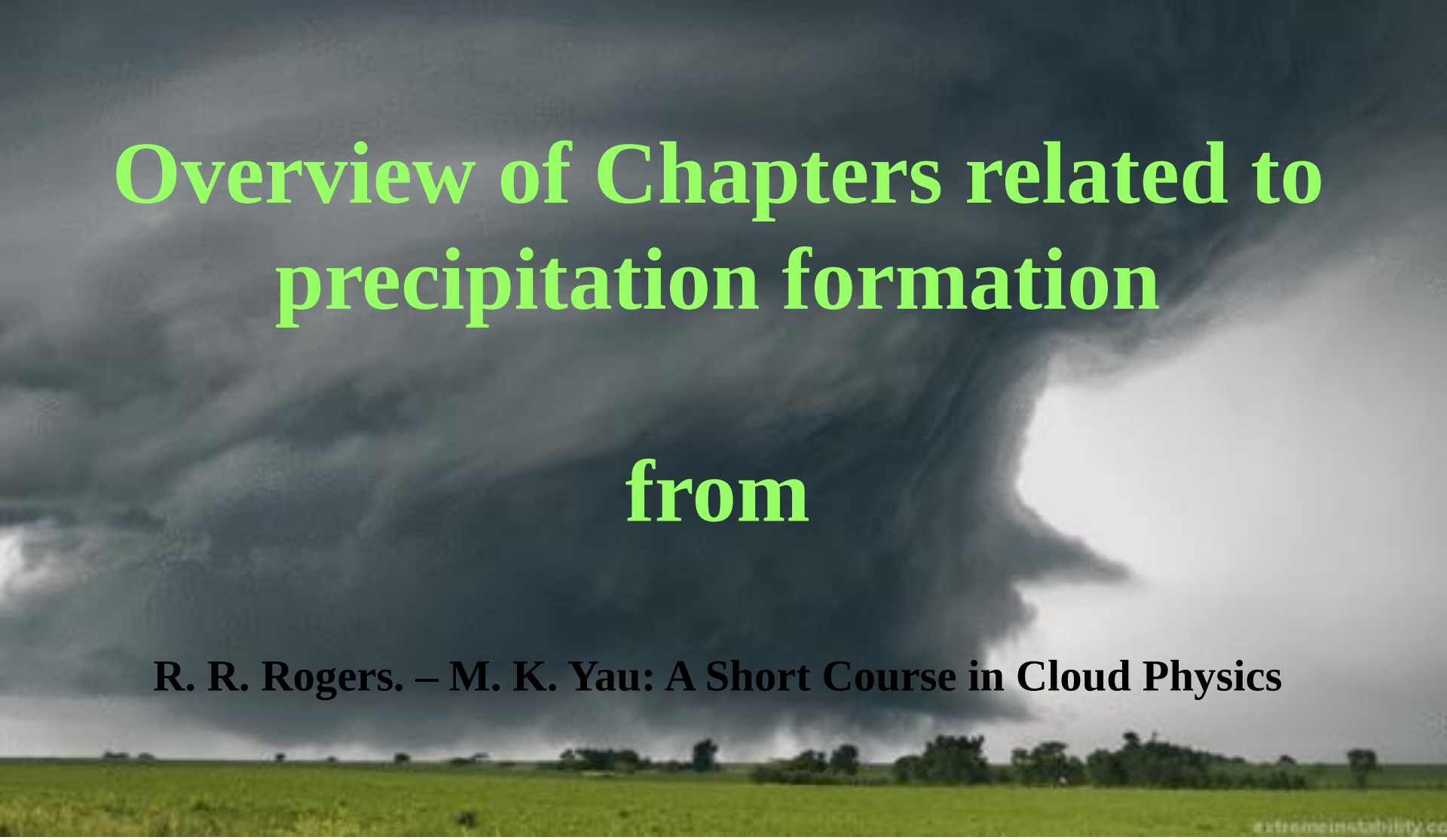

Overview of Chapters related to precipitation formation

from

R. R. Rogers. – M. K. Yau: A Short Course in Cloud Physics

Jeevan Kumar Bodaballa
PhD student
Under the Guidance of
Prof. Istvan Geresdi

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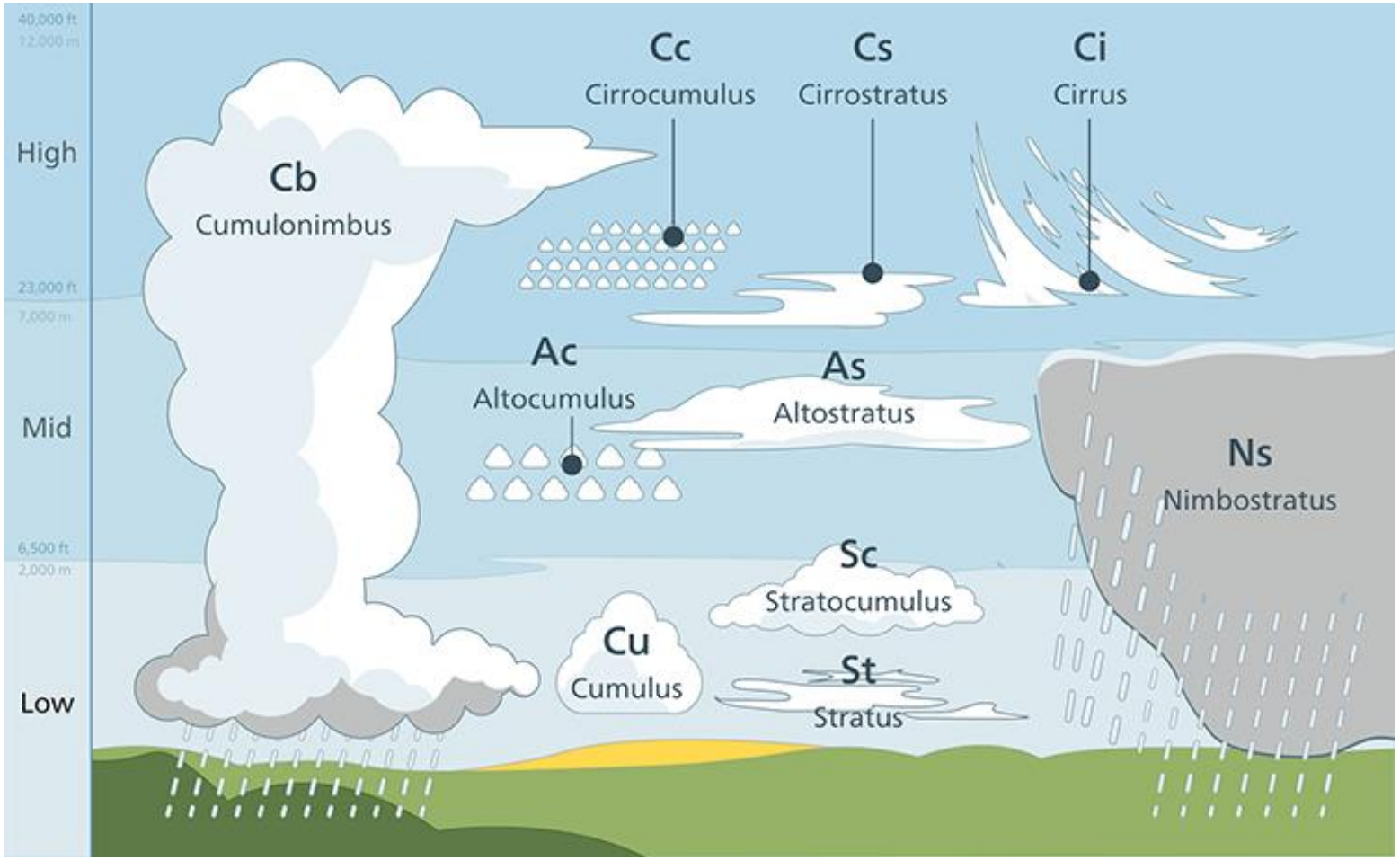
UNIVERSITY OF PÉCS

Overview:

- Types of Clouds
- Cloud formation
- Cloud Droplets Formation
- Precipitation.

