New Versus Conventional Approach for Modeling Flexure of Foreland Basins

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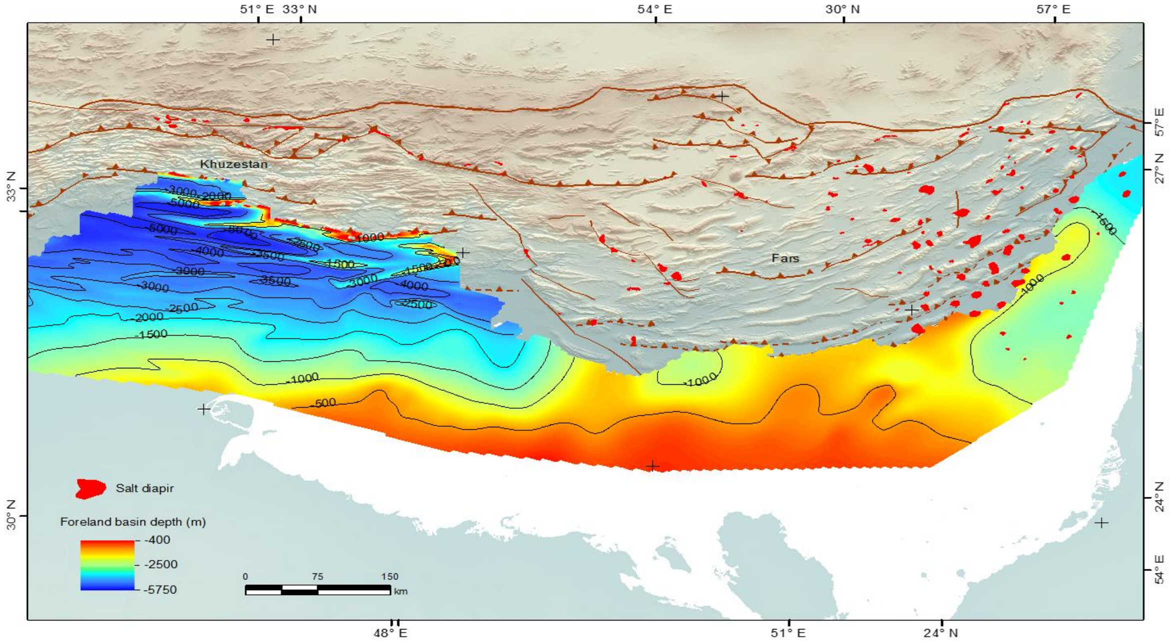
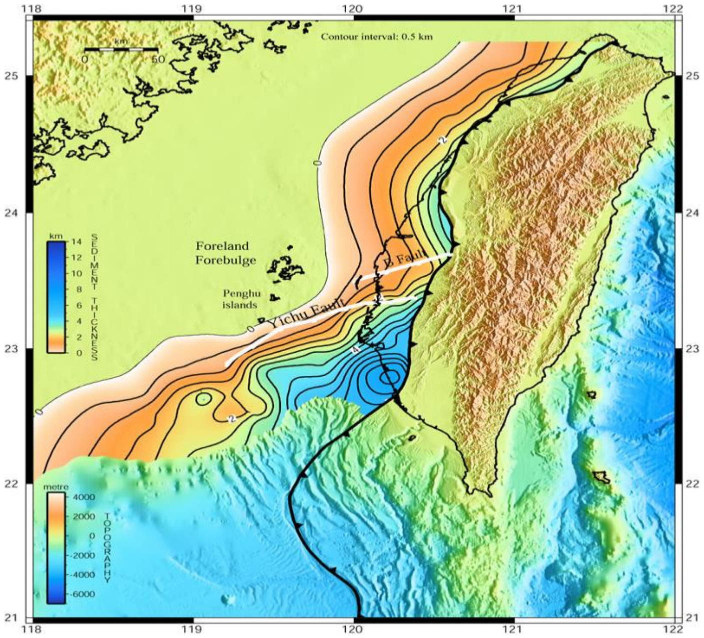
Motivation

