ORIGIN OF ATMOSPHERICS IN THE FAR EAST

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1. Introduction

A long course of study on atmospherics reveals us that there are two kinds of atmospherics, classifying according to their sources or origins. The one is the stationary whose origin moves very slowly after the changes of seasons. The other is the migratory whose origin moves rather swiftly with active centre of the local weather phenomena.

In order to study the correlation of atmospherics with almost all weather phenomena and at the same time to investigate the seasonal variation or displacement of the origins of atmospherics in the Far East, we made extensive investigation on the origin of atmospherics dy using many direction finding stations distributed all over Japan from October 1943 to December 1944.

We found that the origins of the stationary atmospherics in summer are some kind of thunderstorms or other bad weather in Malacca, Siam, Annam and the Sunda Islands, while in winter those in the Sunda Islands, New Guinea and the northern part of Australia. The yellow sand storm in Manchuria in May and June, the heat thunderstorms in the Japanese Alps as well as in the Chichibu and Nikko Ranges in summer, the volcanic smoke cloud in Mt. Asama and the sand storm in the Kanto Plains in spring are also found to be local orgins of the stationary atmospherics. As the origins of the migratory one we observed the active centre of the weather phenomena such as thunderstorms, typhoons, fronts, snow storms, heavy rains, cumulo-nimbus, etc. But the study on the relative displacement between the origin of atmospherics and the exact centre of the active weather phenomena should, I believe, be left to the future study.

2. Method of Observation

To study the detailed radio-electric properties of the active weather phenomena, it is necessary to use the means for detecting the exact position of the origin of atmospherics. For this purpose we generally adopt the cathode ray direction finder with photographic recording instrument, but it is so expensive to operate that we use them only to the research purpose for limited period[3].

Those direction finders of rotating frame type with sharp directivity, employed by us in Japan, Bureau[1] in France, and Lutkin[2] in England, are appropriate to observe, automatically and economically, the atmospherics of distant origin for a long period continuously. Even typhoons do not move with a speed of more than 40 km/hr., at most, and consequently the angular displacement of the origin of atmospherics per hour will be less than 1°, if we observe it at a station 2,000 km distant from the sources. In fact, in our case the number of rotation is 5 per hour, and therefore the angular displacement is less than 0.2° or 12′ per revolution. The direction finding stations used are as follows:

1) Cathode ray direction finder with photographic recording instrument:

Iwatsuki, Saitama-Pref., Honshû.

Kakioka, Ibaragi-Pref., Honshû.

2) Direction finder of rotating frame type with sharp directivity accompanied by automatic recording instrument:

Chitose, Hokkaido; Tokoyo; Yokosuka, Kanagawa-Pref., Honshû;

Kanoya, Kagoshima-Pref., Kyûshû; Kanaya, Shizuoka-Pref., Honshû;

Tainan, Formosa; Truk Island, The Caroline Islands; Rabaul, New Pommern Island near New Guinea (Fig. 1).

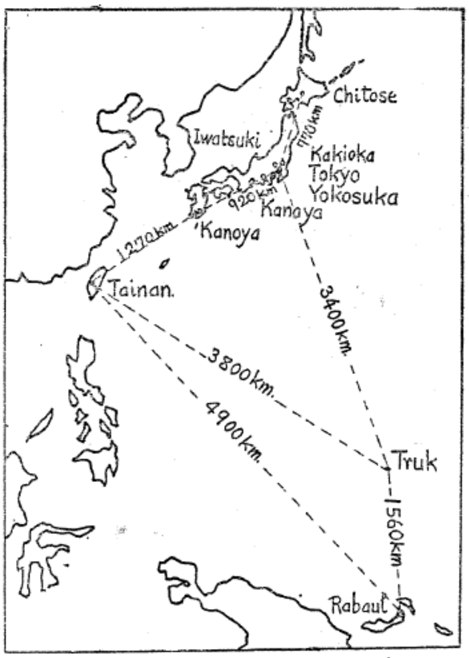

Fig. 1. Distribution of the direction finding stations of atmospherics.

This type of direction finder consists of two shielded frame antennae oriented vertically and mutually perpendicularly, two amplifiers connected to each frame antenna independently, and the automatic recording instrument.

The antenna system is composed of two shielded frames oriented vertically, crossing perpendicularly with each other at the middle point to avoid mutual inductive coupling and vertical pick up effect. Each of the component frame antennae is a square loop whose side is 50 cm in length and is wound up to 400 turns of enameled copper wires.

The antenna system is rotated once in 12 sec. by a pendulum clock mechanism in the one and by an electro-magnetic relay controlled by an electric clock connected to a 50 cycle power line in the other.

