Camada equivalente aplicada ao processamento e interpretação de dados de campos potenciais

Vanderlei C. Oliveira Jr.

2016

Distúrbio de gravidade (parte B)

Vanderlei C. Oliveira Jr.

2016

$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$

Vetor distúrbio de gravidade

$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$

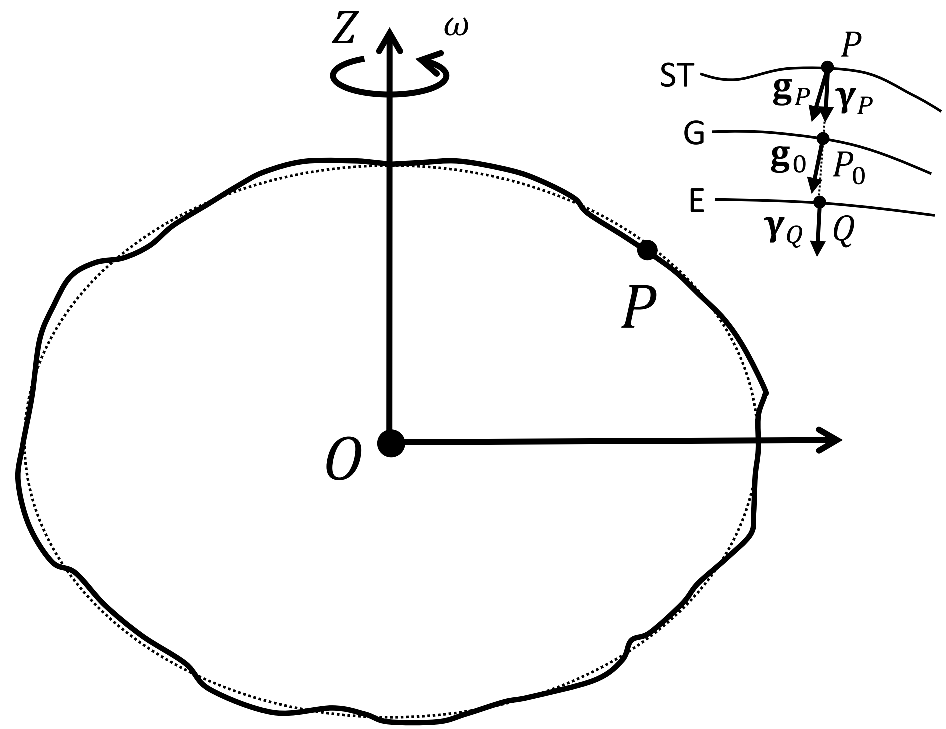
Vetor anomalia de gravidade

$\delta g_P = g_P - \gamma_P$

Distúrbio de gravidade

$\Delta g_P = g_0 - \gamma_Q$

Anomalia de gravidade



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

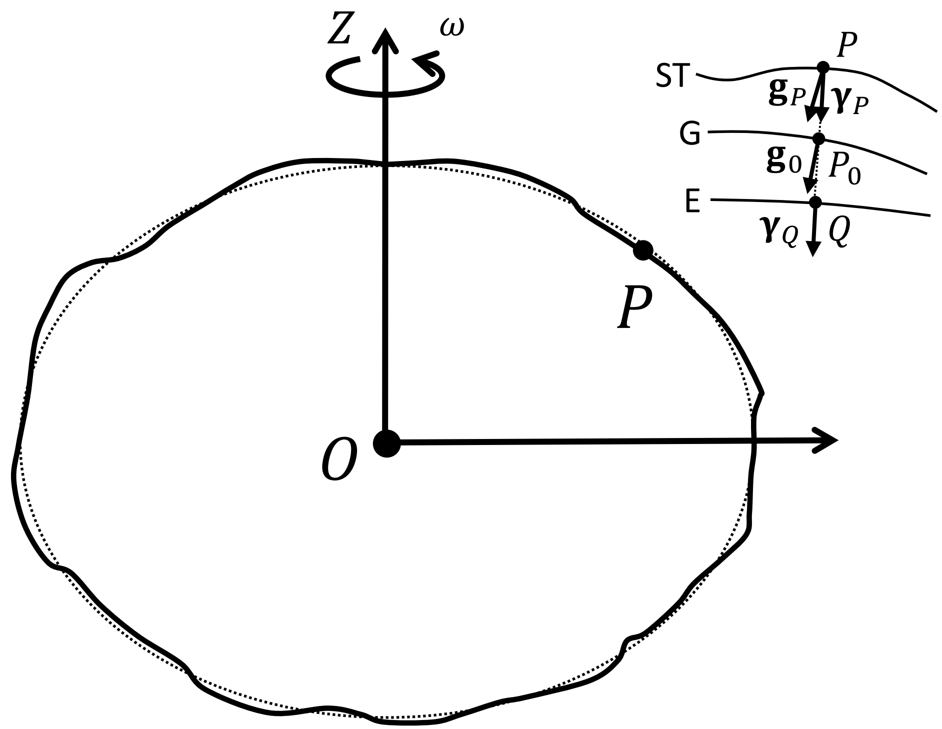
Anomalia de gravidade

Vetor gravidade normal

$$\begin{aligned} \boldsymbol{\gamma}_P &= \nabla \widetilde{W}_P \\ &= \nabla U_P + \nabla \Phi_P \end{aligned}$$

Vetor gravidade

$$\begin{aligned} \mathbf{g}_P &= \nabla W_P \\ &= \nabla V_P + \nabla \Phi_P \end{aligned}$$



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

Anomalia de gravidade

Vetor gravidade normal

$$\boldsymbol{\gamma}_P = \nabla \widetilde{W}_P = \nabla U_P + \nabla \Phi_P$$

Vetor gravidade

$$\mathbf{g}_P = \nabla W_P = \nabla V_P + \nabla \Phi_P$$

Potencial de gravidade normal

$$\widetilde{W}_P = U_P + \Phi_P$$

Potencial de gravidade

$$W_P = V_P + \Phi_P$$

Potencial centrífugo

$$\Phi_P = \frac{10^5}{2}\omega^2(X^2 + Y^2)$$

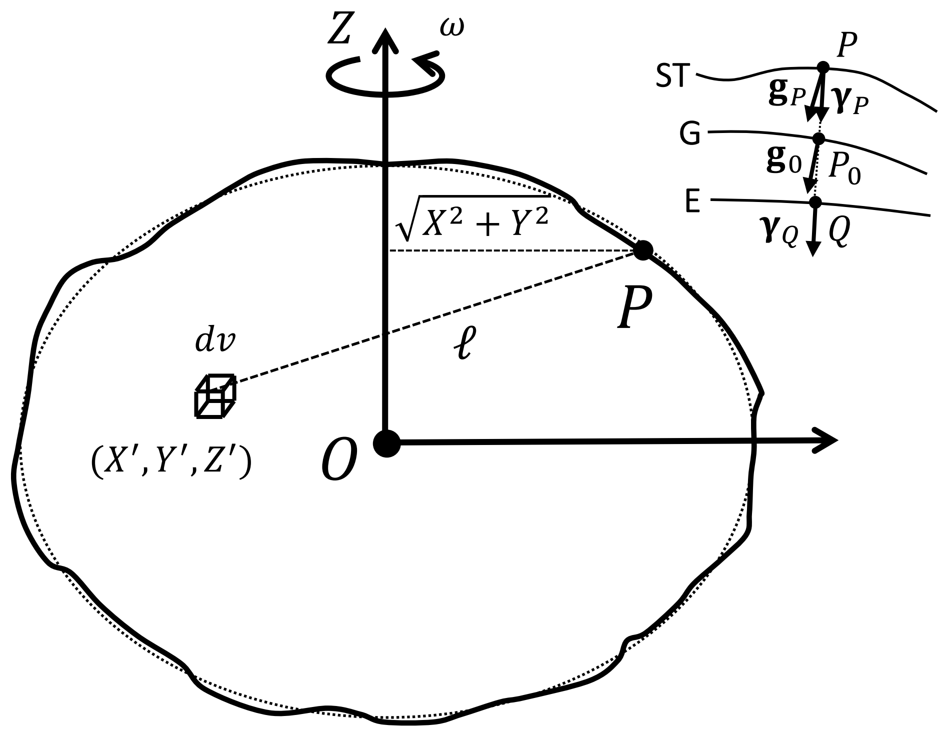
Potencial gravitacional normal

$$U_P = \kappa_g \iiint \frac{\tilde{\rho}}{\ell} dv$$

Potencial gravitacional

$$V_P = \kappa_g \iiint \frac{\rho}{\ell} dv$$

$$\kappa_g = 10^5 G$$



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

Anomalia de gravidade

Vale lembrar que as derivadas são calculadas em relação às variáveis (X, Y, Z)

