permanent early warning system based on automatic/sensor measurement systems.

2. Recommendation #1: Establishing a landslide / torrent / avalanche (event) early warning system for Tergi Valley highway

The purpose of an event warning system is to provide an alarm when a debris flow is in progress. The sensors used for event warning systems are often the same adopted in debris-flow channels monitored for research purposes.

The sensors for detecting debris flows are only one component of event warning systems. Further components include a data acquisition and processing unit and devices to spread the alarm. The data acquisition and processing unit, installed in a safe position, receives data from debris-flow sensors, elaborates them and forwards the signals to the alarm devices (sirens, traffic light, etc.).

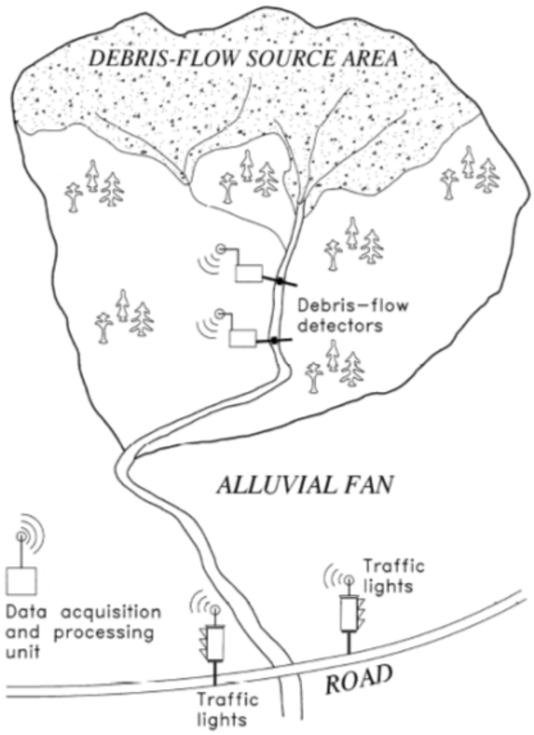
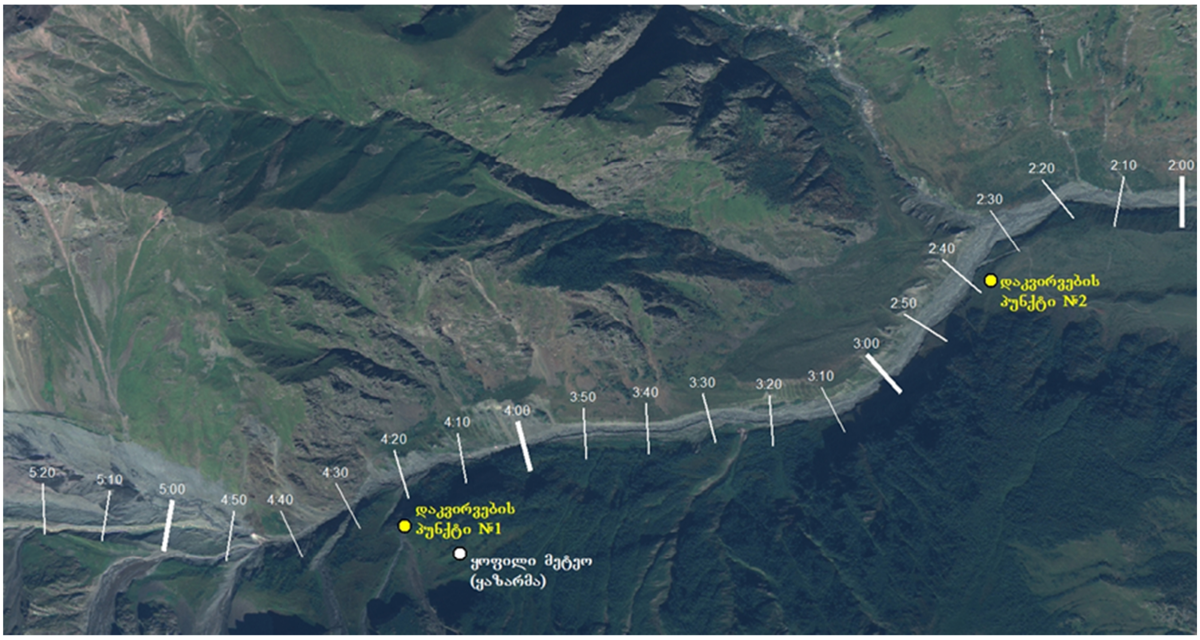


