Features of using statistical methods in Black sea sandy coast macroinvertebrates investigations

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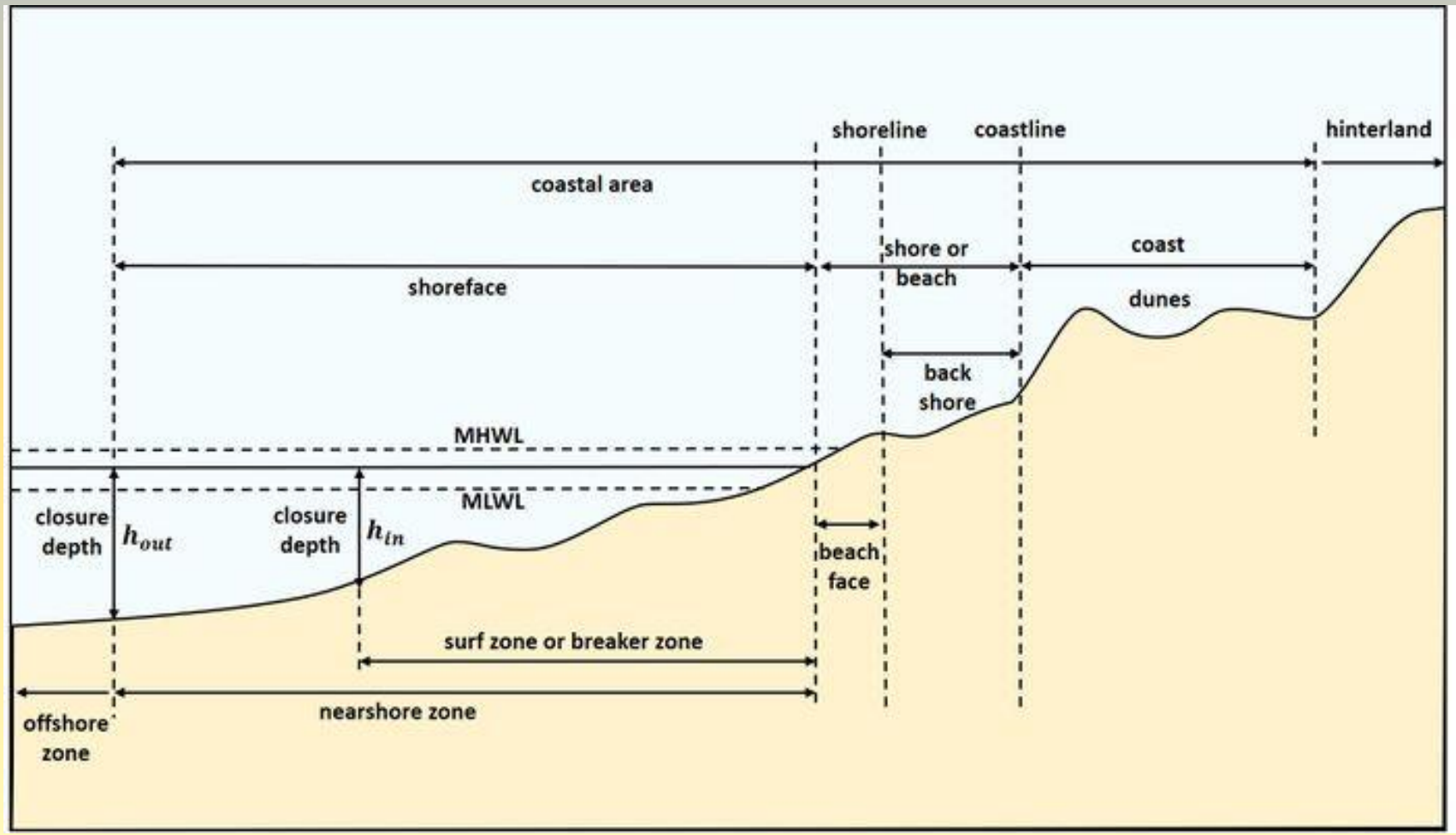
Features of Black sea sandy coast

- Negligible tidal range, absence of littoral zone
- Close to littoral communities occupy pseudolitoral zone
- Relatively high wind tide impact on the beaches

