

## A SIMPLYFIED DIGITAL ELEVATION MODEL OF HESSDALEN VALLEY

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## 1. Introduction

One of the most meaningful information regarding the unidentified lights of Hessdalen phenomenon is their real spatial position; this information is fundamental for a correct quantitative analysis of the energy involved in this phenomenon. Until now all the available data are lacking of this important information. The aim of this paper is to define a simplified Digital Elevation Model (DEM) of the area where the lights appears, in order to make an a-posteriori spatial analysis of photographic documentation in which those lights are superimposed on recognizable landscape morphological elements, as seen from an observation point of view. In this paper we focus on the landscape reconstruction as seen from the observation point of 2002 EMBLA on field study of the phenomenon, called Aspåskjolen, Long. 11.18139 Deg. East, Lat. 62.83778 Deg. North, ( Leone M., 2003).

## 2. Methodology

In order to build a terrain model of the Hessdalen region, it is necessary to generate an input dataset with geographical information about the interested area. Generally, this dataset is represented by a column matrix with X Y Z columns of spatial coordinates (X and Y) and elevation (Z) of the points sampled from isolines. The sampling process needs a base chart with an explicit coordinate system; we used an on-line topographical 1:50000 scale chart of Hessdalen valley, downloaded from <http://hessdalen.hiof.no/map/>; this chart has a kilometrical square grid of 1 km of side, so the resulting Digital Elevation Model is referred to this projected reference grid. The digitalization was performed with Geosoft Oasis Montaj 5.1, georeferencing the downloaded raster chart with its square grid. The original chart has isolines every 20 meters of topographic altitude variation; all this level lines and topographic tops were used in digitalization process. In order to generate a digitalized topographic map it is necessary to calculate a regular distribution of spatial points from the irregular distribution of points obtained from isolines sampling process. This procedure, called "gridding", calculates a square distribution of points using the real elevation values of spatial

points near the grid nodes, using an inverse distance weight algorithm. In particular we used Minimum Curvature algorithm generating a grid cell size of 50 meters, defining a numerical spatial resolution of 100 meters.

