Nature-based Solutions in actions: improving landscape connectivity during the COVID-19

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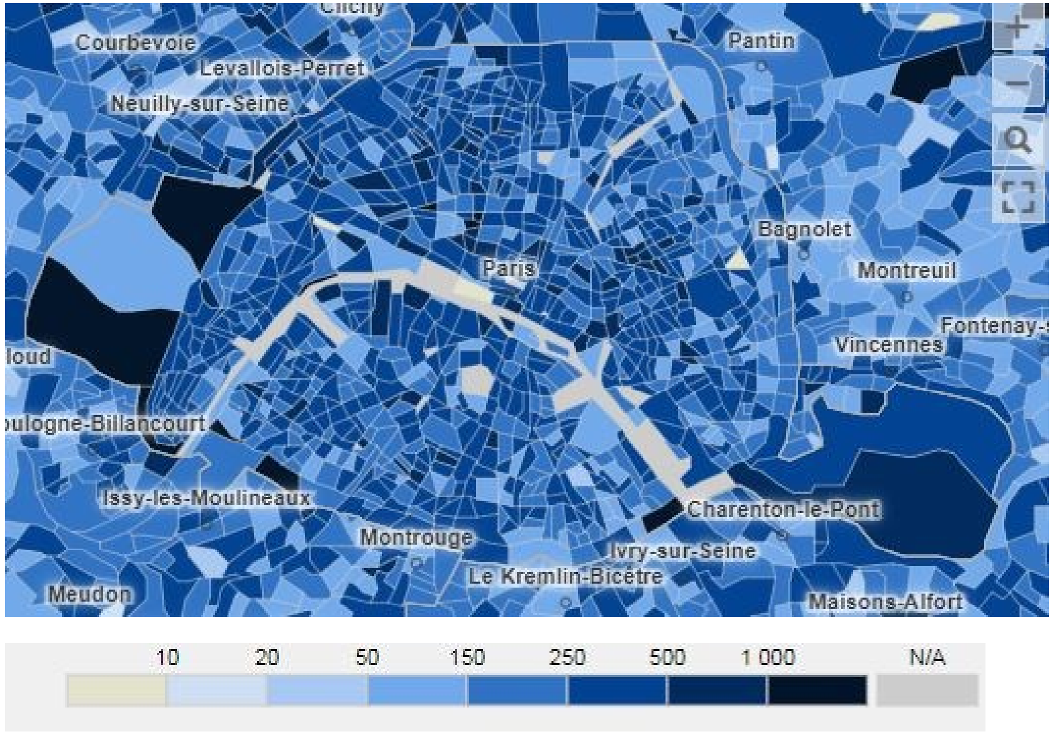
ITS3.5/NP3.1 – Geoscience and health during the Covid-19 pandemic

Research background

- **With the rapid onset of the COVID-19 pandemic, the inner relationship between humans and nature becomes apparent.**

Example of weekly data: 2020-09-26-2020-10-02



COVID-19 Incidence rate by per week in Paris (per 100,000) - all ages (Source: actuparis).

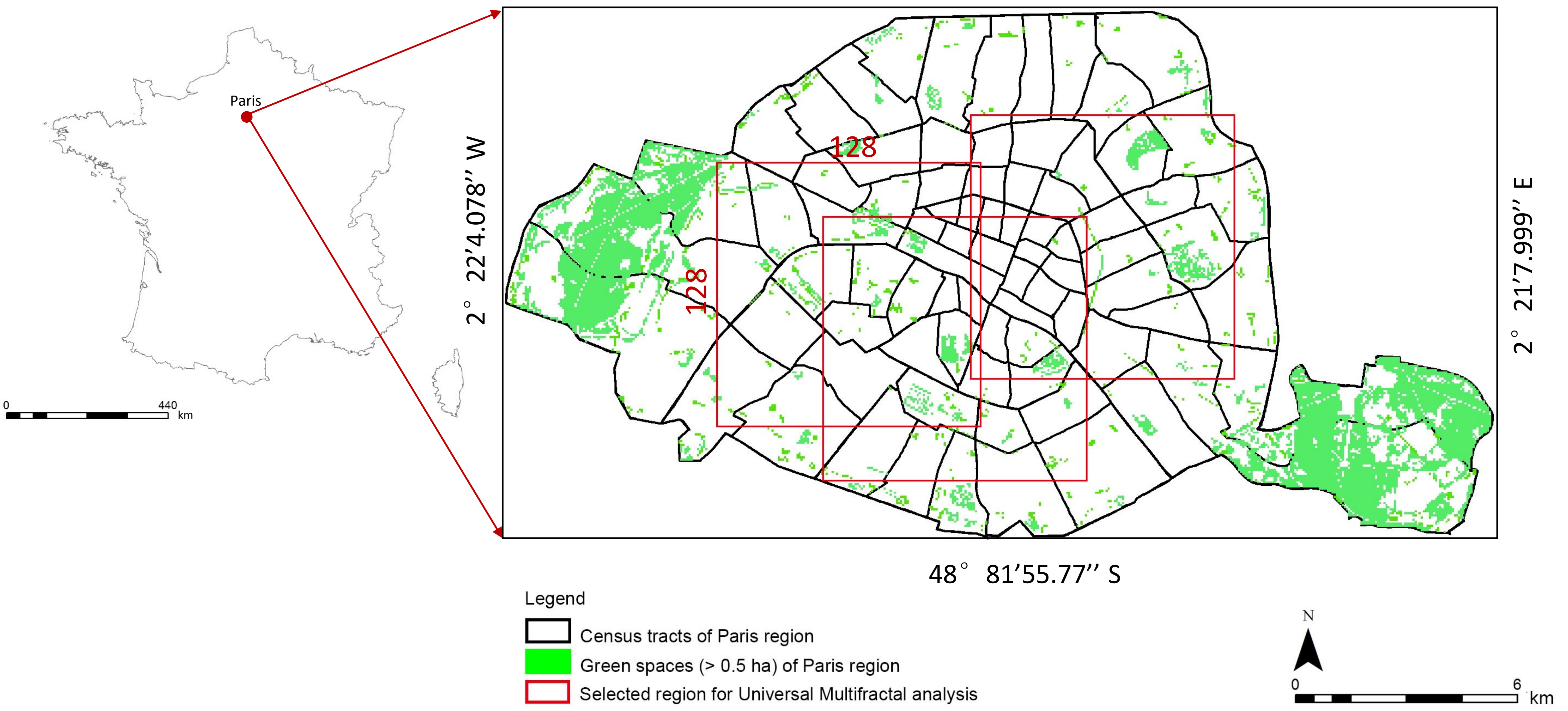
European Commission 2015:

'Nature-based Solutions *are the solutions inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience.'*

Image of a possible intervention foreseen by the Paris community strategy (Source: Paris en Commun).

