<D25-2> Revised version

Application Form for World Centre of Excellence on Landslide Risk Reduction 2023-2026

1. Name of Organization: **Charles University**

2. Name of Leader: **Vít Vilímek**

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   Core members of the activities Names/Affiliations: (4 individuals maximum)

   Gianvito Scaringi, Institute of Hydrogeology, Engineering Geology and Applied Geophysics, Faculty of Science, Charles University

   Marco Loche, Institute of Hydrogeology, Engineering Geology and Applied Geophysics, Faculty of Science, Charles University

   Jan Kropáček Department of Physical Geography and Geoecology, Faculty of Science, Charles University

   PhD students will be included into the planned WCoE as well (e.g. J. Smolíková, O. Dhakal)

3. Date of Submission of Application: **March 28th, 2023**

4. Activity scale and targeted region.

   1) ~~Global, 2) Intercontinental~~, 3) **Continental**, **4) Regional,** 5) **National**

5. Short Title characterizing past and planned activities**: Effects of precipitation, moisture and temperature changes on landslides in the process chains.**

6. Objectives for 3 years:

   To quantify rainfall thresholds for shallow landslide at local and regional scale. To quantify the sensitivity of clay and non-clay soils to seasonal temperature fluctuations and long-term warming in terms of volume changes and variations in shear resistance and creep rates. Evaluate how thermal sensitivity can influence slope stability and landslide kinematics. Study the role of temperature changes in destabilizing hanging glaciers and following debris flows. Cooperation in the frame of Czech Republic is planned (e.g. with the Czech Academy of Sciences – Institute of Rock Structure and Mechanics and

Brown Coal Research Institute).

7. Background Justification: Landslides may be triggered by a variety of factors and processes. Amongst the most important and common of these is rainfall whether in the form of high-intensity short-duration storms, lower intensity higher-duration antecedent events or a combination of both. Nevertheless, we have to consider carefully all of the meteorological factors as triggers with respect to the complexity of the natural environment. Experimental research in the field of geomechanics has demonstrated the strength and hydraulic parameters of soils and rocks change with temperature, especially for materials containing clay minerals owing to the strong influence of temperature on water adsorption capacity at microstructural level. While rather in-depth knowledge of volumetric effects has been achieved, less is known about the effect of temperature on the critical-state and residual shear strength and on the rate of shear strains under constant effective stress (shear creep). These phenomena can be especially relevant in existing landslides where, together with changes in moisture and pore water pressures driven by infiltration of precipitation, they could control their potential for reactivation, fast runout, and triggering of process chains. Owing to rapid changes in climatic patterns, making the ground experience enhanced seasonal changes and progressive warming in combination with changes in precipitation inputs, the combined study of thermal, hydraulic and mechanical interactions in landsliding is becoming increasingly urgent.

8. Resources available for WCoE activities

   Personnel, Facilities, Budgets, and Affiliation and Contribution to ICL/IPL and KLC2020.

   Financial resources are available from the project COOPERATIO (institutional financing of research at Charles University) and from the ERC-CZ project on “Temperature effects on landsliding in temperate climates” (funded by the Czech Ministry of Education). Beside this, a research project for analysis of large run-out landslides triggered by hanging glaciers and a research project on thermal behaviors of landslides were submitted in March 2023 to the Grant Agency of the Czech Republic. All facilities necessary for our research are available in the frame of laboratories of Charles University. We plan to support ICL/IPL and KLC2020 with our activities.

9. Description of your past activities related to risk reduction of landslides and other related earth system disasters: Determination of triggering rainfall patterns is mostly based on a single rainfall parameter or a combination of two parameters, which often differ and are not uniform across studies. That makes the