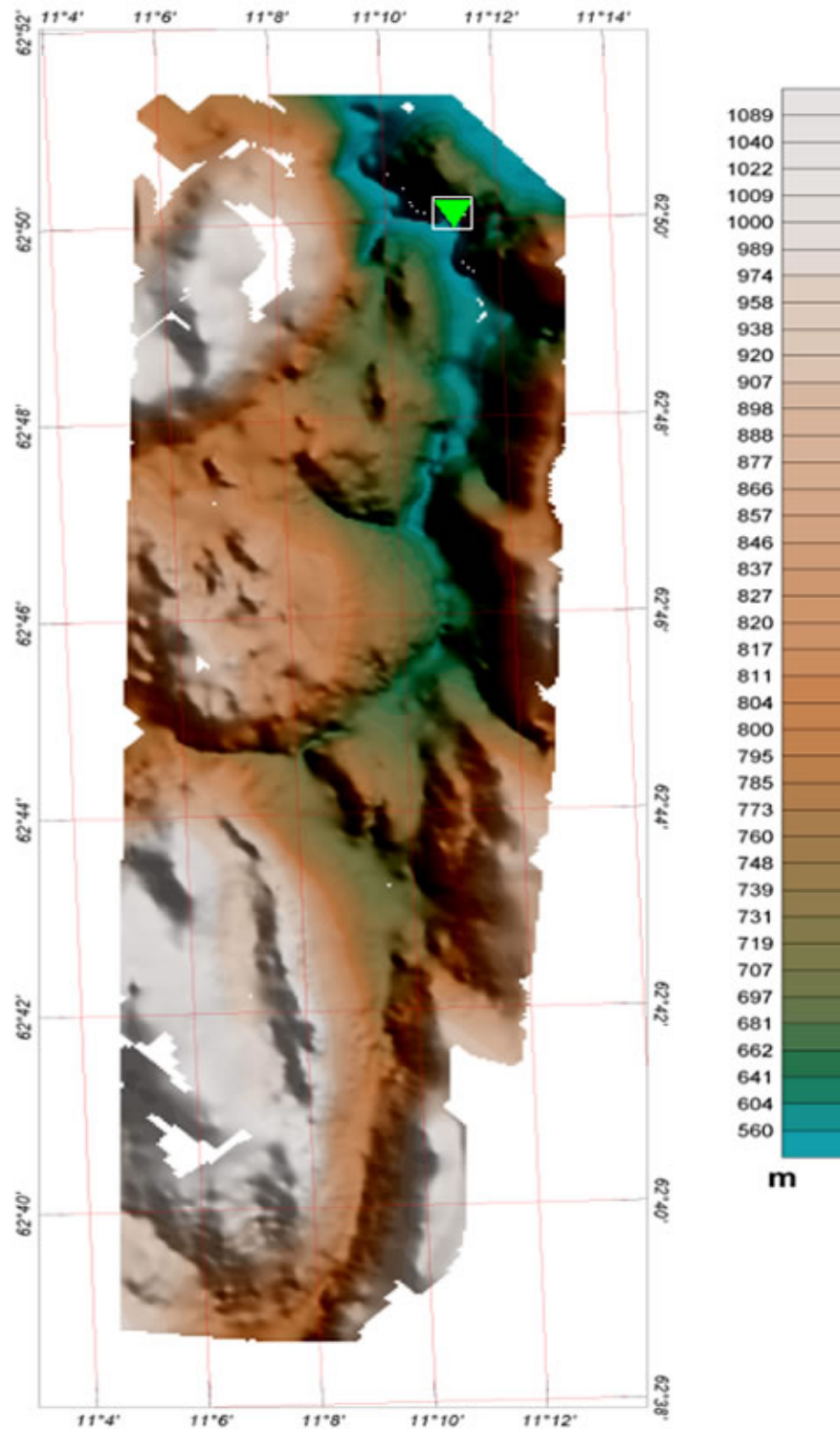


Figure 1: the resulting false colours elevation digitalized model after gridding (grid cell size 50 m), in geographical coordinate system, with an illumination from NE. The inverted green triangle marks the location of Aspåskjolen observation site.

Fig. 1 shows the resulting digital elevation model in false colours, as obtained from gridding process of the isolines samples. The green inverted triangle in the map represents the spatial position of the Aspåskjolen observation point ; as visible from the map, the direction of observations is southward. The white areas on the map represents zones in which the gridding interpolation algorithm can't rebuild the topographic structures due to the lack of data samples from digitalization process. Since our target was to study the landscape view from Aspåskjolen, we acquired only the areas visible from this observation point.

Using Oasis Montaj 5.1 it is possible generate a 3D image of the digitalized area as seen from a generic point of view, simulating a realistic perspective eye naked view.

### 3. Results

Our first study was applied to the lights images which are shown in Teodorani's paper regarding the 2002 EMBLA optical mission report; our aim was to evaluate a possible distance range of the cluster of lights in figure 1 of Teodorani's paper. Our attention was focused on frame 5 of Teodorani's fig. 1, also discussed by M. Leone's critical paper ("A Rebuttal of the EMBLA 2002 report on the optical survey in Hessdalen"). In this last paper an Author's photo of the landscape view from the Aspåskjolen observation