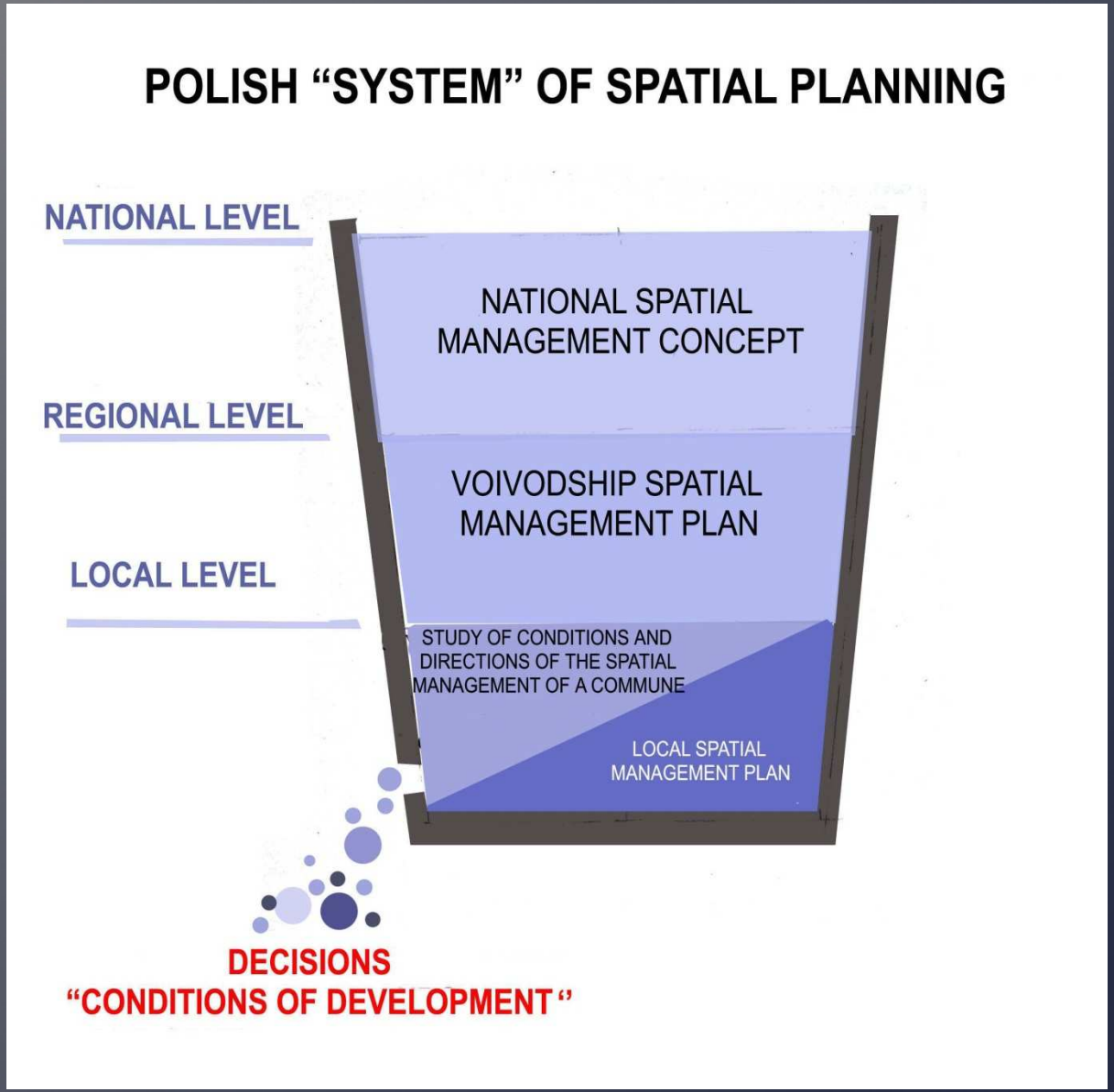
Thematic school on modelling and visualising spatial dynamics:
Reasoning on long time spans and uncertainty

Frejus, 8 -12 October 2012

Computer modelling of landscape aesthetic values and visual preferences

Agnieszka Ozimek
Paweł Ozimek
Institute of Computer Science
Cracow University of Technology

Computer modelling of landscape aesthetic values and visual preferences



Böhm's bucket

Planning is connected with time, simulation of the different scenarios of development and with modelling the future, as well.

Digital models are very efficient as far as simulation of different states and phenomena are concerned:

- We visualize the effect of changes in land management on the attractiveness of views from different places.
- The method of visualisation is directly connected with types of digital data, digital models and ways of their representation.

During the last three years we have been conducting the research upon the methods of computer modelling of relations between landscape sensations and profits that can come out from exposition of these attractions.

Our intention is to show that land management, oriented into the attractive landscape preservation and places where you can sense it, can bring more benefits than the other ways of exploitation of this terrain.

The receivers of this research should be spatial planers, landscape architects and landowners who make decisions about regional development.

Pilot project – Czorsztyn Lake Valley

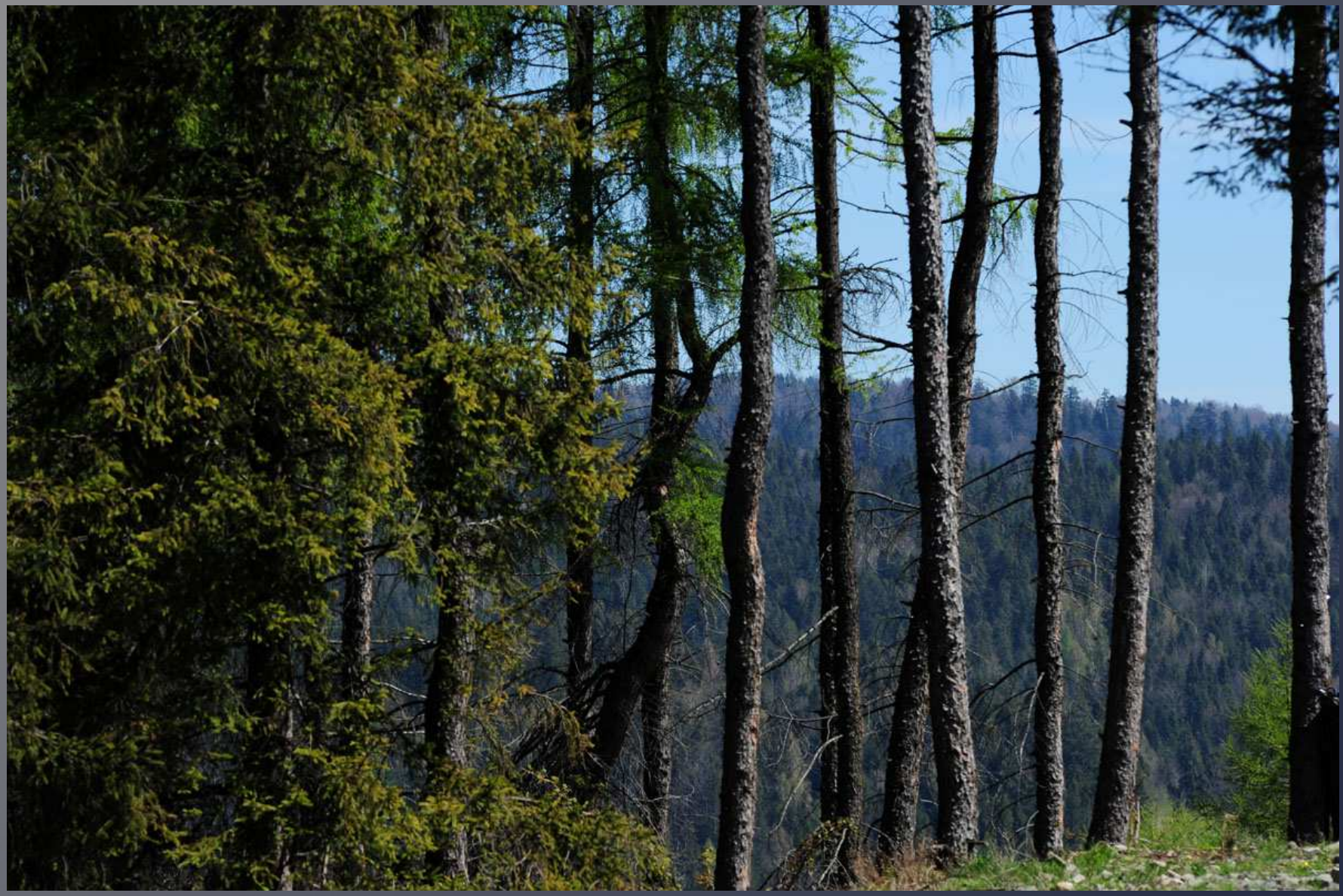
Computer modelling of landscape aesthetic values and visual preferences

Computer modelling of landscape aesthetic values and visual preferences

Computer modelling of landscape aesthetic values and visual preferences

Computer modelling of landscape aesthetic values and visual preferences

Computer modelling of landscape aesthetic values and visual preferences

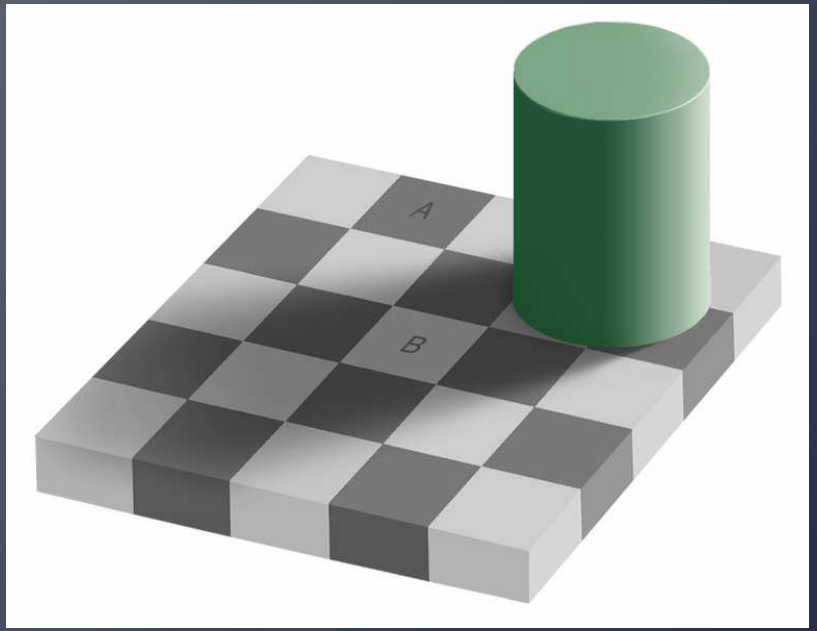


Computer modelling of landscape aesthetic values and visual preferences

Computer modelling of landscape aesthetic values and visual preferences

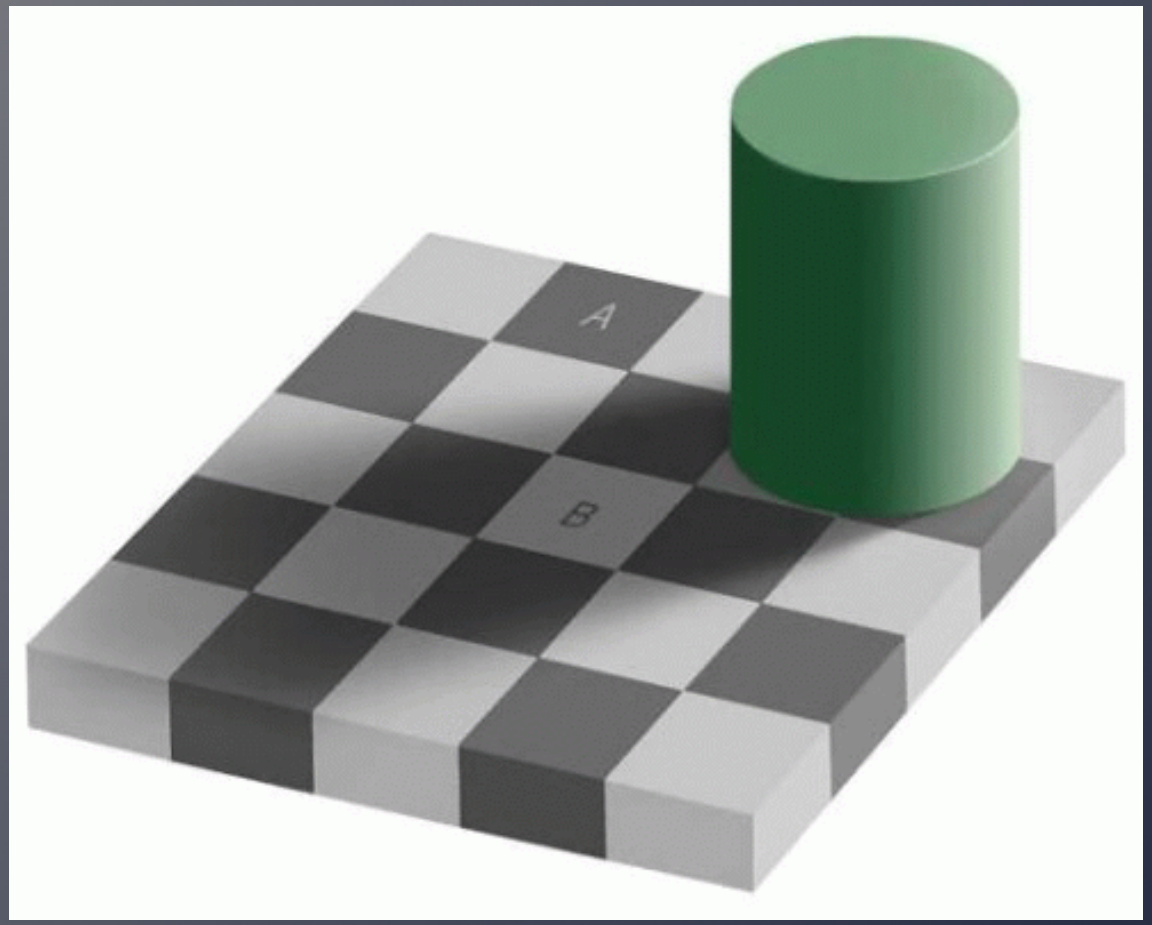
Computer modelling of landscape aesthetic values and visual preferences

What’s the reason of using computer analyses?



Adelson’s chessboard
Our perception is not objective

(http://pl.wikipedia.org/)



Adelson’s chessboard
Our perception is not objective

(http://pl.wikipedia.org/)

The process of landscape perception:

purpose,
expectation,
preconception,
context (environment),
movement (mode, speed, conditions),
visibility,
perception (scanning),
seeing (understanding),
evaluation (meaning and affect),
acting (or not),
remembering,
recalling (repeating)….

Ervin S., Steinitz C., „Landscape visibility computation: necessary, but not sufficient”, Environment and Planning B: Planning and Design 2003, volume 30, p.. 763

“Qualified judges method” – distinguishing of aspects that have positive effect on the landscape perception:

unusualness,
sublimity,
persistence,
abundance of planes/wings,
image dynamics,
rare species of flora and fauna,
diversity of colours and textures,
harmony of composition,
objects connected with the leisure time or with local tradition and folklore,
outstanding monuments and cultural edifices,
motifs arousing historical associations,
objects that encourage to explore local attractions,
folk events and festivals,
outstanding technical structures,
non-visual sensations welcomed in landscape.

“Qualified judges method” - aspects lessening the overall impression:

industrial buildings,
energetic infrastructure elements,
mining areas,
waste dumps,
large-scale agricultural objects,
dispersed development,
primitive forms of engineering structures,
big entertainment centres,
large-scale advertisements,
disharmonious buildings’ forms,
prefabricated elements of landscape architecture,
foreign species of flora and fauna,
pseudo-historical arrangements out of the natural context,
temporary commercial objects,
big car parks,
motorization in the wild land,
seasonal devastations.

Rating of the positive aspects

feature / value	III	II	I
„U” uniqueness	global	national	regional
„A” authenticity	unimpaired	impaired to a certain degree	definitely impaired
„W” scale	panorama	landscape interiors ans sequences of views	motifs
„S” structure	integrated	fragmentary	dispersed

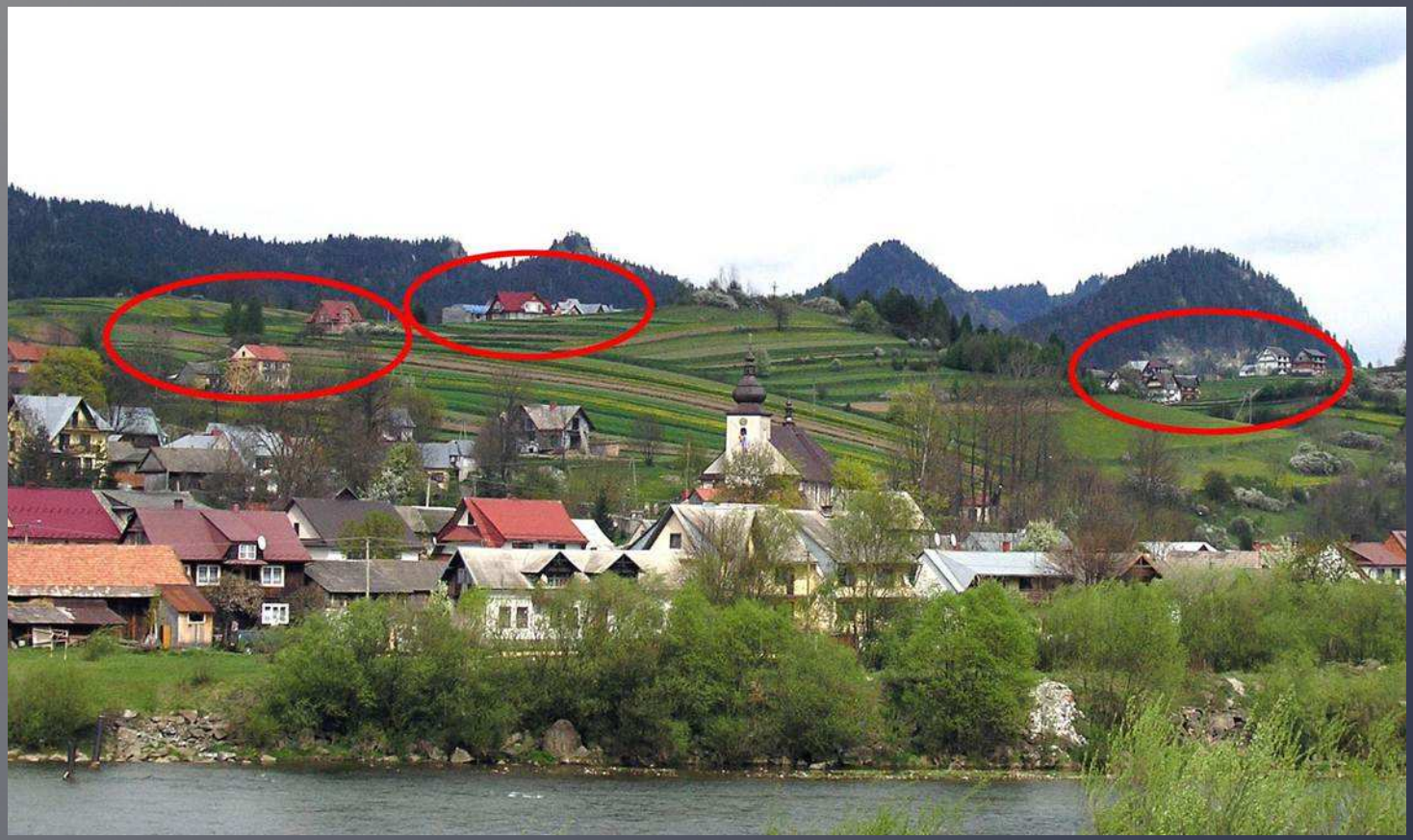
Rating of the negative aspects

feature / value	III	II	I
„B” triviality	global	national	regional
„N” artificiality	striking	visible	hardly noticeable
„W” scale	panorama	landscape interiors ans sequences of views	motifs
„S” structure	integrated	fragmentary	dispersed

Levels of perception

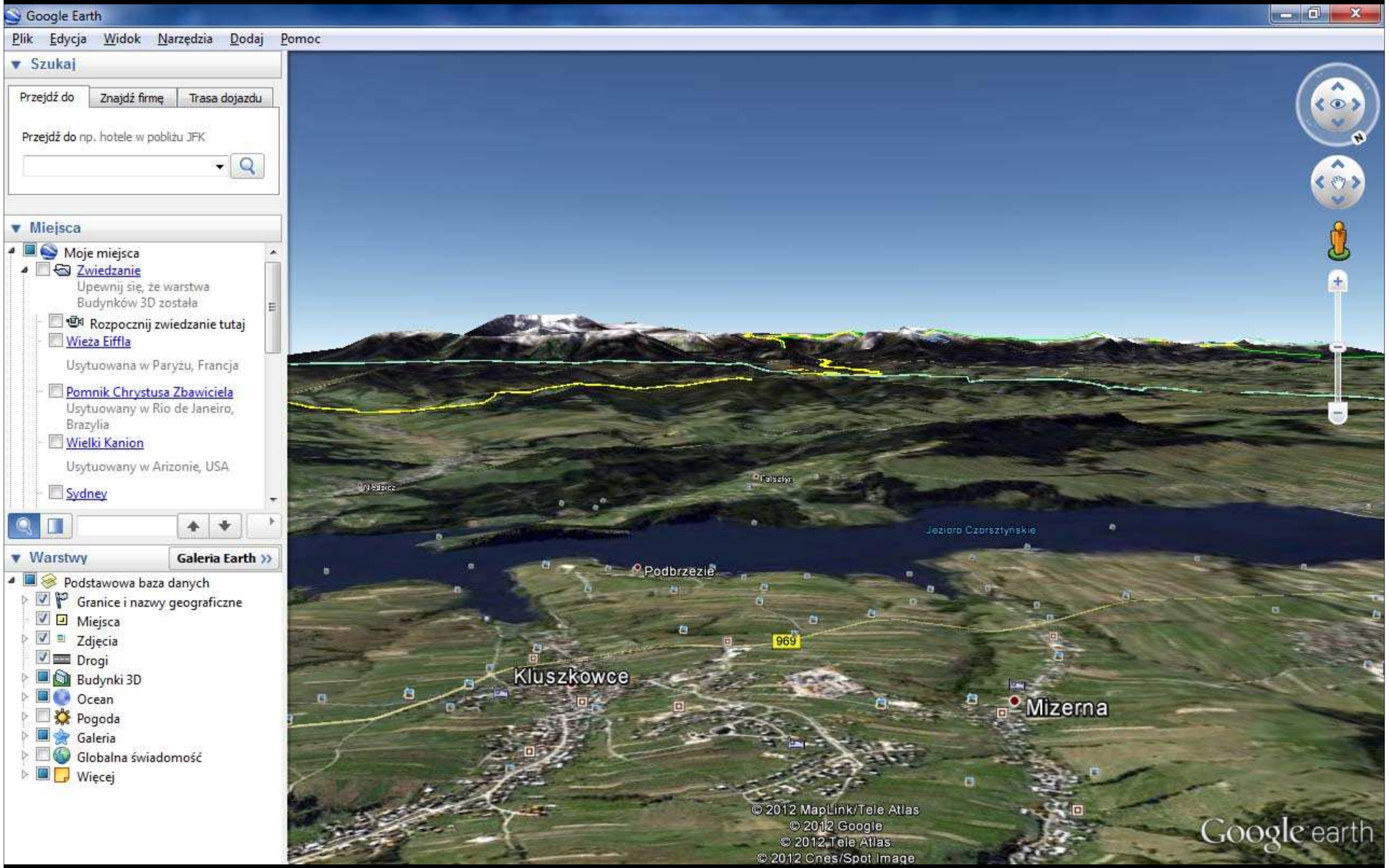
sensory-motor	automatic perception of stimuli through senses (sight, hearing, sense of smell, touch…)	**I**
semantic-functional	attaching meaning to the received stimuli (e.g. a church, a forest...)	**II**
Semantic-symbolic	attaching feelings to phenomena (e.g. admiration, nostalgia, aversion…)	**III**

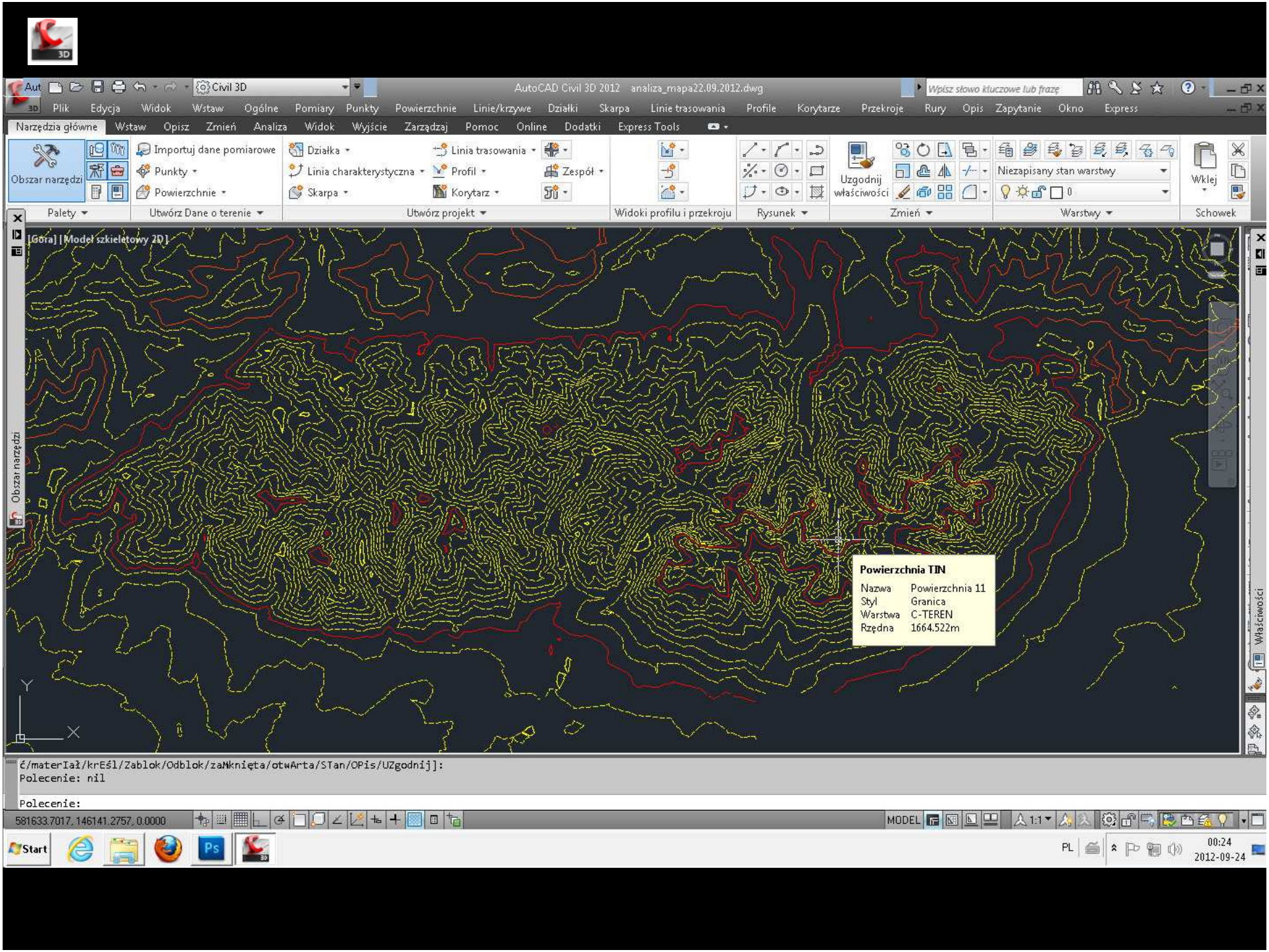
Tatras panorama and a „sea of haze” (a view from the Luban hill)	U	A	W	S	P
Sublimity – captivating power of Nature (e.g. sea, mountains, wilderness…) without feeling of fear	II	III	III	III	III

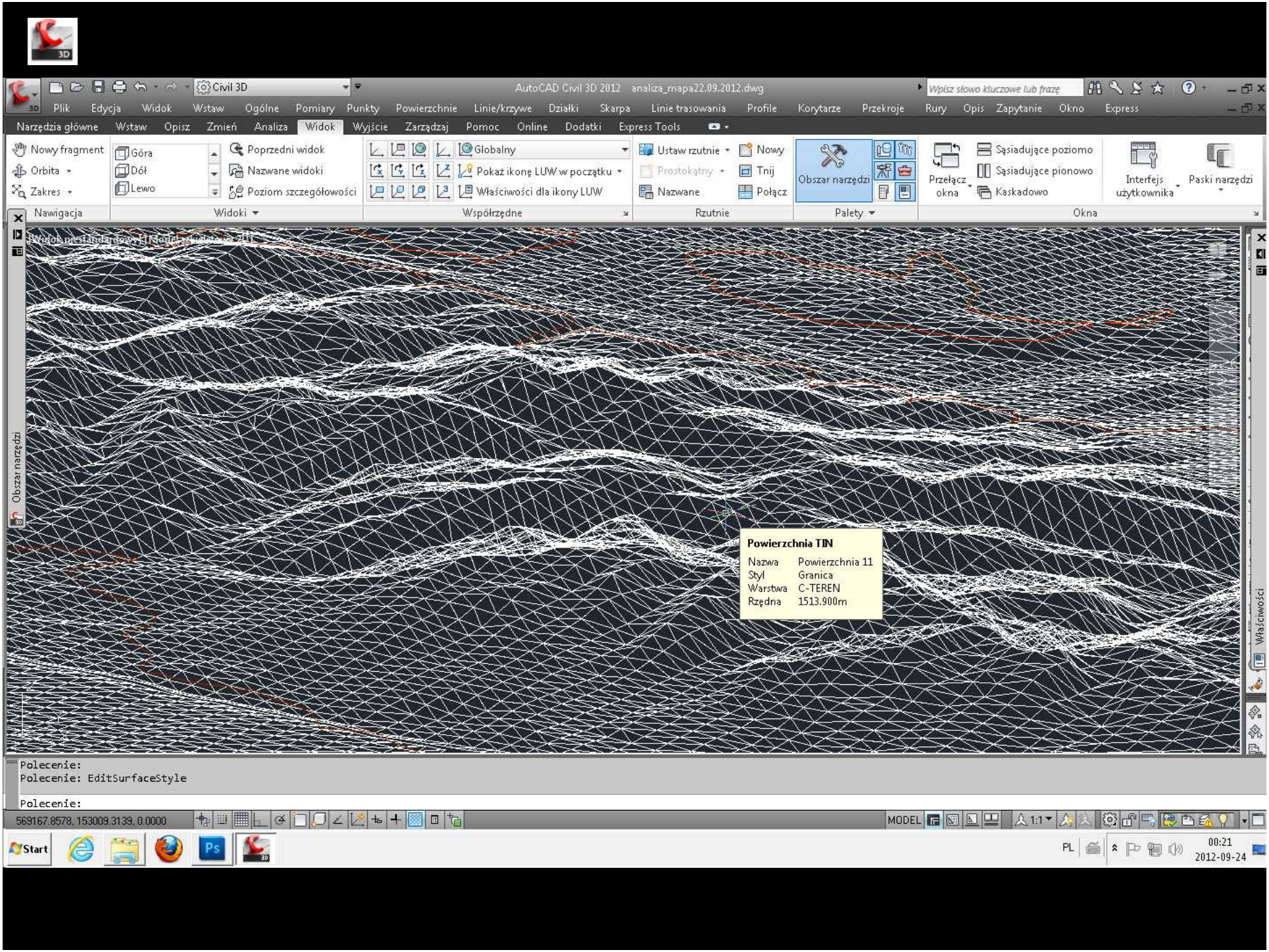


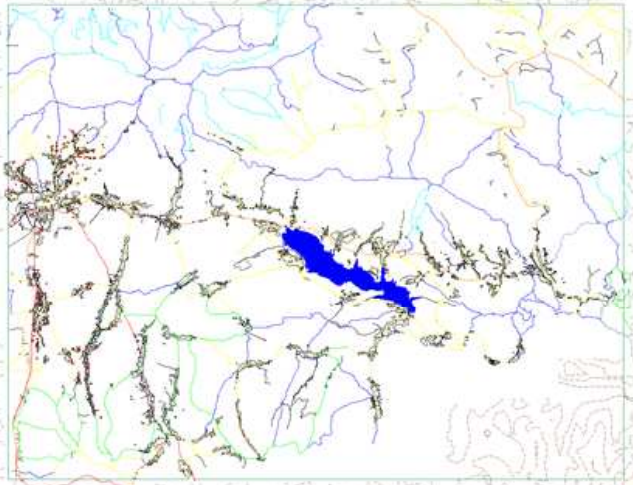
Rapid development in the neighbourhood of the National Park (Sromowce village)	U	A	W	S	P
Chaos – degradation of open space	II	III	III	III	III

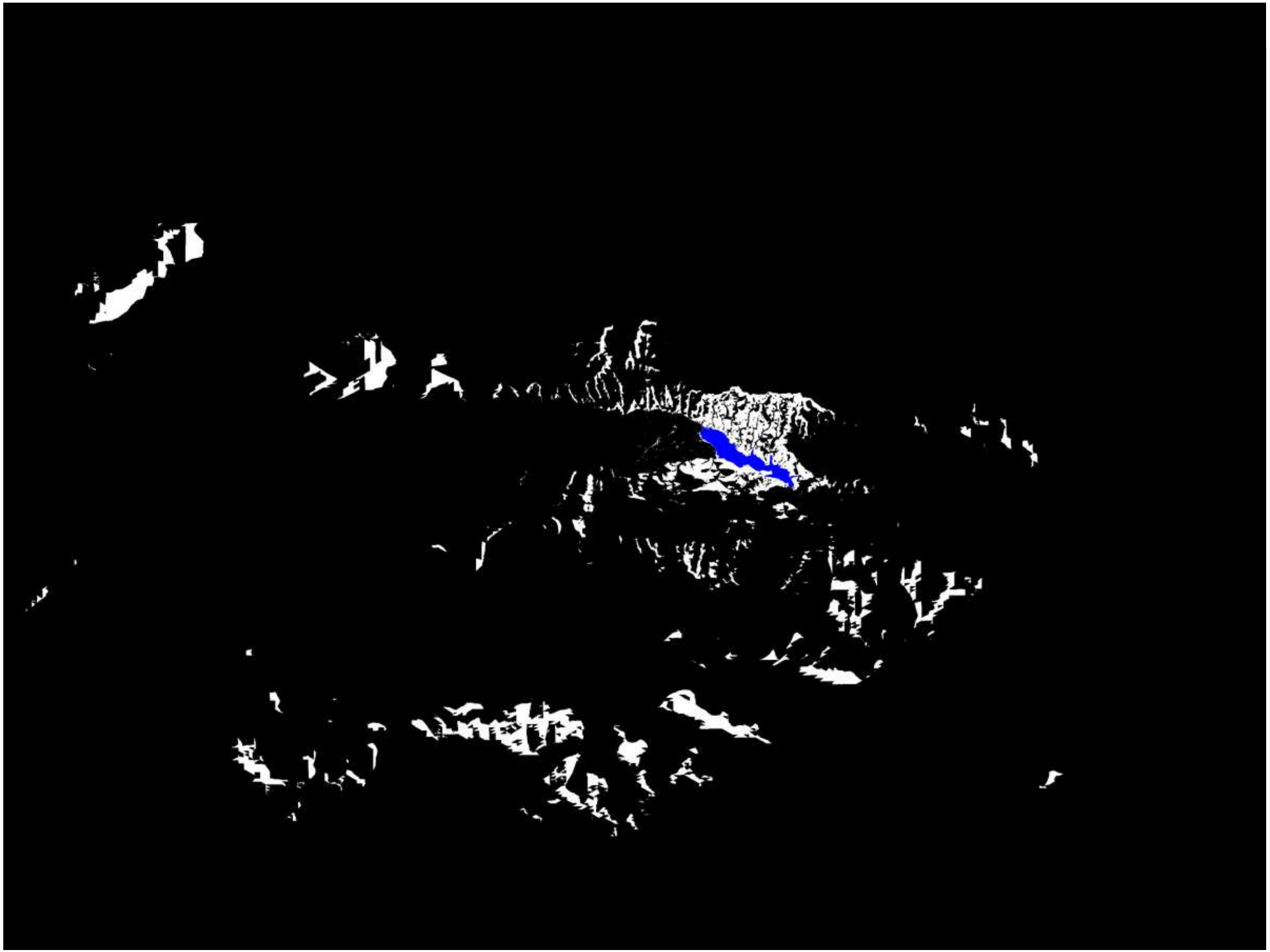
Computer modelling of landscape aesthetic values and visual preferences.

