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LIGHTNING CHARACTERISTICS IN JAPAN OBSERVED BY THE JLDN FROM 2001 TO 2010

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1. INTRODUCTION

The Japanese Lightning Detection Network (JLDN), operated by Franklin Japan Corporation, began operation in 1998 and has covered the four main islands of Japan (Hokkaido, Honshu, Shikoku and Kyushu) since 2000. Currently, the JLDN consists of 10 IMPACT-ESP, 9 LPATS-IV and 11 LS7001 sensors. The sensor locations of the JLDN in 2011 are shown in Figure 1.

The authors previously summarized the lightning characteristics in Japan for the complete five year period from 2000 to 2004 observed by the JLDN (Sugita et al. 2006). This paper will report on the authors' continued analysis for the complete ten year period from 2001 to 2010.

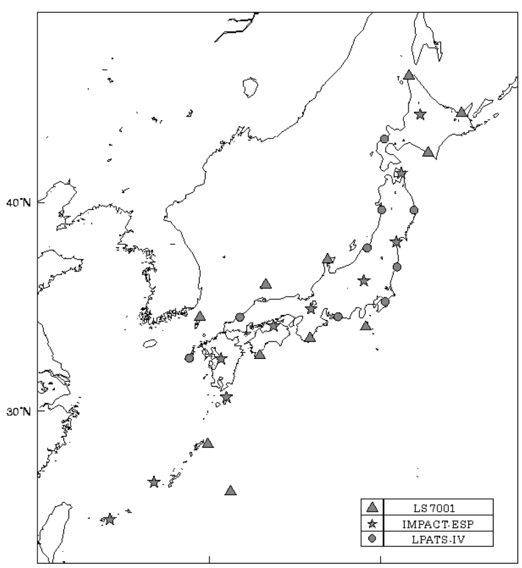

Figure 1: JLDN Sensor Map in 2011. The circles are LPATS-IV sensors, the stars are IMPACT-ESP sensors and the triangles are LS7001 sensors.

2. DATA

The authors analyzed lightning stroke data observed by the JLDN from 2001 to 2010. Unlike Sugita et al (2006), small discharges with peak currents ranging from –2kA to 5kA are not counted in this paper. This is because LS7001 sensors detect more small discharges than the LPATS-IV and IMPACT-ESP sensors. The LS7001 sensor installations began in 2008. Other differences like the influence of changes in the JLDN configuration or sensor characteristics have not been considered. For example, more lightning strokes may have been reported in the area south of Kyushu Island after 2002 due to the addition of new sensors in the southwestern islands of Japan resulting in an improvement in detection efficiency.

All analyses were done in the region from 26.5N to 48.5N in latitude and from 126E to 148E 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.

3. RESULTS

3.1 *The number of lightning strokes*

Figure 2 shows monthly distribution of the number of lightning strokes from 2001 to 2010. It is clear that the monthly distribution of lightning strokes is different in each year. Looking closely, there were remarkable features in each year. There were extremely numerous lightning strokes in August 2008 when it was terribly hot in summer. There were an unusually high number of lightning strokes for December in 2010 when Japan experienced a warm winter.

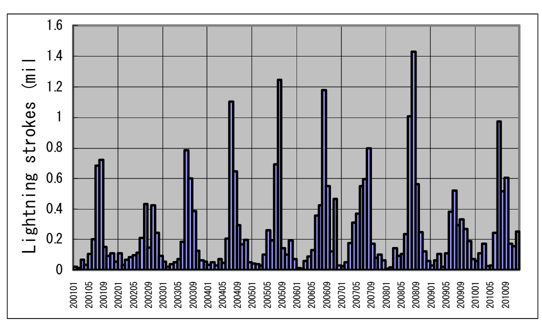

Figure 2: The monthly distribution of lightning strokes from 2001 to 2010.