Vetor gravidade normal

$$\boldsymbol{\gamma}_P = \nabla \widetilde{W}_P = \nabla U_P + \nabla \Phi_P$$

Vetor gravidade

$$\mathbf{g}_P = \nabla W_P = \nabla V_P + \nabla \Phi_P$$

Potencial de gravidade normal

$$\widetilde{W}_P = U_P + \Phi_P$$

Potencial de gravidade

$$W_P = V_P + \Phi_P$$

Potencial centrífugo

$$\Phi_P = \frac{10^5}{2}\omega^2(X^2 + Y^2)$$

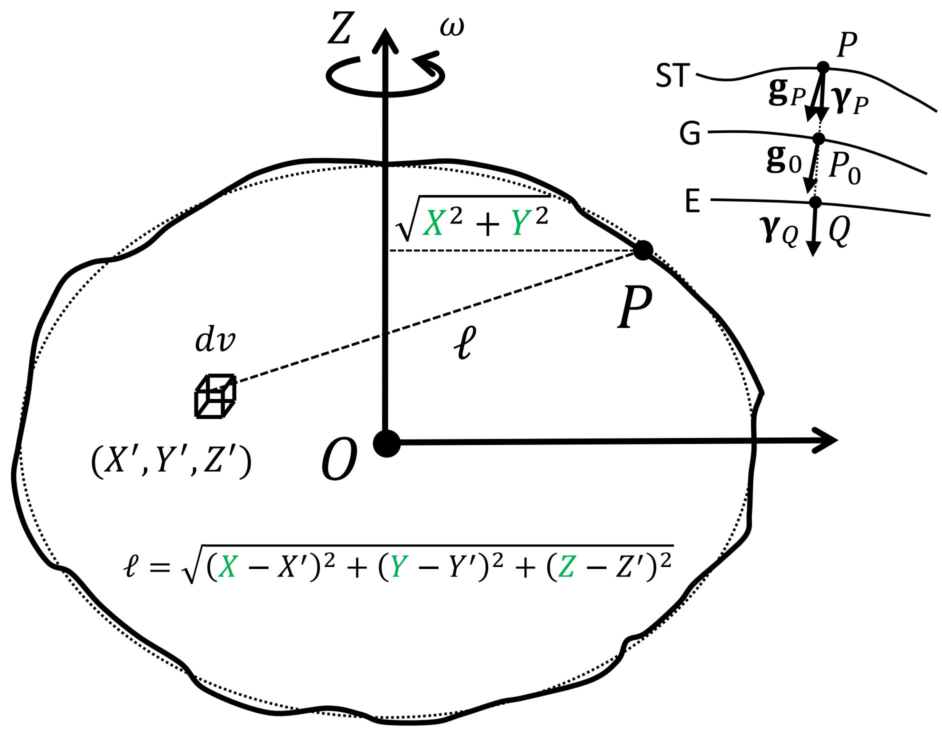
Potencial gravitacional normal

$$U_P = \kappa_g \iiint \frac{\tilde{\rho}}{\ell} dv$$

Potencial gravitacional

$$V_P = \kappa_g \iiint \frac{\rho}{\ell} dv$$

$$\kappa_g = 10^5 G$$



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

Anomalia de gravidade

Vetor gravidade normal

$$\begin{aligned}\boldsymbol{\gamma}_P &= \nabla \widetilde{W}_P \\ &= \nabla U_P + \nabla \Phi_P\end{aligned}$$

Vetor gravidade

$$\begin{aligned}\mathbf{g}_P &= \nabla W_P \\ &= \nabla V_P + \nabla \Phi_P\end{aligned}$$

Potencial de gravidade normal

$$\widetilde{W}_P = U_P + \Phi_P$$

Potencial de gravidade

$$W_P = V_P + \Phi_P$$

Potencial centrífugo

$$\Phi_P = \frac{10^5}{2}\omega^2(X^2 + Y^2)$$

Potencial gravitacional normal

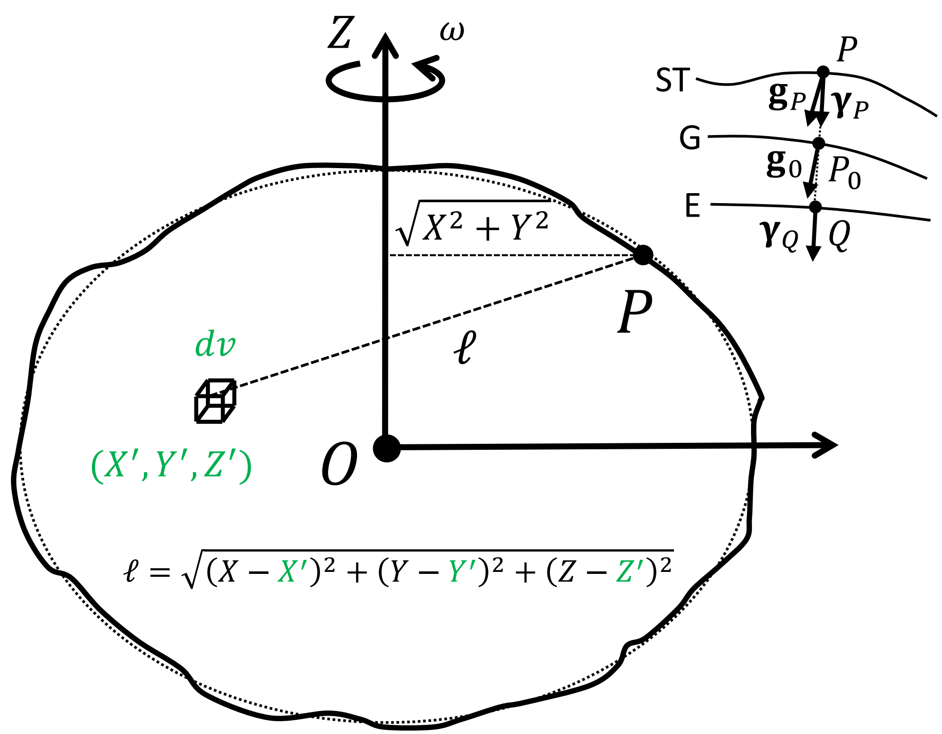
$$U_P = \kappa_g \iiint \frac{\tilde{\rho}}{\ell}\, dv$$

Potencial gravitacional

$$V_P = \kappa_g \iiint \frac{\rho}{\ell}\, dv$$

$$\kappa_g = 10^5 G$$

As distribuições de densidade são funções das variáveis de integração (X', Y', Z')



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

Anomalia de gravidade

$$U_P = \kappa_g \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \frac{\tilde{\rho}}{\ell} dv$$

Considere que $\tilde{\rho}$ se anula fora do volume da Terra Normal

Considere que ρ se anula fora do volume da Terra

$$V_P = \kappa_g \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \frac{\rho}{\ell} dv$$

Vetor gravidade normal

$$\boldsymbol{\gamma}_P = \nabla \widetilde{W}_P = \nabla U_P + \nabla \Phi_P$$

Vetor gravidade

$$\mathbf{g}_P = \nabla W_P = \nabla V_P + \nabla \Phi_P$$

Potencial de gravidade normal

$$\widetilde{W}_P = U_P + \Phi_P$$

Potencial de gravidade

$$W_P = V_P + \Phi_P$$

Potencial centrífugo

$$\Phi_P = \frac{10^5}{2} \omega^2 (X^2 + Y^2)$$

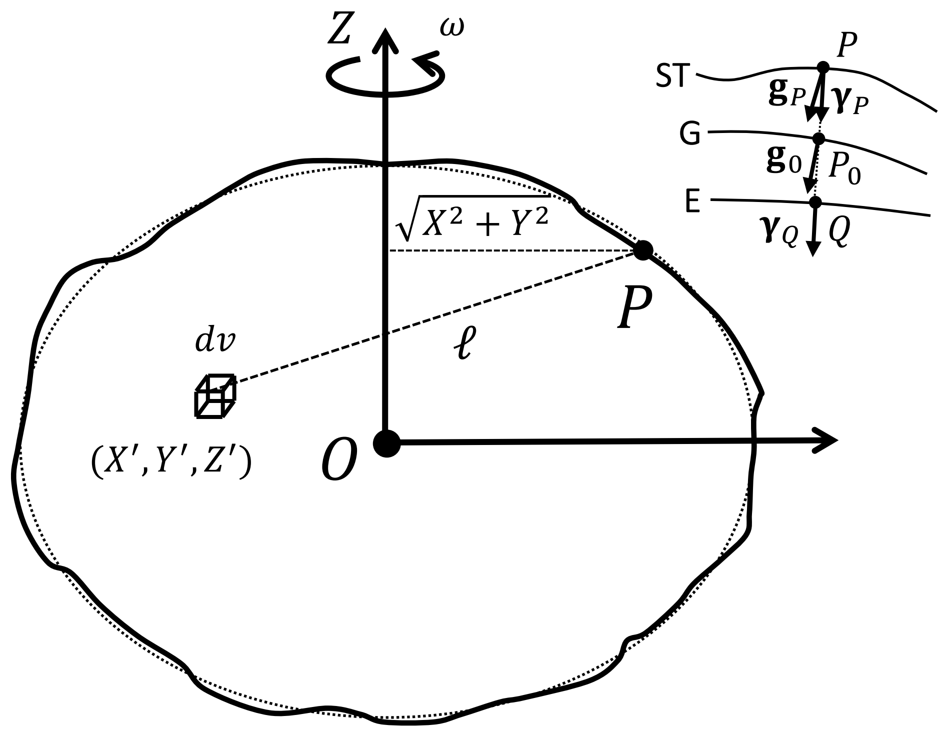
Potencial gravitacional normal

$$U_P = \kappa_g \iiint \frac{\tilde{\rho}}{\ell} dv$$

Potencial gravitacional

$$V_P = \kappa_g \iiint \frac{\rho}{\ell} dv$$

$$\kappa_g = 10^5 G$$



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

Anomalia de gravidade

Vetor gravidade normal

$$\begin{aligned}\boldsymbol{\gamma}_P &= \nabla \widetilde{W}_P \\ &= \nabla U_P + \nabla \Phi_P\end{aligned}$$

Vetor gravidade

$$\begin{aligned}\mathbf{g}_P &= \nabla W_P \\ &= \nabla V_P + \nabla \Phi_P\end{aligned}$$

