

The Roofscape of Graz

Josef GSPURNING

Institute for Geography and Regional Science University of Graz, Austria

Abstract: In 1999 the almost gap-less and beautifully preserved roofscape of the old town center of Graz has been one of the most important reasons for conceding the status of an UNESCO World Heritage Site to the city. But, despite its importance in local, regional and even global scale and although the roof from authors typically is addressed as the fifth façade of a building which is significant for a town's character in a crucial way, the expression "roofscape" (or its German pendant "Dachlandschaft") often is defined by terms taken from architecture, artistry or legal regulations. In contrast the approach proposed within this paper doesn't understand roofs as a summary of a mainly functional set of characteristics or as a zone of colliding planning interests (for example solar potential versus protection of historical buildings). Instead of that the means of Geographical Technologies (basically GIS and RS concepts) are employed to derive an unbiased definition of roofscape and emphasize its identity by specific criterions like shape, colour, raw materials as well as texture, elements of patchiness and roof ensembles. Besides, the usage of GIS and RS elements enhance the underlying research design not only with new technology (i.e. spatial toolboxes for delineation of a roofscape) but also with new data types (i.e. laserscanner data) and metrics for describing the investigation outcomes. The results of the work described in the paper could be summarized in the following manner: Delineation and characterization of effective roofscape areas, design of a problem-oriented data model, implementation of this 3d spatial database and visualisation of the findings.

Introduction, motivation and legal issues

In 1999 the almost gap-less and beautifully preserved roofscape of the old town center of Graz has been one of the most important reasons for conceding the status of an UNESCO World Heritage Site to the city. But, despite its importance in local, regional and even global scale and although the roof from authors typically is addressed as the fifth façade of a building which is significant for a town's character in a crucial way, until now the expression "roofscape" (or its German pendant "Dachlandschaft") often is only defined by terms taken from architecture, artistry or legal regulations (GMÜR 2009, HARTLEITNER 2012).

"In the area protected by the Grazer Historic Town Conservation Law 1980 is to be respected that openings and superstructures as well as other changes concerning the characteristics of the roof membrane must not affect the appearance of the historical roofscape of Graz." In this context the term roofscape covers the entire shape-effective characteristics of the housetop zone like size of the roofs, shape, construction type, inclination, cornices and/or cullis forms, roofing material, element form, roofing paint, superstructures (dormers, gable lucarnes, smoke or exhaust air outlets and such like) as well as the roof blending (GRAZER ALTSTADTERHALTUNGSGESETZ 1980, revised in 2008; GAEG 2008). The extension of the roof protection area is defined literally

„ by the visibility of this roofscape from the castle hill (Schloßberg), from the surrounding hills in the vicinity of Graz as well as from intra-urban public traffic areas and all remaining publicly accessible open spaces (yards and such like) of the town”

(DACHLANDSCHAFTERHALTUNGSVERORDNUNG 1986)

In addition to the more traditional fields of activity (mostly caused by architectural interventions) the Altstadtsachverständigenkommission (Commission of experts for the conservation of the historic core) recently has to deal with problems resulting from modern trends: So sustainability, the green city idea and the increasing usage of clean and renewable energy sources mean inherent potential for conflicts such as impermissible modifications of the historic roofscape by installation of thermal solar or photovoltaic panels (GRAZER ALTSTADTSACHVERSTÄNDIGENKOMMISSION 2013). Therefore it seems that the given amount of resources (i.e. usable rooftops) resulting from the current approach of definition has to be questioned and modified, maybe by altering the legal foundations or implementing rules. The approach proposed by the author focuses on the reassessment of the application process; the means of geographical information toolboxes in combination with modern spatial databases are used to produce a more accurate differentiation of the investigation area which until now was considered as a more or less homogenous protection zone (GSPURNING 2002).