Study area

- Location of Paris (a total area of 105.4 km²)

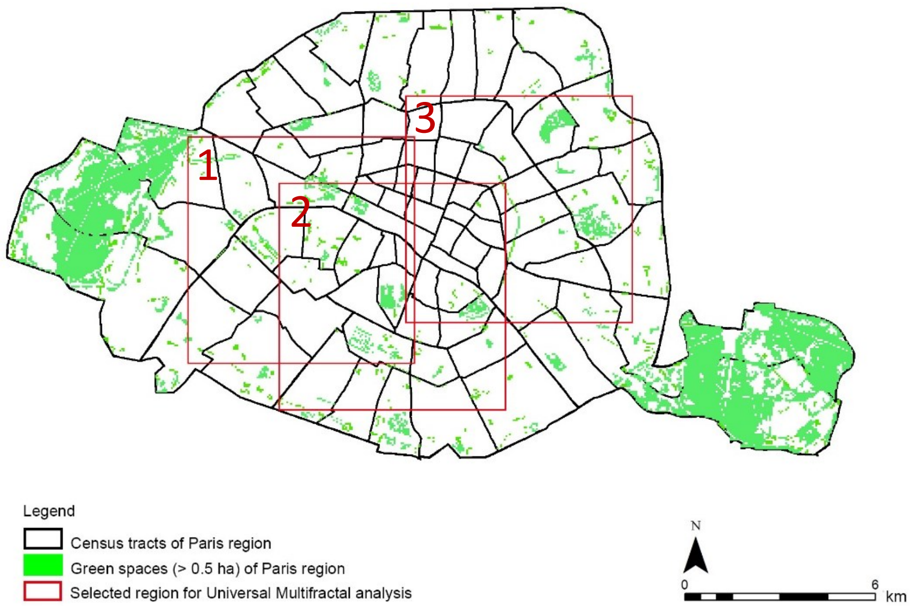


Fractal dimension

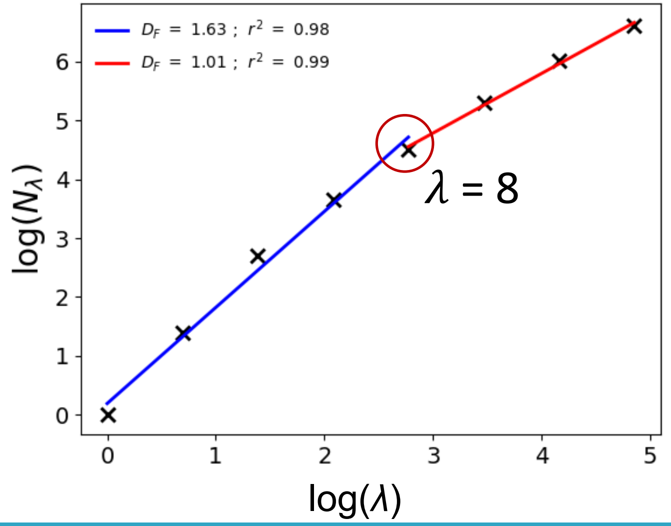
It assumes that there is a power-law relation between the fractal dimension and the number of "non-empty" pixels of the set (N_λ) at the resolution λ ($\lambda = \frac{L}{l}$):

$$N_\lambda \approx \lambda^{D_F}$$

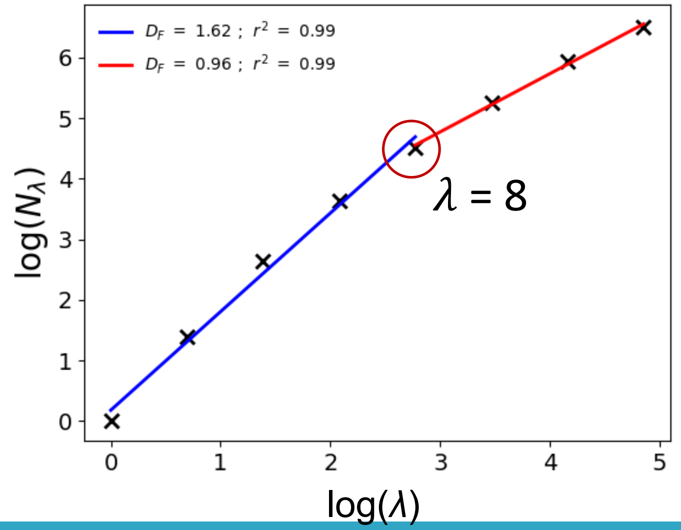
where the exponent D_F is the fractal dimension, the symbol ≈ means an asymptotic relation.



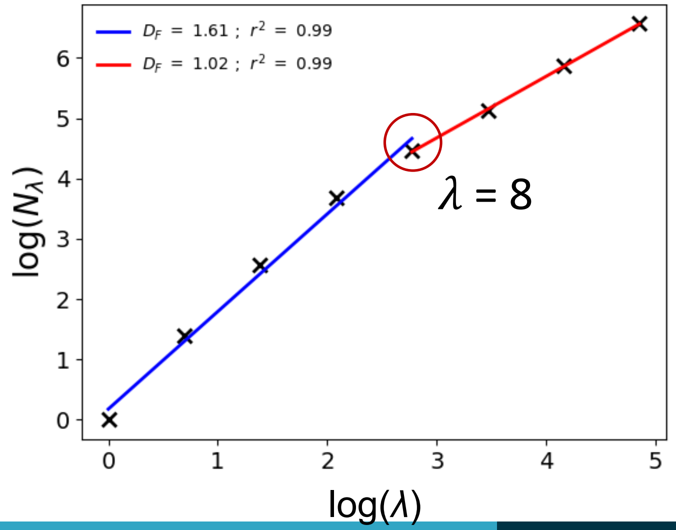
Fractal dimension of the first selected area



Fractal dimension of the second selected area



Fractal dimension of the third selected area



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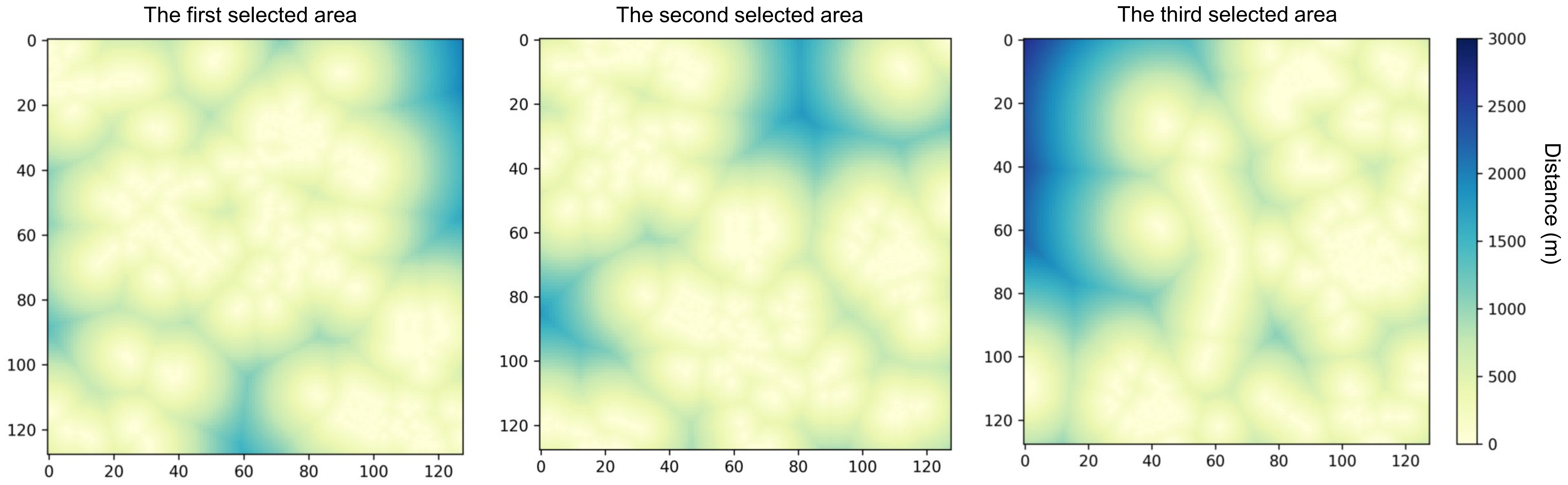
Distance analysis

