Application of a GIS-aided method for the assessment of volcaniclastic soil sliding susceptibility to sample areas of Campania (Southern Italy)

Sebastiano Perriello Zampelli · Eliana Bellucci Sessa · Marco Cavallaro

Abstract A significant part of Campania is extensively covered by volcaniclastic soils, deriving from the alteration of airfall-sedimented formations of layered ashes and pumices that were ejected by Campi Flegrei and Mt. Somma–Vesuvius during explosive eruptions. Where such soils cover steep slopes cut in carbonate bedrock, landforms depend essentially on the morpho-evolution of such slopes prior to the deposition of the volcaniclastic soils, because these are generally present only as thin veneers, up to a few meters of total thickness. Historical records and local literature testify that, in this part of Campania, landslides that originate on carbonate slopes covered by such soils and terminate at their foot or at gully outlets are frequent, following critical rainfall events. Such landslides can be classified as *complex*, occurring initially as debris slides, but rapidly evolving into debris avalanches and/or debris flows. The localization of the initial sliding areas (i.e. "sources") on the slopes depends on both the spatial distribution of characters of the soil cover and the spatial distribution of the triggering rainfall events. It therefore appears reasonable to separate the two aspects of the problem and focus on the former one, in order to attempt an assessment of soil sliding susceptibility in the event of landslide-triggering rainfall. In this paper, some results of the application of a method aimed at such an assessment are presented. The method, called SLIDE (from SLiding Initiation areas DEtection), is based on the concept that, for a spatially homogeneous soil cover and a spatially homogeneous landslide-triggering rainfall sequence, different values of threshold slope gradient for limit equilibrium conditions exist, depending on morphological characters of the soil cover, such as its continuity and planform curvature. The method is based on the assessment of (1) soil cover presence, (2) discontinuities within soil cover, (3) slope gradients and curvature, by means of good resolution DEMs. It has been applied to sample

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carbonate slopes of Campania, where landslides originated either repeatedly or recently. Results are encouraging, and a soil sliding susceptibility map of a large area, based on a simplified version of method, is also presented.

Keywords Debris-slide susceptibility · Volcaniclastic soil cover · Soil cover discontinuities · Planform curvature

Abbreviations

A_{I} Study area with slope angle $\geq 30°$
A_{unst} Landslide area with slope angle $\geq 30°$
A_{st} Area with slope angle $\geq 30°$ *not* including landslide areas
A_{c} Area considered as susceptible to sliding
$A_{\mathrm{c}}^{\mathrm{in}}$ Area considered as susceptible to sliding *intersecting* landslide area
$A_{\mathrm{c}}^{\mathrm{out}}$ Area considered as susceptible to sliding *outside* landslide area
I_{s} $\sum A_{\mathrm{c}}^{\mathrm{in}}/A_{\mathrm{unst}} \times 100$
I_{e} $\sum A_{\mathrm{c}}^{\mathrm{out}}/A_{\mathrm{st}} \times 100$

1 Introduction

Landslides that can be classified, according to Cruden and Varnes (1996), Hungr et al. (2001), and Jakob and Hungr (2005), as complex, debris slides—debris avalanches—debris flows are frequent in a large part of Campania (Southern Italy, Fig. 1), following intense and/or persistent rainfall (see, among others: Del Prete et al. 1998; Calcaterra et al. 2000;
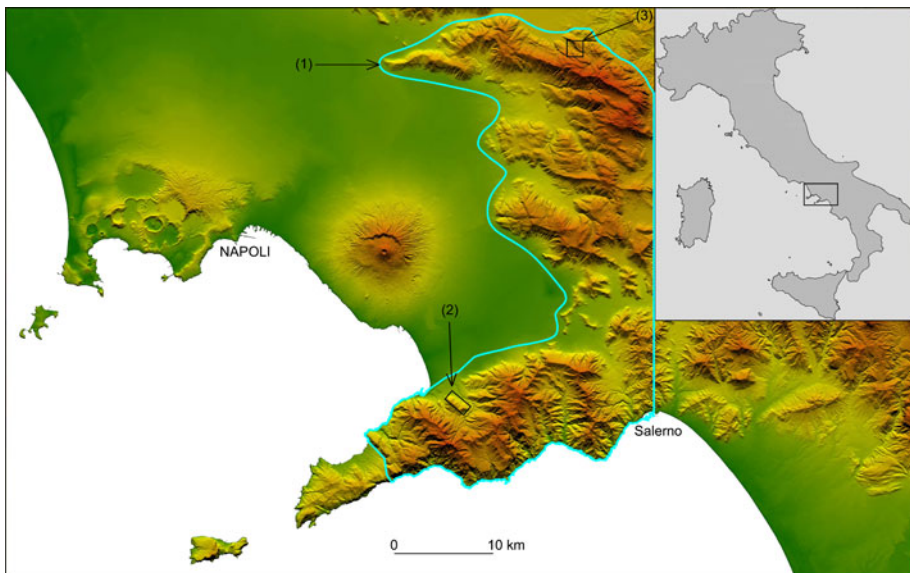