Types of Clouds:



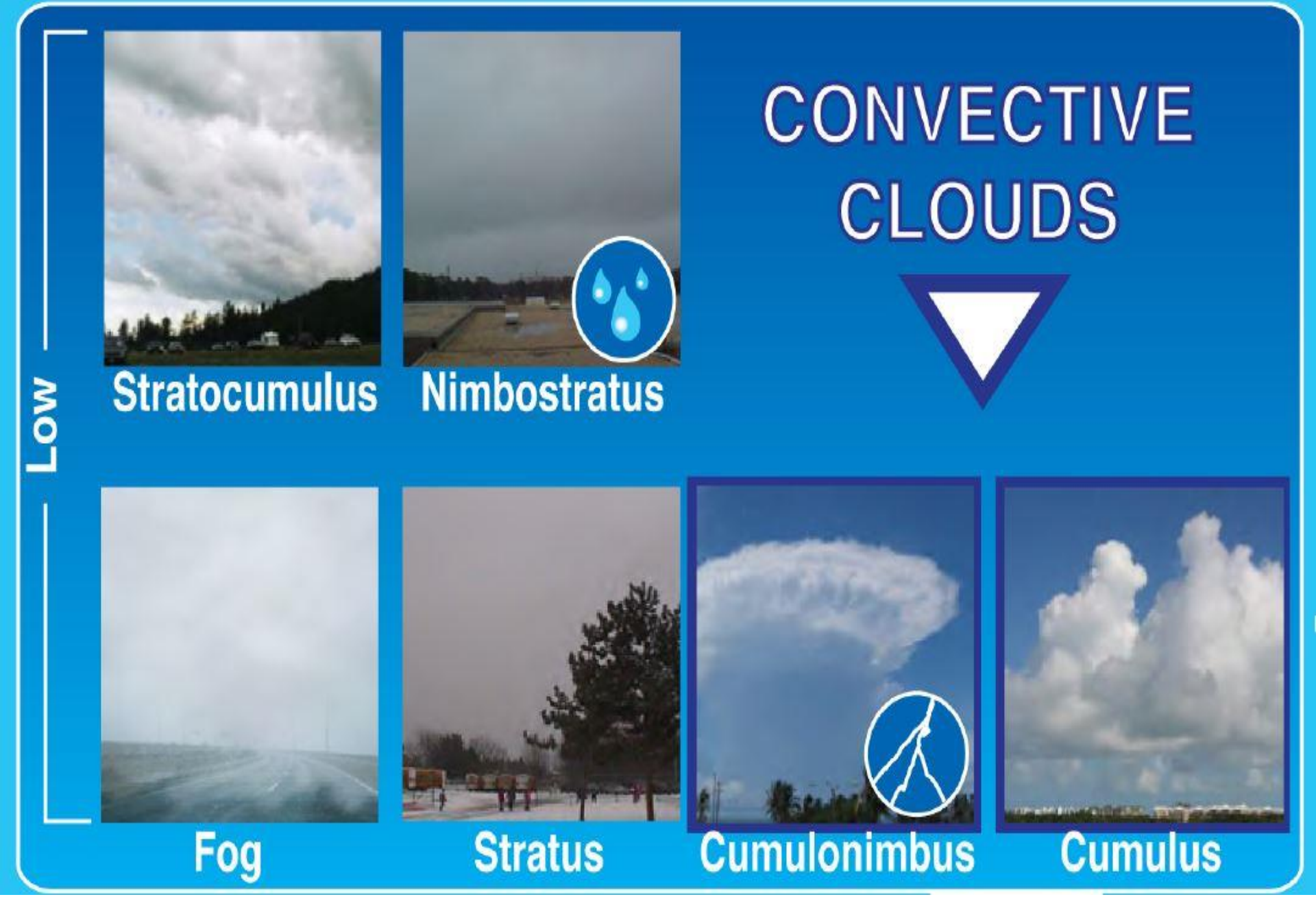

Contrails
2 Cirrocumulus
3 Cirrostratus
Cirrus
1
10 Cumulonimbus
5 Altocumulus
4 Altostratus
9 Cumulus
6 Nimbostratus
8 Stratocumulus
7 Stratus
Fog

Identifying Clouds

To better communicate and understand the many cloud forms in the sky, meteorologists identify clouds based on five basic cloud characteristics:

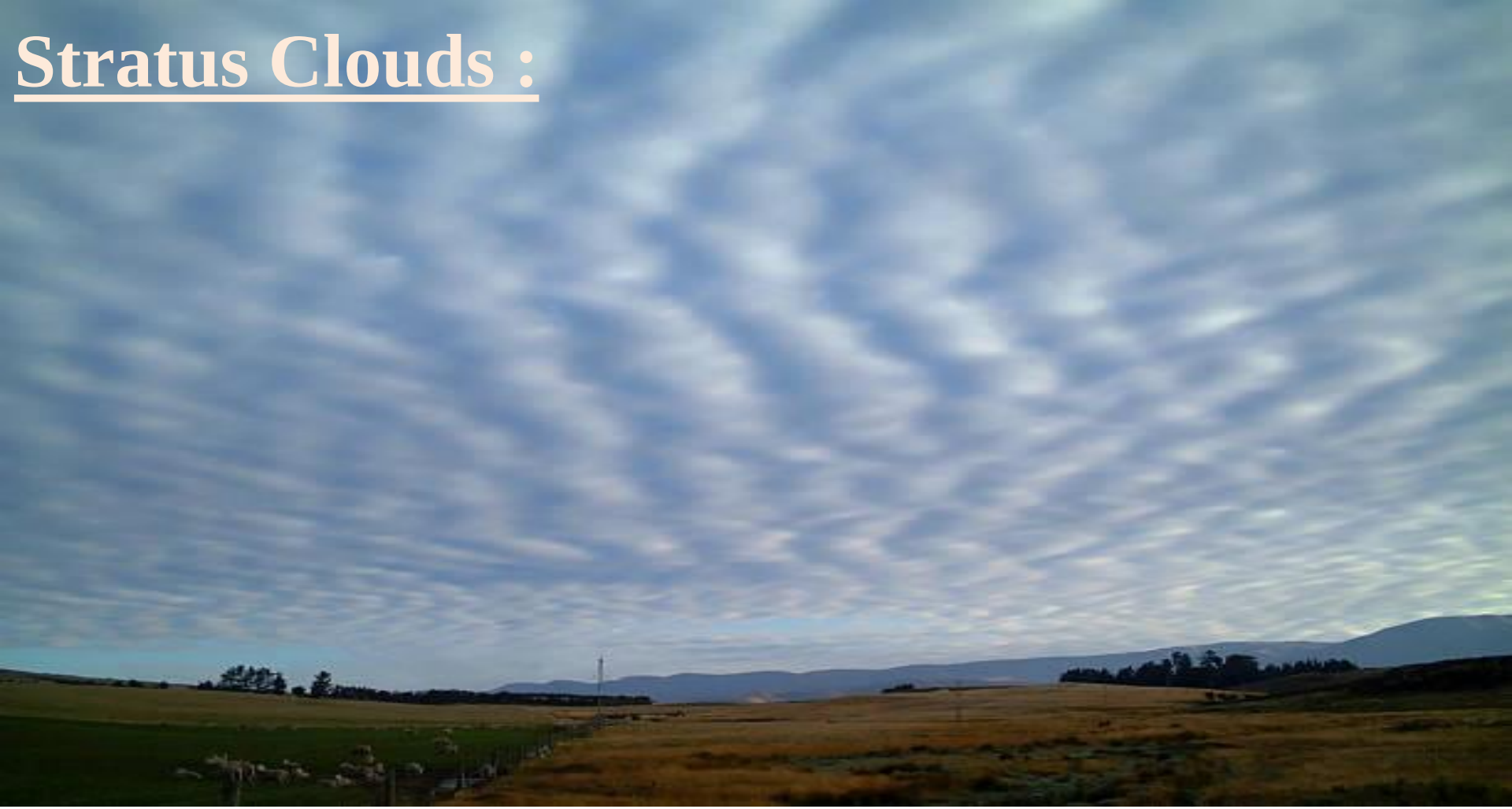
1. **The altitude at which they occur**
2. **Color**
3. **Density**
4. **Shape**
5. **Degree of cover.**

From this information, we can identify three basic cloud types and seven other common cloud types.



Between 0 to 2000m (6500ft)

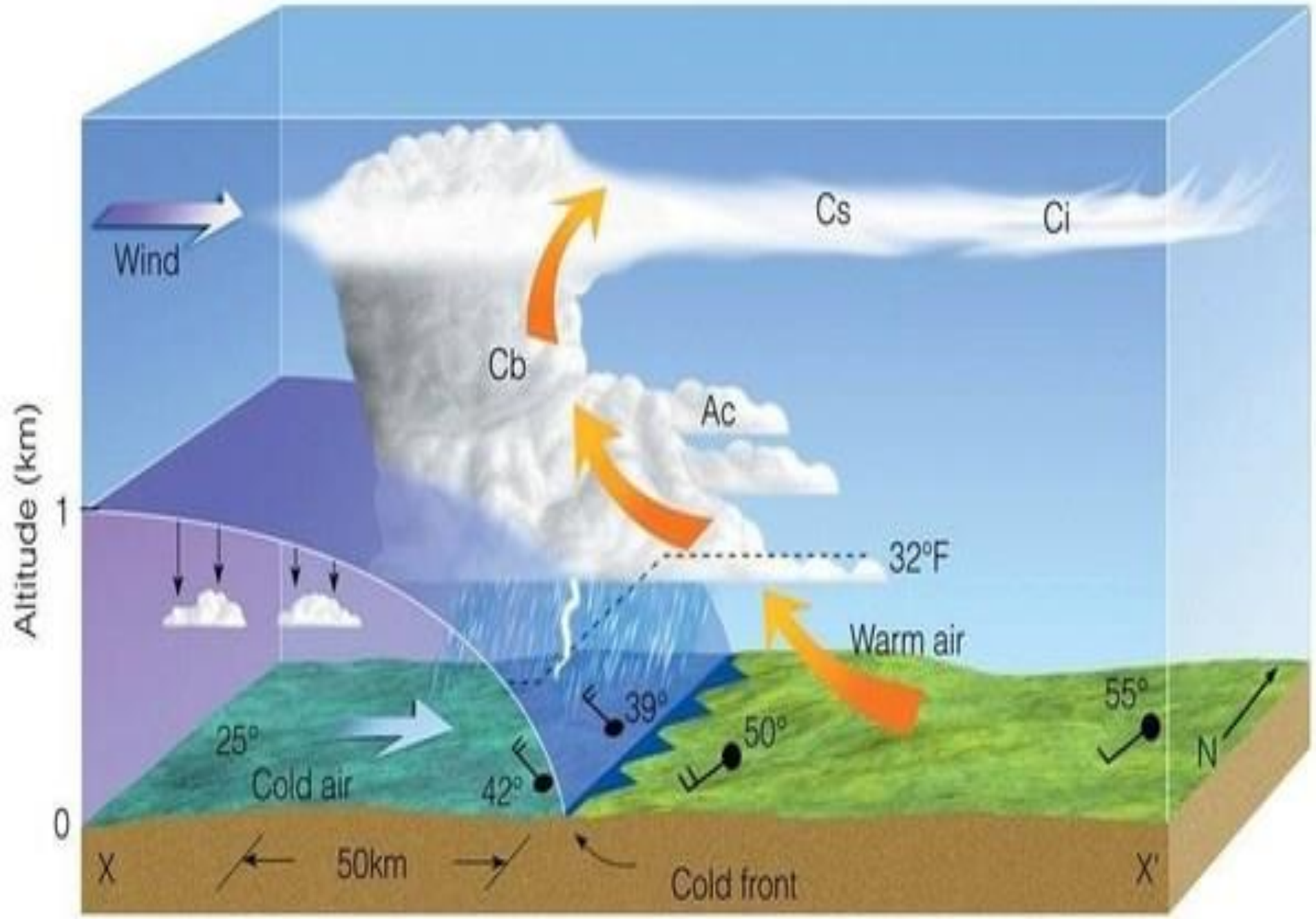
Stratus Clouds :