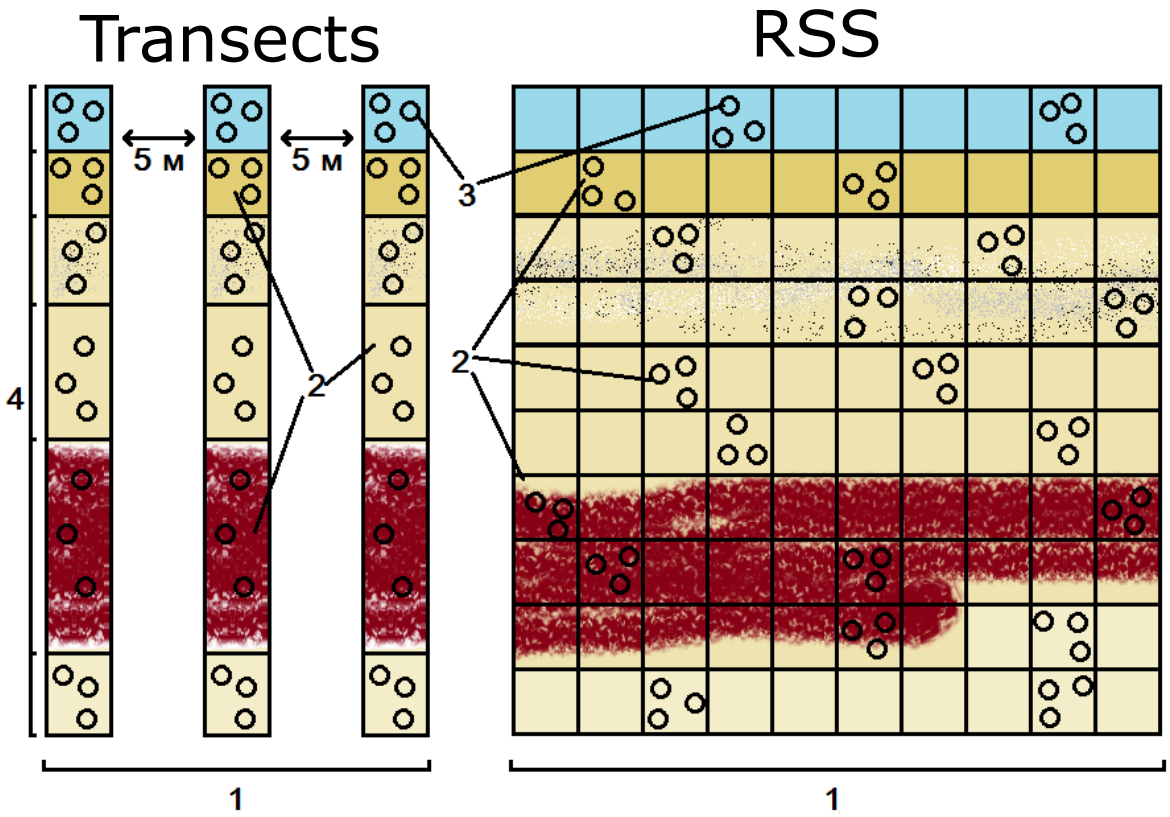
Zonation of sandy beaches



Sampling devices

- Circular cores can simplify the sampling
- Depth of coring must exceed 20 cm, if it possible.

