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LIGHTNING DISTRIBUTIONS IN WINTER 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 thirteen IMPACT-ESP sensors, eleven LPATS-IV sensors and six LS7001 sensors. The JLDN sensor locations in 2010 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. The authors introduced four examples of typical lightning distribution patterns in winter observed by the JLDN in their previous paper (Sugita et al. 2008). The four types are named the frontal type, the mesoscale-low type, the isolated type and the coastline type. This paper will report on the authors' continued research.

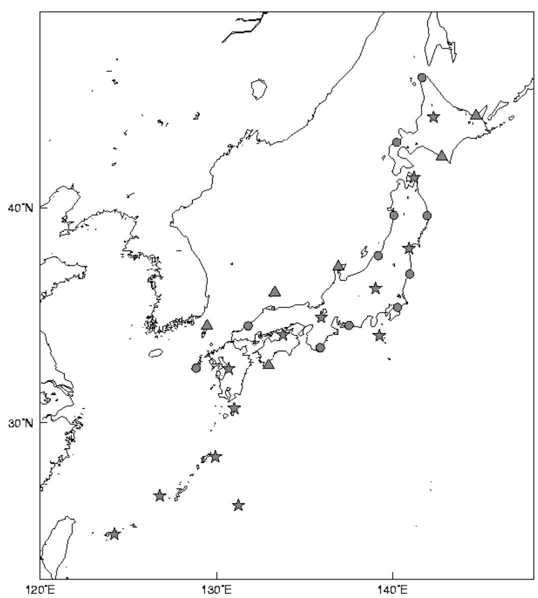

Figure 1: JLDN Sensor Map in 2010. Circles show LPATS-IV sensors, stars show IMPACT-ESP sensors and triangles show LS7001 sensors.

2. DATA

The authors analyzed lightning stroke data observed by the JLDN during three winter seasons on the western side of Japan and over the Sea of Japan. We studied data from October 1, 2007 to March 31, 2008, from October 1, 2008 to March 31, 2009 and from October 1, 2009 to February 15, 2010. We excluded small current value events from –2kA to 5kA. The analyzed region is shown in Figure 2. In this paper, the data identified as cloud lightning by the JLDN are also analyzed, because there is a high probability that those events 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.

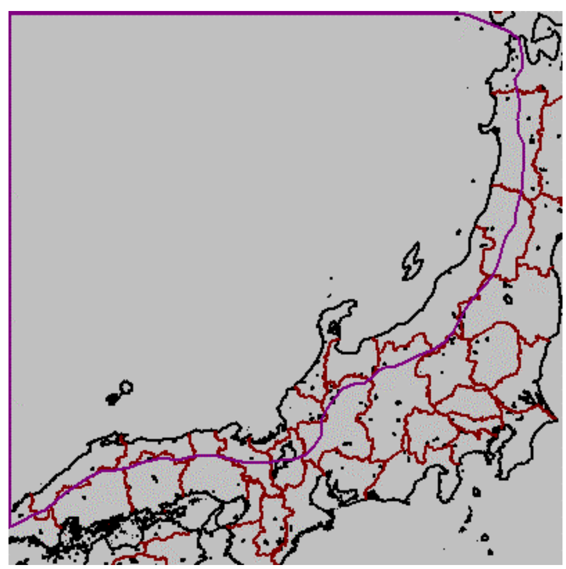

Figure 2: Analyzed region. Lightning strokes inside the purple line were counted.

There were 426 days that had one or more lightning strokes in the analyzed region in Figure 2. Lightning strokes distributed only over the Sea of

Japan were not classified even they had the characteristics of one of the four types. In the isolated type events, if the number of lightning strokes over the Sea of Japan was larger than those on the coast, the distribution was not counted.

3. ANALYSYS

Patterns of winter lightning are classified into four types simply according to the daily distribution of lightning strokes observed by the JLDN. No meteorological features are taken into consideration to help understand the lightning conditions except those included in 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.

It is very difficult to classify all the lightning distributions into the four types because there are composite events that include more than one type. The 109 lightning distributions reported in this paper are relatively easy to classify.

The dates of the frontal type, the mesoscale-low type and the coastline type are shown in Table 1 and the dates of the isolated type are shown in Table 2.

Each type has the same lightning characteristics as were shown in Sugita et al. (2008) although the number of lightning distribution examples has increased.

TABLE 1: List of dates three types occurred.

