

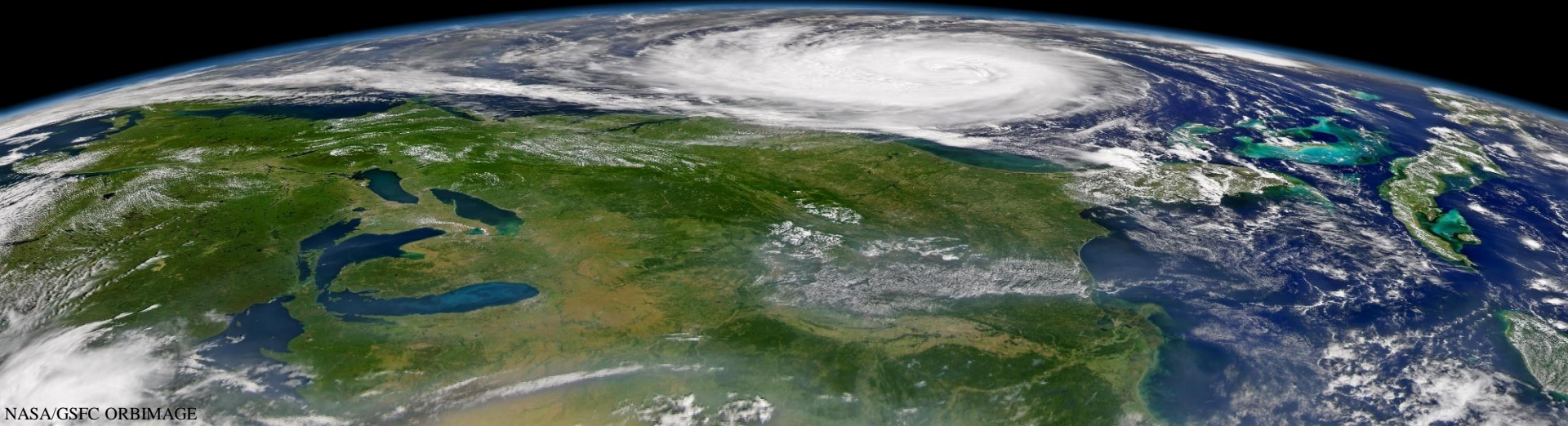
# Egy hétköznapi jelenség rejtélyes háttere: hogyan keletkeznek a villámok?

JÁNOSI IMRE

ELTE TTK KOMPLEX RENDSZEREK FIZIKÁJA TANSZÉK  
KÁRMÁN KÖRNYEZETI ÁRAMLÁSOK LABORATÓRIUM

<http://www.atomcsill.elte.hu>

<http://lecco.elte.hu>



















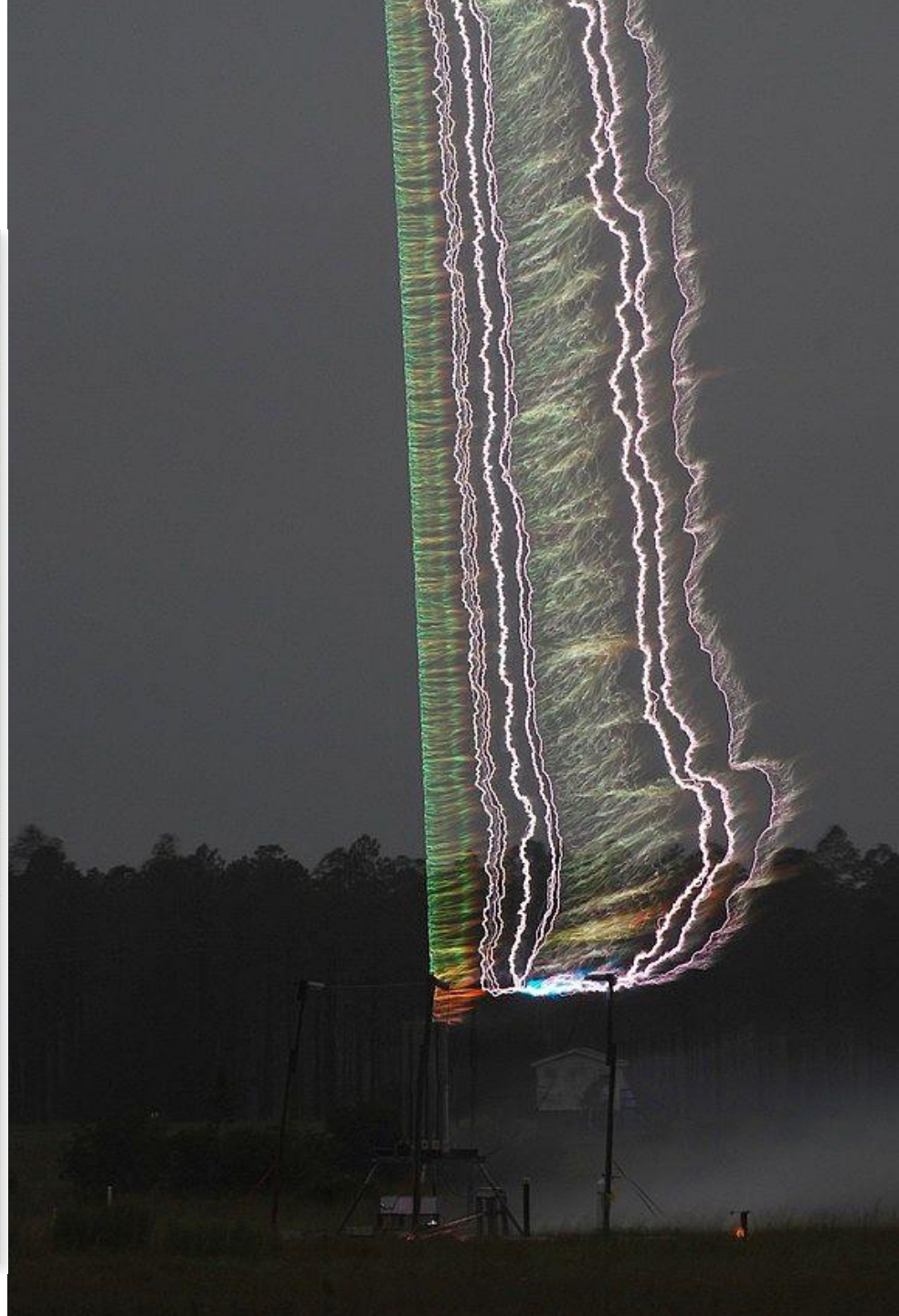
*Benjamin Franklin Drawing Electricity from the Sky*  
c. 1816 at the Philadelphia Museum of Art,  
by Benjamin West

