# Synthétisation d'une image numérique

- Préambule : NH90 VMT

# Synthétisation d'une image numérique

- I / Rendu graphique
- II / Champ de hauteur


Optimalité :

Choix, contraintes, hasards.

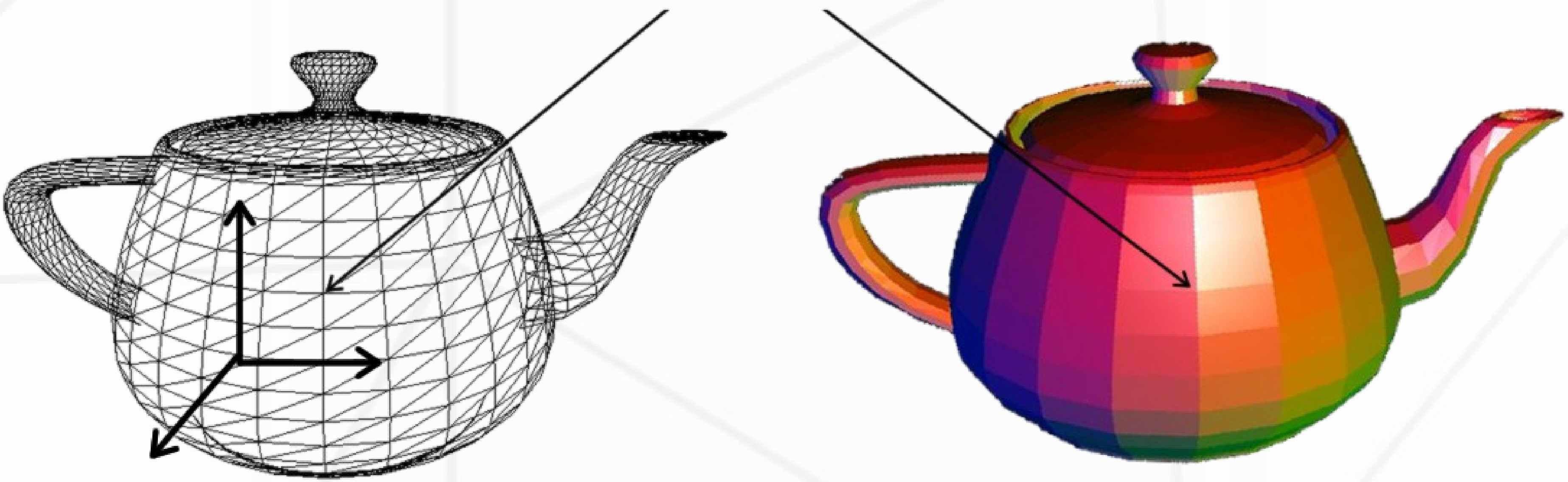
# Rendu graphique

- Objet numérique

$$L=((V_{1,}V_{2,}V_3),(V_{1,}V_{2,}V_4),\ldots,(V_i,V_j,V_k))$$

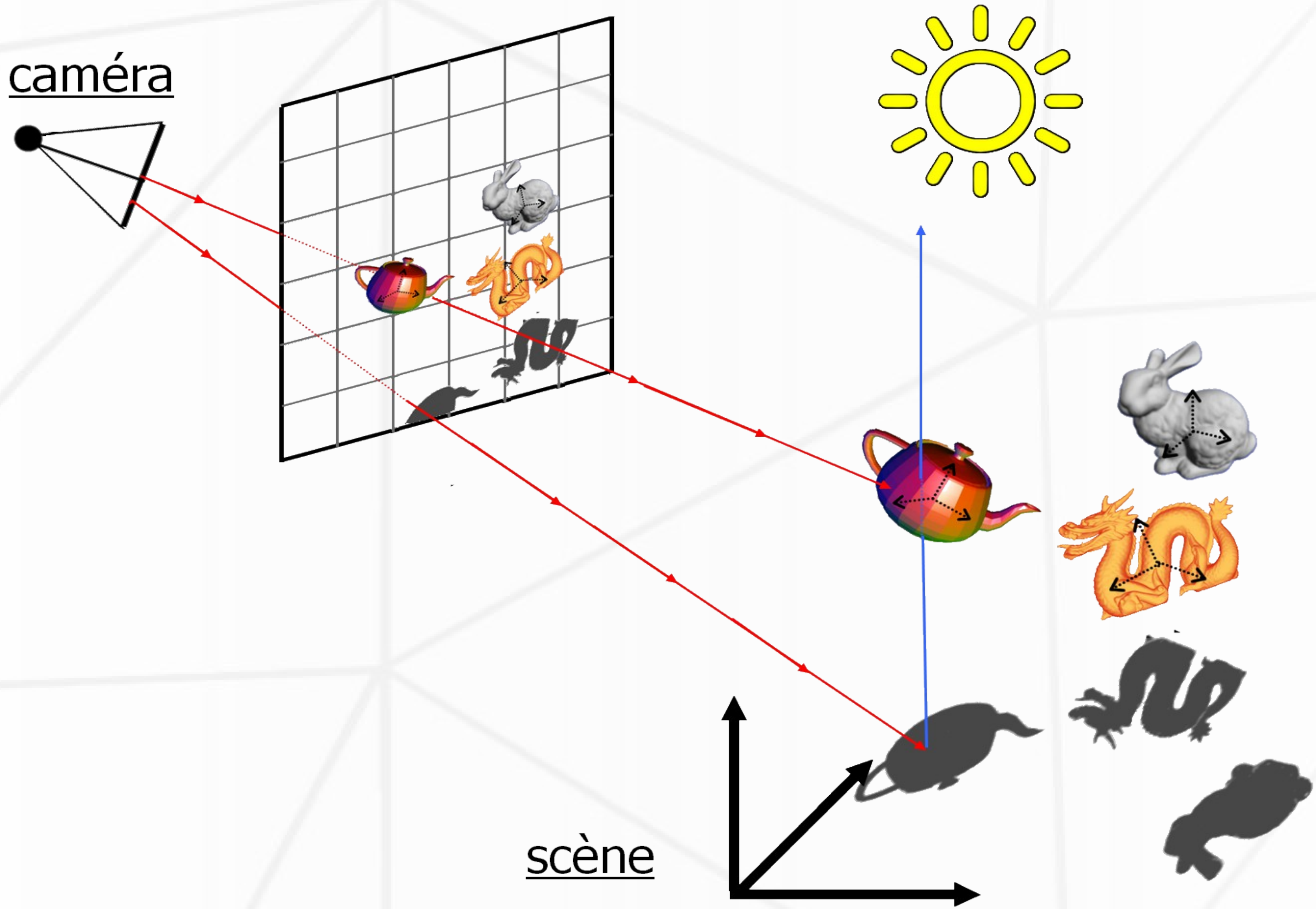
$$V_i=((x_i,y_i,z_i),(r_i,g_i,b_i),\ldots)$$