Potencial de gravidade normal

$$\widetilde{W}_P = U_P + \Phi_P$$

Potencial de gravidade

$$W_P = V_P + \Phi_P$$

Potencial centrífugo

$$\Phi_P = \frac{10^5}{2}\omega^2(X^2 + Y^2)$$

Potencial gravitacional normal

$$U_P = \kappa_g \iiint \frac{\tilde{\rho}}{\ell} dv$$

Potencial gravitacional

$$V_P = \kappa_g \iiint \frac{\rho}{\ell} dv$$

$$\kappa_g = 10^5 G$$

$$U_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \frac{\tilde{\rho}}{\ell} dv$$

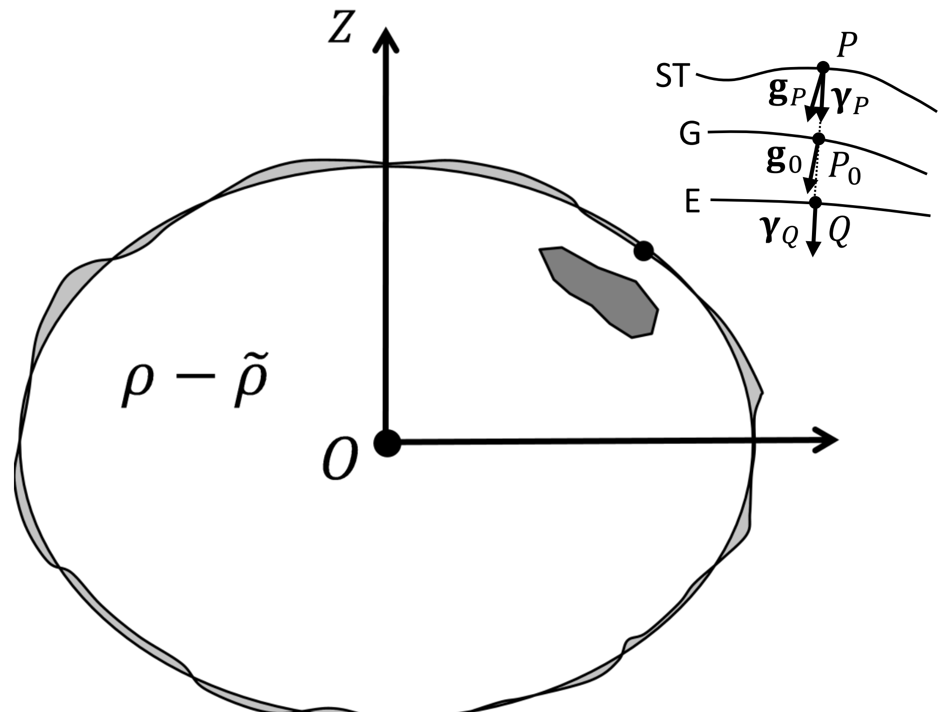
Considere que ρ se anula fora do volume da Terra

Considere que $\tilde{\rho}$ se anula fora do volume da Terra Normal

$$V_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \frac{\rho}{\ell} dv$$

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} (\rho - \tilde{\rho}) \nabla \frac{1}{\ell} dv$$

Representa a atração gravitacional exercida pelas **massas anômalas** ou **fontes gravimétricas**!



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\boldsymbol{\Delta}\mathbf{g}_P = \mathbf{g}_0 - \boldsymbol{\gamma}_Q$$

Vetor anomalia de gravidade

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

$$\Delta g_P = g_0 - \gamma_Q$$

Anomalia de gravidade

Vetor gravidade normal

$$\boldsymbol{\gamma}_P = \nabla \widetilde{W}_P = \nabla U_P + \nabla \Phi_P$$

Vetor gravidade

$$\mathbf{g}_P = \nabla W_P = \nabla V_P + \nabla \Phi_P$$

Potencial de gravidade normal

$$\widetilde{W}_P = U_P + \Phi_P$$

Potencial de gravidade

$$W_P = V_P + \Phi_P$$

Potencial centrífugo

$$\Phi_P = \frac{10^5}{2}\omega^2(X^2 + Y^2)$$

Potencial gravitacional normal

$$U_P = \kappa_g \iiint \frac{\tilde{\rho}}{\ell} dv$$

Potencial gravitacional

$$V_P = \kappa_g \iiint \frac{\rho}{\ell} dv$$

$$\kappa_g = 10^5 G$$

$$U_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \frac{\tilde{\rho}}{\ell} dv$$

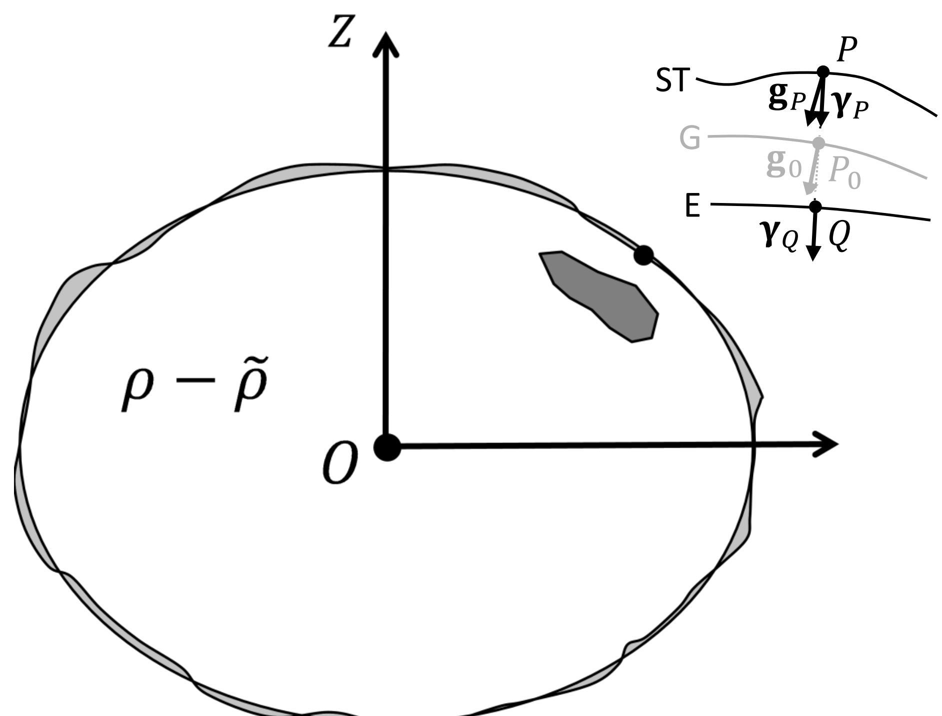
Considere que ρ se anula fora do volume da Terra

Considere que $\tilde{\rho}$ se anula fora do volume da Terra Normal

$$V_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \frac{\rho}{\ell} dv$$

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} (\rho - \tilde{\rho}) \nabla \frac{1}{\ell} dv$$

Representa a atração gravitacional exercida pelas **massas anômalas** ou **fontes gravimétricas**!



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

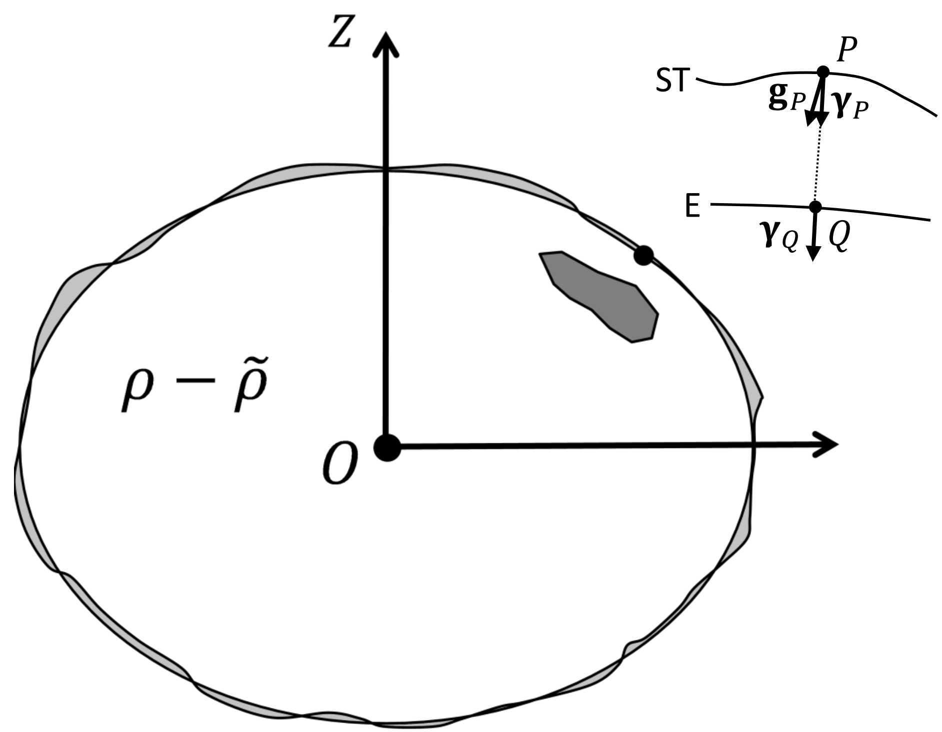
Distúrbio de gravidade

$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} (\rho - \tilde{\rho}) \nabla \frac{1}{\ell} dv$$

Representa a atração gravitacional exercida pelas **massas anômalas** ou **fontes gravimétricas**!



