1.(1)

air parcel is a volume of air in atmosphere, and its volume is defined by the researcher. In most of the cases, the air parcel is defined in kilometer scale. Also, due to the conduction in atmosphere is too slow to be considered, air parcel can be regarded as adiabatic.

Because we can take average value of air parcel to describe the characteristics such as humidity, temperature, etc. It's a much easier way to describe how the atmosphere change.

1.(2)

Through the definition of specific humidity:

$$q_v = \frac{\rho_v}{\rho_{atm}}$$

Assume that $\rho_{atm} = 1.225\frac{kg}{m^3}$

Through the question: $\rho_v = 20\frac{g}{m^3}$

Then $q_v = \frac{20\frac{g}{m^3}}{1.225\frac{kg}{m^3}} \approx 16.33\frac{g}{kg}$

1.(3)

Assume water vapor only exist in troposphere (12km on average)

Through the definition of column water vapor:

$$cwv = \int_{surface}^{ToA} \rho_{atm} \cdot q_v \, dz = \int_{surface}^{ToA} \rho_v \, dz \approx \int_{surface}^{ToTropo} \rho_v \, dz$$

Assume the ration of height to specific humidity is t.

$$\rho_{water} = 1000[\frac{kg}{m^3}]$$

$$\rho_{atm}(z) = 41.748 * 10^{-12} * (288.19 - 0.00649z)^{4.256}$$

(this equation is derived from:

https://www.grc.nasa.gov/www/k12/airplane/atmosmet.html)

Case 1: surface specific humidity =10 [g/kg]

The function of specific humidity decrease depends on height:

$$q_v(z) = -\frac{5}{6}z + 10\ (z\ in\ km)$$

$$cwv = \int_0^{12} 41.748 * 10^{-12} * (288.19 - 0.00649z)^{4.256} * (-\frac{5}{6}z + 10)\, dz$$

$$= 73.57\ [\frac{kg}{m^2}]$$

$$\frac{cwv}{\rho_{water}} = \frac{73.57\left[\frac{kg}{m^2}\right]}{1000\left[\frac{kg}{m^3}\right]} = 0.07357\ [m] = 73.57\ [mm]$$

Case 2: surface specific humidity =20 [g/kg]

The function of specific humidity decrease depends on height:

$$q_v(z) = -\frac{5}{3}z + 20\ (z\ in\ km)$$

$$cwv = \int_0^{12} 41.748 * 10^{-12} * (288.19 - 0.00649z)^{4.256} * (-\frac{5}{3}z + 20)\ dz$$

$$= 147.14\ [\frac{kg}{m^2}]$$

$$\frac{cwv}{\rho_{water}} = \frac{147.14\left[\frac{kg}{m^2}\right]}{1000\left[\frac{kg}{m^3}\right]} = 0.14714\ [m] = 147.14\ [mm]$$

Case 3: surface specific humidity=30 [g/kg]

The function of specific humidity decrease depends on height:

$$q_v(z) = -\frac{5}{2}z + 30\ (z\ in\ km)$$

$$cwv = \int_0^{12} 41.748 * 10^{-12} * (288.19 - 0.00649z)^{4.256}(-\frac{5}{2}z + 30)\ dz$$

$$= 220.71\ [\frac{kg}{m^2}]$$

$$\frac{cwv}{\rho_{water}} = \frac{220.71\left[\frac{kg}{m^2}\right]}{1000\left[\frac{kg}{m^3}\right]} = 0.22071\ [m] = 220.71\ [mm]$$

1.(4)

Saturation vapor pressure:

at 0°C= 6 (hPa)

at 10°C= 12 (hPa)

at 20°C= 23 (hPa)

at 30°C= 42 (hPa)

the changing rate from 0°C to 10°C: 0.6 $[\frac{hPa}{°C}]$

the changing rate from 20°C to 30°C: 1.9 $[\frac{hPa}{°C}]$

Via the change rate at different temperature intervals, we can know that:
The higher the temperature is, the faster the saturation vapor pressure grow.
On the other hand, the function of saturate water vapor pressure is exponentially increase as the temperature rise.