➢ The Euclidean Distance from non-green spaces to green spaces

Let point p have coordinates (p_1, p_2), and let point q have coordinates (q_1, q_2), the distance between p and q can be obtained as follows:

$$d(p,q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2}$$



Maximum distance = 2008.38 m
Averaged distance = 439.1 m

Maximum distance = 1785 m
Averaged distance = 464.5 m

Maximum distance = 2671.03 m
Averaged distance = 563.85 m

Universal Multifractal

➢ **UM parameters**

The statistics of a highly intermittent field, $\varepsilon_{\lambda,}$ is described by its probability:

$$Pr(\varepsilon_\lambda \geq \lambda^\gamma) \approx \lambda^{-c(\gamma)}$$

where λ is the resolution, γ is a singularity (order), $c(\gamma)$ is a co-dimension function.c

UM have only three fundamental parameters (Schertzer and Lovejoy, 1987, 1992):

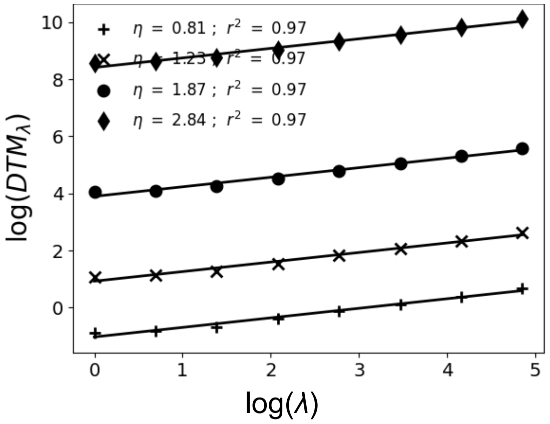
✓ *Hurst's exponent H*, which measures the degree of non-conservation of the field. If the field is conservative, H = 0.

✓ *Mean intermittency C_1*, which measures the average sparseness of the field (homogeneous fields: C_1=0).

✓ *Multifractality index α* ($0 \leq \alpha \leq 2$), describes the degree of multifractality of the process.

➢ **Double Trace Moment analysis of distance of the three selected areas**

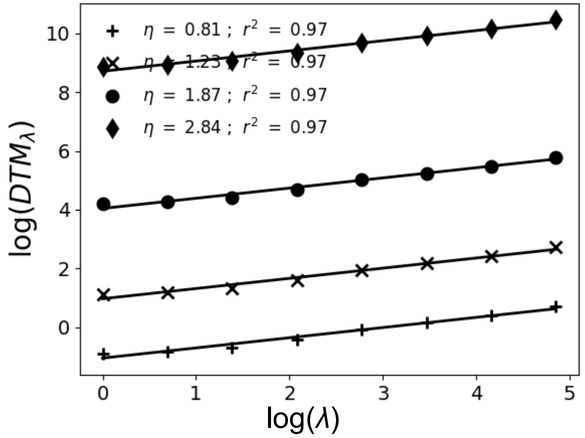
DTM analysis of the first selected area



$\alpha = 1.40$

$C_1 = 0.07$

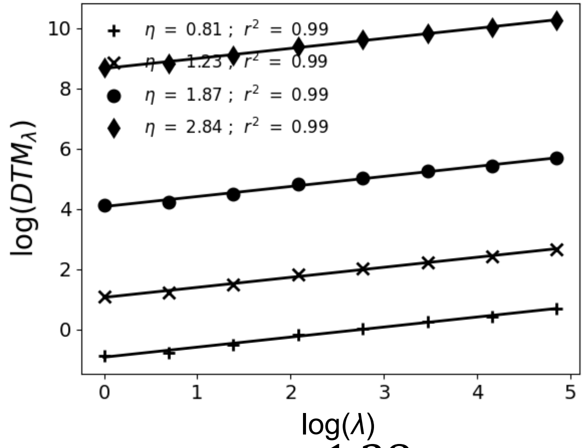
DTM analysis of the second selected area



$\alpha = 1.33$

$C_1 = 0.07$

DTM analysis of the third selected area

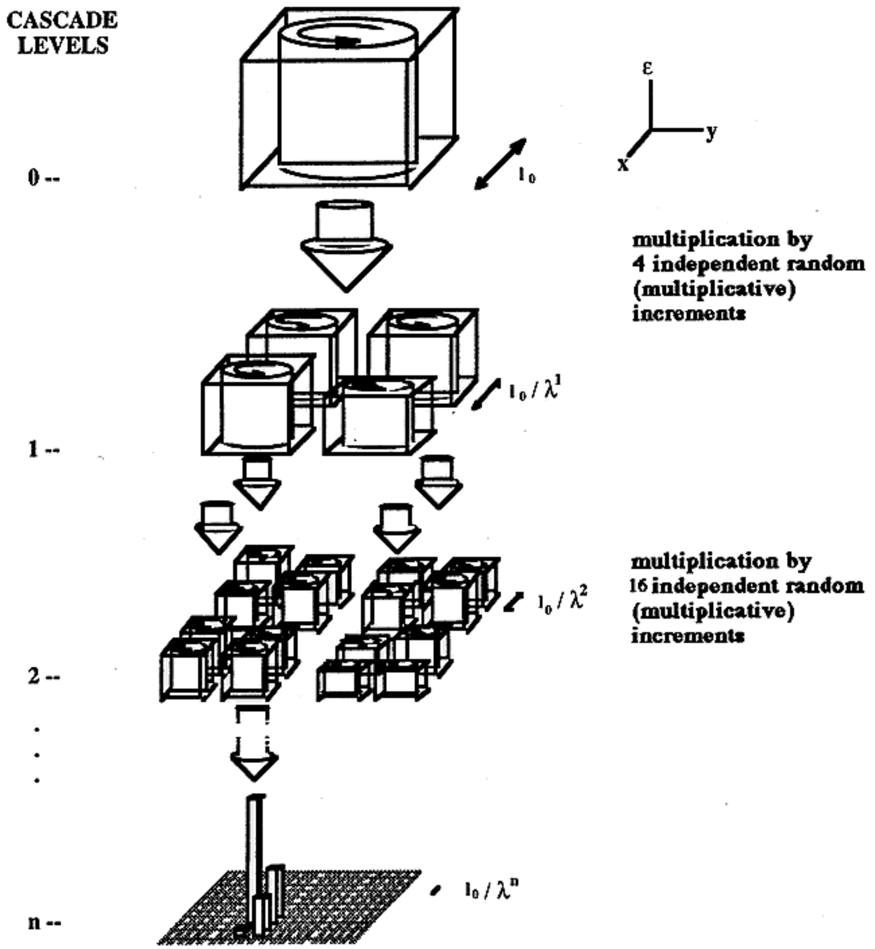


$\alpha = 1.38$

$C_1 = 0.08$

Universal Multifractal (Simulation of UM fields)

➢ Discrete multifractal cascades:



A schematic diagram showing a two-dimensional cascade process at different levels of its construction to smaller scales (adapted from Schertzer and Lovejoy, 1997).

1) Each pixel (in 2D) is divided into ${\lambda_0}^2$ pixels (λ_0=2).

