Source of Acquisition
NASA Marshall Space Flight Center

Observations of Lightning on Earth from the Lunar Surface. S. J. Goodman,[1] D. E. Buechler,[2] H. J. Christian, Jr.,[2] and H. P. Stahl[1], [1]NASA George C. Marshall Space Flight Center, NSSTC, 320 Sparkman Dr., Huntsville, AL 35805, [2] The University of Alabama in Huntsville, NSSTC, 320 Sparkman Dr., Huntsville, AL 35805.

Introduction: The NASA Optical Transient Detector (OTD) launched into a 70° inclination orbit in April 1995 aboard the MicroLab-1 satellite and the Lightning Imaging Sensor (LIS) launched into a 35° inclination orbit in November 1997 (and still operating today) aboard the Tropical Rainfall Measuring Mission have produced the most comprehensive global observations of lightning activity on Earth [1, 2]. The OTD collected data for 5-yr from an altitude of 740 km while the LIS, in its 10th year of operations, is still collecting data from its current altitude of 402 km. From these altitudes the OTD observes an individual storm within its field of view for ~3 min and the LIS for ~90 sec as the satellites orbit the earth.

Figures 1-4 show the combined LIS/OTD distribution of lightning for day and night during the Northern Hemisphere warm season from April through August (Fig. 1,2) and the cool season from October through February (Fig. 3,4) as might be observed from the lunar surface (12-h daylight and 12-h nighttime observations). The day and night plots are for the twelve hour periods centered on local noon and midnight. The total viewtime of the global lightning activity is 200 hours or less, depending on latitude (Fig. 5).

Most of the observed lightning occurs over the northern hemisphere land areas as reported in previous studies. More lightning activity is seen at the higher northern latitudes during the day. The greatest lightning maxima occurs in the southeastern U.S. during the day. The corresponding region at night shows much less lightning activity. In contrast, there is a maxima in lightning activity at night over the high Plains area of the U.S. This region had lower lightning rates during the daytime period. During the cold season, the southern hemisphere has significantly more lightning. The maxima in Central Africa is still present, and a secondary maxima is observed in South Africa. In South America, the maxima in Argentina occurs at night in association with large-scale mesoscale convective storm complexes. This is the region on the earth having the greatest frequency of extreme storms with flash rates exceeding 1000 flashes min^{-1}. A daytime maxima is seen extending from Northern Argentina to Brazil. In the U.S., the Gulf of Mexico and the Gulf Coast states exhibit a maximum in lightning activity both day and night.

The Next Generation: The next generation NOAA Geostationary Operational Environmental Satellite (GOES-R) series with a planned launch in 2014 will carry a Geostationary Lightning Mapper (GLM) that will provide day and night observations of lightning from the west coast of Africa (GOES-E) to New Zealand when the full constellation is fully operational (Figure 6). However, global coverage cannot be provided by only the two GOES-E and W satellites. The northern boreal forests of Asia and the central Africa lightning "hotspot" in the Democratic Republic of Congo will not be observed. Predictions and indicators of climate change suggest noticeable impacts at high latitudes as well as increasing storm intensity. The thunderstorm (and fire) season at high latitudes in the northern hemisphere will begin ealier in the year.

Conclusions: A lunar-based Lightning Transient Imager with a 1-m aperture will be capable of mapping lightning on Earth with the same resolution as the GLM. Such an instrument would provide a global climatology of lightning activity with more extensive observations throughout the diurnal cycle than is possible today or even ten years from now. In addition, electric field perturbations associated with the lightning discharge process also can produce gamma ray bursts, x-rays, sprites, jets, and other middle atmosphere phenomena [3, 4]. Integrated multi-platform observations of these phenomena would be possible using the vantage points of LEO, GEO, and the moon.

References:

[1] Christian, H. J., et al. (2003): Global frequency and distribution of lightning as observed from space by the Optical Transient Detector, JGR, 108(D1), 4004, doi:10.1029/2002JD002347, [2] Goodman, S., D. Buechler, and E. McCaul. (2007): "Lightning," chapter in *Our Changing Planet: A View From Space*, M. King, ed., Cambridge University Press, in press, [3] Fishman, J., et al. (1994): Discovery of intense gamma-ray flashes of atmospheric origin, Science, 1313-1316, [4] Cummer, S. A., et al. (2006), Submillisecond imaging of sprite development and structure, Geophys. Res. Lett., 33, L04104, doi:10.1029/2005GL024969.

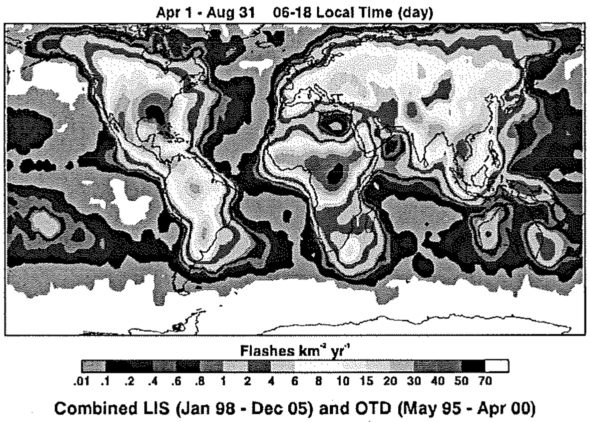

Figure 1. Mean annualized lightning flash density for the 12-hr period centered on local noon from the combined observations of LIS/OTD for April 1-August 31.

