EGU2013-2658 Update on CRUST1.0: A 1-degree Global Model of Earth's Crust

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http://igppweb.ucsd.edu/~gabi/crust1.html

Abstract

Our new 1-by-1 degree global crustal model, CRUST1.0, was introduced last year and serves as starting model in a comprehensive effort to compile a global model of Earth's crust and lithosphere, LITHO1.0 (Pasyanos et al., 2012). The Moho depth in CRUST1.0 is based on 1-degree averages of a recently updated database of crustal thickness data from active source seismic studies as well as from receiver function studies. In areas where such constraints are still missing, for example in Antarctica, crustal thicknesses are estimated using gravity constraints.

The compilation of the new crustal model initially followed the philosophy of the widely used crustal model CRUST2.0 (Bassin et al., 2000; http://igppweb.ucsd.edu/?gabi/crust2.html) to assign elastic properties in the crys- talline crust according to basement age or tectonic setting (loosely following an updated map by Artemieva and Mooney (2001; http://www.lithosphere.info). For cells with no local seismic or gravity constraints, statistical aver- ages of crustal properties, including crustal thickness, were extrapolated. However, in places with constraints the depth to basement and mantle are given explicitly and no longer assigned by crustal type. This allows for much smaller errors in both.

In each 1-degree cell, boundary depth, compressional and shear velocity as well as density is given for 8 lay- ers: water, ice, 3 sediment layers and upper, middle and lower crystalline crust. Topography, bathymetry and ice cover are taken from ETOPO1. The sediment cover is based on our sediment model (Laske and Masters, 1997; http://igppweb.ucsd.edu/?sediment.html), with some near-coastal updates. In an initial step toward LITHO1.0, the model is then validated against new global surface wave disperison maps and adjusted in areas of extreme misfit. CRUST1.0 will soon be available for download.

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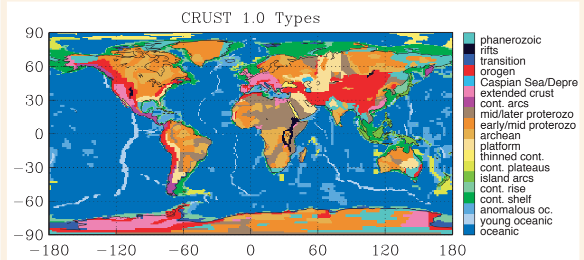
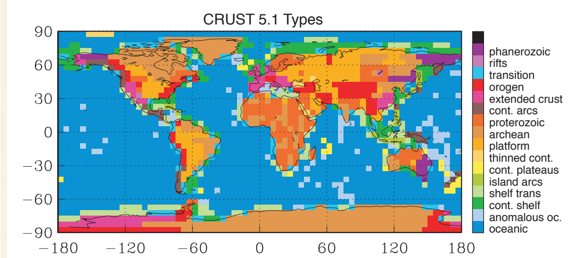
A: Crustal Types in CRUST1.0





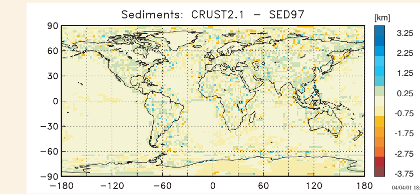
D- 01: Platform
E- 02: slow thin Platform
F- 03: Archean (Antarctica)
G1 04: early Archean
G2 05: late Archean
H1 06: early/mid Proterozoic
I1 07: late Proterozoic
I2 08: slow late Proterozoic
J- 09: island arc
K- 10: forearc
L1 11: continental arc
H2 12: early/mid Proterozoic (Antarctica, Greenland, S. America)
M- 13: extended crust
N- 14: fast extended crust (Antarctica)
O- 15: Orogen (Antarctica), very thick upper crust, very thin lower crust
P- 16: orogen, thick upper crust, very thin lower crust
Q- 17: orogen, thick upper crust
R- 18: orogen
T- 19: Margin-continent/shield transition
U- 20: Margin/Shield
X- 21: Rift
Z1 22: Phanerozoic
A1 23: normal oceanic
B- 24: melt affected o.c. and oceanic plateaus
C- 25: continental shelf
S- 26: continental slope, margin, transition
V1 27: inactive ridge, Alpha Ridge
V2 28: thinned cont. crust, Red Sea
W- 29: oceanic plateau with cont. crust
Y1 30: Caspian depression
Y2 31: intermed. cont./oc. crust, Black Sea
Y3 32: Caspian Sea oceanic
A0 33: oceans 3 Myrs and younger
Z2 34: Phanerozoic (Antarctica, Greenland)
L2 35: slow continental arc