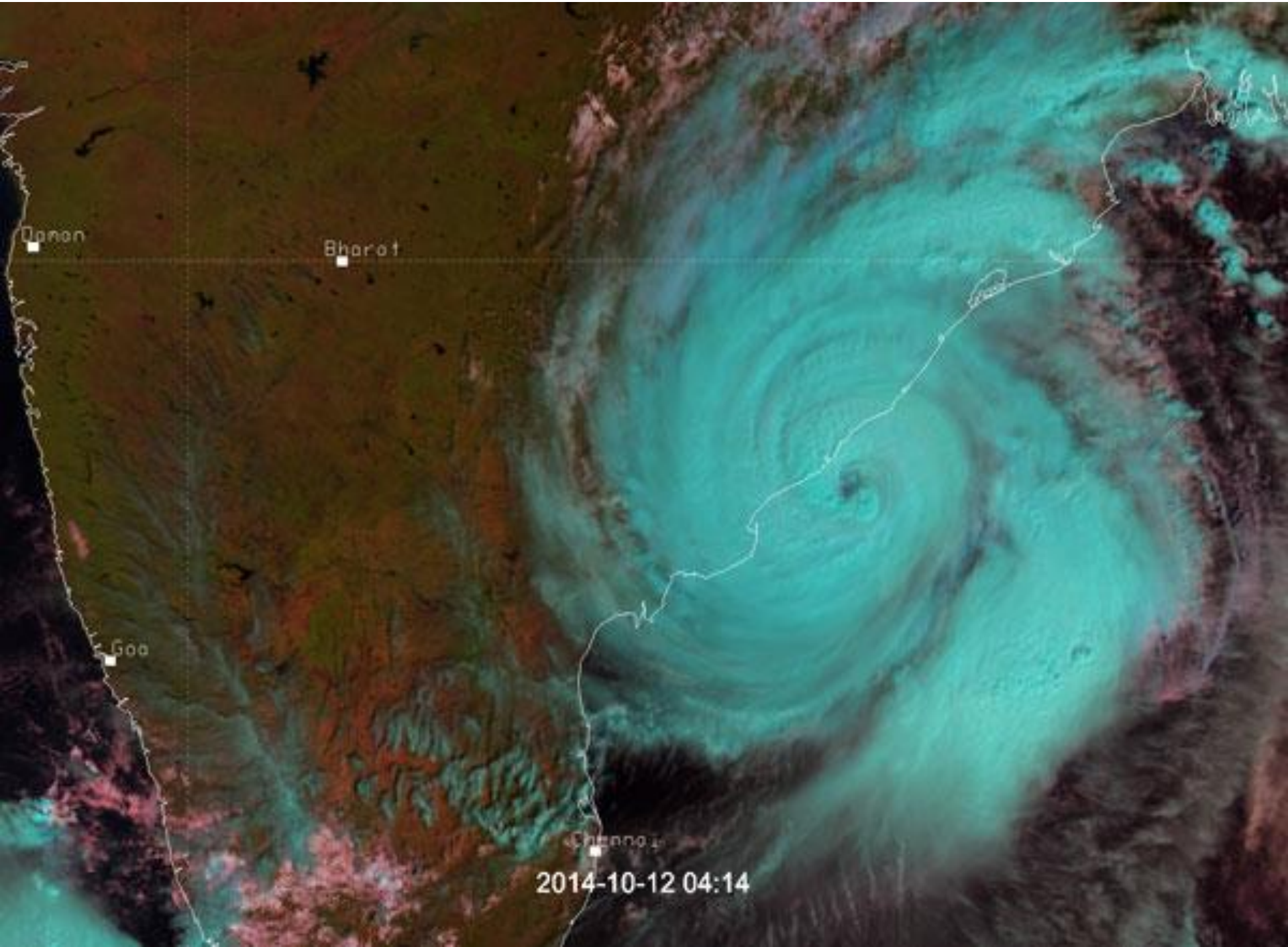


Stratus clouds are thin, sheet-like clouds. These are usually accompanied by little to no rainfall, however if they are thick enough they can produce light drizzle. This drizzle can also fall in the form of light snow if cold. They are frequently gray and thick.

Cumulonimbus :

Cumulonimbus clouds are thunderstorm clouds that form if cumulus congests clouds continue to grow vertically. Their dark bases may be no more than 300 m (1000 ft) above the Earth's surface. Their tops may extend upward to over 12,000 m (39,000 ft). Tremendous amounts of energy are released by the condensation of water vapor within a cumulonimbus. Lightning, thunder, and even violent tornadoes are associated with the cumulonimbus.




Daman
Bharat
Goa
2014-10-12 04:14

Mid

Altostratus

Altocumulus

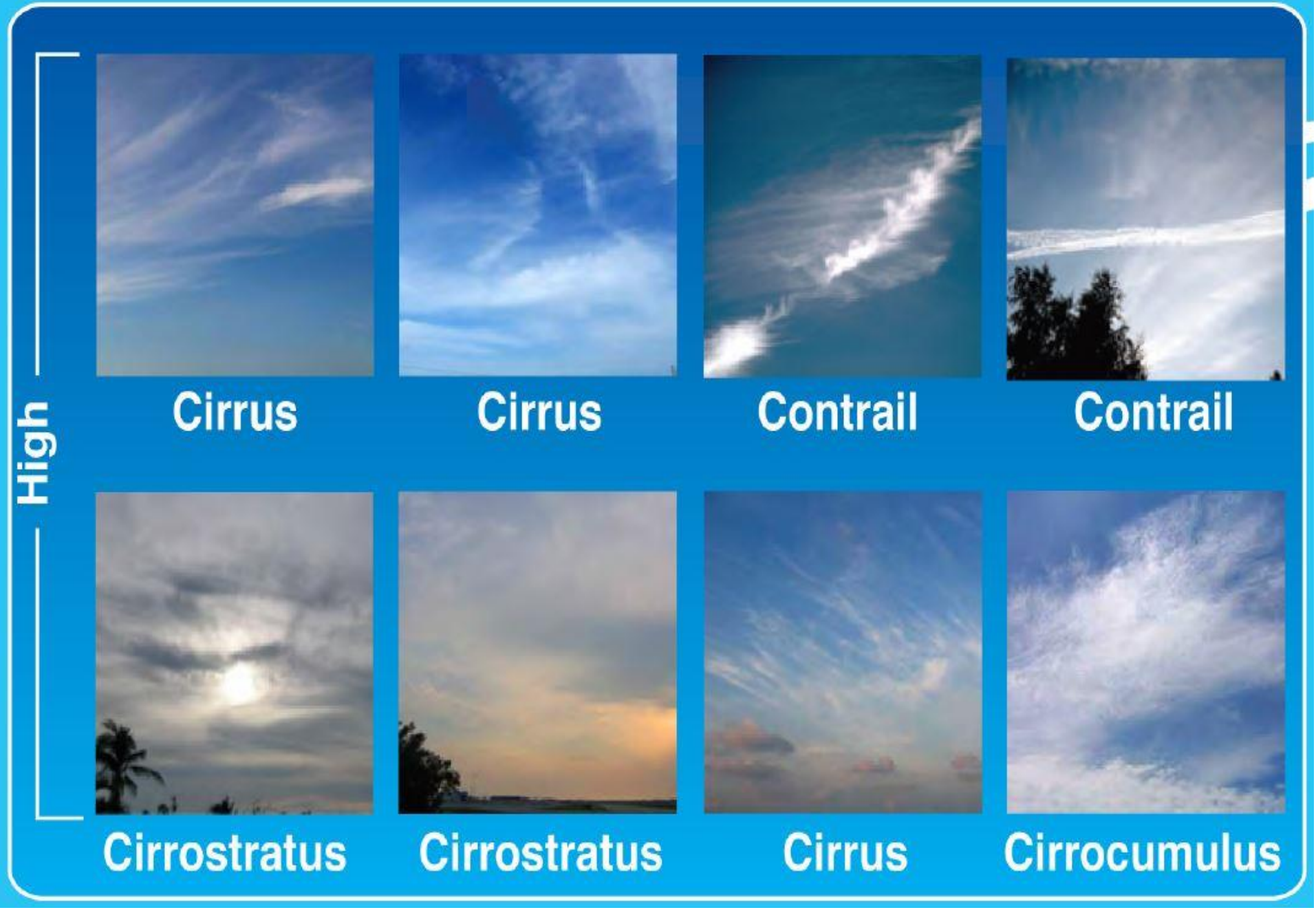
Altocumulus

Altocumulus

Between 2000m to 7000m

Cumulus Clouds:

