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Lightning Occurrence Characteristics in 2015 in Japan as Observed by the JLDN

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***Abstract*—The Japanese Lightning Detection Network (JLDN) started observing lightning discharges in 1998 and grew to cover the four main islands of Japan in 2000. Lightning observed in 2015 was greatly different from Japan's typical years. The annual number of lightning strokes in the analyzed area in 2015 was 2,104,004. This is the lowest number of strokes since 2002. In 2015, the number of lightning strokes in July, October and December was the lowest since the JLDN began observations.**

Keywords—LLS; lightning frequency; thunderstorm days;

I. Introduction

The Japanese Lightning Detection Network (JLDN), owned and operated by Franklin Japan Corporation (FJC), began operation in 1998 and has covered the four main islands of Japan (Hokkaido, Honshu, Shikoku and Kyushu) since 2000. FJC is currently working to replace the older sensors in the network with new sensors. As of December 2015, the JLDN consists of six IMPACT-ESP, three LPATS-IV, eleven LS7001 and ten TLS200 sensors.

The authors described the characteristics of lightning in Japan observed by the JLDN for the decade from 2001 to 2010 at the 2012 ILMC [Sugita and Matsui, 2012]. There are two main seasonal variations in lightning occurrence characteristics. One is the tendency of the monthly number of lightning strokes to increase rapidly in July and to go even higher in August. The other is the frequent occurrence of lightning in winter on the coast of the Sea of Japan especially in the Hokuriku region. However, lightning activity in 2015 varied greatly from the typical pattern. This paper compares the characteristics of lightning that occurred in 2015 in Japan with the average values obtained covering 10 years of historical data.

II. Data

The authors analyzed lightning stroke data observed by the JLDN in 2015. Small discharges with peak currents ranging from -2kA to 5kA are not counted in this paper.

All analyses were done in the region from 26.5°N to 48.5°N in latitude and from 126°E to 148°E in longitude, and the geographical plots in this paper are done with a spatial resolution of 0.2 degrees. All the lightning data analyzed in this paper are not flashes but strokes, because the JLDN outputs only stroke data. It should also be pointed out that the influence of the changes of the JLDN configuration and sensor characteristics have not been considered.

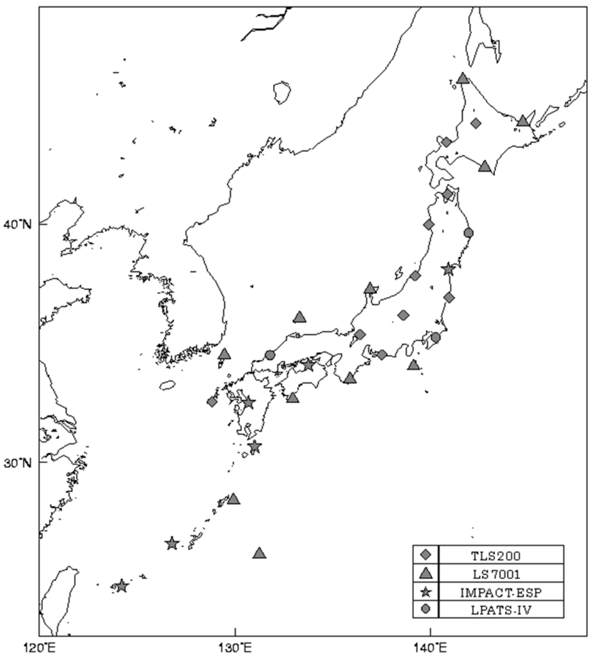

Fig. 1. JLDN Sensor Map as of December 2015. The circles are LPATS-IV sensors, the stars are IMPACT-ESP sensors, the triangles are LS7001 sensors and the diamonds are TLS200 sensors.

III. Results

A. The Number of Lightning Strokes

Figure 2 shows the annual number of lightning strokes from 2001 to 2015. The annual number of lightning strokes in the analyzed area in 2015 was 2,104,004. This is the second lowest value after 2002 and the number of strokes is approximately 800,000 lower than the mean annual number of lightning strokes during the ten year period ending in 2010, 2,932,332 [Sugita and Matsui, 2012]. As shown in Figure 2, the annual number of lightning strokes has tended to decrease after peaking in 2012.

