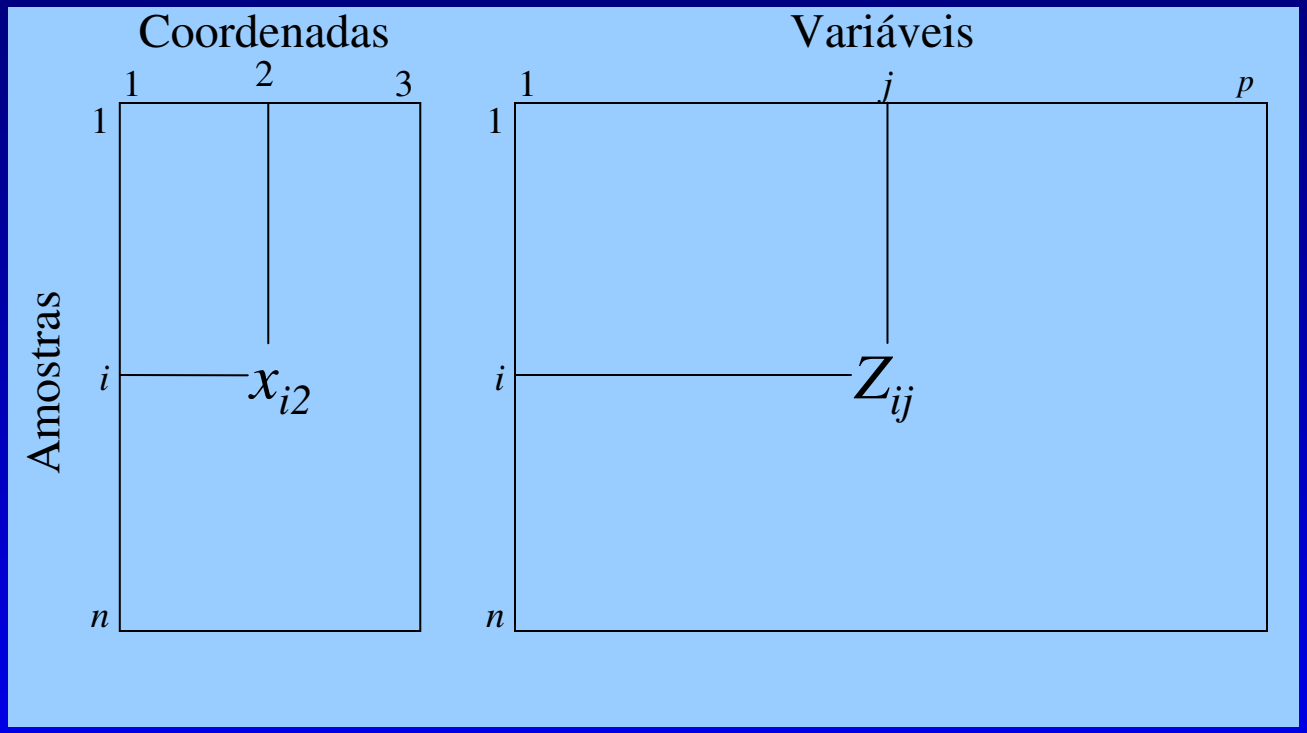
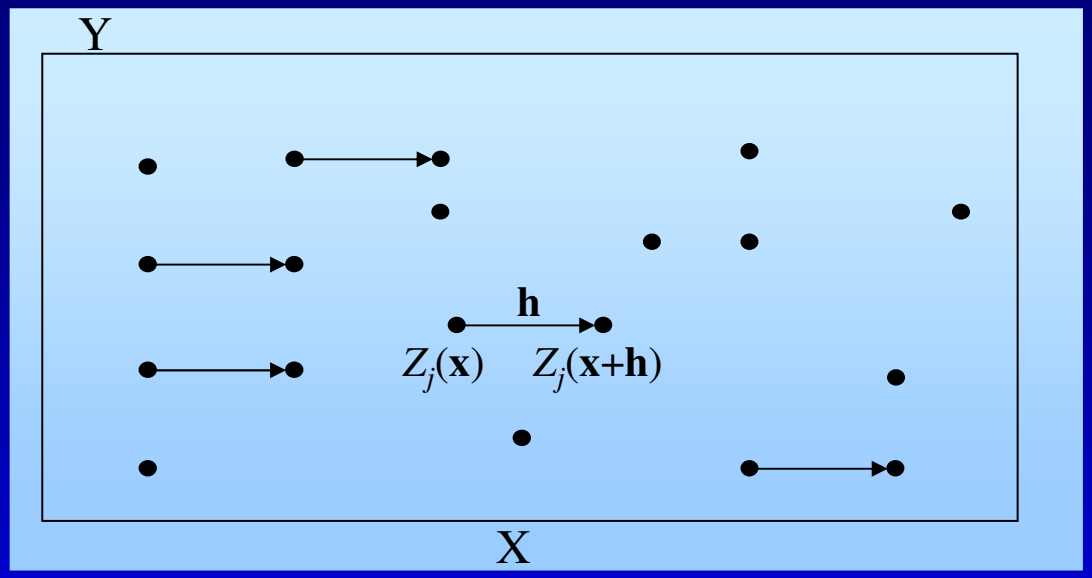
ORGANIZAÇÃO DOS DADOS