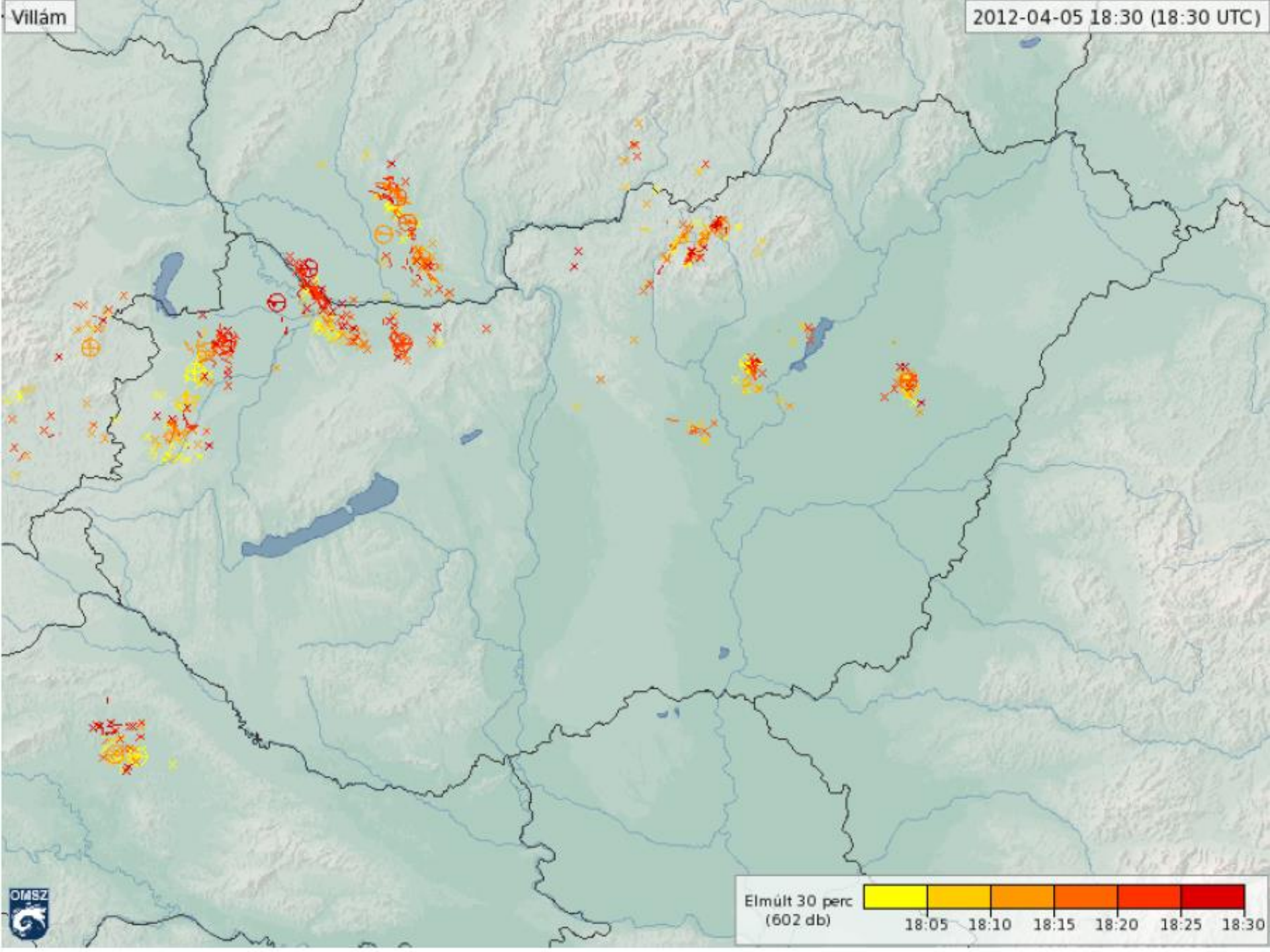


*Georg Wilhelm Richmann,*  
1753 aug. 6., Szentpétervár

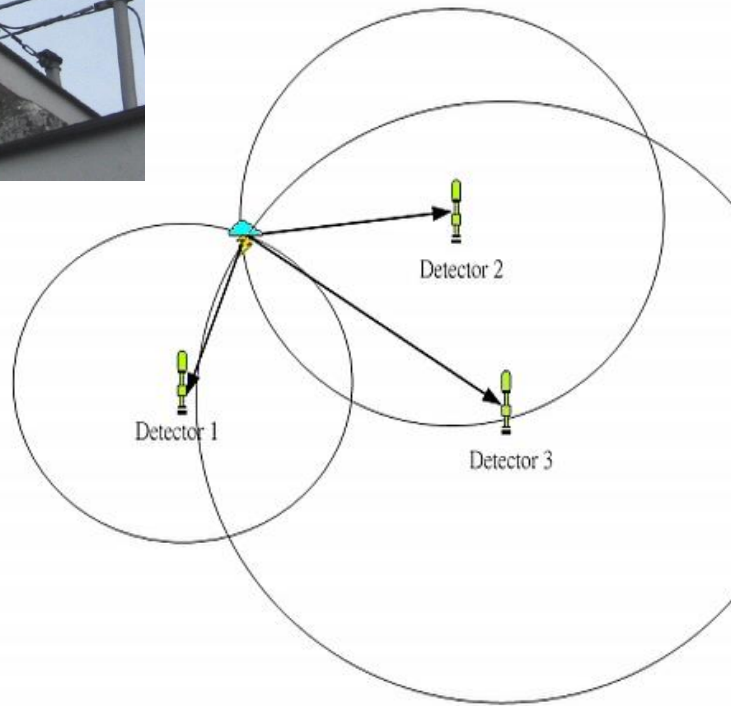
