Lecture 22
Fogs and Haze

- **Mist** – a suspension of small **water droplets or moist hygroscopic particles** that slightly obscures visibility. Mist is reported when visibility exceeds 1 km; below that limit the obscuration would be classed as fog.
- **Fog** – a visible suspension of water droplets in the atmosphere near the surface, and defined by international agreement as **reducing visibility to less than 1 km**. There is no physical distinction between fog and cloud, other than the fact that the base of clouds is above the surface of the ground.
- **Haze** is reported when visibility decreases to values from 1 to 10 km (dry haze: **relative humidity is less 100%).**

Condensation and fog

- Properties of water
- Formation of dew, frost, rime
- Types of fog
  - formation
  - clearance

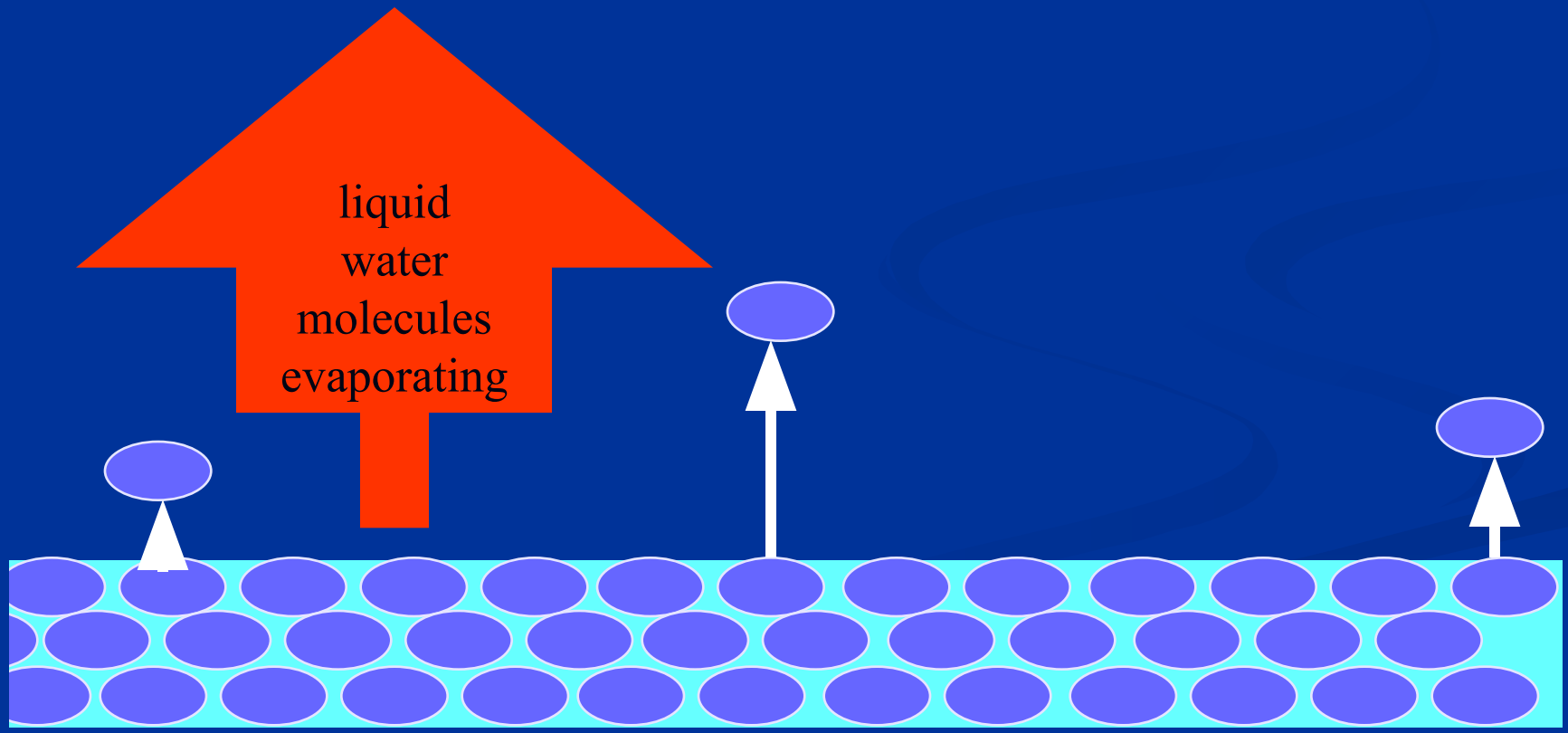
Synoptic situations

Water

- Three phases … solid, liquid, gas (vapour)
- Latent heat
  - heat absorbed or emitted to change state.
- Relative humidity
  - amount of water vapour the air holds as a percentage of amount it could hold when saturated.
- Dew-point temperature
  - temperature at which air just becomes saturated w.r.t water when cooled at constant pressure.

