V/S Modellieren in der Landschaftsarchäologie

Freie Universität Berlin
M.Sc. Landschaftsarchäologie

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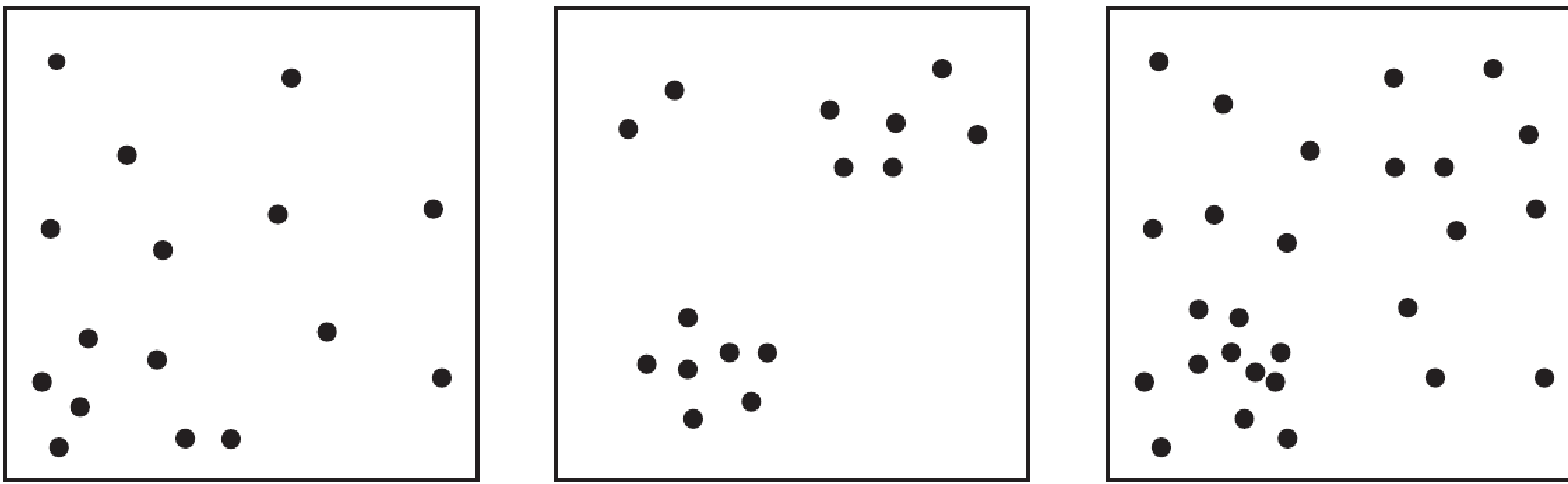
EXCELLENCE CLUSTER TOPOI

Point Pattern

What caused these patterns? First- or Second order effects?



Point pattern analysis aims to distinguish between both effects
– helping you to understand the genuine process creating the pattern –

(O'Sullivan & Unwin, 2010)

Point Pattern

Simple measures:

- mean center

$$\bar{\mathbf{s}} = (\mu_x, \mu_y) = \left(\frac{\sum_{i=1}^{n} x_i}{n}, \frac{\sum_{i=1}^{n} y_i}{n} \right)$$

- standard distance

$$d = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \mu_x)^2 + (y_i - \mu_y)^2}{n}}$$

- intensity of a pattern

$$\hat{\lambda} = \frac{n}{a} = \frac{\#(S \in A)}{a}$$

Number of events in the pattern found in study region

Area of study region

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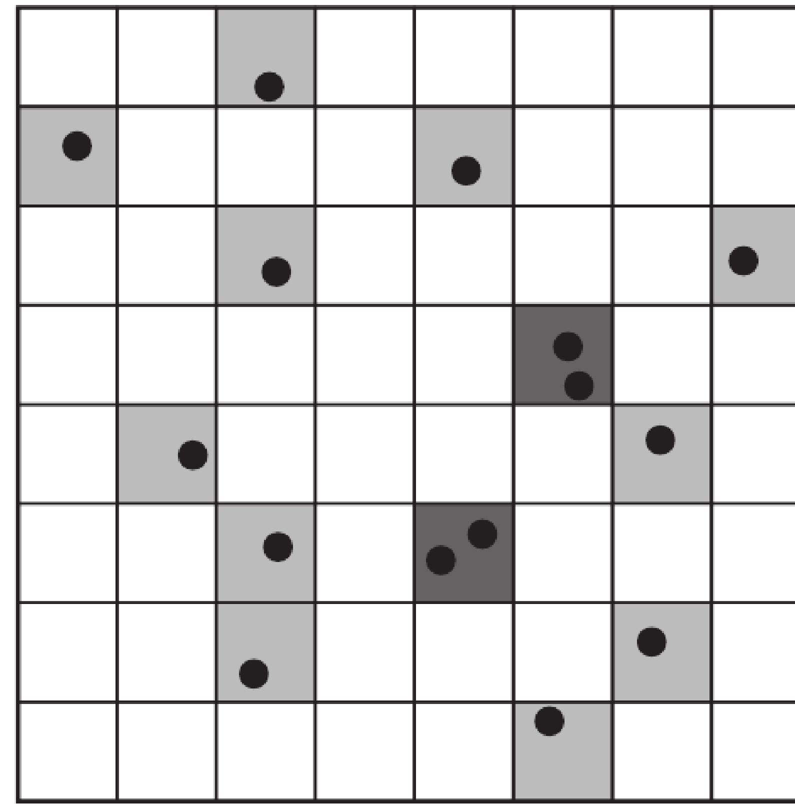
Point Pattern – first order effects

Intensity – more advanced

Independent Random Process (IRP)
= Complete Spatial Randomness (CSR)

→ any event has equal probability to be located a quadrant
→ the occurrence of points is independent of the Positioning of other events

