THE TYPHOON KEZIA AND ATMOSPHERICS

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1. Condition of the Generation of Atmospherics

Since the beginning of our study on atmospherics in 1928, we have long been investigating the correlation of atmospherics with individual active weather phenomena such as thunderstorms, showers, typhoons, fronts, cyclones, cumulo-nimbus, etc., in observing their wave form[3] and at the same time in measuring their direction of arrival.[1)2)4)7)] The origin of atmospherics, however, was located very often on the sea, where there are generally few meteorological observatories, and so it is sometimes difficult to make "one to one" correspondence between the origins of atmospherics with weather phenomena.

In these two or three years, however, documents, concerning upper atmosphere such as 3,000 m or 6,000 m high measured by airplanes or radio soundings, are available in addition to the ordinary meteorological data on the earth; the former informs us not only reliable meteorological situation on the sea or in the inlands, but also weather conditions correlated more intimately with the origin of atmospherics. According to the measurement made by O. H. Gish and H. G. Booker[6] on the ionization in the troposphere and lower stratosphere, it increases with the altitude above sea level till 15,000 m. Therefore, it is quite natural that disturbances in the upper region are most intimately correlated with electrical phenomena, in particular with atmospherics.

Recently we studied carefully the correlation of atmospherics with the meteorological information in the upper atmosphere, especially at 3,000 m high, and found that origins of atmospherics are mainly scattered over the area of conditional instability liable to develop frontal thunderstorms or air-mass thunderstorms.[11] The former occurs on account of instability released through ascent of air along frontal surfaces, the latter develops on account of instability within the air masses. Both are coincident in generating a strong ascending current of warm and wet air masses which develops at least cumulo-nimbus; when it is more active, it generates showers or thunderstorms according to the degree of activity.

On the other hand, we observed from 1940 to 1944[3] many wave forms of atmospherics originating from several kinds of lightning flashes and cumulo-nimbus. Lightning flashes, whatever they may be—discharge between clouds and earth, or among clouds—they are generally considered as some kinds of damped wave generator. Really, we find high frequency components in the discharging current of lightning flashes as shown in Fig. 1, and we find also light and dark stripes of some 100 μs intervals in the picture of lightning, taken by Boys' camera.[9] According to the analysis made on the observation of the wave form of atmospherics, the maximum energy is found to be concentrated in 7.5[3] to 10[5] kc/s, which is fairly well coincident with the frequency of main component of discharging current, and also with the stripe intervals of lightning pictures. These facts confirms us that the lightning flash is the most powerful origin of atmospherics as approved by many researchers for long.

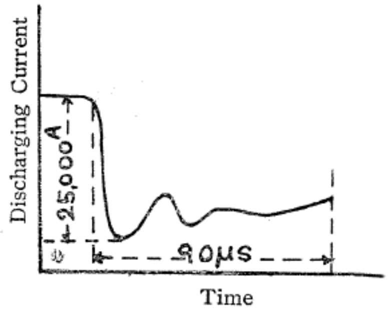


Fig. 1. The discharging current of lightning flashes.

