z_i : parcel height at t_i (m)

w_i = vertical velocity (m/s)

$T_{p,i}$ = parcel temperature (K)

$q_{p,i}$ = parcel water vapor mixing ratio (kg/kg)

T°(z) : $\begin{cases} 301 - 6,5 \cdot 10^{-3} z & z < 15 \text{ km} \\ 216,65 & z > 15 \text{ km} \end{cases}$

humidity : $q_e(z) = 0,0018 \exp\left(\frac{-z}{2000}\right)$

parcel pressure : $p(z) = p_0 \exp\left(\frac{-z}{H}\right)$ $\quad H \simeq 8000$ m

saturat° vapor pressure : $e_s(T) = 611,2 \exp\left(17,67 \frac{T - 273,15}{T - 29,65}\right)$

mixing ratio at saturat° : $q_s = \epsilon \frac{e_s}{p - e_s}$ $\quad \epsilon = \frac{R_d}{R_v}$

adiabatic lapse rate : $\Gamma_m = \frac{-\partial T}{\partial z} \simeq \Gamma_d \frac{1 + \frac{L q_s}{R_d T}}{1 + \frac{L^2 q_s \epsilon}{c_p R_v T^2}}$

dry lapse : $\Gamma_d = \frac{g}{c_p}$

virtual temp

- of parcel $T_{v,p} = T_p (1 + 0,608 q_p)$

$T_{v,e} = T_e (1 + 0,608 q_e)$

Bouyancy accelerat° $B = g \frac{T_{v,p} - T_{v,e}}{T_{ve}}$

vertical momentum w/ linear drag $\frac{dw}{dt} = B - \varepsilon_{drag} w$

$\downarrow$

$w_{i+1} = w_i + (B - \varepsilon_{drag} w_i) \Delta t$

height update $\frac{dz}{dt} = w \Rightarrow z_{i+1} = z_i + w_i \Delta t$

Temp :

if $q_p < 0,99 q_s$: $\frac{dT_p}{dt} = -\Gamma_d w$

$\hookrightarrow$ no condensat° $\frac{dq_p}{dt} = 0$

if $q_p \simeq q_s$: $\frac{dT_p}{dt} = -\Gamma_m(T_p, p_p)\, w$

condensation : $\left.\frac{dq_p}{dt}\right|_{cond} = -\alpha(q_p - q_s)\frac{w}{\mu_c}$

$\mu_c \simeq 8000\ m$

α chosen ad hoc?

entrainment

↳ mix envi humidity to the parcel

$$\left.\frac{dq_p}{dt}\right|_{ent} = \mu_{entr}(q_e - q_p)\frac{|w|}{\max(z, 100)}$$

total humid tendency

$$\frac{dq_p}{dt} = \left.\frac{dq_p}{dt}\right|_{cond} + \left.\frac{dq_p}{dt}\right|_{ent}$$

Euler time stepping

$$T_{p,i+1} = T_{p,i} + \frac{dT_p}{dt}\Delta t$$

$$q_{p,i+1} = q_{p,i} + \frac{dq_p}{dt} \Delta t$$