Figure: Sketch of the components of a debris-flow warning system (M. Arattano and L. Marchi, 2008)

Alarms are disseminated to address both the public, by means of sirens and traffic lights, and the personnel in charge of disaster management, by means of signals in emergency rooms (*112.ge / border post / trafic police / others*) and short messages on mobile phones.

Debris flows are fast mass movements, as a consequence, warning times for event alarm systems seldom exceed 3-5 minutes (see map below).



Map: Warning Times (Min/Sec), Observation points (left/right point at 2.284m and at Amali/Devdoraki confluence (1.715m) and Warning and Communication point (right).

Source: Geographic (GIS & RS Consulting Centre)

This causes important limitations in the use of event warning systems, which can be suitable for protecting transportation routes by stopping the traffic, whereas they are normally unfit to effectively protect inhabited areas because warning times are too short to evacuate people from endangered areas (M. Arattano and L. Marchi, 2008).

It is obviously of the utmost importance to minimize the risk of system failure when issuing an alarm in the event of a debris flow. It is then advisable to adopt redundancy criteria into the design of an event warning system for debris-flows; the various components of the system (sensors, powering, data transmission, processing unit) should all be duplicated. At the same time, it is imperative to minimize false alarms; this can be achieved through a wise choice of sensors and installation sites. As previously mentioned, the use of integrated systems might also greatly help (M. Arattano and L. Marchi, 2008).

The protection against (alpine) natural hazards is a service of general interest which is to be provided by the state

(Torrent and Avalanche Control – Austria).

2.1. *On-site problems (Mt. Kazbegi)*

- ► No long-term data available (missing weather data, hydrological data, glaciological measurement, etc.)
- ► Remote area with limited network access (internet, GSM, GSMR)
- ► Limitation in infrastructure (e.g. electricity)

The mentioned problems may cause restrictions for some measurement systems e.g.

- ► Video- and radar measurement system (data transmission limitation).
- ► Geophones (less seismic data for correlation available)

Note: Technical solutions for a monitoring and early warning system for Mt. Kazbegi that could be operated on site (based on experiences in Tirol and possible on-site limitations), will be now described.

2.2. *EWS – System for Tergi Valley (Mt. Kazbegi)*

Based on our EUCP field assessment with Georgian experts from *NEA (National Environment Agency)* and *EMD (Emergency Management Department),* experiences in Austria (*Province of Tirol*) and several discussion with colleagues representing all departments operating measurement and warning systems in the province of Tirol and experts from the federal *Ministry of Agriculture, Forestry, Environment and Water Management– Forest Engineering Service in Torrent and Avalanche Control* we could recommend to start with following measurement systems:

ONE LASER MEASUREMENT STATION (LAMS)

ONE OR TWO LEVEL MEASUREMENT STATION(S) (LEMS)

ONE AUTOMATIC WEATHER STATION (AWS)

SOFTWARE FOR DATA COLLECTION, PROCESSING AND ALERTING (ACTION)

2.3. *Laser measurement station (LAMS)*

Laser measurement can trigger a first alarm to the EWS system. As soon as a defined change movement is recorded (to be defined by local experts), the first alert is given to the system (software).

Laser-Measurement (LASER-PT-01 / "Old Pluviometer"): (42°43'30'' N / 44°35'38'' E) at app. 1.800 m
Distance to glacier: 2.5 km

Location LASER-PT-01 / "old pluviometer":

- √ Infrastructure: road access (4WD, Truck)
- √ Electricity / generator at MOI – Border Police Post
- √ GSM coverage (data transmission to processing unit)

Laser measurement, 2nd possible location: old Glacier/Glaciology hut – 2.270 m

Possible problem at location “old glaciology hut”:

No infrastructure available

Data transmission ?

