Moho depth inversion from gravity and gravity gradient data

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Outline

- *Background introduction*
- *Development methodology*
- *Application of Moho inversion*
- *Summary*

Background introduction

Schematic of irregular interface

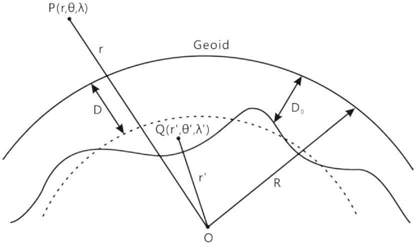


Figure 1: Schematic of irregular interface

$$T(r,\theta,\lambda) = G\Delta\rho^{c/m} \iint_{\sigma'} \int_{r'=R-D}^{R-D_0} l^{-1}(r,\theta,\lambda)\, r'^2 dr' d\sigma' \quad (1)$$

Development methodology

Moho inversion from gravity data

$$D(\theta,\lambda) = -\frac{1}{4\pi}\sum_{n=0}^{\infty}\sum_{m=0}^{n}\frac{2n+1}{n+1}\left(\frac{r}{R}\right)^{n+2} h_{nm}^{\delta g} Y_{nm}(\theta,\lambda) + \frac{D^2(\theta,\lambda)}{R} - \frac{1}{32\pi R}\iint_{\sigma'}\frac{D^2(\theta',\lambda') - D^2(\theta,\lambda)}{\sin^3(\psi/2)}d\sigma' \tag{2}$$

$$\begin{aligned} D(\theta,\lambda) = &-\frac{2R+3H}{4\pi R}h^{\delta g}(\theta,\lambda) + \frac{H}{32\pi^2 R}\iint_{\sigma'}\frac{h^{\delta g}(\theta',\lambda') - h^{\delta g}(\theta,\lambda)}{\sin^3((\psi/2))}d\sigma' \\ &+ \frac{R+H}{16\pi^2 R}\iint_{\sigma'} h^{\delta g}(\theta',\lambda')\left(\frac{1}{\sin(\psi/2)} - \ln\left(1 + \frac{1}{\sin(\psi/2)}\right)\right)d\sigma' \\ &+ \frac{D^2(\theta,\lambda)}{R} - \frac{1}{32\pi R}\iint_{\sigma'}\frac{D^2(\theta',\lambda') - D^2(\theta,\lambda)}{\sin^3(\psi/2)}d\sigma' \end{aligned} \tag{3}$$

Moho inversion from vertical gravity gradient data

$$D(\theta,\lambda) = \frac{R}{4\pi}\sum_{n=0}^{\infty}\sum_{m=0}^{n}\frac{2n+1}{(n+1)(n+2)}\left(\frac{r}{R}\right)^{n+3} h_{nm}^{\Gamma} Y_{nm}(\theta,\lambda) + \frac{D^2(\theta,\lambda)}{R} - \frac{1}{32\pi R}\iint_{\sigma'}\frac{D^2(\theta',\lambda') - D^2(\theta,\lambda)}{\sin^3(\psi/2)}d\sigma' \tag{4}$$

$$\begin{aligned} D(\theta,\lambda) = {} & \frac{H}{2\pi}h^{\Gamma}(\theta,\lambda) - \frac{R+2H}{16\pi^2}\iint_{\sigma'} h^{\Gamma}\left(\theta',\lambda'\right)\left(\frac{1}{\sin(\psi/2)} - \ln\left(1+\frac{1}{\sin(\psi/2)}\right)\right)d\sigma' \\ & + \frac{3(R+H)}{16\pi^2}\iint_{\sigma'} h^{\Gamma}\left(\theta',\lambda'\right)\left(\frac{1}{\sin(\psi/2)} - 3\left(2\sin(\psi/2) - 1 + \cos\psi\ln\left(1+\frac{1}{\sin(\psi/2)}\right)\right)\right)d\sigma' \\ & + \frac{D^2(\theta,\lambda)}{R} - \frac{1}{32\pi R}\iint_{\sigma'}\frac{D^2(\theta',\lambda') - D^2(\theta,\lambda)}{\sin^3(\psi/2)}d\sigma' \end{aligned} \tag{5}$$