$z_{ij}(x_i)$ - Variável regionalizada

Exemplos: Teores químicos
Porosidades
Intensidade de fracturação

MEDIDAS DE CONTINUIDADE ESPACIAL



$$m_j^* = \frac{1}{n}\sum_{i=1}^{n} Z_j(\mathbf{x}_i)$$

$$\sigma_j^{2^*} = \frac{1}{n}\sum_{i=1}^{n}\left[Z_j(\mathbf{x}_i) - m_j\right]^2$$

$$m_j^*(-\mathbf{h}) = \frac{1}{N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})} Z_j(\mathbf{x}_i)$$

$$\sigma_j^{2^*}(-\mathbf{h}) = \frac{1}{N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})}\left[Z_j(\mathbf{x}_i) - m_j(-\mathbf{h})\right]^2$$

$$m_{j'}^*(+\mathbf{h}) = \frac{1}{N(h)}\sum_{i=1}^{N(h)} Z_{j'}(\mathbf{x}_i + \mathbf{h})$$

$$\sigma_{j'}^{2^*}(+\mathbf{h}) = \frac{1}{N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})}\left[Z_{j'}(\mathbf{x}_i) - m_{j'}(+\mathbf{h})\right]^2$$

MEDIDAS DE CONTINUIDADE ESPACIAL

Covariância Espacial Cruzada

$$C^*_{jj'}(\mathbf{h}) = \frac{1}{N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} \left[Z_j(\mathbf{x}_i) - m(-\mathbf{h})\right]\left[Z_{j'}(\mathbf{x}_i + \mathbf{h}) - m_{j'}(+\mathbf{h})\right]$$

Correlação Espacial Cruzada (Correlograma)

$$\rho^*_{jj'}(\mathbf{h}) = \frac{1}{N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} \frac{C_{jj'}(\mathbf{h})}{\sqrt{\sigma_j^2(-\mathbf{h})\,\sigma_{j'}^2(+\mathbf{h})}}$$

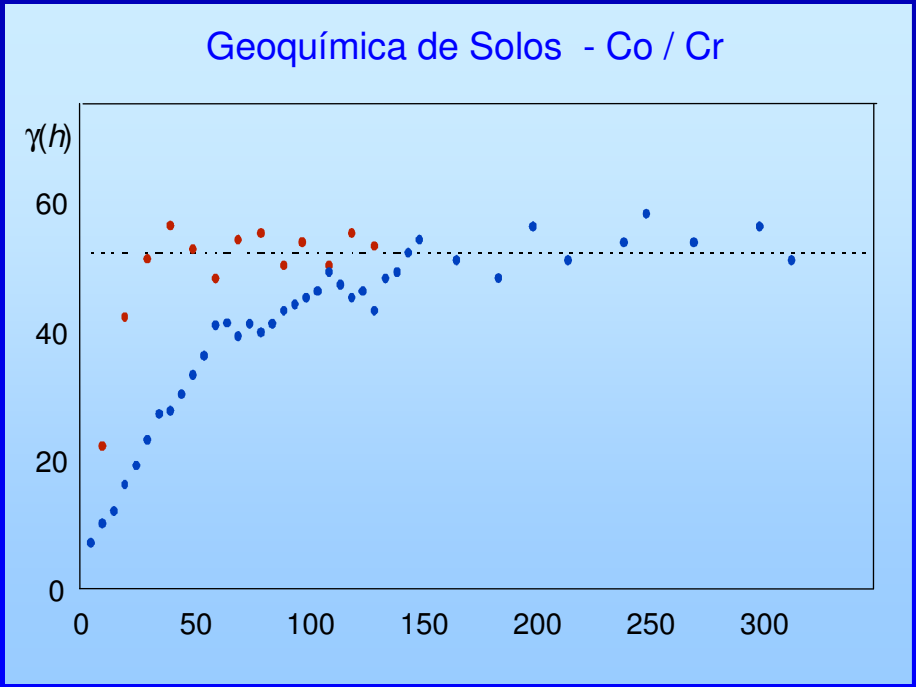
Variograma Cruzado

$$\gamma^*_{jj'}(\mathbf{h}) = \frac{1}{2N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} \left[Z_j(x_i + \mathbf{h}) - Z_j(x_i)\right]\left[Z_{j'}(x_i + \mathbf{h}) - Z_{j'}(x_i)\right]$$