Investigation area and data layers

Because of its legal foundation and the singularity of the underlying implementation concept, the delineation of the area of investigation can be derived from the administrative boundary of Graz, the extension of the 13 protection zones within this boundary and – last but not least – the most important elevations inside and outside the municipal area of the capital of Styria. Therefore the analysis area lies in a rectangle bounded by 5195039m respectively 5218055m (North) and 524186m respectively 542437m (East; referring to UTM 33N) and covers about 418 km² (Fig. 1).

The second spatial reference layer is defined by the viewpoints used for viewshed calculations and located on surrounding elevations such as Admonter Kogel (566m), Pfangberg (585m), Platte (651m), Gaisberg (636m), Mühlberg (720m), Fürstenstand (763m) and Jungfernsprung (569m). Because of the characteristics of the real world situation the investigation's "hot zone" can be estimated with nearly 7 km² and is largely equivalent to the historical inner core of the urban area (Fig. 2).

As already mentioned, a fundamental element of the proposed approach is the availability of a spatially referenced dataset which represents the real world surface (terrain, buildings, vegetation as well as all other sight obstructing features), with an accuracy high enough to provide realistic visibility results (NIEMEIER & KERN 2001); in absence of higher resolved datasets, the calculations are done based on nDSM (normalized Digital Surface Model) derived from Airborne Laser Scanning data acquired during surveying flights on behalf of the government of Styria in 2010. Although the ground resolution of the raster cells is 1m², with respect to the context the quality seems to be good enough for an almost relatively unbiased result. In addition to the z-dimension (accuracy of the original point cloud vertical: +/- 15 cm and horizontal: +/- 40cm), nDSM also allows the extraction of other problem relevant information like the location of hilltops,