1.(5)

If there is adequate water vapor and cloud condensation nuclei in the atmosphere, the nuclei would gather water vapor to become cloud droplets. If the nuclei is highly hydrophilous, then when the relative humidity reach about 90%, the vapor will condense and become cloud droplets. However, if the nuclei is highly hydrophobious, then the relative humidity may have to reach over 100% to make cloud droplets.

At the time when vapor condense, and become a cloud droplet, the bonding between nuclei and H_2O molecules are bulit up. Building up a bonding will cause the total energy of the system decrease, and emit with the form of heat. That released heat is called latent heat.

After the cloud droplets are formed, the air flow will make these droplets to collapse with each other, which make the volume of the droplets become bigger. Eventually, if the weight if the droplet is heavier than the air flow can afford, it'll become raindrops and start to precipitation.

2.(1)

a. Stability:

Whether the air parcel easy to lift or not when there is a small perturbation. If the environmental lapse rate is lesser than wet lapse rate, the atmosphere in that case absolute stable, because at the same height, the environment always cooler than the air parcel. On the other hand, if the environmental lapse rate is greater than dry lapse rate, the atmosphere is quite unstable, because at the same height, the environment always hotter than air parcel.

b. Perturbation:

Small changing of the condition or environment, which make significant phenomenon.

c. Conditionally unstable:

If the value of lapse rate of an air parcel is between dry adiabatic lapse rate and wet adiabatic lapse rate, then the air parcel is conditionally unstable.

d. Convection:

A process that makes the atmosphere mix and reach thermal equilibrium. When an air parcel is heated by the ground, the density of it become lower than the environment, then lift into the air, forming thermal. The cooler air soon fill the empty space, then doing the same process as a cycle.

e. Precipitation:

the phenomenon that the raindrop, ice crystal or snowflakes fall from atmosphere to ground.

2.(2)

At afternoon, infrared radiation emitted from ground reach its maximum of the day, heating the near ground air parcel, making it become low density air parcel. In most of the cases, air parcel is conditionally unstable, once there is an adequate perturbation, the air parcel will start to convect in atmosphere.

Once the temperature is lower than saturation vapor pressure, vapor will start to condense to be cloud droplet. When lifting force cannot afford the weight of the raindrop, then precipitance happened.

The features of this phenomenon is large precipitation in a very short time.

2.(3)

I would say that it is a good article, for it’s easy to understand these information. But it can be better. Because some words about atmospheric science are really hard. If you can write down examples following the meaning, readers can understand the words more easily.

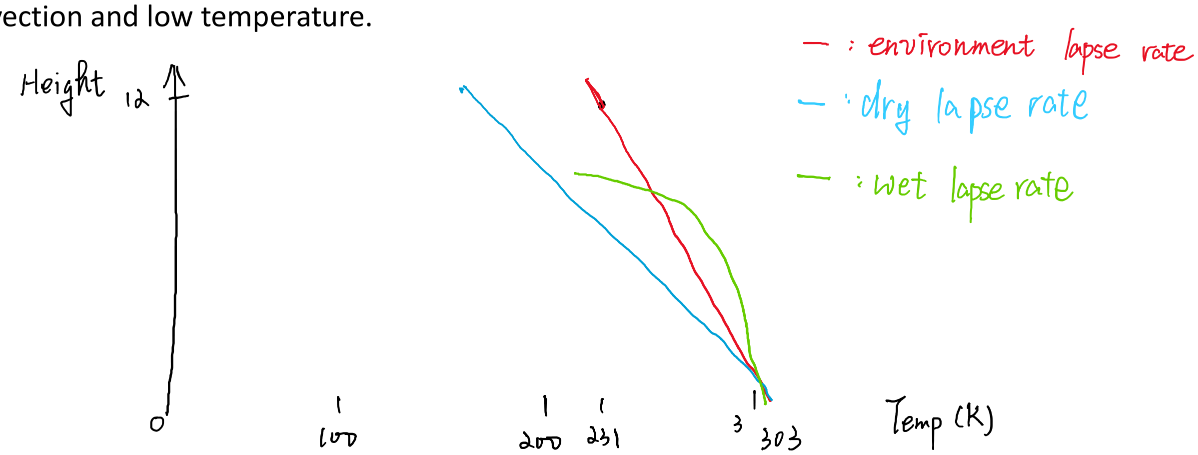
1. What is the difference between dry adiabatic lapse rate and wet adiabatic lapse rate?