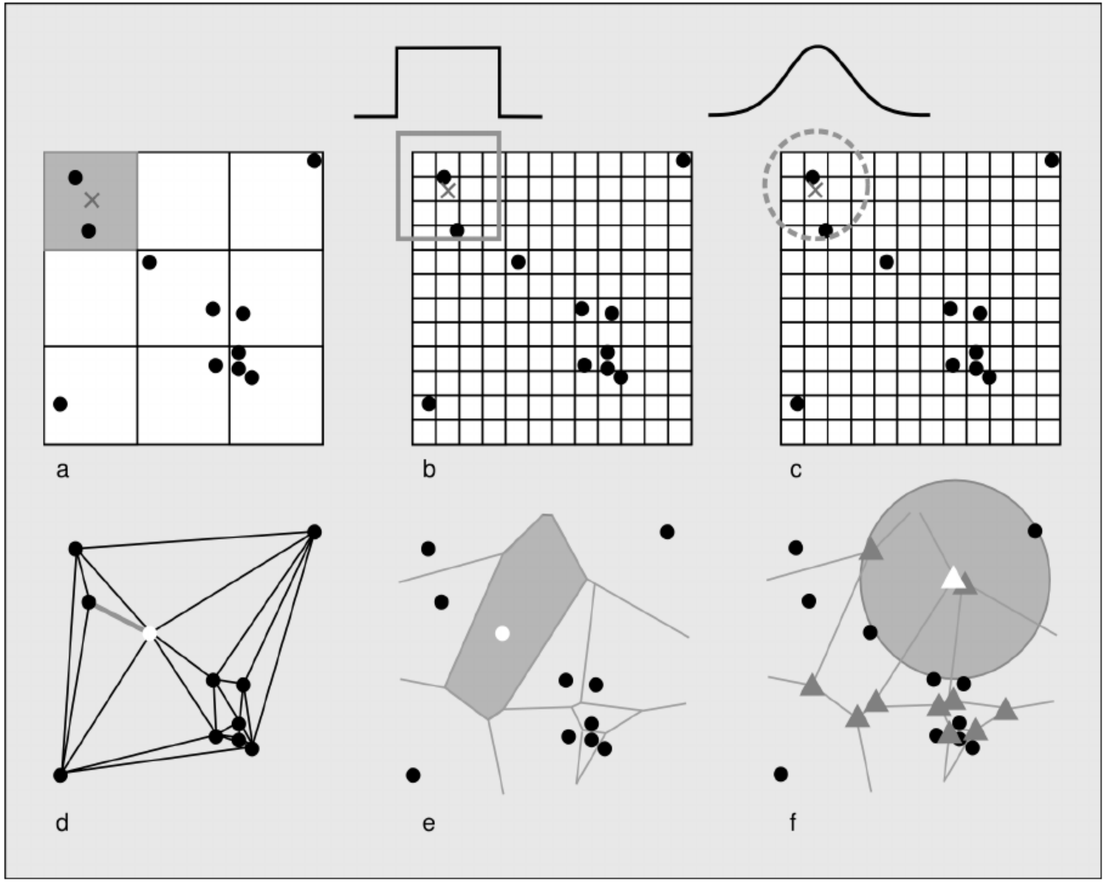
P (event in a quadrant) = 1/64



(O'Sullivan & Unwin, 2010)

Point Pattern – first order effects

Intensity – possibilities to calculate



(Nakoinz & Knitter forthcoming)

Point Pattern – first order effects

Intensity – more advanced

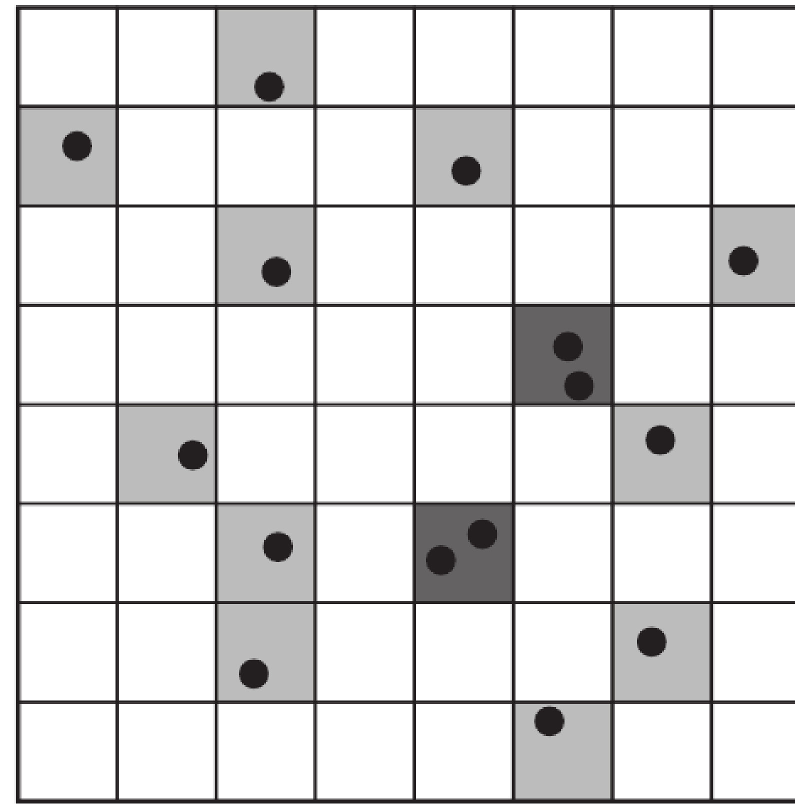
Independent Random Process (IRP)
= Complete Spatial Randomness (CSR)

Probability of *k* events in a quadrant is calculated with Poisson distribution

$$P(k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

intensity

Base of natural logarithm (2.78…)

