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Detection of hydrological mass variations by means of an inverse tesseroid approach

T. Grombein (1), K. Seitz (1), J.L. Awange (2), and B. Heck (1)

(1) Geodetic Institute, Karlsruhe Institute of Technology (KIT), Englerstr. 7, D–76128 Karlsruhe, Germany (grombein@kit.edu), (2) Western Australian Centre for Geodesy and The Institute for Geoscience Research, Curtin University, GPO Box U1987, Perth, Western Australia 6845, Australia

Modern satellite missions like GRACE (Gravity Recovery and Climate Experiment) provide monthly global geopotential models allowing to analyze the time-variable part of the Earth's gravity field. From a hydrological point of view the monthly changes are mainly caused by variations of the Earth's water storage. The usual procedure for the detection of such hydrological mass variations is based on the elastic Love number theory, in which global spherical harmonics are used to derive geoid anomalies that can be converted to equivalent water column heights. Alternative procedures in the space domain result in an inverse problem of forward modeling based on the evaluation of functionals of Newton's integral. This procedure is particularly suitable for regional applications.

In contrast to often used point-mass approximations, in this contribution an approach based on tesseroidal mass bodies is proposed. Tesseroids (spherical prisms) are bounded by geographical grid lines and surfaces of constant heights and therefore directly linked to the curvature of the Earth. As volume integrals occurring in the formulas for the gravitational field of tesseroids cannot be solved analytically, a Taylor series expansion of the integral kernel in combination with a subsequent term-wise integration is carried out. The resulting formulas are introduced as observation equations in a least-square adjustment, in which gravity data, e.g. derived from GRACE measurements, is utilized as observations and the heights of particular tesseroid bodies are the unknowns. Since these equations are non-linear, a linearization has to be performed. Using a constant density value of 1.00 g/cm^3 the solved unknown tesseroid heights can be associated with the desired water column heights.

The present paper provides an overview of the briefly outlined inverse tesseroid approach. Furthermore, taking the Australian continent as an example, results from a realistic closed-loop simulation are presented showing possibilities and limitations of the suggested tesseroid method.