MEDIDAS DE CONTINUIDADE ESPACIAL

Análise Estrutural (variograma)

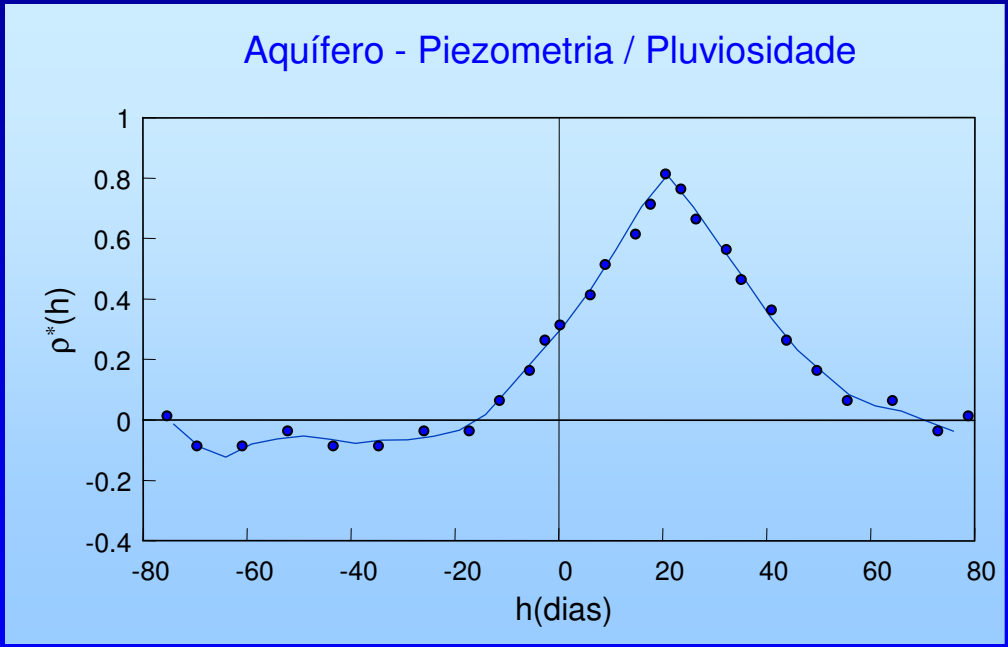
- Comportamento junto à origem
- Comportamento a distâncias elevadas
- Anisotropias



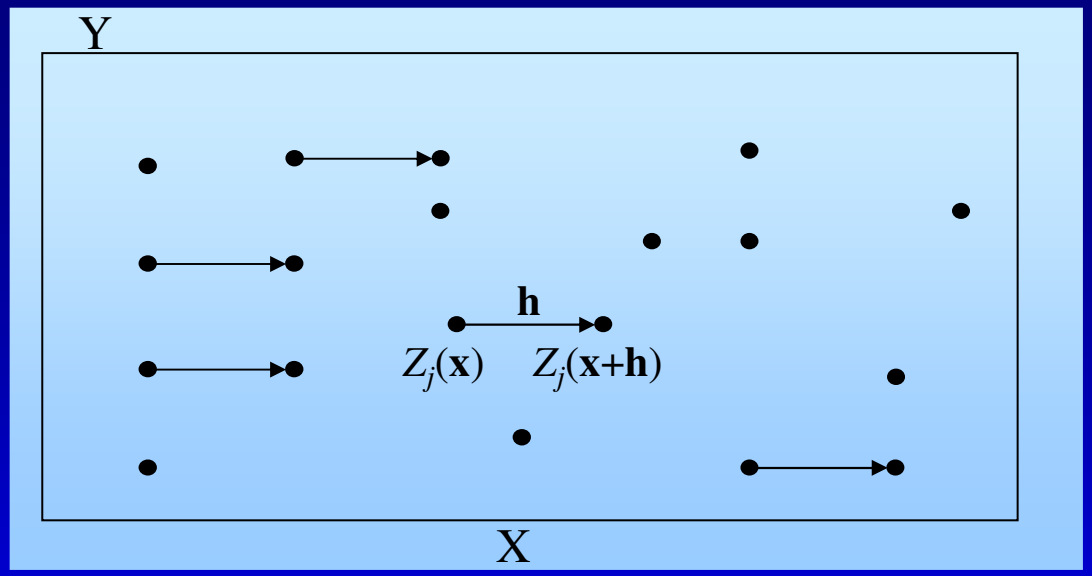
MEDIDAS DE CONTINUIDADE ESPACIAL

Análise estrutural (correlograma)

