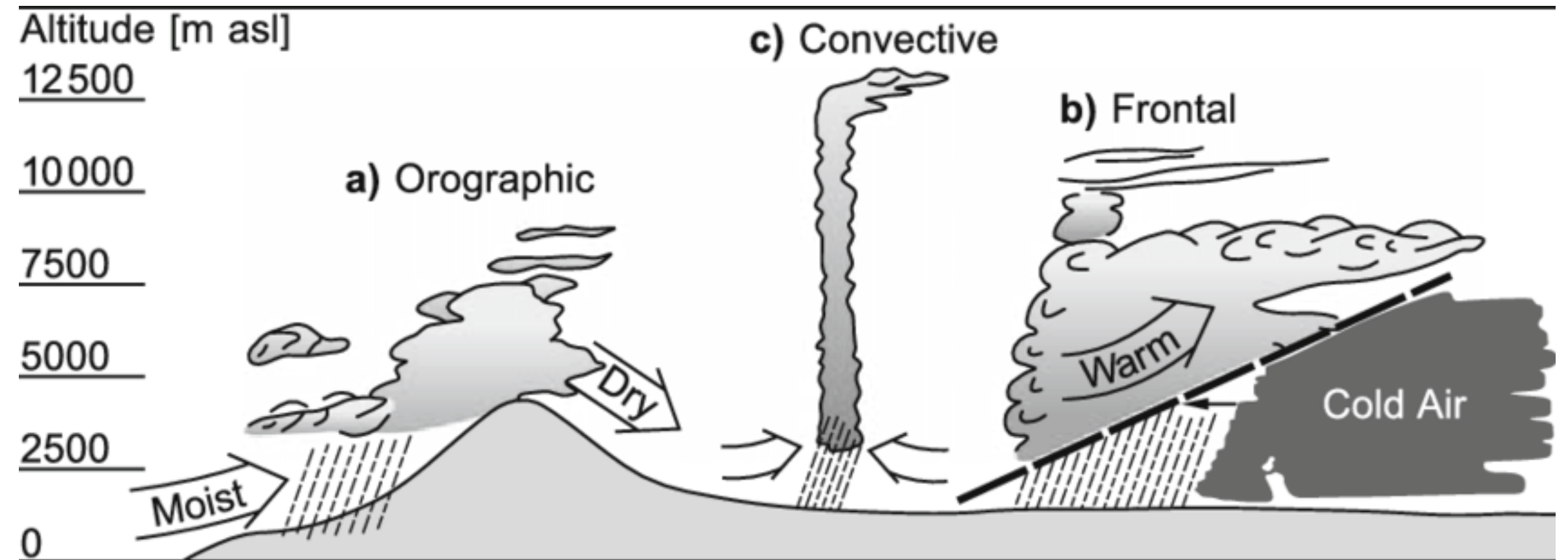
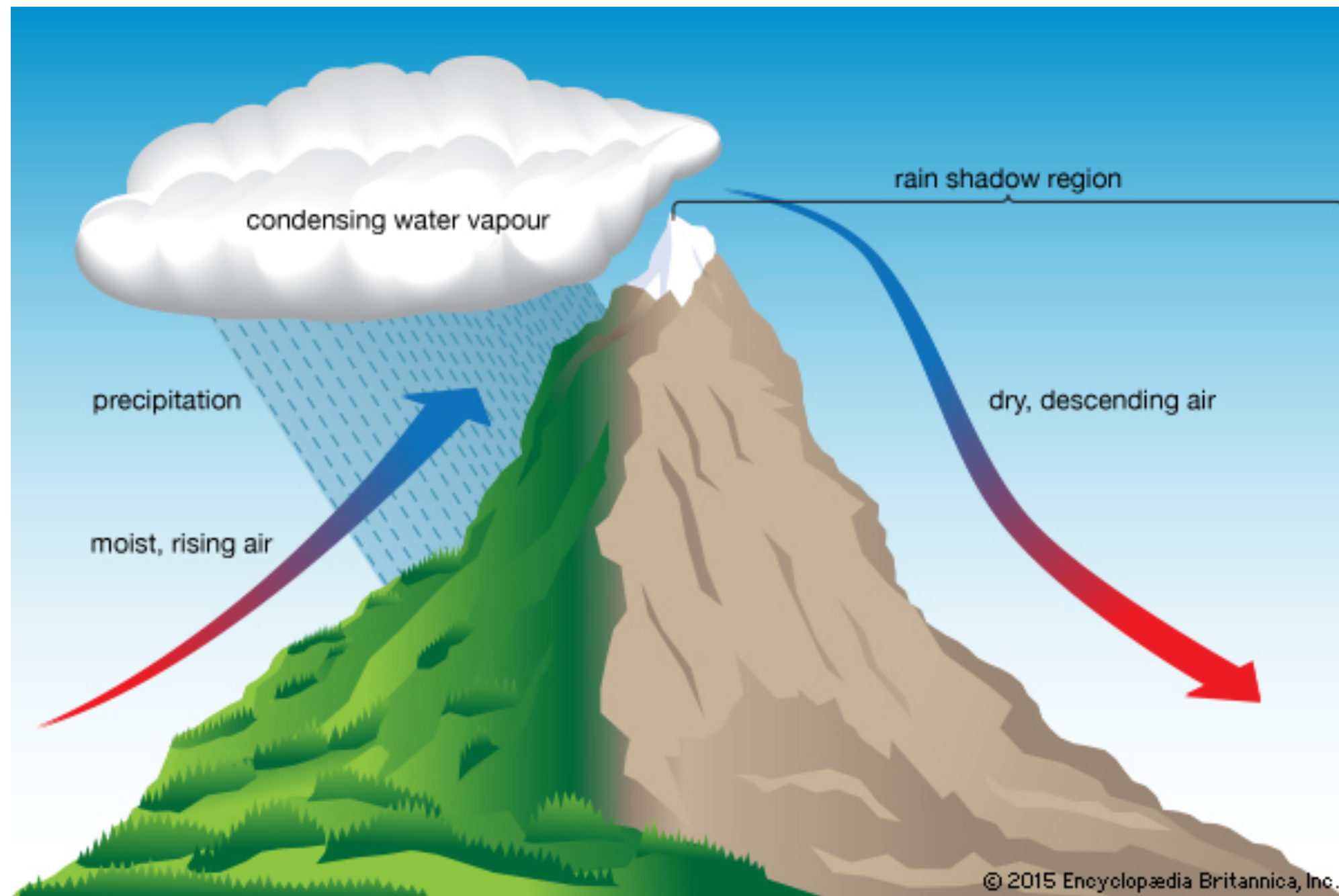