Laser measurement station – equipment (example)

Definition location and requirement:	Government of Tirol experts (Geodata, Geology)
Maintenance	Trained technicians - Government of Tirol staff (electricians, mechanics)
Laser technology provider (see note)	Leica or. Jenoptic (e.g. LDM301 Series)
Costs per laser unit	**up to 20.000,- €**
Additional: Solar panel, data logger and data transmission, battery (emergency power supply), box, steel pipe mast	e.g. www.sommer.at
Costs per unit	**approx. 6.000,- €**

Note: Tirol (Gov. of Tirol) is operating laser measurement systems, but on shorter distances (<500m) only. Government of Tirol is using Leica products!

2.4. Level measurement station (LEMS)

In order to be able to monitor the height of river levels timely and accurately, reliable sensors are an absolute necessity. Ultrasonic or radar sensors hung over the channel measure the distance between the flow surface and the sensor itself, making it possible to record debris-flow.

Advantage: Easy to set warning thresholds.

Possible limitation: Sensors have to be hung over the channel; installation can prove difficult if the channel banks are unstable.

The best place(s) for one or two stations are (to be defined/confirmed by NEA):

Location close to "old pluviometer" (confluence Amali / Devdoraki valley):

- √ Infrastructure: road access (4WD, Truck)
- √ Electricity / generator at MOI – Border Police Post
- √ GSM coverage (data transmission to processing unit)

Problem:

Short early warning time

The example below shows a LEMS, installed in the province of Tirol, using radar sensor for measurement as an alternative to ultrasonic systems. Radar was used because of its independence of temperature influence, wind movements, fog or rain.

Solar panel Data logger / Power supply Radar sensor unit

Example: Government of Tirol (Dep. of Hydrology) – K. Niedertscheider (Gov. of Tirol)

Level measurement station in Tirol (example)

Definition location and requirement:	Government of Tirol experts (Hydrology)
Maintenance	Trained technicians - Government of Tirol staff (electricians, mechanics)
Data logger incl. GPRS-modem	OTT netDL - www.ott.com
Provider radar measurement:	VEGAPLUS 61 – www.vega.com
Costs per unit	**approx. 15.000,- €** (excluding base construction)

2.5. *Automatic weather station (AWS)*

In addition to early warning system equipment, a meteorological station should be established. Automatic weather station (AWS) measuring the fundamental meteorological categories. The weather station measures, log, transmit and visualize the measured values.

Sensors:

- Air temperature
- Wind direction and speed
- Air pressure
- Precipitation

Technical features:

- 5m steel pipe mast
- Solar power supply
- Measuring distributor with data logger and lightning protection
- Remote data transmission by GSM or GPRS (TCP/IP) or radio

AWS – Weather station in Tirol (example)

Definition location and requirement:	Government of Tirol experts (Hydrology, Avalanche Warning Service)
Maintenance	Trained technicians - Government of Tirol staff (electricians, mechanics) in co-operation with www.sommer.at
AWS provider (implementing), design, installation	www.sommer.at
Costs per AWS unit including data transmission unit, software etc.:	**approx. 15. – 20.000,- €**

2.6. Alarm System (AS)

After implementing described measurement systems (LAMS, LEMS, AWS) and data transmission to data storage server, existing data has to be used in a warning system. Existing data has to be used as the basis for identifying constellations triggering mudflows / debris flows / floods alarms or actions.

Software for directly querying data loggers (OTT or Sommer logger are used in Tirol) by remote data query with stations in the field (GSM, GRSM, radio, internet). Data storage and processing are the next steps.

Finally there has to be a connection to public warning systems e.g. sirens or traffic lights.