- Efeito de atraso



TEORIA DAS VARIÁVEIS REGIONALIZADAS

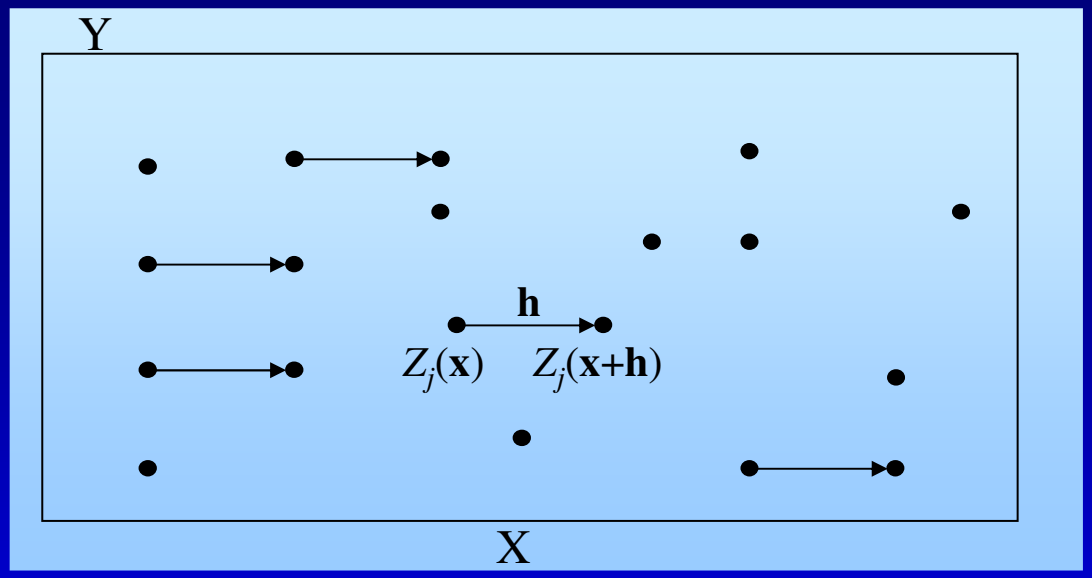


$z_j(x)$ - Variável regionalizada ⟵ $z_j(x)$ - Variável aleatória

Variável cujos valores dependem da localização espacial que apresentam características intermédias entre as variáveis puramente aleatórias e as variáveis determinísticas.

$Z_j(x)$ - Função aleatória

MEDIDAS DE CONTINUIDADE ESPACIAL



$$m_j^* = \frac{1}{n}\sum_{i=1}^{n} Z_j(\mathbf{x}_i)$$

$$\sigma_j^{2^*} = \frac{1}{n}\sum_{i=1}^{n}\left[Z_j(\mathbf{x}_i) - m_j\right]^2$$

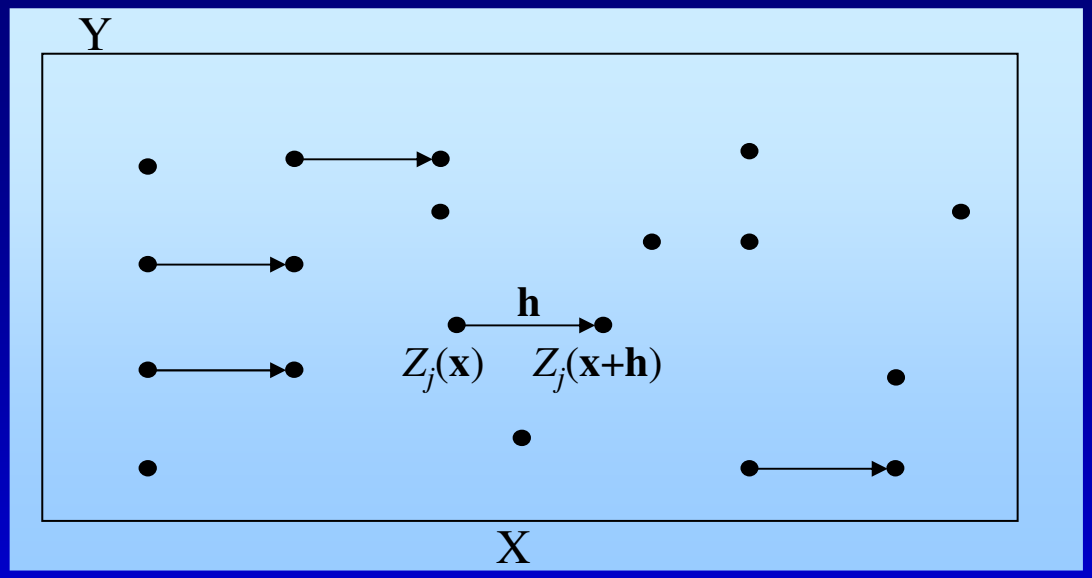
$$m_j^*(-\mathbf{h}) = \frac{1}{N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})} Z_j(\mathbf{x}_i)$$

$$\sigma_j^{2^*}(-\mathbf{h}) = \frac{1}{N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})}\left[Z_j(\mathbf{x}_i) - m_j(-\mathbf{h})\right]^2$$

$$m_{j'}^*(+\mathbf{h}) = \frac{1}{N(h)}\sum_{i=1}^{N(h)} Z_{j'}(\mathbf{x}_i + \mathbf{h})$$

$$\sigma_{j'}^{2^*}(+\mathbf{h}) = \frac{1}{N(\mathbf{h})}\sum_{i=1}^{N(\mathbf{h})}\left[Z_{j'}(\mathbf{x}_i) - m_{j'}(+\mathbf{h})\right]^2$$