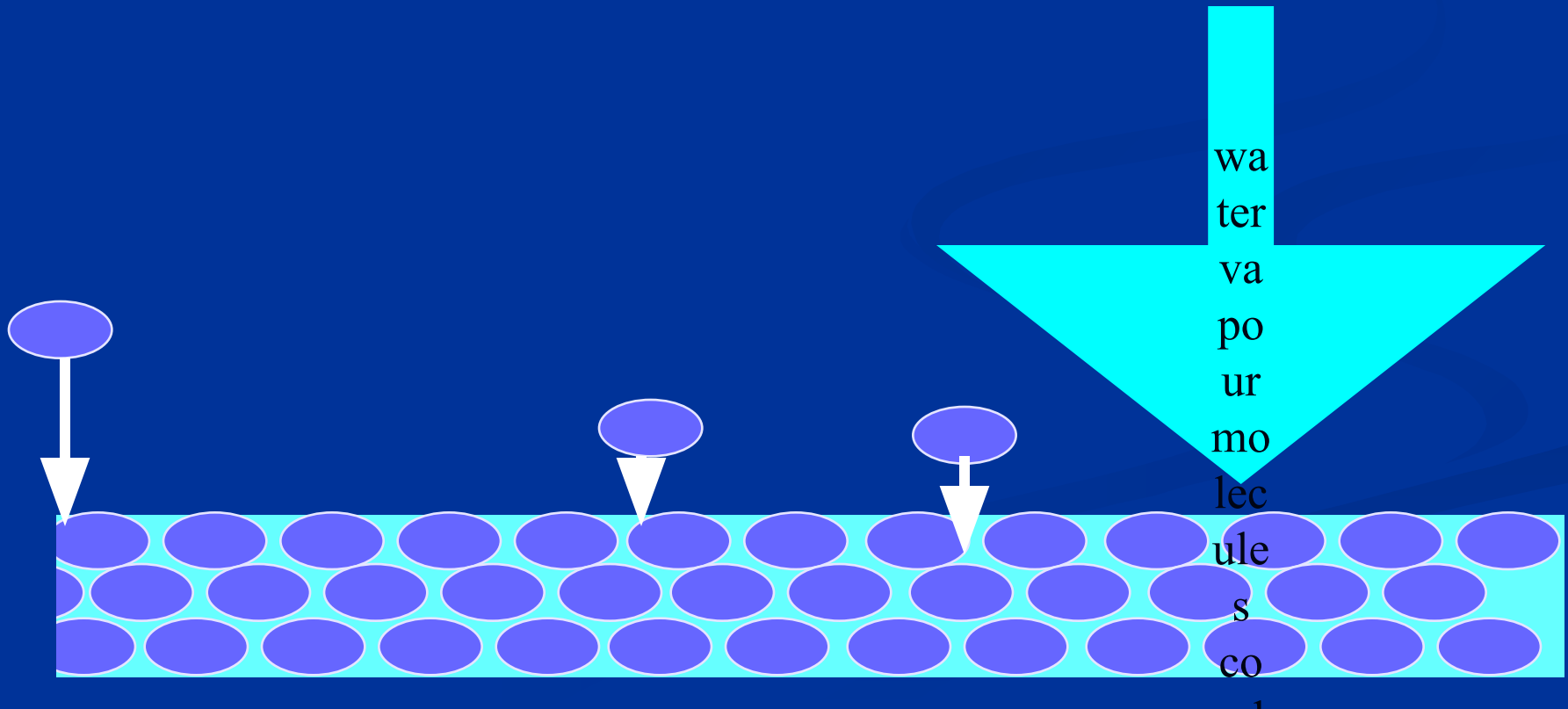
Evaporation and condensation

Evaporation = transfer of liquid water molecules to the vapour state



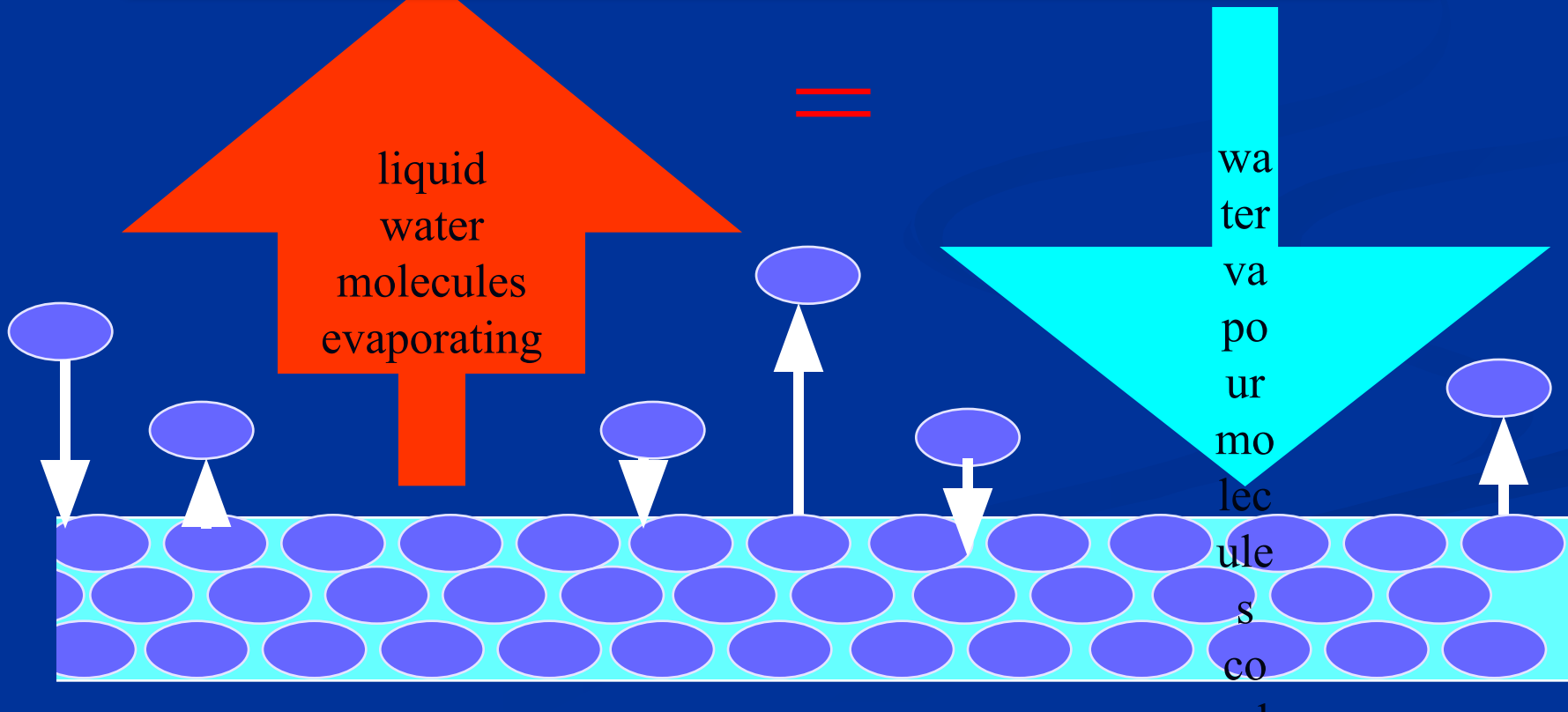
Evaporation and condensation

Condensation = transfer of water vapour molecules to the liquid state



Evaporation and condensation

Dynamic equilibrium for a plane surface of pure water occurs when ... no. of molecules transferring to vapour state = no. transferring to liquid state - Saturation



Dew

What is it?

- Condensation of water vapour onto surface whose temperature is < Td
- small water drops D < 1mm

What do you need?

- Moisture, cooling, condensation surface
- Clear skies at night (loss of long wave radiation)
- Light/calm winds to prevent mixing
- Moisture source

Dew

- Ground cools
- Air near ground is cooled to dew point
- Water condenses onto ground
- Latent heat given out during condensation
  - slows temperature fall
- Air near the ground becomes drier
  - ∴ Dew point falls