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

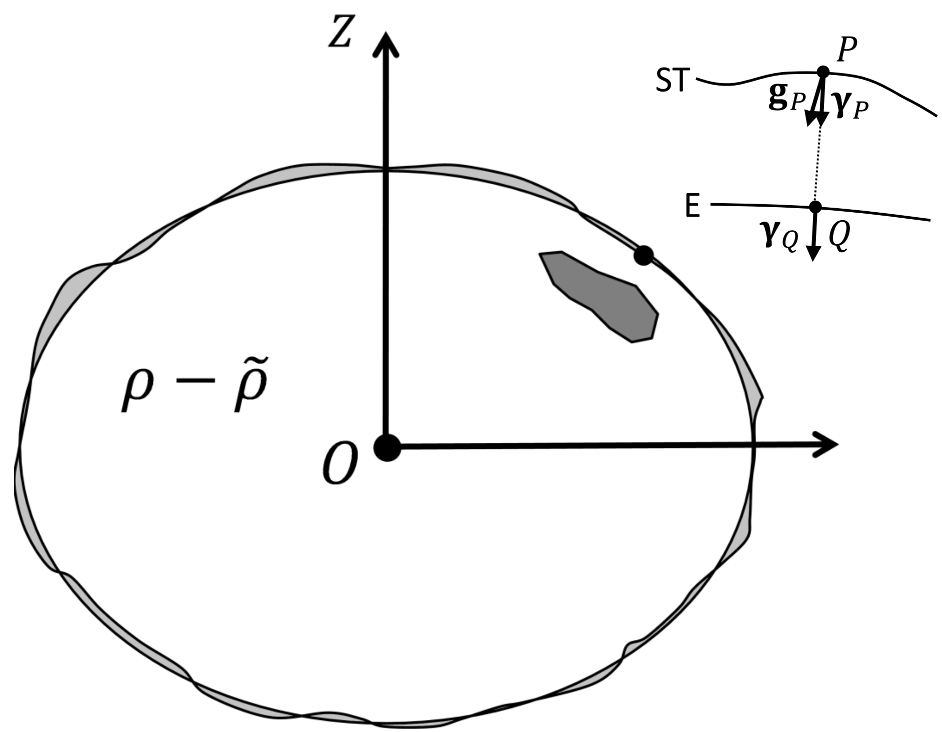
$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

Esta integral pode ser reescrita de tal forma que represente o efeito de cada fonte, separadamente

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} (\rho - \tilde{\rho}) \nabla \frac{1}{\ell} \, dv$$

Representa a atração gravitacional exercida pelas **massas anômalas** ou **fontes gravimétricas**!



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

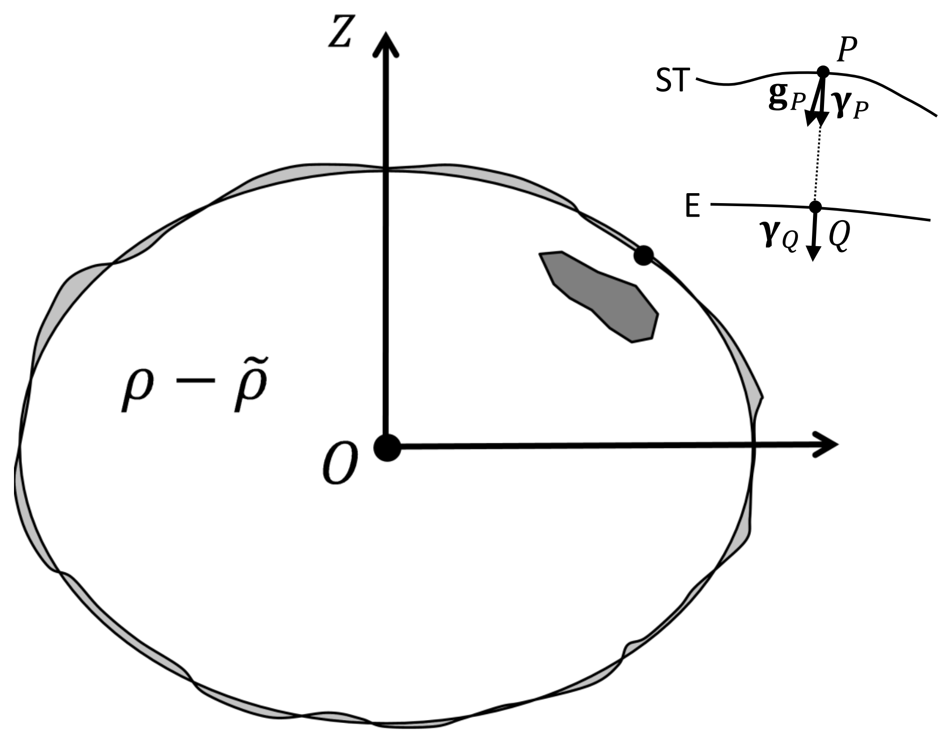
Distúrbio de gravidade

$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

Contraste de densidade no interior da j-ésima fonte

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} dv$$



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

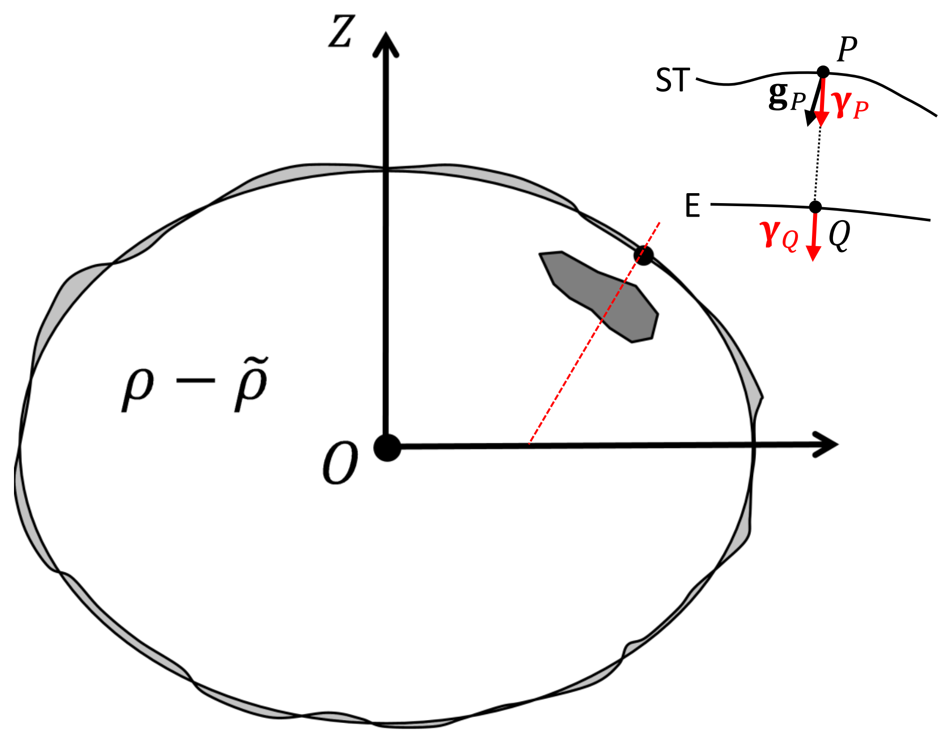
Distúrbio de gravidade

$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} dv$$

Em geral, considera-se que a direção do vetor gravidade normal no ponto P é igual a direção do vetor gravidade normal no ponto Q. No sistema de coordenadas geodésicas, esta direção é constante ao longo da normal ao elipsoide



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

Distúrbio de gravidade

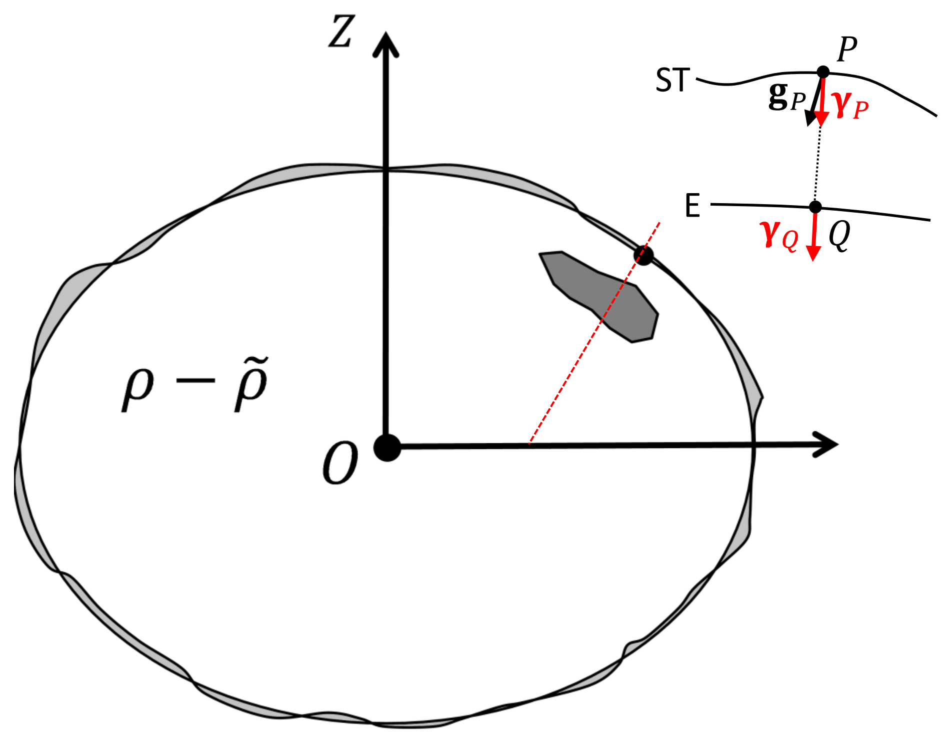
$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} dv$$

$$\boldsymbol{\gamma}_P = \gamma_P \hat{\boldsymbol{\gamma}}_0$$

Direção constante normal ao elipsoide



Em geral, considera-se que a direção do vetor gravidade normal no ponto P é igual a direção do vetor gravidade normal no ponto Q. No sistema de coordenadas geodésicas, esta direção é constante ao longo da normal ao elipsoide

