Avalanche Forecasting with GIS

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Key words : Local Avalanche Forecasting, Geographic Information System

INTRODUCTION

Avalanches depend on snowpack stability as well as terrain conditions. Thus, these two kinds of information are required to perform punctual predictions. However, if the site is very large, including many gullies and slopes, it may be difficult to define the starting zone. Therefore, a detailed topographic analysis of the site is useful. This analysis can be done by a Geographic Information System (GIS).

This paper presents an *idea* : using a GIS to determine and describe the starting zone(s) of a large avalanche site in order to provide computed inputs to a local avalanche forecasting model.

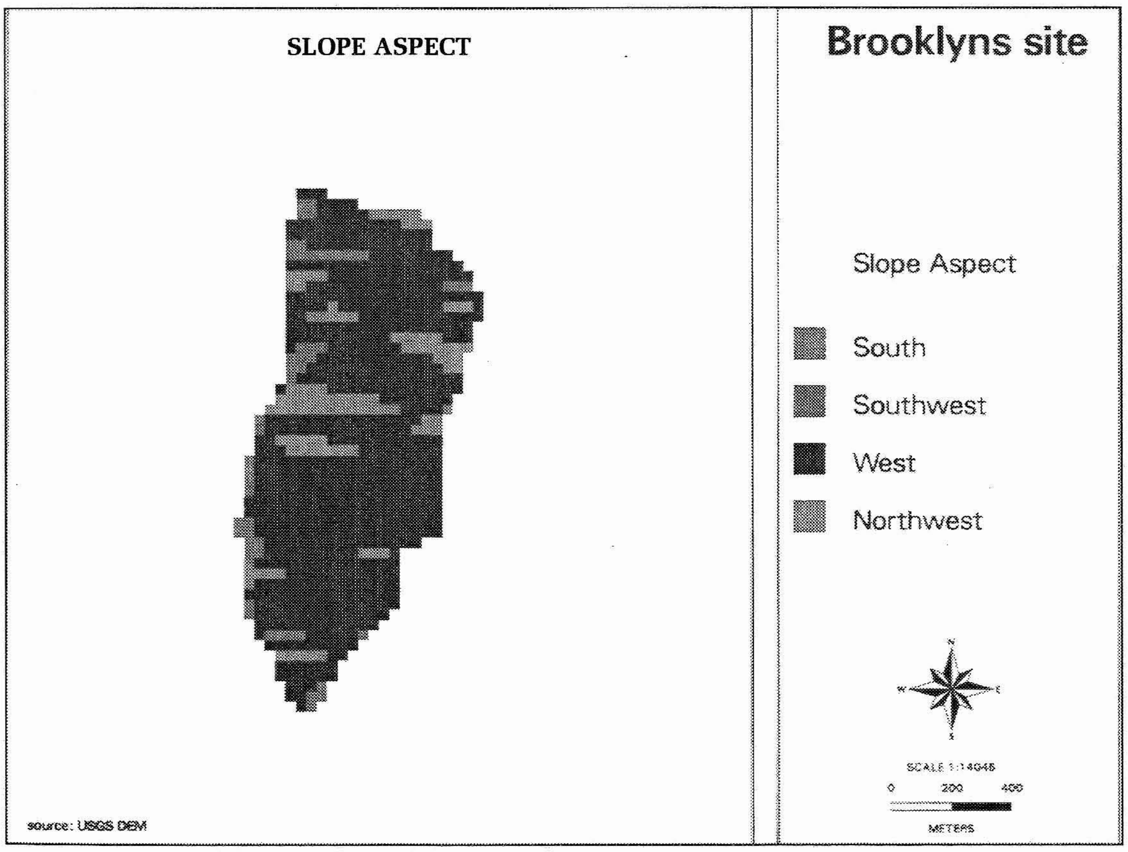
This model is the NxLog system, which was designed at the Swiss Federal Institute for Snow and Avalanche Research (Bolognesi, 1994). NxLog is an expert system running symbolic calculations as well as nearest neighbor procedure. The aim of this system is to provide every day the probability of avalanche occurrence for each starting zone of a defined area (a ski resort for example). Is it possible and profitable to make the GIS and NxLog work together ? This is the question we want to answer.