Figure 3 shows the annual number of lightning strokes from 2001 to 2010. The total number of lightning strokes for the ten year period was 29.32 million. As shown in Figure 3, the number of lightning strokes did not increase year after year. The annual number of lightning strokes ranged from a low of 2.07 million in 2002 to a high of 4.03 million in 2008, about double the 2002 number. The mean annual number of lightning strokes was 2.93 million.

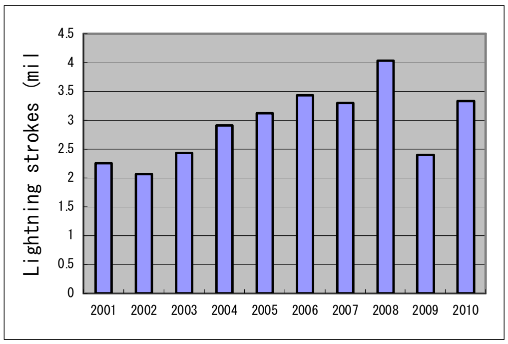

Figure 3: The annual number of lightning strokes from 2001 to 2010.

Figure 4 shows the mean monthly distribution of lightning strokes for the years from 2001 to 2010. The mean monthly number of lightning strokes ranged from a low of 41,275 in January to a high of 786,497 in August. The number of lightning strokes increases rapidly in July and goes even higher in August. About half of the annual lightning strokes occur in July and August. The mean number of lightning strokes in both July and August increased rapidly after 11:00 when the sunshine was strongest and peaked at 16:00 as shown in Figure 5. This indicates that lightning strokes in July and August are caused by convection resulting from solar heating. The mean number of lightning strokes in both July and August had a second peak at 6:00 as shown in Figure 5, but the reason for this is not clear yet. Zooming in on the months with fewer lightning strokes, Figure 6 shows that there are patterns in stroke frequency at different hours of the day. This daily pattern of lightning occurrence changes gradually from month to month. December, January and February seem to have more night lightning though there is no clear peak in activity. June and September seem to have similar patterns of activity. This is also true of October and November.

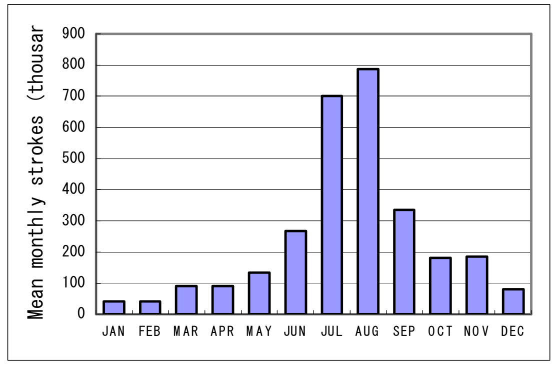

Figure 4: The mean monthly distribution of lightning strokes for the years from 2001 to 2010.

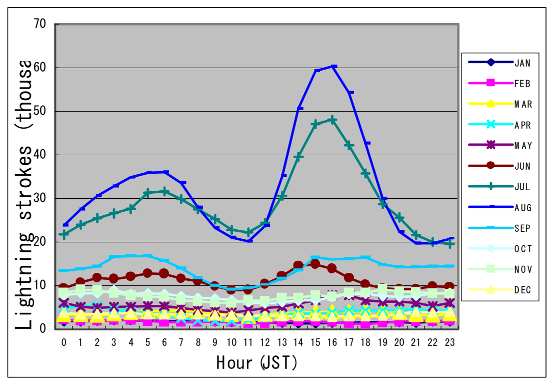

Figure 5: The mean hourly distribution of lightning strokes in each month for the years from 2001 to 2010.