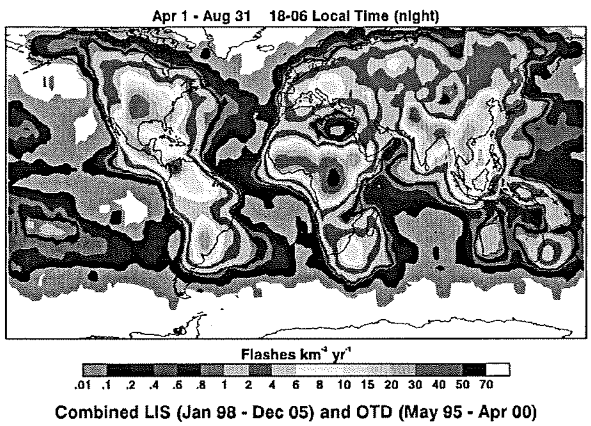

Figure 2. Mean annualized lightning flash density for the 12-hr period centered on local midnight from the combined observations of LIS/OTD for April 1- August 31.

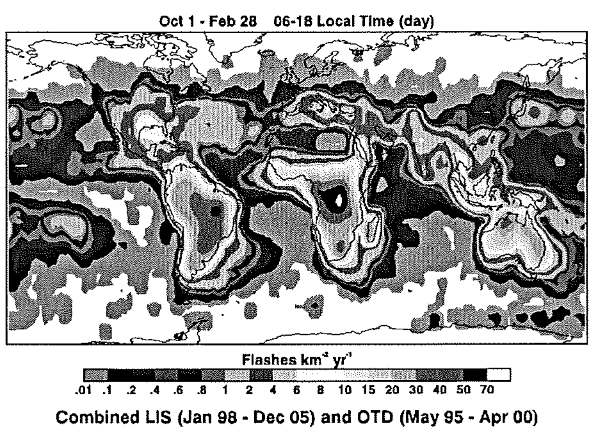

Figure 3. Mean annualized lightning flash density for the 12-hr period centered on local noon from the combined observations of LIS/OTD for October 1- February 28.

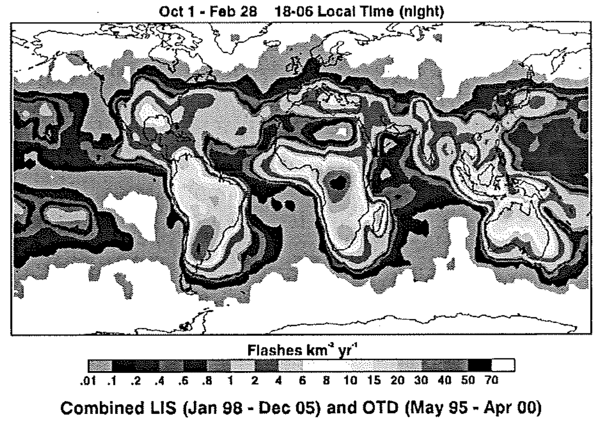

Figure 4. Mean annualized lightning flash density for the 12-hr period centered on local midnight from the combined observations of LIS/OTD for October 1- February 28.

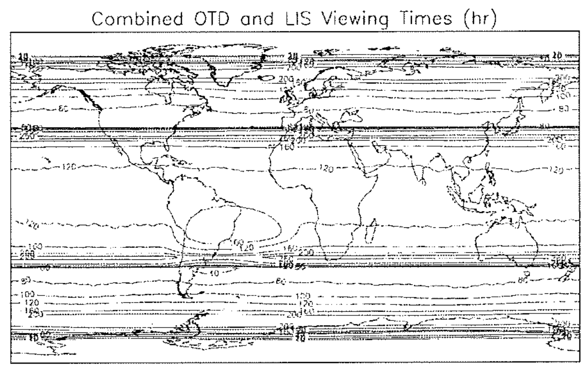

Figure 5. The viewtime plot is the combined viewing time of the combined OTD and LIS data sets (LIS orbits through 2005). The discontinuity near 38 degrees N and S is the limit of the LIS viewing due to the 35 degree inclination orbit (the FOV extends to +- 37.5 degrees).

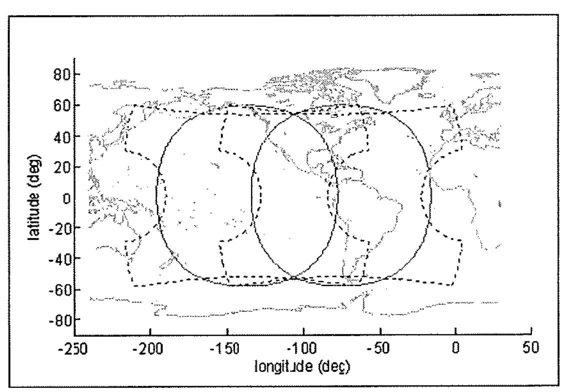

Figure 6. The GLM full-disk is defined as the intersection of circular and square Earth-centered fields-of-view having minimum diameter 16.0° and minimum length 15.1° respectively.