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Nonlinear optimization of buoyancy-driven ventilation flow
SALEH NABI, PIYUSH GROVER, Mitsubishi Electric Research Labs, C.P. CAULFIELD, BP Institute & DAMTP, University of Cambridge — We consider the optimization of buoyancy-driven flows governed by Boussinesq equations using the Direct-Adjoint-Looping method. We use incompressible Reynolds-averaged Navier-Stokes (RANS) equations, derive the corresponding adjoint equations and solve the resulting sensitivity equations with respect to inlet conditions. For validation, we solve a series of inverse-design problems, for which we recover known globally optimal solutions. For a displacement ventilation scenario with a line source, the numerical results are compared with analytically obtained optimal inlet conditions available from classical plume theory. Our results show that depending on Archimedes number, defined as the ratio of the inlet Reynolds number to the Rayleigh number associated with the plume, qualitatively different optimal solutions are obtained. For steady and transient plumes, and subject to an enthalpy constraint on the incoming flow, we identify boundary conditions leading to ‘optimal temperature distributions in the occupied zone.

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