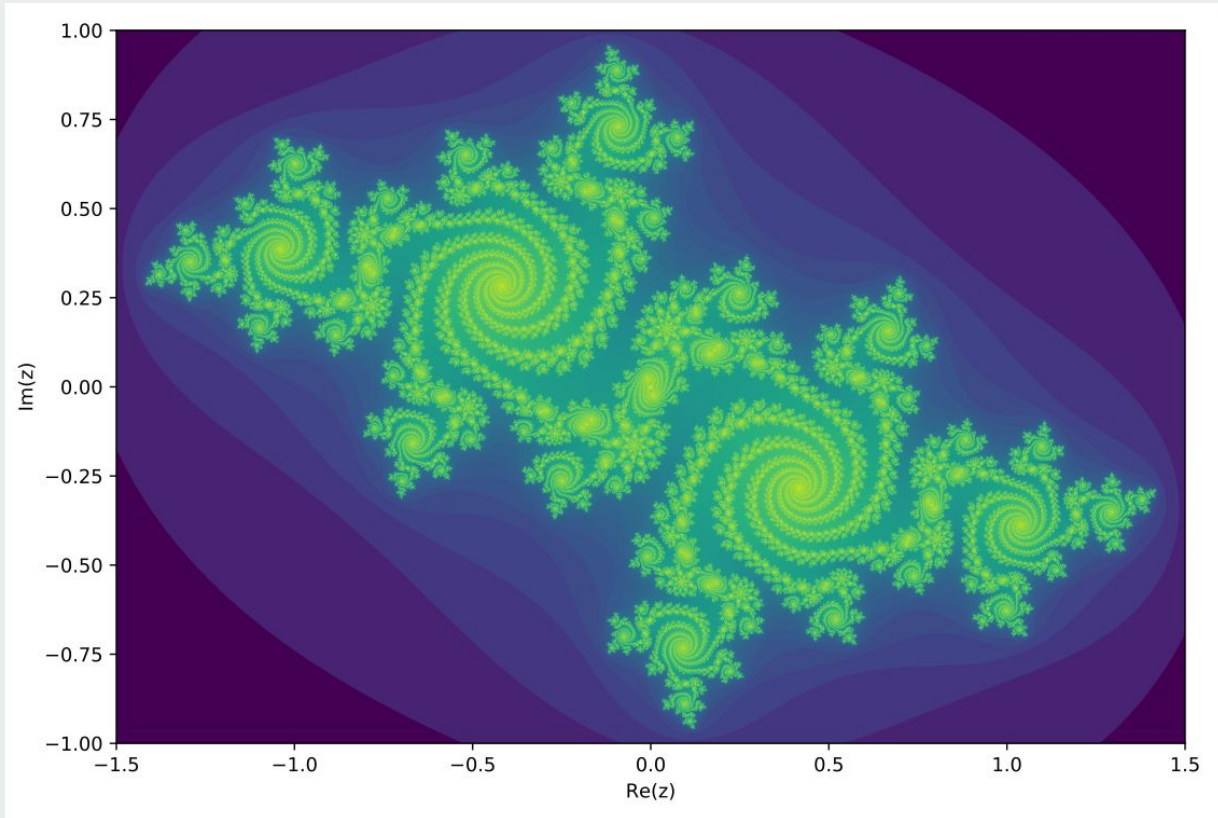


Fractales





Indice

- Historia
- Qué es un fractal?
- Pseudo-fractales
- Propiedades matemáticas
- Aplicaciones