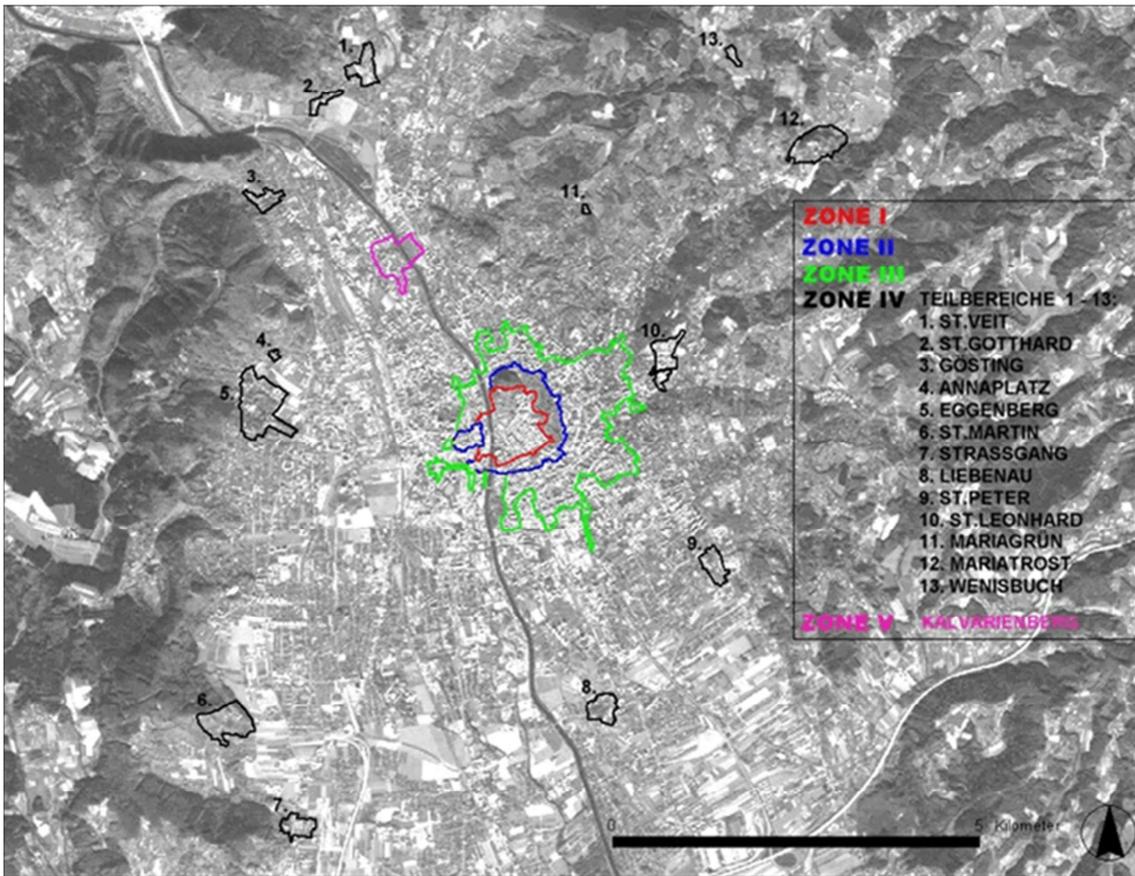


Fig. 1 – Areas protected by the Grazer Historic Town Conservation Law 1980/2008. Zone I – the main investigation area – is delineated in red (Copyright: Land Steiermark - Amt der Steiermärkischen Landesregierung)

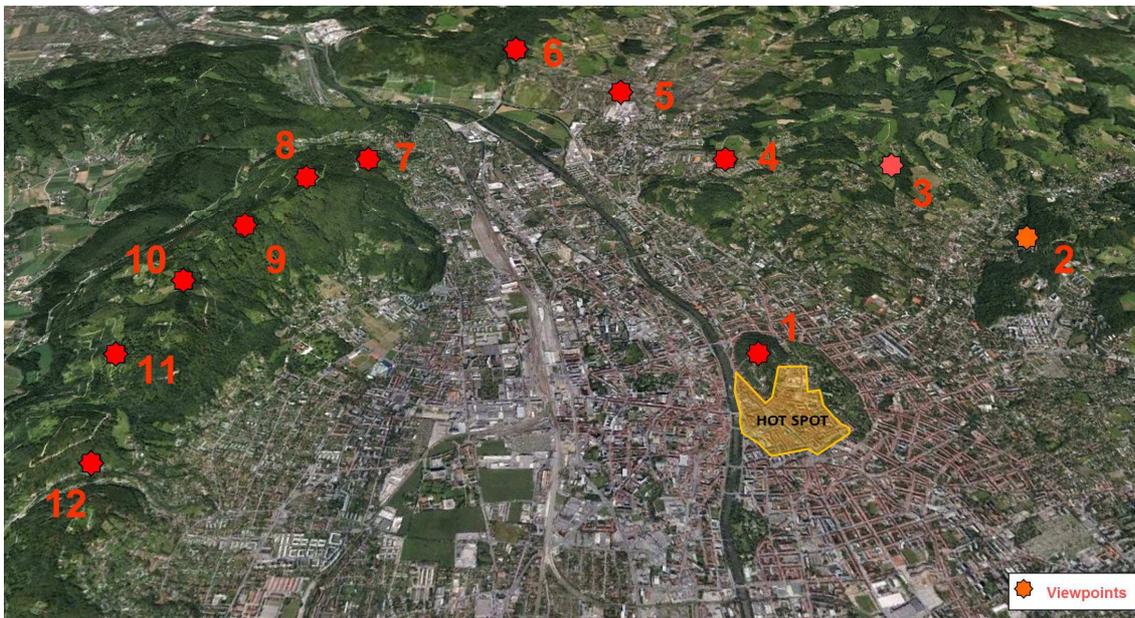


Fig. 2 – Famous highest points in the urban hinterland of Graz; 1=Schloßberg (474m), 3=Platte (654m), 6=Admonter Kogel (566m), 7=Jungfernsprung (546m), 8=Fürstenstand (754m), 10=Plabutsch (657m) and Gaisberg (636m). (Copyright Orthophoto, DTM: Land Steiermark - Amt der Steiermärkischen Landesregierung; additions by J.Gspurning)

