Corrigendum

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In section 3c of Torri and Kuang (2016), a quantification of the contributions to the total work done by rain evaporation and condensate loading was presented. A closer look at Eq. (15) indicates that the estimated contribution only takes into account the local effects of rain evaporation, meaning the contributions given by the change in the thermodynamic state of a parcel due to rain evaporation. However, the changes of the parcel's thermodynamic state at a given time step have repercussions for all the successive time steps, until the end of the parcel's descent. For this reason, Torri and Kuang (2016) underestimated the role of rain evaporation, as the nonlocal effects of rain evaporation have to be accounted for as well. The sum of local and nonlocal effects can be estimated by

$$W_{\mathrm{ev}}^{\mathrm{TOT}} = -g\int_{t_i}^{t_{\mathrm{core}}}\left[\frac{L_v}{c_p}(1+\epsilon q_v - q_l) - \epsilon\theta\right]\left(\frac{\partial_t q_{\mathrm{ev}}}{\overline{\theta}_\rho}\right)[z(t) - z_{\mathrm{core}}]\,dt\,, \tag{1}$$

where t_i and t_{core} are, respectively, the time when a particle enters the downdraft and when it enters the cold pool core, $\partial_t q_{\mathrm{ev}}$ is the evaporation rate, and the other symbols are the same as those used in Eq. (15) of Torri and Kuang (2016). Conceptually, the main difference between the two equations is that now each contribution from evaporation is integrated from the height where it begins until the bottom of the downdraft, whereas before the integration was only on the segment of the downdraft where the contribution took place.

The total contribution by rain evaporation for particles descending from different heights is given by the green line of Fig. 8 in this document, which should replace Fig. 8 of Torri and Kuang (2016). The nonlocal effects of rain evaporation are found to give a much higher contribution to the total work than the local ones, resulting in a nonlinear growth with increasing particle's initial heights. For example, the contribution of condensate loading at 1150 m—corresponding to the mode of the particles' distribution presented in Fig. 2 of Torri and Kuang (2016)—amounts to 13 J kg^{-1}, while the total contribution by rain evaporation equals 29 J kg^{-1}, which is 2.2 times greater. Repeating the consistency check illustrated in section 3c of Torri and Kuang (2016) with the updated formula to include nonlocal components yields a ratio between the contribution by rain evaporation and that by the condensate loading of 2.0, which is slightly smaller than the ratio obtained using the Lagrangian particles. Because this was intended as a basic consistency check and used evaporation rate averaged over the entire domain, we deem the comparison satisfactory.

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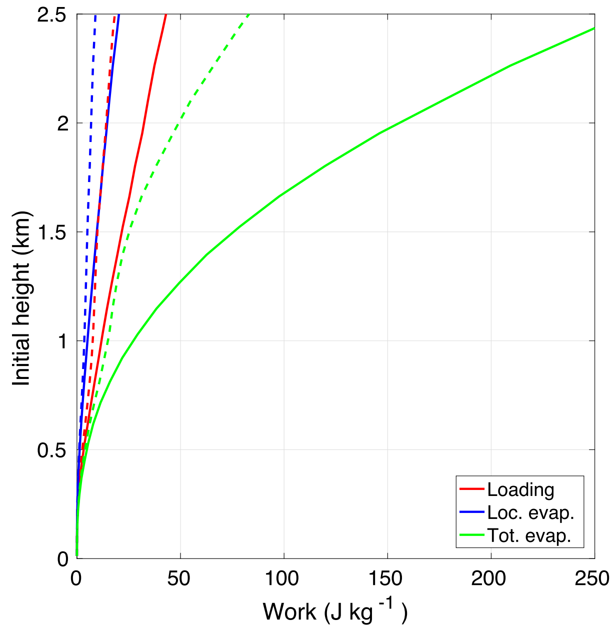

FIG. 8. Comparison between the total work done on Lagrangian particles with different initial heights by different contributions to buoyancy (solid lines) and total buoyancy (dashed lines). The red lines refer to the contributions by condensate loading, while the blue and the green correspond, respectively, to the local and the total contribution by rain evaporation.

Using the concept of buoyancy ratio introduced in Torri and Kuang (2016), it is possible to obtain an estimate of the contributions of rain evaporation and condensate loading to the total work. For particles descending from different initial heights, these are represented by the dashed curves in Fig. 8, the color convention being the same as the one adopted above to show the contributions to the Archimedean buoyancy. The curves show that, including the aforementioned nonlocal effects, rain evaporation seems to contribute more to total work than condensate loading for all values of initial heights.

It should also be noted that the changes in buoyancy due to rain evaporation represented in the right panel of Fig. 9 of Torri and Kuang (2016) only refer to local changes. These were shown mainly to make the point that particles experience rain evaporation mostly in the subcloud layer, so the figure need not be modified.

Given the above discussion, one of the conclusions of Torri and Kuang (2016) should be revisited: while condensate loading provides a nonnegligible contribution to the total work, particularly for particles descending from low altitudes, rain evaporation is the dominant forcing at all heights. At 1150 m, where the largest number of particles originates, the contribution of rain evaporation is roughly twice that of condensate loading.

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REFERENCE

Torri, G., and Z. Kuang, 2016: A Lagrangian study of precipitation-driven downdrafts. *J. Atmos. Sci.*, **73**, 839–854, doi:10.1175/JAS-D-15-0222.1.