$$V_i=((1.4,2.8,1.1),(255,80,100),\ldots)$$



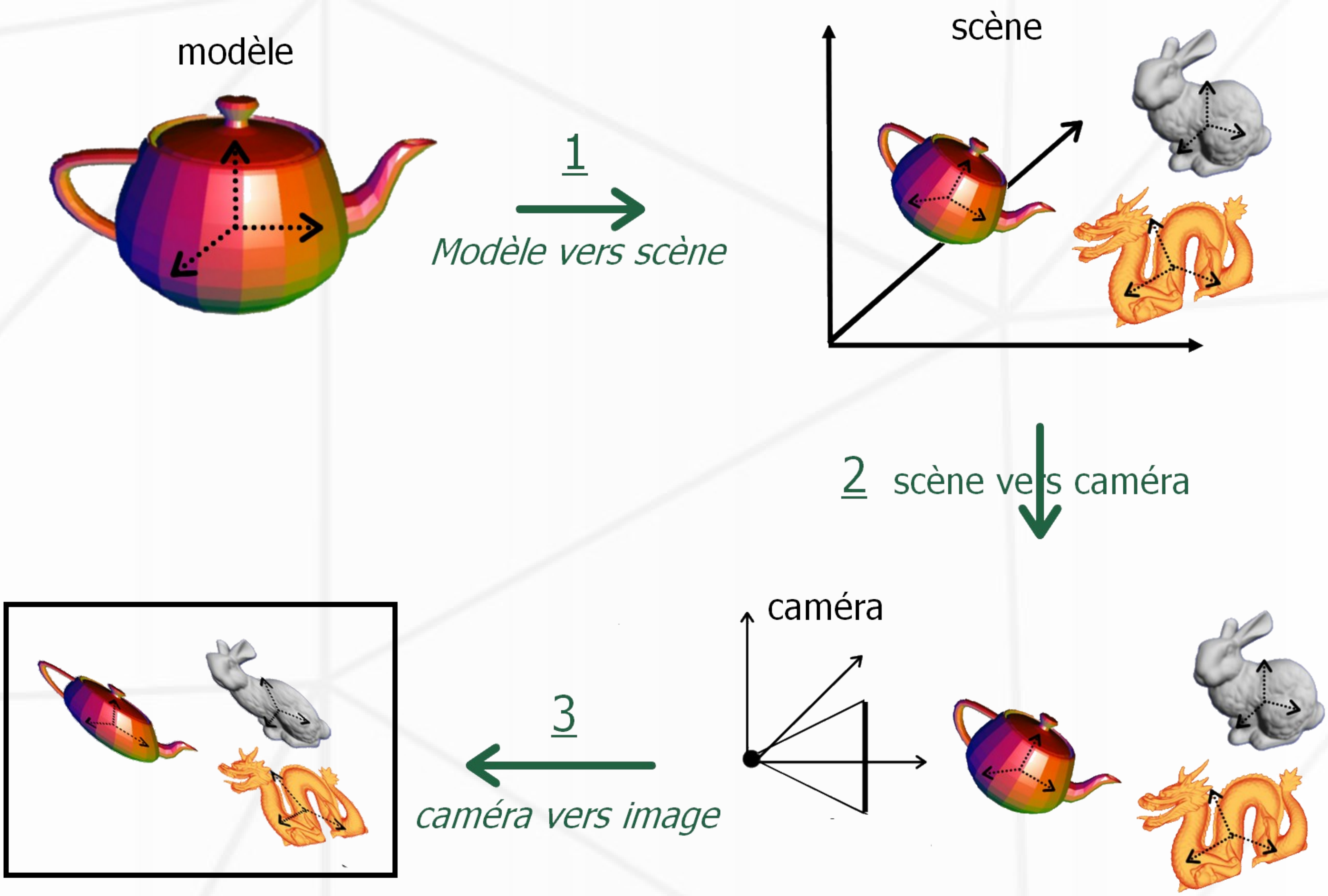
# Rendu graphique

- Lancer de rayons



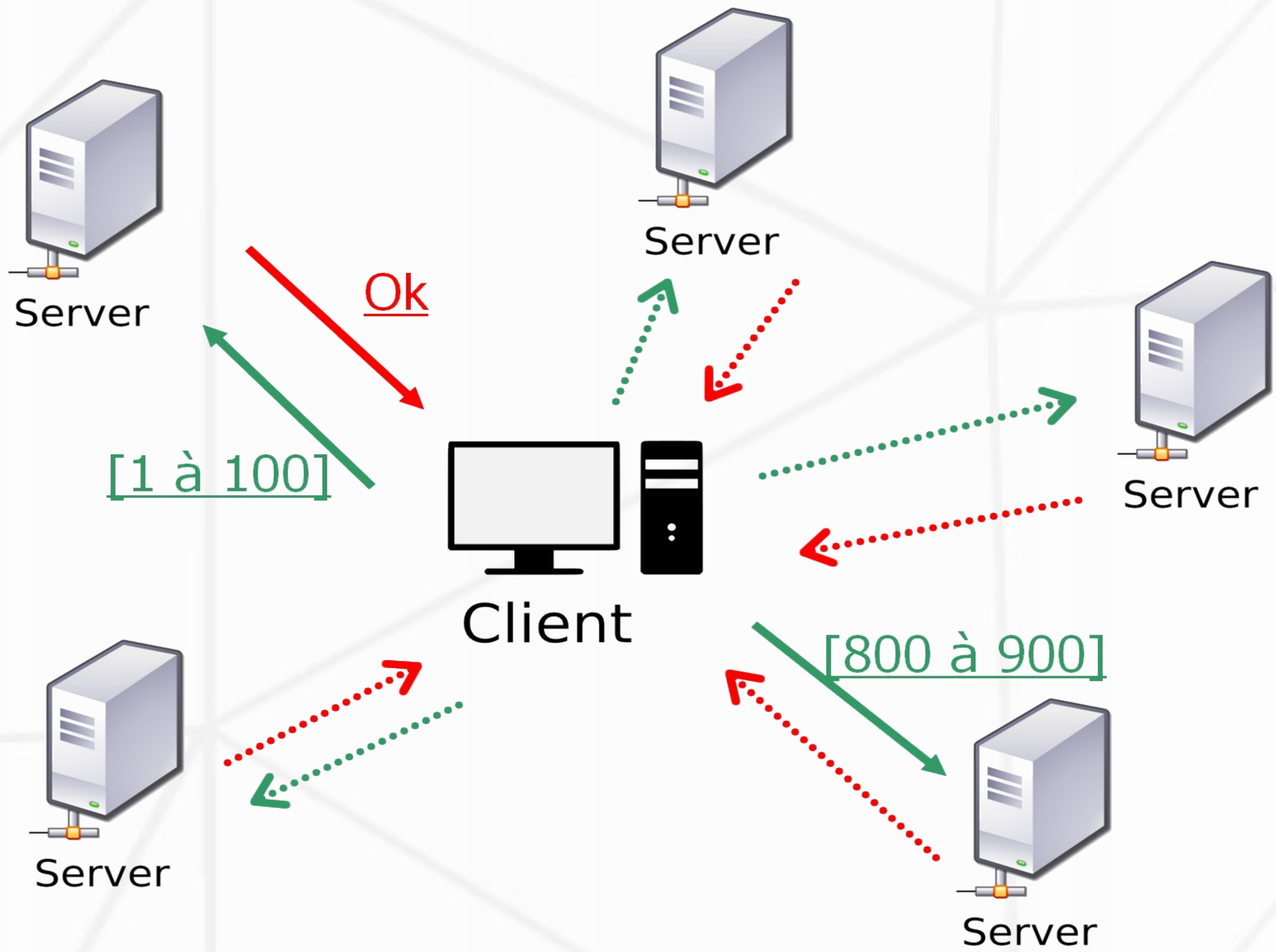
# Rendu graphique

- Rastérisation



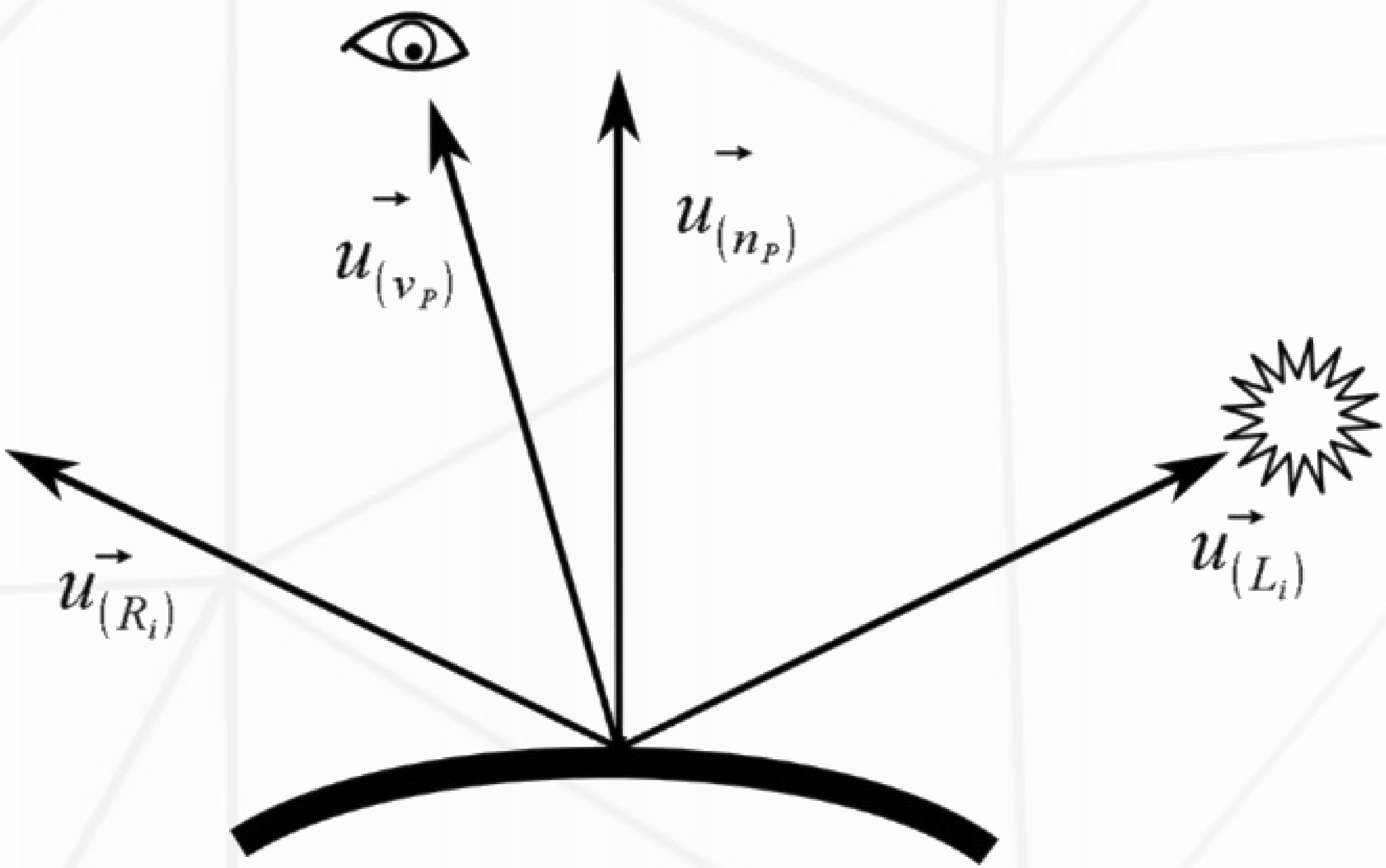
# Rendu graphique

- Parallélisation



# Eclairage : ombrage de Phong

$$I(P) = I_A(P) + \sum_{i=1}^{n} \vec{u_{(L_i)}} \cdot \vec{u_{(n_P)}} * I_i + (\vec{u_{(R_i)}} \cdot (\vec{u_{(v_P)}}))^{\alpha} * I_i$$

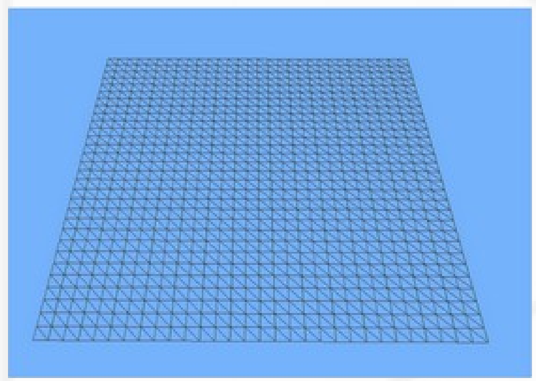