point in southward direction is presented (figure 2 on his work), from where Teodorani's pictures were acquired. The Author also superimposed a red rectangular area that correctly identifies the area of Teodorani's pictures. In this paper we analyze the original Teodorani's picture, kindly furnished by the Author; using the gridded digital data we defined a possible perspective view from Aspåskjolen in order to match the real photo with our 3D terrain model. In fig.2 there is the real landscape image compared with our landscape reconstruction from DEM; it's easy to identify all the same landscape morphological elements, even if the Digital Elevation Model is a simplification of the real morphology. The red line on the reconstruction represents the track of the Våruskjølen's road, a private track road, as seen from the observation point.

In Fig.3 a selection of Teodorani's picture, containing the unidentified lights analyzed also by M. Leone, is overlapped on the 3D model; changing the prospectical view of the 3D reconstruction (Fig. 5), it's easy to correlate the morphological elements of the picture and of the 3D reconstruction with the

topographic map of that area, giving them a name; the ridge hill, beyond which the lights seems to be located, belongs to the Heggsethøgda hill complex. (yellow dashed line in Fig 5), while the hill on which the lights seem to be superimposed is the Løbergsvollen-Eggevollen hills (white dashed line in Fig. 5). The nearest ridge is the Våruskjølen hill, beyond which the Våruskjølen road disappears. The background mountain is identified as the Nyvollhøgda peak.

