MODULE 3.1D

DIAGNOSIS

Low Cloud

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STRATUS CLOUD

Definition (From Glossary of Meteorology)

"A principle cloud type in the form of a grey layer with a rather uniform base."

"A common mode of development is the transformation of fog."

"Particulate composition is quite uniform, usually of fairly widely dispersed water droplets and, at lower temperatures, of ice crystals (although this is much less common)."

"Often occurs in the form of ragged patches, or cloud fragments, (stratus fractus) in which case rapid transformation is a common characteristic."

"Does not usually contain precipitation., but when it does occur, it is in the form of minute particles, such as drizzle, ice crystals or snow grains."

Formation Process

Similar to that required to form fog, except that the cloud does not reach the ground.

Why?

Winds strong enough to cause vertical mixing, but the lapse rate remains stable.

Radiation balance allows for saturation at a level other than at the earth's surface.

Stratus may form either as a result of:

1. initial conditions (ab initio),
2. transformation from fog or another cloud type.

Typical vertical atmospheric structure:

1. lapse rate less than moist adiabatic necessary (stable)
2. temperature inversion normally present.

Implications from vertical structure:

1. lack of any extended vertical motion,
2. stability of cloud both in process and appearance.

Types of Stratus

UPSLOPE STRATUS

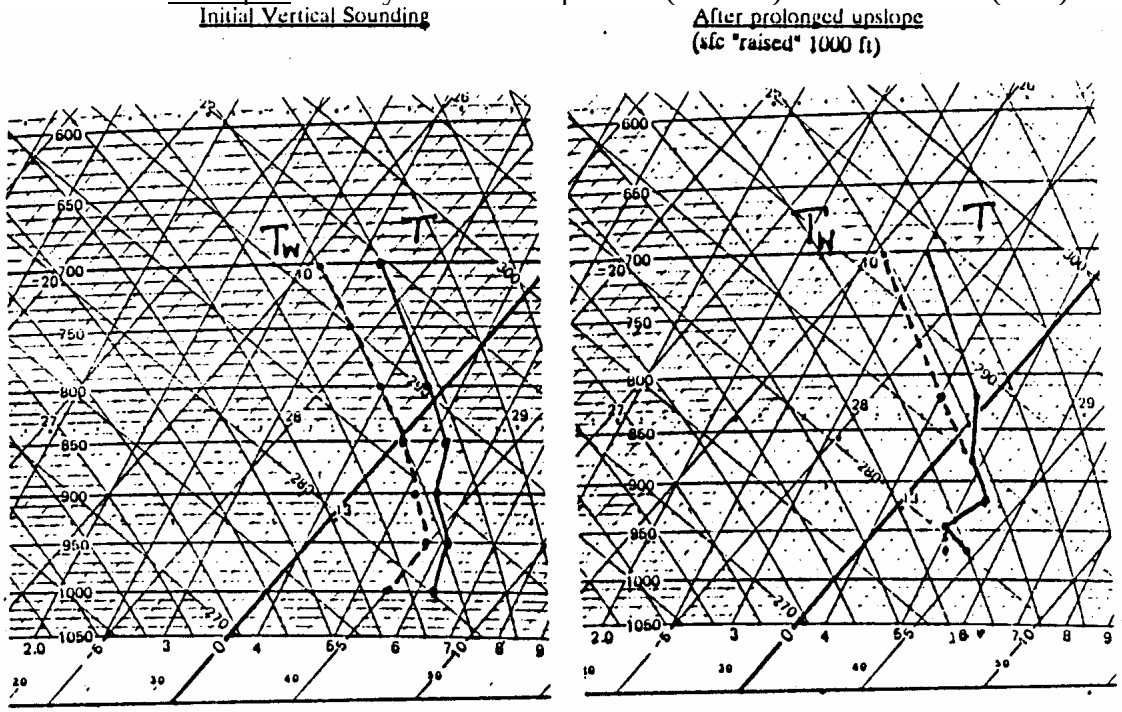
Formation/Dissipation:

- Adiabatic cooling due to ascent induced by sloping terrain.
- Air must be absolutely or conditionally stable in layer being lifted. Why ?
- Cloud will persist as long as flow persists (what is a logical dissipation mechanism?).

Favourable conditions:

1. gradually sloping terrain,
2. flow of 10-20 knots against this terrain.

Example: easterly flow across prairies (Canada) or Great Plains (U.S.).