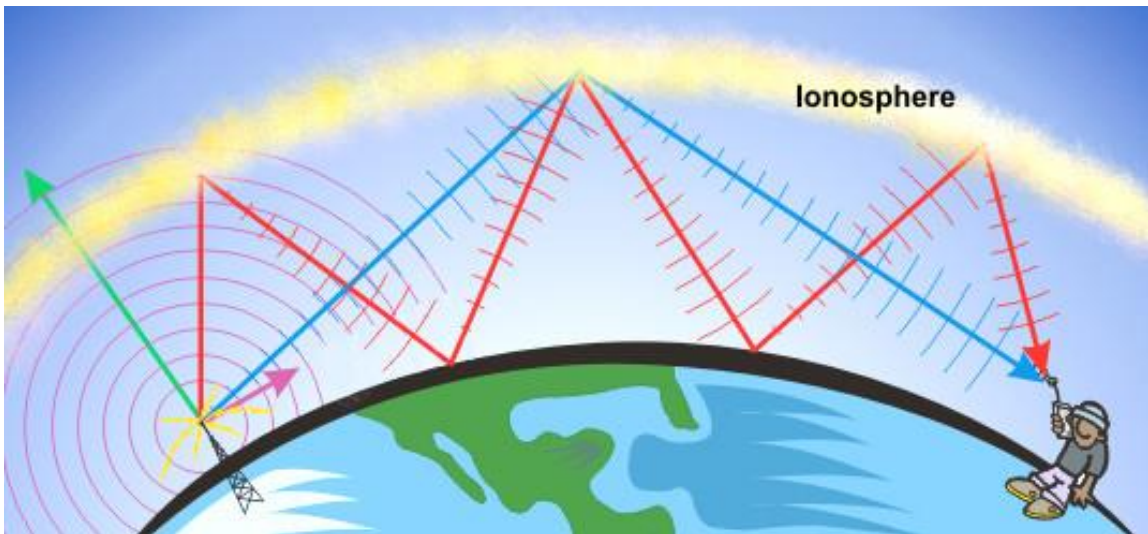


*Thomas Francois D'Alibard, 1752*

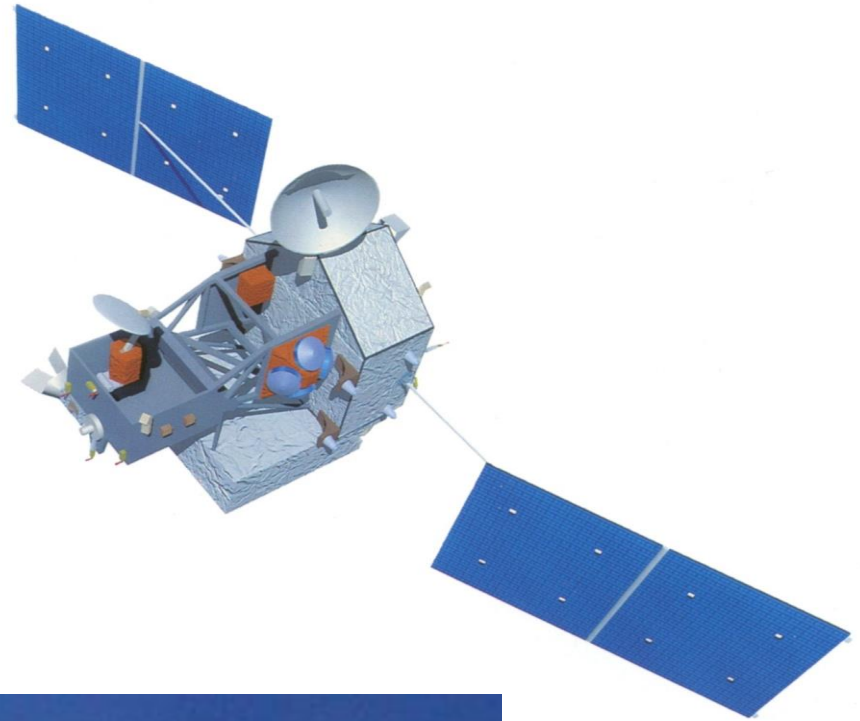
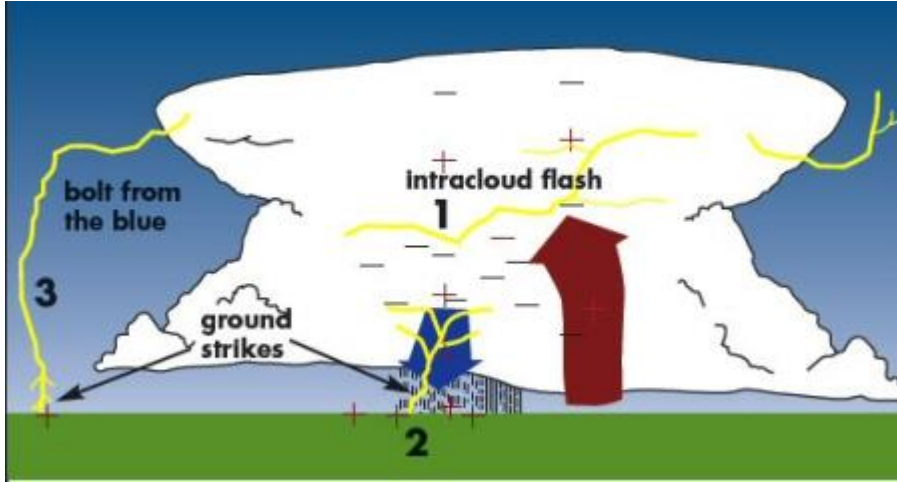