Methods of sampling



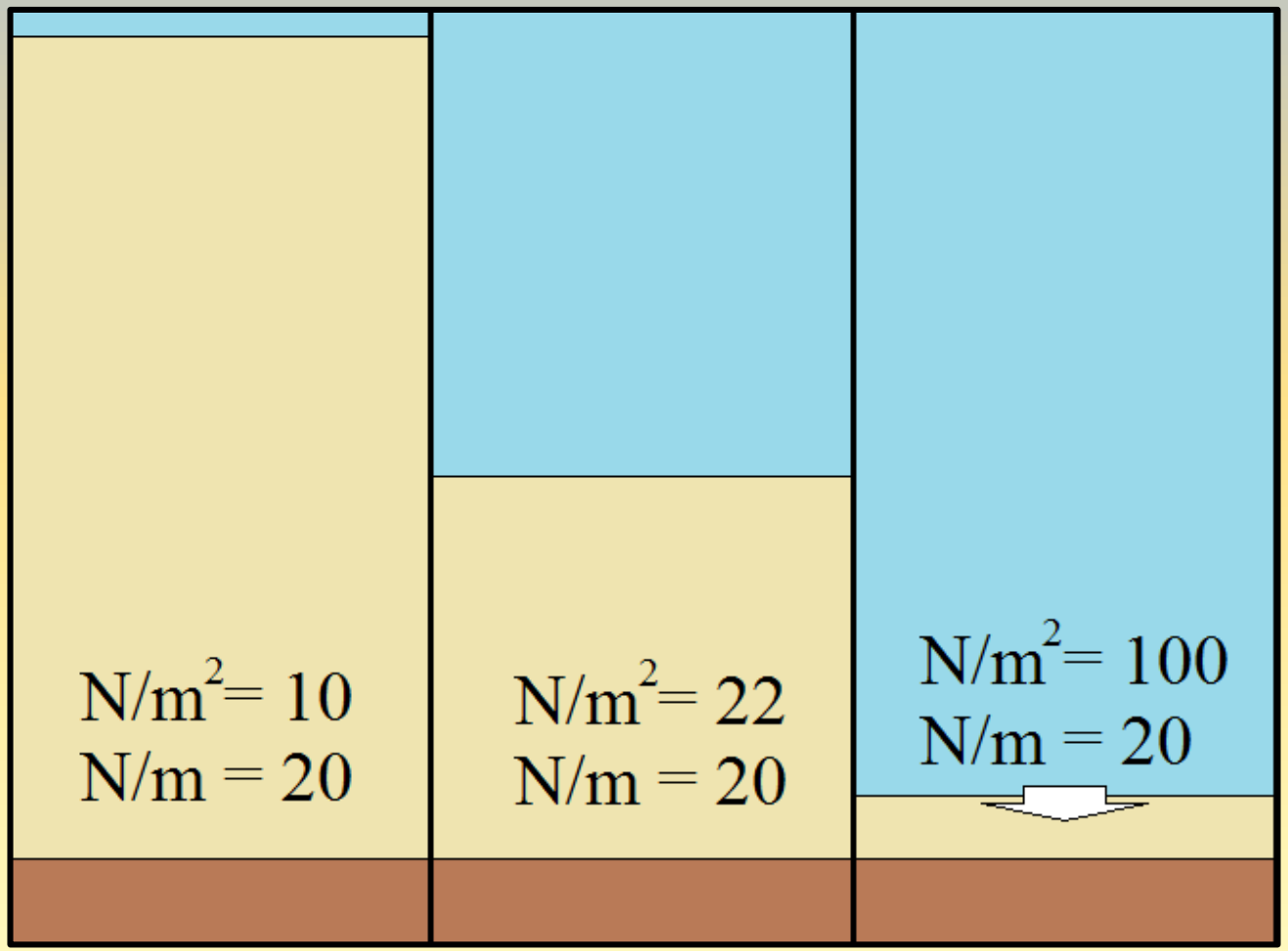
1 - Sampling station 2 - Sampling unit 3 - Core 4 - Along-shore level

Area of sampling station

Range of water fluctuations	Morphodinamic type	Square
<20	Reflective	2 м^2
20-50	Reflective/intermediate	3 м^2
50	Intermediate/dissipative	4 м^2

NB! Total area of samples from one unit must exceed 0,3 m^2

Density estimation



Distribution in space

There are three main distributions of individuals:

Uniform – appears, when specimens are repulsed each other.

Random – individuals are indifferent to each other

Aggregated – individuals attracted to each other, same environment conditions, resources

One-dimensional indices of aggregation

- Indices of aggregation estimate the distribution of individuals in space
- All simple aggregation indices are based on the ratio of variance to absolute average, and do not take into account the location of the sampling units
- Often, a certain value of the index corresponds to the Poisson distribution (random), and the deviations suggests as aggregated or regular structure

One-dimensional indices extension

$$ID = \frac{S^2}{\bar{x}} \Longrightarrow ICS = ID - 1 \longrightarrow ICF = \frac{\bar{x}}{ICS} \longrightarrow IP = \frac{1}{ICF} + 1 \longrightarrow I_M \frac{n\bar{x}IP}{n\bar{x} - 1}$$

$$\rightarrow GI = \frac{ICS}{n-1}$$

$$\rightarrow IMC = ICS + \bar{x}$$

$$\rightarrow J = \frac{ICS}{\bar{x}}$$

$$C_{1,2} = \frac{Cov_{1,2}}{\bar{x}_1 \bar{x}_2}$$

$$\rightarrow A_{1,2} = \frac{(J_1 + 1)(J_2 + 1)}{(C_{1,2} + 1)^2}$$

List of indices

- ID – Dispersion index
- ICS – Index of cluster size
- ICF – Index of cluster frequency
- GI – Green`s index
- IMC – Index of mean crowding
- IP – Index of patchiness
- I_M – Morisita Index
- J – Index of intraspecific aggregation
- $C_{1,2}$ – Index of interspecific aggregation
- $A_{1,2}$ –J&C $_{1,2}$ ratio
- etc…