results difficult to compare. In addition, most studies consider only days with recorded landslides. They do not consider days when rainfall significantly exceeds the triggering rainfall, and no landslides occur. This leads to the question, “Why did the landslide not occur on a day when the rainfall was more extreme than the triggering rainfall”? We already performed the rainfall threshold study from two localities (e.g. Smolíková et al., 2021) in the Central Europe, nevertheless we need to verify it more. We have also explored temperature effects, both in soil and rock materials affected by landslides (Scaringi and Loche, 2022), by means of laboratory experiments (ring shear experiments and infrared thermography) and modelling (Deng et al., 2023; Loche and Scaringi, under review). We carried out thermography monitoring in unstable sites in the Czech Republic and Italy, especially to identify relationships between thermal responses and material properties (porosity, strength). We investigated the use of remotely sensed land surface temperature data in landslide susceptibility modelling at catchment scale, identifying relationships between prolonged landsliding after a strong earthquake (in the Wenchuan case study in China) and the surface temperature of the slopes (Loche et al., 2022). We are performing similar analyses in Italy by focusing on specific lithologic groups and landslide types (for instance, slow-moving slides in clay soils)." Some of the studies of large runout landslides were already published in our research team (journal Landslides) - we worked on the large run-out landslides both in Czech Republic (Burda et al. 2018) and Indian Himalayas (Kropáček, 2021) using field works or remote sensing data. Our past activities already supported ICL/IPL and KLC2020, such as Vilímek et al. (2020 and 2021).

10. Planned future activities /Expected Results:

    After a review of several approaches (1. year) to establishing a rainfall threshold, we would like to show a more universal approach (2.-3. year). We will focuse on several individual parameters or combinations of two or more parameters (10- and 15-min intensities, hourly amounts, daily amounts, cumulative amounts, and antecedent precipitation including evapotranspiration for 2, 3, 5, 10, 15, 20, 30, 60, and 90 days), which will set as the best matching thresholds. The level of detail of the threshold analysis also depends on the spatial scale of the study area. The global scale is independent of geological, morphological, land use, or climatic conditions and global thresholds are established simply as a minimum level below which landslides do not occur. The regional scale and regional thresholds are determined for areas extending from a few to several thousand square kilometers. We plan to systematically investigate the role of temperature changes as a predisposing factor to failure and reactivation of landslides and as a factor promoting continued instability (creep movement) – 1. year. We will tackle the problem at various scales: through specially designed laboratory experiments (in modified

ring shear and direct shear boxes, equipped with temperature-control functionality), through numerical modelling of individual slopes/landslide bodies (using physically-based modelling approaches that can account for temperature: thermo-hydro-mechanical (THM) models), through numerical modelling of landslide triggering and runout at catchment scale (by implementing novel THM modelling solutions within existing frameworks such as the material point method), and finally through geostatistical modelling at regional scale (using logistic regression, Bayesian approaches, machine learning to identify correlations between landslide patterns/trends and thermal variables) – 2.-3. year. Both individual studies of precipitation and temperature changes and their influence on landslide activity will meet in the process chain, where large runout landslides play an important role (3 year). Both the analysis of precipitation and temperature changes are planned to be published in IF journals (Q1 – Q2), including the journal Landslides and in the book series established by ICL ("P-LRT books."). Participation on WLF VII in 2026 is planned as well.

11. Beneficiaries of WCoE: (5 lines maximum; who directly benefits from the work?)
    Field research, laboratory tests and related data processing – benefit for international scientific community as well as local communities and agencies who may use the results for regional planning and for risk governance; networking – benefit for ICL/IPL especially networks (e.g. Landslides in cold regions). Internationally realized projects (bilateral) and projects with global significance (connected with climate and environmental changes in high mountain areas) – benefit for the KLC2020.

12. References:

    - Deng Y., Fan X., Scaringi G., Wang D., He S. (2023): Effect of particle crushing and thermally induced pressurization on rockslide mobility. Landslides, doi: 10.1007/s10346-023-02053-3.
    - Scaringi G., Loche M. (2022): A thermo-hydro-mechanical approach to soil slope stability under climate change. Geomorphology, 401, 108108.
    - Loche M., Scaringi G., Yunus A.P., Catani F., Tanyaş H., Frodella W., Fan X., Lombardo L. (2022): Surface temperature controls the pattern of post-earthquake landslide activity. Sci. Reports, 12, 988.
    - Kropáček J., Vilímek V., Mehrishi P. (2021): A preliminary assessment of Chamoli ice and rock fall in Indian Himalayas by remote sensing. Landslides, 18, 8, 3489-3497.
    - Smolíková J., Hrbáček F., Blahůt J., Klimeš J., Vilímek V., Loaiza Usuaga J.C. (2021): Analyses of the rainfall pattern triggering the Lemešná debris flow, Javorníky Range, the Czech Republic. Natural Hazards, 106, 2353-2379.

