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Dynamic sensitivity analysis of long running landslide models through basis set expansion and meta-modelling

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Predicting the temporal evolution of landslides is typically supported by numerical modelling. Dynamic sensitivity analysis aims at assessing the influence of the landslide properties on the time-dependent predictions (e.g., time series of landslide displacements). Yet two major difficulties arise: 1. Global sensitivity analysis require running the landslide model a high number of times (> 1000), which may become impracticable when the landslide model has a high computation time cost (> several hours); 2. Landslide model outputs are not scalar, but function of time, i.e. they are n–dimensional vectors with n usually ranging from 100 to 1000. In this article, I explore the use of a basis set expansion, such as principal component analysis, to reduce the output dimensionality to a few components, each of them being interpreted as a dominant mode of variation in the overall structure of the temporal evolution. The computationally intensive calculation of the Sobol' indices for each of these components are then achieved through meta-modelling, i.e. by replacing the landslide model by a "costless-to-evaluate" approximation (e.g., a projection pursuit regression model). The methodology combining "basis set expansion – meta-model – Sobol' indices" is then applied to the La Frasse landslide to investigate the dynamic sensitivity analysis of the surface horizontal displacements to the slip surface properties during the pore pressure changes. I show how to extract information on the sensitivity of each main modes of temporal behaviour using a limited number (a few tens) of long running simulations. In particular, I identify the parameters, which trigger the occurrence of a turning point marking a shift between a regime of low values of landslide displacements and one of high values.