# Champ de hauteur

- Définition

$$\begin{array}{cccc} H : & \mathbb{R}^2 & \rightarrow & \mathbb{R} \\ & (x,z) & \rightarrow & H(x,z)=y \end{array}$$


+



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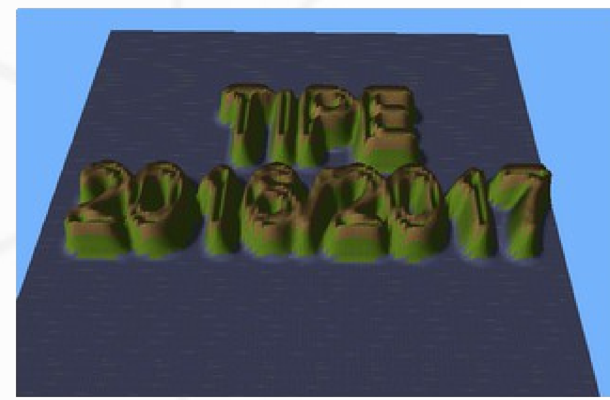
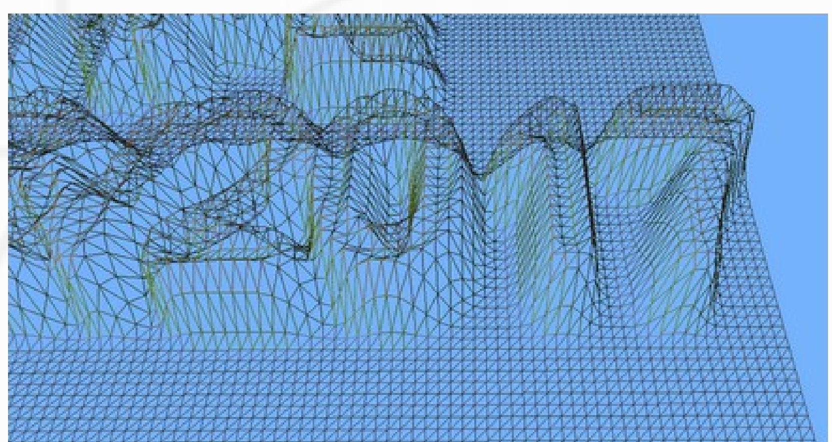
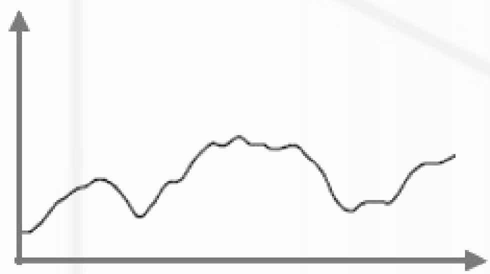


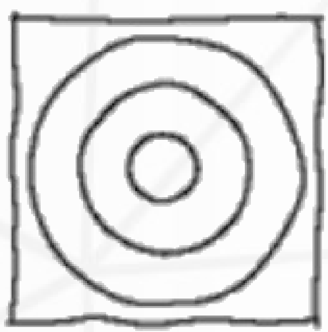



# Champ de hauteur

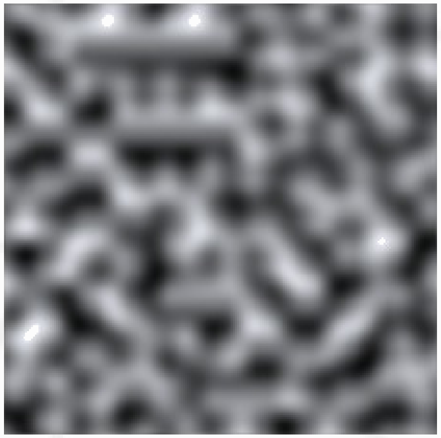
- Génération procédural : fonctions de bruits

