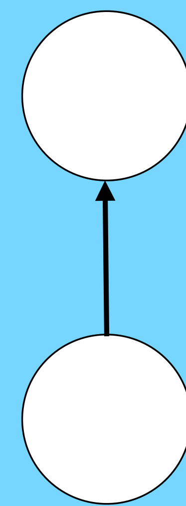
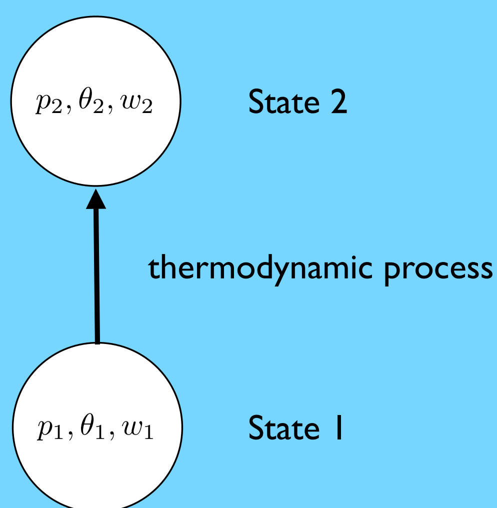
Parcel Model

- Goal is to predict how the properties of a parcel change due to various processes.
- The processes include dry adiabatic vertical displacements, condensation/evaporation, precipitation formation, entrainment and mixing, and radiative heating/cooling.
- Buoyancy and vertical acceleration can be calculated if the environmental profile of virtual potential temperature is known.

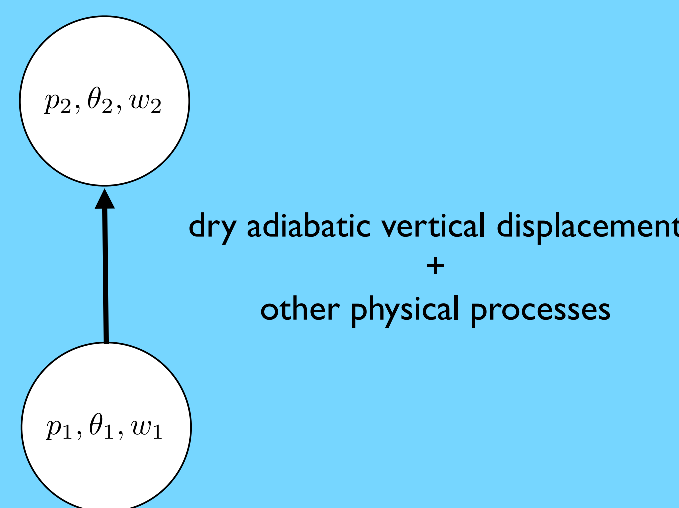
Parcel Model



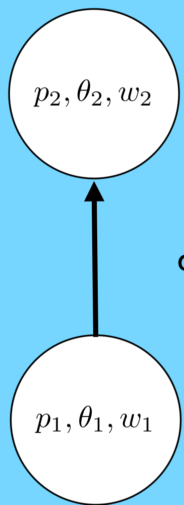
Parcel Model



Parcel Model



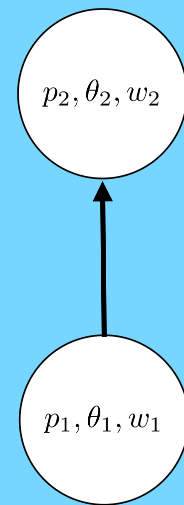
Parcel Model



$$
\begin{aligned}
p_2 &= p_1 + dp \\
\theta_2 &= \theta_1 \\
w_2 &= w_1
\end{aligned}
$$

dry adiabatic vertical displacement

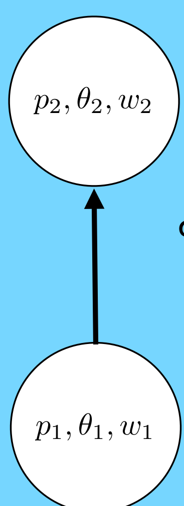
Parcel Model



$$
\begin{aligned}
p_2 &= p_1 \\
\theta_2 &= \theta_1 + d\theta \\
w_2 &= w_1 + dw
\end{aligned}
$$

isobaric processes

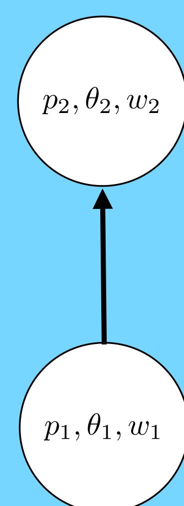
Parcel Model



$$
\begin{aligned}
p_2 &= p_1 + dp \\
\theta_2 &= \theta_1 + d\theta \\
w_2 &= w_1 + dw
\end{aligned}
$$

dry adiabatic vertical displacement
+
other physical processes

Parcel Model: Buoyancy



$\overline{p_2}, \overline{\theta_2}, \overline{w_2}$ *(environment)*

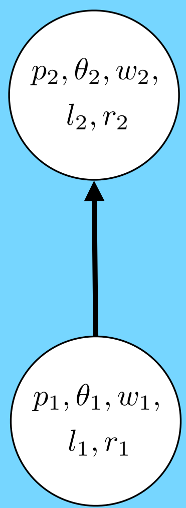
$$
W = \frac{dz}{dt} \quad \textit{(vertical velocity)}
$$

$$
\frac{dW}{dt} = -\frac{1}{\rho}\frac{\partial(p-\bar{p})}{\partial z} + g\frac{\theta_v - \overline{\theta_v}}{\overline{\theta_v}}
$$