Fig. 1 Overview of the studied area. Key: *1* perimeter of the study area (see also Fig. 4); *2* Gragnano—M. Pendolo northern slope (see also Fig. 2); *3* Cervinara Dec. 1999 landslides area (see also Fig. 3)

Guadagno and Perriello Zampelli 2000; Fiorillo et al. 2001; Di Crescenzo and Santo 2005; Guadagno et al. 2005).

While debris slides cause a relatively small risk at the source locations (the sites of initial sliding failure), the consequent debris avalanches (Hungr et al. 2001; Fiorillo et al. 2001; Guadagno et al. 2005) and/or debris flows that can evolve from them constitute a serious threat to people and structures along their paths, especially where they become channelled (Di Crescenzo and Santo 2005) and travel long distances, after becoming more fluid and bulking due to the incorporation of water and any transportable material in the channels. The consequences of such landslides in the foothill zones have too often been catastrophic: In addition, during the last decades, the associated risk has been growing, due primarily to increased, often uncontrolled urbanization.

The landslides originate on steep slopes, within usually unsaturated soils constituted by thin layers of variously altered volcaniclastic ashes and pumices, herein referred to as volcaniclastic soils (see, among others: Scandone et al. 1993; Rolandi et al. 1998; Cioni et al. 1999; Basile et al. 2003; De Vita et al. 2006), when rainfall causes infiltration, increase in pore pressure, and consequent decrease in shear strength due to lowering of its suction-related apparent cohesion term (Olivares and Picarelli 2003; Bilotta et al. 2005; Damiano and Olivares 2010).

The localization of the initial sliding areas (i.e. "sources") on the slopes depends on both the spatial distribution of characters of the soil cover and the spatial distribution of the triggering rainfall events. Regarding the latter, antecedent rainfall over a time span ranging between several days and several weeks together with the cumulated 24–48 h rainfall before a given landslide(s) event appears as the key factor controlling the possibility of occurrence of slides (see, among others: Guadagno 1991; Guadagno and Perriello Zampelli 2000; Fiorillo and Wilson 2004; Pagano et al. 2010). In addition, recent research (Mazzarella and De Luise 2007) and weather radar data (Casagli N, personal communication) showed that critical, landslide-triggering rainfall sequences can indeed be concentrated over very limited areas, as in the case of the April 2006 Ischia (Campania) landslides. Monitoring (with adequate spatial resolution) and, perspectively, forecasting rainfall sequences with respect to their landslide-triggering capability represents a difficult problem that, in Campania, still has to be addressed systematically.

It appears reasonable to separate the two aspects of the spatial occurrence problem, focusing on the spatial variability of some characters of the soil cover. This in order to attempt an assessment of the sliding susceptibility (Soeters and Van Westen 1996; Dai et al. 2002) of volcaniclastic soil-covered slopes in the event of landslide-triggering rainfalls.

Such an assessment could provide, together with estimates of the consequent potential debris avalanche/flow paths and run-out (see, among others: Revellino et al. 2004, 2008; Iovine 2008) coupled with analyses of vulnerability and of exposed values at the foot of slopes, useful elements for the inclusion of *active*, targeted soil stabilization on the slopes within the evaluation of debris avalanche/flow hazard- and risk-reduction options.

2 Applied method

In the following, some results of the application of a GIS-aided method for the assessment of the susceptibility to sliding of volcaniclastic soil are presented.

The method, named SLIDE (from SLiding Initiation areas DEtection: Iovino and Perriello Zampelli 2007; Perriello Zampelli 2009), is intended as a practical

engineering–geological tool. It was developed as an alternative to physically-/process-based models, which are based on numerical modeling of the processes of rainfall, infiltration, unsaturated/saturated flow, pore pressure increase, and shear strength decrease in a continuous (while not necessarily homogeneous) soil cover (see, among others: Montgomery and Dietrich 1994; Dietrich and Sitar 1997; Iverson 2000; Crosta and Frattini 2003; Frattini et al. 2004; Sorbino et al. 2010). Such models, based on the infinite slope assumption, are in fact inapplicable to slope areas where the soil cover is discontinuous. To this regard, it has widely been recognized that the majority of debris slides in the interested area originated very close to interruptions of the continuity of the soil cover, such as rocky cliffs and track cuts (Guadagno 2000; Guadagno and Perriello Zampelli 2000; Crosta and Dal Negro 2003; Di Crescenzo and Santo 2005; Guadagno et al. 2005; Perriello Zampelli 2009). This implies a significant role for soil cover discontinuities in reaching limit equilibrium conditions, which has been explained, among others, by Basile et al. (2003), Crosta and Dal Negro (2003), Guadagno et al. (2003), Dutton et al. (2005), Mele et al. (2007) and Cascini et al. (2008a), notwithstanding the different methods employed.