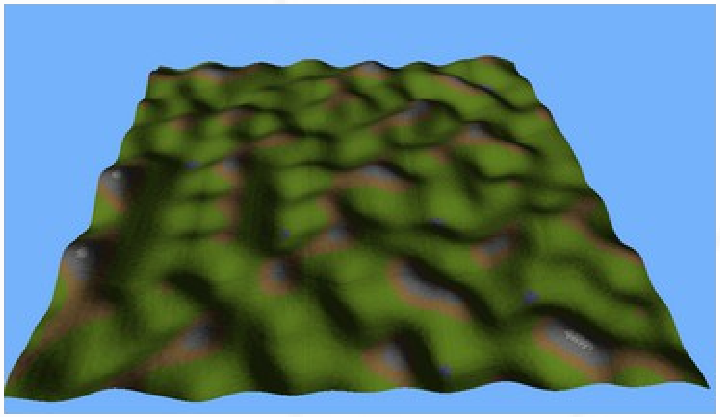
**F(t) = x**





**F(x, y) = z**

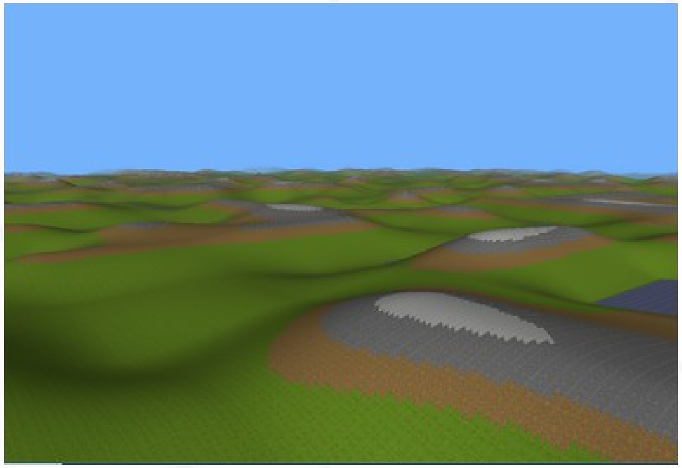




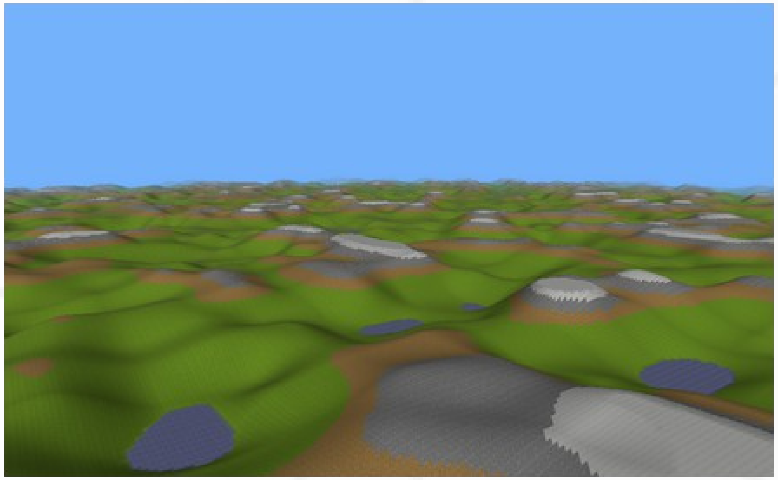
# Champ de hauteur

- Génération procédural : combinaisons

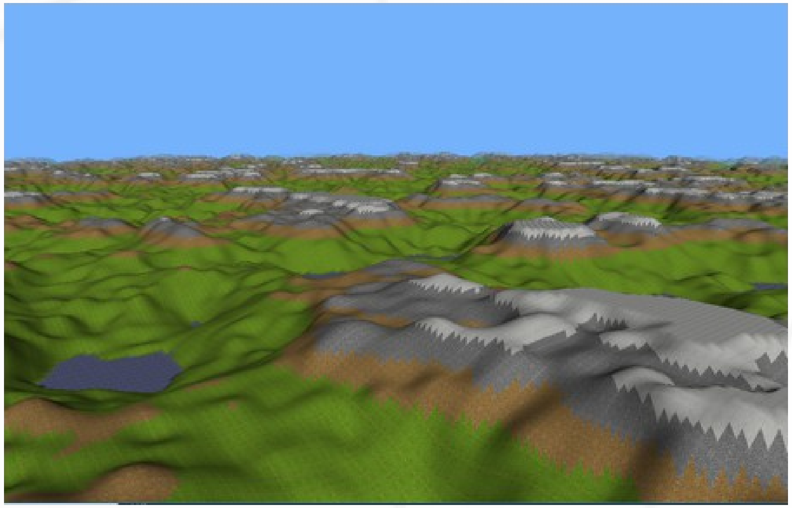
```
x, y
hauteur = 0
Pour chaque octave dans octaves:
    f = octave.frequence
    I = octave.amplitude
    h = h + F(x * f, y * f) * I
```