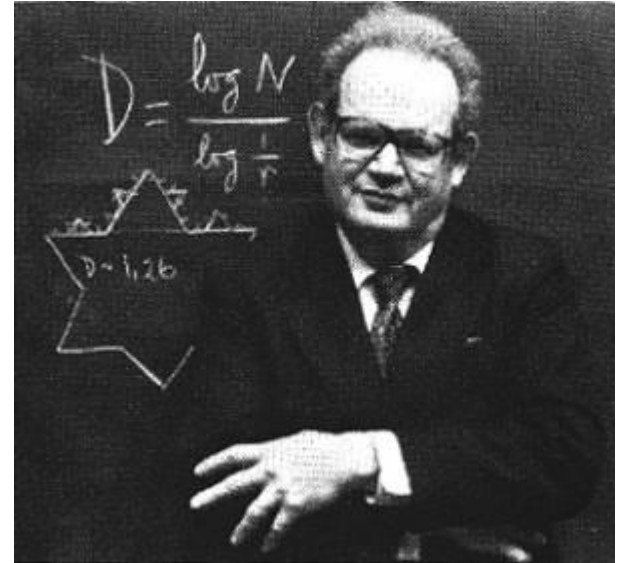


Julia

Fatou

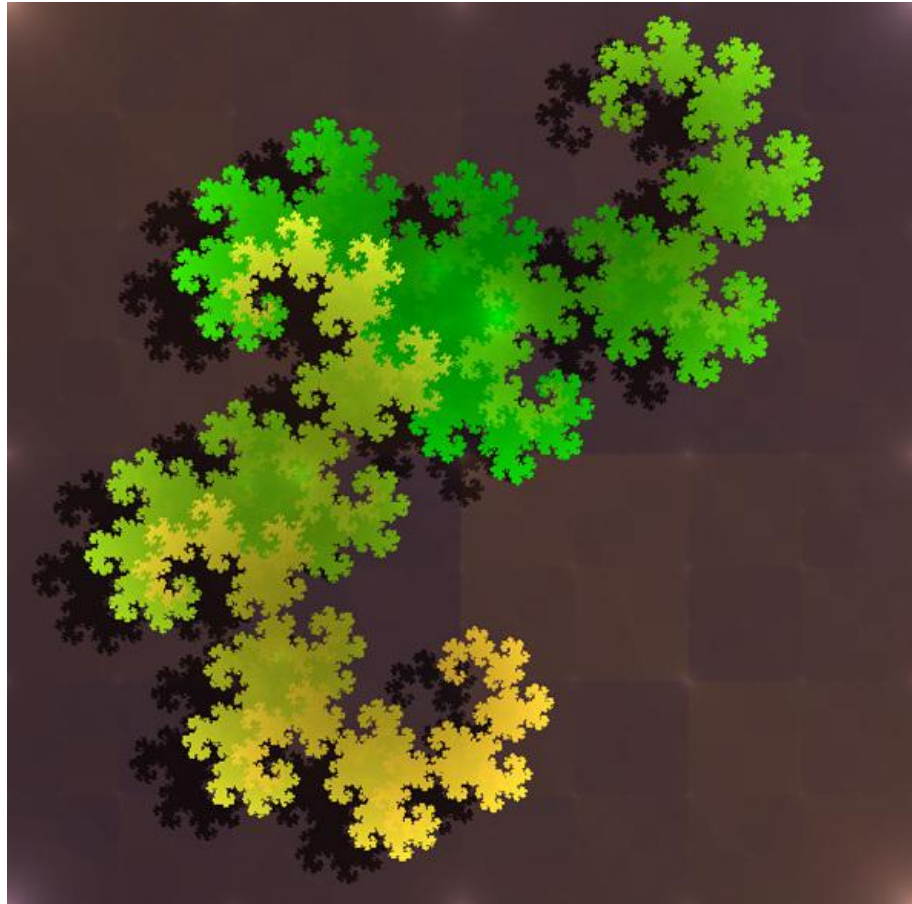


Mandelbrot



Fractales

1. Estructura recursiva