vegetation or buildings. Digital color orthophotos (ground resolution: 20 cm) published in 2009 were used for alignment and proofing of the information taken from the surface layer. To calculate the viewsheds, distinct points of interest fulfilling special selection criteria (e.g. accessibility, appropriate field of view) have to be located. These vantage points were digitized from the underlying orthophoto / topographic map and saved into a point shape file for further processing. In addition to these officially available datasets, the investigation employs some other vector data sources (saved in ESRI's shape file or personal geodatabase format), most of them digitized from different kinds of maps or aerial/satellite imagery (e.g. viewpoints, vegetation, selected portions of the road network and roof area polygons).

Concept and methodology

Methodically the concept discussed in this paper is based on the considerations, that roofscapes deserving protection in normal case consist of an existing historic fabric of buildings and, secondly, that the intended urban conservation measures can be recognised by the people; the latter argument implies, that the results of this activities can be seen under every day conditions and without requiring a special equipment. At this point it is crucial to accept that visibility is the key term which itself is only defined by laws and rules and that this key term literally defines what is to be protected and how. In other words: Architectural interferences in the structural substance of the built environment play a minor role because of the fact, that the state of the technology enables many modifications on buildings and structures (buildings improvements and betterments) with little or none consequences for the over all appearance of building and rooftop. This finding leads to the - in the given context - most important question: What can be seen? And further: From where can it be seen? Referring to these insights this survey is focussed only on the most realistic viewshed scenario, an earthbound observer positioned at a slightly elevated lookout point (Fig. 3).



Fig. 3 – Part of the historic town center of Graz as seen from the Schloßberg looking southwards (Copyright: J. Gspurning)

Due to their relative minority and because of the fact that the interests of this observer type are hardly overlapping the intentions of the GAEG 2008, the actual study does not take into account other scenarios like airborne viewing from planes or balloons or observers in the streets; these cases have turned out to be irrelevant.

The delineation of an area which can be seen from a specific viewpoint (visibility analysis) is usually done by the means of GIS toolboxes, most of them working with regularly gridded raster geodatasets. During the calculation procedure the visibility of each cell center is determined by comparing the altitude angle to the cell center with the altitude angle to the local horizon. The local horizon is computed by considering the intervening surface/terrain between the point of observation and the current cell center. If the point lies higher than the local horizon, it is considered visible. An optional above ground level (AGL) output raster is provided by the tool. Each cell on the AGL output raster records the minimum height that needs to be added to that cell to make it visible by at least one observer. Usually the analysis can be influenced by applying some steering parameters: The optional curvature correction parameter (allows the correction for the earth's curvature) was not applied for calculation. Also a refractivity coefficient (regulates the coefficient of the refraction of visible light in air) was not set. Because of the fact that the highest elevations in the vicinity of Graz are used for viewshed delineation, the relatively small extension of the resulting area-of-interest polygon is responsible for the marginal influence of both parameters on the results.

According to the recommendations given in the corresponding specialist literature (BOHLER et.al. 2004, OBERTREIBER & STEIN 2005, DENDLER 2007 and SCHELLBERG et.al. 2010) in the next step the LIDAR-based surface model (provided by GIS Steiermark) is used instead of digital terrain models applied in comparable approaches; because of its a power of ten finer grid the ALS dataset allows a considerably improvement of the surface representation, especially single objects identification, improved structural element recognition and a more realistic classification of visible areas (ESSER 2008). Potential adverse effects on the field of sight were extracted to a separate vegetation layer and included in the following analyses. As an intermediate result a baseline has been constructed, running circumferential around Graz and defining the location of relevant viewpoints. To reduce the calculation effort only 46 very important points were used for the visibility investigation and – in a second step – for the weighting process. During this stage each time a raster cell within the investigation area can be seen from one of the very important points, a credit is stored in the referring field of the value attribute table; so highest ranking parts of the raster mark areas which can be seen more often than others or, with other words, indicate more valuable regions in terms of roofscape conservation (Fig. 4).

