FOG AT SEA

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In these articles, the author proposes to give a general account of fog at sea. The modes of formation of fog at sea have already been explained in detail in the article of H. KEETON, published in *The Marine Observer*, Volume VI, May 1929, pages 106-109, and the author supplements them by short descriptions of other occasional modes of formation of fog at sea and the occurence of fog in strong winds. He outlines the general distribution of fog over the oceans and certain individual areas as well as their causes. The detailed distribution and frequency of fog over the oceans, in so far as the available information allows to do it, are reviewed by areas in the sequel of this interesting article, a few paragraphs of which are reproduced hereafter.

GENERAL REMARKS.

Fog consists of minute water droplets in suspension in air, but the actual water content of the densest fog is much smaller than might be supposed. During the investigation of the U. S. cutter *Seneca* over the Grand Banks of Newfoundland in May, 1915, a fog which restricted visibility to 100 feet was found by measurement to contain 20,000 droplets per cubic inch. Nevertheless, a section of air 100 feet long, 6 feet high and 3 feet wide under these conditions was found to contain less than one-seventh of a glass of liquid water, distributed among 60 thousand million drops. Furthermore, it was shown that in the thickest fog met with in this notoriously foggy region only 8 per cent of the water in the atmosphere was condensed into liquid form.

Three essentials are necessary for fog formation, dust, moisture in the air and some cooling process of the air, and many meteorological conditions therefore enter into the matter. Atmospheric pressure, temperature, humidity, dust content of the air and wind force are the chief factors. Fog is an unstable phenomenon and a delicate balance of factors is necessary to produce it, though in suitable conditions it may be very persistent. A temperature fall of 2 degrees Fahrenheit is often sufficient to produce a fog, a corresponding rise, to dispel it.

As stated above, some kind of dust must be present in the atmosphere to act as nuclei for the condensation of the droplets of water. This subject is too technical to consider here in detail, but it is probable that the chief substance comprising such nuclei is common sea salt present in the air in finely divided state, assisted also by ordinary dust of all types and smoke particles, which, while more numerous over land areas, are by no means lacking even in the open ocean owing to dispersion by the winds.

Five modes of formation of fog in the open sea are referred to in the present article, but it is possible that others also exist:

(i) Fog formed during the passage of air over water which is cooler than air.
(ii) Fog formed during the passage of air over water which is warmer than the air.
(iii) Fog caused by the mixing of two air currents of different temperatures.
(iv) Fog formed at the warm front of a cyclonic depression.
(v) Fog formed in connection with hygroscopic sea salt at relatively low humidities.

This classification brings out the great importance of wind in fog formation at sea, as opposed to typical land fog (radiation fog), which normally takes place in the presence of calm or very light winds.

Fog formed by the passage of warm air over cooler water may be described as normal sea fog. It is much the most frequent kind and it has been estimated that about 80 per cent of all sea fogs are produced in this way. As a typical example the fog of the Grand Banks may be given, but it should be noted that fogs produced in other ways may occur in that region.

The fog may be extremely shallow or may reach as high as two or three thousand feet above the sea surface. It should be noted that the warm air necessary to the process may have more than one kind of origin. It may be warm air blowing off the land; "continental air", or it may be air which has been warmed in its passage over a warm sea current, such as the Gulf Stream, or again it may be air of tropical origin coming from lower latitudes. Normal sea fog is in general most frequent in the spring and early summer, when the neighbouring land masses are becoming rapidly warmed, so that sea temperature lags behind that of the air. Hence sea fogs may normally be regarded as summer fogs, though fog formed in other ways may occur in winter. This mode of formation is least frequent in winter when the air temperature is normally lower than that of the sea.

The second method of formation is not infrequent in suitable localities and seasons but, as stated above, it is of far less importance than normal sea fog. It has been observed both in the Arctic and Antarctic regions and is then generally referred to as "Arctic Smoke". In such cases, and also in the Norwegian Fjords, the fog consists of ice crystals.

Fog caused by the mixing of two air-currents at different temperatures occurs occasionnally. In such a case where extensive air-currents exist the fog will be more or less uniform, but where the mixing fog is due to more local air currents it may be streaky, with irregular tongues and patches.

A deterioration in visibility usually accompanies the passage of a well-marked warm front and occasionally just sufficient mixing occurs between the warm air and the cold air to produce surface fog at the line of meeting. As the production of rain is the normal accompaniment of the passage of the warm front, rain or drizzle may fall through fog formed in this way. Fog at the warm front of a depression is thus likely to be occasionally experienced in certain regions, for example, in the temperate latitudes of the North Atlantic and in the Roaring Forties.