CONTINENTAL STRATUS

Formation/Dissipation:

Continental stratus forms as a result of radiational cooling of a moist layer beneath a late afternoon inversion. Turbulent mixing may occur near the surface. The lifting condensation level must be located beneath the base of the inversion.

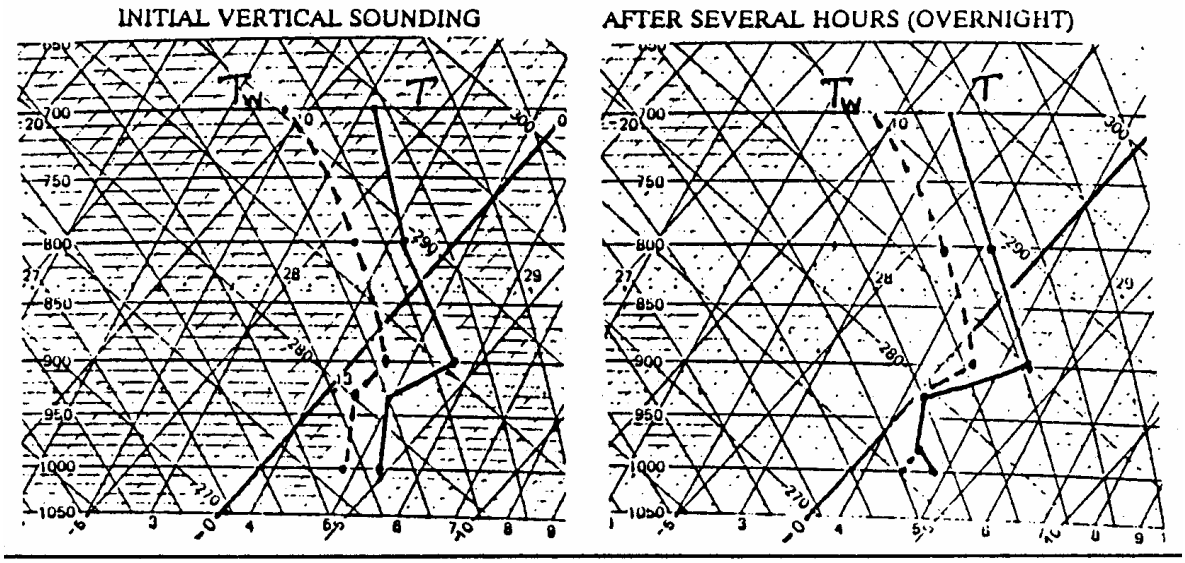
At night, cooling at the newly formed cloud top is dominant. The instability created causes turbulent mixing which raises the cloud top and strengthens the inversion. This mixing aids in the lowering of the cloud base as well.

The cloud top will continue to radiate away energy (cloud droplets more radiatively active for terrestrial than solar radiation [i.e., cloud top does not burn off as commonly believed]). If the initial turbulence inversion is low enough, sufficient nocturnal radiation will allow stratus to build down to the surface and produce fog.

Dissipation occurs due to the absorption of solar radiation deep inside the cloud (daytime). his heating causes instability and mixing which transfers heat to surface; the cloud base lifts.

Favourable conditions:

- clear skies,
- light winds,
- low level inversion,
- moist surface (ground dampened by recent rain, for example),
- in southeastern Canada, the warm sector of winter lows is a typical situation; may also occur in southern USA, but may have an advective component involved).



FRONTAL STRATUS

Formation:

Addition of moisture due to evaporation of precipitation; warm rain fall, into cooler air under a frontal inversion over a period of several hours.

Formation time required depends on differences between airmasses (differences in vapour pressure); also on surface temperature (heat input from below will inhibit condensation).

