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11

PREDICTING PREHISTORY

PREDICTIVE MODELS AND FIELD RESEARCH METHODS FOR DETECTING PREHISTORIC CONTEXTS

Giovanna Pizziolo Lucia Sarti (eds)

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SUMMARY

WORKSHOP PROGRAM

Thursday 19 September

Opening Session
Lucia Sarti - Welcome to delegates
Giovanna Pizziolo - Introduction to aims and organisation of the Workshop

Session 1: Theory and perspectives

Juan Manuel Vicent Garcia - Theoretical remarks on predictive models in Landscape Archaeology
Anita Casarotto, Giovanni Leonardi - Predictive modeling for the study of prehistoric contexts: two possible levels of applicability
Nicholas Vella - Looking at land and sea: predicting and identifying prehistoric activity in a small Mediterranean island group
Discussion

Session 2: New operational designs and applications

Stefanie Rogers - Least cost path analyses in the Pennine Alps
Hans Peter Blankholm - Fifty-nine sites in six days: Macro-Level predictive modeling of early Stone Age pioneer settlement locations in Varanger, Norway
Ezra Zubrow - Predicting the Unpredictable, Structuring the Unstructurable, Constructing the Unconstructed
Discussion

Session 3: Models and interpretations

Maurizio Cattani - Predicting Landscape: resources, sustainability and strategic planning in the Bronze Age
Philippe Curdy - Models of prehistoric settlement in the Upper Rhone Valley (Western Swiss Alps)
Raffaella Poggiani Keller - Predicting prehistory in Lombardy
Discussion

Friday 20 September

Session 4: Predictivity, field survey strategies and "good practices"

Andrea Pessina - Predictive and preventive archaeology for prehistoric contexts: a perspective from above
Martijn Van Leusen - Detecting unobtrusive pre- and protohistoric remains in the Raganello Basin: recent experiences and results from the Rural Life Project
Pierluigi Rosina - Geoarchaeological investigations applied to fluvial terraces archaeological sites in Central Portugal
Giovanna Pizziolo, Nicoletta Volante - Landscape changes and site discovery potential: predictive criteria and field survey strategies for prehistoric contexts
Discussion

Field Trip: Parco Regionale della Maremma - Alberese (Grosseto). Scoglietto and Spaccasasso Caves and Sasso delle Donne

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LEAST COST PATH ANALYSIS FOR PREDICTING GLACIAL ARCHAEOLOGICAL SITE POTENTIAL: SCALE AND PARAMETER INVESTIGATIONS

Stephanie R. Rogers, Philippe Curdy***

Abstract *- Increasing global temperatures are causing shrinkage in Earth's frozen environments due to the melting of ice and snow at high latitudes and altitudes. This phenomenon is relevant from many environmental perspectives as well as from an archaeological standpoint. Archaeological remains or artefacts which have been locked in frozen environments for hundreds or thousands of years are at risk of becoming exposed due to increased melting at high altitudes and latitudes. In an attempt to gauge archaeological potential in a mountainous region in western Europe, we further develop the least cost path analysis (LCPA) work conducted by Rogers et al. (2014) to investigate the results of least cost path (LCP) modeling in mountainous terrain. Different geographic scales and various parameter weighting schemes are used to test the effects of these changes on the resulting LCPs. The results show both similarities and differences between the paths calculated from the point and line scales and that increasing parameter weights in the LCPA model affect the spatial distribution of paths, and their respective travel times.*

Introduction

The Pennine Alps, a mountainous region located on the border of south-western Switzerland and northern Italy, have been used as a crossing point between valleys on each side of the border for thousands of years (Ammann 1992; Bezinge and Curdy 1994; 1995; Coolidge 1912; Curdy *et al.* 2003; Curdy 2007; Harriss 1970; 1971; Lehner and Julen 1991) (Fig. 1). First indications of their use stem from the Mesolithic period and range until historic times (Curdy 2007). The high altitude, often glaciated, mountain passes located along the border are of interest to historians and archaeologists in the region. Some of these passes are well-studied, for example, the Grand Saint-Bernard and Simplon passes are known to be two of the principle crossing points between Switzerland and Italy over history (Benedetti and Curdy 2008; Curdy *et al.* 2010; Vesan 2008). However, other less documented second-