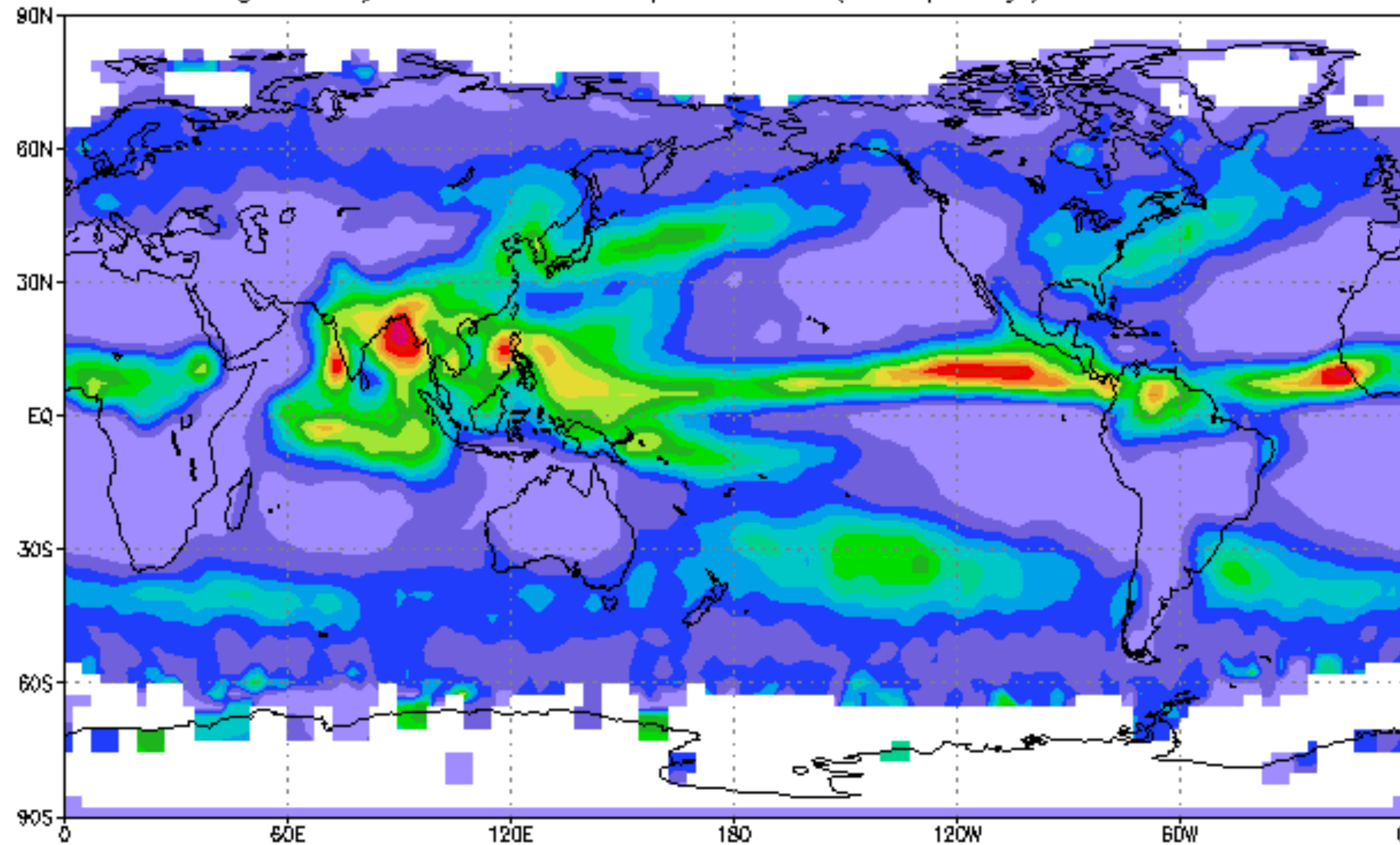
Precipitation Rate



