

KARTOGRAFICKÁ KONFERENCIA
22. ROČNÍK
20-21. OKTÓBER 2016

INTERAKTÍVNA
GEOVIZUALIZÁCIA A
PUBLIKOVANIE 3D MODELOV
KRAJINY NA INTERNETE

1 – Ústav geografie, Prírodovedecká fakulta,
Univerzita Pavla Jozefa Šafárika v Košiciach,
Jesenná 5, Košice

geografia.science.upjs.sk

2 – Visual Computing Lab, ISTI, CNR, Pisa, ITA
<http://vcg.isti.cnr.it>

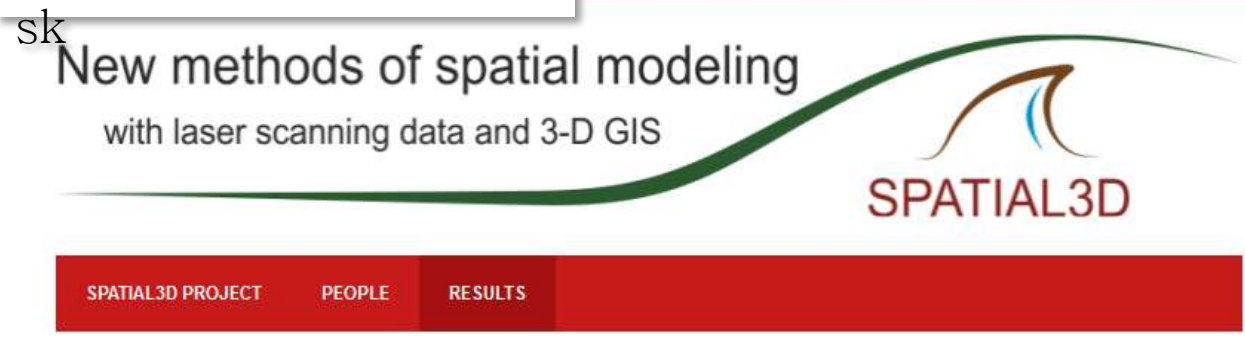


Michal GALLAY
Marco CALLIERI



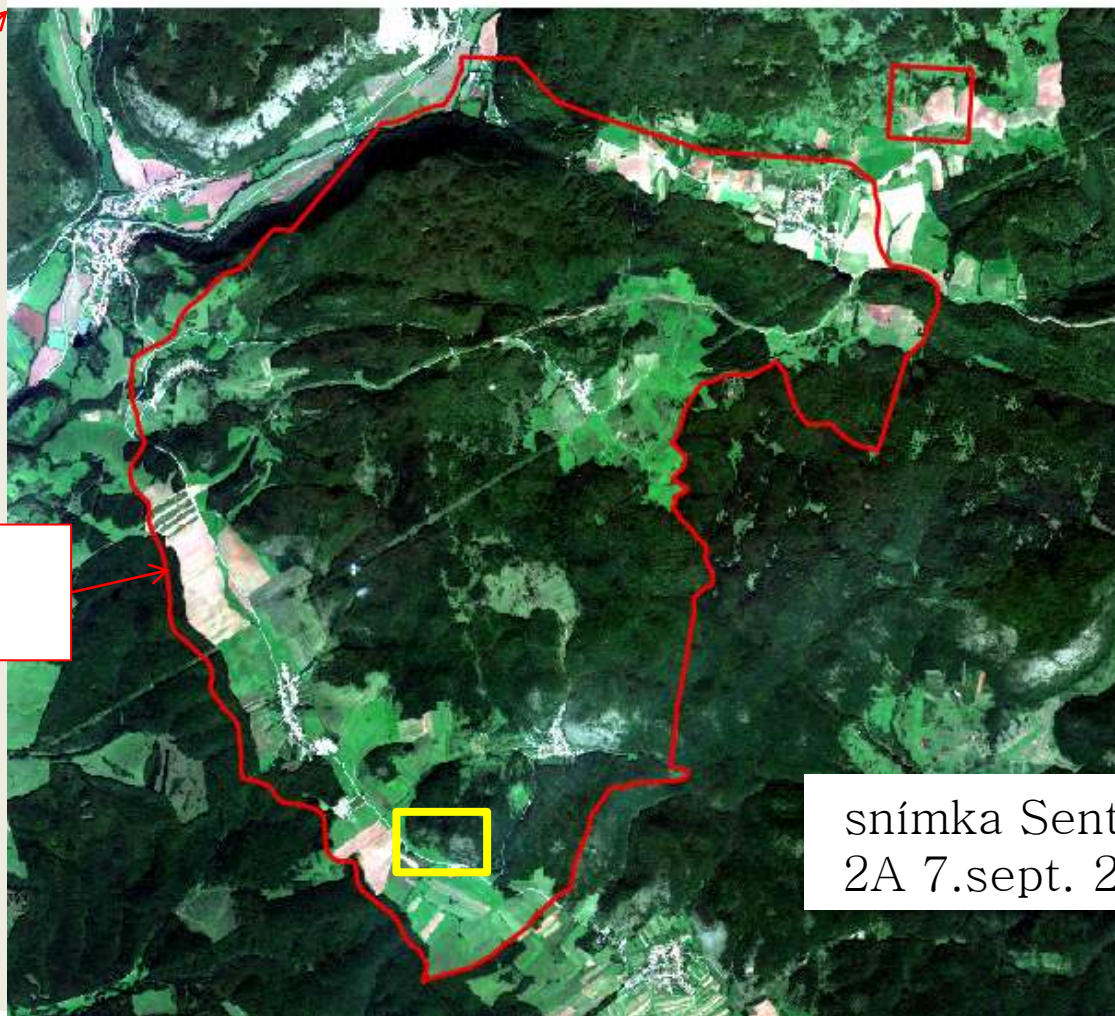
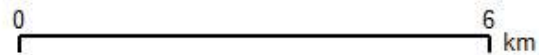
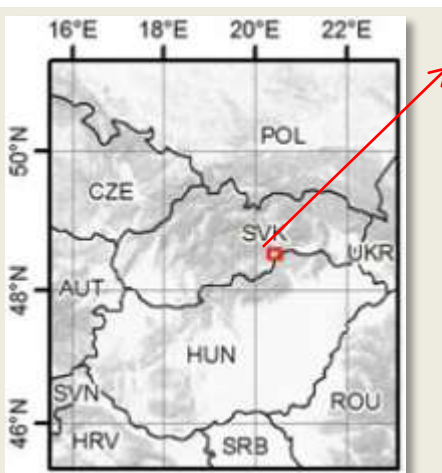
MOTIVÁCIA PREDNÁŠKY

- Riešený výskumný projekt „Nové metódy priestorového modelovania s použitím laserového skenovania a 3D-GIS“ (APVV-01 spatial3d.science.upjs.sk)



- Objektom je krasová krajina s vysokou mierou horizontálnych aj vertikálnych väzieb,
- Silická planina, jaskyňa Domica a okolie
- Hofierka, Hochmuth, Sedlák, Gallay, Kaňuk, Barabas, Gessert