  - Temperature must fall further for condensation to continue.

For sub-zero temperatures

- Frost occurs when T < 0°C
  - ground frost for ground temp < 0°C
  - air frost for screen temp < 0°C
- Classified as slight, moderate, severe, very severe (temperature and wind)
- Ice deposits onto cooled surfaces are hoar frost (terminology: deposition/sublimation)

Hoar frost or rime?

- Super cooled droplets required
- Deposits of ice when drops meet a sub-zero surface.
- Rime builds up on windward sides of objects (fence posts).

Fog

What is it?

A suspension of microscopic water droplets in the air reducing visibility at the earth's surface to:

< 1000m for met. observations, aviation and shipping.

< 200m for public service purposes

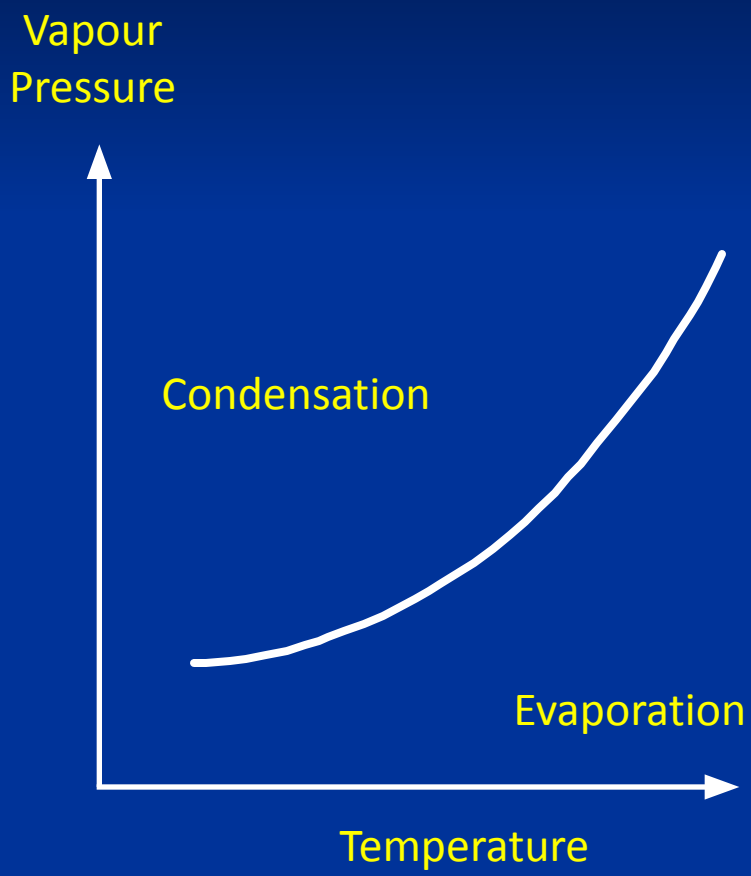
Fog

- Freezing fog
  - Super-cooled fog drops which freeze on impact with a surface
- Ice fog
  - Tiny suspended ice particles
  - Usually requires T= -30°C
  - Very rare in the UK but often in Siberia!