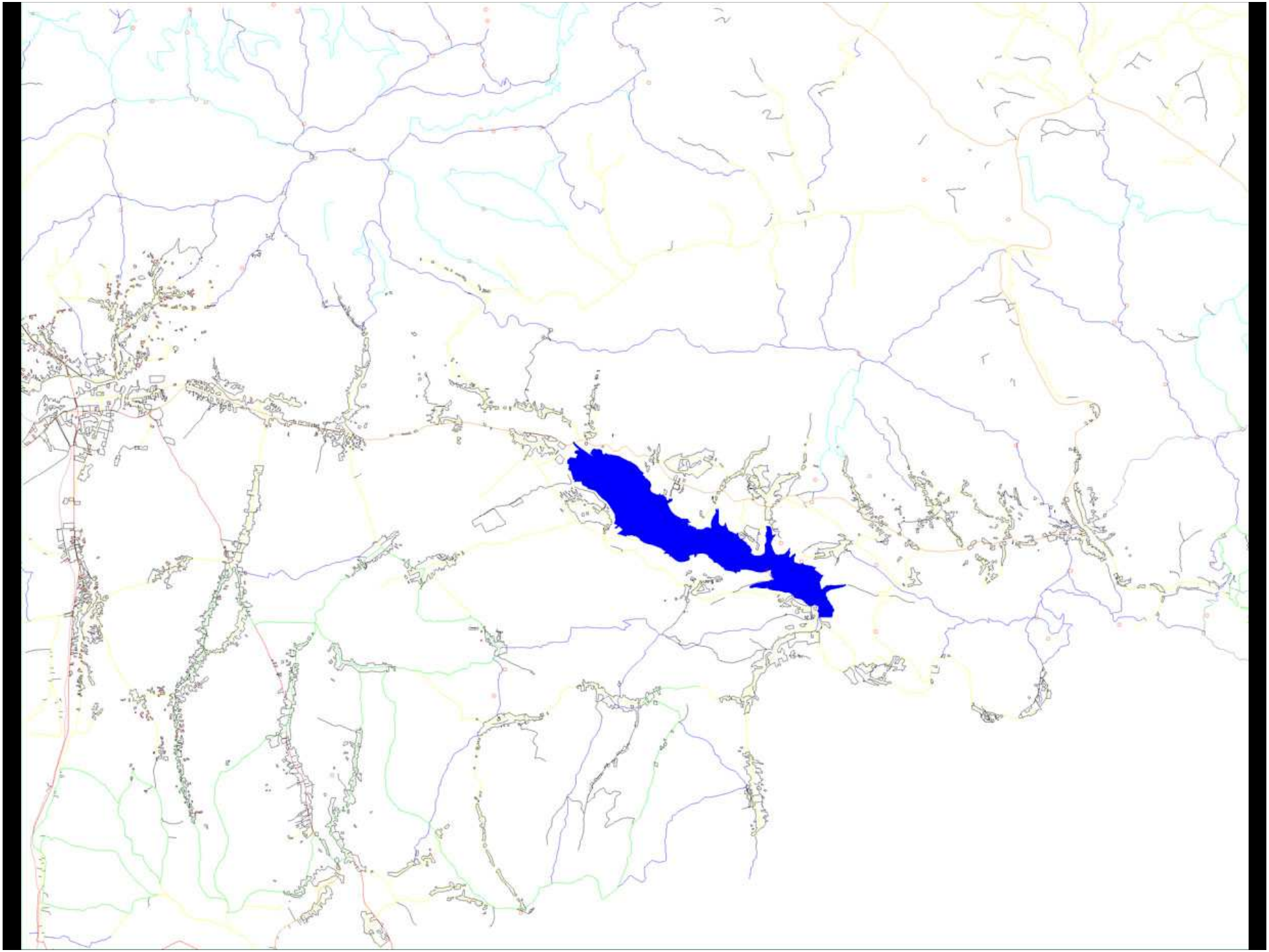


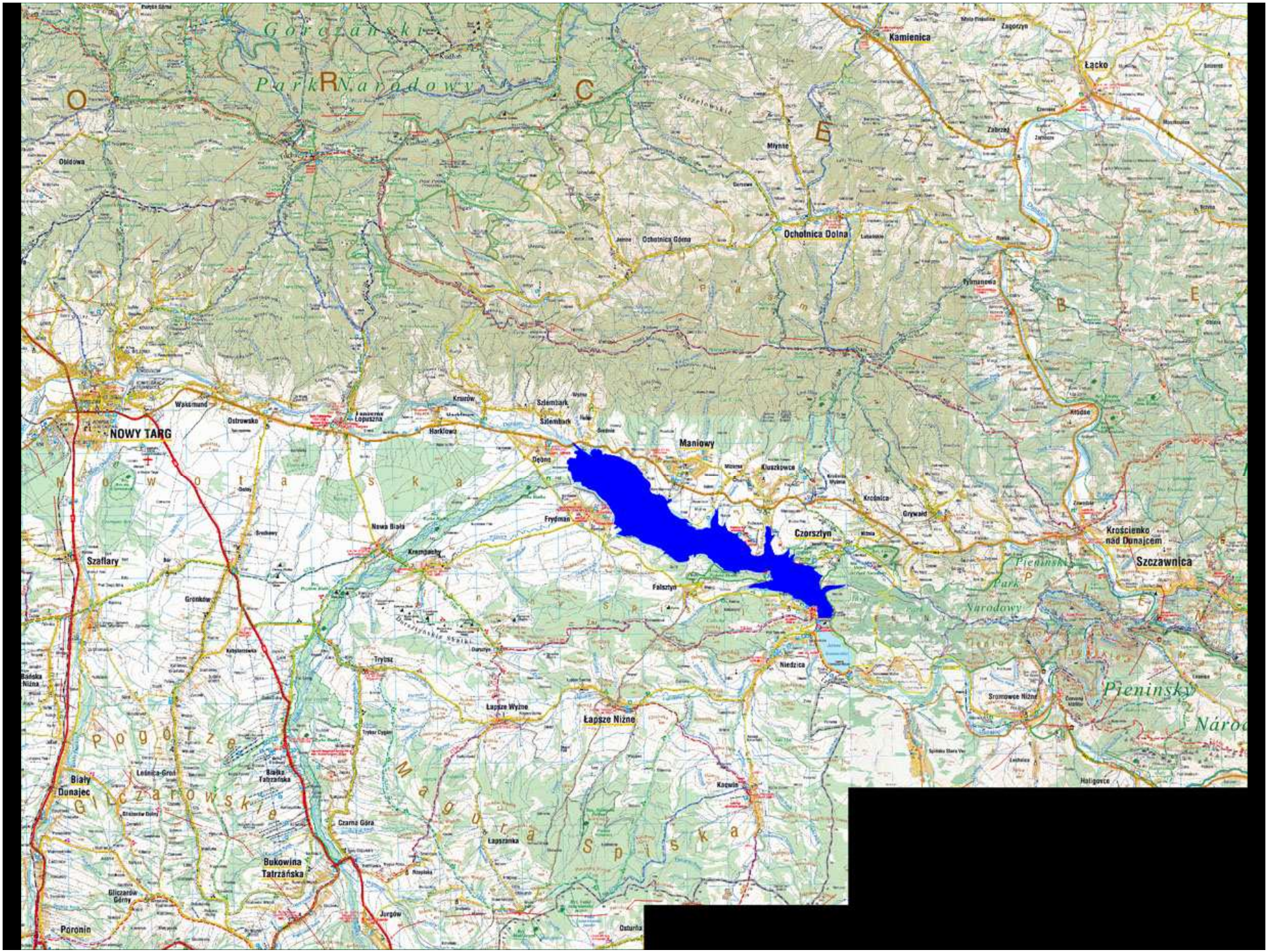

AutoCAD Civil 3D 2012 analiza_mapa22.09.2012.dwg
Civil 3D
Wpisz słowo kluczowe lub frazę
Plik Edycja Widok Wstaw Ogólne Pomiary Punkty Powierzchnie Linie/krzywe Działki Skarpa Linie trasowania Profile Korytarze Przekroje Rury Opis Zapytanie Okno Express
Narzędzia główne Wstaw Opisz Zmień Analiza Widok Wyjście Zarządzaj Pomoc Online Dodatki Express Tools
Obszar narzędzi
Importuj dane pomiarowe
Punkty
Powierzchnie
Działka
Linia charakterystyczna
Skarpa
Linia trasowania
Profil
Korytarz
Zespół
Uzgodnij właściwości
Niezapisany stan warstwy
Wklej
Palety
Utwórz Dane o terenie
Utwórz projekt
Widoki profilu i przekroju
Rysunek
Zmień
Warstwy
Schowek
[Góra] [Model szkieletowy 2D]
Obszar narzędzi
Właściwości
Powierzchnia TIN
Nazwa Powierzchnia 11
Styl Granica
Warstwa C-TEREN
Rzędna 1664.522m
ć/materIał/krEśl/Zablok/Odblok/zaMknięta/otwArta/STan/OPis/UZgodnij]:
Polecenie: nil
Polecenie:
581633.7017, 146141.2757, 0.0000
MODEL
1:1
Start
PL
00:24
2012-09-24

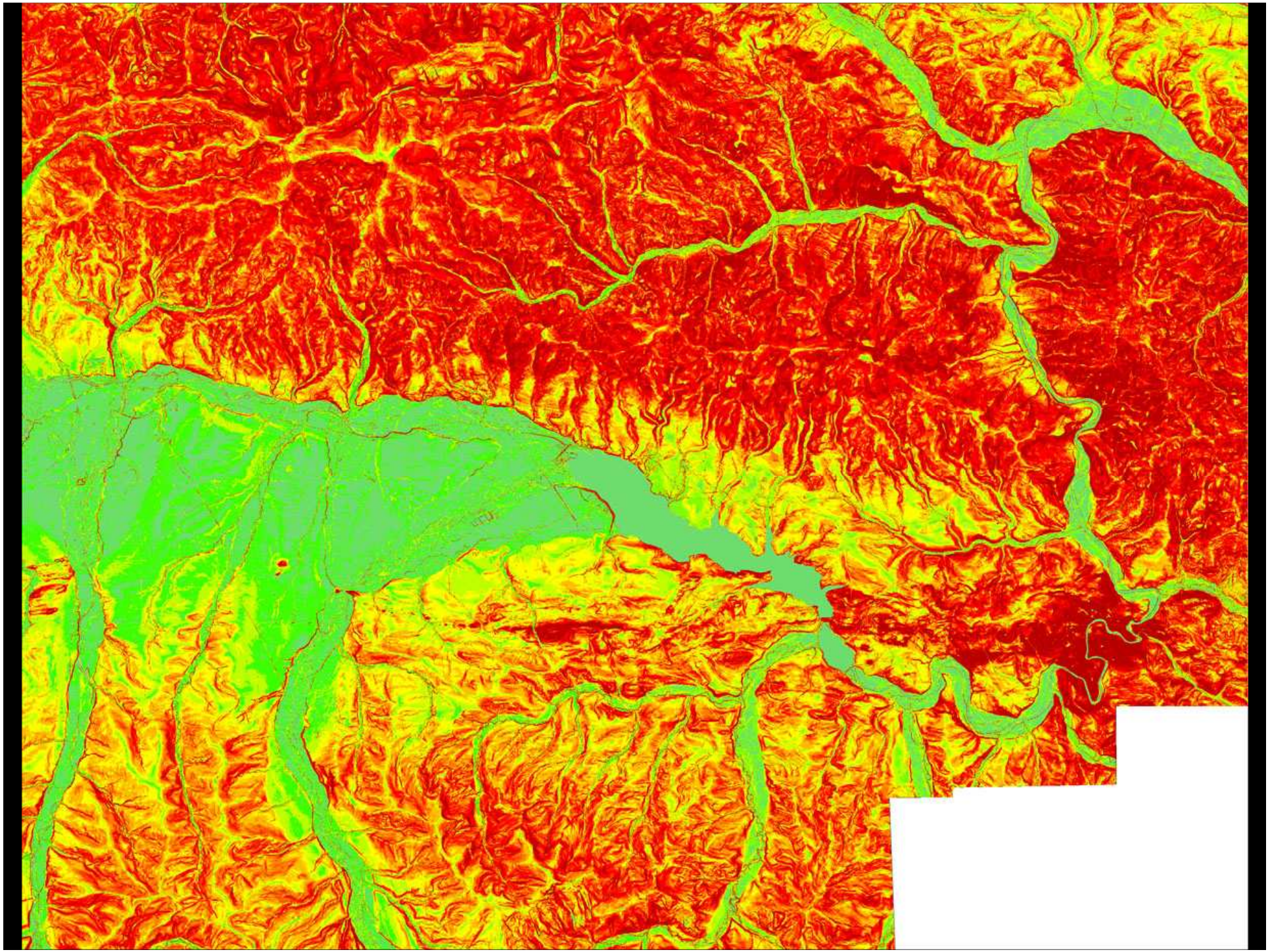

Civil 3D
AutoCAD Civil 3D 2012 analiza_mapa22.09.2012.dwg
Wpisz słowo kluczowe lub frazę
Plik Edycja Widok Wstaw Ogólne Pomiary Punkty Powierzchnie Linie/krzywe Działki Skarpa Linie trasowania Profile Korytarze Przekroje Rury Opis Zapytanie Okno Express
Narzędzia główne Wstaw Opisz Zmień Analiza Widok Wyjście Zarządzaj Pomoc Online Dodatki Express Tools
Nowy fragment
Orbita
Zakres
Nawigacja
Góra
Dół
Lewo
Poprzedni widok
Nazwane widoki
Poziom szczegółowości
Widoki
Globalny
Pokaż ikonę LUW w początku
Właściwości dla ikony LUW
Współrzędne
Ustaw rzutnie
Prostokątny
Nazwane
Nowy
Tnij
Połącz
Rzutnie
Obszar narzędzi
Palety
Przełącz okna
Sąsiadujące poziomo
Sąsiadujące pionowo
Kaskadowo
Interfejs użytkownika
Paski narzędzi
Okna
Obszar narzędzi
Właściwości
Powierzchnia TIN
Nazwa Powierzchnia 11
Styl Granica
Warstwa C-TEREN
Rzędna 1513.900m
Polecenie:
Polecenie: EditSurfaceStyle
Polecenie:
569167.8578, 153009.3139, 0.0000
MODEL
1:1
Start
PL
00:21
2012-09-24

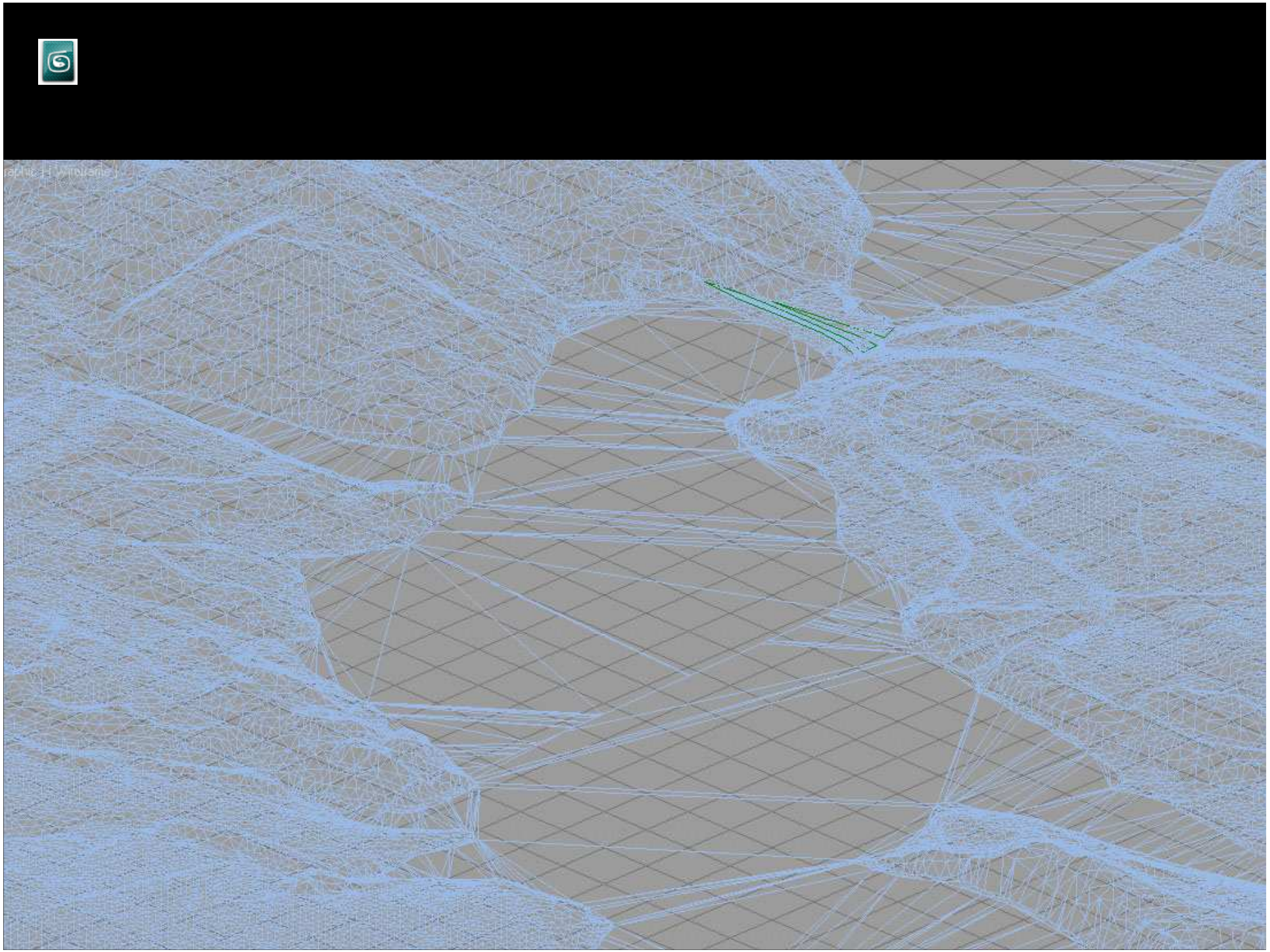


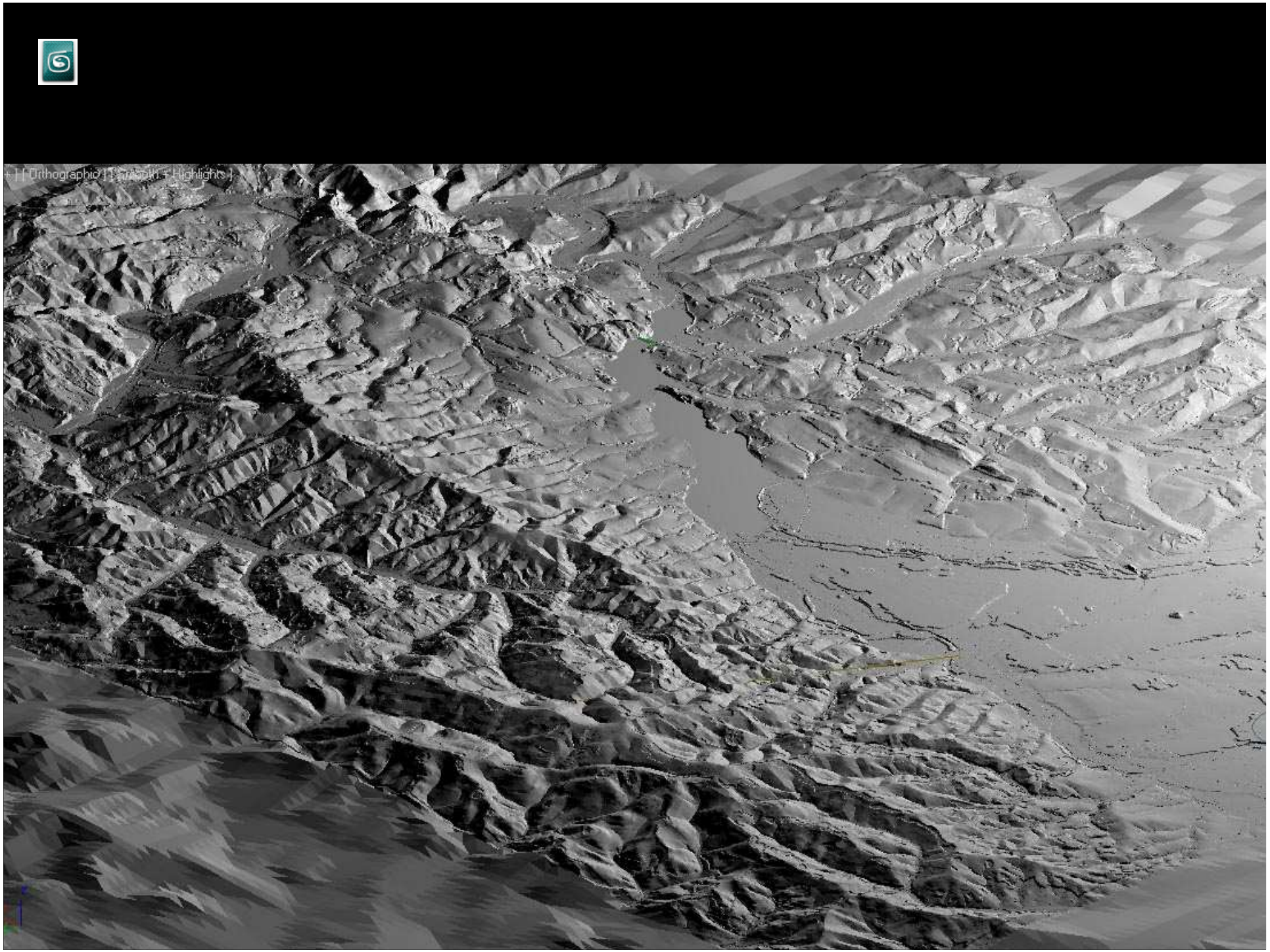




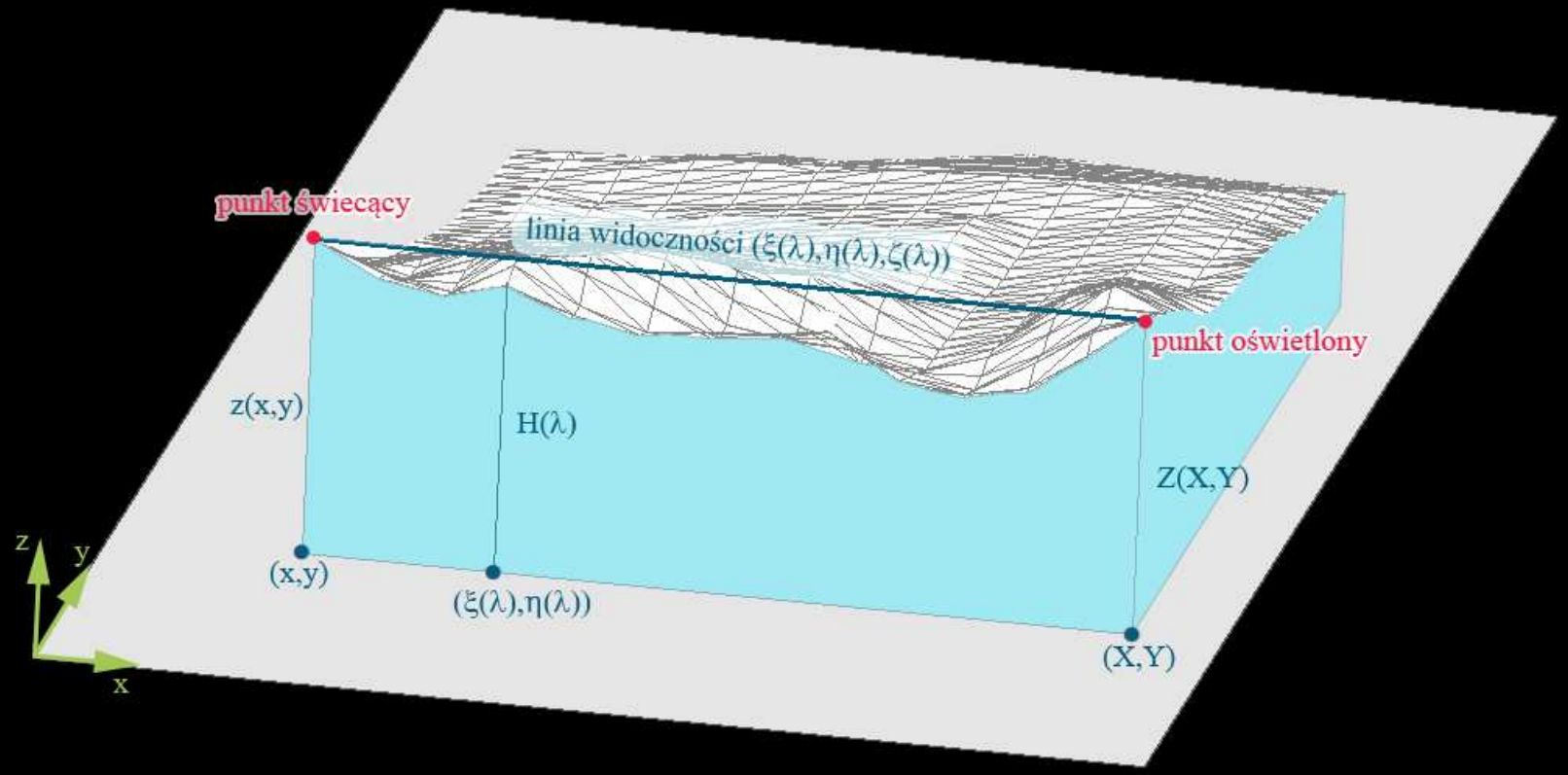

Gorczański
Park Narodowy
Kamienica
Łącko
Obidowa
Ochotnica Górna
Ochotnica Dolna
Maniowy
Krościenko nad Dunajcem
Szczawnica
NOWY TARG
Szaflary
Czorsztyn
Niedzica
Łapsze Niżne
Łapsze Wyżne
Biały Dunajec
Bukowina Tatrzańska
Poronin
Pieniński Park Narodowy
Pieninský Národný
Pogórze Gliczarowskie
Magura Spiska







Model of visibility calculation



(x,y) – point on the map
z = z(x,y) – height of point (x,y)
(x,y,z) – spatial coordinate
w(X,Y,Z,x,y,z) – visibility function of point(x,y,z) from point(X,Y,Z)

For any 2 points (X,Y,Z), (x,y,z): w(X,Y,Z,x,y,z) = w(x,y,z,X,Y,Z).

$$w(X,Y,Z,x,,z) = \begin{cases} 1, & point\ \ (x,y,z)\ is\ visible(X,Y,Z) \\ 0, & point\ (x,y,z)\ is\ invisible\ (X,Y,Z) \end{cases}$$

Visibility line (straight segment) linking points (X,Y,Z) i (x,y,z):

$$\begin{aligned} \xi(\lambda) &= X + \lambda(x - X) \\ \eta(\lambda) &= Y + \lambda(y - Y) \quad ,\boldsymbol{\lambda \in [0,1]} \\ \zeta(\lambda) &= Z + \lambda(z - Z) \end{aligned}$$

Point height in terrain „under" visibility line:

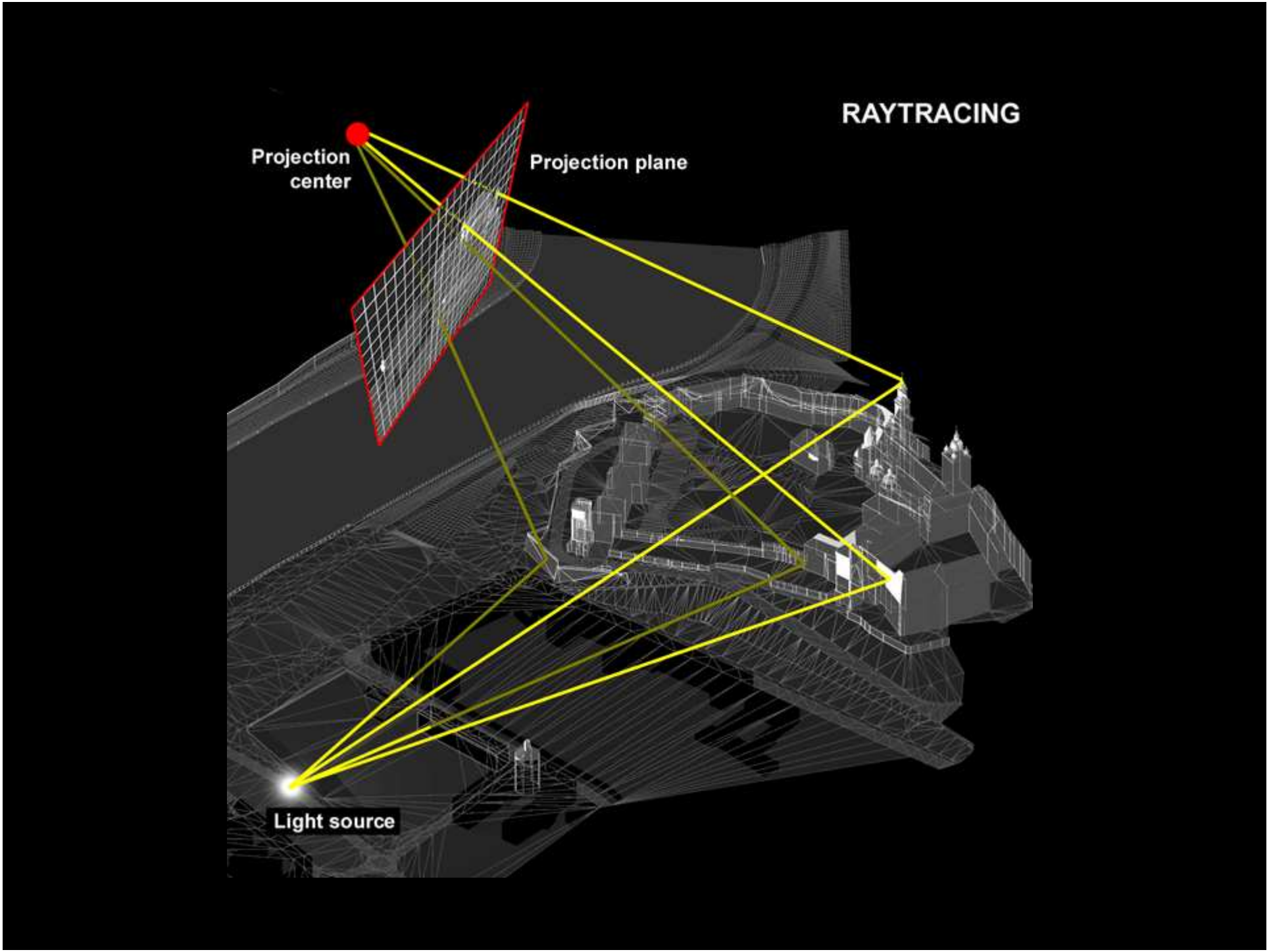
$$H(\lambda) = z(\xi(\lambda), \eta(\lambda))$$

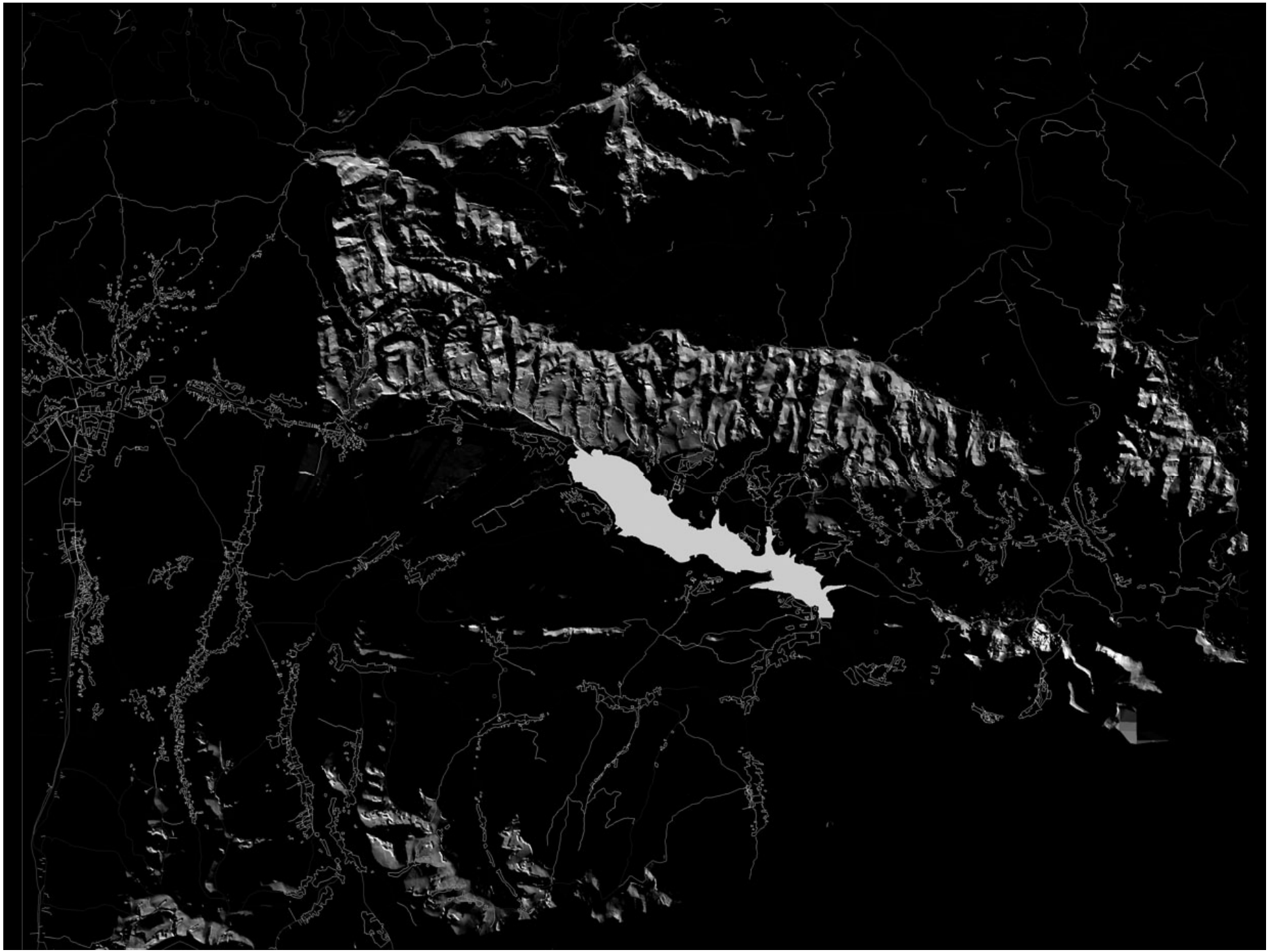
Visibility chart:

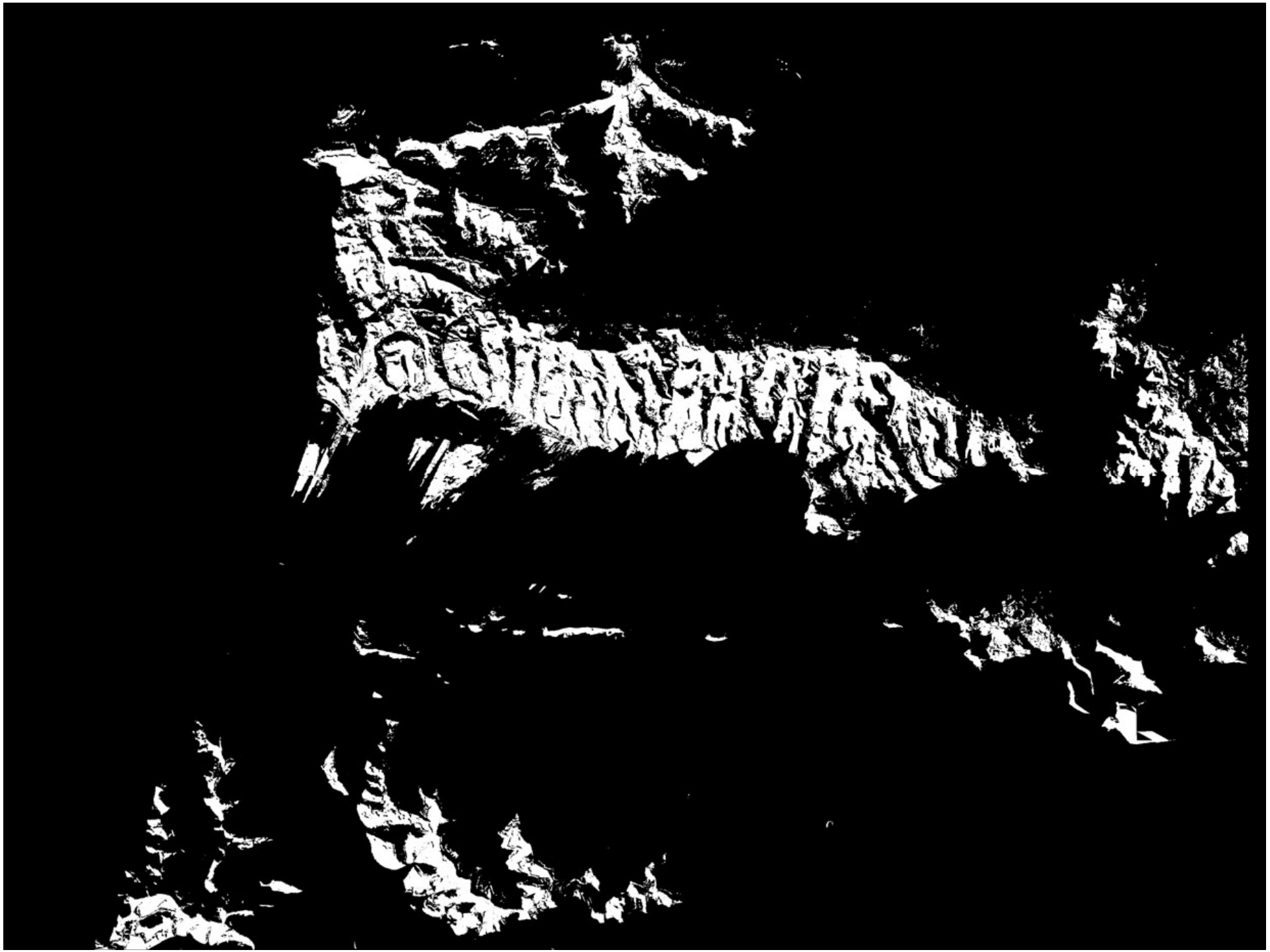
$$m(X,Y,Z,x,y,z) = \max\{H(\lambda) - \zeta(\lambda)\}, \qquad \lambda\epsilon[0,1]$$

