

MODULE 3.1C

DIAGNOSIS

Fog Formation and Dissipation

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INTRODUCTION

Fog and stratus clouds are formed in the lowest levels of the atmosphere when certain synoptic situations are present.

Conditions favourable and unfavourable for the formation of these weather elements are given in this document. The physical processes leading to the formation and dissipation of fog and stratus are explained. The effects of local topography on these processes are highlighted.

The material presented is necessary knowledge for accurate analysis and diagnosis and timely forecasting of fog and stratus. These elements are critical to the social, economic and recreational activities of any major city. Airports may be closed, social and sporting events may be cancelled, low visibilities may cause hazardous driving conditions, mountain passes may be inaccessible; all these events affect thousands of users. Fog-related problems are not confined to land. Even with sophisticated electronic equipment, dense fog in the open sea hampers navigation. With fog-related problems such as these, it is no wonder that it is of primary interest to understand the formation processes and the dissipation processes and recognize the synoptic and mesoscale characteristics of the different types of fog in order to analyse, diagnose and forecast these events.

Knowledge of this document will aid in attaining the goals of terminal objective 3.1.2.

FOG

Definition : A hydrometeor consisting of a visible aggregate of minute water droplets or ice crystals, or both, suspended in the boundary layer near the earth's surface. According to international definition, fog reduces visibility below one kilometre (5/8 mile or 0.62 mile). If the visibility is better than 5/8 mile it is called mist, even though most of the physical processes involved in its formation are very similar to fog (except that it is less dense).

Fog differs from cloud only in that the base of fog is at the earth's surface while clouds are above the surface. When composed of ice crystals, it is termed ice fog. Fog is like a stratiform cloud that touches the earth's surface.

The most important tools in dealing with fog are:

- a) a thorough understanding of the various physical processes that can produce the different types of fog;
- b) an understanding that most fogs are formed by a combination of physical processes and that they dissipate as the processes of formation weaken or are counteracted;

- c) local personal experience with a particular location;
- d) insights into fog dissipation.

Formation of Fog

To produce fog, it is necessary to create saturation or nearly so, and either condensation (fog) or sublimation (ice fog). The saturation occurs because the capacity of air to hold water vapour is temperature dependent. When saturation is reached or nearly reached water vapour generally condenses because of additional cooling and the presence of condensation nuclei. The process depends on the number and type of condensation nuclei present. Some hygroscopic nuclei have an affinity for water as they are composed of water soluble substances and can initiate condensation at relative humidities as low as 70-75%. In general however, fog seldom forms when the temperature-dew point spread is greater than 2°C.

Basically, there are two ways in which fog forms (fog being defined in simplistic terms as a cloud on the ground):

- a) Cooling of air to its dew point: Cooling the air temperature T until T_d is reached to produce saturation, or when the saturation mixing ratio r_s is decreased to reach the mixing ratio r . The process of cooling the air produces advection fog, radiation fog and upslope fog.
- b) Addition of water vapour to the air: Increasing the water vapour content of the air T_d until T is reached or when r is increased to reach r_s to produce saturation. The process of adding moisture produces steam fog, and frontal fogs.

Fog is often formed by a combination of these mechanisms, although one mechanism may dominate. Once fog forms it is maintained by new fog droplets, which constantly form on available nuclei. In other words, the air must maintain its degree of saturation either by continual cooling or by evaporation and mixing of vapour into the air.

As a general rule, fog tends to be thicker and produce greater restriction to visibilities near “industrial” centres (i.e., urban areas) due to higher concentrations of condensation nuclei, the input of low level moisture, and pollution. City air, with its abundant nuclei, produces many tiny fog droplets, which greatly increase the opacity of the fog. This is not to say urban areas cause a greater number of fog events, however when fogs do form they form more quickly, last longer and the pollution makes them seem “dirtier”. Moreover, fog that forms in polluted air can turn acidic as the tiny liquid droplets combine with gaseous impurities, such as oxides of sulphur and nitrogen. Acid fog poses a threat to human health, especially to people with respiratory problems.

Types of Fog

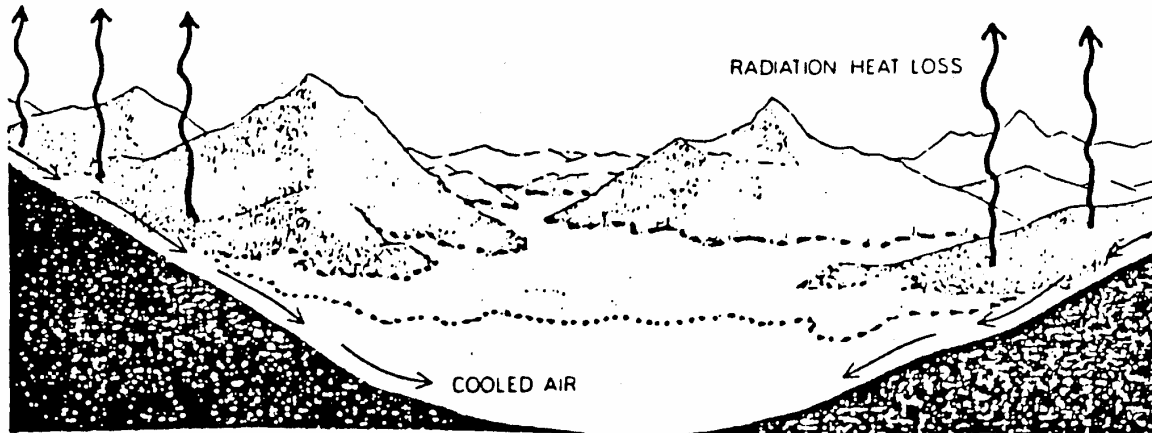


Figure 1. Radiation fog.