To compare the advantages of the two receiving systems we employed a straight amplifier with 120 db. gain in the one system, and a superheterodyne amplifier with 140 db. gain, adopting 60 kc/s as an intermediate frequency, in the other. Both of them could be tunable to 10 to 20 kc/s and the superheterodyne system was found better for sufficient gain with high selectivity.

As a recording system we used a pen and ink recording equipment on a rotating cylinder in the one system, and a speaking arrangement to a chemical paper on the cylinder in the other, both of which are rotated in synchronism with the rotating antenna system. We found finally the sparking method better suited for the reliable recording action.

3. Results and Discussions

1) Stationary Atmospherics

Observations were made on 12 kc/s. Main origins of the stationary atmospherics attacking Japan day and night all the year round are found to be thunderstorms and stormy weathers in the following places:

In summer: Sumatra, Java, Borneo, Malacca, Siam, and Annam (Fig. 2).

In winter: Sumatra, Java, Borneo, New Guinea, and the northern part of Australia (Fig. 3).

In spring: Sumatra, Java, Borneo, Malacca, Siam, Annam, and New Guinea (Fig. 4).

In autumn: Almost the same as in spring (Fig. 5).

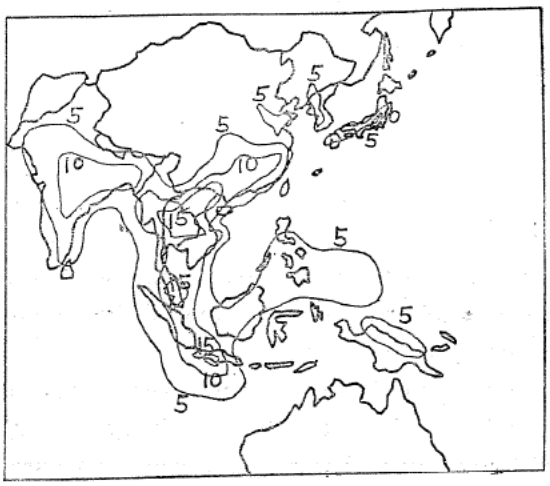

Fig. 2. Distribution of the origins of atmospherics in summer, number indicating the mean number of thunderstorm days per month.

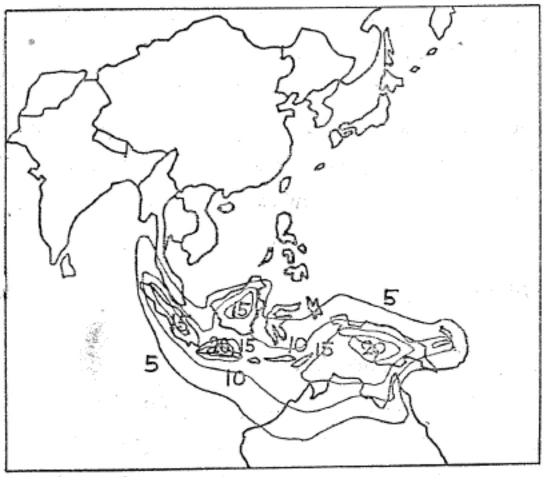

Fig. 3. Distribution of the origins of atmospherics in winter, number indicating the mean number of thunderstorm days per month.

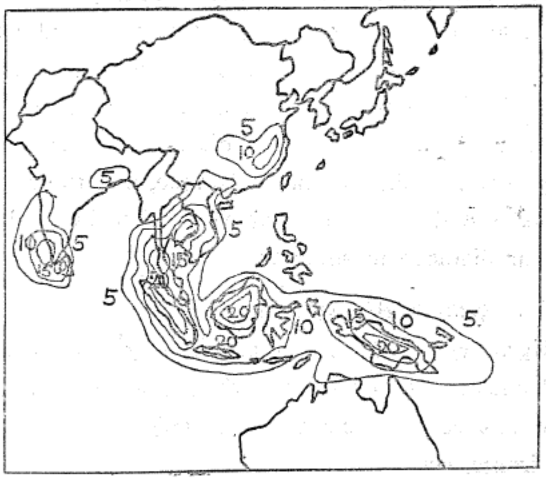

Fig. 4. Distribution of the origins of atmospherics in spring, number indicating the mean number of thunderstorm days per month.