In addition to already (or still to be) implemented weighting factors (like visibility values, touristic attractiveness and other attributes) the preliminary ultimate processing step is focused on the roofscape itself as it integrates some appropriate variables for a reliable characterisation of the roofscape's current state. In more detail, the aim of this sub-module is to find a feasible solution for the assessment of the status quo. This methodically can be done in two ways, by (eventually repeated) description via a set of descriptive attributes or by comparison of the real world situation with an only theoretically reachable optimum.

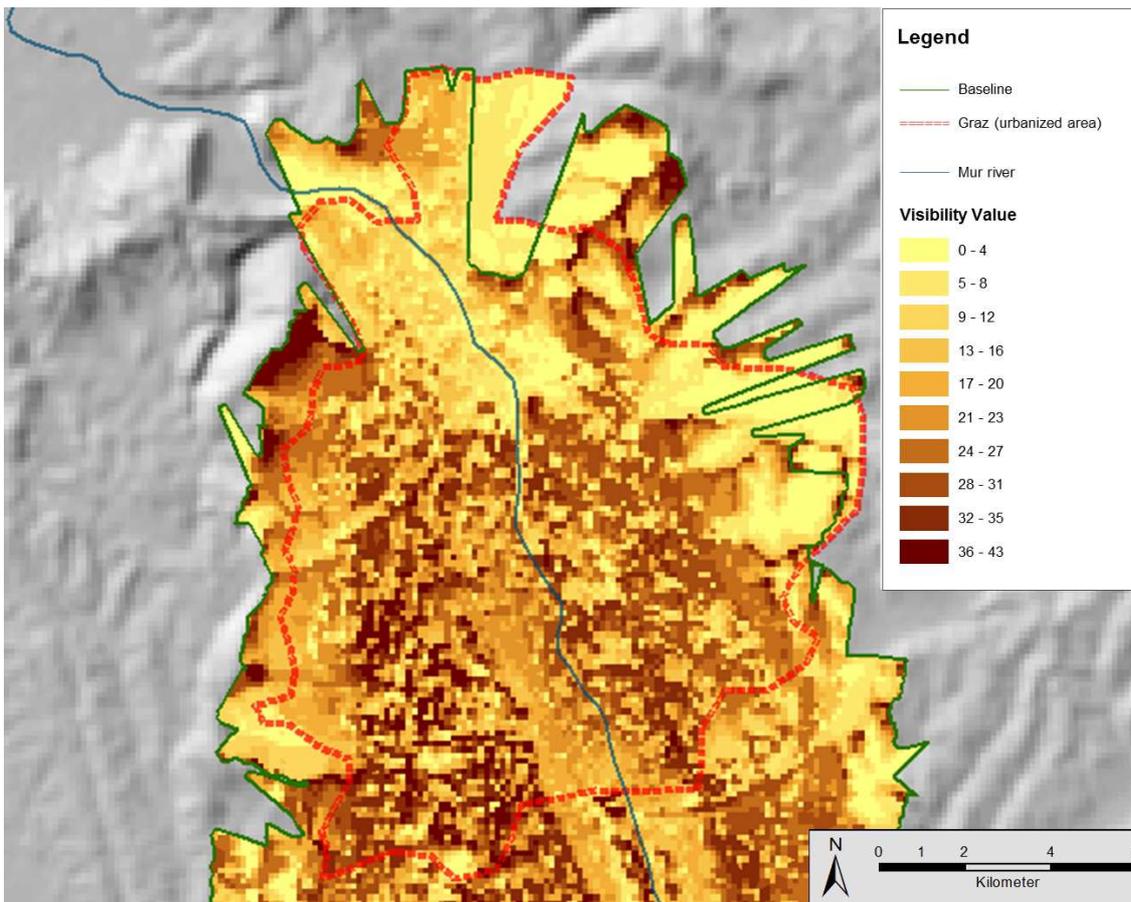


Fig 4 – Visibility values of the urbanized area of Graz (Copyright of the geodata: Land Steiermark - Amt der Steiermärkischen Landesregierung; adaptation by J.Gspurning)