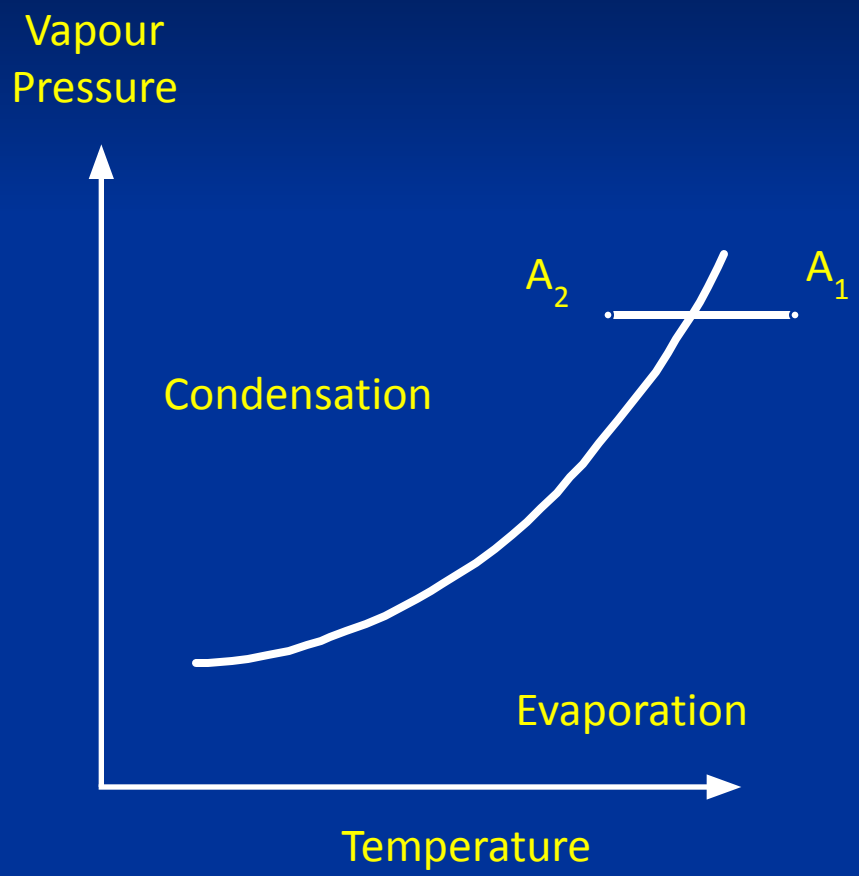
Why does fog form?

- Water vapour condenses onto atmospheric particles.
- For condensation we need saturation.
- How do we turn unsaturated air into saturated air?

