# Microphysics for Alaro0

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on behalf of Bart Catry

# Outline

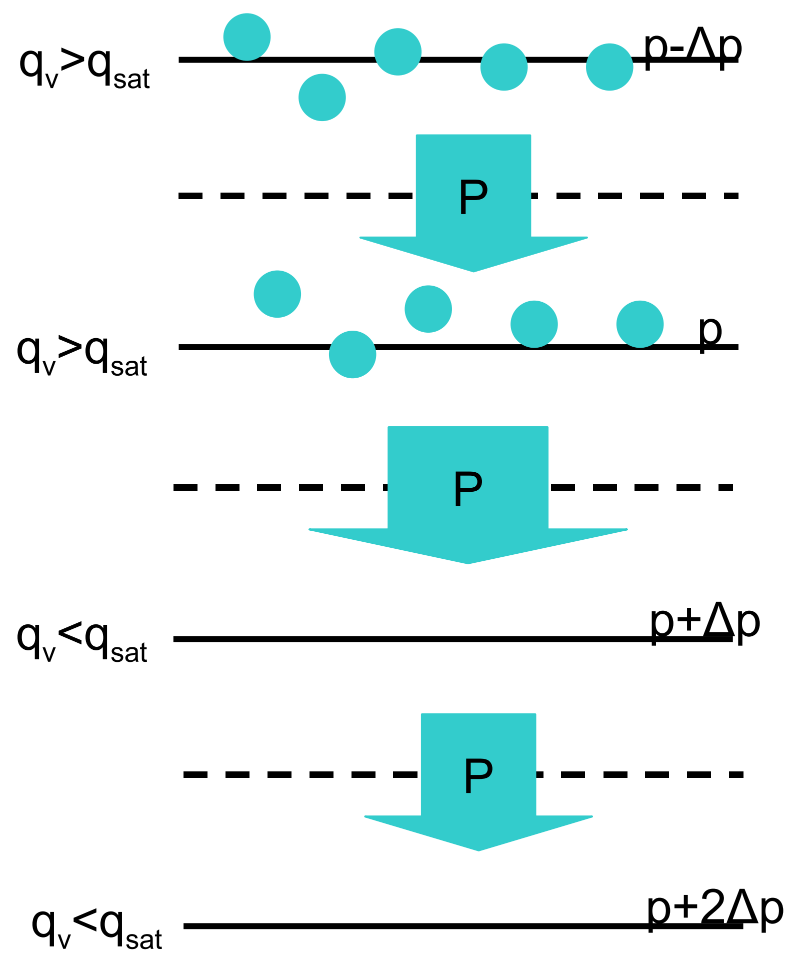
- Operational large scale condensation
- Including prognostic cloud and precipitation condensates
- Allowed fluxes
- Parameterized processes
  - accummulation
  - collection
  - evaporation and melting
- Conclusion

