Do all lightning produce TGF's? Approaching this question from two angles using data from RHESSI, TRMM and WWLLN

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The main aim of this project is to get a more accurate estimate of how common terrestrial gamma ray flashes (TGF's) are. The working hypothesis is that all optical lightning flashes are accompanied by a TGF [1]. Data about lightning strikes from the Tropical Rainfall Measuring Mission (TRMM) and World Wide Lightning Location Network (WWLLN) will be compared with gamma ray data from the Reuven Ramaty High Energy Solar Spectroscopy (RHESSI). We extract data when both the satellite RHESSI and one of the lightning detection systems, TRMM or WWLLN, have the lightning in it's field of view. Gamma ray data from hundreds of lightning events are then superimposed in the hope that a peak will form around the time of the optical flash.

1. The project

Our hypothesis is that all lightning produce terrestrial gamma ray flashes (TGF's) [1]. In this project we will test this hypothesis. It is not wildly improbable that the small number of TGF's detected in relation to optical flashes is due to the intensity being too low when the signal reaches the detector. There might be a gamma signal every time there is a lightning flash, only that the gamma signal drowns in the background noise. To search for TGF's we use data from the satellite RHESSI, as well as data from two different lightning detection systems; the satellite TRMM and the ground system WWLLN. To be more specific, we will approach this problem using two methods. The first method will use RHESSI together with WWLLN, while the second method will use RHESSI together with TRMM. The methods are similar, but they have some strengths and weaknesses when compared.

2. The two methods

2.1. Method 1: RHESSI and WWLLN

Using the programming language IDL a program will be made that searches through the WWLLN data and singles out the lightning flashes where RHESSI is close enough to also have the lightning flash in its footprint. WWLLN does not measure optical photons, but rather radio wave disturbances (sferic) in the atmosphere caused by lightning. Presently there are 40 WWLLN sensors worldwide [2]. Figure 1 shows the location of WWLLN sensors.

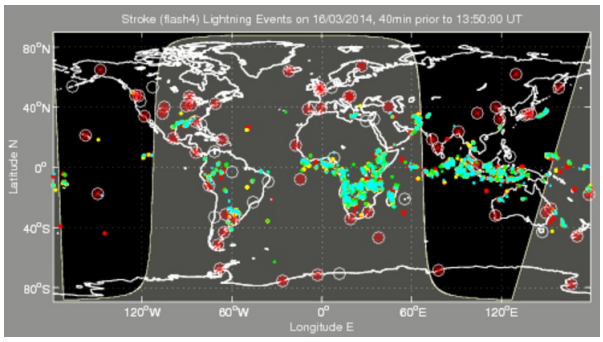

Figure 1: The WWLL Network. The red stars inside white circles show the location of WWLLN sensors. The colored dots are recent lightning strokes. [3]

The WWLLN data used is for August 2013, amounting roughly to 17-18 million data sets of lightning flashes in total.

If we extract the events that are inside RHESSI's footprint, we'll be left with the datasets we want to work with. We want to superimpose all the RHESSI data, with the time of the flash at exactly the same position, to see if a peak rises up from the noise.

2.2. Method 2: RHESSI and TRMM

The data handling in method two will be the same as in method one, only that here we will use the Lightning Imaging Sensor (LIS) on board the satellite TRMM, instead of the ground based network WWLLN. Due to this we do not have worldwide coverage, however in the 600 x 600 km footprint of LIS the lightning sensitivity is higher than for WWLLN. Figure 2 is an illustration of LIS' field of view as it orbits the Earth. Both satellites are in low Earth orbit, and they circle the Earth fairly

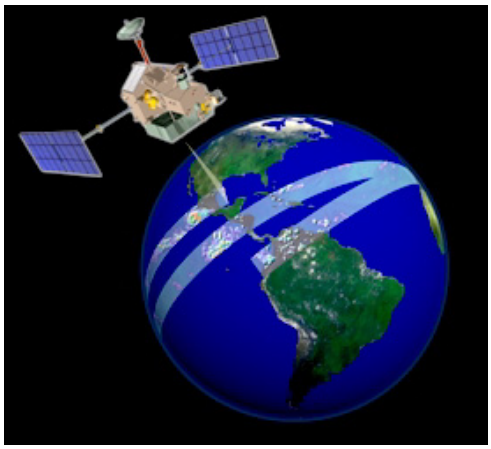

Figure 2: Illustration of TRMM's field of view as it swipes around the planet. [4]

close to the equator. LIS has an inclination of 35º, and RHESSI an inclination of 38º. This is fortunate for us since nearly 80% of all lightning occurs between ±30º latitude [5].

Just as for method one, gamma ray data from RHESSI will be superimposed to see if a peak emerges from the noise around the time of the lightning strikes. Figure 3 illustrate how we will treat the data. Method two will use RHESSI data from 2002 through 2013.

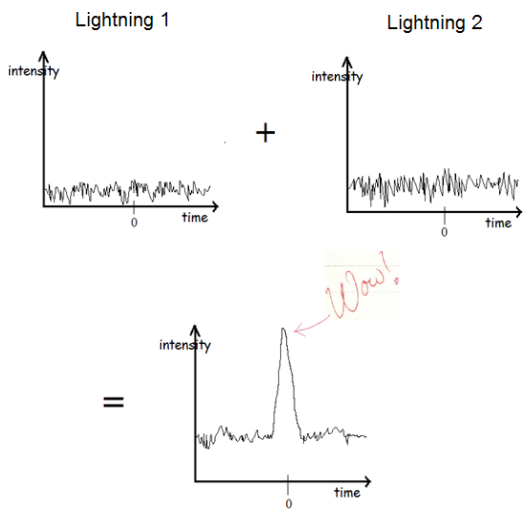

Figure 3: Basic illustration of how we will manipulate the data. RHESSI data from to different lightning events are placed on top of each other, resulting in an exaggerated peak. In reality we will superimpose hundreds of events.

3. References

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