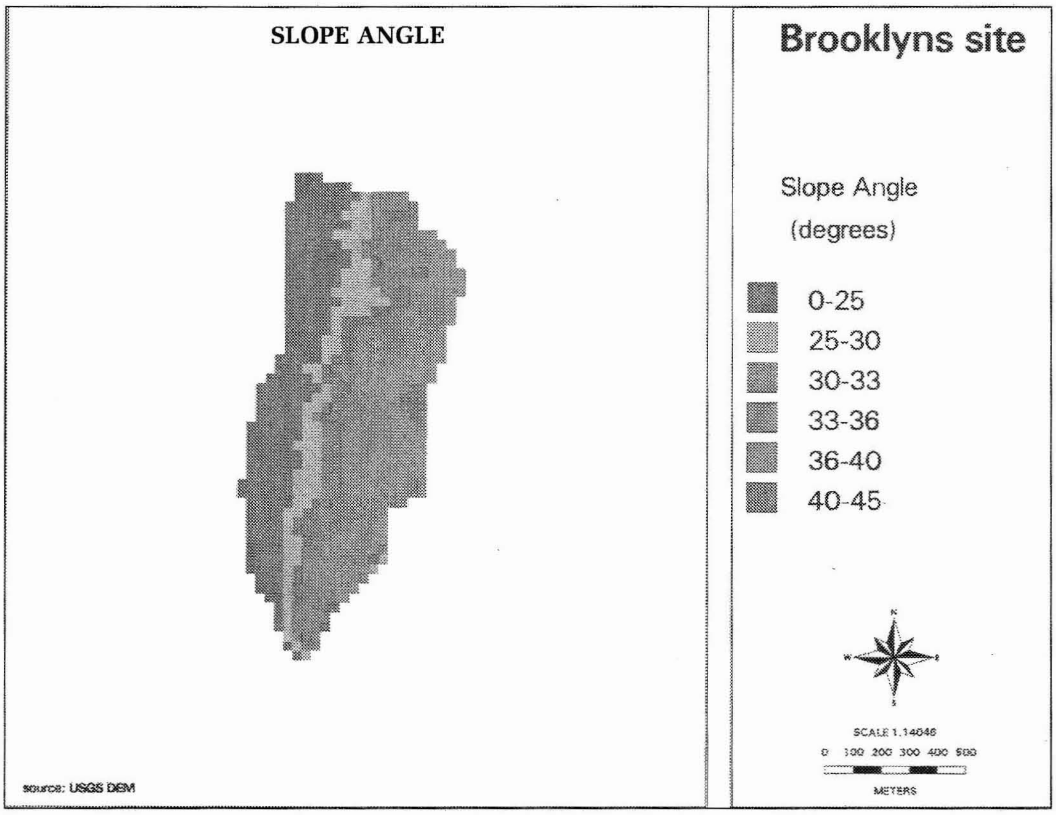
1. GIS IMPLEMENTATION

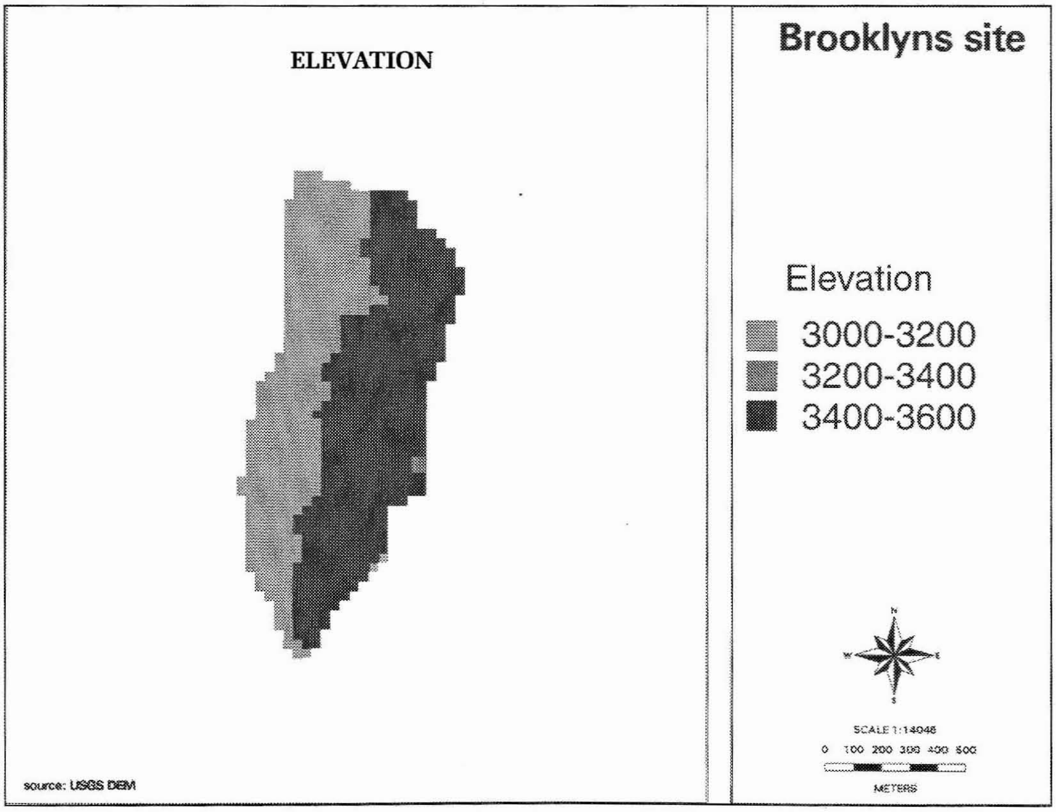
The source of information used for the topographic analysis of the avalanche sites is the Digital Elevation Model (DEM). Such DEMs are useful for any terrain analysis or representation. The data included in the DEMs is elevation, and geographical coordinates. Using a GIS software, this data can be derived into slope angle and slope aspect. With slope aspect, slope angle, and elevation, a topographic representation and analysis of any avalanche site can be done in greater precision. The minimum size unit of terrain of such data is 30x30 meters cell which is the standard format of a DEM in the USA. The GIS software used to derive the data in slope aspect, slope angel, and elevation is the GRID module of ArcInfo™. The GIS implementation can be divided into two steps.