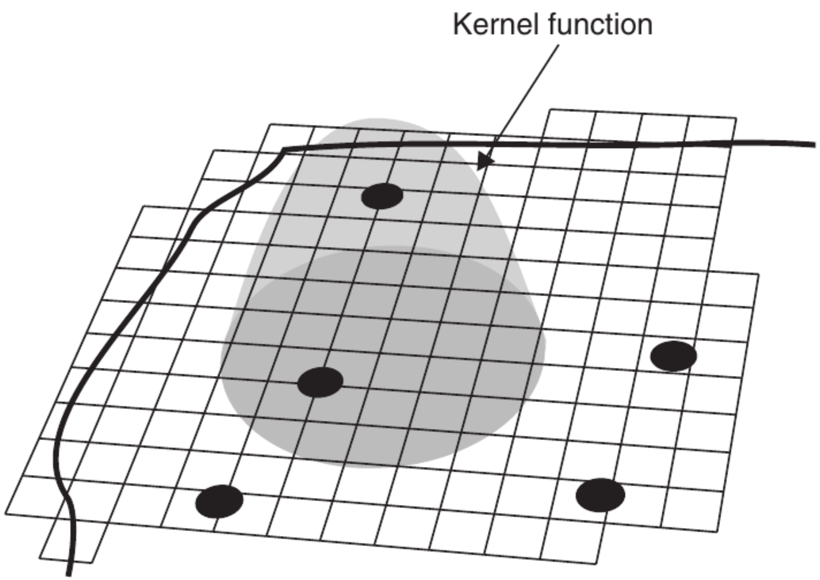


(O'Sullivan & Unwin, 2010)

Point Pattern – first order effects

Intensity – more advanced

Kernel density estimation (KDE)



Edge correction

kernel location

$$\hat{\lambda}_p = e(p) \sum_i k(x_i - p)$$

(Gaussian) Kernel function

mean

$$\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

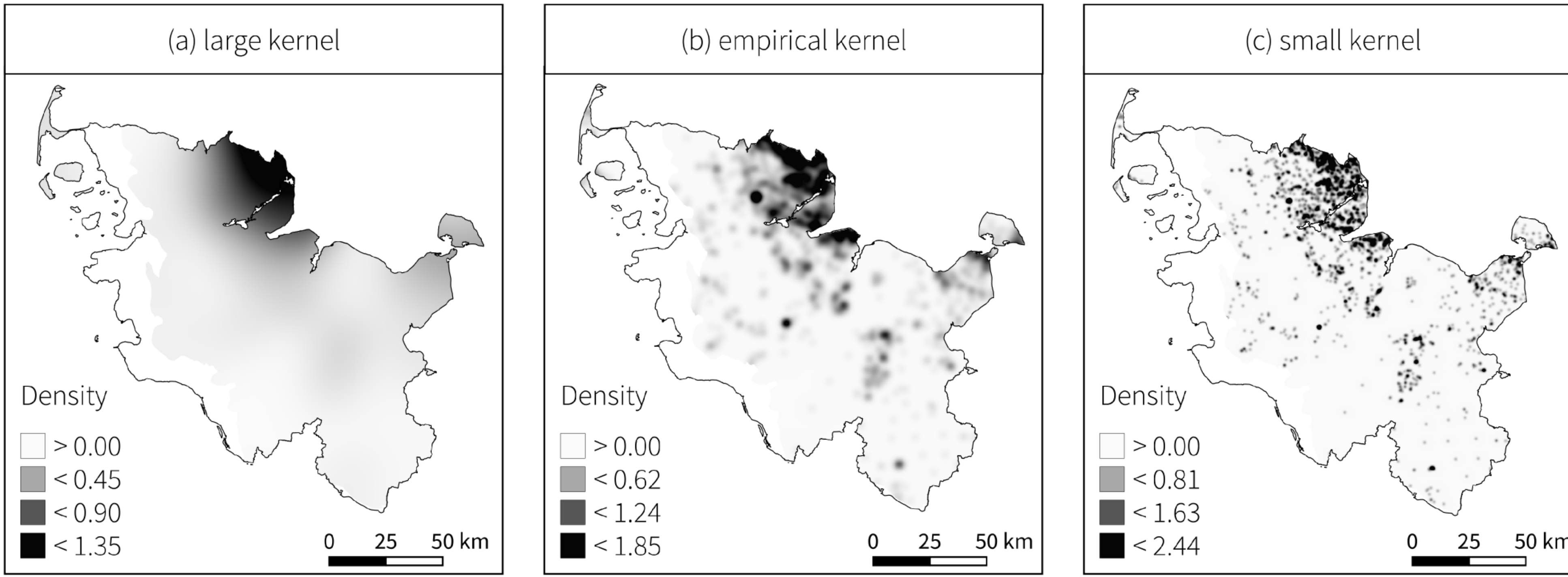
Standard deviation

(Knitter & Nakoinz (submitted); (O'Sullivan & Unwin, 2010)

