Geophysical Research Abstracts
Vol. 15, EGU2013-5492, 2013
EGU General Assembly 2013
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Global gravity gradients: a new view on Earth's mantle

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Since 2009, the GOCE mission has been measuring the second-order derivatives of the Earth's gravity potential. Because of their directionality, these data are particularly sensitive to the geometry of the sources and thus very appropriate to investigate Earth's interior processes. By combining the GOCE measurements with a GRACE-based model, the GOCE High-Level Processing Facility expresses Earth's gravity gradients in a terrestrial frame. From these data, we constructed global maps of the non-hydrostatic part of the Earth's gravity gradients at satellite altitude. In addition to the lithospheric signal, our maps show strikingly clear large-scale patterns. Comparisons with gradients from an isostatic lithosphere model, and from a mantle dynamics model, show that these anomalies reflect deep mantle structure related to slabs and thermo-chemical upwellings. Synthetic tests demonstrate a great sensitivity in the upper part of the lower mantle. The joint analysis of this gradient dataset with other geophysical measurements thus opens new perspectives to design integrated models of Earth's interior and dynamics.