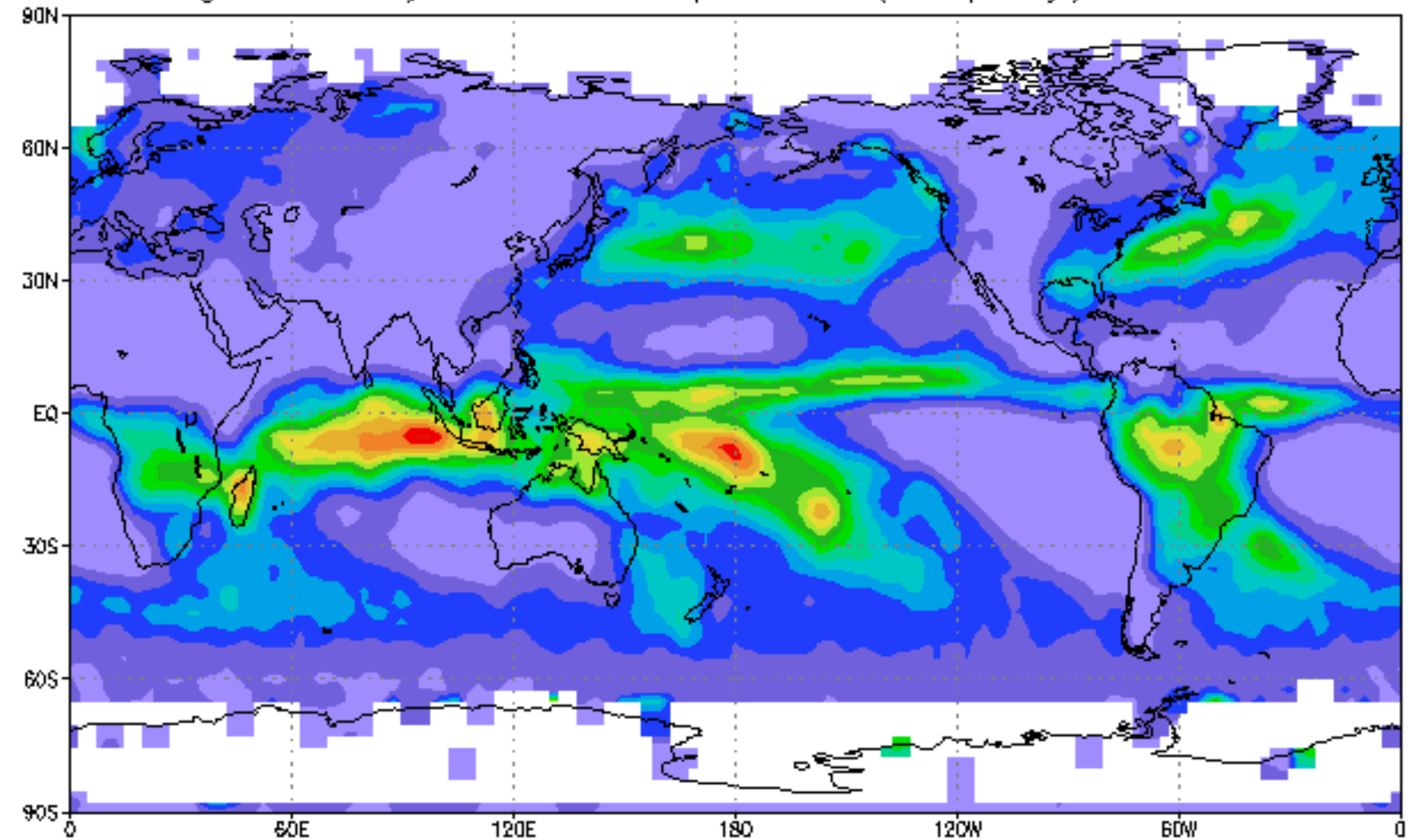
Air must ascend to produce precipitation.