The first step is to create the three layers (slope aspect, slope angle, and elevation) from the DEMs. After creating those layers with GRID, we divide each layer into intervals of critical importance for avalanche release. These intervals was chosen according to experts' opinion (K.Birkeland, R.Bolognesi, L.Dexter, A.Gleason, D.Hogan).

The slope aspect layer is broken down into 8 intervals of 45 degrees each representing North, North East, East, South East, South, South West, West, North West. The slope angle layer is divided into 9 intervals. The eleva-




SLOPE ANGLE
Brooklyns site
Slope Angle
(degrees)
0-25
25-30
30-33
33-36
36-40
40-45
N
W
E
S
SCALE 1:14046
0 100 200 300 400 500
METERS
source: USGS DEM


ELEVATION
Brooklyns site
Elevation
3000-3200
3200-3400
3400-3600
N
W
E
S
SCALE 1:14046
0 100 200 300 400 500
METERS
source: USGS DEM

tion is broken down into 11 equal intervals of 200 meters from 2000 meters to 4000 meters. The total possibilities of such different panels are 8x9x11 equaling to 792. This means that this classification of the layers permits the evaluation of 792 possible panels within an avalanche site.

The second step consist in overlaying the chosen avalanche sites boundaries on top of each layer of information determined previously (slope aspect, slope angle, and elevation). This first set of overlays allows to eliminate any information not falling into the perimeters of the chosen avalanche sites. The second set of overlays consist in overlaying each layers of information within the avalanche sites on top of each other. This final operation will give the output necessary to analyze each avalanche area and represent it with details by dividing each slope into panels of similar topographic characteristics.

The final output is separated into two purposes. The first purpose uses the final overlay which permits the breakdown of the avalanche site into panels of similar characteristics. NxLog will then consider each panel as an individual starting zone and will assess a forecast given the topographic information for each panel within the site. Such prediction will help the forecaster by locating a potential danger zone within a site. The second purpose of the final output is the topographic representation of the avalanche site and of the forecast. A topographic representation of each avalanche site can assist any forecaster to visualize the area in greater details while evaluating a potential danger. Control work can also benefit the visual representation of the site and of the potential danger on the field.

2. STUDY SITE AND EVALUATION

The study will be achieved during the 1996-97 winter in the San Juan Mountain Range, in Colorado. The two particular avalanche sites picked for the study are located between Silverton and Red Mountain Pass on Highway 550. Both sites present a danger to the traffic of Highway 550 during the winter due to high avalanche activity.

The evaluation will consist in relating the forecast of the model to the actual occurrence of the avalanches within those two chosen sites. Natural and artificial releases will be recorded and checked with the models forecast. The area of release will be cross checked with location of the potential forecast emulated from the model. A percentage of accuracy will be evaluated from the amount of actual starting zones of real events matching the panels forecasted dangerous by the model.

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