Appraisal of the Thesis **"Numerical modeling of present day mantle convection"** by Nicola Tosi.

The candidate discusses several aspects of numerical modeling of mantle dynamics. Since many important issues, such as the role of lateral viscosity variations (LVV), cannot be addressed by classical methods based on the propagator technique, numerical tools are needed. Commercial packages such as Marc and Abaqus offer the possibility of tackling such a problem, and indeed many researchers are using these tools for solving a number of problems in global geodynamics, including mantle convection in the presence of realistic lateral rheological variations. Here an effort is made to develop codes and procedures virtually from scratch (a valuable tradition of scientists of this Department), leading to a spectral finite element (hereinafter SFE) method that is applied successfully to mantle convection.
The Thesis constitutes a self-contained discussion of mantle convection, and illustrates in a rigorous but concise way all the basic concepts starting from geoid undulations, tomography, and the equations governing the motion of a very viscous fluid driven by internal density anomalies. In the bulk of the dissertation, the SFE is described and validated against known semi analytical results. Finally, an application to lithospheric subduction is made. Thought I did not check all the mathematics into detail, I could appreciate the originality of the approach. The material is well presented, and the general features of the method could be (at least in principle) extended to linear visco-elasticity in the presence of LVV, as an alternative to "pure" finite elements approaches by commercial products.
Still lacking a 3D implementation of the SFE, the last Chapter is devoted to a study of the long-wavelength geoid undulation above a subducting slab in an axis symmetric model. This is indeed a classical problem in global geodynamics, first addressed in the 80's in a suite of milestone papers. The merit of the analysis made here is the large set of viscosity models considered, and the serious efforts to model small scale viscosity structure of the subducting lithosphere. Given a realistic slab buoyancy, the main result (which is perhaps not totally surprising) is that geoid undulations are mainly

governed by the viscosity contrast between the upper and lower mantle, while LVV cause major effects on mantle flow. This finding will be probably confirmed in the upcoming 3D computations. Perhaps, in view of the geophysical implications, in the future it could will be useful to address an important issue that surfaces again from this study, i. e., the need of a significant viscosity increase across the 670 km depth discontinuity, which seems to contradict evidence from glacial isostatic adjustment.

To summarize, in view of the importance of this work in relation to its field, to its scientific *rationale*, to the originality of the results, and to the clear presentation, I strongly recommend that the thesis is accepted in fulfillment of the requirements for the degree of Doctor of Philosophy.

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Yours sincerely,

Giorgio Spada, External examiner