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GLOBAL DISTRIBUTIONS OF THUNDERSTORMS BASED ON 7+ YEARS OF TRMM

Daniel J. Cecil
University of Alabama in Huntsville, Huntsville, AL, 35805

1. INTRODUCTION

The Tropical Rainfall Measuring Mission (TRMM) satellite has observed more than a quarter million thunderstorms since its launch in late 1997. The unique suite of instruments – Precipitation Radar (PR), TRMM Microwave Imager (TMI), Lightning Imaging Sensor (LIS), and Visible / Infrared Scanner (VIRS) – allows examination of many characteristics of these thunderstorms. The extended lifetime of the TRMM mission allows increasingly robust thunderstorm statistics.

A precipitation feature database from the first three years of the TRMM mission (December 1997 – November 2000) was examined in some detail by Cecil et al. (2005). The same methodology is applied to the expanded database here (March 1998 – February 2005). Precipitation features are defined as contiguous areas with at least four raining PR pixels; statistics including total flash rate, total horizontal area, minimum brightness temperature, maximum reflectivity, and volumetric rain rate are compiled for each precipitation feature; features are sorted using these statistics to emphasize the top 1%, top 0.1%, top 0.01%, etc. of the distribution.

The general characteristics of global precipitation feature distributions do not change by adding the 2001-2005 data to that documented by Cecil et al. (2005). Some highlights of these distributions will be summarized in Section 2. The expanded database does allow a more detailed look at regional and seasonal variability in the precipitation feature distributions. These are addressed in Section 3.

2. GLOBAL DISTRIBUTIONS

In the initial three-year study, 2.4% of precipitation features in the TRMM domain were observed by LIS to have lightning (minimum detectable flash rate ~0.7 flashes per minute). Because of this, the smallest or weakest 97.6 of precipitation features according to any of the statistics were designated as “CAT-0”. CAT-0 and CAT-1 combined accounted for 99% of the population, CAT-2 added the next 0.9%, and categorizations continued until CAT-5 included only the top 0.001% of precipitation features.

Corresponding author address: Daniel J. Cecil, Earth System Science Center, University of Alabama in Huntsville, 320 Sparkman Dr, Huntsville, AL 35805; Daniel.Cecil@nasa.gov.

In the seven years of data presented here, 2.5% of precipitation features have observed lightning. The thresholds for CAT-0 through CAT-5 are adjusted accordingly (Table 1), but are quite similar to those in Cecil et al. (2005). The maximum flash rate in the first three years was 1351 flashes per minute for an MCS along the Argentina – Paraguay border in November 1998. One MCS in the seven-year database barely exceeds this mark – it had 1389 flashes per minute in northeastern Argentina, December 2003. The minimum 85 GHz PCT is the same in both databases (42 K), and the minimum 37 GHz PCT is actually less extreme in the seven year database – no subsequent storm has matched the 69 K 37 GHz temperature that was observed in northern Argentina in December 1997.

TABLE 1. Thresholds used for sorting precipitation features by lightning flash rate, minimum 85 GHz PCT, and minimum 37 GHz PCT.

	%	Flash Rate	Min 85 GHz	Min 37 GHz
CAT-0	97.5	0	>194	> 258
CAT-1	1.5	0.6-2.7	194-161	258-252
CAT-2	0.9	2.7-32.2	161-106	252-221
CAT-3	0.09	32.2-125	106-75	221-179
CAT-4	0.009	125-309	75-60	179-140
CAT-5	0.001	310-1389	60-42	140-84

A global map of precipitation feature locations is plotted in Fig. 1, with colored symbols representing the different categories of flash rates (as in Cecil et al. 2005). Black triangles mark the 132 greatest flash rates (CAT-5: the top 0.001% of the 13.2 million precipitation features). High flash rate storms tend to be over landmasses; this is almost exclusively so for the very highest flash rate storms. The CAT-5 thunderstorms with over 300 flashes per minute are especially clustered in the subtropical Americas. To an extent this is because orbital sampling has not been accounted for in this figure. The subtropics are sampled a few times as often as the deep tropics. Central Africa is the only location in the deep tropics that produces many of the extremely high flash rate storms.

In general, other statistics measuring the vigor of deep convection (e.g., minimum passive microwave brightness temperature, maximum vertical extent of some radar reflectivity value, maximum radar reflectivity at some height level) have similar global distributions as that of the lightning flash rate. Important differences do exist, but are not the focus here. As such, similar plots of lightning flash rate are used to examine seasonal variability below.

