Large eddy simulations of forced plumes subjected to volumetric heating

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Over the years, turbulent plumes had been a subject of interest for many researchers because of their ubiquity in nature and engineering applications. Plume rising in a stratified environment is one of the building blocks in the formation of clouds in the atmosphere. Two factors which primarily affect the cloud dynamics are the release of latent heat due to condensation and the background stratification strength. In this study, we performed large eddy simulations of forced plume under varying strengths of volumetric heating (mimicking the latent heat release) and for various background strengths.

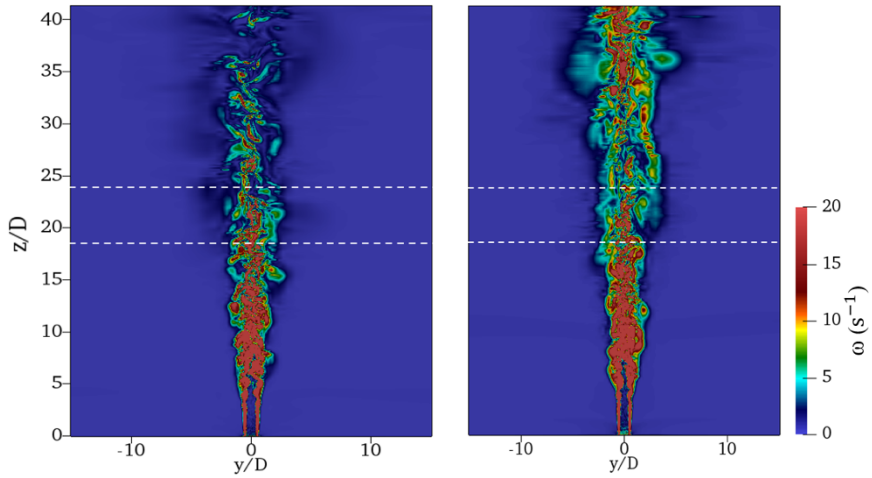

Figure 1: Contours of vorticity magnitude (a) without off-source heating (b) with off-source heating for uniform density medium. White dotted line indicates the vertical extent of the heat injection zone.

Figure 1 shows the contours of vorticity magnitude with and without volumetric heating. The left panel shows the contours without any heating, and the right panel shows the contours with the volumetric heating. White dotted lines show the region where volumetric heating is added. We clearly observe the increase in the vorticity associated with the increase in small scale features above the heat injection zone. Correspondingly the turbulent kinetic energy (TKE) is found to increase above the heat injection zone, however, we observed a decrease in the TKE in the heat injection zone. The entrainment is also found to increase in the heat injection zone with the addition of volumetric heating. For a given magnitude of volumetric heating, increase in the stratification strength is found to reduce the turbulent kinetic energy.

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