Multifunctional RADAR-system in alpine mass movement monitoring

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INTRODUCTION

For investigation and detection of important mass movements in alpine regions a reliable monitoring system is required. Parameters for detecting and characterizing movements are volume, mass and velocity. A reliable technology to measure velocities very accurate is the RADAR-technology using the Doppler-Effect on moving objects. The RADAR cross-section of an object for a given wavelength is a function of the magnitude, material, incident and reflecting angle which determines the scattered intensity. Therefore, this reflected intensity is a parameter that belongs to the cross section of the moving volume of the detected object.
So RADAR-technology is able to measure both magnitude and velocity. Similar systems have been used in snow avalanche research since the early 1980s (H. Gubler, SLF, later on TU Graz/BFLW Innsbruck and NGI, most recently University College London), but they have never got beyond the prototype stage.

PRINCIPLE

The RADAR operates according to the principle of the coherent pulse Doppler RADAR. A high-frequency generator produces a signal in the X-band (10.425 GHz). The used frequency is far away of the absorption line of water, which is 22.235 GHz. Therefore, the frequency is a compromise of low absorption cross-section, high reflection cross-section and attenuation in air to detect wet moving objects. The signal itself is pulse-modulated in a high-frequency switch, amplified to an output power of about 1 W and radiated from a parabolic antenna to the detection area. The reflected beam from the illuminated area passes the parabolic antenna again and goes through the receiver. There, the signal is sampled and converted by an analog-digital converter. Afterwords, a digital signal processor processes the raw data from the signal. This data are streamed via Ethernet to a second computer that allows to editing them or the data are processed with alerting software in order to produce possible alerts.
Figure 1 shows the illumination of a mountain slope with a pulse-shaped electromagnetic wave packet limited to discrete steps in time in Umhausen /Tirol Austria. The maximal detection range in heavy weather condition for a moving object with a 1 m² radar cross-section is about 2000 m. The range is divided in 15-250 m long range gates and for each range gate a velocity intensity spectrum is obtained every 1/3 of a second. This spectrum is very characteristic for each different moving objects like avalanches, debris flow, river flow rain or single moving objects like people or vehicles. The alarming software can easily distinguish between them and can calculate the main interesting parameters.

RESULTS

The experience over 5 years now, with more than 10 RADAR installed, showed the enormous potential of the presented RADAR technology in use as an independent warning and monitoring system in the field of natural hazards in an impressive manner. The results proof, that not only avalanches and fluvial natural hazard processes can clearly and reliably be detected, but the RADAR can also be used as an accurate monitoring system for water levels and flow volumes as well and with an additional antenna, looking upward in the sky, it is also possible to use the system as a local Rain-RADAR, which detect and quantify heavy rainfalls in a monitored catchment.
The high frequency RADAR device was already successfully tested in different projects (for snow avalanches: evaluation project Sedrun/Switzerland (Lussi et al., 2012), pilot installation Ischgl/Austria (Kogelnig et al., 2012), for debris flows: Pians/ Austria (Koschuch et al., 2014); pilot installation with test wise operative integration in the ÖBB

alarming system (ÖBB-ASFINAG-FFG Project VIF2011-Naturgefahrenradar (HÜBL et al., 2014)) and it is already available as a commercial product.

CONCLUSION

Thus, with just one system you get following functions:

– Alarming system for avalanches, debris flows, floods.
– Monitoring system for heavy rainfalls, water levels, flow volumes, rockfall and people entering a dangerous area.

One further main advantage is, that for the installation of the RADAR only a mast and a power supply of 40 Watt is necessary, which can be installed even in the restricted places in one day.

Figure 1. Installed RADAR-System (smaller picture) with 2 antennas and solar power supply in Umhausen/Tirol Austria and view from the RADAR-system with monitored area subdivided in range gates.

REFERENCES

- Lussi D., Schoch M., Meier L., Rüsch M. (2012). Projekt Lawinendetektion Schlussbericht, WSL-Institut für Schnee- und Lawinenforschung SLF
- Kogelnig A., Wyssen S., Pichler J. (2012). Artificial release and detection of avalanches: Managing avalanche risk on trafic infrastructures, a case study from Austria, Congress contribution ISSW 2012.
- Koschuch R., Jocham P., Hübl J. (2014).One Year Use of High-Frequency RADAR Technology in Alpine Mass Movement Monitoring: Principles and Performance for Torrential Activities. [IAEG XII Congress 2014, Turin, ITALY, SEPT 15-19, 2014]
- Hübl J., Pichler J., Jocham P., Koschuch R. (2014). Automatische Detektion alpiner Massenbewegungen mittels Hochfrequenzradartechnik, Naturgefahren-Radar, Abschlußbericht;(VIF2011)

KEYWORDS

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