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OBJECT-BASED MAPPING OF GULLY EROSION IN KARSTIC AREA THROUGH THE USE OF MEDIUM SPATIAL RESOLUTION MORPHOMETRIC PARAMETERS

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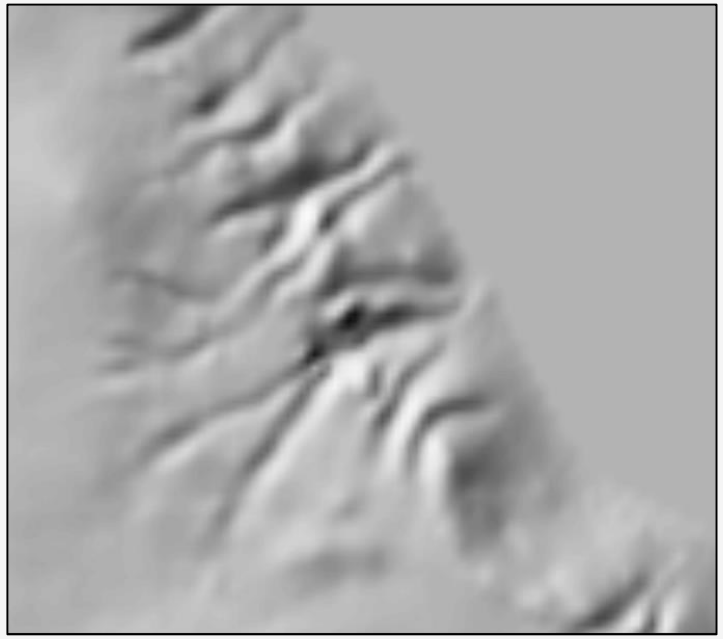
S04. Denudation in the Mediterranean Zone

Introduction

- Mapping of gully erosion is important for better understanding of erosion spatial distribution and characteristics
- Inaccessibility and disperse spatial distribution of gullies often makes terrain mapping challenging (time and cost consuming process) →not suitable for large areas
- Several studies successfully used VHR satellite imagery for object-based mapping of gully erosion → ***morphometric parameters not used***
- Detailed and accurate gully erosion mapping is especially challenging in remote areas → high spatial resolution data not available

How can medium spatial resolution data be used for mapping of gully erosion ?



Representation of gullies in medium resolution hillshade

Gullies located in Eastern part of Pag island

*Medium spatial resolution → 2 m – 30 m

Study aims

I. Test the possibility for gully erosion mapping based on different morphometric parameters derived from medium resolution digital elevation data