2) The value affected to the new time steps is the one of the former time step multiplied by a random multiplicative increment $\mu\varepsilon$:

$$\varepsilon_n = \mu\varepsilon\, \varepsilon_{n-1}$$

The simulation of multifractal fields is achieved by building a random multiplicative cascade, to obtain a UM field of parameter C_1 and α, the following equation is applied:

$$\mu\varepsilon = exp\left[\left(\frac{C_1 In(\lambda_0)}{|\alpha-1|}\right)\right] L(\alpha)/\lambda_0^{\frac{C_1}{\alpha}}$$

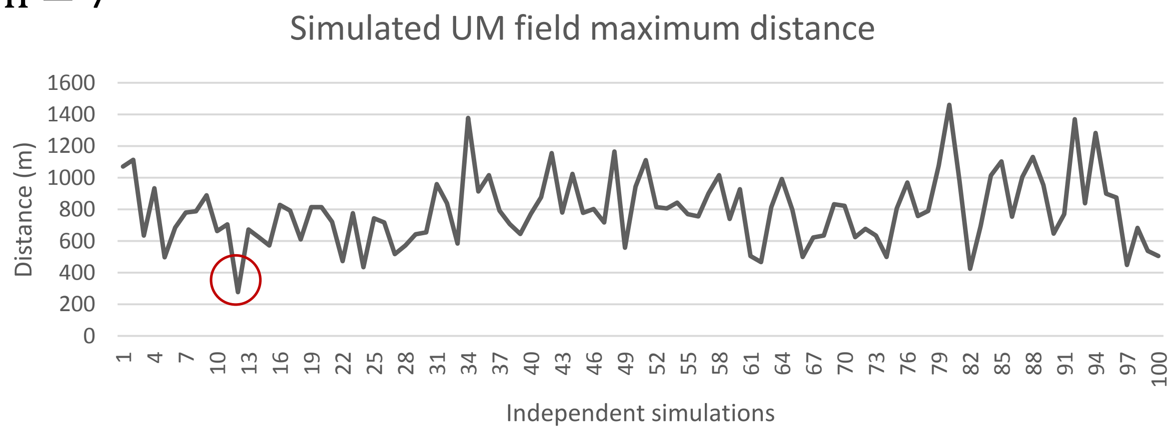
Discrete Universal Multifractals

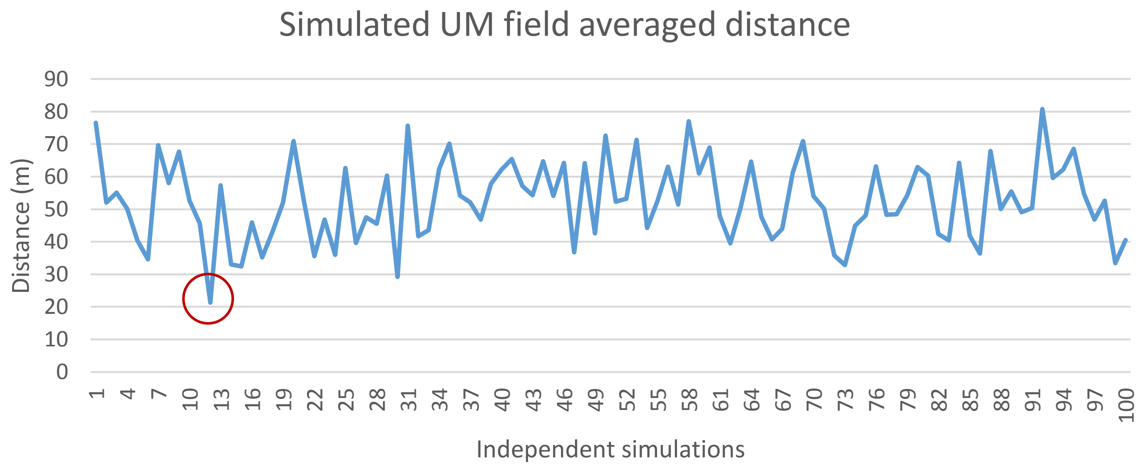
➢ The first selected region (100 simulations)