Because of the fact that the last-mentioned option is heavily affected by the lack of well accepted definitions of an „optimal roofscape“, the rating in this study is based on two distinct aspects which easily can be derived from existing attribute data: The first approach concerning the visual impact and the distribution of historical housetop areas is intended to parameterise the patterning and follows the main principle: Larger homogeneous tiled roof areas are on principle more valuable than smaller disconnected ones; but in the case of Graz with its comparatively large contiguous roof scenery this argument has turned out to be not very useful as a differentiator. The second approach concerning the colouring of the roof panel is intended to reflect the visual impression caused by the roofscape. In that case the parametrisation can be conducted by the colour map of the selected roofage area and the grade of its mosaicking. Optimal conserved roofs (consisting of roof tiles conforming to legal regulations) define an ideal (highly rated) reference colour map; this rating is reduced according to the degree of deviation from that given reference sample (in situ calibration). The procedure used to assess the roofscapes is done in an analog manner: The optimum patterning is defined by law/use of accredited roofing materials and by the reference colour map. In practice the analysis starts with the differentiation of roofage and non-roofage areas done by means of high resolution orthophotos which were clipped by the vector layer carrying the footage of the buildings within the test site. The resulting layer shows the projected real roofage areas (e.g. without atria) with all the colours included and allows the compilation of colour maps as well as the extraction of corresponding codes (RGB

as well as CMYK or other systems). Furthermore, this procedure is basically also applicable for pictures taken by standard digital cameras, so data from different sources can be easily used for calibration purposes (Fig. 5).