2. Area finita
3. Perimetro infinito

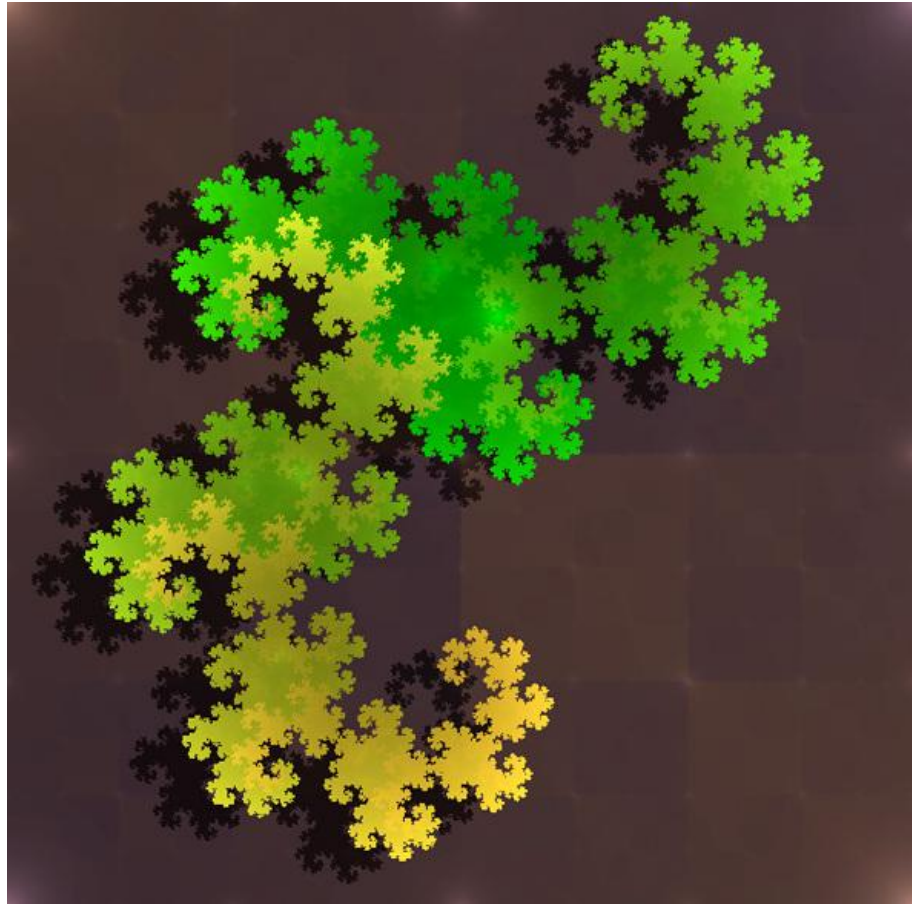


Fractales

3. Perimetro infinito:

Bordes fracturados

