CEILING AND VISIBILITY IN THE UNITED STATES

NORTHEASTERN STATES

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In the northeastern portion of the United States a well-defined excess of cloudiness and low ceiling is found along the shores of the Great Lakes and southeastward over a large portion of the inland areas. Much of the region is mountainous, which is conducive to further cloud formation by mechanical raising of moving air masses. Bounded on one side by the Great Lakes, on the other by the Atlantic Ocean, much of this area has high humidity. Clouds form quickly and easily and they frequently persist for several days, with ceilings which are little more than 500 feet above average ground elevations.

Between the two sources of moisture lie the Applachian ridges, which are frequently clouded, while areas on either side are almost clear. Such clouds are, of course, low, with ceilings dangerously near the mountain tops. The best average ceilings occur on the eastern flanks of the Blue Ridge where descending air is found with the prevailing westerly winds.

Besides the topography which tends to produce an abundance of low-ceiling weather, the drift toward the St. Lawrence valley of all LOWS and their attendant areas of condensation is a favoring factor in producing low ceilings. The average LOW has a low ceiling area around either its warm or cold front; sometimes along both.

Generally, high-pressure conditions are least likely to be accompanied by low ceiling, although one well defined exception is the HIGH which stagnates with its center over the mouth of the St. Lawrence. Other high-pressure conditions which result in low clouds are those of midwinter when cold air drifts across the warmer water over the Great Lakes.

A seasonal variation in low-ceiling conditions is well marked, especially in the Appalachian mountain regions and along the Great Lakes where the warmer seasons experience less and the colder more occurrences of low ceilings. Summer is as usual less subject to periods of low ceilings than is winter, over the whole area.

Low ceiling is especially important to air transport lines that operate across mountains because its presence may preclude flying over these mountains. Numerous cities, each with its encircling zone of air polluted by the products of combustion and manufacturing intensify the low-ceiling hazard at the airports in their vicinity and air pollution is therefore relatively higher in this section of the country than in any other.

Low ceiling in this area is dangerous in winter also because of its relation to ice accumulation on the planes, since it increases to a high degree the hazard involved in flying in the clouds. The low ceilings which attend line squalls and are sometimes obscured by violent rain and snowfalls have taken toll of several unwarned or unheeding pilots.

Use of dew-point data and careful study of their relation to the formation of low clouds are recommended as aids in predicting changes in ceiling. A rising dew point when the interval is small between it and the dry temperature is a fairly reliable indication of lowering cloud masses, on the warmer sides of LOWS.

Two peculiarities which occur occasionally are worth noting because of their danger. One is the tendency for two slightly separated horizontal cloud sheets to merge into one on the flanks of mountains. A pilot proceeding mountainward between the layers suddenly finds himself "pinched in." Mechanically induced vertical flow in the atmosphere near the mountains is the cause of this condition. The other peculiarity is the production of a fairly low ceiling by rain falling from clouds which may be more than several hundred feet high, sometimes in the alto-cumulus levels. This lower overcast develops first as scattered and windblown low scud masses. These grow, if the rain continues and the ground is well soaked, until they attain solid formation of an additional sheet of cloud only a few hundred feet off the ground, with ragged and billowy lower edges.

Visibility.—Low visibility restricts flying operations more in the northeastern section of the country than in any other part of the United States. Several causes are involved which are highly developed or frequent in this quarter and are in general similar to the causes of low ceilings but also include many others, some man made, which do not reduce ceiling. Some of these are on the increase.

Water vapor as an obstruction to vision is well identified with high humidity in air masses which have come across the Great Lakes or the Atlantic Ocean. Masses which have come inland from a long run over the sea and are not too briskly moved by the wind are more likely to produce fogs of wide extent than are those which have come inland after a short passage over the ocean and are moving at moderate or higher velocities. Sunlight and wind as a general rule are the main preventives of fog and the strongest agents in its dispersion.

Visibility is reduced in this section by other sources which are more effective here than elsewhere because of their abundance. The pollution of the air by products of combustion and manufacturing is definitely high in this section, not merely in the immediate vicinity of the offending agents but for considerable areas around.

Thus, large cities as a rule are surrounded by areas of low visibility resulting from pollution. Industrial works of certain kinds discharge products which reduce visibility to less than 2 miles for a distance of 15 miles or more. The effect is direct and indirect. Directly, such a quantity of small particles is spread through the air that visibility is reduced. Indirectly these particles tend to assist in the suspension in the air of moisture particles which by themselves would present no great obstacle to vision. Oily or tarry substances hold moisture and resist the drying influence of sunshine, and as the products of combustion often consist of such substances this action commonly intensifies fogs. Hydroscopic chemicals are abundant in the vicinity of many manufacturing plants which discharge fumes into the air. Pollution is a growing factor, and measure toward its control and reduction are likely to be necessary in the near future.

Dust plays no great part in reducing visibility in this area. Drifting snow in windy weather during the winter is a cause for lowered visibility along the ground and results in a hazard to planes when landing, but is otherwise more apparent than real as a danger.

The worst obstruction to vision in the moisture class is fog. Fine rain is likewise a serious obstruction to vision. As a rule, with both moisture and other particles the finer the particles the worse the visibility. A heavy rain with large drops does not hinder vision nearly as much as does one-tenth the rainfall in the form of a

drizzle. The densest fogs are those in which the droplets of moisture are exceedingly tiny.

Fog in the northeastern quarter of the country generally may be described as (1) valley, (2) mountain, (3) ocean, (4) snow or rain. Fog can frequently be ascribed to two or more of these conditions; often their origin and cause are more or less obscure because it is difficult to secure full information as to their exact extent.