There are 3 ways

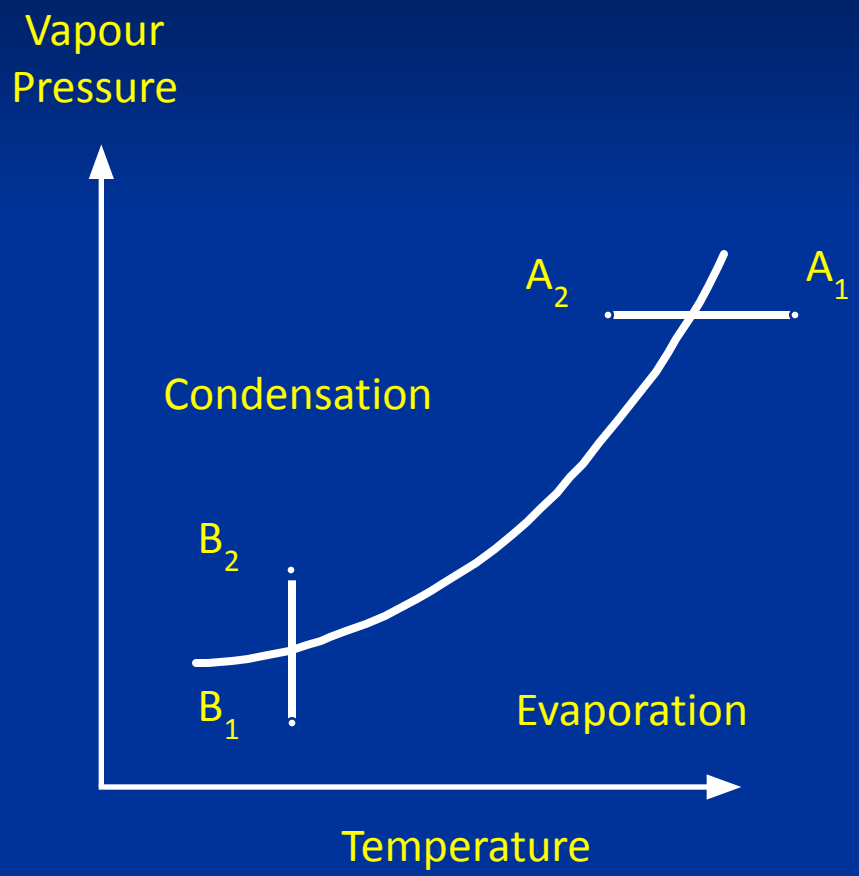


There are 3 ways



(1) Cool air to dew-point

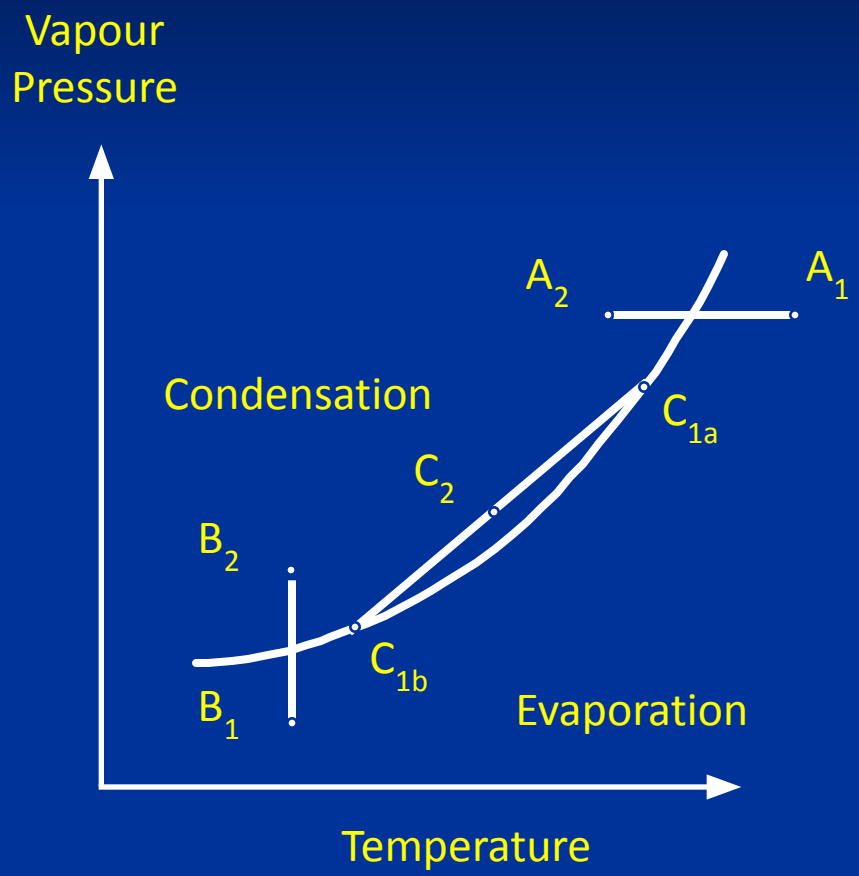
There are 3 ways



(1) Cool air to dewpoint

(2) Add water vapour

There are 3 ways



(1) Cool air to dewpoint

(2) Add water vapour

(3) Mix moist parcels at different temperatures

Fog Classification

There are four main types:

- Radiation - cooling of ground by radiation
- Advection - (warm advection) cooling of air by conduction
- Upslope - cooling of air by adiabatic expansion
- Frontal - increasing moisture by evaporation

Also:

- Steam - (cold advection) increasing moisture by evaporation

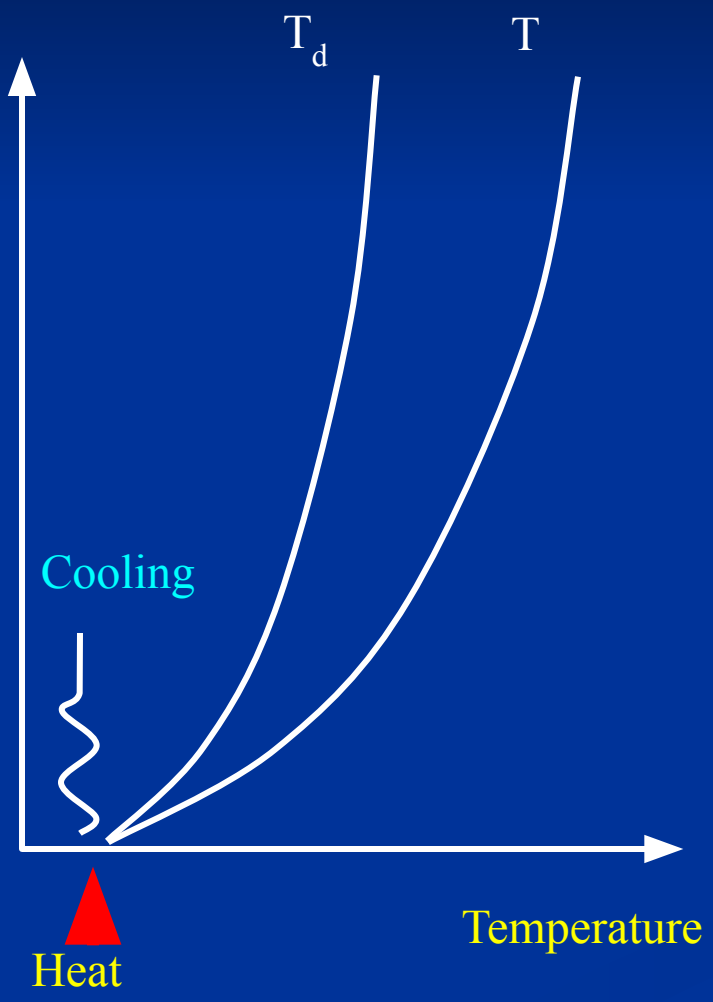
1. Radiation fog

Favourable conditions

- Clear sky or thin, high cloud
- Moist air in lowest 100m
- Moist ground
- Light surface wind
- Favourable local topography

