How time-varying heating of a wall changes the stratification in a room

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Building interiors often experience time-dependent heating of vertical surfaces, for example, through sunlight falling on walls. How do these heated surfaces change the temperature stratification in a room? We extend the constant flux, vertically distributed source of buoyancy of Cooper and Hunt [2] to allow for a time-dependent source of buoyancy.

We consider a vertically distributed source of buoyancy, in a sealed insulated space, that provides a linearly-varying-in-time (with slope a) buoyancy flux. This source drives a time-dependent flow: a plume rising up the wall, and return flow in the ambient. We solve the governing equations numerically, using Germeles's method [1], but we allow the plume to intrude at its neutral buoyancy height. We find that at small times, the ambient stratification profiles for rates of decrease of source buoyancy flux that are slower than a critical rate, $a_c < a < 0$, are qualitatively similar to those with $a > 0$, with the profiles getting steeper near the ceiling, while the profiles for $a < a_c < 0$ are qualitatively different, with the profiles getting shallower near the ceiling, as shown in Fig. 1.

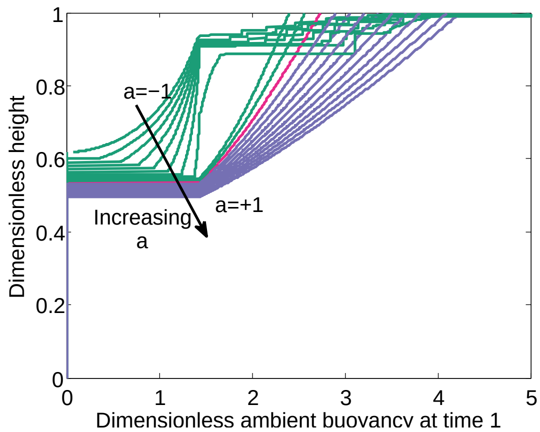

Fig. 1: The dimensionless ambient buoyancy distribution with height, in a sealed space with a vertically distributed buoyancy source that provides a linearly-varying-in-time (with slope a) buoyancy flux.

We also present results from analogue laboratory experiments, where the plume is observed to detrain, as in Fig. 2.

Fig. 2: We observe detrainment, as seen in Gladstone and Woods's [3] experiments.

References

[1] A. E. Germeles *J. Fluid Mech.* **71**:601-623, 1975.
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