<u>Data management software used in Tirol:</u>

www.sommer.at (ComWin)

www.kisters.eu (Water Information Systems Kisters)

Technical support in system integration or interoperability:

Mr. Markus Buchauer (Technical office), Innsbruck; AT www.tbbm.info (info@tbbm.at)

Definition software requirement:	Government of Tirol experts (Hydrology, Avalanche Warning Service)
Maintenance	Software provider / private consultant
SW (implementing), design, installation	www.sommer.at / www.kisters.eu
SW costs	Depending to SW requirements

Consultant for EWS - AT:

Austrian Ministry of Agriculture, Forestry, Environment and Water Management – Forest Engineering Service in Torrent and Avalanche Control, Mr. Gebhard Walter (gebhard.walter@die-wildbach.at)

3. Recommendation #2: Re-establishing Mt. Kazbegi as scientific research area

In addition to recommendation #1 (event EWS), Mt. Kazbegi area should be used as scientific research area again. All relevant geo-sciences *(Geology, Glaciology, Geomorphology, Meteorology, Volcanology, Seismology, GIS/Mapping/Modelling,…)* should re-establish scientific programmes. This will help to understand processes much better and may help to introduce advanced warning systems in future. Advanced early warning systems predict the possible occurrence of a debris flow event before its occurrence by monitoring predisposing conditions.

3.1.Airborne Laser Scanning (ALS)

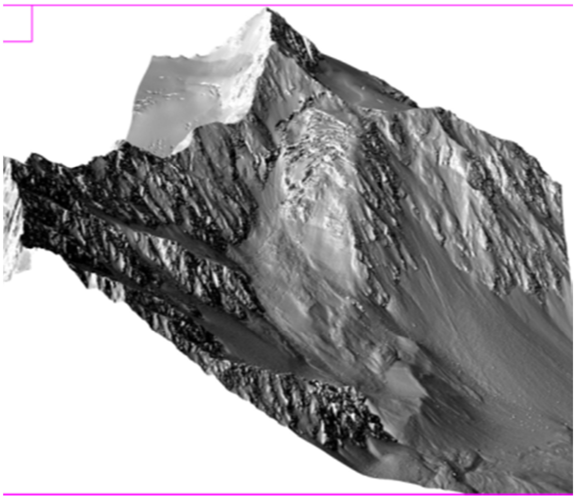
To understand how Mt. Kazbegi's environment (e.g. Devdoraki glacier, slope areas) looks like and is changing, airborne laser scanning data are used for computer models. We would recommend starting a monitoring programme at Mt. Kazbegi with airborne laser scanning (one helicopter flight / year).

Computer models that are as precise as possible are required to predict natural hazards in the Alps, such as floods, mudflows, slides, rock falls and avalanches. An important foundation for this is the Digital Terrain Model (DTM). The quality of the DTM depends significantly on point density, the position and height accuracy and the actuality. Airborne Laser Scanning (ALS) has proven to be a method with high precision and a large point density. In alpine areas airborne laser scanning is significant complex in comparison to laser scanning in lowland. The technical specifications of the laser scanning campaign are a point density of 1 point per m^2 in the Alps and a height accuracy of 0.08 m (rms). Therefore the DTM is also appropriate for different geo-scientific tasks (Dorsch, et.a., 2010).
In the last decades the mass loss of glaciers has increased. ALS data provide a current 3-dimensional mapping of the terrain; in relation to older geodetic or cartographic data mass balances get obvious.

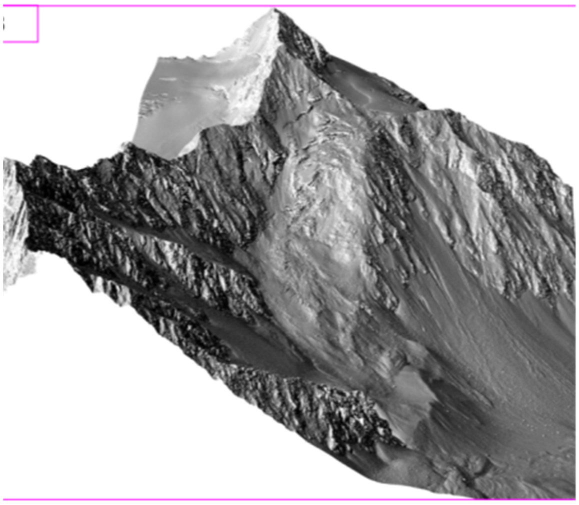
An example in the Tyrolean Alps (Ötztaler Alpen) is shown where the slide of ice and rock mass endangers a water reservoir underneath. For the monitoring of the hazard zone several airborne laser scanning flight campaigns took place (Dorsch, et.a., 2010).

