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Characteristics of Lightning Activity in Japan in 2017 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. Although lightning activity was low not only in 2015 but also in 2016, it was almost normal in 2017 except for the factors that caused lightning production in summer. The annual number of lightning strokes in the analyzed area in 2017 was 3,308,080, exceeding the mean annual number of lightning strokes from 2001 to 2010 for the first time in three years.**

Keywords—LLS; JLDN; 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 involved in an ongoing project to replace the older sensors in the network with new sensors. FJC installed its first TLS200 sensor in December 2013 and the last LPATS-IV sensor in the JLDN was replaced with a TLS200 sensor in September 2017. As of October 2017, the JLDN consisted of four IMPACT-ESP, fourteen LS7001/7002 and thirteen TLS200 sensors. The sensor locations of the JLDN as of October 2017 are shown in Fig. 1.

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] and reported the reduced lightning activity in Japan in 2015 at the 2016 ILMC [Sugita and Matsui, 2016]. This paper describes the lightning characteristics in Japan in recent years and compares the characteristics of lightning that occurred in 2017 with the average values obtained covering ten years of historical data.

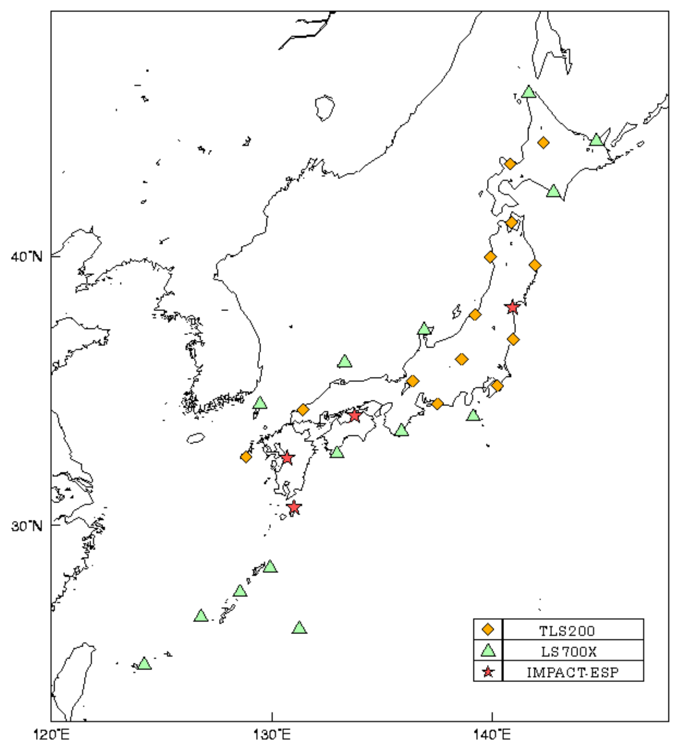

Fig. 1. JLDN Sensor Map as of October 2017. The stars are IMPACT-ESP sensors, the triangles are LS7001/7002 sensors and the diamonds are TLS200 sensors.

II. Data

The authors analyzed lightning stroke data observed by the JLDN in 2017 and counted cloud-to-ground stroke data only. 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 possible influence of the changes in the JLDN configuration and sensor characteristics has not been considered.

III. RESULTS

A. The number of Lightning Strokes

Fig. 2 shows the annual number of lightning strokes from 2001 to 2017. The lightning activity in Japan was low not only in 2015 but also in 2016. The annual number of lightning strokes was 2,104,004 in 2015 and 2,386,159 in 2016 while the mean annual number of lightning strokes from 2001 to 2010 was 2,932,332 [Sugita and Matsui, 2012]. In 2017, the annual number of lightning strokes in the analyzed area was 3,308,080, exceeding the mean annual number of lightning strokes for the first time in three years. As shown in Fig. 2, the annual number of lightning strokes tended to decrease after peaking in 2012 but increased again after bottoming in 2015

Fig. 3 shows the monthly distribution of the number of lightning strokes in 2017 and the mean monthly distribution of lightning strokes from 2001 to 2010. As shown in Fig. 3, there were a lot of lightning strokes in summer in 2017. The number of lightning strokes in July was 947,665, 848,895 in August and 613,961 in September. This is the first year since 2014 that the number of lightning strokes exceeded 600,000 in July and August. Also, it is the first time since 2012 that the number of lightning strokes in September exceeded 600,000.