Using the coordinates of the Aspåskjolen site indicated in M. Leone's paper, we estimated the azimuth of the cluster lights in  $185^\circ$ . Then we traced an elevation profile line from the Aspåskjolen observation location along this azimuth direction (Fig.6) and, drawing a tangent line to the Heggsethøgda ridge from Aspåskjolen observation site, we estimated the apparent angular elevation of the lights; in this way we obtained a value of about  $+0.4^\circ$ . Another information given by the profile is that the lights distance must range between 4 and 12 Km, that are the distances of the two hills between which the lights appear.

Pictures Courtesy by Dr. M. Teodorani

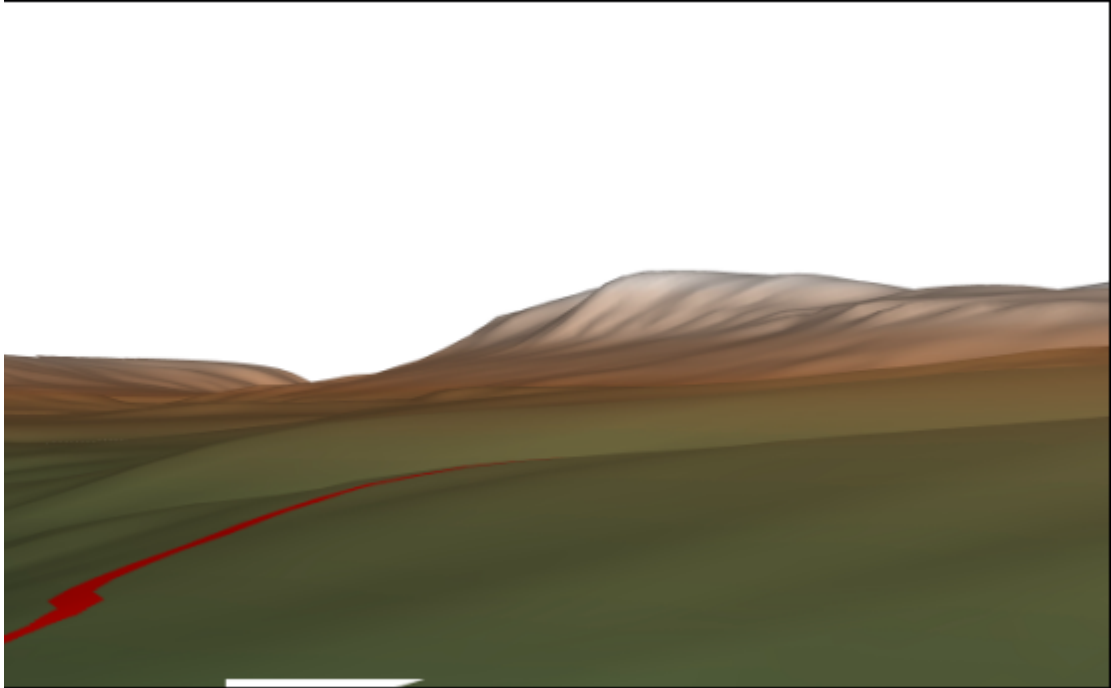
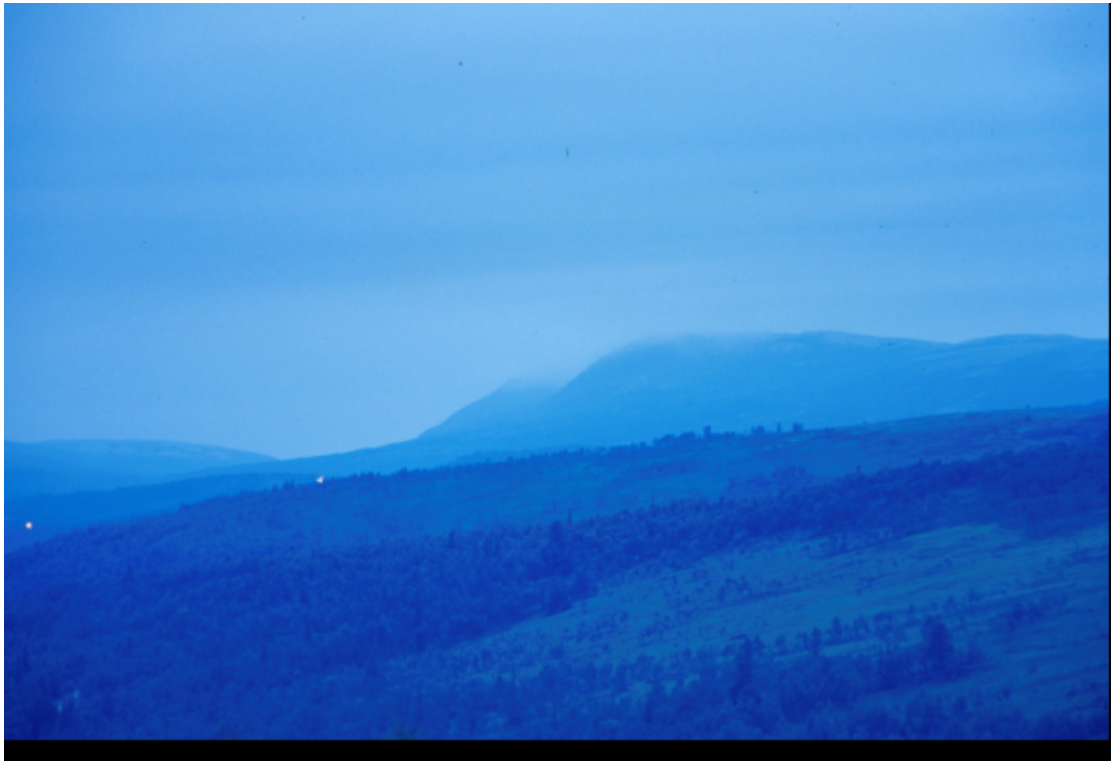


