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Analysis of lithospheric stresses using satellite gravimetry: Hypotheses and applications to North Atlantic

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A major source of lithospheric stresses is believed to be in variations of surface topography and lithospheric density. The traditional approach to stress estimation is based on direct calculations of the Gravitational Potential Energy (GPE), the depth integrated density moment of the lithosphere column. GPE is highly sensitive to density structure which, however, is often poorly constrained. Density structure of the lithosphere may be refined using methods of gravity modeling. However, the resulted density models suffer from non-uniqueness of the inverse problem. An alternative approach is to directly estimate lithospheric stresses (depth integrated) from satellite gravimetry data. Satellite gravity gradient measurements by the European Space Agency (ESA) GOCE mission ensures a wealth of data for mapping lithospheric stresses if a link between data and stresses or GPE can be established theoretically. We adopt the method (1) that constrains lithospheric stresses by direct utilization of the gravity gradient tensor. For comparison, we use more traditional methods as well, (2) the filtered geoid approach and (3) the direct thin-sheet approximation based on depth integration of density moment. Whereas the last two approaches (2)-(3) calculate GPE and utilize a computationally expensive finite element mechanical modeling to calculate stresses, the approach (1) uses a much simpler numerical treatment but requires simplifying assumptions that yet to be tested. We applied all methods to the North Atlantic region where reliable additional constraints are available and tested results against the World Stress Map.