Most of the flexural models declared additional subsurface load is needed to obtain models that fit to the geometry of basins in different parts of the world. The idea is to investigate if there any systematic error we involve in our calculation? Or how we can make sure our calculation is reasonable and we can trust our results. That is because one of the outcomes of flexural modeling is to obtain an elastic thickness of the lithosphere and that is something that is not visible and is not a parameter that we can directly measure. In this study, we only show the results of three studies that we conducted for a large dataset including Zagros, Taiwan, and Alaska.

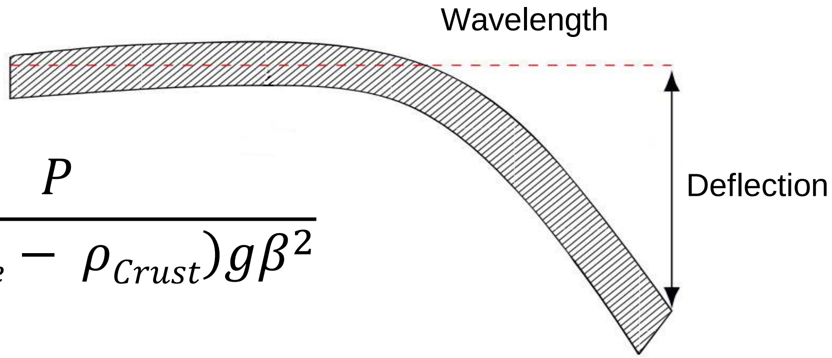
Zagros foreland basin



Taiwan foreland basin



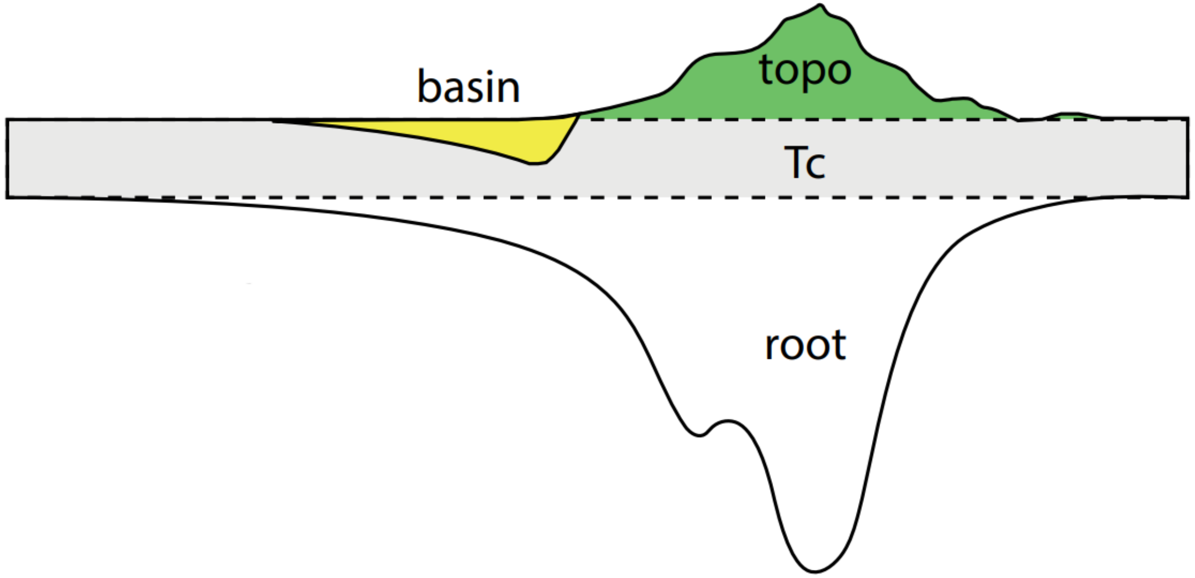
Flexural Model – Conventional approach



$$\omega = \frac{P}{8\,(\rho_{Mantle} - \rho_{Crust})g\beta^2}$$

$$\beta = \sqrt[4]{\frac{D}{(\rho_m - \rho_c)g}} = \sqrt[4]{\frac{E\,T_e^{\,3}}{12(1-\vartheta^2)}\,\frac{1}{(\rho_m - \rho_c)g}}$$