Taylor’s law

$$S^2 = a + \bar{x}^b$$

- The coefficient b does not depend on the number of sites and the number of organisms in them and is relatively constant over time.
- For b> 1, the distribution is aggregated, and for b <1 - regular
- To test the hypothesis of randomness of the distribution using the Student's t-test

Mean crowding regression

$$IMC = \alpha + \beta\bar{x}$$

- Based on linear dependence
- $\beta<1$ – regular, $\beta=1$ – random, $\beta>1$ aggregated
- $\alpha\leq 0$ – individuals, $\alpha>0$- colonies

Geostatistics

- Geostatistical methods take into account spatial distribution
- Based on the conception of ergodicity
- For clear estimation of data, sample must be stationar and multinormal

Stationarity: check and fit

Procedure	Methods	Result
Visualization of data	Sampling maps, frequency histograms, plots	Revealing a mistakes, clusters, heterogenity, trends and anisotropy.
Declusterisation *	Polygonal or cellular declusterisation	Giving a weights for points
Trend revealing	Trend model (multiple linear regression)	Detection of connections between coordinates and values
Trend elimination*	Calculation of remains	Formation of detrended sample
Selection of homogenous areas*	Visualization, Analysis of variance.	Separation on homogenous subsamples

Variograms

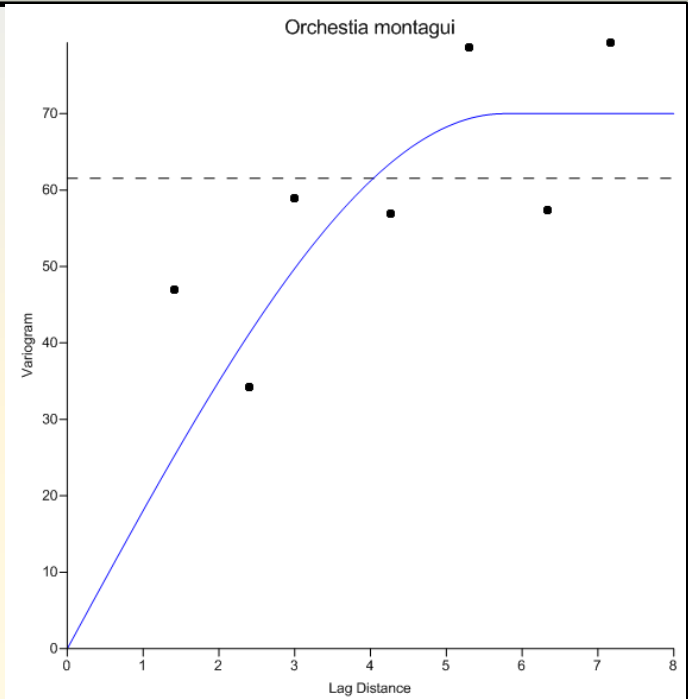
- Variogram is a graph of semivariance to lag dependence
- A variogram is a description of the spatial continuity of the data
- Allows to evaluate the main parameters of the distribution
- Theoretical model

Parameters of variogram

- The main model of theoretical variogram is spherical function.
- Wave model (hole effect) appears in such cases:

1) Aggregation in «lenses»

