DEVELOPMENT OF AUTOMATED AVALANCHE TERRAIN EXPOSURE SCALE MAPS: CURRENT AND FUTURE

*Contact: Håvard T. Larsen, htla@nve.no

Håvard Larsen[1*], John Sykes[2], Andrew Schauer[3,4], Jordy Hendrikx[3], Rosemary Langford[2], Grant Statham[5], Cam Campbell[6], Michael Neuhauser[7], Jan-Thomas Fischer[7]

INTRODUCTION:

The Avalanche Terrain Exposure Scale (ATES) is a terrain classification system developed by Parks Canada to to better communicate the complexities and risks of traveling in avalanche prone terrain (Statham et al. 2006). Campbell and Gould (2013) proposed a model for GIS assisted classification using ATES. Larsen et al., (2020) extended this model, and developed an automated ATES, available nationwide in Norway. The aims of this presentation are to present the current and ongoing development towards an automated ATES model, which can uniformly be applied to avalanche terrain worldwide.The benefits of this approach are to standardize mapping of avalanche terrain across large spatial extents, and increase efficiencies at larger scales.

ATES v1.0 Classes

- Simple
- Challenging
- Complex

ATES v2.0 Classes

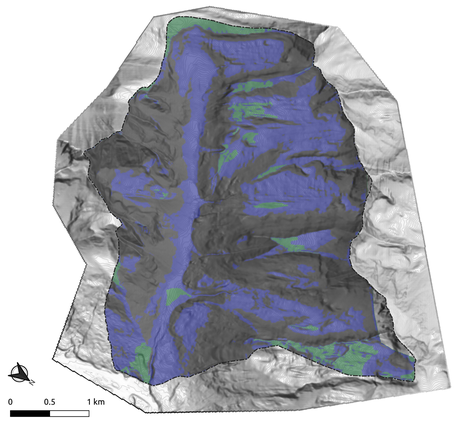
- Non-Avalanche Terrain
- Simple
- Challenging
- Complex
- Extreme

ATES VERSION 2.0:

An updated version of ATES (v2.0) is currently under development, including two new classes (non-avalanche and extreme terrain). The additional classes are intended to make the rating system more meaningful for advanced backcountry recreationists. Updating the rating system also offers an opportunity to update the definitions of each class. ATES v2.0 is being developed by a collaboration of researchers and practitioners from Canada, Norway, and the USA.

AUTOMATED MAPPING DEVELOPMENT:

Connaught Creek - Rogers Pass, BC, Canada

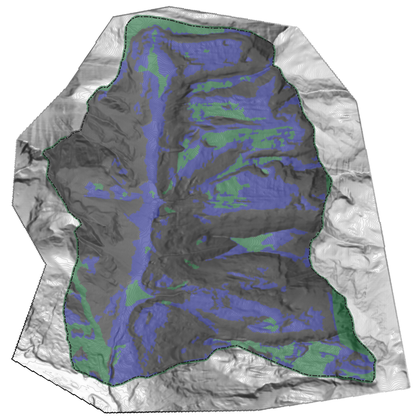


Auto ATESv1

Version 1.0

Model as per Larsen et al., 2020. Uses ATES v1.0 class definitions. Veitinger (2016) release area model, TauDEM for avalanche runout, no explicit representation of vegetation. Proprietary software needed.

esri python R

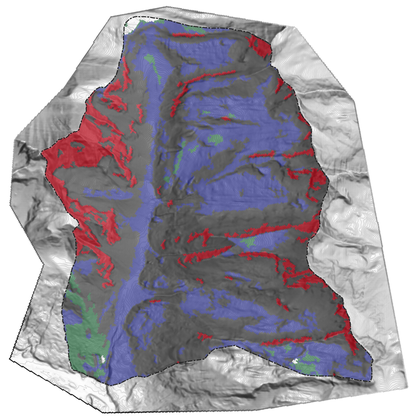


Auto ATESv2

Version 2.0

Update focused on vegetation and efficient raster processing from Larsen et al., 2020. Uses ATES v1.0 class definitions. Uses crown coverage derived from satellite imagery to account for vegetation.

esri python R

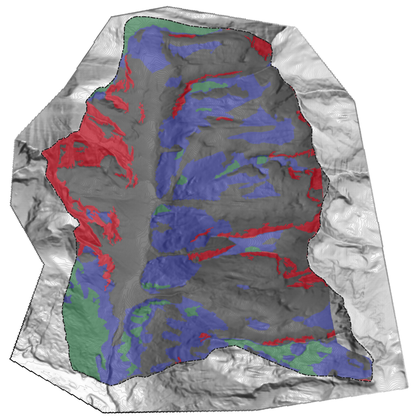


Auto ATESv3

Version 3.0

Updated with ATES v2.0 class definitions. Model parameters tuned by comparing to Avalanche Canada manual ATES maps. Model script converted to use open source software.