1) RADIATION FOG

Figure 1 above indicates how a radiation fog, one of three kinds of ‘cooling fog’, forms. Night cooling reduces the air temperature and causes water droplets to appear. The cold, fog-filled air drains downhill and accumulates in low-lying areas.

Terminology: Ground Fog, Low Fog, Valley Fog, High Inversion Fog, Shallow Fog, Mist

Formation process:

There are two physical processes of cooling involved in the formation of radiation fog: radiation and conduction. At night there is no solar radiation, allowing the air to cool as long wave radiation is emitted skyward. Also, the temperature of the stagnant air in contact with the cooling ground is decreased by conduction. Since the air is a poor heat conductor, the air nearest the ground will cool more than the air above it, and a surface inversion will form which inhibits mixing and favours the formation of fog.

Radiation fogs form upward from the ground as the night progresses and are usually deepest around sunrise. However, fog may occasionally form after sunrise, especially when evaporation and mixing take place near the surface. This usually occurs at the end of a clear, calm night as radiational cooling brings the air temperature close to the dew point in a rather shallow layer near the ground. At the surface, the air becomes saturated, forming a thick blanket of dew on the grass. At day break, the sun’s rays evaporate the dew, adding water vapour to the air. A light breeze then stirs the moist air with the drier air above, causing saturation and hence the fog.

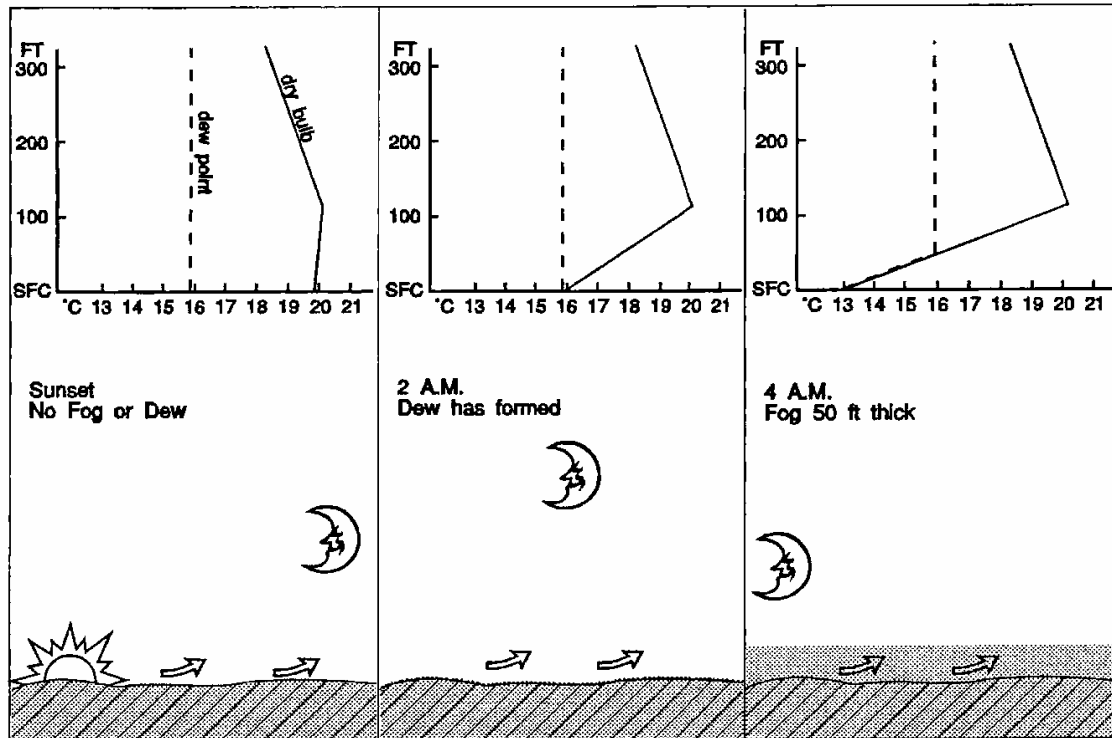


Figure 2. Typical radiation fog formation under: 1. Clear skies at night. 2. Sufficient moisture. 3. Light winds

Favourable Conditions of Formation :

- I. clear skies: to optimise the earth radiation cooling process, the longer the night, the longer the time of cooling and the greater the likelihood of fog. Hence, radiation fogs are most common over land in late fall and winter.
- II. small dew point depression at sunset ($T - T_d$): less cooling is required to form the fog.
- III. light winds, < 10 knots, or slight turbulence: slight air movement brings more of the moist air in direct contact with the cold ground in order to distribute the cooling effect more rapidly through a deep enough layer.
- IV. mixing ratio value increases with height ($dr/dz > 0$) : for dense persistent fog.
- V. wet surface : less cooling is required to form the fog.
- VI. local topography: valley or low spot with cold air drainage favouring the cooling of the air. Because colder air drains downhill and collects in valley bottoms, we normally see radiation fog forming in low lying areas. Hence, radiation fog is often called *valley fog*.
- VII. Condensation nuclei : the more the better for favouring the condensation phase.