Global Precipitation: Seasonal Variation

Average July GPCP Precipitation (mm/day) for 1988–96

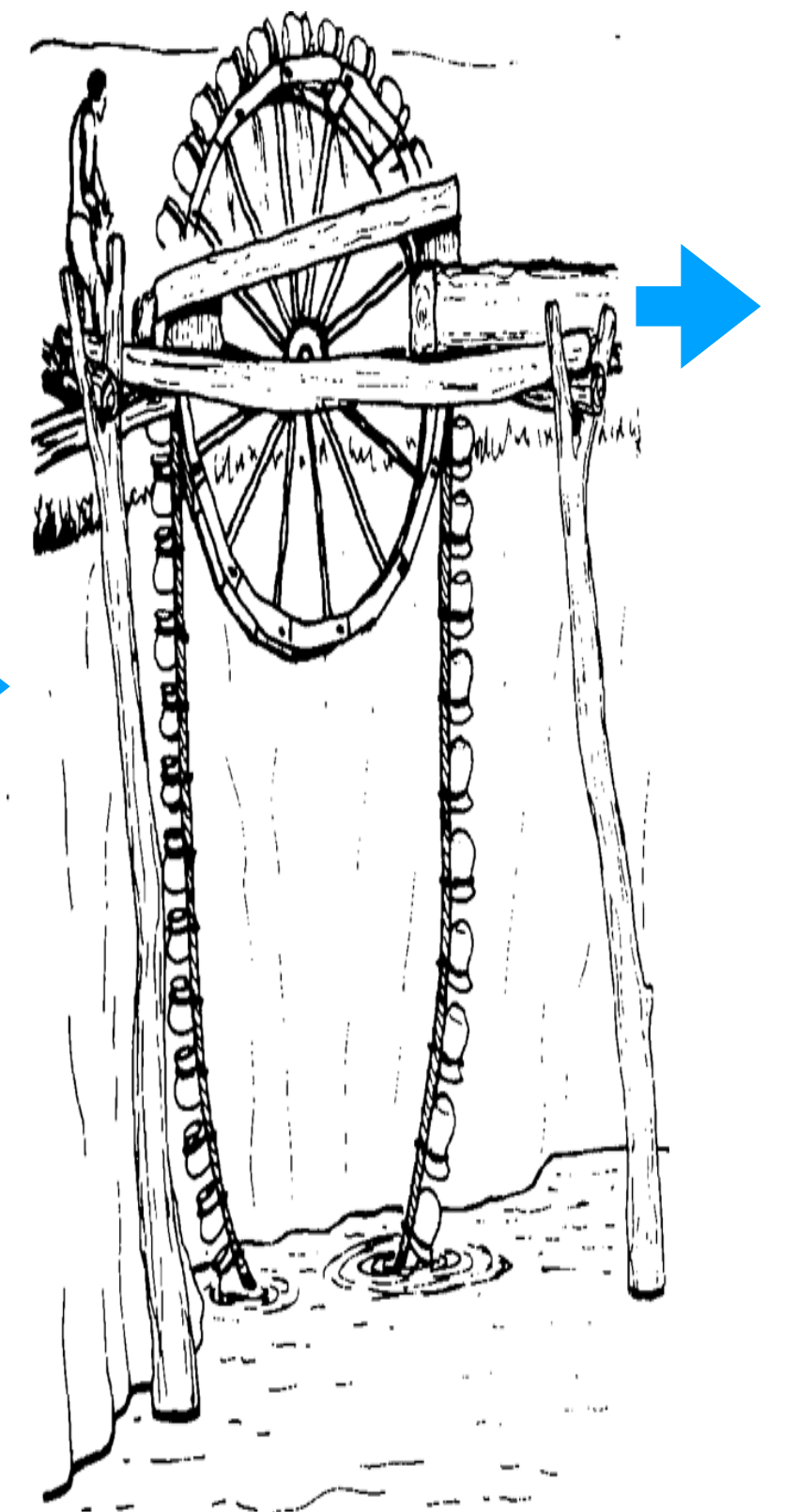