- **Cumulus clouds are flat-based, billowing clouds with vertical doming. Often the top of cumulus clouds have a "cauliflower-like" appearance.**
- **Cumulus clouds are most prominent during the summer months.**
- **Cumulus or fluffy clouds form when air is forced up rapidly and therefore rises higher.**



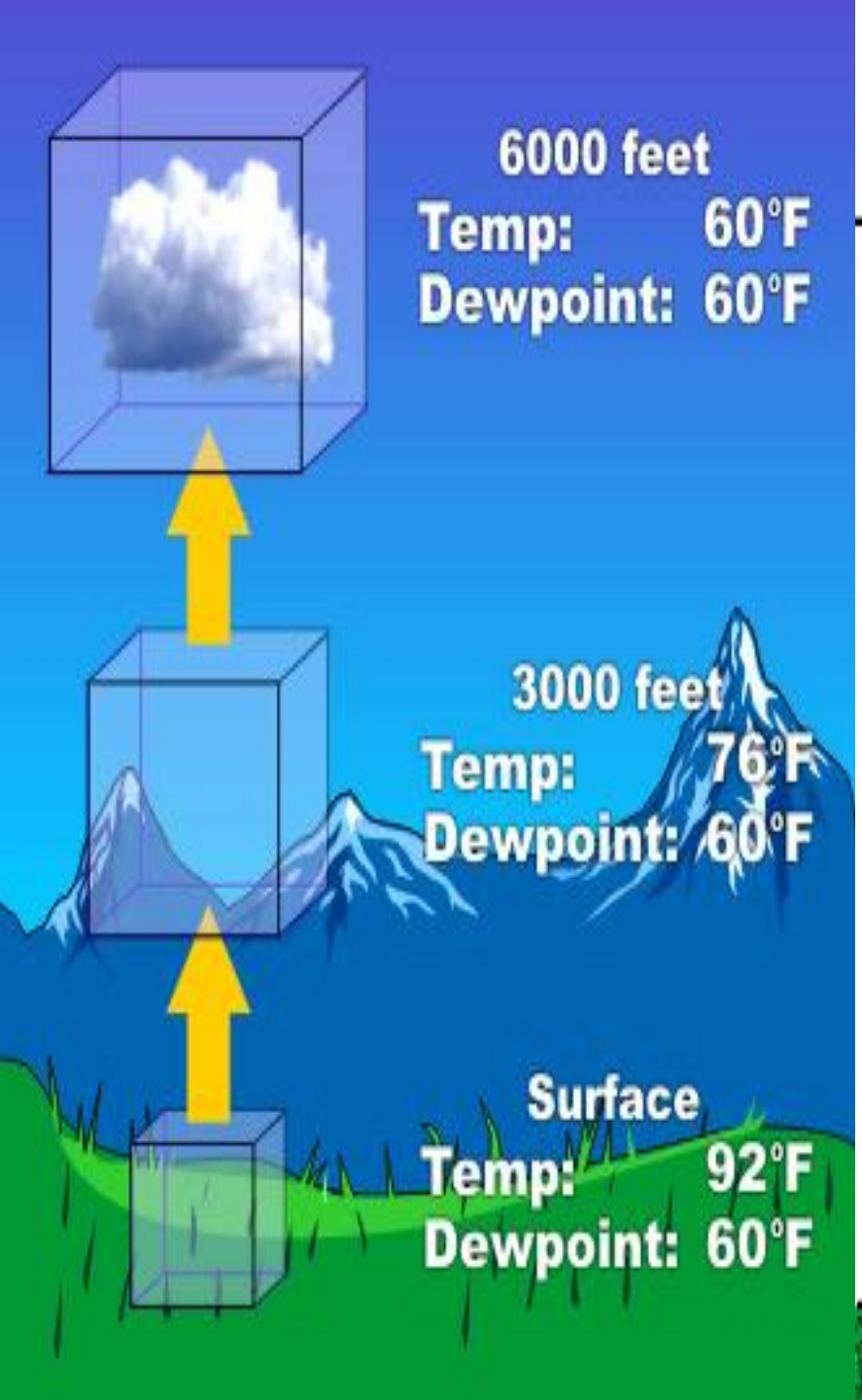
Above 7000meters (23000ft)

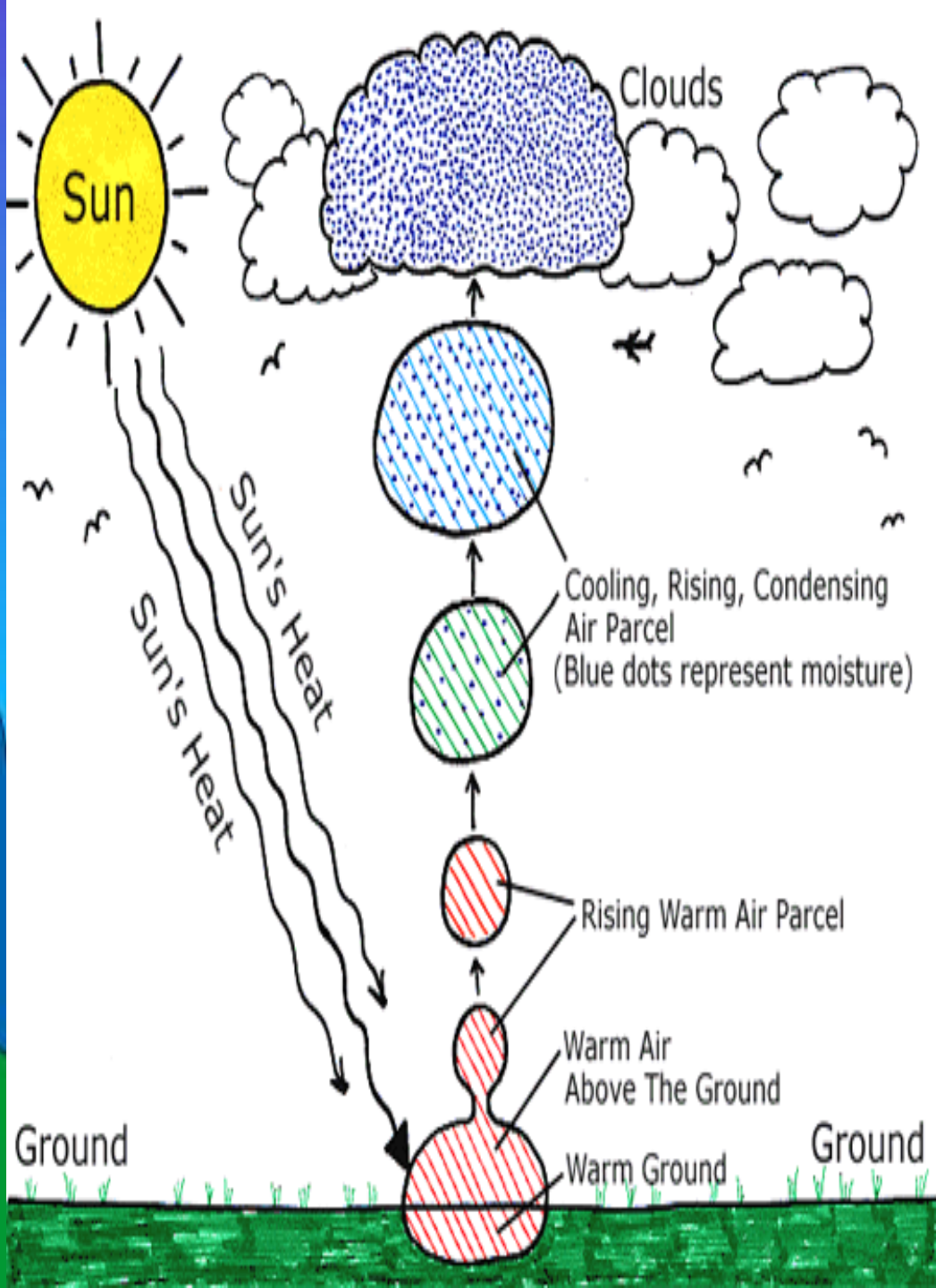
Cirrus Clouds :

- **Cirrus clouds are thin, white clouds with a feathery appearance.**
- **They are the highest of all clouds forming at heights of 30,000 feet or more above the earth's surface.**
- **Cirrus clouds are formed by ice crystals.**
- **They generally occur in fair weather and point in the direction of air movement at their elevation. Cirrus clouds are usually the first sign of an approaching storm.**

How Clouds form ?

