P2.14 CLOUD TO GROUND FLASHES IN MEXICO AND ADJACENT OCEANIC AREAS: A PRELIMINARY STUDY USING DATA FROM THE WWLL NETWORK

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1. INTRODUCTION

Lightning constitutes a striking evidence of the microphysical and electrification processes taking place in clouds. It is directly linked to the presence of graupel and supercooled droplets in the cloud and it has been also linked to the intensification of precipitation at the surface. The spatial and temporal distribution of lightning provides evidence of the evolution of the convective activity. In this study we present for the first time a preliminary climatology of the cloud-to-ground discharges over Mexico and the adjacent oceanic areas.

2. DATA AND METHODOLOGY

The data utilized come from a global network of spherics initiated by LF*EM (R. Dowden, New Zeland) and currently managed by R. Holtzworth at the University of Washington. The network called World Wide Lightning Network, consists of almost thirty stations distributed in 5 continents and is based on the Time of Group Arrival (TOGA; for more details: http://webflash.ess.washington.edu) detected by at least 4 stations, to locate the coordinates of the ultra low frequency component (3 to 30 kHz) of the flash to ground (Dowden et al, 2002; Lay et al, 2004). The uncertainty in the determination of the coordinates varies with location around the globe, ranging from 4 to 14 km in the region of this study, when only 4 stations are used to determine the discharge location (Rodger et al, 2004; 2005). This uncertainty is reduced to 4-6 km when 5 stations are used for the determination.

We have analyzed 2 years of data (2004 and 2005) to determine the spatial and temporal patterns over Mexico (**labeled 1**) and the adjacent oceanic areas were divided into 4 sub-areas, as shown in Figure 1:

- Caribbean (**labeled 2**, 10°-22° N, 87°-60° W)
- Gulf of Mexico (**labeled 3**, 18°-30° N, 97°-83° W)
- North Pacific: (**labeled 4**, 20°-32° N, 117°-105° W)
- South Pacific (**labeled 5**, 10°-20° N, 105°-92° W).

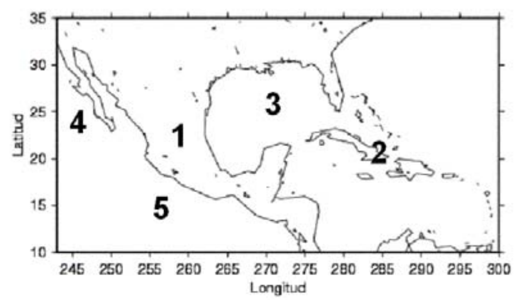

Figure 1. Geographical areas into which the area of study has been divided.

3. RESULTS

Table I presents the total number of events to ground detected in the five different areas considered (note that the numbers are not per unit area, and the regions cover different areas). An increase in the total number is observed in three of the oceanic regions from 2004 to 2005, ranging from 63 to 160% in the Gulf of Mexico. The continental sector of Mexico showed virtually no change, while the South Pacific sector 5 showed a 22% decrease in activity. The latter is consistent with the increased convective activity observed in the Caribbean region, which typically coincides with somewhat suppressed convection in the Mexican ITCZ. The

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substantial increase in the Gulf of Mexico is likely related to the increased tropical storm activity in the area.

The monthly totals for each year as a function of the five different sectors are presented in the following figures. Figure 2 corresponds to the continental sector, evidencing the rainy and dry seasons.

Table I. Total cloud to ground events as a function of region for the 2 years studied.

	2	5	3	4	1
2004	436575	237762	120649	17576	141687
2005	716799	185863	315698	32218	150153
	+64%	**-22%**	**+160%**	**+83%**	**+6%**

Note: the last row corresponds to the percentage change from 2004 to 2005

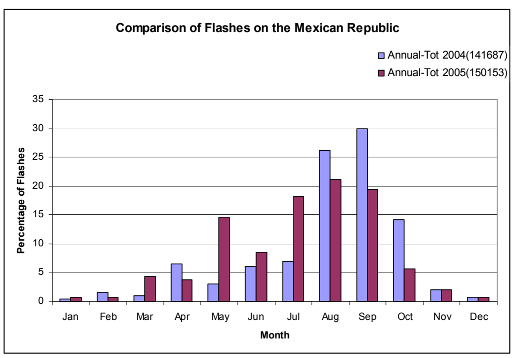

Figure 2. Monthly variation of flashes to ground over the continental sector of Mexico, labeled 1 in Fig. 1.