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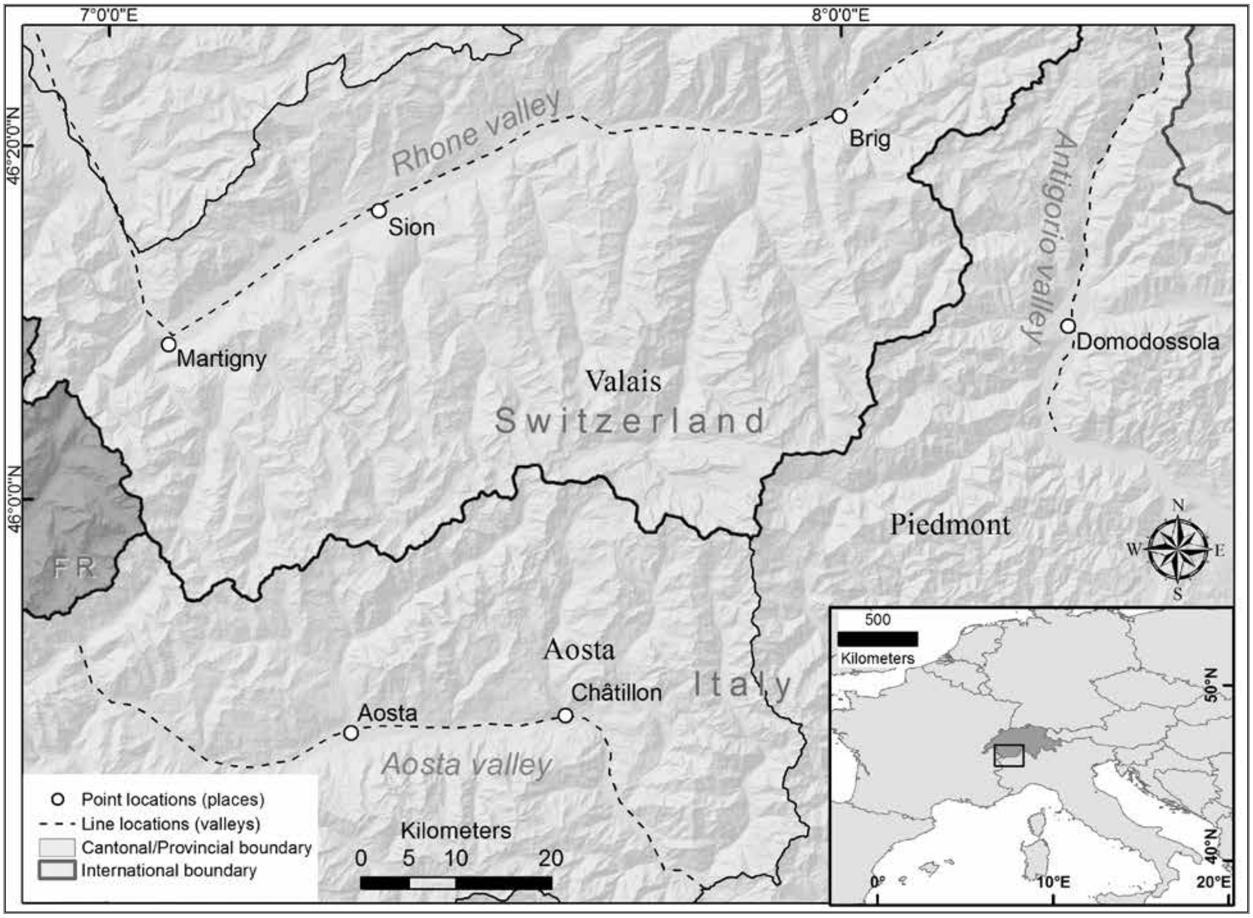

Fig. 1 - Overview of the study region.

ary passes exist which also have historical significance. These secondary passes are said to have been used for the purposes of commerce and migration as a direct, although often difficult route between the valleys. Several archaeological remains have been uncovered on the way to, and on top of, these secondary mountain passes of the Pennine Alps; among these discoveries, the remains and artefacts discovered near the margins of the Oberer Theodul glacier which is located south of the town of Zermatt in Switzerland. These findings are said to have belonged to the "Mercenary of Theodul", and include bones, weapons, leather clothing, shoe soles, and coins dating back to the 16th century (Julen-Lehner and Lehner 2012; Lehner and Julen 1991; Meyer 1992). Due to recent increases in global temperatures, finds such as these are becoming more common in the Alps as well as in frozen environments on other continents (Alix *et al.* 2012; Andrews and MacKay 2012; Andrews, MacKay and Andrew 2012; Beattie *et al.* 2000; Callanan 2012; 2013; Dixon *et al.* 2005; Farbregd 1972; Farnell *et al.* 2004; Hafner 2012; Hare *et al.* 2004: 2012; Lee 2012; VanderHoek *et al.* 2007; 2012). With each uncovered glacial archaeological remain, researchers are able to piece together how frozen environments have been used over history. These findings, which have melted out of glaciers, ice patches, or permafrost, have led to the development of a new archaeological domain which will refer to here as “glacial archaeology”. In general, glacial archaeology refers to any archaeological finding which has melted out of a frozen environment.

Glacial archaeology in the Pennine Alps has attracted substantial interest because of its prehistoric reputation and topographic characteristics. This region is at particularly high risk of glacier retreat and melting due to its high altitude and the inherent properties of glacier sensitivity to climate change (WGMS 2013; Zemp *et al.* 2009). Between the Little Ice Age (LIA) maximum in 1850 and now, glacier area has declined by approximately 50% in the European Alps (Fischer *et al.* 2014; Zemp *et al.* 2006) because of climate change acting on the region. Thus, increasing temperatures are responsible for releasing archaeological remains which have been locked in their respective frozen environments for centuries. These remains are at risk of rapid decomposition as they are often made up of organic materials. To collect and preserve these remains, systematic prospection is needed to identify specific areas of archaeological potential. Rather than undertaking the impossible task of visiting every site of interest in the Pennine Alps - which cover 4,500 km^2 - and to narrow down this large study region, we have used least cost path analysis (LCPA) to obtain a better understanding about how people could have crossed the Pennine Alps based on the assumption that they would have taken the easiest route possible from one location to another. Various archaeological studies have used this decision-support tool successfully for archaeological investigations in large and remote study regions (Bell and Lock 2000; Egeland *et al.* 2010; Gaffney and Stancic 1991; Howey 2007; Verhagen and Jeneson 2012). The first step in LCPA is to calculate an accumulated cost raster from which the least cost path (LCP) is calculated in the second step (Yu *et al.* 2003). The cost raster can be made up of single or multiple isotropic and anisotropic variables, that is, variables with friction that is equal in all directions (i.e. landcover), or variables where the friction varies depending on the direction of movement (i.e. slope), respectively (Bell and Lock 2000; Conolly and Lake 2006; van Leusen 1999; Wheatley and Gillings 2002). The selection of weights for the input variables into the LCPA model can also affect the outcomes of the calculated LCPs and should be taken into selected with care (Berry 2004; Howey 2007). Here, we provide an update to the work by Rogers *et al.* 2014, which calculated LCPs in the Pennine Alps taking into account the slope and prehistoric landcover properties of the terrain. We will hereby refer to the Rogers *et al.* (2014) study as the “original study”. First, we calculate LCPs from six point locations, i.e. modern agglomerations situated in strategic positions, well-known for their rich archaeological and historical past, including the three already used in the original study. Next, we calculate LCPs from lines, i.e. along entire valleys, to investigate the effects of using different geographic scales on the results of the LCPA. Furthermore, we test the effects of altering the input variable weights in the LCPA model with the ultimate goal of obtaining a better understanding about how the inputs to the LCPA model affect the results. Additional historical and archaeological information about each of the selected passes is discussed in the last section at the end of the document.