- **Clouds form when the invisible water vapour in the air condenses into visible water droplets or ice crystals.**
- **Sunlight causes water to evaporate into the atmosphere.**
- **This air containing the water vapour is heated at the surface of the earth and rises.**
- **There is water around us all the time in the form of tiny gas particles, also known as water vapour. There are also tiny particles floating around in the air - such as salt and dust - these are called aerosols.**
- **Atmospheric particles come from many different sources. Good cloud condensation nuclei (CCN) must be small particles, so that they do not settle too fast, and must be hydrophilic, which means that water can stick. They can be either soluble (i.e., dissolvable in water), or insoluble, but most are soluble.**


6000 feet
Temp: 60°F
Dewpoint: 60°F
3000 feet
Temp: 76°F
Dewpoint: 60°F
Surface
Temp: 92°F
Dewpoint: 60°F


Sun
Clouds
Sun's Heat
Sun's Heat
Sun's Heat
Cooling, Rising, Condensing
Air Parcel
(Blue dots represent moisture)
Rising Warm Air Parcel
Warm Air
Above The Ground
Warm Ground
Ground
Ground

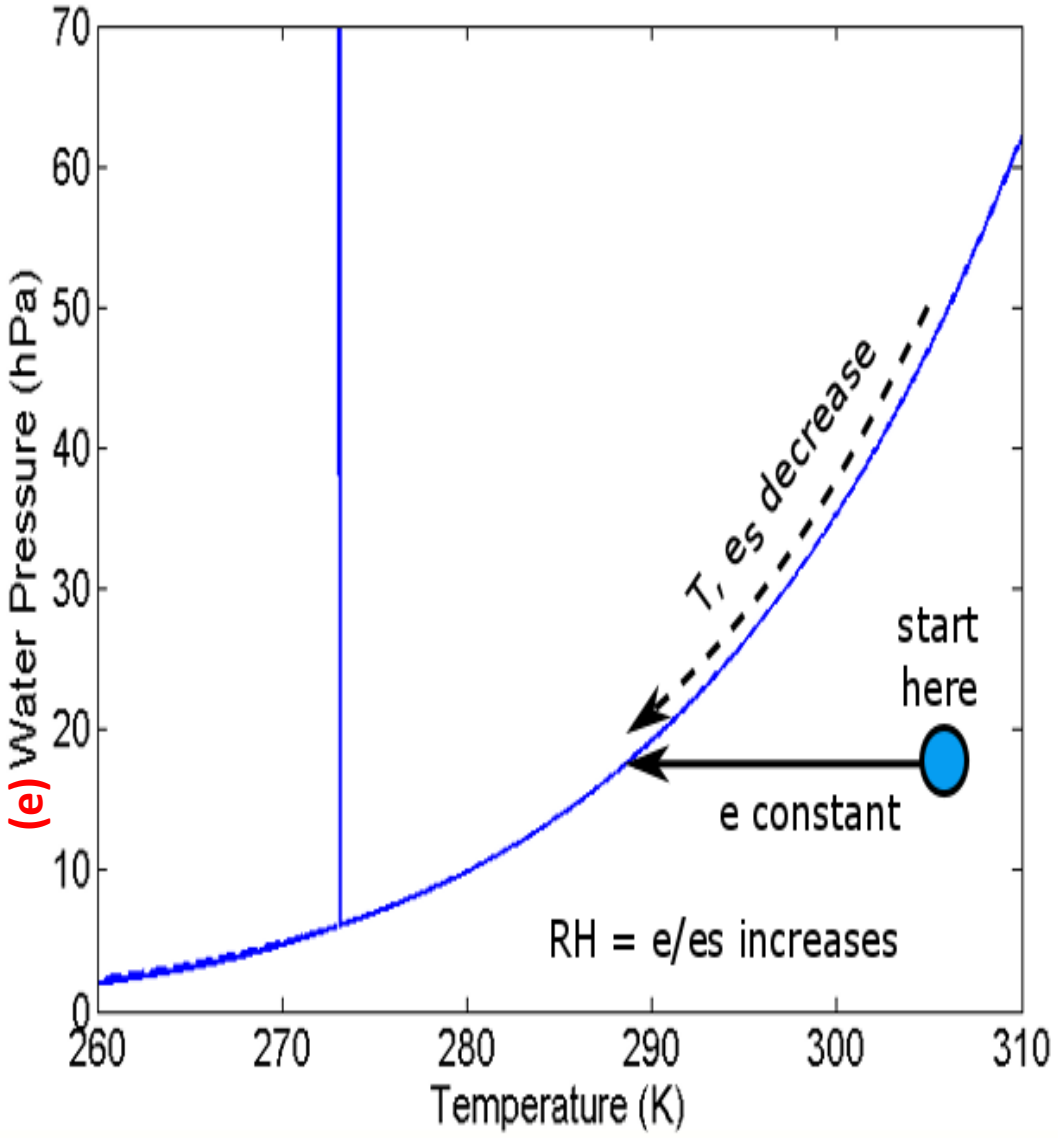
- **Clouds will not form unless the air becomes supersaturated, meaning that it's relative humidity is slightly greater than 100%. Or it's supersaturation is greater than 0%.**

- **Three ways that supersaturation can be achieved,**

  1. **Radiative cooling**
  2. **Mixing**
  3. **Adiabatic ascent.**

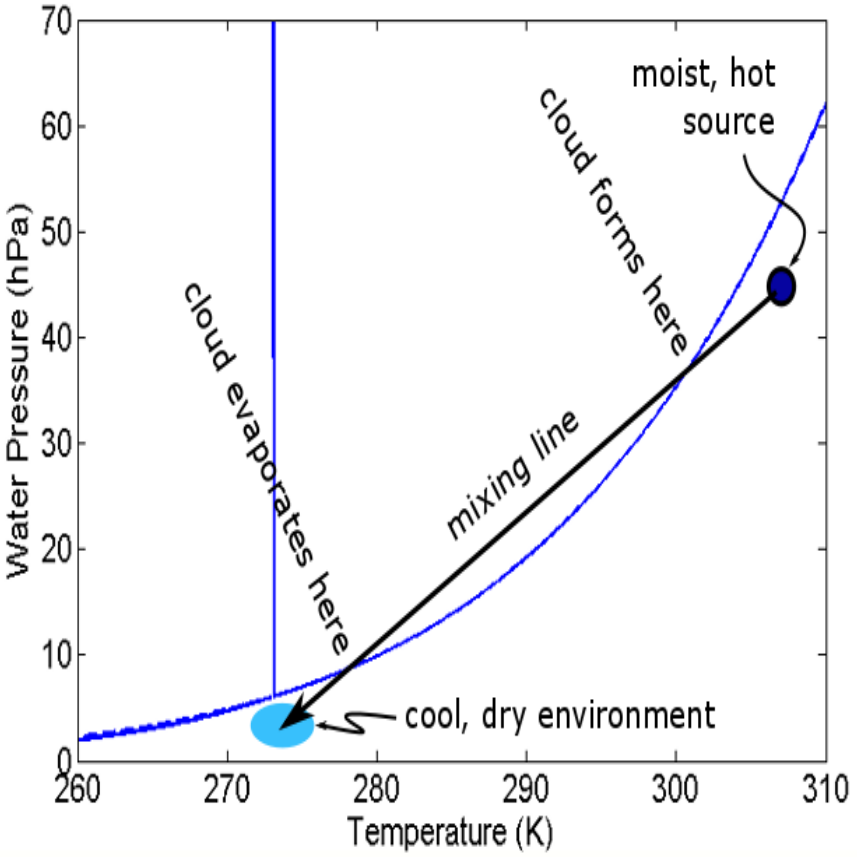
Radiative Cooling :

- The water vapor pressure stays the same, but the temperature drops.
- Because the saturation vapor pressure depends on the temperature. the pressure also drops.
- The Saturation vapor pressure decreases until it gets equal to and then a less than the vapor pressure.
- And then the supersaturation above 0.



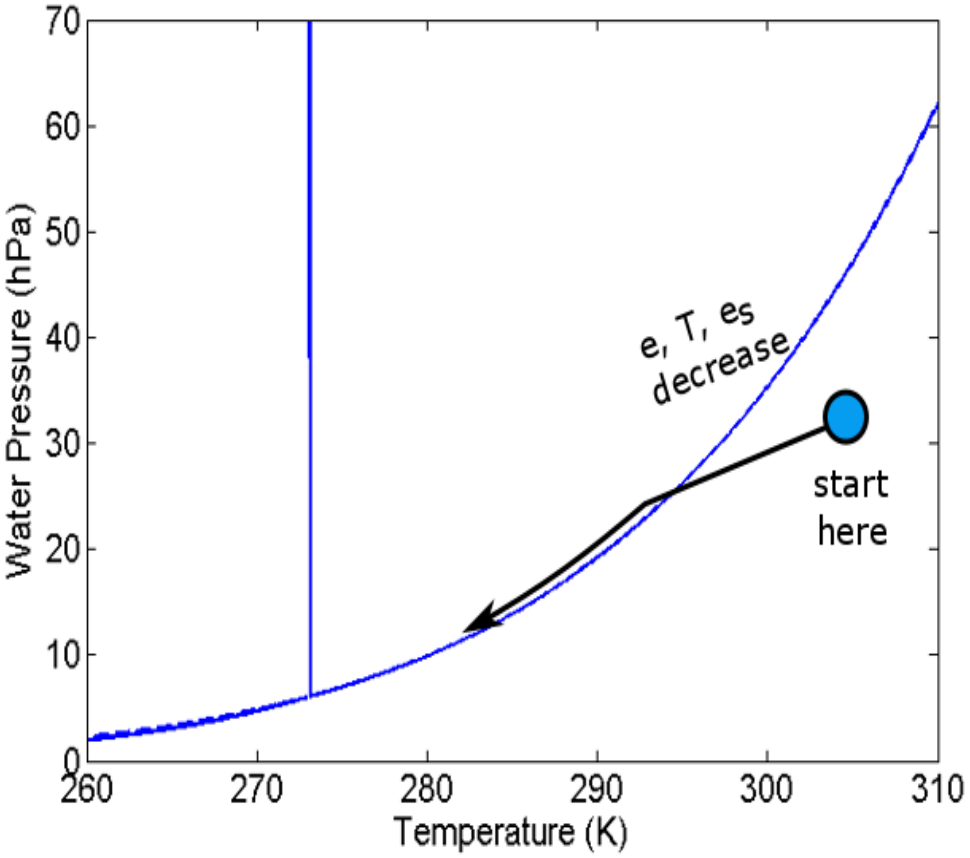
Mixing :