*1 octave*



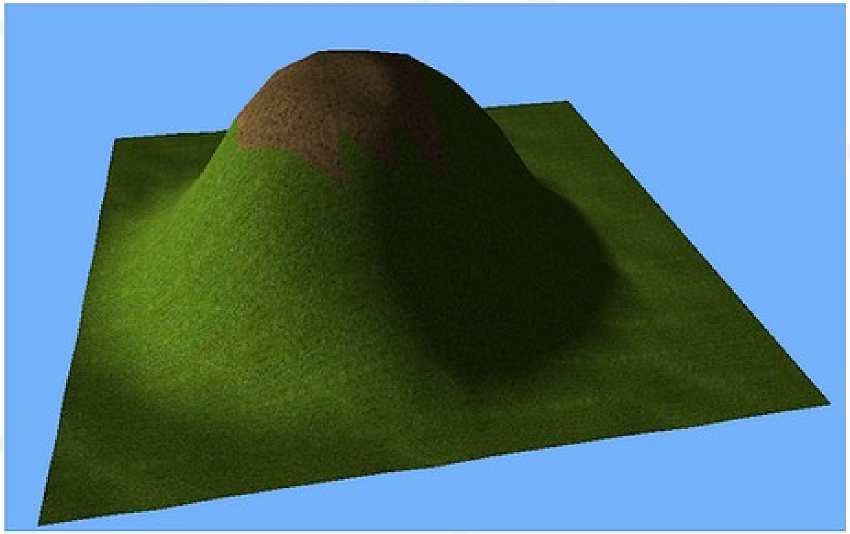
*2 octaves*

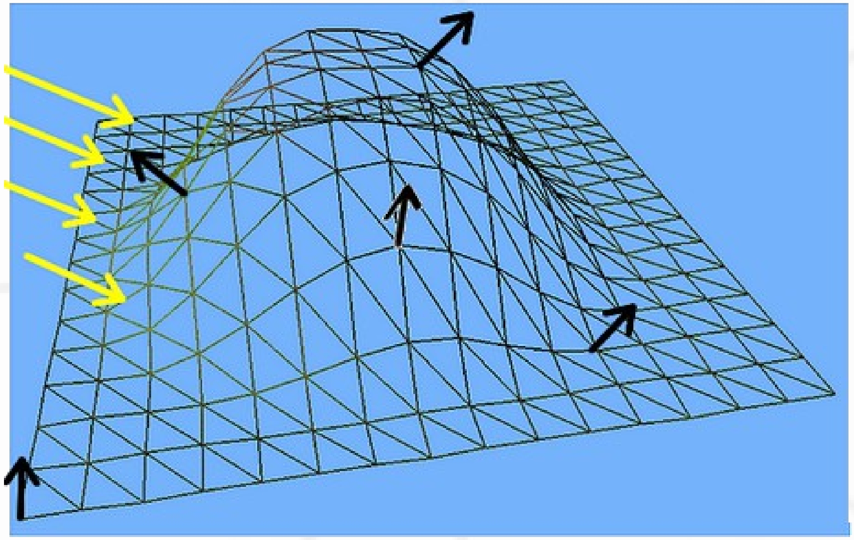


*4 octaves*

# Champ de hauteur

- Calcul des normales





$$F(x,y,z)=H(x,z)-y$$

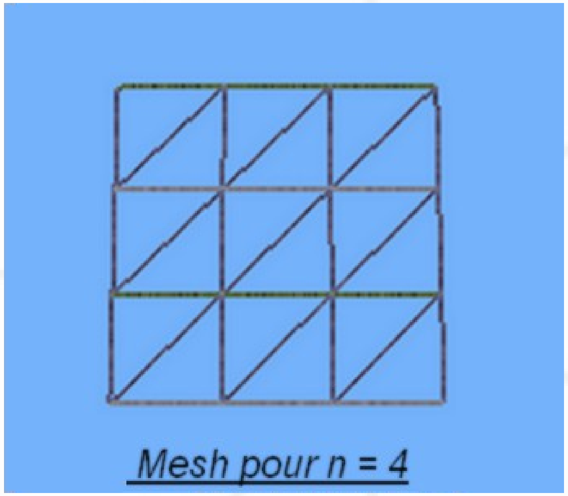
$$\vec{N}(x_0,y_0,z_0)=\left|\begin{array}{c}\dfrac{\partial F(x_0,y_0,z_0)}{\partial x}\\ \dfrac{\partial F(x_0,y_0,z_0)}{\partial y}\\ \dfrac{\partial F(x_0,y_0,z_0)}{\partial z}\end{array}\right.$$

$$\boxed{=\left|\begin{array}{c}\dfrac{H(x_0+dx,z_0)-H(x_0,z_0)}{dx}\\ -1\\ \dfrac{H(x_0,z_0+dz)-H(x_0,z_0)}{dz}\end{array}\right.}$$

# Champ de hauteur

- Complexité spatiale

$$n = \text{'nombre de points sur un coté du terrain'}$$
$$M(n) = \text{'mémoire total utilisé'}$$
$$N(n) = \text{'nombre de vecteurs distincts'}$$
$$T(n) = \text{'nombre de triangles'}$$
$$I(n) = \text{'nombre d'indices du maillage'}$$




$$S = (3+3+1) * 4 = 28\ octets$$
$$V = ((x, y, z), (n_x, n_y, n_z), c)$$

$$\boxed{\begin{aligned} N(n) &= n^2 \\ T(n) &= 2(n-1)^2 \\ I(n) &= 3T(n) \end{aligned}}$$

# Champ de hauteur

- Complexité spatiale
  - Formats de stockage

$$L_1(n)=((V_{1,}V_{2,}V_3)_{1,}(V_{1,}V_{2,}V_4)_{2,}\dots,(V_a,V_b,V_c)_{(T(n))})$$