Visibility function:

$$w(X,Y,Z,x,y,z) = \begin{cases} 1, & if\ m \leq 0 \\ 0, & if\ m > 0 \end{cases}$$


RAYTRACING
Projection center
Projection plane
Light source





Visibility description (illumination of point(X,Y,Z)):

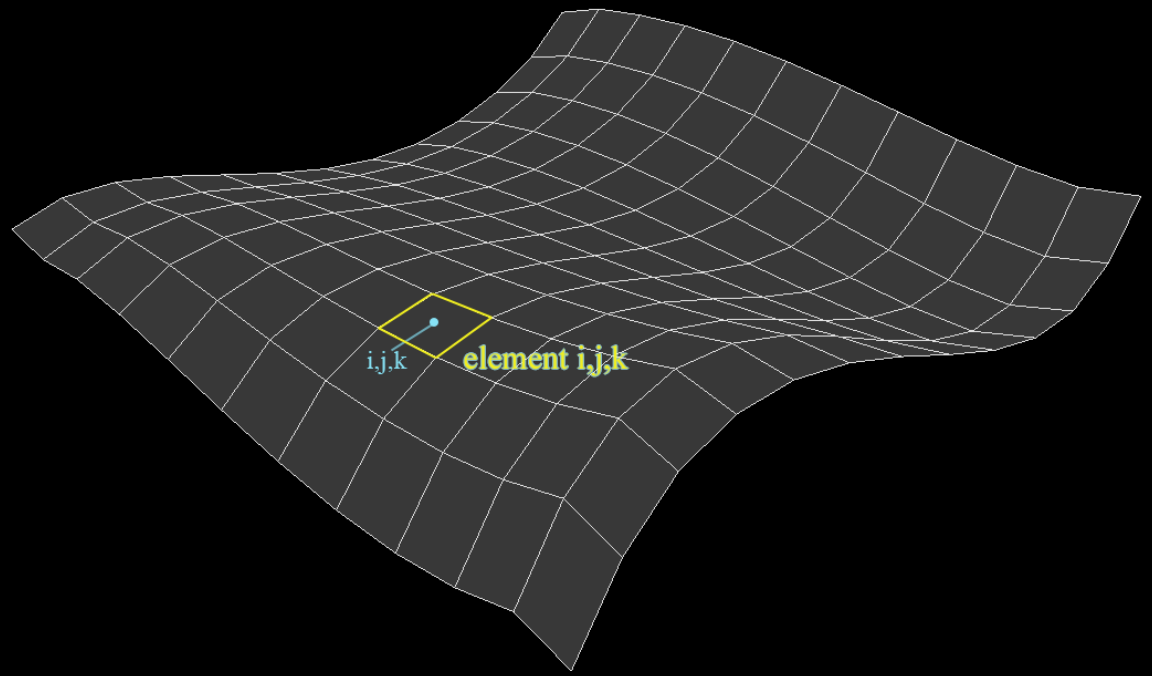
$$F(X,Y,Z) = \iint_S w(X,Y,Z,x,y,z)dS(x,y,z)$$ (integral surface not oriented)

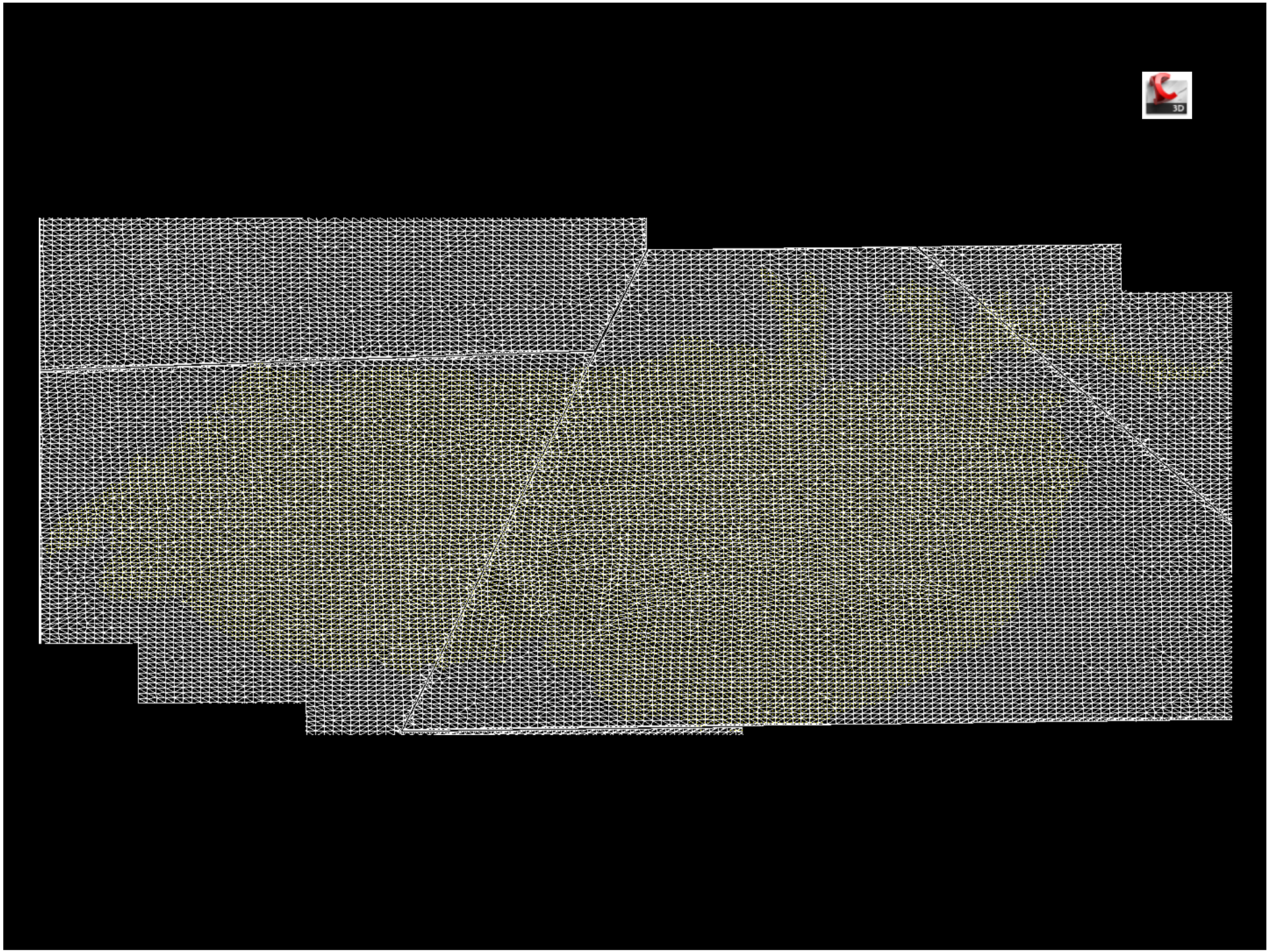
S – surface light object

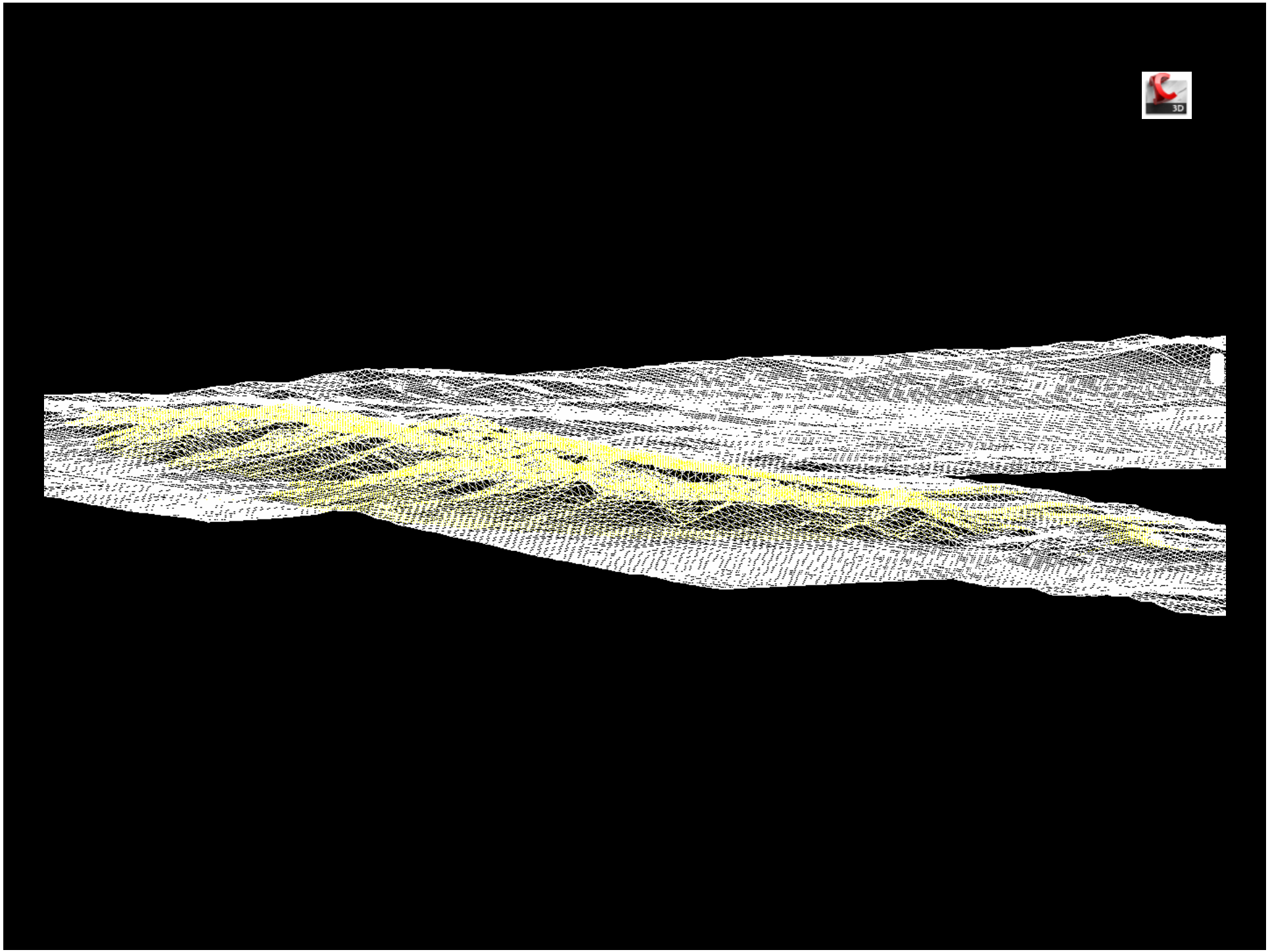
$$\iint_S f(x,y,z)dS = \lim_{n\to 0}\sum_{i=1}^{n_i}\sum_{j=1}^{n_j} f(\xi_i,\eta_j,\zeta)a_{i,j,k}$$

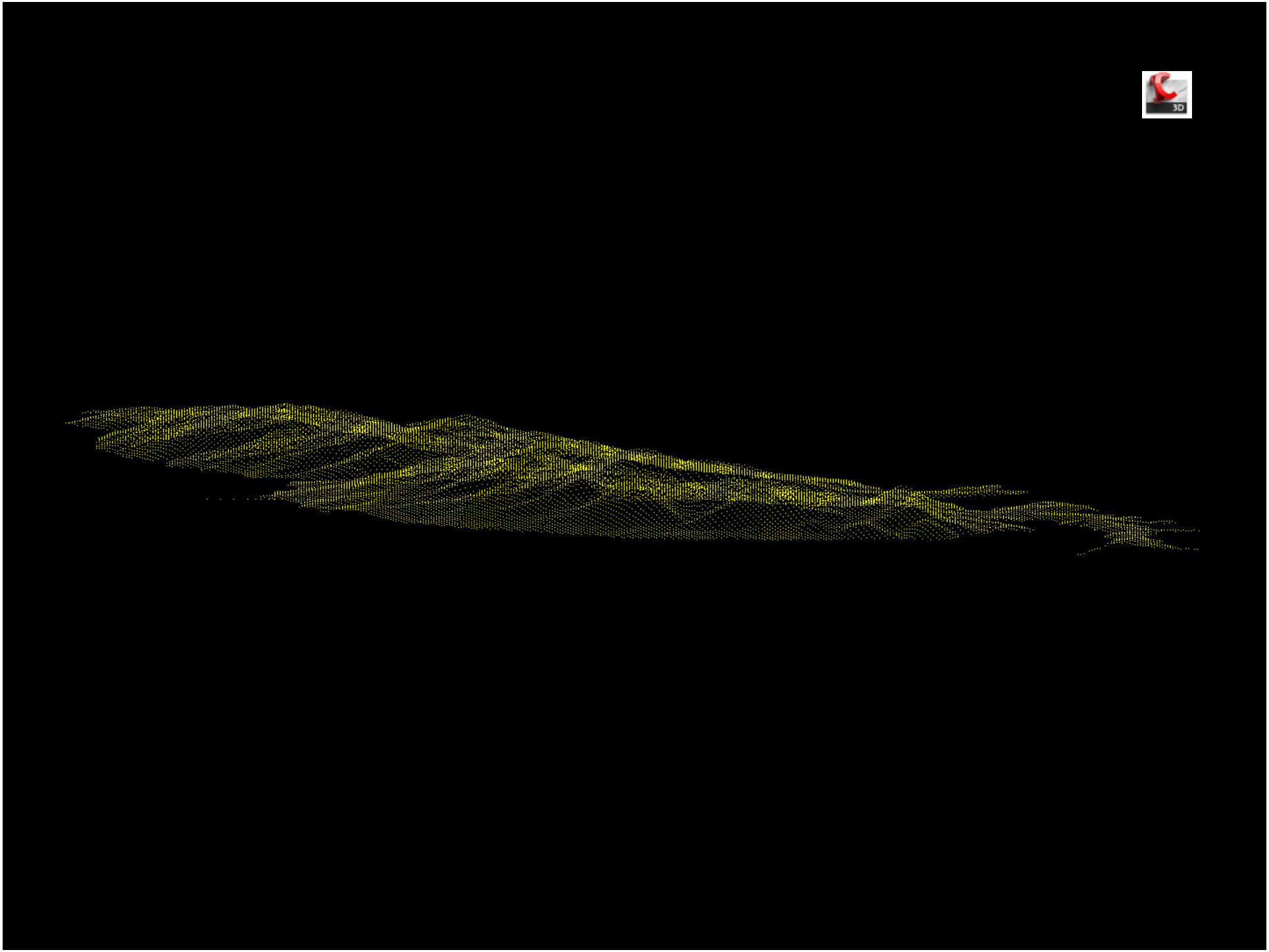
$a_{i,j,k}$ - surface object with indicators i,j,k.