ω	*Deflection*
P	*Topographic Load*
ρ_{Mantle}	*Mantle density*
ρ_{Crust}	*Crust density*
g	*Gravity*
β	*Flexural parameter*



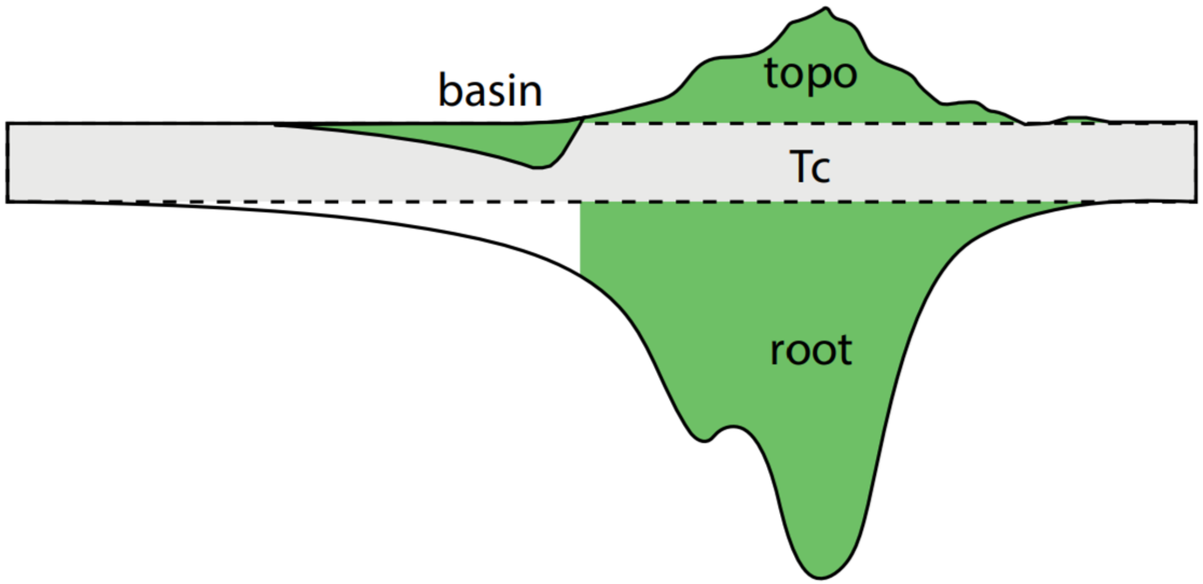
$(\rho_{Mantle} - \rho_{Crust})$ accounts for replacement of Mantle by a crustal rock or in other words deflected volume is filled by crustal rocks

Pirouz et al., Geophysical Journal International, 2017, Pages 1659–1680

Flexural Model – New method

$$\omega = \frac{\lambda\, P}{8\,(\rho_{Mantle} - \rho_{Air}) g \beta^2}$$

$$\beta = \sqrt[4]{\frac{D}{(\rho_m - \rho_{fill=air})g}} = \sqrt[4]{\frac{E\,T_e^{\,3}}{12(1-\vartheta^2)}\,\frac{1}{(\rho_m - \rho_{fill=air})g}}$$



