Transport and scavenging of radionuclides in deep convection

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- What processes explain the evolution of the concentration?
- How does convection influence the particle distribution in the atmosphere?

Goal

- Provide diagnostics for atmospheric processes parameterized assessment

Transport of tracer

$$(\partial_t q)_{\text{large scale}} + (\partial_t q)_{\text{conv}} + (\partial_t q)_{\text{PBL}} + (\partial_t q)_{\text{deposition}} = S$$

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Deep convection

Deposition terms

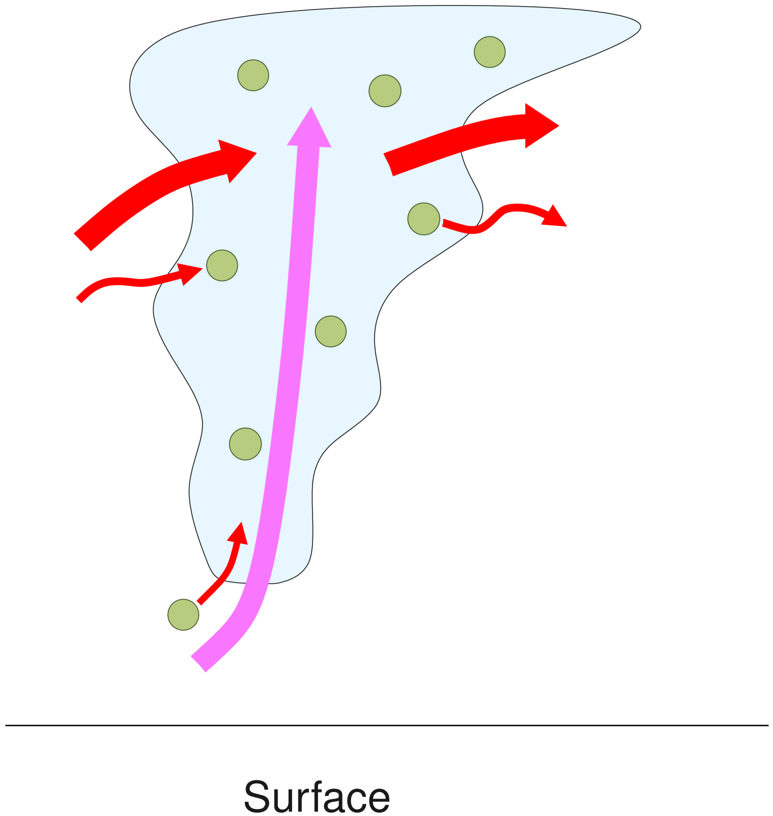
Wet scavenging, dry scavenging, radioactive decay

- Radionuclide ^{7}Be →neutral tracer
- Half-life 53days
- Source mainly in upper tropo lower strato