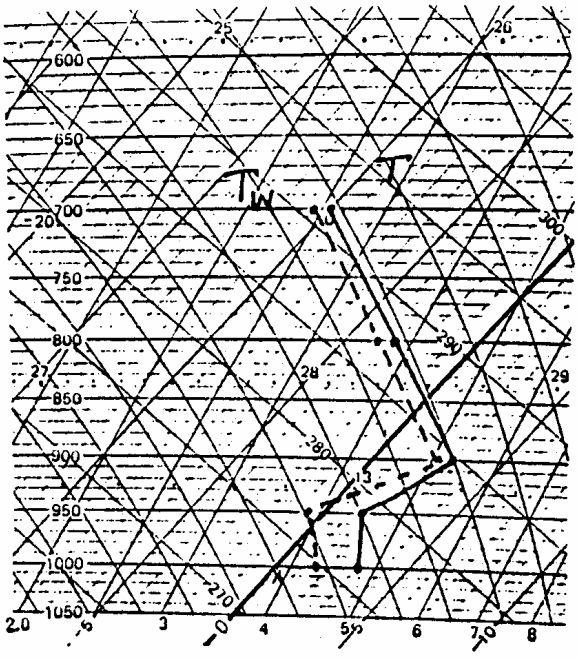
As time progresses, stratus base will lower (can produce fog if ground is cold enough).

Favourable Conditions:

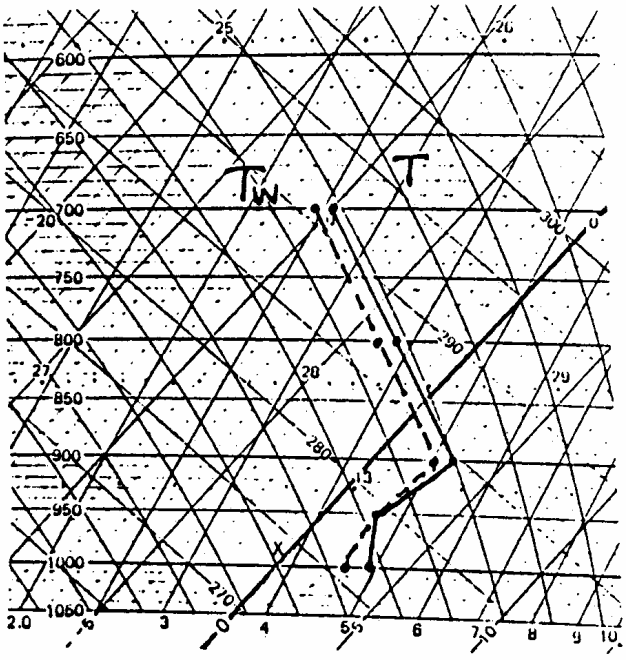
A slowly moving frontal wave with extensive area of rain falling from air with wet-bulb potential temperature much higher (say 5-10 degree C) than underlying air,

- cold surface (snow or ice covered, or cold water**,** for example),
- snow falling instead of rain not favourable for stratus formation (what is the thermodynamic explanation for this?).

INITIAL VERTICAL SOUNDING



AFTER SEVERAL HOURS OF RAIN



ADVECTION STRATUS (COASTAL)

Formation:

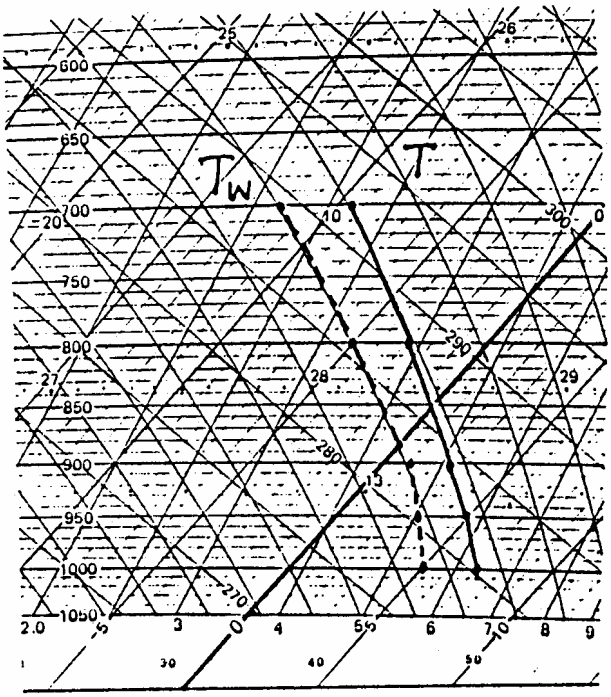
Cooling by contact of warm moist air blowing over a cold surface.

Similar to advection fog formation except that sufficient mixing at surface raises cloud base above the ground. Similarly a drier surface will coincide with higher cloud bases than a moist surface.