⇒ detalle infinito



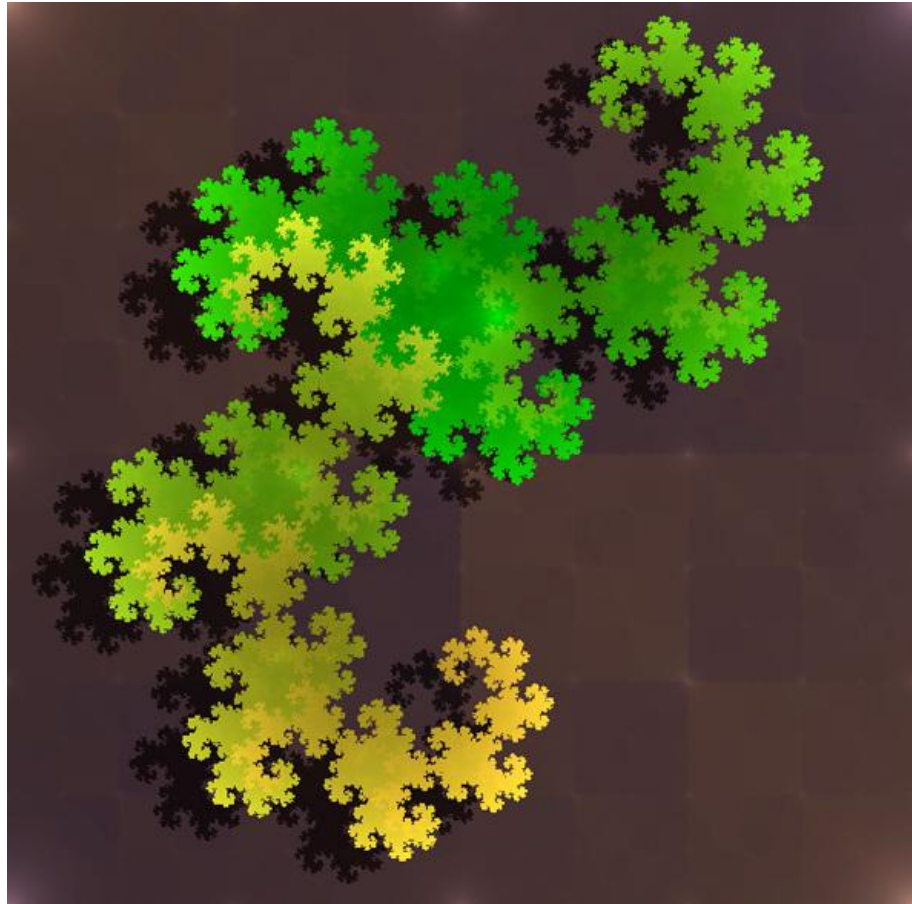
Fractales

3. Perímetro infinito:

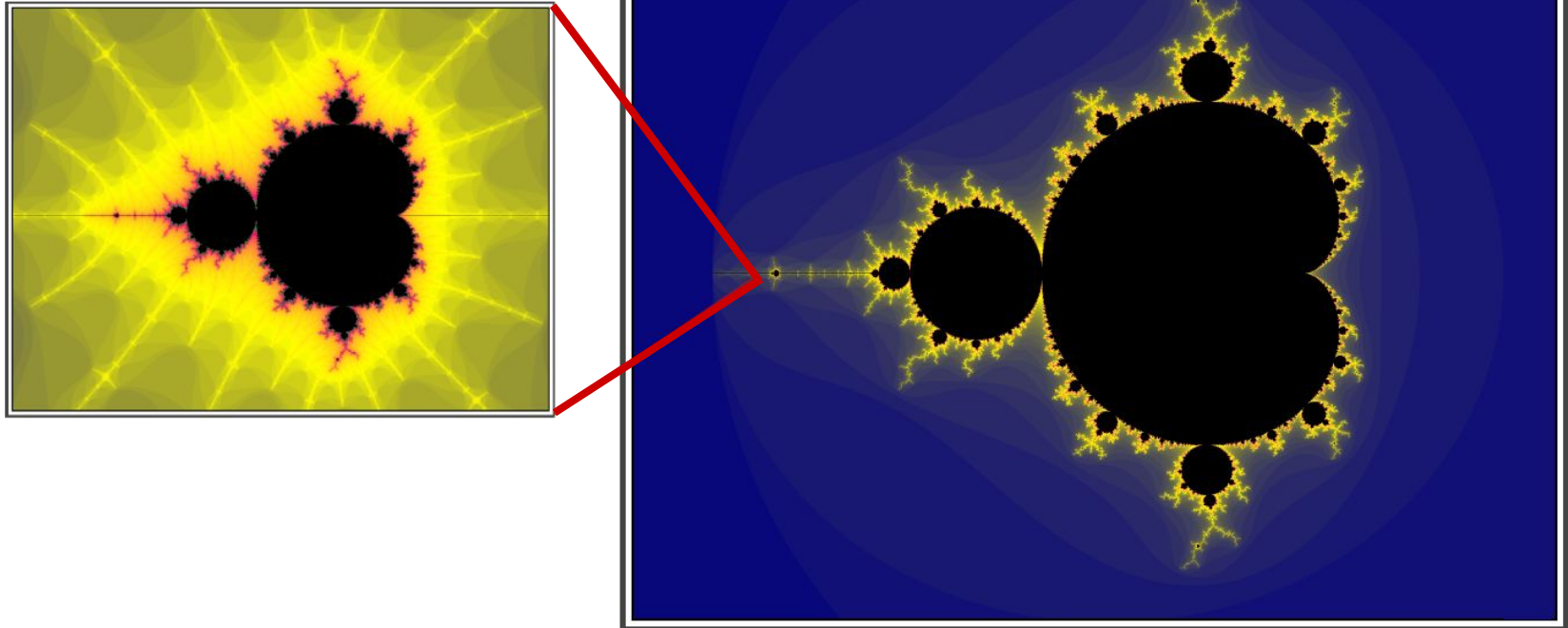