Emanuel mass-flux scheme

Parameterization of convective scavenging

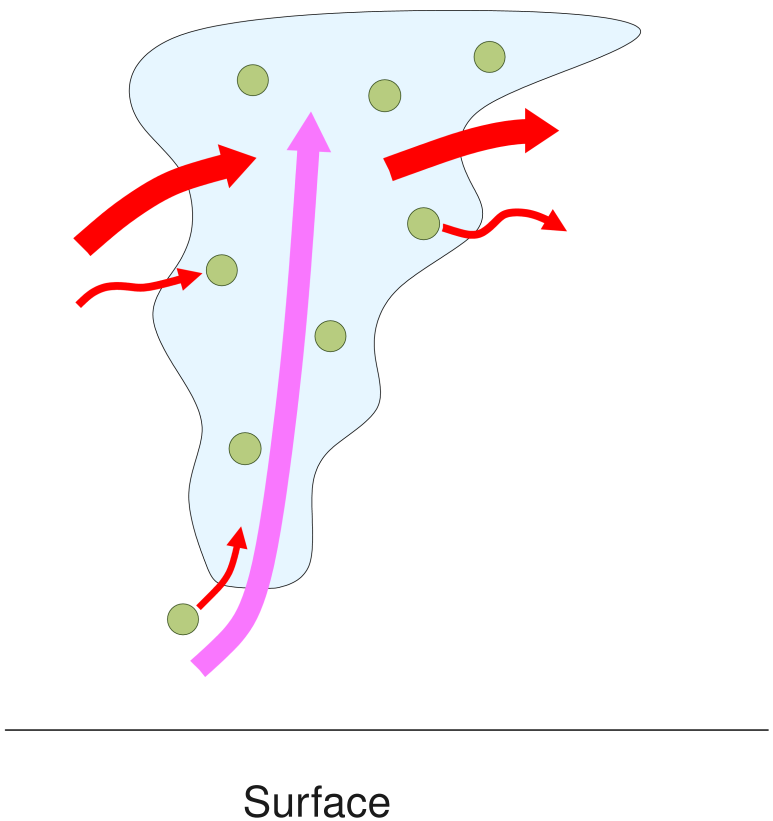
Convective saturated updraft

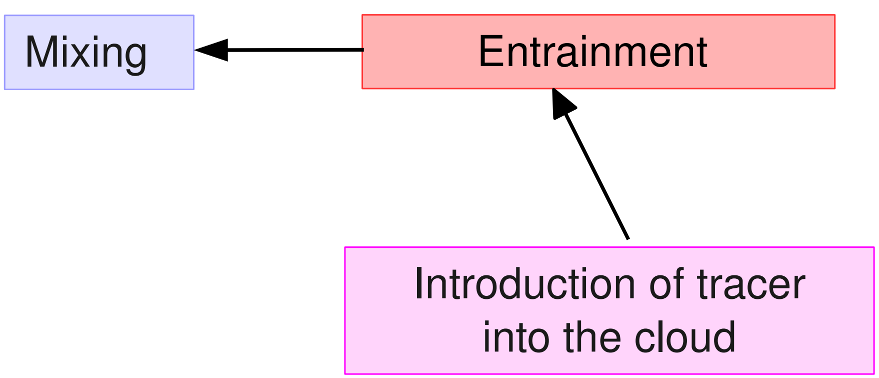


Introduction of tracer into the cloud

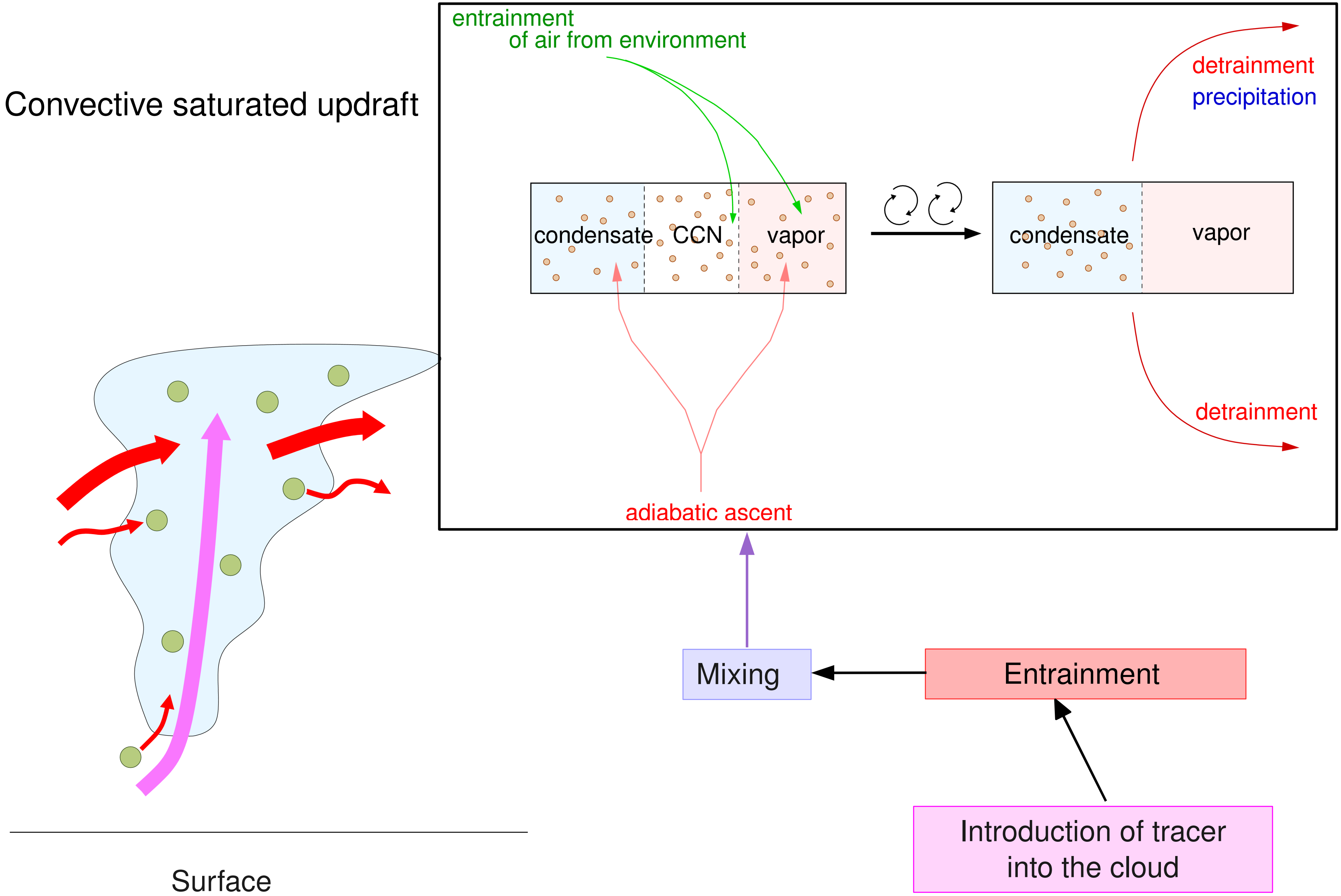
Parameterization of convective scavenging

