

A STUDY OF WINTER THUNDERSTORMS IN THE HOKURIKU COASTAL AREA, JAPAN

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ABSTRACT: For about a century, studies concerning summer thunderstorms in the middle latitude zone have elucidated data on both their meteorological and electrical features. By contrast, winter thunderstorms have been studied only for the last few decades. For both reasons of scientific interest and the practical purpose of preventing serious damage by winter thunderbolts to aircrafts and electric power systems, studies of winter thunderstorms have currently become one of the focuses of lightning research. The authors carried out thunderstorm observations in winter in the vicinity of Komatsu airport, which is situated on the Hokuriku coastline, for about 20 years. They used radar with CAPPI (Constant Altitude Plan Position Indicator) performance for thundercloud observations, a VHF sferics direction-finder system for lightning detection, and a network of field mills installed on 27 sites mutually separated by about 10 km for the investigation of thundercloud electrical structure. The present work elucidates the meteorological and electrical nature of winter thunderstorms and clarifies how the aerological conditions determine the grade of the lightning activity. Also, the authors introduce a new direction-finding system (SAFIR), which was installed in the vicinity of Komatsu airport on 1st March 2003. We can present latest results which were obtained with this new SAFIR system.

INTRODUCTION

Figure 1 shows the map of the Hokuriku district including Komatsu Airport and Wajima aerological weather station of Japan Meteorological Agency, including the sferics direction finder antenna sites at Komatsu, Shishiku and Kariyasu.

Figure 2 shows the detailed map of our observational field in the surrounding Komatsu Airport. This figure shows the 5.7 cm wave-length weather radar (No. 1), three antennas of the

sferics direction-finder system (No. 1, 12, 23), and 27 field mills (No. 1-27).



Figure 1. Map of Hokuriku district

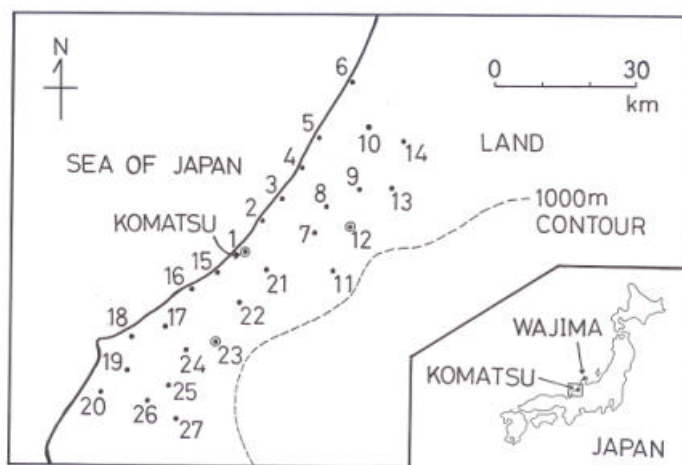
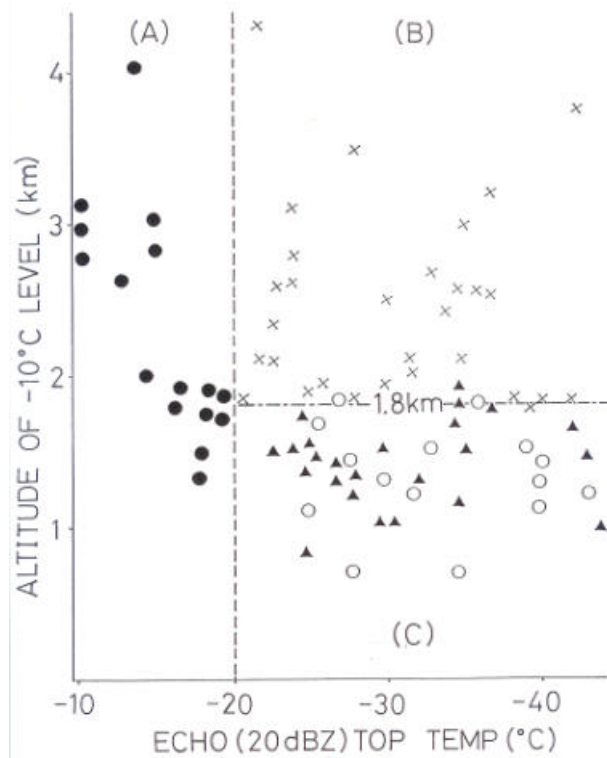