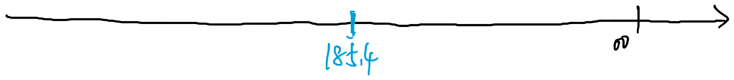
Dry adiabatic lapse rate is the temperature decreasing rate of air parcel that is not saturation. On the other hand, wet adiabatic lapse rate is the temperature decreasing rate of air parcel that is saturation.

2. What is the factor that decides that it would be a rainfall or a hail?

It is decided by the height that the cloud droplet saturate, if the environmental temperature is lower than melting point, the cloud droplet will freeze. However, if the convection of air parcel in high atmosphere is not strong enough, hail will melt in the path dropping to the ground. Thus, the factors to form a hail are strong convection and low temperature.

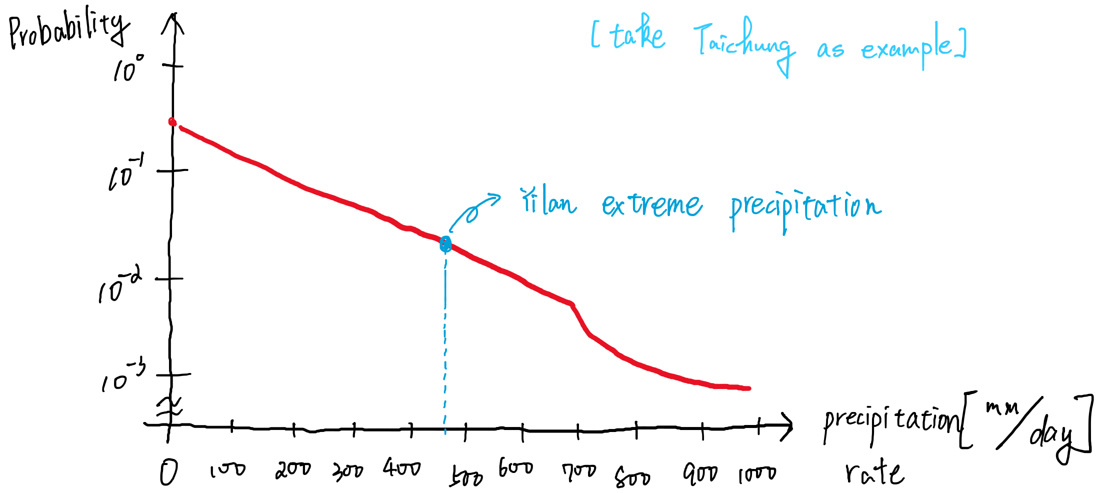
2.(4)





When air parcel starts to rise, the percentage of water vapor will affect the lapse rate. On average, consider it is hydrostatic equilibrium in atmosphere, the dry lapse rate is about $-9.8\ [\frac{°C}{km}]$. And the wet lapse rate is determined by the ratio of mass of water vapor and dry air. When the temperature of an air parcel is greater than the environment, then it is easy to rise due to the low density. After it start to lift, if the value of environmental lapse rate is greater than the one of air parcel, the atmosphere is in a stable condition. Because the air parcel has lower temperature in the same height compared with environment. However, if in the opposite situation, the atmosphere is quite unstable. The air parcel has higher temperature in the same height compared with the environment. Thus, the air parcel will rise constantly, not only makes the convection in the atmosphere continue, but also helps cloud with vertical development and cumulonimbus to grow, higher the possibility to precipitate.

2.(5)



[The precipitation of Yilan extreme precipitation is taking average number of total precipitation.]