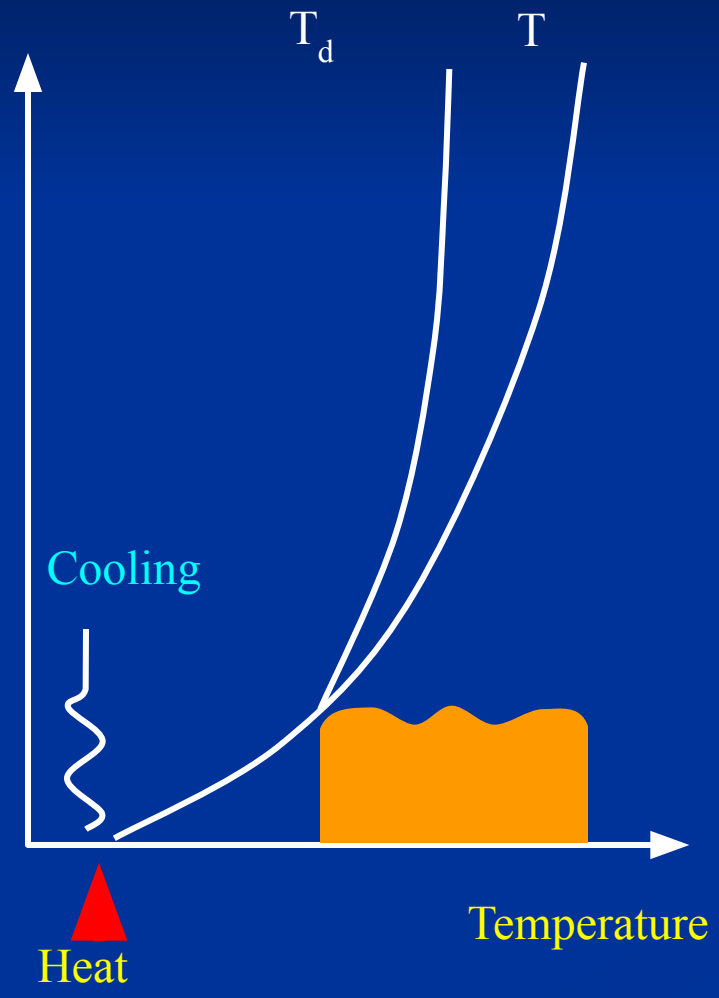
When are these conditions likely?

Stage 1. Dew deposition



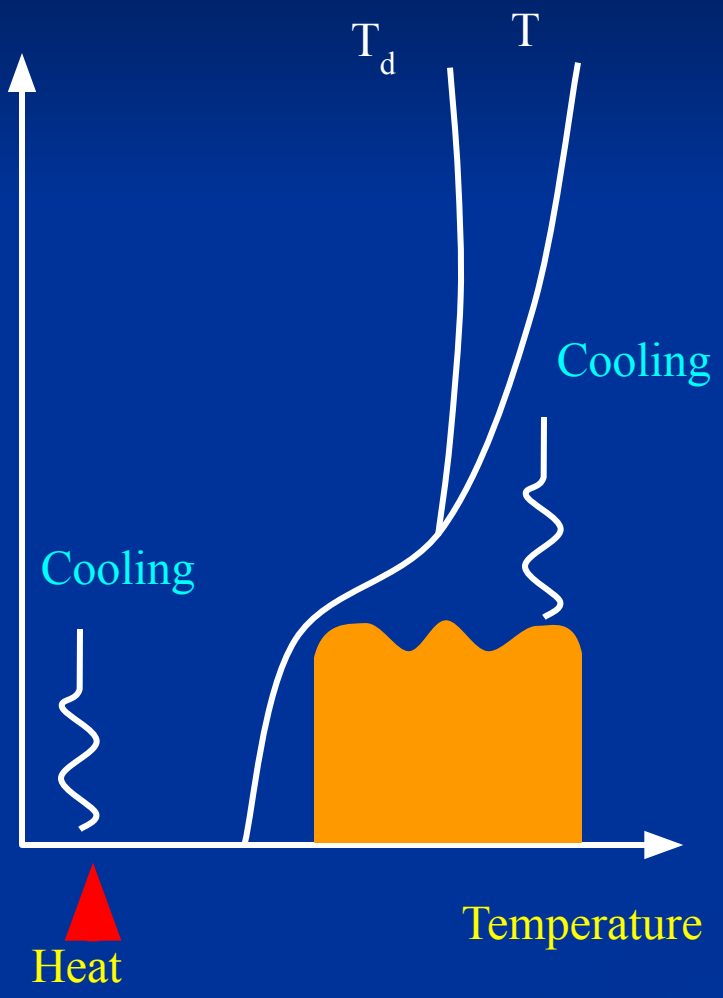
- Clear night, strong radiative cooling
- Light winds
- Rapid fall in surface temperature
- Cools to dew point
- Dew deposition
- Air dries, dew point falls but … mixing maintains condensation

