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Towards A System of Data Systems in geoscience: Marussi Tensor and Invariants of the New Earth Gravity Field Models

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Global combined gravity field models of the Earth, based on satellite and terrestrial data, have today worldwide high resolution (for example 5x5 arcmin for EGM2008) and precision (of order 1 miliGal). They are subject of intensive international data exchange with a feedback in an extensive palette of geo-applications, namely in geodesy, geophysics, geology and physical geography. In our paper two modern gravity field models are applied, both combined from recent satellite and extensive terrestrial data; EIGEN 6C comprises already GOCE data while EGM2008 has only older GRACE data.

With the gravity field models, which consist of the harmonic geopotential coefficients or Stokes parameters to high degree and order in spherical harmonic expansion (e.g., to 2160 in the case of EGM2008), detailed geoid undulations and gravity anomalies (or disturbancies) can be computed. Moreover, we computed the full Marussi tensor of the second derivatives of the disturbing potential, namely Tzz, the invariants of the gravity field I2, I3 and a ratio of them. These quantities give much more evidence about details of near-surface (not deep) structures and can be used in local scales (few kilometers) for petroleum, metal, diamond, ground water etc. explorations and in regional scales (~100 km), e.g., for studies of large impact craters and active tectonic zones. Using EGM2008 we have a resolution ~ 9 km half-wavelength on the Earth surface: it is not sufficient for studies of local details, however, it is very valuable for regional and large-scale surveys.

In the presented paper are studied selected regions where the second derivatives and the invariants are valuable for geo-applications, that is in the Arctic and Antarctic areas, in the Himalaya and similar mountain belts and in further localities, such as are impact craters. For example, they are demonstrated our results of the correlation of Tzz values computed from EGM2008 with morphogenetic and orographical patterns of the Nepal Himalaya. Very variable values of Tzz display significant gravitational signatures of extensive differences and changes in mass density and/or rock massif and regolith distributions which occurred during very dynamic landform evolution of the Nepal Himalaya in the late Cenozoic. Variable large-scale configurations of values of Tzz give evidence of the long-term operation of certain complexes of morphogenetic processes producing the evolution of not only distinctive topographic features, but also, especially, of specific relief types of the Earth.

Our primary interest in this study is to compute abovementioned quantities for the territory of Japan and surrounding seas/ocean for possible application and further investigation by Japanese geophysicists. This may lead to exchange of data and results and to an extension of application of the gravity field models in various specializations (which would be nice feedback for us).

キーワード: gravity field of the Earth, Marussi tenzor, gravity invariants, System of Data Systems in geoscience, satellite GRACE, satellite GOCE
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