Figure 3 shows the monthly distribution of the number of lightning strokes in 2015 and the mean monthly distribution of lightning strokes from 2001 to 2010. As shown in Figure 3, the monthly distribution of the number of lightning strokes in 2015 is greatly different from the historic mean. The mean monthly number of lightning strokes is approximately 700,000 in July and 786,500 in August. However, the number of lightning strokes in July 2015 was the lowest for that month since the JLDN began observations. The number of lightning strokes in July 2015 was 122,721. This is the first time that the number of lightning strokes did not reach 200,000 in summer and this value is less than 20% of the mean monthly number of lightning strokes in July. There were 551,941 lightning strokes in August 2015. This value is 30% below the mean monthly number of strokes in August. Although we know lightning characteristics vary greatly from year to year, we were surprised at the low level of lightning activity in the summer of 2015.

One of the causes of the reduced number of lightning strokes in July 2015 was the Baiu front that remained stationary for a long period of time. Another reason is that three typhoons came to Japan one after another. Cloudy and rainy days were dominant on the Pacific side of Japan. The convection resulting from solar heating which frequently occurs in summer in the mountainous regions of Japan and causes lightning strokes only occurred in limited areas in 2015.

The number of lightning strokes was very low in winter as well as summer. The number of lightning strokes in December 2015 was 16,289 and this value is approximately 20% of the mean monthly number of lightning strokes in December. The Japan Meteorological Agency reported that the winter monsoon was weaker than normal and sustained periods of extremely warm days persisted in December 2015 causing monthly mean temperatures to be significantly above normal all over Japan [Japan Meteorological Agency, 2016]. This is the reason that winter lightning did not occur in Hokuriku as frequently as usual. In 2015, July, October and December had the lowest number of lightning strokes since the JLDN began observations.

On the other hand, the number of lightning strokes in April, June and September exceeded the mean values. This is because of fronts that stayed longer and areas of low pressure that frequently passed through and around Japan.

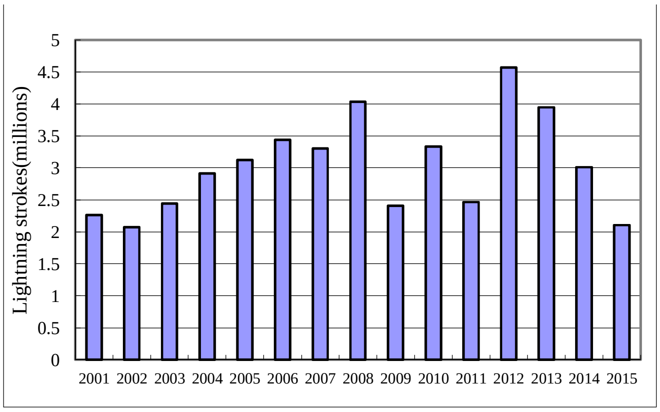

Fig. 2. The annual number of lightning strokes from 2001 to 2015

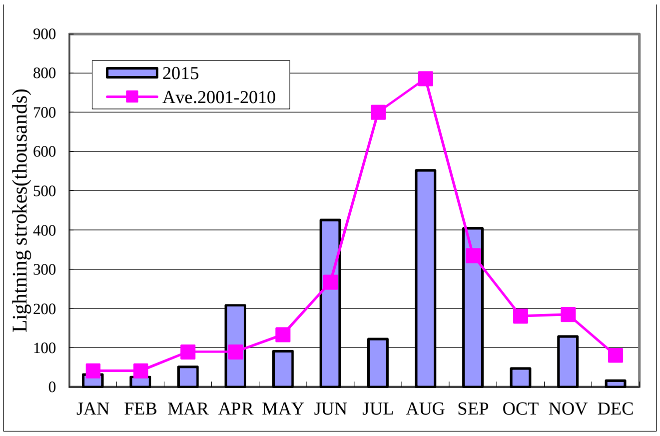

Fig. 3. The monthly distribution of lightning strokes. The bars represent the number of strokes in 2015. The line represents the average value of ten years data from 2001 to 2010.

B. Lightning Frequency

Figure 4 shows the annual lightning stroke frequency in 2015. It is important to note that, unlike flash density maps, each map is a plot of the number of lightning strokes on a 0.2 degree grid.

It is clear that the light blue region where the number of lightning strokes was less than 100 has spread widely in comparison to the map of mean annual lightning strokes shown in Figure 5 that we introduced in our earlier paper [Sugita and Matsui, 2012]. This shows the lightning activity was very low in 2015. The number of lightning strokes was high mainly around the southwestern islands of Japan where fronts stayed longer and areas of low pressure frequently passed through.

