

Course title: PL: Zagrożenia geomorfologiczne na stokach EN: Geomorphological Hazards of Slopes
Discipline: materials engineering, mathematics, Earth and related environmental sciences *
Number of ECTS: 2
The entity coordinating the module: Institute of Geophysics of the Polish Academy of Sciences, Institute of Mathematics of the Polish Academy of Sciences, Institute of Oceanology of the Polish Academy of Sciences, Faculty of Natural Sciences of the University of Silesia, Faculty of Science and Technology of the University of Silesia*
Coordinator: Dr Michał Cieplý, Uniwersytet Śląski w Katowicach (academic degree or title, name, surname, affiliation)
Lecturer: Prof. Ola Fredin Norwegian University of Science and Technology - NTNU
Description (a brief description of the course — up to 300 words): PL: EN: This short course introduces the fundamentals of slope instability and geohazards in steep terrain, with emphasis on landslides, debris flows, debris falls, and rock falls. Students will learn to apply the Varnes classification system to identify and compare different types of slope movements, and to understand the soil mechanical principles that govern slope failure. Core concepts such as effective stress, shear strength, pore-water pressure, and the Mohr–Coulomb criterion will be linked directly to real-world slope processes. The course will explore the main triggering factors for landslides, including rainfall, snowmelt, freeze–thaw, earthquakes, and human activity, and will discuss how climate extremes and land use change affect slope hazards in Central Europe, Scandinavia, and globally. Special attention will be given to debris flows, their initiation from shallow landslides, entrainment and runout behaviour, and their destructive impact on mountain valleys. Teaching combines lectures with hands-on exercises. Students will classify slope failures using case examples, analyze aerial photographs and LiDAR hillshades, and perform basic slope stability calculations with simple Python scripts. Exercises include plotting Mohr circles, assessing infinite slope stability, and sketching runout paths using statistical methods. These activities will demonstrate how geotechnical concepts translate into hazard assessment. By the end of the course, students will be able to: • Recognize and classify different slope failure types. • Explain the mechanical conditions required for slope failure. • Identify key triggers and their regional importance. • Apply simple analytical tools to evaluate slope stability and hazard. The course provides a foundation for understanding and managing landslide hazards in mountainous regions and serves as preparation for more advanced studies in engineering geology, geomorphology, and natural hazard risk management.
Scope of topics: PL: EN: Introduction to Geohazards • Hazard versus risk: concepts and terminology • Importance of landslides and debris flows in mountain environments Classification of Landslides • Varnes (1978) and updated system by Hungr et al. (2014)

- Types of movement: falls, topples, slides, flows, spreads
- Materials: rock, debris, earth

Soil Mechanics and Slope Stability

- Effective stress, pore-water pressure, suction
- Shear strength: cohesion and friction
- Mohr–Coulomb criterion and factor of safety
- Infinite slope model

Landslides in Steep Terrain

- Shallow translational slides and deep-seated landslides
- Debris falls, rock falls, and rock slope failures
- Runout behaviour and entrainment

Debris Flows

- Initiation from shallow landslides and gully erosion
- Flow processes and mobility
- Runout models (α – β , dynamic models overview)

Triggering Factors

- Rainfall, snowmelt, freeze–thaw, earthquakes, volcanic activity
- Human activity: deforestation, construction, slope loading
- Role of climate extremes and climate change

Regional and Global Perspectives

- Cases from Central Europe (Carpathians, Sudetes, Tatras)
- Scandinavian examples (alpine valley-/fjord slopes, rock slope failures)
- Comparisons with global hotspots (Alps, Himalayas, Andes, New Zealand)

Hazard Assessment and Risk Management

- Landslide mapping and susceptibility models
- Rainfall thresholds and early warning systems
- Mitigation measures: structural and non-structural
- Communication of hazard and risk

Practical Exercises

- Aerial photo and LiDAR interpretation of landslides
- Jupyter notebook demonstrations (Mohr circles, slope stability)
- Simple runout sketching and hazard mapping

Form of classes: workshop, seminar, lecture, seminar, laboratory, other:*

Teaching methods:

PL:

EN: The course combines short lectures with student-active learning. Lectures introduce core concepts and provide regional and global context. Group work on case studies, aerial photographs, and LiDAR imagery develops classification skills and critical discussion. Practical components include simple hazard mapping exercises and Python-based laboratory sessions (Jupyter notebooks) to explore slope stability, Mohr circles, and runout models. This mix of lecturing, group activities, and hands-on computation ensures that students actively engage with theory, data, and real-world examples throughout the course.