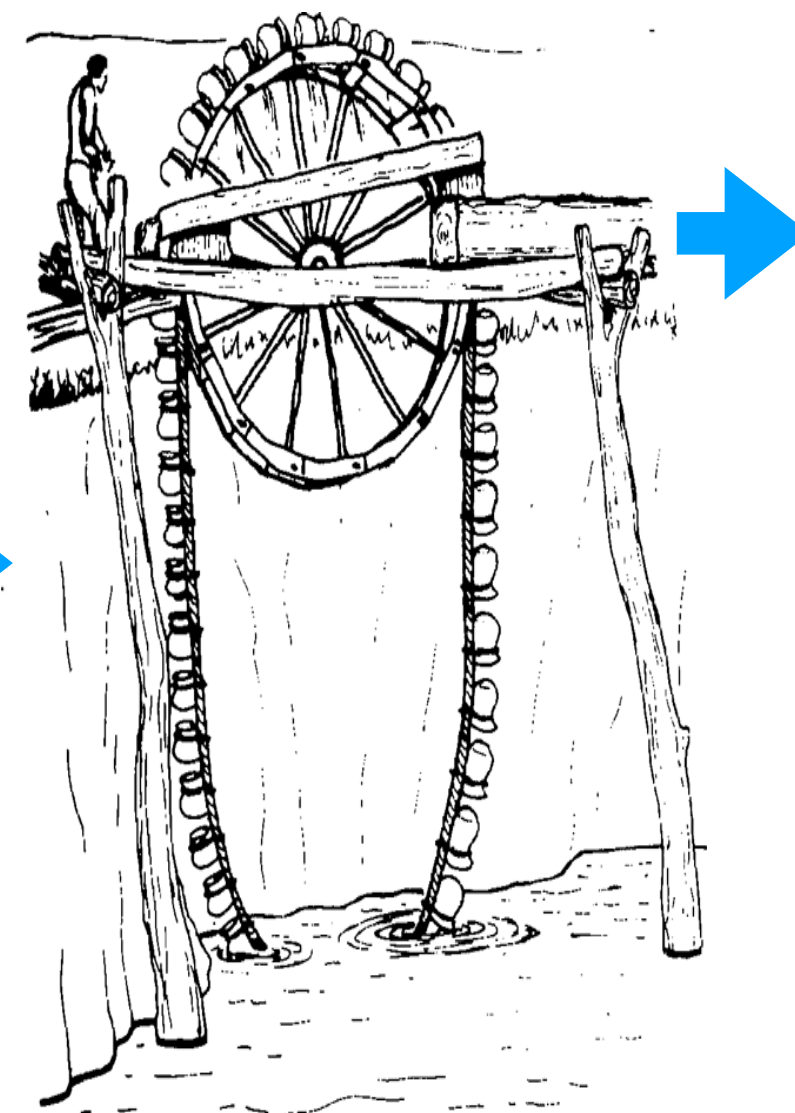
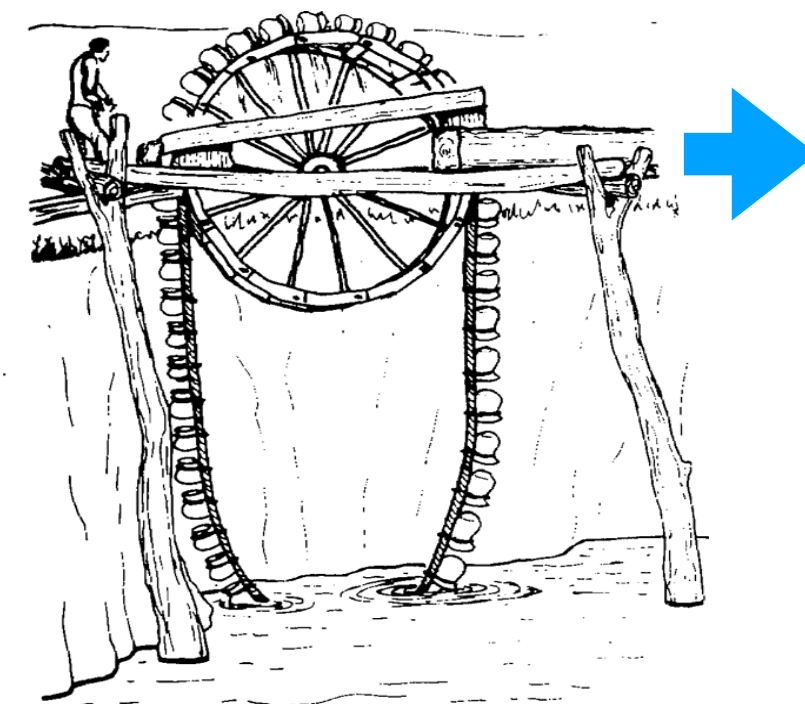
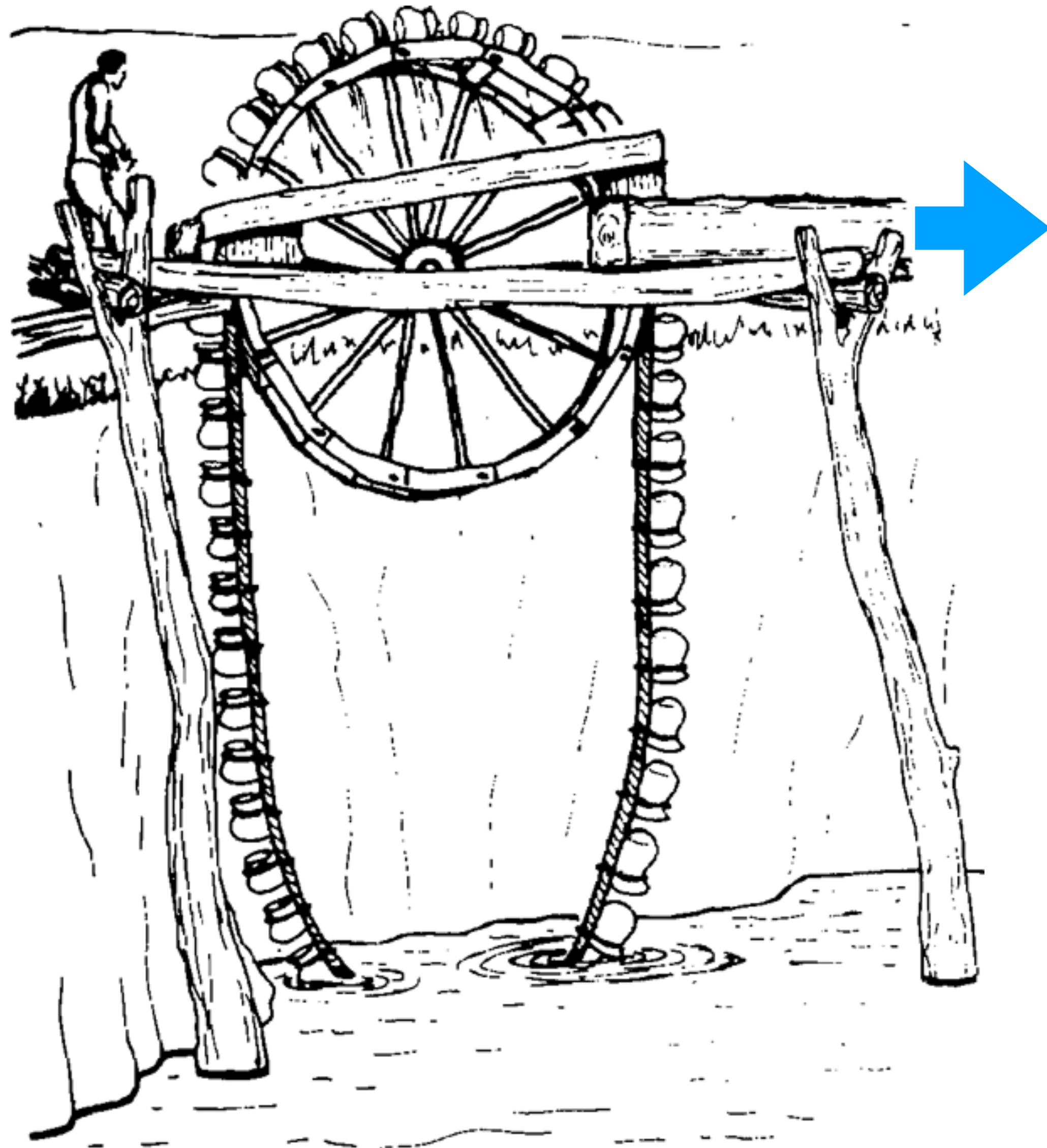