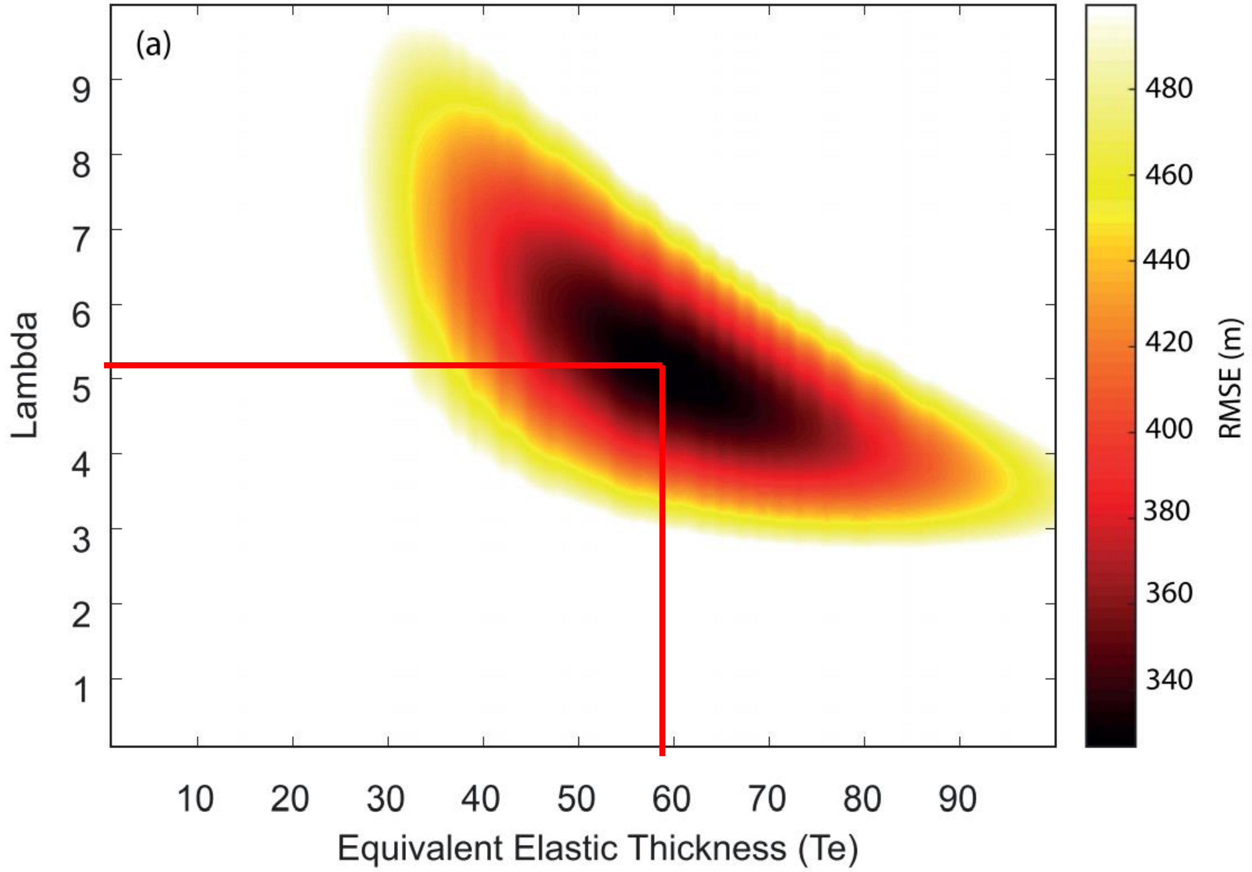
ω	*Deflection*
P	*Topographic Load*
λ	*Ratio between topography and crustal root*
ρ_{Mantle}	*Mantle density*
ρ_{air}	*Air density*
g	*Gravity*
β	*Flexural parameter*

$(\rho_{Mantle} - \rho_{Air})$ accounts for replacement of Mantle by air or in other words deflected volume is empty. In this condition, we are able to include crustal root weight relative to the topography. A precise Moho depth can help to find out the ratio between topography and root.