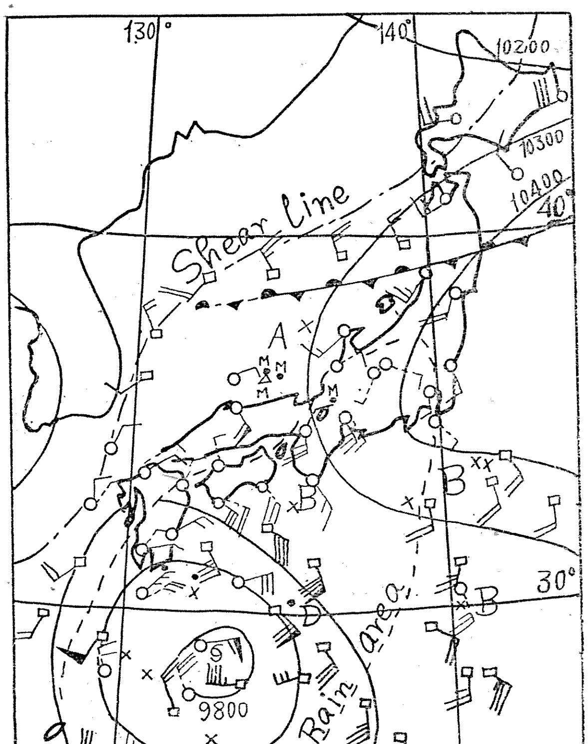
The shower is a similar kind but somewhat weaker disturbances than those of thunderstorms, and so it is very natural to consider the shower also to be the source of atmospherics, and, really, in our experience, we have found very often it is true. It is well known that cumulo-nimbus has a very strong electric field within it,[10] at least between the top and the bottom; in consequence, there should be many random discharges between small drops of water within the cloud under the strong field. To see the feature of random discharges between water drops under the strog field, we made a model experiment by taking photographs of a suspension insulator poured with rain drops under the strong electric field. In enlarging the film we found many random discharges between the water drops on the insulator. Accordingly similar random discharges within cumulo-nimbus should radiate atmospherics, and we observed really a lot of their wave forms already[3].

In summer, when a warm and wet air mass is heated heavily by the radiated heat from the earth due to sunshine, we observe thunderstorms, showers, cumulo-nimbus, etc. of so called air mass type; and we observe corresponding atmospherics mainly on land. When a hot and wet air mass, blown by a heavy wind, strikes a slope of mountains, it generates a strong ascending air current and results cumulo-nimbus, showers, and thunderstorms respectively according to the activities. This is one of another air mass type and it occurs often in the mountains in the tropical zone by the monsoon,[7] and sometimes in Japan influenced by the approaching typhoon.[4] In other seasons, however, sometimes even in summer as in 1950, convergence of two or more air masses of different characteristics occurs very often. They develop cold fronts, occluded fronts, some kind of active warm fronts, and other similar disturbances and we observe thunderstorms, showers, cumulo-nimbus, etc. of frontal type; corresponding atmospherics are found in the convergence zone, the latter occupying the main part of atmospherics generally observed either on land or on the sea.

2. Method and Circumstances of Observation

To prove the consideration adove mentioned we are going to show some examples taken from the observation made in last autumn. At first we shall make brief remarks on the method and circumstances of observation. It was made in the autumn of 1950 at the observatory of Nagoya University in Nagoya (35° 09′ N, 136° 58′ E) and the observatory of the Research Institute of Atmospherics, Nagoya University at Toyokawa (34° 50′ N, 137° 22′ E); as the distance between them, about 50 km, is too small and we have experienced inconveniences, we opened recently a new station in Chiba-Prefecture, distant about 300 km from Toyokawa, and the spring observation is to be made there. These two stations mentioned above are in the middle of the wide plains in Aichi-Prefecture, being free from disturbances due to electric railways, factories, power transmission lines, communication lines, woods or forests, hills or mountains, etc. The power lines and communication lines are introduced by under ground cables. Those circumstances make the observatories quite ideal as to the elimination of artificial noises and the distortionless wave propagation, although the base line is too short.

Cathode ray direction finders with photographic camera are employed together with receivers of a straight amplification type with 126 db. gain; the high gain is required due to the necessity of using photosensitive cathode ray oscillograph. The



Fig, 2. The distribution of origins of atmospherics on September 12th, 1950. (11.01 to 13.02 JMT). ··· indicates surface wind, × origins of atmospherics at 11.01, ● at 11.31, and △ at 12.31.

film speed is 10 mm/s. Every day observation was made at 08.00, 12.00, 17.00, 18.00, 19.00, 23.00 JMT, each time from 01 to 02 for one minute.

3. Examples

We shall explain following examples after our interpretation.