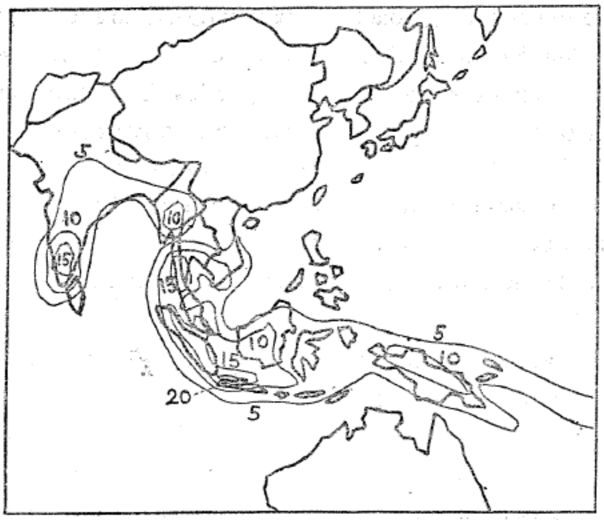

Fig. 5. Distribution of the origins of atmospherics in autumn, number indicating the mean number of thunderstorm days per month.

Thunderstorms in Africa do not arrive to Japan because of heavy attenuations in the course of propagation over the continent. But, those developed in the central part of India in summer are observed often late at night in the western direction, on the favourable condition of propagation. The seasonal variation of the main origin of the stationary atmospherics in the Far East suggests us to classify the four seasons unconformable to the calendar atmospherically as follows:

Spring: March, April.

Summer: May, June, July and August.

Autumn: September, October.

Winter: November, December, January and February.

The winter and snmmer are likely to be longer as compared with the spring aud autumn in the view of atmospherics. General tendency of the activity of atmospheric disturbances in Japan is found to be slight in the morning and heavy at night; in summer, however, much heavier atmospherics in the afternoon than those in the night are often observed on account of local thunderstorms. Main local origins of atmospherics in summer are heat thunderstorms in the Japanese Alps, the Chichibu and Nikko Ranges, while some in late spring result from yellow sand storms in Manchuria. Although these disturbances are of small scale, they are proved to be very powerful due to short distance, and their masking effect often so strongly overcomes the distant one that we used to be unable to detect the powerful origins in the far distance in summer.

2) Migratory Atmospherics

Migratory atmospherics are closely related to lightning flashes, cumulo-nimbus, typhoons, fronts, cyclones in the Japan Sea, heavy rains, showers, snow storms, yellow sand storms in Manchuria, volcanic smoke clouds of Mt. Asama, low pressures on the fronts, ect.

The typhoon is generated in the Caroline Islands mainly from June to October every year, and then, going up to the north, approaches Japan in describing a parabolic course. Consequently, the direction finding stations in Japan observe, at first, some peculiar modification in the direction of stationary atmospherics from the tropics, being mixed with that of typhoon; as it draws to Japan the relative displacement between the origin of atmospherics and the typhonic centre appears clearly and the atmospherics of typhoon seems to come from its south-eastern sector where the weather is considered to be most active (Fig. 6). For the present, however, we are deficient in the data concerned, and so the conclusion is to be postponed to the future study.

The cyclone is one of the most active stormy weather phenomena in winter originated in the temperate zone. Several kinds of cyclone are observable in the neighbourhood of Japan in winter, among which those developed in Siberia, passing the Japan Sea from November to February in describing a parabolic course to Kamchatka Peninsula, are most intimately correlated with atmospherics (1 in Fig. 7). Their

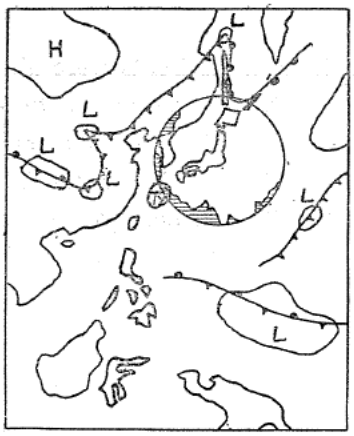

Fig. 6. Directional distribution of atmospherics in Tokyo and the weather conditions on 1st August, 1944 (6.00 JST).

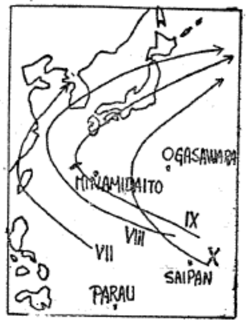

Fig. 6 a. Typical course of typhoon in the Far East, the numbers VII, VIII, IX and X indicating the names of the months, *i.e.* July, August, September and October respectively.

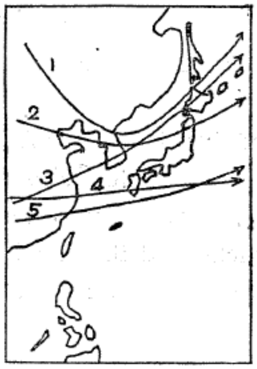

Fig. 7. Typical course of cyclone in the Far East, numbers indicating their kinds.

intensity depends upon the activity of cyclones, while it becomes unobservable when the cyclonic activity decays. Whether the atmospherics are generated in the cold front or the warm front of the cyclone is not yet ascertained and their solution is expected in future study.