Point Pattern – first order effects

Sigma large

Sigma small



General trend

Local trend

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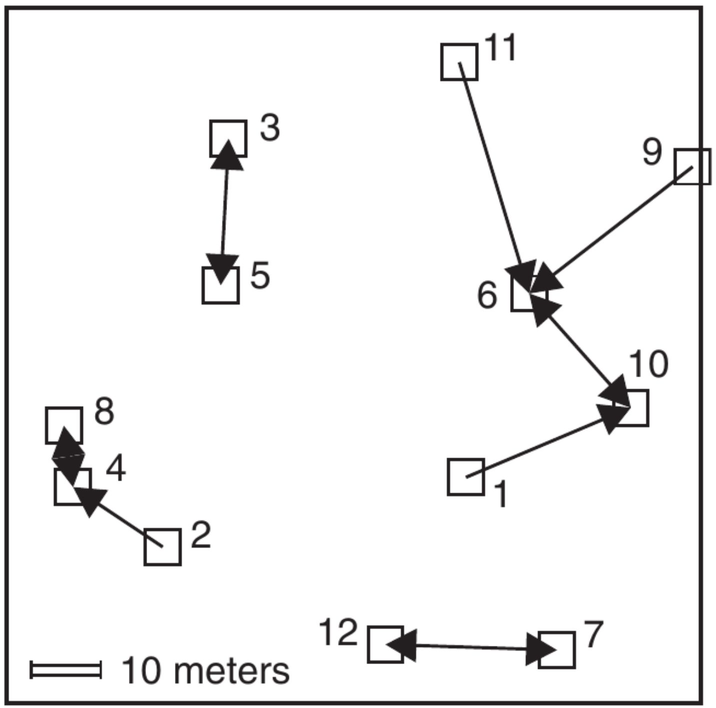
(Knitter & Nakoinz (submitted))

Point Pattern – second order effects

Point patterns described by distance measures
- nearest-neighbor distance → euclidean distance



mean nearest-neighbor distance

$$\bar{d}_{\min} = \frac{\sum_{i=1}^{n} d_{\min}(\mathbf{s}_i)}{n}$$

Are the points clustered or dispersed?
Use Clark and Evan's *R* statistic of nearest neighbor distances

$$R = \bar{d}_{\min} \Big/ \frac{1}{(2\sqrt{\lambda})}$$

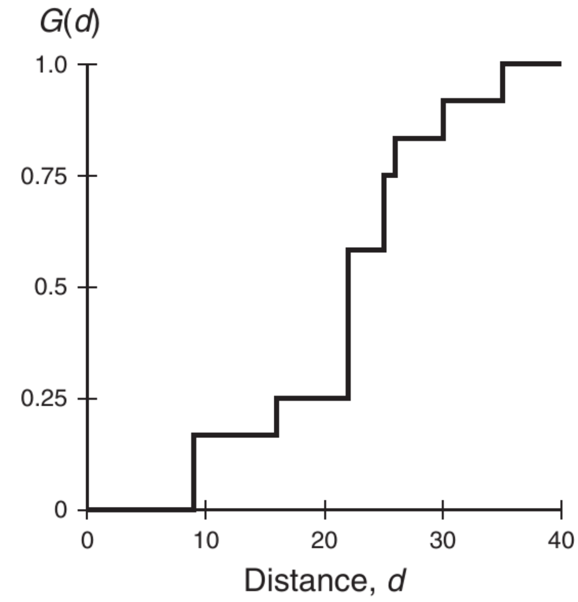
more clustered < 1 > more dispersed

(O'Sullivan & Unwin, 2010)

Point Pattern – second order effects

Point patterns described by distance measures
→ cumulative frequency distribution of the nearest-neighbor distances = G(d)

$$G(d) = \frac{\#(d_{\min}(\mathbf{s}_i) < d)}{n}$$

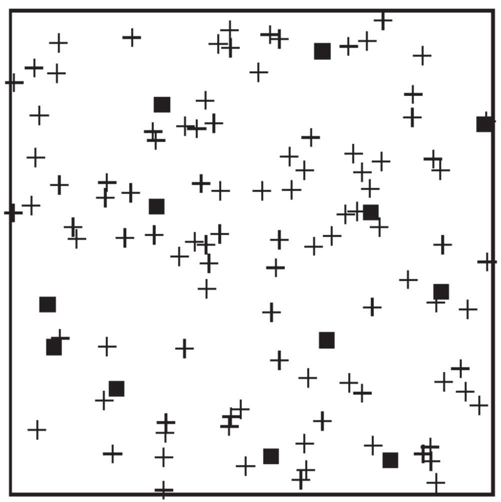


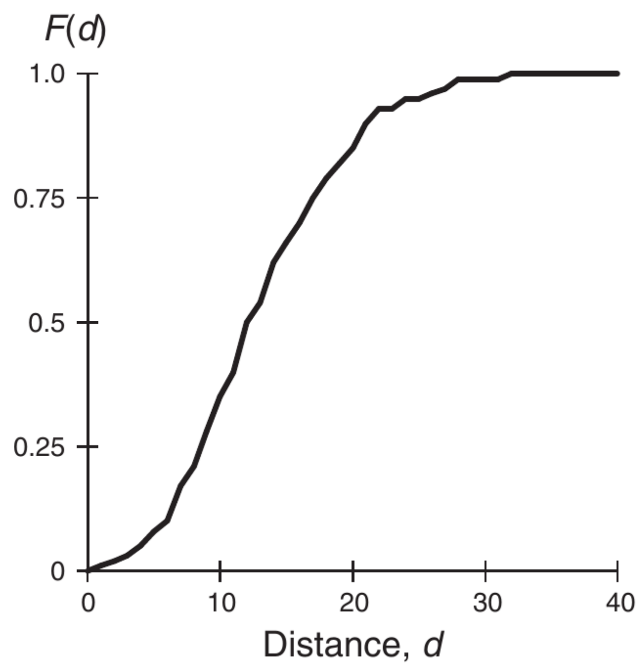
→ G(d) tells us what fraction of all n-n distances is less than d

(O'Sullivan & Unwin, 2010)

Point Pattern – second order effects

Point patterns described by distance measures
→ cumulative frequency distribution of the nearest-neighbor distances of *arbitrary events* to known events = F(d)





