Global patterns of lightning properties derived by LIS

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The Lightning Imaging Sensor **LIS** aboard the TRMM satellite detects optical pulses from lightning flashes, therewith providing an unmatched empirical data set of the **tropical lightning distribution** from end of 1997 on (Fig. 1). Climatological flash rate densities derived from LIS are a standard reference, e.g. for flash rate parameterizations used in GCMs.

Flash characteristics are quite **variable**, and various quantities (like the peak current, the flash energy, or the NO_x production per flash) vary considerably, statistically as well as systematically on regional and seasonal scales. However, current knowledge of **spatio-temporal variations** of such lightning characteristics is quite limited.

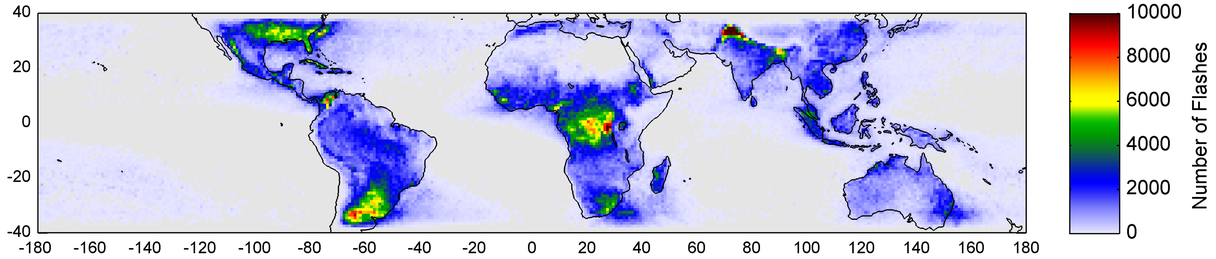

Figure 1:
Total number of flashes detected by LIS 1998-2008.

LIS detects **optical** pulses by a **CCD**. A pixel exceeding a background threshold is defined as an **Event**. A cluster of events (close in (pixel)space and time) is defined as **Group**. Finally, a cluster of groups (in geo-coordinates) defines a **Flash**. Thus, a Flash consists of several Groups, each consisting of several Events. Additionally, LIS provides information on the flash **Footprint**, the total flash **Radiance**, and the flash **Duration**.

Here we present a **statistical analysis** of **global patterns** of the various lightning properties derived from LIS; in relation to the total number of flashes (Fig. 2, Table 1). These **mean flash characteristics** show **consistent spatial patterns** of regions with **"strong"** versus regions with **"weak"** lightning. Though oceanic means are rather noisy due to the low number of flashes, a clear **land-ocean contrast**, with oceanic flashes being generally "stronger" than continental flashes, can be observed. But also over continents, flash strength shows **systematic variations**. **Highest** continental values are found over the **US**, while values over **South America** and **India** are quite **low**. Note that these regional variations cannot be simply parameterized as function of latitude.

Information on **spatial patterns of flash "strength"**, though not easy to interpret quantitatively, is potentially a valuable input for **improving empirical parameterizations based on flash counts**, like **precipitation** or **lightning NO_x** production. Further investigation is in progress to reach a more **physical and quantitative understanding** of the observed spatial patterns of the different LIS properties. In particular, it has to be checked (a) how far they are influenced by **cloud characteristics**, as LIS observes the cb clouds iluminated by a flash below/within the cloud, or if they could be related to (b) physical lightning properties like **peak currents**, or the **fraction of intra-cloud to cloud-to-ground flashes**, and/or (c) **meteorological quantities** such as CAPE.

Table 1: Mean LIS quantities 1998-2008. The **red numbers** are **relative** to the respective global mean.

Selection	Flashes	Groups per Flash	Events per Flash	Mean Footprint [km^2]	Mean Radiance [J/ster/m^2/µm]	Mean Duration [s]
Total	14480763	11.7	54.8	296	760	0.262
	1	1	1	1	1	1
Land	10948475	10.5	47.6	275	625	0.254
	0.756	0.895	0.869	0.927	0.823	0.969
Ocean	3532288	15.5	77	363	1178	0.287
	0.244	1.32	1.41	1.22	1.55	1.1
Day	7130755	10.7	45	269	755	0.26
	0.492	0.914	0.821	0.909	0.994	0.992
Night	7350008	12.7	64.3	323	764	0.264
	0.508	1.08	1.17	1.09	1.01	1.01
US East	617567	14	61.3	298	897	0.302
	0.043	1.2	1.12	1.01	1.18	1.15
Argentina	955287	10.5	43.1	234	549	0.241
	0.066	0.898	0.786	0.788	0.723	0.919
Congo	891571	10.4	51.3	294	625	0.273
	0.062	0.888	0.935	0.991	0.823	1.04
India	383513	7.58	27.1	175	334	0.185
	0.027	0.647	0.495	0.59	0.439	0.707

References:

For details on the LIS algorithms see

Christian, H. J., R. J. Blakeslee, S. J. Goodman, and D. M. Mach (Eds.) (2000), Algorithm Theoretical Basis Document (ATBD) for the Lightning Imaging Sensor (LIS), NASA/Marshall Space Flight Center, Alabama. (Available at http://eospso.gsfc.nasa.gov/atbd/listables.html, posted 1 Feb. 2000)

D. M. Mach, H. J. Christian, R. J. Blakeslee, D. J. Boccippio, S. J. Goodman, and W. L. Boeck, Performance assessment of the Optical Transient Detector and Lightning Imaging Sensor, J. Geophys. Res., 112, D9, doi:10.1029/2006JD007787, 2007.