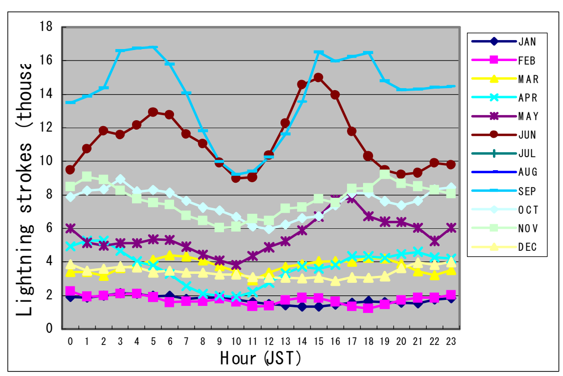

Figure 6: The same data as shown in Figure 5 but the scale has been changed.

3.2 *The percentage of positive lightning strokes*

Figure 7 shows the mean monthly percentage of positive lightning strokes. The mean percentage of positive lightning strokes for the years from 2001 to 2010 was 12.5%. The monthly percentage of positive lightning strokes ranged from a low of 8.9% in August to a high of 36.6% in January. The tendency for the percentage of positive lightning strokes to be high in winter and low in summer is the same in every year but the monthly percentage of positive lightning strokes is different in each year as shown in Figure 8. The percentage of positive lightning strokes was not so high in the months with higher lightning frequency even in winter.

The number of lightning strokes in July ranged from a low of 211,263 in 2002 to a high of 1,104,054 in 2004, but it is interesting that the percentage of positive lightning strokes in July in Figure 8 shows little change from year to year regardless of the lightning frequency.

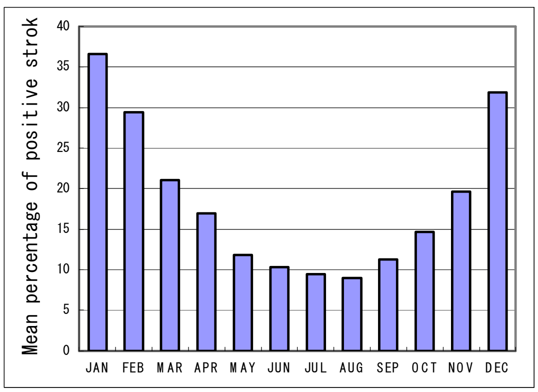

Figure 7: The mean monthly percentage of positive lightning strokes for the years from 2001 to 2010.

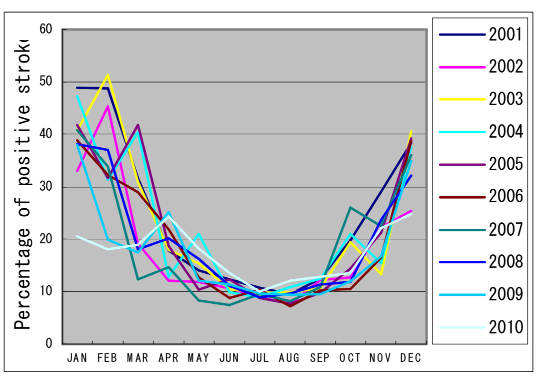

Figure 8: The monthly percentage of positive lightning strokes in each year from 2001 to 2010.

3.3 *Lightning frequency*

Figure 9 shows the mean annual lightning stroke frequency for the years from 2001 to 2010 in Japan. It is important to note that, unlike flash density maps, the map is a plot of the number of lightning strokes on a 0.2 degree grid.

The maximum mean value of lightning strokes per year in the 0.2 degree grid is 4578 in northern Kanto. The number of lightning strokes is very high in mountainous regions such as Chugoku, Hida, and Northern Kanto where solar heat caused convective thunderstorms occur frequently in summer. On the other hand, there are fewer lightning strokes in the eastern portion of Hokkaido.

The maximum annual number of lightning strokes in the 0.2 degree grid for the years from 2001 to 2010 was 8,085 in Northern Kanto in 2010.