H1: *Gullies can be mapped from medium resolution morphometric parameters*

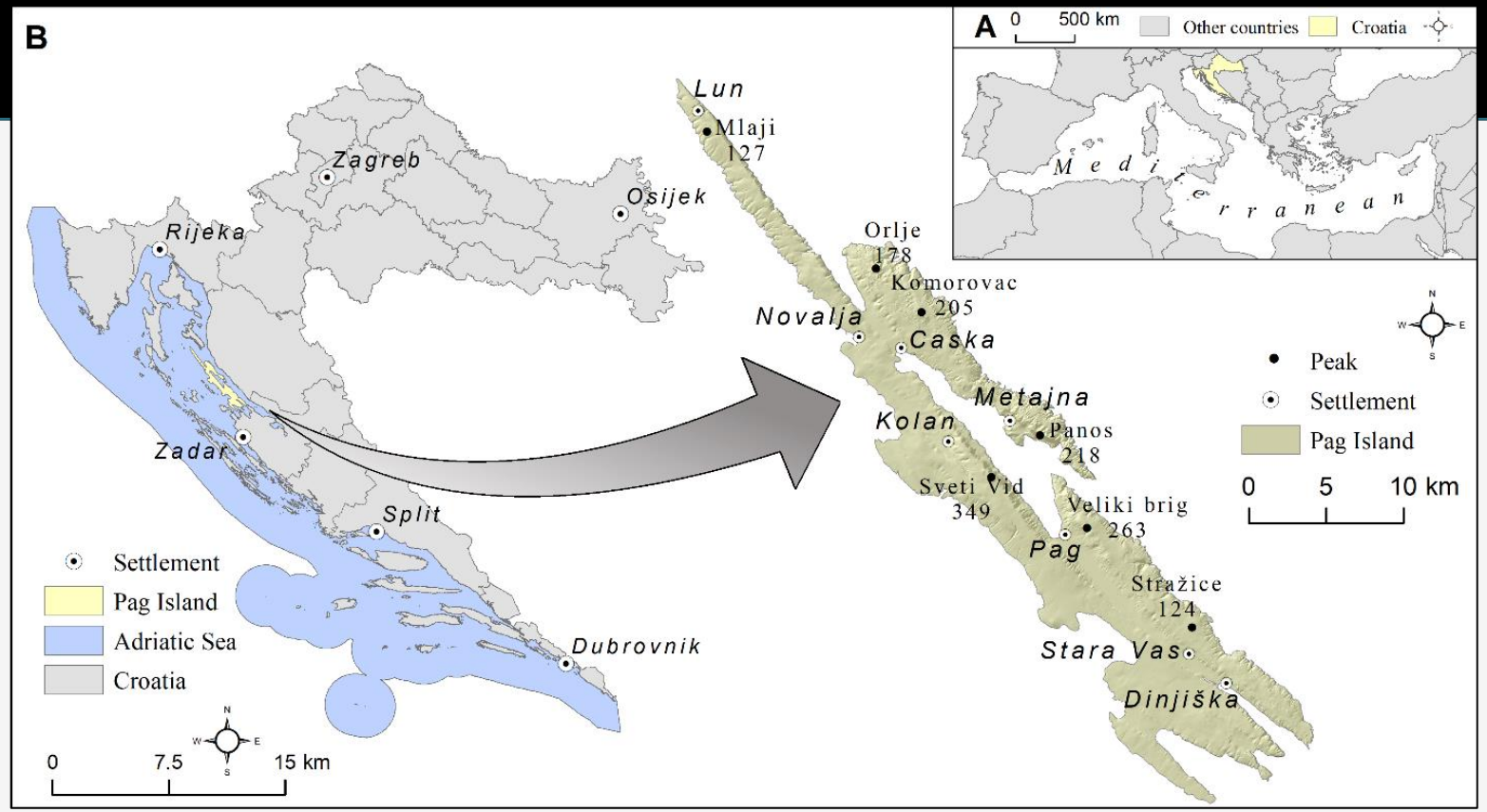
H2: *Short gullies (<100 m) won't be mapped from medium resolution morphometric parameters*

II. Determine the number, spatial distribution and basic characteristics of gullies

H3: *Total number of detected gullies will be higher then determined by previous research*

Study area

- Pag Island (284 km²) is situated within Northern Dalmatia archipelago, Croatia
- Scarce vegetation and harsh climatic conditions (bora wind) → development of specific karst landscape



Location of Pag Island within Croatia

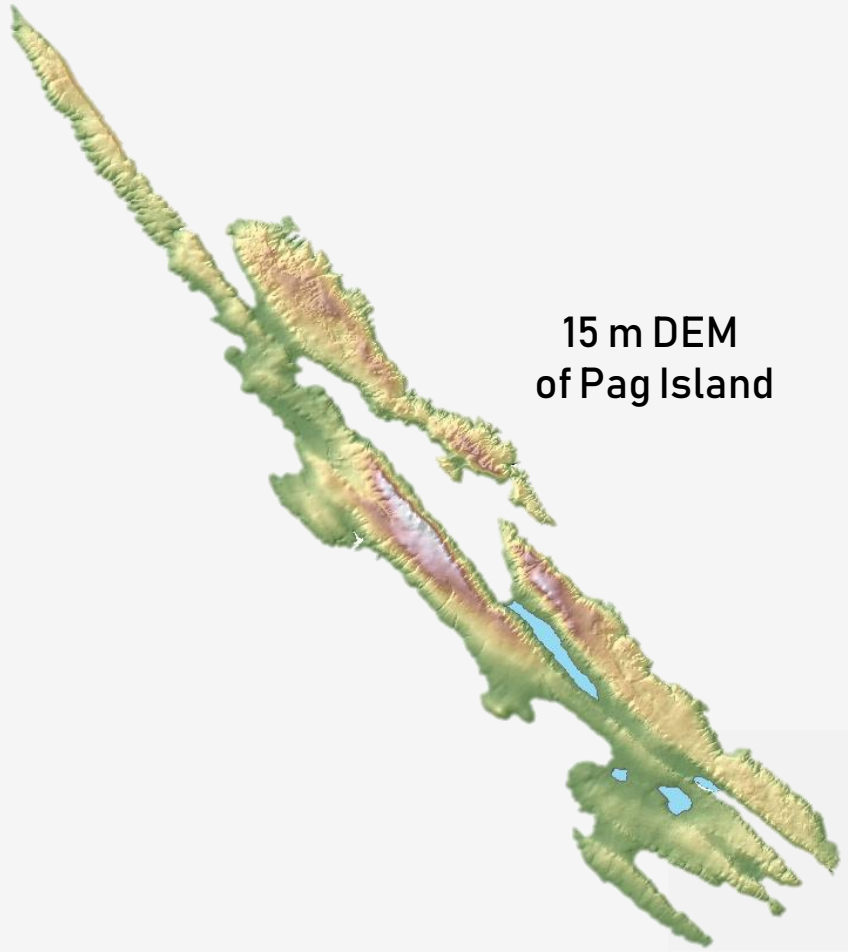
- Widespread denudation processes → gully erosion present in almost all parts of island