SILICKÁ PLANINA, SLOVENSKÝ KRAS

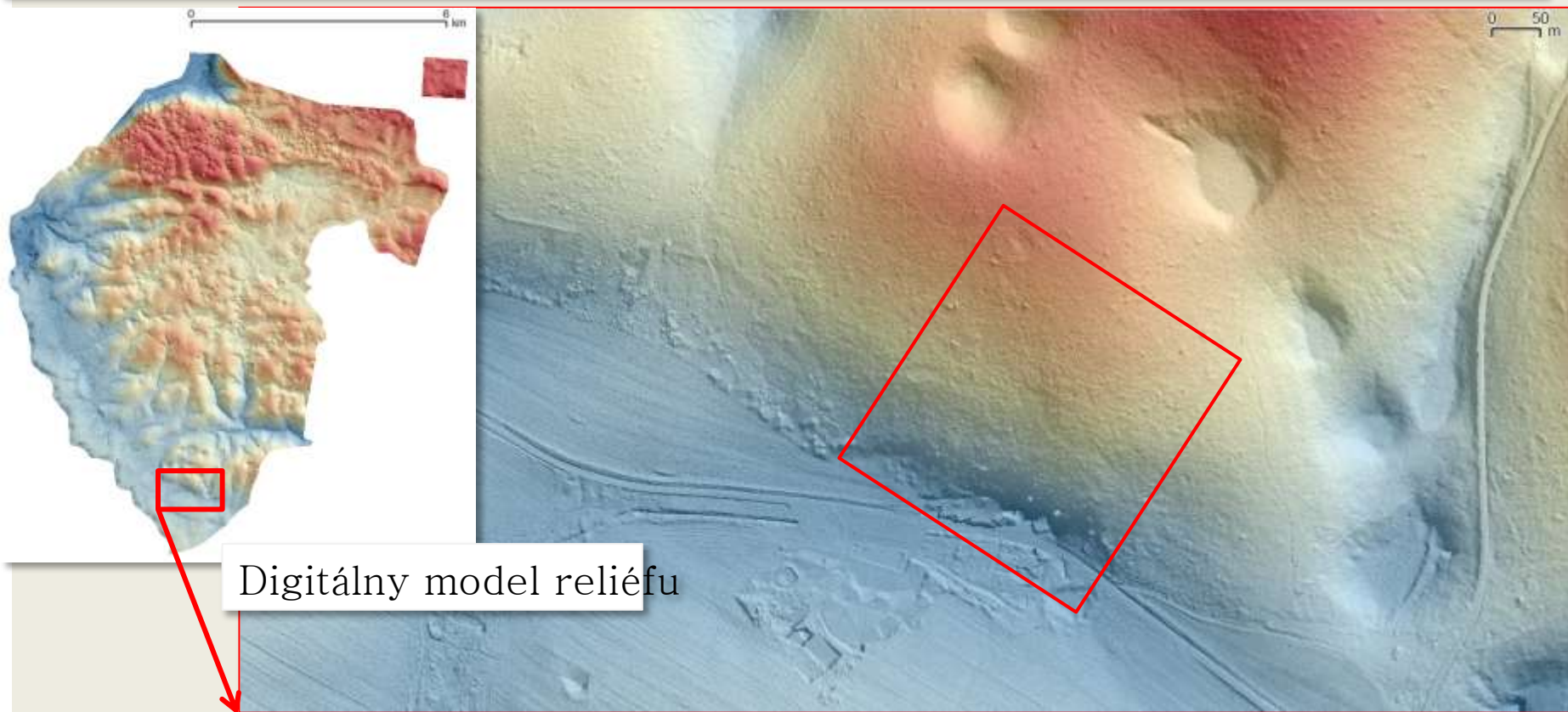


územie leteckého
laserového
skenovania

snímka Sentinel
2A 7.sept. 2016

LETECKÉ LASEROVÉ SKENOVANIE

HOFIERKA, J., GALLAY, M., KAŇUK, J., ŠAŠAK, J. (2017). Modelling Karst Landscape with Massive Airborne and Terrestrial Laser Scanning Data. In: Ivan, I., Singleton, A., Horák, J., Inspektor, T. (eds.) *The Rise of Big Spatial Data, Lecture Notes in Geoinformation and Cartography*, Springer International Publishing, 1-14.



POZEMNÉ LASEROVÉ SKENOVANIE JASKYNE DOMICA

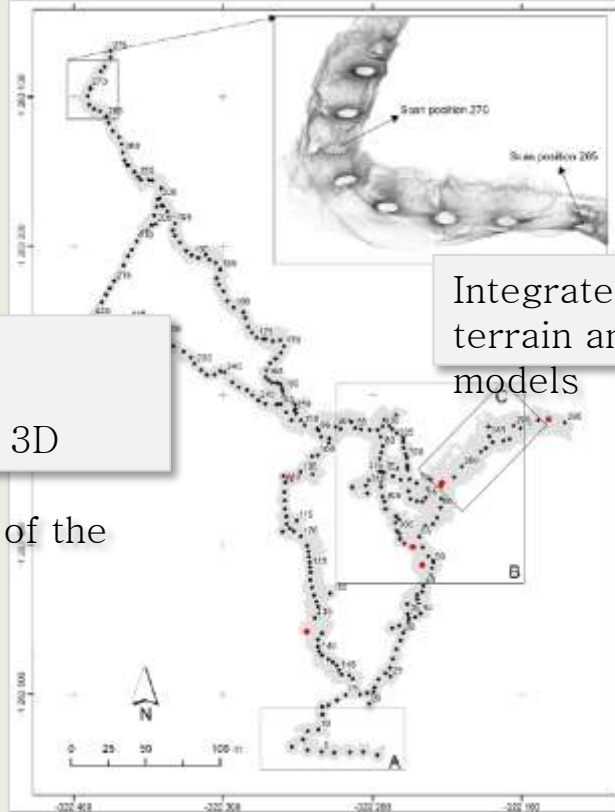
GALLAY, M., KAŇUK, J., HOCHMUTH, Z., MENEELY, J., HOFIERKA, J.,
SEDLÁK, V. (2015): Large-scale and high-resolution 3-D cave mapping by
terrestrial laser scanning: a case study of the Domica Cave, Slovakia.
International Journal of Speleology 44(3): 277–291.



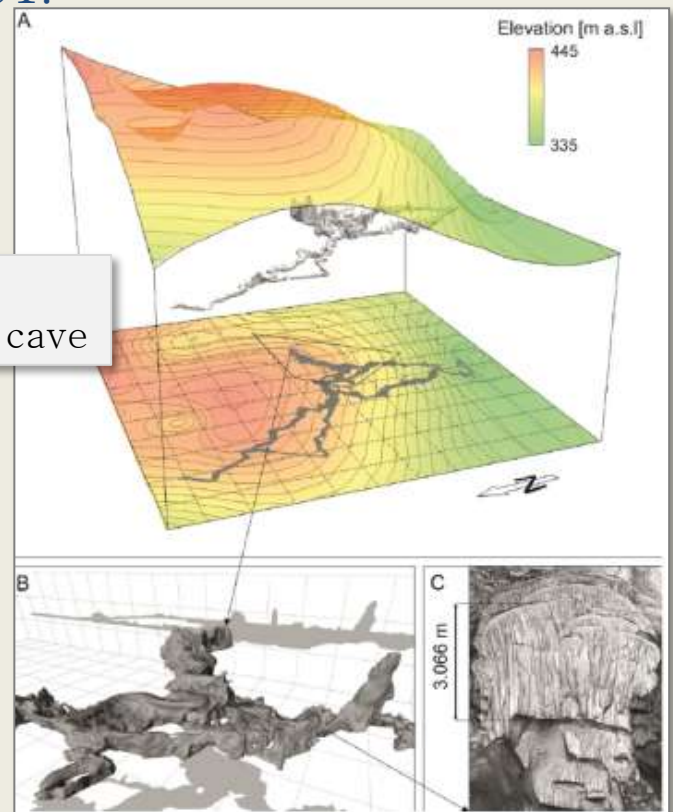
327 scanning
positions
11 billions of 3D



points
1500 metres of the
cave



Integrated
terrain and cave
models



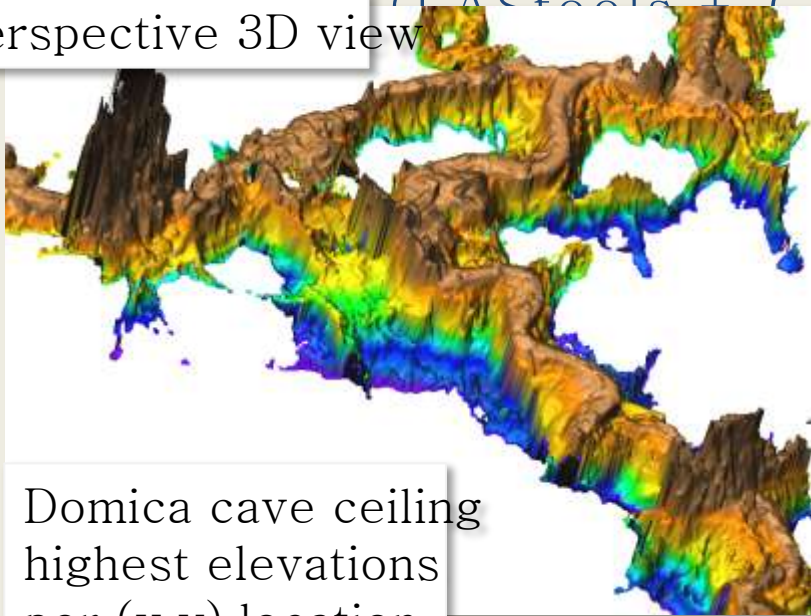
METODIKA MODELOVANIA POVRCHU JASKYNE 3D POVRCH – 2D RASTRE

- Rozdelenie mračna 3D bodov na súbor najvyšších bodov a najnižších bodov pre istú plochu (bunka rastra DMR)
- Umožňuje použiť tradičný bivariačný prístup (rasterový DMR)