Bordes fracturados

No es diferenciable

en ningún punto!



4. Estructura autosimilar



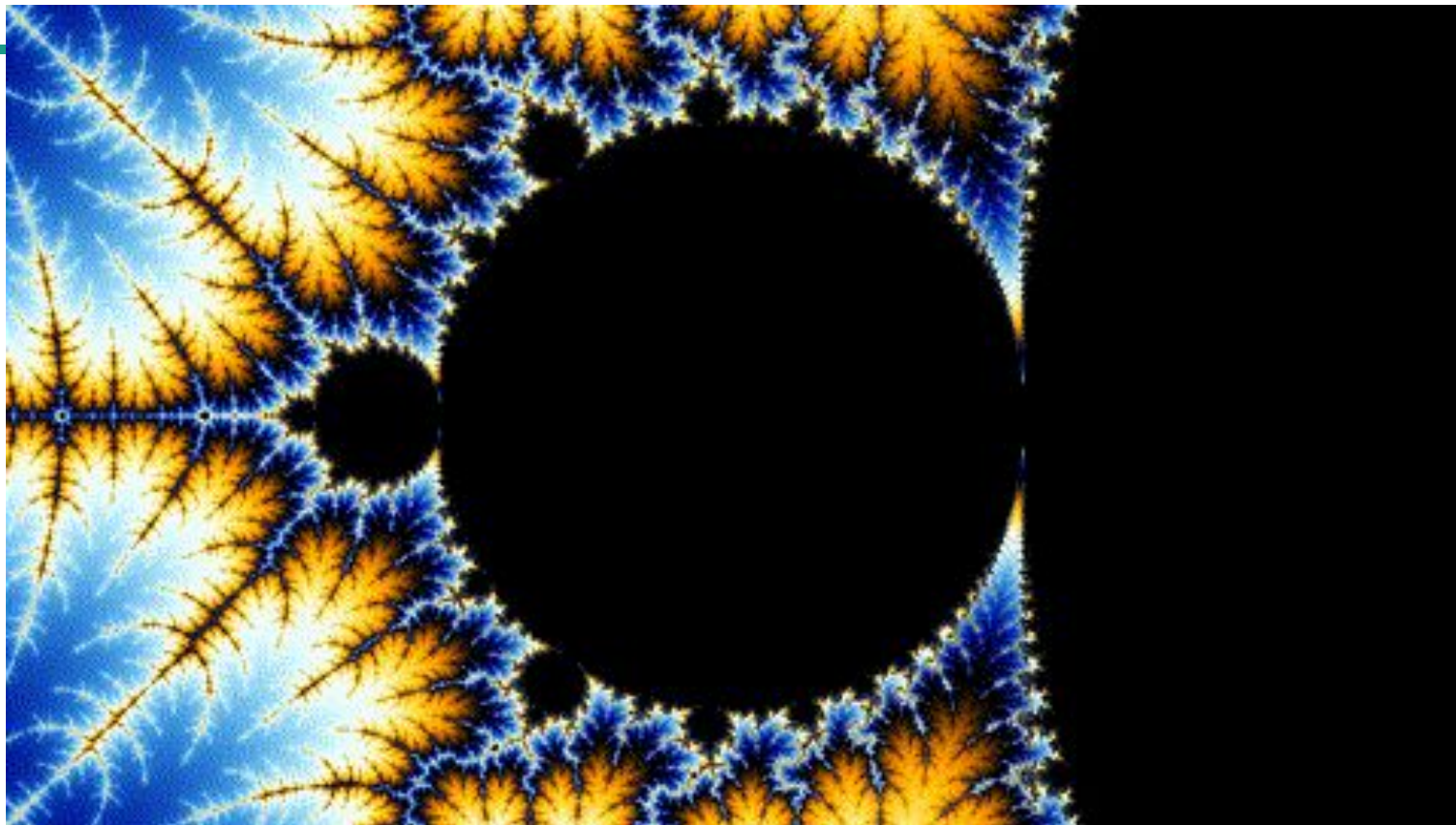
"Pseudo-fractal"