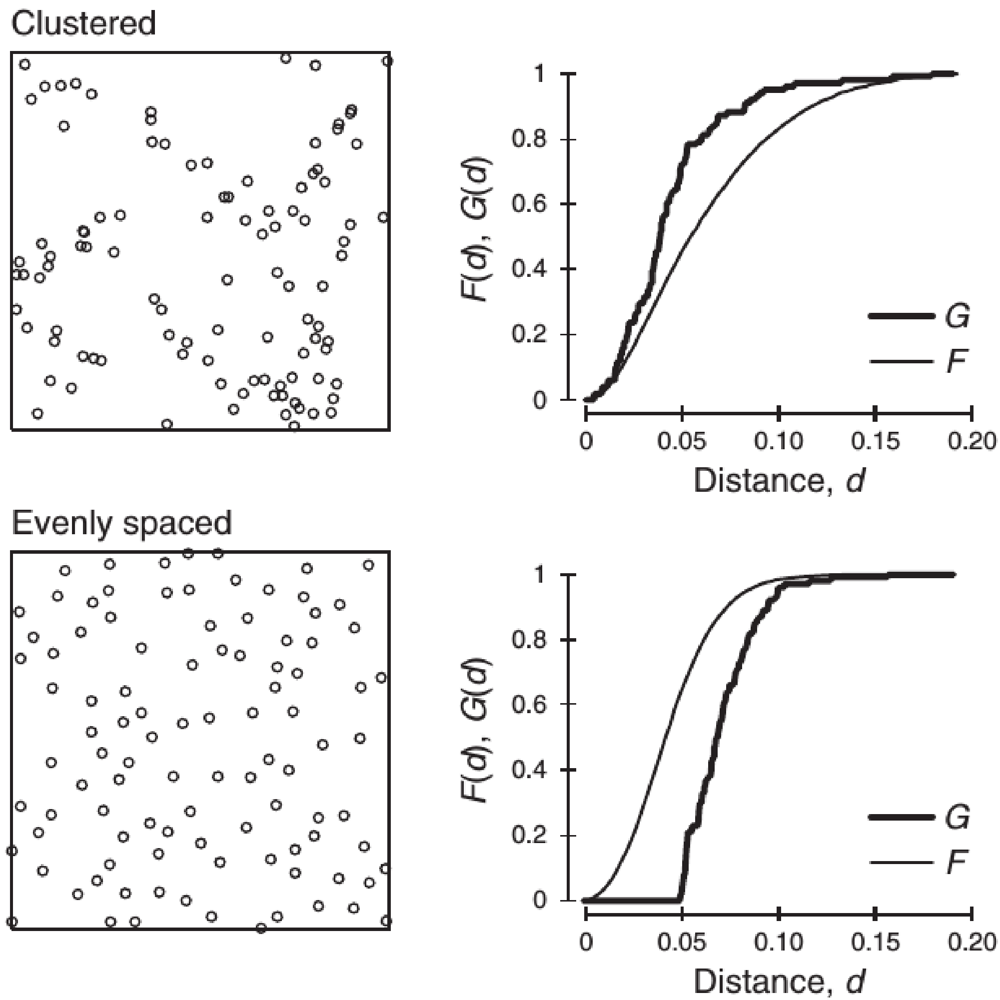
minimum distance from random point pi to an event

$$F(d) = \frac{\#[d_{\min}(\mathbf{p}_i, S) < d]}{m}$$

set of randomly selected locations

(O'Sullivan & Unwin, 2010)

Point Pattern – second order effects



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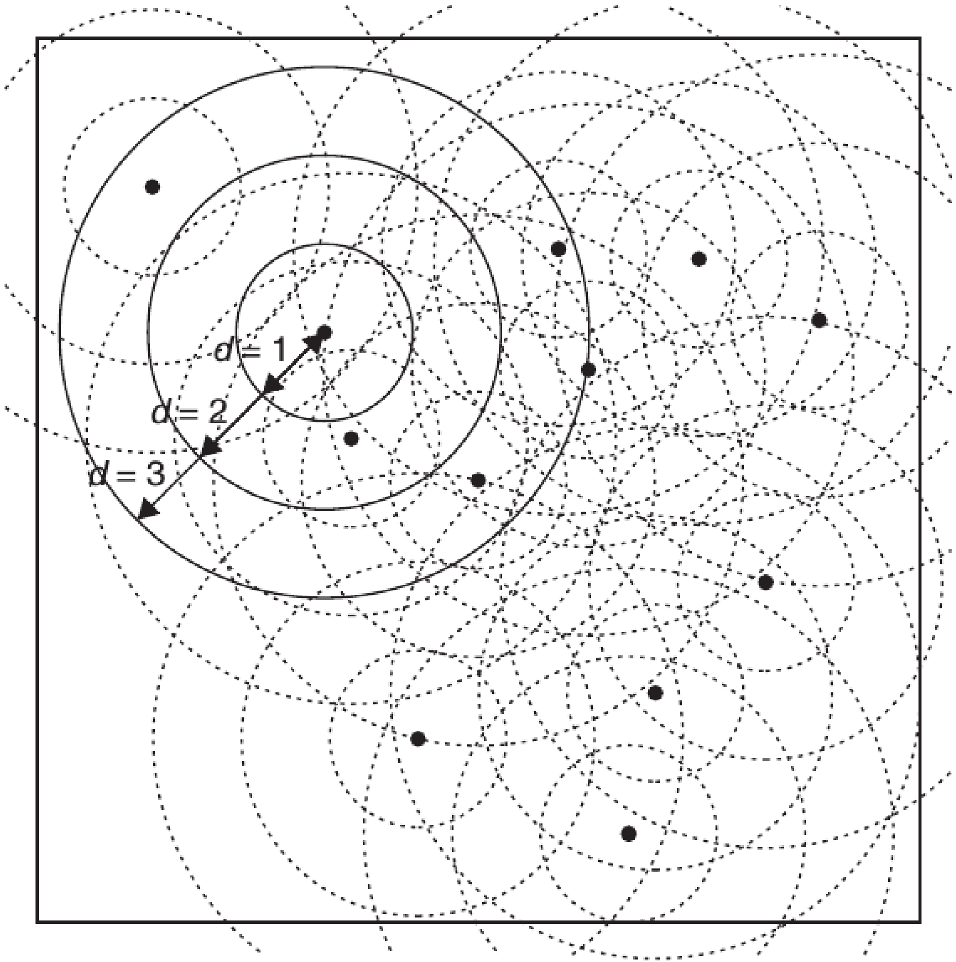
(O'Sullivan & Unwin, 2010)