Methods

The LCPA method proposed by Rogers *et al.* (2014) was used as a base of investigation. Briefly, walking times of LCPs were calculated using the *Path Distance* and *Cost Path* tools in ArcGIS 10.1 by accounting for surface distance, landcover, and slope of the terrain. Landcover was modelled isotropically while slope was modelled anisotropically, using Tobler's hiking function to calculate walking times across the terrain (Tobler 1993).The inputs to the model included a digital elevation model (DEM) from the Advanced Spaceborne Thermal Emission Radiometer Global DEM 30 m (ASTER GDEM V2) (NASA 2012), and a prehistoric landcover layer which was adapted from the 2006 version of the Coordination of Information on the Environment (Corine) 100 m resolution landcover layer (European Environment Agency 2012) (Rogers *et al.* 2014). Both layers were resampled to 25 m resolution for calculations.
The LCPA methods presented in the original study were further developed in three ways. First, LCPs were calculated using six point locations, including the three from the original study, to obtain a comprehensive overview of the high mountain passes selected and the respective times it took for the paths to get from one side of the Pennine Alps to the other. These point locations included: Martigny, Sion, and Brig in Switzerland, and Aosta, Châtillon, and Domodossola in Italy (Fig. 1). Aosta, Sion, and Domodossola were selected because they are well-known historical points of departure to the Grand Saint-Bernard and Simplon passes, which were the most frequented passes in history between Sion and Aosta or Brig and Domodossola. Châtillon was used because of its strategic location in the Aosta valley, located at the foot of the Theodulpass, between the Upper Rhone valley (Brig) and the release of the Aosta valley in the Po valley. Second, LCPs were calculated from lines along the Rhone valley in Switzerland, and the Aosta and Antigorio valleys in Italy (Fig. 1), to obtain a regional scale view of LCPS. Third, the "Rock" and "Glacier/Perpetual snow" variables from the landcover input layer were altered by changing their isotropic friction weights, which are a set of relative values, to test the effects of the weighting scheme on the overall results of the LCPA (Tab. 1). These two variables were selected because they constitute the majority of the landcover parameters at high altitudes in this region thus they were assumed to be most pertinent to this study.

Results

LCPs from points

The LCPs calculated from the point scale took direct routes across the Pennine Alps from one side of each valley the other (Fig. 2). From Martigny to Aosta, the shortest calculated route, the Col Ouest de Barasson was selected as the crossing pass in both directions (Tab. 2). In the southern direction, this path took 32 hours, 29 minutes, and 21 seconds (32:29:21), and in the northern direction, it took 32:45:20 (Tab. 2).

LANDCOVER CATEGORY	COST RASTER NAME AND WEIGHTS					
	Original*	Rock4	Rock10	Rock100	Glac3	Glac10
Open space above 2000m	1.5	1.5	1.5	1.5	1.5	1.5
Forest below 2000m	2	2	2	2	2	2
Rock	2.5	4	10	100	2.5	2.5
Glacier/Perpetual snow**	1.5	1.5	1.5	1.5	3	10
Swamp	5	5	5	5	5	5
Lake	499.5	499.5	499.5	499.5	499.5	499.5

Tab. 1 - Landcover parameter weightings from respective landcover rasters. *The Original raster corresponds to the one used in Rogers *et al.* 2014. **This parameter was originally included in the "Open space above 2000 m" category in the Rogers *et al.* 2014 study.