Another spatial factor controlling soil cover stability is planform curvature (Zevenbergen and Thorne 1987) which, where concave upwards (i.e. in "hollows"; Reneau and Dietrich 1987), controls surface and subsurface flow convergence. Several investigations (see, among others: Fernandes et al. 1994; Montgomery et al. 1997) have shown that, following rain storms, pore water pressure increases more rapidly in hollows. Indirectly, the SHALSTAB model (Montgomery and Dietrich 1994) can also be considered as a method for measuring planform curvature in soil-covered hillslopes subjected to steady-state subsurface flow.

The SLIDE method is based on simple engineering–geomorphological considerations. Such considerations, assuming spatially homogeneous triggering rainfall and soil cover, are as follows:

– debris slides are likely to occur on soil-covered slopes above certain slope gradient thresholds;
– threshold slope gradient is lower near discontinuities and in hollows of the soil cover (all other controlling factors considered constant), with respect to planar, continuous slopes (referable to as infinite slopes).

Therefore, the method is based on the assessment of:

– the presence of volcaniclastic soil on the slopes;
– the presence of discontinuities in the soil cover;
– slope gradients and curvatures, by means of good resolution Digital Terrain Models.

According to the rev. 2 SLIDE method (Perriello Zampelli 2009), a carbonate slope area is considered susceptible to shallow landsliding, in case of slide triggering-capable rainfall sequences, where it:

1. is covered by volcaniclastic soils AND has a slope angle $\geq$ 45°;
2. is covered by volcaniclastic soils AND is within 10 m of either bedrock outcrops or centerline of roads and tracks, AND has a slope angle $\geq$ 30°;
3. is covered by volcaniclastic soils AND has a slope angle $\geq$ 35°, AND has a ground planform upwards concavity $\geq$ 0,1.

Differentiation of volcaniclastic soils in terms of thickness and behavior is consciously neglected, as (1) thickness of such soils at slope angles $\geq$ 30°, where most debris slides

originated in the past, is generally modest (De Vita et al. 2006; Cascini et al. 2008b; Andriola et al. 2009) and (2) detailed thickness, layering, geotechnical and hydraulic characterizations generally become available only at those specific sites where landslides have already occurred. The assumption underlying the SLIDE method resides in the fact that, given the presence of volcaniclastic soils on steep slopes, their continuity and surface morphology (in particular, planform upwards concavity) are the most important factors controlling rainfall-induced soil cover instability. Should thickness and layering (as well as geotechnical and hydraulic characterization) data show meaningful correlation with the localization of past slides' sources and become widely available, they could be implemented in the SLIDE method, too.

In Perriello Zampelli (2009) the SLIDE rev. 2 method, when back applied against the same 145 Pizzo d'Alvano May 1998 landslides' source areas whose analysis allowed for its formulation and parametrization, provided interesting results, with good resolution. Areas that were considered as susceptible to sliding by the method encompassed about 94% of the actual source areas, with the slope–planform concavity condition (n. 3, above) areas encompassing about 71% of them. The method overestimated the areas where debris slides actually originated on May 1998, but areas considered as susceptible to sliding covered not more than 25% of the area's slopes at angles $\geq 25°$.

Herein, further results concerning the validation of the method in other similar areas of Campania, which have both been affected and are likely to be affected in the future by landslides of the studied type, are presented.

3 Results: application of the method to sample areas

3.1 Gragnano—M. Pendolo

M. Pendolo (cf. 2 in Fig. 1), above the town of Gragnano, is a small, NW–SE-elongated carbonate monocline ridge, dipping about 10–20° to SW and reaching 616 m a.s.l. Its slopes are covered by volcaniclastic soils that derive primarily from products of the historical AD 79 Vesuvius plinian eruption (Scandone et al. 1993; Cioni et al. 1999). Many rainfall-triggered, disastrous debris slides—debris avalanches—debris flows have occurred in the past, mainly on the northern slope, and an inventory of such landslides in historical times is available (Mele and Del Prete 1999; Di Crescenzo et al. 2008).