# Large scale condensation (oper)

- Up to now we had increase of precipitation flux when air was saturated

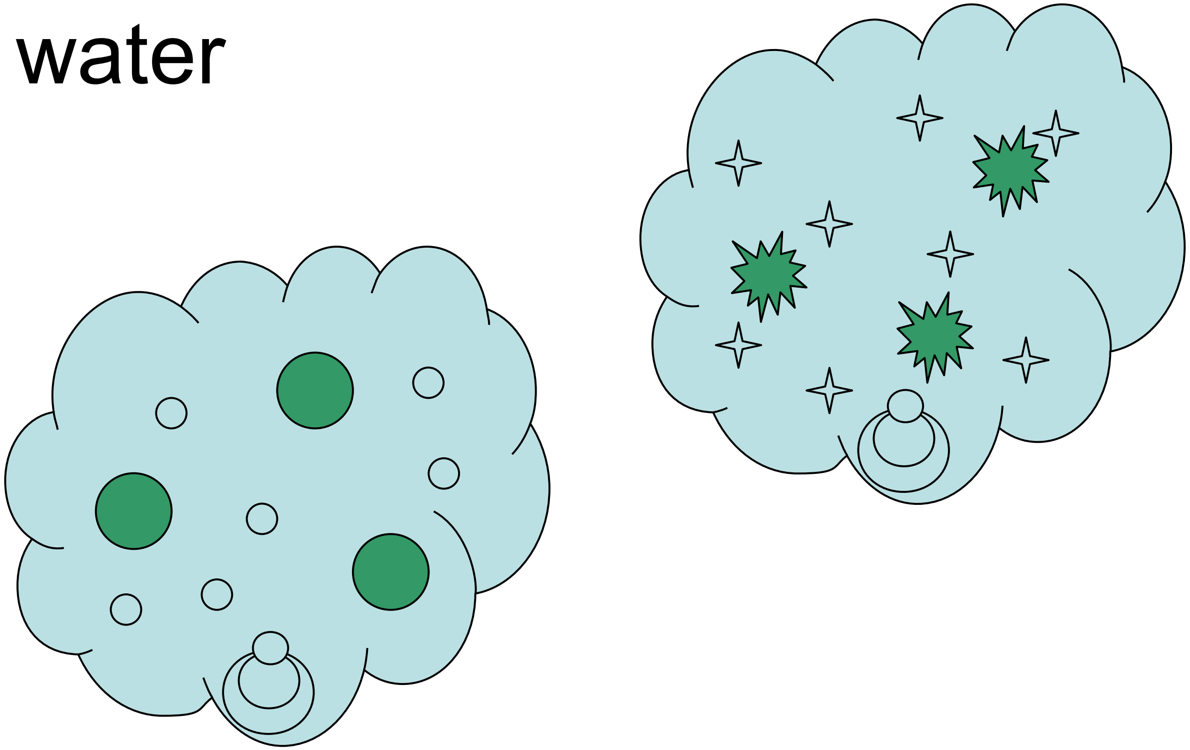
$$\frac{\partial \sqrt{P}}{\partial p} = [EVAP(1-r_i) + EVAP \cdot RVr_i] \frac{1}{p^2}(q_v - q_w)$$

was not saturated



# New variables

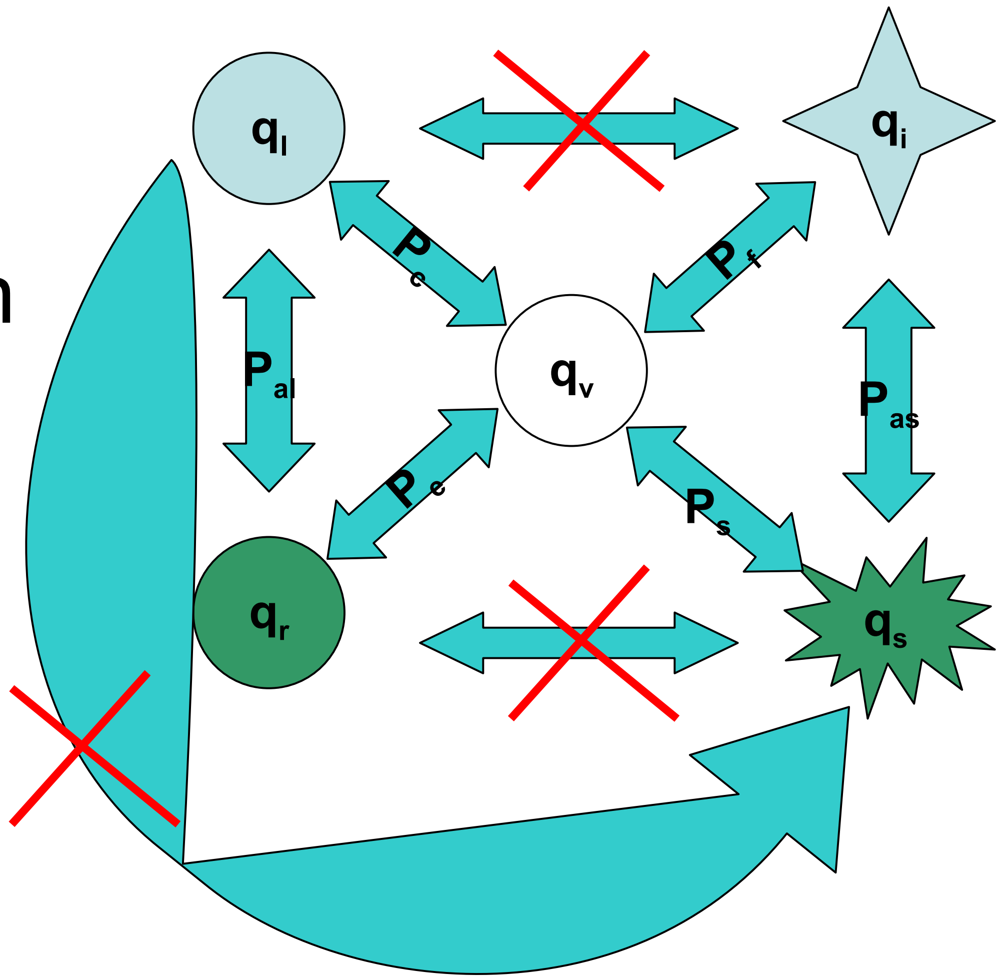
- cloud liquid water
- cloud ice
- rain
- snow