# Villám-detektálás a felszínen



# Villám-detektálás műholdakról



80 – 85 %

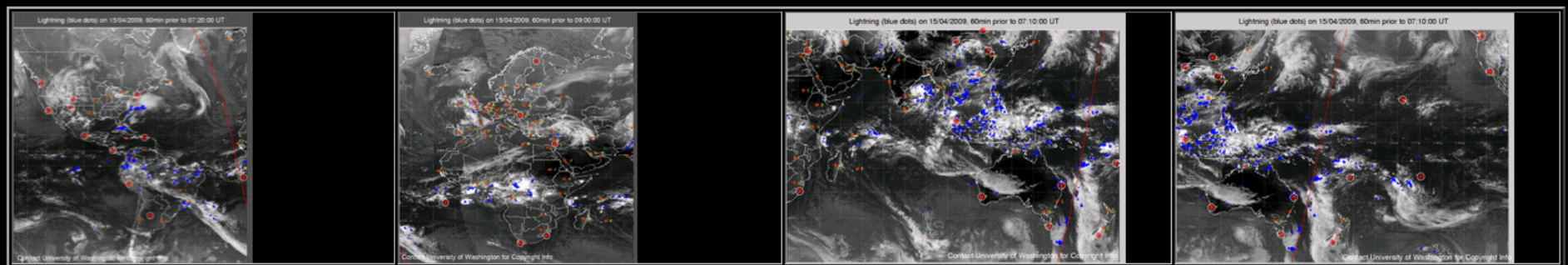
# WWLLN

## World Wide Lightning Location Network ([wwlln.net](http://wwlln.net))

SYSTEM MESSAGE: Welcome to several new hosts for stations in Yakutsk, Russia, Beijing and Nanjing, China, Scott Base Antarctica, and SANAE Base Antarctica.

Have you tried our Google Earth overlays? Try the one offered by our high speed data distribution partner [GuiWeather](#) (and parent WDT) which includes a sample from the last 30 minutes - start with the tab at the top, or zoom in a little with our own 1-hour overlay distribution at [WWLLN 1-hour](#) or play them together! RHH

Contact Prof. Holzworth at [bobholz@washington.edu](mailto:bobholz@washington.edu), Director of WWLLN, with any questions you may have.

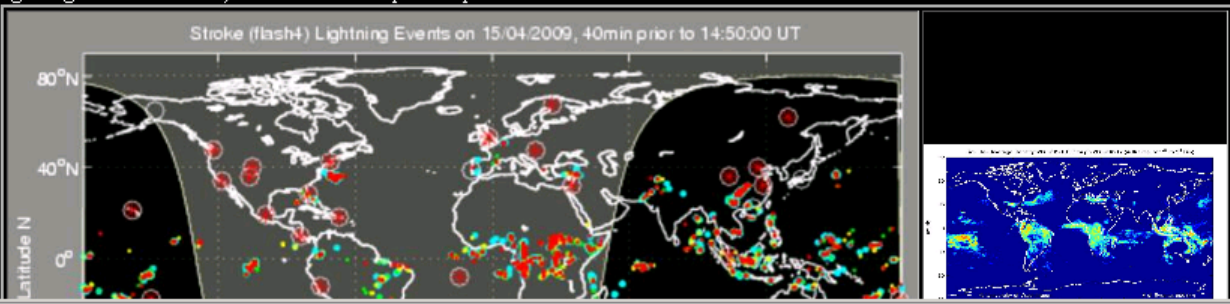


- click on image to get a bigger version -

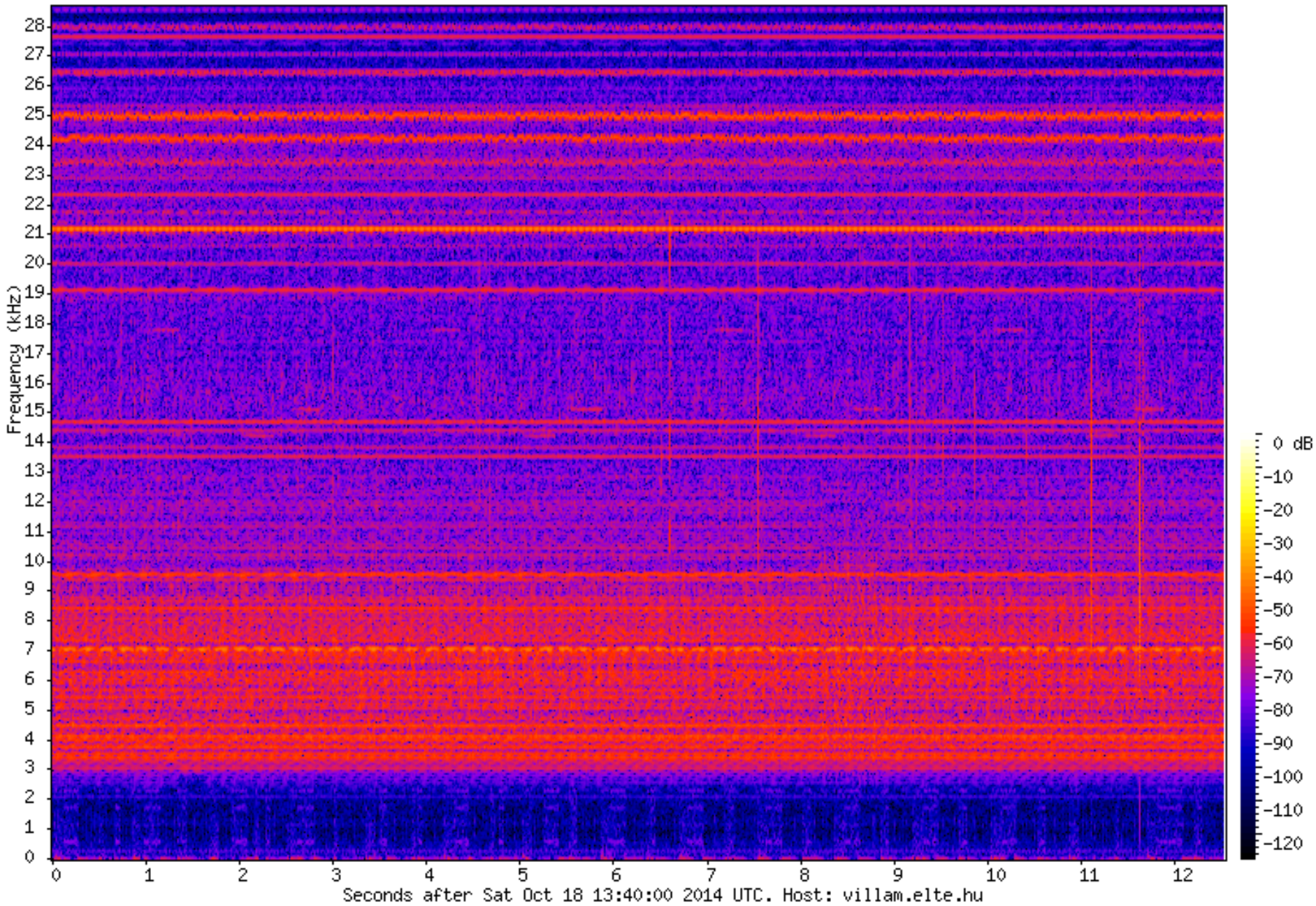
(Notes: cloud data thanks to National Weather Service/Aviation Weather Center; blue overlay dots are WWLLN Lightning; Red circles are WWLLN receivers; Red line is the terminator)

