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Trajectory of a plume in a power-law velocity profile ALI TOHIDI, NIGEL KAYE, Clemson University — Highly buoyant plumes, bent-over by a cross flow, occur in many situations ranging from waste-water discharges into rivers up to wildfire plumes in the atmosphere. Highly buoyant plumes have a steeper initial trajectory and, therefore, rise to regions of higher velocity. Hence, their trajectory will be more greatly affected by vertical variations in horizontal velocity. It is shown that, for a power-law boundary layer, the volume and momentum fluxes scale on the square of the plume's path (s^2) compared to $s^{3/4}$ for a uniform velocity. The plume's trajectory is flatter with the plume angle scaling on s^{-1} compared to $s^{-1/3}$ in the uniform case. However, experimental evidence in the literature indicates that, under certain conditions, the boundary layer velocity profile makes little difference to the plume trajectory and algebraic equations developed for plumes in a uniform cross flow are adequate. Source length scale analysis is used to establish criteria for when to include boundary layer velocity variations. Such variations are only important when either the momentum length scale or buoyancy length scale is considerably greater than the release height of the plume. This result is particularly crucial for modeling wildfire plumes.

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