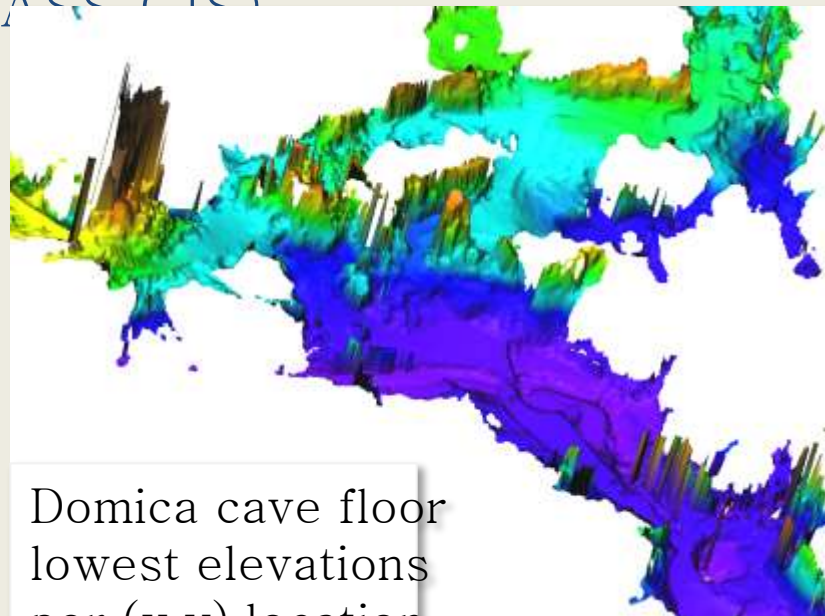
- Lundberg & McFarlane (2012), McFarlane et al. (2013)

$$z = f(x, y)$$

Perspective 3D view



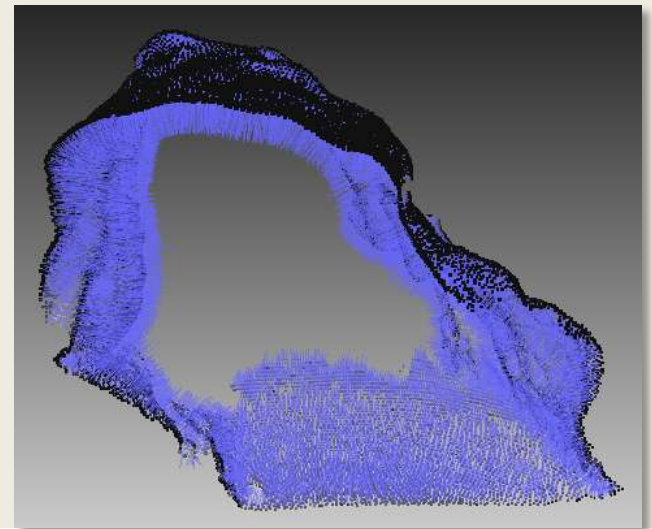
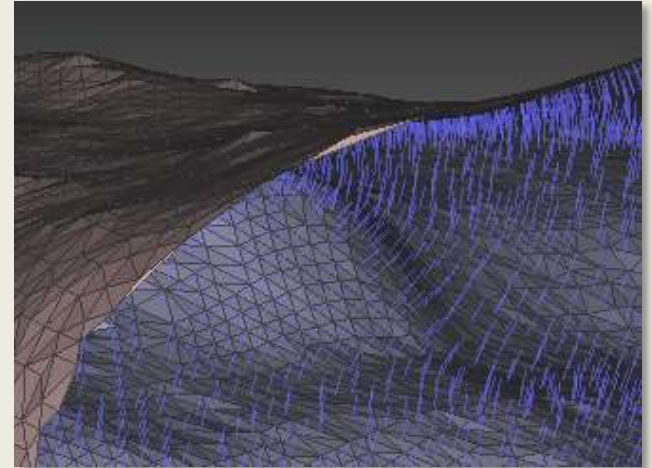
Domicca cave ceiling
highest elevations
per (x,y) location



Domicca cave floor
lowest elevations
per (x,y) location

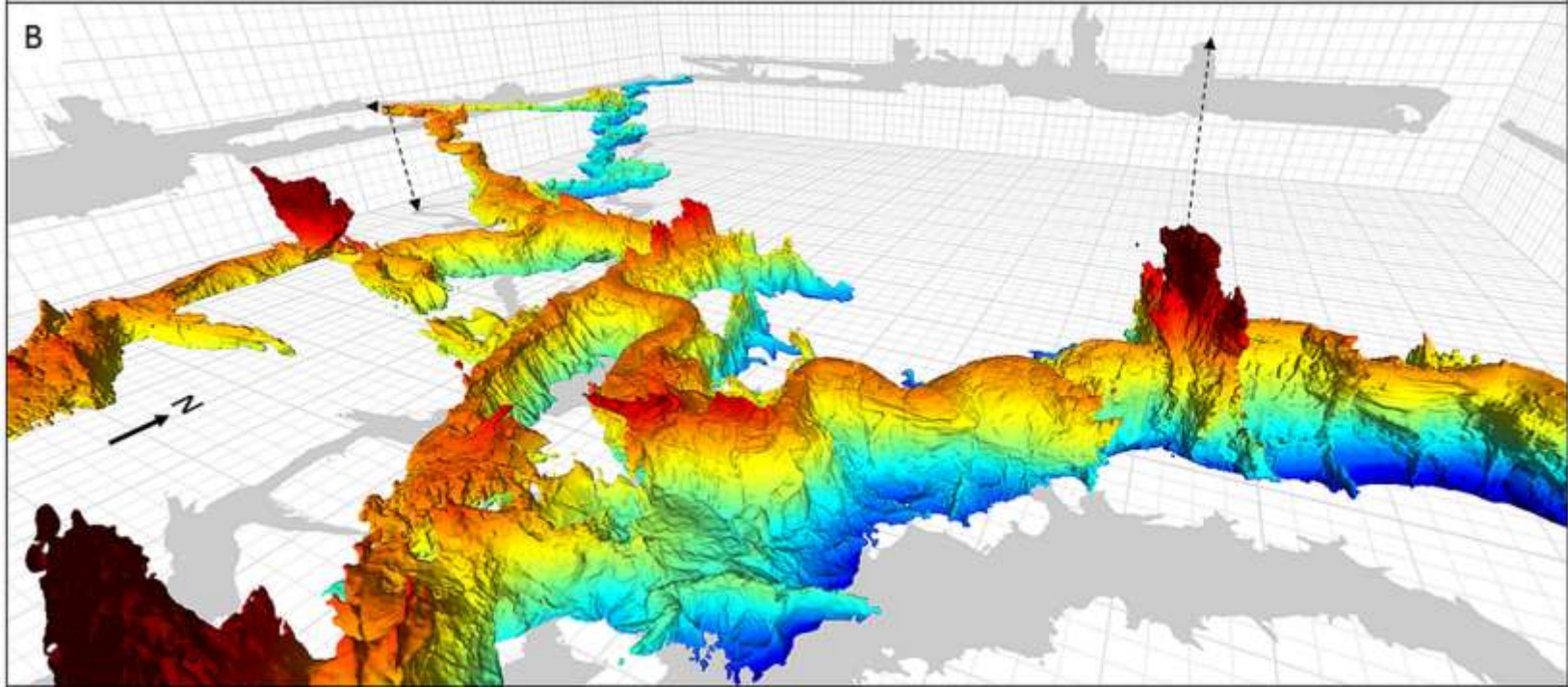
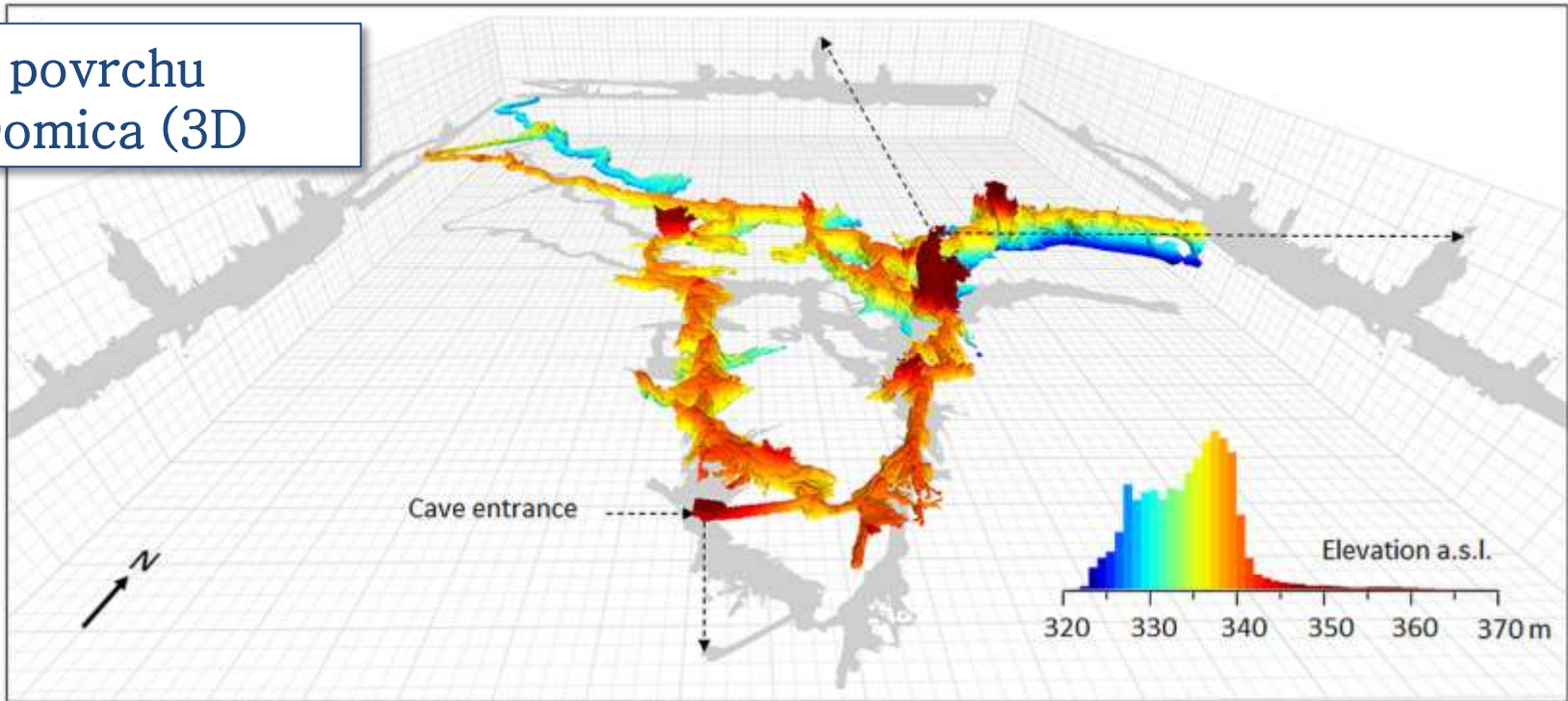
METODIKA MODELOVANIA POVRCHU JASKYNE 3D POVRCH – 3D TROJUHOĽNÍKOVÉ SIETE