(1) *September 12th, 1950.* (11.01 to 13.02 JMT) (Fig. 2)

Origins of atmospherics are plotted on the weather chart of upper atmosphere at 700 mb, and wind directions, fronts and rain areas on the earth are also described as reference. A high pressure is on the Pacific Ocean and the Typhoon Kezia is on the sea south-east of Kyûshû. We shall explain the origins of atmospherics in classifying in four groups, i.e. *A, B, C* and *D.*

B and *D* are generated in the convergence area of the warm and wet air mass coming from the high pressure region on the North Pacific Ocean and the hot and wet air mass coming from the tropical zone accompanied by the Typhoon Kizia. *A* is generated in the convergence zone made by these hot and warm air in ascending above the cold air coming from Siberia by way of the Japan Sea. In fact, at Kanazawa (in *A* region) cumulo-nimbus and thunderbolts were observed, and at Shiono-

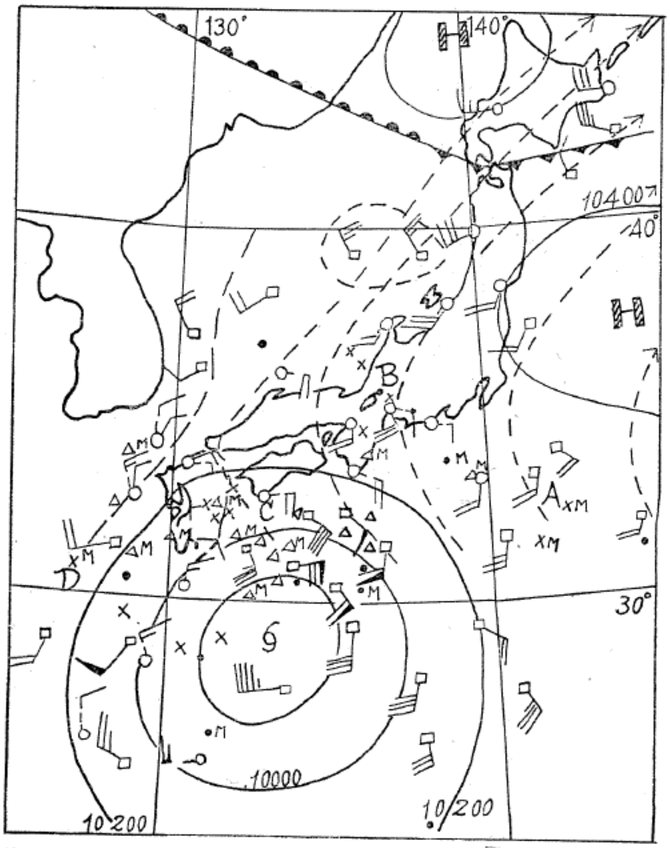


Fig. 3. The distribution of origins of atmospherics on September 12th, 1950. (17.01 to 19.02 JMT). ··· indicates surface wind, ◉ origins at 17.01, △ at 18.01, × at 19.01.

misaki (in *D* region) cumulo-nimbus. In *D* region the wind velocity in 700 mb layer was so large as to reach 30 to 40 m/s, and the disturbance is considered to be very heavy there. *C* is generated by the contact of the hot and wet air mass accompanied by the typhoon with the warm and dry air mass from China. At Yakujima (in *C* region) showers are observed, and at Naze (in *C* region) cumulo-nimbus.

(2) *September 12th, 1950.* (17.01 to 19.02 JMT) (Fig. 3)

Origins of atmospherics are plotted in the same way as in case (1). A high pressure is on the Pacific Ocean and the Typhoon Kezia is on the sea south-east of Kyûshû. Origins of atmospherics are classified in four groups, *A*, *B*, *C* and *D*.