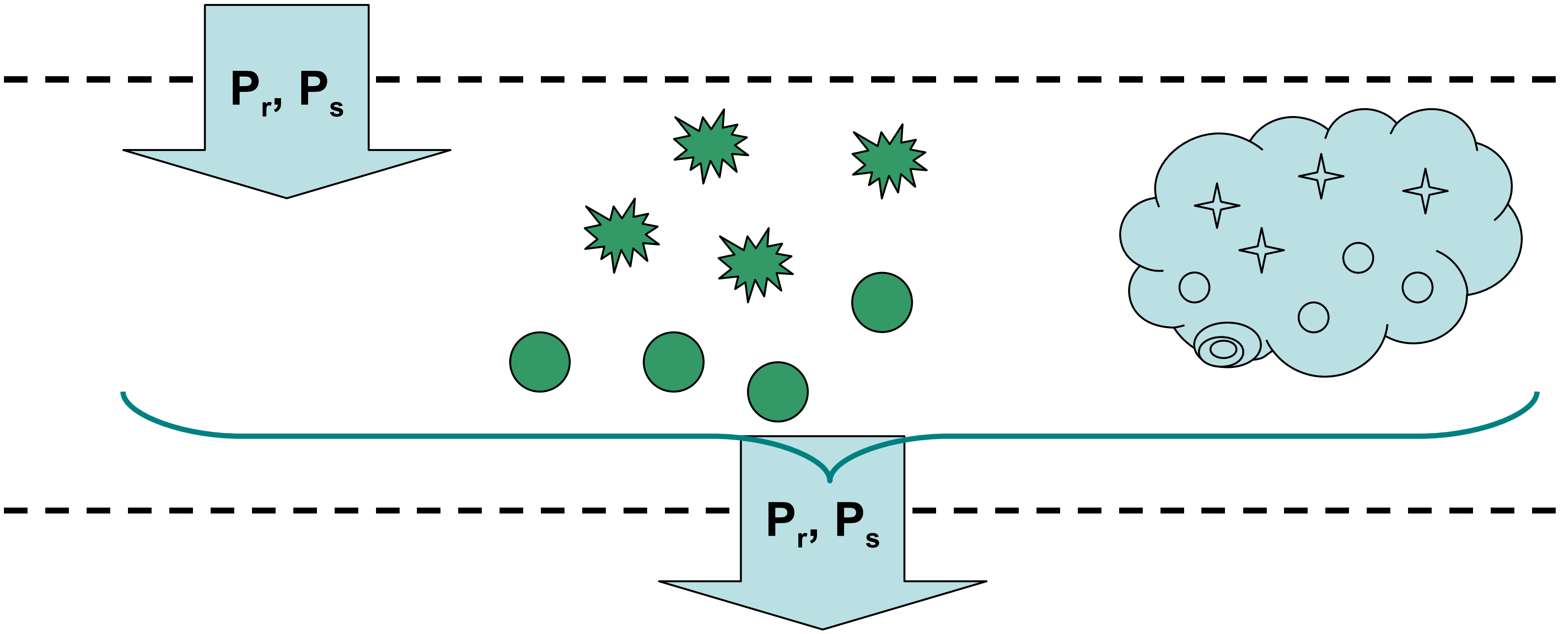
  – the last two fall!