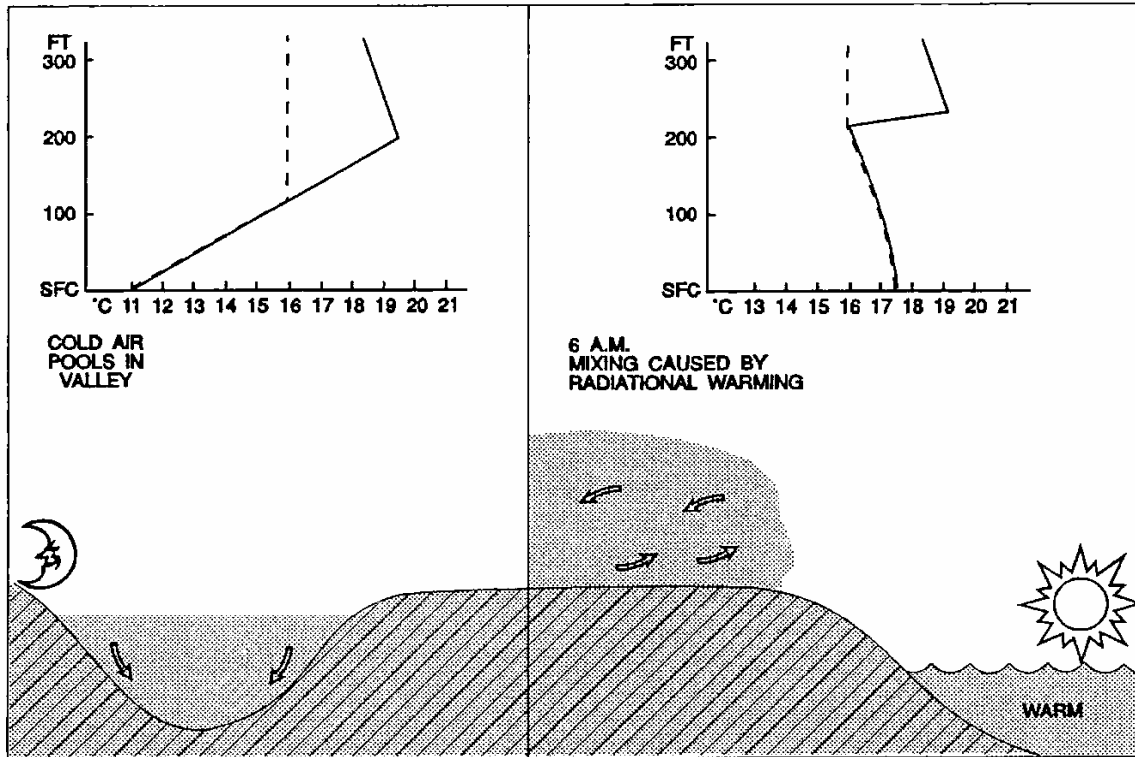


Figure 3. Favourable conditions for radiation fog: 1. Low lying area(left) 2. Soon after sunrise(right) with small turbulent mixing.

Unfavourable Conditions :

- I. strong winds (> 10 kts): diffuse the water vapour available by mixing the moist air near the surface with drier air above, and may lift the fog to form stratus cloud.
- II. cloudy skies: limit the radiational cooling of the earth.
- III. large dew point depression : this could require too much cooling for what is possible at night to allow the fog to form.
- IV. no wind in lowest few feet: promotes formation of dew.

Characteristics and synoptic conditions:

- I. Stable air: inversion
- II. Can form or thicken at sunrise: the mixing caused by the heating of the air stirs up the moisture with cold air near the ground.
- III. Drains to low laying areas : cold air is more dense
- IV. Usually burns off during the morning: as the incoming solar radiation exceeds the lost of earth radiation r_s increases while r remains the same
- V. More common in high pressure areas: light winds and clear skies prevail in these areas.
- VI. Can be initiated by aircraft: due to the release of nuclei and water vapour in their exhaust.
- VII. Since radiation fog normally forms in lowland, hills may be clear all day long, while adjacent valleys are fogged in.

VIII. More radiation fog in fall and spring than in winter due to smaller supersaturation requirements.

IX. Frequent in maritime areas in fall.

X. When a high pressure system fog moves slowly over an area, radiation fog may form on many consecutive days.

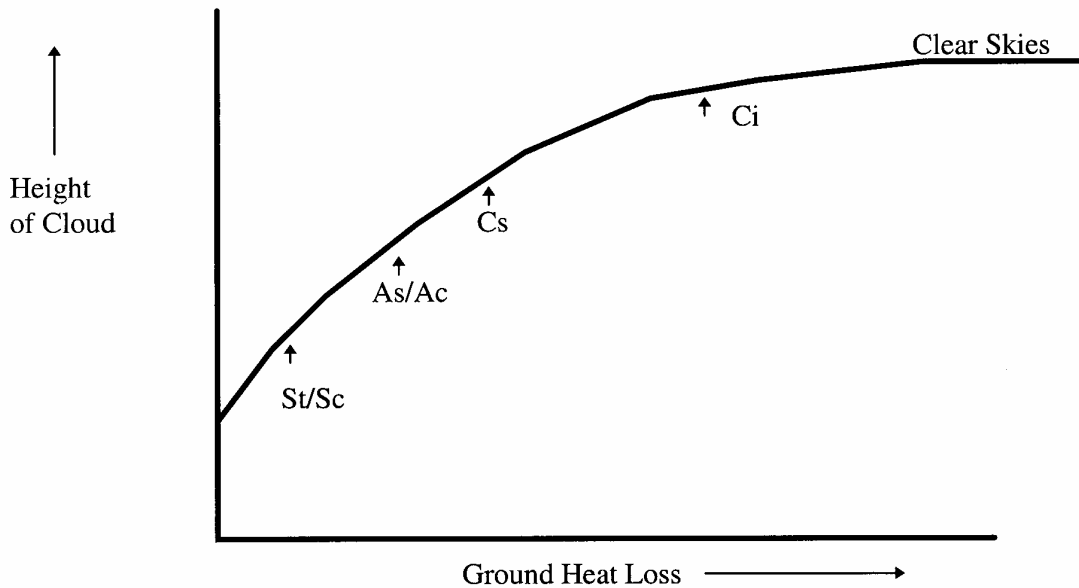


Figure 4. Heat Loss at the ground for various cloud types

Dissipation of Radiation Fog

- I. solar heating (“burning off”) causing turbulent mixing and mixing with drier air. Usually dissipates under clear skies 3-4 hours after sunrise.
- II. Strong winds give turbulent mixing
- III. Note: Over a snow surface if $T_{\text{AIR}} < 0^{\circ}\text{C}$ then air must become supersaturated with respect to frost point for ice fog formation.