The maximum number of lightning strokes in the 0.2 degree grid was 4,831 around the Tokara Islands. There were only three squares in the grid where the number of lightning strokes exceeded 4,000. The number of lightning strokes in mountainous regions where thunderstorms usually occur frequently in summer was not so high in 2015.

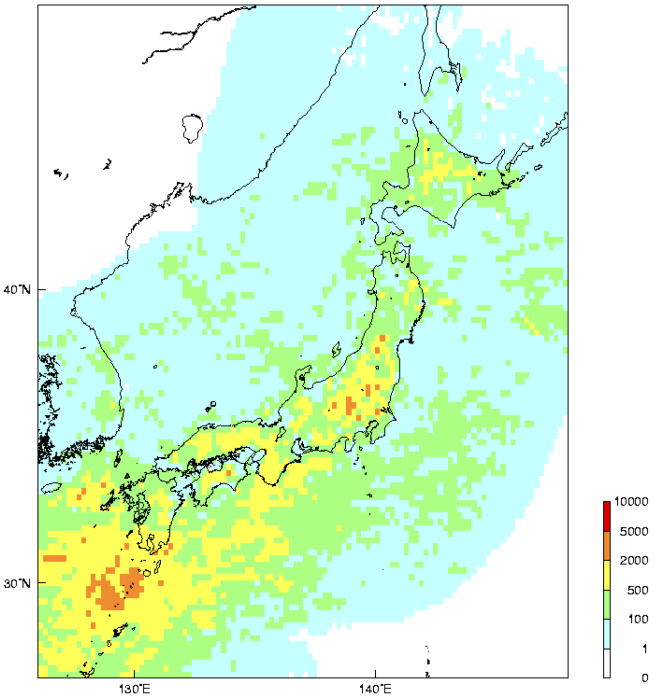

Fig. 4. The distribution of annual lightning strokes in a 0.2 degree grid in 2015

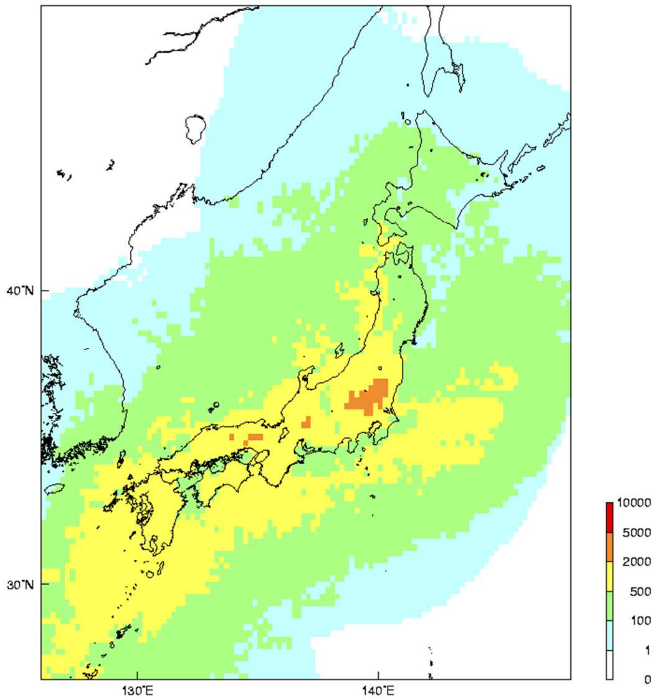

Fig. 5. The distribution of mean annual lightning strokes in a 0.2 degree grid for the years from 2001 to 2010.(from Sugita and Matsui, 2012)