# Allowed fluxes

- condensation evaporation
- autoconversion
- melting and freezing are computed through $q_v$



# 3 sources of precipitation




- falling from the layer above
- from the previous time-step
- generated durig current time-step

# Sequential computations

**aplmphys**

**$q_v$ -> $q_v^{tmp}$ $q_l$ -> $q_l^{tmp}$ $q_i$ -> $q_i^{tmp}$**

**begin loop on levels**

**acacon**

**compute autoconversion – output fluxes**

**upgrade $q_l^{tmp}$ and $q_i^{tmp}$**

**accoll**

**compute collection – output fluxes**

**upgrade $q_l^{tmp}$ and $q_i^{tmp}$**

**acevmel**

**compute evaporation and melting – output fluxes**

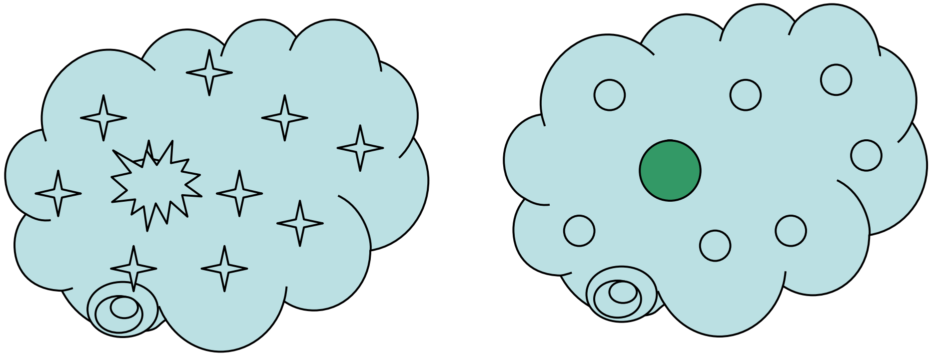
**upgrade $P_r$ and $P_s$ and go to next level**

**output: fluxes**

- Computations inside microphysics are sequential, but the input variables remain unchanged

# Autoconversion

- cloud droplets and ice crystals grow and become rain droplets or snow

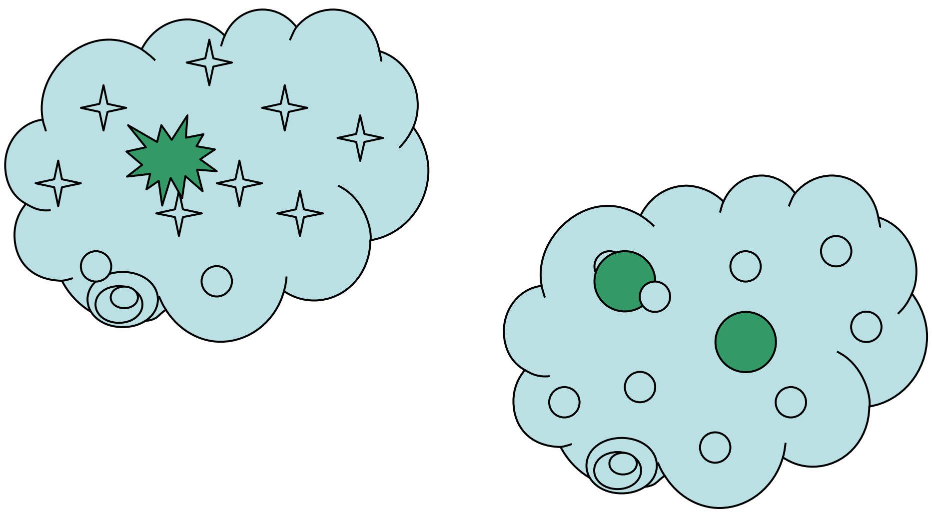


$$\left(\frac{\partial q_l}{\partial t}\right)_{auto} = -\frac{q_l}{\tau_l}\left(1 - e^{-\left(\frac{q_l}{q_r}\right)^2}\right)$$

$$\Delta F_{al} = q_l\left[1 - e^{-\left(\frac{q_l}{q_r}\right)^2}\right]\frac{1}{\tau_l}\frac{\Delta p}{g\Delta t}$$