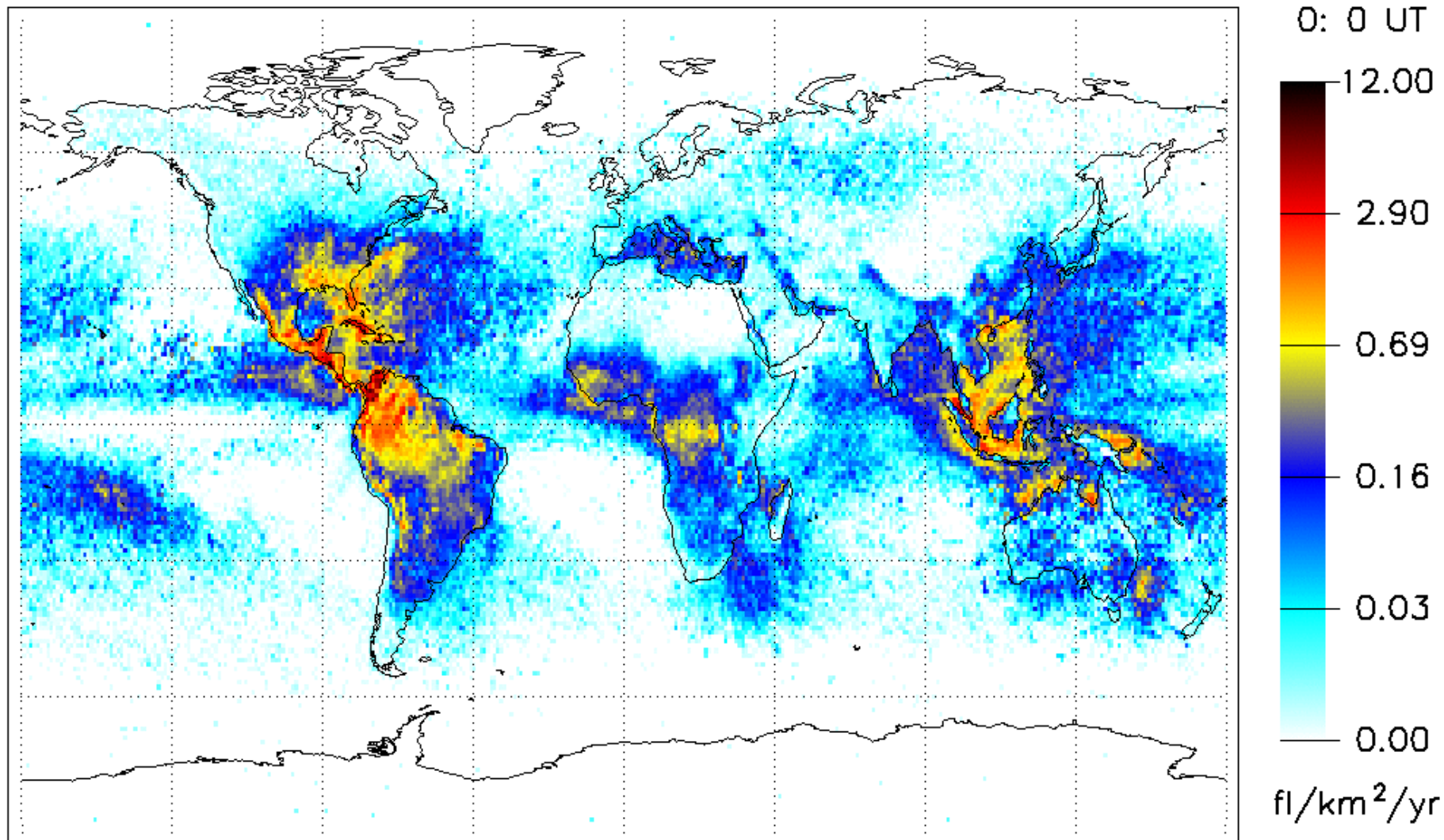
University of Washington in Seattle operating a network of lightning location sensors at VLF (3-30 kHz). Most ground-based observations in the VLF band are dominated by impulsive signals from lightning discharges called "sferics". Significant radiated electromagnetic power exists from a few hertz to several hundred megahertz, with the bulk of the energy radiated at VLF.

With our network of sferic sensors we are producing regular maps of lightning activity over the entire Earth. Our map showing the entire world uses coloured spots to indicate lightning strokes (red stars inside an open circle are active WWLLN lightning sensor locations). Click on the map for explanation.