- Polyhedrické siete (v podstate 3D TIN) s definovanými normálovými vektormi
 - Roncat et al. (2011), Jaillet et al. (2013), Cosso et al. (2014), Hoffmeister et al. (2015), Silvestre et al. (2015), Gallay et al. (2015, 2016)
- Skutočný model 3D povrchu
- Aj pre 3D povrch možno odvodiť morfometrické parametre podobne ak pre DMR na báze 2D rastra
 - gradient, krivosť, tieňovanie, drsnosť
- Možné v softvéry pre tvorbu 3D grafiky
 - Meshlab, Cloud Compare, Blender, HMTU



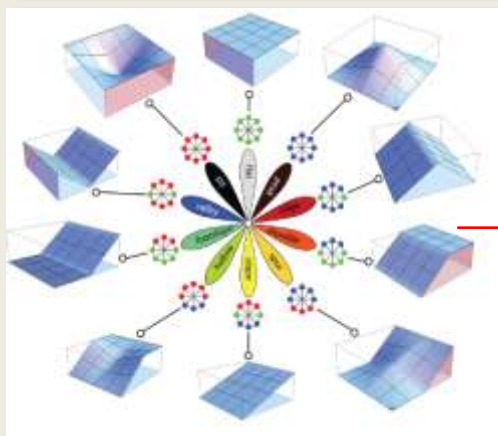
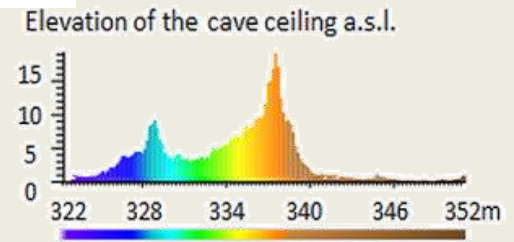
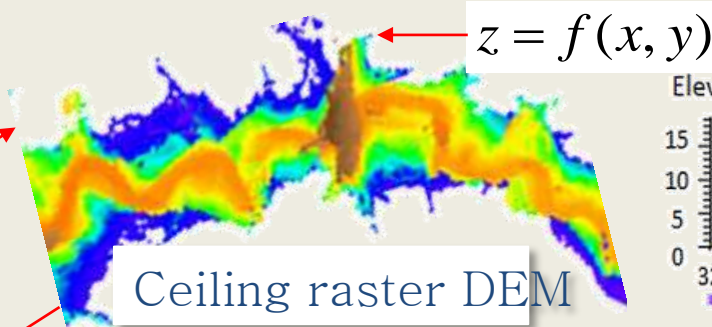
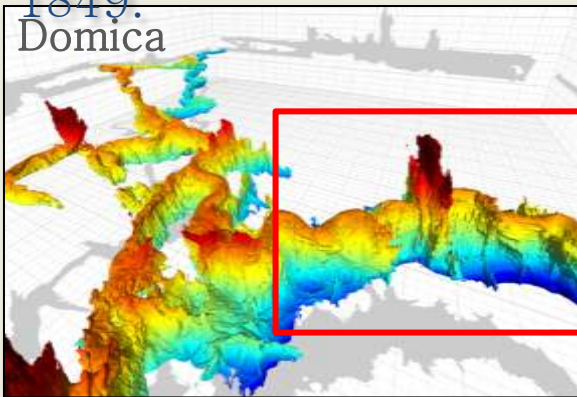
3D model povrhu jaskyne Domica (3D

mesh)

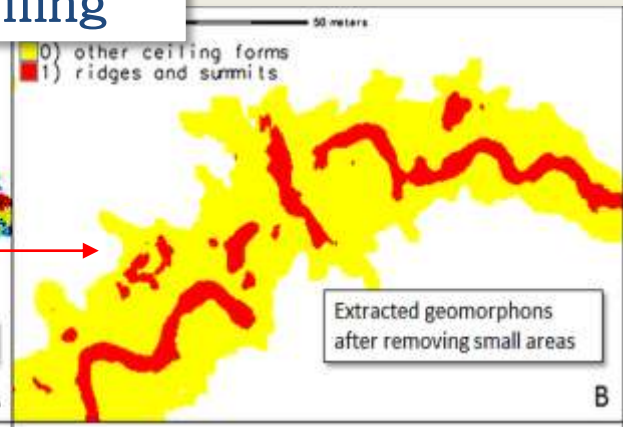
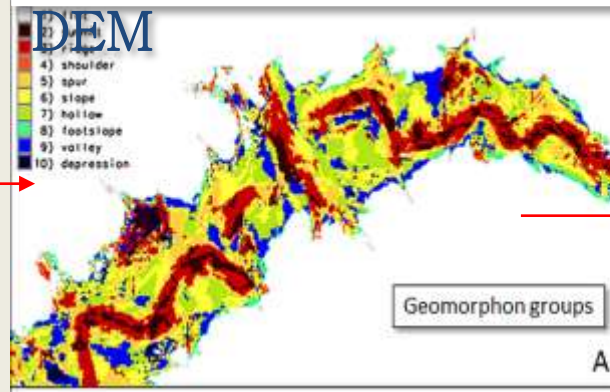


METODIKA MODELOVANIA POVRCHU JASKYNE 3D POVRCH – 2D RASTRE

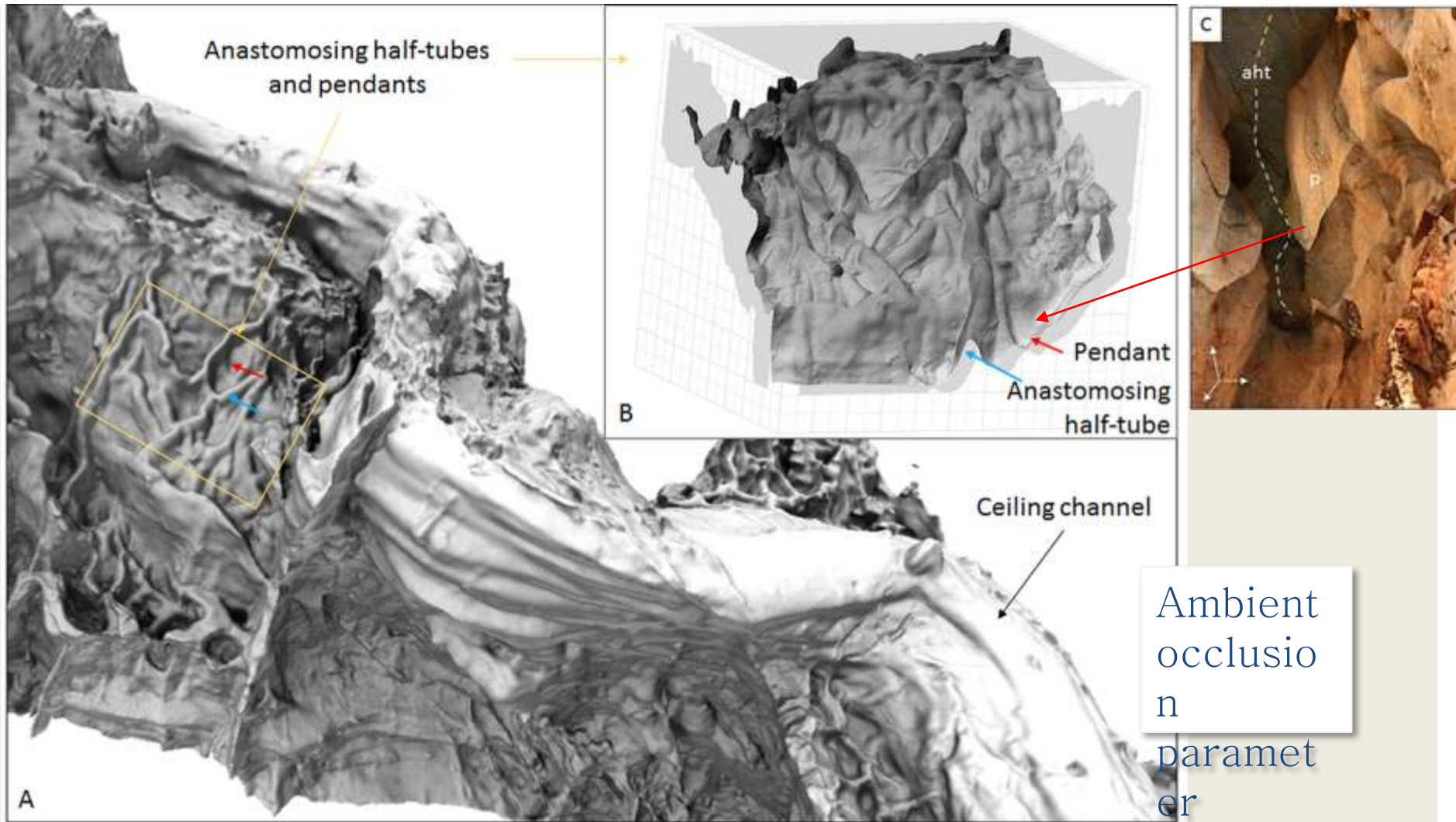
GALLAY, M., HOCHMUTH, Z., KAŇUK, J., HOFIERKA, J.
(2016). Geomorphometric analysis of cave ceiling channels mapped with 3D
terrestrial laser scanning, *Hydrology and Earth System Sciences*, 20, 1827–
1849.