Although there were a lot of lightning strokes, the summer climate in Japan in 2017 was not typical. In the past, the number of lightning strokes produced has been dependent on the occurrence of thunderstorms caused by convection resulting from solar heating which frequently occurs in summer in the mountainous regions of Japan. In 2017, there were also a lot of lightning strokes caused by inflows of cold air, low pressure systems, typhoons and fronts in the summer. For example, the maximum number of lightning strokes per day was 187,954 on July 19, 2017 and that was the sixth highest single day total since the JLDN began observations. However, these were not lightning strokes produced by convection resulting from solar heating which frequently occur in summer in Japan, because they occurred early in the morning and a low pressure system was passing through at that time.

Unlike summer, the number of lightning strokes rapidly decreased from October as shown in Fig. 3. The number of lightning strokes in October 2017 was only 42,029. This is the lowest number of lightning strokes in October since the JLDN began observations. Also the number of lightning strokes in December was 21,643 and this was the second lowest December total since the JLDN began observations. There were a lot of thunderstorms from October to December but they were not large and the lightning activity associated with those storms was not significant.

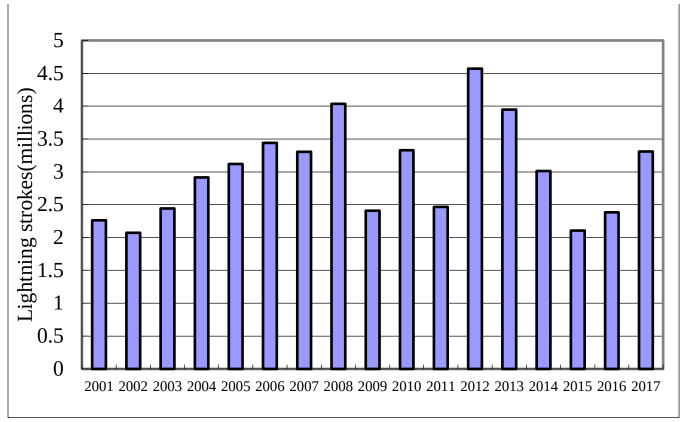

Fig. 2. The annual number of lightning strokes from 2001 to 2017

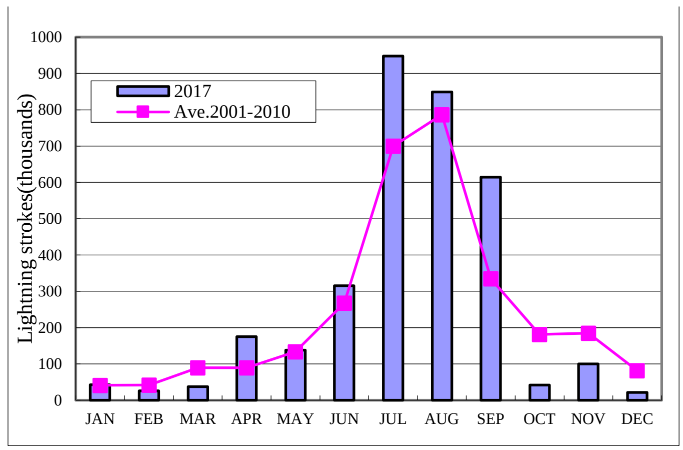

Fig. 3. The monthly distribution of lightning strokes. The bars represent the number of strokes in 2017. The line represents the average value compiled from ten years data from 2001 to 2010.

B. Lightning Frequency

Fig. 4 shows the annual lightning stroke frequency in 2017. 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 yellow region where the number of lightning strokes was more than 500 has not spread widely in comparison to the map of mean annual lightning strokes shown in Fig. 5 that we introduced in our earlier paper [Sugita and Matsui, 2012]. On the other hand, the orange and red regions where the number of lightning strokes exceeded 2000 has spread near Kyushu. This means lightning activity was high locally rather than all over Japan.

Actually, the lightning activity was very high in the region southwest of Kyushu in 2017 where fronts stayed longer and areas of low pressure frequently passed. It was the first time in the four years since 2013 that there were the squares in the grid where the number of lightning strokes exceeded 5,000. The maximum number of lightning strokes in the 0.2 degree grid in July was 6,541 and 5,475 in August.

