GEMMA2.0: an improved global crustal model based on GOCE data

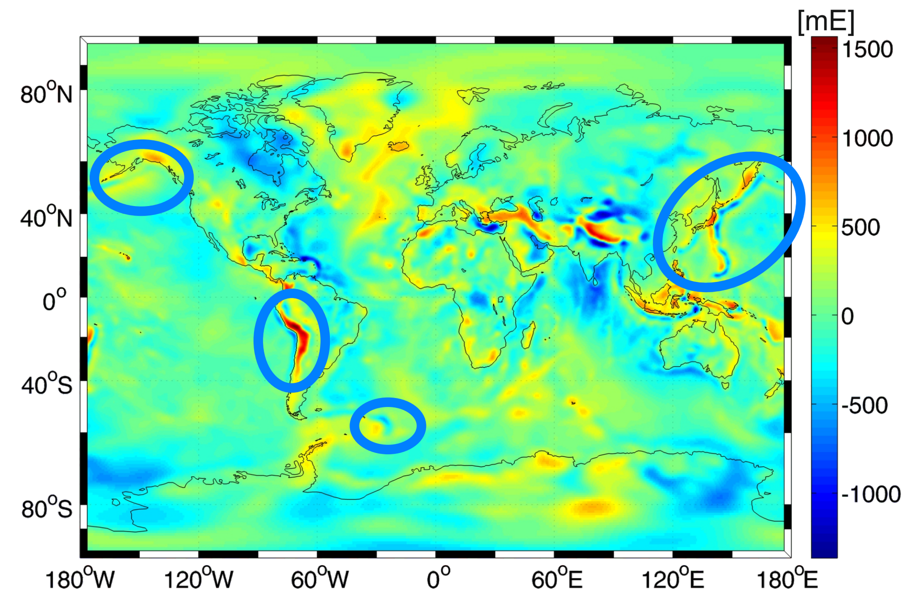
Lorenzo Rossi[1], Mirko Reguzzoni[1], Daniele Sampietro[2]
[1] DICA, Politecnico di Milano, Piazza Leonardo da Vinci 32, 20133 Milano, Italy
[2] GReD s.r.l., Via Valleggio 11, 22100 Como, Italy

Introduction

The use of GOCE gravity field observations to estimate the structure of the lithosphere has been deeply studied (among others) in the GEMMA project (GOCE Exploitation for Moho Modeling and Application) where a global crustal model constrained by GOCE observations has been computed.

In order to compute a crustal model from GOCE gravity observations the data have to be reduced to the effect of the crust anomalies only, and then inverted by means of a proper procedure.

In this work a preliminar study to improve the modeling of the data reduction by modelling the main subduction plates is shown.