Average January GPCP Precipitation (mm/day) for 1988–96

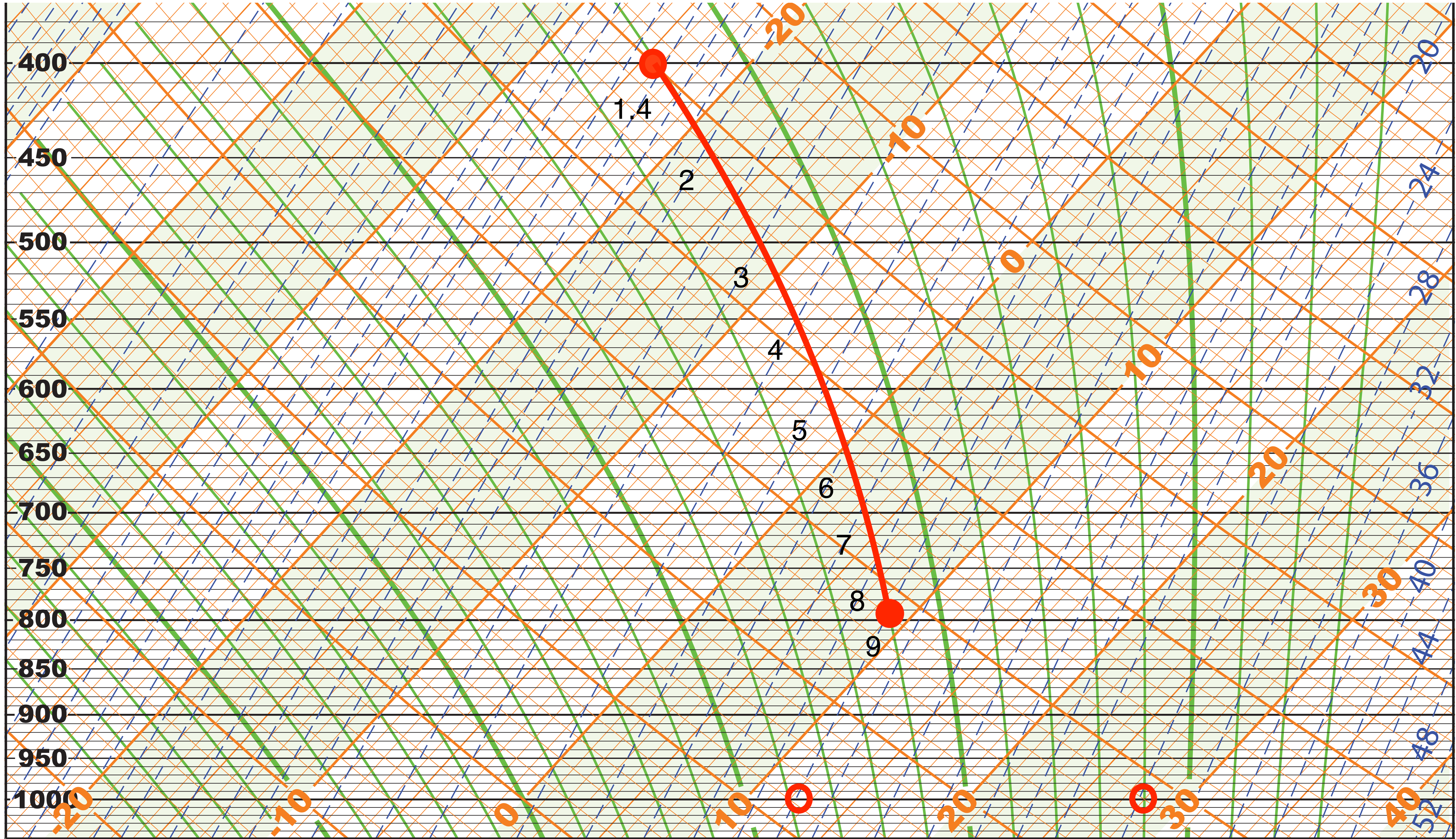