$$M_1(n)=I(n)*S$$

$$\boxed{=168n^2+o(n^2)}$$

$$L_2=(V_1,V_{2,}\dots,V_n)$$

$$I_2=((1,2,3)_{1,}(1,2,4)_{2,}\dots,(a,b,c)_{(T(n))})$$

$$M_2(n)=N(n)*S+2*I(n)$$

$$\boxed{=40n^2+o(n^2)}$$

# Champ de hauteur

- Complexité spatiale

$M_2(n) - M_1(n)$

$$n_0 = \frac{\sqrt{(6 * S * (S-2))} + 6 * (S-2)}{5 * S - 12}$$

| $n$ | $0$ | $n_0$ | $+oo$ |
|---|---|---|---|
| $M_2(n) - M_1(n)$ | + | | - |

$S = 28\,octets \Rightarrow n_0 = 2$

$n = 1024 \Rightarrow M_1(n) = \boxed{168\text{Mo}}$

$M_2(n) = \boxed{40\text{Mo}}$

$M_2(n) - M_1(n) = -128\text{Mo}$

$T(n) = 2\ 000\ 000\ triangles$

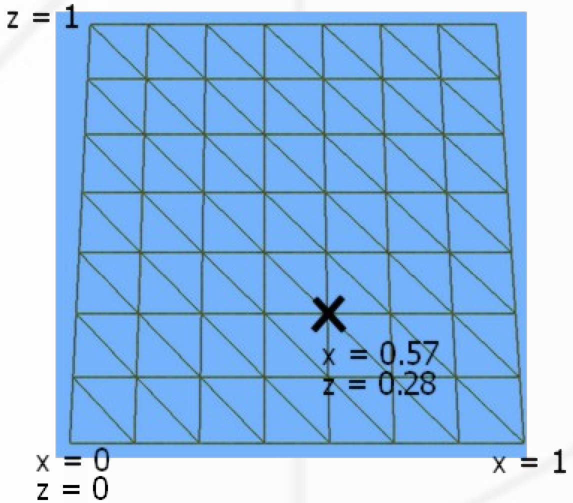
→ 2ème méthode

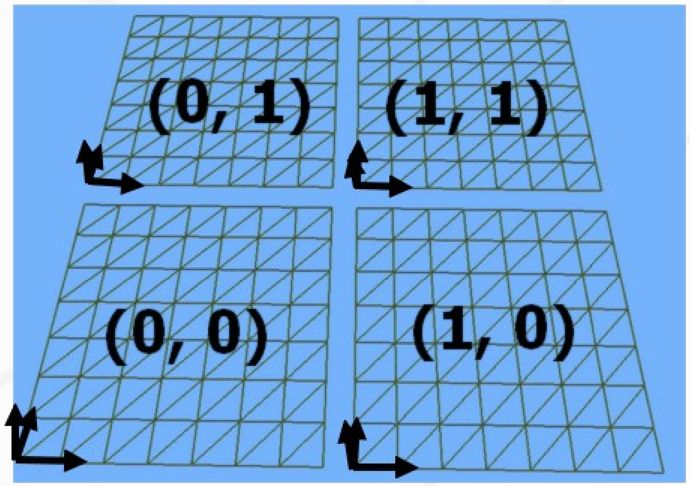
# Champ de hauteur

- Complexité spatiale

$$((\cancel{x}, y, \cancel{z}), (n_x, \cancel{n_y}, n_z), c)$$

$$7 * 4 = 28\, octets \rightarrow 4 * 4 = 16\, octets$$



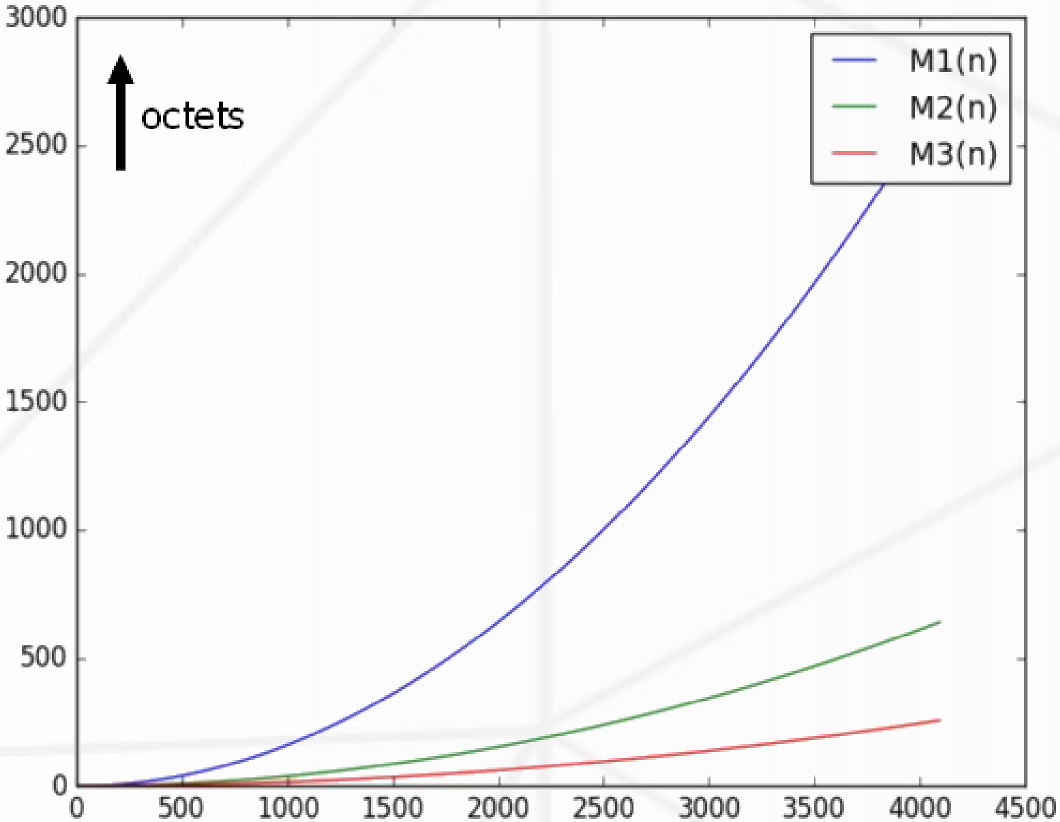



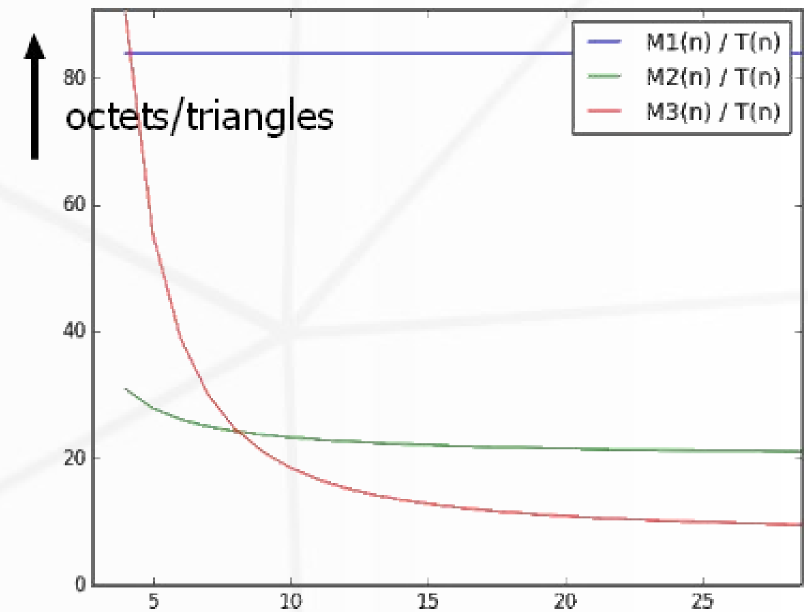

$$M_3 = N(n) * S + \frac{n}{n_u} * (16 * 4 + 2 * 4) + I(16) * 2$$

$$\boxed{= 16 n^2 + o(n^2)}$$

# Champ de hauteur

- Complexité spatiale : conclusion

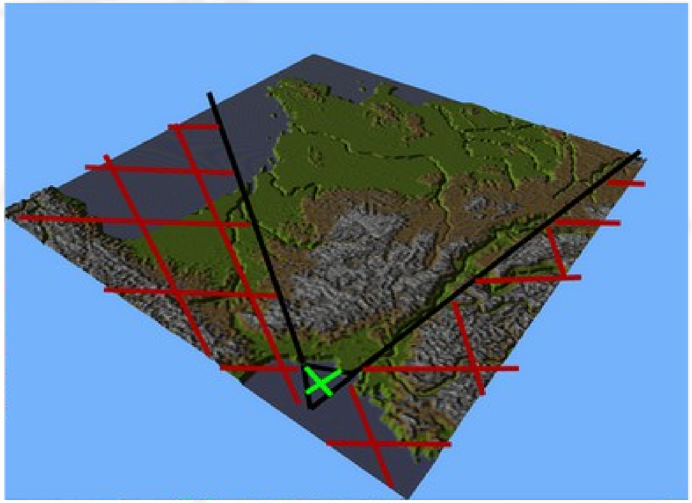


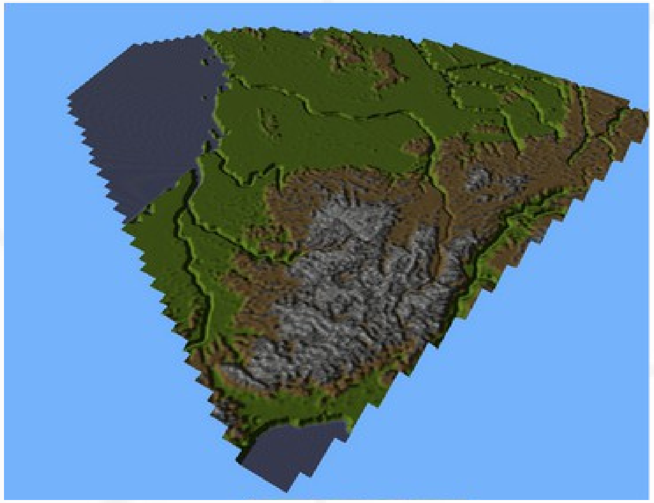

| *format* | $M_1$ | $M_2$ | $M_3$ |
|---|---|---|---|
| *octet / vecteur* | $S=28$ | $S=28$ | $S=16$ |
| *octets / triangles* | 84 | 20 | 8 |