Medium spatial resolution data source

USED DIGITAL ELEVATION MODEL (DEM)

- DEM was made from height data collected by the photogrammetric restitution (DGU, 2017).
- Ordinary kriging (OK) interpolation of 148 518 height points

  → 15 m spatial resolution of DEM (284 km²)
- Optimal interpolation method chosen by cross-validation results → RMSE = 1,0279



15 m DEM
of Pag Island

Workflow of object-based gully erosion mapping

APPLIED OBIA WORKFLOW

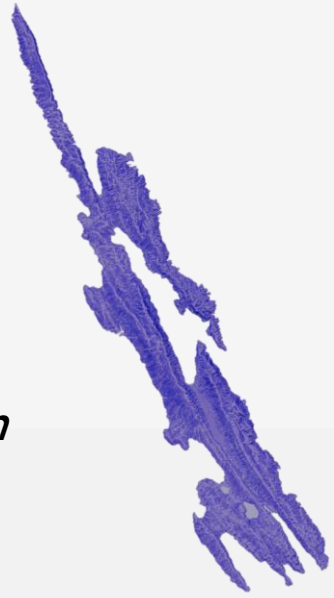
1. Determination of parameters
2. Parameter standardization
3. Segmentation
4. Object classification
5. Gully candidate filtration
6. Model validation (reference data)

- In total seven parameters (SPI, MBI, TPI, PLAN, SLO, TWI, VDC) were chosen for OBIA mapping
- All chosen parameters were standardized to the same scale:
    a) SPI, MBI, TPI, PLAN → scale A [-1, 1]
    b) SLO, TWI, VDC → scale B [0, 1]

Chosen morphometric parameters

STREAM POWER INDEX (SPI)

- Represents the measure of the erosive power of surface runoff
- Influences the intensity of gully erosion



Higher SPI

→ higher erosion potential (EP)

TERRAIN WETNESS INDEX (TWI)

- Measure of potential humidity of given terrain
- Allows the differentiation of saturated and unsaturated areas

Higher TWI

→ lower EP

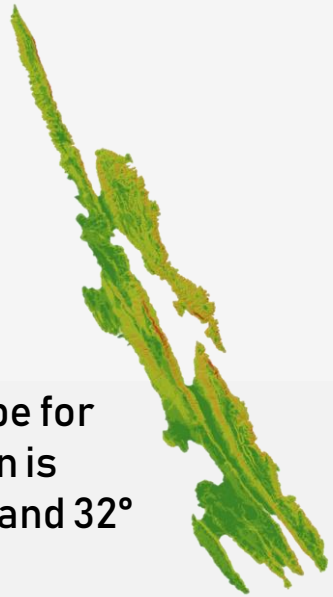
MASS BALANCE INDEX (MBI)

- Measure used for classification of accumulation and erosion processes
- Negative MBI → depressions (accumulation)
- Positive MBI → slopes (erosion)

Chosen morphometric parameters

SLOPE (SLO)

- Influences the intensity of the gully erosion
- Too gentle or steep slopes are less suitable for gully erosion



Optimal slope for gully erosion is between 12°and 32°

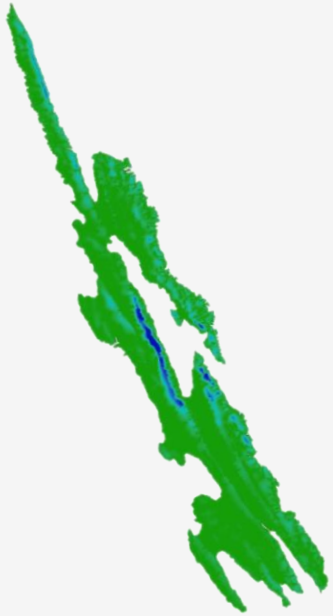
PLANAR CURVATURE (PLAN)

