COMPLEXITY OF DIRECT NUMERICAL SIMULATIONS OF TURBULENT NATURAL CONVECTION

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Summary We derive the scaling of the dimensionless velocity of Large-Scale Circulation and turnover time in turbulent natural convection with respect to the Rayleigh, Nusselt and Prandtl numbers, based on Prandtl-Blasius boundary layer equations. Analyzing the kinetic dissipation rates in the bulk and within the boundary layers, we obtain the lower-bound scaling of the Nusselt number with respect to the Rayleigh number, which allows to evaluate the number of dimensionless time units, required for statistical averaging in Direct Numerical Simulations (DNS) dependently on the Rayleigh number. It is shown that this number scales as the Rayleigh number taken with the exponent 0.1. Finally, based on the estimations of the turnover time and the Kolmogorov time and length scales in the boundary layers, we find the scaling of the total DNS complexity. The theoretical estimates for the wind velocity and turnover time are supported by numerous DNS. Finally we discuss the reasonability of the usage of implicit numerical schemes is DNS of turbulent natural convection.

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