A and *C* are generated in the convergence area of the warm and wet air mass coming from the high pressure region on the North Pacific Ocean and the hot and wet air mass coming from the tropical zone accompanied by the Typhoon Kezia; in particular, in *C* region the wind velocity is very high, i.e. 30 to 40 m/s, and consequently the disturbance is taken to be very strong there. *B* is generated in the convergence zone made by the hot and wet air in ascending above the cold air coming from Siberia across the Japan Sea. *D* is mainly due to the convergence of the warm and

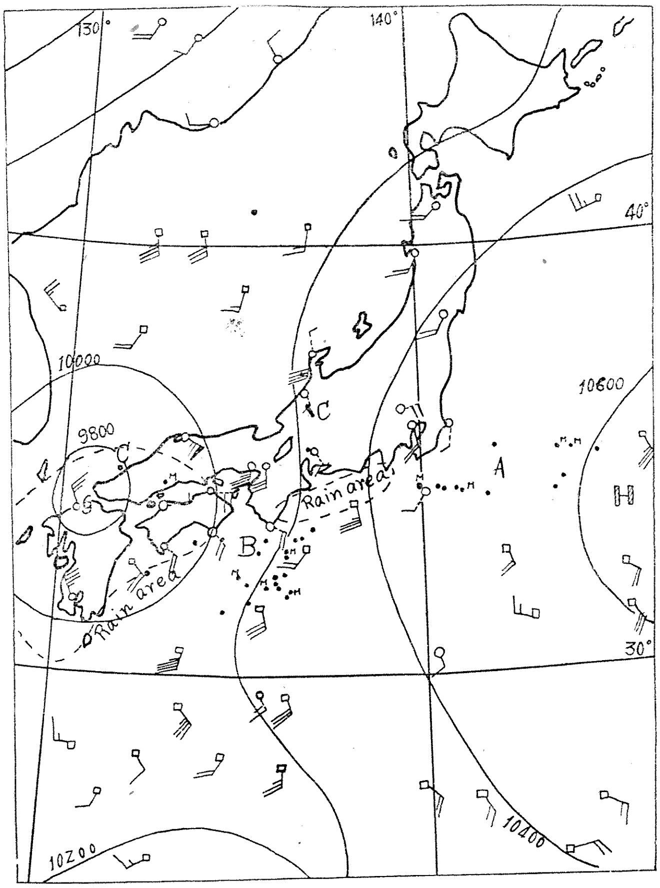


Fig. 4. The distribution of origins of atmospherics on September 13th, 1950. (23.01 to 23.02 JMT). ··· indicates surface wind, ● origins of atmospherics.

dry air mass coming from China and the hot and wet air mass of the typhoon, but there is a trough passing the Korea Strait from the Japan Sea to the East China Sea, and therefore some part of D may be connected to the convergence of the cold air mass from Siberia and the air mass mentioned above.

(3) *September 13th, 1950.* (23.01 to 23.02 JMT) (Fig. 4)

Origins of atmospherics are plotted in the same way as in case (1). A high pressure is on the Pacific Ocean and the typhoon Kezia is on the north end of Kyûshû. Origins of atmospherics are classified in three groups, A, B and C. In this case tropical cyclones are at 16° N, 145° E and 15° N, 133° E, and they are coming to the north. Consequently A and B are due to the convergence of the warm and wet air mass coming from the high pressure region on the North Pacific Ocean and the hot and wet air mass coming from the tropical zone accompanied by the typhoon or tropical cyclones. C is generated in the convergence region made by the hot and wet air mass coming from the tropical zone in ascending above the cold air mass coming from Siberia.