$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

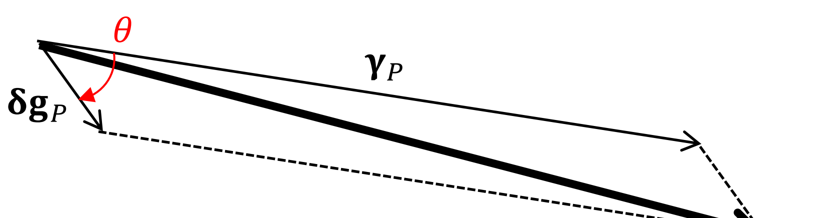
Distúrbio de gravidade

$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

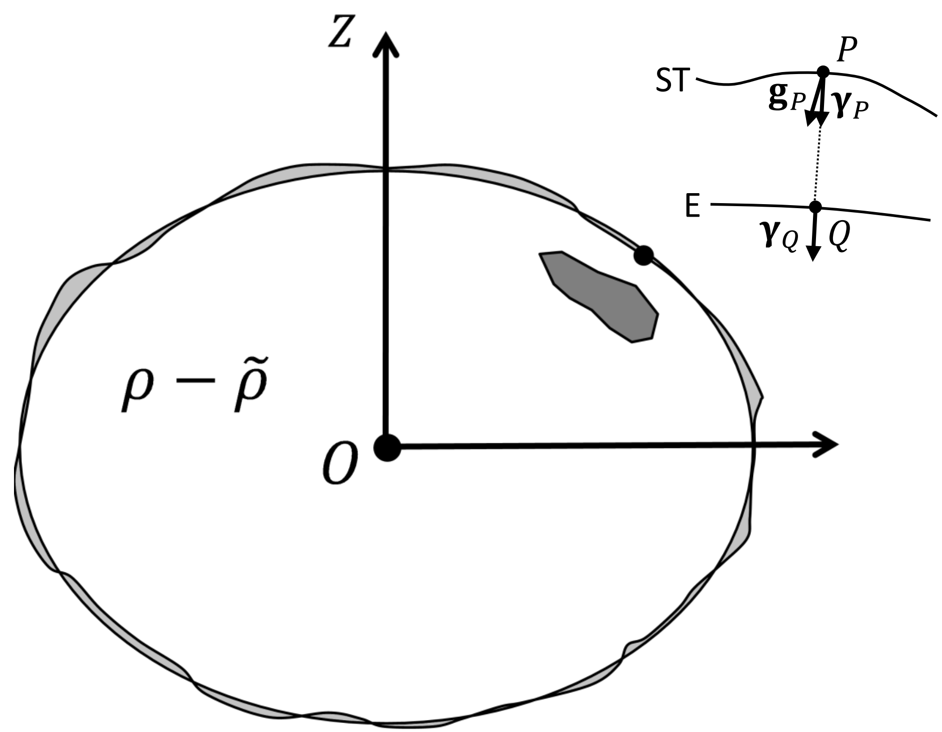
Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} \, dv$$

$$\boldsymbol{\gamma}_P = \gamma_P \hat{\boldsymbol{\gamma}}_0$$



Tal como no caso magnético



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

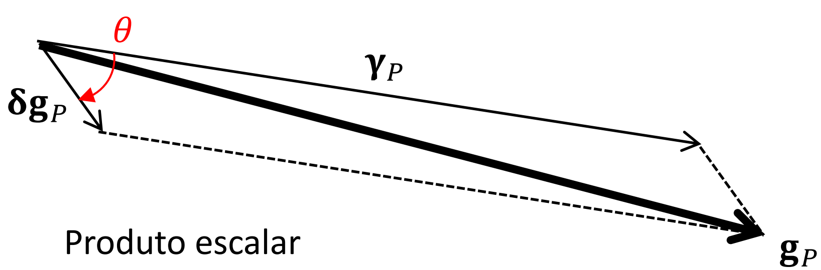
Distúrbio de gravidade

$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} dv$$

$$\boldsymbol{\gamma}_P = \gamma_P \hat{\boldsymbol{\gamma}}_0$$

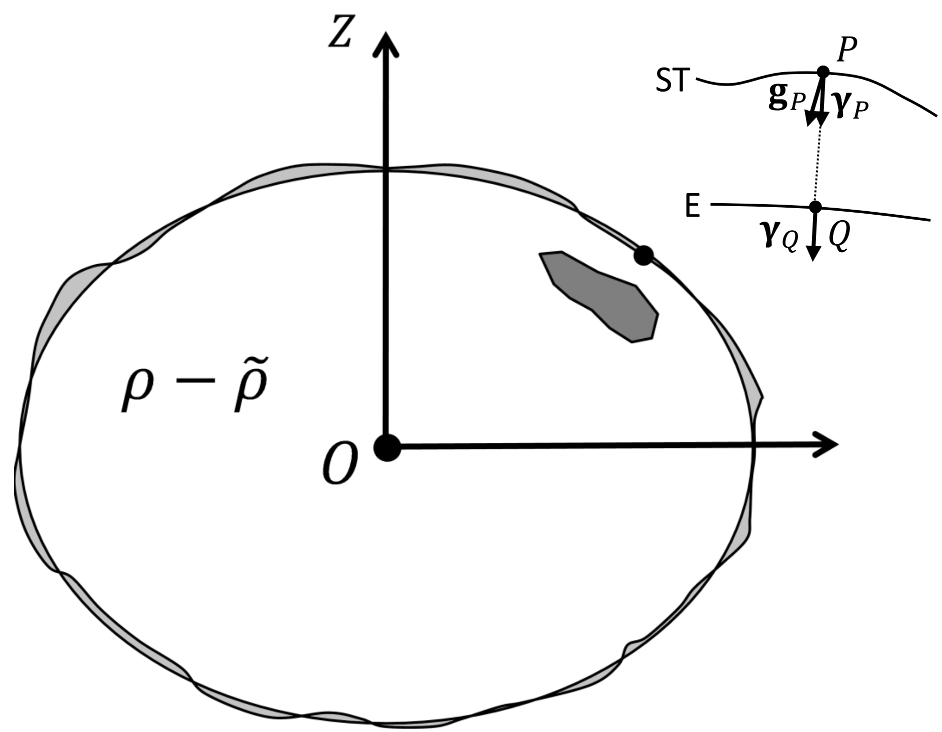


Produto escalar

$$\boxed{\begin{aligned}\mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta\end{aligned}}$$

$$g_P \approx \gamma_P + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_P$$



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

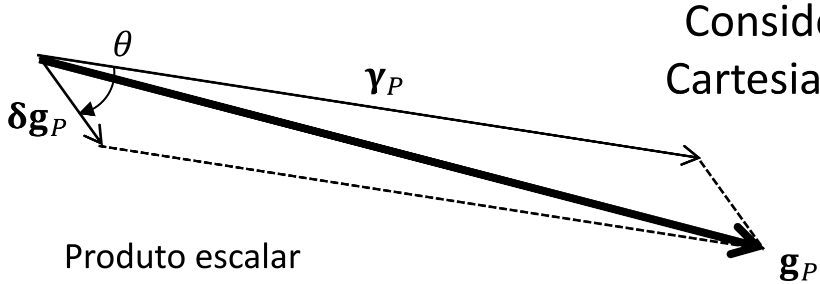
Distúrbio de gravidade

$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} \, dv$$

$$\boldsymbol{\gamma}_P = \gamma_P \hat{\boldsymbol{\gamma}}_0$$



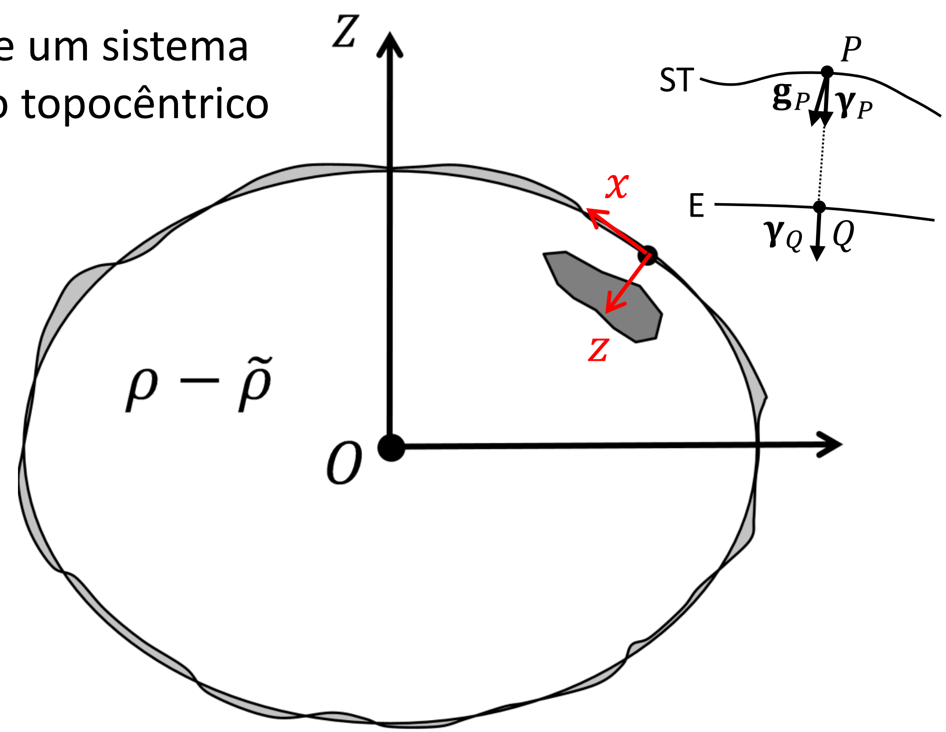
Produto escalar

$$\boxed{\begin{aligned}\mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w \cos\theta\end{aligned}}$$

$$g_P \approx \gamma_P + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_P$$