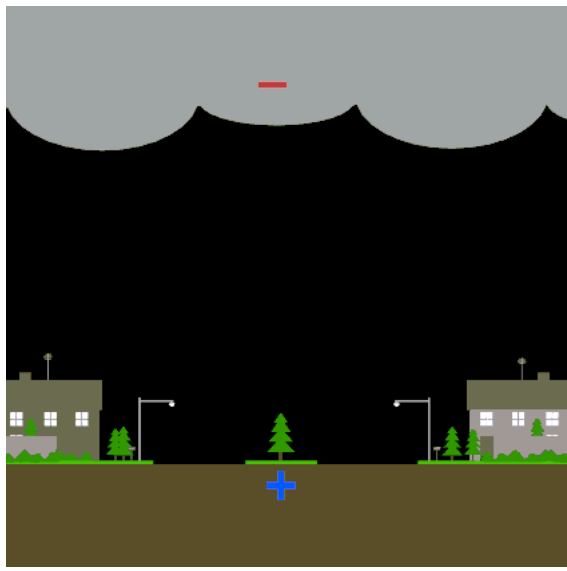
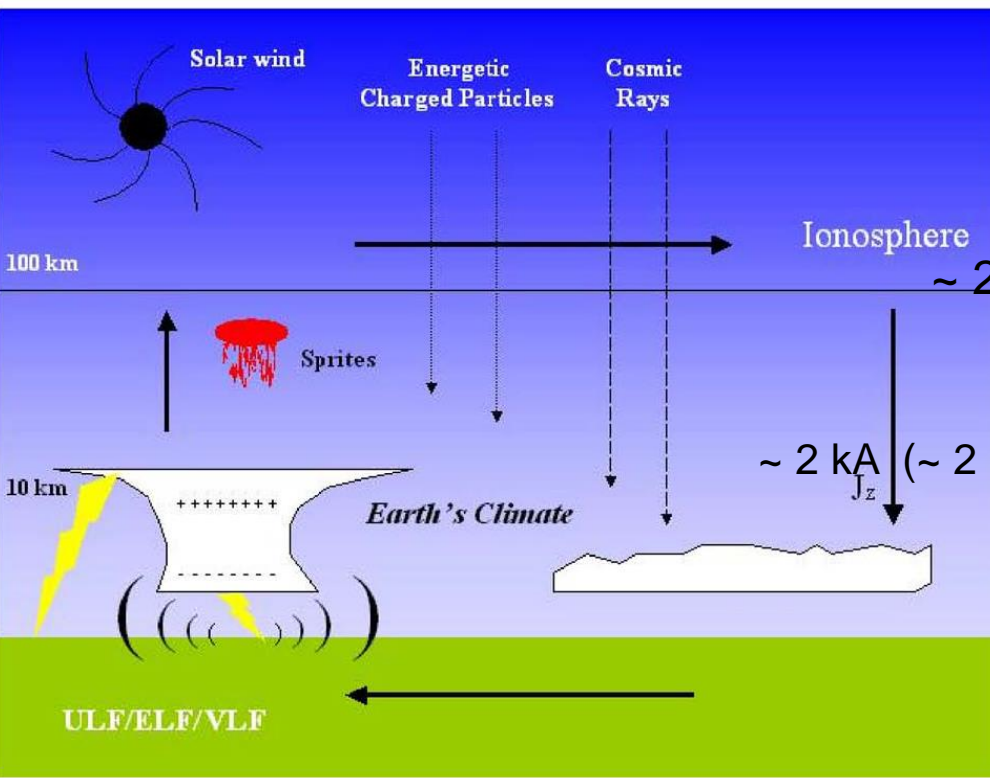


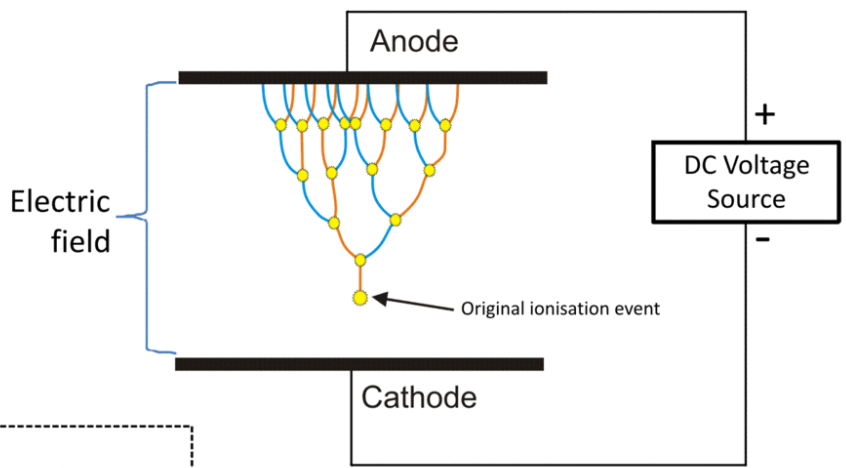
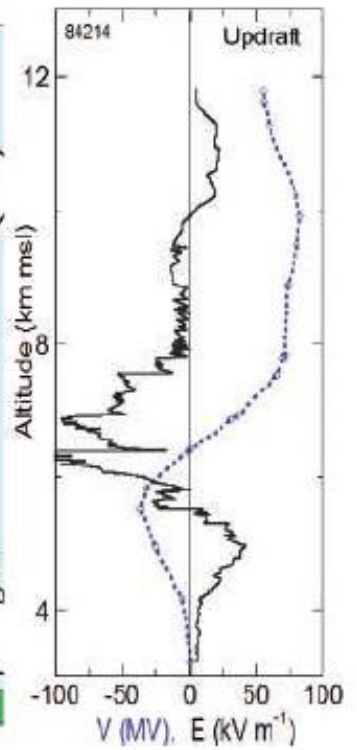
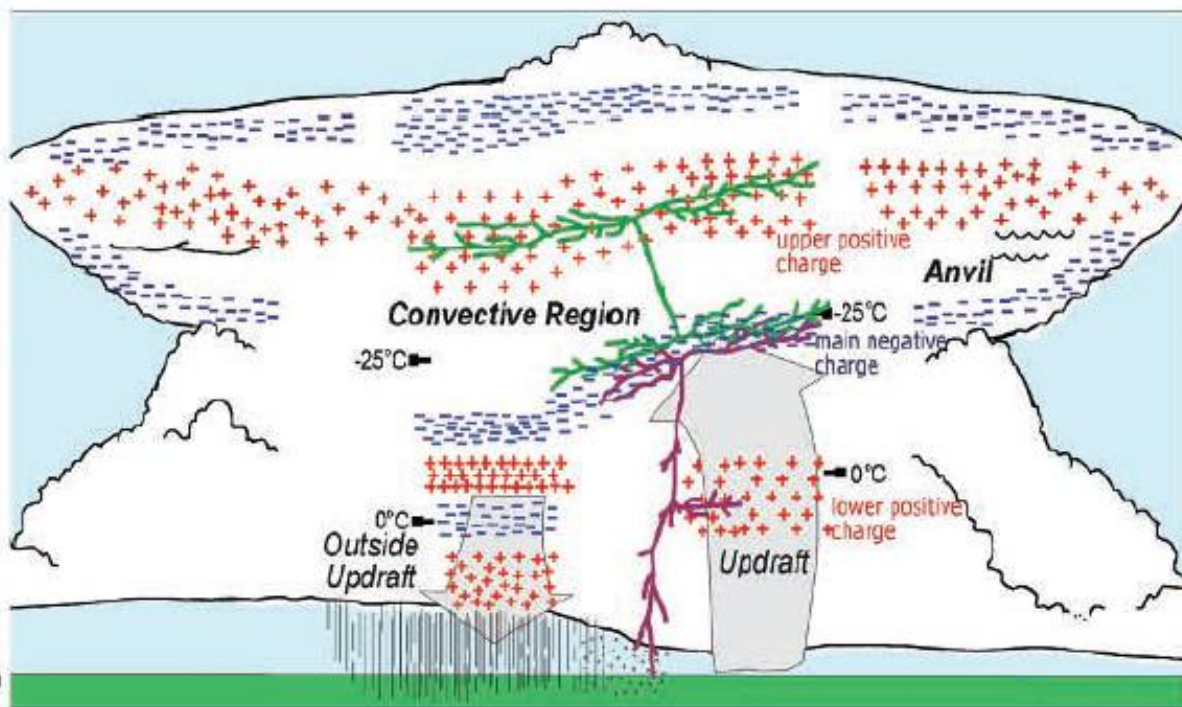
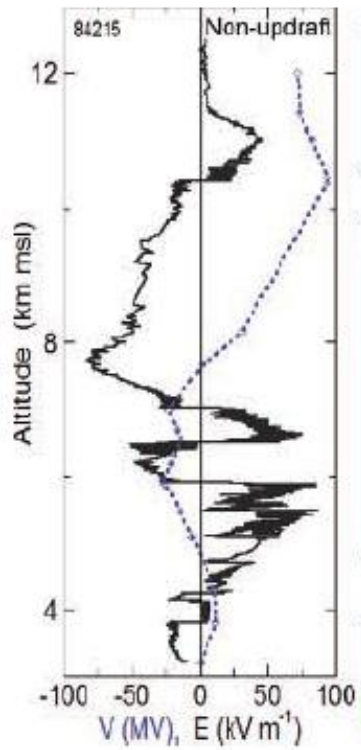
[http://wwlln.net/WWLLN\\_movies/Movie\\_of\\_Lightning\\_in\\_Pacific\\_BIG.gif](http://wwlln.net/WWLLN_movies/Movie_of_Lightning_in_Pacific_BIG.gif)