Application of Moho inversion

Process of Moho inversion

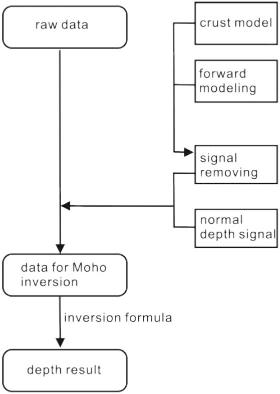
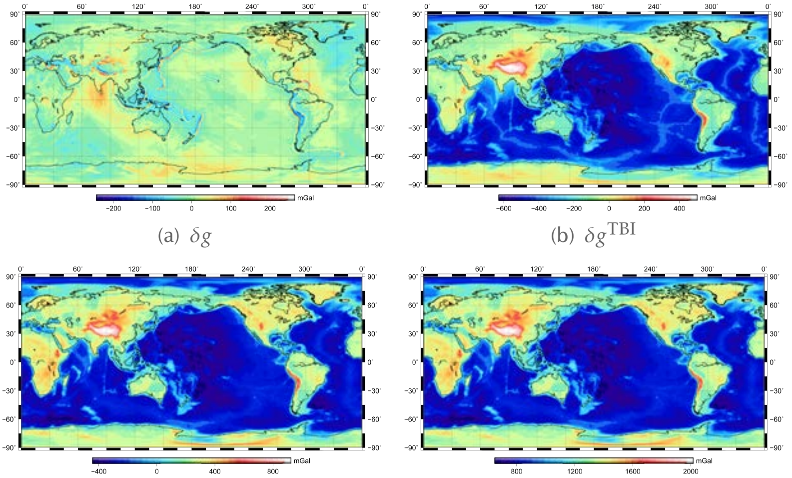


Figure 2: Process of Moho inversion

Data for Moho inversion (gravity)

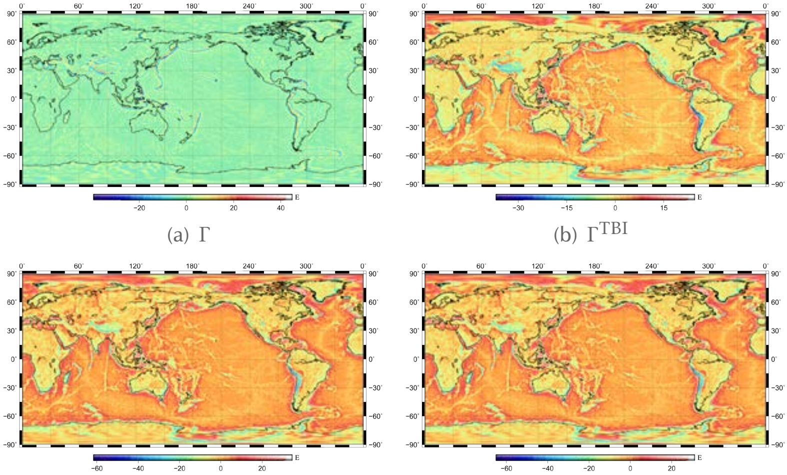


(a) δg (b) δg^{TBI}

(c) δg^{CS} (d) δg^{CSN}

Figure 3: Data for Moho inversion (10 km, step-wise correction)

Data for Moho inversion (vertical gravity gradient)



(a) Γ (b) Γ^{TBI}

(c) Γ^{CS} (d) Γ^{CSN}

Figure 4: Data for Moho inversion (10 km, step-wise correction)

Global Moho result

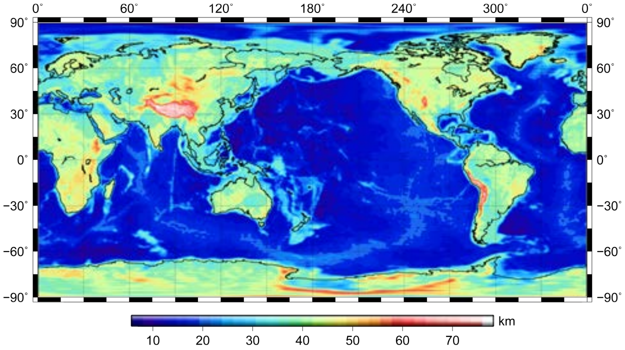


Figure 5: Global Moho result (from spectral expressions)