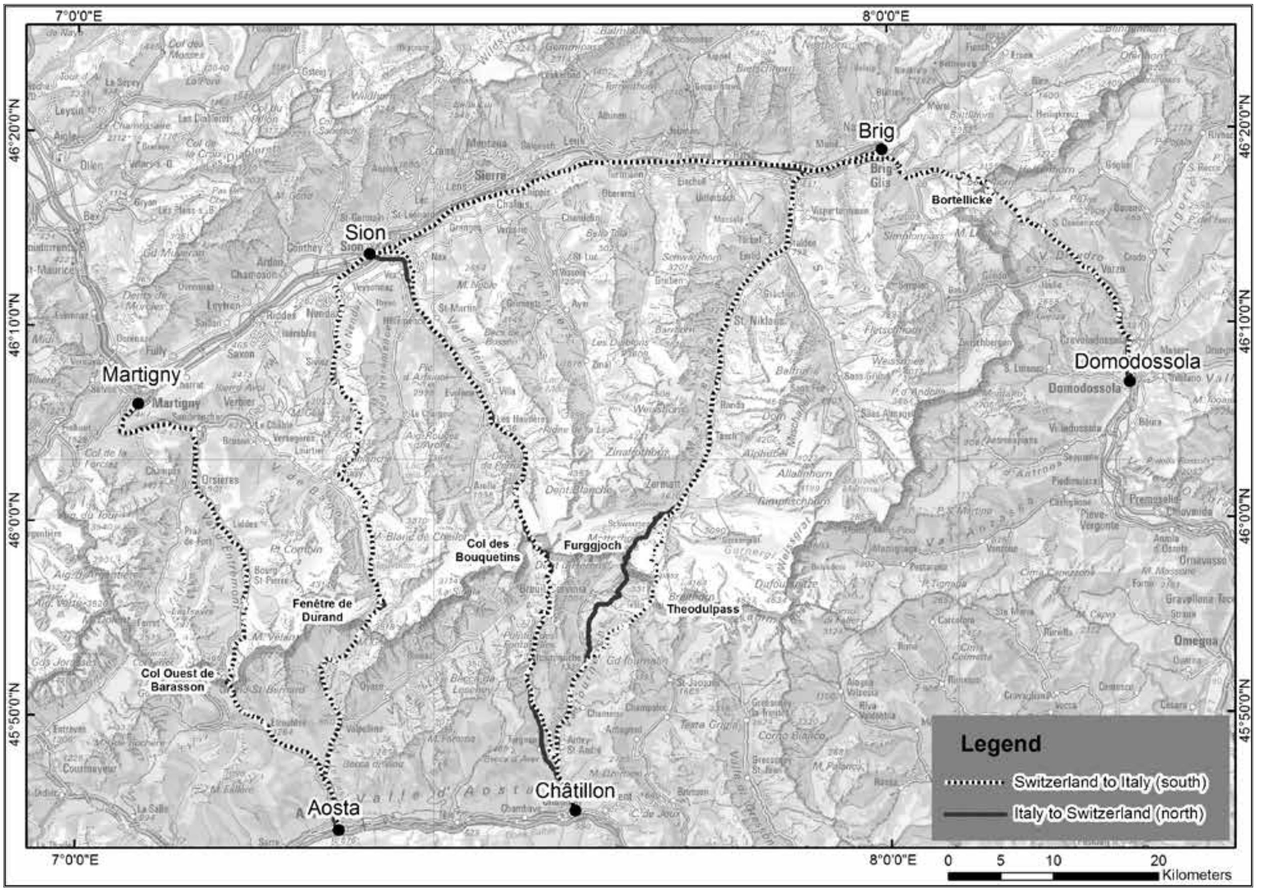

Fig. 2 - Results of LCPA from the point scale.

POINTS	DIRECTION	PASS SELECTED	TIME	DIRECTION	PASS SELECTED	TIME
Martigny/Aosta	South	Col O. de Barasson	32:29:21	North	Col O. de Barasson	32:45:20
Sion/Aosta	South	Fenêtre de Durand	39:56:08	North	Fenêtre de Durand	39:56:41
Sion/Châtillon	South	Col des Bouquetins	42:20:41	North	Col des Bouquetins	42:11:54
Sion/Domodossola	East	Bortellicke	48:54:39	West	Bortellicke	48:34:00
Brig/Châtillon	South	Theodulpass	43:34:05	North	Furggjoch	43:15:42

Tab. 2 - Results from point scale analysis including passes selected and the time required.

