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Finite volume numerical scheme for high-resolution gravity field modelling and its parallel implementation

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The paper discusses a numerical solution of the geodetic boundary value problem (GBVP) by the finite volume method (FVM). The FVM is a numerical method where numerical flux is conserved from one discretization cell to its neighbour, so it's very appropriate for solving GBVP with the Neumann and the Dirichlet BCs. Our numerical scheme is developed for 3D computational domain above an ellipsoid. It is shown that a refinement of the discretization in height's direction leads to more precise numerical results. In order to achieve high-resolution numerical results, parallel implementations of algorithms using the MPI procedures were developed and computations on parallel computers were successfully performed. This basis includes the splitting of all arrays in meridian's direction, usage of an implementation of the Bi-CGSTAB non-stationary iterative solver instead of the standard SOR and an optimization of communications on parallel computers with the NUMA architecture. This gives us higher speed up in comparison to standard approaches and enables us to develop an efficient tool for high-resolution global or regional gravity field modelling in huge areas. Numerical experiments present global modelling with the resolution comparable with EGM2008 and detailed regional modelling in the Pacific Ocean with the resolution 2x2 arc min. Input gravity disturbances are generated from the DTU10-GRAV gravity field model and the disturbing potential is computed from the GOCE_DIR2 satellite geopotential model up to degree 240. Finally, the obtained disturbing potential is used to evaluate the geopotential on the DTU10 mean sea surface and the achieved mean dynamic topography is compared with the ECCO oceanographic model.