Segmentation of the ceiling

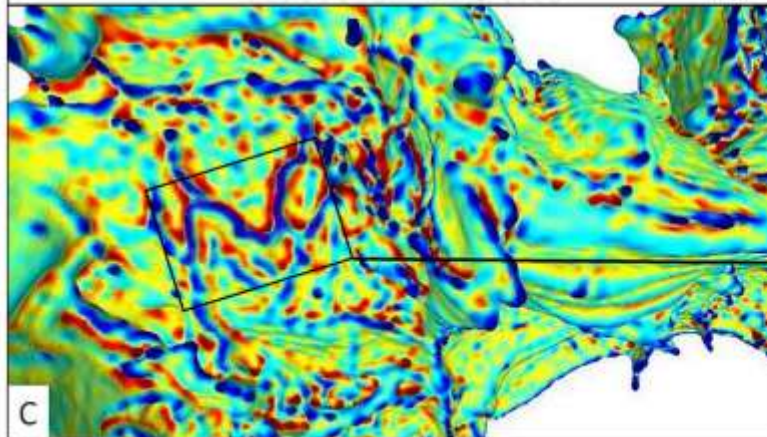
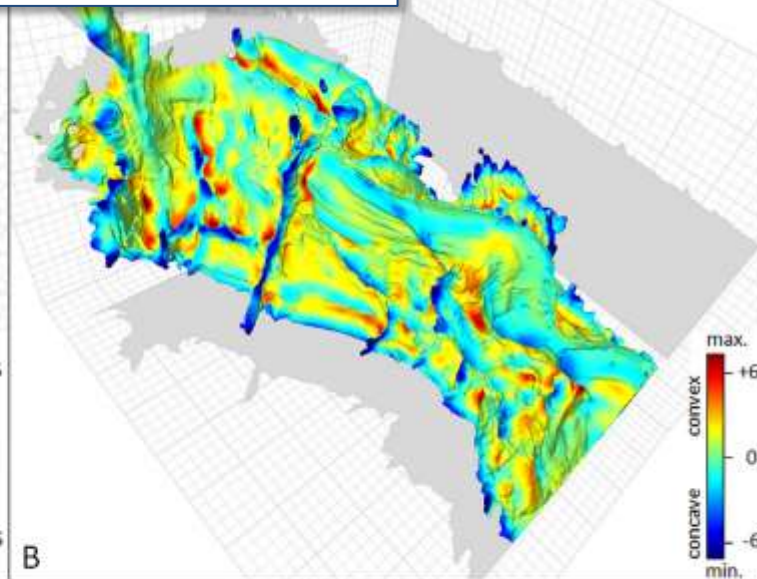
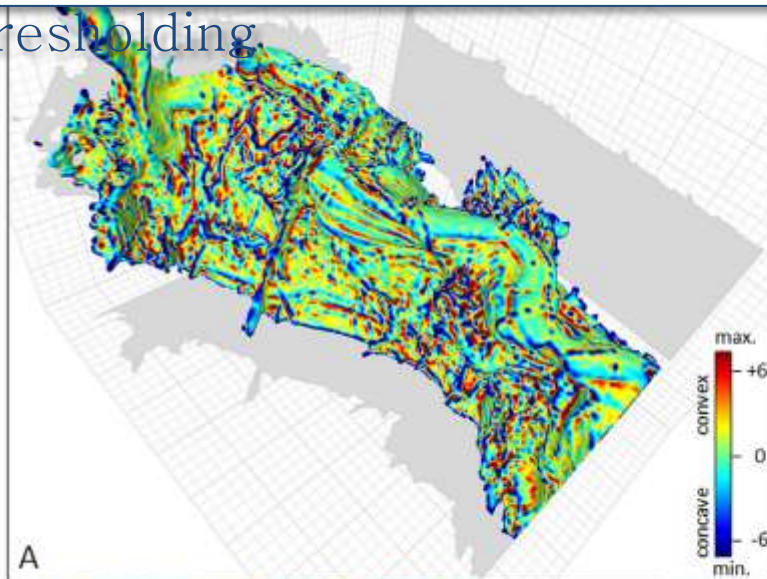


VÝHODY 3D MODELU OPROTI 2D RASTRU



VÝHODY 3D MODELU OPROTI 2D RASTRU

Extracting 3D features by parameter
thresholding.



MODELOVANIE 3D POVRCHU: POSTUP PRÁCE

Zber dát

- Skenovanie, registrácia skenov, redukcia mračna bodov (rozostup 5 cm)

Súradnicové priradenie SJTSK a BPV

- Banské geodetické zameranie r. 1976, GNSS r. 2014

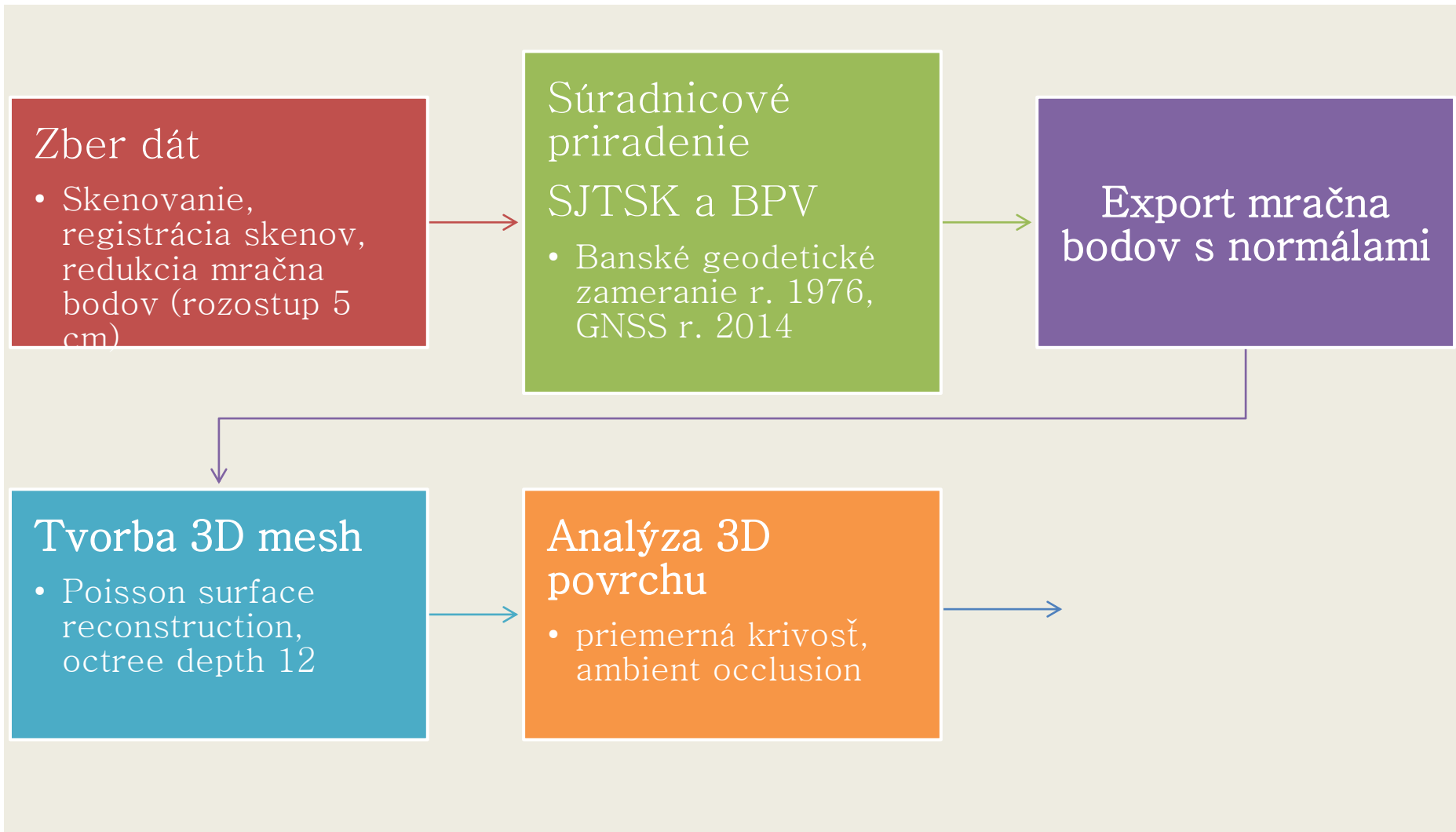
Export mračna bodov s normálami

Tvorba 3D mesh

- Poisson surface reconstruction, octree depth 12

Analýza 3D povrchu

- priemerná krivosť, ambient occlusion



ČO ĎALEJ S
VÝSLEDKAMI?
AKO ICH
PREZENTOVAŤ?