Frontal	Mesoscale-low	Coastline
20071112	20071118	20071230
20081026	20071121	20071231
20081121	20071214	20080101
20081211	20081118	20081231
	20081119	20090101
	20081218	20090113
	20081225	20090125
	20090119	20091218
	20091010	20091231
	20091217	20100106
	20091220	20100113
	20100105	

TABLE 2: List of dates the isolated type occurred.

20071009	20081002	20091007
20071010	20081012	20091008
20071122	20081104	20091024
20080102	20081206	20091103
20080111	20081215	20091112
20080112	20081221	20091113
20080113	20081226	20091124
20080114	20081227	20091207
20080116	20081228	20091212
20080125	20090102	20091215
20080131	20090103	20100101
20080201	20090111	20100109
20080202	20090115	20100116
20080208	20090122	20100117
20080213	20090123	20100122
20080214	20090127	20100123
20080216	20090131	20100126
20080217	20090208	20100130
20080224	20090210	20100131
20080226	20090216	20100203
20080227	20090217	20100204
20080228	20090218	20100206
20080304	20090221	20100207
20080305	20090227	20100215
20080310	20090306	
20080317	20090311	
20080319	20090314	
20080320	20090327	
20080329	20090328	

3.1 Frontal Type

There are four frontal type events in the analyzed data. An example of this type is shown in Figure 3. As shown in Table 1, this type does not occur frequently. The number of lightning events is very high but the percentage of positive strokes is relatively low in this type. The total number of negative strokes is higher than the number of positive strokes but, among the 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 3, the total number of positive strokes is 6889 and there were 9778 negative strokes. There are 374 positive lightning strokes and 131 negative strokes with absolute current values higher than 100kA.

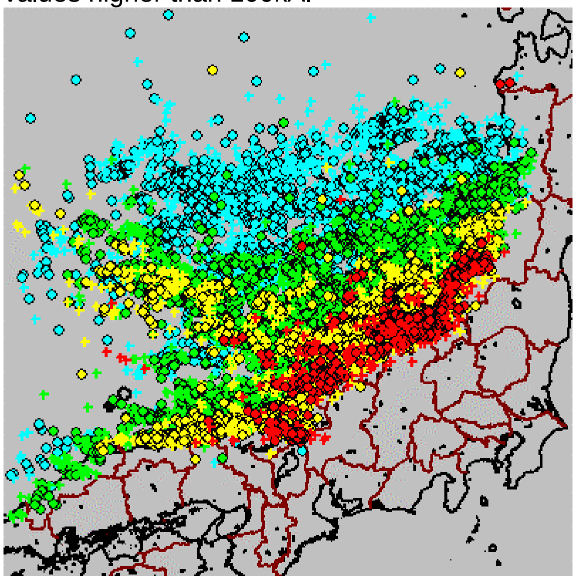

Figure 3: Lightning strokes detected by the JLDN on November 21, 2008.

3.2 Mesoscale-low Type

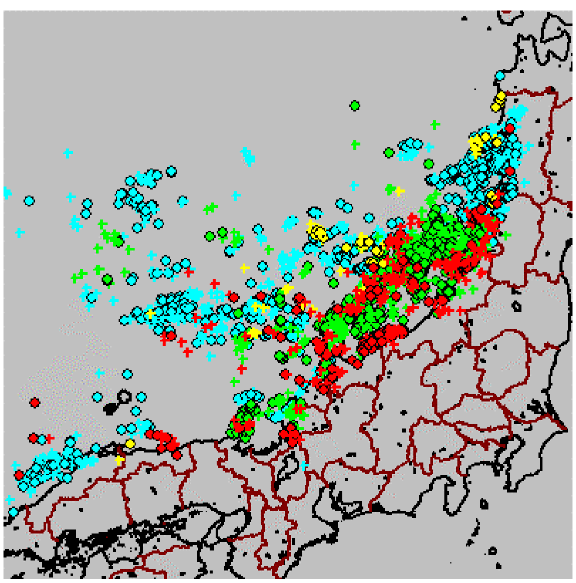

Figure 4: Lightning strokes detected by the JLDN on November 18, 2008.

There are 12 mesoscale-low type events in the analyzed region. An example of this type is shown in Figure 4. 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 1507 and that of negative strokes is 1454. Among lightning strokes with absolute current values higher than 100kA, there are 107 positives and 13 negatives.