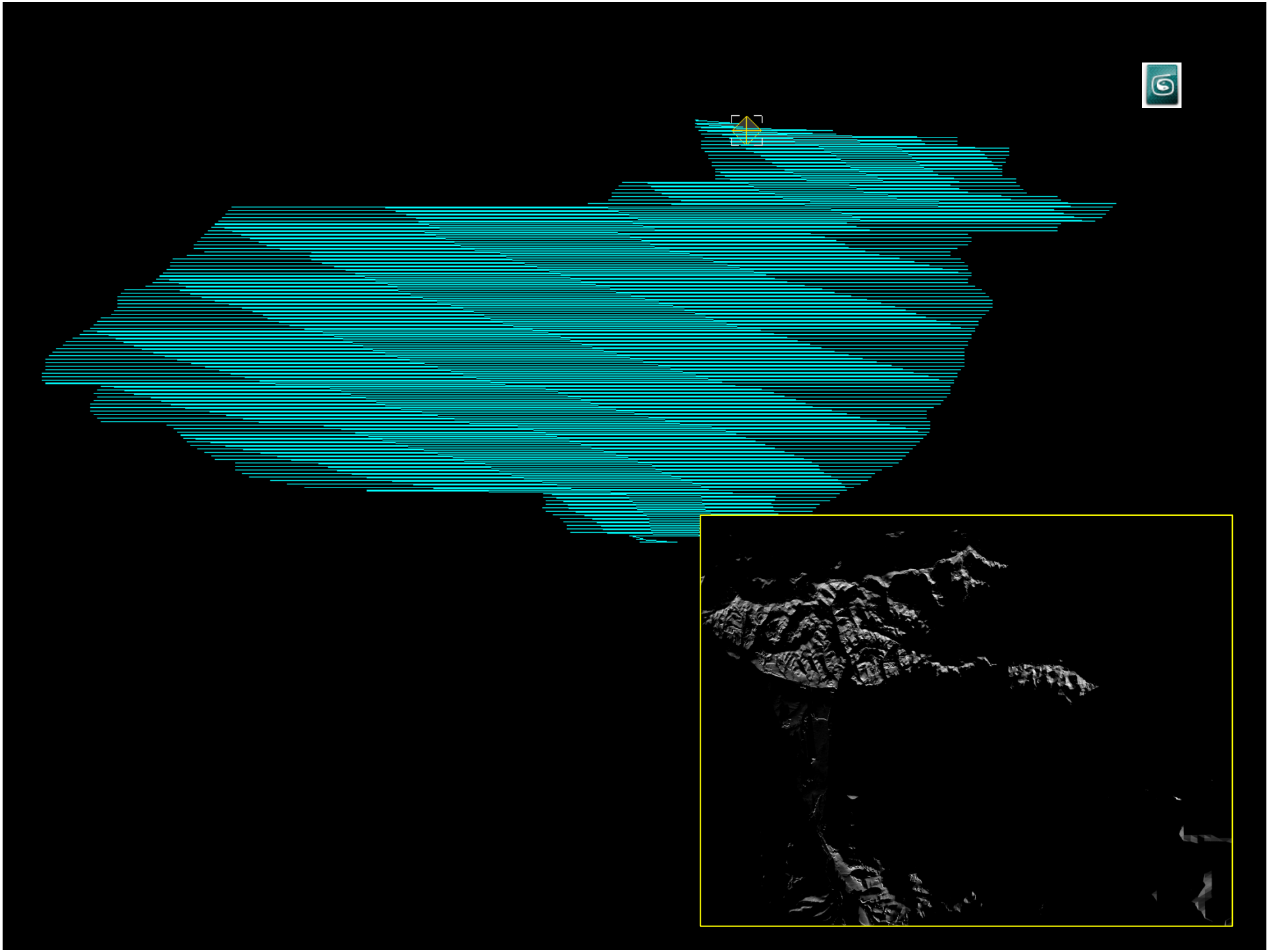
(ξ_i,η_i,ζ) - point in element

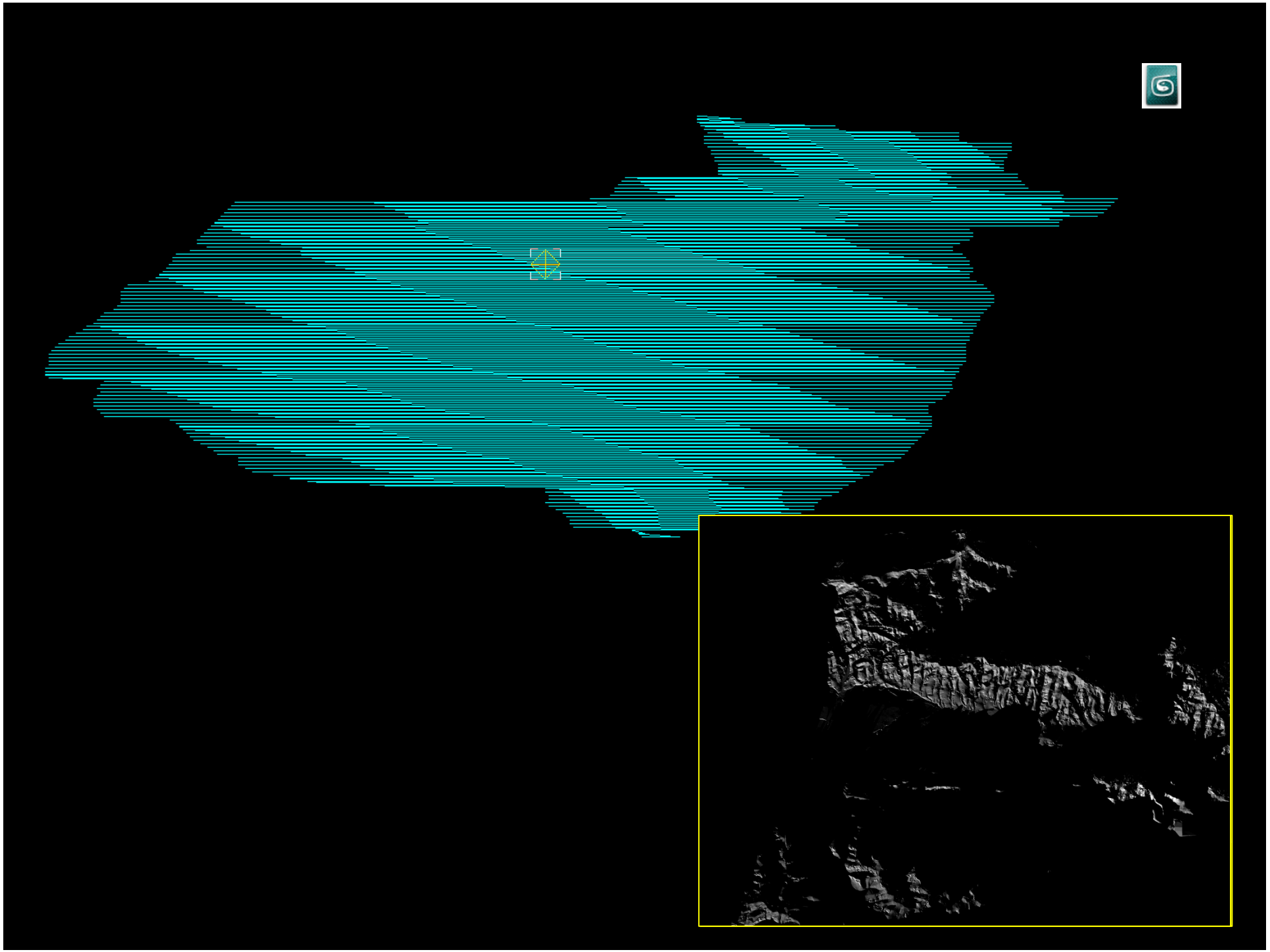


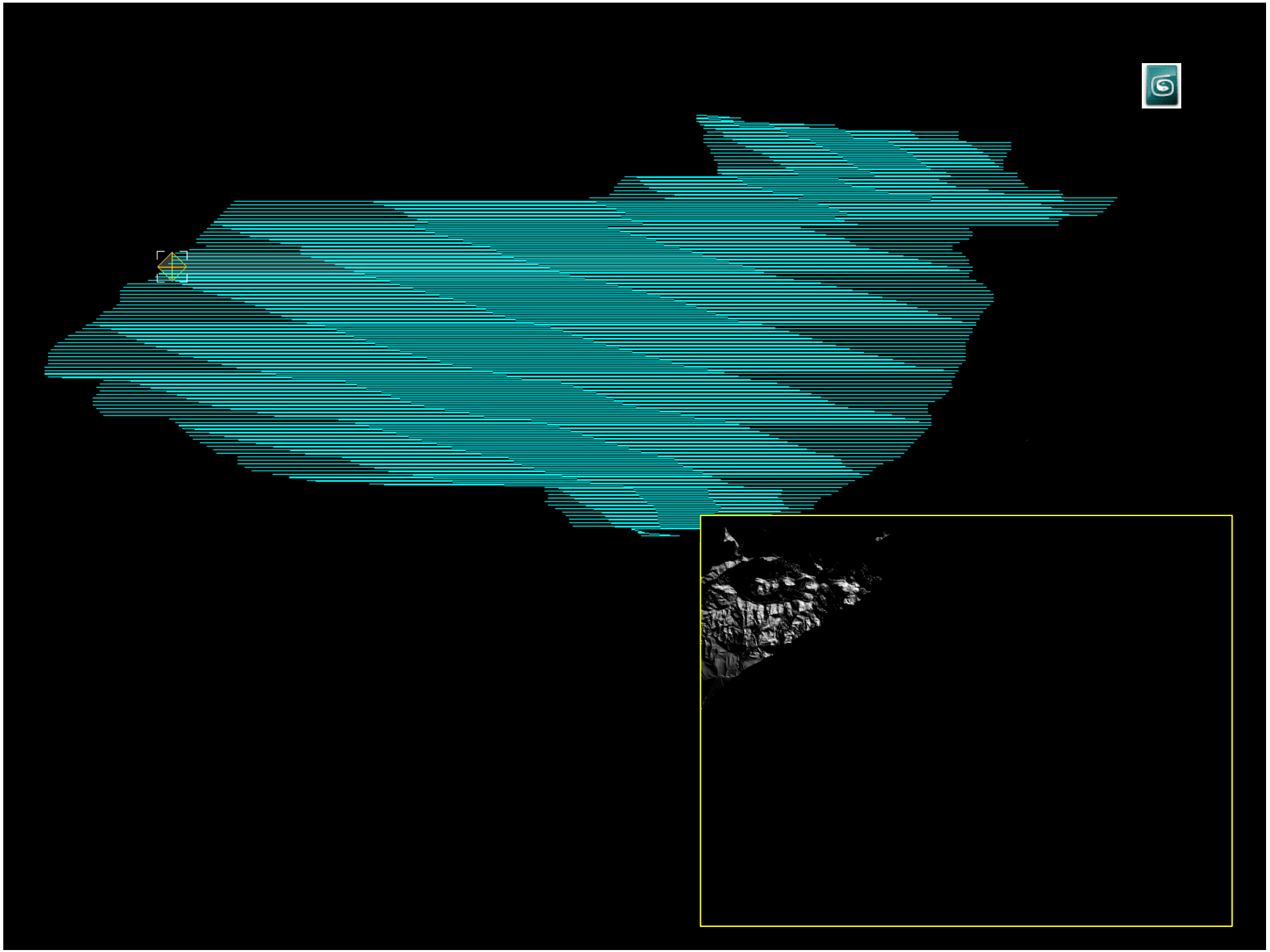


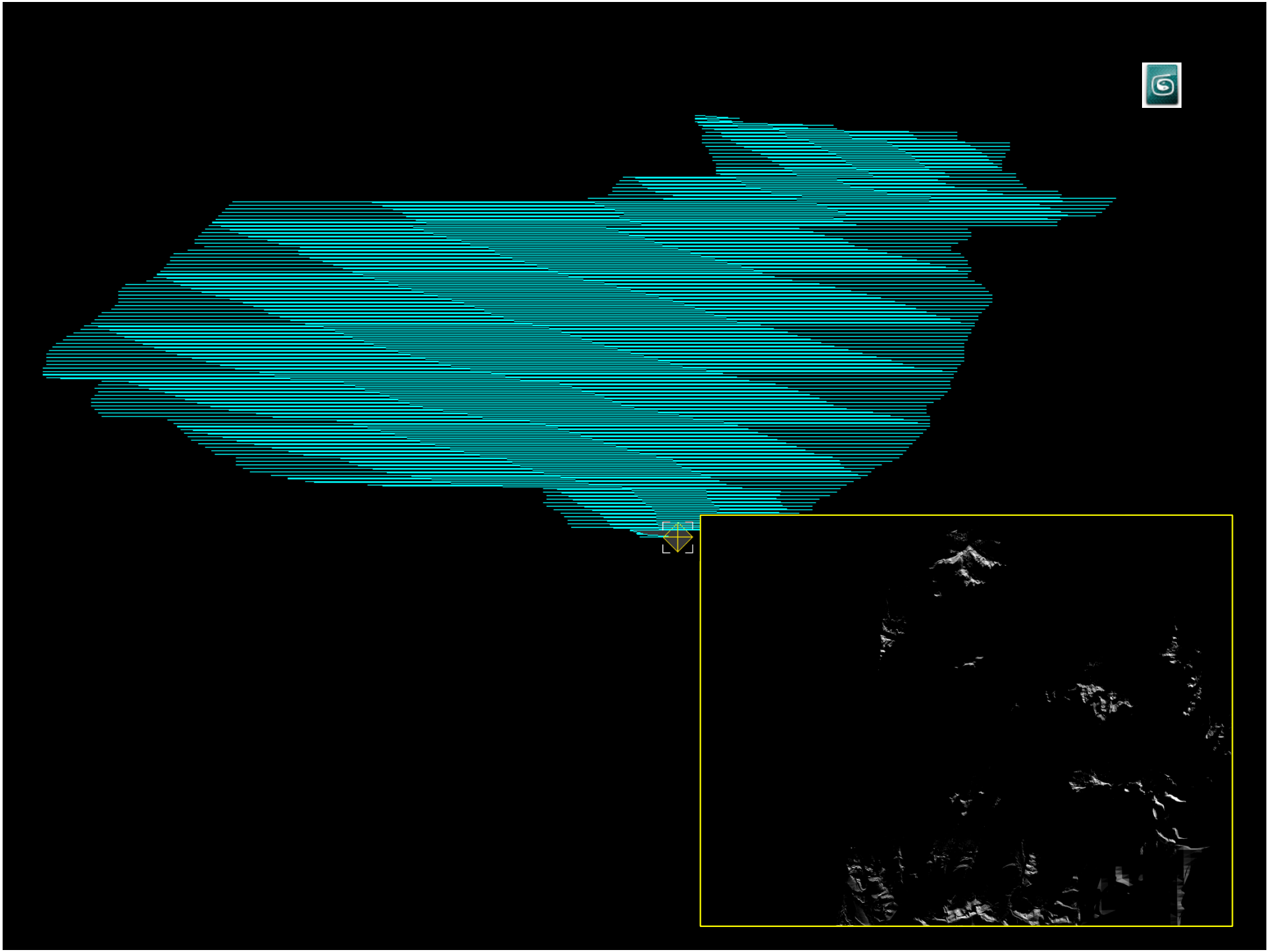


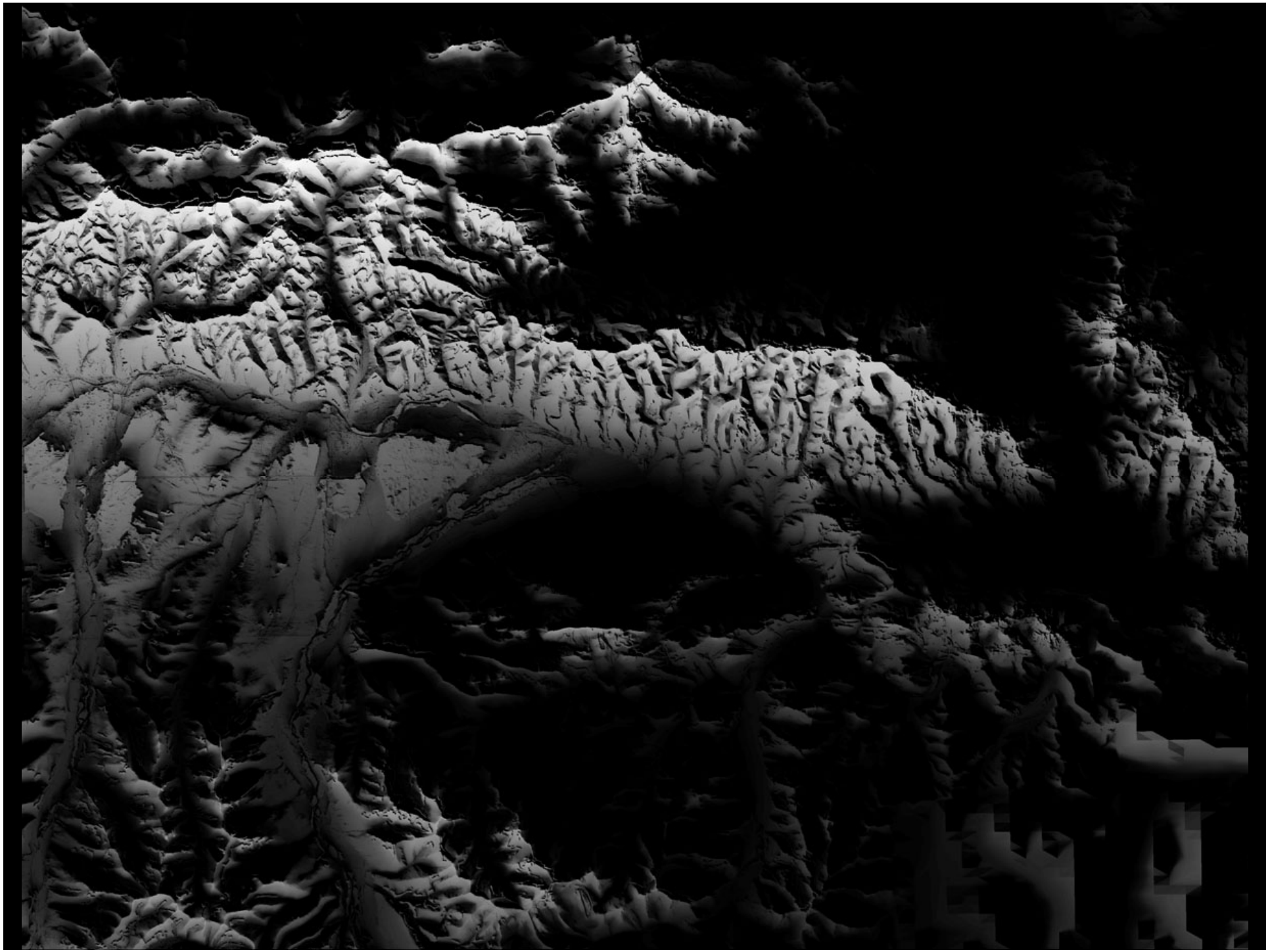


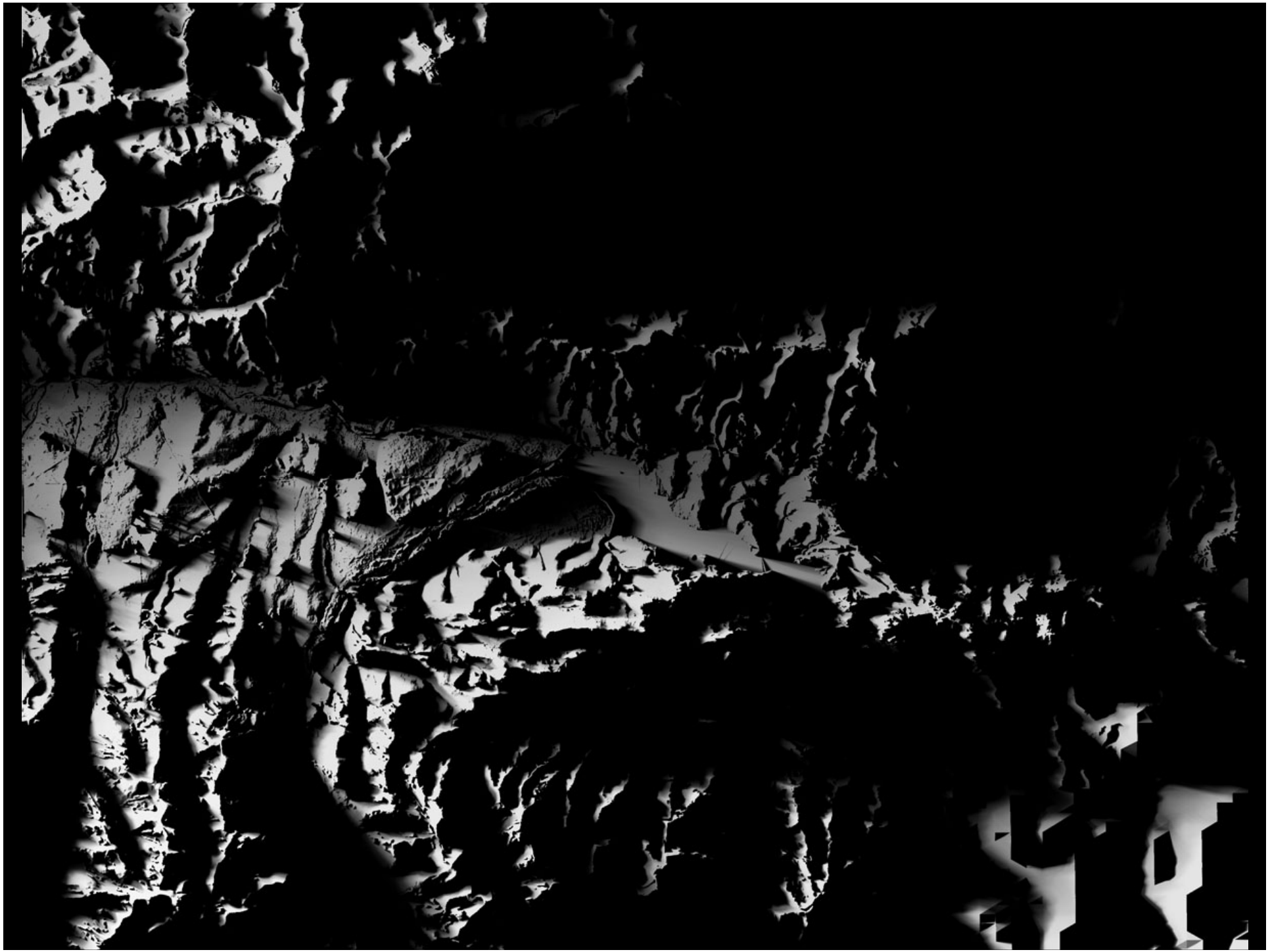


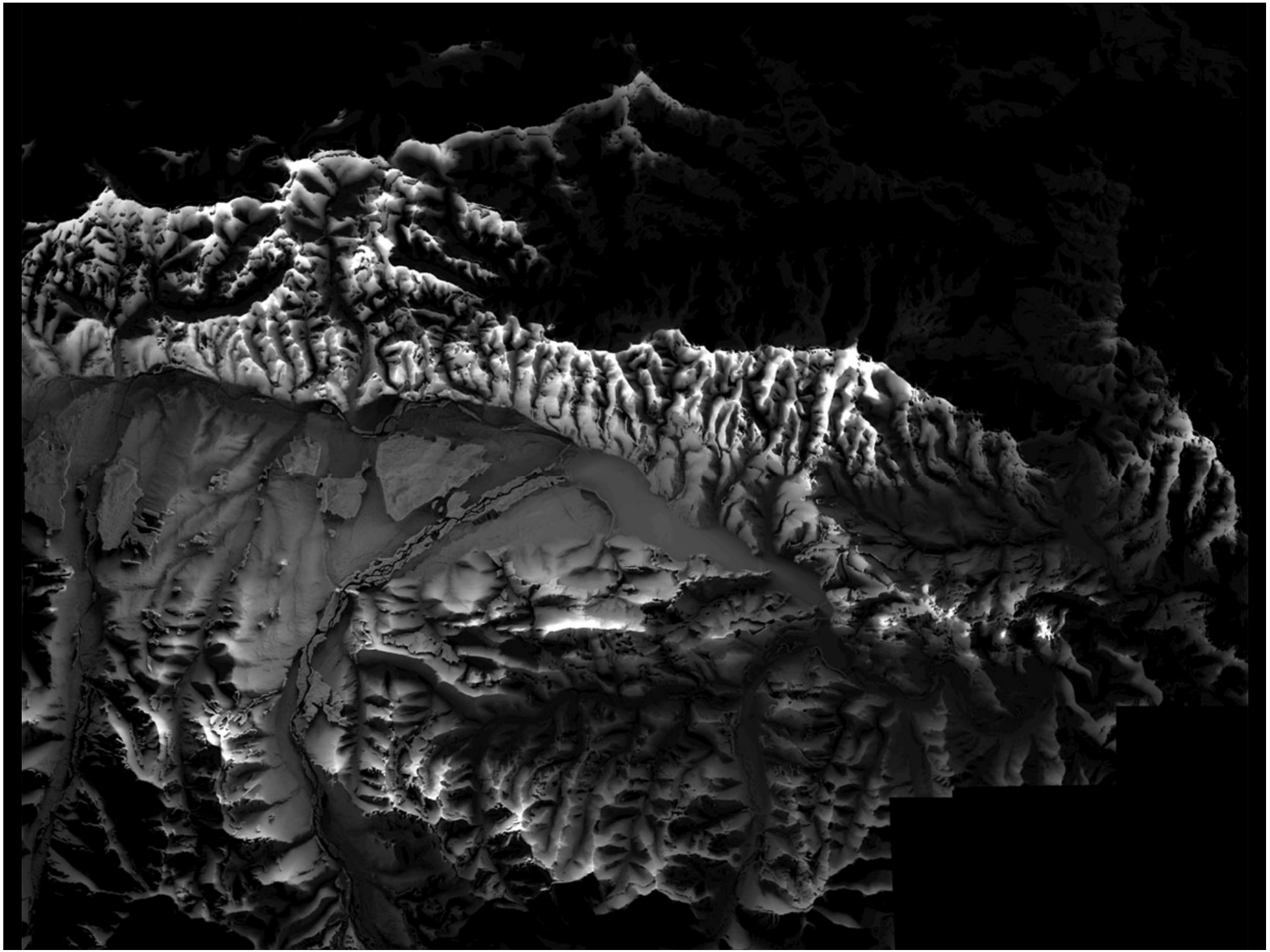


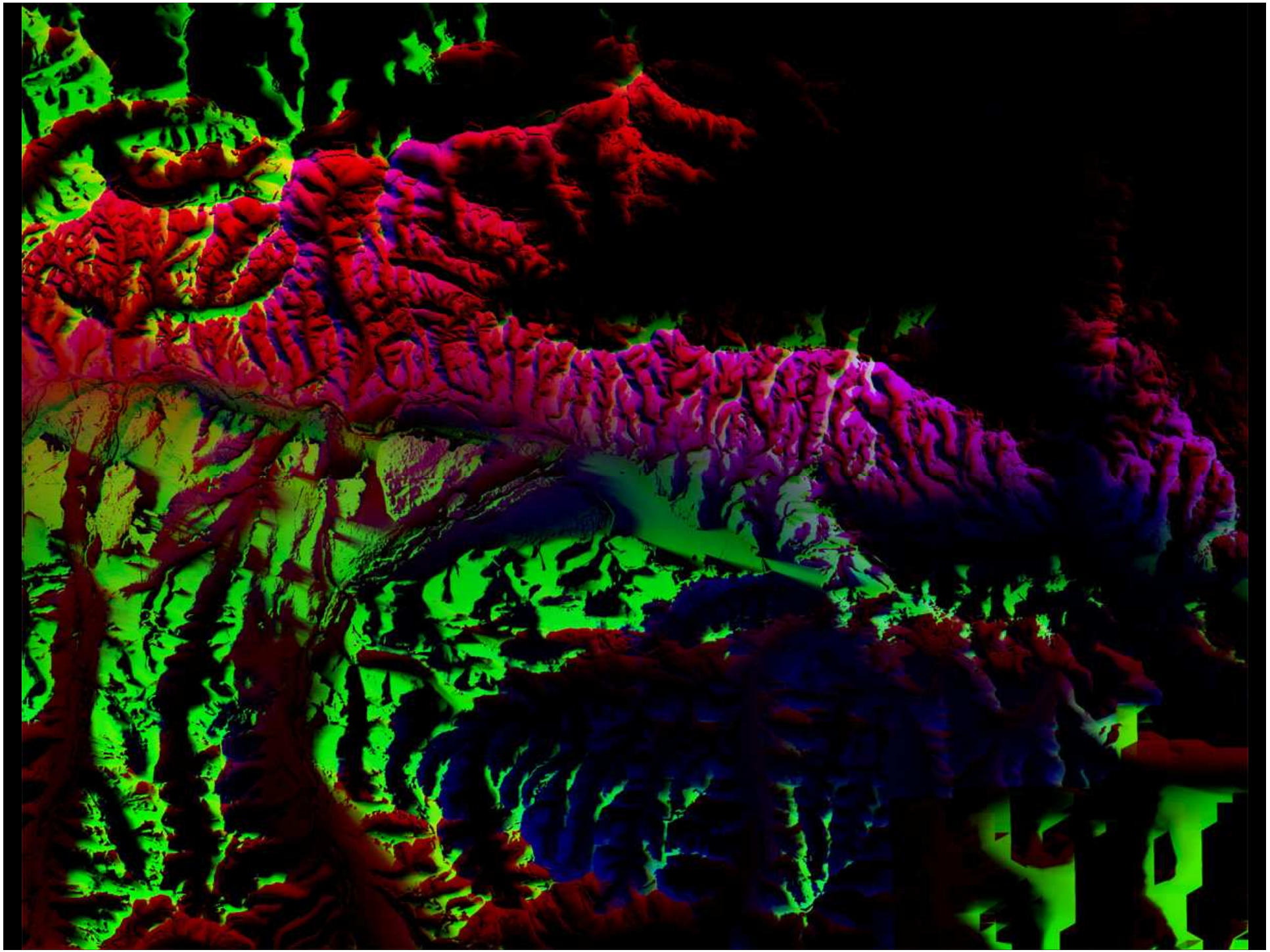


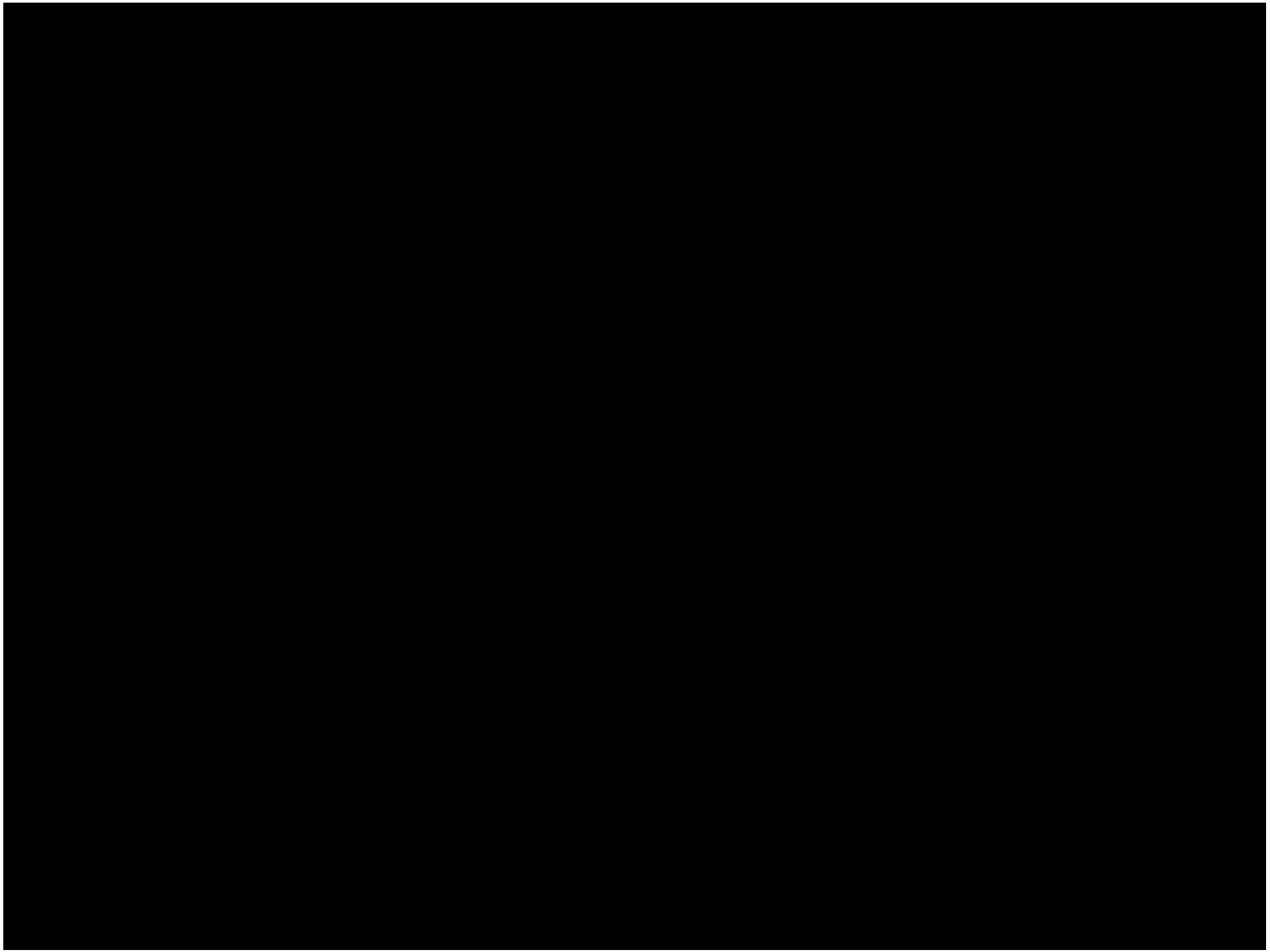


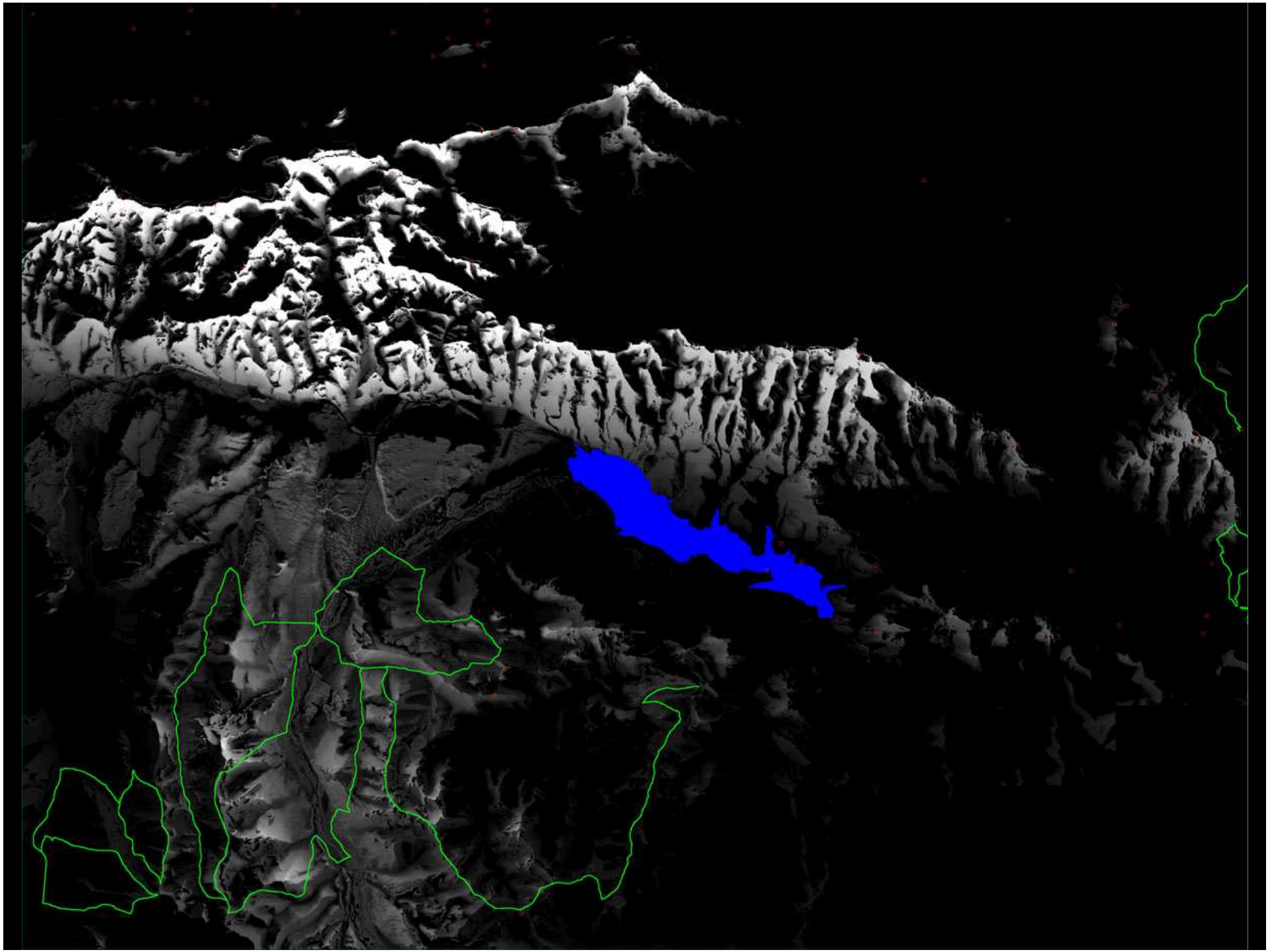


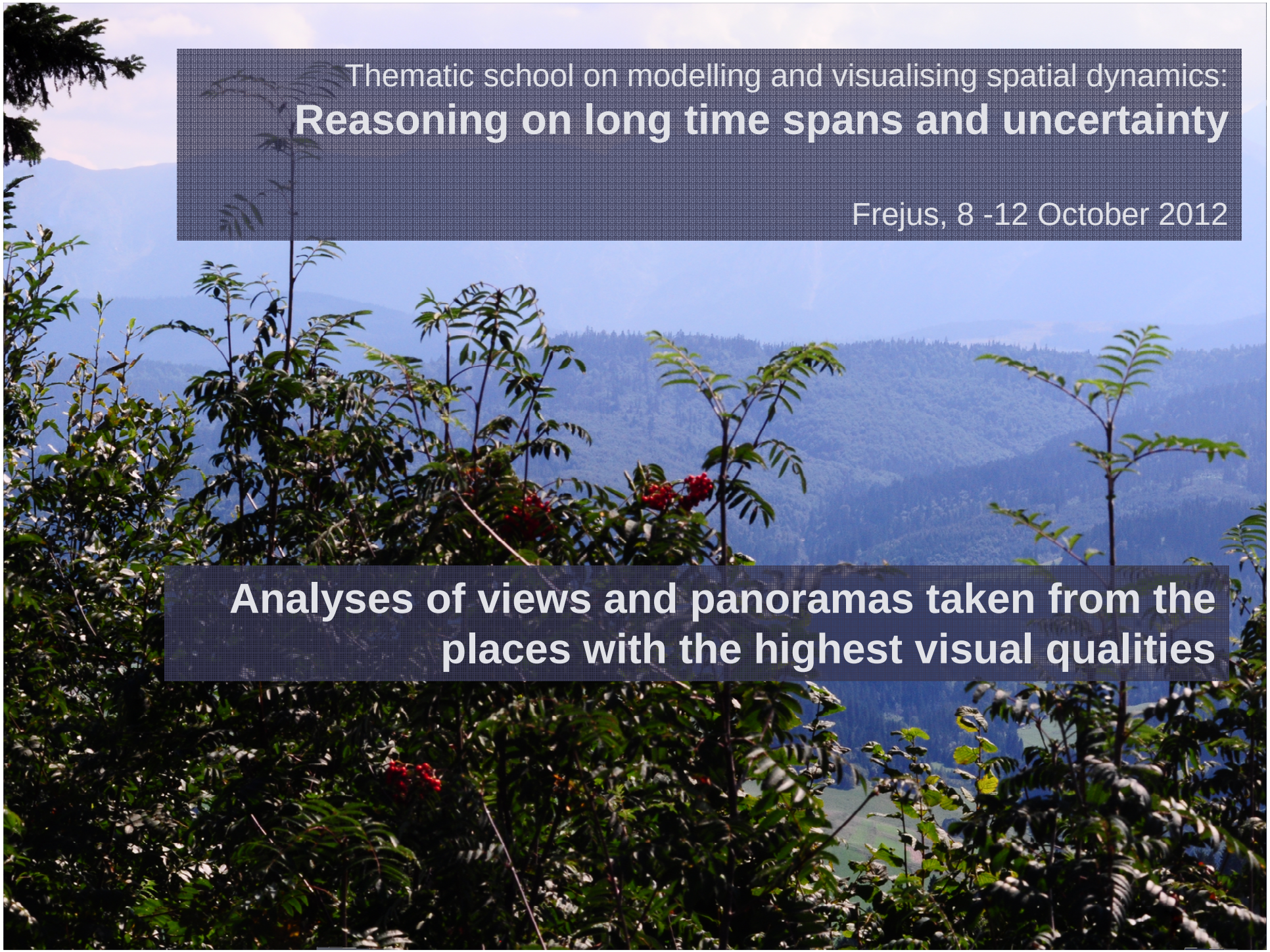












Thematic school on modelling and visualising spatial dynamics:

Reasoning on long time spans and uncertainty

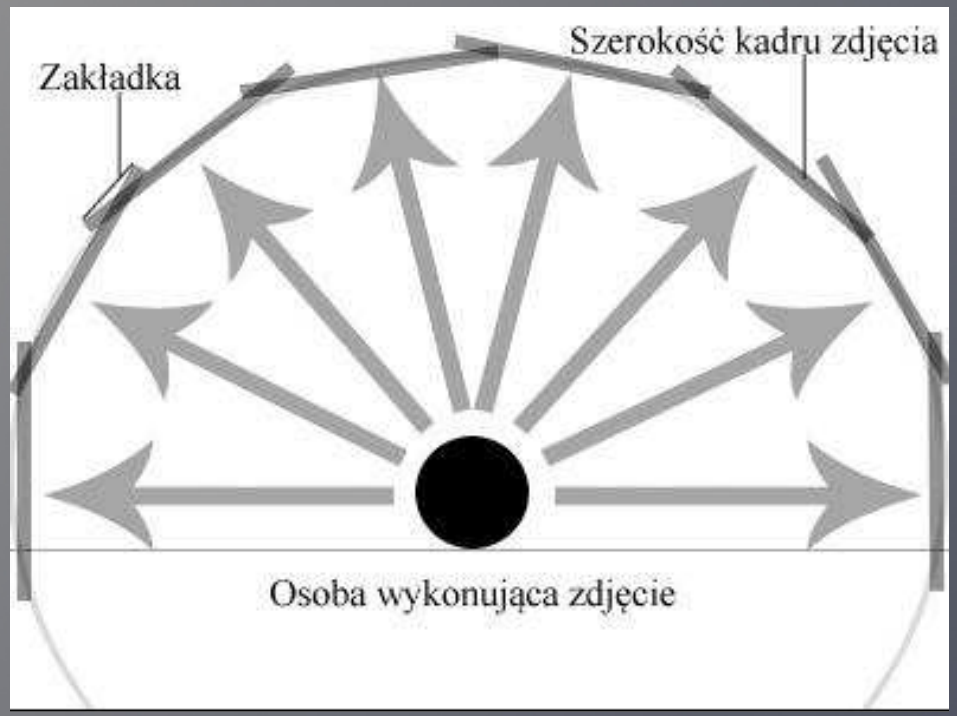
Frejus, 8 -12 October 2012

Analyses of views and panoramas taken from the places with the highest visual qualities

Analyses of views and panoramas taken from the places with the highest visual qualities

Visibility assessment

Distinction of places
with the most attractive views
that should be monitored
in time and preserved



Panorama

„in painting, drawing, graphics – extensive landscape or view of the city observed from a distance, usually from the elevated place".

Encyklopedia Powszechna PWN (wersja internetowa), http://encyklopedia.pwn.pl,

Systematics of the views depending on the angle:

- cameral view- 12°,
- narrow angle (vista) – less than 45°,
- the normal angle to the wide angle – from 45 to 90°
  (including the angle of the sharp view),
- panoramic view – od 90 do 180°,
- super-panorama – the half angle (180°) or the full angle (360°).

Problems connected with the presentation and reproduction of wide angle panoramas
Panorama embracing the view „all-aroud the head" (360^0)

Quantity and quality analyses of the view:

- The percentage share of the „positive” and the „negative” elements in the given view (how much?)
- Studies of the view structure (what kind of?)

Quantity evaluation – the average brightness

A binary mask (a bi-level image) with the given objects distinguished in white (on the black background) – representation of sub-image area (e.g. a forest, mountains, building development…)

The average brightness = the number of white pixels/the number of the pixels in the whole image

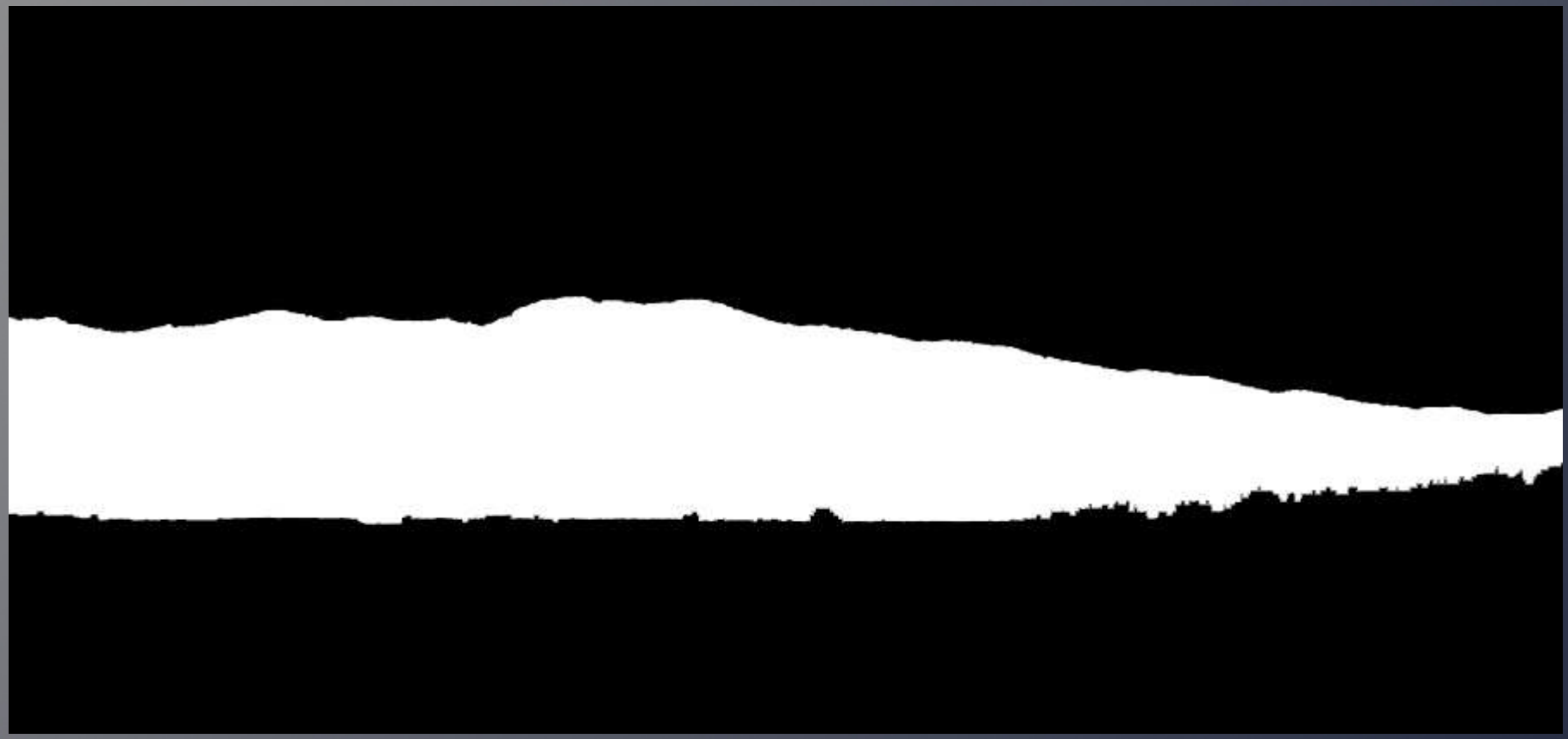
A white pixel – a value of 255,
a black pixel – 0,
therefore the results are in the range between 0 and 255.

Analyses of views and panoramas taken from the places with the highest visual qualities

A binary image – the distinction of building development

A fragment of panorama – a view on the lake and Gorce Mountains in the background

Analyses of views and panoramas taken from the places with the highest visual qualities



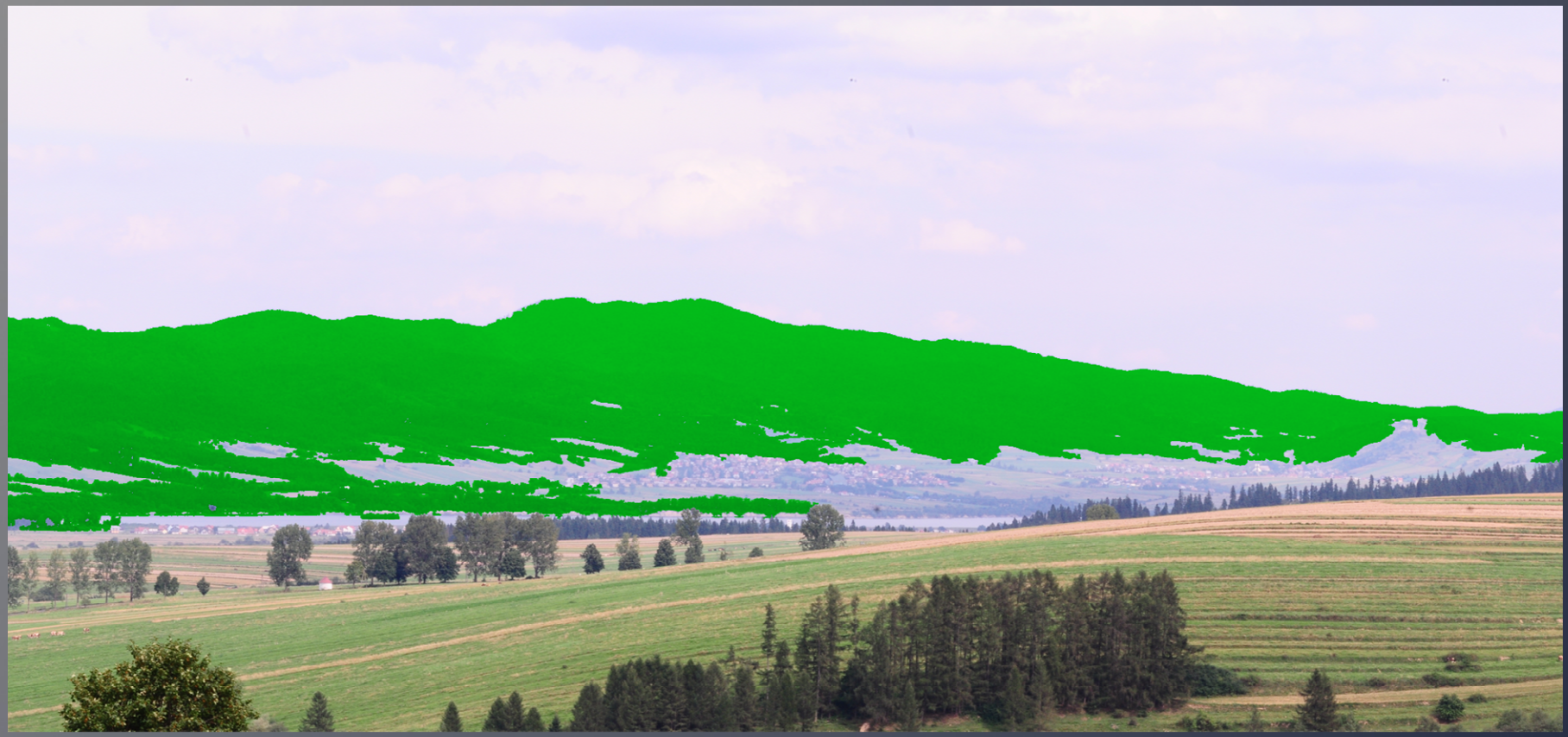
Gorce Mountains - (1) Unusualness
(2) Sublimity

Percentage in the view – 22,3%

Analyses of views and panoramas taken from the places with the highest visual qualities

Czorsztyńskie Lake - (1) Unusualness

Analyses of views and panoramas taken from the places with the highest visual qualities



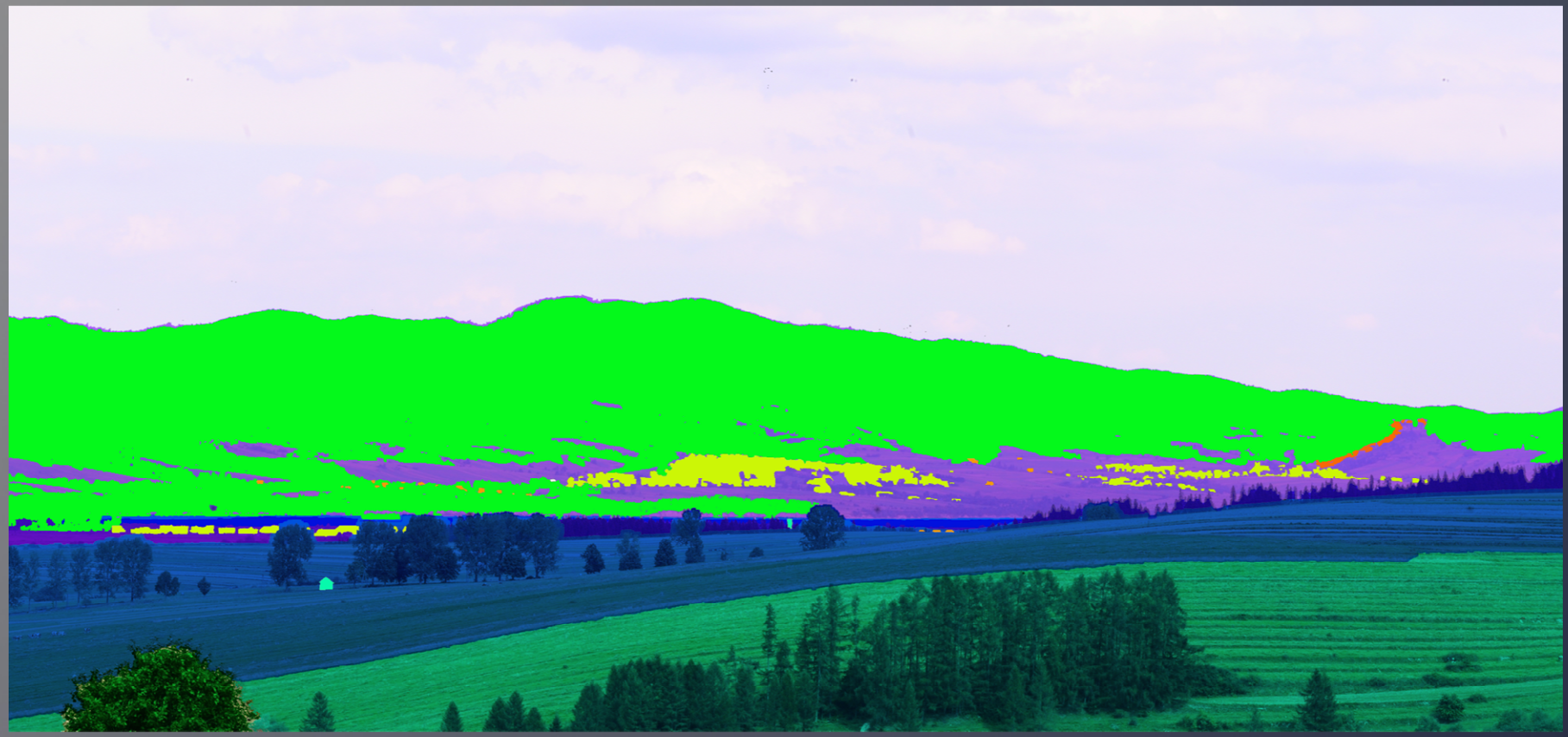
Extensive stretches of the forest – (2) Sublimity

Percentage in the view – 17,8%

Analyses of views and panoramas taken from the places with the highest visual qualities

Abundance of planes/wings (4)