2) ADVECTION FOG

Terminology: Advection Fog or Sea Fog.

Formation process:

Advection fog forms as a result of advective cooling. As warm moist air is advected over a cold surface, it cools through conduction as it is giving its heat to the cold surface. The cooling of the air to its dew point (T_d) causes saturation. The presence of nuclei along with further cooling will produce condensation and therefore the fog forms. This cold surface could be cold water, a cold ground or an area covered with snow or ice. The surface must be sufficiently cooler than the air above so that the transfer of heat from air to surface can reduce the air temperature to the dew point temperature.

Favourable Conditions of formation:

- I. high relative humidity: if the air is moist it requires less cooling
- II. stable stratification in lower atmosphere: warm air over a cold surface
- III. moderate winds (i.e., 8-17 knots: the fog will be less dense with lighter winds and stronger winds will produce stratocumulus.
- IV. $T_{\text{AIR}} - T_{\text{SFC}} = \text{large}$ i.e. the air is warm: this will optimize the advective cooling.
- V. large horizontal temperature gradient: this will favour the air mass contrast and the moderate winds.
- VI. in the lowest levels $dT/dz < 0$: thus providing moisture flux
- VII. cold surface could be: land, snow, ice or cold sea or lake

Characteristics and synoptic situation:

- I. Will persist until air mass or wind direction changes: a new wind direction may bring dryer air or may not push the warm moist air over the cold area anymore.
- II. May be stopped by land barriers: wind barrier effect.
- III. May thin as ground heats: as the temperature increases r_s will increase and RH will decrease. Advection fogs prevail where two ocean currents with different temperatures flow next to one another. Such is the case in the Atlantic Ocean off the coast of Newfoundland, where the cold southward-flowing Labrador Current lies almost parallel to the warm northward-flowing Gulf Stream. Warm southerly air moving over the cold water produces fog in that region.
- IV. Warm air over cold open arctic lands in summer.
- V. Spring: warm air over cold (Great) Lakes.
- VI. winter: mild air moving northward over snow cover or ground with frost.
- VII. in case of sea fog: tends to drift onshore, and, if land warm, the resultant turbulent and convective motion will dissipate fog or produce stratus cloud. At night, the cooling of the land surface may well lead to the spread of fog far inland from the coast.

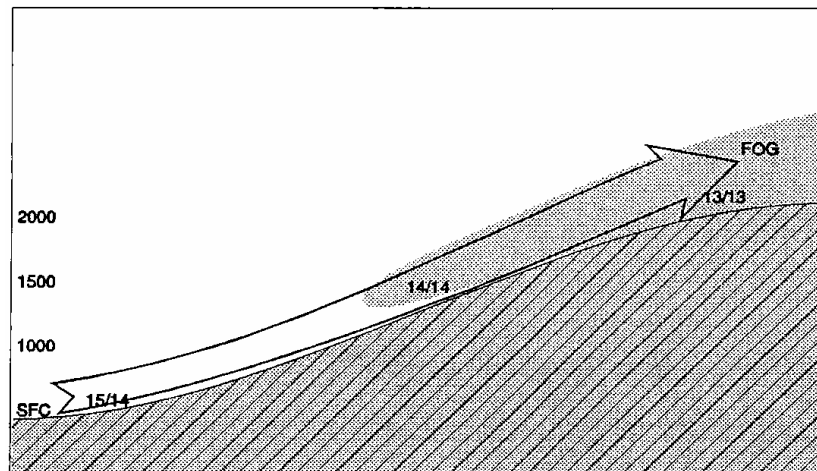
3) UPSLOPE FOG

Figure 5. Upslope fog and stratusFormation process:

Upslope fog forms as a result of adiabatic cooling by expansion of the air as it rises along a slope. Winds produce the initial motion upward along the slope. The cooling of the air to its dew point causes saturation. The presence of nuclei with more cooling will produce the condensation leading to the fog. Basically, this fog is a cloud that touches the ground or more precisely, the ground rises to touch the cloud.

Favourable conditions of formation:

- I. Hilly terrain, elevated plain, hill, mountain or sloping ground : so that the adiabatic cooling can take place as the air is forced to rise.
- II. Upslope or onshore winds: the fog will be less dense with lighter winds and stronger winds will produce more mixing near the ground so that it may form some stratus or stratocumulus. The strength of the winds is important but its effect is dependant on several factors such as the slope itself, the R.H available, the roughness of the terrain, etc. Sometimes dense fog can form with strong winds (Cheyene type fog in Colorado) if air saturated through a deep layer.
- III. High relative humidity (small T-T_d): requires less cooling.
- IV. Increase of moisture with height.
- V. Stable air mass

Characteristics or synoptic situation:

- I. Persist until air mass or wind direction changes.
- II. Dissipates on leeward side due to subsidence.
- III. Height of the slope is an important factor so that T_d decreases by about 2 degrees per 1000m.
- IV. Frequently observed in easterly flow across prairies (YWG to YEG) and in moist flow off Atlantic to Appalachians;
- V. It is closely related to local topography.

Dissipation:

Change of wind direction or mixing with drier air.