Point Pattern – second order effects



To get rid of the nearest-neighbor limitation: use the K Function

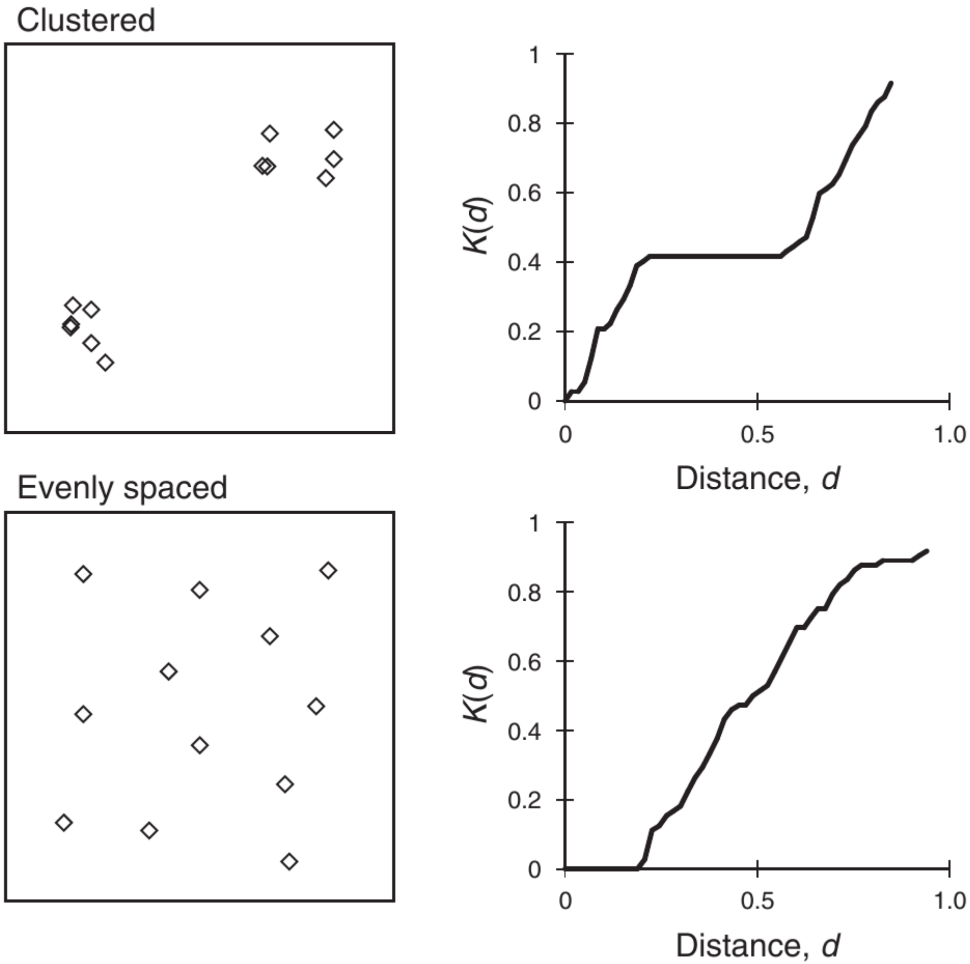
Events in circle radius d centered at s

$$K(d) = \frac{\sum_{i=1}^{n} \#[S \in C(\mathbf{s}_i, d)]}{n\lambda}$$

Event density in the study area

(O'Sullivan & Unwin, 2010)

Point Pattern – second order effects



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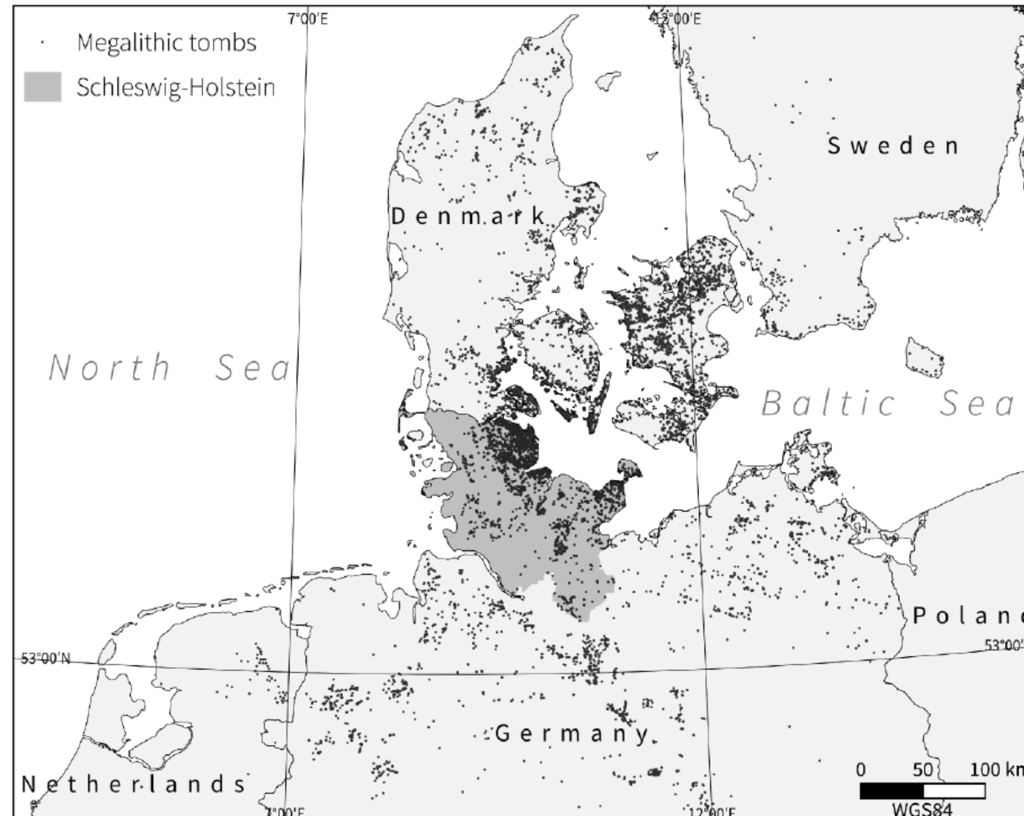
Point Pattern – second order effects

Shows the point pattern clustering/dispersion; does it deviate from CSR?