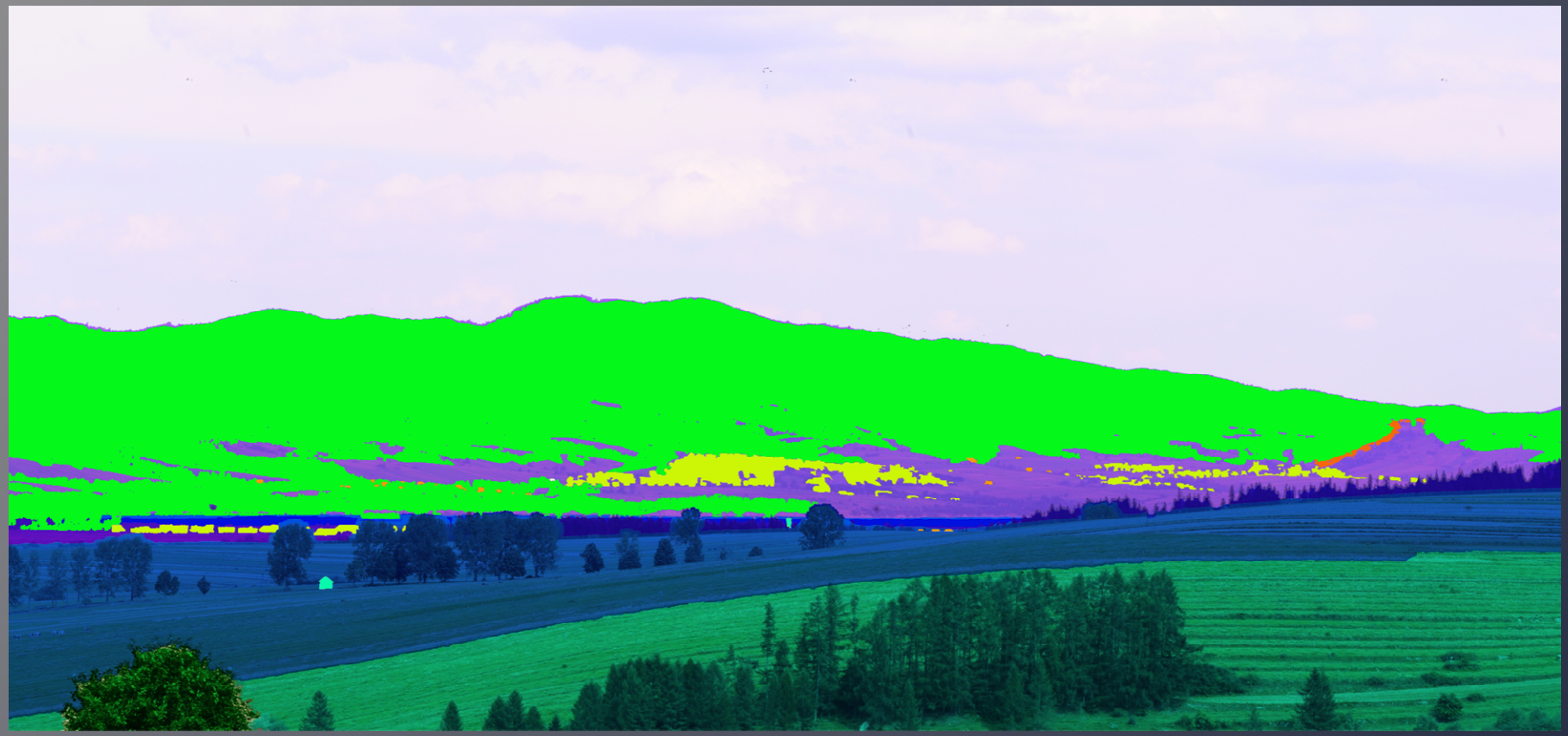
Analyses of views and panoramas taken from the places with the highest visual qualities



Harmonic composition composed of different planes and motifs (8)

Persistence of characteristic ‚classical' motifs
(distinct buildings/monuments, churches, chapels) (3)

Analyses of views and panoramas taken from the places with the highest visual qualities



Panorama’s valorisation with regard to the rating of positive and negative aspects, worked out as a result of employing of ‚the qualified judges method’

Analyses of views and panoramas taken from the places with the highest visual qualities

Tatras mountains range – (2) Sublimity

Percentage in the view – 5,42%

Analyses of views and panoramas taken from the places with the highest visual qualities

Abundance of planes/wings (4)

Analyses of views and panoramas taken from the places with the highest visual qualities

Gorce Mountains - (1) Unusualness
(2) Sublimity

Analyses of views and panoramas taken from the places with the highest visual qualities

Abundance of planes/wings (4)

Qualitative evaluation

Image segmentation

The division into planes (distance-dependent zones) allows for the objects' comparisons

Analyses of views and panoramas taken from the places with the highest visual qualities

Planes’ distinction in the view

Analyses of views and panoramas taken from the places with the highest visual qualities

The percentage share of the development in the view

Analyses of views and panoramas taken from the places with the highest visual qualities

The percentage share of the development in the view

Analyses of views and panoramas taken from the places with the highest visual qualities

Building development in the background

Analyses of views and panoramas taken from the places with the highest visual qualities

Building development in the background

Analyses of views and panoramas taken from the places with the highest visual qualities

Building development in the intermediate distance

Analyses of views and panoramas taken from the places with the highest visual qualities

Dispersed development (5)

Analyses of views and panoramas taken from the places with the highest visual qualities

Dispersed development detection:

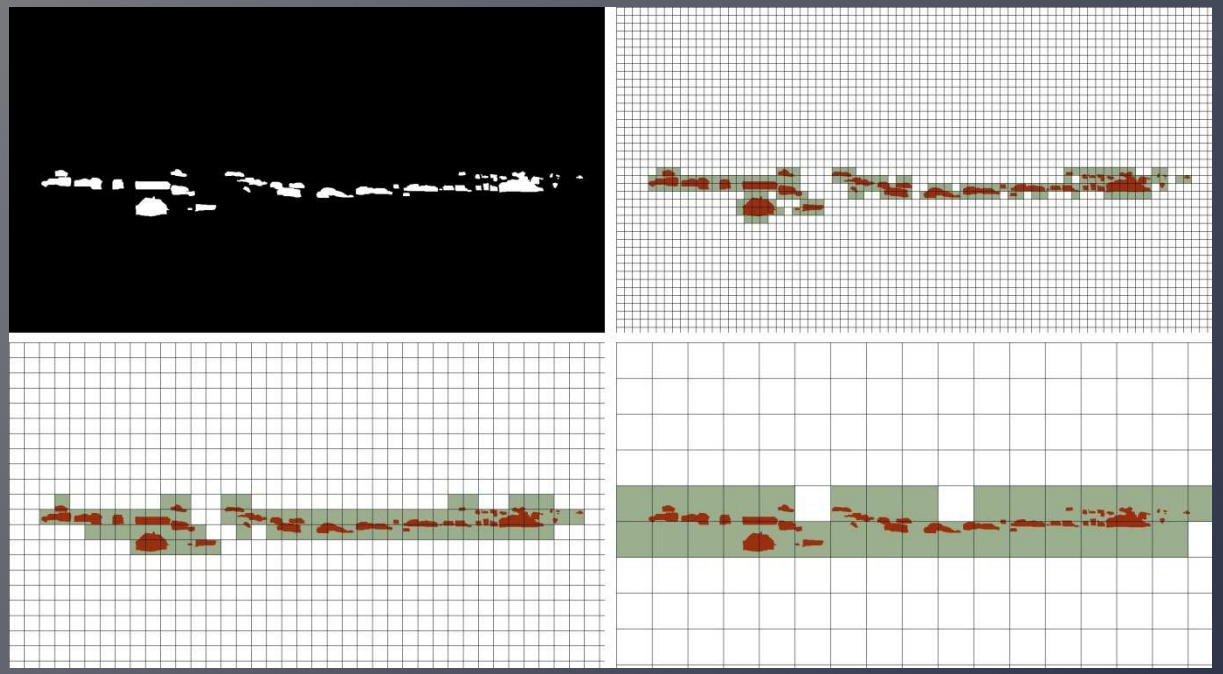
- Morphological operation (dilation) – adding the ‚envelope' to the buildings, with the size depending on the distance.
- Remote objects selection.

Analyses of views and panoramas taken from the places with the highest visual qualities

Dispersed development (5)

Disharmonious buildings' forms (9)

Analyses of views and panoramas taken from the places with the highest visual qualities



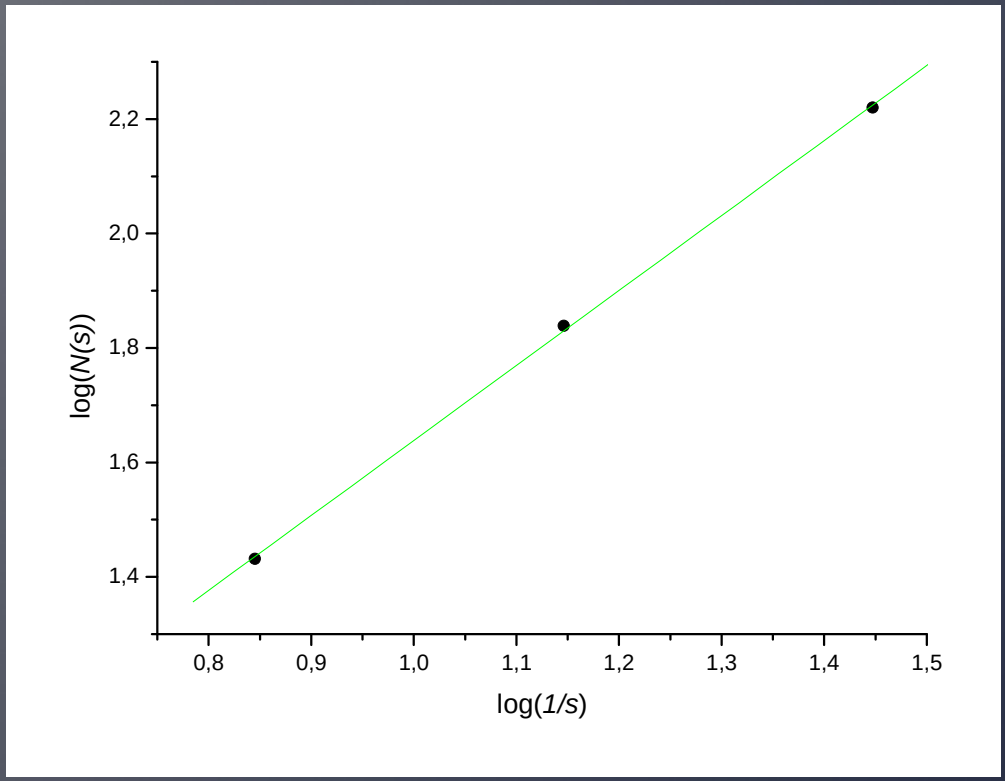
Box-counting fractal dimension calculating:

- The image is covered by the regular mesh with the size *s*.
- We count the meshes when even the tiniest fragments of the objects appear.
- The number of filled meshes *N* is connected with their size, so we register it as *N(s)*.
- In the next step the mesh size is reduced twice, and the filled meshes are counted again.

Analyses of views and panoramas taken from the places with the highest visual qualities

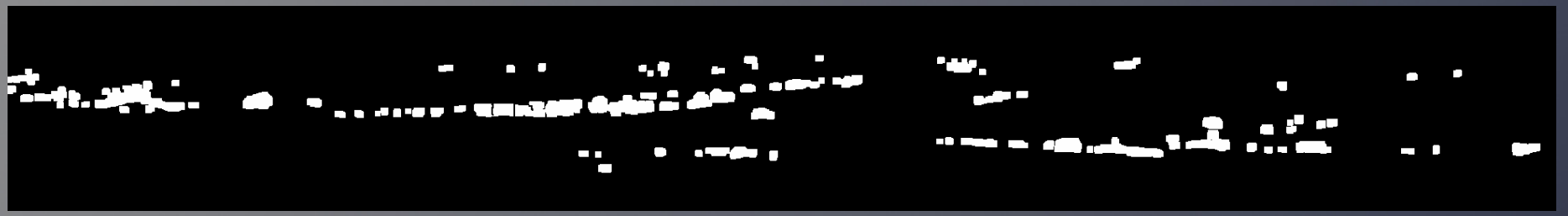
The results of this iteration operation are shown in the diagram. On the horizontal (x) axis we have inverse logarithms of mesh sizes, on the vertical axis (y) – logarithms of the filled meshes.

To these data we can adjust the straight line of regression, which suggests linear dependency.

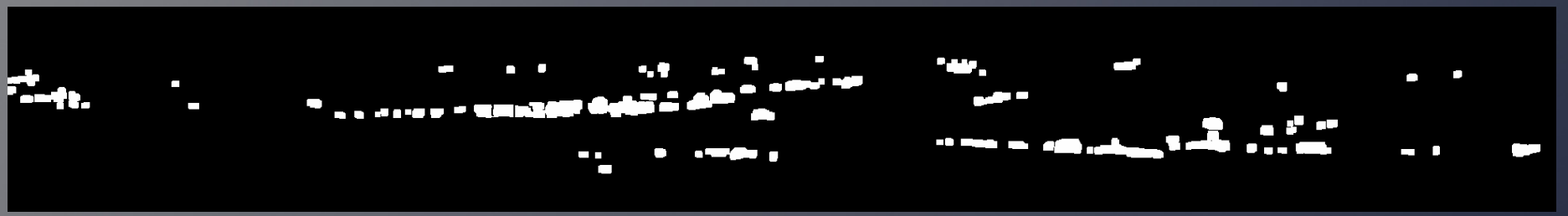


The coefficient of this line inclination depicts the fractal dimension. For 2D images it reaches the values in the range [1 2].

Disharmonious buildings' forms detection



Calculations of box dimension for the chosen fragment of development (1,466)



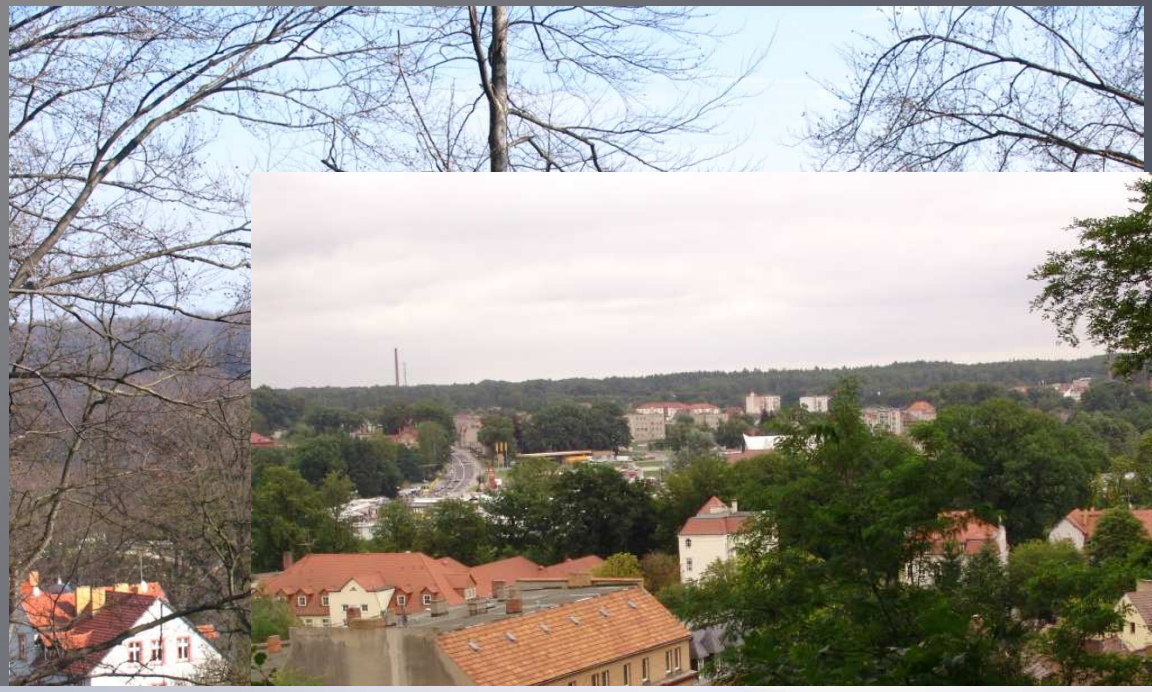
Calculations for the same fragment, but without the new buildings (1,449)

Calculations of the difference (0,017%).

The bigger the difference,
the more the new building is different than its environment.

Landscape images segmentation

Analyses of views and panoramas taken from the places with the highest visual qualities



Analyses of views and panoramas taken from the places with the highest visual qualities

Analyses of views and panoramas taken from the places with the highest visual qualities

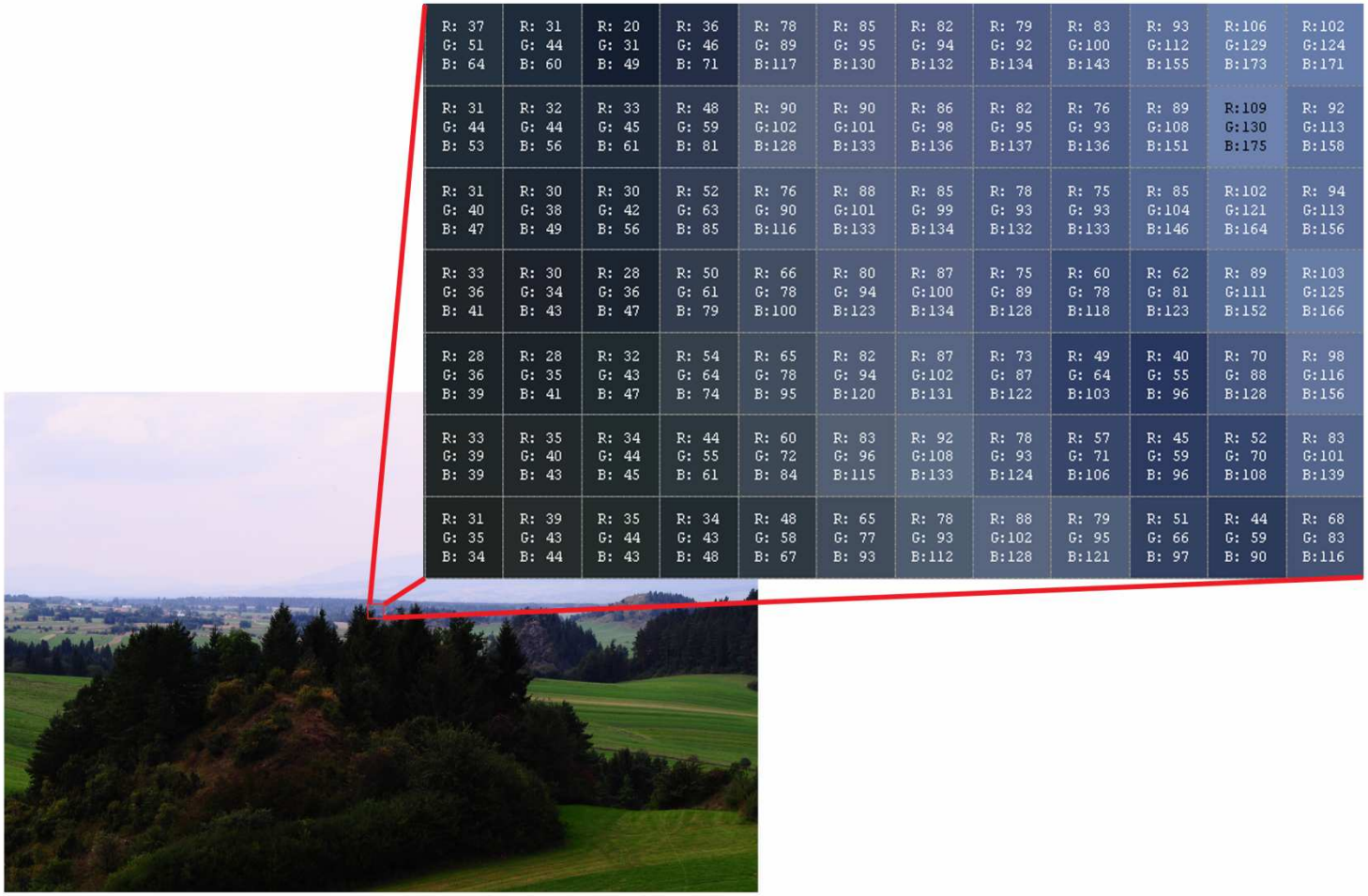
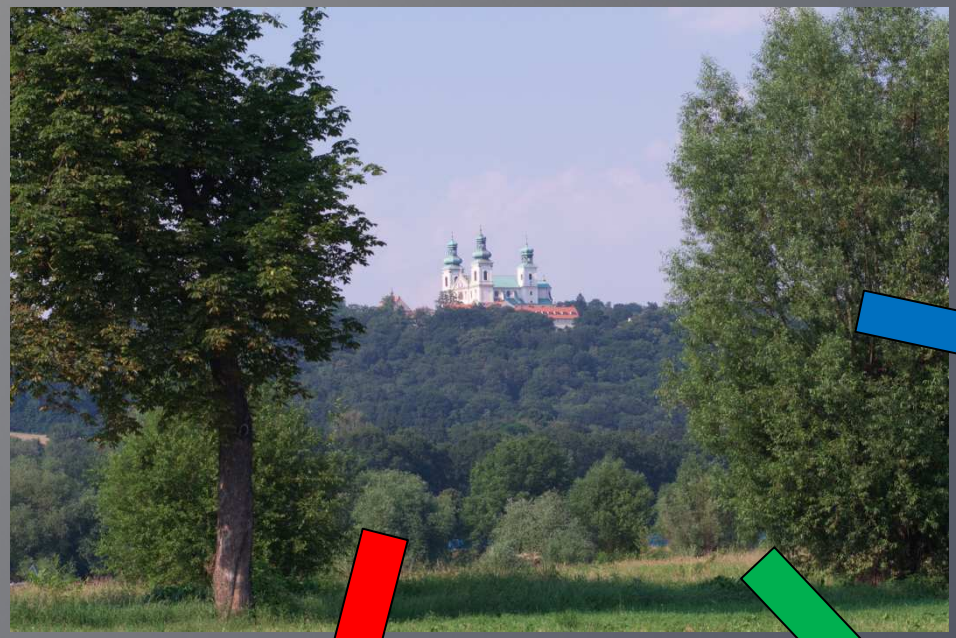
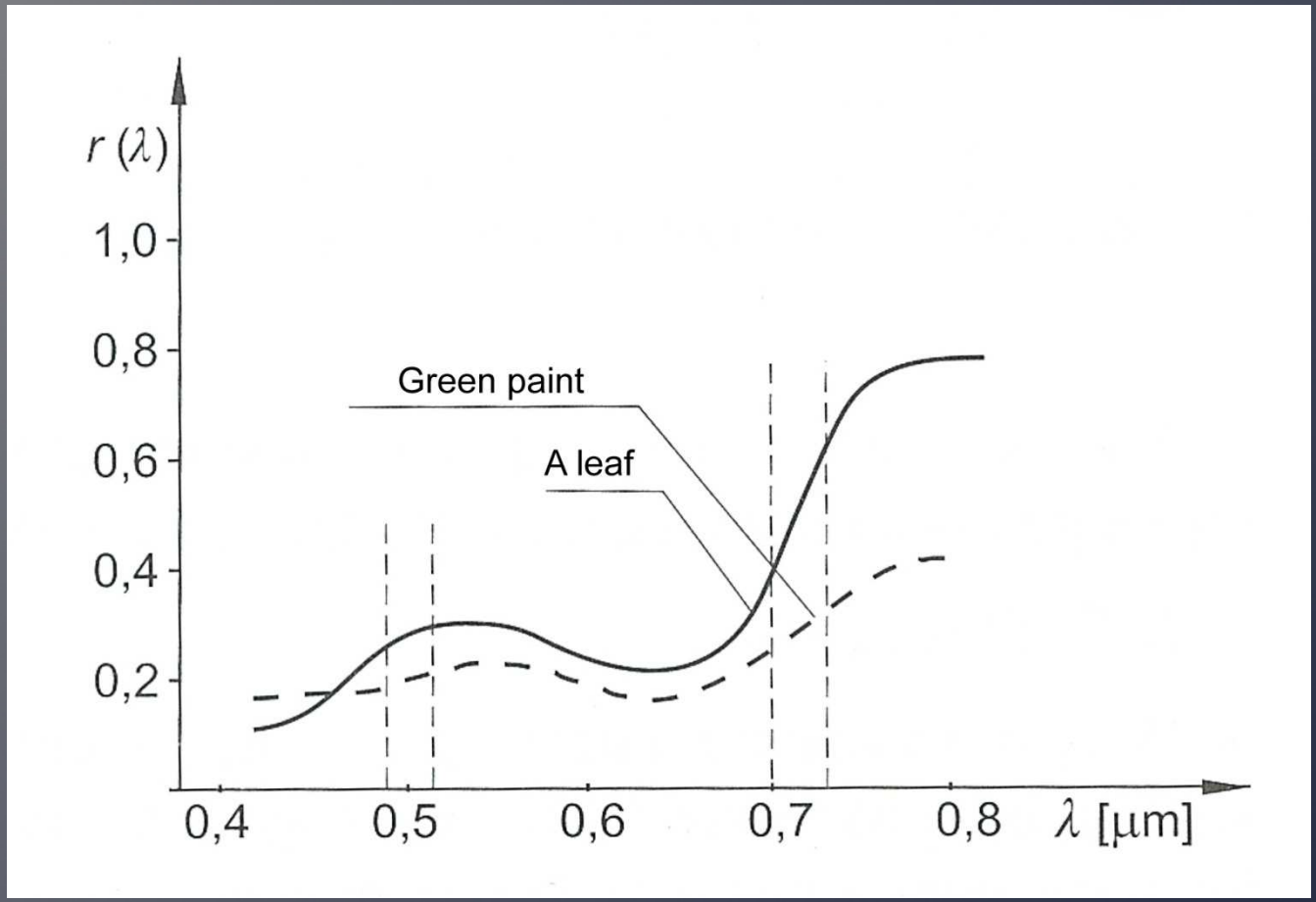


Image registration using RGB colour model
Values for the particular channels

Analyses of views and panoramas taken from the places with the highest visual qualities

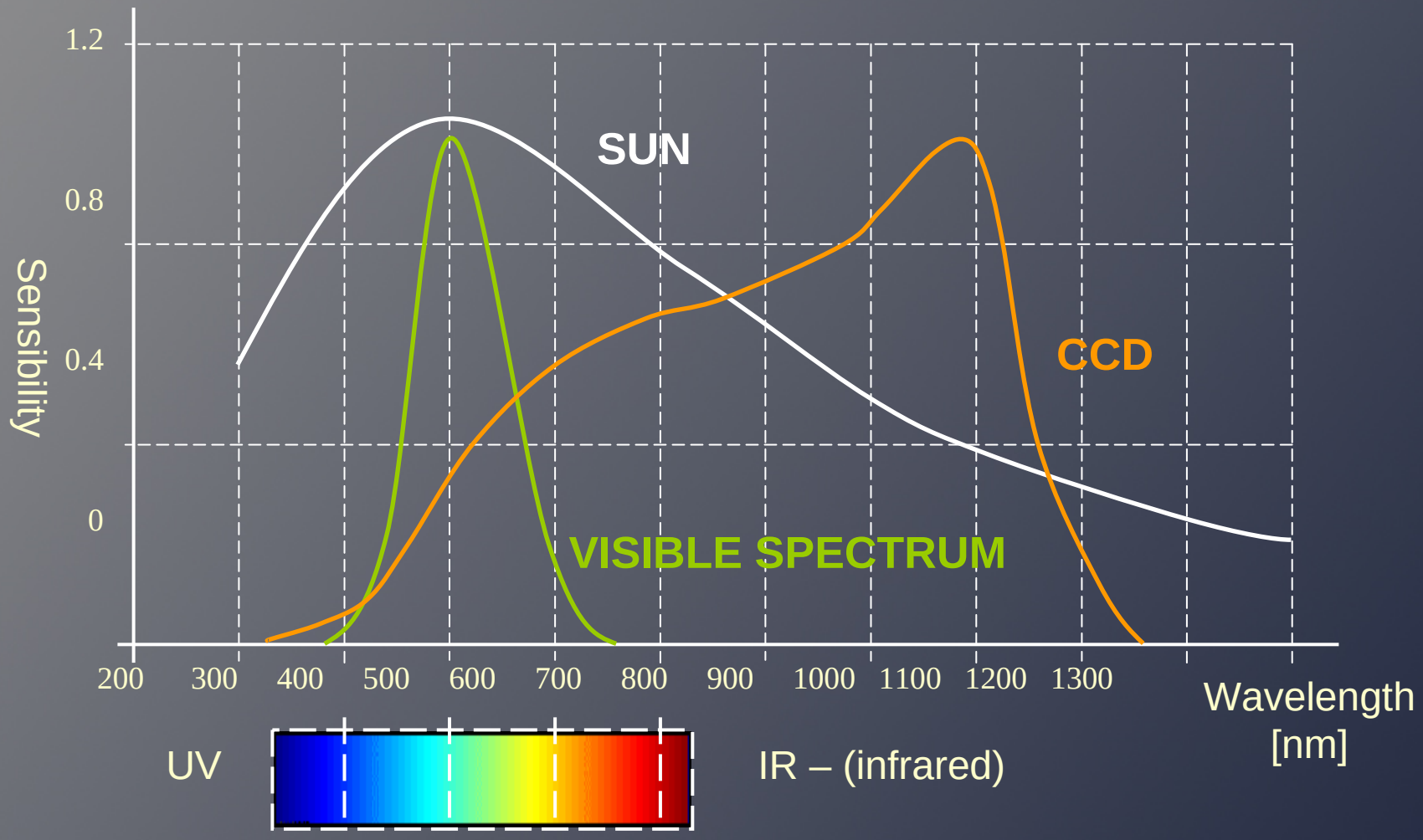


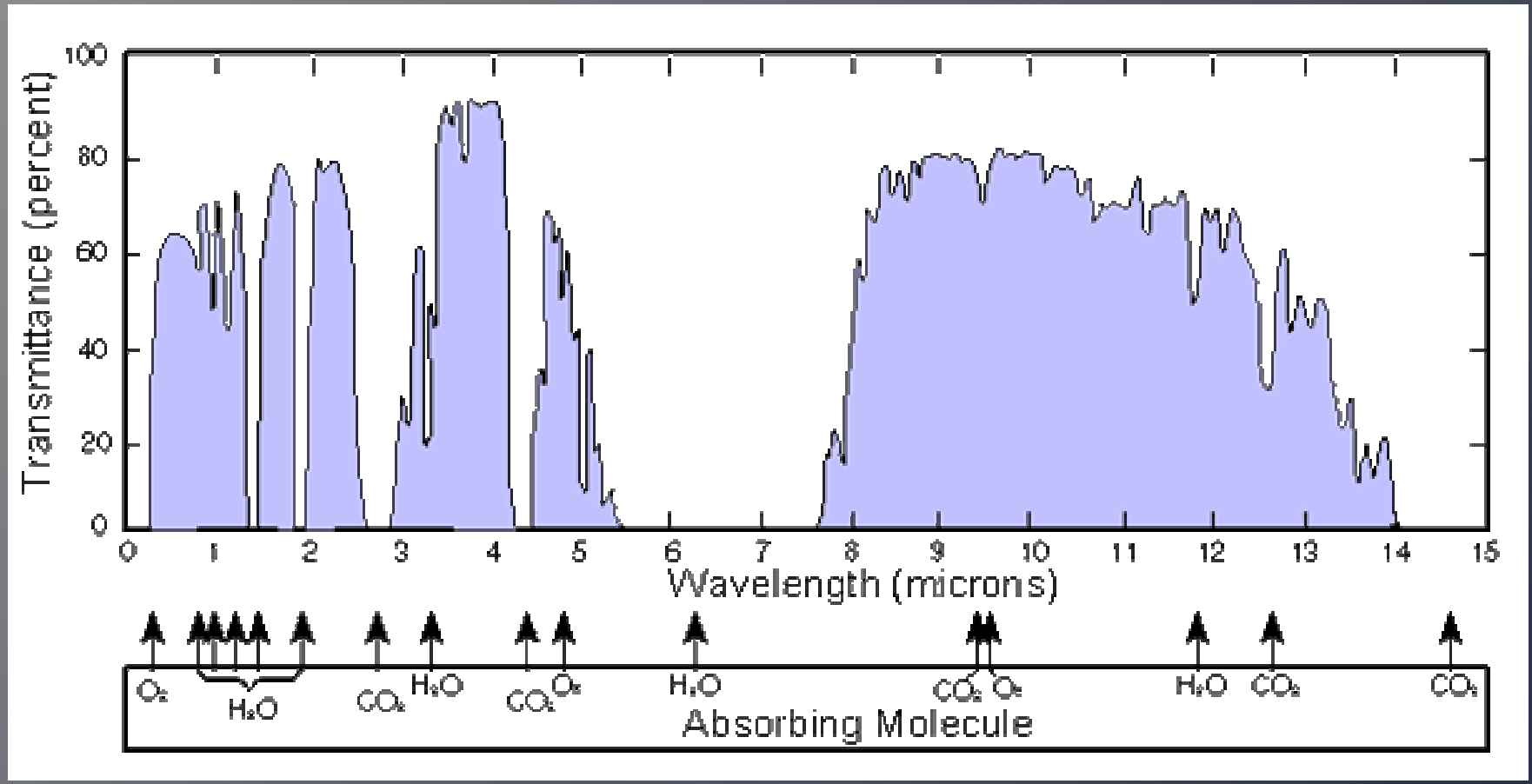


Spectral characteristics of leaves vs green paint

(Sanecki J. (pr. Zb.): “Teledetekcja. Pozyskiwanie danych”, WNT, Warszawa 2006)

Analyses of views and panoramas taken from the places with the highest visual qualities





Absorption and dispersion of radiation in the atmosphere (‚atmospheric windows')

(http://en.wikipedia.org/)

Analyses of views and panoramas taken from the places with the highest visual qualities

Image registered in the infrared range
(wavelength > 830 nm)

NDVI – Normalized Difference Normalized Index

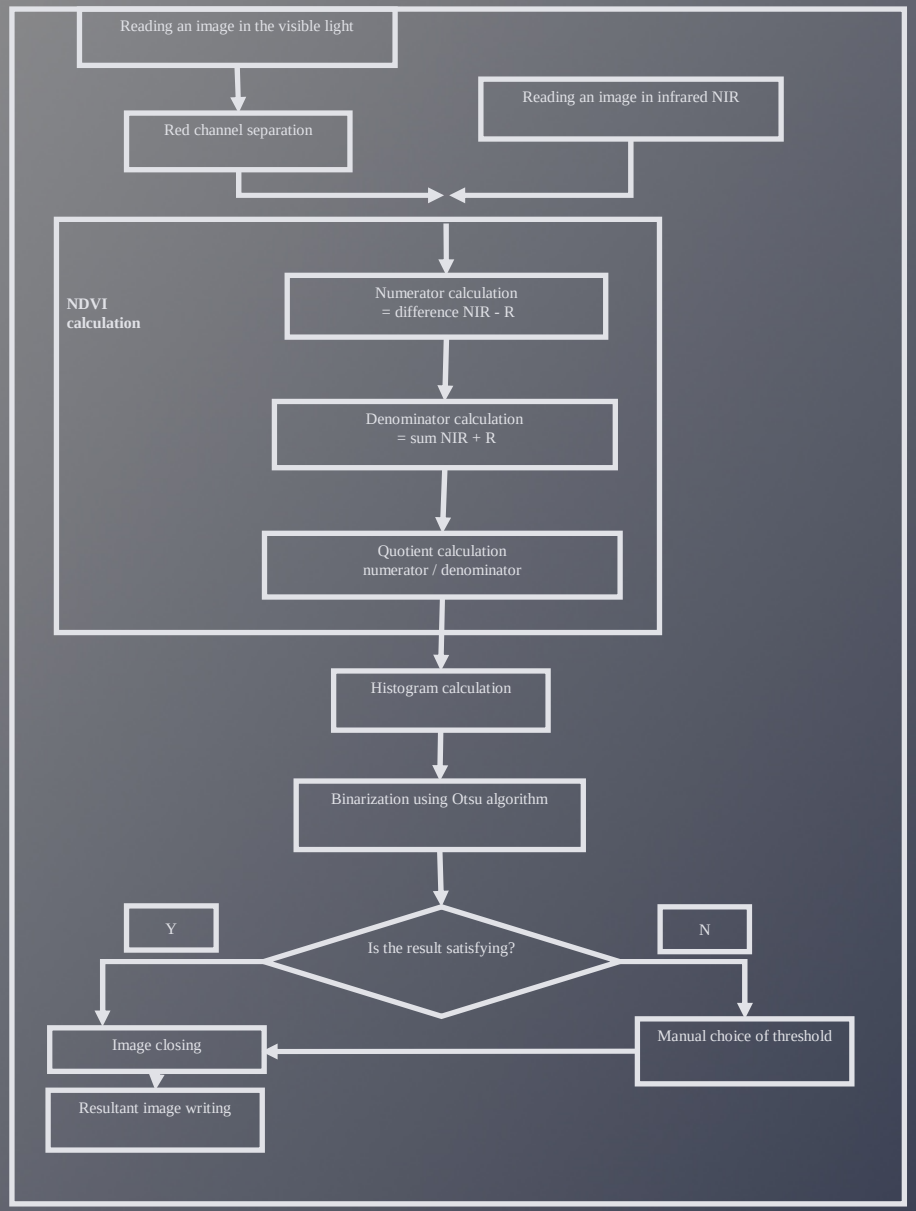
$$NDVI = \frac{NIR - R}{NIR + R}$$

where:

NIR – near infrared channel

R – red channel

Analyses of views and panoramas taken from the places with the highest visual qualities



Algorithm of NDVI calculation

EVI – Enhanced Vegetation Index

$$EVI = G\frac{NIR - R}{NIR + C_1R + C_2B + L}$$

where:

G - gain factor

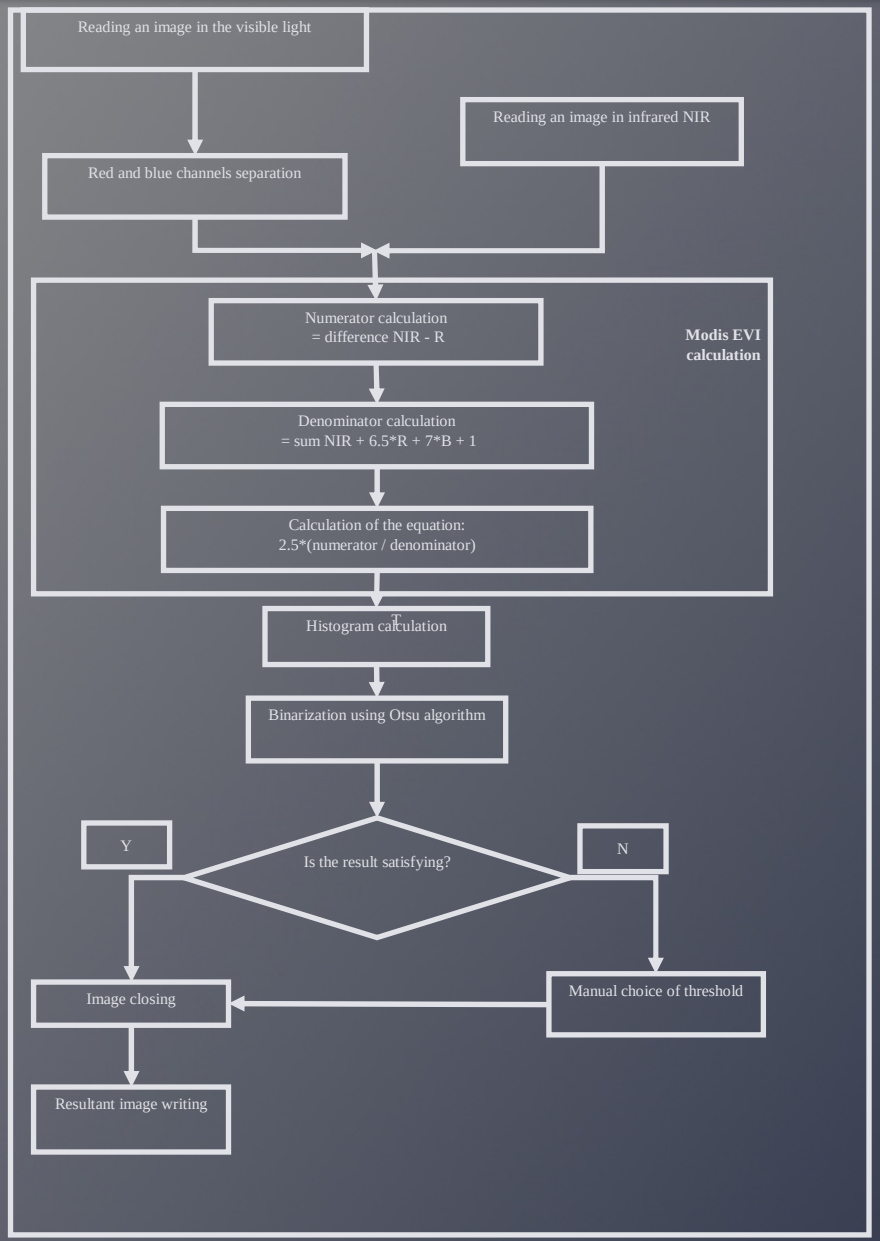
C_1, C_2 – the coefficients of the aerosol resistance term, which uses the blue band to correct for aerosol influences in the red band

L – the canopy background adjustment

MODIS EVI
(Moderate Resolution Imaging Spectroradiometer)

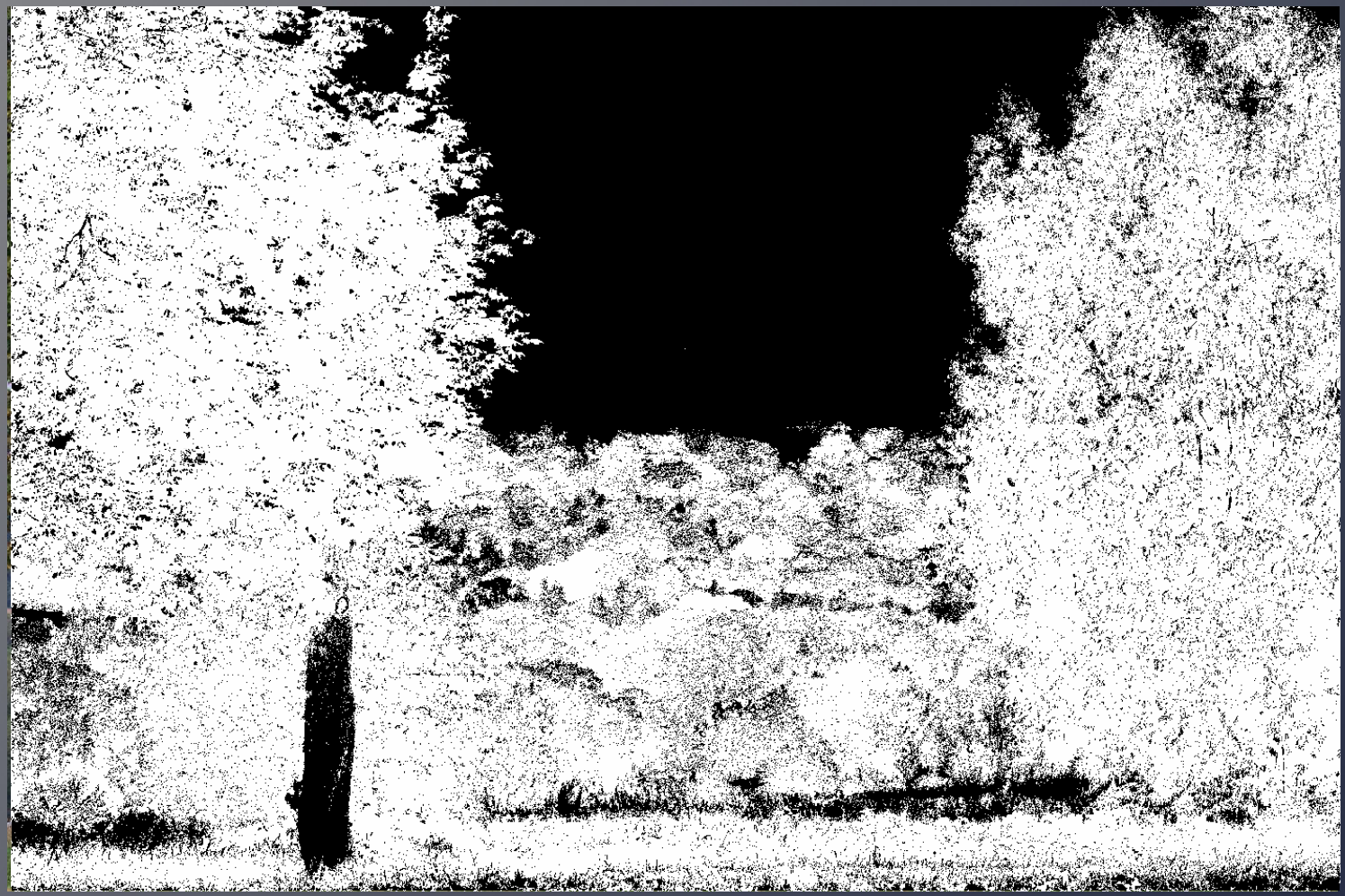
$$MODIS\_EVI = \ , \ \frac{NIR - R}{NIR + \ * R + \ , \ * B +}$$

Analyses of views and panoramas taken from the places with the highest visual qualities



Algorithm of EVI calculation

Analyses of views and panoramas taken from the places with the highest visual qualities



The efficiency of greenery detection in the eye-level views
by the means of the vegetation indices

Analyses of views and panoramas taken from the places with the highest visual qualities

The efficiency of greenery detection in the eye-level views
by the means of the vegetation indices

Problems with greenery detection by means of vegetation indices:

•The chlorophyll is responsible for the high values in the infrared band, thus only green parts of plants can be detected (leaves).

•The phenomena of overlapping cause that the dry ends of plants (grass) are not detected.

•In he autumn, yellow leaves reflect highly in the red band, therefore they not be detected.

•Reflections in glossy surfaces are classified as plants (it can be reduced, but not eliminated using polarizing filter).

•Raster images formats automatically generate antialiasing (blurry edges of objects) – errors occur ain these areas.

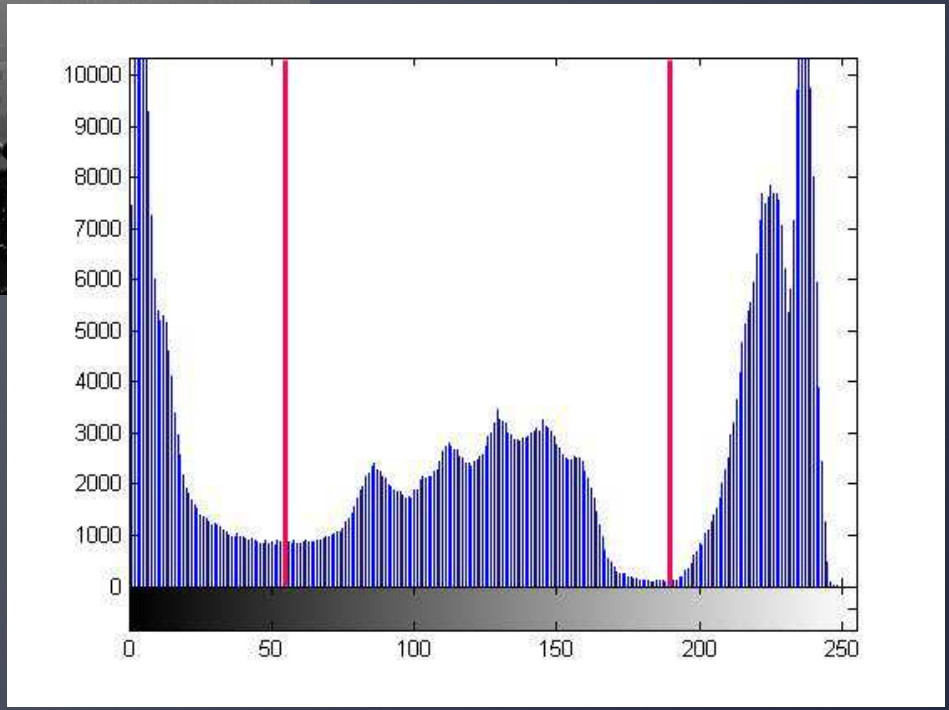
Analyses of views and panoramas taken from the places with the highest visual qualities

Bayes naive classifier in landscape photography segmentation

Distance-dependent factors:

- atmospheric haze (air perspective),
- colours intensity,
- colours variety,
- contrast.

Analyses of views and panoramas taken from the places with the highest visual qualities



Atmospheric haze

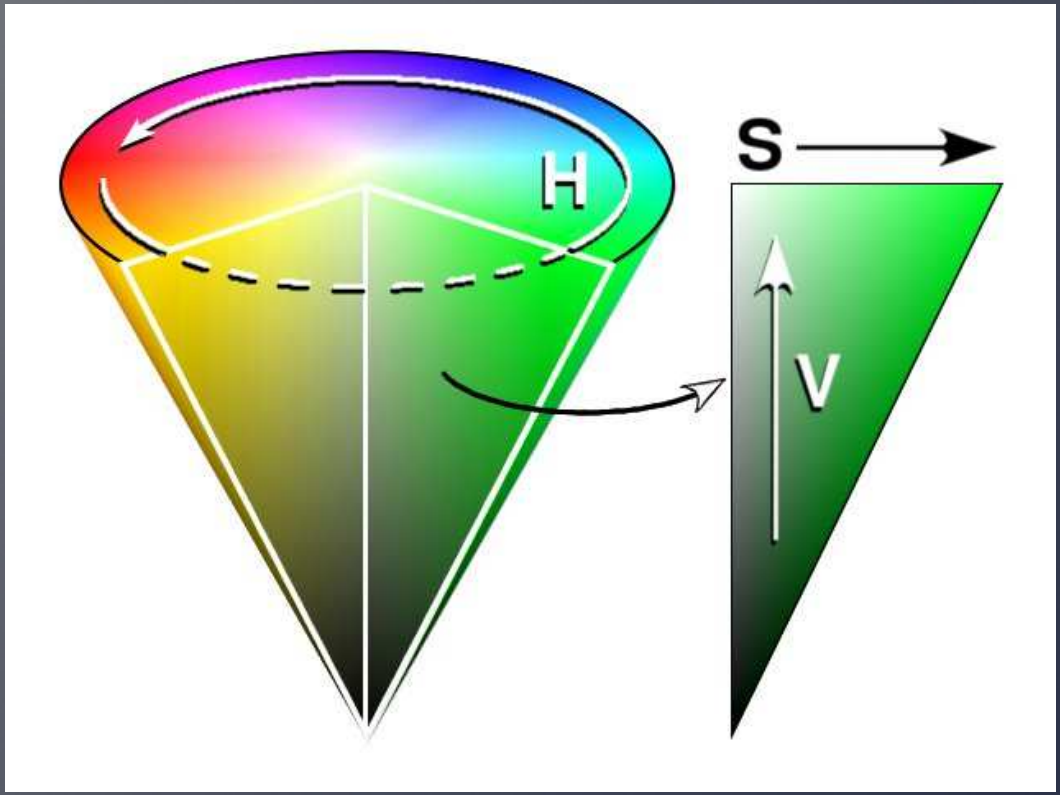
Blue channel and its histogram

Analyses of views and panoramas taken from the places with the highest visual qualities

Separation of the distance-dependent zones in case of big distance difference

Intensity of colours

RGB to HSV convertion and choice of the saturation channel



Colour model HSV

Pixel’s colour is defined by three parameters:
Hue (basic colour), Saturation, Value.

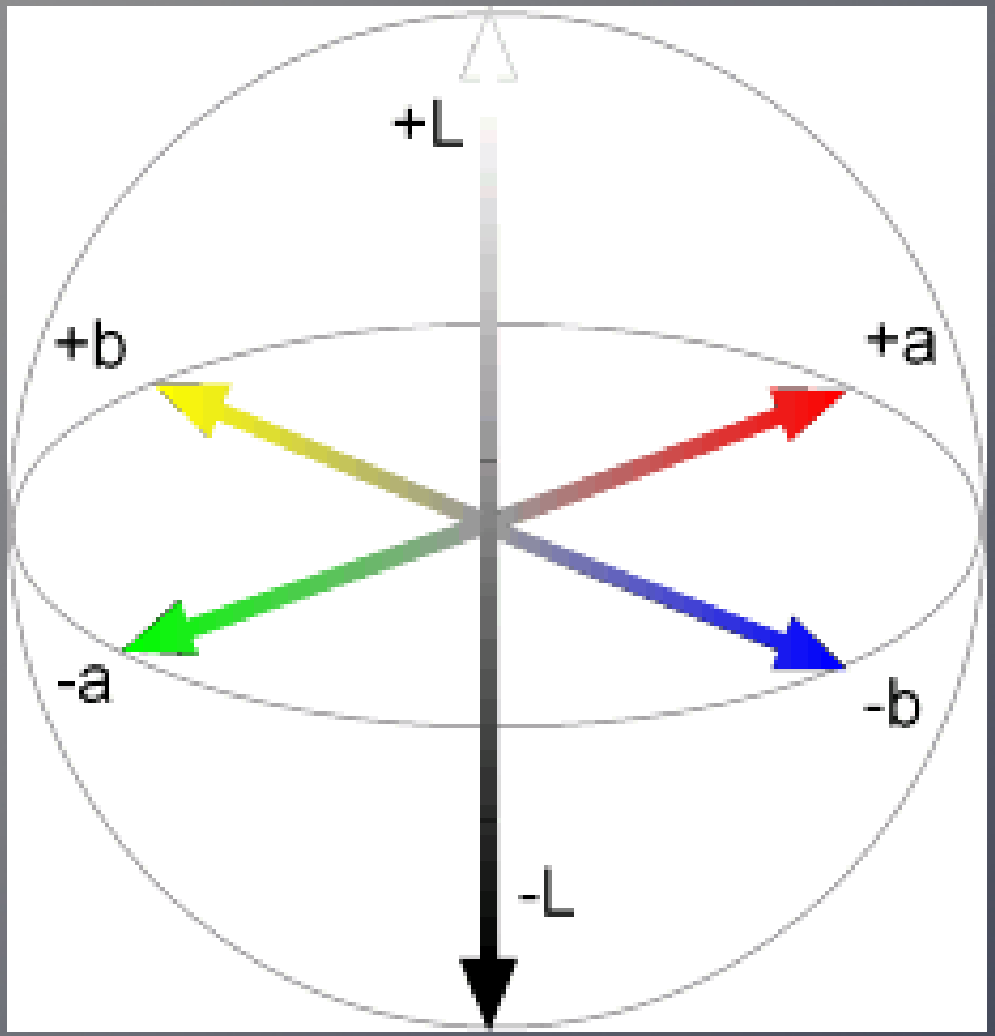
(http://pl.wikipedia.org/)

Analyses of views and panoramas taken from the places with the highest visual qualities

Contrast

A measure employed in industry

$$\Delta \quad = \left[(\Delta \quad) + (\Delta \quad) + (\Delta \quad) \right]$$



Colour model CIE La*b*

Pixel colour is described by three parameters:
intensity (brightness),
‚a' channel (from green to red),
‚b' channel (from blue to yellow).

http://www.jiscdigitalmedia.ac.uk/stillimages/advice/colour-theory-understanding-and-modelling-colour)

Analyses of views and panoramas taken from the places with the highest visual qualities

Colour variety:

•absolute difference between pixel's value and the whole image mean,
•absolute difference between pixel's value and the whole image median,
•standard deviation…

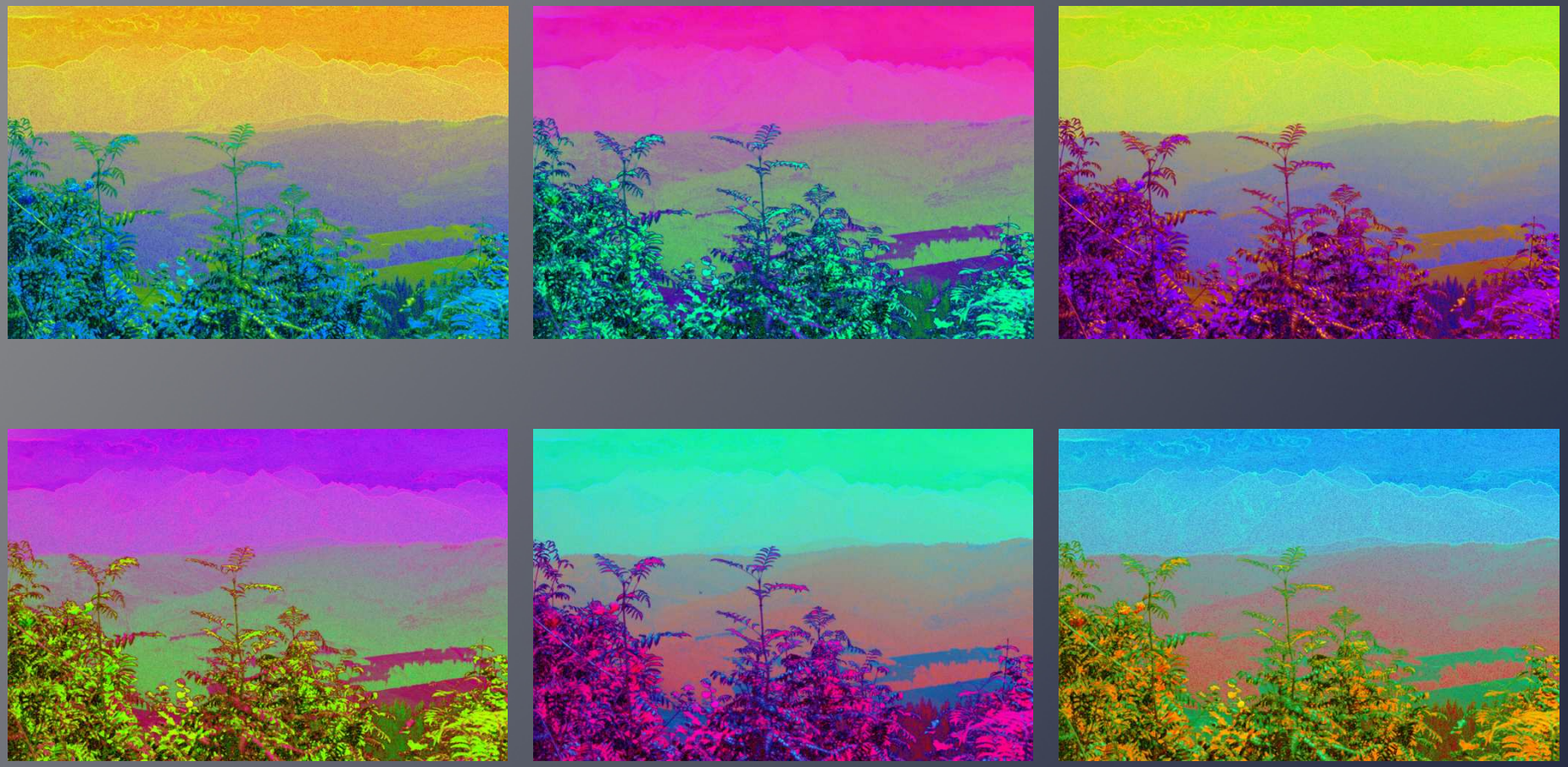
Distance-dependent colour space:

R – saturation (intensity),
G – 0.5*contrast + 0.5*difference between the pixel's value and the median,
B – blue channel

Analyses of views and panoramas taken from the places with the highest visual qualities

The colour space utilizing the standard deviation

Analyses of views and panoramas taken from the places with the highest visual qualities

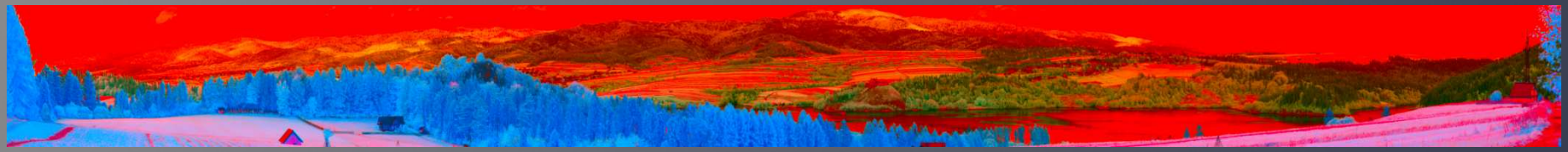


6 combinations of 3 distance-dependent factors

Analyses of views and panoramas taken from the places with the highest visual qualities

Mountains’ detection in the new colour space

False Colour Composition

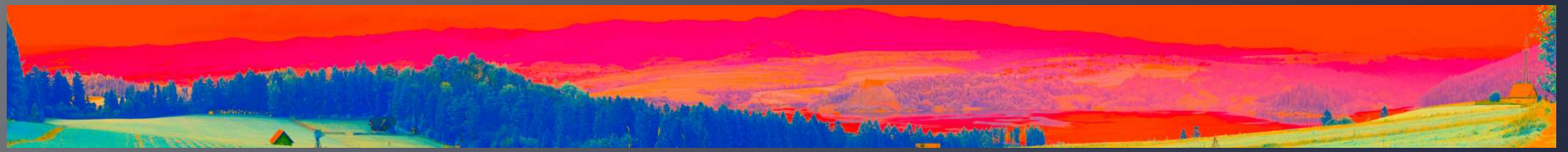


above:

Two visible channels and infrared band composed as CIE La*b* colour space

below:

Three colour channels composed in CIE La*b* colour space



Analyses of views and panoramas taken from the places with the highest visual qualities

Three visible channels (G B R)

Efficiency in the skyline detection

Analyses of views and panoramas taken from the places with the highest visual qualities

Two visible channels and infrared (R IR G)

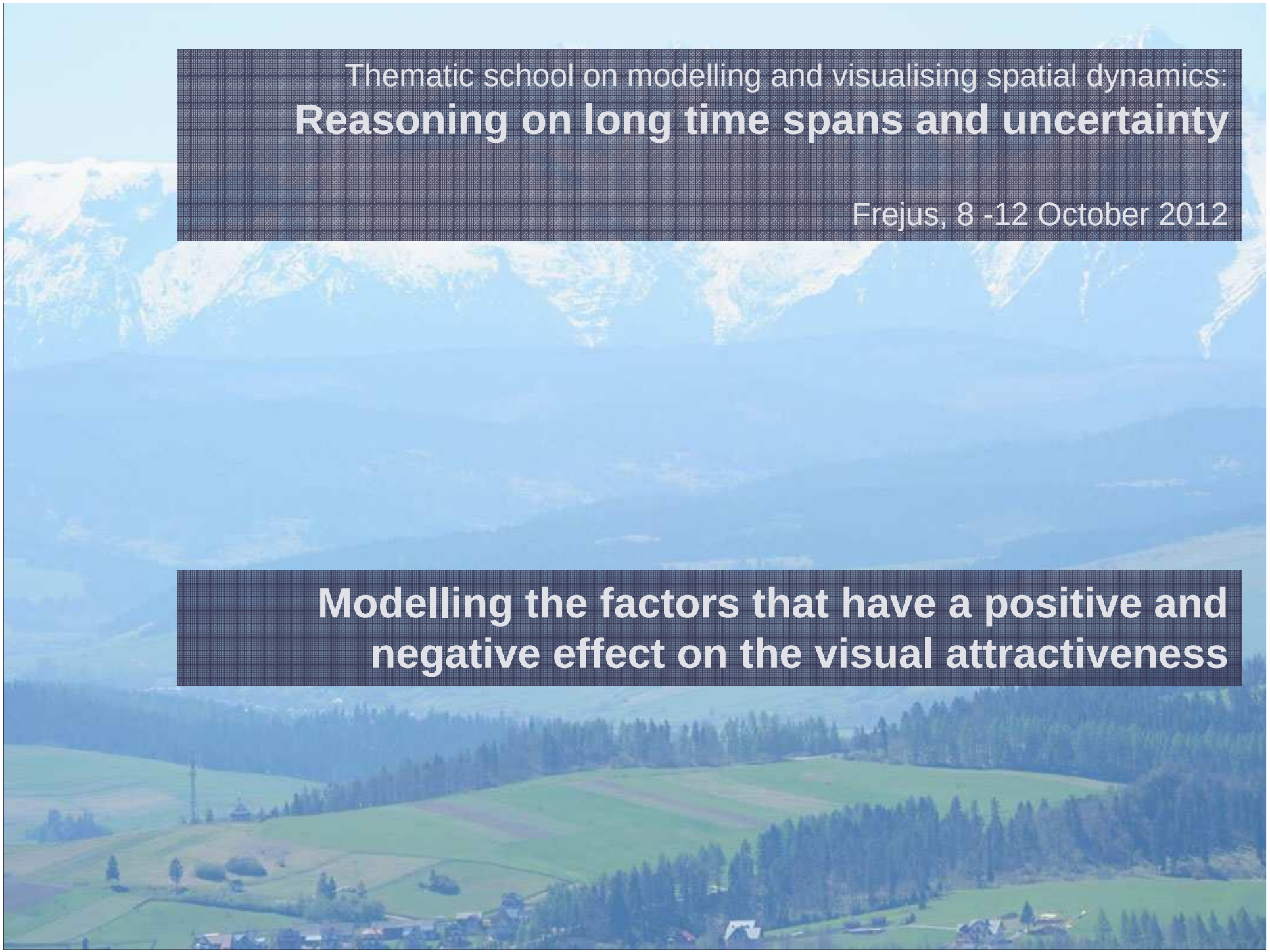
Efficiency in details' detection

Thematic school on modelling and visualising spatial dynamics:

Reasoning on long time spans and uncertainty

Frejus, 8 -12 October 2012

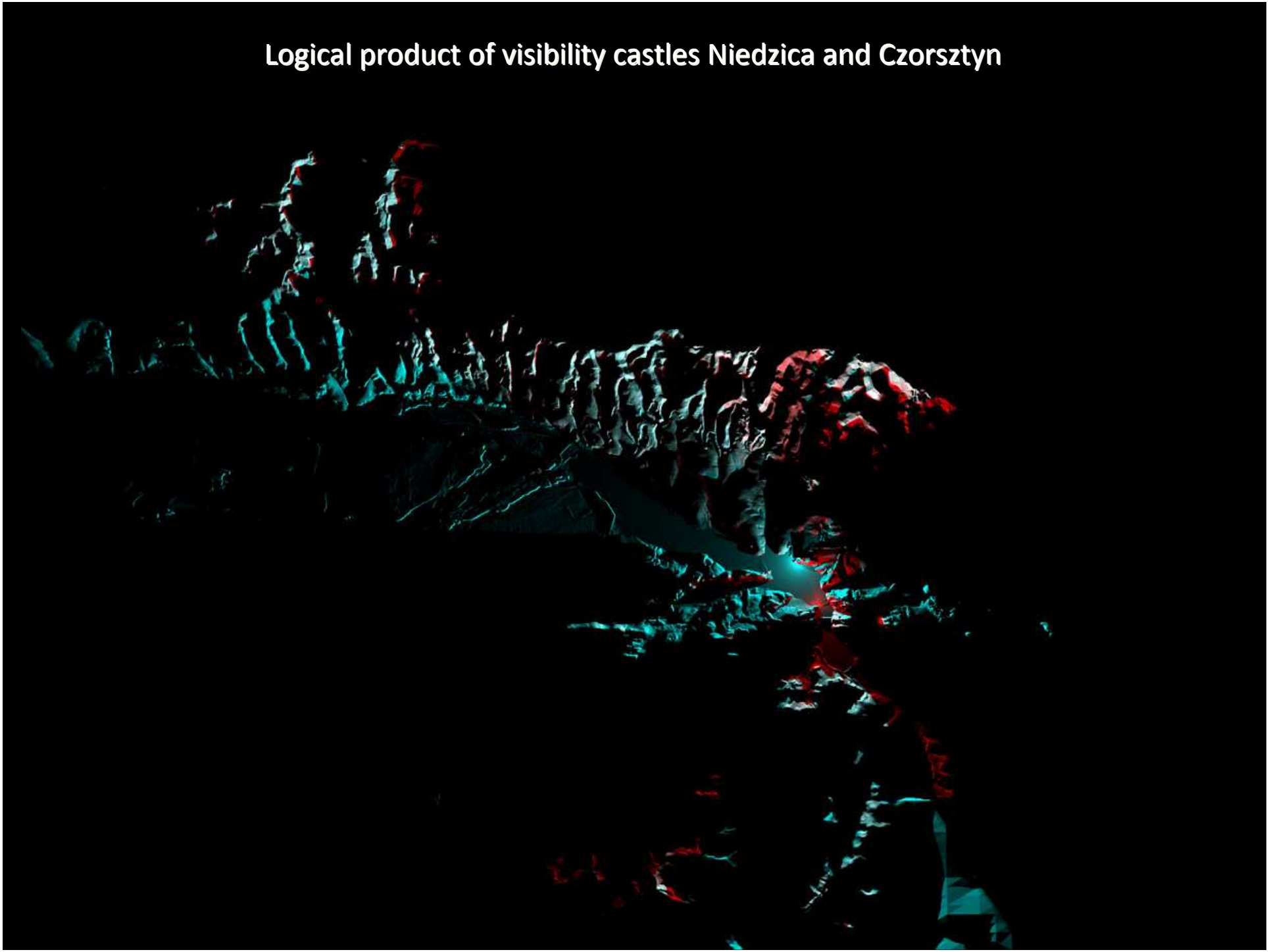
Modelling the factors that have a positive and negative effect on the visual attractiveness



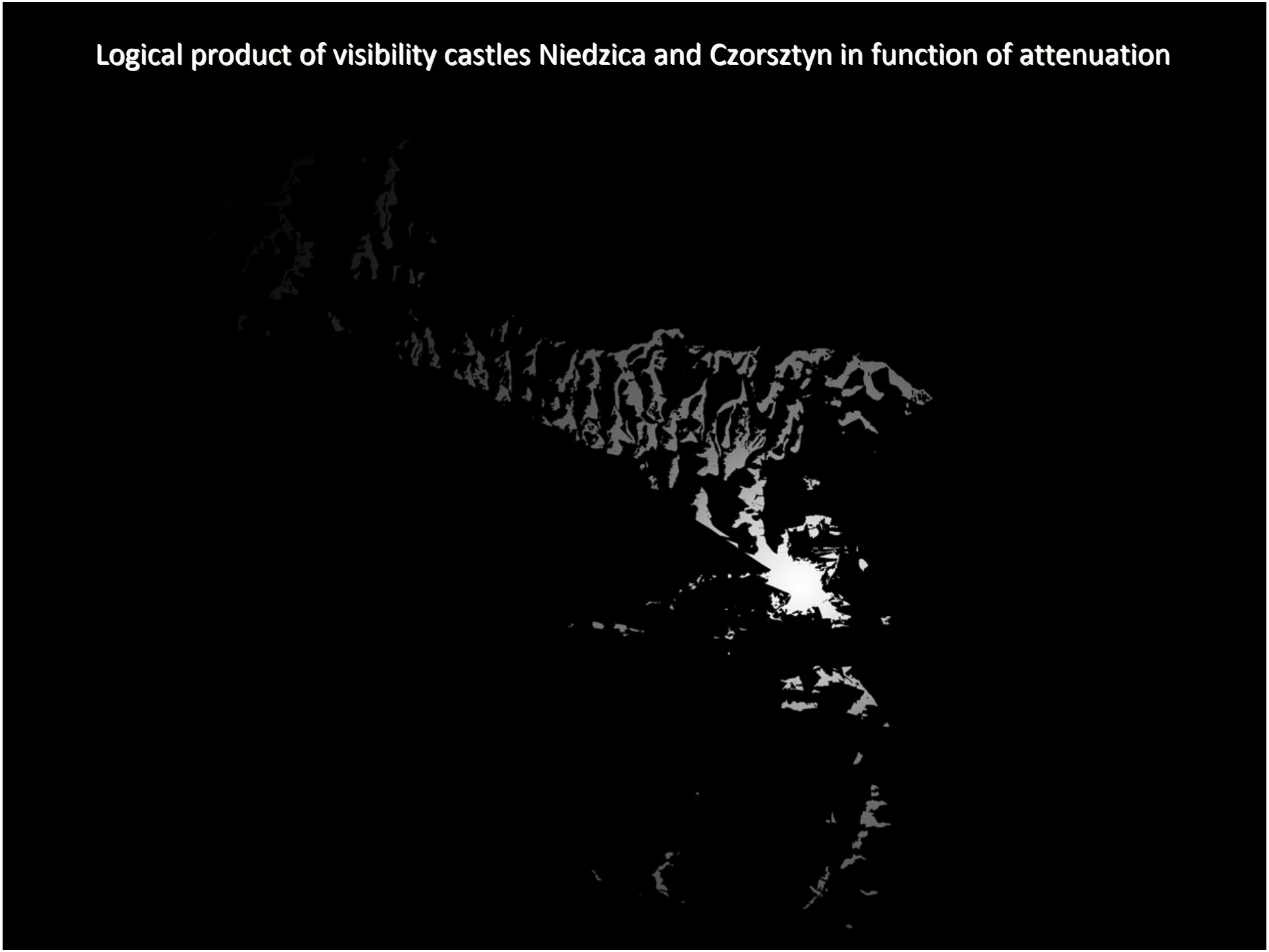
Modelling the factors that have a positive and negative effect on the visual attractiveness