The most remarkable source of atmospherics is, of course, the lightning flash of every kind, and the cumulo-nimbus is also found to radiate atmospherics whose intensity and frequency of incidence increases as it develops. We made an extensive study on these phenomena and reported already in another papers.[6)7)8)] Almost all cases of thunderstorms and cumulo-nimbus in the thunderstorm report as well as in the aeronautical weather report in Japan were observed as the sources of atmospherics. Consequently, accustomed operators in the receiving stations could often forecast the afternoon thunderstorms in summer by noticing the atmospherics in the morning.

Low pressures accompanying precipitation or those on the fronts were always found to be origins of atmospherics, while the other inactive low peressures to radiate no atmospherics (Fig. 8). Snow storms, sand storms in spring, volcanic smoke clouds of Mt. Asama, heavy rains, showers, and yellow sand storms in Manchuria were also found to be the sources; especially in the neighbourhood of centres of snow storm or yellow sand storms the radio communications are seriously disturbed.

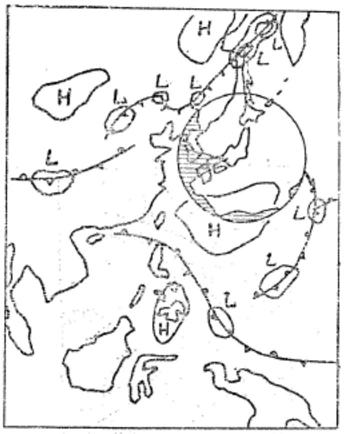

Fig. 8. Directional distribution of atmospherics in Tokyo and the weather conditions on 11th July, 1944 (10.00 JST).

The fronts are generally extended in long curves, over which the origins of atmospherics are scattered at random. The curves connecting these sources coincide fairly well with the fronts on the weather maps, and therefore they contribute much to make weather maps.

It seems very likely that the most favourable condition for developing the heavy atmospherics due to disturbed small particles, such as sand storms in spring, snow storms, yellow sand storms, volcanic smoke, clouds, depends upon the disturbing wind velocity, the magnitude of sand or snow particles and the humidity of snow. These should be studied in the laboratory in addition to the observatory in the next period.

4. Acknowledgement

This work has been done under the direction of the Lightning Research Committee in Japan whose president is Dr. S. Fujiwara. The author wishes to acknowledge his indebtness to Dr. M. Shibuzawa and Dr. T. Otani for their kind support and useful suggestions, and to Messrs. Fujita, Amano, and Kondo for their heartful assistances.

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Appendix

The Effect of Local Conditions on Direction Finding of Atmospherics

According to our experience for constructing the direction finders of atmospherics on very long wave range such as 10 to 20 kc/s, it is not difficult to get the accuracy of 0.5°, if we take adequate precautions for making and setting. We can easily mention several causes to degrade the accurracy, among which so called 'night effect' is of course the heaviest; even in day time, however, we have often experienced harmful influences by the surrounding objects and find very few literature concerning the problem in very long wave range. Therefore, in order to get numerical data for accuracy, we made a direction finding test by receiving the wave of 17.442 kc/s (17.4 km in wave length) from Yosami Sending Station, situated at a distance of 25 miles south-east of our observatory.

We selected the two receiving points where we could see by the transit the down lead of the sending antenna of Yosami Station. The one is the Higashiyama Observatory of Nagoya University, and the other is the former naval aerodrome at Kôwa. We compared the direction of the down lead of the antenna by the transit observation with that observed by the direction finder. Three specimens of direction finders of rotating frame type were employed and the following results were obtained.

1) Direction finder itself has errors less than 0.5°, which was found at the Higashiyama Observatory.

2) The error due to 3,300 volts power line is 15° at a distance of 3 meters and 3 at 15 meters.

3) The error due to local telephone line is 3° at a distance of 3 meters.

4) The error due to iron frame work is 16° at a distance of 1 meter and 5° at 3 meters.

5) The error due to near-by tuned frame antenna not in the direction of the sending station is 2° at a distance of 8 meters.

6) The effect due to thick woods is not simple. In the thick pine forest, even in winter, it is impossible to get lemniscate or cardioid figure, while on the tower as high as the top of the trees in the same forest, it was very easy to get rid of this disturbance. It may be due to the induced current in the tree which is max. at the surface of the earth as Smith-Rose said. In this experiment the field intensity was about 110 mV/m, which may probably be considered as a higher value for the intensity of atmospherics, and so it may be safe to consider this value as a somewhat lower value and to take precautions to avoid any possible effects due to surrounding objects.