Silvretta Historica: Satellite-assisted Archaeological Survey in an Alpine Environment

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In this paper we report on a new archaeological project in the central Alps, titled Silvretta Historica, in which satellite-assisted archaeological surveying is intended to play a key role. Following an overview of the Silvretta study area on the Swiss-Austrian border and its archaeology, we present the first results of recent archaeological fieldwork focussing on the remains of prehistoric alpine pasture economy or Alpwirtschaft. We then continue to discuss why spectral and geometric analysis of high-resolution satellite images are considered a promising method to assist archaeological survey in a high alpine environment.

Keywords: archaeological prospection, satellite remote sensing, alpine archaeology

1. Introduction

In recent years satellite images have become an important data source in archaeological survey (PARCAK, 2009). This is due to increased spatial resolution and improved analytical methods.

Around a dozen satellite sensors, mostly operated by commercial providers, currently obtain spaceborne images with a spatial resolution of ≤ 1 m. As high spatial resolution is crucial for the detection and documentation of archaeological features, satellite images have become an alternative to aerial images, over which they have the advantage of worldwide availability. The spectral resolution of high resolution spaceborne sensors is moderate, covering mainly the visible and near infrared light (VNIR). This fits well the purpose of many archaeological projects, as the NIR channel tends to facilitate the detection of crop marks, a classic archaeological proxy.

The analysis of satellite images, both with high spectral and high spatial resolution, has also improved considerably over the past years. While image correction and enhancement aide visual image interpretation, advanced methods of digital image analysis, such as pixel or object-based classification, vegetation indices, feature detection algorithms etc., are now used to either provide helpful contextual information or even to automatically detect possible archaeological features (e.g., DE LAET et al., 2009; TRIER et al., 2009; see also overview in DE LAET and LAMBERS, 2009).

The increased resolution and availability of satellite images, as well as improved analytical methods lead us to believe that such images, if chosen and analyzed properly, will be a valuable data source to assist archaeological surveys in the high Alps above the tree line, an environmental context in which, to our knowledge, they have not yet been used for archaeological purposes. In what follows, we introduce our study region in the Silvretta Alps, the first results of archaeological fieldwork, and our new collaborative project in this region. In the discussion we pay special attention to archaeological and environmental features and contexts of the Silvretta region that we expect to be especially susceptible for satellite image-based detection.

2. Alpine archaeology in the Silvretta region

Research into the prehistory of the Alps has been intense and widespread over the last decades, focusing in particular on the Mesolithic, the Iceman discovery and related finds, intensification of settlement in the Bronze Age, and trans-alpine contacts in the Iron Age. While the principal components of the early utilization and colonization of the Alps now appear more or less pinpointed, many questions concerning the environmental, economic and social contexts of early
human presence, settlement and economy still remain unanswered. This is especially true for the «Inner Alps», the regions between and beyond the major river valleys up to the alpine pastures and watersheds, and the question of seasonal summer farming known as Alpwirtschaft.

Therefore, in 2007 the Dept. of Pre- and Protohistory of the University of Zurich initiated a new diachronic and multi-disciplinary study of human/landscape dynamics in the high-alpine zone of the Silvretta mountains along the Swiss-Austrian border (> 2000 m a.s.l.; fig. 1). The main aim of the project is to compose a long-term history of human settlement and activity in the high altitude zone. This allows an investigation of people's changing influence on and adaptation to their environment and vice versa, with a specific focus on the prehistoric origins of vertical transhumance. The results of three years of intense archaeological survey activities and excavations, during which we were able to obtain a significant sequence of 14C-dates, have established a new chronology for over 11 000 years of human activity in this region, modeling processes of utilization and colonization (REITMAIER, 2010a, 2010b). The most important sites discovered are several seasonal base camps of mesolithic and neolithic hunting groups, preferably located under large rock shelters, with rich assemblages of flint and bone tools. Architectural stone structures like huts and enclosures (animal pens) give an important indication of Bronze and Iron Age pasture activity as part of a perfectly adapted alpine agro-pastoral ecosystem. Moreover, palynological analyses conducted mainly by the University of Innsbruck, combined with other climatic proxies allow a precise reconstruction of the environmental and anthropic situation and verify this early human impact on the mountainous landscape.

Building on these results, the new Silvretta Historica project, starting in 2010, intends to intensify and complete the archaeological survey in the Silvretta region. To this end, and in collaboration with the University of Konstanz, we plan to acquire high-resolution satellite images of the study region in the summer of 2010. These images will serve a twofold purpose (LAMBERS, 2010): Firstly, their spectral and geometric analysis will provide valuable base data to assist archaeological fieldwork. Secondly, the resulting products such as digital terrain models and orthophotos will be incorporated in a digital guide to historical and archaeological sites in the region. This will be produced in close cooperation with local tourist agencies, which is another important goal of the Silvretta Historica project and is aimed at tourists as well as the local population.

During our archaeological survey so far we have found that certain typical categories of archaeological sites share common properties that are expected to allow their detection in satellite images through either visual interpretation or automated extraction methods. Since the images have not yet been acquired, we limit our following discussion to these properties and their expected correlations in satellite images and derived products in order to illustrate the potential of this data source to assist archaeological survey (cp. TUCKER, 2009).

