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EXAMPLES OF WINTER LIGHTNING OBSERVED BY THE JLDN

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1. INTRODUCTION

The Japanese Lightning Detection Network (JLDN), owned and operated by Franklin Japan Corporation (FJC), currently consists of 13 IMPACT-ESP and 16 LPATS-IV sensors. The sensor locations of the JLDN in 2007 are shown in Figure 1.

Lightning occurs over a broad area on the western side of Japan in winter and there are several types of lightning distributions observed by the JLDN. This paper presents four examples of typical lightning distribution patterns in winter observed by the JLDN.

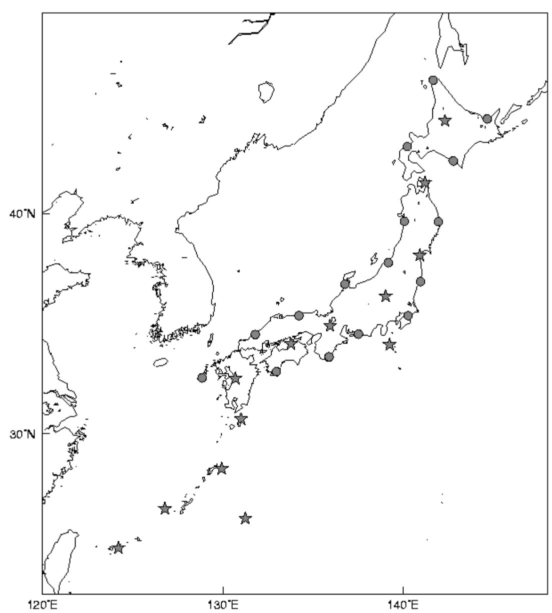

Figure 1. JLDN Sensor Map in 2007. Circles show LPATS-IV sensors and stars show IMPACT-ESP sensors.

2. DATA

The authors analyzed lightning stroke data observed by the JLDN on the western side of Japan and over the Sea of Japan from November to December in 2007 excluding small current value events from –2kA to 5kA. Lightning stroke data on the Pacific side of Japan and over the Pacific were also not included in the data set. In this paper, the data identified as cloud lightning by the JLDN are also analyzed, because there is a high probability that they might be upward lightning if they are high current events (Saito et al. 2006). All the lightning data analyzed in this paper are strokes, not flashes.

3. FOUR TYPES OF WINTER LIGHTNING DISTRIBUTIONS

Patterns of winter lighting are classified into four types simply according to the distribution of lightning strokes observed by the JLDN. No meteorological features are taken into consideration to help to understand lightning conditions except surface weather maps provided by the Japan Meteorological Agency (JMA).

In all the lightning distribution maps in this paper, dots indicate negative strokes and crosses are positive strokes. The color of these symbols changes every 6 hours in the order of blue, green, yellow and red.

In this paper, "coast" means the area roughly along the coastline of the Sea of Japan. The distances between the coastline and topographical features are not considered because of the broad area of analysis approximately 880km long. The paper does not distinguish between the mountains and plains.

<u>3.1 Frontal Type</u>

The first type is lightning associated with a cold front. An example of this type is shown in Figure 2. The distribution of lightning strokes approaching Japan corresponded to the movement of the cold front described in Figure 3.

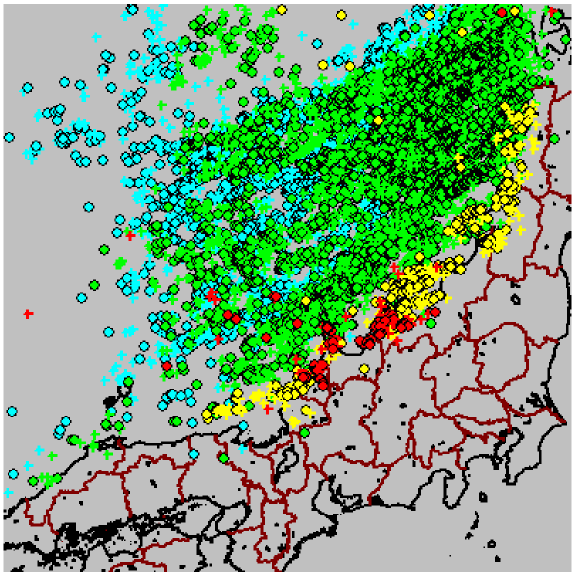

Figure 2. Lightning strokes detected by the JLDN on November 20, 2007.