# Collection

- falling raindrops or other cloud water droplets can collect other cloud water droplets

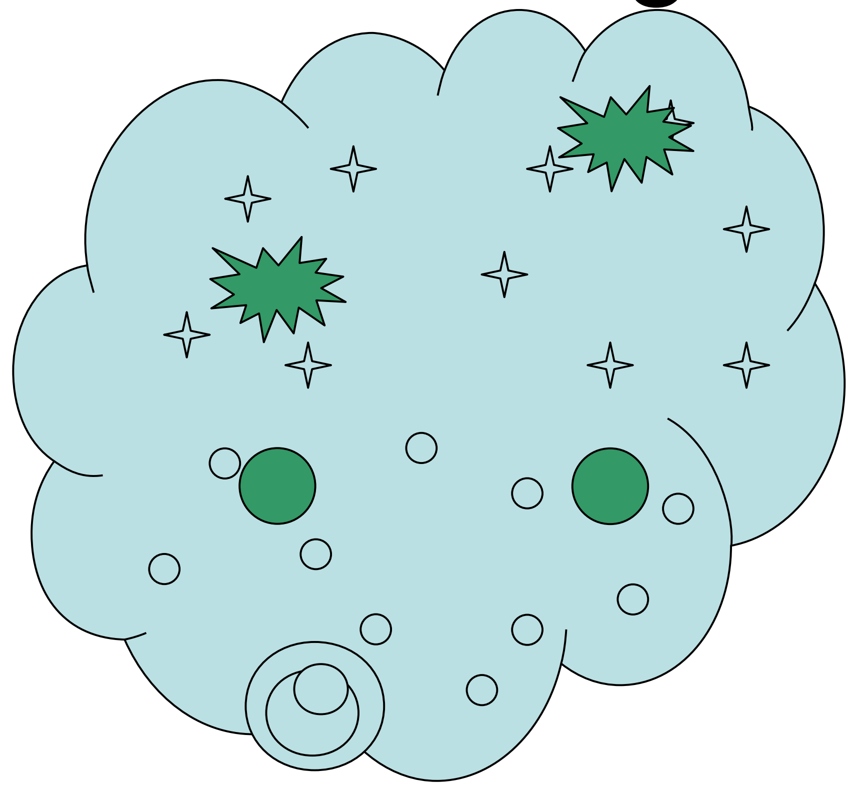


$$\left(\frac{\partial P_l^{\frac{1}{5}}}{\partial p}\right)_{coll} = 0.0069 q_l$$

$$\left[\left(P_r + \frac{1}{2} q_r \frac{\Delta p}{g \Delta t} + \frac{1}{4} F_{al}\right)^{\frac{1}{5}} + C_{oll} q_l \frac{\Delta p}{g \Delta t}\right]^5 - \left(P_r + \frac{1}{2} q_r \frac{\Delta p}{g \Delta t} + \frac{1}{4} F_{al}\right)$$

# Evaporation and melting

- on the way down snow melts, rain freezes and both evaporate in unsaturated layers



$$\left(\frac{\partial\sqrt{R}}{\partial\frac{1}{p}}\right)_{evap} = EVAP(1 - m_e(1 - REVGSL))(q_w - q_v)$$

# Evaporation

- evaporation of all 6 kinds of precipitation

$$\left[P_l^{\frac{1}{2}} + EVAP(1 - m_i(1 - REVGSL))ZDQL\left(\frac{1}{p_b} - \frac{1}{p_h}\right)\right]^2 - P_l$$

