Introduction to Cloud Modeling - report 3

Kamil Kolasa

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The main topic during last few Introduction to cloud modeling tutorials was implementation of buoyancy and drag force into the adiabatic parcel code. An equation of motion for such an adiabatic parcel was given as

$$\frac{d^2z}{dt^2} = g\frac{\theta_v - \theta_{v,0}}{\theta_{v,0}} + f_d, \tag{1}$$

where f_d was the drag force divided by the parcel mass and was given as

$$f_d = -\frac{3}{8}\frac{\rho_0 C_d}{(\rho_i \rho^2 R_i^3)^{1/3}}. \tag{2}$$

Symbols ρ_i, R_i, ρ and w were the initial density, initial radius, density and velocity of the parcel, respectively. The numerical problem of finding z and $z' = w$ was solved with use of second order Runge-Kutta method.

In the Figures below one can find results found for various concentrations c compared with results obtained for the saturation adjustment model. For every case initial value of velocity w was zero and there was a very small initial difference between θ_v and $\theta_{v,0}$ to make parcel move upwards.

As one can see at Figure 1, under condensation level velocity quickly reaches equilibrium value. Over that level w rapidly grows and when parcel reaches inversion level it becomes to oscillate around it. Moreover, relation $w(t)$ depends very weakly on c. As in previous numerical exercises, saturation S reaches bigger values for lower concentrations c.

Figure 2 shows that thermodynamic parameters for non-constant w reconstruct ones obtained for saturation adjustment scheme.

In Figure 3 one can see that variance of radii distribution firstly grows after crossing, then rapidly decreases and after reaching inversion level it begins to oscillate.