Considere um sistema Cartesiano topocêntrico



$$\boldsymbol{\delta}\mathbf{g}_P = \mathbf{g}_P - \boldsymbol{\gamma}_P$$

Vetor distúrbio de gravidade

$$\mathbf{g}_P = \boldsymbol{\gamma}_P + \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P = g_P - \gamma_P$$

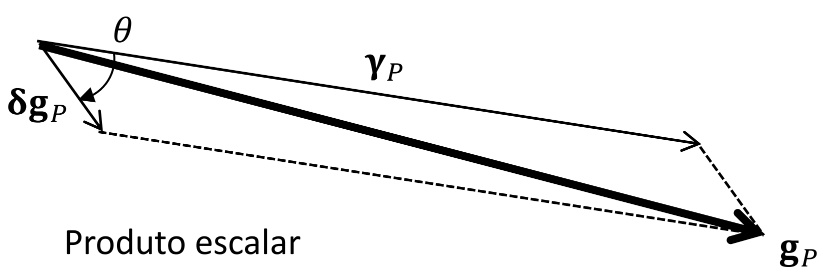
Distúrbio de gravidade

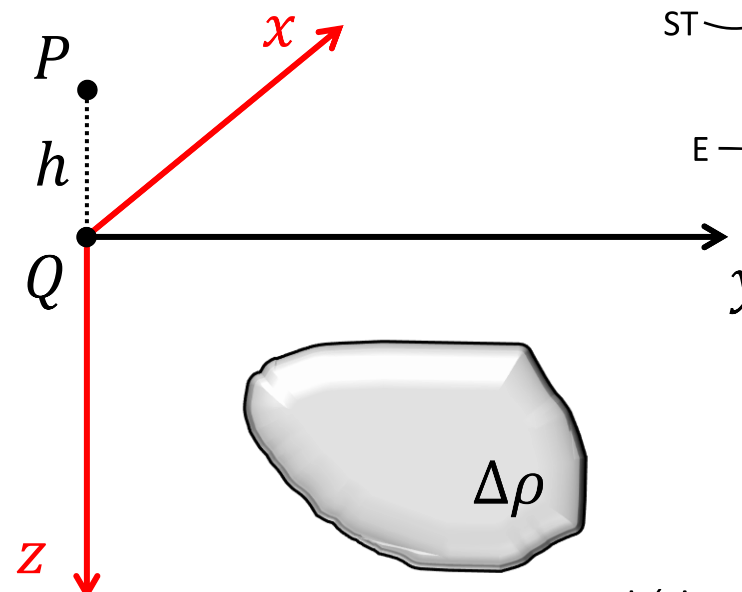
$$\gamma_P \gg \|\boldsymbol{\delta}\mathbf{g}_P\|$$

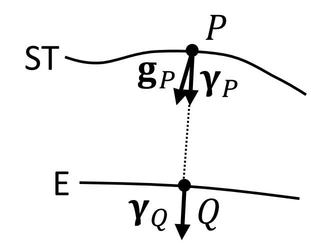
Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_P = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{\ell} dv$$

$$\boldsymbol{\gamma}_P = \gamma_P \hat{\boldsymbol{\gamma}}_0$$







Produto escalar

$$\boxed{\begin{aligned} \mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v \, w \, cos\theta \end{aligned}}$$

$$g_P \approx \gamma_P + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_P$$

$$\delta g_P \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_P$$

j-ésima fonte gravimétrica

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

$$\delta g_i = g_i - \gamma_i$$

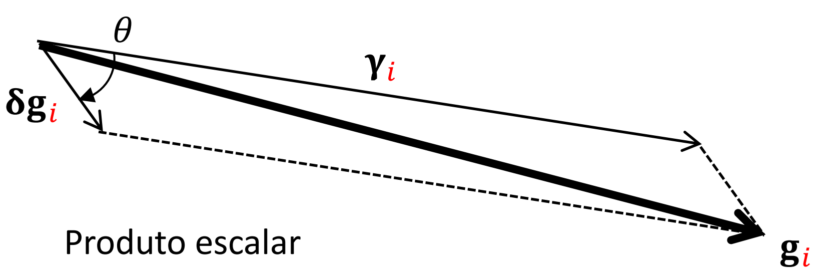
Distúrbio de gravidade

$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

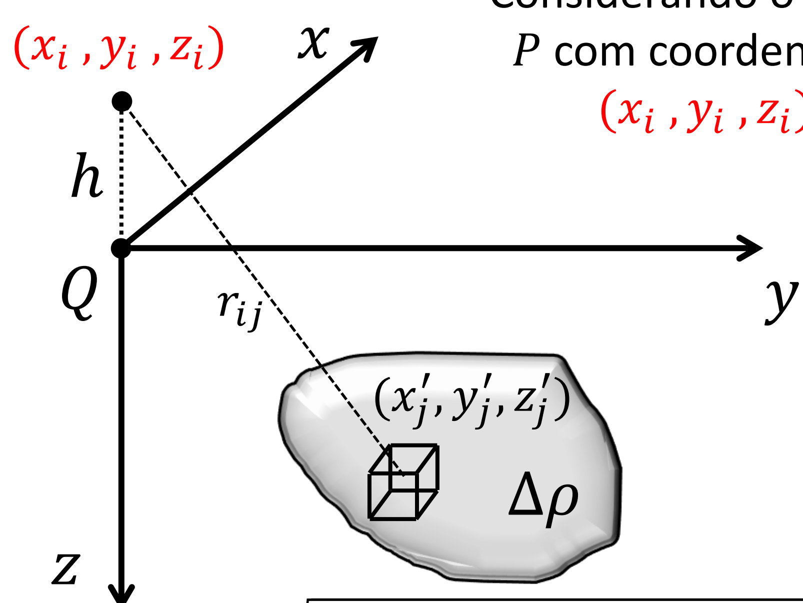
Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{r_{ij}} \, dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$



Considerando o ponto P com coordenadas $(x_i\,, y_i\,, z_i)$



Produto escalar

$$\boxed{\begin{aligned} \mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta \end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$

$$r_{ij} = \sqrt{\left(x_i - x'_j\right)^2 + \left(y_i - y'_j\right)^2 + \left(z_i - z'_j\right)^2}$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

Embora tudo esteja calculado na posição $(x_i\,, y_i\,, z_i)$, as equações também podem ser avaliadas em outros pontos próximos referidos a este mesmo sistema de coordenadas

$$\delta g_i = g_i - \gamma_i$$

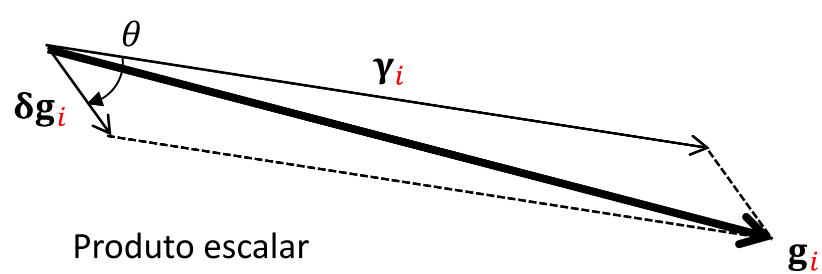
Distúrbio de gravidade

$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho\, \nabla \frac{1}{r_{ij}}\, dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$



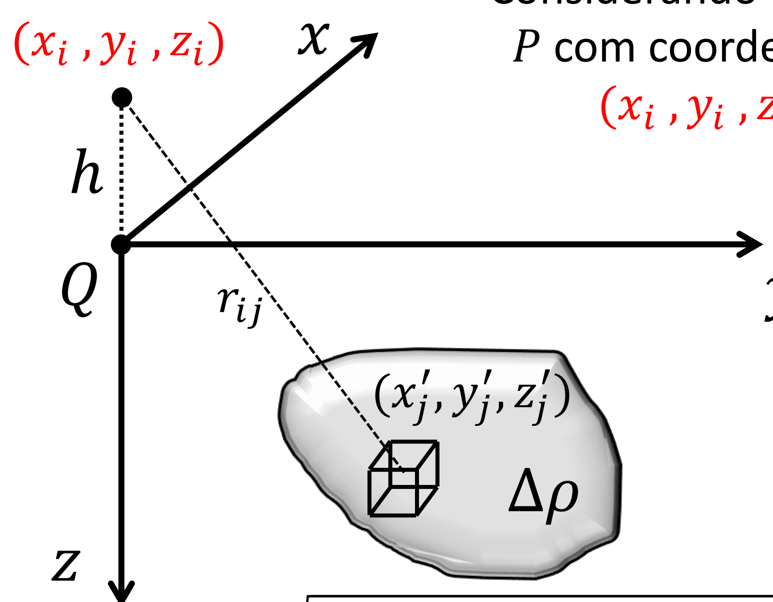
Produto escalar

$$\boxed{\begin{aligned} \mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta \end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$