Convective saturated updraft



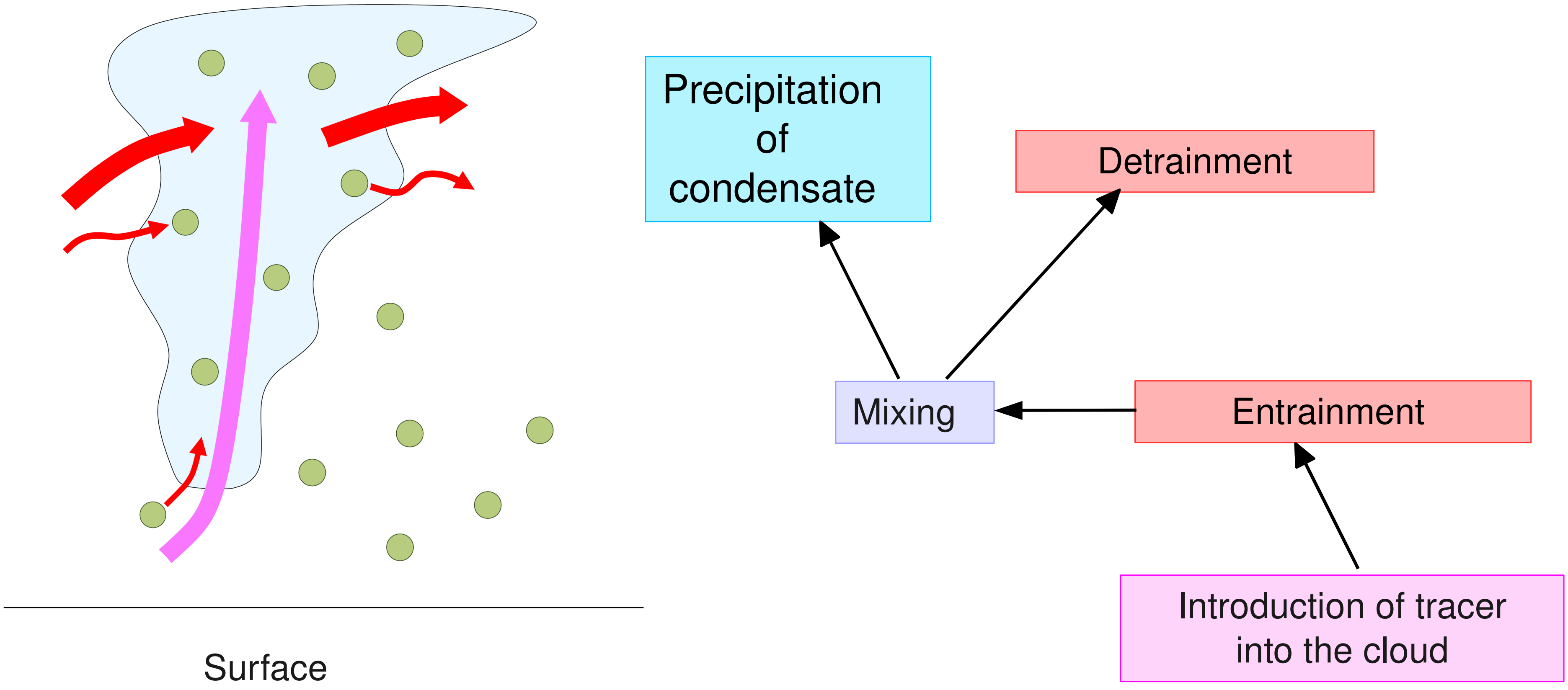


Parameterization of convective scavenging



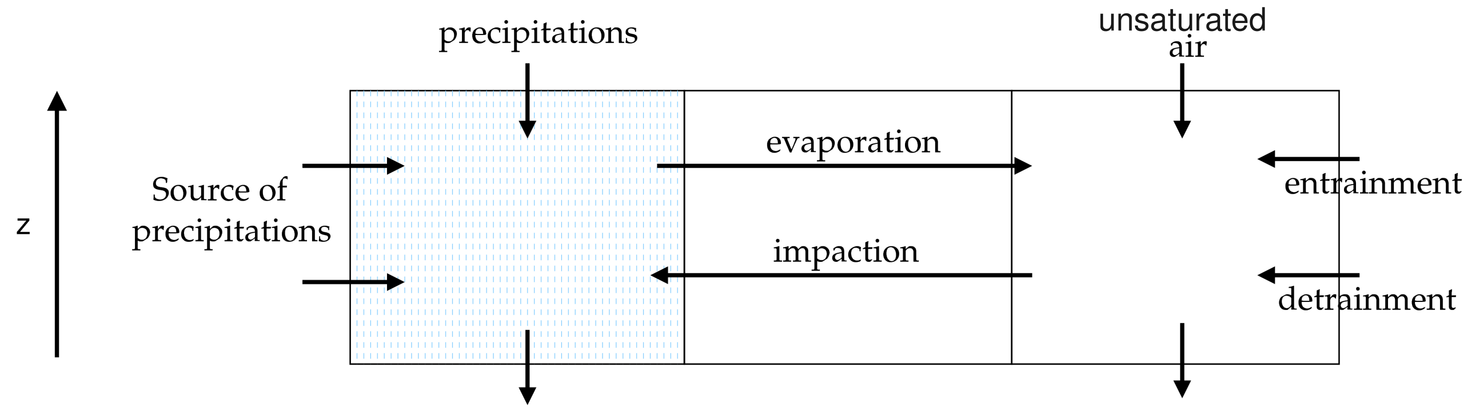
Parameterization of convective scavenging