→ Simulation approach based on Monte Carlo simulations



(Knitter & Nakoinz (submitted))

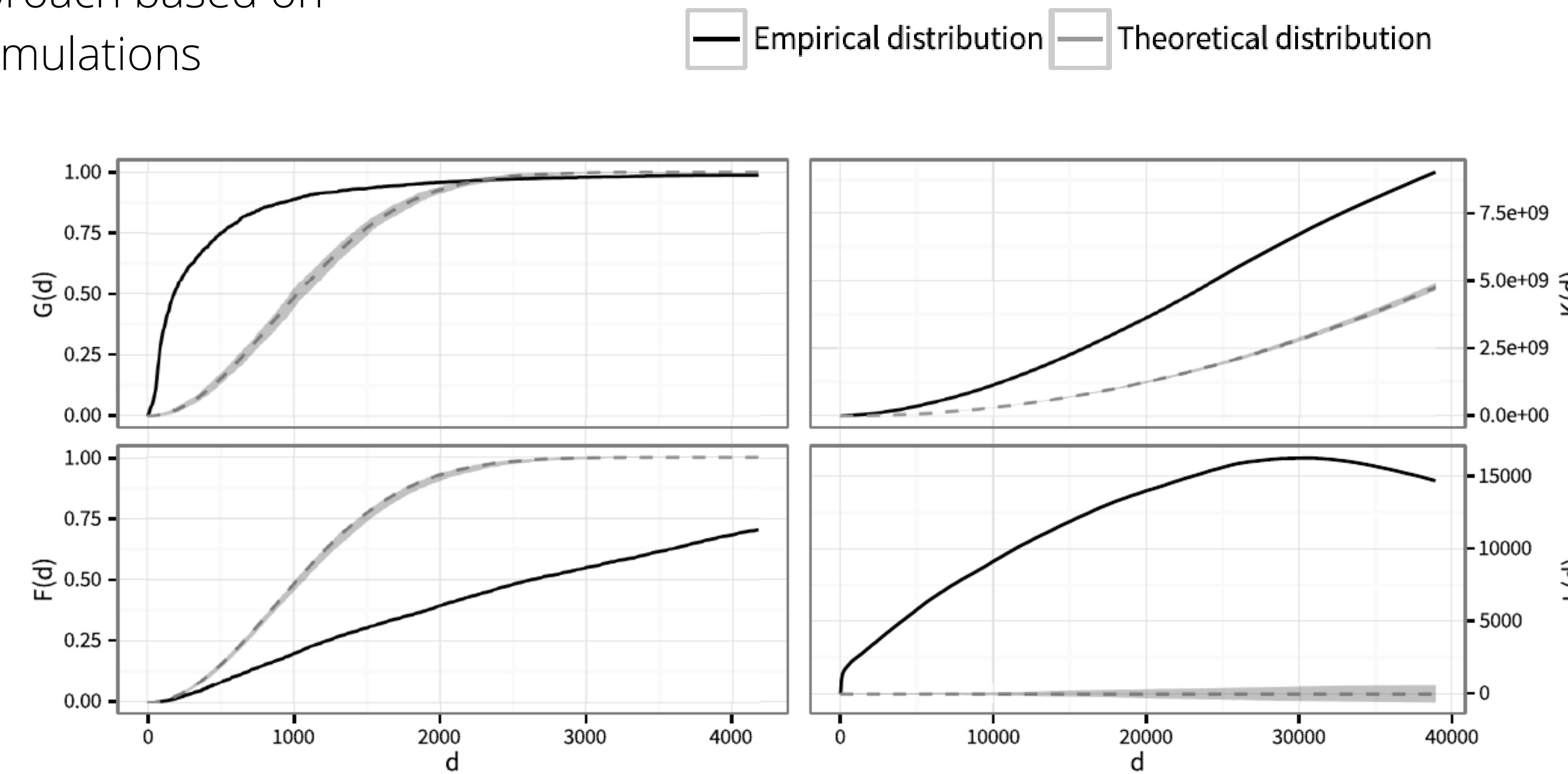
Point Pattern – second order effects

Shows the point pattern clustering/dispersion; does it deviate from CSR?