- Affects the homogeneity of the surface runoff
- Convergence or divergence of runoff

Concave slopes
→ runoff convergence
→higher EP

VERTICAL DISTANCE TO CHANNEL NETWORK (VDC)

- Determines the vertical distance from pixel to given channel network
- Gullies related to surface runoff → low VDC values

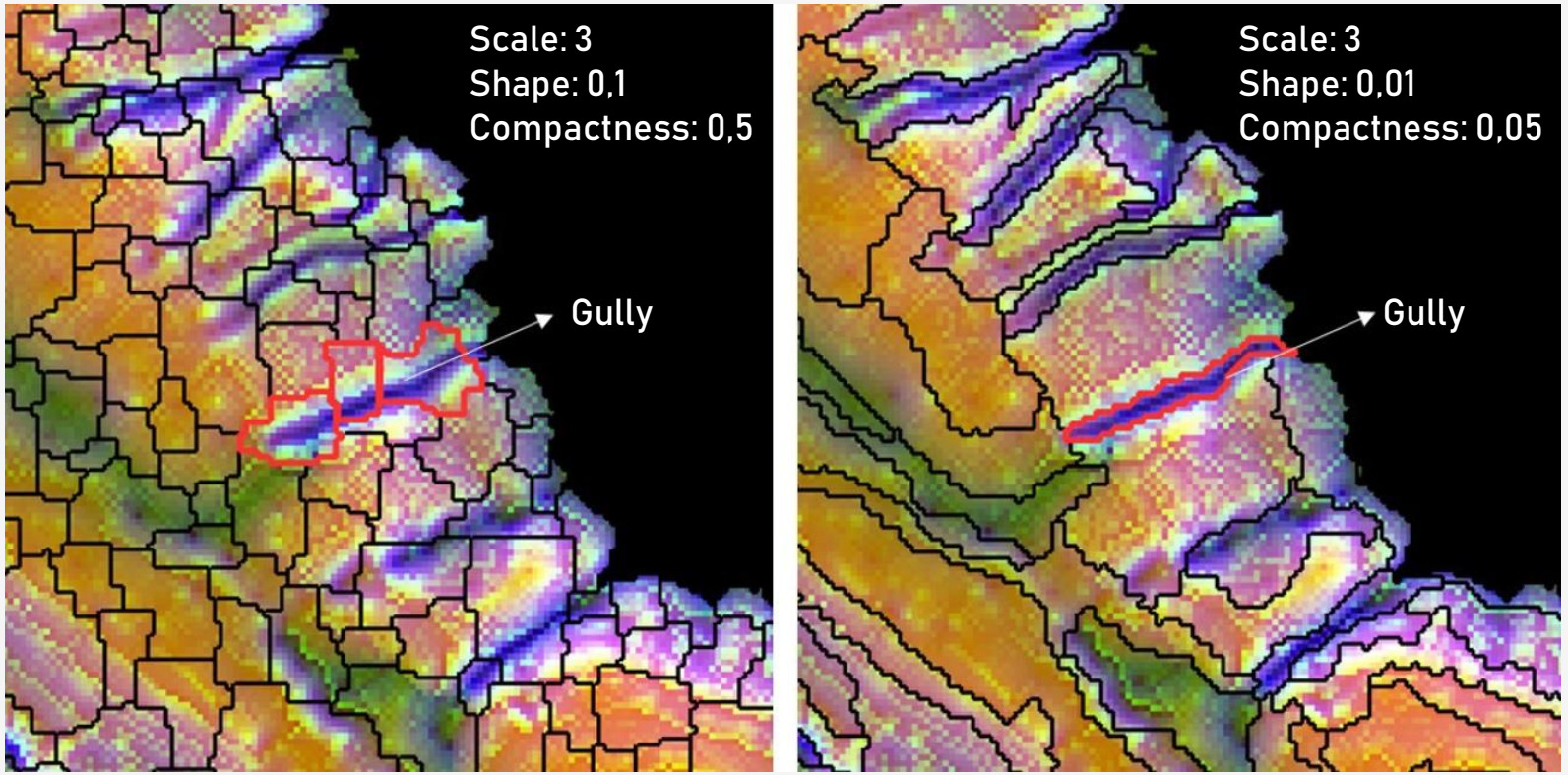


TOPOGRAPHIC POSITION INDEX (TPI)

- Determines the position of central pixel in relation to its neighbourhood
- Gullies → linear features lower then surrounding terrain