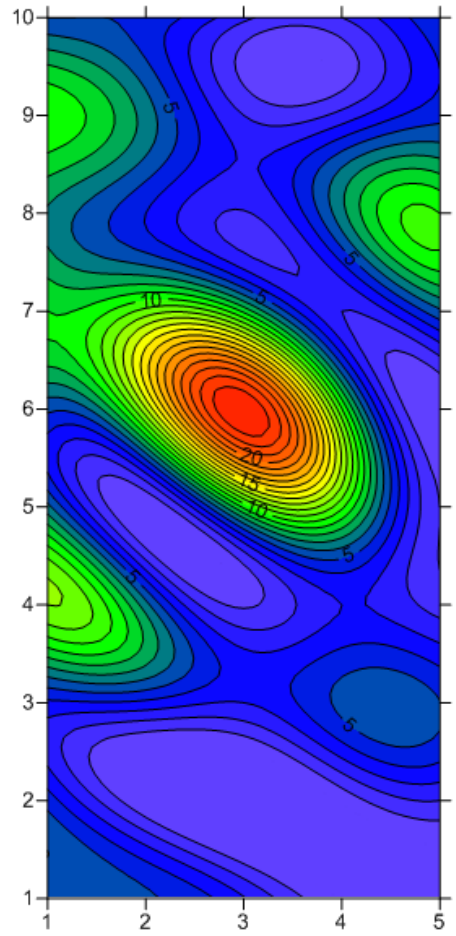
2) Sampling space divided on irregular levels

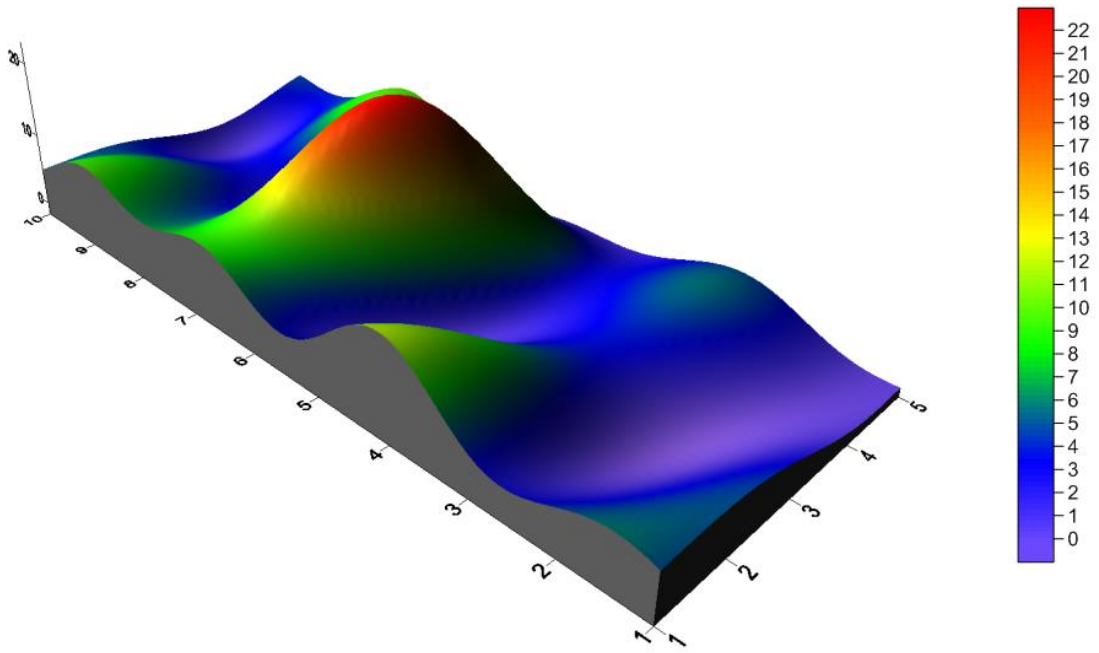


Spatial interpolation

- The main method of spatial interpolation is krigging
- Krigging uses the theoretical variograms for filling the gaps between sample points

Visualization





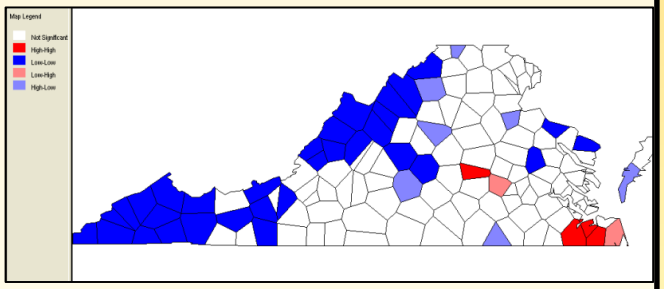
Spatial pattern of *Hediste diversicolor* on dissipative shore