Statistics

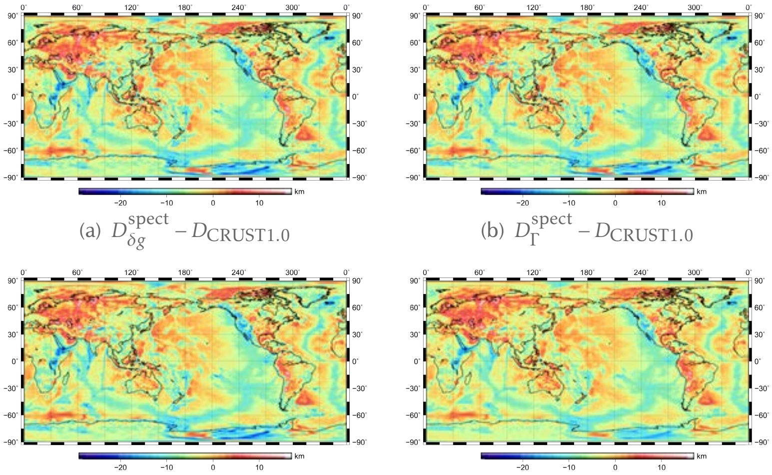
Table 1: Statistics of Moho depth differences with CRUST1.0

Moho difference	Max(km)	Min(km)	Mean(km)	STD(km)
$D_{\delta g}^{\mathrm{spect}} - D_{\mathrm{CRUST1.0}}$	16.75	-28.42	-3.92	4.74
$D_{\Gamma}^{\mathrm{spect}} - D_{\mathrm{CRUST1.0}}$	16.75	-28.42	-3.92	4.74
$D_{\delta g}^{\mathrm{spat}} - D_{\mathrm{CRUST1.0}}$	16.51	-28.23	-3.96	4.71
$D_{\Gamma}^{\mathrm{spat}} - D_{\mathrm{CRUST1.0}}$	16.46	-23.09	-3.55	4.24

Table 2: Statistics of Moho depth differences with different methodologies

Moho difference	Max(km)	Min(km)	Mean(km)	STD(km)
$D_{\Gamma}^{\mathrm{spect}} - D_{\delta g}^{\mathrm{spect}}$	0	0	0	0
$D_{\delta g}^{\mathrm{spat}} - D_{\delta g}^{\mathrm{spect}}$	2.06	-2.05	0.04	0.18
$D_{\Gamma}^{\mathrm{spat}} - D_{\delta g}^{\mathrm{spect}}$	5.57	-15.52	-0.37	1.32
$D_{\Gamma}^{\mathrm{spat}} - D_{\delta g}^{\mathrm{spat}}$	6.07	-14.69	-0.41	1.27

Comparison



(a) $D_{\delta g}^{\text{spect}} - D_{\text{CRUST1.0}}$

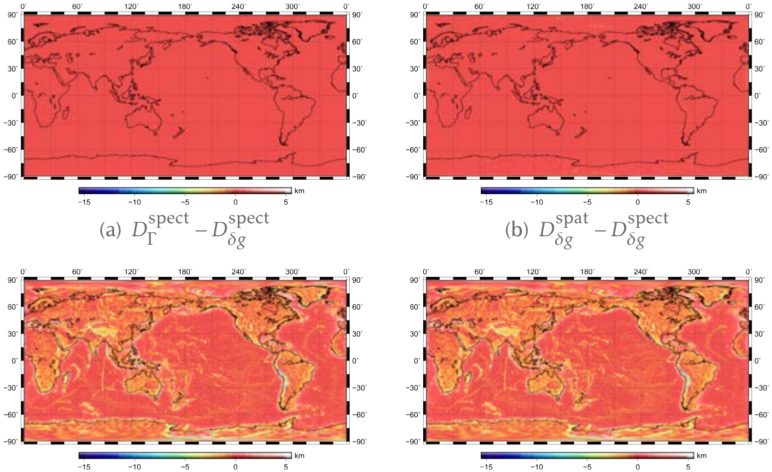
(b) $D_{\Gamma}^{\text{spect}} - D_{\text{CRUST1.0}}$

(c) $D_{\delta g}^{\text{spat}} - D_{\text{CRUST1.0}}$

(d) $D_{\Gamma}^{\text{spat}} - D_{\text{CRUST1.0}}$

Figure 6: Comparison with CRUST1.0 model

Comparison



(a) $D_{\Gamma}^{\text{spect}} - D_{\delta g}^{\text{spect}}$

(b) $D_{\delta g}^{\text{spat}} - D_{\delta g}^{\text{spect}}$

(c) $D_{\Gamma}^{\text{spat}} - D_{\delta g}^{\text{spect}}$

(d) $D_{\Gamma}^{\text{spat}} - D_{\delta g}^{\text{spat}}$

Figure 7: Moho depth differences with different methodologies

Summary

- *Global Moho from spectral expressions are close to CRUST1.0 model with a mean difference of -3.9 km and a standard deviation of 4.74 km.*
- *Spectral methodologies of gravity and vertical gravity gradient have the same accuracies because of the same approximation during the formulae derivations.*
- ......

Thanks for your attention!