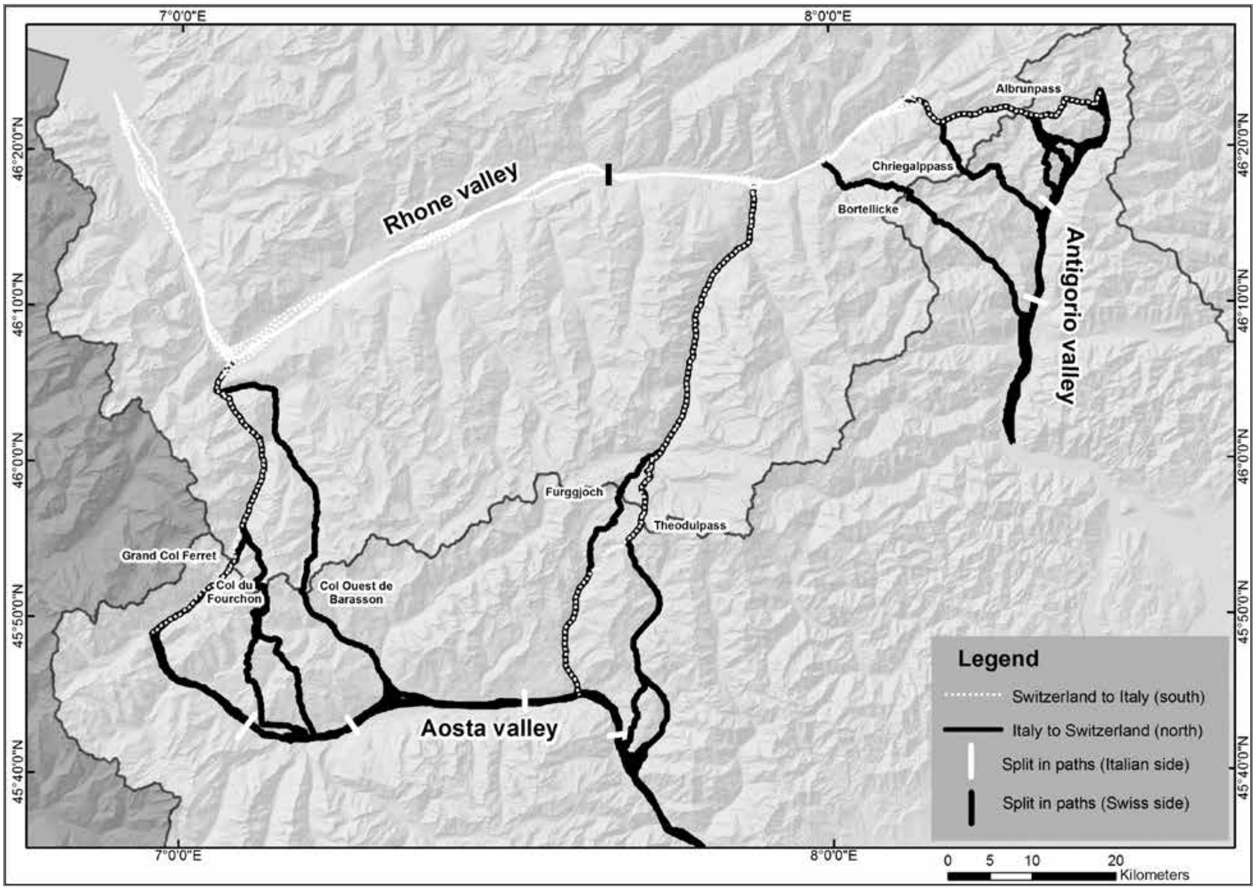

Fig. 3 - Results of LCPA from the line scale. The splits in the paths indicate when a path starts moving in the opposite direction.

VALLEYS	COST RASTER NAME AND AVERAGE TIMES					
	Original	**Rock4**	**Rock10**	**Rock100**	**Glac3**	**Glac10**
Rhone to Aosta	37:44 :34	37:06:39	38:05:20	39:25:28	37:15:49	37:40:43
Aosta to Rhone	36:50 :04	38:15:13	39:03:07	39:00:21	38:34:21	38:31:04
Rhone to Antigorio	22:17:31	22:45:48	23:16:42	23:20:55	22:19:18	22:46:48
Antigorio to Rhone	22:49:31	23:13:41	23:17:04	23:19:32	22:48:42	22:45:32

Tab. 3 - Results, shown in average times, from line scale analysis.

From Sion to Aosta, the Fenêtre de Durand was selected in both directions. In the southern direction this path took 39:56:08, and in the northern direction, it took 39:56:41. Between Sion to Châtillon, the Col de Bouquetins was selected for both directions. It took the southern path 42:20:41 to reach the destination and the northern path 42:11:54. The paths between Sion and Domodossola took the greatest amount of time due to the sheer distance between them. The Bortellicke pass was selected in both directions. The path moving east from Sion took 48:54:39 to reach Domodossola, while the path in the western direction took 48:34:00. The paths between Brig and Châtillon were the only ones to select different passes when moving in the south and north directions. From Brig to Châtillon, the Theodulpass was selected and took 43:34:05.

In the northern direction from Châtillon to Brig, the Furggjoch was selected and took a total of 43:15:42.

LCPs from lines

LCPs were calculated from the Rhone to Aosta and Antigorio valleys, and vice versa, using the original landcover classification by Rogers et al. (2014) (Tab. 1). Results are provided in average times which were calculated by summarizing all paths from one valley to another (Tab. 3, Original). From the Rhone to Aosta valley, the average time was calculated to take 37:44:34 (Tab. 3). The high mountain passes used were the Grand Col Ferret, the Theodulpass, and the Albrunpass (Fig. 3).
From the Aosta and Antigorio valleys to the Rhone valley, the average calculated time was 36:50:04. The passes used in this direction were the Grand Col Ferret, the Col du Fourchon, the Col Ouest de Barasson, the Furggjoch, the Theodulpass, the Bortellicke, the Chriegalppass, and the Albrunpass. From the Rhone to Antigorio valleys the average time was 22:17:31 and the only pass used was the Albrunpass. From the Antigorio back to the Rhone, the average time was 22:49:31 and the passes used were the Bortellicke, the Chriegalppass, and the Albrunpass (Fig. 3, Tab. 3).

Parameter investigations

As weights for the "Rock" and "Glacier/Perpetual snow" parameters were increased (Tab. 1), the average times (Tab. 3) changed and the resulting LCPs were spatially different (Fig. 5a, b). From the Swiss side to the Italian side of the border, as Rock values were increased from 2.5 (Original) to 4 (Rock4), the average time decreased because the Furggjoch was selected instead of the Theodulpass (Tab. 3, Fig. 4a). The other two passes taken were the Grand Col Ferret and the Albrunpass. As Rock values increased to 10 (Rock10), the paths kept their same spatial distribution for this direction (Fig. 4b) but the average time increased. When the Rock value was set at 100 (Rock100) the paths avoided the entire middle section of the study region to avoid the rocky areas and thus only the Grand Col Ferret and Albrunpass were used (Fig. 4c)
As the Glacier/Perpetual snow parameter was increased to 3 (Glac3), the high mountain passes used were the Col Grand Ferret, the Furggjoch, and the Albrunpass, with slightly different times (Fig. 4d). As the Glacier/Perpetual snow weight was increased to 10 (Glac10), the average time remained despite the path crossing the Theodulpass instead of the Furggjoch (Fig. 4e). In the opposite direction from Italy to Switzerland, changes could also be observed when parameter weightings were altered. As Rock values were increased to 4, the average times increased and the Grand Col Ferret, Col Ouest de Barasson, Furggjoch, Theodulpass, Bortellicke, and Albrunpass were used (Fig. 4a). As Rock was increased to 10, the Grand Col Ferret, Col Grand Saint-Bernard, Schwarztor, Bortellicke, and Albrunpass were used and times decreased slightly (Fig. 4b, Tab. 3). When Rock was increased to 100, the spatial distribution of paths was decreased and the only passes used were located on the east and west of the study