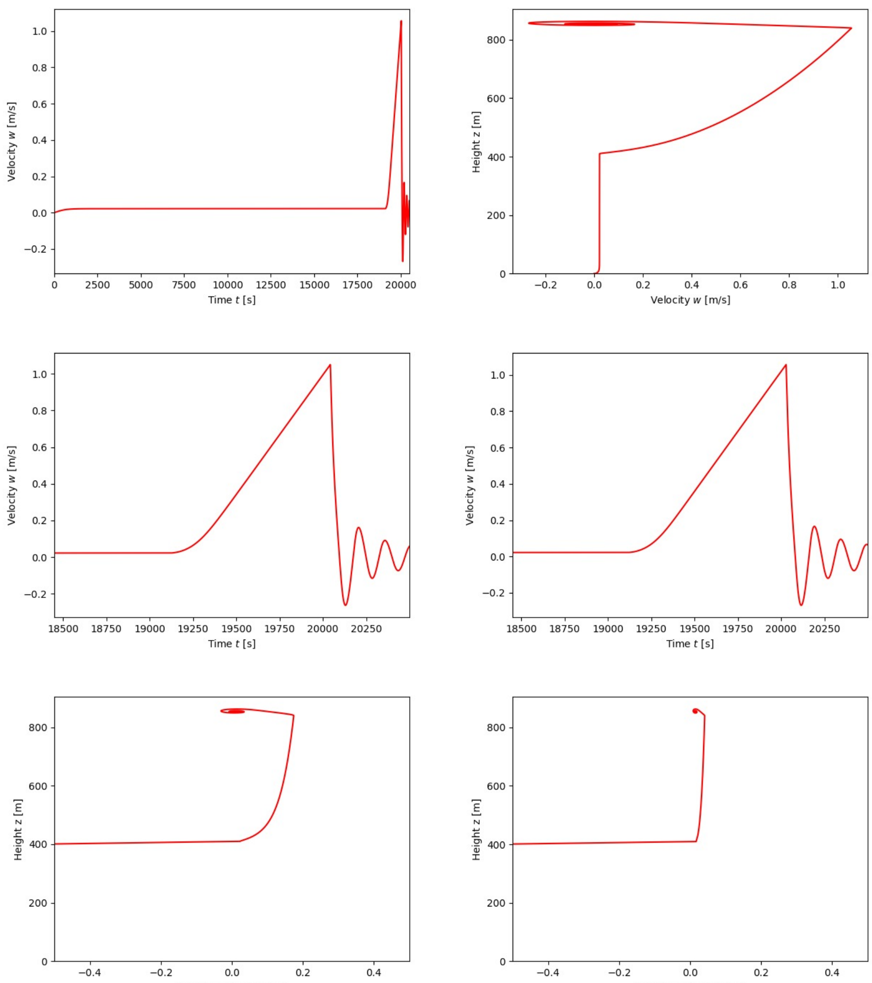

Figure 1: Relations between velocity w, height z, time t and saturation S for adiabatic parcel model with implementation of buoyancy force: top-left panel is $w(t)$, top-right is $w(z)$, mid-left is $w(t)$ during last segment of a simulation for $c = 100$ cm^{-3}, mid-right is the same relation for $c = 1000$ cm^{-3}, bottom-left is $S(z)$ for $c = 100$ cm^{-3} and bottom-right is $S(z)$ for $c = 100$ cm^{-3}.

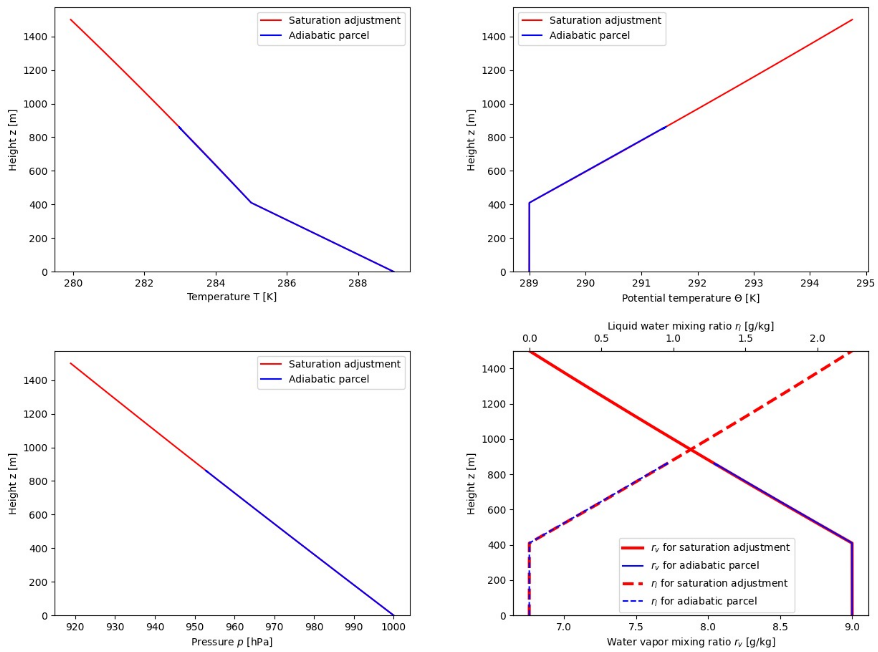

Figure 2: Relations between height z and thermodynamic parameters: temperature T (top-left), potential temperature θ (top-right), pressure p (bottom-left), water specific masses r_l and r_v (bottom-right).

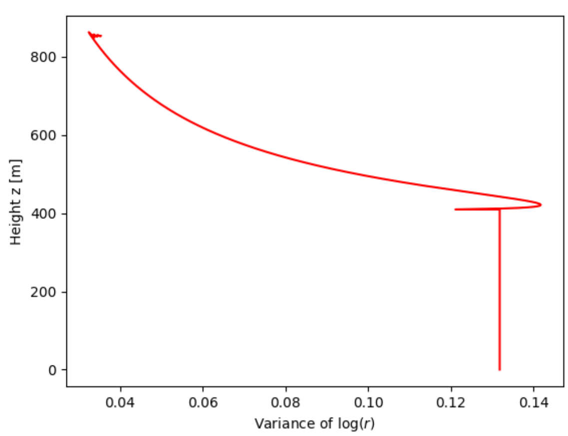

Figure 3: Relation between variance of logarithm of droplet radii distribution and height z for $c = 200$ cm^{-3}.