(4) *September 14th, 1950.* (08.01 to 08.02 JMT) (Fig. 5)

Origins of atmospherics are plotted in the same way as in case (1). A high pressure is on the Pacific Ocean and the Typhoon Kezia is off the coast of San-in

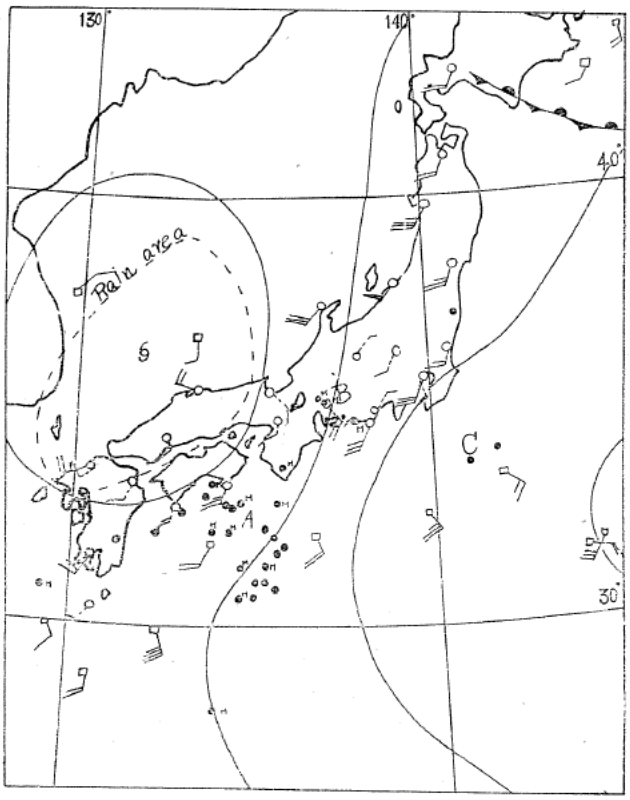


Fig. 5. The distribution of origins of atmospherics on September 14th, 1950. (08.01 to 08.02 JMT). ··· indicates surface wind, ● origins of atmospherics.

District on the Japan Sea. Tropical cyclones are at 23° N, 140° E and 16° N, 133° E, and are coming to the north. Origins of atmospherics are classified in three groups, *A*, *B* and *C*.

All of them are considered to be due to the convergence of the warm and wet air mass of the high pressure on the North Pacific Ocean and the hot and wet air mass coming from the tropical zone accompanied by the typhoon or tropical cyclones, in particular, in *A* the influence of the typhoon seems to appear remarkably, and the wind velocity is fairly high, i.e. about 25 m/s. It is rather interesting that the disturbance seems to be prevented by the Honshû to advance and is staying off the coast of Shikoku on the Pacific Ocean, decaying gradually as the typhoon goes through Kyûshû into the Japan Sea. The tendency was noticed in the observations following this one.

(5) *September 14th, 1950*. (17.01 to 19.02 JMT) (Fig. 6)

Origins of atmospherics are plotted in the same way as in case (1). A high pressure is on the Pacific Ocean and the typhoon is somewhat modified to be the low pressure of the middle latitude and generates a cold front from its centre to the south-western direction. Tropical cyclones are at 20° N, 133° E and 15° N, 146° E and are coming to the north. Origins of atmospherics are classified in three groups, *A*, *B* and *C*.