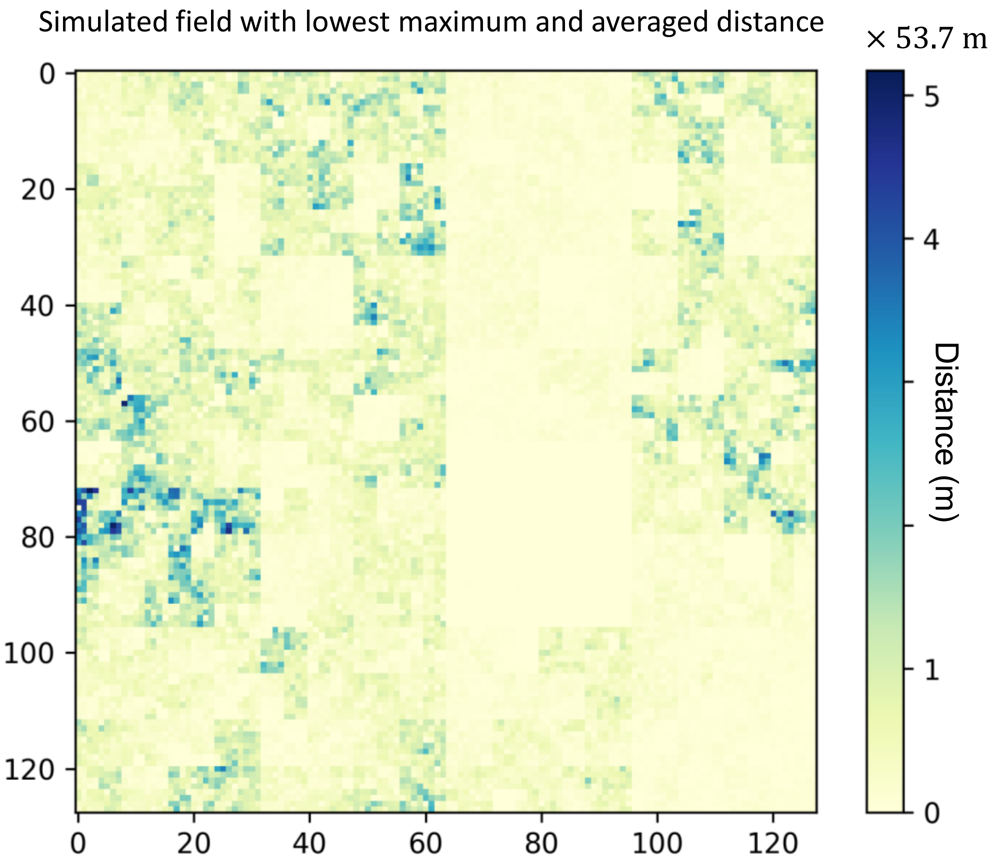
$\alpha = 1.40$

$C_1 = 0.07$

$n = 7$







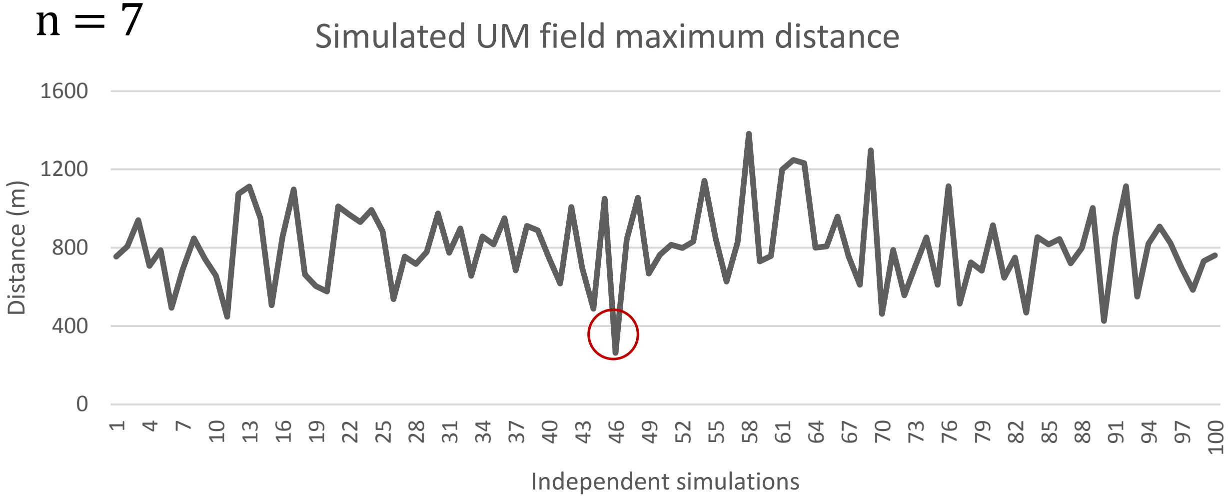
Discrete Universal Multifractals

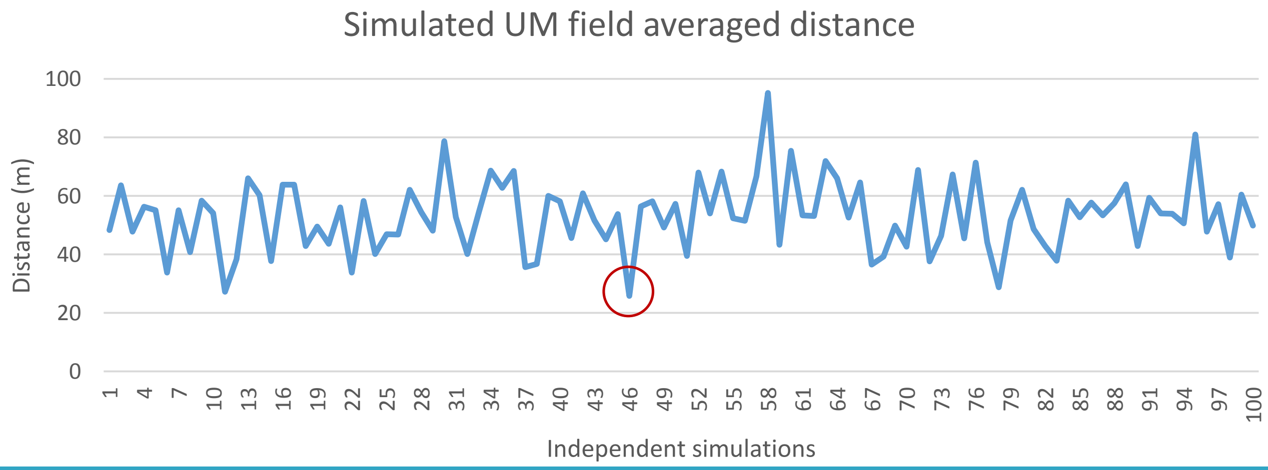
➢ **The second selected region (100 simulations)**