# Champ de hauteur

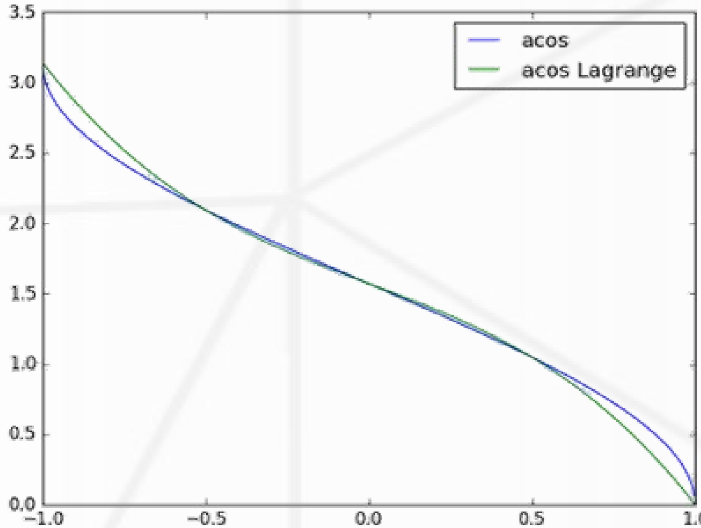
- Etude temporelle : culling

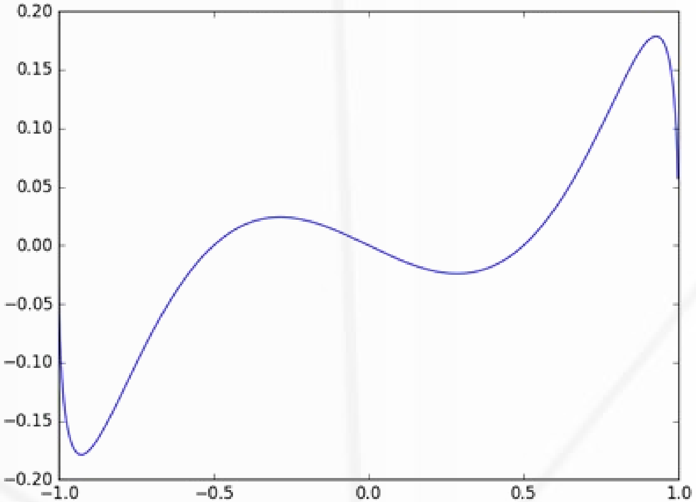


**1024 terrains**



**791 terrains**



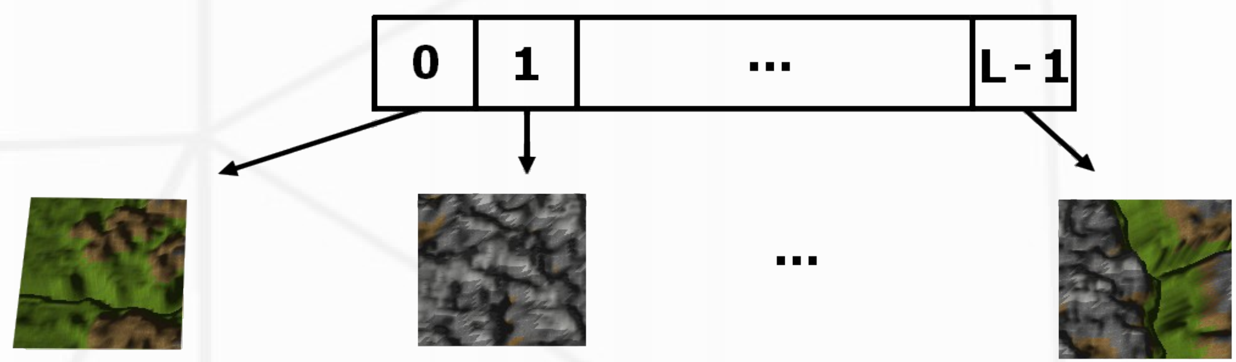
# Champ de hauteur

- Etude temporelle : table de hashage

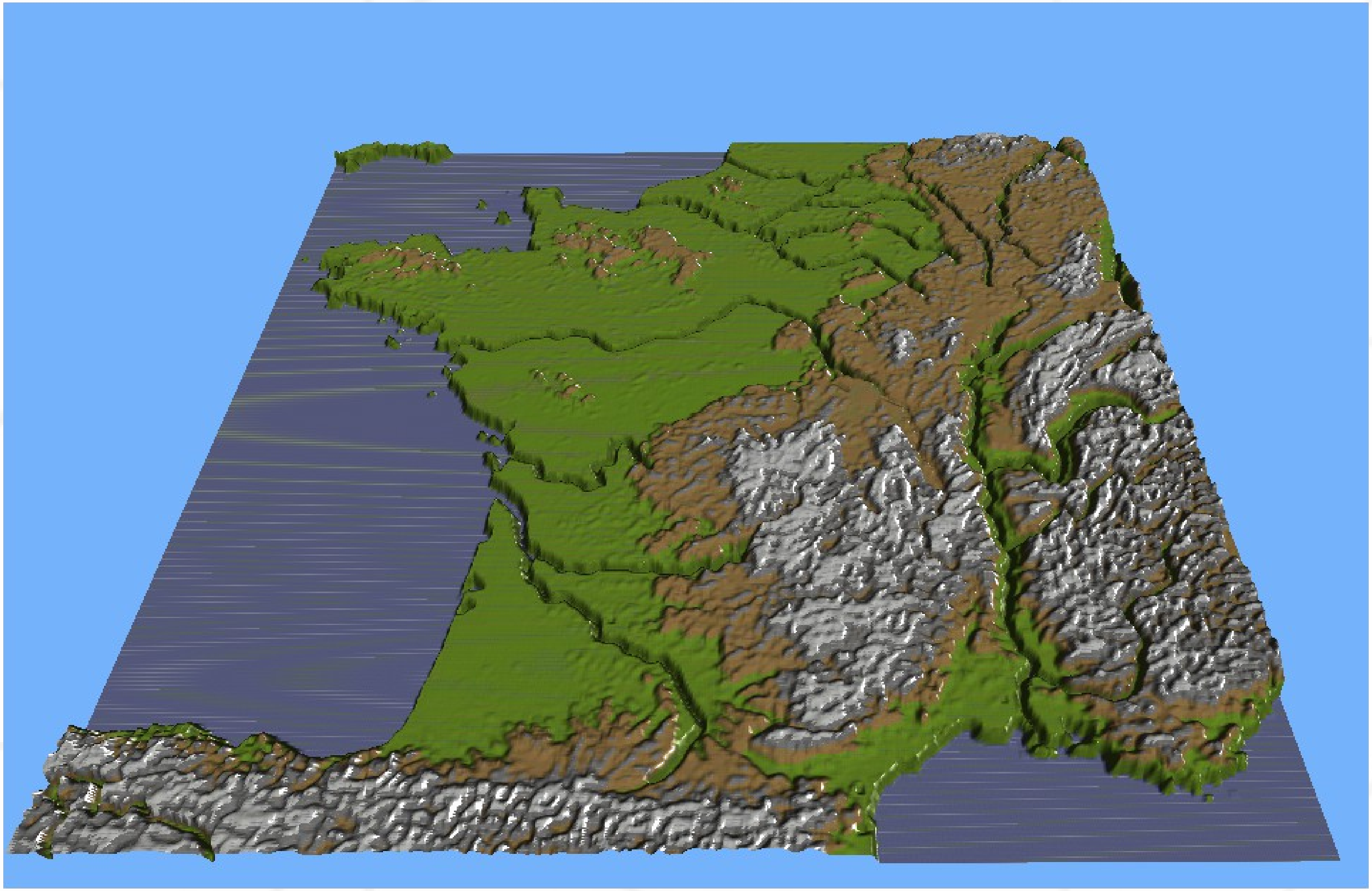
| | | | | |
|---|---|---|---|---|
| 3 (0, 4) | 4 | 5 | 3 | 4 (4, 4) |
| 0 | 1 | 2 (2, 3) | 0 | 1 |
| 6 | 7 | 8 | 6 | 7 |
| 3 | 4 (1, 1) | 5 | 3 | 4 |
| 0 (0, 0) | 1 (1, 0) | 2 (2, 0) | 0 (3, 0) | 1 (4, 0) |

$$i \ : \ \mathbb{N}^2 \rightarrow [0 ; L^2[$$
$$(x, y) \rightarrow (x + y * L) \% L^2$$