- **Mixing clouds usually form when unsat urated, warm, moist air from a source i s mixed into the unsaturated, colder, dr ier environmental air.**
- **As the air parcel mixes with more envir onmental air, the parcel's temperature and vapor pressure move along the mix ing line between the two initial air parc el states**
- **If the line crosses the equilibrium line and goes into the liquid part of the phase diagram, supersaturation becomes greater than 0 and the cloud forms.**
- **If the air parcel continues to entertain the dry air, along the mixing line and it may eventually cross the equilibrium line and back into the vapor region, then cloud will be evaporate.**



Adiabatic ascent

- This adiabatic ascent can be driven by convection, by a less dense air mass overriding a more dense one, or by air flowing up.
- As an air parcel ascends, it's water vapor pressure and temperature drops.
- Because the water vapor mixing ratio is constant until a cloud forms.
- At the same time, a drop in the temperature means a drop in th e saturation vapor pressure, which depends only on temperature. So vapor pressure and saturation vap or pressure are both dropping.
- However, in adiabatic ascent, the sat uration vapor pressure drops faster th an the vapor pressure, and eventually , they become equal. And then supers aturationbecomes greater than 0, and the cloud forms.



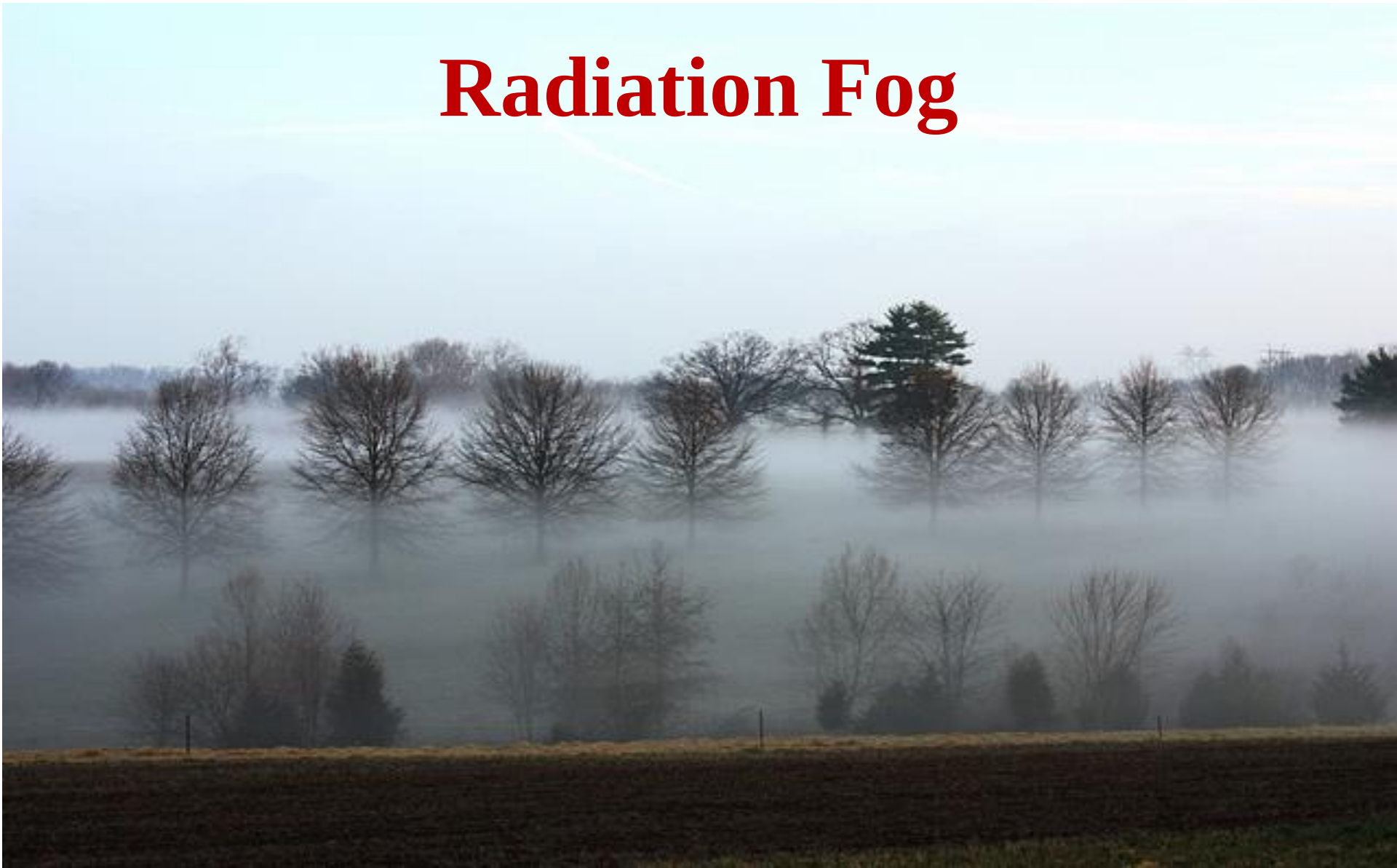
Fog : **Clouds at ground level**

Radiation fog: **Forms at night when cold ground cools the air above it (mostly in valleys and lakes)**

Advection fog: **forms when warm, moist air moves over colder surface and cools (mostly in coastal areas)**

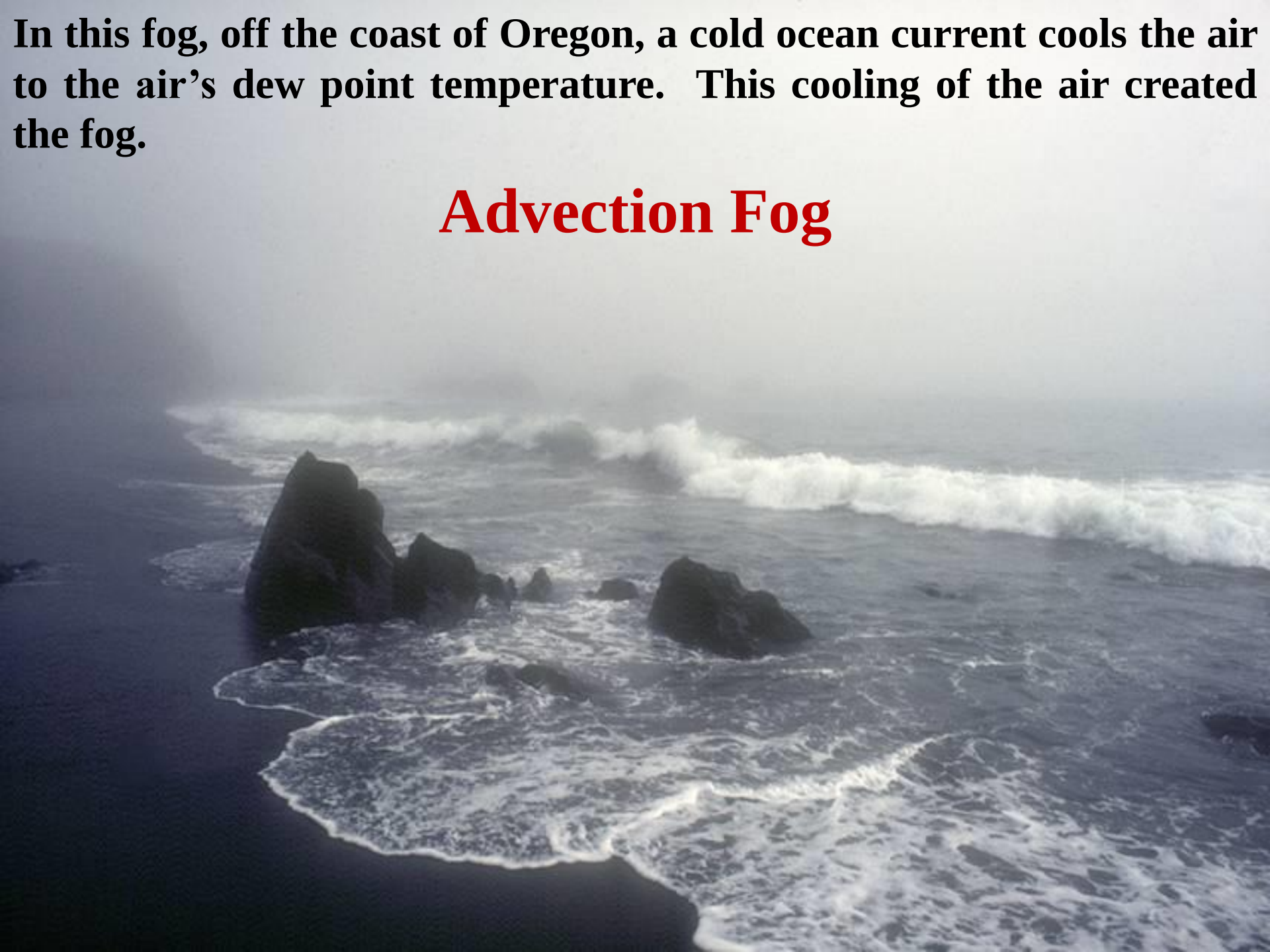
For the development of this fog, warm water is evaporating into cool air. The cool air becomes saturated (its relative humidity becomes 100%) and condensation creates the fog.

