Notes on Paper- “Uncertainties in crustal thickness models for data sparse environments: A review for South America and Africa.” Meijde (2015)

Identifying the gap-

* Still white spots in in the worlds crustal thickness map. Most regions are in Africa, South America, and parts of Asia.
* Uneven data coverage has resulted in large lateral variations in resolution.

How to fill the gaps-

* Most traditionally use deep seismic surveys but over such large scale as continents may prove costly and time consuming as most white spots are locates in areas that are difficult to access such as the Sahara.
* Variations in the Earth gravity field are a result of four main factors. The first three are the Earth’s shape, rotation, and topography. The fourth factor is due to inhomogeneous composition of the Earth’s interior. Would need to remove all other effects of gravity to accurately determine any boundaries within the Earth.
* GOCE filled in the gaps meaning there is a very large gravitational data set for the whole world.
* For regions for sparse data coverage GOCE data significantly increases opportunities to obtain improved or new knowledge on these regions.
* Will show in the paper that the choice and parametrization of a modelling technique has more impact than using different data sources or data sources of supposed higher quality.

Modelling techniques-

* To overcome the non-uniqueness problem, it is possible to do a joint inversion of gravity data with a priori information on crustal structure like seismic point observations or profiles and lateral density variations. Due to differences in accuracy and quantity of Seismological data would be difficult to create a constraint for unmapped areas from mapped areas.

Models-

* Meijde (2013) chose not to use the constraints in the inversion. This way they show the strength of the method, without using priori information, to provide a 1st order estimate of crustal thickness. The sediment corrected Bouguer gravity anomalies were modelled to obtain estimates of crustal thickness throughout the continents. To avoid high frequencies a low pass filter was used with an upper boundary set at 200km.
* Delft Moho model uses first-order Tikhonov regularization scheme. The weights for each exploited data set is estimated using the Variance Components Estimation procedure. Spherical harmonic coefficients of the first 10 degrees are excluded from the set of input data, so that the nuisance signals related to deep heterogeneities are damped.
* Vening Meinesz’s model deals with the recovery of the Moho depth, using Bouguer gravity anomalies and the normal Moho depth. The principle of solving Moritzs generalization of the Vening-Meinesz inverse problem of isostasy is based on generating the isostatic gravity disturbances/anomalies, such that these are equal to zero.
* GEMMA model has been developed to combine seismic global model CRUST2.0 with gravity inversions from GOCE. Data reduced to a two-layer model by removing external effects such as topography.
* CRUST1.0 based on one-degree averages of crustal thickness data from active source seismic studies as well as from receiver function studies. Where constraints are missing model uses local averages to extrapolate the data.
* Assumpcao12 is mainly focused on South America and the joint inversion of surface-wave dispersion, regional wavetrains, and point constraints.

Comparison-

* Often no uncertainty given with models, mainly because it is difficult to quantify it, whereas with seismic studies uncertainty is relatively small of ±3km.
* Need to establish reliability of modelled crustal thickness due to the models being created in data sparse environments.
* Difficulties with modelling Moho depth in the Andes with all models showing large differences to the seismic models.
* Overall, the comparison between observed crustal thickness and modelled crustal thickness shows the closest fit to the 1:1 line for Assumpcao12 and CRUST1.0. All other models underestimate Moho interfaces, especially in the Andes.
* Assumpcao12 is a good fit with GMSA12. For Venezuela and the Guyana shield DMM-1 is very similar to the seismological models.
* Shape quite similar for most models, the maximum modelled thickness can vary more than 20km between models. It is evident that the coarser models cannot model the steep dip of the Moho in that region very well, leading to underestimation.
* In Africa models show quite different spatial patterns. The spread for all models is far less than for South America. CRUST1.0 partly shows the tightest clustering to the optimal 1:1 line, but also shows some of the largest deviations.
* The Tugume model shows a thicker crust for southern Africa and thinner crust north of the Central Africa Rift zone with only a few places where crustal thickness exceeds 35km.

The way forward-

* Observed similarity between the gravity only, gravity based, and seismological models. However, no consistent similarities between models are observed.
* Main differences between models occurs in regions where no data points are available. Apparently, the control provided by the point observations provides little to no stability for regions without data.
* Best way to improve the modelling in data sparse regions is to increase coverage of seismological networks to improve data coverage in point observations. Another option is to increase the density of crustal thickness point observations. These are purely seismology-based solutions.

Geodynamical perspective-

* The conclusion is that the different continental and global crustal thickness models compared in this study are showing remarkable differences. Not possible to state whether gravity or seismology models are better as both have advantages and disadvantages.
* Shown that different global and continental crustal thickness models are significantly different from each other. It is not possible to derive a measure that proofs one model better than the others.
* Future work should focus on developing a standard for modelling in data sparse environments, and expand seismological efforts in those regions that are most different between the shown models to verify the actual crustal thickness.