TEORIA DAS VARIÁVEIS REGIONALIZADAS



Estacionaridade de 2ª ordem

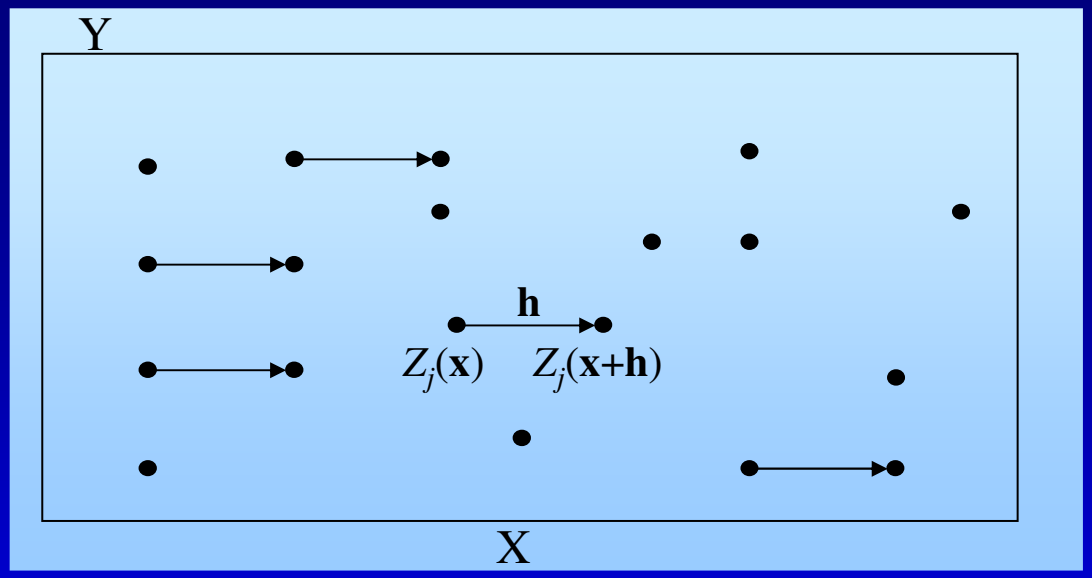
$$\mathrm{E}\{Z_j(x)\} = m_j \qquad \forall x$$

$$\sigma_j^2 = \mathrm{E}\left\{\left[Z_j(\mathbf{x}) - m_j\right]^2\right\} \qquad \forall x$$

$$C_{jj'}(\mathbf{h}) = \mathrm{E}\left\{\left[Z_j(\mathbf{x}_i) - m_j\right]\left[Z_{j'}(\mathbf{x}_i + \mathbf{h}) - m_{j'}\right]\right\} \qquad \forall x$$

$$\gamma_{jj'}(\mathbf{h}) = \mathrm{E}\left\{\left[Z_j(x_i + \mathbf{h}) - Z_j(x_i)\right]\left[Z_{j'}(x_i + \mathbf{h}) - Z_{j'}(x_i)\right]\right\}$$

TEORIA DAS VARIÁVEIS REGIONALIZADAS



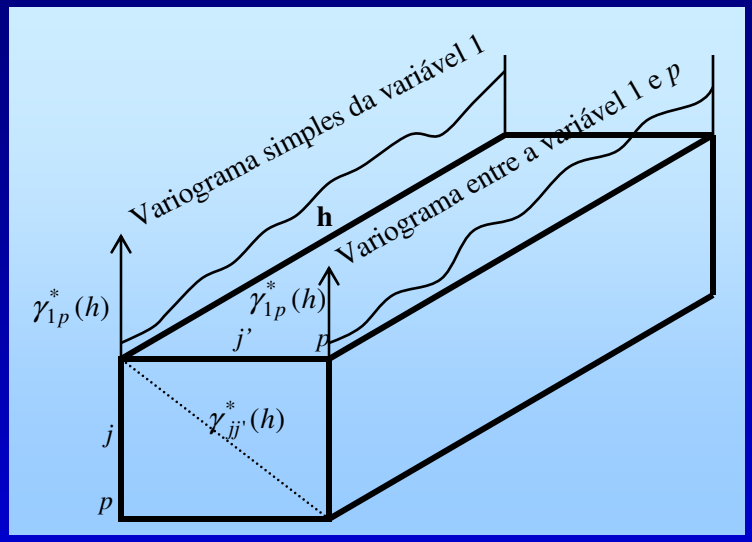
Estacionaridade de 2ª ordem

$$\gamma_{jj'}(\mathbf{h}) = C_{jj'}(0) - \frac{1}{2}\left[C_{jj'}(\mathbf{h}) + C_{j'j}(\mathbf{h})\right]$$

$$\gamma_{jj}(\mathbf{h}) = C_{jj}(0) - C_{jj}(\mathbf{h})$$

O variograma cruzado é uma função mais *pobre* do que a covariância que não pode no entanto ser estimada sem enviezamento