Pirouz et al., Geophysical Journal International, 2017, Pages 1659–1680

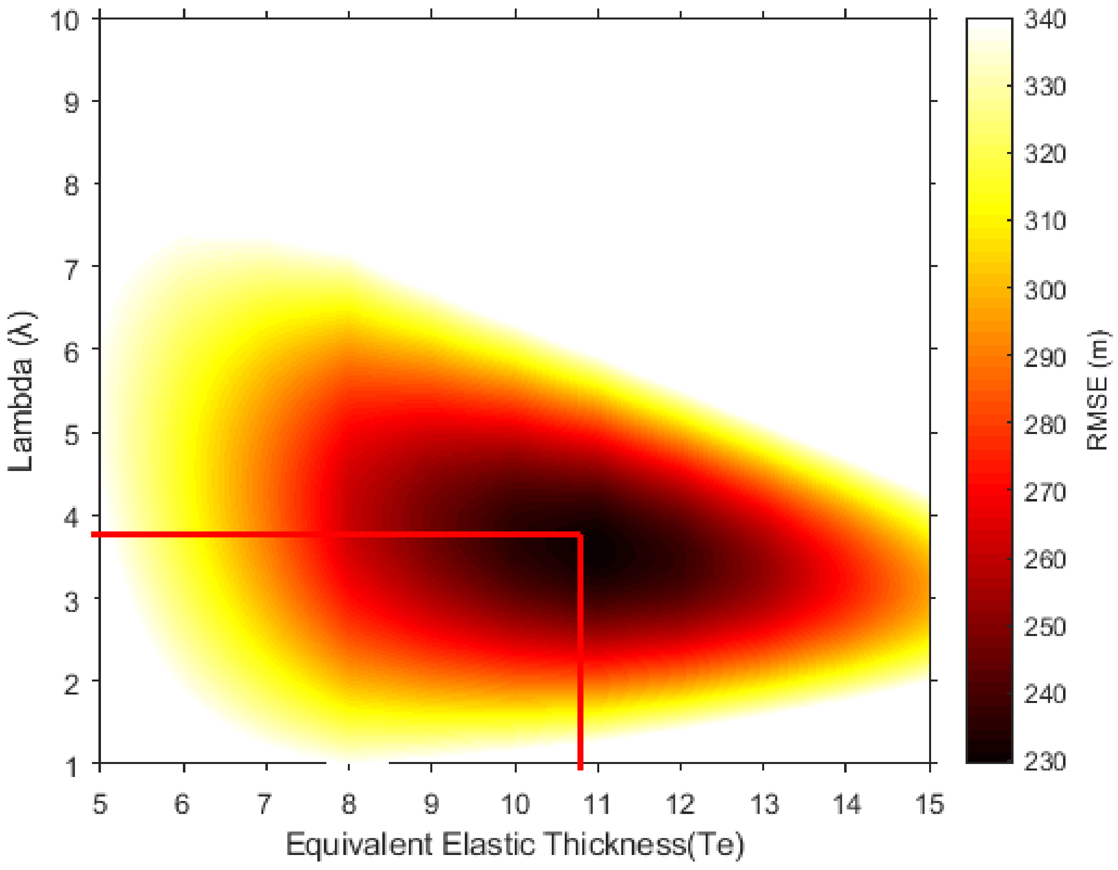
Example 1: Zagros Basin

- Deepest part of the Zagros basin has 6000m depth
- Mist fit between model and observation is 330m – ca. 5%
- Elastic thickness is about 58km
- Ratio between topography and crustal root is about 5.2:1