Motiváci
a
prednášk
y

CIEĽ VÝSKUMU: 3D WEB PRE DOMICU

- Vytvoriť užitočný nástroj, ktorý umožní iným odborníkom pracovať s 3D modelom jaskyne Domica, a tak posunúť „veslo“ ďalej.
 - meranie vzdialeností v rámci jaskyne a vzhľadom na terén nad ňou,
 - určovanie 3D súradníc
 - tvorba vertikálnych a horizontálnych rezov
 - zobrazovanie rôznych 3D morfometrických parametrov povrchu

3DHOP: PREZENTAČNÝ NÁSTROJ 3D MODELOV

- užitočný nástroj pre zdieľanie modelov vo vysokom rozlíšení
- primárne pre oblasť kultúrneho dedičstva, archeológia
- vytvorený v jazyku JavaScript
- založený na knižnici WebGL a protokole HTML5
- umožňuje voľné zobrazovanie a interakciu vo webovom prehliadači bez potreby inštalovania doplnkov (plug-in)



3DHOP: 3D Heritage Online Presenter

Marco Potenziani ^{a,*} Marco Callieri ^b, Matteo Dellepiane, Massimiliano Corsini, Federico Ponchio, Roberto Scopigno

Visual Computing Lab, ISTI CNR, Pisa, Italy



Web-based visualization for 3D data in archaeology: The ADS 3D viewer

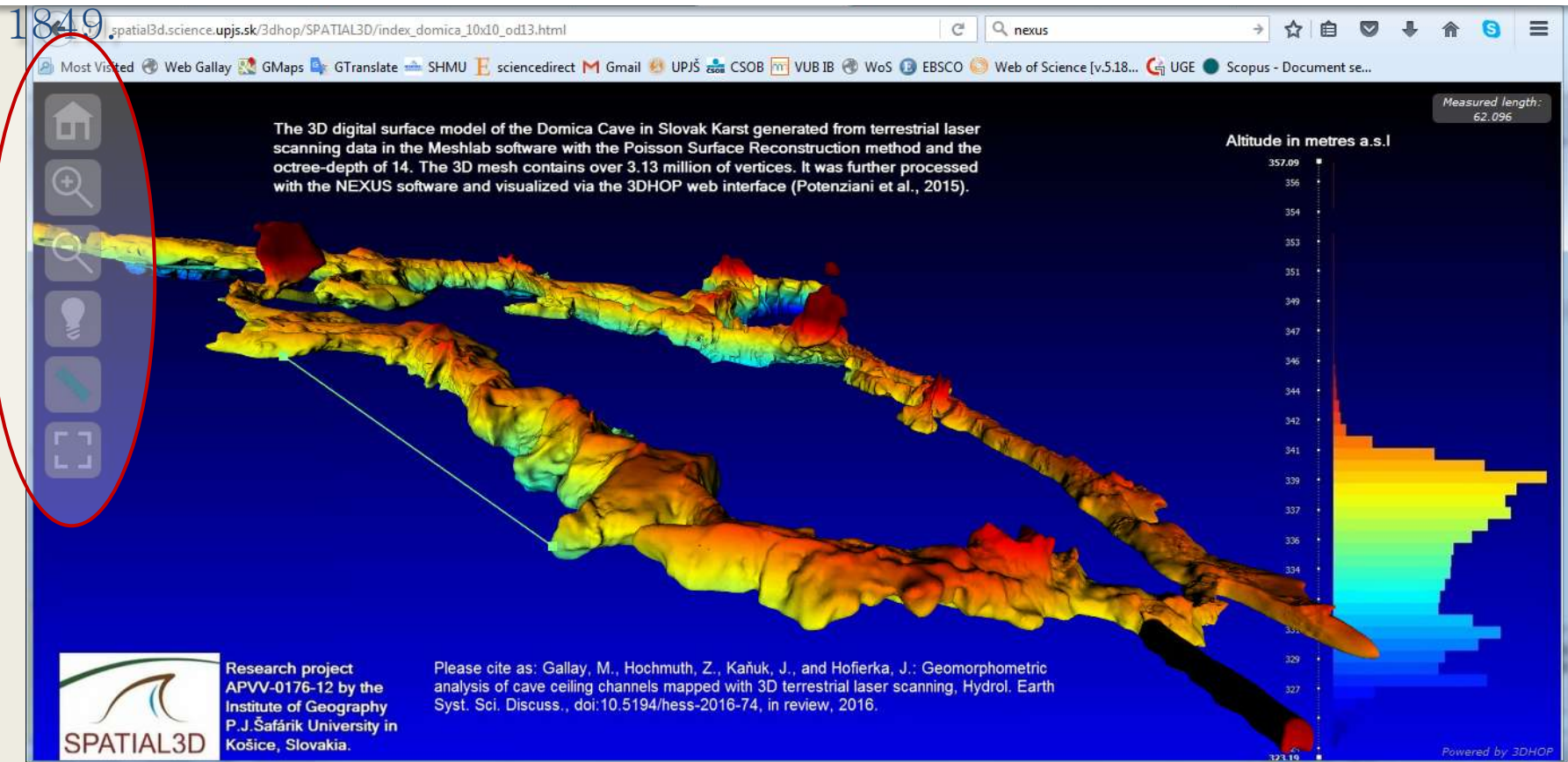
Fabrizio Galeazzi ^{a,*} Marco Callieri ^b, Matteo Dellepiane ^b, Michael Charno ^a, Julian Richards ^a, Roberto Scopigno ^b

^a *Archaeology Data Service, University of York, UK*

^b *Visual Computing Lab, ISTI - CNR, Pisa, Italy*

JEDNODUCHÁ PREZENTÁCIA 3D MODELU DOMICA

GALLAY, M., HOCHMUTH, Z., KAŇUK, J., HOFIERKA, J. (2016). Geomorphometric analysis of cave ceiling channels mapped with 3D terrestrial laser scanning, *Hydrology and Earth System Sciences*, 20, 1827–1849.



POSTUP PRÁCE

Príprava dát pre publikovanie na webe

- Export 3D modelu vo formáte PLY
- Konverzia 3D modelu do formátu NEXUS
- Komprimácia dát vo formáte NEXUS

Tvorba webového rozhrania 3DHOP

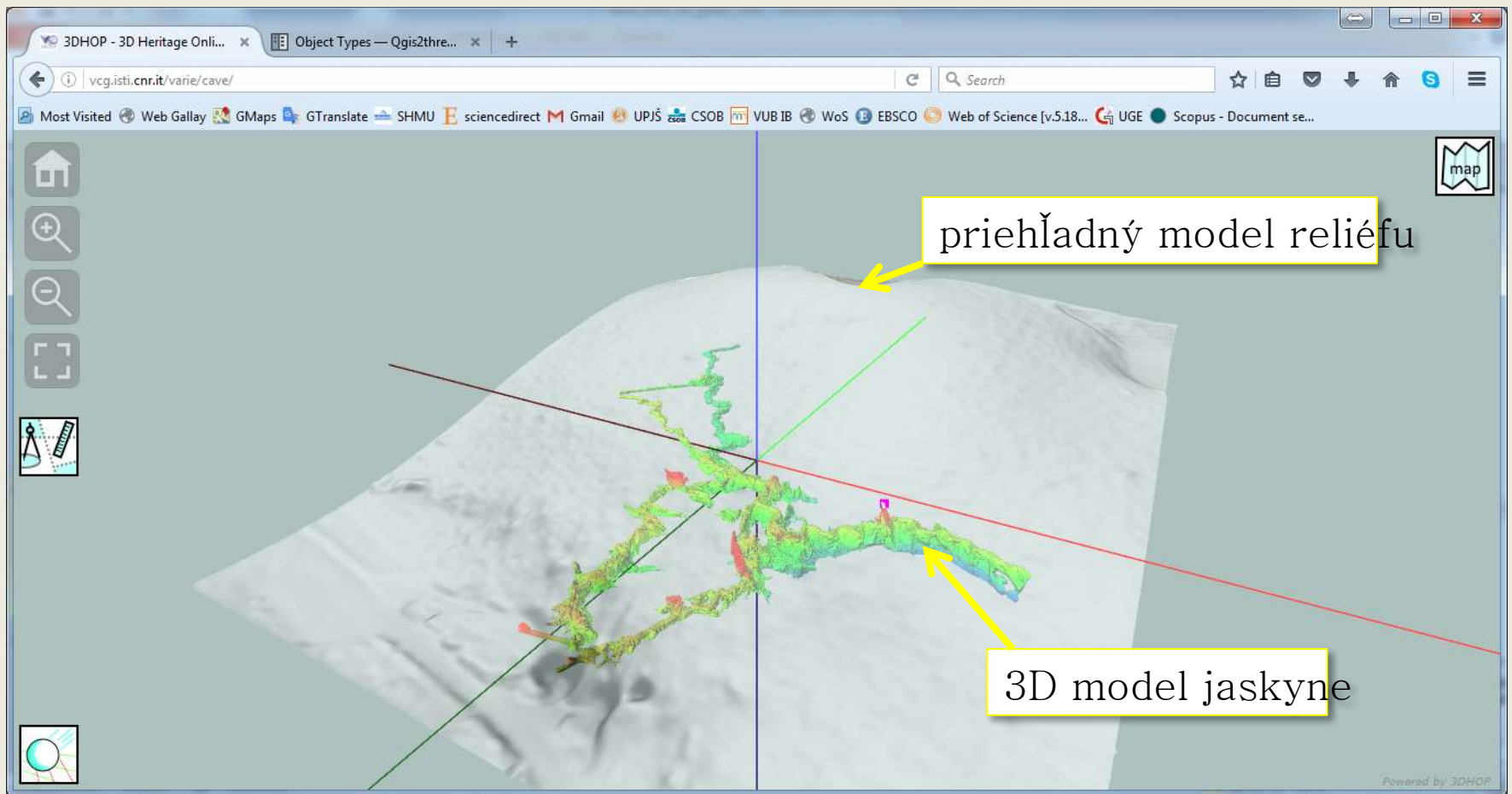
- Návrh funkcionality
- Tvorba nástrojov
- Marco Callieri, Visual Computing Lab, Pisa, ITA