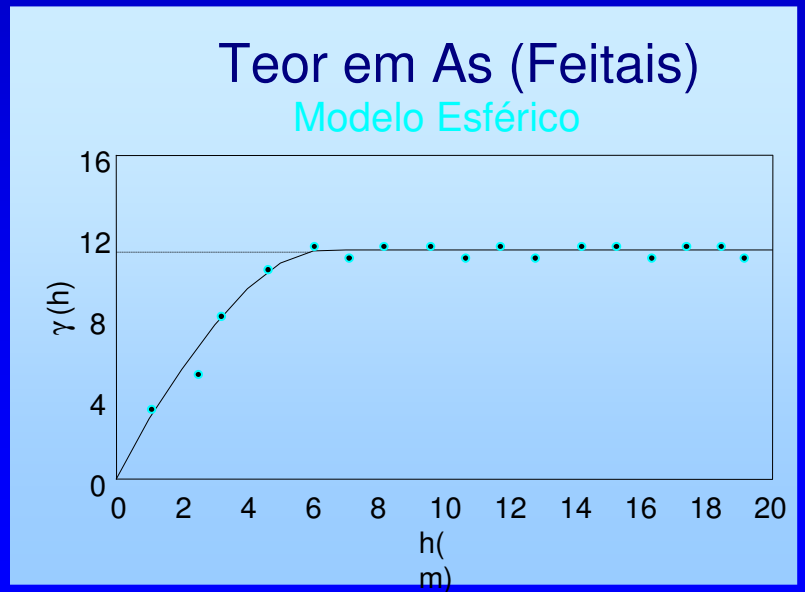
MODELOS DE CORREGIONALIZAÇÃO



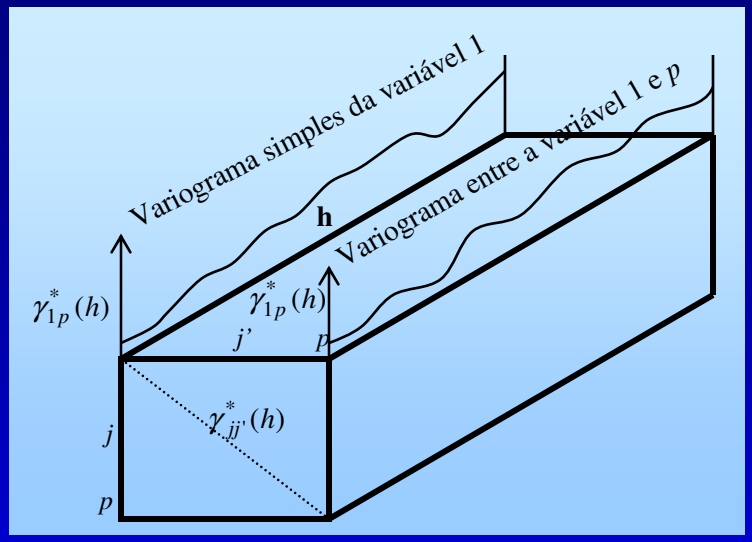
- Modelar cada um dos variogramas
- Modelar cada uma das matrizes