3. Potential of satellite-assisted survey

Prior to image analysis, the timing of image acquisition is important to ensure useful image content. The short summer season in the high Alps offers favorable conditions for image acquisition only between June and September, as snow covers much of the study area during the rest of the year. Within this time window, cloud-free days are difficult to predict. Volatile weather conditions thus narrow the available time window more than plant growth. Except for a short period of time following the snowmelt, when the vegetation has yet to recover from the winter, the alpine grassland potentially provides useful information for archaeological survey during the entire short summer.

Once images have been acquired, certain remains of prehistoric alpine seasonal pasture farming lend themselves to detection based on their spectral or geometric properties, as discussed below.

3.1. Spectral analysis

The harsh environmental conditions in the Alps above the tree line – rugged terrain, short vegetation periods, and sparse vegetation coverage – generally prevent the use of crop and soil marks as archaeological proxies based on spectral signatures of vegetation affected by near-surface archaeological remains. There is, however, a notable exception to this rule. Sites regularly used to herd livestock, often over decades or even centuries, feature highly fertilized soils that support a special type of campsite vegetation known as Lägerflora. In early summer, such herding sites can be visually recognized as intense green patches even if they have fallen in disuse long ago (fig. 2). They often feature the archaeological remains of structures associated with pasture farming that may or may not be visible on the surface, such as cattle enclosures, huts, or hearths. This type of campsite vegetation can thus serve as proxy
hinting at the location of possible archaeological remains. It is expected to be distinguishable from the surrounding vegetation based on the spectral signature that can potentially be discerned through pixel-based classification.

Figure 2: Abandoned cattle herding site in Val d’Urezzas, Switzerland, marked by Lägerflora (dark green vegetation).

3.2. Geometric analysis

The archaeological analysis of high-resolution satellite images, be it through visual interpretation or digital image analysis, is often restricted to its spectral content. However, since most of these images are routinely acquired in stereo mode, they can also be used to generate digital elevation models (DEMs) in high resolution and high accuracy. Such a geometric analysis is an important tool in alpine regions, where DEMs from other sources often have certain limitations. For example, the Swiss Federal Office of Topography is now offering a new high-resolution DEM of Switzerland based on airborne laser scanning data, but its coverage is limited to areas below 2000 m a.s.l., leaving large parts of our study area uncovered. Above this level, only DEMs at lower resolution are available. Spaceborne high-resolution stereo images are thus a useful data source for DEM generation, even though strong shadowing effects in steep terrain and a scarcity of passpoints complicate the photogrammetric analysis. On the plus side, vegetation cover is not an issue above the tree line, which enables the generation of digital terrain models (DTMs) instead of digital surface models that include vegetation.

There are several types of archaeological sites in the Silvretta region that may be recognized based on the geometry of their terrain surface, the most important being plateaus and rock shelters.

While flat or nearly flat terrain is not uncommon where the valleys widen in the lower reaches of our study area, it is evidently scarce in the higher reaches. Here we find only a few natural plateaus or terraces on the slopes. In addition, the valley bottoms are often narrow. As we found during our survey, the few available relatively flat areas were used for the erection of cattle enclosures and huts (fig. 3). In steep terrain such as the high Alps, flat terrain can thus serve as archaeological indicator due to its scarcity and economic importance.

Figure 3: Naturally occurring flat terrace at the foot of a slope in Val Tasna, Switzerland, on top of which an Iron Age cattle enclosure was found (note excavation tent near the center).

Another terrain feature often holding archaeological remains are rock shelters, either natural rock outcrops on slopes or large rocks on the valley floors (abri sous-bloc, fig. 4). Both features were frequently used by herders and hunters as temporary campsites, as shown by the regular occurrence of hearths. Excavation results show that many of these sites were frequented over centuries and are indeed occasionally used even today by hikers sheltering from sudden weather changes. Both rock shelters on slopes and groups of large blocks on valley floors are recognizable in high resolution DTMs as local deviations in the terrain surface. They are furthermore expected to show in slope layers that can be derived from DTMs in GIS.

While flat areas and rock shelters may be relatively easy to detect in DTMs or layers derived thereof, there are other terrain features that in alpine contexts often hold archaeological remains yet are less distinctive and more difficult to detect based on their shape. Among them are terrain promontories or spurs overlooking portions of valleys that allow the control of certain areas or traffic routes leading through them, e.g. towards mountain passes. Furthermore, places that due to their microtopography offer a certain protection from
snowslides, landslides or other natural hazards are potential candidates for containing archaeological sites. The contexts and terrain shapes of such sites may, however, vary greatly, making them difficult to detect based on geometric information alone.

Figure 4: Group of large rocks in Val Tasna, Switzerland, of which several were used as shelters by herders and hunters over centuries (note excavation below central block).

Conclusions

The spectral and geometric content of high-resolution satellite images holds a high potential for archaeological survey in an alpine environment in which the location of economic infrastructure, and the corresponding archaeological remains, is heavily dependent on environmental features. As our review shows, their spectral or geometric properties are likely to facilitate the detection in satellite images of certain key features of Alpwirtschaft such as seasonal campsites and cattle enclosures. Satellite images are thus expected to be of valuable assistance to archaeological survey. This is important in a region as large and difficult to access as our study area. The images are furthermore intended to play a key role in the public dissemination of our project's research results.

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References