Figure 2: landscape perspective view as seen from Aspåskjolen observation site. The top picture is the real image, the bottom is our 3D model. The red continuous line is the track of Våruskjølen's road.

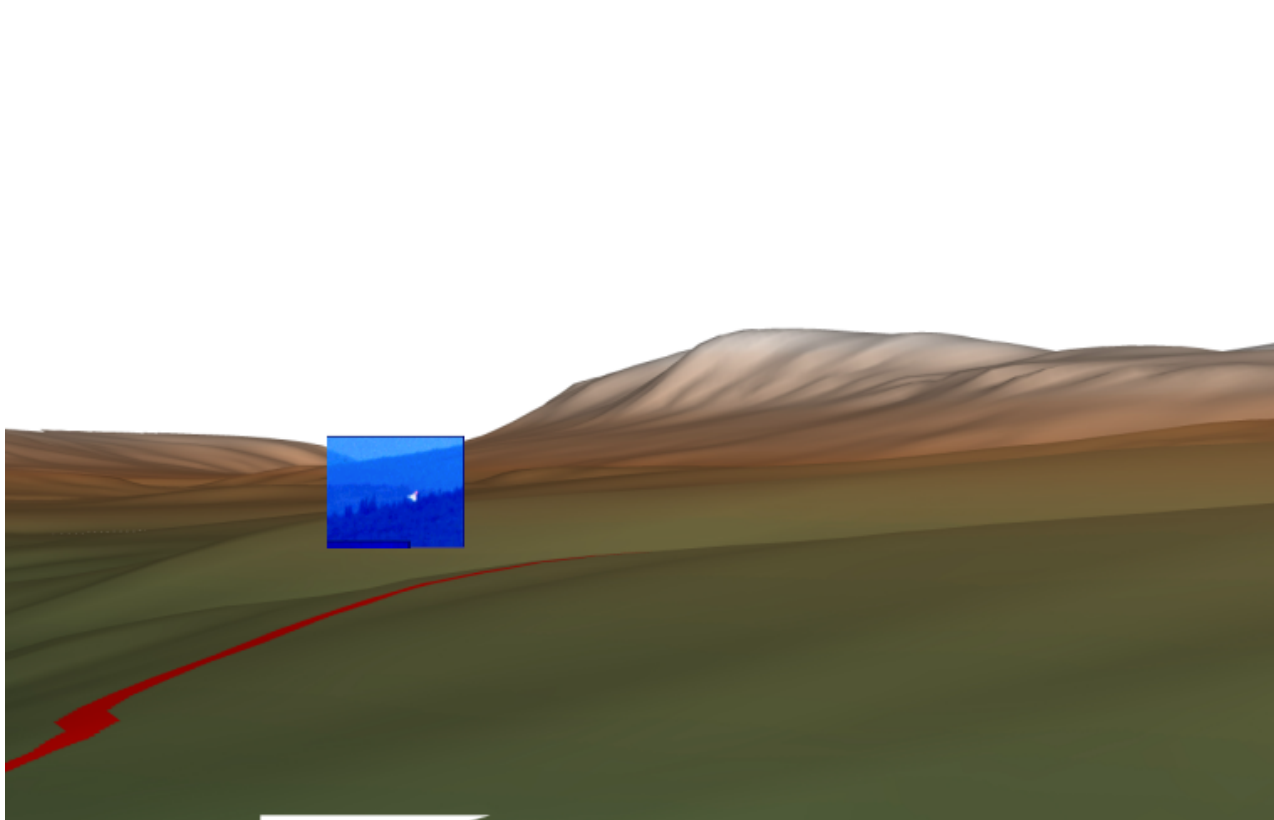


Figure 3: superimposition of a rectangular box, extracted