Coliflor Romanesco



Verdadero fractal





Estructuras Fractales

Fractal Mandelbrot



$$f(z) = z^2 + c$$

Fractal Mandelbrot



$$f(z) = z^2 + c$$

Para cada punto c del plano complejo, tomar $z_0 = 0$
Calcular $f(z_0)$, $f(f(z_0))$, $f(f(f(z_0)))$, etc.

Fractal Mandelbrot

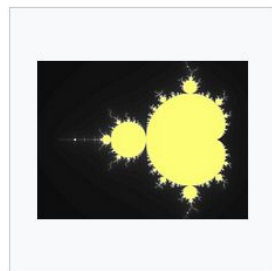


$$f(z) = z^2 + c$$

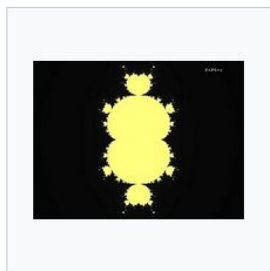
Para cada punto c del plano complejo, tomar $z_0 = 0$
Calcular $f(z_0)$, $f(f(z_0))$, $f(f(f(z_0)))$, etc.

Sistema dinámico en \mathbb{C}

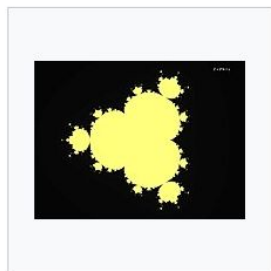
Conjunto Mandelbrot: $z = z^m + C$



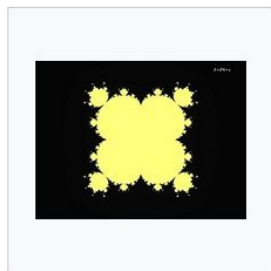
$$Z = Z^2 + C$$



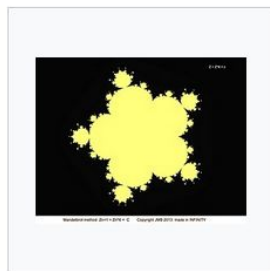
$$Z = Z^3 + C$$



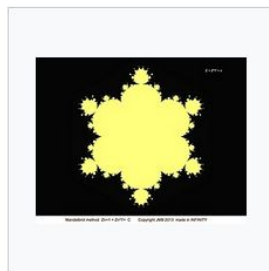
$$Z = Z^4 + C$$



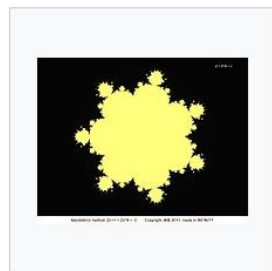
$$Z = Z^5 + C$$



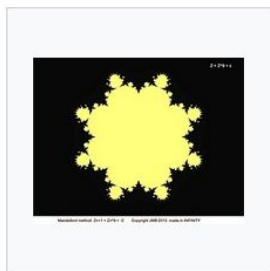
$$Z = Z^6 + C$$



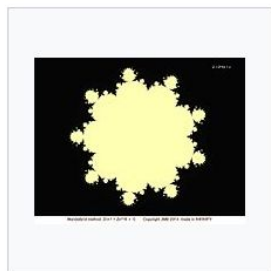
$$Z = Z^7 + C$$



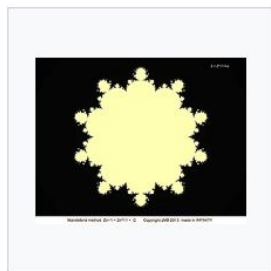
$$Z = Z^8 + C$$



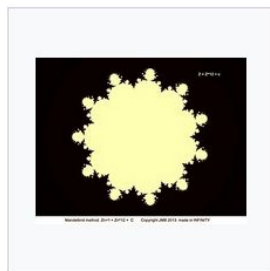
$$Z = Z^9 + C$$



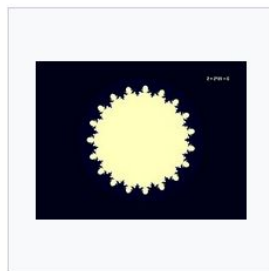
$$Z = Z^{10} + C$$



$$Z = Z^{11} + C$$

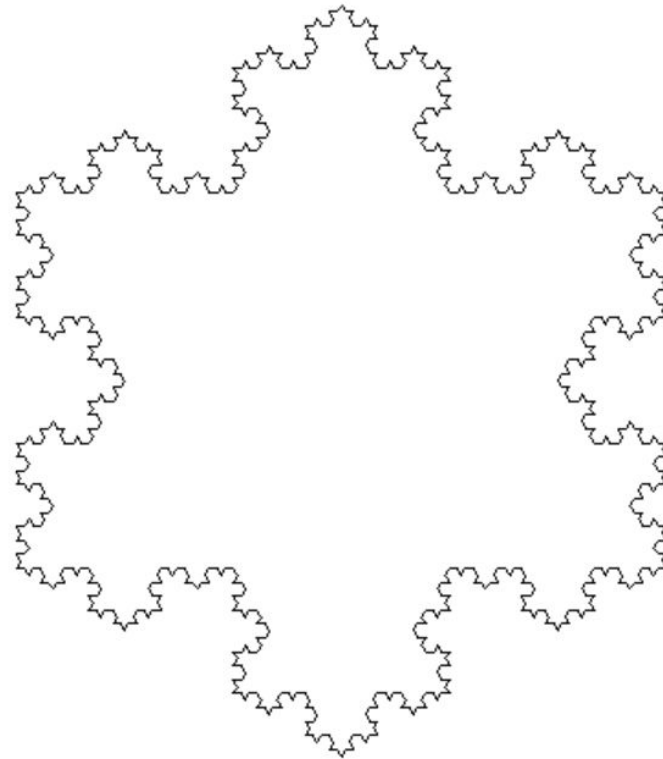


$$Z = Z^{12} + C$$



$$Z = Z^{20} + C$$

Sistemas L



Koch's snowflake

Axiom: $F++F++F$

Rule: $F \rightarrow F-F++F-F$

Angle: 60

[Koch's snowflake](#)