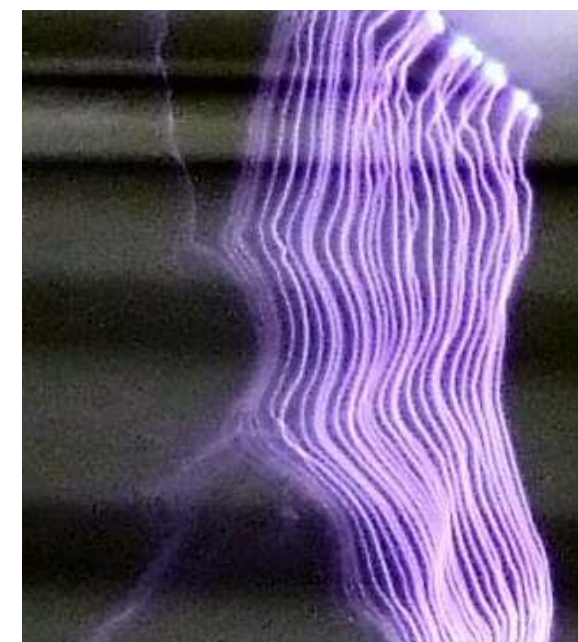






- Key**
- Ionisation event
  - Ionising electron path
  - Liberated electron path

Not to scale



## Főbb tulajdonságok:

Átlagos áramerősség: ~ 30 kA (max.: ~120 kA, pozitív töltésűeknél ~ 300 kA)

Szállított töltés: ~ 15 C (max.: ~ 350 C)

Energia: ~ 500 MJ (145 liter benzin!)

Időtartam: ~ 30  $\mu$ s – 1 ms (pozitív töltésűeknél sokkal hosszabb)

Átmérő: ~ néhány cm

Hosszúság: ~ 3-5 km

Gyakoriság: 40-50 villámcsapás/s (globális)

Halálos áldozatok száma: 6000 – 24000 / év (?)

Halálozási ráta: 10 – 30% (!)



Roy Sullivan (1912-1983)

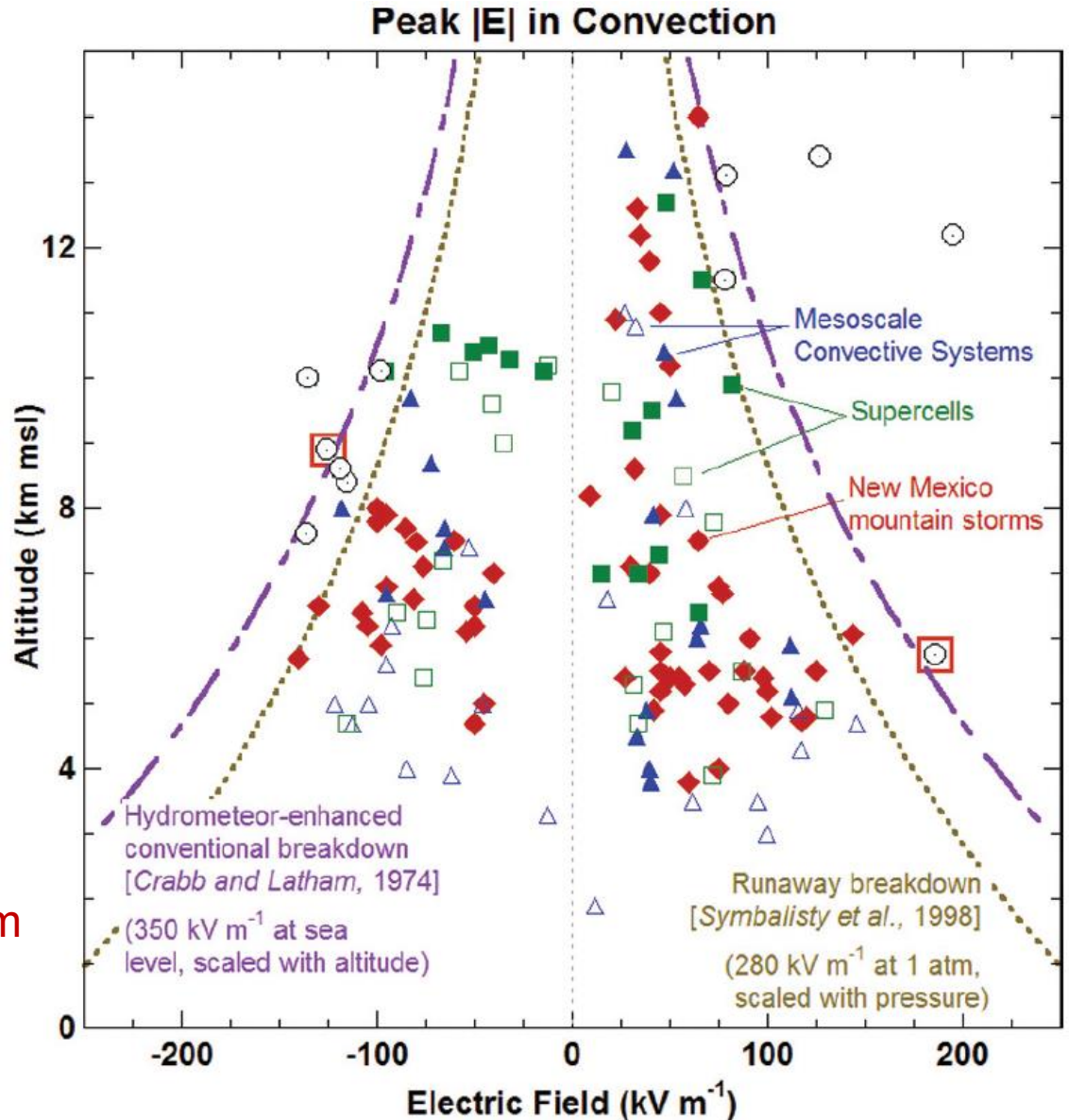
# Lightning: Principles, Instruments and Applications