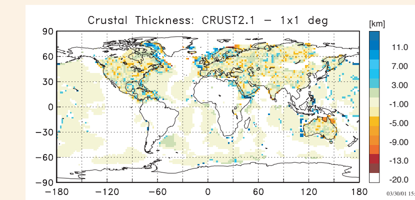
	CRUST 1.0	CRUST2.0	CRUST5.1
crustal types			
# crustal types	35	360	139
ice	-	binned	binned
		Brit. Ant. Serv.	Drewry, 83/Weidick 92
sediments	-	binned	binned
		closer L&M 97	loosely L&M 97
Moho depth	-	binned map	binned database
Vp, Vs, ρ	scaled	scaled	scaled
	validated		
layer thickness	relative	absolute	absolute
Vpn	in progress	CRUST5.1	estimated
basement age	Artemieva	loosely USGS	loosely USGS
type-independent			
topography	ETOPO1	ETOPO5	ETOPO5
ice thickness	NGDC/ETOPO1	-	-
sediments	updated L&M 97[(1)]	-	-
Moho depth	new model[(1)]	-	-
Vpn	LLNL+UCSD[(1)]	-	-

[(1)] work in progress

The role of crustal types has changed and now plays a minor role to only assign properties of the crystalline crust. The crustal types were completely reassigned to resemble the basement age of Artemieva and Mooney (2001). The scaling of the crustal elastic parameters were carefully validated in a similar fashion as sediment velocities. Some new crustal types where introduced to better match velocity anomalies in certain regions, such as the Himalayan orogenic belt and very young oceans.

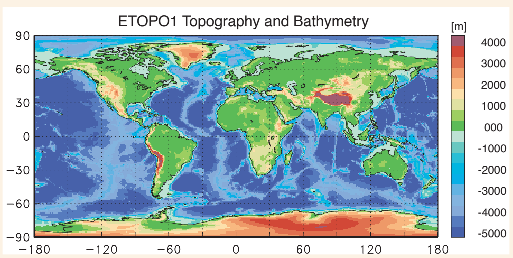
E: CRUST2.0: The Disadvantage of Tying Crustal Types to Sediment and Crustal Thickness





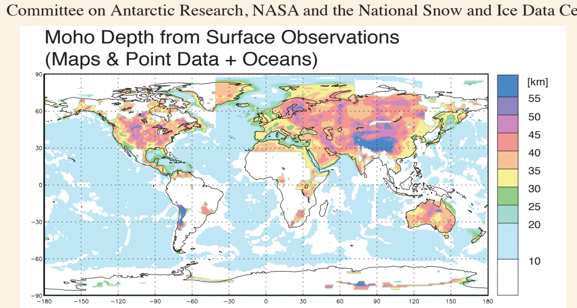
The manual assignment of crustal types is cumbersome. Many types are needed to accommodate variations in sediment and crustal thickness. This is the main reason why the number of crustal types jumped from 139 in CRUST 5.1 to 360 in CRUST2.0. CRUST2.0 tried to represent crustal thickness to within ± 5 km, sediment thickness to within 1.0 km and ice thickness to within 0.25 km of true values. Nevertheless, CRUST2.0 did not succeed everywhere to stay within these boundaries.

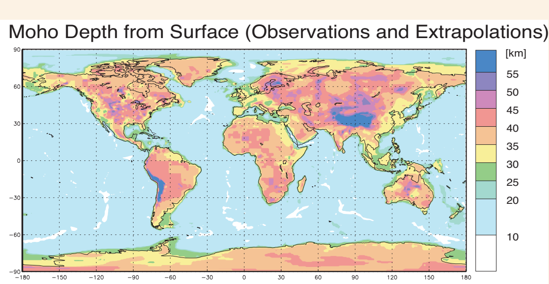
B: Independent Models Binned Into 1x1° Cells



ETOPO1 bathymetry and topography were downloaded from the NGDC website and binned/averaged into 1° cells. Source: http://www.ngdc.noaa.gov/mgg/global/global.html

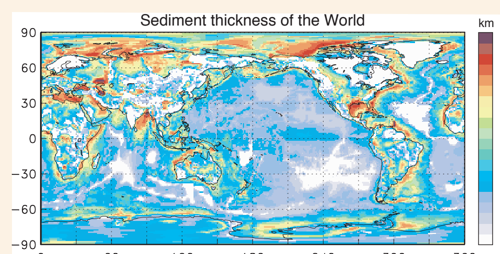
Ice surface and bedrock data are also part of the ETOPO1 dataset. They were downloaded from the NGDC website and binned/averaged into 1° cells. The raw data come from various sources, incl. Antarctic Digital Database, European Icesheet Modeling Initiative, Scientific Committee on Antarctic Research, NASA and the National Snow and Ice Data Center.



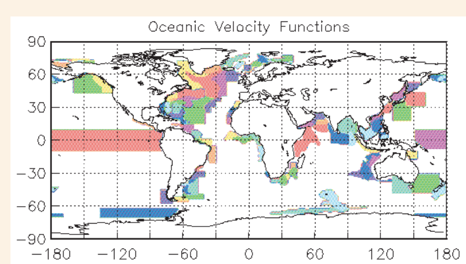


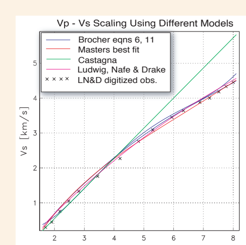
We compiled a new crustal thickness model from a combination of active source experiments, receiver functions and published Moho maps. A weighting scheme was applied in areas of data overlap.
In areas of no data coverage, crustal thicknesses were adopted from CRUST2.0. In areas with no data in the oceans, a standard crustal thickness was assumed.

