Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

The dependence of plumes on Reynolds number[1] DANIEL WARD, SAM PEGLER, University of Leeds, SOM DUTTA, Utah State University, DAVID FERGUSON, University of Leeds — Buoyant plumes in stratified environments are a common fluid-dynamical phenomenon present across a wide range of Reynolds numbers (Re), from volcanic eruptions to the convection generated above a human head. However, classical theories of turbulent plumes, such as the Morton, Taylor & Turner (1956) model, do not incorporate the dependence of plumes on viscosity (nor thermal diffusivity). They are therefore unable to address the dynamics of plumes at intermediate scales, and the transition to Re-independent dynamics. In order to address these open questions, we conduct the first complete theoretical investigation of plume dynamics in stratified ambients across the full range of Re using direct numerical simulations of the Navier-Stokes equations. By constructing a universal regime diagram, we reveal the asymptotic transition from a new theory of the rise height of a laminar plume in a stratified environment to a Re-independent turbulent regime at sufficiently large Re. The results establish the general dependence of plumes on viscosity, and clarify for the first time the conditions necessary for simulations to reproduce high-Re natural phenomena such as volcanic eruptions.

[1]Engineering and Physical Sciences Research Council

Daniel Ward
University of Leeds

Date submitted: 10 Aug 2020 Electronic form version 1.4