Segmentation and classification

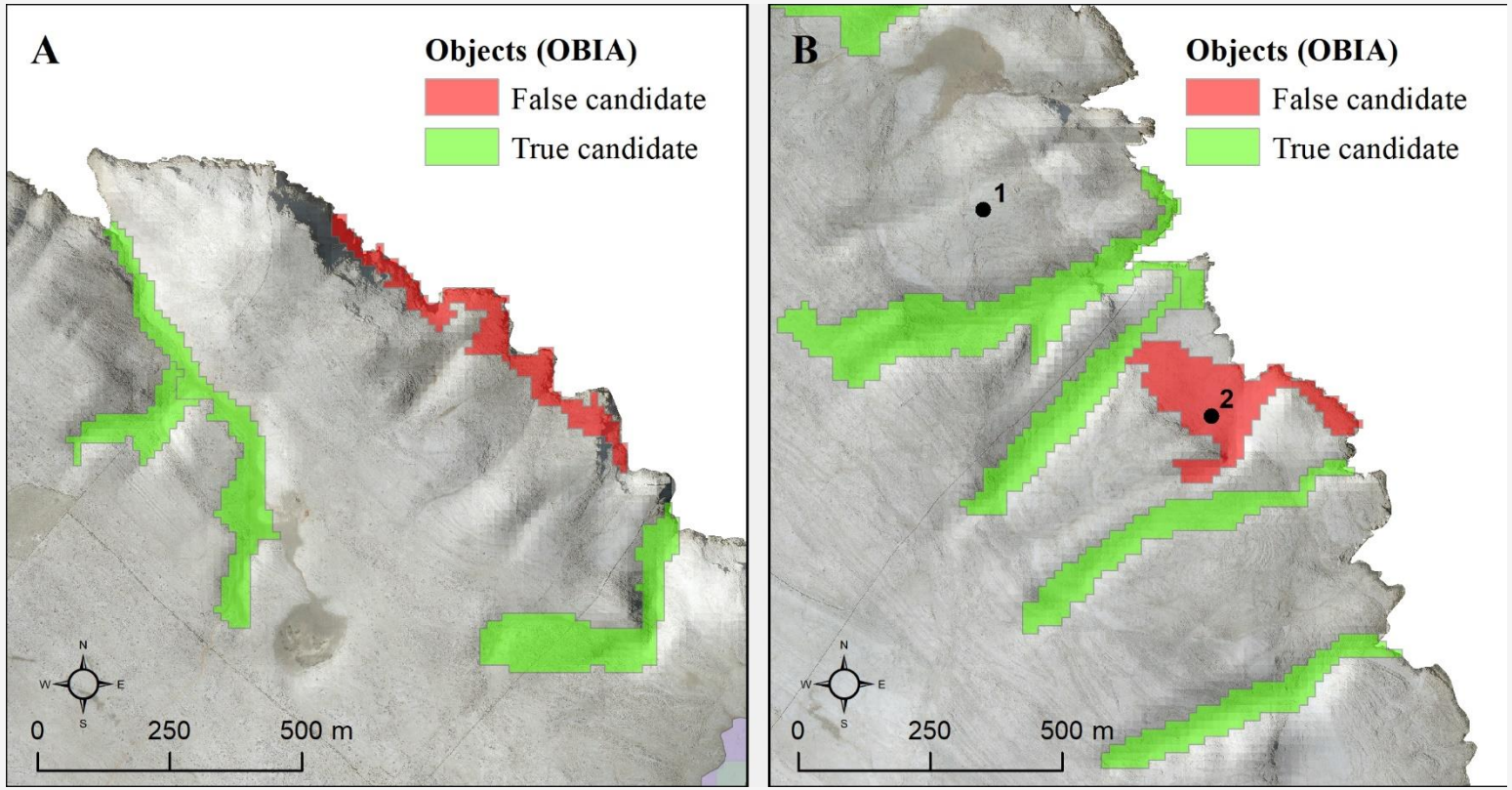
- Multiresolution segmentation (MRS) algorithm applied
- User-defined parameters were set according to the visual interpretation of results
- Threshold classification used for all 7 parameters



Influence of user-defined parameters on segmentation result

Gully candidate filtration

- Filtration of 384 gully candidates performed by visual interpretation → DOF (0.5 m)
- Most "false candidates " occur in steep coastal areas, while most small gullies (length <200 m) were not mapped
- 134 true objects → 120 gullies