The SLIDE rev. 2 method has been applied to this area, based on photointerpretation and direct surveying. A 5 × 5 m DEM model of the area was interpolated (ESRI ArcGis Topo to Raster tool), based on the Campania Region 1:5.000 3D digital topographic maps. The landslide perimeters resulting from the historical inventory were then modified so as to comprehend only landslide areas with a slope angle of at least 30°, in order to eliminate debris avalanche and flow accumulation zones.

The corresponding results are shown in Table 1, Fig. 2 and Table 2. Table 1 reports the number of landslide source areas falling within each one of the three SLIDE susceptibility categories, as well as within the Boolean union of the three categories. About 74% of the 23 source areas fall within at least one of the three categories. As noted above, such percentage is probably biased by the inventory's approximation of the source areas.

Figure 2a shows the qualitative agreement between the SLIDE method susceptibility and the modified historical inventory. In Fig. 2b, a further susceptibility category is introduced, consisting of areas falling within the Boolean intersection of two out of three of the rev. 2 method original categories. It could be stated that such areas, satisfying not

Table 1 Gragnano—M. Pendolo northern slope (cf. 2 in Fig. 1): modified historical landslides source areas falling within SLIDE method susceptible areas

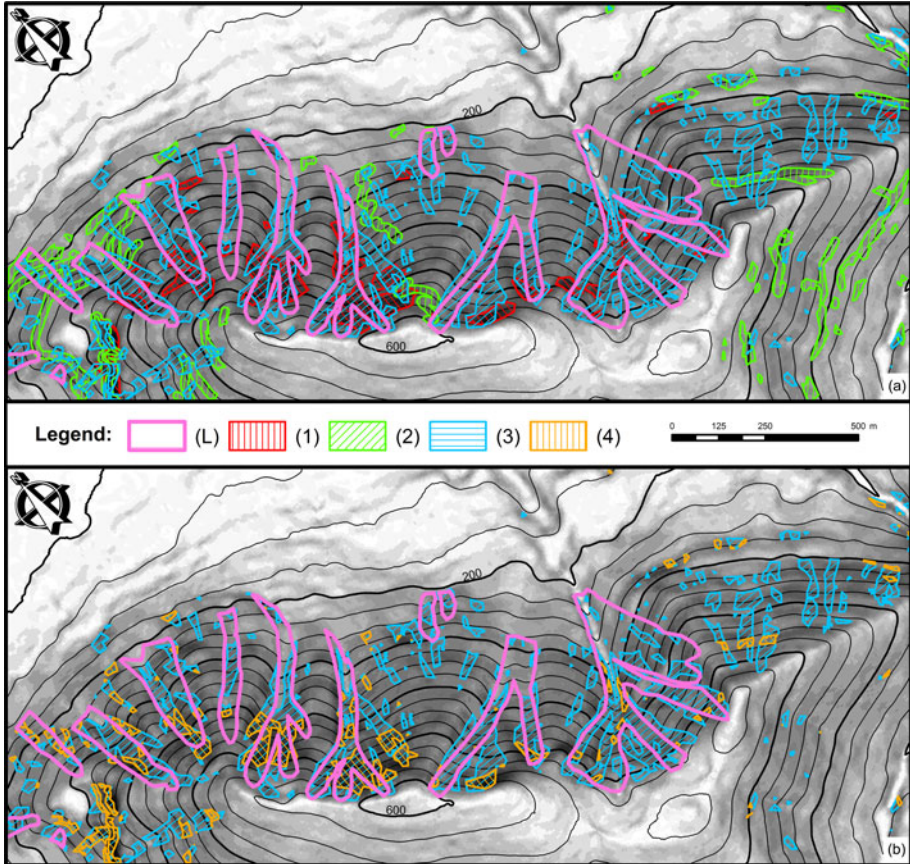| Sector	Source areas	# of source areas falling in cat. 1	%	# of source areas falling in cat. 2	%	# of source areas falling in cat. 3	%	# of source areas not falling in any category	%
Gragnano— M. Pendolo	23	3	13	2	9	12	52	6	26

Fig. 2 Gragnano—M. Pendolo northern slope (cf. 2 in Fig. 1): modified historical landslides as compared to SLIDE method susceptible areas. Key: *L* historical landslides with slope angle $\geq 30°$; *1* category 1 of susceptibility: areas covered by volcaniclastic soils having slope angles $\geq 45°$; *2* category 2 of susceptibility: areas within 10 m of bedrock outcrops or of the centerline of roads and tracks, covered by volcaniclastic soils, and having slope angles $\geq 30°$; *3* category 3 of susceptibility: areas covered by volcaniclastic soils having slope angles $\geq 35°$, and ground planform concavity $\geq 0,1$; *4* areas falling in two out of three of the above categories

only one, but any two conditions for sliding susceptibility in case of critical rainfall, are indeed *more* susceptible to sliding than areas where only one condition is satisfied. This topic is currently under development.