(vertical p.g.f.) (buoyancy)

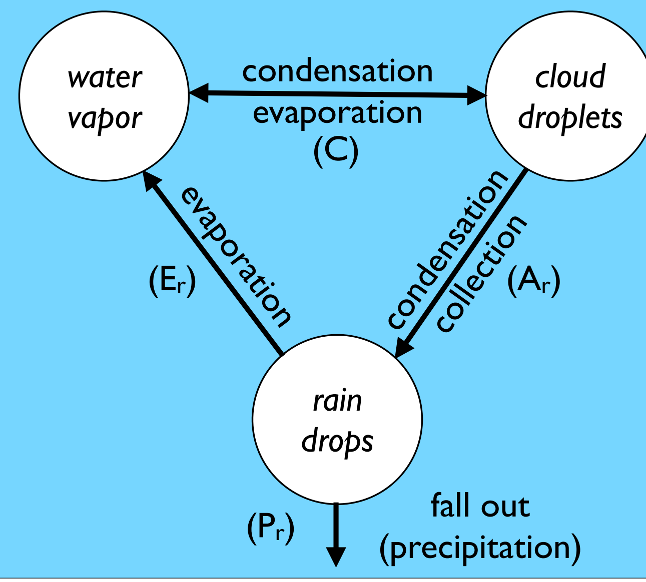
$\overline{p_1}, \overline{\theta_1}, \overline{w_1}$ *(environment)*

Parcel Model: More Variables



θ = potential temperature
w = water vapor mixing ratio (g/kg)
l = cloud water mixing ratio (g/kg)
r = rain water mixing ratio (g/kg)

Microphysics



Parcel Model: More Variables

$$\frac{d\theta}{dt} = \frac{L}{c_p\bar{\pi}}(C - E_r) + D_\theta$$

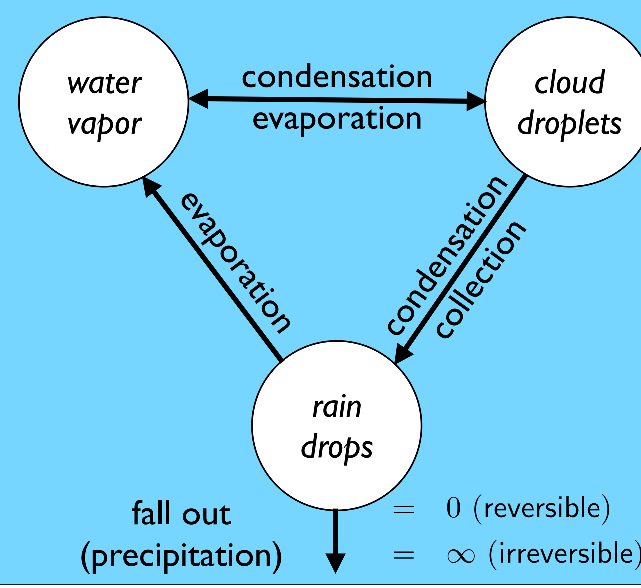
$$\frac{dw}{dt} = -(C - E_r) + D_w$$

$$\frac{dl}{dt} = C - A_r + D_l$$

$$\frac{dr}{dt} = P_r + A_r - E_r + D_r$$

$\bar{\pi} = (\bar{p}/p_0)^{R/c_p}$, C is the net condensation rate, E_r is the rain evaporation rate, A_r is the cloud-to-rain water conversion rate, P_r is the convergence of rain water flux, and D_i represents the effects of entrainment and mixing.

Simplified Microphysics



Simplified Microphysics

$$\frac{d\theta}{dt} = \frac{L}{c_p\bar{\pi}}C$$
$$\frac{dw}{dt} = -C + E_r$$
$$\frac{dl}{dt} = C - A_r$$
$$\frac{dr}{dt} = P_r + A_r - E_r$$

$$P_r = 0 \text{ (reversible)}$$
$$P_r = \infty \text{ (irreversible)}$$

More Simplified Microphysics

$$\frac{d\theta}{dt} = \frac{L}{c_p\bar{\pi}}C$$
$$\frac{dw}{dt} = -C$$
$$\frac{dl}{dt} = C - A_r$$

$$A_r = 0 \text{ (reversible)}$$
$$A_r = \infty \text{ (irreversible)}$$

Parcel Model