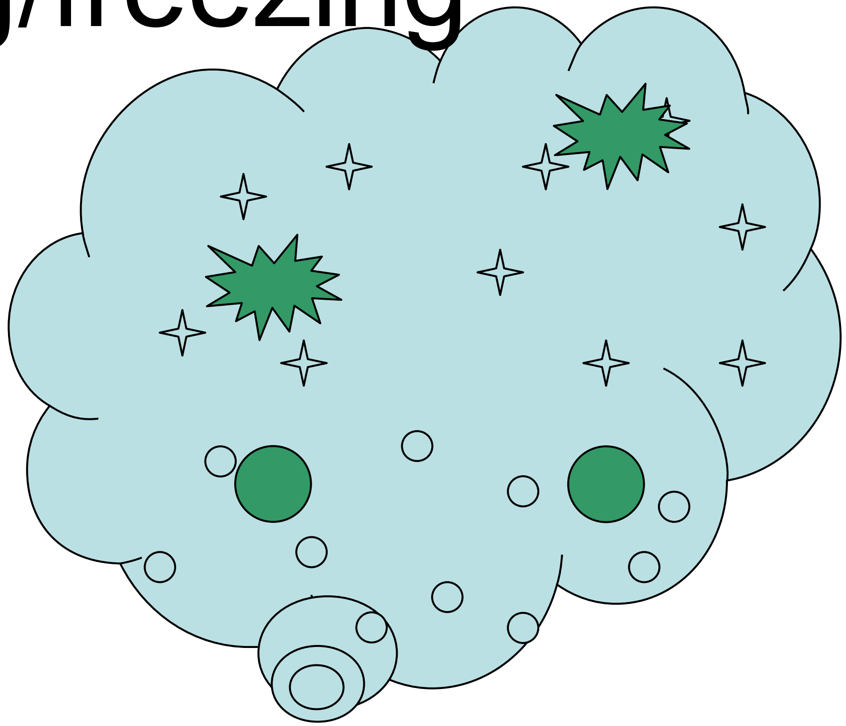
$$\left[\left(\frac{1}{2}q_r\frac{\Delta p}{g\Delta t}\right)^{\frac{1}{2}} + EVAP(1 - m_i(1 - REVGSL))ZDQL\left(\frac{1}{p_b} - \frac{1}{p_h}\right)\right]^2 - \frac{1}{2}q_r\frac{\Delta p}{g\Delta t}$$

$$\left[\left(\frac{1}{4}F_{al}\right)^{\frac{1}{2}} + EVAP(1 - m_i(1 - REVGSL))ZDQL\left(\frac{1}{p_b} - \frac{1}{p_h}\right)\right]^2 - \frac{1}{4}F_{al}$$

- ZDQL shows how dry is the air

# Melting/freezing

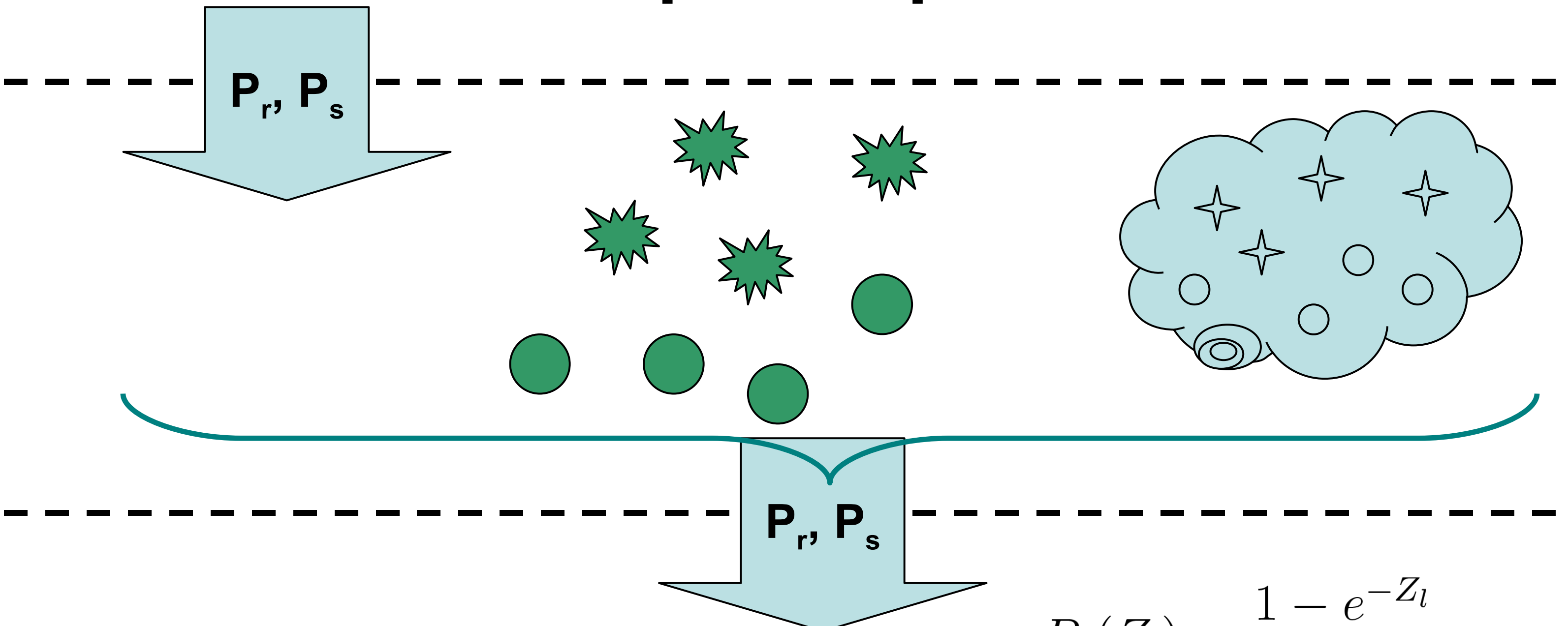
- Melting and freezing of precipitation are computed