Moran`s I

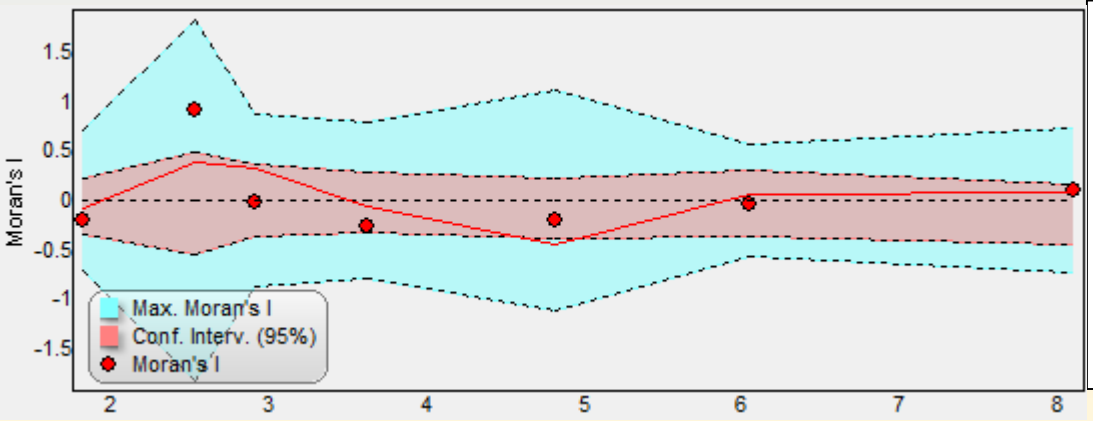
- Global Moran's I measures spatial autocorrelation
- Null hypotheses are tested by z-score and p-value (95%)
- Sample must have more then 30 values
- L.I.S.A. map –

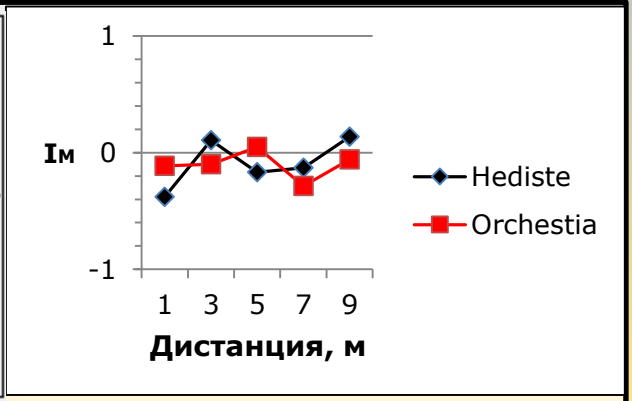
local I_M values of zones

in comparison with global



Corellograms





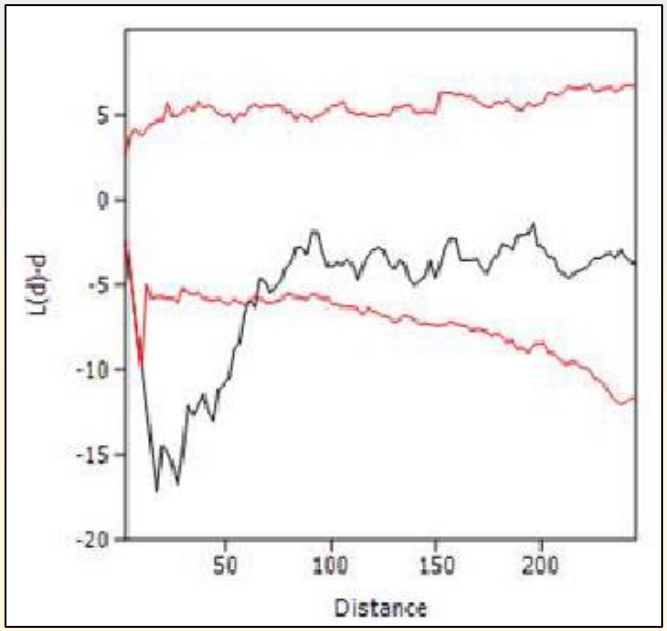
- Moran’s I to lag ratio
- Provide numeric estimation of mean aggregation size, trend and autocorrelation

Geary`s C

- Measure of spatial autocorrelation
- More sensitive to local spatial autocorrelation, then Moran`s I.
- Ranges from 0 to 2