C: The Sediment Model and Scaling

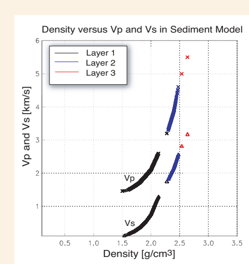


A fundamental difference from CRUST2.0 is that a complete sediment model is included in CRUST1.0 with its own parameterization, independent of crustal types. The updated Laske and Masters (1997) sediment model consists of three layers. It was updated in about 20 regions to fit surface wave group velocities (e.g., section F).



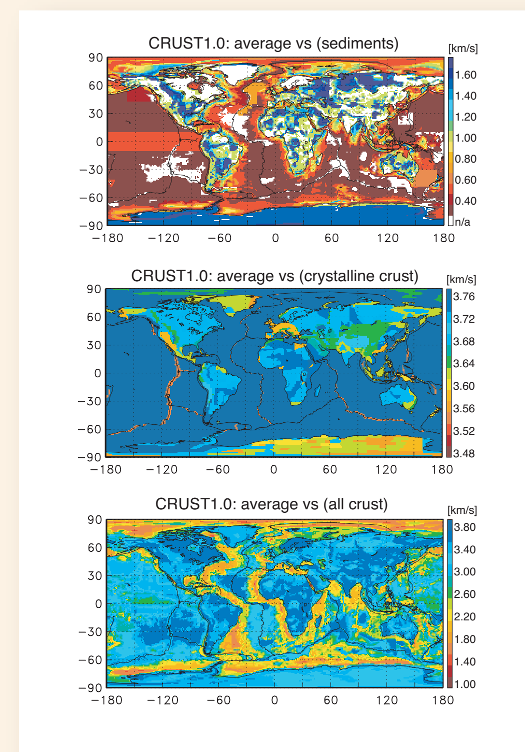


We use 170 distinct published and unpublished velocity functions to assign Vp as function of depth. The majority of these, 140, are in the oceans, while 20 distinct functions are assumed for continents. Discrepancies between observed and predicted 40-mHz group velocities (part D) may result from erroneous velocity functions and adjustments are in order.



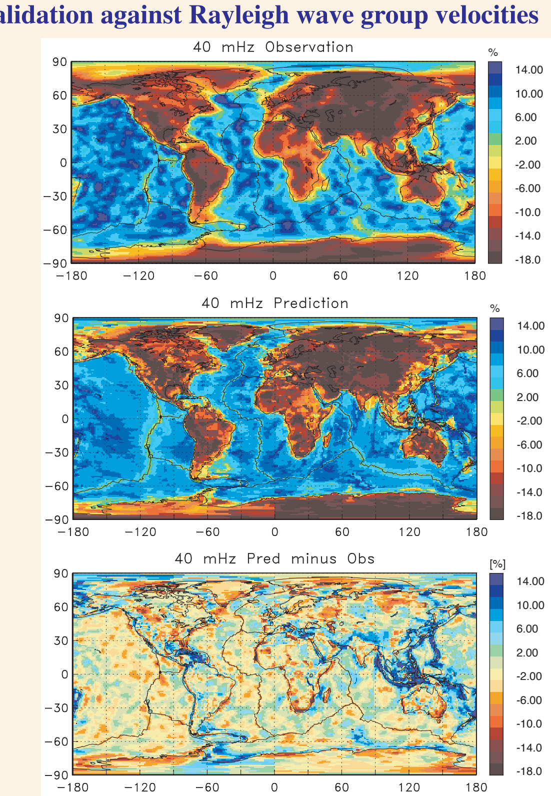
Top: The scaling of Vp, Vs and ρ was validated against Brocher, 2005, and other references. Bottom: Vp, Vs and density as actually used in the sediment model.

D: Average Seismic Velocities



For the sediments, we assign Vp as shown in section B, while Vp in the crytalline crust is assigned according to crustal types, following the philosophy of CRUST5.1 and CRUST2.0.
Using the scaling shown in section B, we assemble Vs and density accordingly. Average Vs crustal velocities in the sediments, in the crystalline crust and in the combined crust is shown in the three panels above.

F: Validation against Rayleigh wave group velocities



We validate our new crustal model against Rayleigh wave group velocity maps. That 40 mHz, group velocity is sensitive primarily to crustal structure, but also uppermost mantle structure. Validation therefore has to take into account that some discrepancies between observations and predictions can result from mantle structure that was not accounted for. The largest unexplained signal is found along subduction zones where the crustal model currently only accounts for the crust in the overriding plate but ignores anomalous deeper structure. Backarc basins also exhibit a significant mismatch.

Our highest priority before the release, however, is to remove some of the still existing discrepancies in some sedimetary basins.Our suspicion is that either sediment thickness is wrong by a 1km or the applied velocity function does not correctly prepresent Vp as function of depth.