Radiation Fog



In this fog, off the coast of Oregon, a cold ocean current cools the air to the air's dew point temperature. This cooling of the air created the fog.

Advection Fog



Cloud Droplets Formation:

There are three requirements for forming a cloud drop:

Moisture & Aerosol & Cooling

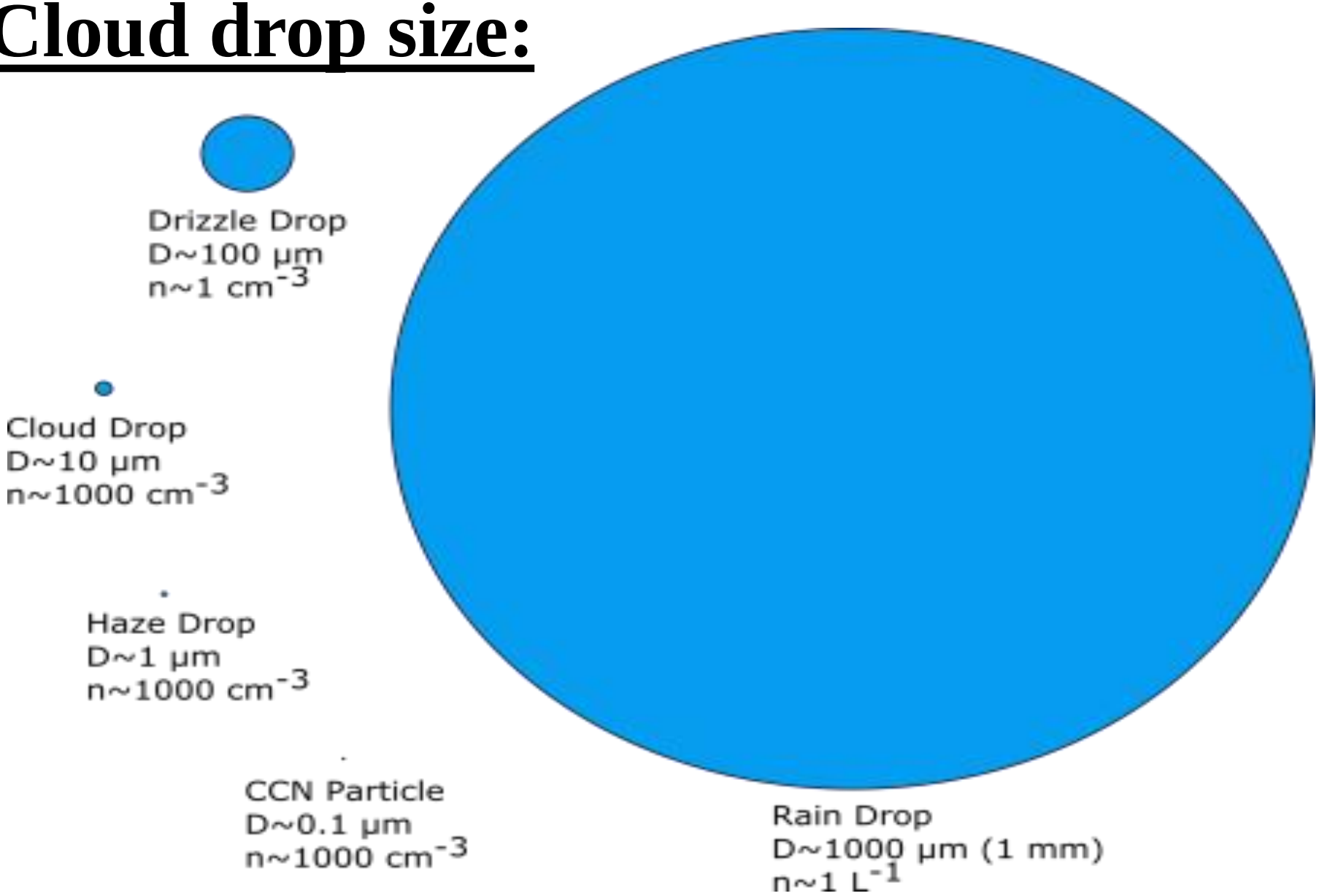
If any one of these three is missing, a cloud cannot form.

- If the air temperature cools below the dew point (RH > 100%), water vapor will tend to condense and form cloud/fog drops.
- As with dew and frost, cloud drop formation prefers to condense on a surface of some sort - we call these particles cloud condensation nuclei (CCN).
- CCN surfaces offer a locally lower saturation vapor pressure that facilitates condensation.
- The most effective CCN are water soluble.
- Without these particles clouds would not form in the atmosphere
  - RH of several hundred percent required for pure water drop formation.

Aerosol Sources :

- **Terrestrial Sources**
  - **Dust/sand/dirt particles**
  - **Smoke - volcanic, fires, and pollution (sulfates)**
  - **Pollens and spores**
- **Oceanic Sources**
  - **Sea Salts**
- **Chemical sources**
  - **Photodissociation**
  - **Heterogeneous/Homogeneous chemistry**

Cloud drop size:



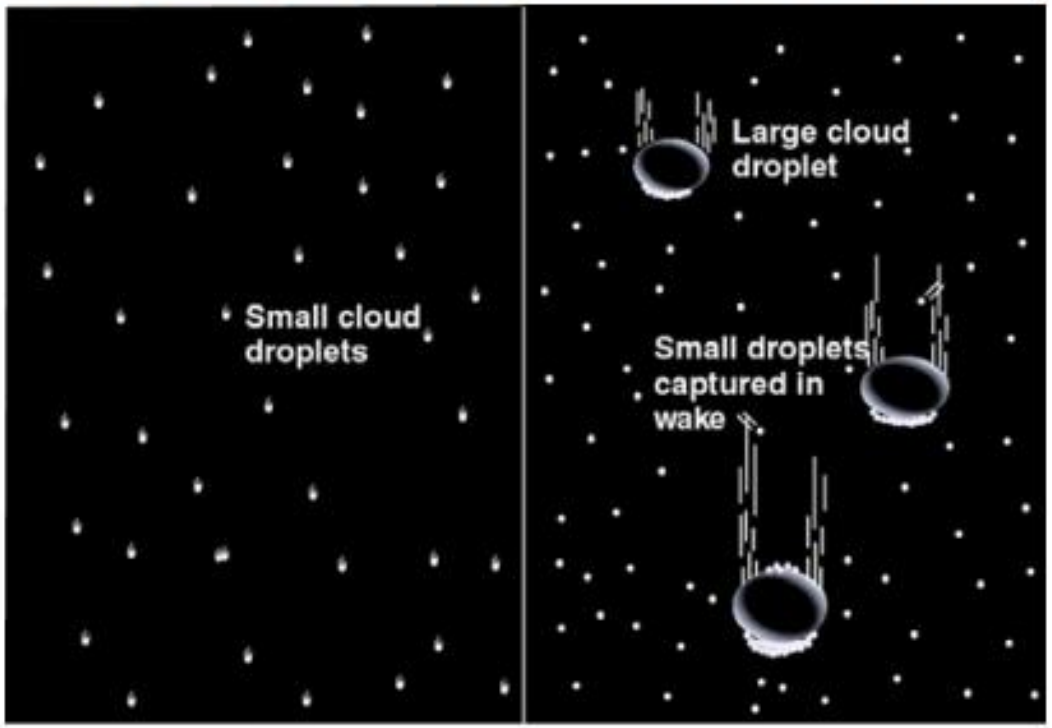
D is the diameter;
n is the number per volume of Air.

Precipitation :

- The total amount of rain received on a given area during a given time as measured by a rain gauge.
- The speed of a falling droplet increases until the air resistance equals the pull of gravity.

How rain drop fall to ground ?

Collision and Coalescence



- Exists in relatively warm clouds with tops warmer than –15°C (5°F).
- Larger drops collide with smaller ones and grow.

