observed facts indicate that small, undercooled raindrops occur *not infrequently*: (1) Droplets that freeze onto objects without entirely flattening out; (2) the dryness of icy posts on which raindrops are continually falling; (3) the formation of glaze from raindrops on twigs and roofs where snowflakes had just been melting (5). Theoretical considerations of the rate of cooling of a raindrop and the known temperatures and thickness of below-freezing layers of air through which liquid raindrops fall confirm this (4) (6). The maximum size which such drops can attain without rippling on falling, is at least 0.5 mm. (measured on several occasions) and is probably 1 mm., and perhaps more in relatively calm air (in which the "air-speed" of the drop does not change as in passing through turbulent air).

The descriptive definition of sleet given on page 71 may be strengthened by the addition of the following sentence:

A sleet particle may be (1) a snowflake partly melted and refrozen, or (2) a frozen raindrop, or (3) a frozen combination of snowflake and raindrop or liquid (not undercooled) cloud droplets.

GRAUPEL.

Coated snowflakes.—A snowflake on falling through a cloud of undercooled liquid droplets is likely to become coated with a layer of rough ice if there is sufficient turbulence to make it fall with different sides downward. Such a coated snowflake becomes a pellet of the type usually known abroad as *soft hail, Graupeln*, etc. If, however, the falling crystal presents the same face downward throughout its passage through the wet cloud, the intercepted cloud particles may arrange themselves in accordance with the axes of the snow crystal. The following notes were written about such a case observed at New Haven, Conn., March 10, 1918, for a half hour at about noon; surface wind, west-north:

In the center of an intense cyclone, while the pressure oscillated slightly under the influence of the changing proportions of cool and warm air layers above, a fall of "soft hail" in the form of truncated fluted hexagonal pyramids, 3 to 5 mm. high and 3 to 5 mm. in diameter across the base, occurred. The tops of the pyramids were formed by symmetrical snow crystals and so were the bases. The sides were grooved corresponding to the indentations of the edges of the snow crystals. The texture was relatively coarse, and the structure partook of the character of mountain hoar frost [rime] which has formed in a windy fog, from the congealing of the cloud particles onto the already formed ice crystals.

Evidently there had been a fall of snowflakes from the upper nimbus, and these in passing through a quiet layer of stratus or fracto-nimbus had kept their horizontal positions and in this way accumulated more and more cloud droplets as they settled and grew in diameter. Mixed with the fall of "soft hail" were ice needles, representing, apparently, the direct condensation into ice which was taking place within the scud.

Genetically there is really but little difference between this collection of cloud particles on a falling snowflake and the collection of undercooled [?] raindrops on the falling hailstone. If the fracto-nimbus were turbulent the deposits might occur on all sides, making a rounded pellet.

Clouds at 8 a. m.: Layer at about 700 m. from west, Fr.Nb. below from northeast. Northwest wind-shift [followed with] snow squall [lasting till] 3 p. m.

A previously formed sleet particle may receive a rough coating by falling through a cloud of undercooled droplets.

SLEET, GRAUPEL AND HAIL CONTRASTED.

Sleet.—Partly melted snow or rain frozen while falling from a warm layer through a cold one. (Different from hail—not carried aloft by strong convection.)

Graupel.—Snowflake coated with rime on falling through a cloud of undercooled liquid droplets. (Different from sleet—temperature not above freezing aloft.)

Hail.—Accretion of snow and rain, usually in layers, formed by being carried by strong convection from a warm *up* to a cold level. (Different from sleet—no cold, surface layer necessary.)

VERTICAL SECTION OF SLEET WEATHER.

Figure 1 is a diagrammatic representation of the conditions which seem to be responsible for the formation of the various types of sleet observed. It is an improvement over its predecessor published in 1914 (4) in that it is more detailed and based on more observationst Still it is hypothetical in part, and it may be corrected by simultaneous observations at different levels on high towers and mountains or by means of kites, balloons, or airplanes.

CONCLUSION.

Close observation of the form of precipitation, of surface wind, temperature and pressure conditions, and of clouds, when interpreted in the light of some understanding of the processes of the atmosphere enable meteorologists to surmise with reasonable assurance what the winds and temperatures are aloft. Let us have *sleet* in our records always be significant of the probable occurrence of winds with above-freezing temperatures over a cold, surface layer of air.

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A WEATHER CONDITION WHICH PRODUCES GLAZE IN NORTHERN NEW YORK.

By DOUGLAS F. MANNING.

[Alexandria Bay, N. Y., Mar. 4, 1920.]

An interesting state of weather occurs here not infrequently during January, February, and March. Such a condition prevailed during March 2 and 3, 1920, proving that the intensely cold northerly winds sometimes extend only a short distance above the earth's surface.

Under such conditions, there is a fresh to brisk northerly to northeasterly wind of a temperature between 10° below zero F. and zero, or a few degrees above, and a sky covered with a warm-looking, smoky-appearing strato-cumulus cloud at moderate altitude moving slowly from the southwest or west and with which the sun, when seen shining through the occasional clear space, is a ball of lurid red.

Sometimes large feathery flakes of snow fall, the fact of the large flakes proving a warmer current aloft, and at times when the condition is well-developed a fine rain falls covering everything with a coat of glaze ice.

At such times an examination of the weather map shows we are to the north of the axis of a trough of low pressure and that but a little way south of us warm west to southwest winds are blowing and no doubt overriding this cold northerly air, producing the clouds and sometimes rain. As a rule this condition is followed by a shift of wind to SW. and a rapid rise in temperature, the clouds all disappearing.