Publikovanie na webe

PRÍPRAVA 3D MODELU PRE 3DHOP

- 3D model vo formáte PLY
- Konverzia z PLY do NEXUS
- NEXUS – formát uskladňujúci 3D model vo viacerých rozlišovacích úrovniach
- Podporuje efektívne interaktívne prekresľovanie dátovo-masívnych 3D modelov a ich hladké online streamovanie
- 3D model je segmentovaný do menších jednotiek (kusov), ktoré sú používané podľa toho, čo užívateľ práve zobrazuje a prenášajú sa cez internet, iba keď je to potrebné.
- Výsledkom je pružná interakcia s 3D modelmi a efektívne používanie kapacity siete

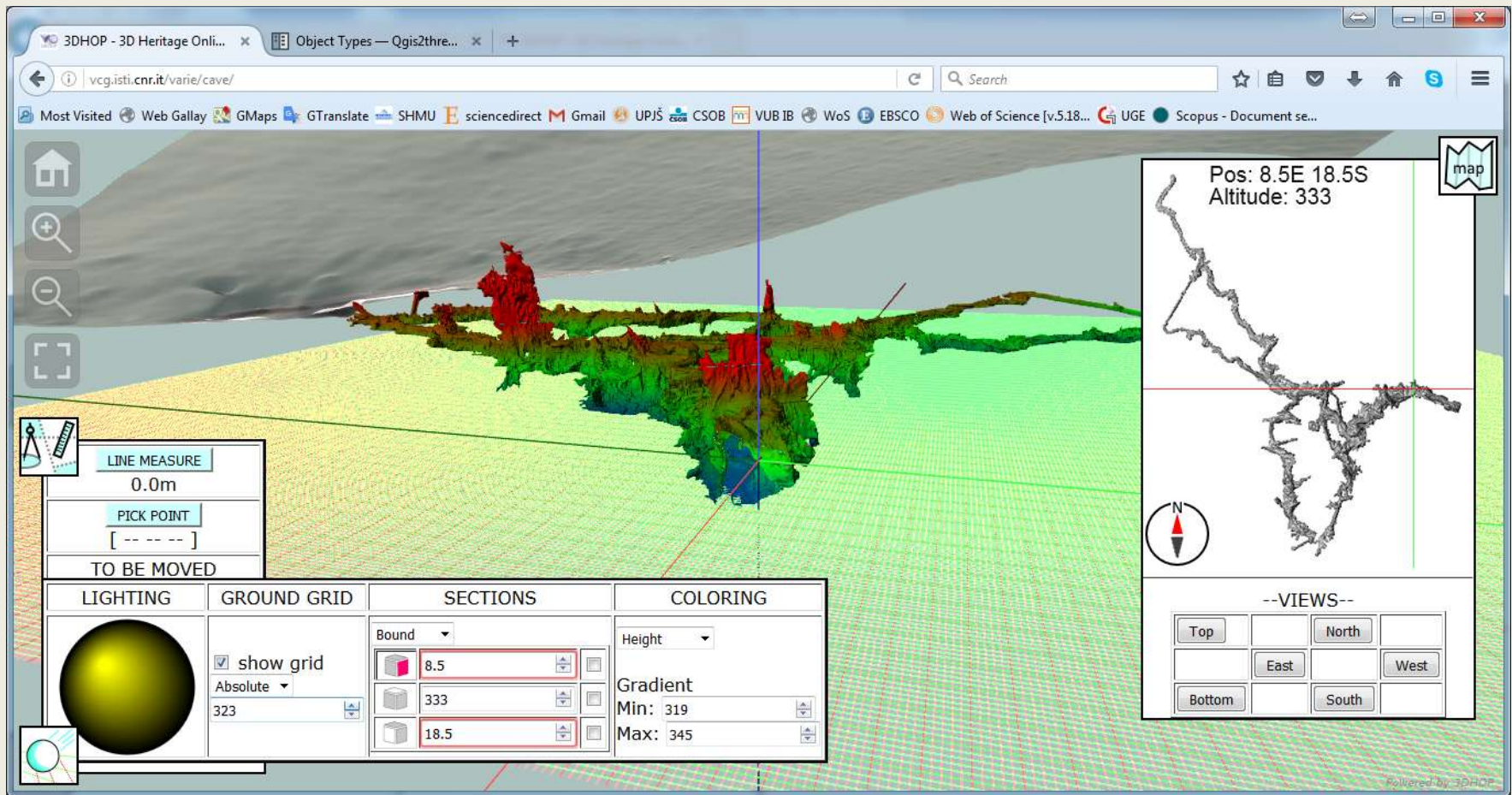
FUNKCIONALITA: INTERAKTÍVNE PREPÍNANIE ZOBRAZOVANIE



FUNKCIONALITA: OVLÁDANIE VLASTNOSTÍ MODELU



FUNKCIONALITA: VERTIKÁLNE REZY



FUNKCIONALITA: HORIZONTÁLNE REZY

vcg.isti.cnr.it/varie/cave/

LINE MEASURE
15.45 m
PICK POINT
[- - - -]
TO BE MOVED

Bound	Min	Max
-37	322	327
333	322	327
49.7	322	327

Height
Min: 322
Max: 327

Gradient

--VIEWS--
Top North
East West
Bottom South

Pos: 37W 49.7S
Altitude: 333

map

Powered by 3DHOP

FUNKCIONALITA: POMOCNÁ MRIEŽKA

The screenshot displays the 3DHOP web application interface. The main view shows a 3D model of a cave system rendered on a green grid. The interface includes a browser window at the top with the URL `vcg.isti.cnr.it/varie/cave/`. On the left, there are navigation icons for home, search, and zoom. A toolbar on the left contains a ruler icon, a 'LINE MEASURE' button (showing 0.0m), a 'PICK POINT' button, and a 'TO BE MOVED' button. Below the toolbar is a 'LIGHTING' panel with a sphere icon. The 'GROUND GRID' panel is highlighted with a red circle and contains a checked 'show grid' checkbox, an 'Absolute' dropdown, and a value of 337. The 'SECTIONS' panel shows a 'Bound' dropdown and three rows of values: 33.2, 333, and 30.2. The 'COLORING' panel includes a 'Height' dropdown, a 'Gradient' section with 'Min: 319' and 'Max: 345', and a 'Min' field. On the right, a 'map' panel shows the current position: 'Pos: 33.2E 30.2S' and 'Altitude: 333', along with a 2D map of the cave system and a compass. Below the map is a '--VIEWS--' panel with buttons for 'Top', 'North', 'East', 'West', 'Bottom', and 'South'. The bottom right corner of the interface is labeled 'Powered by 3DHOP'.

FUNKCIONALITA: MERANIE VZDIALENOSTÍ

The screenshot displays the 3DHOP web application interface. The main 3D view shows a cave system with a red and yellow highlighted section. A red arrow points from the 'LINE MEASURE' tool in the left sidebar to this section. A yellow oval highlights a vertical line measurement on the cave wall. The 'LINE MEASURE' tool shows a distance of 27.34 m. Below the 3D view is a control panel with sections for LIGHTING, GROUND GRID, SECTIONS, and COLORING. The SECTIONS panel shows a 'Bound' list with values -22, 333, and 28.9. The COLORING panel shows 'Height' and 'Gradient' settings. On the right, a map panel shows the current position: Pos: 5.8W 28.9S, Altitude: 333. The map panel also includes a compass and view controls (Top, North, East, West, Bottom, South). The browser address bar shows the URL vcg.isti.cnr.it/varie/cave/.