The maximum number of annual lightning strokes in the 0.2 degree grid was 8,046 around the Koshikijima Islands in the region over the sea west of Kyushu.

C. Thunderstorm Days

Fig. 6 shows the annual thunderstorm days in the 0.2 degree grid in 2017. Except for the fact that the orange and red regions where the number of thunderstorm days was more than 30 have increased slightly in number, it seems that the pattern of thunderstorm day distribution is similar to the map of mean thunderstorm days in Fig. 7 that was introduced in our earlier paper [Sugita and Matsui, 2012]. Although the number of lightning strokes was very low in winter in 2017 as shown in Fig. 3, the number of thunderstorm days in Hokuriku where lightning usually occurs frequently in winter exceeded 40 for the first time in three years. This means the probability of lightning occurrence was not low in winter in 2017 in Japan. The number of thunderstorm days over the sea east of Kanto, the other area famous for winter lightning [Sugita and Matsui, 2012], was higher in January than in December.

The number of thunderstorm days in July was 23 in Kyushu where low pressure systems with cold air frequently passed. The maximum number of annual thunderstorm days was 54 in Noshiro, in Akita Prefecture in the region of Tohoku and second maximum was 53 on Yakushima Island. In the Hokuriku region, the maximum number of thunderstorm days was 48 in 2017.

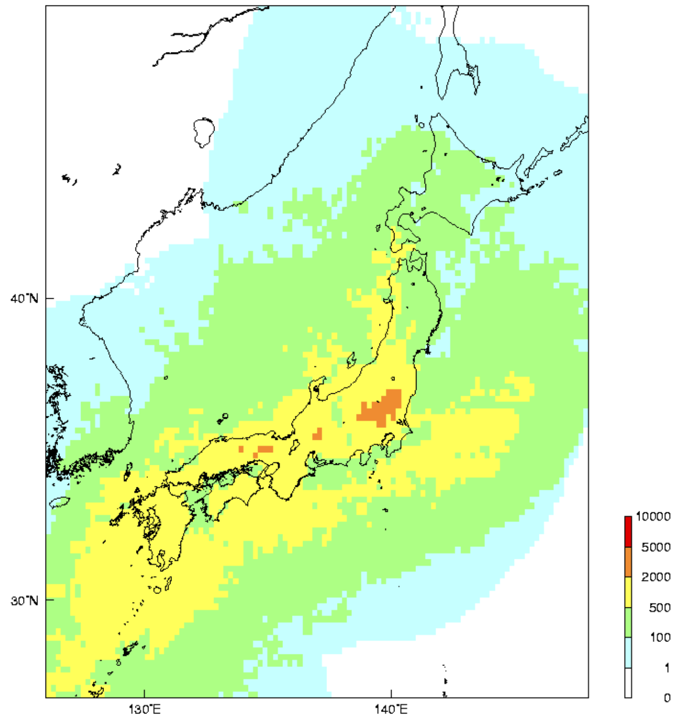

Fig. 5. The distribution of mean annual lightning strokes in a 0.2 degree grid for the years from 2001 to 2010.(from Sugita and Matsui, 2012)