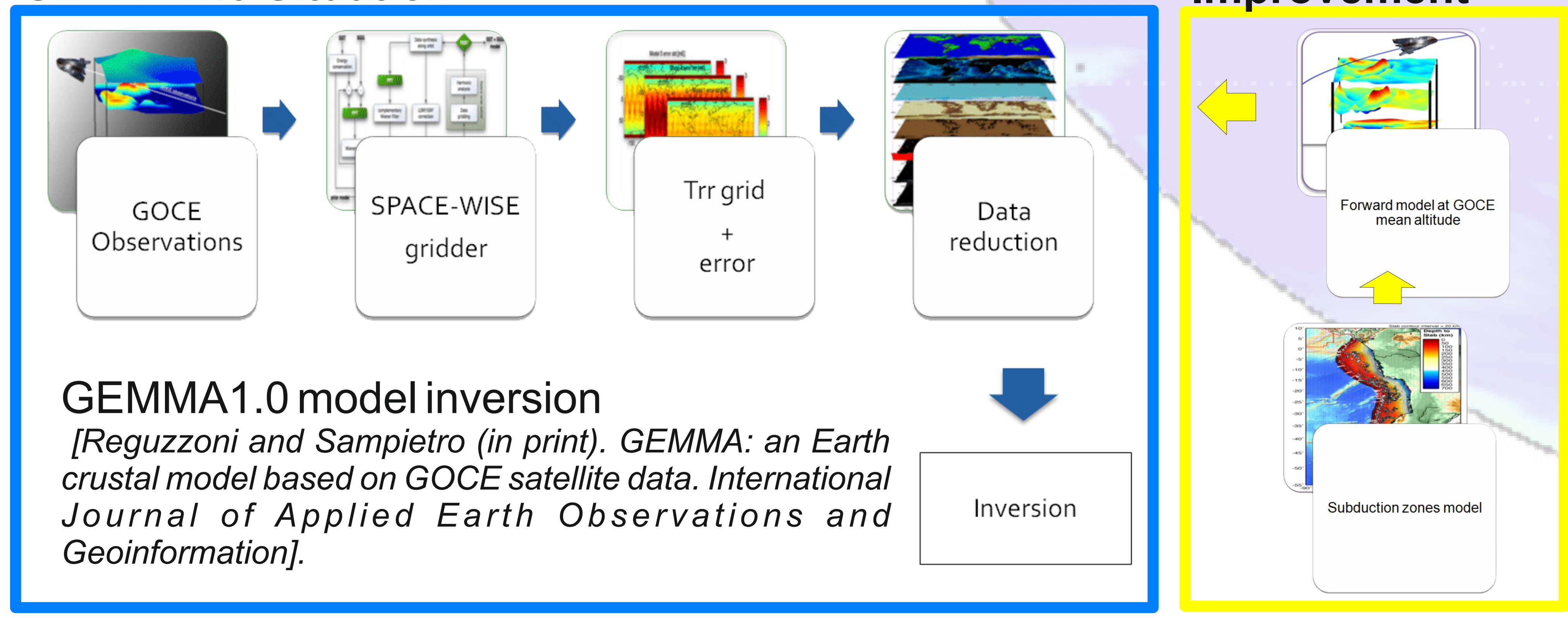


Second radial derivative of the gravitational potential from GOCE data;

Considering GOCE grids of second radial derivative of the anomalous gravitational potential it can be clearly seen that the most powerful signal is related to subducting plates, i.e. the process in which one plate is pushed downward beneath another plate into the underlying mantle.

GEMMA1.0 Situation

Improvement



GEMMA1.0 model inversion

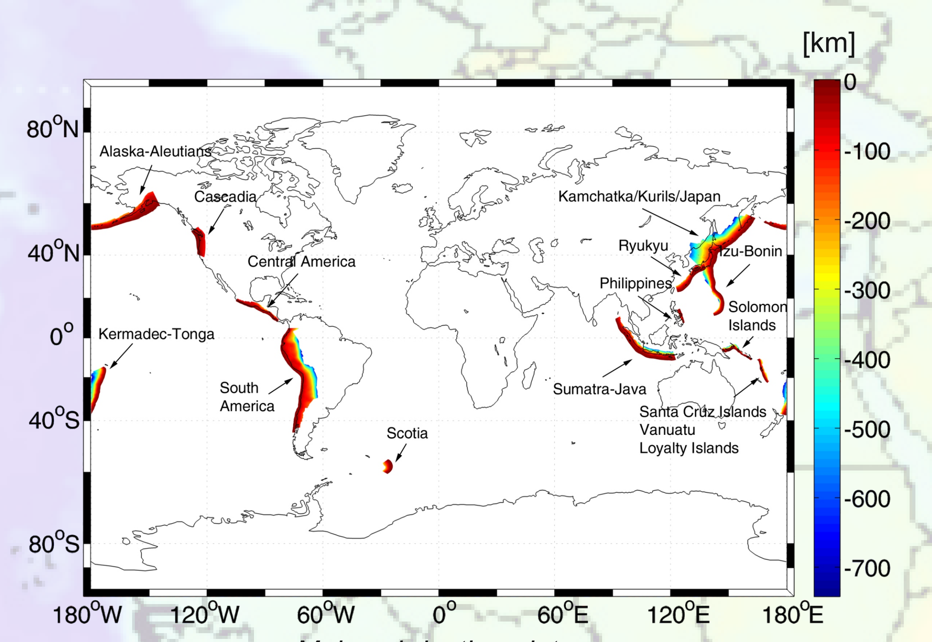
[Reguzzoni and Sampietro (in print). GEMMA: an Earth crustal model based on GOCE satellite data. International Journal of Applied Earth Observations and Geoinformation].