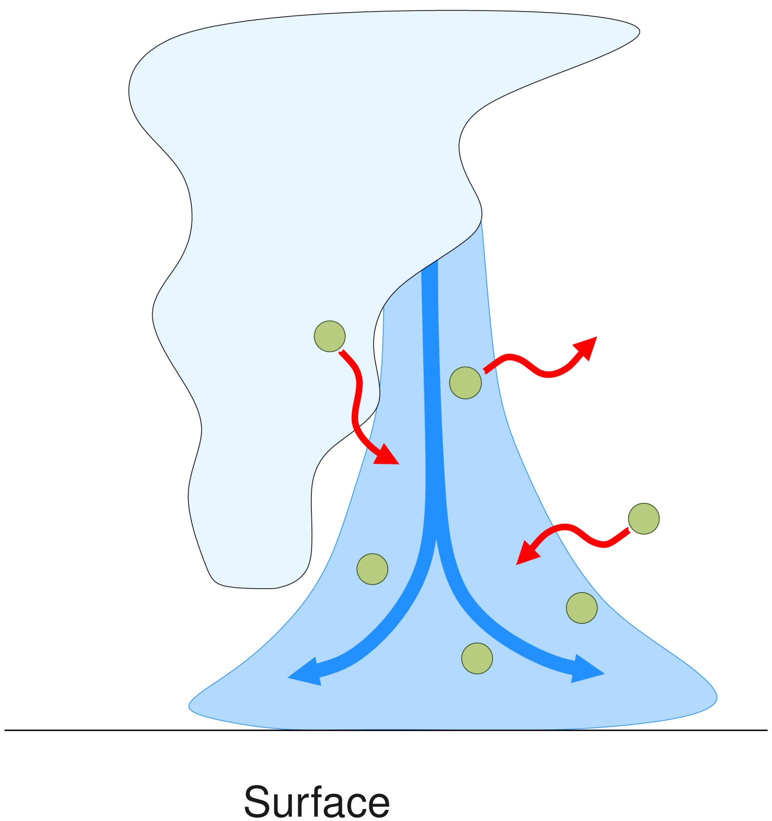
Convective saturated updraft



Parameterization of convective scavenging

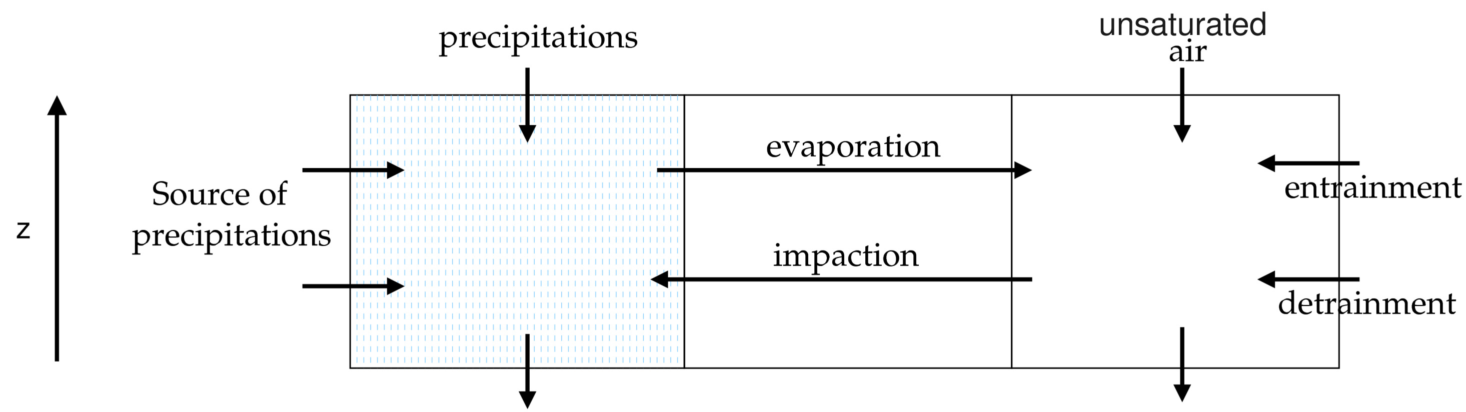
Unsaturated downdraft





Parameterization of convective scavenging

Unsaturated downdraft

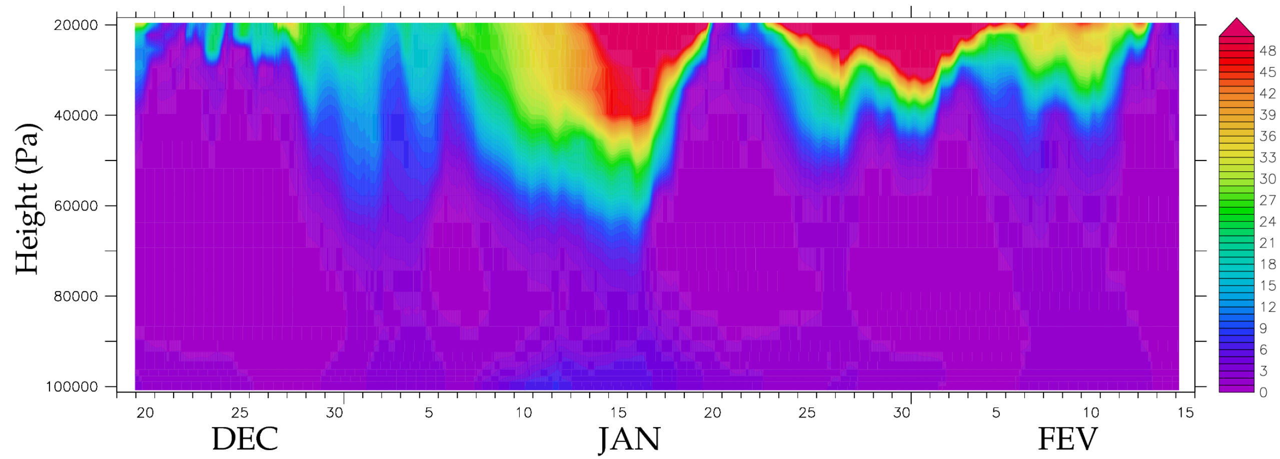


Resolving these budget equations