3.3 Isolated Type

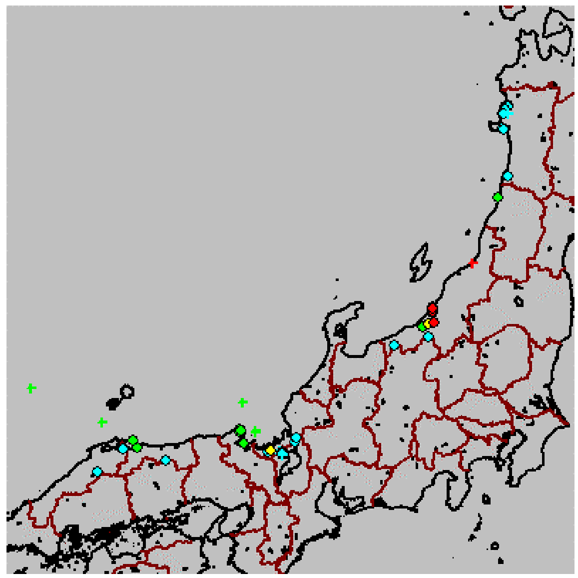

Figure 5: Lightning strokes detected by the JLDN on December 26, 2008.

There are 82 isolated type events in the analyzed region. This type occurs most frequently of the four types. That is, this is the most typical winter lightning in Japan including a single lightning stroke. An example of this type is shown in Figure 5.

The total number of strokes is very low and there are more negative strokes than positive strokes. High current lightning strokes sometimes occur.

In Figure 5, the total number of positive strokes is 10 and the number of negative strokes is 44. There are 1 positive lightning stroke and 3 negative strokes with absolute current values higher than 100kA.

3.4 Coastline Type

There are 11 coastline type events in the analyzed region. It is interesting that this type occurs on almost the same day in each year as shown in Table 1.

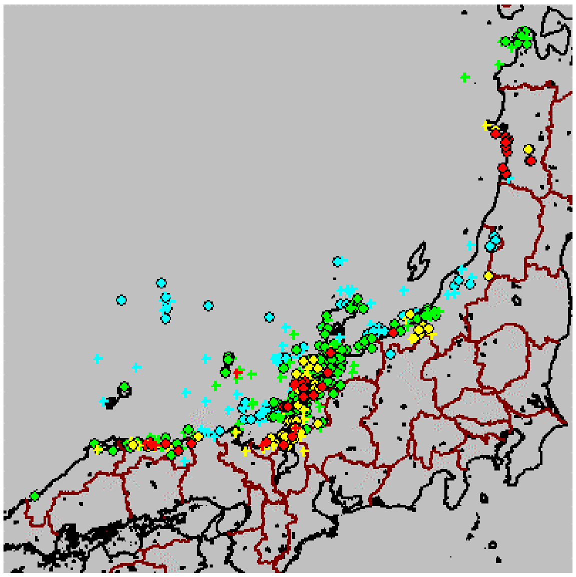

Figure 6: Lightning strokes detected by the JLDN on December 31, 2009.

This type has a low percentage of positive lightning strokes and more high current negative lightning strokes. An example of this type is shown in Figure 6.

In Figure 6, the total number of positive strokes is 237. There are 434 negative strokes. There are 18 positive lightning strokes and 16 negative strokes with absolute current values higher than 100kA.

4. DISCUSSION

Table 3 shows the averaged lightning characteristic values of each type. It is very clear that each type has different lightning characteristics.

The total number of lightning strokes is very high in the frontal type and very low in the isolated type. The percentage of lightning strokes with absolute current values higher than 100 kA is high in the coastline type and low in the frontal type. The mesoscale-low type and the isolated type have almost the same percentage of lightning strokes with absolute current values higher than 100 kA. This means high current lightning strokes occur with almost the same probability both types.

Among the lightning strokes with absolute current values higher than 100 kA, the percentage of positive strokes is very high in the frontal type and the isolated type although the percentage of total lightning strokes of both types that was positive is not so high. The coastline type has more high current negative lightning strokes than the other three types.

TABLE 3: Averaged lightning characteristic values of the frontal type (F), mesoscale-low type (M), isolated type (I) and coastline type (C).

	F	M	I	C
Total number	12780	2099	15.5	601.5
Percent Positive	36.01	45.53	28.69	35.33
Percent Over 100kA	2.05	4.83	4.32	6.70
Percent of Strokes over 100kA that were Positive	82.00	75.84	69.09	32.28

5. CONCLUSIONS

Winter lightning distributions observed by the JLDN were classified into four types. There are discernable differences in the lightning characteristics of each type even though the classifications were done using only distribution patterns and the number of lightning distribution examples increased from one winter season set of data to three. The effort to classify other types of lightning distributions for further investigations and meteorological analyses of these classifications will be the most important future work.

Acknowledgement

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