Subducting plates modeling

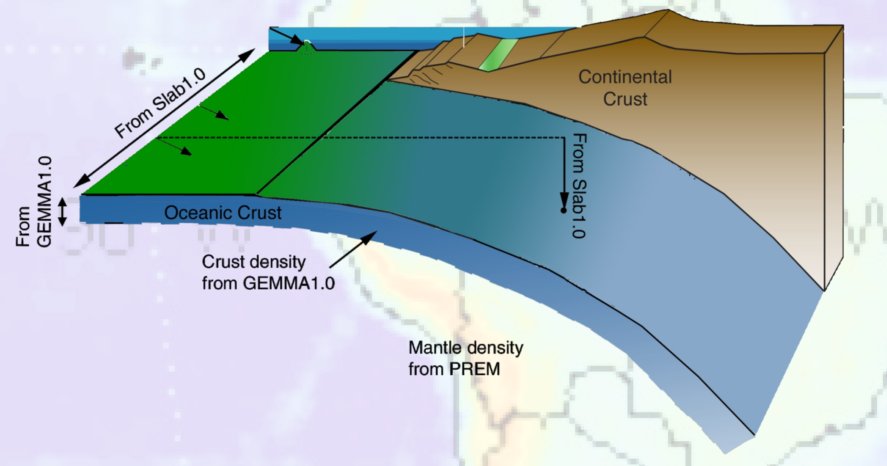
1) Geometry of the top of the subducting plates is taken from SLAB1.0 model.

It is a 3D compilation of global subduction geometries from historic earthquake catalogs, CMT solutions, active seismic profiles, global plate boundaries, bathymetry and sediment thickness information.

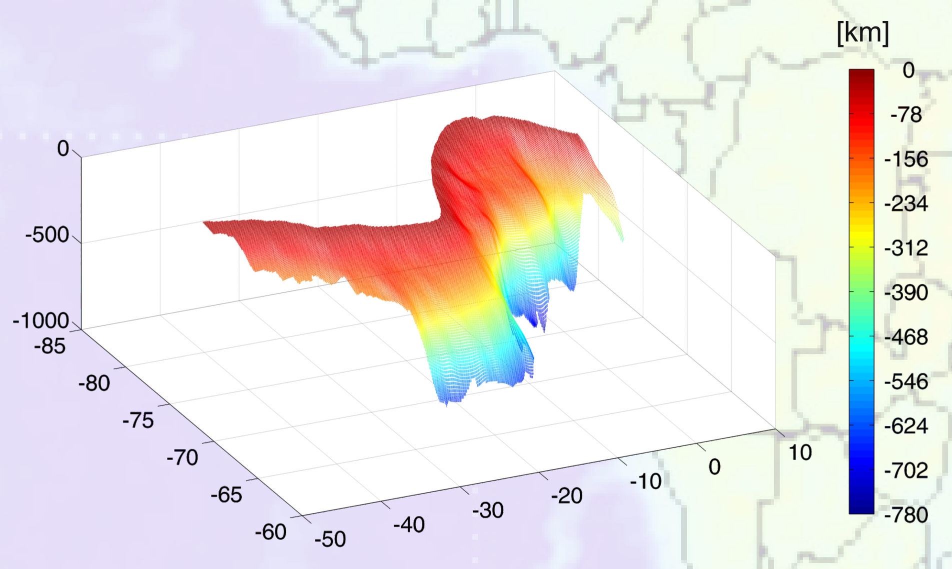
[Hayes, G. P., D. J. Wald, and R. L. Johnson (2012), Slab1.0: A three-dimensional model of global subduction zone geometries, Journal of Geophysical Research].