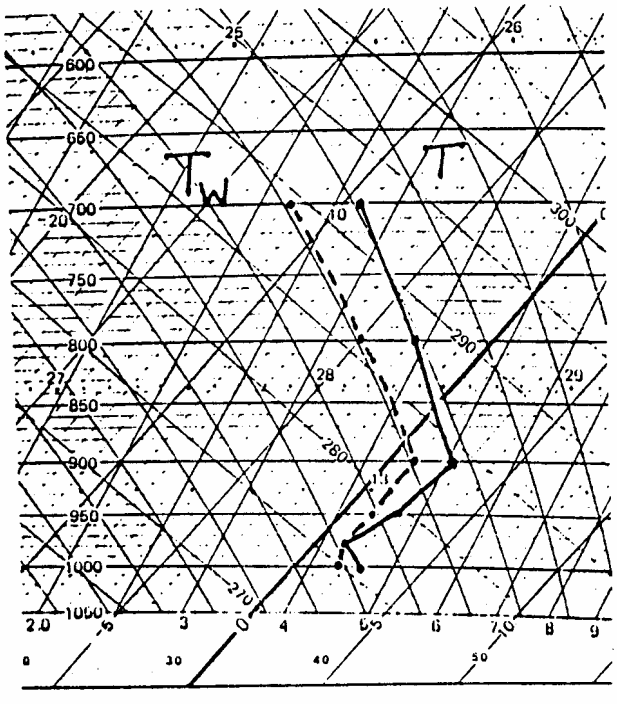
Favourable Conditions:

- warm moist air advected over colder water and then over coastal land areas (which cool radiatively overnight),
- subsidence inversion extending down into the boundary layer,
- typically forms in Atlantic coastal areas in spring/summer and in Arctic areas in summer; where dissipative processes are absent, the stratus persists.

INITIAL VERTICAL SOUNDING



AFTER SEVERAL HOURS



STRATOCUMULUS CLOUD

Definition (From Glossary of Meteorology)
"A principal cloud type in the form of a grey and/or whitish layer or patch, which nearly always has dark parts and is non-fibrous."

"Its elements are tessellated, rounded, roll-shaped etc., and may or may not be merged; these elements are generally flat-topped, smooth and large."

"Composed of small water droplets, sometimes accompanied by larger droplets, soft hail and by snowflakes."

"Frequently forms in clear air, also from the rising of stratus, and by the convective or undulatory transformation of stratus, with or without change of height."

FORMATION PROCESS

Requires conditions similar to those for stratus formation except that the lapse near the ground is typically unstable.

Thus production of significant turbulent eddies and creation of a mixed layer near the surface is important.

Idealised Structure:

i) mixed layer (below LCL) lapse rate dry adiabatic; constant mixing ratio,

ii) mixed layer (above LCL) lapse rate moist adiabatic; cloud present,

iii) above mixed layer
- marked inversion (up to $8^{o}C$),
- rapid moisture decrease (up to 20% R.H. decrease in 100m).

Transformation into other cloud types is associated with a change in eddy structure, and occurs as follows:

i) stronger surface heating will produce cumulus,

ii) decrease in wind strength may allow stratus to form,

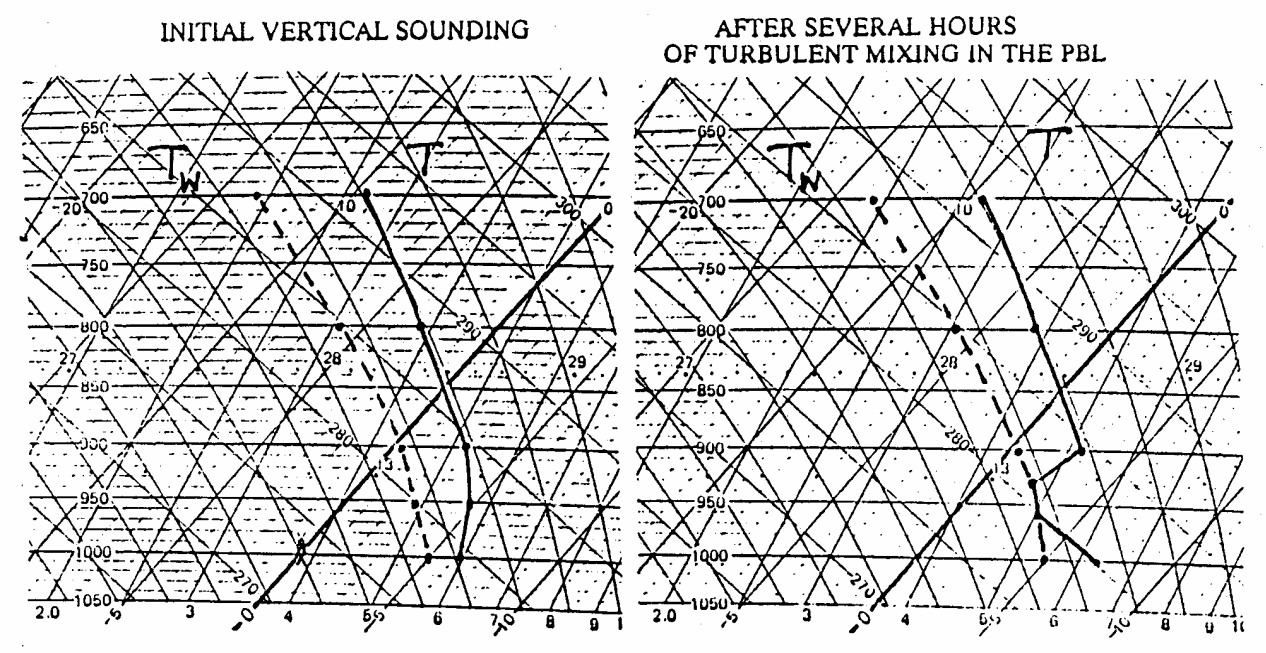
iii) increase in wind strength may break up cloud deck into streets or lines,

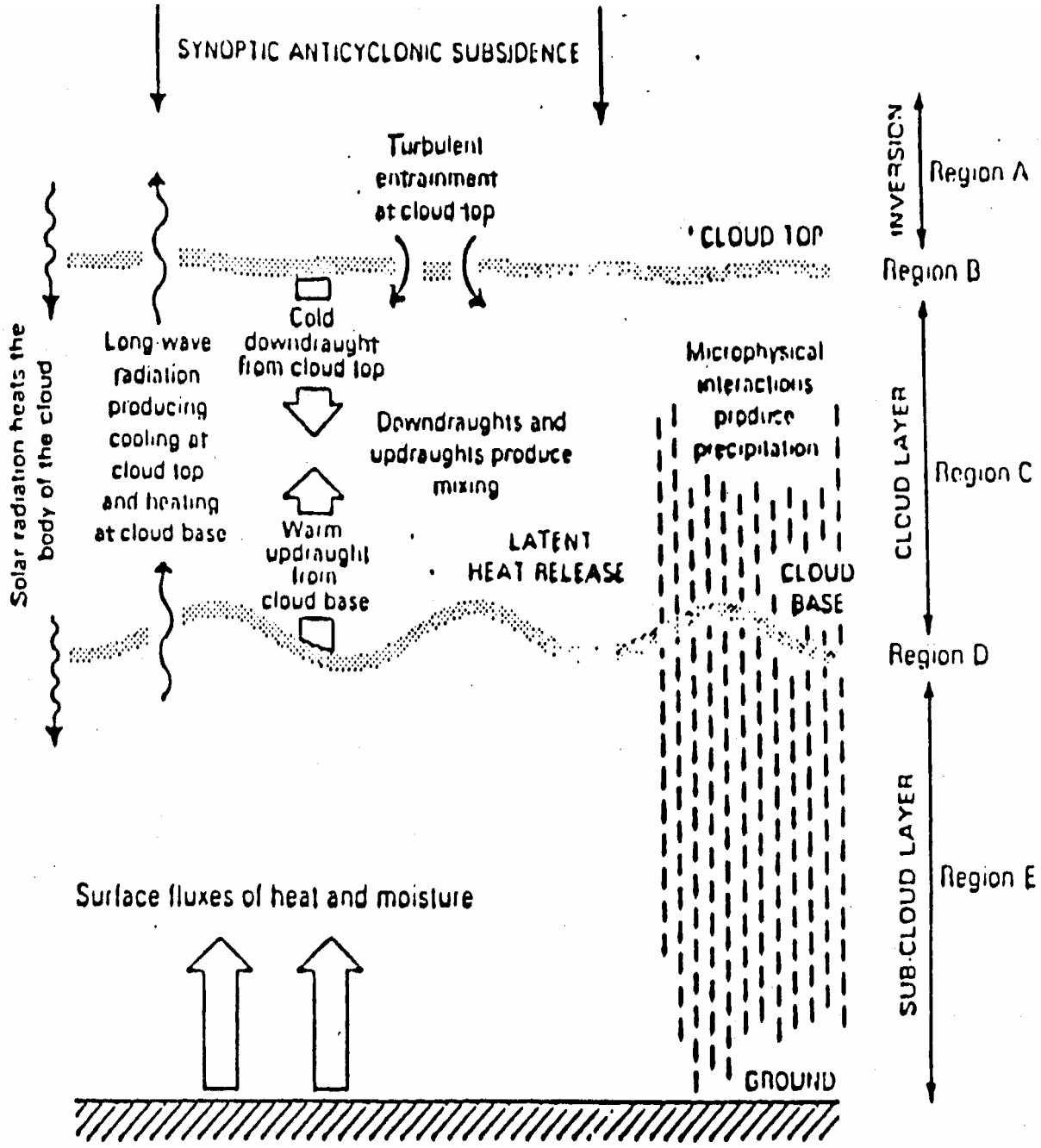
iv) cumulus will transform into stratocumulus by "spreading out" underneath a strong inversion.