4) FRONTAL FOG : prefrontal (warm front) and post frontal (cold front)

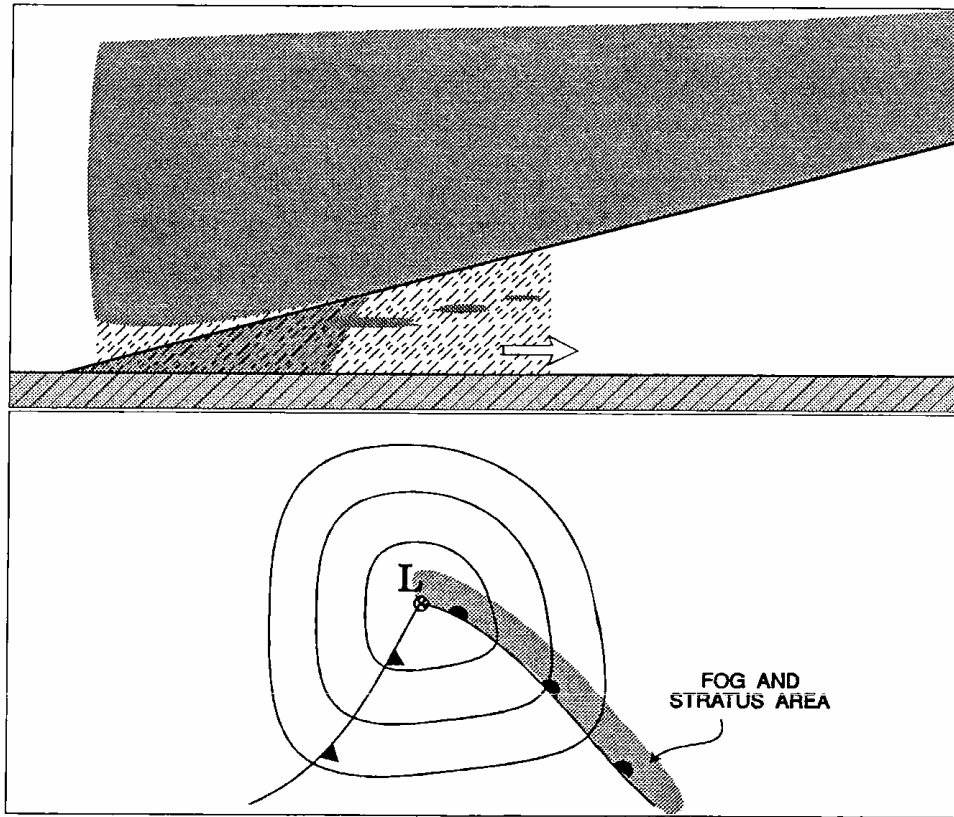


Figure 6. Precipitation fog and stratus associated with a warm front.

Formation process:

Prefrontal fog/warm front: Fog in advance of a warm front, caused mainly by the increase of moisture in the underlying cold air resulting from the evaporation of pre-frontal rain.

Relatively warm rain falls through a cold layer. This cold layer is nearly saturated. The mixing ratio (r) of the cold air increases as precipitation evaporates as it falls within this colder air. Consider the above sounding which is typical for a warm front. Suppose rain begins falling from cloud based at the top of the inversion. The raindrops have a temperature T_R . Note that the rain remains warmer than the surrounding air all the way down to the surface. Consequently, the cloud base will gradually build down to the surface, as the warm rain evaporates it initiates saturation, then condensation forms throughout the entire layer of colder air. Usually the formation of stratus fractus forming in the precipitation ahead of the warm front is a precursor sign for the occurrence of prefrontal fog.

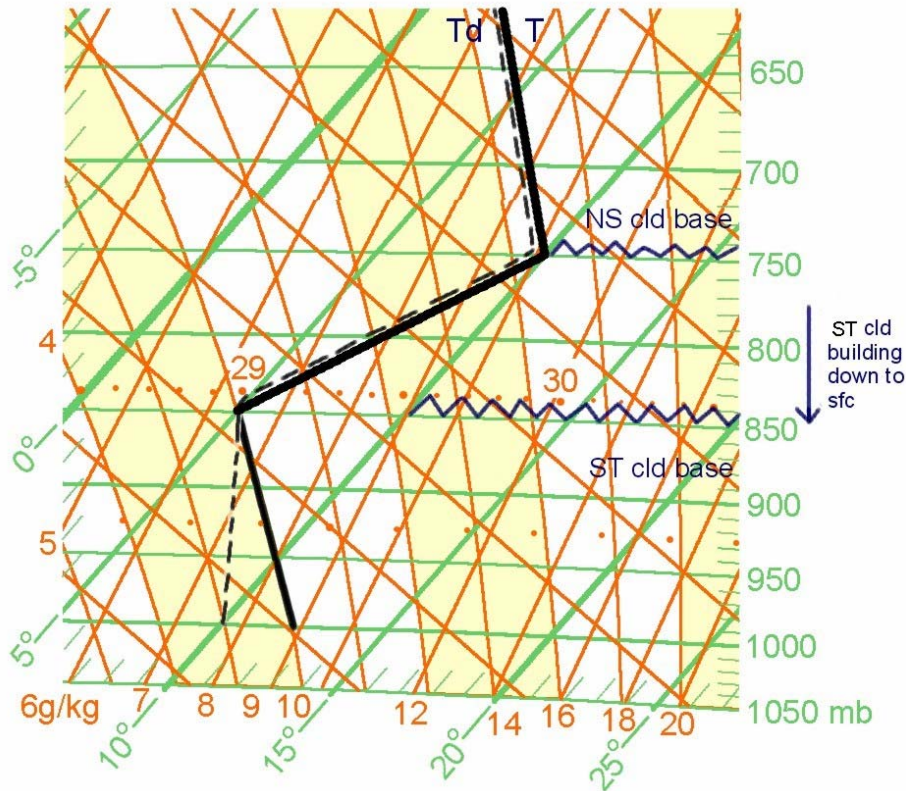


Figure 7. Typical warm front sounding.

Post frontal fog /cold front: Often it is the result of precipitation falling into cold stable air, raising the dew point temperature. It will form especially if the winds are light. This is also seen as a type of radiational fog which occurs over wet ground after the passage of a cold front.

Forecasting hint: Expect warm frontal fog when the temperatures ahead of the front are lower than the dew points behind the front.