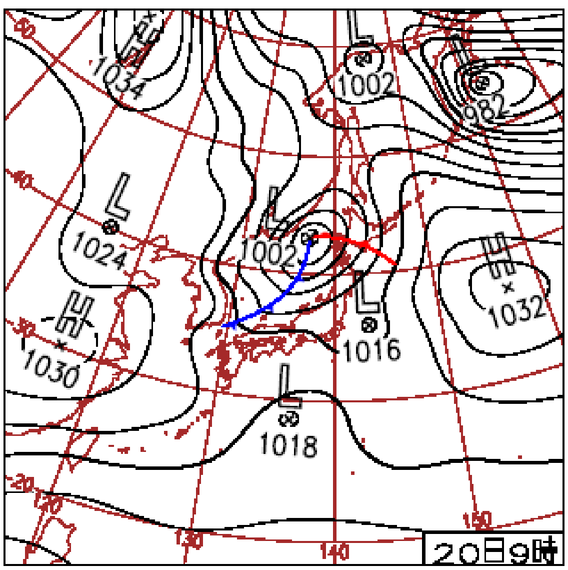

Figure 3. Surface weather map at 0900 JST on November 20, 2007 provided by the JMA.

The frequency of lightning is very high but the ratio of positive strokes is not so high in this type. The total number of negative strokes is higher than the number of positive strokes but, among lightning strokes with absolute current values higher than 50kA, there are more positive strokes than negative strokes. Most of the high current lightning strokes occur over the sea.

In Figure 2, the total number of positive strokes is 4320 and that of negative strokes is 9466. There are 225 positive lightning strokes and 43 negative strokes with absolute current values higher than 100kA.

3.2 Mesoscale-low Type

A second type of lightning is shown in Figure 4. This is lightning associated with a mesoscale-low including a weak, small depression and a pressure trough that does not appear clearly on a surface weather map as shown in Figure 5. Lighting strokes occur not only on the coast, but also over the Sea of Japan away from the coastline. The ratio of positive strokes is very high in this type of lightning and the ratio of positive strokes with high current is also high.

In Figure 4, the total number of positive strokes is 634 and that of negative strokes is 504. The total quantities of lightning strokes with absolute current values higher than 100kA are 62 positives and 5 negatives.

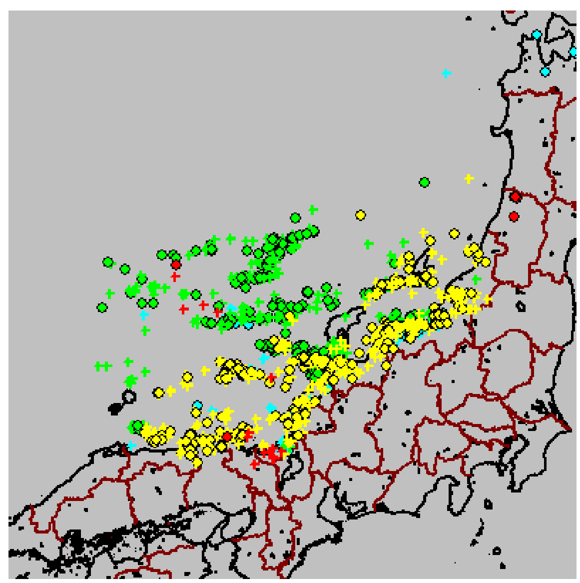

Figure 4. Lightning strokes detected by the JLDN on November 21, 2007.