Valley fogs are essentially phenomena due to radiation and air drainage. Their formation is best watched by assuming that they will form, unless inimical conditions are present, in any broad valley during the night hours. The longer the night the greater the chance and extent of fog. There is little chance for fog if at sunset the temperature and dew point have a difference of 15° F. or more. Such fogs may fill the valleys by sunrise but usually "burn off" under rising temperatures during the first four hours of daylight. If, however, a sheet of high clouds comes in over these fogs their dispersion is greatly delayed.

Mountain fogs are strictly low cloud ceilings which envelop the higher points of the terrain. When the ceiling lifts the fog observed as such by an observer on the mountain top disappears.

Ocean fogs occur on the coastal plain of the Atlantic seaboard and are frequenters of the southern and western sections of HIGHS which are located a short distance to the east of the Canadian and New England coasts. From local indications it is practicable to predict their occurrence by closely observing the wind direction and velocity and the temperature at stations on the coast. A desultory south or southeast wind whose temperature is normal or below in the daytime will often suddenly turn back to a chilly east or northeast light breeze at night and fog will attend this shift of wind. Once formed such fogs are persistent and depend for their dispersion on a greatly altered pressure distribution, as it often happens that an incoming LOW from the west will draw southerly to southwesterly winds up over the top of the fog for several hours before it gradually wears away the upper surface of the fog and draws out the colder inversional temperature layer of foggy air.

Fog in the vicinity of the Great Lakes is less common but similar in production to the ocean fogs. It is easily formed when precipitation has occurred or is still occurring with winds which are light to calm, if the temperature of the water surfaces is above that of the land. In winter the lakes have ice and their temperature is therefore near freezing. At other seasons lake temperatures are normally colder than land temperatures, and therefore, the fog is slow to develop over the land.

Any widespread fog is the result of a widespread condition, hence slower to disperse than a local or limited one. On the other hand, during the evening or the period of development all fogs are likely to start as local phenomena and if the night is long the merging of several local fogs may result by sunrise. A winter fog usually is less mobile and more likely to stagnate than a summer fog, while the spring fogs are involved in cold surfaces and are often abnormally stagnant.

"Snow" fogs result when warm, moist air blows over snow-covered terrain. The reduction of the air temperature by the snow is the cause. If the snow is substantial enough to last under the influence of the warm air fog will form. The farther to the windward the snow cover exists, the more likely is the fog to form at any specific point.

Rain in summer sometimes chills and wets the ground in a region to the extent that the lower strata of air are abnormally chilled while blowing very slowly over this region. Fog will result if the chilling is great or the moisture content of the air is high. Such fogs are usually transient, although if they occur in the early evening they may merge into valley fogs. Rising wind will disperse them quickly.

SOUTHEASTERN STATES

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The southeastern portion of the United States lies south of the most frequented storm tracks. The storms that cause heavy rainfall in this region are southwestern LOWS, including those that form in the Gulf of Mexico and those from the northwest that move far to the south before recurving. A considerable portion of the West Indian hurricanes pass inland on the Gulf coast or move up the Atlantic coast, causing widespread cloudiness, high winds, and heavy precipitation. But these storms are confined mostly to late summer and autumn and, in most years, are not frequent enough seriously to affect flying.

This comparative freedom from storms, however, does not mean that the flying weather of the Southeast is better than that of other sections. In fact the topography of the region and the proximity of an abundant supply of heat and moisture from the Gulf of Mexico and the Atlantic combine to produce weather conditions that seriously interfere with flying at frequent intervals during a considerable part of the year.

The Appalachians, forming a high backbone between the Mississippi River and the Atlantic, are a decided topographic factor in determining ceiling and visibility. Even in fair weather a perpetual haze hangs over these mountains, as such names as Great Smoky and Blue Ridge suggest. This haze is sometimes so stratified as to resemble clouds, and the upper surface at 4,000 to 6,000 feet (1,200 to 1,800 meters) often furnishes a distinct horizon from above.

A notable instance of the effect of moist winds blowing across mountain ranges is found in northern Georgia and southwestern North Carolina. On the southern slope the rainfall increases from 50 and 55 inches (130 to 140 centimeters) over the lower slopes to 60 and even 80 inches (150 to 200 centimeters) a year on the higher slopes, while in the valleys beyond the rainfall drops to less than 40 inches (100 centimeters). The ridges of the southern Appalachians in Tennessee, Alabama, and Georgia seem to stretch out like fingers to grapple with the prevailing winds and squeeze out the moisture to form clouds, fog, and rainfall.

The Gulf of Mexico, as R. DeC. Ward points out,[1] is an important control of the climates east of the Rocky Mountains. It is a very warm body of water, and the most important source of moisture for the heavy rainfall of the Southeast.

The Atlantic probably exercises an equally important control over flying conditions on the Atlantic seaboard and as far west as the Blue Ridge Mountains, easterly winds being definitely associated with low stratus clouds which are the most serious handicap to flying in this region. At Atlanta, for instance, the percentage of rain during the time the wind is northeast is five times as high as with northwest winds. Taking this value as unity for northeast winds the relative probability of rain for the other directions is as follows: North, 0.31; northeast, 1; east, 0.56; southeast, 0.59; south, 0.32; southwest, 0.61; west, 0.26; northwest, 0.17.[2]

[1] The climates of the United States.

[2] Cf. The rain-bearing winds at Atlanta, Ga., by C. F. Von Herrmann, Monthly Weather Review, Nov., 1925.