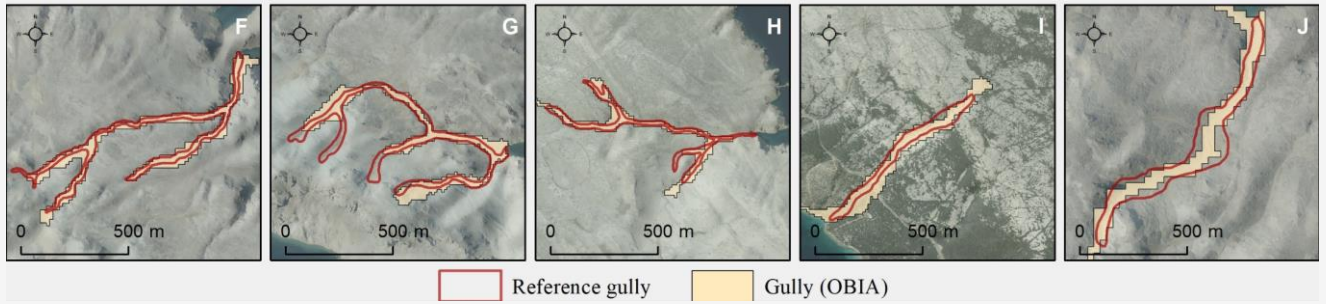


(A and B2) – false candidate in steep coastal areas;

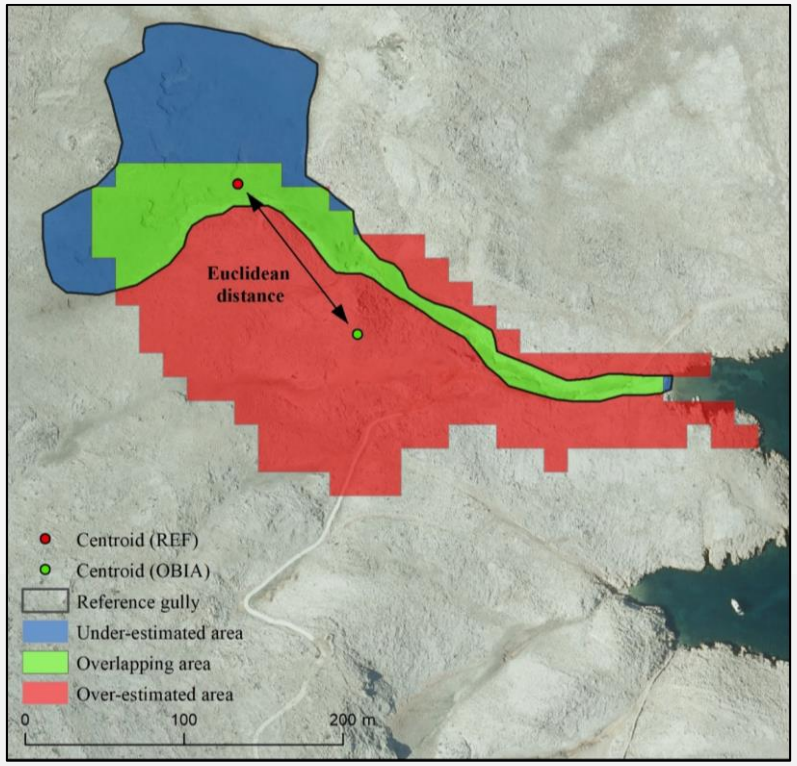
(B1) – small gully undetected by OBIA

Model validation

- Model validation performed by overlapping of extracted gullies with 12 manually vectorized gullies → DOF (0.5 m)



Extracted gullies (OBIA) overlapped with reference gullies



- 4 mapping quality indices used:

$$\textit{Correctness (COR)} = \frac{A_p}{A_e} \qquad \textit{Overall Quality (OQ)} = \frac{A_p}{A_r + A_e - A_p}$$