area; those were the Grand Col Ferret, Col Grand Saint-Bernard, and the Albrunpass (Fig. 4c). The average time remained approximately the same. As the Glacier/Perpetual snow parameter was changed to 3, the Grand Col Ferret, Col du Fourchon, Col Ouest du Barasson, Furggjoch, Theodulpass, Bortellicke, Chriegalppass and Albrunpass were selected. The resulting passes were identical to those selected in the original weighed landcover raster. As Glacier/Perpetual snow was increased to 10, the selected passes decreased from 8 to 5 and were the Grand Col Ferret, Col du Fourchon, Col Ouest du Barasson,

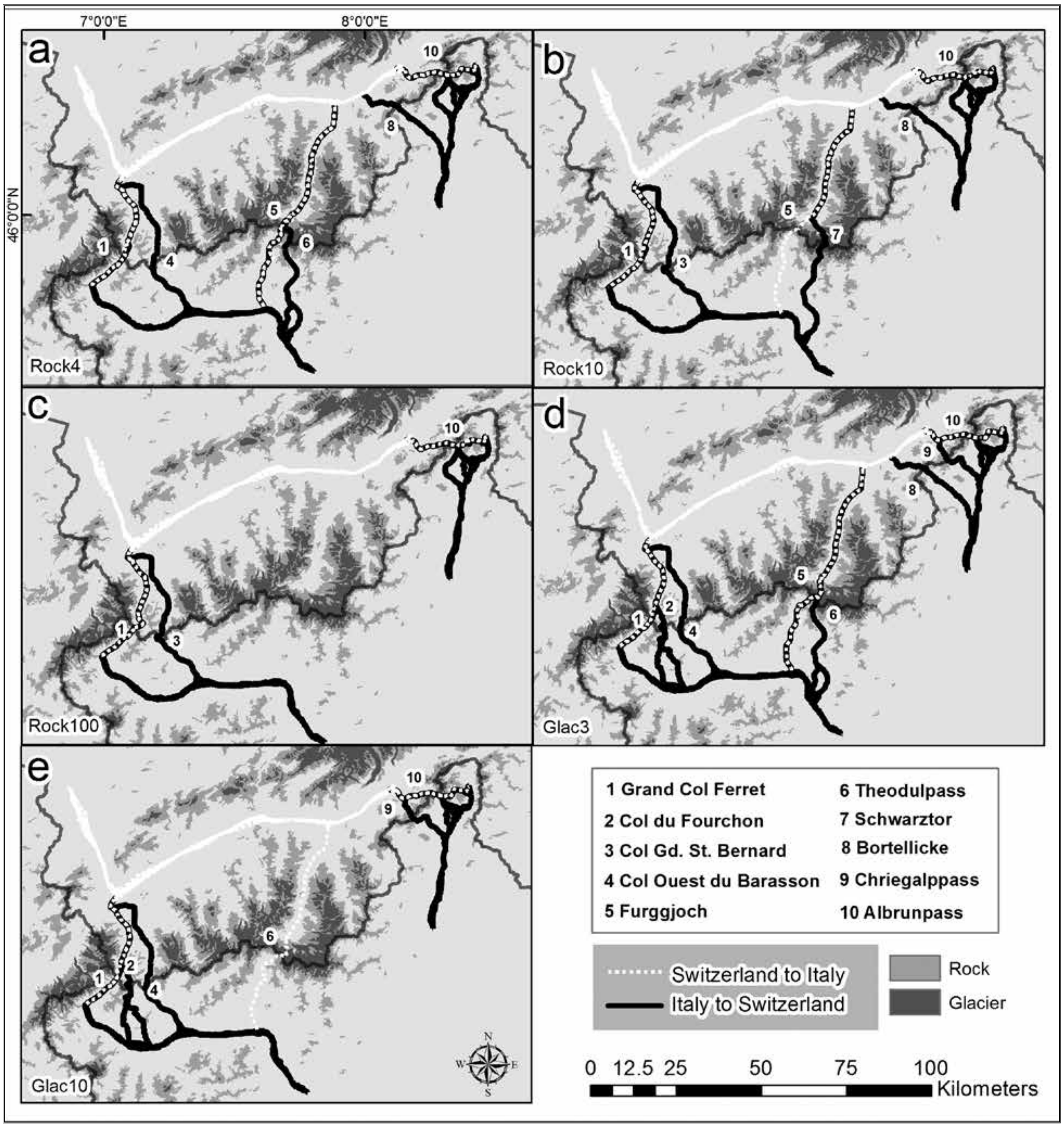

Fig. 4 - Results of parameter weighting investigations from the (a) Rock4, (b) Rock10, (c) Rock100, (d) Glac3 and (e) Glac10 cost rasters.