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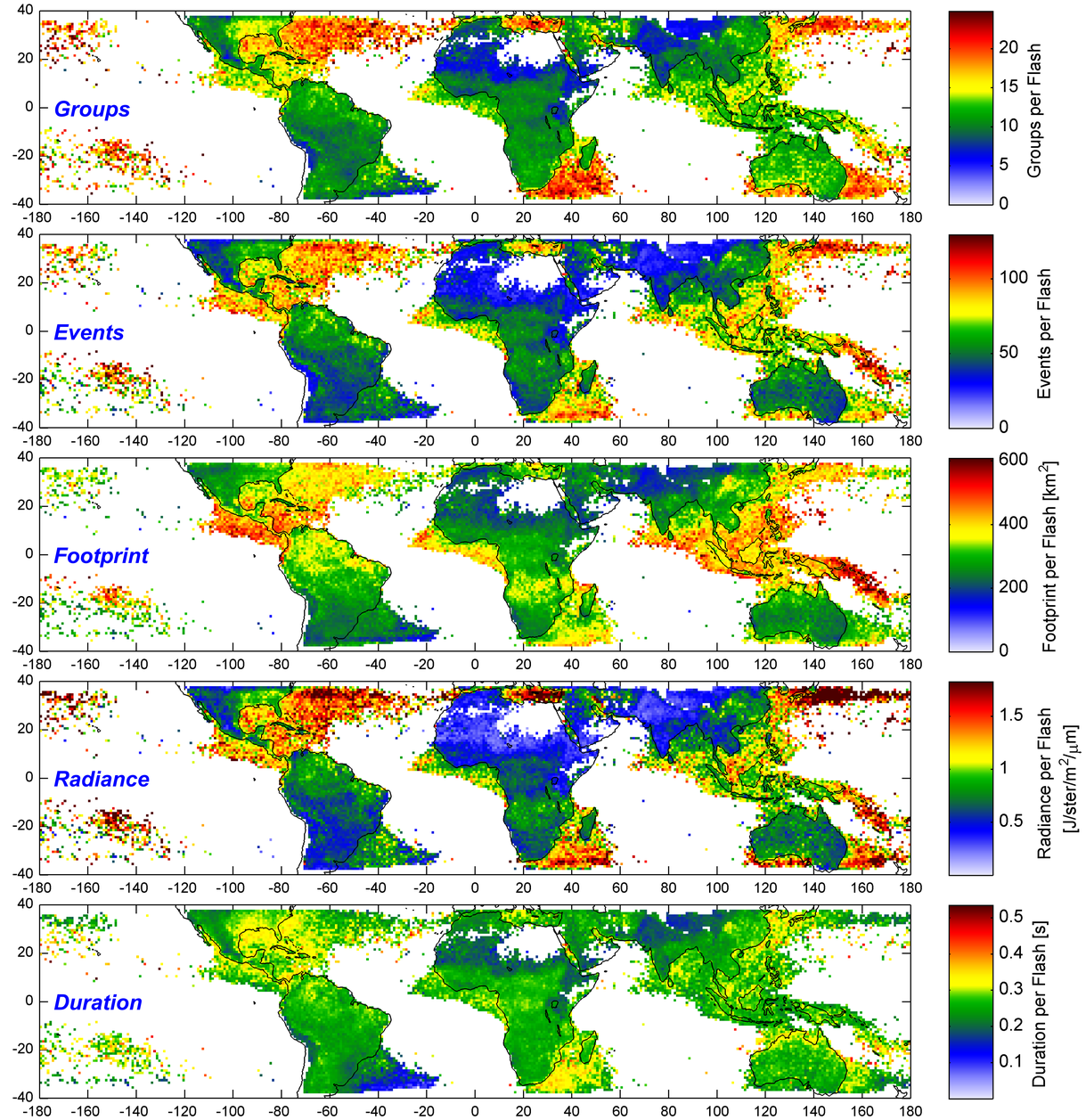

Figure 2:
Global distribution of **mean LIS quantities** 1998-2008. All "means" are defined as the total sum of the respective quantity 1998-2008 divided by the total sum of flashes (as shown in Fig. 1).
Pixels (on a 1°x1° grid) with less than 100 flash counts are masked out. The colorscales range from 0 to the double of the respective global mean.