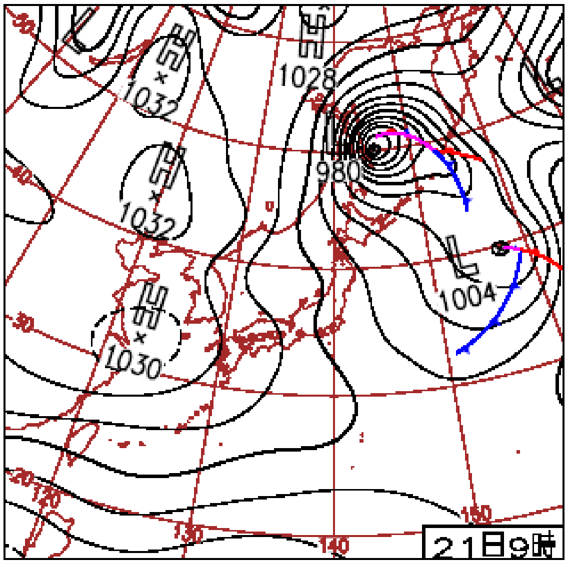

Figure 5. Surface weather map at 0900 JST on November 21, 2007 provided by the JMA.

3.3 Isolated Type

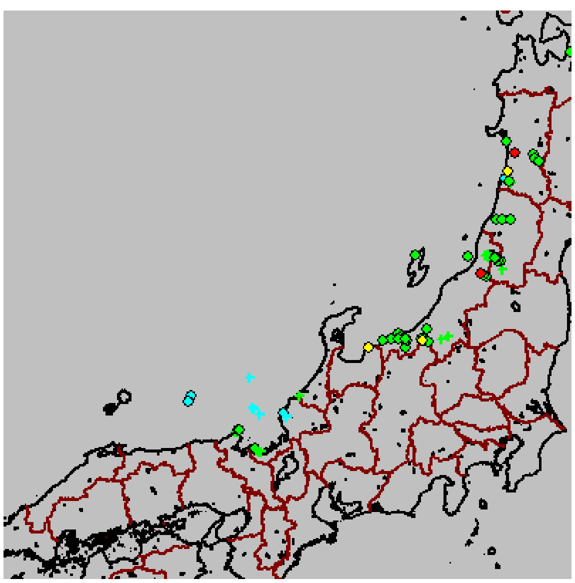

Figure 6. Lightning strokes detected by the JLDN on November 22, 2007.

The third type is lightning occurring sparsely as shown in Figure 6. The surface pressure pattern is a high to the west and a low to the east as shown in Figure 7 when this type occurs. The total number of strokes is very low and there are more negative strokes than positive strokes. High current lightning strokes sometimes occur, but it is not possible to say whether there are a lot or a few because of the limited total number of strokes.

In Figure 6, the total number of positive strokes is 21 and that of negative strokes is 48. There are 2 positive lightning strokes and 3 negative strokes with absolute current values higher than 100kA.

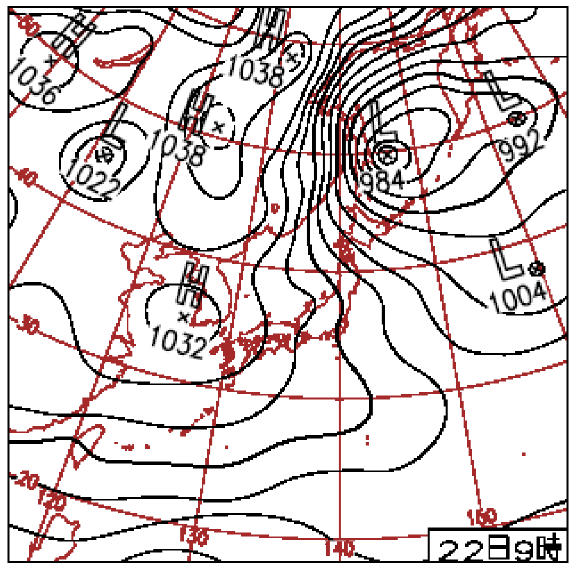

Figure 7. Surface weather map at 0900 JST on November 22, 2007 provided by the JMA.

3.4 Coastline Type

The fourth type is lightning occurring continuously on the coast of the Sea of Japan as shown in Figure 8. Like the isolated type, the coastline type is seen in the so-called winter pressure pattern in Japan shown in Figure 9. Other data is necessary to distinguish the different meteorological factors associated with each type.