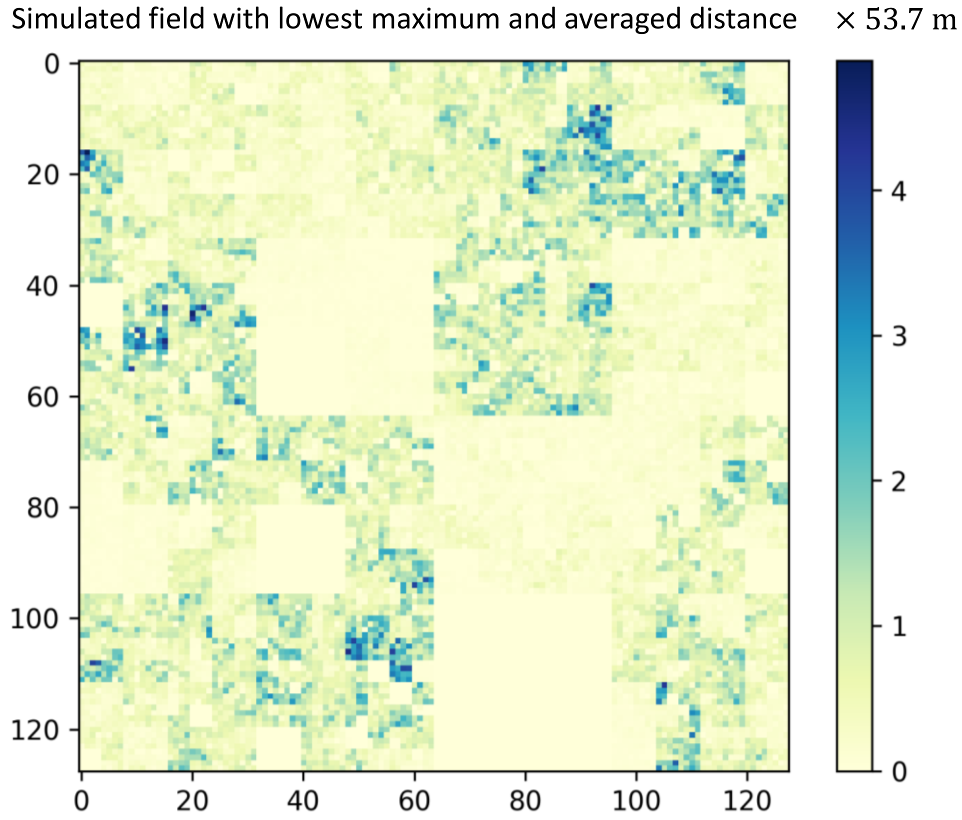
$\alpha = 1.33$

$C_1 = 0.13$

$n = 7$



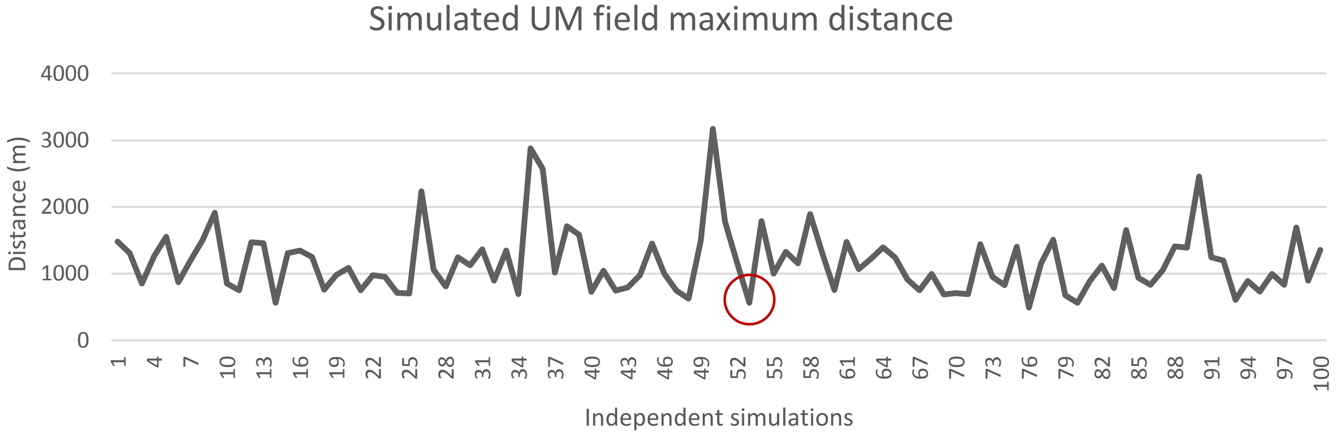


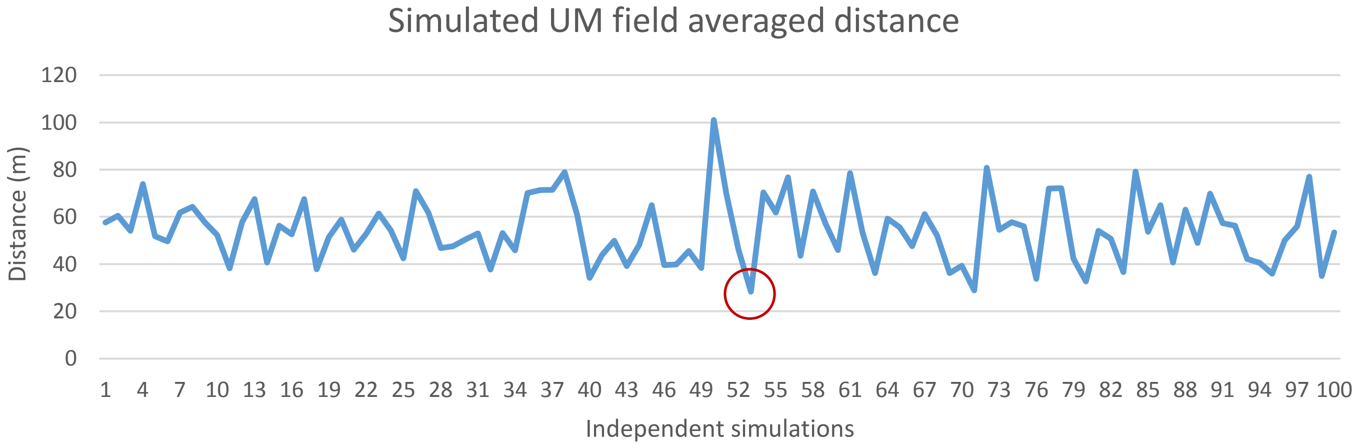


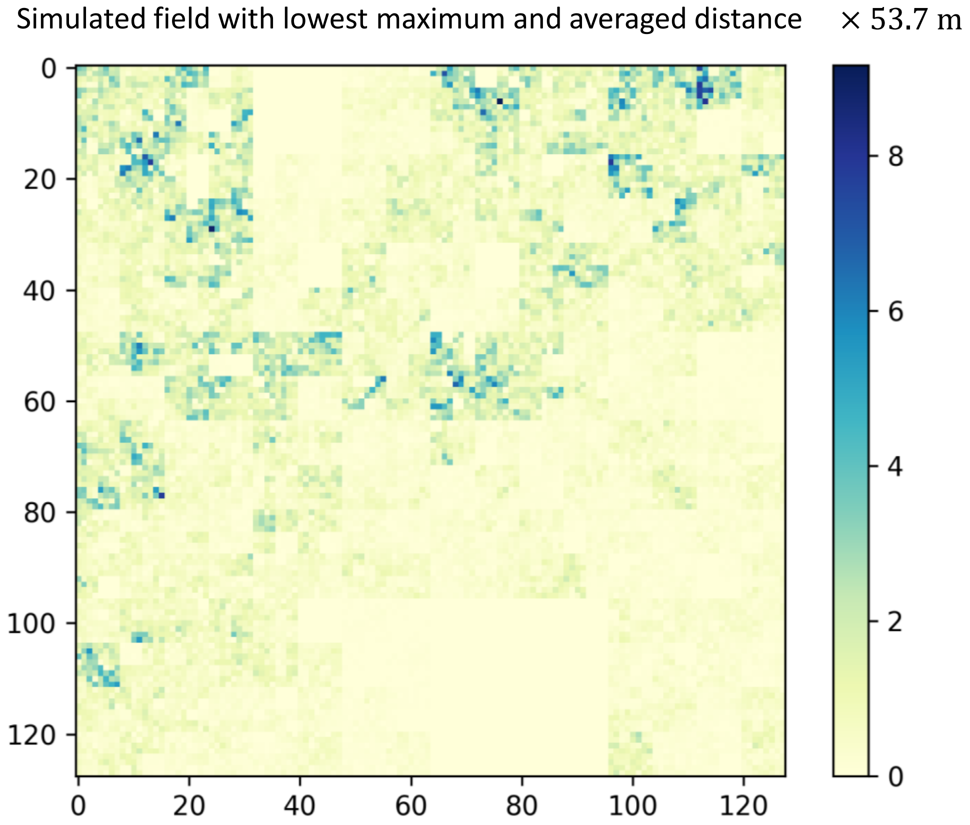
Discrete Universal Multifractals

➢ **The third selected region (100 simulations)**

$\alpha = 1.38$
$C_1 = 0.15$
$n = 7$



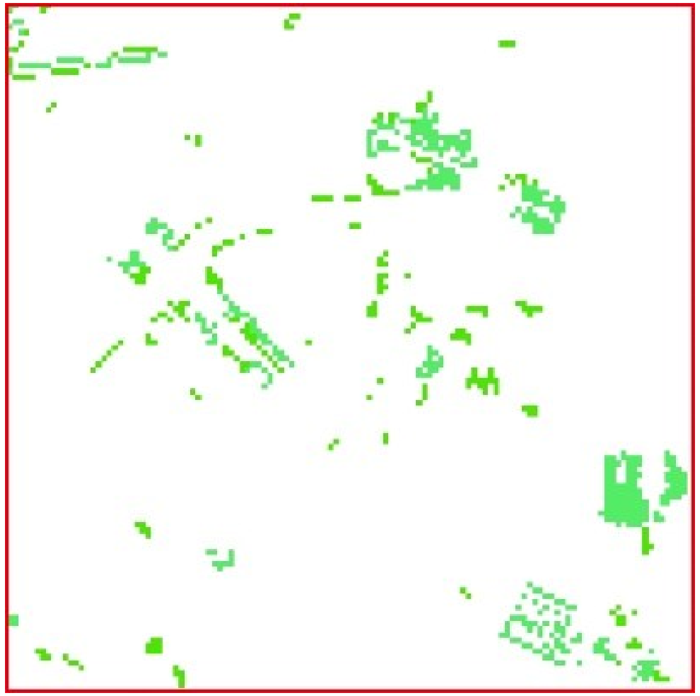




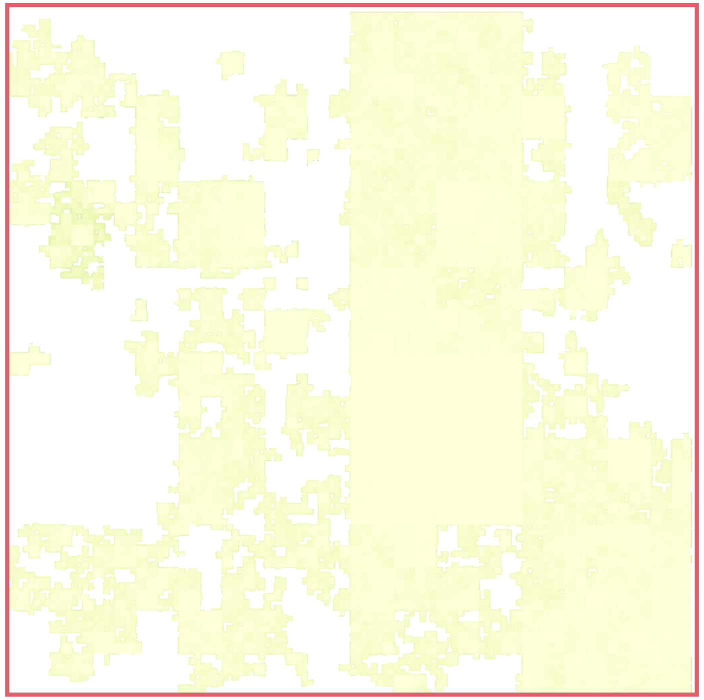
Nature-based Solutions scenarios

➢ **The first NBS scenario**

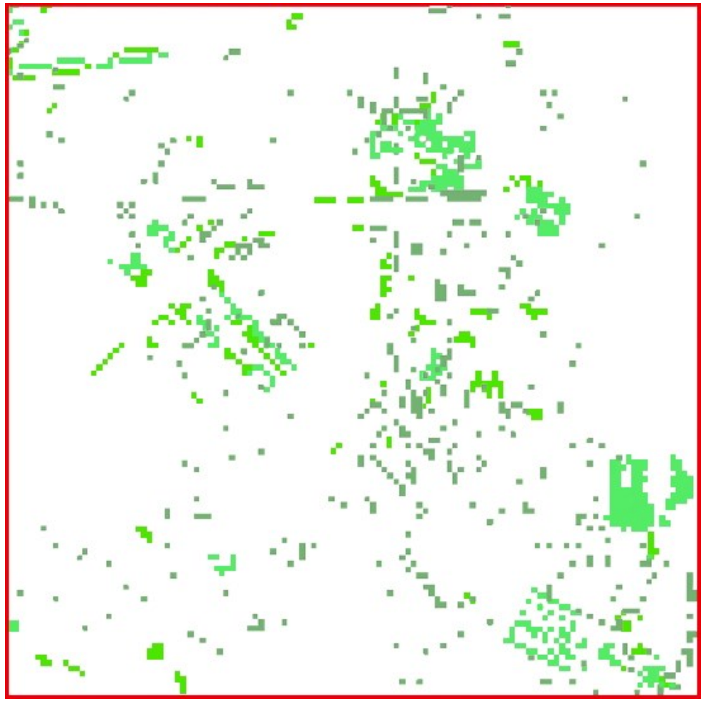
Original spatial distributions of green spaces (The first selected region)



Simulated spatial distributions of green spaces (the first selected region)