Favourable Formation Conditions:

An extensive water surface where a uniformly high relative humidity at the surface will contribute to buoyant eddy production (region usually capped by a subsidence inversion); lowest level conditionally unstable.

An area over land where sufficient terrain roughness will produce mechanical eddies (with a similar inversion aloft) often the ground will have recently been rained upon.



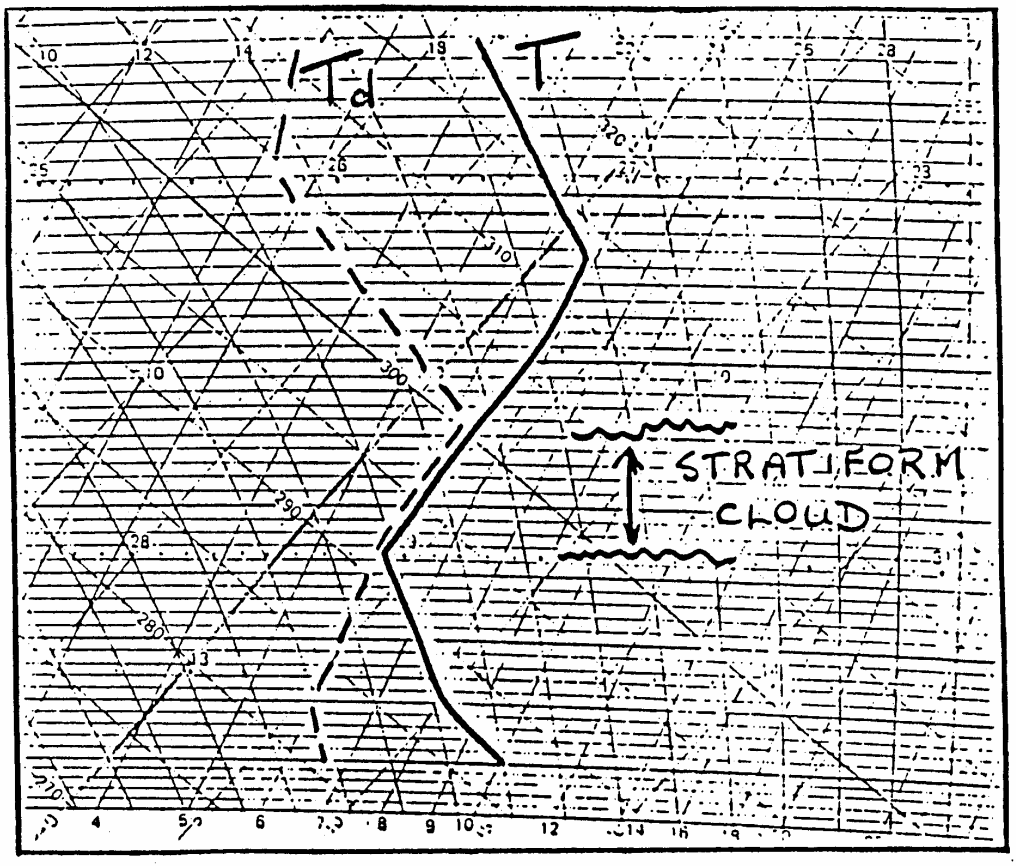


Summary of Physical Processes Important to the Formation of Stratocumulus.