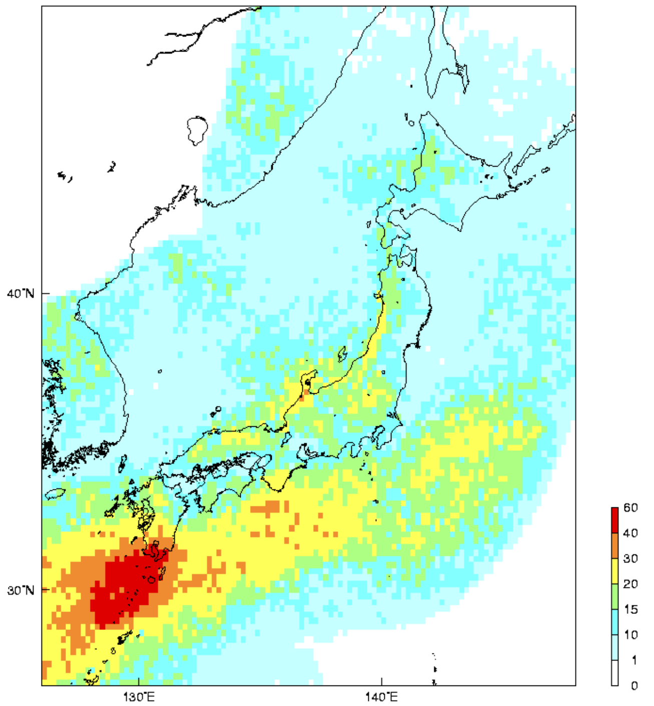

Fig. 6. The distribution of annual thunderstorm days in a 0.2 degree grid in 2015

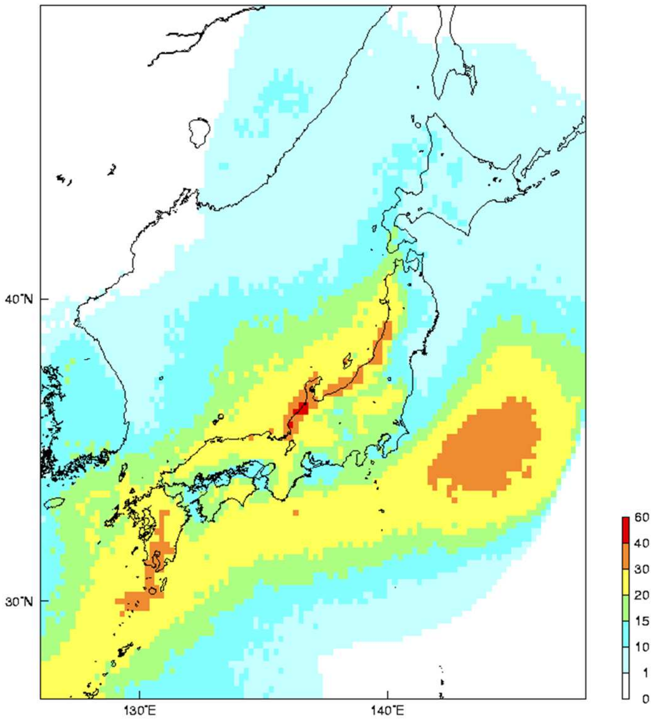

Fig. 7. The distribution of mean annual thunderstorm days in a 0.2 degree grid for the years from 2001 to 2010. (from Sugita and Matsui, 2012)

C. Thunderstorm Days

Figure 6 shows the annual thunderstorm days in the 0.2 degree grid in 2015. In the same way as with lightning frequency, it is clear that the pattern of the thunderstorm day distribution is quite different from the map of mean thunderstorm days in Figure 7 that introduced in our earlier paper [Sugita and Matsui, 2012].

The number of thunderstorm days was higher in the region over the southern sea of Kyushu than it was over the coast of the Sea of Japan which is famous for its winter lightning. This indicates that fronts and low pressure areas with lightning were located on the sea south of Kyushu more frequently than usual. The maximum number of thunderstorm days was 55 in the region of the Tokara Islands.

On the other hand, the number of thunderstorm days is not so high on the coast of the Sea of Japan in 2015, where lightning usually occurs frequently in winter. In the Hokuriku region, the maximum number of thunderstorm days was only 31 in 2015. This value is significantly lower than the maximum mean number of thunderstorm days in this region, 42 [Sugita and Matsui, 2012]. Also the number of thunderstorm days over the sea east of Kanto was not so high in response to the low frequency of lightning occurrences in winter in 2015.

IV. CONCLUSION

The characteristics of lightning occurring in 2015 in Japan were greatly different from usual, reflecting the influence of abnormal weather. Excluding the region over the sea south of Kyushu, not only the lightning activity but also the probability of lightning occurrence was very low in 2015 in Japan. In summer, thunderstorms caused by convection resulting from solar heating did not occur as frequently as usual in 2015 because cloudy and rainy days were dominant on the Pacific side of Japan. In winter, thunderstorms did not occur as frequently as usual in Hokuriku because the winter monsoon was weaker than normal and extremely warm days persisted.

The authors would like to continue to describe the characteristics of lightning in Japan in future papers.

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