$$(ici, L = 3)$$



# Illustrations



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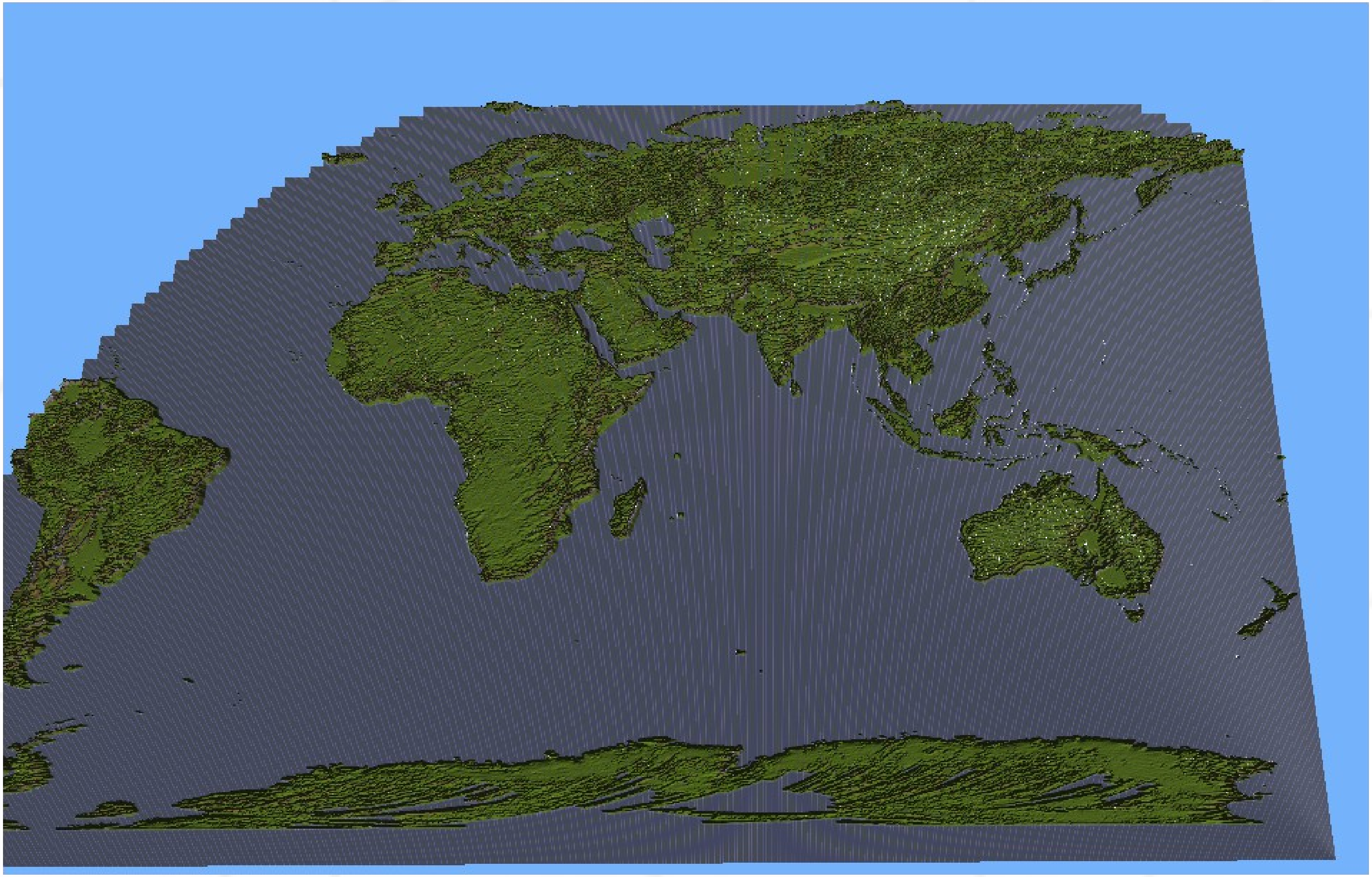

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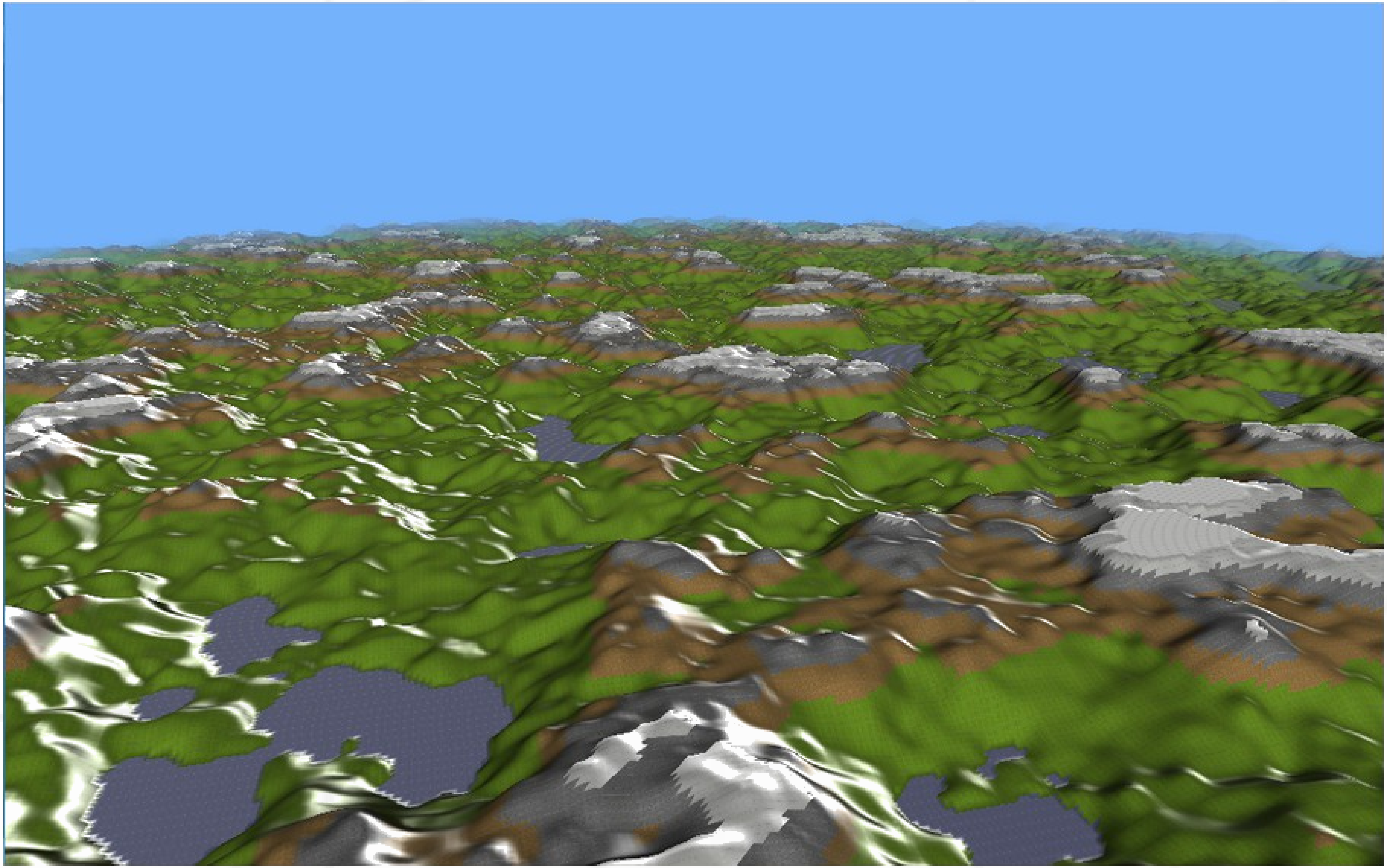

# Illustrations

# Sources


- [1] Wikipédia : Infographie : https://fr.wikipedia.org/wiki/Infographie
- [2] Wikipédia : Rastérisation : https://fr.wikipedia.org/wiki/Rasterisation
- [3] Wikipédia : Maillage triangulaire : https://fr.wikipedia.org/wiki/Mesh_(objet)
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- [8] Adrian BIAGIOLI : Bruit de Perlin : http://flafla2.github.io/2014/08/09/perlinnoise.html
- [9] Simulateur de vol : http://www.defense.gouv.fr/actualites/economie-et-technologie/la-dga-presente-le-1er-simulateur-europeen-de-formation-a-la-maintenance