BASIC CLOUD FORMS

STRATUS CLOUDS

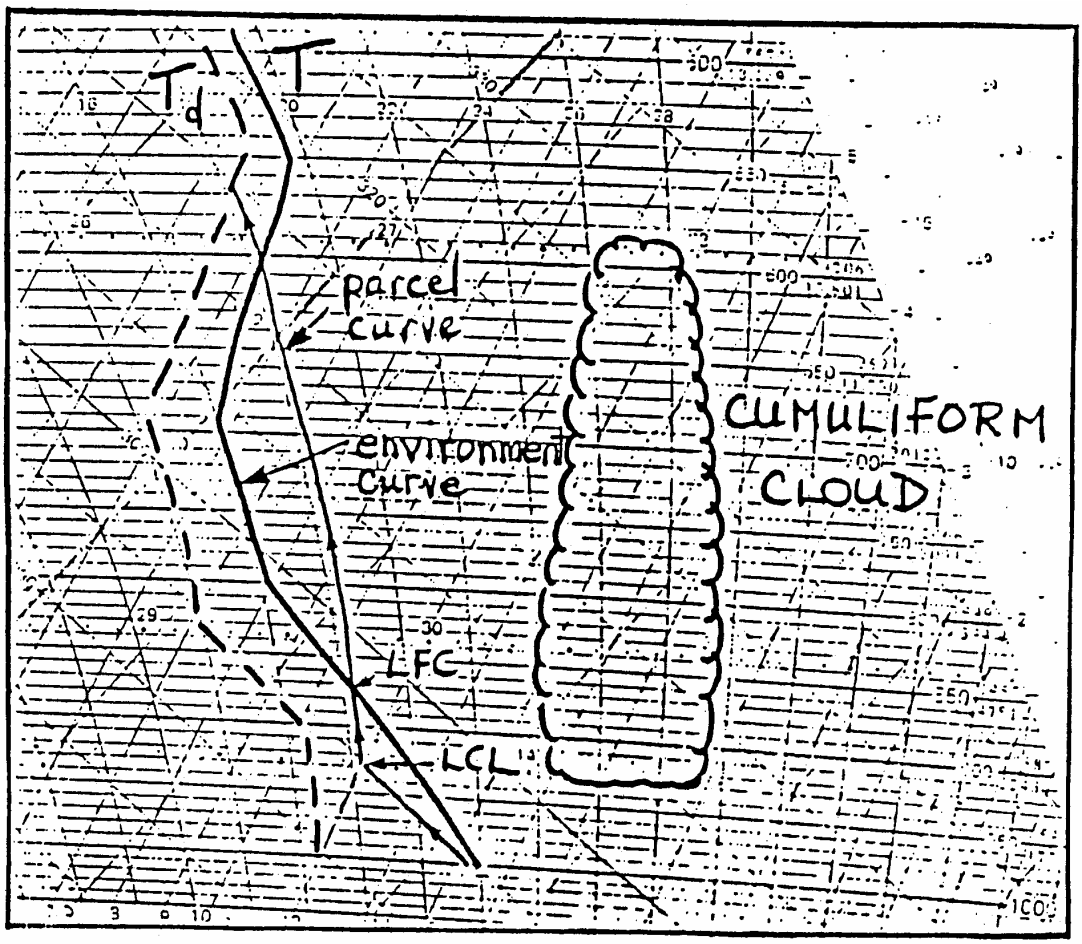
Stratus clouds are closely related to fog with respect to the physical processes responsible for its formation, maintenance and dissipation. Vertical motions of the cloud parcels are small.



Common stratiform clouds are fog, stratus, stratus fractus, altostratus, nimbostratus, cirrostratus and orographic wave clouds (lenticular).