from the original Teodorani's image, on our 3D Digital Elevation Model. As visible, there is a good correlation between the two images, and the morphological landscape elements can be easily evaluated from DEM.

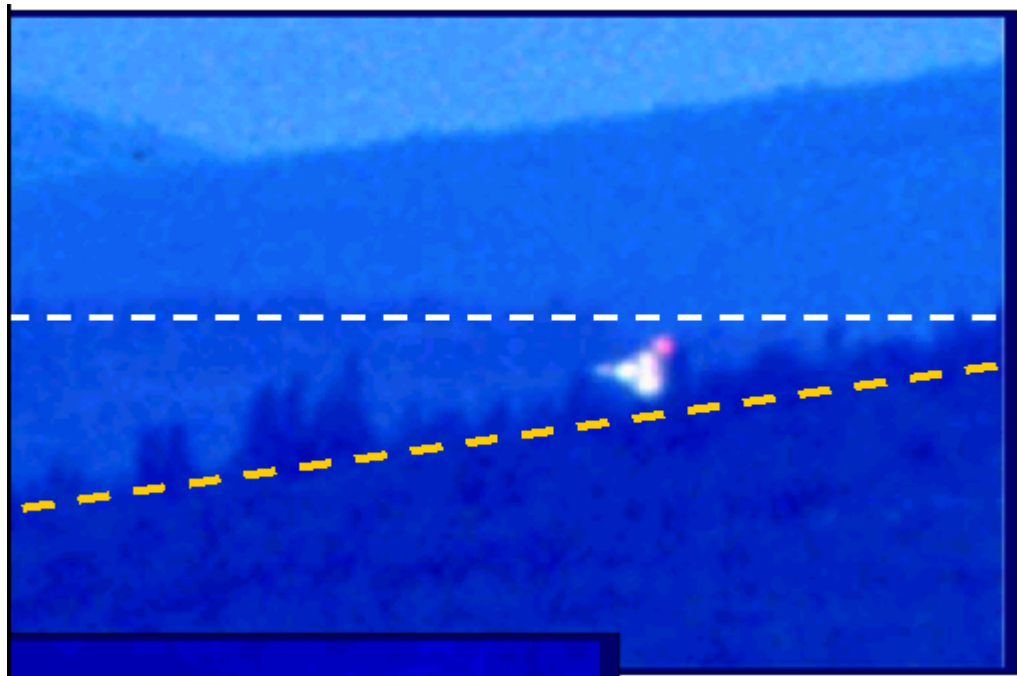
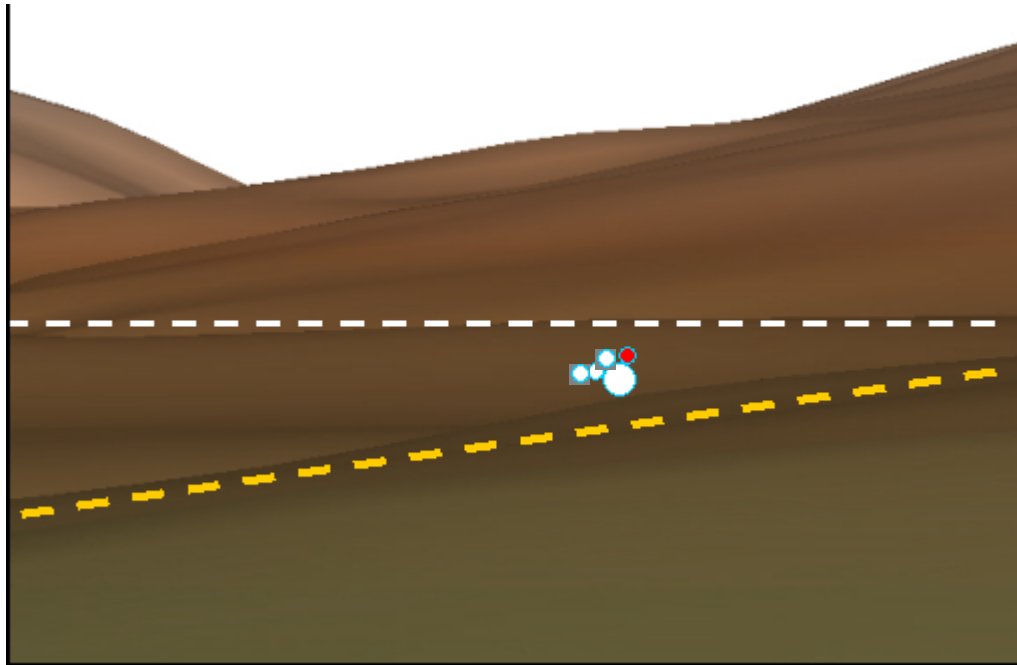