Initial formation



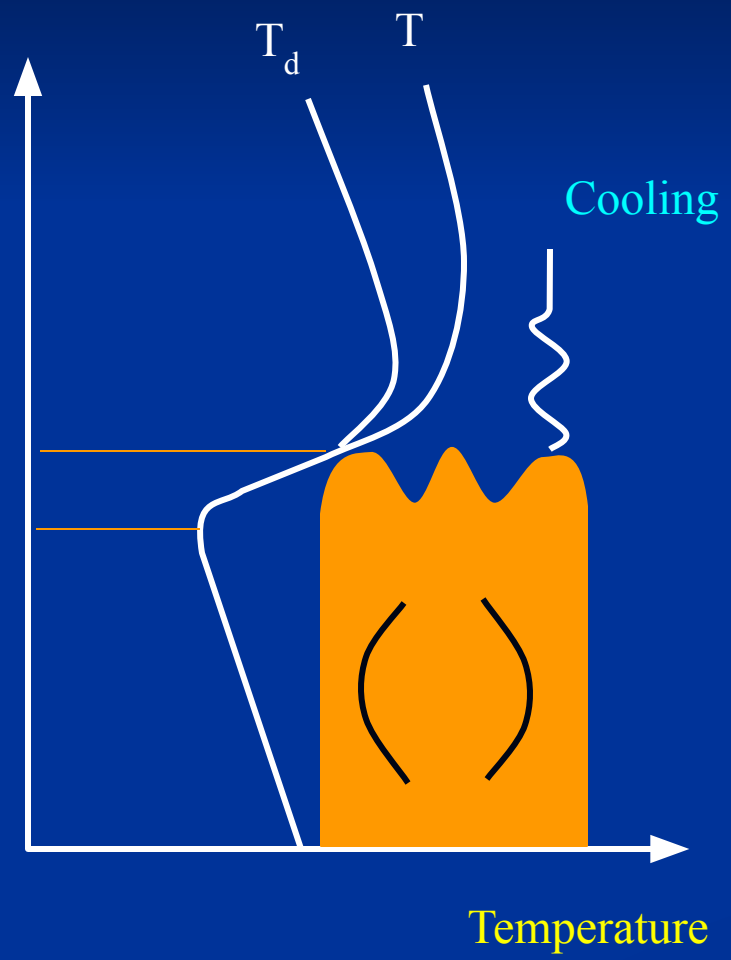
- Surface cooling
- 2 metre wind < 1kn
- Air becomes saturated
- Shallow fog forms

Stage 3. Mature fog - sky visible



- Sky visible so radiative cooling continues
- Temperature falls, fog thickens
- Fog now alters radiation balance
- Restricts surface cooling
- Soil heat flux also significant

Stage 4. Mature fog - sky obscured



- Sky obscured
- Surface cooling stops
- Fog top becomes radiating surface.
- Fog deepens due to radiative cooling from top.

Additional processes…

- Advective Effects
  - Fog upwind
  - Air mass change
  - Upslope motion
- Lowering of stratus to the ground

- Sunrise
  - Turbulence
  - Dew evaporating
- Pollution
  - Smog

Clearance mechanisms

- Solar radiation – raises air temperature above dew point.
- Increase in gradient wind – turbulence
- Advection of cloud over the fog – radiation warms the fog top (most efficient method)
- Advection of drier air – lowers surface dew point

2. Advection Fog

Warm advection fog:

- Warm moist air moving over cold land or sea.
- Cooling to dew point from below.
- Mostly sea fog
- Over land, stratus

Cold advection fog:

- Cold air moving over warm water.
- Moisture evaporates then condenses again.
- Arctic Sea Smoke.

3. Upslope fog

Formed by

- Warm, moist air forced to rise over hills.
- Air cools adiabatically on ascent
- Very common in western and northern Britain
- Tropical maritime airmass

4. Frontal fog

Formed by:

- Ahead of warm front … rain from warm air falling into very cold, stable air.
- Rain evaporates
- Layer eventually becomes saturated and fog develops
- Often produces stratus not fog.