Characteristics and synoptic situation:

- I. Prefrontal fog is associated with a nimbostratus that will produce rain for a few hours and the base of the nimbostratus will lower to the ground to form the fog as the warm front is approaching and it clears after the passage of the front .
- II. Status fractus is formed by the same process as the prefrontal fog.
- III. Prefrontal fog is often observed with drizzle.

5) STEAM FOG

Terminology: Steam Fog or Arctic Sea Smoke

Formation process: forms as a result of evaporation. Steam fog occurs when cold air flows over much warmer water. As the warm water evaporates, it increases the water vapour content of the air above it. At the same time the water heats the air but the mixing

ratio (r) increases more rapidly than the saturation mixing ratio (r_s), thus resulting in a state of supersaturation and condensation.

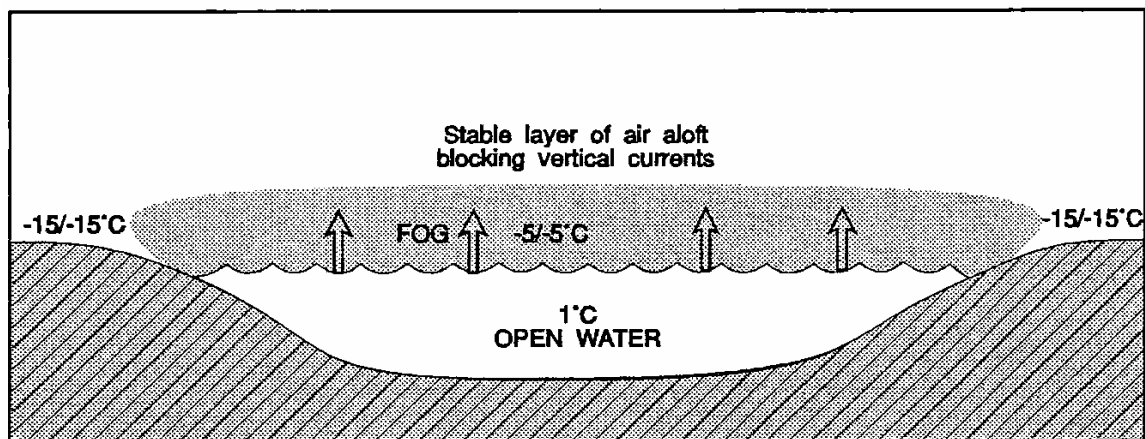


Figure 8. Steam fog/Arctic sea smoke

Favourable conditions:

- I. early in the morning : favourable temperature of water vs temperature of air
- II. in autumn : favourable temperature of water vs temperature of air
- III. light winds : stronger winds will dissipate the water vapour concentration
- IV. high relative humidity : it requires less evaporation
- V. high concentration of condensation nuclei : to favour the condensation process
- VI. in winter in Arctic regions over polynyas (open water areas)

Characteristics:

- I. is known as Arctic Sea smoke in Arctic areas : occurs over open water in Arctic
- II. unstable layer near the water surface: since the water is warmer than the cold air above it
- III. the instability in the low level will favour the evaporation as it produces upward motion, usually this portion is cloud/fog free
- IV. coastal airports can be seriously affected
- V. if the open water is very large this will favour local snow flurries or some snow squalls instead of the steam fog.

6) LOW TEMPERATURE FOG (ICE FOG)

Terminology: low temperature fog or ice fog

Formation process: Low temperature fog occurs when air, with an initial temperature of well below zero, cools well below its frost point. Because the required supersaturation for ice fog increases with decreasing temperature, and because condensation nuclei are generally scarce in cold regions, ice fog is more pronounced near inhabited areas. This is because man in his normal activities provides warm moisture via combustion products which supersaturate the air sufficiently for the formation of ice fog. Often, a single

aircraft, while departing from an airfield, will provide sufficient moisture to fog in the entire airfield.

Ice fog is the result of the evaporation of moisture into air at very low temperatures, and the subsequent formation of a suspension of minute ice crystals. The occurrence is favoured in northern locations in winter

Favourable conditions:

- I. an adequate moisture supply in low levels: for example near settlements, or power plants.
- II. air temperature colder than -32°C : could be present at lower temperature depending on the source of crystallisation nuclei available.
- III. a low level temperature inversion : to inhibit dispersion of particles
- IV. surface winds less than 5 knots : stronger winds will dissipate the water vapour concentration available for the formation of the ice fog.

Characteristics:

- I. combustion from furnaces, aircraft engines and automobiles are all sources of moisture and nuclei
- II. should be expected near open water and settlements
- III. winds are calm, winds stronger than about 5 kts will dissipate the fog
- IV. is usually man made
- V. might become a major problem during a cold wave situation especially in larger towns

7) SNOW FOG

This type of fog can be formed by advection or evaporation. It is rare to have fog form over snow if the temperature of the air is greater than 5°C or less than -10°C (exception made with the fogs of low temperatures which we have just examined).

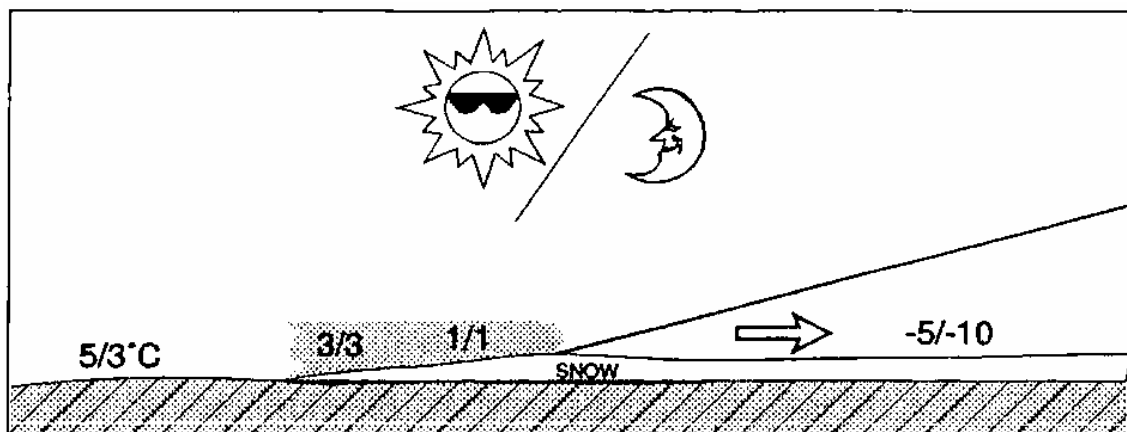


Figure 9. Advection fog over snow.