Figure 4: comparison between the enlargement of the rectangular box extracted from the real image and the corresponding area of the model; the white full circle in the reconstruction represents the lights location, as seen in the real picture. The white and yellow dashed lines on images represent the reference ridges to identify the position of the cluster lights.

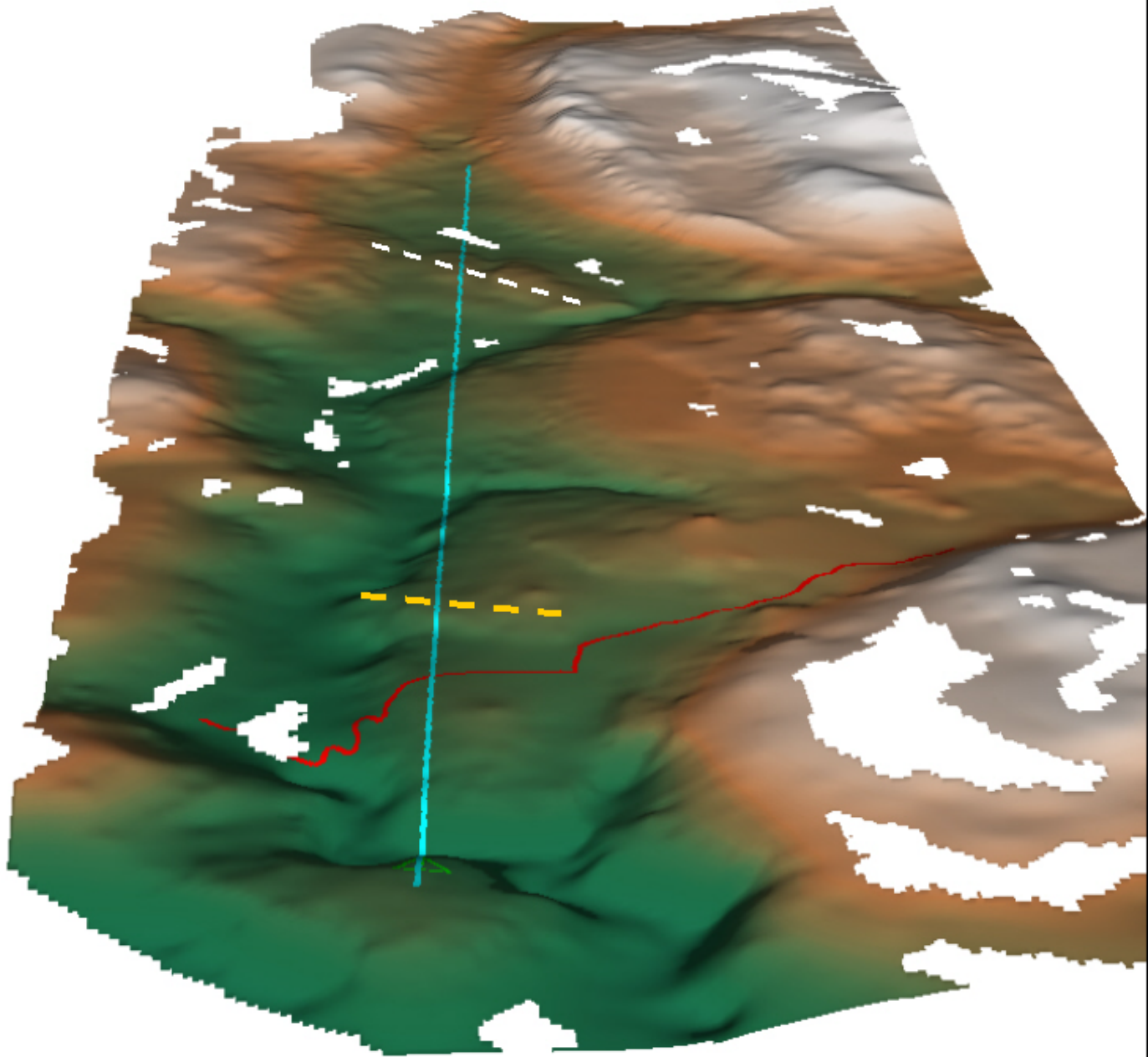


Figure 5: the same reconstruction of Fig. 3, seen from a different point of view. Yellow and white dashed lines of fig. 4 are identified as Heggsethøgda and Løbergsvollen-Eggevollen ridge respectively; the blue line represents the 185 deg. azimuth profile line from Aspaskjolen.

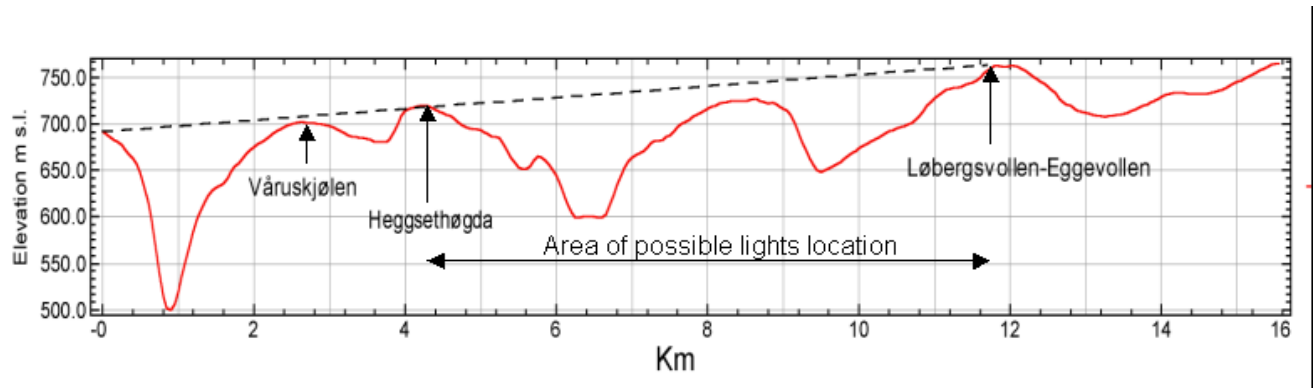


Figure 6: elevation profile line along 185 deg. azimuth direction from Aspåskjølen. The apparent angular elevation of this line of view, tangent to Heggsethøgda's hill complex and about the same of the cluster lights, is  $+0.4^\circ$ .