Modelos teóricos de variogramas

- Esférico
- Exponencial
- Gaussiano



MODELOS DE CORREGIONALIZAÇÃO

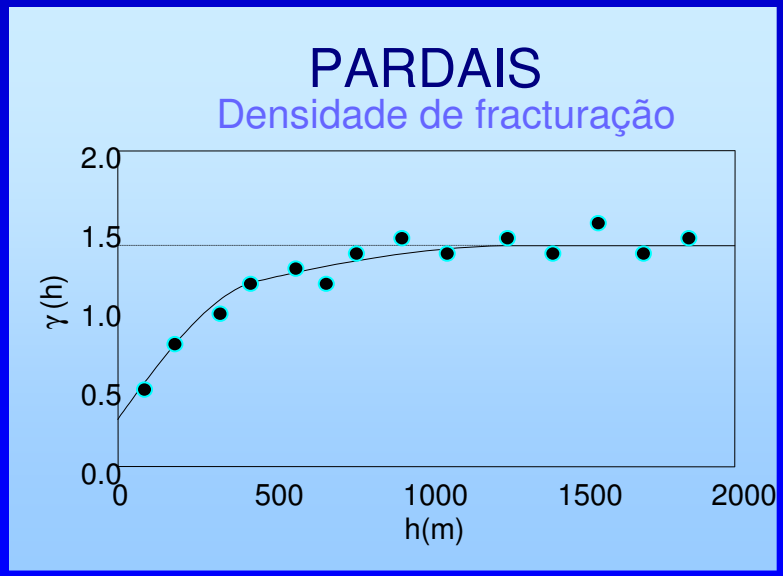


- Modelar cada um dos variogramas
- Modelar cada uma das matrizes

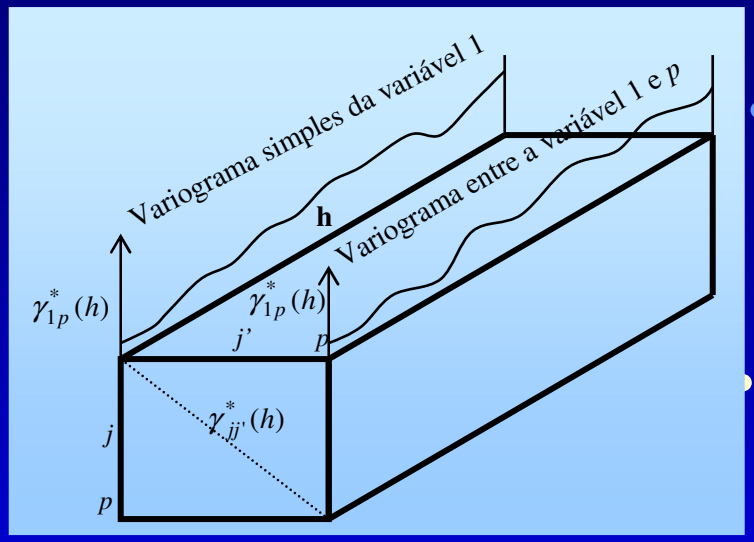
Modelos teóricos de variogramas

- Estruturas sobrepostas

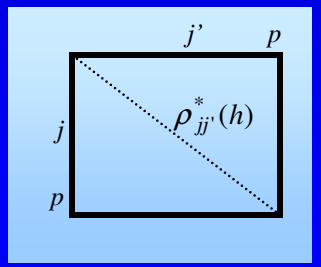
$$\gamma(\mathbf{h}) = \sum_{u=0}^{N^e-1} b^u \gamma^u(\mathbf{h})$$