This might seem strange especially when one observes warm moist air masses cooling by more than 30 °C during their passage over the snow and without producing fog. To explain this phenomenon, we are going to study two cases:

- The case of the air cooled below 0 °C and;
- The case of the air cooled to 0 °C.
- First case: When an air mass of temperature $T_A > 0$ °C and with vapour pressure E moves over a snowy surface of temperature $T_S < 0$ °C, there is a heat flux from air to snow. The temperature of the air in touch with the snow decreases and its relative humidity increases. However, for a given temperature, the pressure of saturated vapour with regard to the ice E_I is lower than the pressure of saturated vapour with regard to the water E_W . It follows that the cooling of the air will provoke saturation with regard to the ice before there is saturation with regard to the water; that is, E will equal E_I .

As soon as E becomes bigger than E_I , there will be sublimation on the snow and a loss of water vapour. As long as E remains lower than E_W and greater than E_I , the process of sublimation will continue and there will be no fog. On the other hand, if cooling is very fast, E_W will decrease very quickly and will be able to become equal to E and, at this moment, there will be condensation of supercooled liquid water and a supercooled fog will form. However, the spread between E_I and E_W increases as one gets closer to -12 °C; then to maintain E greater or equal to E_W , will be needed a bigger rate of cooling. This will be extremely difficult because cooling will be slowed down by the presence of the fog and especially because E becomes more and more greater than E_I , and so sublimation increases and tends to decrease at the same moment the value of E .

The rate of necessary cooling to maintain E greater or equal to E_W is rarely observed when temperature comes down below -10 °C. Then if a fog exists, it will dissipate by sublimation on the snowy surface.

- Second case: Now let us examine the case of the air of which temperature is $T_A > 0$ °C and which moves on a surface of melting snow with a temperature of 0 °C. The heat flux will be from air to snow and this heat will be used to melt the snow. The temperature of the air in touch with the snow will decrease and will reach 0 °C very quickly. This will have the effect of producing an inversion with a temperature on the ground of 0 °C and a pressure of saturated vapour E_W (0 °C). To produce a fog, it is necessary that there is advection of warm and wet air in the upper parts of the inversion. The mixture of this warm and wet air with the cold saturated air of the surface will provoke saturation. However, if the initial temperature of the air is greater than 5 °C, the produced inversion will be very pronounced and thin, and necessary turbulent movements for the mixture will not be realized except when winds are excessively strong, which is extremely rare in

these levels. Quite likely, a stratus or stratocumulus would be the result of such turbulence.

These explanations allow us to understand the reasons why the formation of fog on a snowy surface is a rare phenomenon unless the temperature of the air is somewhere between -10 °C and +5 °C.

FOG DISSIPATION

It is important to know the mechanisms by which the fog formed in order to forecast its dissipation. As a general rule, a change in the conditions that caused the fog, for example a wind shift in the case of advection fog, will bring about its dissipation.

As a rule any of the following conditions will minimize the effect of fog:

1. prolonged sunshine
2. brisk winds
3. any significant changes in the fog formation mechanisms that were responsible for the formation of fog.

1. Sunshine:

Solar radiation can play two roles, the effect of sunshine as a dissipating mechanism depends on its ability to heat the air to reduce the relative humidity. The fog does not really “burn off”; rather, sunlight penetrates the fog and warms the ground, causing the air temperature in contact with the ground to increase. The warm air rises and mixes with the foggy air above, which increases the temperature of the foggy air. In the slightly warmer air, some of the fog droplets evaporate, allowing more sunlight to reach the ground, which produces more heating, which causes the fog to completely disappear. If dew is present along with the fog, the dew evaporation rate may be sufficient to allow persistence of a fog for several hours longer than over a dew-free surface. Eventually solar heating causes the saturation vapour pressure to increase above the actual vapour pressure, even in spite of the evaporation of dew if available. This leads to fog dissipation, first at the surface and then propagating upward. This is the origin of the term “fog lifting”. As the fog lifts, the fog no longer touches the ground, and a strong inversion exists above it, the fog is called a *high inversion fog*. The low cloud above the ground is called stratus, or, simply, *high fog*.

The angle of the sun plays a critical role. The “critical” angle for the sun to have a positive effect will vary for many reasons. Also this critical angle will be related to time of day and time of year and latitude of the location of the fog. Therefore, sunshine is a better mechanism for dissipation in the summer than the winter and better for low latitudes than high latitudes with increasing effectiveness from sunrise to noon as sun angle increases.

Also solar radiation causes sufficient mixing with drier air around the fog. It has been shown by satellite imagery (Roach et al 1976), that radiation fog and stratus dissipates from its outer edges inward rather than the whole area simultaneously, as had previously been assumed. The reason for this is that the ground on the outside of the fog heats up more quickly. This generates a weak circulation which dissipates the fog by a process referred to now as “inward” mixing. Often during the summer months lines of convective cloud will form along the early morning fog boundaries and spread out.