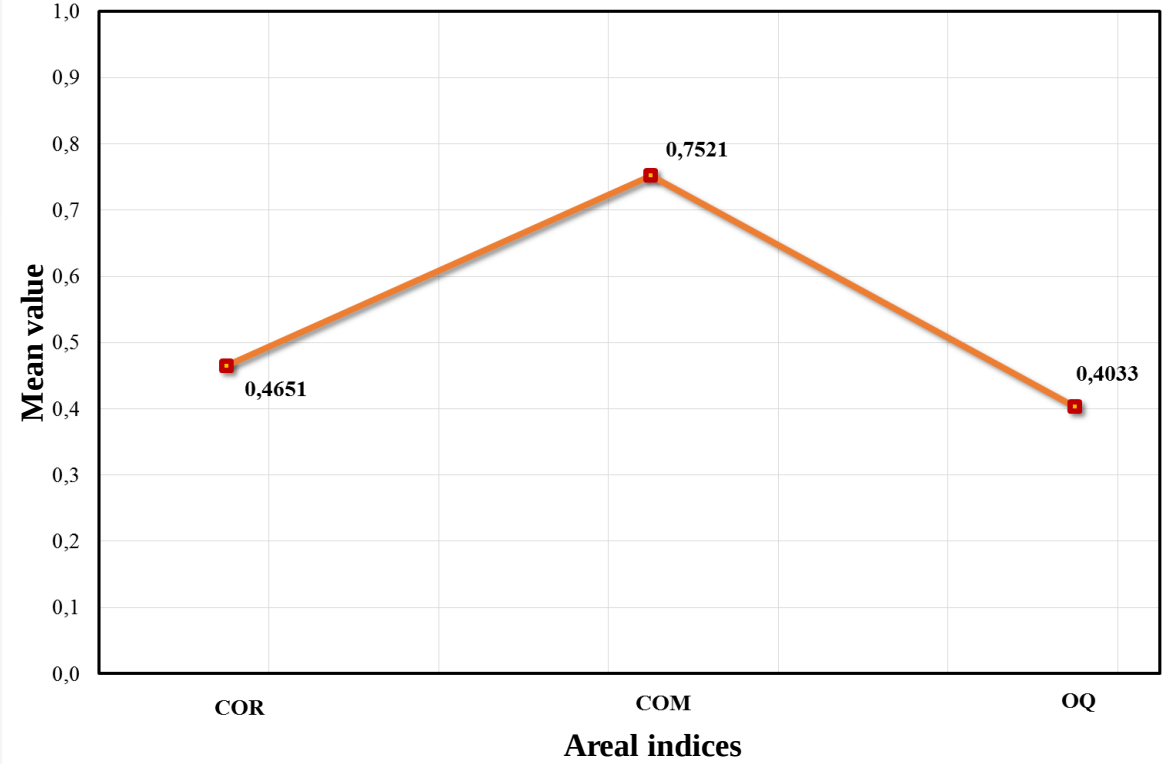
$$\textit{Completeness (COM)} = \frac{A_p}{A_r}$$

$$\textit{LOC measure (LOC)} = \sqrt{(X_e - X_r)^2 + (Y_e - Y_r)^2}$$

A_p - overlap area; A_e - area of OBIA gully; A_r –area of reference gully

Validation results

- Relatively low values of areal indices → area of mapped gullies is exaggerated in comparison to the reference gullies
- MeanLOC value = 55 m → horizontal location error of 3,6 pixels
- Inverse proportion between mapping errors and gully size → gullies with length <200 m not mapped



Mean values for three areal indices

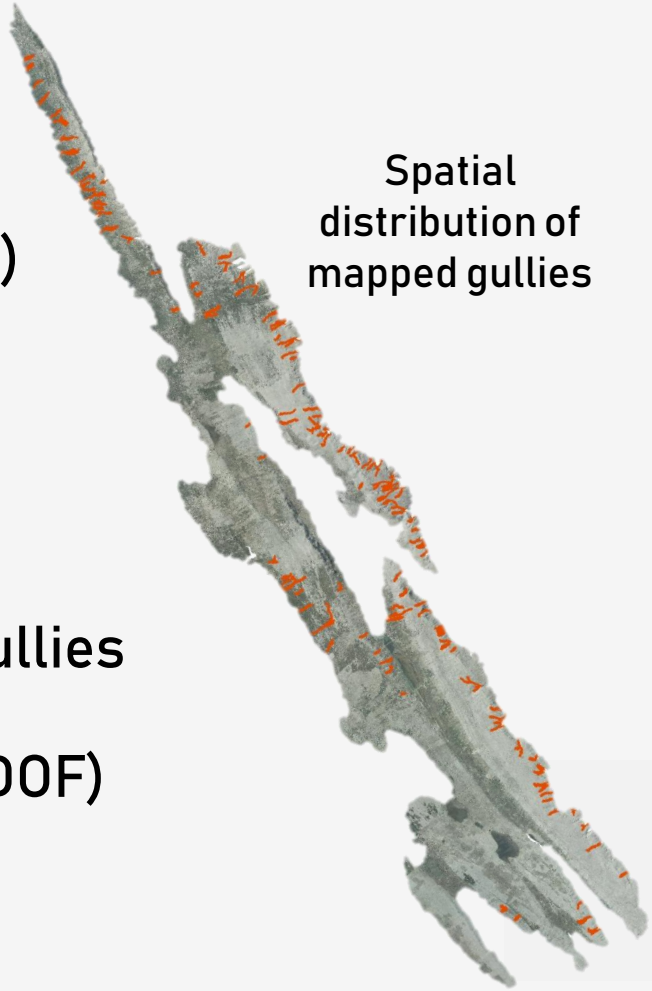
(*Value 1 shows perfect overlap between reference and extracted data*)