	Area (m^2)	I_s (%)	I_e (%)
Table 2 Gragnano—M. Pendolo northern slope (cf. 2 in Fig. 1): modified historical landslides as compared to SLIDE method susceptible areas			
$\sum A_I$	1,194,179		
$\sum A_{unst}$	262,727		
$\sum A_{c1}$ (SLIDE cat. 1)	777,367	12.1	4.8
$\sum A_{c2}$ (SLIDE cat. 2)	112,290	2.6	11.1
$\sum A_{c3}$ (SLIDE cat. 3)	287,700	48.2	17.0
$\sum A_{cu}$ (SLIDE union)	413,820	53.3	28.9

Table 2 provides quantitative comparison between the SLIDE rev. 2 method and the modified historical landslide inventory. Success Index I_s (ratio between summation of areas considered as susceptible to sliding *intersecting* landslide areas and summation of landslide areas with slope angle $\geq 30°$, see: Abbreviations) and Error Index I_e (ratio between summation of areas considered as susceptible to sliding *outside* landslide areas and summation of areas with slope angle $\geq 30°$ *not* including landslide areas, see: Abbreviations), derived from those used by Sorbino et al. (2010), are reported: while the former is just above 50%, the latter is significantly lower (< 30%), showing a reasonable tendency to overestimation of the method, to be however evaluated also with respect to the possibility of *future* landslides.

To this regard, assuming effectiveness of the SLIDE method, Fig. 2 provides useful considerations about possible *residual* sliding susceptibility on the slope, as there are areas considered as susceptible that do not appear as having been interested by sliding in the past and could, therefore, reasonably be considered as still susceptible to sliding.

3.2 Cervinara area

The SLIDE rev. 2 method was also applied to the carbonate slopes of the Cervinara area (cf. 3 in Fig. 1; details in Fiorillo et al. 2001) where, during the night between December 15 and 16, 1999, several debris slides, triggered by intense rainfall, rapidly evolved into avalanches and flows, with the largest of them (ML in Fig. 3) causing six victims.

The method has been applied to this area using the same workflow as in the previous example, with modification of the original landslide perimeters resulting from Fiorillo et al. (2001), in order to eliminate debris avalanche and flow accumulation zones.

The corresponding results are shown in Fig. 3 and Table 3. While statistics (such as those reported in Table 1) were not performed due to the limited number of the December 1999 landslides, it resulted that very few of them had their source areas outside of areas considered as susceptible by the method.

Figure 3a shows the qualitative agreement between the SLIDE method susceptibility and the December 1999 landslides. In Fig. 3b, a further susceptibility category is shown, consisting of the areas falling within the intersection of two out of the three rev. 2 method original categories. While the topic, as mentioned earlier, is still under development, such areas, satisfying not only one, but two conditions for sliding susceptibility in case of critical rainfall, could be considered as *more* susceptible to sliding than areas where only one condition is satisfied. To this regard, it is interesting to analyze the source area of the main December 1999 landslide (ML in Fig. 3). The observation by Fiorillo et al. (2001), regarding worsening of the stability of volcaniclastic soil cover due to construction of slope
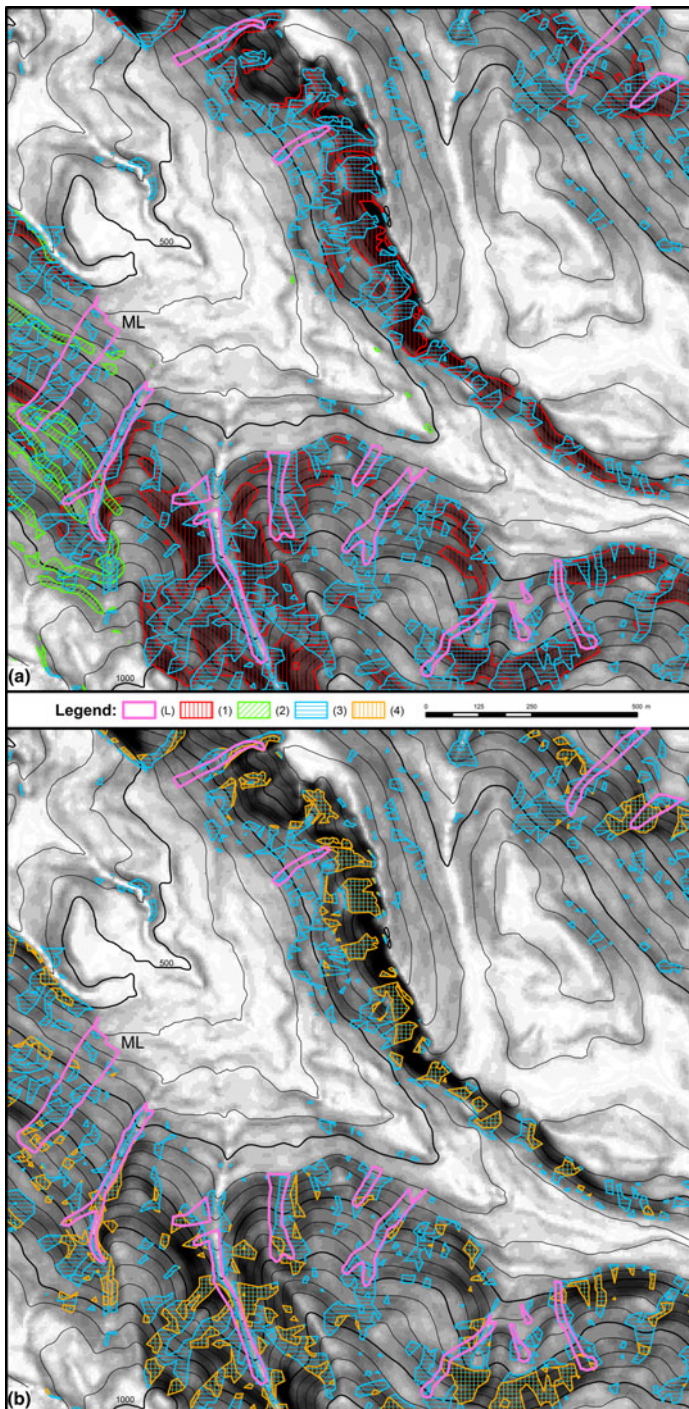
Fig. 3 Cervinara area (cf. 3 in Fig. 1): modified December 1999 landslides as compared to SLIDE method susceptible areas. Key: *L* December 1999 landslides with slope angle $\geq 30°$; *1–4*: cf. Fig. 2