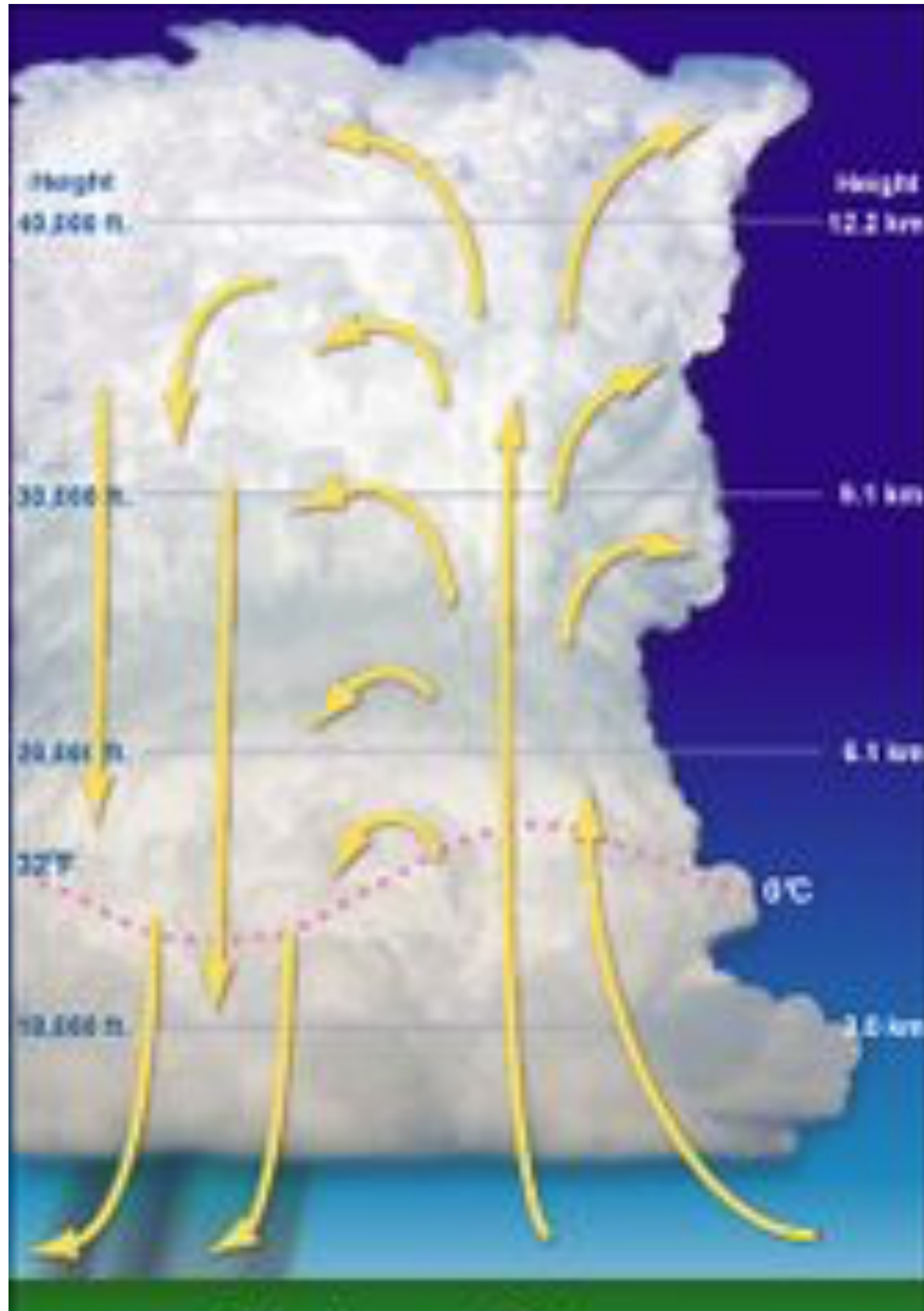
What meteorological processes lead to ascent and precipitation in different regions and seasons?

