

SHORTER CONTRIBUTION

ARCTIC SEA-SMOKE IN SOUTHERN QUEENSLAND

by H. E. Whittingham

Divisional Office, Brisbane

(Manuscript received 20th July, 1956)

On Sunday, 1st July, 1956, at 07 hours E.S.T. there occurred the unusual phenomenon of Arctic sea-smoke over the Pacific Ocean at Palm Beach, southern Queensland, in latitude $28^{\circ}7'$ S. Sea-smoke, frost smoke or steam fog as it is variously called is common in the Arctic (whence it derives its name) but is rare in tropical and subtropical waters. Starbuck (1953) describes an occurrence at Hong Kong. On this occasion the wind was north 23 knots, air temperature 44°F . and sea temperature 69°F . Hay (1956) states: "The chief features common to nearly all descriptions of frost smoke are that it is very shallow only a few feet thick - and only occurs when the air is considerably colder than the sea, and in these circumstances it is almost always associated with strong winds". Jacobs (1954) found in the Gulf of St. Lawrence that a minimum temperature difference of 16°F . between sea and air temperature was necessary before frost smoke would form. Hay (1953) describes Arctic frost smoke at a British weather ship and states that "it is not very widely observed outside the polar regions". On that occasion the air temperature was 27°F . and sea temperature 48°F . Wind was N force 7. The phenomenon depends on the vapour pressure gradient near the sea surface. In this case the vapour pressure difference was 8 mb. Hay mentions that in that particular region "a strong wind is essential to maintain a steep vapour pressure gradient", but on the other hand the resulting vigorous mixing is unfavourable for its formation, and suggests that "perhaps frost smoke can occur only in temporary lulls of the wind, which are sufficient to give time for the production of a thin saturated layer before the destructive process of turbulence starts afresh".

Byers (1944) quotes the unpublished work of P. E. Church on Lake Michigan which indicates that fog will form only if the vapour-pressure difference between the

water and the air at ship-deck level is in the vicinity of 5 mb or more. He points out that criteria based on minimum temperature differences are not sufficient since the vapour-pressure difference and the temperature difference do not stand in the same ratio at various temperatures. Church further found that the wind speed does not have a direct effect on the formation of steam, although it regulates its structural appearance. For a large vapour-pressure difference of the same magnitude, the steam will occur regardless of the wind speed. Furthermore, the steam occurs whether or not there exists a temperature inversion. In fact, some fogs were observed when the temperature lapse rate obviously was steep.

The phenomenon seen at Palm Beach was that of a shallow fog only a few feet thick extending over the Pacific Ocean to a distance of a half-mile or more from the shore. Viewed from a distance it appeared uniform but examination from the beach at a height of about 20 feet above sea level revealed a pattern resembling that of smoky fires set at the intersections of a rectangular grid.

This is in keeping with the formation of convective cells. The local surface wind was west force 2 at the time. This is interesting in view of the strong winds thought essential elsewhere. Eagle Farm airport pilot at 08 hours was as follows:-

3000 feet	250 deg.	21 knots
2000 "	250 "	26 "
1000 "	260 "	11 "

The radiosonde at 14 hours that day revealed a superadiabatic lapse rate from the ground to 350 feet, thence dry adiabatic up to an inversion at 4700 feet. The mixing ratio was constant at 4.0 gm/kgm up to the inversion.

Details of 07 hour temperatures at Palm Beach were:-

Air Temperature	37°F.
Grass Minimum	33°F.
Sea Temperature	66°F.
Relative Humidity	100%

Accordingly the vapour pressure difference between sea and air was at least 14 mb (compare Church's criterion of 5 mb).

REFERENCES

- | | | |
|-------------|------|--|
| Starbuck | 1953 | Weather, March 1953, pp. 77 - 78. |
| Hay, R.F.M. | 1956 | The Marine Observer, Vol. 26, pp. 89 - 94. |
| Jacobs | 1954 | The Marine Observer, Vol. 24, pp. 113 - 114. |
| Hay, R.F.M. | 1953 | The Marine Observer, Vol. 23, pp. 218 - 225. |
| Byers, H.R. | 1944 | General Meteorology. |