Figure 2. Detailed map of observational area

ANALYSES

Figure 3 shows the relationship of lightning activity with the altitude of the -10 degrees of centigrade (hereinafter -10C) level in winter convective clouds. The observation was made in the vicinity of Komatsu Airport. Temperature at the top of echoes is indicated on the abscissa and the altitude of the -10C level on the ordinate. Area (A) shows that, when the temperature at the top of echoes does not exceed the -20C level (broken line), convective clouds exhibit no lightning activity (black circles). Area (B) shows that, when the -10C level is higher than 1.8 km (dashed-and-dotted line), convective clouds exhibit relatively intense lightning activity (cross marks). Area (C) shows that, when the -10C level is lower than 1.8 km, convective clouds exhibit no lightning activity (open circles) or only very weak lightning activity (black triangles).



When the altitude of the -10C level is lower than about 1.4 km, convective clouds exhibit no natural lightning discharge.

Figure 3. The relationship of lightning activity with the -10C altitude level

CASE STUDY AND STATISTICS OF LIGHTNING STRIKES TO THE AIRCRAFT

These are suitable highly in midwinter thunderstorms along the coast of the Sea of Japan. In fact, in midwinter almost all lightning activities that occur are weak ones known as “Single-Flash Thunderstorms” (“Ippatsu-Rai” in Japanese).

On 6th January 1997, an aircraft took off Komatsu Airport and was struck by lightning that was obviously triggered by its invasion into the graupel area of the active convective clouds.

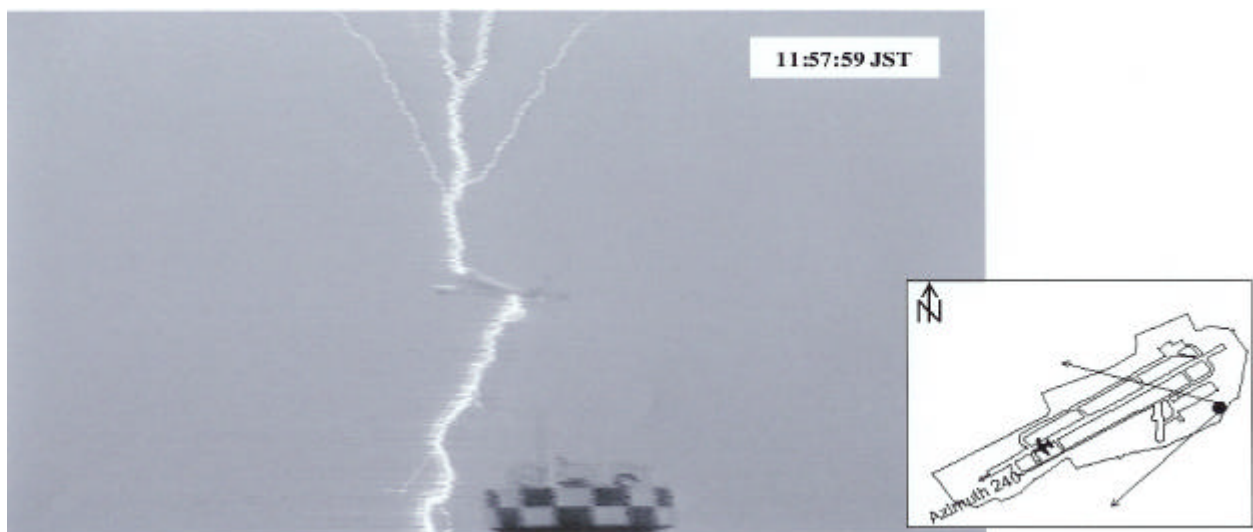


Figure 4. Video image of the lightning strike to the aircraft on 6th January 1997

Figure 4 shows the video image of the lightning strike to the aircraft over Komatsu Airport at 11:57:59 JST on 6th January 1997. According to our sferics direction finding system and optical observations around Komatsu Airport, there were no lightning flashes on the day. We can assert that the lightning strike to the aircraft was obviously triggered lightning by the aircraft's invasion into the graupel area.