	Area (m^2)	I_s (%)	I_e (%)
$\sum A_I$	1,344,636		
$\sum A_{unst}$	89,008		
$\sum A_{c1}$ (SLIDE cat. 1)	277,176	10.6	21.2
$\sum A_{c2}$ (SLIDE cat. 2)	42,847	5.4	3.0
$\sum A_{c3}$ (SLIDE cat. 3)	366,004	44.0	25.9
$\sum A_{cu}$ (SLIDE union)	564,350	50.1	41.2

Table 3 Cervinara area (cf. 3 in Fig. 1): modified December 1999 landslides as compared to SLIDE method susceptible areas

tracks in recent decades, can be articulated further: Construction of such tracks appears particularly inappropriate where both slope angles exceed 30° AND planform hollows are present.

Table 3 provides quantitative comparison between the SLIDE rev. 2 method and the December 1999 modified landslide inventory. The Success Index I_s is 50%, while the Error Index I_e latter is about 40%, showing also here the tendency to overestimation of the method, to be however evaluated with respect to both a limited (and related to a single triggering rainfall event) landslide inventory, as well as to the possibility of *future* landslides.

3.3 Application to a large area of a simplified version of the method

Assuming effectiveness of the SLIDE method, a sliding susceptibility map of a 780 km^2 area (cf. 1 in Fig. 1), where volcaniclastic soils cover carbonate slopes, is presented here. The area encompasses most of that affected in the past (Cascini et al. 2008b; Bisson et al. 2010; Sorbino et al. 2010) by complex landslides originating as slides within volcaniclastic soils and is very likely to be interested in the future by further ones. The map was prepared according to a simplified version of the method (Perriello Zampelli 2009), whose conditions for sliding susceptibility are the same as those of the complete one. The difference between the complete and the simplified method consists of the fact that for the simplified one, the presence of soil cover and of discontinuities within it (namely, cliffs where bedrock crops out and road/track cuts) is neither surveyed independently nor verified, but simply extracted from the relative thematic layers of the 1:5,000 Campania Region digital topographic maps. To this regard, it has to be pointed out that the available geological maps do not provide sufficiently detailed and reliable information about volcaniclastic soil cover on the slopes, because (1) the scale of such maps is generally too small and (2) thin soil covers are very often not mapped at all, because such maps traditionally favor representation of bedrock formations, also where they do not actually crop out.

Such simplified procedure, as verified in sample areas, causes overestimation of the extent of the soil cover, as well as approximation and overall underestimation of soil cover discontinuities (especially regarding slope tracks), with respect to the complete SLIDE method.

