A MODEL PERFORMANCE MEASURE FOR VALIDATION OF GEOPHYSICAL MASS FLOW SIMULATION

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BIOGRAPHY

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INTRODUCTION

The Geophysical Mass Flow group at the University at Buffalo is developing a computer model of the physical phenomena, integrated with visualization at different levels of fidelity and communications tools for various users, from public safety planners to scientists (Patra et al. 2005). The geophysical mass flows are particularly hazardous in volcanic environments where a series of mass flows ranging from gas emissions and slow effusions of lava to explosions create a mix of ash, water, and rock, that the seismic activity at a volcano can trigger slope failures to generate debris avalanches that have the potential to destroy land, structures, and kill people.

A model performance has to be summarized in a global measure for validation of the model and to compare with other models. In an ideal situation, results from a simulation using the models are directly compared to data from a real event that is being simulated, and the global measure can be obtained, for example, comparing differences to calculate the root mean square of the squared differences. In some other models, the comparison can be executed on one location only, such as in simulating sediment yield in catchment, and the performance can be measured by the difference between the simulation result value at that location and the model output.

Geophysical mass flows, such as debris flows, volcanic avalanches, landslides, presents particular challenges for validation. In the simulation of these types of flows, the interest is on the extent and duration of an event. Other challenges relate to the poor quality of data collected from the real world event to be used in the comparison. In most cases there is no quantified data with most of the values being estimated from indirect measurements, such as scars on the terrain created by the flow. Due to these difficulties, the performance measure of the simulation of geophysical flow models is rudimentary, based only on subjective visual analysis (Itoh et al. 2000; Crisci et al. 2004).

PROPOSED METHOD

In this study, a method of performance measure for geophysical mass flows has been proposed, providing a global quantitative measure, contrasting existing approaches for these types of phenomena where only qualitative analysis is made for performance assessment. From the acknowledgement that data from the real event is weak, logistic regression analysis, using the real event flow footprint, distances derived from the footprint, and a summary of the model simulation results, was selected to provide the performance measure.

The proposed performance measurement procedure is divided in three phases: creation of a summary of simulation results; definition of a map with distances to the real event footprint; and the quantitative analysis using statistics and spatial database approach.

The flow numerical simulation generates files that are appropriate for dynamic, interactive visualization, with every output file corresponding to the state of the flow at the selected instant, therefore it contains a snapshot of the flow at a particular time. For the performance measurement, a summary needs to be used, allowing comparison with field data related to the flow path. The summary consists of maximum flow height at every location inside the study region for all outputs of the simulation.

The footprint of a real event is obtained from maps generated by fieldwork and it is used to create distances in relation to the flow footprint. The fieldwork map is scanned and imported into GIS, where it is georeferenced and converted vector representation. Delaunay triangulation is used to generate the medial axis line of the flow polygon. Maps of distances are generated from the flow footprint medial axis and the footprint boundaries.

Statistical analysis of the available data from the numerical simulation and the field work data using correlation provides the quantitative measure of performance. Analysis of correlation is on aggregated units, each with averaged distance and simulation output flow value.

Correlation is searched using a logistic regression model with the dependent variable being the probability of being inside the real event flow footprint and the independent variables being the flow height in the model simulation and a measure of distance based on the real event. The performance measure is given by the slope the logistic regression.

The test of the methodology using two simulation results created from the real event flow footprint to represent the best results, and two simulation outputs from the numerical simulation proved that the proposed method provides quantitative performance measures that are coherent with visual analysis.

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