- Vilímek V., Wang F., Strom A., Sassa K., Bobrowsky P., Takara K. eds. (2021): Understanding and Reducing Landslide Disaster Risk Reduction. Catastrophic Landslides and Frontiers of Landslide Science, Springer. Vol. 5, 427 p.
- Vilímek V., Klimeš J., Ttito Mamani R.V., Bastante Abuhadba J., Astete Victoria F., Champi Monterroso P.Z., (2020): Contribution of the collaborative effort of the Czech WCoE to landslide risk reduction at the Machupicchu, Peru. Landslides. 17, 8, 2683-2688.
- Burda J, Veselý M., Řehoř M., Vilímek V. (2018): Reconstruction of a large run-out landslide in the Krušné hory Mts. (Czech Republic). Landslides, 15, 3, 423-437.

13. If your organization is an ongoing WCoE 2020-2023, please attach the articles as pdf files reporting activities of WCoE, IPL project and ICL network published/contributed or a list of planned reports of WCOE 2020-2023 to either journal "Landslides" or/and "P-LRT books."

    Charles University was a cooperating institution in the "Czech WCoE" during the period 2020 – 2023. We decided to submit our own proposal for the next period 2023 – 2026. The list of publications, where Charles University supported the ICL/IPL and KLC2020 is following:

    - Vilímek V., Wang F., Strom A. (2021): Catastrophic Landslides and Frontiers of Landslide Science, Landslides, 18, 11, 3733-3735. DOI 10.1007/s10346-021-01765-8
    - Kropáček J., Vilímek V., Mehrishi P. (2021): A preliminary assessment of Chamoli ice and rock fall in Indian Himalayas by remote sensing. Landslides, 18, 8, 3489-3497.
    - Vilímek V, Klimeš J, Stemberk J, Burda J, Kycl P, Blahůt J (2021) Complex Geomorphological and Engineering Geological Research of Landslides with Adverse Societal Impacts. In Sassa K, Mikoš M, Sassa S, Bobrowsky PT, Takara K, Dang K (Eds) Understanding and Reducing Landslide Disaster Risk. WLF 2020. ICL Contribution to Landslide Disaster Risk Reduction. Volume 1: Sendai Partnerships and Kyoto Landslide Commitment. Springer, Cham, p. 275-280. https://doi.org/10.1007/978-3-030-60196-6_20
    - Burda J., Vilímek V. (2021): An interdisciplinary assessment of a coal-mining-induced catastrophic landslide. In: Vilímek et al. (eds.) Understanding and Reducing Landslide Disaster Risk Reduction. Catastrophic Landslides and Frontiers of Landslide Science, Springer. Vol. 5., 133-145.
    - Kroczek T., Vilímek V. (2021): Rockfall hazard, lake expansion and dead-ice melting assessment: Imja Lake, Nepal. In: Vilímek et al. (eds.) Understanding and Reducing Landslide Disaster Risk Reduction. Catastrophic Landslides and Frontiers of Landslide Science, Springer. Vol. 5., 103-110.

- Vilímek V., Wang F., Strom A., Sassa K., Bobrowsky P., Takara K. eds. (2021): Understanding and Reducing Landslide Disaster Risk Reduction. Catastrophic Landslides and Frontiers of Landslide Science, Springer. Vol. 5, 427 p.
- Vilímek V., Klimeš J., Ttito Mamani R.V., Bastante Abuhadba J., Astete Victoria F., Champi Monterroso P.Z., (2020): Contribution of the collaborative effort of the Czech WCoE to landslide risk reduction at the Machupicchu, Peru. Landslides. 17, 8, 2683-2688.

(Those organizations with no activity report/no achievement in WCOE 2020-2023 will not be accepted as the candidate of WCOE 2023-2026 to be submitted to the Independent Panel of Experts for WCOEs.)

Note: Please fill and submit this form by 30 March 2023 to **KLC2020 secretariat** <klc2020@iclhq.org>