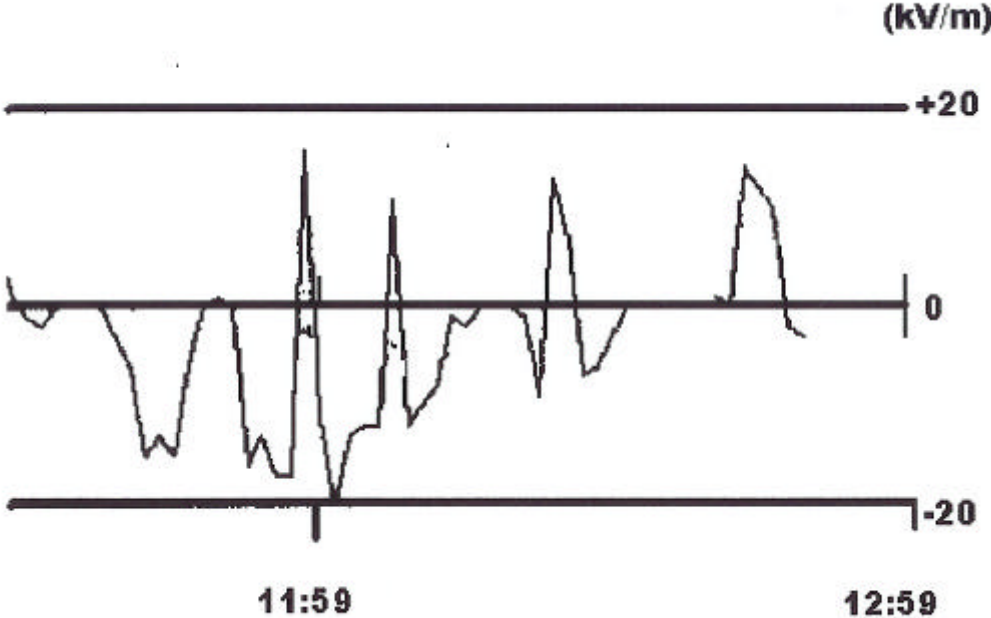


Figure 5. Surface electric field variation obtained by the field mill at Komatsu Airport

Figure 5 shows the variation of electric field at Komatsu Airport. It indicates that the positive peak value occurred right before the lightning strike to the aircraft, and this means that falling positive charged graupel particles were located over Komatsu Airport. From the result, this triggered lightning strike to the aircraft was a negative Cloud-to-Ground flash initiated by an upward positive leader to the negative charged region and a downward negative leader to the ground after falling out of the "Positive charged graupel" particles.

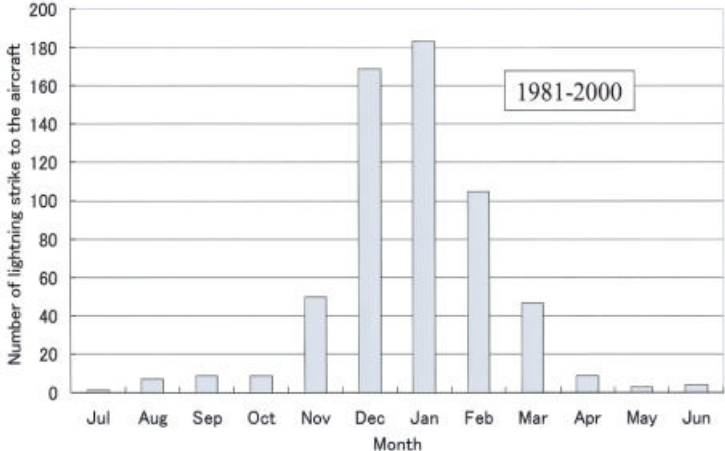


Figure 6 shows the seasonal variation of lightning strikes to aircraft around Komatsu Airport for the 20-year period from 1981 to 2000. The peak value occurred in January and most lightning strikes to the aircraft occurred in winter, and especially in December, January and February.

Figure 6. Seasonal variation of lightning strikes to aircraft around Komatsu Airport

NEW DIRECTION FINDING SYSTEM (SAFIR)

Table 1 presents a comparison between the new direction-finding system (SAFIR) and the old one. We can obtain intra- or cloud-to-cloud lightning discharges and cloud-to-ground discharges distinguished from each other.

We intend to use this new SAFIR system to observe lightning discharges in thunderstorms and lightning strikes to aircraft. Several observational results will be presented in the ICAE conference in Versailles, France.

Table 1. Comparison between the new system (SAFIR) and the old one

	New direction-finding system (SAFIR)	Old system
Reception frequency	VHF (110-118MHz)	VHF (100.5MHz)
Antenna	Dipole antenna	Yagi antenna
Time control	GPS	Internal crystal watch
Effective range	200km	100km
Resolution	3km rms	7km rms
Discrimination	Intra, C-C and C-G	None

CONCLUSION

To prevent aircraft-triggered lightning, we need more observation results and have to further clarify the electrical structure of winter thunderclouds.

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