1. Unusualness visibility map :
   VM_Tatry + VM_Babia Góra + VM_Gorce + VM_Pieniny + (VM_Czorsztyn * VM_Niedzica)

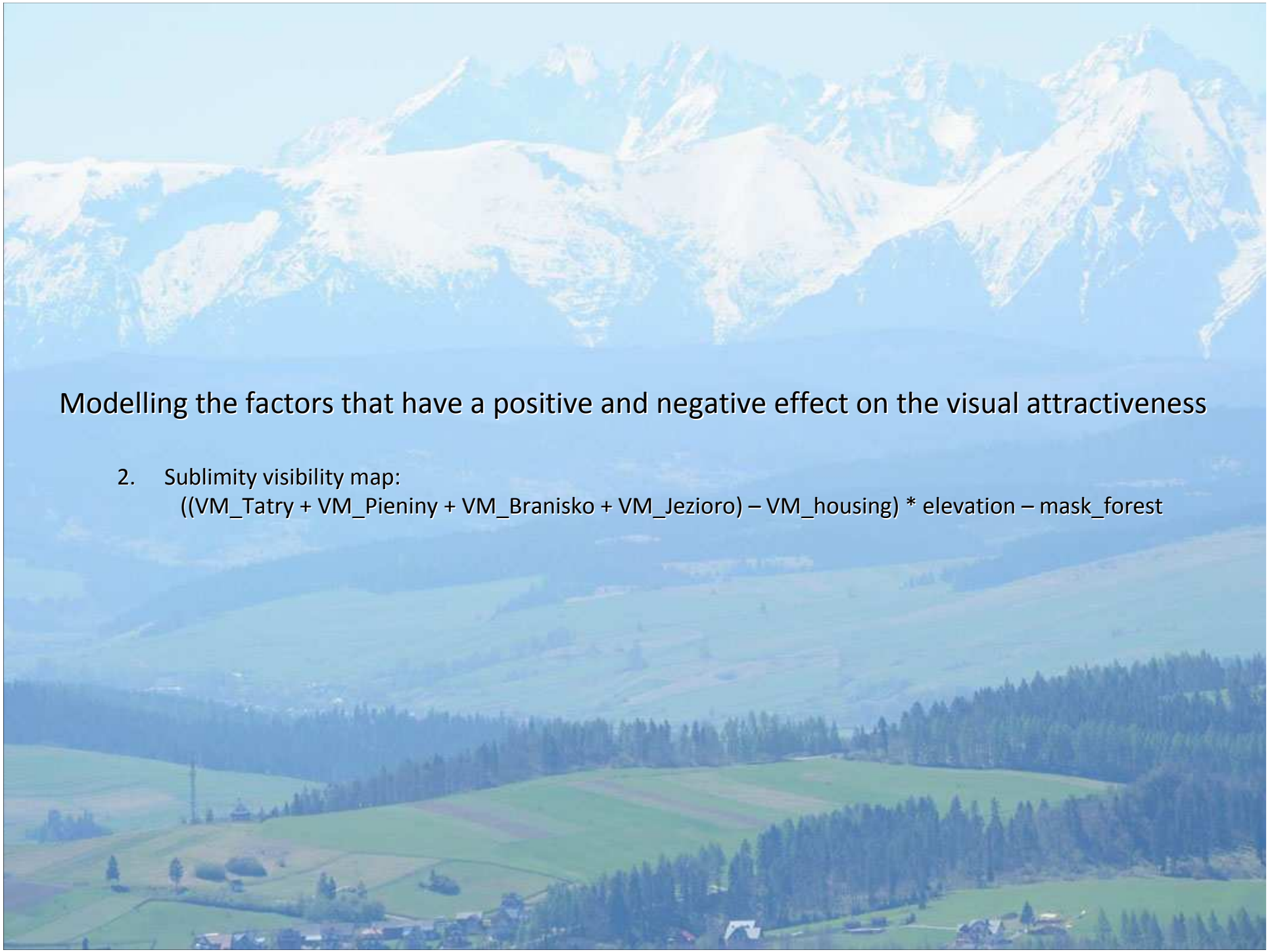
Logical product of visibility castles Niedzica and Czorsztyn



Logical product of visibility castles Niedzica and Czorsztyn in function of attenuation

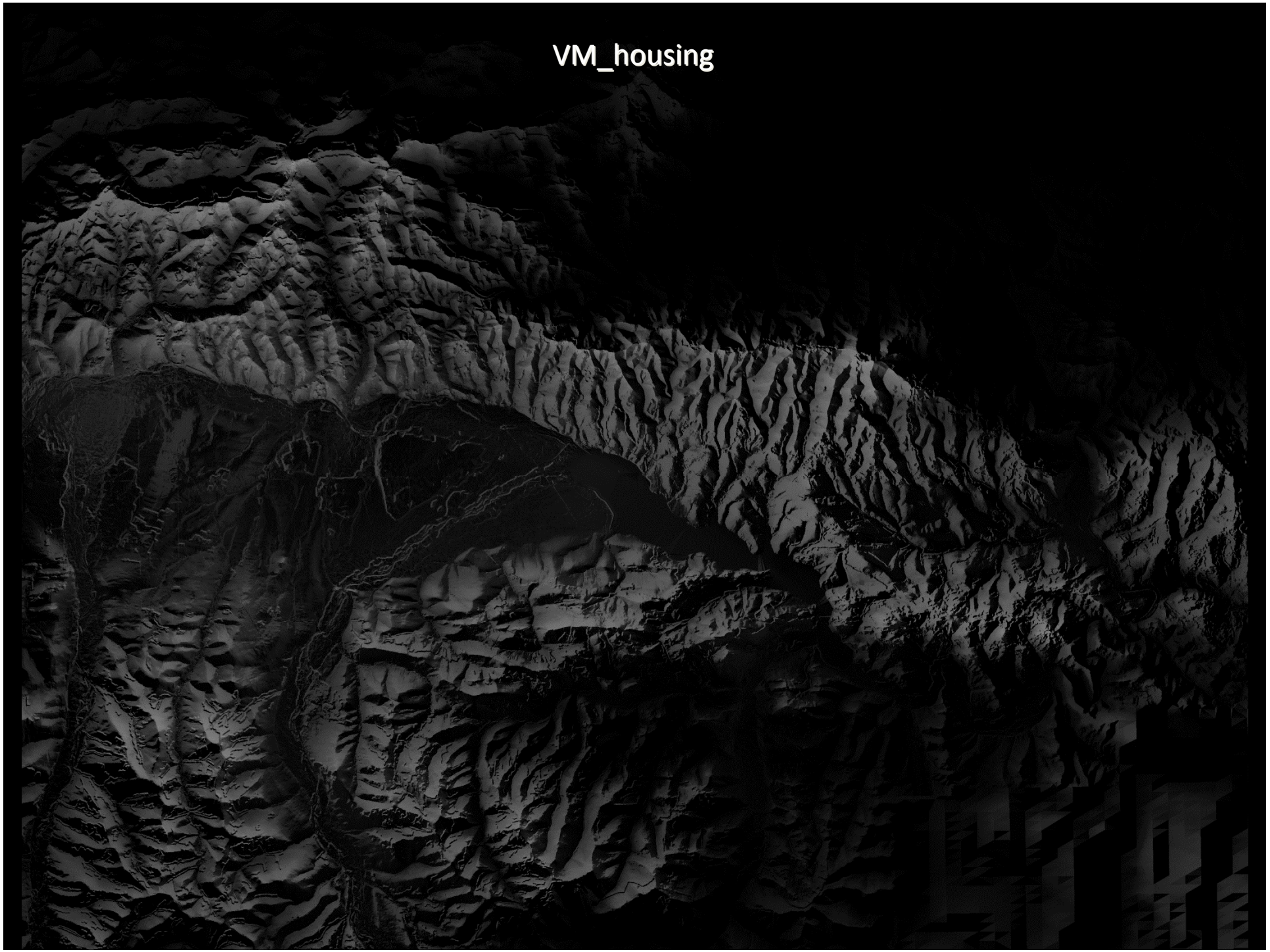


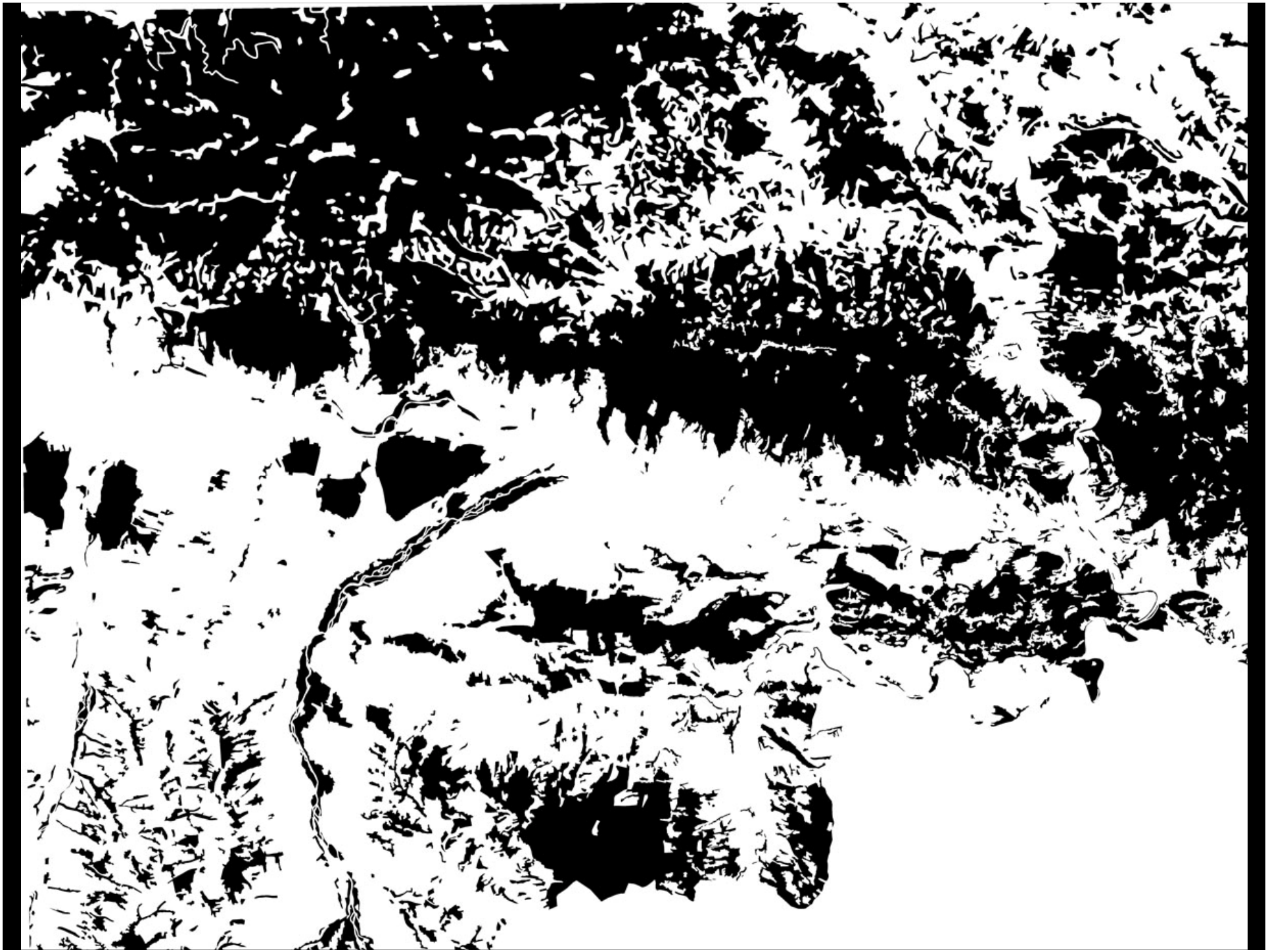

Unusualness visibility map

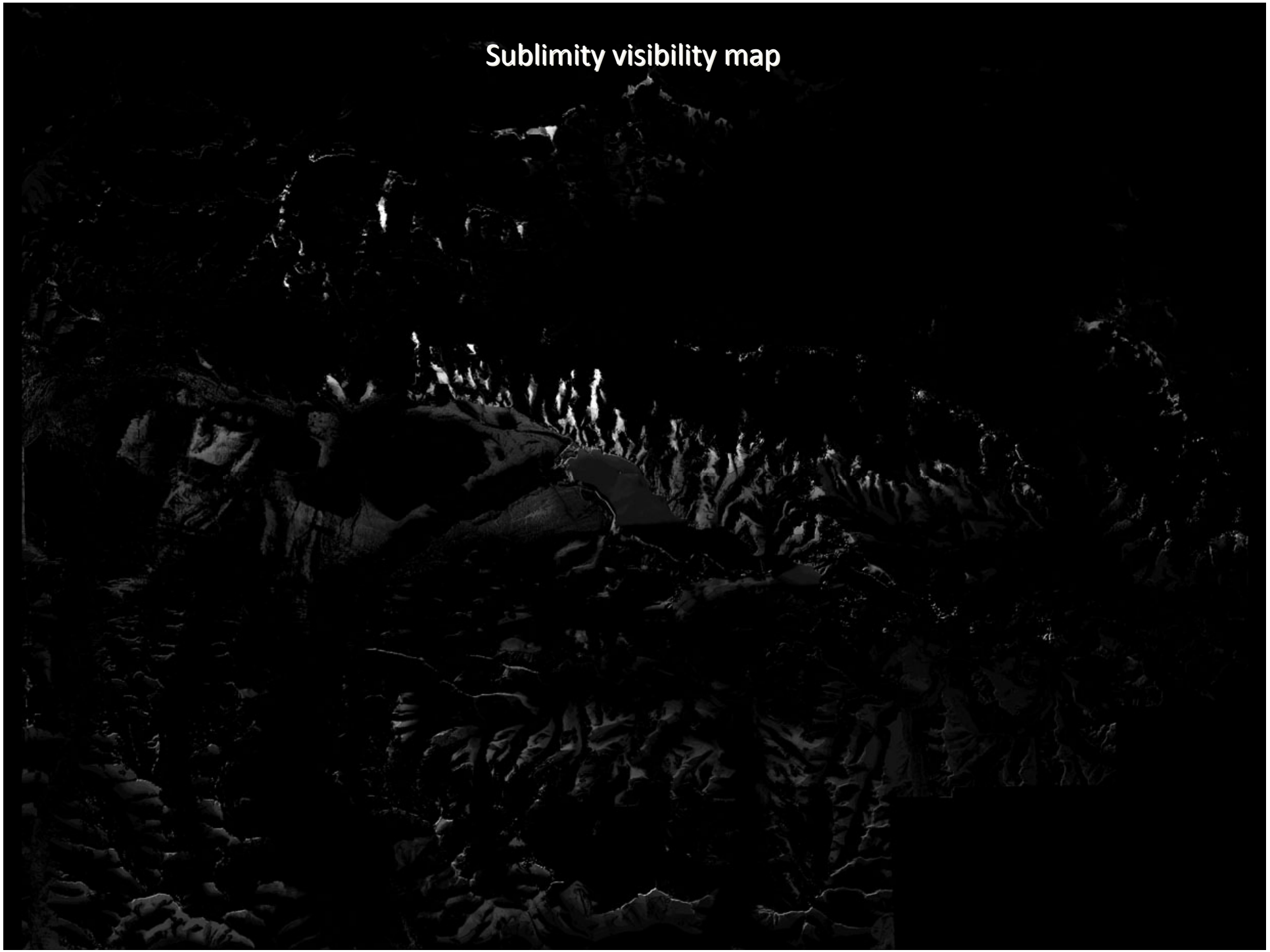


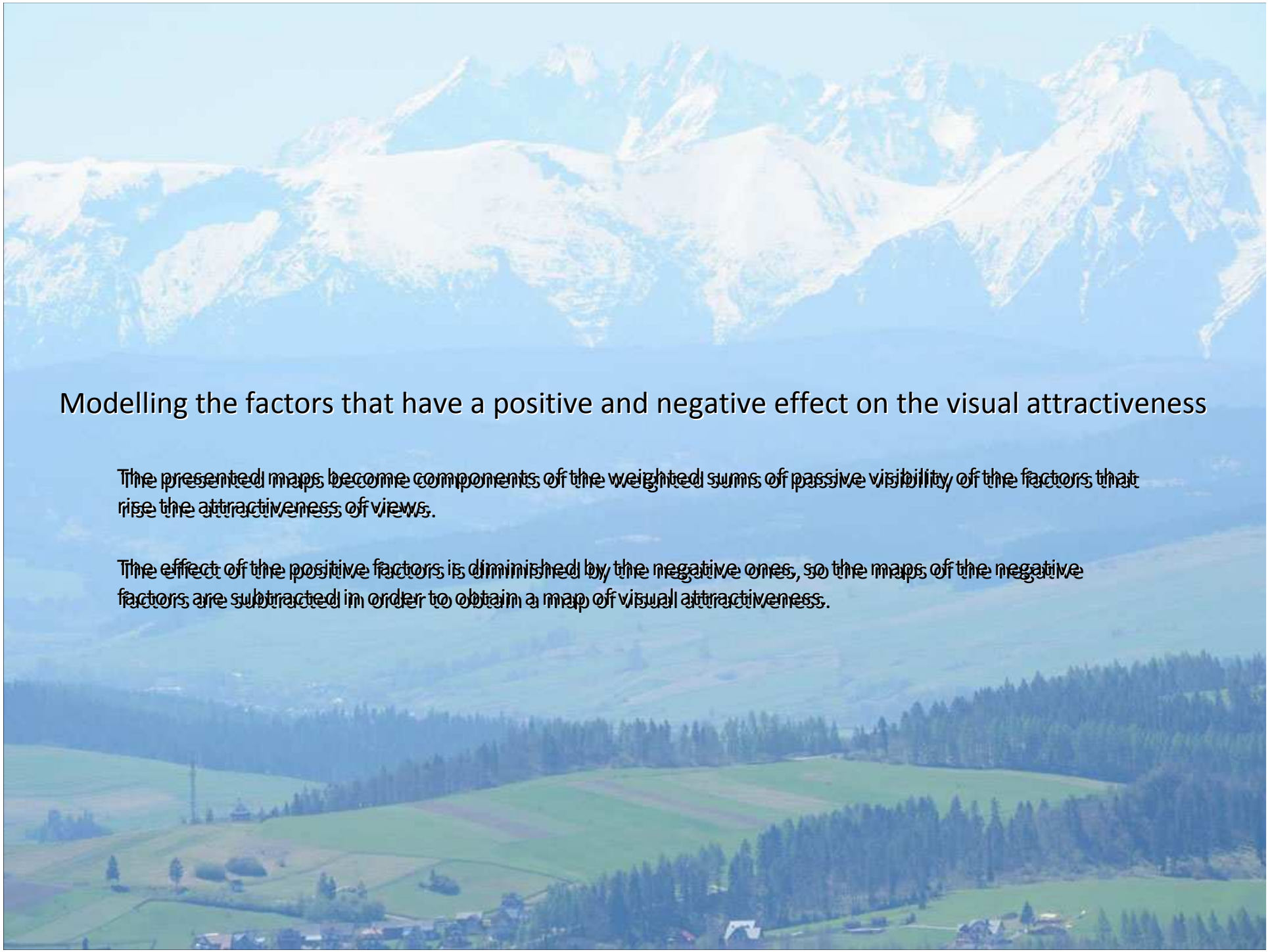
Modelling the factors that have a positive and negative effect on the visual attractiveness

2. Sublimity visibility map:
   ((VM_Tatry + VM_Pieniny + VM_Branisko + VM_Jezioro) – VM_housing) * elevation – mask_forest


VM_housing




Sublimity visibility map



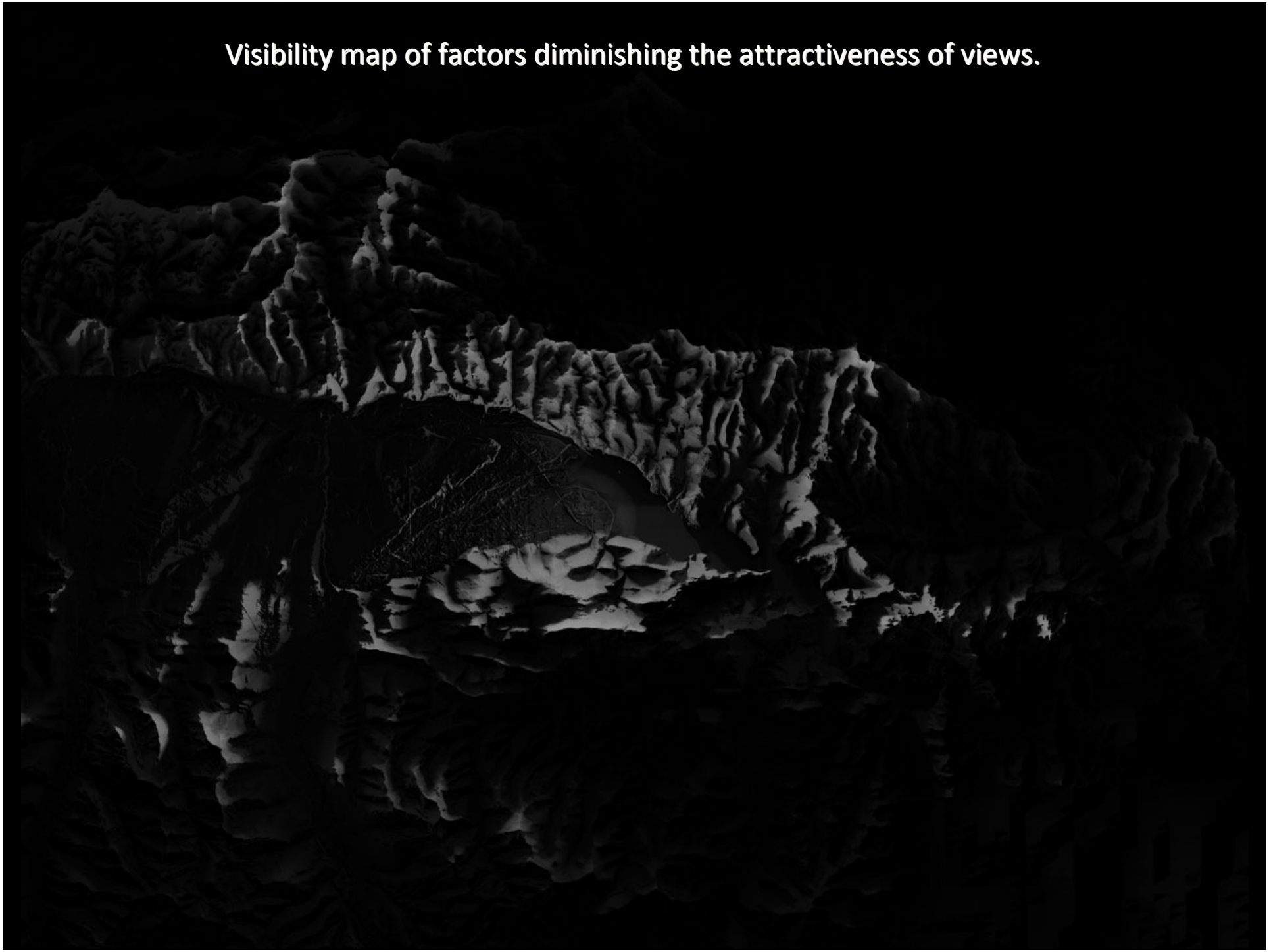
Modelling the factors that have a positive and negative effect on the visual attractiveness

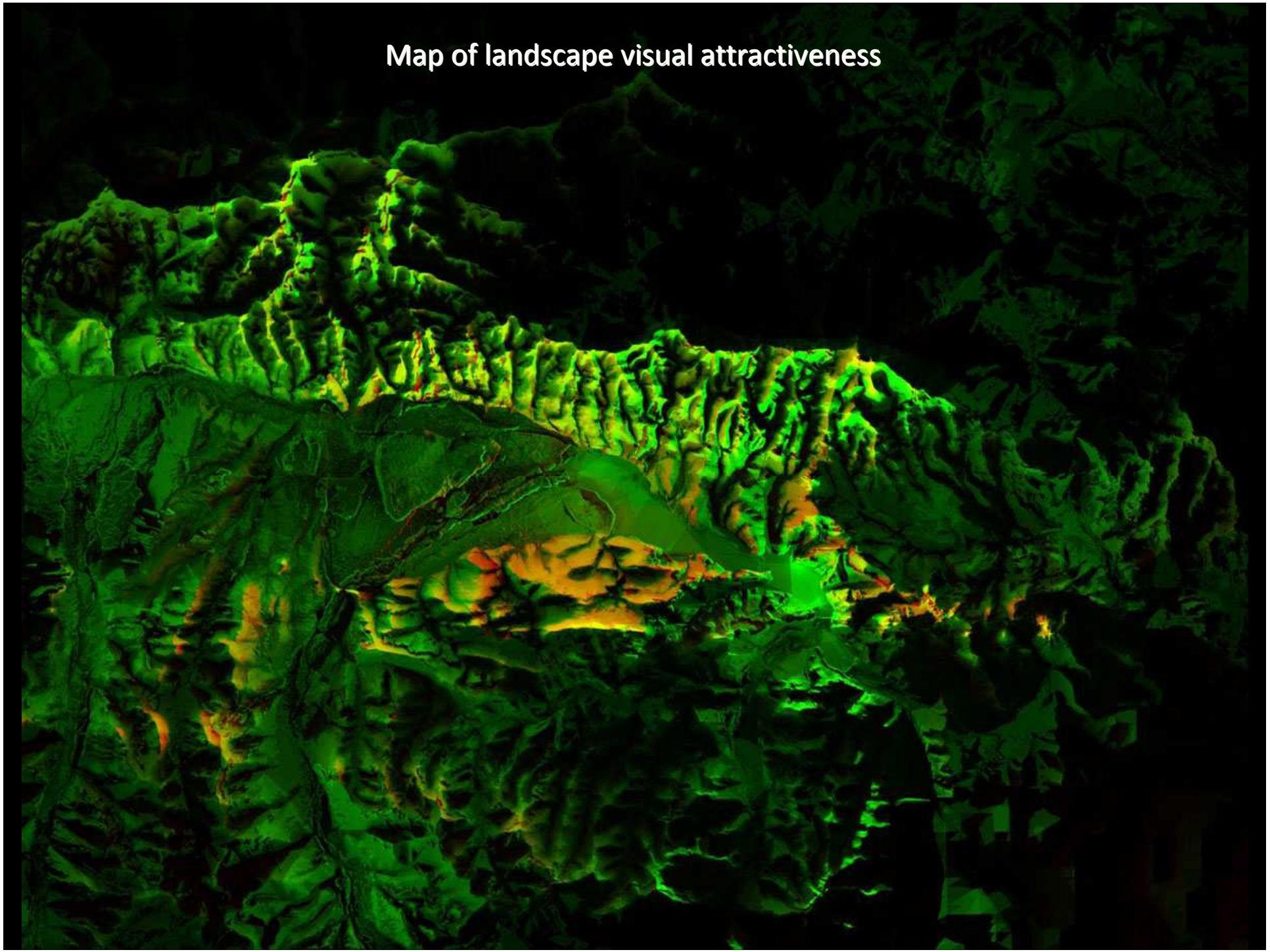
The presented maps become components of the weighted sums of passive visibility of the factors that rise the attractiveness of views.

The effect of the positive factors is diminished by the negative ones, so the maps of the negative factors are subtracted in order to obtain a map of visual attractiveness.

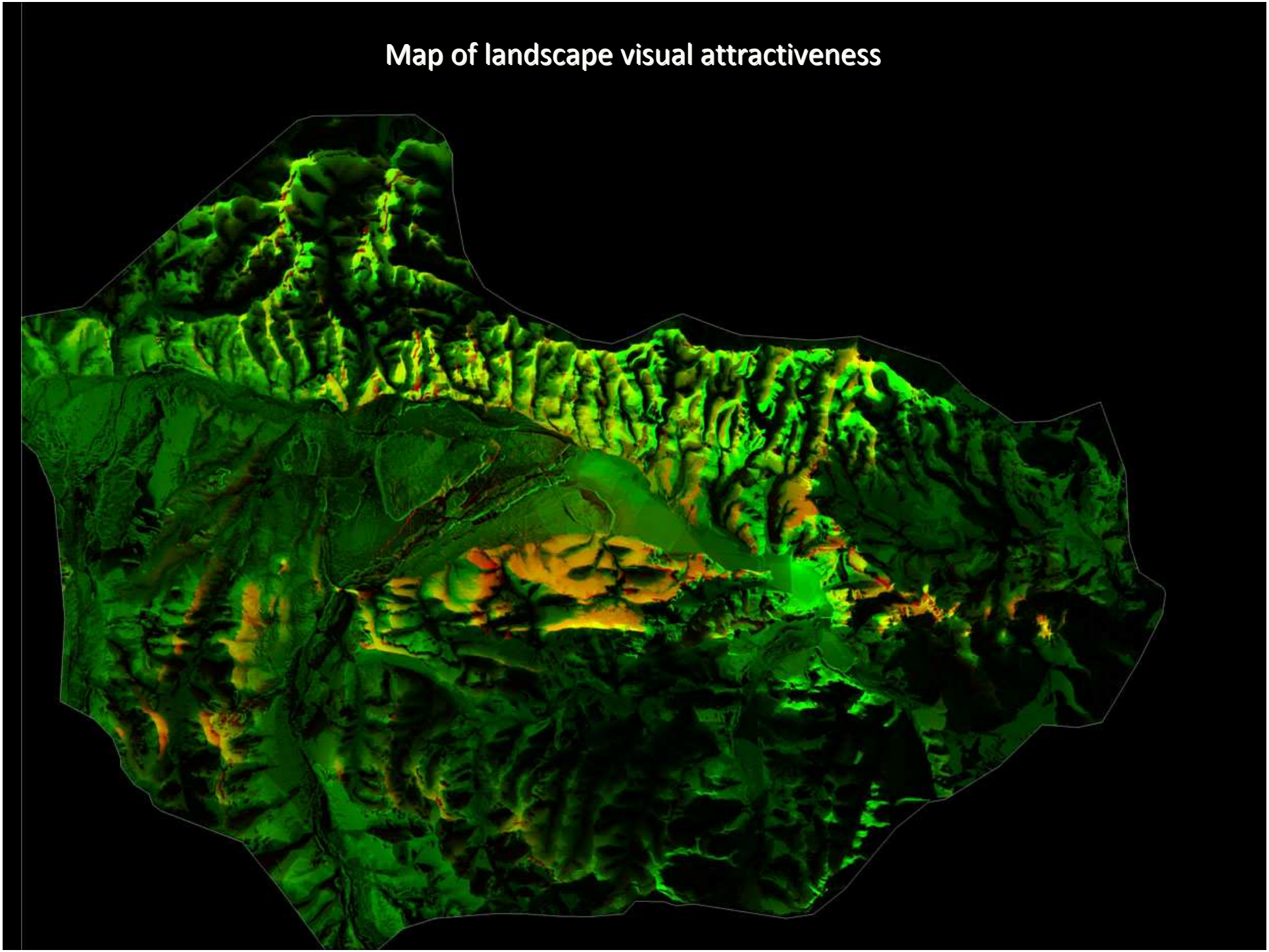

Visibility map of factors rising the attractiveness of views.

Visibility map of factors diminishing the attractiveness of views.