Main subduction plates



Sketched geometry of the subduction plate and data sources;

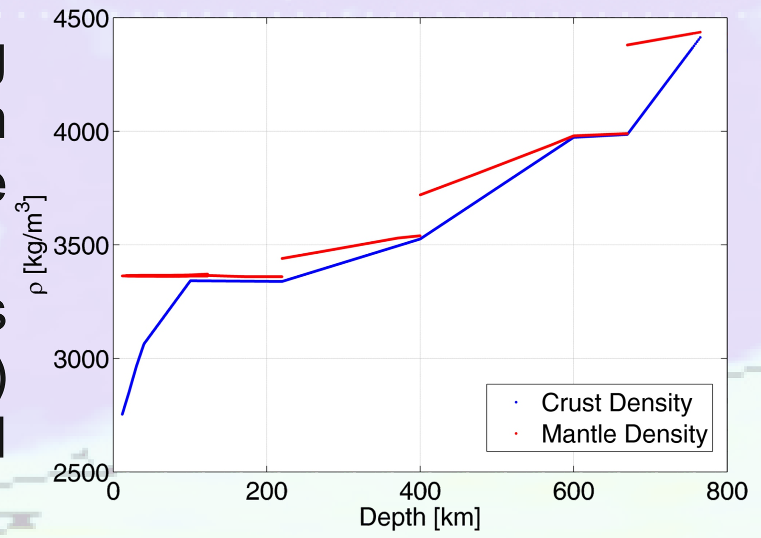


3D model of the Nazca plate;

2) Thickness of the subducting plates is taken from GEMMA1.0 as mean global thickness of the 'undisturbed' oceanic crust (i.e. 7 km).

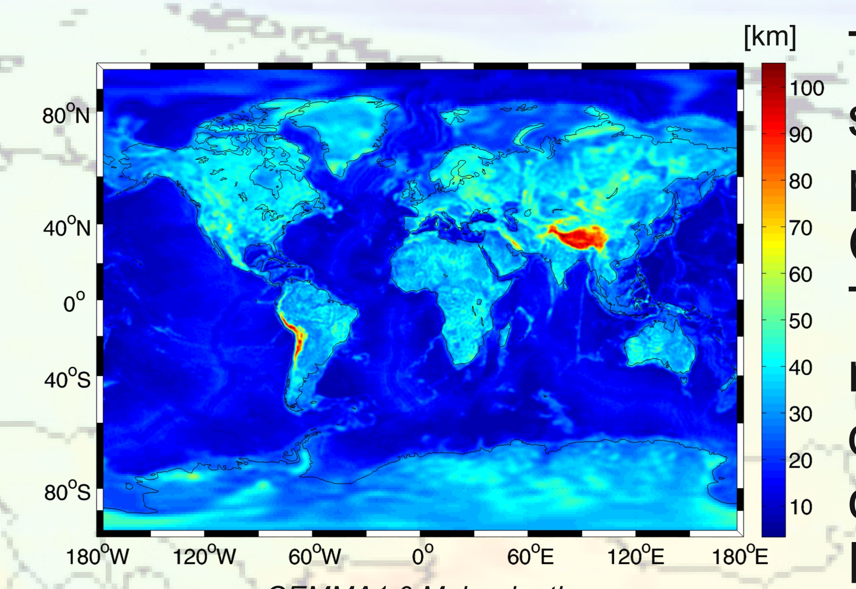
3) Density contrast of the top of the subducting plates (down to ~120 km) is taken from GEMMA1.0 where both crust and upper mantle densities are defined.
Below the upper mantle the crust density is modelled as shown in the figure below (red line) while the mantle density is taken from PREM (blue line).

[Dziewonski, A. M., & Anderson, D. L. (1981). Preliminary reference Earth model. Physics of the earth and planetary interiors].