Considerando o ponto P com coordenadas $(x_i\,, y_i\,, z_i)$



$$r_{ij} = \sqrt{\left(x_i - x_j'\right)^2 + \left(y_i - y_j'\right)^2 + \left(z_i - z_j'\right)^2}$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

Embora tudo esteja calculado na posição (x_i, y_i, z_i), as equações também podem ser avaliadas em outros pontos próximos referidos a este mesmo sistema de coordenadas

$$\delta g_i = g_i - \gamma_i$$

Distúrbio de gravidade

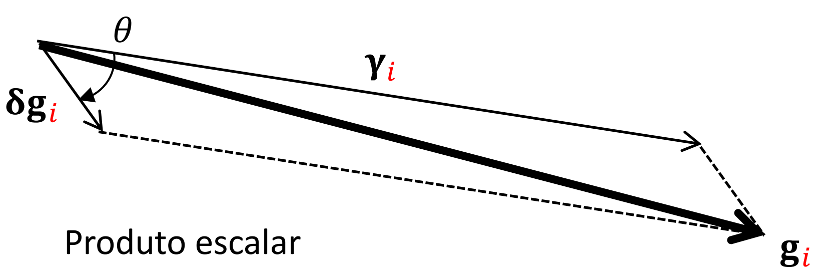
$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{r_{ij}} dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$

Neste sistema, as derivadas são calculadas em relação às coordenadas (x_i, y_i, z_i) do ponto de observação!



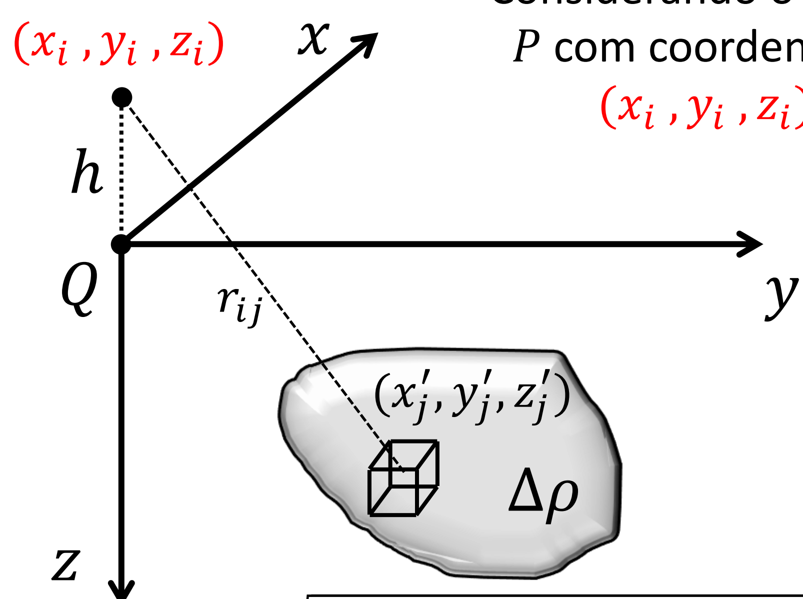
Produto escalar

$$\boxed{\begin{aligned}\mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta\end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$

Considerando o ponto P com coordenadas (x_i, y_i, z_i)



$$r_{ij} = \sqrt{(x_i - x_j')^2 + (y_i - y_j')^2 + (z_i - z_j')^2}$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

$$\delta g_i = g_i - \gamma_i$$

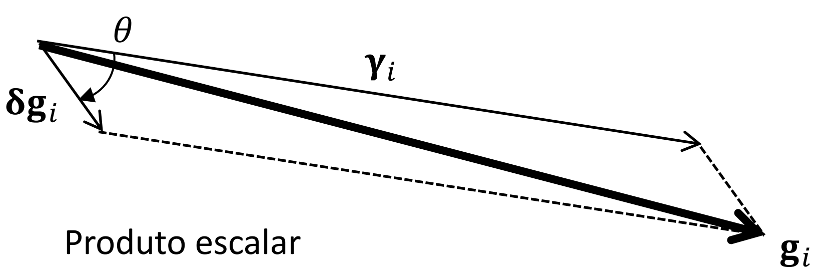
Distúrbio de gravidade

$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{r_{ij}} \, dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$

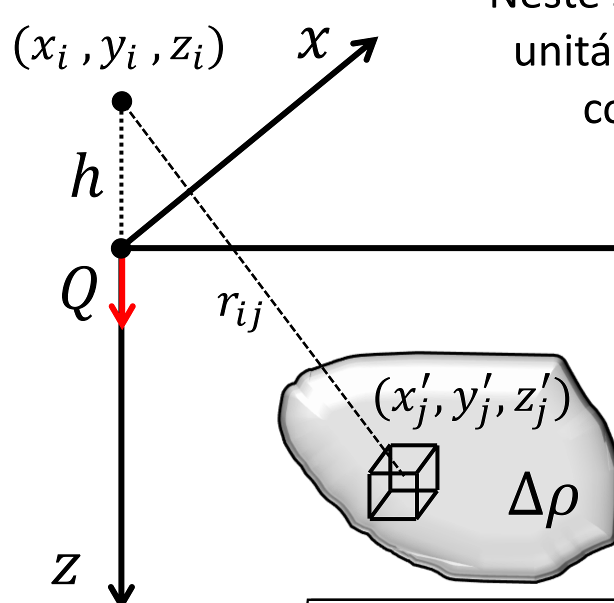


Produto escalar

$$\mathbf{v}^{\mathrm{T}}\mathbf{w} = v_x w_x + v_y w_y + v_z w_z = v \, w \cos\theta$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$



Neste sistema, o vetor unitário $\hat{\boldsymbol{\gamma}}_0$ coincide com o eixo z

$$r_{ij} = \sqrt{(x_i - x'_j)^2 + (y_i - y'_j)^2 + (z_i - z'_j)^2}$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

$$\delta g_i = g_i - \gamma_i$$

Distúrbio de gravidade

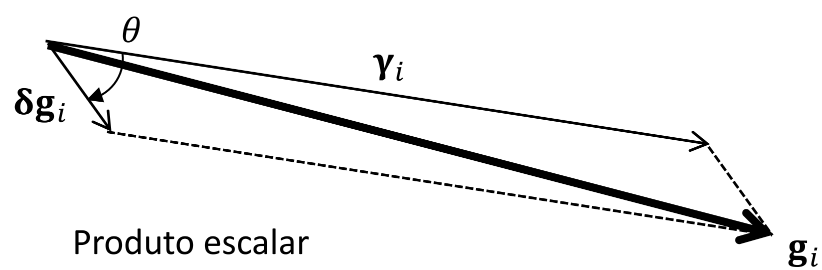
$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

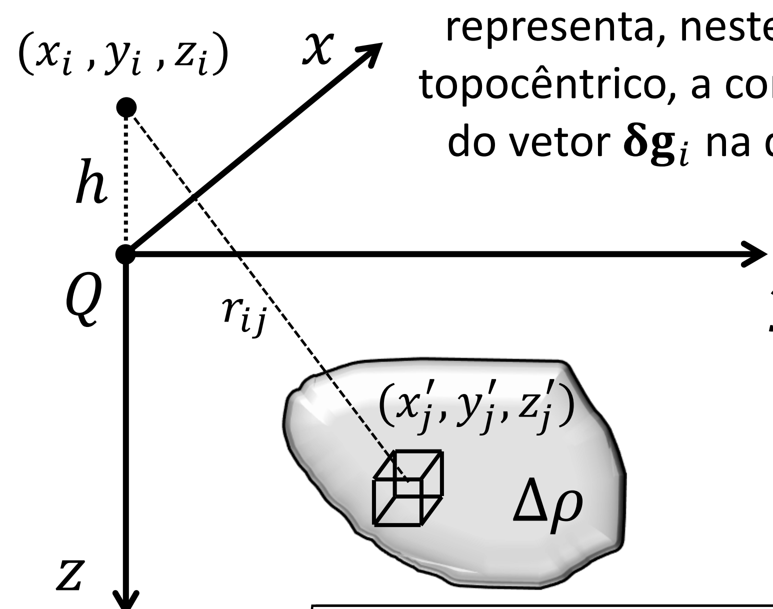
Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{r_{ij}} dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$

Consequentemente, o distúrbio de gravidade representa, neste sistema topocêntrico, a componente do vetor $\boldsymbol{\delta}\mathbf{g}_i$ na direção z





Produto escalar

$$\boxed{\begin{aligned} \mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v \, w \, cos\theta \end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$

$$r_{ij} = \sqrt{\left(x_i - x_j'\right)^2 + \left(y_i - y_j'\right)^2 + \left(z_i - z_j'\right)^2}$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

$$\delta g_i = g_i - \gamma_i$$

Distúrbio de gravidade

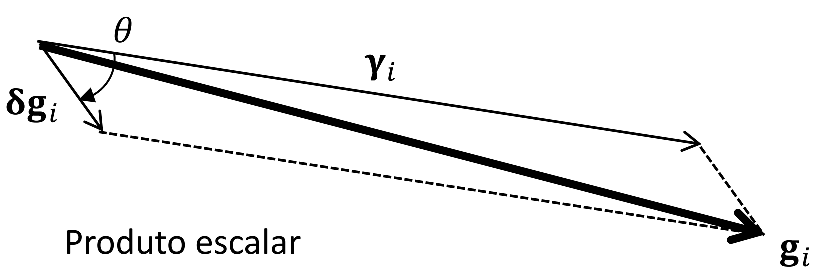
$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho \, \nabla \frac{1}{r_{ij}} \, dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$