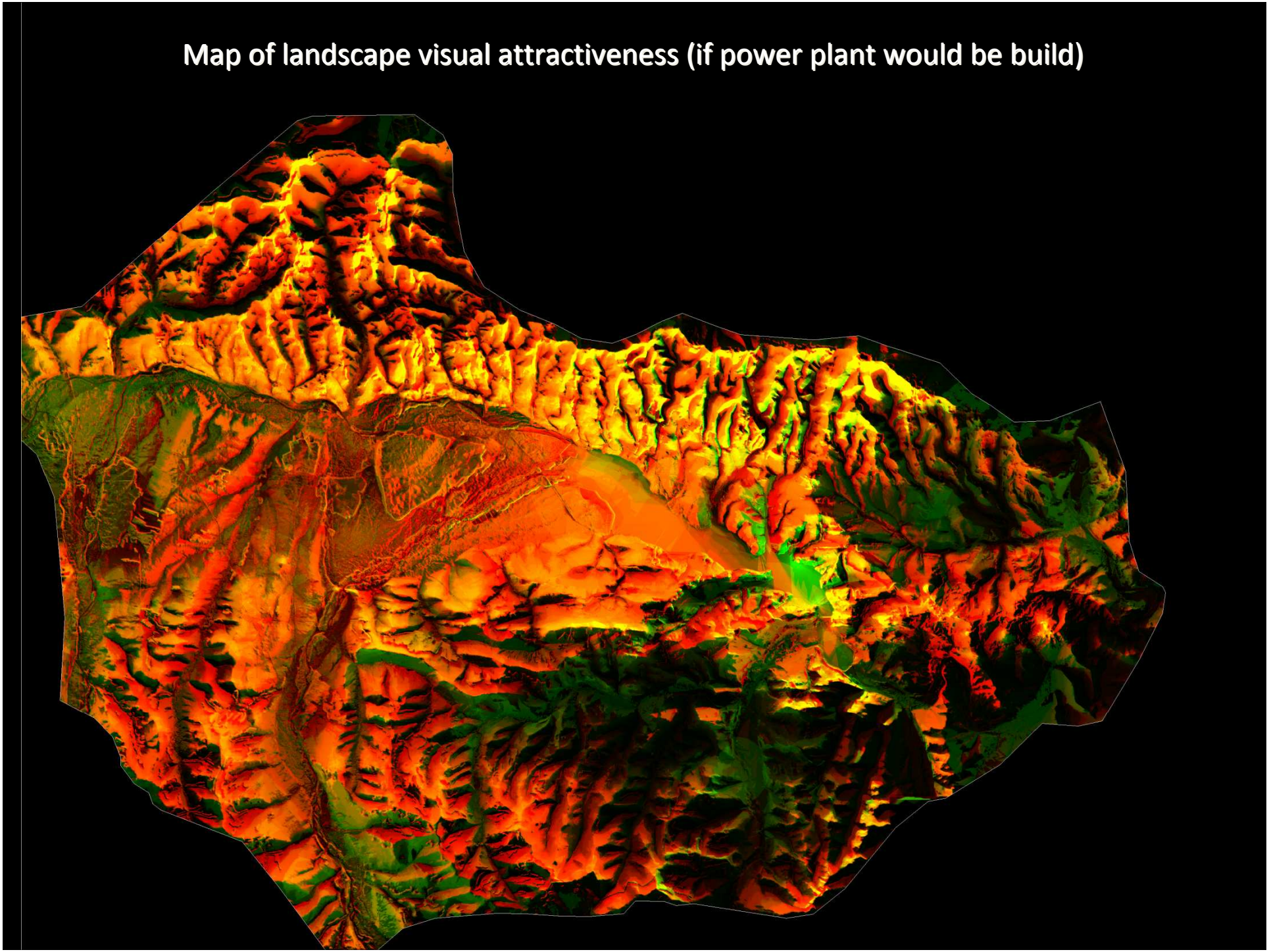



Map of landscape visual attractiveness

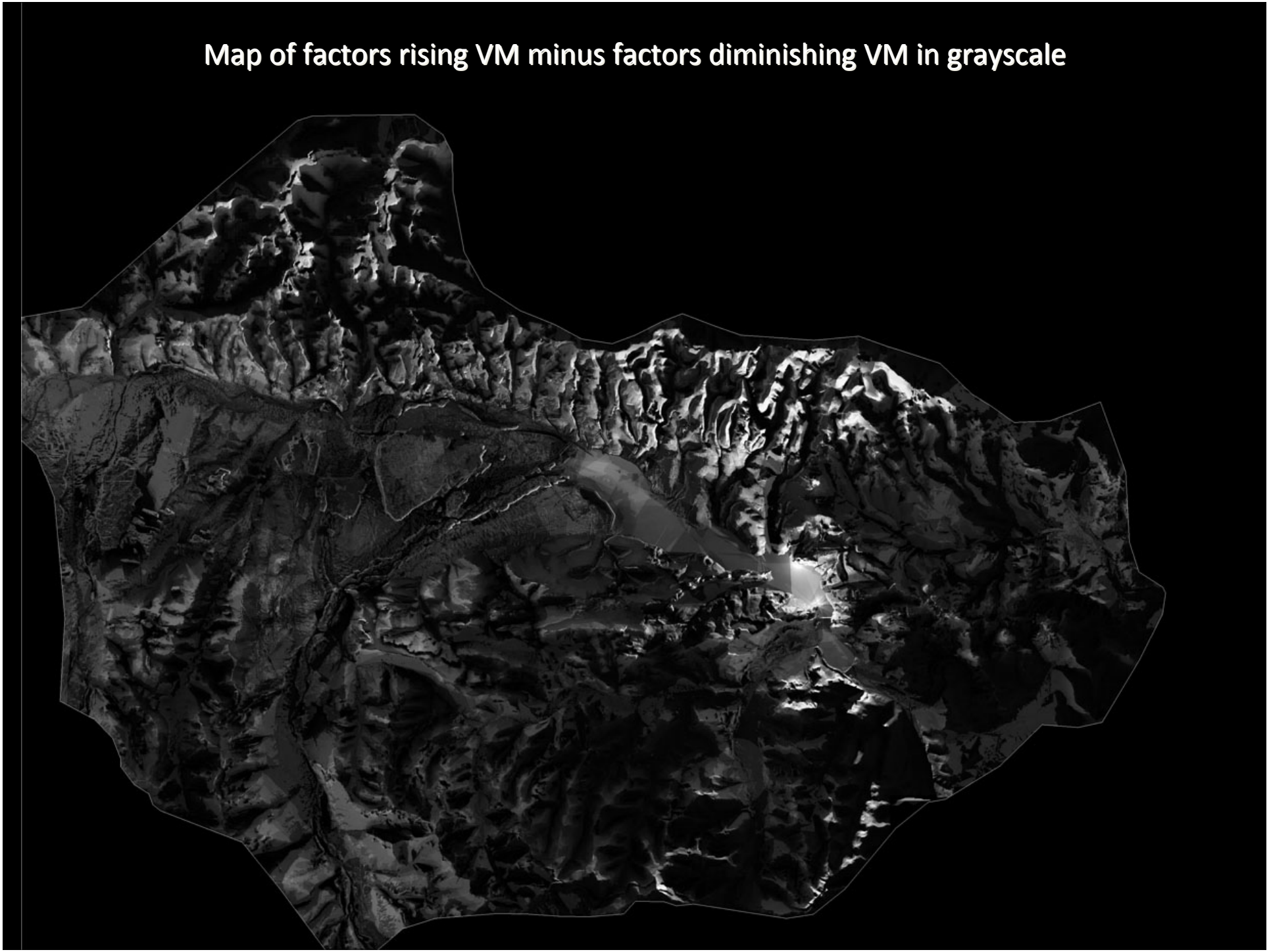
Map of landscape visual attractiveness

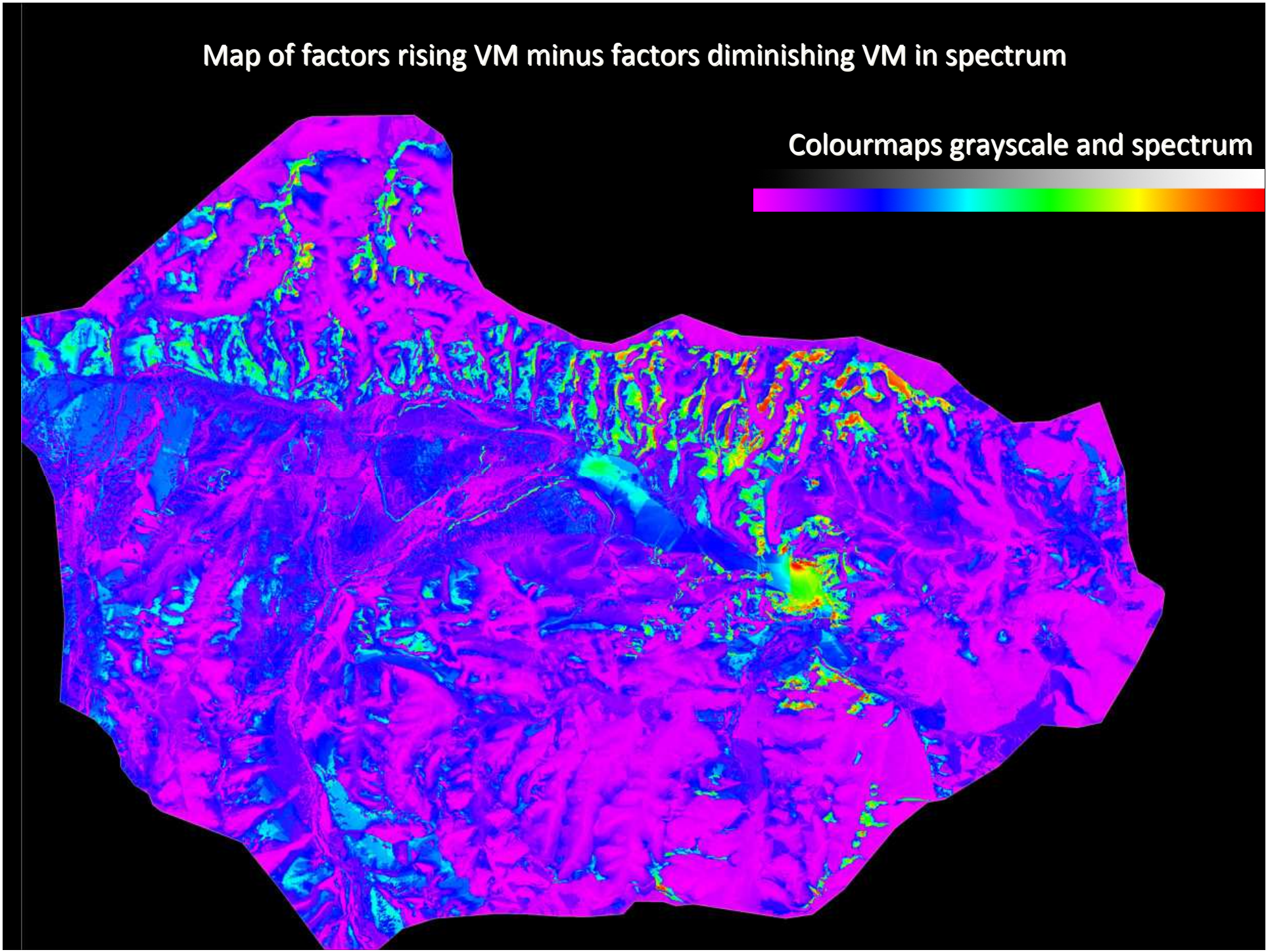


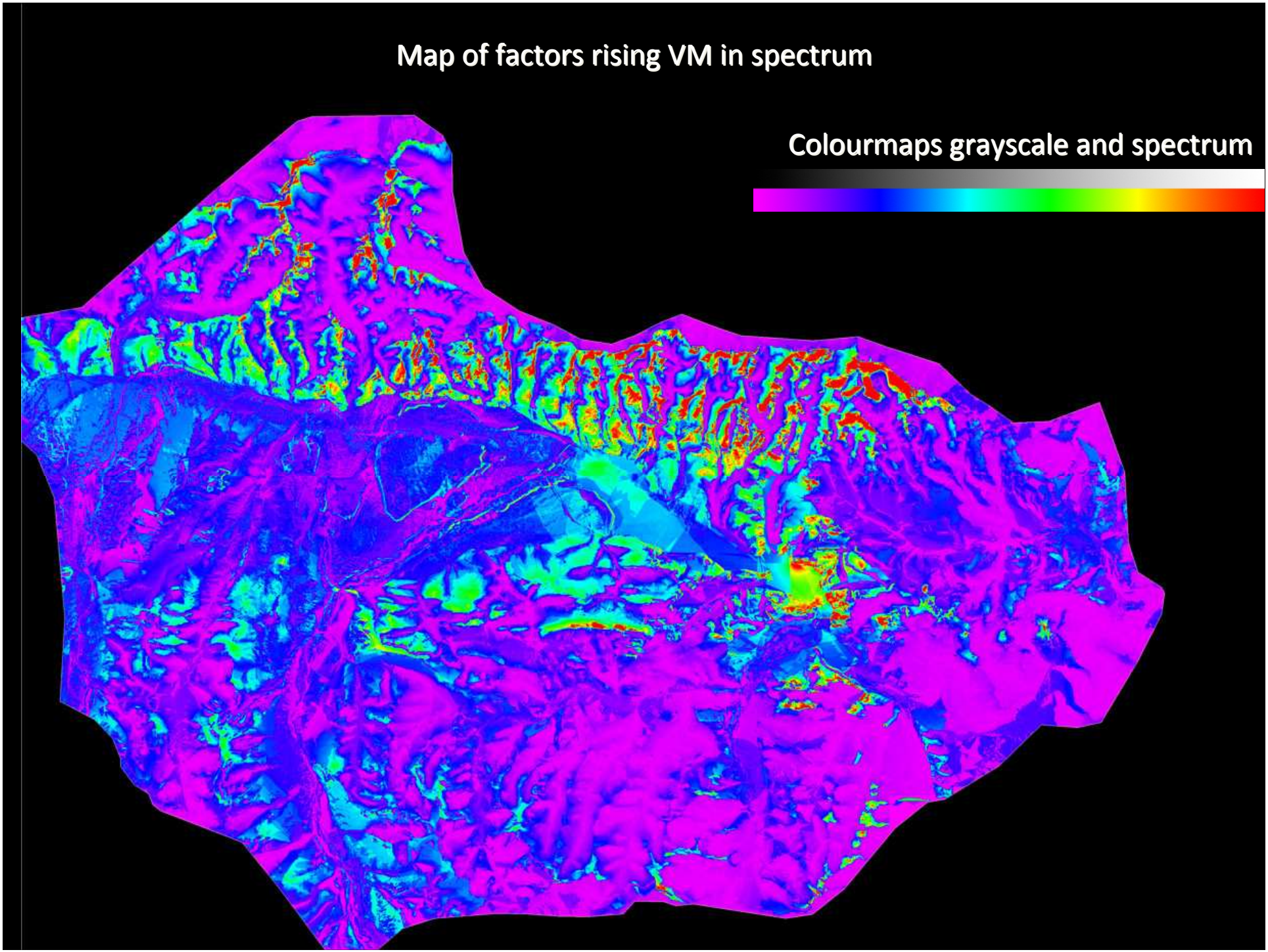
Map of landscape visual attractiveness (if power plant would be build)

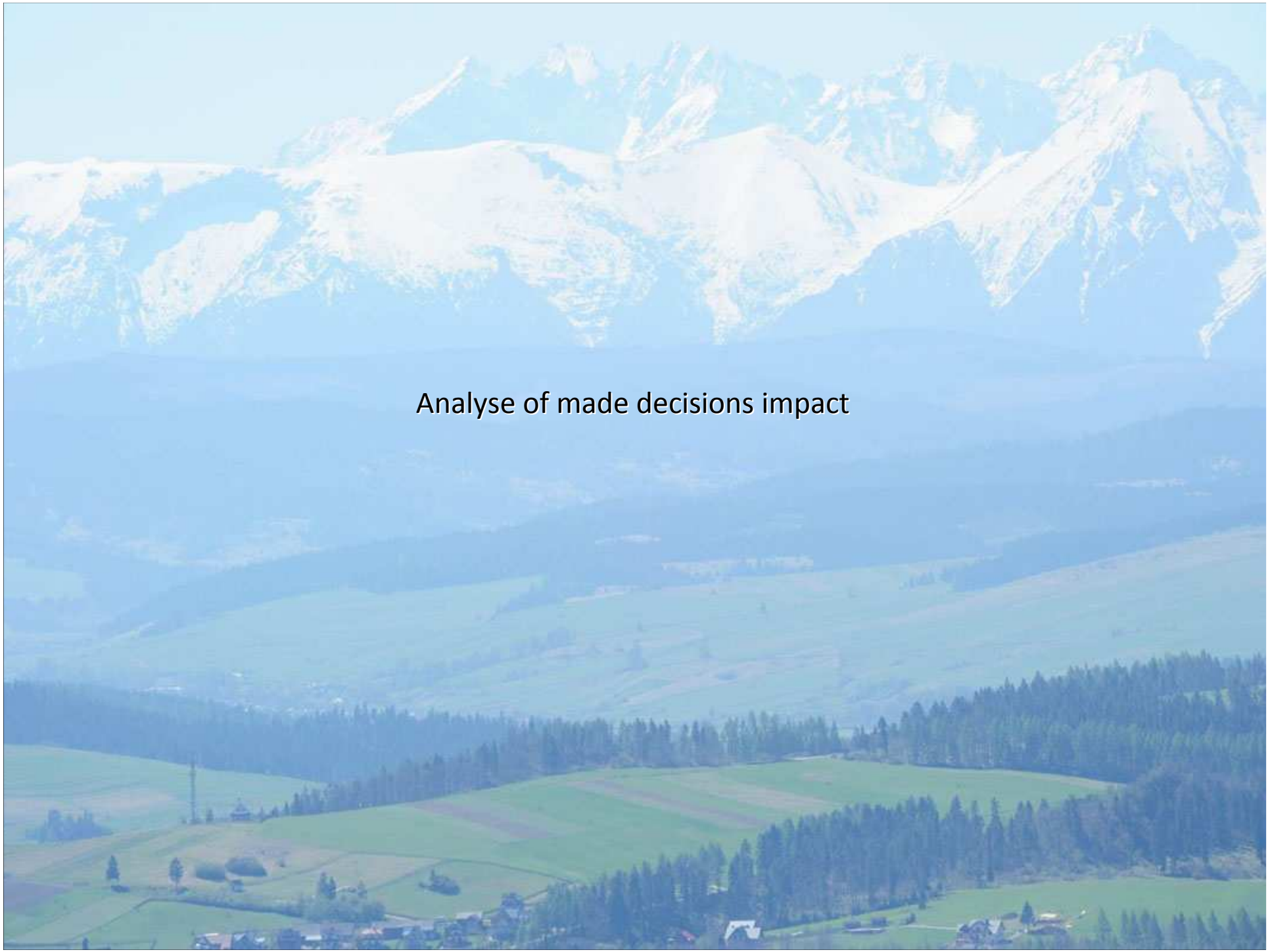


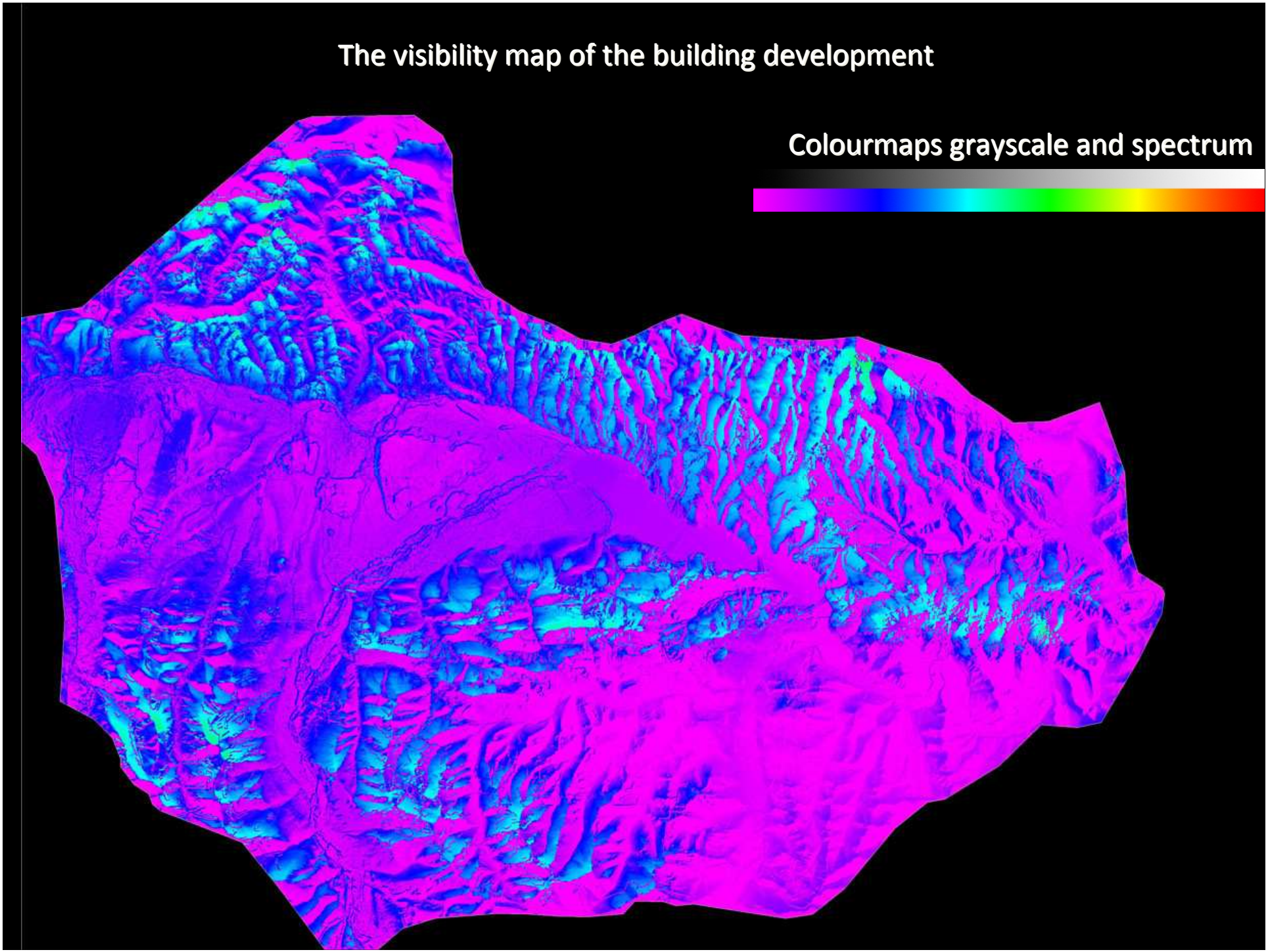
Map of factors rising VM minus factors diminishing VM in grayscale



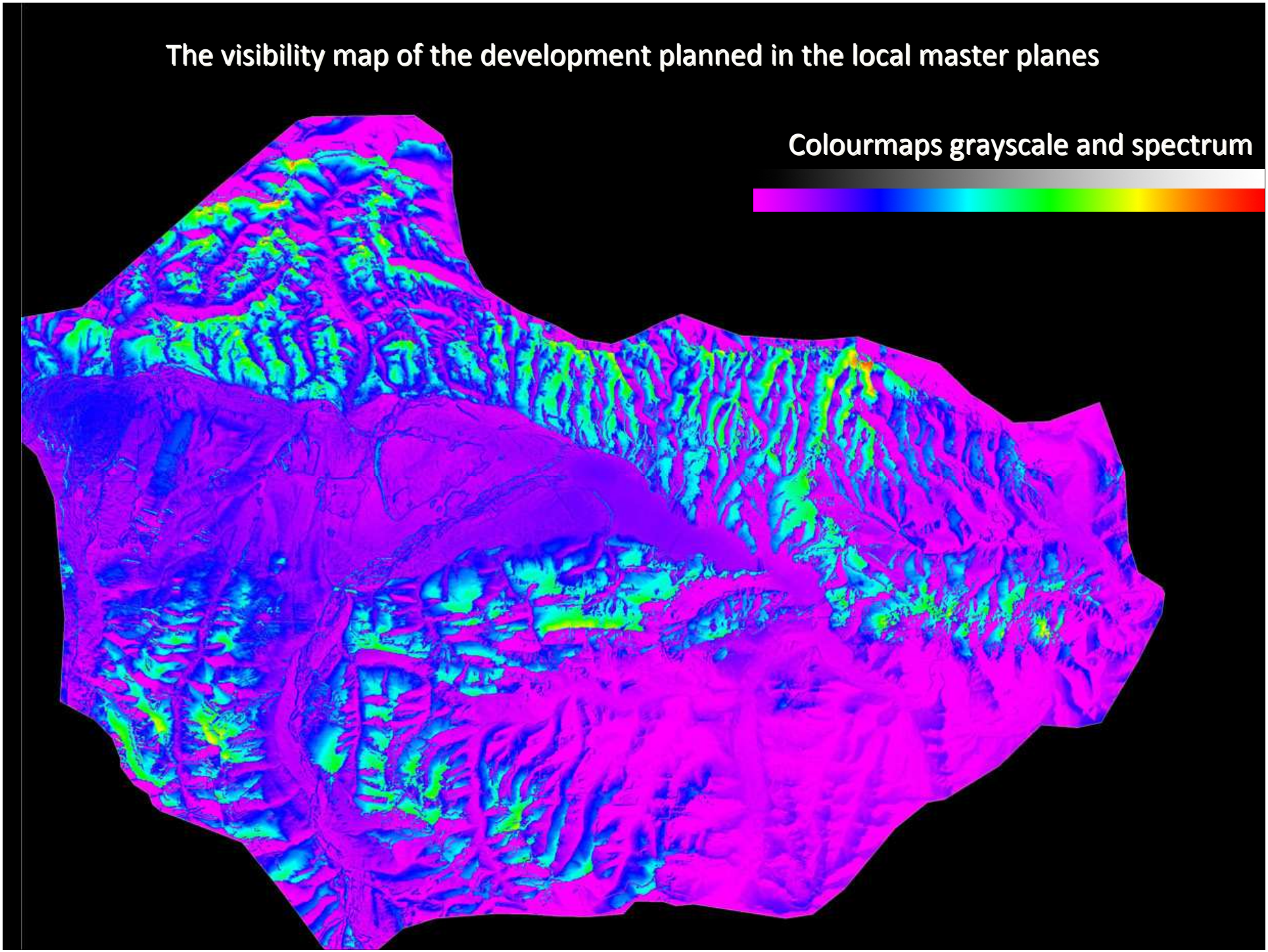

Map of factors rising VM minus factors diminishing VM in spectrum
Colourmaps grayscale and spectrum

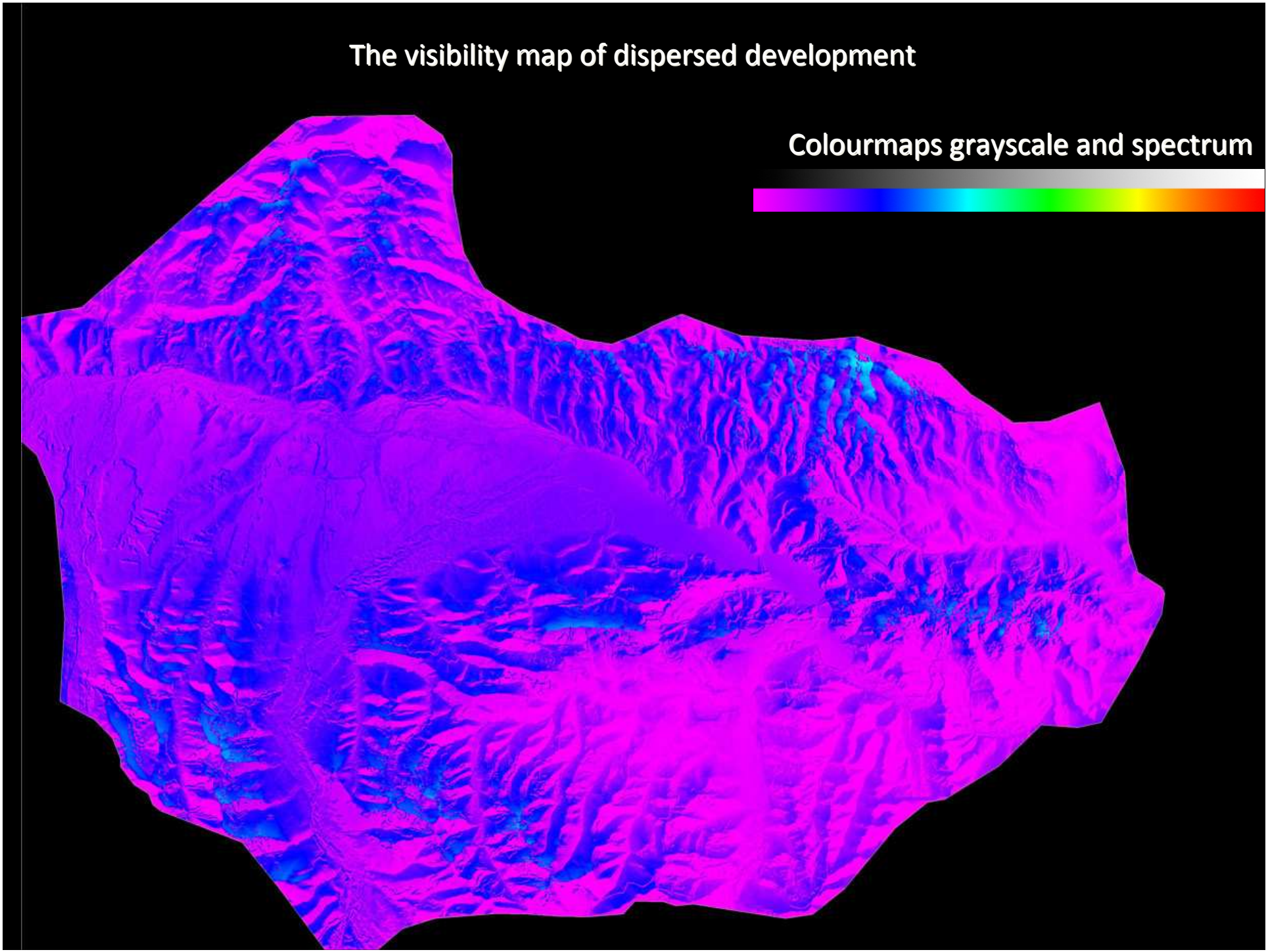

Map of factors rising VM in spectrum
Colourmaps grayscale and spectrum


Analyse of made decisions impact


The visibility map of the building development
Colourmaps grayscale and spectrum

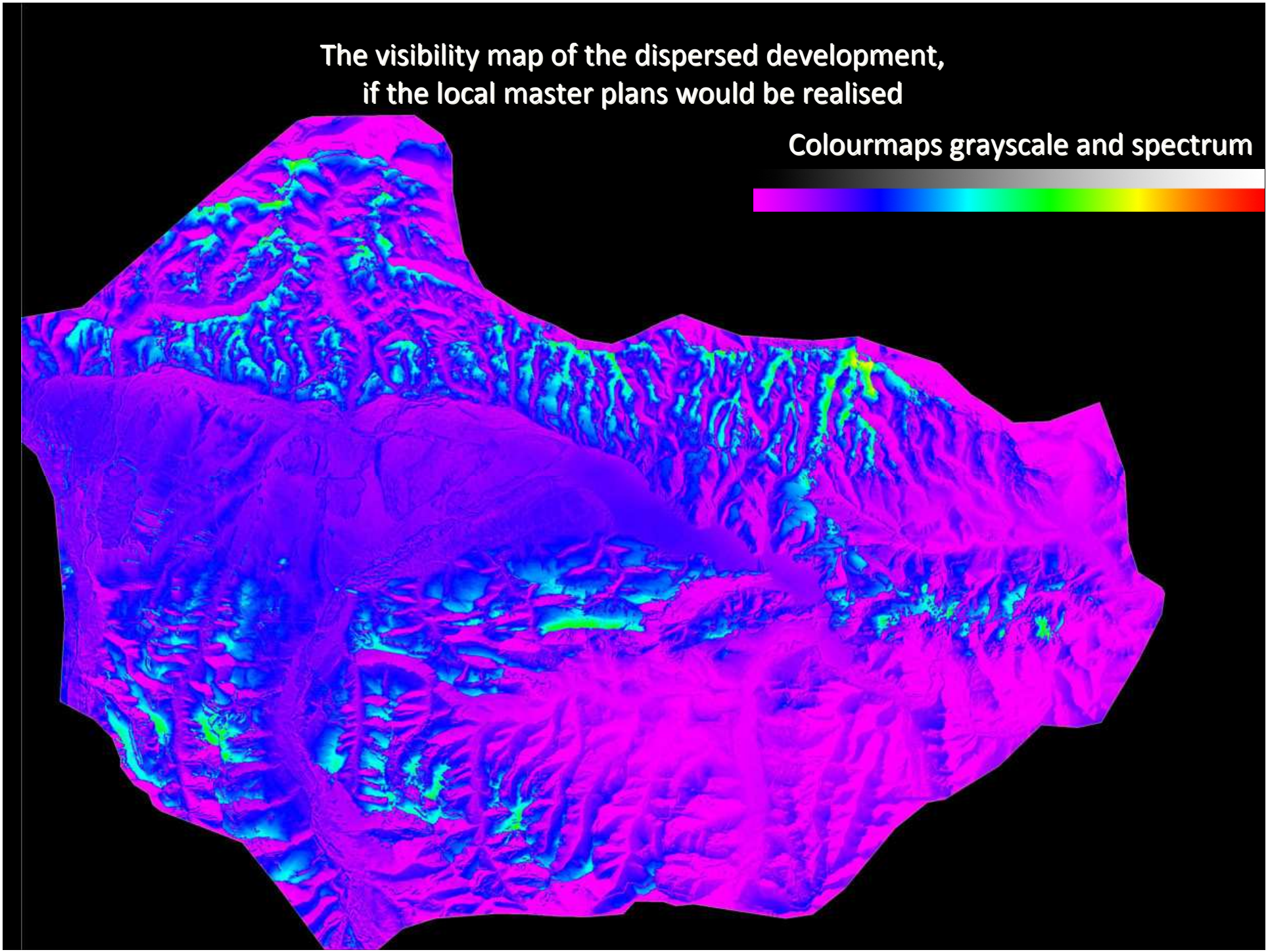
The visibility map of the development planned in the local master planes

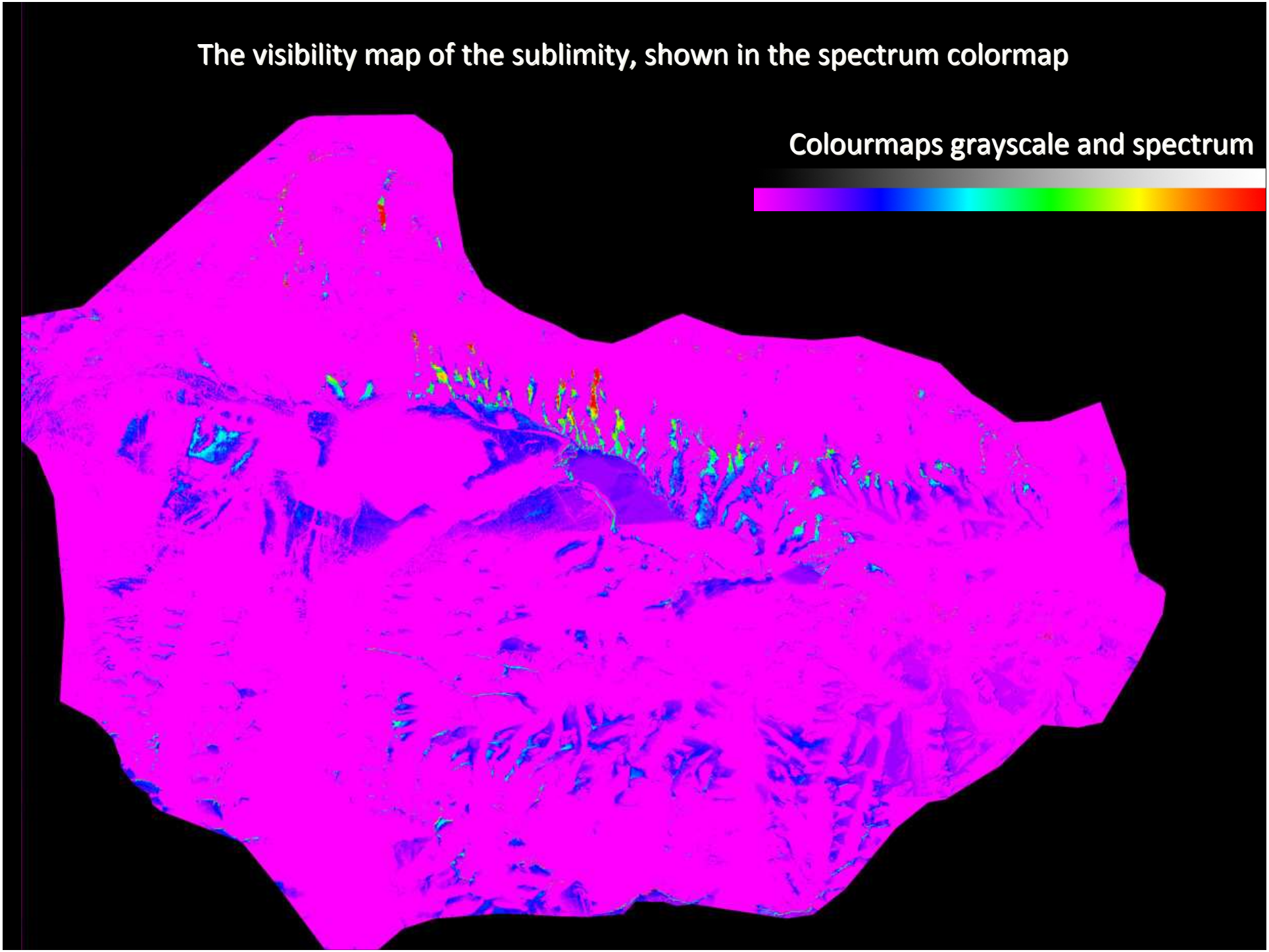



The visibility map of dispersed development
Colourmaps grayscale and spectrum

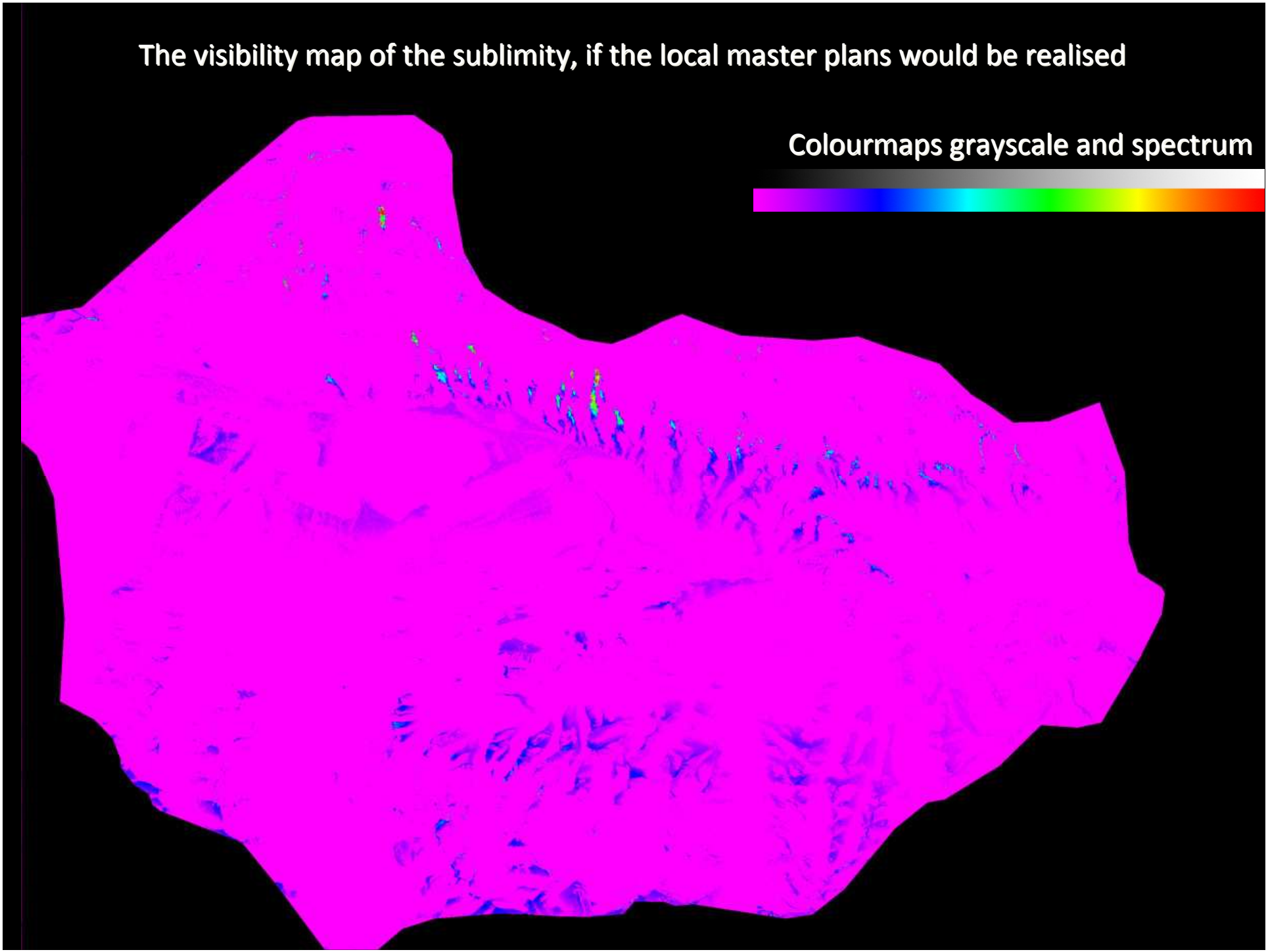
The visibility map of the dispersed development,
if the local master plans would be realised

Colourmaps grayscale and spectrum




The visibility map of the sublimity, shown in the spectrum colormap
Colourmaps grayscale and spectrum

The visibility map of the sublimity, if the local master plans would be realised



Methods, witch we presented were elaborated by teem:

Paweł Ozimek, Faculty of Physics, Mathematics and Computer Science, Cracow University of Technology,
Aleksander Böhm, Faculty of Architecture, Cracow University of Technology,
Agnieszka Ozimek , Faculty of Physics, Mathematics and Computer Science, Cracow University of Technology,
Wiesław Wańkowicz, Institute of Urban Development,

and

Andrzej Karafiat, FoPhMaCS, CUT,
Krzysztof Skabek, FoPhMaCS, CUT ,
Piotr Łabędź, FoPhMaCS, CUT,
Anna Sobos, FoPhMaCS, CUT,
Joanna Tarko, FoPhMaCS, CUT,
Karolina Grzechnik, FoPhMaCS, CUT,
Paweł Macioł, FoPhMaCS, CUT,
Marcin Nejman, IUD
Karol Bury, IUD

Thank you for the attention.