Spatial distributions of original green spaces and designed NBS



Original green spaces

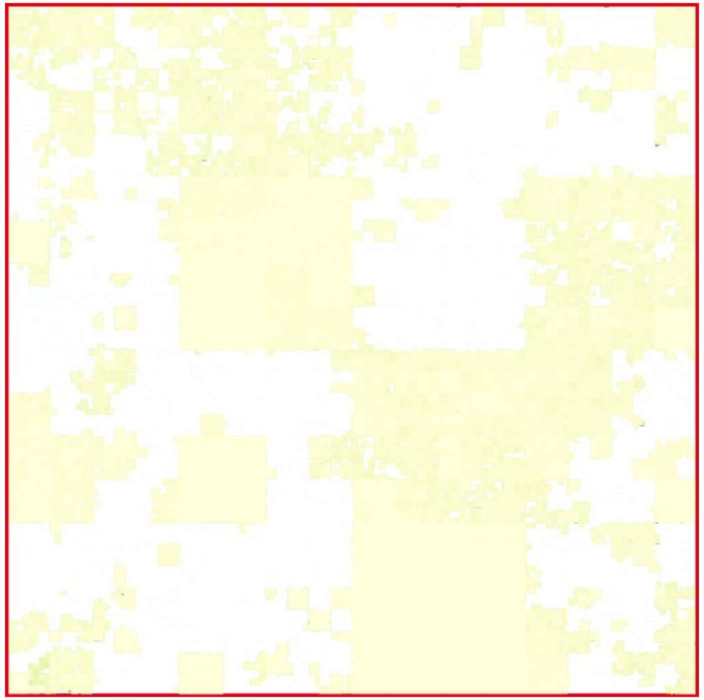
Designed NBS

Nature-based Solutions scenarios

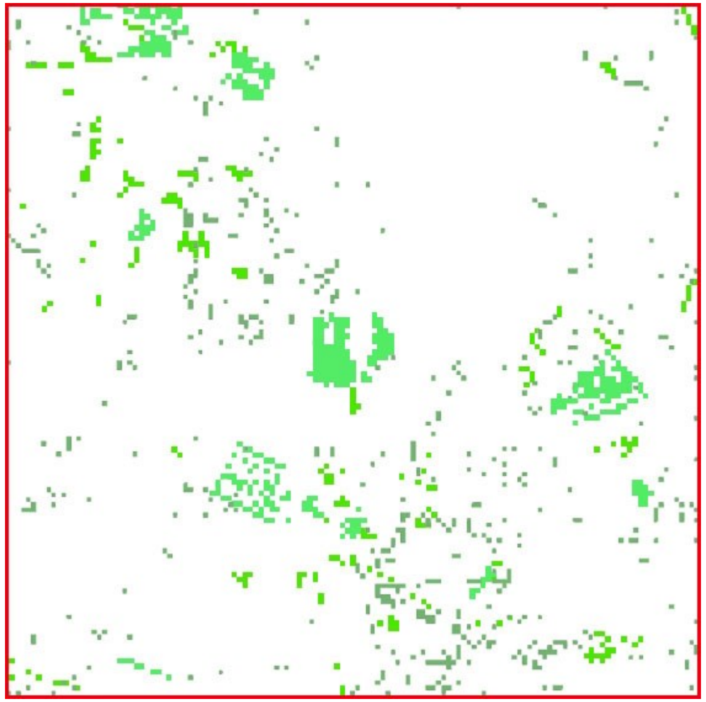
- **The second NBS scenario**

Original spatial distributions of green spaces (the second selected region)

Simulated spatial distributions of green spaces (the second selected region)



Spatial distributions of original green spaces and designed NBS



Original green spaces

Designed NBS

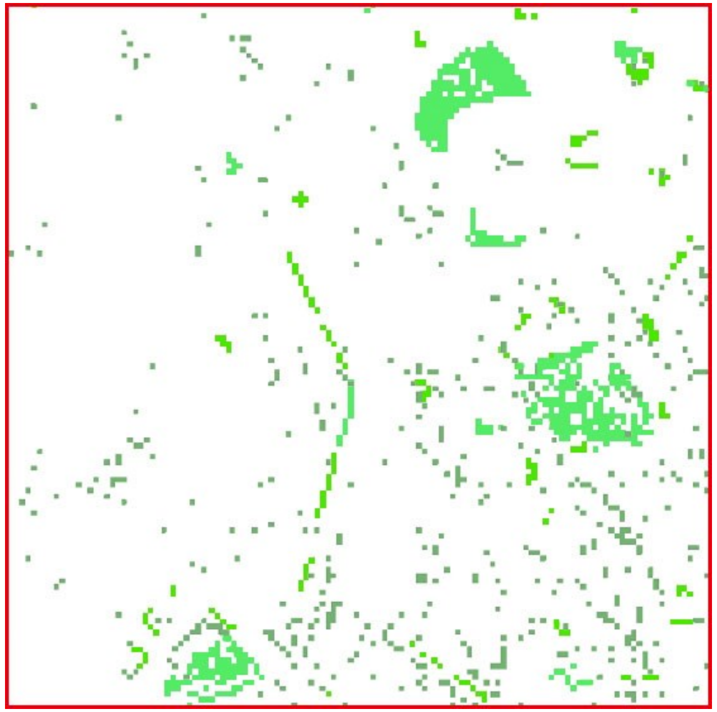
Nature-based Solutions scenarios

➢ **The third NBS scenario**

Original spatial distributions of green spaces (the third selected region)