Example: Bligg Glacier / Ötztaler Alps, Tirol, Austria (Source: Government of Tirol – Heißel)

ALS Data (Example)



2007 – ALS Model "Bligg glacier" (Gov. of Tirol)



2008 – ALS Model "Bligg glacier"

Laser scanning - example Province of Tirol:

ALS - area definition incl. invitation of tender	Government of Tirol experts (Geoinformation)
Private companies cover	Creation of 3D point clouds including planning, flying, accurate geo-referencing of the collected data and analysis (terrain and surface model) are done by private companies (e.g. *www.avt.at* (based in Austria) or *www.bsf-swissphoto.com* (based in Switzerland)).
Products	Detailed terrain and surface model for GIS analysis and other studies (movement of landslides, block glaciers, etc.) used by different departments (GIS, geology, geology, civil protection, forest,..)
SW costs	**150,- and 350;- € per km2** Depending on total area, point cloud density, classification.

3.2. Data collection programme

Re-establishing or introduction of intensive monitoring and measurement studies for Mt. Kazbegi. Including field studies, measurement programmes (additional AWS e.g. next to Mt. Kazbegi meteorological hut), national and international scientific co-operations.

Possible EU support ***(Copernicus):***

Satellite images via www.copernicus.eu processing to monitor volcano and its glaciers, slopes (European Earth Observation Programme).

An intensive data collection programme should include (inputs Government of Tirol/Geology and ILIA State University)

Analyses of subsurface gas emanations
Thermal imaging

Permanent seismic network
Geochemical analyses of the ground water and hot springs.
Rock dating for Kazbegi mountain.
Geophysical field studies to infer massive structure (microgravity measurements, magnetic field measurements; MT measurements);
Satellite image processing to monitor volcano and its glaciers, slopes
Tectonic studies of the region.

4. Sources

Arattano, M, Marchi, L, (2008): Systems and Sensors for Debris-flow Monitoring and Warning, In: *Sensors* 2008*, 8*, 2436-2452

Dorsch, J., Kistler, E. & Attwenger, M. (2010): Großflächiges Laserscanning im Alpenraum als Grundlage für die Vorhersage von alpinen Naturgefahren. [Laser scanning project provides foundation for predicting natural hazards in the Alps.] – Z. dt. Ges. Geowiss., 161: 129–137, Stuttgart.

Huggel, C, Caplan-Auerbach J. & Wessels R. (2008): Recent Extreme Avalanches: Triggerd by Climate Change?. In: EOS, Vol. 89, No. 47, November 2008, p. 469-470

4.1. Internet sources

www.sommer.at/en/home.html - AWS, Software, .. (English)

www.klisters.eu – Software / Water Information System (English)

www.leica-geosystem.com – Laser technology (English)

www.vega.com – Radar system VEGAPLUS (English)

www.ott.com – Data logger, software (English)

www.copernicus.eu – Satellite programme (European Earth Observation Programme)

4.2. Consulting (AT)

Mr. Markus Buchauer (Technical office), Innsbruck; AT – www.tbbm.info (info@tbbm.at)

Austrian Ministry of Agriculture, Forestry, Environment and Water Management – Forest Engineering Service in Torrent and Avalanche Control, Mr. Gebhard Walter (gebhard.walter@die-wildbach.at)

Report (16. June 2014):

B. Noggler (bernd.noggler@tirol.gv.at) / TL EUCP Mission Georgia 25.05. – 03.06.14