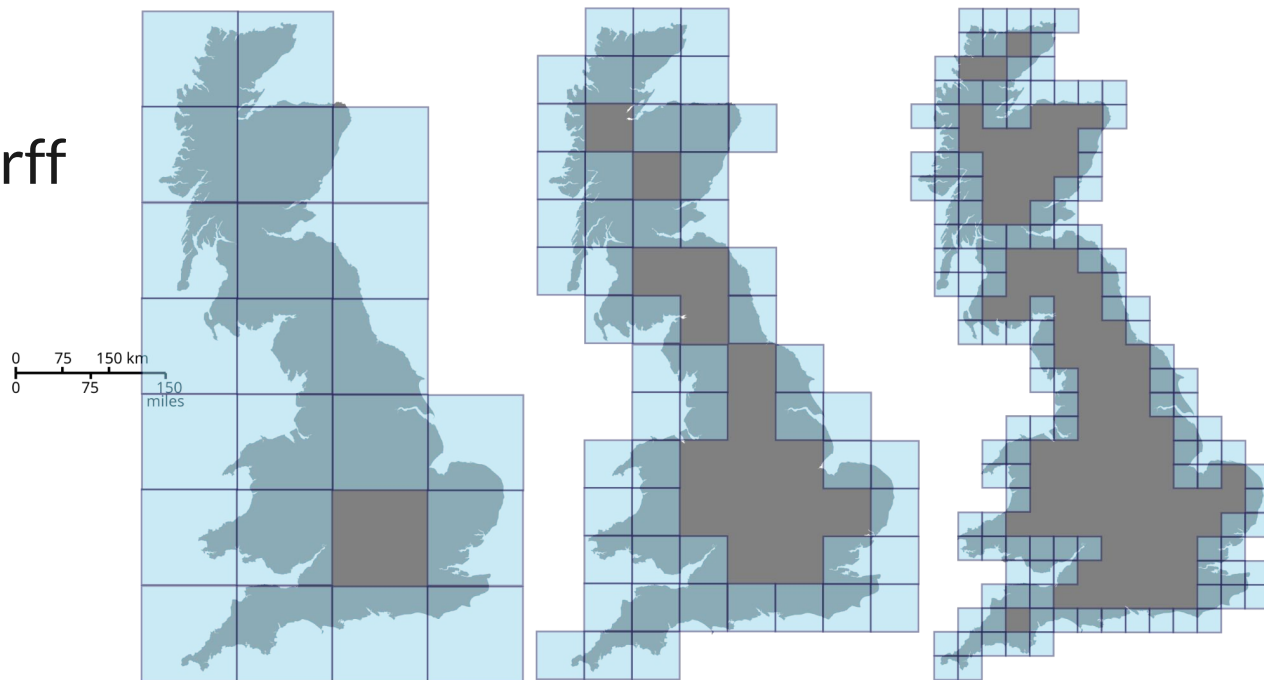
Autosimilaridad en la naturaleza



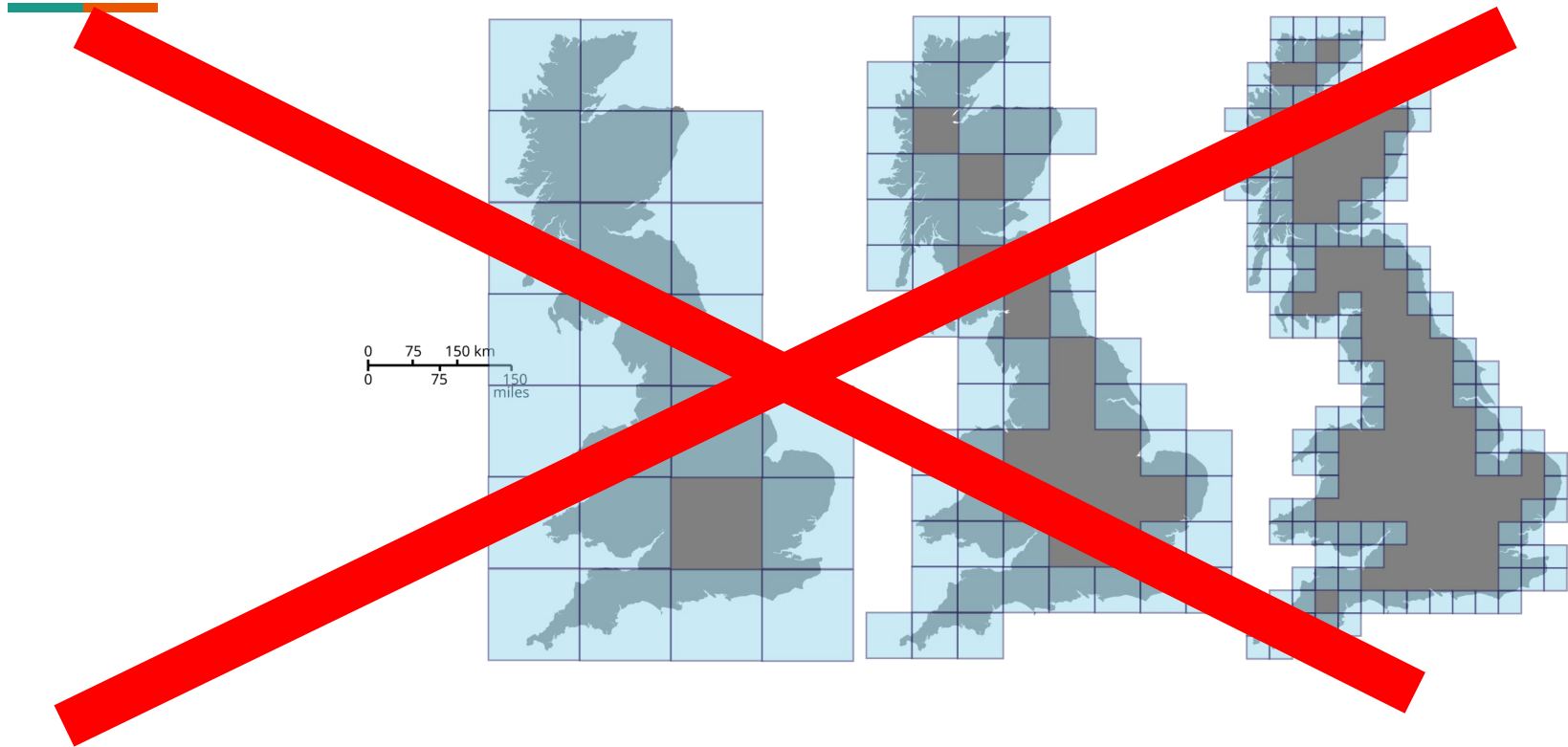
Existen muchas propiedades importantes de los fractales



Dimensión Hausdorff



Dimensión Hausdorff



Qué nos interesa?



