Microphysical time scales, supersaturation fluctuations and at a warm Cloud Top Boundary intemporal decay

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Recent results have shown that there is an acceleration in the spread of the size distribution of droplet populations in the region bordering the cloud and undersaturated ambient[1] We have analyzed the supersaturation balance in this region, which is typically a highly intermittent shearless turbulent mixing layer, under a condition where there is no mean updraft. We have investigated the evolution of the cloud - clear air interface and of the droplets therein via direct numerical simulations. We have compared horizontal averages of the phase relaxation, evaporation, reaction and condensation times within the cloud-clear air interface for the size distributions of the initial monodisperse and polydisperse droplet populations[2] For the monodisperse population, a clustering of the values of the reaction, phase and evaporation times, that is around 20-30 seconds, is observed in the central area of the mixing layer, just before the location where the maximum value of the supersaturation turbulent flux occurs. This clustering of values is similar for the polydisperse population but also includes the condensation time. The mismatch between the time derivative of the supersaturation and the condensation term in the interfacial mixing layer is correlated with the planar covariance of the horizontal longitudinal velocity derivatives of the carrier air flow and the supersaturation field, thus suggesting that a quasi-linear relationship may exist between these quantities.

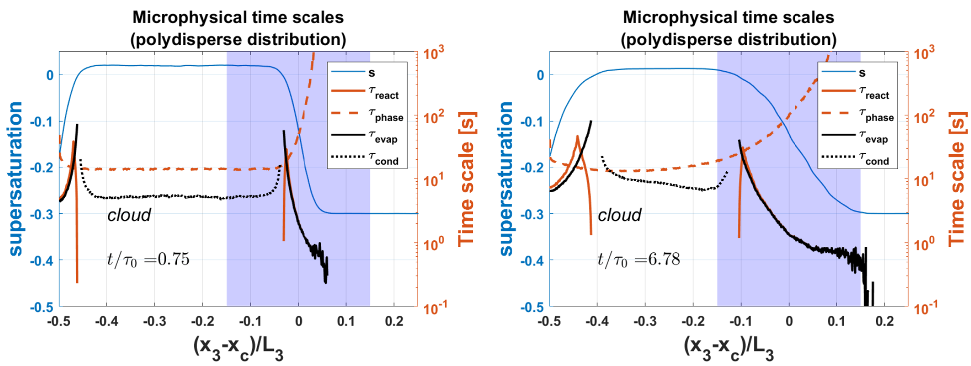

Figure 1: Vertical distribution of the evaporation evap, phase relaxation τ_{phase} and reaction τ_{react} time scales computed inside each grid cell and then averaged on horinzontal planes inside the cloud and mixing regions. Data are displayed for two different time steps at the beginning and the end of the transient. The planar average of supersaturation is also plotted for comparison purposes.

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[1] Golshan et al., *International Journal of Multiphase Flow* **140**, (2021).
[2] Fossà et al., *Physics of fluids* **34**, (2022).