Lifting water with a water wheel



Water vapor condenses during ascent



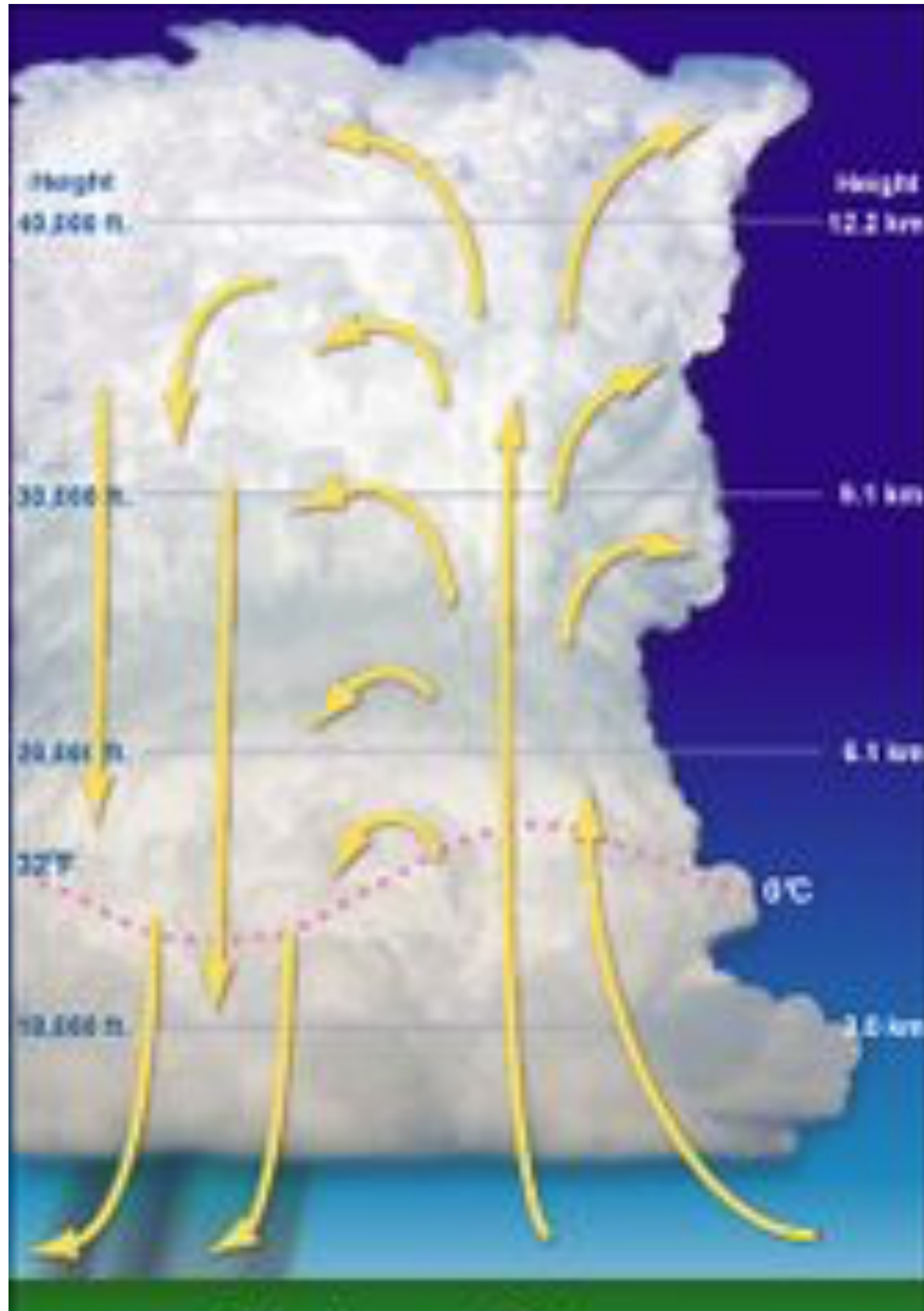


cloud-top temperature, T_t
cloud-top pressure, p_t

constant vertical mass flux, M
(air density \times air vertical velocity)

cloud-base temperature, T_b
cloud-base pressure, p_b

cloud-base precipitation rate, P



cloud-top temperature, T_t
 cloud-top pressure, p_t

constant vertical mass flux, M
 (air density x air vertical velocity)

cloud-base temperature, T_b
 cloud-base pressure, p_b

cloud-base precipitation rate, P

- From these quantities alone, we can estimate the cloud-base precipitation rate.
- Assume precipitation immediately forms from condensed water vapor.
- Then cloud-base precipitation rate = vertically integrated condensation rate.
- The latter is the condensation per unit mass of air during ascent from cloud base to cloud top x vertical mass flux:

$$P = [w_s(T_b, p_b) - w_s(T_t, p_t)] M,$$

$w_s(T, p)$ is the saturation mixing ratio

Cloud Type	Sc	Cu con	Cb	Ns	Ns (Fall)	Ns (Winter)
cloud-base temperature (T_b , °C)	20	20	20	20	0	-10
cloud-base pressure (p_b , hPa)	950	950	950	950	800	800
cloud-top pressure (p_t , hPa)	900	750	300	300	300	300
mass flux (M , $\text{kg m}^{-2} \text{s}^{-1}$)	0.5	2	8	0.1	0.2	0.2
cloud-base saturation mixing ratio ($w_{s,b}$, g/kg)						
cloud-top saturation mixing ratio ($w_{s,b}$, g/kg)						
cloud-base precipitation rate (P , mm hr^{-1})						
maximum cloud-base precipitation rate (P_{max} , mm hr^{-1})						

Cloud Type	Sc	Cu con	Cb	Ns	Ns (Fall)	Ns (Winter)
cloud-base temperature (T_b , °C)	20	20	20	20	0	-10
cloud-base pressure (p_b , hPa)	950	950	950	950	800	800
cloud-top pressure (p_t , hPa)	900	750	300	300	300	300
mass flux (M , kg m ⁻² s ⁻¹)	0.5	2	8	0.1	0.2	0.2
cloud-base saturation mixing ratio ($w_{s,b}$, g/kg)	16	16	16	16	4.8	2.2
cloud-top saturation mixing ratio ($w_{s,b}$, g/kg)	15	11.5	0.8	0.8	0.05	0
cloud-base precipitation rate (P , mm hr ⁻¹)	1.8	32	440	5.5	3.5	1.6
maximum cloud-base precipitation rate (P_{\max} , mm hr ⁻¹)	29	115	460	5.8	3.5	1.6