Factors influence the rainfall

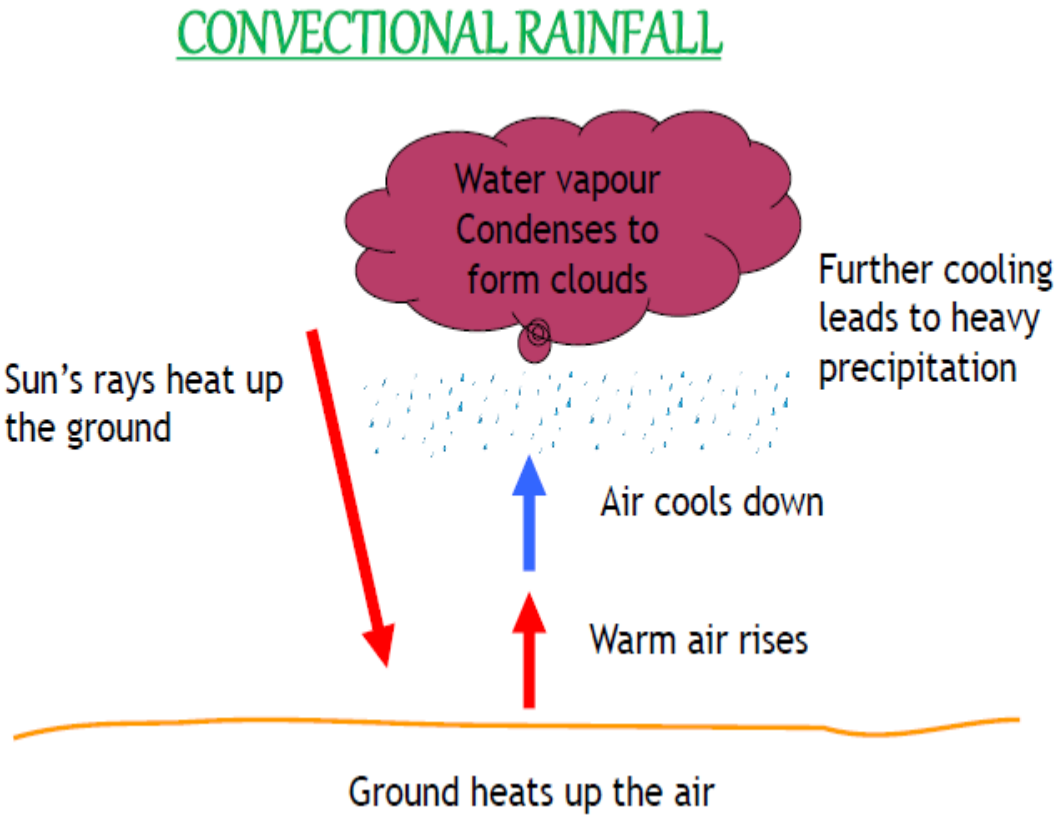
- Latitude
- Temperature
- Moisture
- Air masses
- Frontal activity
- Differential heating
- Mountain barriers
- Distribution of land and water

Types of Rainfall

1. Convectional Rainfall
2. Orographic Rainfall
3. Cyclonic or Frontal Rainfall

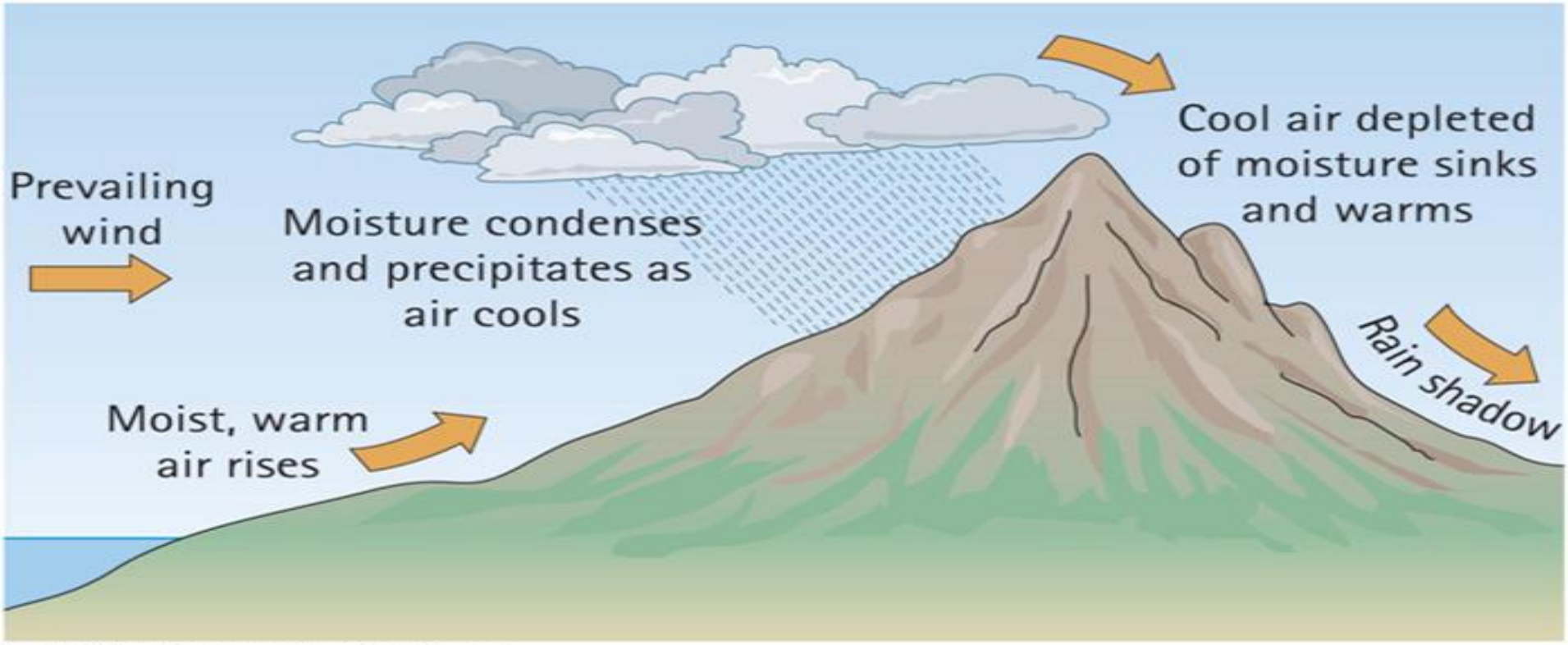
Convectional Rainfall

- Surface air heated up and rises up.
- Cools down in higher altitude.
- Fall down as rain.
- Accompanies with thunder and lightning.
- Resultant clouds are cumulonimbus type



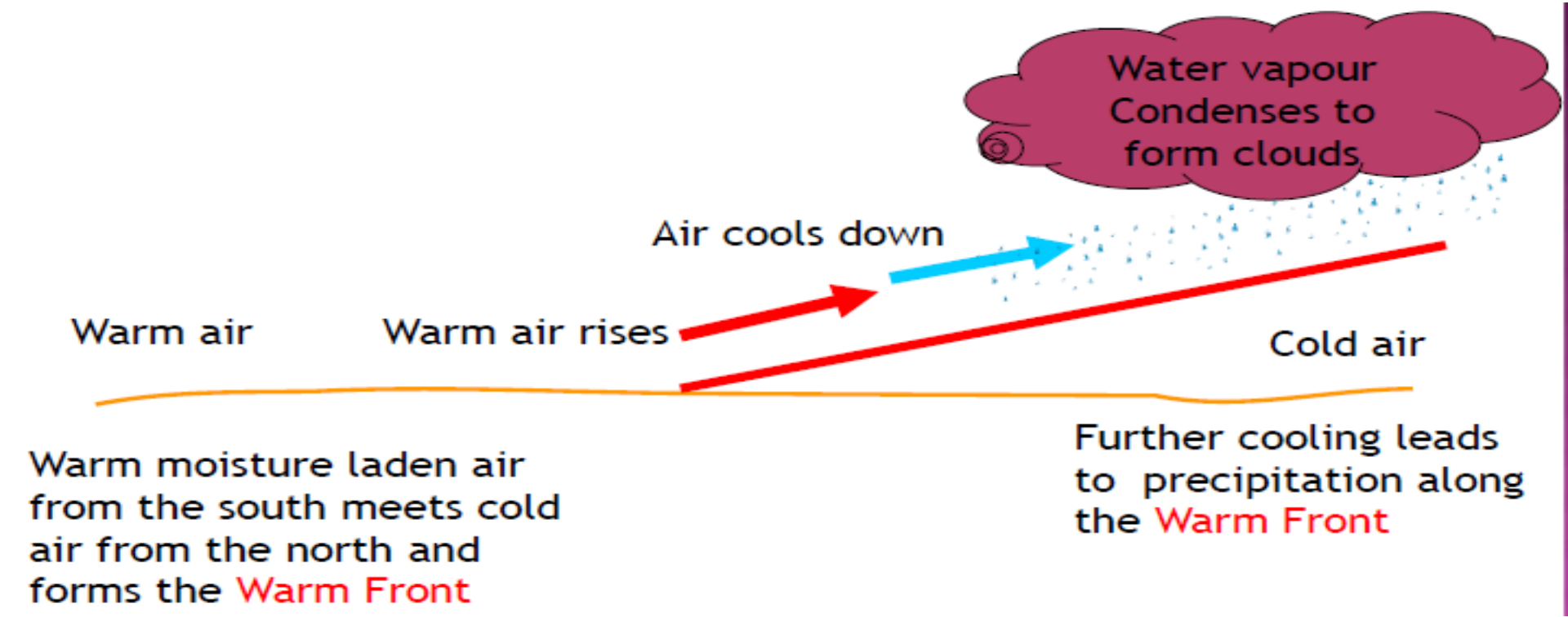
Orographic Rainfall

Orographic rainfall is rain that is produced from the lifting of moist air over a mountain. The moist air rises and cools, producing orographic clouds, which are the source of the rain. Most orographic rain falls upwind of the mountain range, with some also falling a short distance downwind. This process can produce any type of precipitation, including snow, sleet, hail or freezing drizzle.



Cyclonic or Frontal Rainfall

Frontal (or **Cyclonic**) Rain is caused by **cyclonic** activity and it occurs along the fronts of the cyclone. It is formed when two masses of air of different temperature, humidity and density meets. For example meeting of moisture laden warm tropical wind with a polar air mass. A layer separating them is called the front.



Thank you for your attention

Any Queries ?