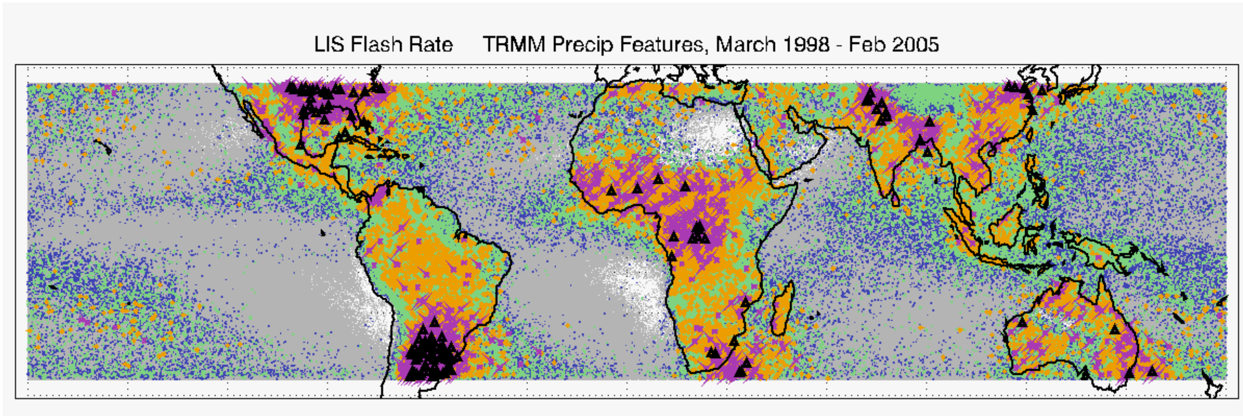

FIGURE 1. Precipitation Feature flash rates, with different colors and symbols assigned to each flash rate category in Table 1. Orbital sampling is not accounted for, with the subtropics sampled a few times more often than the deep tropics.

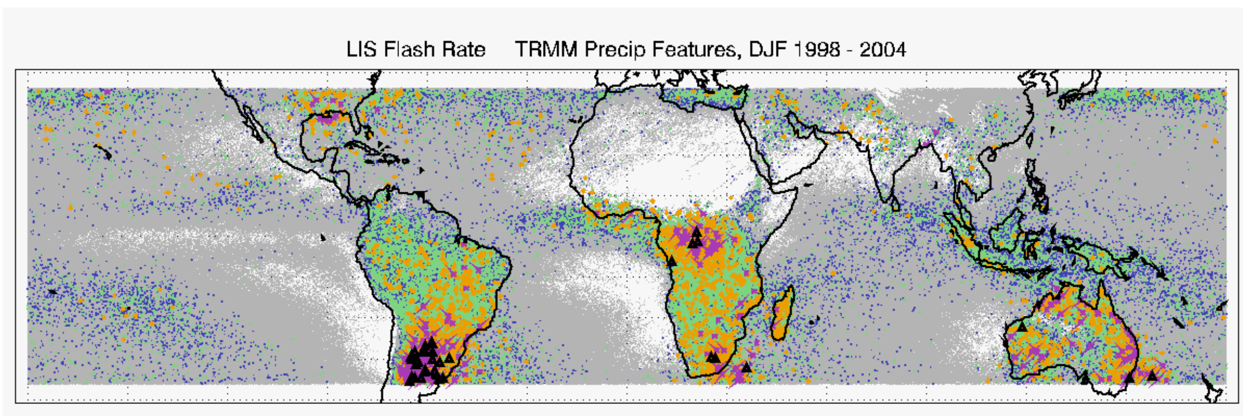

FIGURE 2. As in Figure 1, but for December, January, February only.

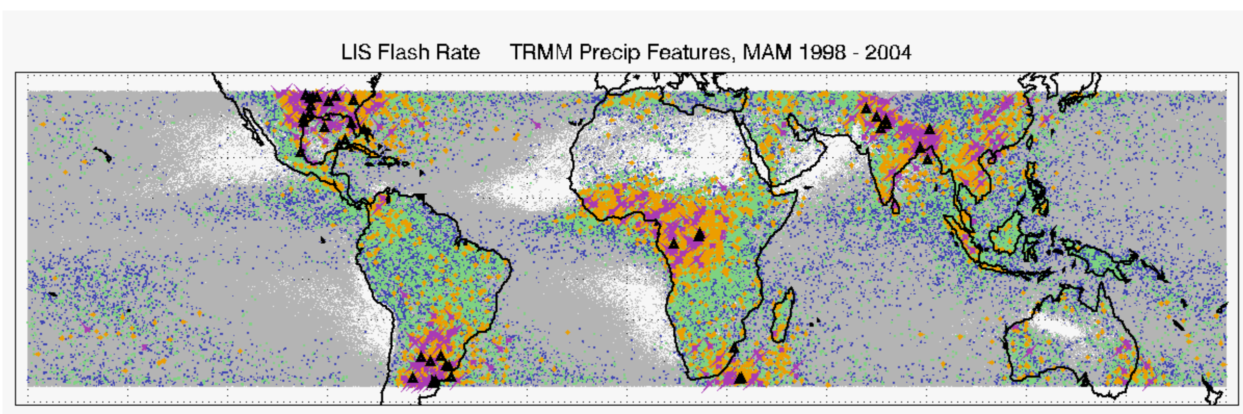

FIGURE 3. As in Figure 1, but for March, April, May only.