The peak frequency of cloud to ground flashes is observed in August-September for both years. There is a significant increase in the frequency during May in 2005, suggesting an earlier than usual onset of the rains over land. Nevertheless, in 2005 there is a decrease of between 5 and 10% in the frequency during the most rainy months of August and September.

The corresponding distribution in sector 4 (North Pacific, is much narrower (Figure 3), with a well defined peak in August for both years. Even though the total number of flashes to ground increased by 83%, the frequency distribution remains unmodified. The precipitation in this region is associated to the “monsoon of North America”, with no precipitation (and insignificant counts) during six months of the year.

The precipitation over land is typically a result of orographic convection, with influence also of tropical storms that move over land. The southern regions of Mexico are influenced by the ITCZ. The frequency distribution appears quite broad, with negligible values (less than 1%) during December January and February.

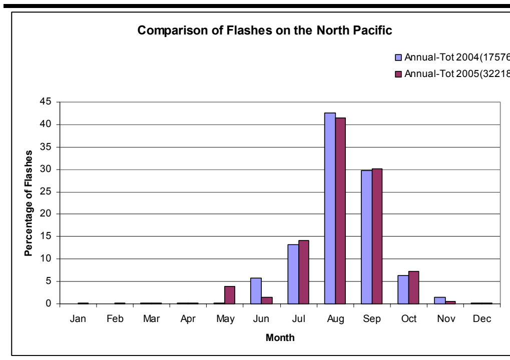

Figure 3. Same as Fig. 2 but for the North Pacific sector, labeled 4 in Fig. 1.

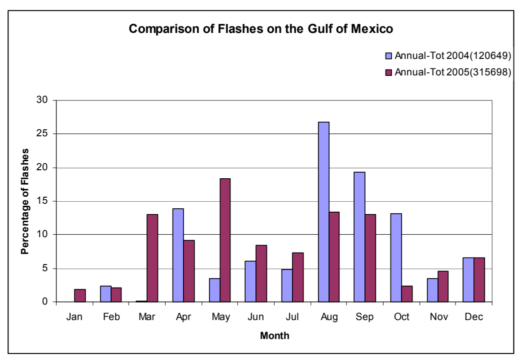

Figure 4. Same as Fig. 2 but for the Gulf of Mexico sector, labeled 3 in Fig. 1.

The frequency distribution in the Gulf of Mexico is very different in 2005, compared to 2004 (as shown in Fig. 4). March and May 2005 have very much increased frequency of events, and in fact May 2005 corresponds to the peak in the distribution, while March, August and September present the same frequency. The precipitation in this sector has a mid-latitude component during the winter months, with convection associated with frontal systems observed during winter. Spring convection is also associated with fronts but also with mesoscale systems developing in the southern states. In 2004, a less active year in terms of tropical storms in the Atlantic, the peak in flash frequency is observed in August.

In contrast, the Caribbean sector (shown in Fig. 5) presents a single peak in the distribution during 2004, while 2005 shows significantly increased activity during May and June and a shift in the peak to October.

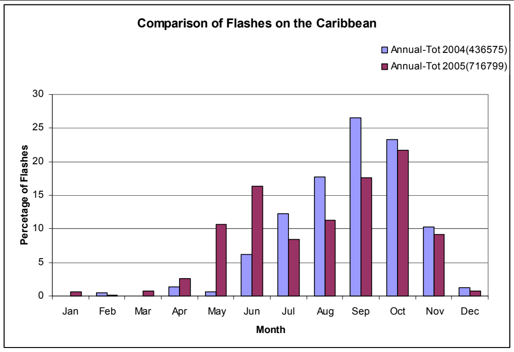

Figure 5. Same as Fig. 2 but for the Caribbean sector, labeled 2 in Fig. 1.