In terms of results, it can thus be observed that the simplified method (1) overestimates areas susceptible to sliding, where it considers the cropping out of soil cover instead of, actually, bedrock, but at the same time (2) underestimates areas susceptible to sliding, where it cannot consider the presence of soil cover discontinuities that actually do exist, but are not reported by the Campania Region digital topographic maps.
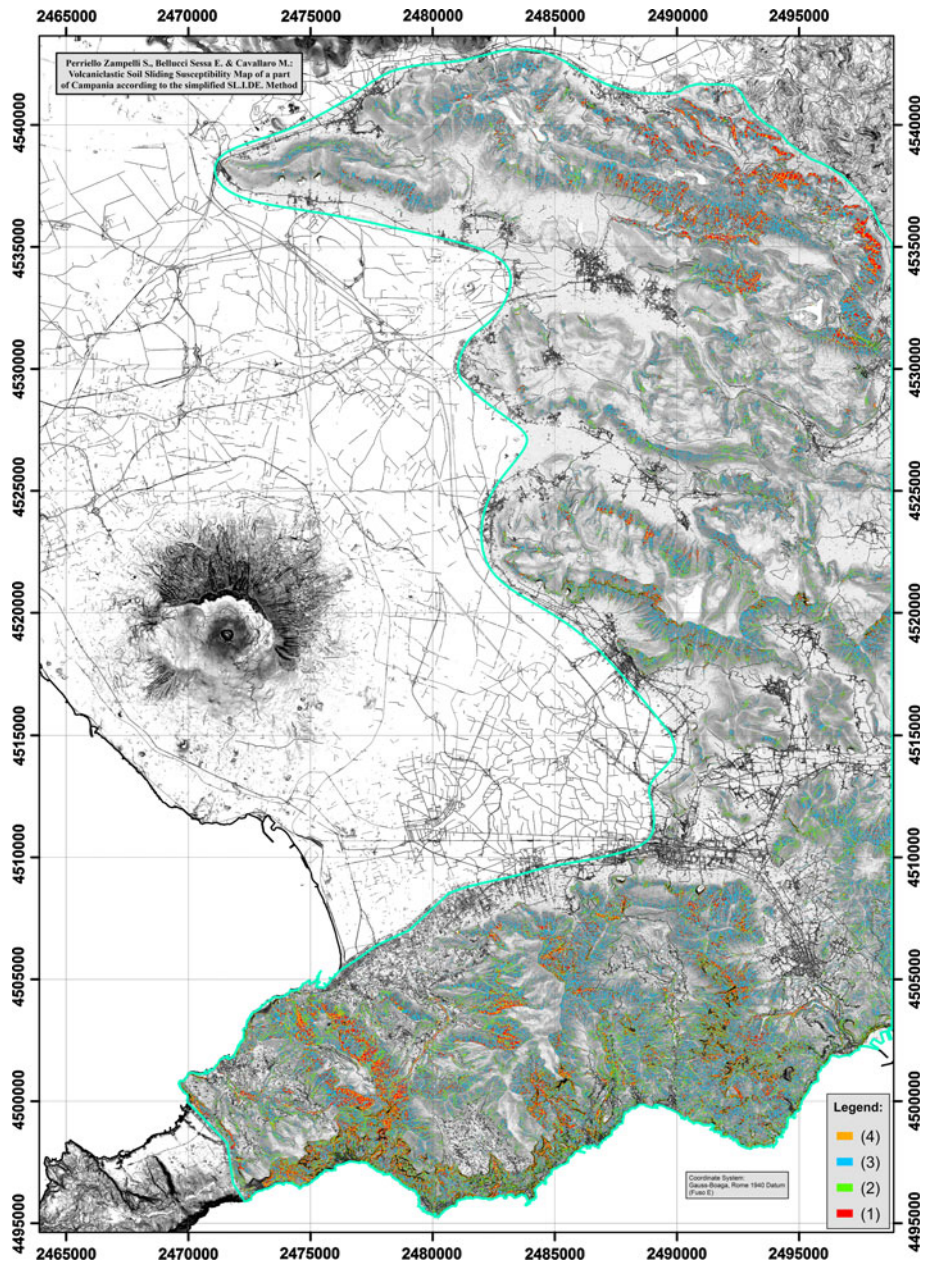
Fig. 4 Volcaniclastic soil sliding susceptibility map of a part of Campania according to the simplified SLIDE (sSLIDE) Method (link to the map as Electronic Supplementary Material). Key: *1* category 1 of susceptibility: areas covered by volcaniclastic soils having slope angles ≥ 45°; *2* category 2 of susceptibility: areas within 10 m of bedrock outcrops or of the centerline of roads and tracks, covered by volcaniclastic soils, and having slope angles ≥ 30°; *3* category 3 of susceptibility: areas covered by volcaniclastic soils having slope angles ≥ 35°, and ground planform concavity ≥ 0.1; *4* areas falling in two out of three of the above categories

Figure 4 shows a volcaniclastic soil sliding susceptibility map of the area according to the simplified SLIDE (sSLIDE) method. In the map, areas possibly displaying higher sliding susceptibility (resulting from the intersection of two out of three of the method's categories) are also outlined.