Form of verification of learning outcomes: credit

Evaluation criteria and method of determining the final grade:

PL:

EN:

Active participation in group work, mapping exercises, and Python laboratories is **mandatory** but will not be graded. These activities are designed to support the achievement of learning outcomes and prepare students for the exam.

Passing the course based on active participation in classes

Language of course: English
Mode of the course: in-person, remote, hybrid*
Location of classes (in the case of in-person classes): (please provide the address)
Number of hours: 16
References: (please, provide basic literature on the content taught during the course) 1. Hungr, O., Leroueil, S., & Picarelli, L. (2014). The Varnes classification of landslide types, an update. <i>Landslides</i>, 11(2), 167–194. https://doi.org/10.1007/s10346-013-0436-y 2. Jonasson, C., Kot, M., & Kotarba, A. (1991). Lichenometrical studies and dating of debris flow deposits in the High Tatra Mountains, Poland. <i>Geografiska Annaler: Series A, Physical Geography</i>, 73(3–4), 141–146. https://doi.org/10.1080/04353676.1991.11880339 3. Lóczy, D. (Ed.). (2013). Geomorphological impacts of extreme weather: Case studies from central and eastern Europe. Springer Geography. https://doi.org/10.1007/978-94-007-6301-2 4. Tichavský, R., Ballesteros-Cánovas, J. A., Šilhán, K., Tolasz, R., & Stoffel, M. (2019). Dry spells and extreme precipitation are the main trigger of landslides in Central Europe. <i>Scientific Reports</i>, 9, 14560. https://doi.org/10.1038/s41598-019-51148-2 5. Migoń, P. (2017). Extreme geomorphic events in the contemporary evolution of forested slopes in a Central European mountain range, the Sudetes. <i>Revista de Geomorfologie</i>, 19, 16–28. https://doi.org/10.21094/rg.2017.017 6. Pawlik, Ł., Migoń, P., Owczarek, P., & Kacprzak, A. (2013). Surface processes and interactions with forest vegetation on a steep mudstone slope, Stołowe Mountains, SW Poland. <i>Catena</i>, 109, 203–216. https://doi.org/10.1016/j.catena.2013.03.011 7. Blikra, L. H., Nilsen, B., Anda, E., Longva, O., & Braathen, A. (2006). Rock-slope failures in Norway: typology, geological controls and hazard management. <i>Norsk Geologisk Tidsskrift</i>, 86(3), 245–264. 8. Derron, M.-H., & Jaboyedoff, M. (2012). Preface: Landslide risk management in the Alps. <i>Natural Hazards and Earth System Sciences</i>, 12(3), 801–803. https://doi.org/10.5194/nhess-12-801-2012 9. Sæmundsson, T., Decaulne, A., Jónsson, H. P., & Jónsson, P. (2003). The avalanche and landslide hazard in Iceland: An overview. <i>Natural Hazards and Earth System Sciences</i>, 3(5), 583–592. https://doi.org/10.5194/nhess-3-583-2003 10. Dikau, R., Brunsden, D., Schrott, L., & Ibsen, M.-L. (1996). <i>Landslide recognition: Identification, movement and causes</i>. Chichester: Wiley. 11. Crozier, M. J. (2010). <i>Landslide geomorphology and geohazards: Perspectives from the Southern Alps of New Zealand</i>. Routledge. 12. Iverson, R.M. (2000). Landslide triggering by rain infiltration. <i>Water Resources Research</i>, 36(7), 1897–1910. 13. Wieczorek, G.F. & Glade, T. (2005). Climatic factors influencing occurrence of debris flows. In <i>Debris-Flow Hazards and Related Phenomena</i> (Springer, pp. 325–362).