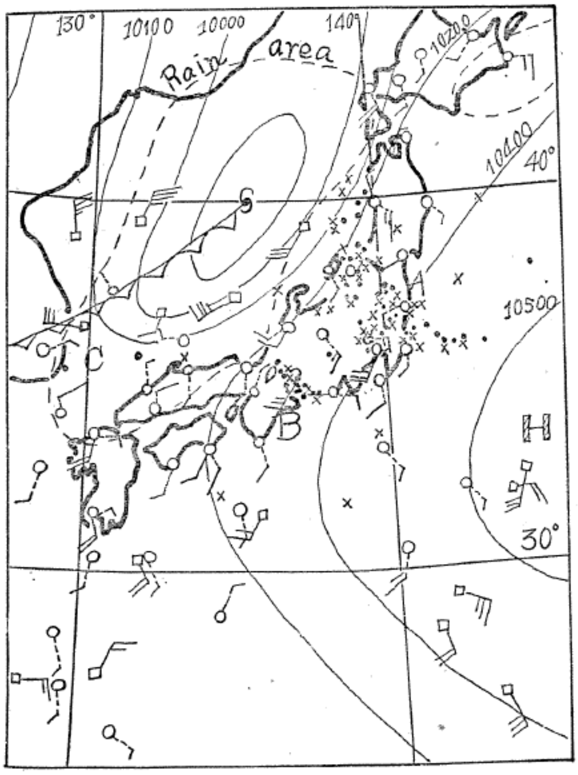
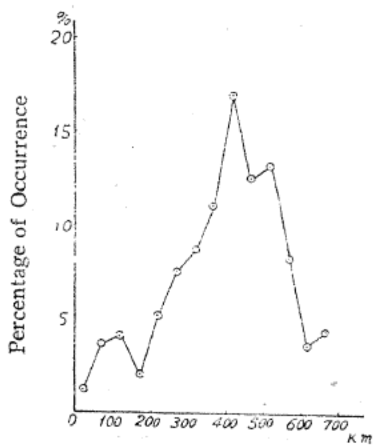


Fig. 6. The distribution of origins of atmospherics on September 14th, 1950 (17.01~19.02 JMT) in the neighbourhood of the Typhoon Kezia. ··· indicates surface wind, ● origins of atmospherics at 18.01, and × at 19.01.

All of them are according to the convergence of the hot and wet air mass coming from the tropical zone and the cold air mass from Siberia, while some part of C may be due to the convergence of the warm and dry air mass from China and the air masses mentioned above. A trough passes through the west of B, and therefore some part of B may be generated in the air mass flowing in to the north-western direction.

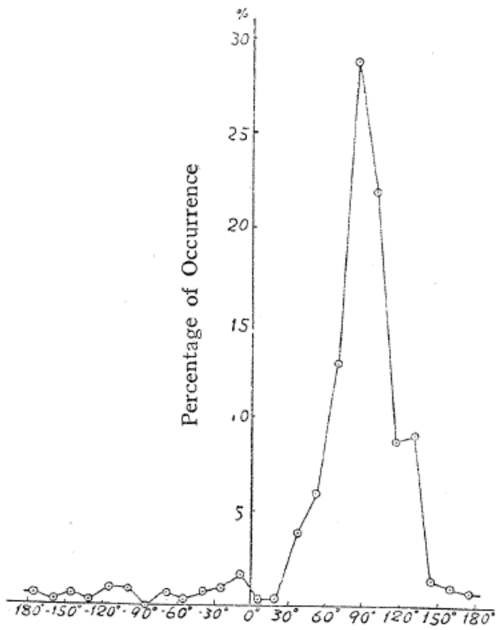
4. Atmospherics of the Typhoon Kezia

As these examples are all concerned with the typhoon Kezia, I shall take this opportunity to make some remarks on the atmospherics connected with it. Taking statistically the distribution of the origin of atmospherics around the typhoon in this series of observation, we obtain the results shown in Fig. 7 and in Table 1, where the origins are distributed most frequently on the right hand side of the centre of the typhoon, especially in the perpendicular direction to the course, and they increase slowly with distance from centre to 400 km, showing a small maximum at 100 km in addition to a remarkable one at 400 km and then decrease rather rapidly to 600 km. In the Typhoon Kitty the distribution of the wind velocity at 3,000 m and 6,000 m high has almost the same tendency with the distribution of origins of atmospherics in our case, and it has maximum at the distance between 300 to 400 km from the centre.[8] As the Kezia came to Japan in about the same season, if we assume almost the same construction for the Kezia, the most frequent distribution of the origin of atmospherics may be considered as the indication of the most active



Distance from Centre

Fig. 7*a*



Direction from the Course.

Fig. 7*b*

Table 1. The distribution of origins of atmospherics in the neighbourhood of the Typhoon Kezia.