CUMULIFORM CLOUDS

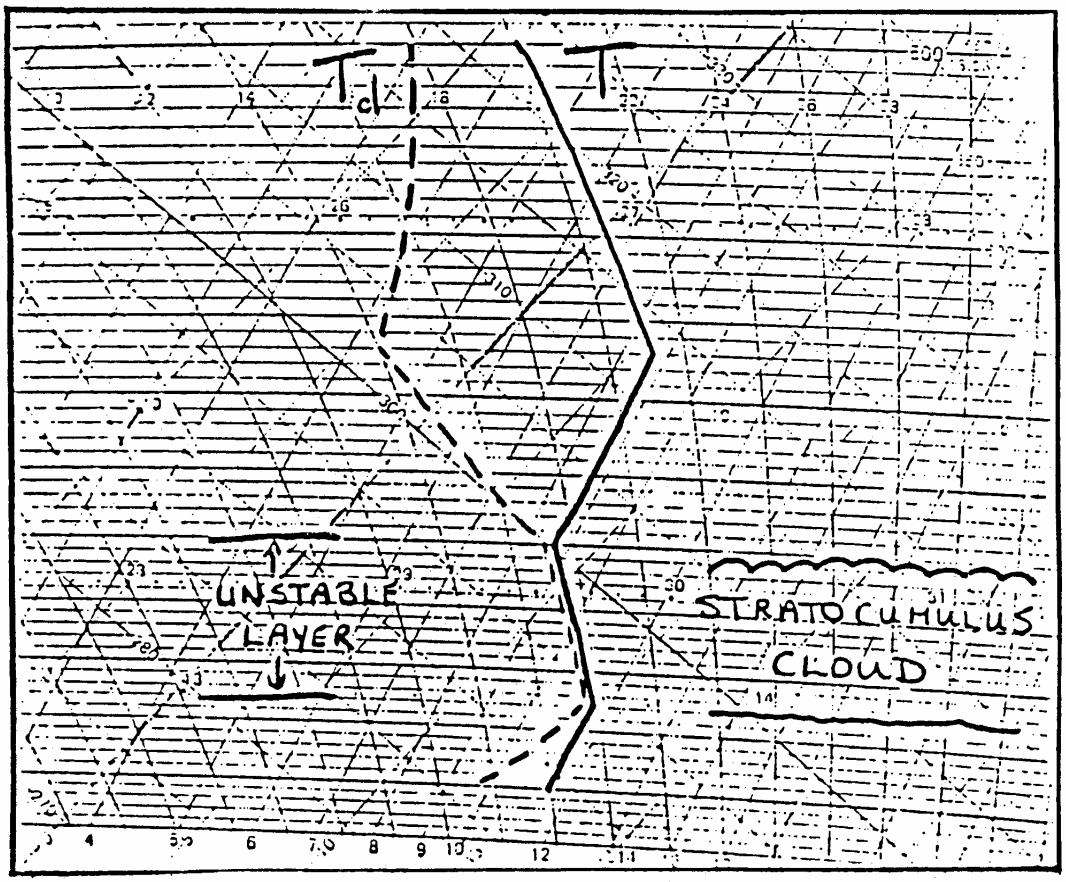
These clouds are billowy in appearance and structure, as the atmosphere is unstable, during the condensation or sublimation process. Vertical motions of the cloud parcels are large.



Common cumuliform clouds are cumulus, cumulonimbus, altocumulus and cirrocumulus.

STRATI-CUMULIFORM CLOUDS

A combination of the above two forms occurs when the atmosphere is stable, except for a narrow layer of instability within the cloud deck itself. The most common strati-cumuliform cloud is stratocumulus.



LOCALLY INDUCED PRECIPITATION

Drizzle/Freezing Drizzle

Formation:

Falls from stratus where cloud droplets have grown sufficiently to fall to the surface. Drizzle requires either:

- strong cooling by the underlying surface,
- gradual upslope flow providing sufficient lift.

Minimum stratus cloud thickness typically 2000 feet. Drizzle may fall in a supercooled state (Freezing Drizzle) at temperatures as cold as -15^{o}C, and freeze on contact with surfaces.

Precipitation type depends upon:

- vertical temperature structure,
- surface temperature.

Freezing drizzle does not require an above-freezing layer.

Favourable conditions:

- as per stratus, except these conditions are enhanced (e.g., prolonged upslope flow).

Light Snow/Flurries

Formation:

Falls mainly from stratus/stratocumulus. Ice nuclei must be present as condensation nuclei (for all things equal, the lower vapour pressure over ice allows snow to be produced selectively before rain) -- cloud depth at least 3,300 feet.

Favourable conditions:

- upslope effect,
- strong surface cooling,
- strong mixing due to turbulence (mechanical eddies).

Because of the thermodynamic consideration given above, an area of locally induced snow of synoptic proportions (light and continuous) may be present for a prolonged period of time, in the absence of any dissipative mechanisms.
Visibilities typically are not drastically reduced (greater than one-half mile in general) as a deep vertical layer is not involved in formation process.