Particles of sea salt, as actually present in the air over or near the sea, are so hygroscopic that they become drops of liquid in air which has humidity of only 75 per cent. Fogs may be caused by this process in circumstances which do not appear likely to produce fog.

COASTAL FOGS.

Fogs in narrow and coastal waters may be either sea fogs formed in one of the above-mentioned ways or land fogs which drift over the sea. There are also true coastal fogs, in which the coast-line assists the formation. The most common cause of true coastal fog is the blowing of warmer air from the sea over the colder air of the coast after a spell of cold weather. Another cause which operates in certain localities is the mixing of warm and cold sea currents near the coast owing to the cold undercurrent being forced to the surface in passing over shoals or in approaching the coast. The fifth method of fog formation referred to above in which the salt particles become hygroscopic at relatively low humidities is perhaps mainly a coastal fog, the air becoming heavily charged with salt owing to the breaking of swells on rocky shores.

DRIFT FOGS.

Fog formed in any way at sea may be carried by the wind into regions where fog would not directly form and where its presence would be otherwise inexplicable. Such fog banks may sometimes drift to a considerable distance from the region of their origin. They may cover an extensive area or be small and patchy.

DISPERSION OF FOG.

It is often impossible to know what cause is responsible for the clearing of a fog. We have seen that sea fog may disappear without observable change in instrumental readings. A change of wind direction, by which the fog was blown over warmer water, caused it to evaporate. The chief cause of the evaporation of fog is probably an incresase of wind force.

FOG AND WIND FORCE.

There has been considerable discussion as to the strength of wind most conducive to fog formation, other factors being similar. We have seen that mixing of the air by turbulence is an essential part of the process of formation of normal sea fog and

this mixing is undoubtedly facilitated by light winds. Winds of forces 2 to 4 are generally considered as being most favourable for the thorough mixing of the layers of air over the sea. Winds of gale force in general act as dissipators of fog.

THE GENERAL DISTRIBUTION OF FOG AT SEA.

Generally speaking, fog decreases in frequency from the polar regions towards the equator and fog, apart from coastal fog, is rarely seen at sea between the parallels of 30° N. and S. We have seen that the main cause of sea fog is the passage of warm air over cooler water and these conditions do not usually occur in equatorial regions owing to the high sea temperatures prevailing there. Sea fog is, therefore, infrequent and light. From an examination of 265,304, days' observations in ships' logs, MAURY found that the foggiest latitudes between 60° N. and S. were between the parallels of 45° to 50° N. and between those of 50° and 55° S. He also determined the frequency of fog in Latitude 45° to 50° N. or S. compared with that in Latitude 5° N. to 5° S. to be in the proportion of 102 to 1. It is interesting to note that he found the corresponding figures for gales to be practically the same, 103 to 1. The polar regions are particularly foggy during the summer months when the warmer winds from the temperate regions reach more northerly latitudes and blow over colder water or over the ice.

In those parts of the oceans normally traversed by shipping the two outstanding foggy areas are the Grand Banks of Newfoundland and a similar region in nearly the same latitude of the Pacific Coast of Northern Asia, between the Aleutian and the Kuril Islands.

INDIVIDUAL FOG AREAS.

Reference is made to some markedly foggy areas, indicating the chief causes of the fog experienced in them, such as:

The Newfoundland Banks.
The corresponding Pacific Ocean area, lying to the south-west of Kamchatka.
On the New England Coast, especially from Cape Cod northward.
The United States Atlantic Coast.
The West Coast of North America.
The Gulf of Mexico.
The South Atlantic Ocean.
The coastal fogs of the North Sea.
The fogs of the Scandinavian Peninsula.

DETAILED DISTRIBUTION OF SEA FOG.

The detailed distribution of sea fog and its seasonal frequency in the open oceans is described.

Almost all the data available is derived from observations made before the introduction for international use of the visibility scale now in operation, in which the observation of fog, mist or conditions of good visibility depends upon the visibility of objects at definite distances. The scales of estimation previously in use were vague and it frequently happened that different observers gave inconsistent estimates, some describing an obscurity as fog while others called the same degree of obscurity mist, and so on. Unfortunately the introduction of the standard visibility scale has not entirely solved the problem of consistent observations at sea since objects at the requisite distance at any particular time are often lacking.

THE RELATION OF WIND DIRECTION TO FOG.

The wind direction associated with most fog should be that from which the warmest moist winds blow and such a direction is in general a fixed one for any given locality and month. In some areas there may, however, be more than one direction from which a wind sufficiently warm to produce fog blows.

Wind, Fog and Mist Roses for the S. W. Approaches to Home Waters are being published monthly in the *Marine Observer.*