LINE MEASURE
27.34 m
PICK POINT
[-----]
TO BE MOVED

LIGHTING	GROUND GRID	SECTIONS	COLORING
	<input checked="" type="checkbox"/> show grid Absolute 322	Bound -22 333 28.9	Height Gradient Min: 319 Max: 348

Pos: 5.8W 28.9S
Altitude: 333

--VIEWS--
Top North
East West
Bottom South

Powered by 3DHOP

FUNKCIONALITA: DOPYTY NA 3D SÚRADNICE

The screenshot displays the 3DHOP web application interface. The browser address bar shows the URL `vcg.isti.cnr.it/varie/cave/`. The main 3D view shows a terrain model with a color gradient from blue (low) to red (high). A red arrow points from a yellow circle on the terrain to a coordinate picking tool. The tool displays the coordinates `[-22.06, 30.32, 350.98]`. A 2D map inset on the right shows the location with coordinates `Pos: 5.8W 28.9S` and `Altitude: 333`. The interface includes a control panel with sections for LIGHTING, GROUND GRID, SECTIONS, and COLORING. The SECTIONS panel shows a 'Bound' list with values `-22`, `333`, and `28.9`. The COLORING panel shows a 'Height' dropdown and a 'Gradient' section with `Min: 319` and `Max: 348`. A 'VIEW' panel on the right allows switching between Top, North, East, West, Bottom, and South views. The interface is powered by 3DHOP.

LINE MEASURE
27.34 m

PICK POINT
[-22.06, 30.32, 350.98]

Pos: 5.8W 28.9S
Altitude: 333

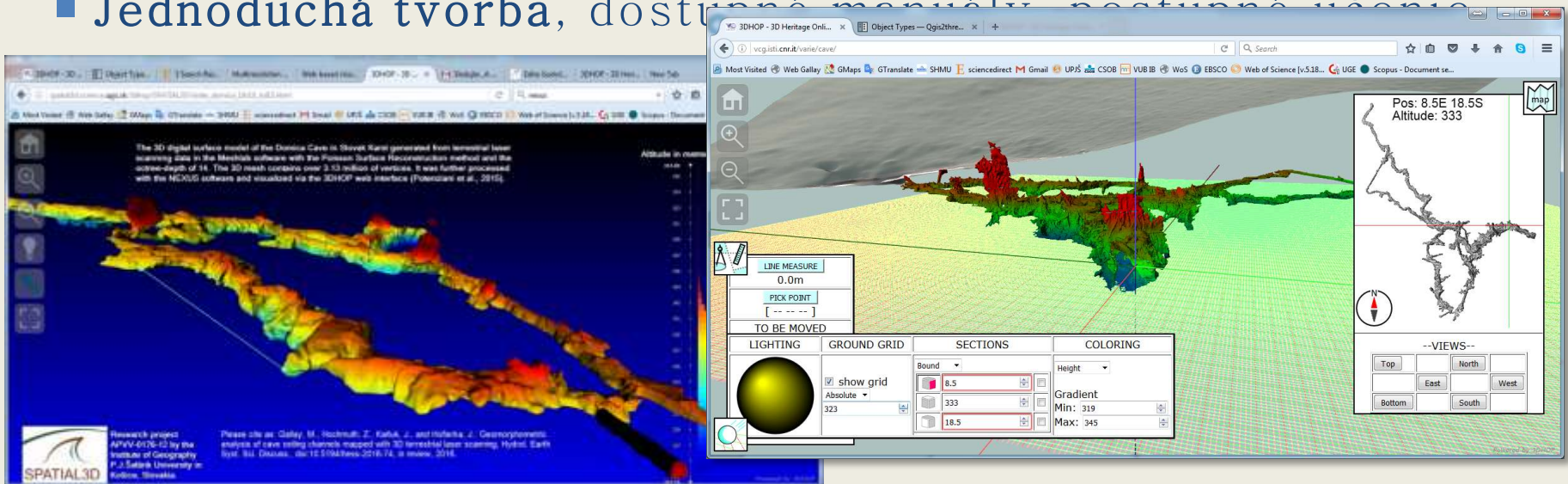
LIGHTING	GROUND GRID	SECTIONS	COLORING									
	<input checked="" type="checkbox"/> show grid Absolute 322	Bound <table border="1"><tr><td></td><td>-22</td><td><input type="checkbox"/></td></tr><tr><td></td><td>333</td><td><input type="checkbox"/></td></tr><tr><td></td><td>28.9</td><td><input type="checkbox"/></td></tr></table>		-22	<input type="checkbox"/>		333	<input type="checkbox"/>		28.9	<input type="checkbox"/>	Height Gradient Min: 319 Max: 348
	-22	<input type="checkbox"/>										
	333	<input type="checkbox"/>										
	28.9	<input type="checkbox"/>										

--VIEWS--
Top North
East West
Bottom South

Powered by 3DHOP

ZHRNUTIE: PREČO 3DWEB A 3DHOP?

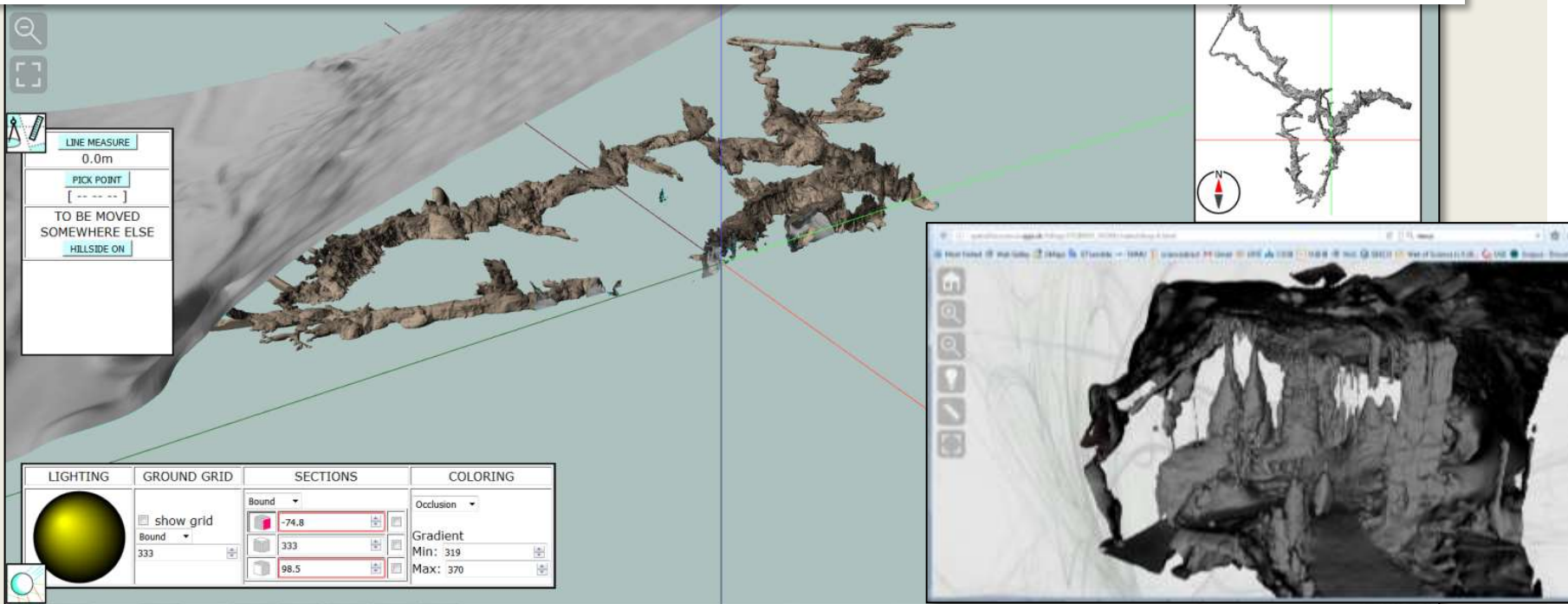
- Sprístupnenie 3D modelov vo vysokom rozlíšení
- sprostredkovanie vedeckých výsledkov vo výučbe, pre odborníkov z iných oblastí/GIS-nešpecialistov, verejnosť
- 3DHOP umožňuje nielen vizualizáciu, ale aj analýzu ako meranie, tvorbu rezov, zisťovanie polohy bodov
- Jednoduchá tvorba, dostupná manuálna nastupná učenie



BUDÚCE SMEROVANIE

- Rozšírenie nástroja o prezentácia častí jaskyne v ešte vyššom priestorovom rozlíšení

CALLIERI, M., GALLAY, M. Interactive 3D web interface for analysis of complex geomorphological systems. *Computers & Geosciences*. (manuscrip in preparation)



INTERAKTÍVNA GEOVIZUALIZÁCIA A PUBLIKOVANIE 3D MODELOV KRAJINY NA INTERNETE

[HTTP://GEOGRAFIA.SCIENCE.UPJS.SK](http://GEOGRAFIA.SCIENCE.UPJS.SK)
MICHAL.GALLAY@UPJS.SK
[HTTP://SPATIAL3D.SCIENCE.UPJS.SK](http://SPATIAL3D.SCIENCE.UPJS.SK)

ĎAKUJEM ZA POZORNOSŤ! OTÁZKY, PODNETY?

Tento výskum finančne podporil výskumný grant APVV-0176-2

New methods of spatial modeling
with laser scanning data and 3-D GIS

SPATIAL3D



Michal
GALLAY

Marco
CALLIERI



Ústav geografie,
Prírodovedecká
fakulta,
Univerzita
P.J.Šafárika v
Košiciach
Jesenná, Košice



Visual Computing