Supervisor's comments on Libor Šachl's doctoral project

Modelling of global ocean circulation and ocean-induced magnetic field

The PhD project was devoted to numerical modelling of global baroclinic ocean circulation. The project was originally motivated by the aim of modelling ocean circulation during last glaciation when the ocean bottom and surface topographies have been changing significantly. For instance, the Bering Strait was a land bridge between the continents of Asia and North America at the beginning of glaciation. The ocean surface temperature was up to 10°C cooler than today in the northern and southern oceans during the last glacial maximum causing that the thermohaline circulation responsible for the heat transfer in ocean differed from today.

Libor Šachl obtained the LSG ocean model from Dr. Butzin at the Max Planck Institute for Meteorology in Hamburg. He studied the model code and learned its basic principles such as the governing equations, spatial discretisation and time-stepping scheme.

In the following period, when Libor became a member of the research team for solving the ESA-funded project' $Swarm + Oceans$' aiming at extracting tidal ocean signals from Swarm data and interpreting them in terms of tidal ocean dynamics, Libor modified the LSG ocean model for present day ocean circulation. The idea was to model not only barotropic but also baroclinic ocean tides.

The new global ocean circulation code, called LSOMG, has significantly changed from the original model. The individual changes include a better computational grid, time stepping scheme, advection schemes, state equation and added mixing parameterizations and tidal forcing. The model was parallelized by implementing the OpenMP and MPI interfaces. The barotropic part of the model was tested in a series of benchmarks and the results were compared with another model called DEBOT. The baroclinic part was also benchmarked. The Gaussian-shape anomaly was preserved by the implemented advection schemes for tracers when it was advected by prescribed velocities, the vertical friction successfully generated the Ekman layer in a benchmark setting and main features of a simplified wind-driven circulation in an enclosed rectangular basin were verified.

Libor's second effort was to use LSOMG together with a magnetic solver to model the ocean-induced magnetic field. He focused on the effect of vertical stratification of ocean flow, oceanic electrical conductivity and horizontal resolution on the ocean-induced magnetic field.

Libor demonstrated by his Ph.D. project that he can work independently. As a supervisor, I had limited knowledge about ocean circulation modelling at the beginning of Libor's project. Nevertheless, Libor collected all possible publications on ocean circulation and was able to test all existing numerical approaches for solving the problem numerically. As any scientist, he needs to discuss his ideas and results from time to time. In these discussions, he can express his views in a clear way. He has no problem in communicating with people, not only on scientific issues but also on other general topics.

Libor enjoys working with theory, both the fundamental pencil work, as well as the programming aspects. He rederived mathematically many numerical approaches found in literature. As an example, at the later stage of his project, he rederived and programmed numerically two approaches for removing singularities of a global grid, the reduced-spherical coordinate grid and Yin-Yang grid.

In summary, Libor is an excellent young scientist with broad and versatile interests. He has demonstrated his flexibility in scientific research while undertaking his PhD project. I am convinced that he would be able to quickly orient himself and start working on any new scientific problem if necessary. Without any reservation, I recommend the thesis to be passed on to a public defense, and Libor Šachl to be awarded the PhD degree after successful defense.

Prague, August 24, 2020 Zdeněk Martinec