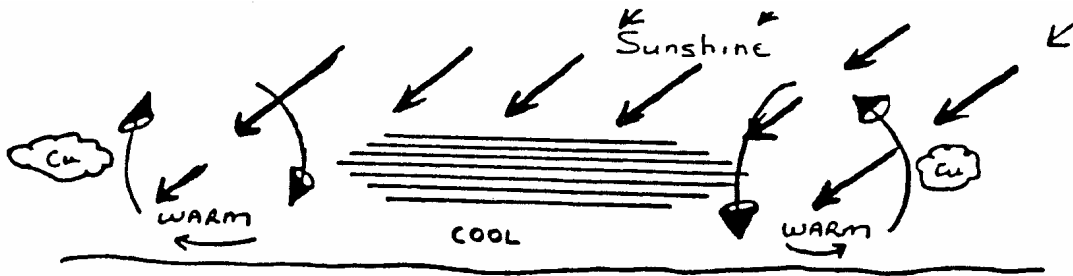


Figure 10.

Figure 10 illustrates an example of the summer time “inward mixing” fog dissipation mechanism. As a consequence of this process of “outer edge” erosion, an important parameter in forecasting the time of radiation fog dissipation at a particular point is the location of the point relative to the fog boundary. The basic tool for this is high resolution satellite imagery (if available). If the fog is thick, with little sunlight penetrating it, and there is little mixing along the outside edges, the fog may not dissipate.

2. Brisk Winds

Turbulent transport of heat and moisture plays an important role in the evolution of a fog. However, there is not a consensus as to whether the role of turbulence is primarily constructive, contributing to the formation of fog or destructive, contributing to the dissipation of fog. In general, turbulent mixing induced by brisk winds mixes drier air with the fog (stratus) and dissipation occurs.

However, brisk winds can be important in the process of fog formation. If the winds are in an upslope direction or the moist surface layer is capped by a strong inversion etc., then fog and stratus may indeed be enhanced by brisk winds.

Roach et al (1976) infer from observations that turbulence hinders fog formation. They formed this conclusion because lulls in wind were accompanied by maximum cooling, and major lulls were accompanied by periods of significant fog development. Conversely, increases in wind to greater than 2 m/s were associated with fog dispersal. They infer that as the wind speed decreases, turbulent transfer of moisture to the surface to form dew ceases. As a result, the moisture remains in the atmosphere, and as radiation

cools the air, fog is formed. Alternately, at higher wind speeds, vertical mixing of drier air may inhibit fog formation.

As with all arguments about fog, discretion and a thorough understanding of the processes involved in each fog formation situation are required before one can give a “subjective” opinion about dissipation.

3. Dissipation of Fog by Heating the Air

When fog evaporates by air heating, the saturation mixing ratio is increased by an amount corresponding to the initial liquid water content of the fog. As you can verify from a tephigram, at 30°C, increasing the saturation mixing ratio by 5 gm/kg corresponds to a temperature rise of about 3°C. However, at -30°C, increasing the saturation mixing ratio by the same amount involves a temperature rise of about 38°C! At low temperatures, much more heating is required to evaporate fog than is required at higher temperatures. Figure 11 is a graph showing the temperature increase required to dissipate fog at various temperatures, for liquid water contents of .3 gm/m³ and .03 gm/m³.

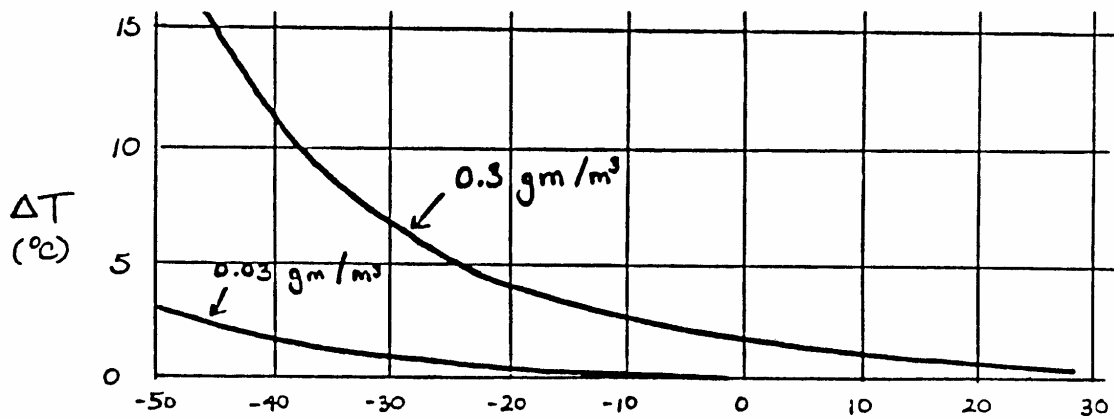


Figure 11.

4. Significant Change

The significant change condition is simply a summary of our previous discussion of fog. Fog and stratus are localized phenomena most of the time, synoptic in nature some of the time with many mechanisms and combinations of mechanisms for formation (some of which are more important than others). Changes in the processes setting up these mechanisms will weaken fog and stratus, and lead to dissipation.

SUMMARY OF FOG

Processes of Formation and Dissipation

(A) FORMATION:

(i) Cooling by:

- (a) outgoing long-wave radiation (Radiational Fog)
- (b) advection over cold surface (Advection/Sea Fog)
- (c) upslope (orographic lift) (Upslope Fog)

(ii) Moisture increase by:

- (a) evaporation of falling precipitation (frontal fog)
- (b) evaporation of a wet surface (steam, frontal, advection, etc.)
- (c) human activity - combustion of hydrocarbons (low temperature fog)

(B) DISSIPATION:

(i) heating:

- (a) solar radiation
- (b) advection of air over a warm surface
- (c) adiabatic warming: subsidence, downslope motion, or turbulent transfer of heat downwards by increasing surface wind speeds.

(ii) local moisture decreases:

- (a) turbulent mixing of fog layer with dry air above resulting in stratus cloud or fog dissipation
- (b) condensation of water vapour: dew or hoar frost.

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