The map is entirely new with respect to those presented in Perriello Zampelli (2009), as it is based on a mosaic of overlapping higher-resolution (5 × 5 m) Digital Elevation Models that resulted from interpolation (ESRI ArcGis Topo to Raster tool) of the Campania Region 1:5,000 3D digital topographic maps.

Apart from any hardcopy scale issue, the resolution of the proposed map is the same as that of the maps of Fig. 2 (Gragnano—M. Pendolo) and Fig. 3 (Cervinara), resulting from the application of the complete SLIDE method. The accuracy is different, because the complete method relies also upon surveying of the volcaniclastic soil cover extent and of its discontinuities.

An attempt was made at comparing the proposed map with the localization of the source areas of past landslides of the studied type. The only inventory that could provide such an information over the entire area was the Italian Inventory of Landslide Phenomena (I.F.F.I.). However, it was decided not to report here any statistics based on such inventory, because it resulted that, for the studied phenomena, the localization of too large a number of source areas displayed inadequate accuracy.

The map can be compared with the "instability proneness map" of Bisson et al. (2010), which approximately covers the same area.

The map is made available in georeferenced form, in the form of Electronic Supplementary Material, in order to allow anyone interested to check its results with respect to existing inventories of source areas of debris slide—debris avalanches—debris flows within the analyzed area, but also to stimulate discussion related to the potential consequences of such landslides in the future in that area.

4 Short discussion and conclusions

The SLIDE method is based on the assumption that, in case of spatially homogeneous slide-triggering rainfall sequences and volcaniclastic soil cover, different slope gradient threshold values for sliding failure exist, depending on soil cover continuity and planform curvature. Such threshold values are considered as higher on planar slopes than on slopes with discontinuities within the soil cover, as well as on slopes that display upwards concavity in planform (hollows). The method is indeed geomorphological, but it is also essentially quantitative, as in its workflow only the delineation of soil cover existence, and of discontinuities within it, is subjective. In the simplified SLIDE method, subjectivity is even lesser, as bedrock outcrops and discontinuities on slopes are extracted from the corresponding thematic layers of the Campania Region 1:5,000 digital cartography.

Comparison between past landslides' source areas localization (although available with variable reliability) and SLIDE method susceptibility is providing encouraging results, especially regarding soil-covered sloping hollows.

Where such a localization was available with adequate accuracy and the number of nearby landslides was large, the method appeared as capable of recognizing most of the actual landslides' source areas (Pizzo d'Alvano—May 1998 landslides, in Perriello Zampelli 2009; Gragnano—M. Pendolo area, herein). At the same time, the method reasonably overestimated (Error Index $I_e < 30\%$ for Gragnano—M. Pendolo area, herein) areas considered as susceptible to sliding with respect to actual source areas. Overestimation,

however, should be considered as such only with respect to past landslides: Areas deemed as susceptible to sliding, but not interested by past landslides, should also be carefully evaluated with respect to the possibility of future landslides.

Developments of the method are being pursued, by analyzing slope areas that fall into more than one susceptibility categories. In practical terms, for instance, opening new slope tracks within volcaniclastic soils covering slope hollows at angles > 30° appears inappropriate with respect to rainfall-triggered potential local instability.

Assessment of soil sliding susceptibility, while only a subset of the related hazard and risk assessments, can certainly be considered worth investigating, as planners and communities could certainly take advantage from knowledge (and its dissemination) regarding *where* landslides can originate in case of critical rainfall. This, together with analyses of potential paths and run-out of debris avalanches/flows, could suggest including also the feasibility of slope stabilization work within evaluations of risk-reduction cost–benefit options, as techniques for the stabilization of soil covers on the slopes are indeed available.

Furthermore, the frequency and areal coverage of the duration/intensity rainfall sequences that trigger the studied landslides might well be negatively affected by global warming and its related rainfall pattern modifications, strengthening the need of such assessments.

Finally, while the SLIDE method has been developed with regard to the volcaniclastic soil covers of carbonate slopes of Campania, where the role of discontinuities is generally deemed as particularly relevant to the spatial distribution of source areas of debris slides, it is believed that it could profitably be used (with suitable adaptation and parameters' calibration) for the assessment of sliding susceptibility also in different, residual, and/or colluvial soil, rainfall-triggered shallow landsliding contexts.

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