Direction from the Course (in degree) \ Distance from Centre (in km.)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	Total No.	%
0								1							1	0.3
15			1												1	0.3
30		2	1				3	2	3						11	3.8
45		2	1	2	2	1	3	2	2	1	1				17	5.9
60		1	3		4	10	5	6	5	1	1			1	37	12.8
75		2	2	1	2	4	5	6	23	12	10	8	4	4	83	28.7
90		1			1	4	6	10	7	10	13	9	1	1	63	21.8
105				1			1		5	6	4	4	4		25	8.7
120	1				1	1		2	3	3	6	2	2	5	26	9.0
135				1					1	1				1	4	1.4
150				1						2					3	1.0
165											1			1	2	0.7
180	1											1			2	0.7
−165		1													1	0.3
−150		1						1							2	0.7
−135	1														1	0.3
−120	1				2										3	1.0
−105					1	1	1								3	1.0
−90																
−75		1	1												2	0.7
−60			1												1	0.3
−45			1				1								2	0.7
−30					1	1					1				3	1.0
−15			1		1			2			1				5	1.7
Total No.	4	11	12	6	15	22	25	32	49	36	38	24	11	13	298	
%	1.4	3.8	4.2	2.1	5.2	7.6	8.7	11.1	17.0	12.5	13.2	8.3	3.8	4.5		

part of them. As T. Otani and others noticed, in the neighbourhood of Japan, in the right hand side of typhoon there are always so heavy convergent phenomena of the hot and wet air mass from the tropics due to the narrow area held between the high pressure on the Pacific and the centre of the typhoon and also due to contact with the cold air mass from the north that there should be concentrated distribution of origins of atmospherics. Consequently, the distinguished peak at the

+90° point of the diagram in Fig. 7*b* is interpreted very naturally according to the heavy disturbances there. Moreover, as shown in Fig. 2 to 6, simple continuous rain areas have no connection with origins of atmospherics.

The Typhoon Kezia seems to have changed its character after passing Kyûshû. At 18.01 JMT, September 13th, when it was crossing Kyûshû, origins of atmospherics were off the coast of Shikoku on the Pacific Ocean. As the typhoon advanced and went into the Japan Sea, origins of atmospherics were found to be gradually weakened, and we can notice it clearly by the observations at 23.01 JMT, September 13th, 08.01 JMT, September 14th, and 12.01 JMT, September 14th; when the typhoon reached at the point 40° N, 135° E on the Japan Sea, new origins of atmospherics appeared on the southern part of Ô-u District and on the northern part of Kantô District mainly on mountain slopes.[4] Origins on the Pacific Ocean are considered mainly due to the convergence of the hot and wet air mass from the tropics and the warm and wet air mass from the high pressure on the pacific, while origins on the Japan Sea due to the convergence of the cold air mass from Siberia and the somewhat modified hot and wet air mass from the tropics. Consequently, as the character of the typhoon changed from tropical to temperate, so changed the system of origins of atmospherics from the one on the Pacific to the one on Ô-u and Kantô District. As described above in (5), it is very likely that the disturbed air mass was hindered by Honshû to go through into the Japan Sea, decaying there and at the same time displacing very slowly to the south.

5. Conclusion

The author proposes the consideration that the main origins of atmospherics are the symbol indicating the degree of disturbances in the region of conditional instability, of which he confirmed the frontal case, i.e. the convergence of two or more air masses of different characteristics in the upper atmosphere (3,000 m to 6,000 m high). This proposition is not only justified on physics of the formation of atmospherics, discussing from the view point of electromagnetic waves and atmospheric electricity as well as from the meteorological point of view, but also it is confirmed by the observations actually made for years. In this paper the examples concerning the Typhoon Kezia are given and explained in detail; the author makes use of the occasion to suggest a useful method for study of the construction and character of the typhoon in observing atmospherics.

6. Acknowledgement

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