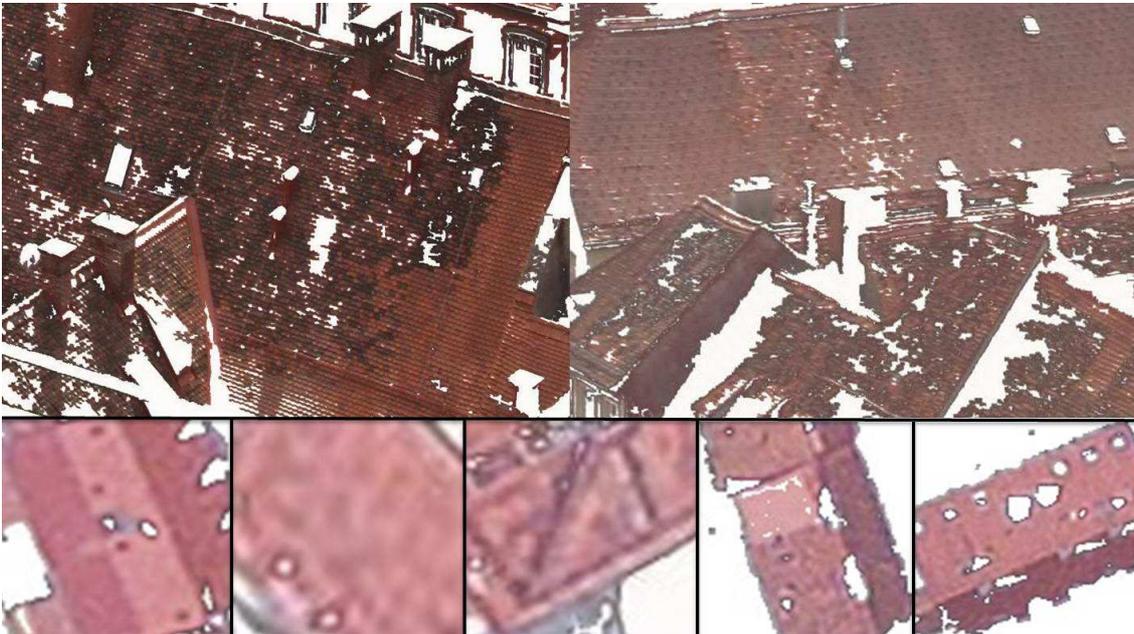


Fig. 5 – Colour map examples for extracted from original oblique images (above) and from gridded orthophotos (below); both scenarios show nearly unbiased portions of the roofscape of Graz. White areas indicate „non-conform“ roofing materials or non-roof areas. (Copyright of images in upper row: Land Steiermark - Amt der Steiermärkischen Landesregierung; Copyright of images in second row: J.Gspurning)

The determination of the colour matrices works slightly different from the method described above. This 2d approach is designed to quantify the clustering of distinct phenomena and it is based much more on spatial autocorrelation statistics and pattern recognition strategies instead of overlay procedures. To enable this modus operandi, the originally raster type data has to be converted to a more flexible point data set carrying nearly the same attributes as already discussed. Although at the moment this technique is only tested in a few sample areas, the employment of point referenced features offers a wide spectrum of additional analyses in the 3d segment turning the attention to the processing of perspective views.

Results and conclusion

Although some parts of the underlying investigations still have to be adopted, this project has already brought feasible results. First and foremost advantage of the suggested solution is that intended acquisition, management and analysis of problem relevant geodata almost necessarily lead to a homogenized data storage concept and a clearly defined workflow enabling spatially referenced aggregation and reclassifications of formerly separate ratings as well as other processing steps throughout the whole project (BIANCHI 2006, BERNDT et.al. 2010). Because of the appropriate quality of the data used for this study, the first level outcomes (i.e. delineation of really visible areas of Graz) are nearly flawless. This statement has