$$\frac{dm_i}{d\frac{1}{p}} = FONT(1 - m_i(1 - REVGSL))\frac{T - T_t}{\sqrt{R}}$$

$$FONT(1 - m_i(1 - REVGSL))(T - T_t)\left(\frac{1}{p_b} - \frac{1}{p_h}\right)\sqrt{P_l + P_n}$$

# Fall of precipitation




- the probabilities that precipitation reaches the bottom of the layer in a given time-step

$$P_1(Z_l) = \frac{1 - e^{-Z_l}}{Z_l}$$

$$P_2(Z_l) = \frac{e^{-Z_l}(1 + Z_l)}{Z_l^2 + 3Z_l + 1}$$

$$P_3(Z_l) = \frac{1}{2Z_l} - \frac{e^{-Z_l}(1 + Z_l)}{Z_l^3 + 4Z_l^2 + 2Z_l}$$

# Z's and fall velocity

- The ratio of the layer thickness and the distance that precipitation might cross during one timestep

$$Z_l = \frac{\frac{\Delta p}{g\Delta t}}{\rho w_l} \qquad Z_i = \frac{\frac{\Delta p}{g\Delta t}}{\rho w_i}$$

- the fall velocities are

$$w_l = \omega \left(\frac{P_l}{\rho^4}\right)^{\frac{1}{6}} \qquad w_i = \omega \left(\frac{P_i}{REVGSL\rho^4}\right)^{\frac{1}{6}}$$

# Precipitation flux

- the final precipitation fluxes (at the bottom of the layer) are

**Σ probability x flux**

$$P_l = P_1(Z_l)P_l + P_2(Z_l)q_r\frac{\Delta p}{g\Delta t} + P_3(Z_l)F_{al}$$

$$P_i = P_1(Z_i)P_l + P_2(Z_i)q_s\frac{\Delta p}{g\Delta t} + P_3(Z_i)F_{an}$$

falling from the layer above

from the previous time-step

generated durig current time-step

# Switches

- LCONDWT activates prognostic convection
- LPIL activates this scheme with prognostic condensates
- LDIFCONS activates vertical diffusion of cloud condensates
- LPHSPSH activates usage of pseudo-historic surface precipitation heat flux
- etc.

# Final remarks

- the deveopements are still in debugging mode of Alaro0
- 3MT issues
  - the microphysics is called after updraft but before the downdraft part of prognostic convection scheme using partially updated values of temperature and moist variables as input

# Wake up!

- it is time for questions ....