Projections of erosion for a temperate watershed on a 10,000 year timescale

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Landscape Evolution Models (LEMs) compute the evolution of the topography through time. One application of LEMs that bridges geologic, critical zone, and human timescales is the assessment of potential erosion and release of contaminants into the environment. We present a multi-model projection-under-uncertainty case study in a post-glacial landscape in which a nuclear-fuel reprocessing facility left a legacy of buried radioactive waste.

A set of 37 candidate models was calibrated using a well constrained time period (13 ka-present) and validated over the same time period in a second watershed. The set of candidate models was designed to systematically add model structure complexity in (a) hillslope processes, (b) channel incision processes, (c) representation of hydrology, and (b) geological materials. Using the nine most successful calibrated models, we make projections from the present to 10,000 years in the future. A fully balanced numerical experiment partitions prediction uncertainty into components associated with model selection and calibration, downstream river incision, future climate scenarios, and human modification to the site surface.

The calibration results indicate that representing geological materials as two distinct lithologies instead of one uniform lithology improves model performance most substantially. Additionally, we find that a simple representation of weathering and soil-depth-dependent erosion is insufficient. Prediction uncertainty partitioning identifies that model error is a significant part of the overall uncertainty.