The pattern of lightning distributions in this type and the mesoscale-low type look apparently alike, but, unlike the mesoscale-low type, the lightning strokes over the sea occur only close to the coast.

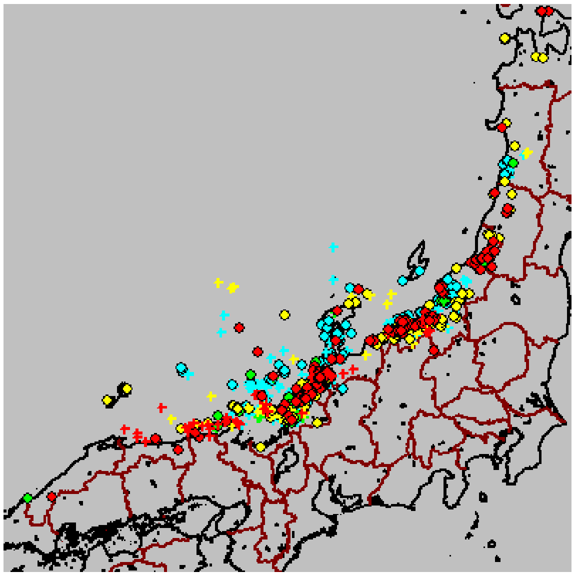

Figure 8. Lightning strokes detected by the JLDN on December 31, 2007.

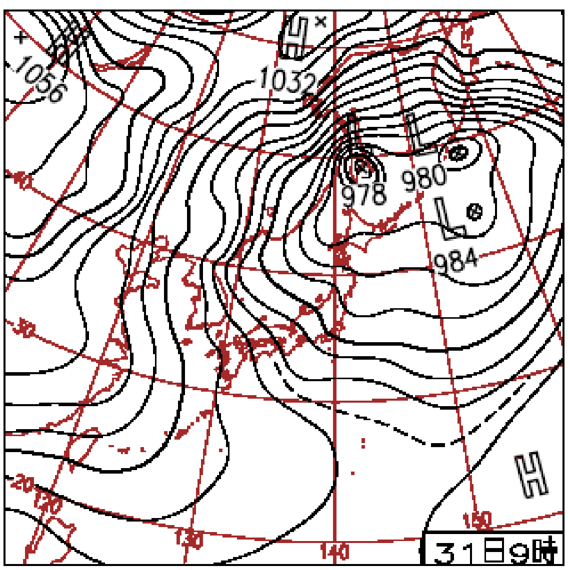

Figure 9. Surface weather map at 0900 JST on December 31, 2007 provided by the JMA.

This type has a low ratio of positive lightning strokes and more high current negative lightning strokes.

In Figure 8, the total number of positive strokes is 308 and that of negative strokes is 570. There are 8 positive lightning strokes and 65 negative strokes with absolute current values higher than 100kA.

5. DISCUSSION

Based on meteorological observations in the Hokuriku District, Kobayashi et al. (1996) pointed out that winter thunderclouds are classified into three types: 1) the frontal type, 2) the winter monsoon type and 3) the cold air mass type. Considering synoptic patterns, the isolated type lightning and coastline type lightning in this paper may be associated with the Kobayashi et al. winter monsoon thunderclouds while the mesoscale-low type in this paper may be associated with their cold air mass type. However, it is difficult to apply their lightning characteristic classifications to the lightning types in this paper. That may be mainly because of differences in the observation area. It may also be because the classifications in this paper were done using daily lightning distributions. The number of lightning strokes depends on the scale of the mesoscale disturbance so it is difficult to define a spatial-temporal standard for the classifications.

6. CONCLUSIONS

Winter lightning distributions observed by the JLDN were classified into four types. There are differences in the lightning characteristics of each type though the classifications were done using only distribution patterns and only two months of data from one winter. It is necessary to accumulate more examples for further investigations. In particular, meteorological analyses of these classifications will be the most important future work.

<u>*Acknowledgement*</u>

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