Ripley`s K

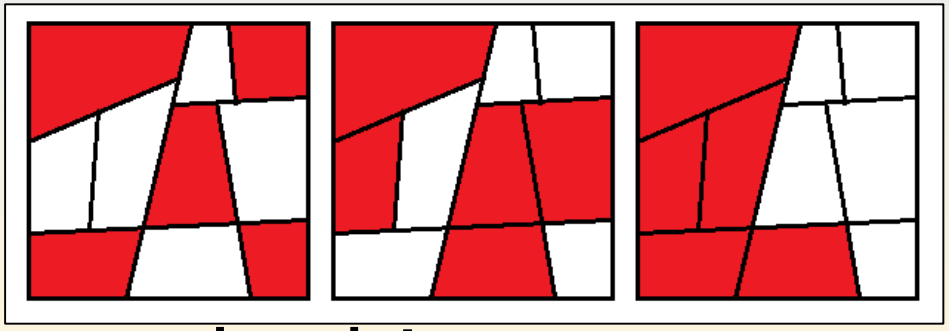
- Describe how point patterns occur over a given area
- Ripley's K function is generally calculated at multiple distances allowing to see how point pattern distributions can change with scale.
- 95% confidence interval of complete spatial randomness is estimated by Monte-Carlo simulations



Getis-Ord general G
Getis-Ord Gi*

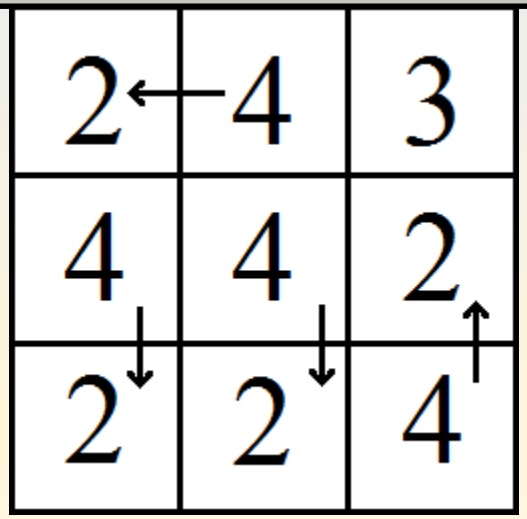
- Getis Ord G identifies statistically significant clusters
- Clusters of minimal values are neutralising clusters of maximal values
- Getis-Ord Gi* detects local clusters

Join-Count Analysis



- Data must be binary.
- Relates the number of observed connections between the zones of property “1" and those of property “0", with the theoretical number of connections of a random distribution.

SADIE

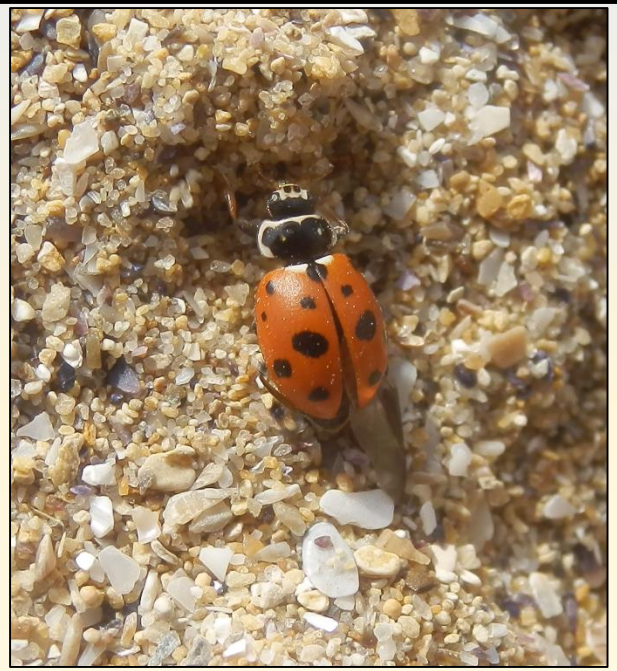


- SADIE estimates distance, which is necessary to reach the uniform distribution by moving individuals.
- I_a interpretation is the same as ID

Mantel`s test

- Estimates correlation of spatial pattern between two species, inhabiting the same location
- Strong spatial autocorrelation can significantly affect its p-value.

Biodiversity estimation



Hippodamia tredecimpunctata

Tetramorium caespitum

Beach indices

$$DFV(\Omega) = \frac{H_b \cdot 100}{W \cdot T}$$

Hb – height of breakers (m), W – sand fall velocity (by Stock`s law), a T – wave period(sec)

>5	2-5	<2
Dissipative	Intermediate	Reflective

Спасибо за внимание!