~~esri~~ → python R

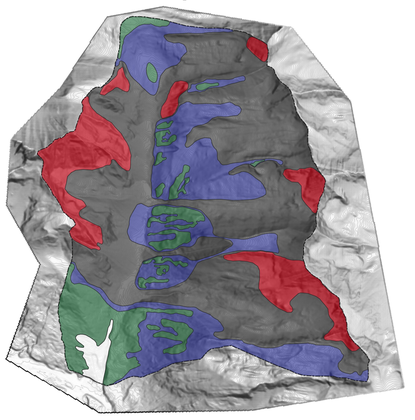


Auto ATESv4

Version 4.0

TauDEM replaced with FlowPy for avalanche runout. FlowPy cell count layer is added to better account for overhead exposure. Vegetation represented in PRA model (Sharp et al, 2018). Parameters tuned with ATES v2.0 manual map from Connaught Creek.

python R



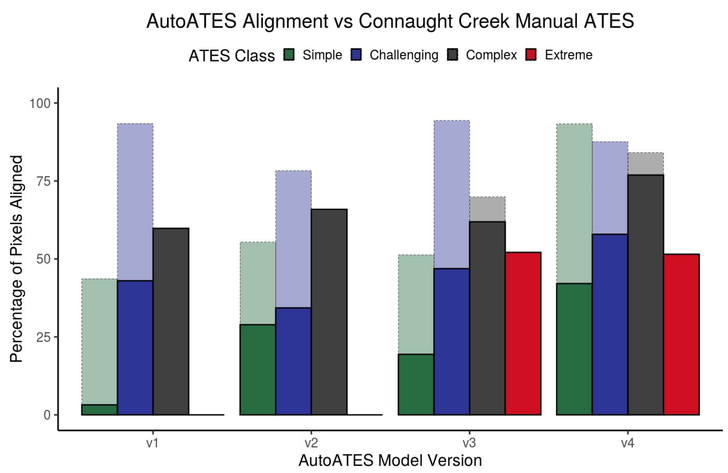
Manual Map ATES v2.0

Manual Mapping - ATES v2.0

Produced by combining individual maps from Statham, Campbell, and Bender. Additional input from Avalanche Canada / Parks Canada staff. Uses ATES v2.0 class definitions. Methods include GIS/Imagery, local expertise, and field surveys.

VALIDATION:

There is no true validation dataset for AutoATES due to differences in scale between automated and manual methods.The plot to the right compares the alignment of each version of the AutoATES model with the Connaught Creek manual map. For each ATES class the darker bar sections show the percentage of exact alignment, while the lighter stacked bars show where the automated map was one class higher than the manual map. This indicates a conservative estimate which is in line with the intended performance of AutoATES. The overall trend is improved agreement between automated and manual methods with each AutoATES iteration.



FUTURE STEPS:

Ongoing work will continue to develop the model so that it is independent of any geospatial software, and will run solely using Python. We will also continue to expand our validation regions, and provide robust assessment of model performance compared to manual mapping. Ultimately, we hope that this automated ATES v2 will allow for large scale, and even possibly global ATES mapping in an efficient and standardized way.

[1] Norwegian Water Resources and Energy Directorate, Oslo, Norway
[2] SFU Avalanche Research Program, Department of Geography, Simon Fraser University, Canada
[3] Snow and Avalanche Lab, Department of Earth Sciences, Montana State University, Bozeman, MT, USA
[4] West Central Montana Avalanche Center, Missoula, MT, USA
[5] Parks Canada Agency, Banff, AB, Canada
[6] Avalanche Canada, Revelstoke BC, Canada
[7] Austrian Research Centre for Forests (BFW) Department of Natural Hazards Division of Snow and Avalanches, Innsbruck, Austria

References: **Campbell C, Gould B., 2013.** A proposed practical model for zoning with the Avalanche Terrain Exposure Scale. In: International Snow Science Workshop Proceedings, Grenoble—Chamonix Mont-Blanc. Pp 385–391; **Larsen, H.T., Hendrikx, J., Slåtten, M.S., and Engeset, R.V., 2020**. Developing nationwide avalanche terrain maps for Norway. Natural Hazards. https://doi.org/10.1007/s11069-020-04104-7. **Tarboton D.G. 2005.** Terrain analysis using digital elevation models (TauDEM); **Statham G, McMahon B, Tomm I., 2006**. The avalanche terrain exposure scale. Int Snow Sci Work Proceedings, Telluride, 491–497; **Veitinger, J., Purves, R. S., & Sovilla, B., 2016.** Potential slab avalanche release area identification from estimated winter terrain: a multi-scale, fuzzy logic approach. Natural Hazards and Earth System Sciences, 16(10), 2211. **Neuhauser. M., D'Amboise, C., Teich, M. and Fischer, JT., 2020.** Flow-Py: Identifying protection forests and their effects on gravitational natural hazard processes on a regional scale. EGU General Assembly 2020. **Sharp, E., Haegeli, P., Welch, M., 2018.** Patterns in the exposure of ski guides to avalanche terrain, in: Proceedings International Snow Science Workshop. Innsbruck, Austria.