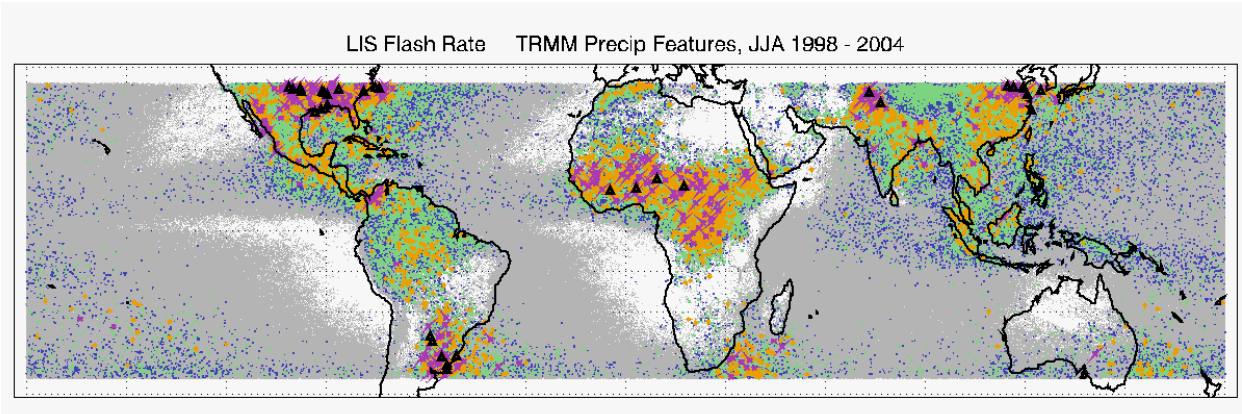

FIGURE 4. As in Figure 1, but for June, July, August only.

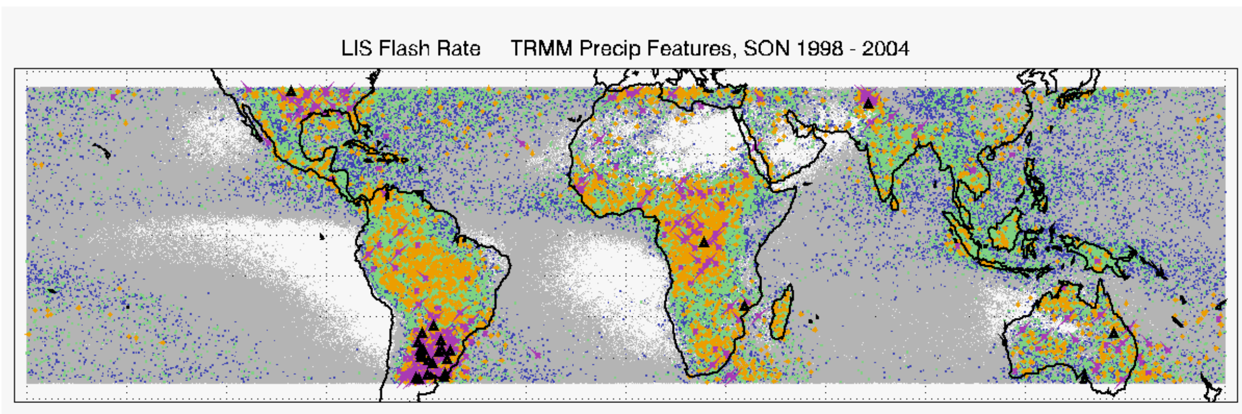

FIGURE 5. As in Figure 1, but for September, October, November only.

3. SEASONAL VARIABILITY

Seasonal migrations of convective activity are seen basically as expected. The spring and summer hemispheres have more of the extreme thunderstorms than do the autumn and winter hemispheres. It is noteworthy, however, that northern Argentina has several extreme storms year-round. In contrast, the southern United States has only a handful of CAT-4 storms and one CAT-5 during its autumn and winter months. Central Africa also has extreme storms year-round, but adjacent regions to the north and south have strong variability. The October-November transition between dry and wet seasons in the Amazon basin is also quite pronounced. The Amazon sees several CAT-3 and some CAT-4 storms during these months; this is the only time of the year that the Amazon comes close to rivaling Central Africa in terms of thunderstorm flash rates.

It is again worth noting the oversampling at high latitudes in these figures. This will be accounted for at the conference presentation.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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