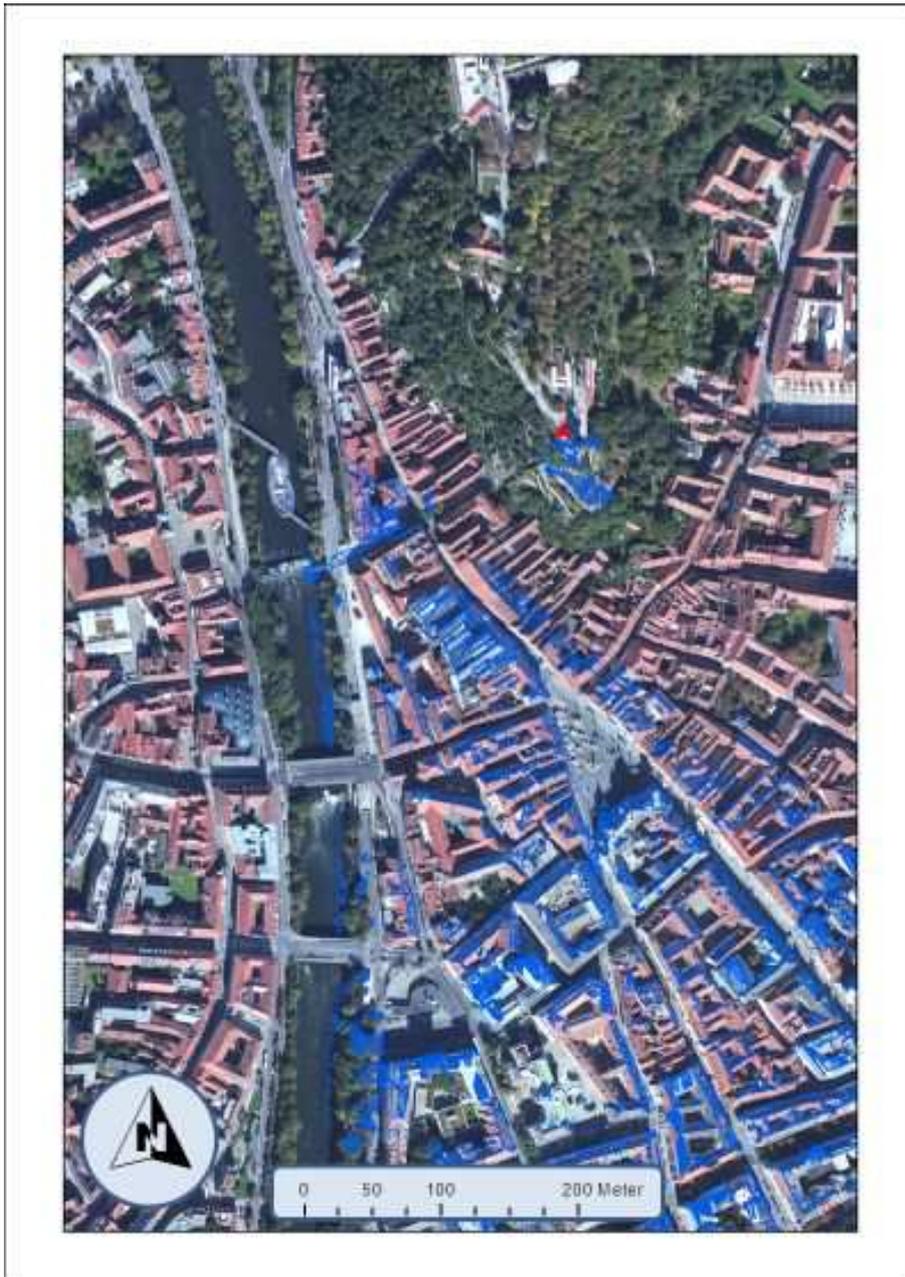


Fig. 6 – Colour orthophoto of the historic center of Graz. The red triangle roughly marks the viewpoint of the visibility analysis as well as the point where the picture in Fig. 3 has been taken from. The blue hatched area indicates the part of the roofscape which can be seen from the given viewpoint. (Copyright: Land Steiermark - Amt der Steiermärkischen Landesregierung)

been verified by a number of empirical visibility tests (well documented by a large series of oblique photographs like the one from Fig. 3 which covers nearly the same visibility field as Fig. 6). Eventually occurring errors probably originate from features finer than the resolution of the ALS-DSM; in that case it may be questionable, if the usage of an ALS with a better resolution than currently used might be worth the additional processing effort.

As part of the second level results (re-assessment of protected areas) the current findings allow three preliminary statements: 1) A surprisingly high amount of rooftops in protected areas can be neglected in the future because – under normal circumstances – they simply cannot be seen! Even considering the principles

of solar radiation (e.g. rejecting roofs with wrong exposition for efficient mounting of photo-voltaic panels) there might be some options open for modifications, reconstruction or other structural improvement. 2) The use of size- and distribution- describing parameters as well as the application of geostatistical tools still seems to be worth trying but implicates conceptual rework and adjustment; especially the determination of correct weighting factors due to missing agreements or audited rule systems will require even more empirical research. Furthermore, the overall size as well as the current preservation state of the roofscape seems to be too narrow margined to allow more profound results. 3) The inclusion of colour map samples as an additional tool for the parameterisation of the historical roofscape's homogeneity and its evaluation has proven a useful instrument, but, in cases of extreme shadow impact the proposed way to generate reference colour samples unfortunately won't work. The recommended workarounds (e.g. the creation of specific "shadowed" reference samples or - if available - the usage of orthophotos with more balanced light condition, calibration by oblique photographs) can solve this problem, but might probably cause other difficulties (e.g. worse or irregular resolution, different date of the pictures,...).

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