MODELOS DE CORREGIONALIZAÇÃO



- Modelar cada um dos variogramas
- Modelar cada uma das matrizes

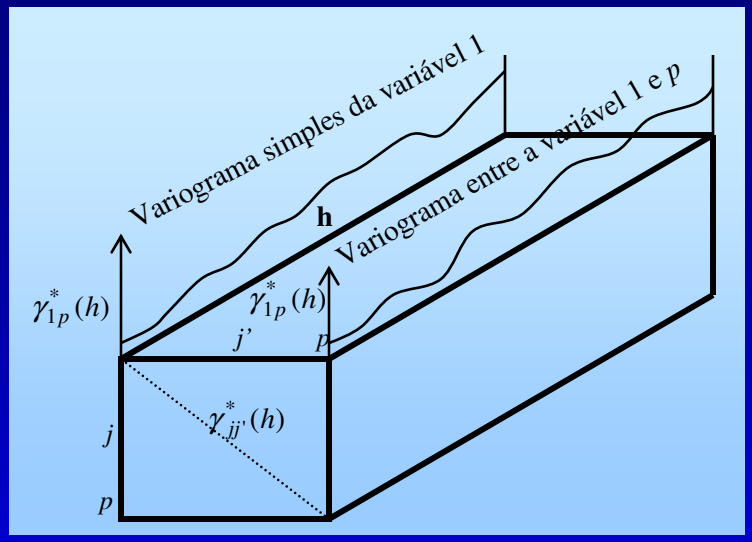


Corregionalização Intrínseca

$$\gamma_{jj'}(\mathbf{h}) = \sum_{u=0}^{N^e-1} b^u_{jj'} \gamma^u(\mathbf{h})$$

$$b^u_{jj'} = b_{jj'} \beta^u$$

MODELOS DE CORREGIONALIZAÇÃO

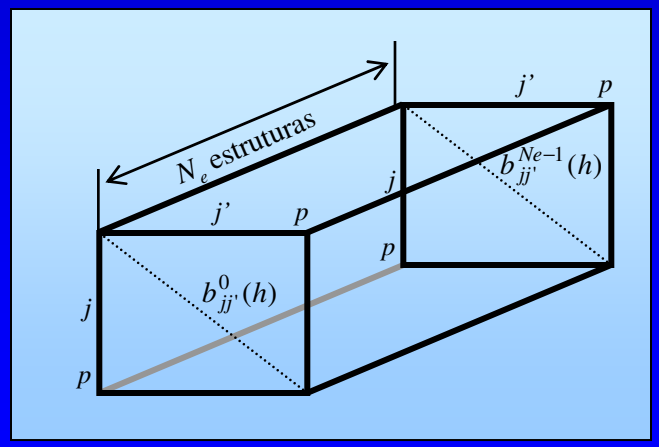


- Modelar cada um dos variogramas
- Modelar cada uma das matrizes

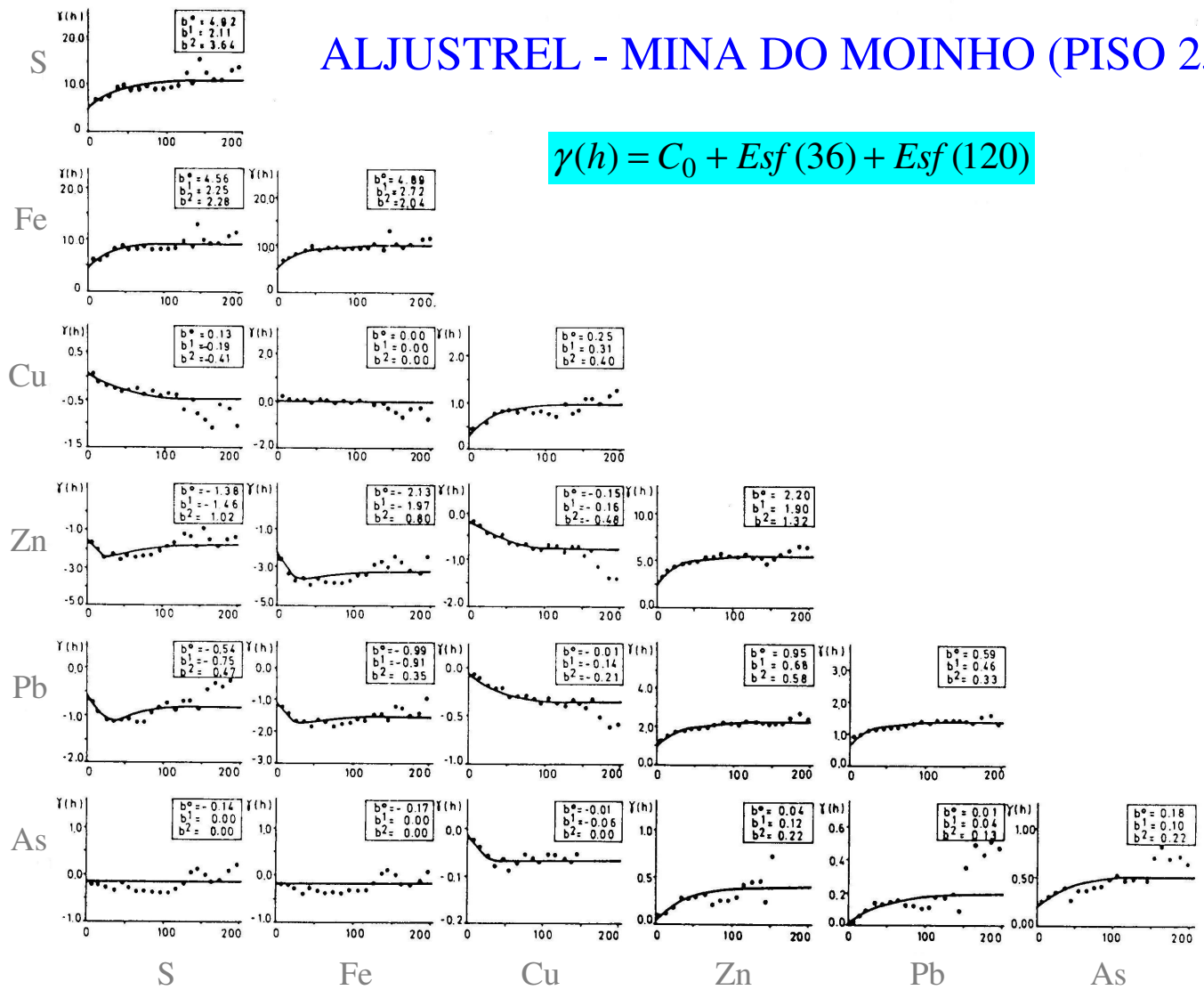
Corregionalização Linear

$$\gamma_{jj'}(\mathbf{h}) = \sum_{u=0}^{N^e-1} b^u_{jj'} \gamma^u(\mathbf{h})$$

$$\sigma^2_{jj'} = \sum_{u=0}^{N^e-1} b^u_{jj'}$$



MODELO LINEAR DE CORREGIONALIZAÇÃO

ALJUSTREL - MINA DO MOINHO (PISO 255)

$$\gamma(h) = C_0 + Esf(36) + Esf(120)$$