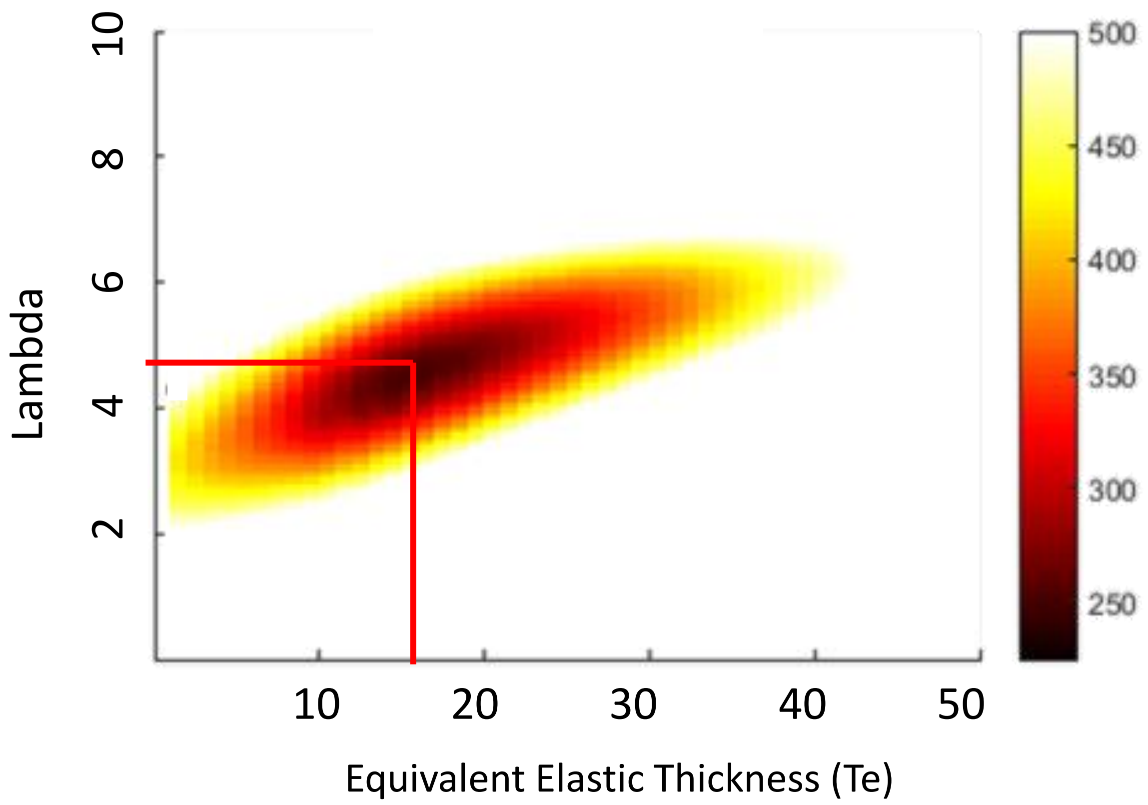
Example 2: Taiwan Basin

- Deepest part of The Taiwan basin has 4000m depth
- Mist fit between model and observation is 230m – ca. 5%
- Elastic thickness about 11km
- Ratio between topography and crustal root is about 3.8:1



Example 3: Colville Basin-Alaska

- Deepest part of the Colville basin has 8000 m depth
- Mist fit between model and observation is 250m – ca. 3%
- Elastic thickness about 16 km
- Ratio between topography and crustal root is about 4.5:1



Conclusion

Replacing density of crust by density of air and applying the total load with topography and crustal root has some benefits:

- Results are comparable to the conventional method, and has better fit to the observation
- Two parameter *(Te and λ)* to tune the model. Having λ involved helps to better load distribution model
- λ value gives clue about need or existence of extra loads including mantle dynamics

MATLAB code is available upon request. (Mortaza.Pirouz@me.com)

Input data: topography, basin depth map, density log of the basin, Free Air Anomaly *(optional)*

Output: modeled basin depth map, elastic thickness value, ratio between crustal root and topography

Link to paper: https://doi.org/10.1093/gji/ggx252

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