MASS DISTRIBUTION OF EARTH LANDFORMS DETERMINED BY ASPECTS OF THE GEOPOTENTIAL AS COMPUTED FROM THE GLOBAL GRAVITY FIELD MODEL EGM 2008

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ABSTRACT

Correlations of large-scale landform patterns with some aspects of the geopotential as computed from the global gravity field model EGM 2008, particularly the radial second derivatives of the disturbing gravitational potential Γ_{33}, the strike angle θ_S and virtual deformations of the ellipse of deformation, are demonstrated. Selected regions with documentation of aspects from EGM 2008 are the Nepal Himalaya and its neighbouring areas, the collision zone of East-Asian and West-Pacific lithospheric plates, the contact region of north-eastern Africa, south-western Asia and south-eastern Europe, morphotectonic contact between the Bohemian Massif, Eastern Alps and the Western Carpathians in Central Europe and regions of ancient rapid events indicated by relics of large impact craters Vredefort, Chicxulub and Popigai. It is suggested that landform patterns with very conspicuous combinations of significantly high positive or negative values of Γ_{33} are under the strong influence of rapid and/or intensive geomorphic processes. These geophysical signatures supported by values of the strike angle θ_S and virtual dilatations or compressions of the ellipse of deformation reflect the regional dynamics of Earth surface evolution as characterised by a very effective integration of tectonic and climate-driven morphogenetic processes.

Keywords: Earth landforms, gravity field model EGM 2008, mass distribution, geodynamics, geomorphic processes

1. Introduction

Progress in satellite geodesy and dynamics of the Earth's artificial satellites, involves satellite altimetry and space-born gradiometry data, together with an extensive, nearly global and often very precise database of terrestrial gravity anomalies. It enables the parameters of the static gravity field of the Earth (the so called harmonic geopotential coefficients or Stokes parameters represented by spherical expansion) to be reliably determined to a high degree and order, and detailed geoid undulations and other quantities derivable from the harmonic coefficients to be observed with high accuracy and resolution. The National Geospatial-Intelligence Agency of the USA developed the *E*arth *G*ravity Field *M*odel 2008 (EGM 2008, Pavlis et al. 2008a,b, 2012) combined from the GRACE satellite data and gravity anomalies over the world (excluding Antarctica) to degree $n_{max} = 2190$.

Global combined gravity field models of the Earth, based on satellite and terrestrial data, can today have worldwide high resolution and precision. The EGM 2008 (Pavlis et al. 2008a,b, 2012) uses satellite multiyear inter-satellite range-rate data from a near polar orbiting tandem of satellites called GRACE (Gravity Recovery and Climate Experiment, NASA + GFZ) with extensive gravity anomalies derived from terrestrial gravimeters and satellite altimetry. EGM 2008 reaches a resolution of 5 × 5 arcmin, which is ~9 km of half-wavelength on the Earth's surface at the equator, and, with the exception of Antarctica and some other areas, a precision of the order 1 miliGal. Such a model offers new opportunities to many applications in geodesy, geophysics, geology, geomorphology and physical geography. The new data coming from the gradiometer on board GOCE (Gravity Field and Steady-State Ocean Circulation Explorer, ESA's gravity mission, Floberghagen et al. 2011) improve the middle-wavelength part (from ~120 to ~250 degrees) of future gravity models where satellite terrestrial data are wanting. The newest gravity field models from 2010–2011 also comprise gradiometry data from the satellite GOCE mission instead of data from GRACE (e.g. EIGEN 6C, Förste et al. 2011). They have only at maximum about half the resolution in comparison with EGM 2008 (Klokočník et al. 2012). Progress in the quality of quantities derived from their harmonic geopotential coefficients has been noted only in Antarctica.

In the presented paper, using the harmonic geopotential coefficients of the EGM 2008, are computed: the detailed geoid undulations N [m], the gravity anomalies Δg [1 mGal = 10^{-5} m s^{-2}], the full Marussi tensor of the second derivatives of the disturbing potential (also known as Full Tensor Gradiometry [1 E = 1 Eötvös = 10^{-9} s^{-2}]), namely its radial component Γ_{33} (sometimes denoted T_{zz} or T_{rr}) in spherical harmonics, the invariants of the gravity field I_0, I_1, I_2, computable from the components of the Marussi tensor, their specific ratio I and the strike angle θ_S, utilizing the theory of Pedersen and Rasmussen (1990) and Beiki and Pedersen (2010). A virtual dilatation or contraction of the ellipse of deformation is added. Some of these quantities are functionals of the geopotential in a mathematical sense and some of them are not. Therefore, they are concisely designated in the paper as *aspects* of the geopotential.

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