Number and characteristics of mapped gullies

- In total 120 gullies have been mapped within Pag Island →

337 gullies mapped by manual vectorization (DOF 0,5 m – Lončar, 2009)

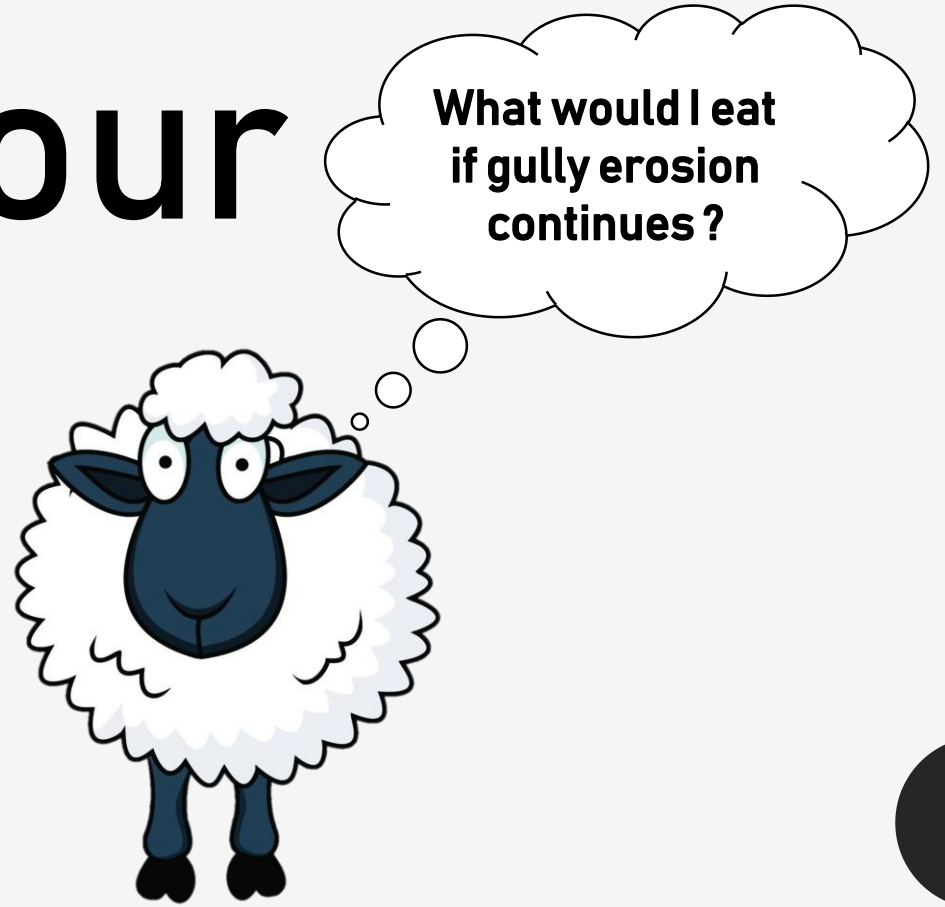
- Most of mapped gullies occur in eastern parts of Pag Island
- Gullied areas cover 5,9 km² of total island area (2,091%)
- Simple, unbranched gullies prevail (88,2 %) over longer branched gullies
- In 49,16 % of mapped gullies traces of active gully erosion detected (DOF)



Spatial distribution of mapped gullies

Conclusion

- Object-based mapping of gully erosion from medium resolution morphometric parameters have provided *satisfactory detection rate* but modest areal accuracy
- Proposed methodology *suitable for large gullies and remote areas with lack of VHR data* → inverse proportion between mapping errors and gully size
- More work should be done on morphometric parameter tresholding → easier with VHR data
- Conducted research didn't account short gullies → most common at Pag island
- Similar object-based mapping should be performed on VHR data if possible → acquisition of Worldview-2 multispectral and stereo imagery (DigitalGlobe Foundation)

Questions ?

Thank you for your attention