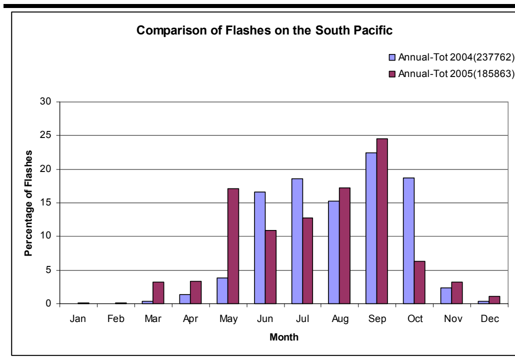

Figure 6. Same as Fig. 2 but for the South Pacific sector, labeled 5 in Fig. 1.

Most of the convection in this sector is associated with easterly waves and tropical storms. Finally, the frequency of flashes in the South Pacific sector (Fig. 6) presents a broad distribution in both years, but the pattern within the rainy season is different. During 2004, the pattern indicates the onset of convective precipitation in June (as it is climatologically) and then a relative minimum in August, with the peak of the distribution observed during September. In contrast, during 2005, there is a high incidence of events in May, and a decrease in activity during June and July with respect to the previous year. No activity is observed during the winter months of December, January and February in either year. The convective precipitation in this sector is associated with the passage of easterly waves and the development of tropical storms, as in the Caribbean sector.

The pattern in terms of frequency of events observed in 2005 is very similar in both sectors, even tough there is a decrease in the total activity in the South Pacific, while there is an overall increase in the Caribbean. The reason for the similarity in the frequency distribution while the total numbers vary so differently is not clear at the moment.

Figure 7 presents the diurnal evolution of flashes to ground observed in the four oceanic sectors surrounding continental Mexico. In all regions (as well as over Mexico, not shown) the maximum counts to ground is observed in the local late afternoon/evening, with the South Pacific and the Caribbean showing broader distributions and maxima at 9pm local time.

Finally, we present two examples of the spatial distribution of cloud to ground lightning over the continental region of Mexico, for July 2004 and 2005 (Fig. 8a and b). There is a clear correlation between lightning location and some of the large mountain ranges in Mexico. Nevertheless, there are regions close to Southern end the Gulf of Mexico, where the lightning frequency is very large and the terrain is mostly flat. The region is heavily populated with oil extraction from the soil, as well as different oil-processing plants and petrochemical facilities.

4. SUMMARY

We present a preliminary study of the lightning spatial and temporal evolution over continental Mexico and the adjacent oceanic areas, based on data from 2004 and 2005. The accuracy of the location is variable, and ranges between 4-6km in the area of study, when 5 stations detect the discharge.

The monthly evolution in the five regions is somewhat different, being mono-modal in the North Pacific and the continental portion, while broader distributions and even bimodal are observed in the South Pacific and Caribbean sectors. These distributions also vary slightly in the month of the highest frequency, between August in the North and September in the Southern regions.

The diurnal variation indicates maximum cloud to ground discharges in the late afternoon and evening (local time), with narrower distributions in the Northern locations and the continental sectors, while the South Pacific and the Caribbean present a broader distribution and later maximum (around 9pm local time).