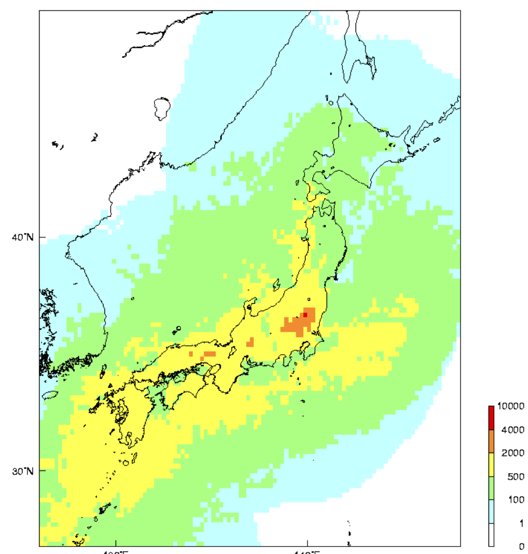

Figure 9: The distribution of mean annual lightning strokes for the years from 2001 to 2010.

3.4 *Thunderstorm days*

Figure 10 shows the mean annual thunderstorm days for the years from 2001 to 2010. The mean thunderstorm days are high on the coast of the Sea of Japan, where the number of lightning strokes is not so high and lightning occurs frequently in winter. This supports the theory that most lightning events in winter consist of a single stroke as has often been suggested. The maximum number of mean annual thunderstorm days is 42 in Hokuriku. There is also high thunderstorm day region over the sea east of Kanto. The reason was not clear in Sugita et al. (2006). Looking at the mean monthly thunderstorm days (not shown), there are high numbers in this area in December and January similar to the region near the coast of the Sea of Japan. That indicates that lightning strokes in this area occur frequently in winter.

The number of mean thunderstorm days on Yakushima Island is also high, 38. There are one or more thunderstorm days in every month on Yakushima Island.

The number of mean thunderstorm days in northern Kanto, where lightning frequency is very high, is less than 27.

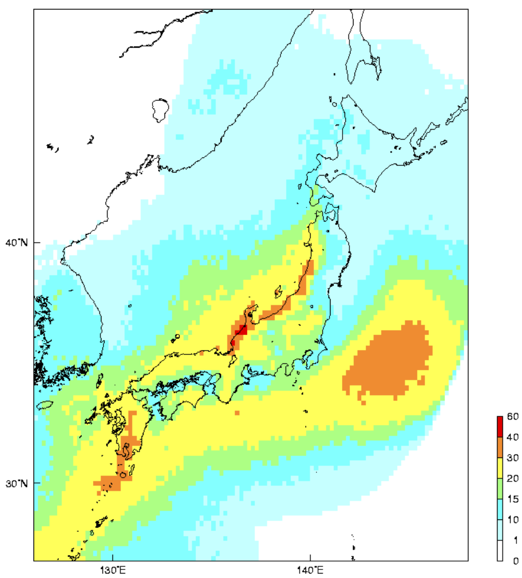

Figure 10: The distribution of mean annual thunderstorm days for the years from 2001 to 2010.

4. CONCLUSIONS

The lightning stroke data observed by the JLDN for ten years was analyzed. The mean annual number of lightning strokes was 2.93 million and the mean percentage of positive strokes was 12.5%.

The tendencies of lightning occurrences in Japan summarized in Sugita et al. (2006) have not changed although the amount of analyzed lightning data increased. That is, first, thunderstorms caused by convection resulting from solar heating frequently occur in mountainous regions such as Northern Kanto, Hida and Chugoku in summer. Second, lightning occurs in winter on the coast of the Sea of Japan especially in Hokuriku. Third, Yakushima Island has lightning strokes throughout the year though they are more numerous in summer.

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

Acknowledgement

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REFERENCES

Sugita, A., M. Matsui, M. Osada, 2006: Lightning characteristics in Japan observed by the JLDN from 2000 to 2004. *Proceedings of the 28th International Conference on Lightning Protection (ICLP 2006), Kanazawa, Japan, Vol.1, No.II-9, pp426-429.*