→ Simulation approach based on
Monte Carlo simulations

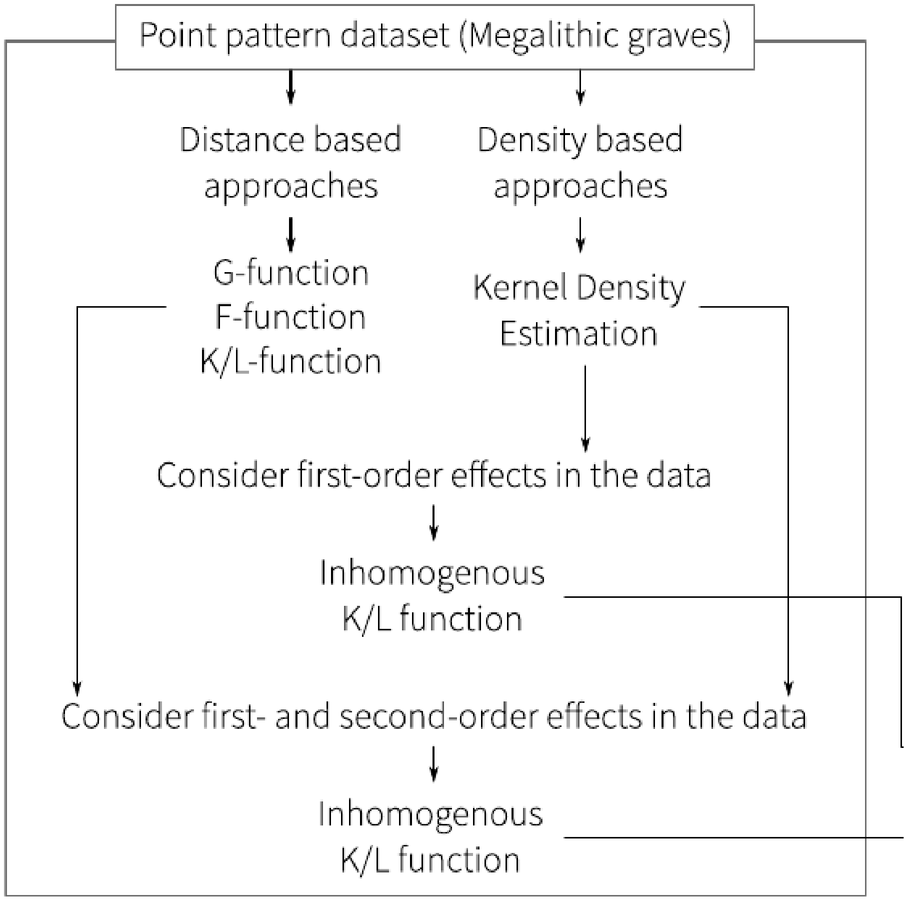
$$L(d) = \sqrt{\frac{K(d)}{\pi}}$$

Just a square root transformation of K(d)



(Knitter & Nakoinz (submitted)

Point Pattern – a look ahead



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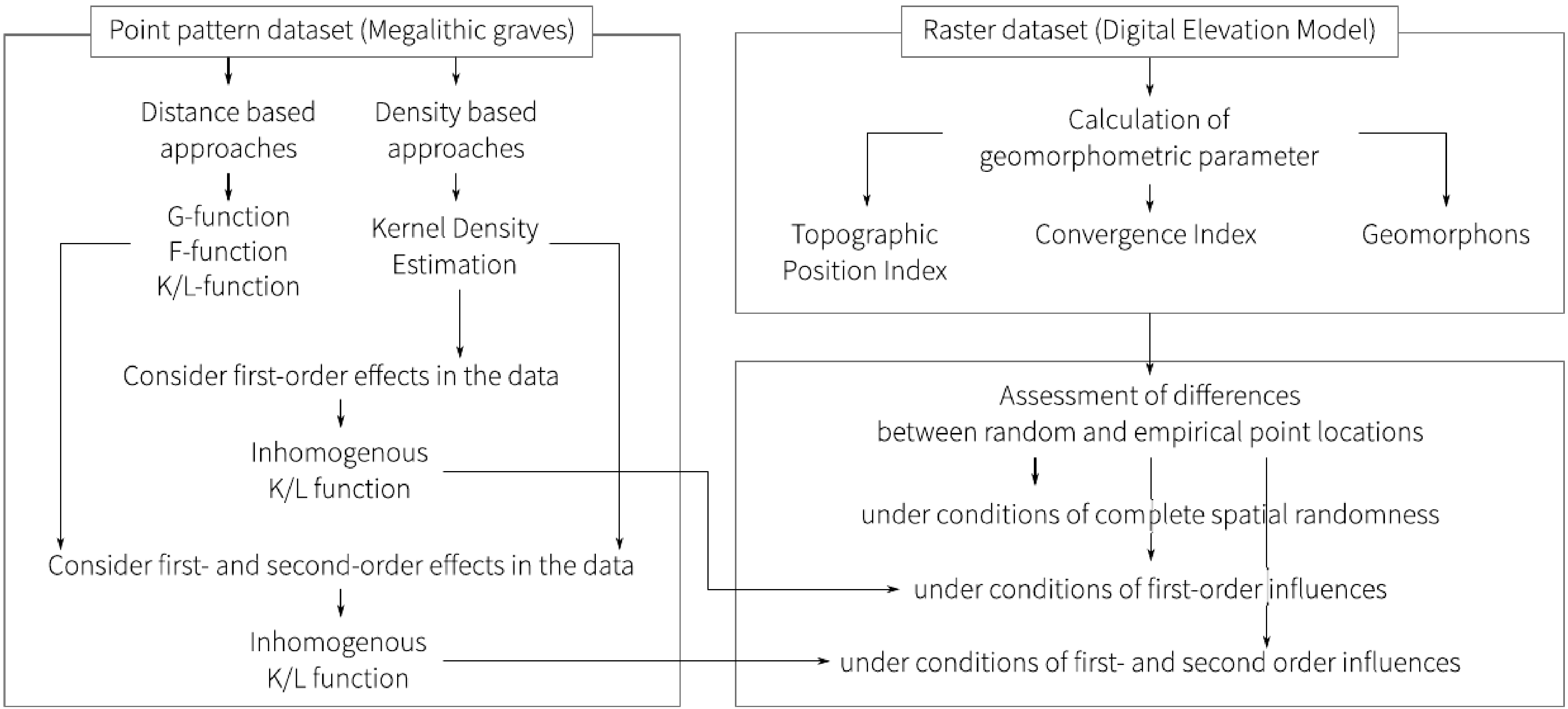
Point Pattern – a look ahead



(Knitter & Nakoinz (submitted))