BOUNDARY BETWEEN A SOUTH WIND AND AN UNDERRUNNING NORTHEAST WIND.[1]

By CHARLES F. BROOKS.

[Blue Hill Observatory, Mass., May, 1913.]

In the late afternoon and evening of May 3, 1913, an anticyclone began to approach Blue Hill from the north. During the day a sea-breeze of three hours' duration had prevented the maximum temperature (80°F.) from occurring until the middle of the afternoon at the summit of the hill (195 m.). The wind remained in a southerly direction till 9 p. m. with momentary exceptions, marked by sharp drops in the thermograph curve.

The wind at the base station (64 m.) became northeast at 5:20 p. m. and therefore for several hours a considerable temperature inversion existed between the base and summit, at one time amounting to 14°F. At 7 p. m. the dividing line between the northeast wind and the south-southeast wind was across the summit of the hill in an east-west direction. This line was very sharp, so sharp that I could stand with the breeze from the northeast blowing on one cheek and that from the south on the other. At this time, as shown by the oscillations of the hygrograph curve up and back again whenever a small volume of northeast wind blew through the instrument shelter, the relative humidity on the dividing line was 80 per cent on one side (northeast) and 40 per cent on the other (south).

With the normal evening cooling the humidity presently reached 100 per cent on the dividing zone, thereby producing a fog. The pressure began its rapid rise at this time. Before long the stratus cloud rose from the top of the hill (3 a. m., by hygrograph), and by 7 a. m., May 4, was some distance above, its appearance giving an inverse "mammato" effect. At about noon the sun first broke through the cloud sheet, and by sundown most was gone.

(NOTE.—Another occasion on which I observed a similar sharp dividing line between winds from two directions was on July 25, 1912 near the Schilthorn, Switzerland. In the late afternoon, when there were thunderstorms in the vicinity, a cloudy current coming up the south side of a ridge on the east met a clear current up the north side with the result that a vertical cloud wall perhaps 100 meters high was formed.)

[1] *See* C. F. Brooks, Three ice storms, *Science*, Aug. 8, 1913, pp. 193-194, for descriptions of somewhat similar conditions.

THE PRECIPITATION OF SLEET AND THE FORMATION OF GLAZE IN THE EASTERN UNITED STATES, JANUARY 20 TO 25, 1920, WITH REMARKS ON FORECASTING.

By C. LEROY MEISINGER.

[Weather Bureau, Washington, D. C., Mar. 29, 1920.]

SYNOPSIS.

An attempt is made, by means of accurate charts of precipitation during the previous 12 hours, current temperature, pressure, and lines of wind flow, in combination with such aerological data as could be obtained, to construct cross-sections of the lower 3 kilometers of the atmosphere, during the period January 20 to 25, 1920. From such charts are shown the actual processes which produce rain, sleet, and snow, separately and in combination, in such a manner as to produce the ice cover, which is called an "ice storm." The condition is, briefly, a cold northerly wind underrunning a warm southerly current, forcing the latter aloft. The vertical distribution of temperature, shown in the cross-sections, indicates the manner in which the isotherms in that territory covered by the northerly wind rise normally until the level of the overrunning southerly wind is attained, where the isotherm swerves sharply northward. The distance that the isotherm of freezing reaches is indicated by the northern limit of the precipitation of sleet.

An empirical relation was obtained between the distance from the wind-shift line to the 32° isotherm and (1) the width of the glaze belt, (2) the width of the sleet belt, (3) the distance of the center of the sleet belt north of the 32° isotherm, (4) the width of the glaze belt on a meridian 4° east 12 hours later, and (5) the width of the glaze belt on a meridian 8° east 24 hours later. These values are presented with the full realization that they may be true for this particular storm only, and are as follows:

(1) The width of the glaze belt=the distance between the 32° isotherm and the wind-shift line;

(2) The width of the sleet belt=0.7 × the distance between the 32° isotherm and the wind-shift line;

(3) The distance between the 32° isotherm and the center of the sleet belt=0.8 × the distance between the 32° isotherm and the wind-shift line;

(4) The width of the glaze belt 4° east, 12 hours later=0.9 × the distance between the 32° isotherm and the wind-shift line; and,

(5) The width of the glaze belt 8° east, 24 hours later=0.8 × the distance between the 32° isotherm and the wind-shift line.

The importance of the wind-shift line in forecasting the region over which sleet or glaze are likely to occur is strongly emphasized, since it marks the point of ascent of the southerly wind and hence is the basis upon which rests the location of this type of precipitation.

INTRODUCTION.

Of all types of storms, there are few which have the wide-spread economic effects of the so-called "ice storm." Not only is traffic, both on railroads and in cities, impeded and often completely tied up, and telephone and telegraph lines crippled, but accidents are numerous also. Moreover, when rain falls on a region previously covered with snow and produces an ice glaze, the snow is held immovable and the glaze forms a gliding surface over which subsequent snow will drift with little hindrance. In New York City recently, when the streets were more effectually blockaded by snow than at any time in the city's history, not a small part of the difficulty in its removal was attributable to the fact that there had been layers of ice formed at various levels in the snow, increasing the rigidity of the drifts and packing them more solidly.

Often such storms are local and do not have a wide-spread effect, but once or twice in a winter they occur over a large area of the country. They are caused, of course, simply by the precipitation of rain upon a region the temperature of which is at freezing or below. In many cases, it is not long before all surfaces exposed to the rain become heavily coated with a crystal-clear layer of ice, sometimes as much as an inch in thickness. This