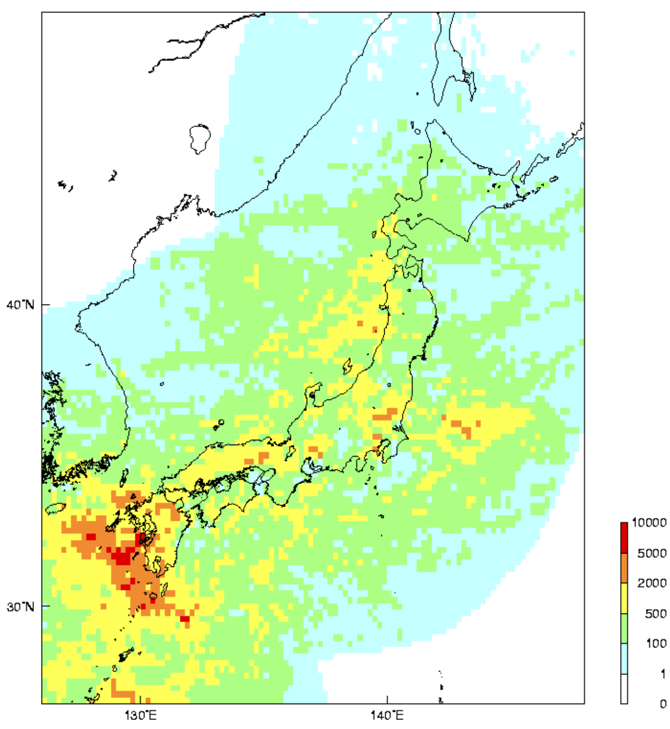

Fig. 4. The distribution of annual lightning strokes in a 0.2 degree grid in 2017

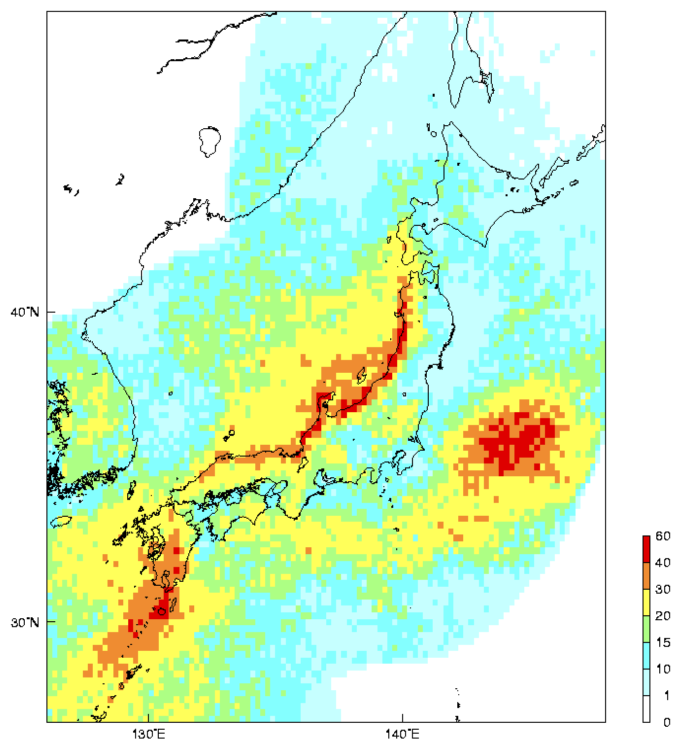

Fig. 6. The distribution of annual thunderstorm days in a 0.2 degree grid in 2017

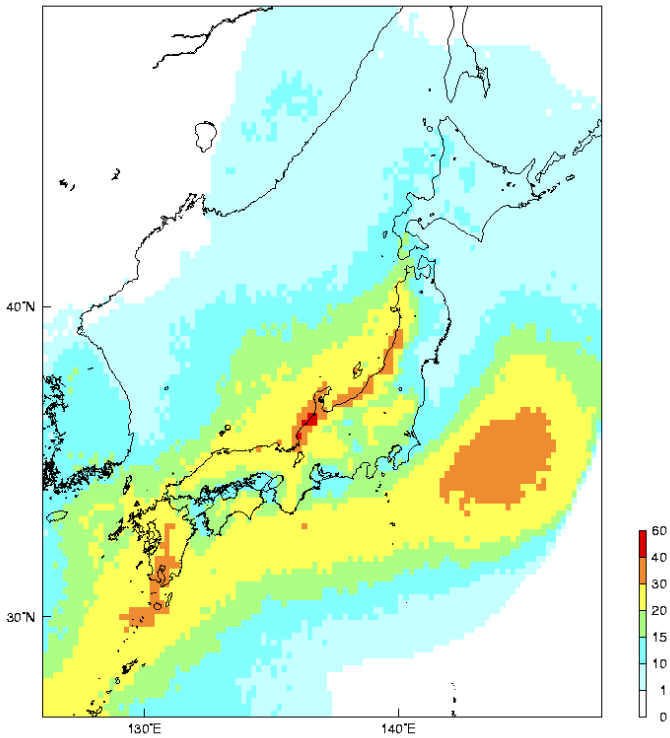

Fig. 7. The distribution of mean annual thunderstorm days in a 0.2 degree grid for the years from 2001 to 2010. (from Sugita and Matsui, 2012)

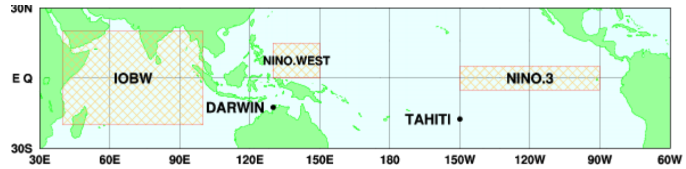

Fig. 8. The region of NINO.3 that is monitored by the JMA [from the Japan Meteorological Agency, 2018].