#### 4. About M. Leone's paper "A Rebuttal of the EMBLA 2002 report on the optical survey in Hessdalen"

In this chapter we want to compare the apparently contrasting results of our's and M. Leone's papers; in his work he correctly identifies the location of Teodorani's picture on a southward landscape image, taken from Aspåskjolen, highlighting it with a red rectangular box (Fig.2 of his work). Afterwards, he tries to define its angular coordinates taking as reference the apparent angular coordinates of two landscape peaks, correctly identified as Mount Hessjøhøgda and Mount Nyvollhøgda; in perspective view the red box azimuth is located between these two mountains, and its elevation is a little bit lower than the two peaks. Using a topographical maps he defines azimuth and elevation of M. Hessjøhøgda and M. Nyvollhøgda as:

Mountain	Azimuth(°)	Elevation(°)
Hessjøhøgda	187.7	+0.023
Nyvollhøgda	180.9	+0.019

Starting from those angular values he estimates the azimuth and elevation of the red box as  $185.1 \pm 0.2^\circ$  and  $-1.0 \pm 0.2^\circ$  (tab.2 of his paper); this elevation value is quite different from our  $+0.4^\circ$  estimate.

From Leone's paper we learn that "...during a week-long stay at Hessdalen, (M.Leone) had two chances to see the almost motionless and point like light phenomenon sighted and photographed by Teodorani and Nobili from the "Aspåskjolen" site.." and that he easily identified the second sighting as car headlamps, using a 60 mm refractor. Since these evaluations, Matteo Leone looked for a road compatible with the location of these presumed car headlamps. He identified a private track road that crosses the Våruskjølen's hill and analyzed the angular coordinates of three spots of this road, obtaining the values:

Våruskjølen's road	Azimuth(°)	Elevation(°)
Spot 1	$187.6 \pm 0.6$	-0.3
Spot 2	$186.2 \pm 0.7$	-0.9
Spot 3	$185.5 \pm 1.0$	-1.7

These values are consistent with those of the red box obtained by M. Leone,

arguing that the area of the red box is crossed by the Vårhuskjølen road. After those results the reader is guided to believe that all lights phenomenon appearing around the red box area are due to car headlamps running across the Våruskjølen's road, also supporting this with revised quantitative energy estimates of lights, after constraining the distance parameter of phenomenon (2.2 km, which is the distance between Aspåskjolen and Våruskjølen's road).

As showed above these results are inconsistent with our elevation estimate of the cluster lights area. To understand this incompatibility we checked all the angular estimates following M. Leone approach; we found that the angular values of Våruskjølen's road are correct, while the elevation of the red box area is wrong due to an error in the angular elevation estimate of the two mountain peaks, taken as reference. In fact, considering that M. Hessjøhøgda peak is 1057 m tall, M. Nyvollhøgda 1044 m tall, that the distance from Aspåskjolen are  $15.9 \pm 0.1$  km and  $18.1 \pm 0.1$  km respectively, and that the Aspåskjolen elevation is 690m, it is easy to evaluate that the apparent angular elevation of the two peaks are  $+1.3^\circ$  and  $+1.1^\circ$  respectively, much more than M. Leone's estimate. From this new angular elevation, and considering that, as M. Leone correctly estimate that the red box is about  $1^\circ \pm 0.2$  below the Hessjøhøgda peak, we can calculate that also with this approach the elevation of the red box seen from Aspåskjolen is  $+0.3 \pm 0.2^\circ$ , matching perfectly, inside the error, our  $+0.4^\circ$  estimate. The conclusions are that, using two different approaches, we obtained the same angular values for the cluster lights area, absolutely incompatible with the Våruskjølen's road. So, M. Leone's evaluation of the cluster lights distance, 2.2 km from the observation point, is wrong, as shown in chapter 3, subsequently also the power out evaluation of the lights has been heavily underestimated, clearly incompatible with car headlamps.

## Acknowledgements

We wish to thank the Sassalbo Project's coordinator Dr. Marco Peruzzi (Mr. Spock) for his precious support during the layout of this paper, and the kindness of Dr. Massimo Teodorani for his critical review.

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Maps of Hessdalen - <http://hessdalen.hiof.no/map/>