Ou, analogamente, o distúrbio de gravidade representa a componente vertical da atração gravitacional exercida pelas fontes gravimétricas

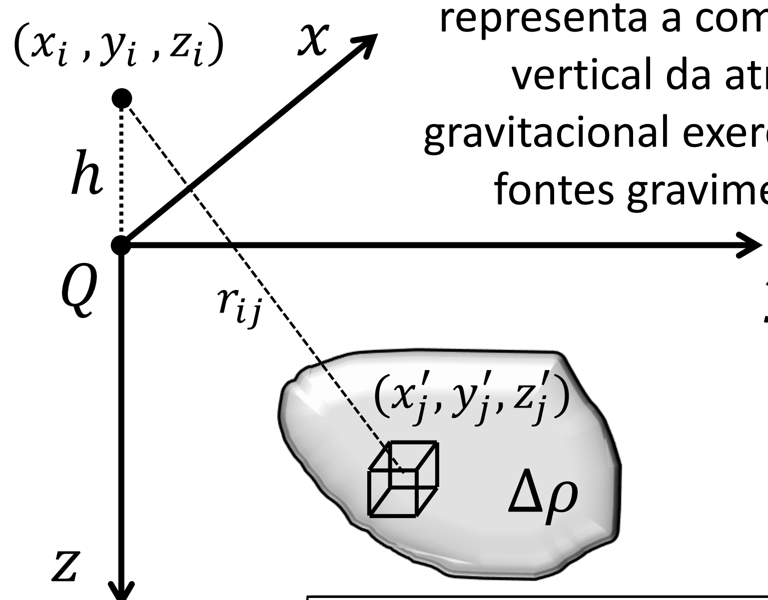


Produto escalar

$$\boxed{\begin{aligned}\mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta\end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$



$$r_{ij} = \sqrt{(x_i - x_j')^2 + (y_i - y_j')^2 + (z_i - z_j')^2}$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

$$\kappa_g = 10^5 G$$

$$\Phi_i^j = \iiint\limits_{v_j} \Delta\rho \frac{1}{r_{ij}} dv_j$$

$$\delta g_i \approx \kappa_g \sum_j \partial_z \Phi_i^j$$

$$\delta g_i = g_i - \gamma_i$$

Distúrbio de gravidade

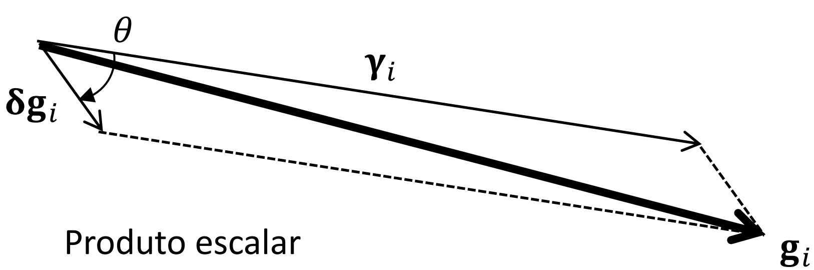
$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

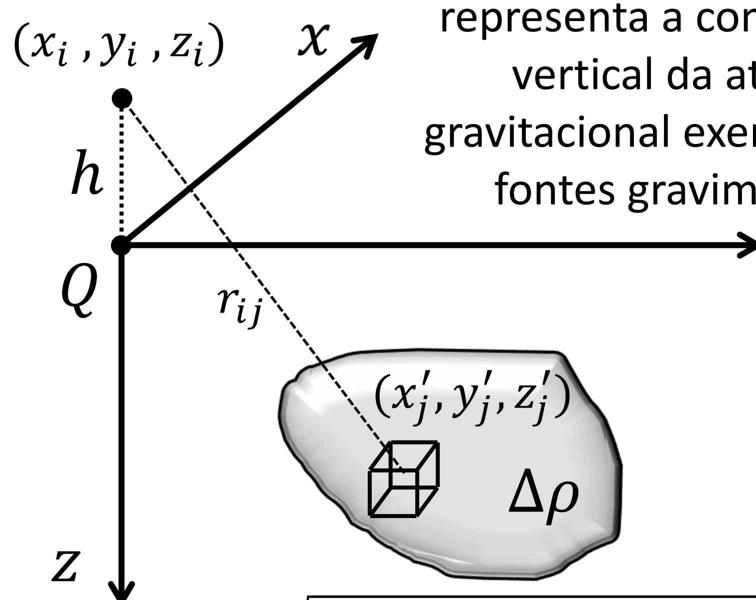
Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint\limits_{v_j} \Delta\rho \, \nabla \frac{1}{r_{ij}} dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$

Ou, analogamente, o distúrbio de gravidade representa a componente vertical da atração gravitacional exercida pelas fontes gravimétricas





Produto escalar

$$\boxed{\begin{aligned} \mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta \end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$r_{ij} = \sqrt{(x_i - x_j')^2 + (y_i - y_j')^2 + (z_i - z_j')^2}$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$

$$\boldsymbol{\delta}\mathbf{g}_i = \mathbf{g}_i - \boldsymbol{\gamma}_i$$

Vetor distúrbio de gravidade

$$\mathbf{g}_i = \boldsymbol{\gamma}_i + \boldsymbol{\delta}\mathbf{g}_i$$

[10^5 m³ kg⁻¹ s⁻²]

$$\kappa_g = 10^5 G$$

$$\Phi_i^j = \iiint_{v_j} \Delta\rho \frac{1}{r_{ij}} dv_j$$

[kg m⁻¹] [kg m⁻³] [m⁻¹]

$$\delta g_i \approx \kappa_g \sum_j \partial_z \Phi_i^j$$

[mGal] [kg m⁻²]

$$\delta g_i = g_i - \gamma_i$$

Distúrbio de gravidade

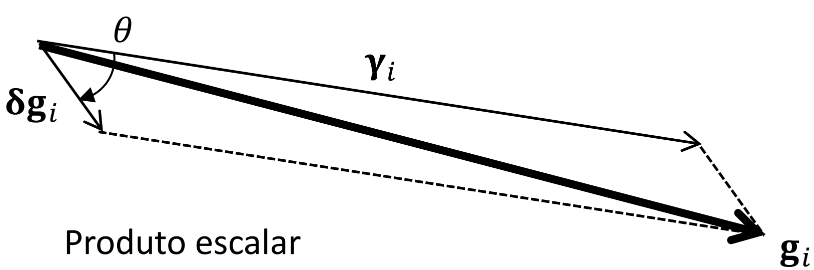
$$\gamma_i \gg \|\boldsymbol{\delta}\mathbf{g}_i\|$$

Condição observada na prática

$$\boldsymbol{\delta}\mathbf{g}_i = \kappa_g \sum_j \iiint_{v_j} \Delta\rho\, \nabla \frac{1}{r_{ij}} dv$$

$$\boldsymbol{\gamma}_i = \gamma_i \hat{\boldsymbol{\gamma}}_0$$

Ou, analogamente, o distúrbio de gravidade representa a componente vertical da atração gravitacional exercida pelas fontes gravimétricas

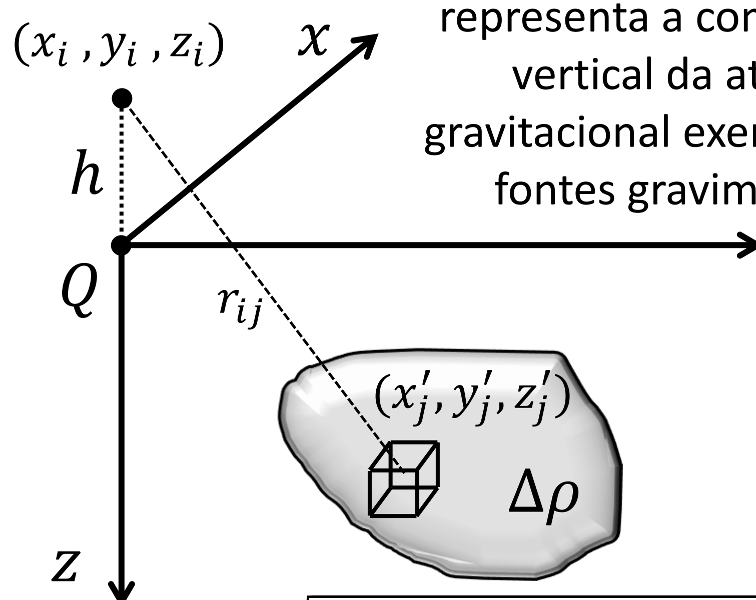


Produto escalar

$$\boxed{\begin{aligned} \mathbf{v}^{\mathrm{T}}\mathbf{w} &= v_x w_x + v_y w_y + v_z w_z \\ &= v\, w\, cos\theta \end{aligned}}$$

$$g_i \approx \gamma_i + \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\boldsymbol{g}_i$$

$$\delta g_i \approx \hat{\boldsymbol{\gamma}}_0^{\mathrm{T}} \boldsymbol{\delta}\mathbf{g}_i$$



$$r_{ij} = \sqrt{(x_i - x_j')^2 + (y_i - y_j')^2 + (z_i - z_j')^2}$$