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Numerical simulation of non-equilibrium transient flow during inhalation OLAF MARXEN, THIERRY MAGIN, von Karman Institute for Fluid Mechanics — The flow in human upper airways may be laminar, transitional, or turbulent. Breadth-by-breadth and patient-specific variability is expected to have a significant influence on laminar-turbulent transition. The flow path of therapeutic drug aerosols may be strongly affected by the transition-induced unsteady structures. The unsteady Navier-Stokes equations are solved numerically to simulate the flow through a channel-flow geometry representative of an airway segment. In order to trigger transition, small-amplitude disturbances are forced via wall blowing/suction. We perform multiple simulations with varying phase of the forced disturbances. Ensemble averaging then allows to compute mean and RMS values. A time-dependent channel center-line velocity serves to model the change in flow velocity during inhalation. The uncertainty associated with variability during breathing is quantified using non-intrusive stochastic collocation. Simulation results reveal that we have intervals in time and space with quasi-steady equilibrium and with strong non-equilibrium flow. The uncertainty associated with the breathing pattern may strongly affect the occurrence of laminar-turbulent transition, leading to large uncertainties when RMS values are peaking.

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