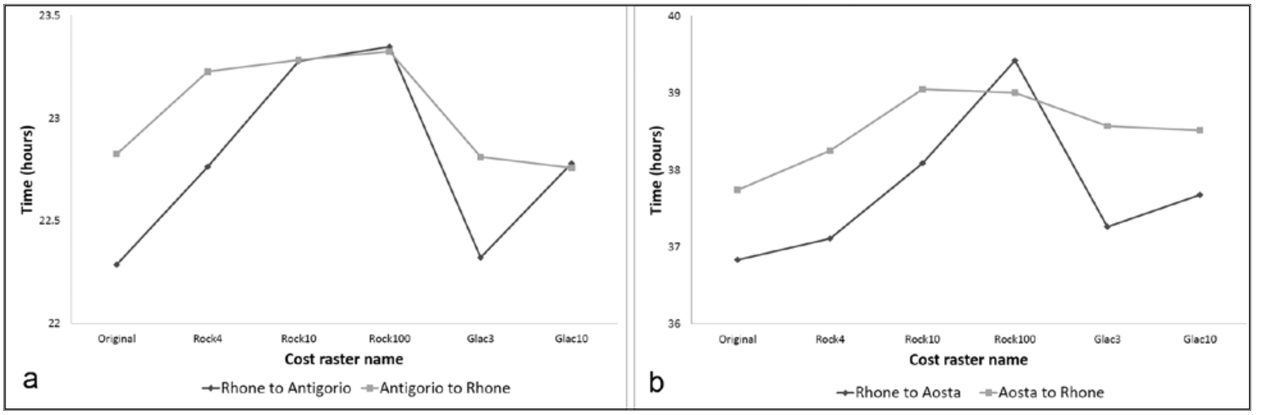

Fig. 5 - Results of LCPs from the Rhone to Antigorio valleys using different parameter weights and cost rasters from the line scale.

Chriegalppass and Albrunpass and the average times decreased slightly from the Glac3 instance.
To summarize the results, Fig. 5 shows the time differences between the averages calculated for the LCPs using seven different cost rasters. Between the Rhone and Aosta valleys, it generally took more time to cross in the northern direction (from Aosta to Rhone) than in the southern direction (from Rhone to Aosta), except for if the Rock category is weighted at a high value (Fig. 5). Between the Antigorio and Rhone valleys, average times were more similar, however, the northern route took more time to cross overall .

Discussion

By further investigating the LCPA methods developed by Rogers *et al.* (2014) we gained a better understanding about the importance of scale and parameter weighting selection on the results of the final LCPs. We identified similarities in the results from both geographic scales, for example, the Col Ouest de Barasson, Furggjoch, Theodulpass, and Bortellicke were selected as passes at both the point and line scale. Differences also exist between the results at each scale. For example, at the line scale fewer passes were selected from the middle of the study area. This shows that it is easier to traverse further down the valley and then selecting a pass, instead of crossing the mountains where there is the highest concentration of rocks or snow and ice. For that reason the Fenêtre de Durand and the Col de Bouquetins were avoided. By starting from a point at the point scale, the paths are forced through potentially inaccessible terrains based on the fact that that is the easiest out of the other options. By taking a regional scale approach, and starting from the line scale, one is more confident in the results because the cost raster incorporates more of the surrounding terrain and thus can calculate the true LCP in that area. Another benefit of taking a regional scale approach is that no previous archaeological knowledge is required. Rogers et al. (2014) selected start and end locations for the LCPA based on their previously archaeological significance. This could be beneficial to some studies but if researchers are interested in a new study area with no former archaeological significance a regional scale approach could be more effective.

There were noticeable differences in the results when weights of the parameters for Rock and Glacier/Perpetual snow were changed. As their weights were increased, walking times generally increased and the spatial distribution of paths decreased. With higher weights, paths were forced to the east and west of the study area. For example, with the Rock100 cost raster it was easier for the paths to travel to the ends of each valley, where there was less topography, rock, snow, and ice, than to cross directly over the middle of the Pennine Alps. The west side of the study area has not been glaciated for at least 150 years (Maisch 2000), therefore that area is more attractive for crossing based on the current parameters of the LCPA model. For that reason, the west side of the study area was unaffected when the weights of the Glacier/Perpetual snow layer was increased (Fig. 4d, e). We were also interested in knowing how past glacier extents would affect the model results. However, the oldest glacier inventory is from 1850 and is only available for the Swiss side. None the less, calculations were performed using the 1850 glacier extents instead of the 2006 Corine glacier extents but results were found to be nearly identical to the ones already calculated. Unfortunately the calculations were not completely representative as the information from the 1850 glacier extents on the Italian side was missing. Also, the 1850 and 2006 extents do not vary enough to make a significant difference in the results. It would be interesting to know what glacier extents looked like between the Last Glacial Maximum (about 10.500 years BP) and 1850, although those datasets do not yet exist for this region. With that information, we could better understand the effects of changing geomorphology and ice cover on the potential of finding archaeological remains. In conclusion, taking a regional scale approach from lines seems to be more realistic when thinking in terms of where people could have begun and ended their journeys in the past. It is unrealistic to consider that all journeys began and ended from a single point on the terrain. The findings in this study highlight the importance of scale and parameter weighting and choice within a LCPA model. By understanding the effects of different weighting schemes, the model can be further validated and improved for the future.

Archaeological data of the passes cited in the model

Grand Col Ferret 2537 m - This pass is situated above the Val Ferret in Switzerland; to the south it leads to the Val Ferret in Italy. Several historical records suggest that this was an important pass in the 14th century AD (Aerni and Herzig 2014b). In Aerni and Herzig (2014), the Col Ferret and the Grand Saint-Bernard are mentioned together which gives it a certain importance. A Roman shoe nail is the only archaeological artefact found in this area. It was located about 3 km below the pass in 2004 during archaeological prospection (Poget 2006).