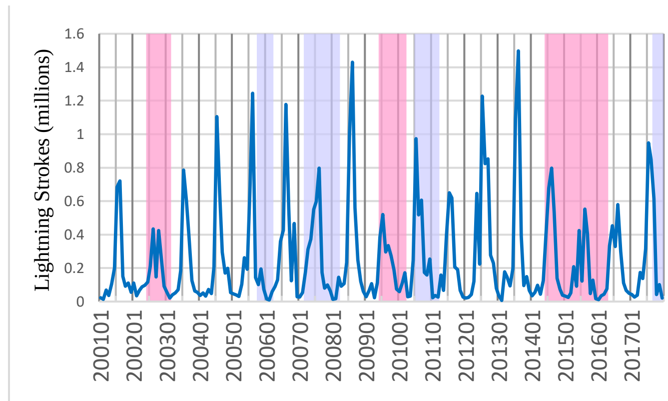

Fig. 9. The monthly distribution of lightning stokes from 2001 to 2017. Red shaded areas denote El Nino periods and blue areas show La Nina periods as defined by the JMA.

IV. Discussion

At the 2016 ILMC, the authors were asked if the decrease in the number of lightning strokes was related to El Nino. Honestly speaking, the authors had never thought about El Nino because we were focused on the abnormal weather in recent years caused by global warming.

The Japan Meteorological Agency (JMA) monitors sea surface temperature (SST) variability in the region "NINO.3" in Fig. 8 and reports its El Nino Monitoring and Outlook. The JMA reports an El Nino (La Nina) condition when the five-month running mean SST deviation for NINO.3 continues to be +0.5°C (-0.5°C) or higher (lower) for six consecutive months or longer [Japan Meteorological Agency, 2018].

Fig. 9 shows the monthly distribution of lightning strokes observed by the JLDN from 2001 to 2017. Red shaded areas denote El Nino periods and blue shaded areas indicate La Nina periods as defined by the JMA

Although it seems that the number of lightning strokes is certainly low at the time of the El Nino conditions in 2002, 2009 and 2015, the number of lightning strokes is also low without the presence of El Nino conditions in 2011 and 2016. In addition, the number of lightning strokes is not very low in 2014 during a period of El Nino conditions. But in 2017, the number of lightning strokes is not low during a period without El Nino conditions. So, it may be said that El Nino is the only one of the causes of the decrease in the number of lightning strokes

V. Conclusion

Not only the lightning activity but also the probability of lightning occurrence was higher in 2017 in Japan for the first time in three years. The lightning activity was locally high, especially around Kyushu in summer, rather than spread all over Japan.

In 2017, the lightning characteristics were almost normal because there are two main seasonal variations affecting lightning occurrence characteristics in Japan as introduced by Sugita and Matsui [2016]. 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, in summer 2017, thunderstorms caused by inflows of cold air, low pressure systems, typhoons and fronts produced more lightning strokes than were produced by convection resulting from solar heating which frequently occurs in summer in the mountainous regions of Japan.

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

Acknowledgment

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References

Japan Meteorological Agency (2018), El Nino Monitoring and Outlook, Available online at http://ds.data.jma.go.jp/tcc/tcc/products/elnino/elmonout.html#table

Sugita, A., M. Matsui (2012), Lightning characteristics in Japan observed by the JLDN from 2001 to 2010, paper presented at 4th International Lightning Meteorology Conference, Broomfield, Colorado, USA

Sugita, A., M. Matsui (2016), Lightning Occurrence Characteristics in 2015 in Japan as Observed by the JLDN, paper presented at 6th International Lightning Meteorology Conference, San Diego, California, USA