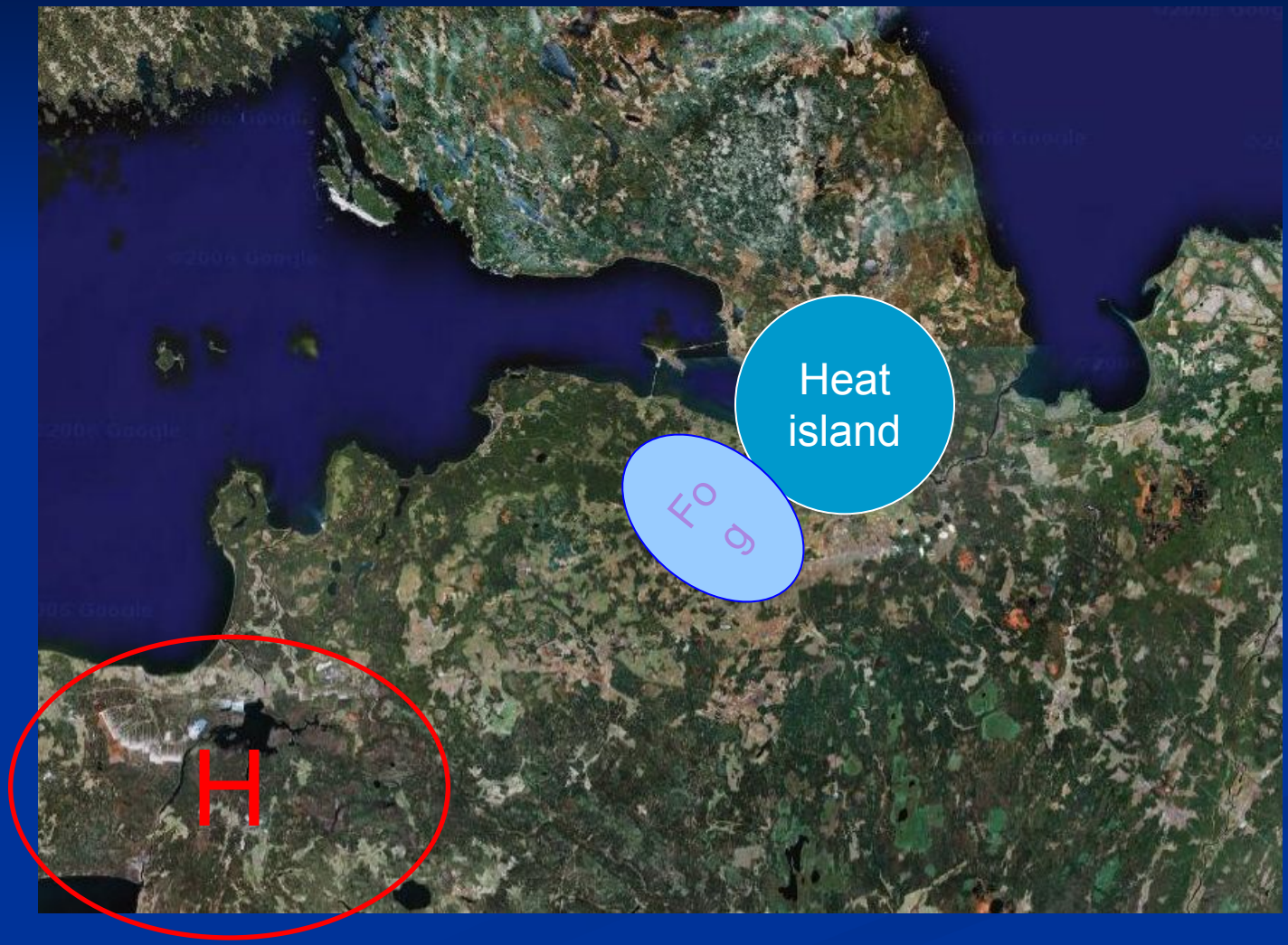
How do you clear it?

Examples

A more concrete example

- *St. Petersburg, end of October–beginning of November.*
- *Here lakes, rivers, and swamps that make the air to be very humid cover for a large area.*
- *A huge anticyclone occupies almost whole Europe. Its center is found to SW from St. Petersburg. Short days and long nights make the air mass colder and colder from day to day.*
- *Cold and stable air mass and clear sky at nighttime plus very humid air (due to local condition) facilitates formation of a **fog**. However, within the town "warm island" (here the air temperature is about 2^0 C higher) no fog may appear, while over colder suburbs the fog forms.*
- *As result, over airport Pulkovo the fog can be formed, over St. Petersburg cannot. That is the local weather.*

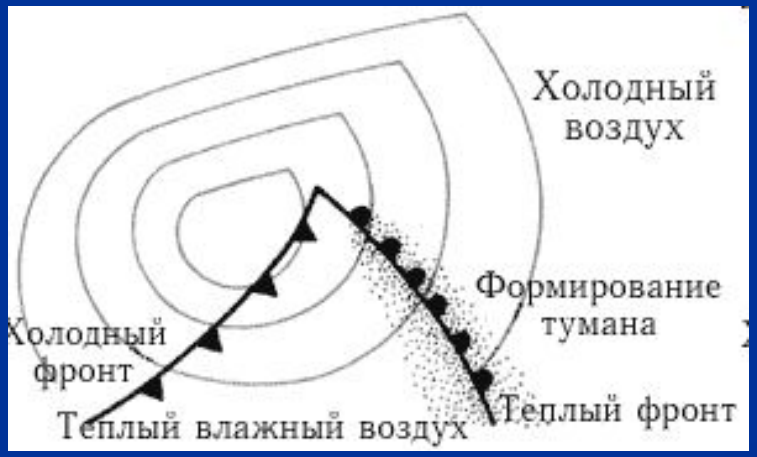
A more concrete example



Types of fogs.

Radiation fog

Advection fog



Mixing fog

Evaporation fog

Could you name more fog types?

- Upslope Fog
- Ice Fog
- Freezing Fog

Weather Sayings

- It's raining cats and dogs.
- Clear moon frost soon
- When ants scatter everywhere, the weather is going to be hot.