Comportamiento
interesante

=

+

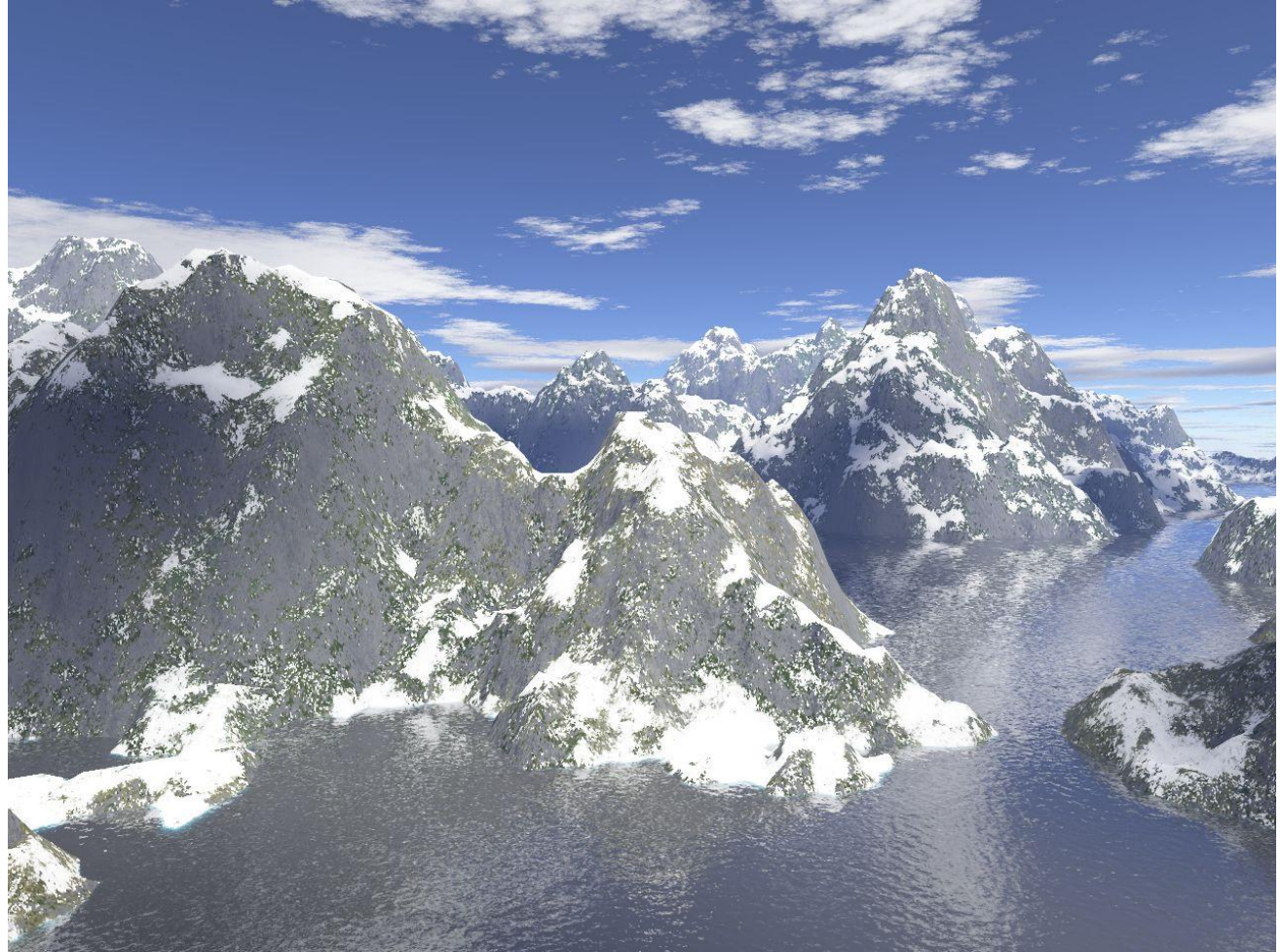
Detalle
infinito





Aplicaciones

Generación de terreno



Demostración: Texturas de ruido fractal en Blender





Conclusión

Bibliografia



<https://iquilezles.org/articles/warp/> Texture warping



<https://iquilezles.org/articles/fbm/> Fractional Brownian Motion landscape



<https://pubmed.ncbi.nlm.nih.gov/34244409/>
Cauliflower fractal forms arise from perturbations of floral gene networks, Science (2021)



Scientific American: Computer Recreations column (1985-08-01) - A.K. Dewdney

Artículo que popularizó el fractal de Mandelbrot explicando cómo implementarlo



<https://mandel.gart.nz/> Explorador del fractal de Mandelbrot más famoso



<https://www.shadertoy.com/view/XdVSW1> Terreno modelado implícitamente con ruido