Simulated spatial distributions of green spaces (the third selected region)

Spatial distributions of original green spaces and designed NBS

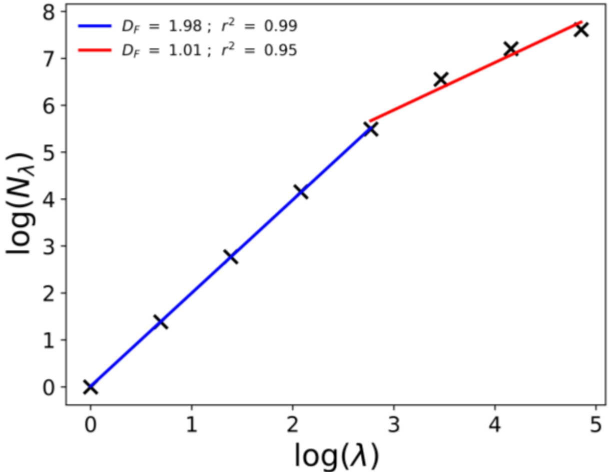


Original green spaces

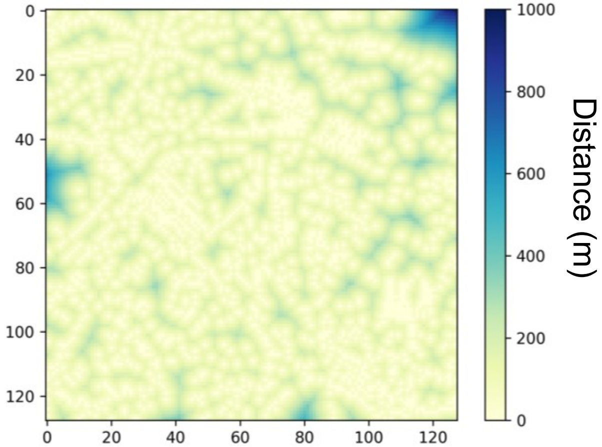
Designed NBS

Fractal dimension and distance analysis of original green spaces combined with NBS

Fractal dimension of original green spaces combined with NBS



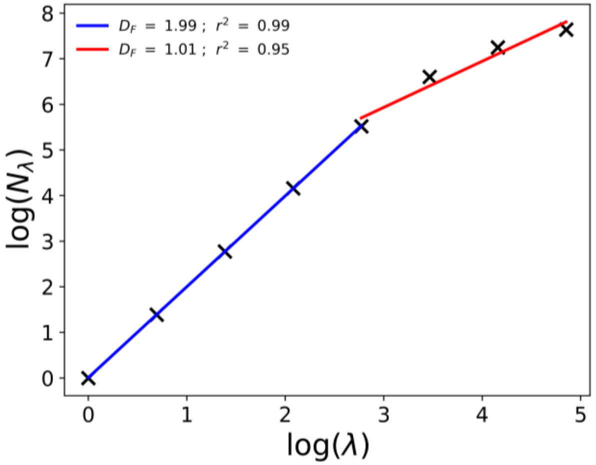
Distance of original green spaces combined with NBS



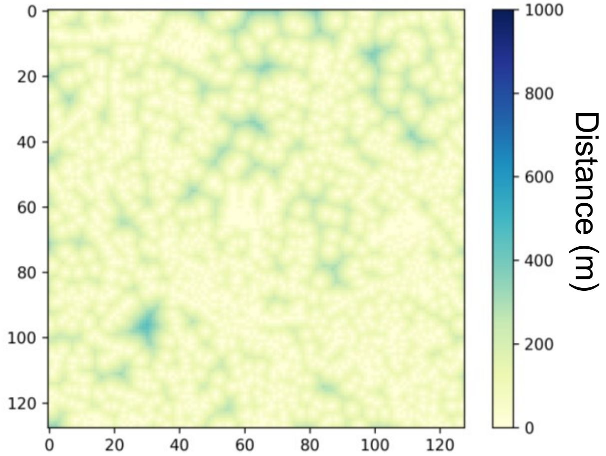
Maximum distance = 951.6 m

Averaged distance = 104.7 m

Fractal dimension of original green spaces combined with NBS



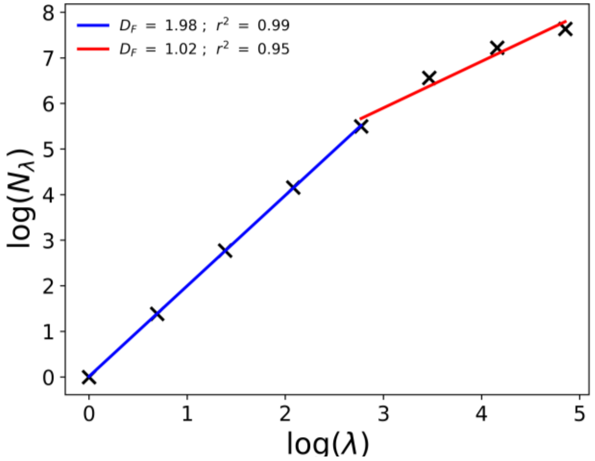
Distance of original green spaces combined with NBS



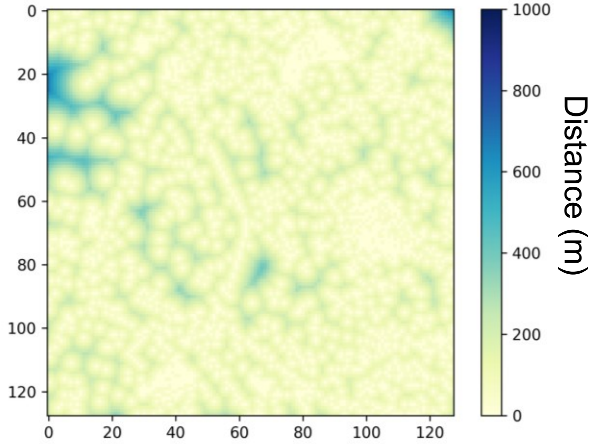
Maximum distance = 455.7 m

Averaged distance = 94.7 m

Fractal dimension of original green spaces combined with NBS



Distance of original green spaces combined with NBS



Maximum distance = 653.3 m

Averaged distance = 100.2 m

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Conclusions and perspective

- ✓ With the help of UM framework, the optimised spatial distributions of green spaces can be quantified across a range of scales.
- ✓ The NBS integrated into the current landscape context can significantly improve the landscape connectivity over the city.
- ✓ The method used in this study can be easily applied in some other regions, which is helpful for the urban development in post-COVID.

- ➢ The future studies will consider the COVID cases in Paris for a certain range of period and further improve the NBS distributions over the cities.
- ➢ Future work will also consider the economic investment of NBS to satisfy the certain budget.