Col du Fourchon 2696 m - To the north, this pass is located above the Swiss Val Ferret. To the south, it leads to the Aosta valley. There is currently easy access to this pass. There are no indications as to whether this pass has been used in history, only recent touristic documentation about this pass exists. For the moment, no archaeological artefacts have been located at this pass.

Grand Saint-Bernard 2469 m - The pass connects the Rhone valley via the Val d'Entremont with the Aosta valley. Due to its easy accessibility, it is currently the only pass of the ones we present in this article, which is passable today. It has a lengthy international reputation and has been the subject of many studies. The majority of archaeological remains found on the pass are from the Roman and Medieval periods. It is impossible to say what it was used for in earlier times because the few objects from the Iron Age that were discovered could be items recovered from the Roman epoch (Vesan 2008).

Col Ouest Barasson 2635 m - This pass, which is above the Val d'Entremont, leads directly to the Aosta valley. Access from the north is relatively easy, but steep slopes, a few hundreds of meters in length, make access on the south side difficult. There is no historical information about this pass. The presence of an undated stone fortification and a Roman shoe nail give indication that this pass was used at certain times to control access to either side of the border (Benedetti and Curdy 2008).

Fenêtre de Durand 2805 m - This pass is located at the end of the Val de Bagnes and leads directly into the Valpelline to the south. Despite its distance from the lower part of the Val de Bagnes, it is an easy route with fairly steep slopes to the north and south. Since at least the 14th century AD, it was an important route for trade purposes or for moving herds of cattle (Coolidge 1912; Eschmann in press). Archaeological surveys conducted in 2004 found a Roman shoe nail, but nothing prior to that (Poget 2006).

Col des Bouquetins 3357 m - This pass, which is located between the Mont Miné glacier, at the end of the Val d'Hérens to the north and the Tsa de Tsan glacier, above the Valpelline, to the south, is currently covered in ice and is difficult to access. There are no indications of its past or current use other than information from a high altitude mountaineering course. Of all the passes proposed by the LCPA model, along with the Schwarztor, these are currently the most inaccessible passes due to the presence of glaciers, crevasses, and rocky terrain.

Furggjoch 3246 m - This pass is partially covered by glaciers and is difficult to access. The Furgg glacier (Mattertal) overlooks the north. To the south is the Della Forca glacier (Valtournenche). From the north, a 60 m rock wall currently makes this a difficult route to cross. To the south, the path crosses steep slopes but no cliffs. There is no historical mention of its use, apart from high altitude mountaineering guides.
Theodulpass 3301 m - This pass connects the Oberer Theodul glacier to the north and the Valtournenche glacier to the south. It is mentioned regularly throughout the Middle Ages and Modern times as a frequently accessed pass between the Rhone valley and northern Italy (Eschmann, in press). Evidence of Roman and Celtic coins found on the pass prove that its use dates back to at least Roman times (Thüry 2012). A neolithic stone axe was also found near the pass (Pétrequin *et al.* 2012). A rock shelter, less than three hours away from the pass by foot, was occupied during the Mesolithic-Neolithic and Bronze age approximately

7,500 - 1,600 years BC (Curdy *et al.* 2003). It is also assumed that this pass was used during the colonization of the Rhone valley by the first Neolithic pastoralists (Curdy *et al.* 2003). Since the 1980's, the melting Oberer Theodul glacier has uncovered a number of objects dating back to the 17th century (Julen-Lehner and Lehner 2012; Providoli and Elsig in press).

Schwarztor, 3731 m - This pass connects the Matteral valley (Zermatt) to the Val d'Ayas. It is the highest pass proposed by the LCPA, is currently covered in ice, and one of the most difficult to access. To the north it is situated above the Schwärze glacier (connected to the Gorner glacier). To the south, it joins the Val d'Ayas via the Verra glacier (Grande Giacchiaio di Verra). It is part of the high mountains paths that can only be visited by experienced mountaineers. According to some legends and oral traditions, it was used by Walser communities who had colonized the Val d'Ayas in the 13th century AD. It was said to directly link this valley to the Zermatt valley (Lüthy 1977; Zinsli 1968).

Bortellicke 2742 m - This secondary pass connects the Gantertal on the north to the Alpe Veglia to the south, in the direction of the Ossola valley. From the north this pass is relatively easy to access. On the contrary, the south is characterized by extremely steep slopes and generally inaccessible. The pass was covered in ice at the beginning of the 20th century. The presence of Roman coin has been mentioned in literature (ASSPA 1915).

Chriegalppass 2536 m - This pass lies between the Chriegalkptal (Binntal) to the north and the Val Devero to the south. It seems to have already been mentioned on a map from 1768 (Aerni and Herzig 2014). No archaeological discoveries have been proven at this site. Because of its location near the Albrunpass, it seems possible that this was the last pass which was busiest in the entire region.

Albrunpass 2409 m - This important pass connects the Binntal (north) to the Val Devero (south). The Binntal was occupied since prehistoric times and discoveries of burial sites from the Iron Age and Roman period indirectly reflect the frequentation of this pass. A series of archaeological finds from the Bronze Age and Roman coins were discovered on the pass and on the path which leads to it (Aerni and Herzig 2014; Di Maio 2007; Sauter 1955). On the flat areas to the north, under the pass, there are traces of prehistoric occupation, dated to the Mesolithic and Bronze Age (Curdy et al. 2010). Historical texts also mention the importance of this pass (Aerni and Herzig 2014).

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