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Closed solution of variational equations for short-arc SST

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For regional gravity-field improvement short-arc SST in the low-low mode is frequently applied. Usually, the regional correction to the gravity-field is expressed as a superposition of localizing base functions:

$$\delta V(x) = \sum_{i=1}^{N} \varphi_i(x, \eta_i).$$

The base functions φ_i depend on parameter vectors η_i, which describe the locations and the shapes of the base functions. These parameter have to be chosen so, that the field correction δV optimally matches the residual SST observations.
In general, the base functions φ_i depend nonlinearly from their parameter vectors η_i. Therefore, the partial derivatives $\partial \varphi_i / \partial \eta_i$ are needed for the least-squares approximation of the residual observations by the gravity-field correction model. In most cases, these partial derivatives are obtained by the integration of the variational equations

$$\ddot{\psi}_{ij} - \nabla^2 V(x) \psi_{ij} = \delta V(x),$$

where the derivative of the i-th base function with respect to the j-th parameter is denoted by ψ_{ij}. This leads to a very large number of differential equations, which have to be integrated.

The paper will show that for

- nearly circular orbits and
- radially symmetric base functions

a closed solution of the variational equations can be derived. For this purpose the representation theory of the SO(3) group is used for the exploitation of the symmetries in the orbits and the shapes of the base functions.