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An analysis of the linear fixed altimetry-gravimetry boundary value problem

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The determination of the Earth's external gravity field is usually formulated in terms of various types of Geodetic Boundary Value Problems (GBVPs) for the Laplace equation. Most investigations on GBVPs have been originated by the need to approximate closer and closer the physical reality and to finding more accurate and reliable procedures to handle a variety of available gravity field related data. Over the past thirty years, there has been a great deal of interest in studying Altimetry-Gravimetry Boundary Value Problems (AGBVPs). These take into account that the situation with available terrestrial geodetic data is different over the sea part and the land part of the Earth surface respectively. Nowadays, with help of the satellite altimetry data we know the Mean Sea Surface (MSS), where we are able to evaluate the disturbing potential. In land areas, respectively, we can have gravimetric data at points with precisely 3D positions provided by the Global Navigation Satellite System (GNSS) which yield surface gravity disturbances. Therefore the surface of the Earth can be considered as a fixed boundary.

In this paper, we show that this situation, from the mathematical viewpoint, can be formulated as a linear, fixed mixed boundary value problem with a Dirichlet condition imposed in the sea areas and an oblique derivative condition on land. We then proceed to prove the existence and uniqueness of weak (or generalized) solution of the aforementioned problem in an unbounded Lipschitz domain. For this purpose we make use of the Lax-Milgram theorem to show that the solution can found in a weighted Sobolev space. Assuming that the data is in suitable functional spaces, we shall further discuss some of our results regarding the regularity of the solution. In particular, we shall show that maximum regularity of the solution is achieved without the need to have any compatibility conditions imposed on the data.