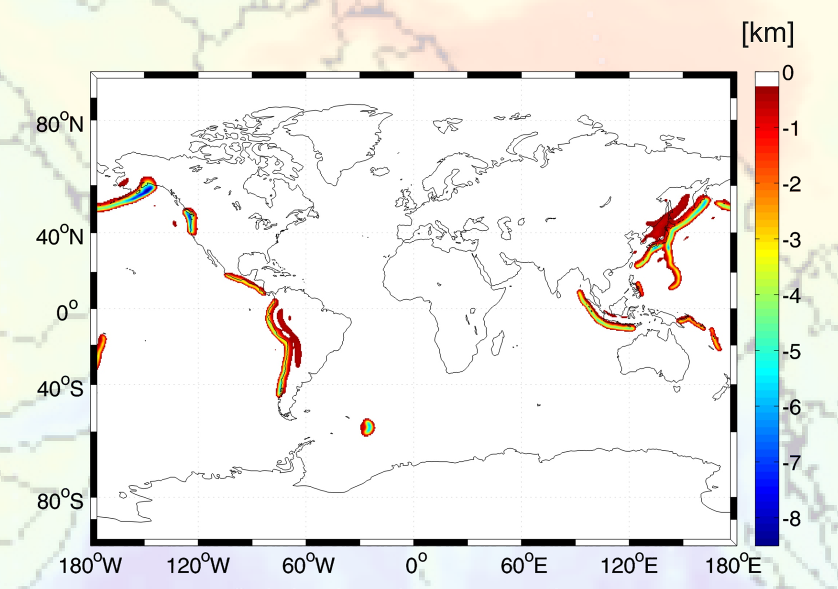


Crust and mantle density models

Results

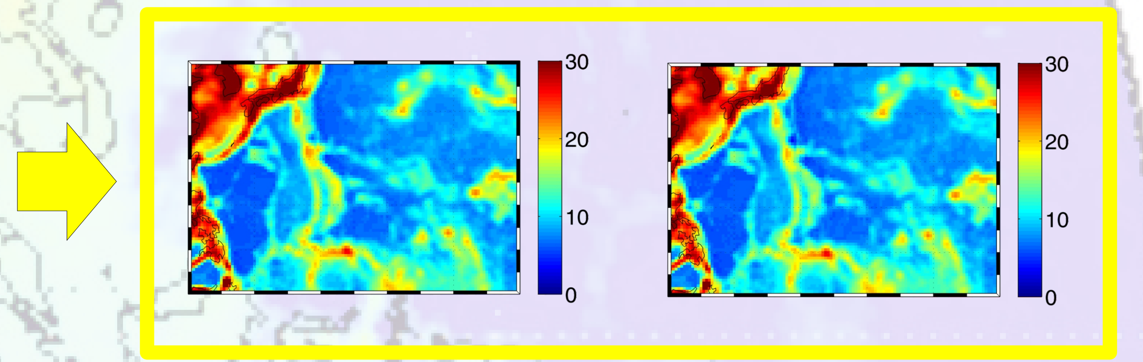


GEMMA1.0 Moho depth



Subduction plates correction

The anomalous gravitational effect of subduction plates is computed by means of point masses approximation and removed from GOCE data.
The residual field is then inverted obtaining a new Moho model. Even if localized the difference between the old and the new model can reach more than 8 km.
Note that the corrections partially remove unphysical anomalies in the Moho model. However due to inconsistencies among SLAB1.0, the GEMMA density model, and GOCE gravity data a better fit is required.



Conclusions and Perspectives

- In the present work a possible 3D model of the main subducting plates, consisting in their geometry and density contrast, is developed and its gravitational effect, in terms of second radial derivative of the gravitational potential at GOCE mean satellite altitude, is also computed.
- The presented preliminary study proves that the impact of the major subduction plates, when inverting the gravitational field to retrieve a global Moho model, is not negligible. Even if the gravitational signal is quite localized it can reach more than 1600 mE that is reflected in a variation up to 8 km in terms of Moho depth.
- As for the future developments, the first step is strengthen the consistency among SLAB1.0, GEMMA1.0 and GOCE. Then, after improving the modelling of the Himalayan crust, which is the other important anomaly in the data, one can finally recompute a new GEMMA model.