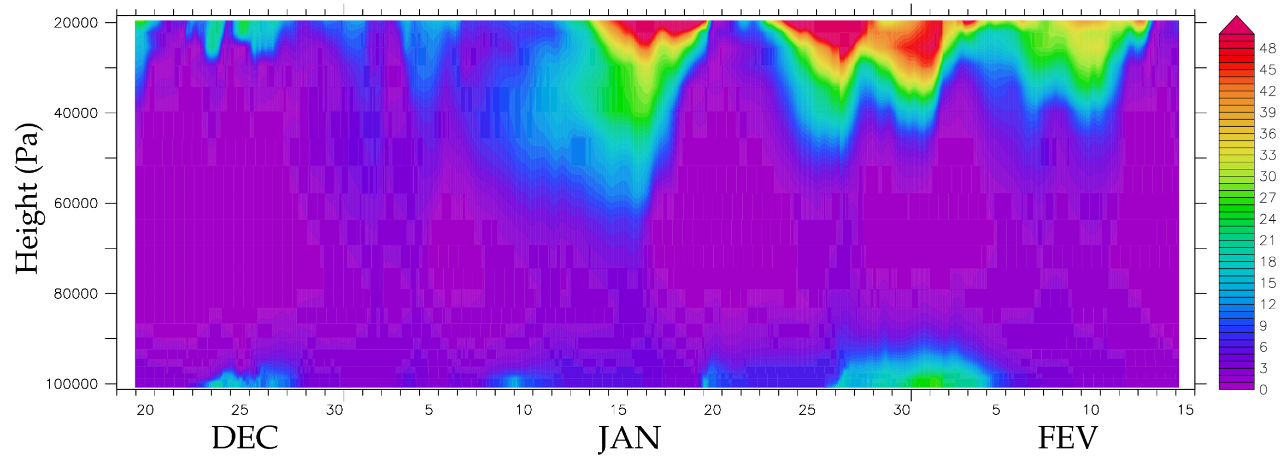
$$\begin{cases} -\dfrac{\partial\left(\mathcal{P} q_p\right)}{\partial z} + \mathcal{S}_p q_C + \rho\sigma_d\left(-E\, q_p + \mathcal{I}\, q_d\right) = 0 \\ -\dfrac{\partial\left(M_d q_d\right)}{\partial z} + e\,\tilde{q} - d\, q_d + \rho\sigma_d\left(E\, q_p - \mathcal{I}\, q_d\right) = 0 \end{cases}$$