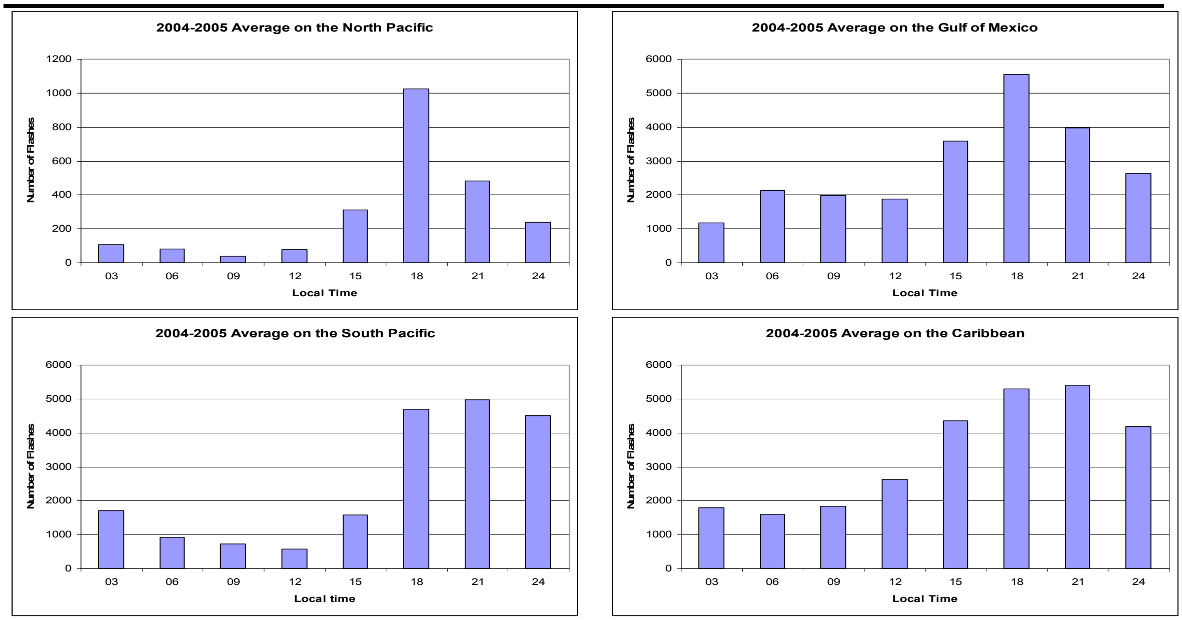

Figure 7. Number of flashes to ground as a function of local time, for all 4 oceanic sectors surrounding Mexico (see Fig. 1)

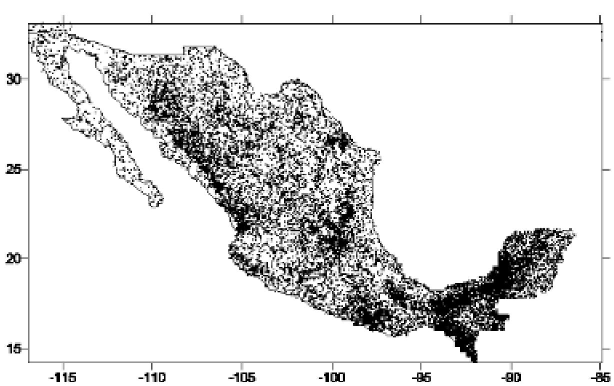

Figure 8a. Spatial distribution of cloud to ground lightning corresponding to the continental sector of Mexico for July 2004.

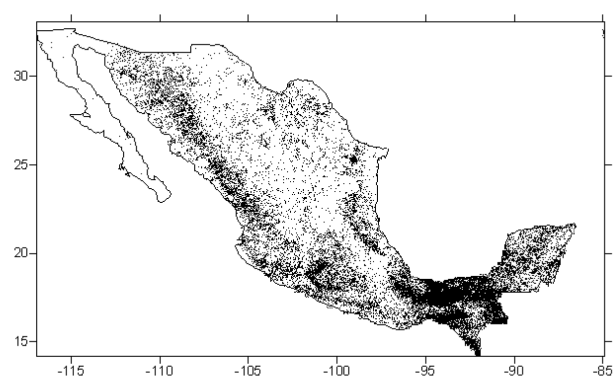

Figure 8b. Spatial distribution of cloud to ground lightning corresponding to the continental sector of Mexico for July 2005.

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