On the physical meaning of the zonal components of the geopotential

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The MacCullagh equation (1855) is of key importance in the study of the Earth, describes the gravity potential outside a bounding sphere of radius $R$ up to the second degree and zeroth order. It connects the geometrical, and the physical properties of the Earth through the geodynamical shape factor $J_2$. This second zonal geopotential coefficient is closely related to the flattening and to the angular spin velocity of the Earth as well as to its equatorial ($A$) and polar ($C$) moments of inertia. Through these moments of inertia the gravitational potential $V$ is connected to the mass density distribution within the Earth.

The main target of the present study is to obtain a generalized form of the MacCullagh equation for even orders $n \geq 2$ by including the higher order zonal coefficients $J_n$ connected with the higher ($n \geq 2$) degree moments of inertia $C_n$ and $A_n$. The higher the degree $n$, the higher is the weight of the near-surface (i.e. shallow) mass density distribution in $J_n$. The second part of this contribution deals with the temporal variations of $J_n$ and $dJ_n/dt$. 