Impaction term $\mathcal{I} = \dfrac{3\mathcal{P}}{4\rho_l\sigma_d r}$

Experimental simulation: TOGA with ^{7}Be

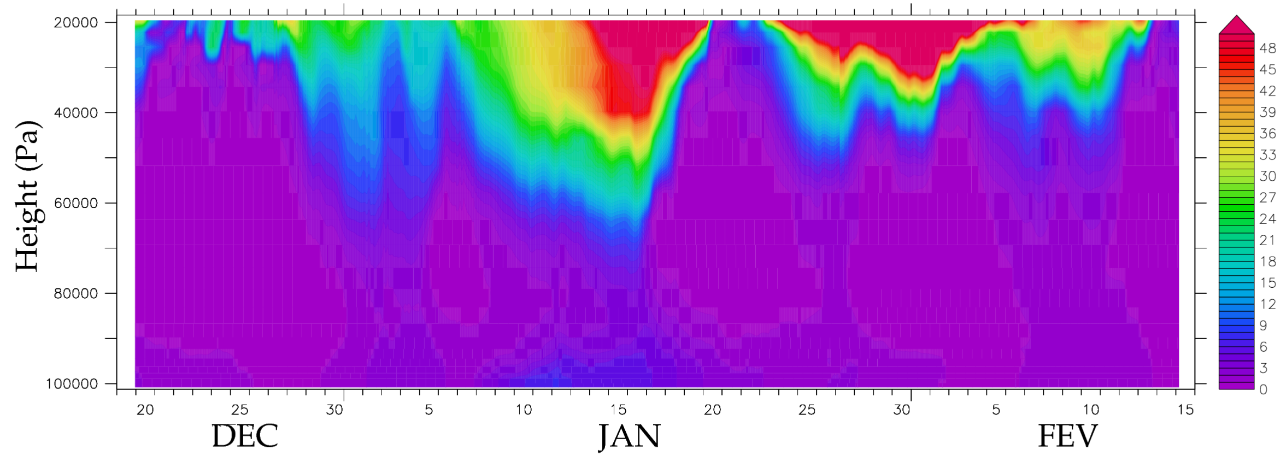


Convective scavenging OFF

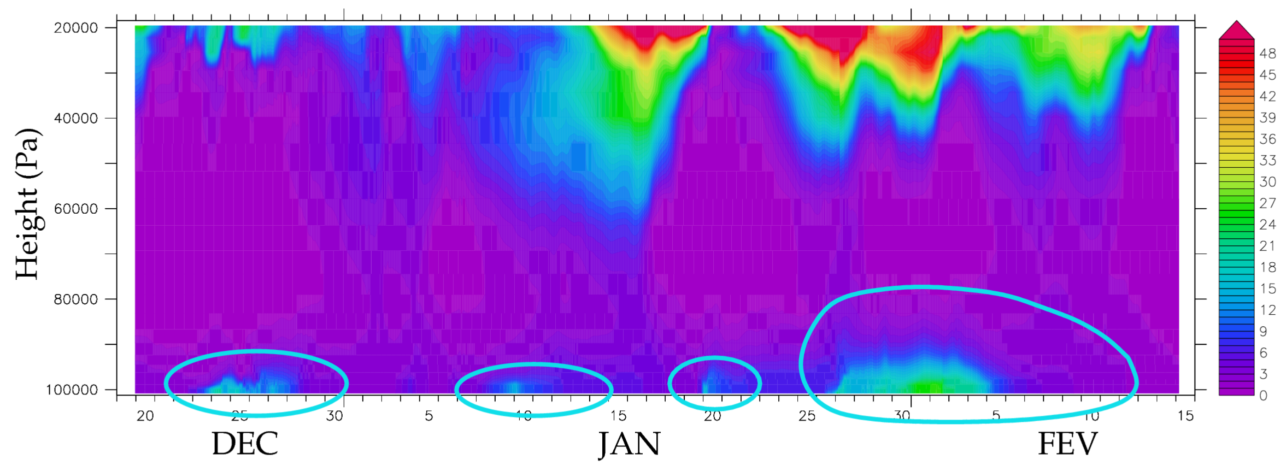


Convective scavenging ON

Experimental simulation: TOGA with ^{7}Be



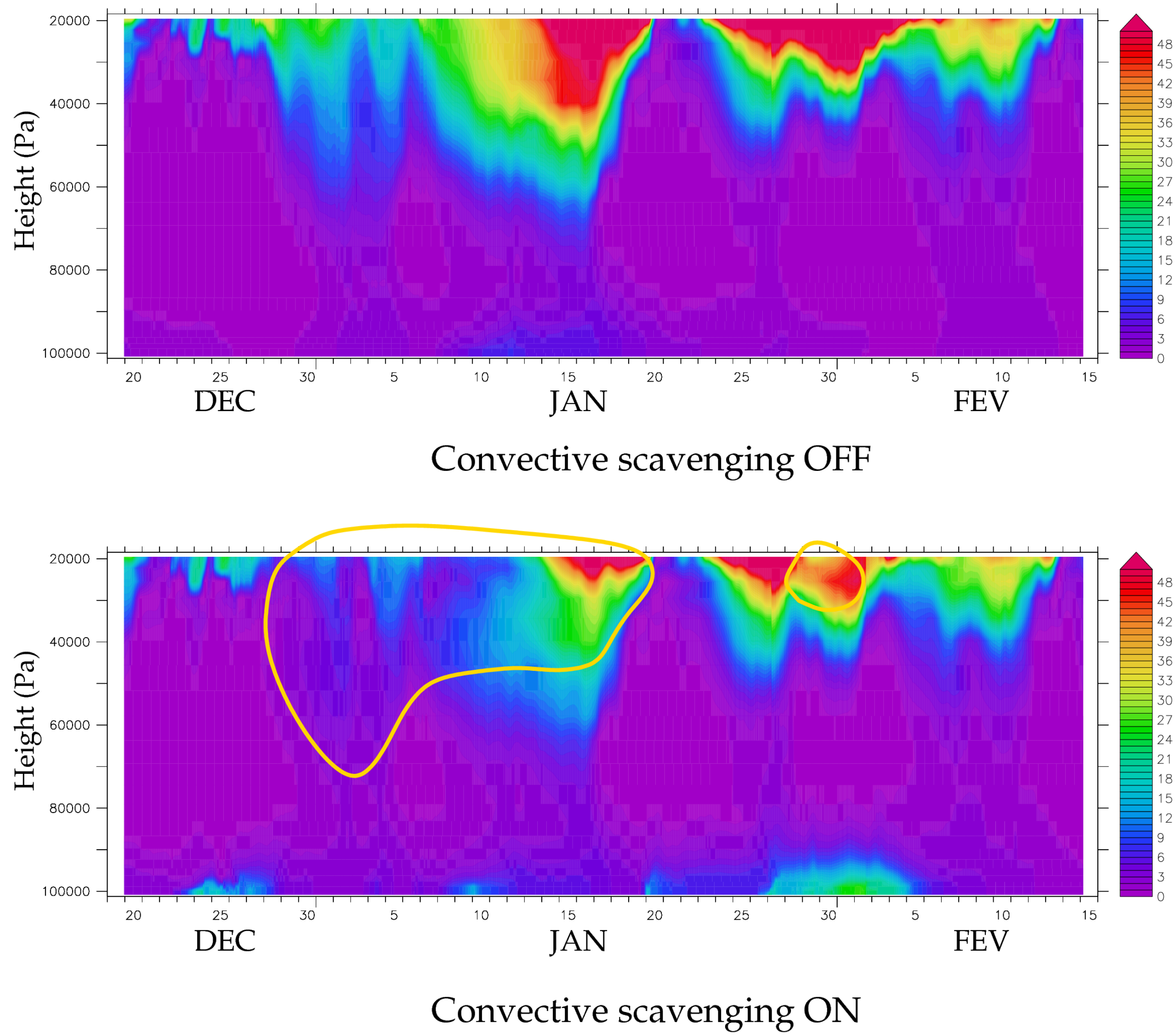
Convective scavenging OFF



Convective scavenging ON

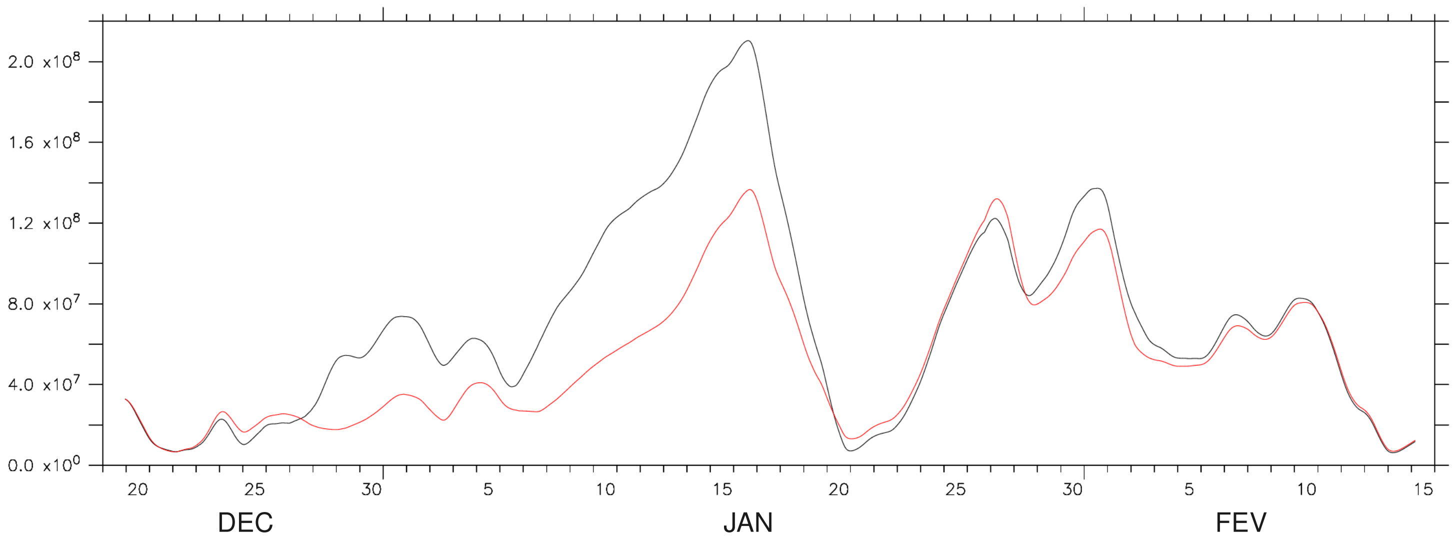
Evaporation

Experimental simulation: TOGA with ^{7}Be



- Precipitation
- Entrainment into the cloud
- Entrainment into the unsaturated downdraft

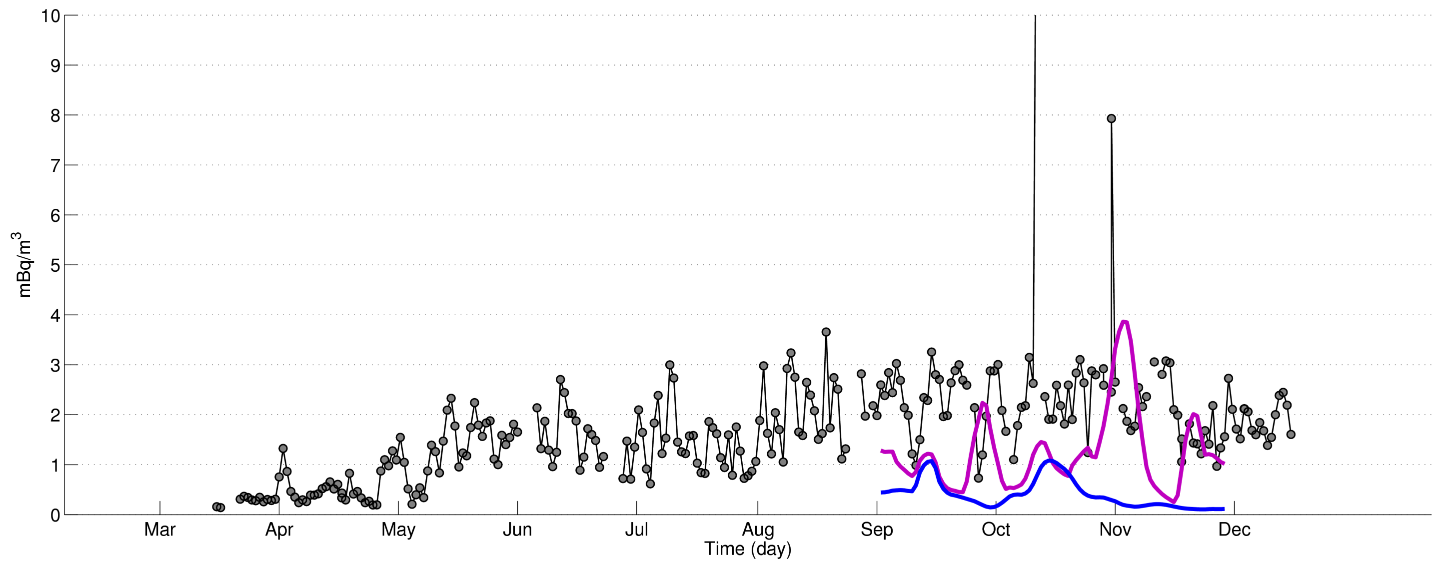
Experimental simulation: TOGA with ^{7}Be



Integral of concentration in the atmosphere
Black: no convective scavenging, red, with convective scavenging

Difference between the 2 curves → precipitation

TOGA with ^{7}Be and datas



Surface concentrations

Black: CTBTO datas, blue: without convective scavenging, purple: with convective scavenging

- Convective scavenging increases levels of concentration at the surface
- Magnitude closer to the datas

Summary and outlook

- Process-based convective scavenging
- Tool for validation of convective scheme parameterization
- Help to understand processes in convection

- Comparison with CRM
- Model-data comparison methodology (GCM)
- Paleoclimatology (^{10}Be)

Wet scavenging

$$\frac{dN(D)_p}{dt} = -\Lambda(D_p, t)N(D_p, t) \quad \text{with} \quad \Lambda(D_p, t) = \int_0^\infty \frac{\pi}{4} D^2 E(D_p, D) V_t(D) N(D) dD$$

particle size

aerosol number concentration

drop size

collision efficiency

terminal velocity of rain drop