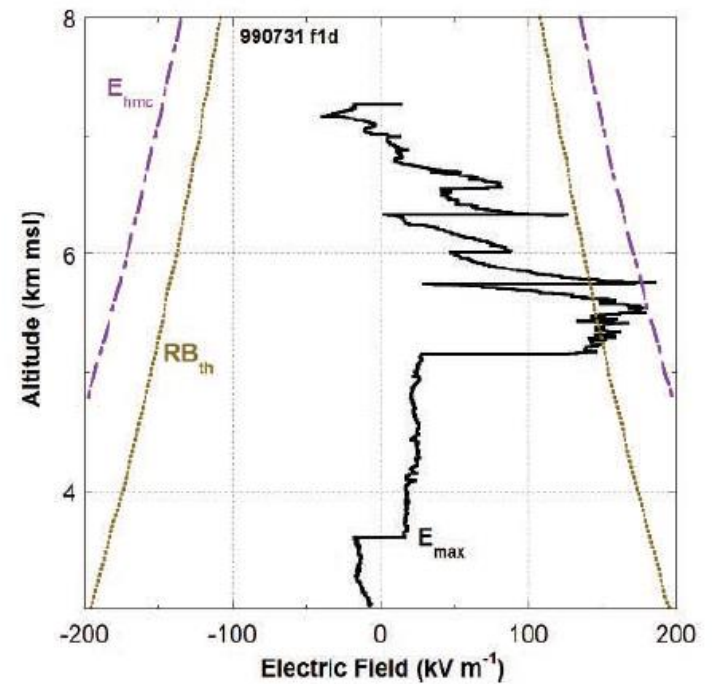
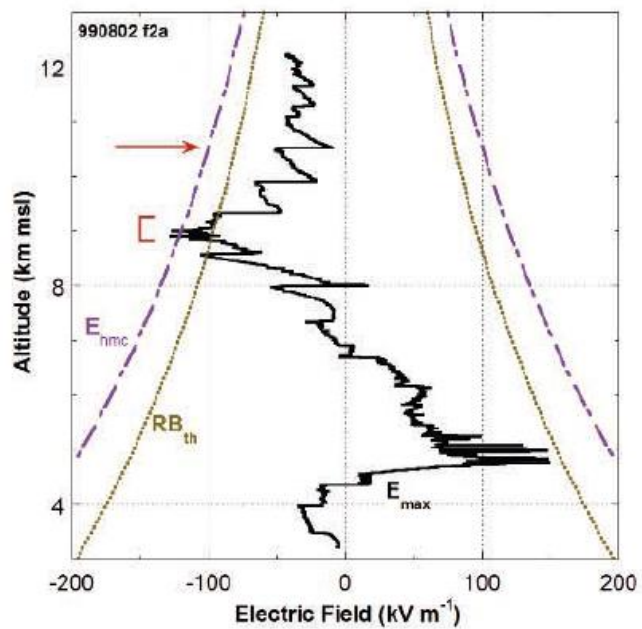
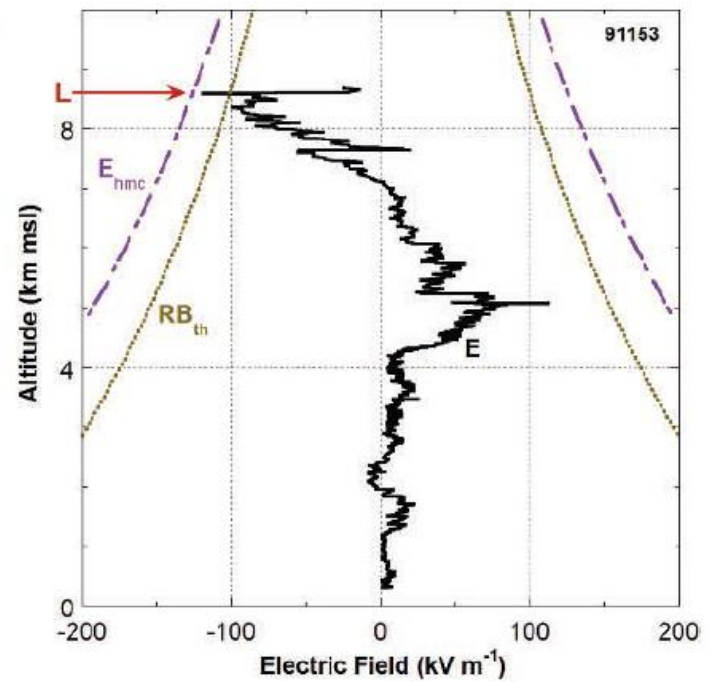
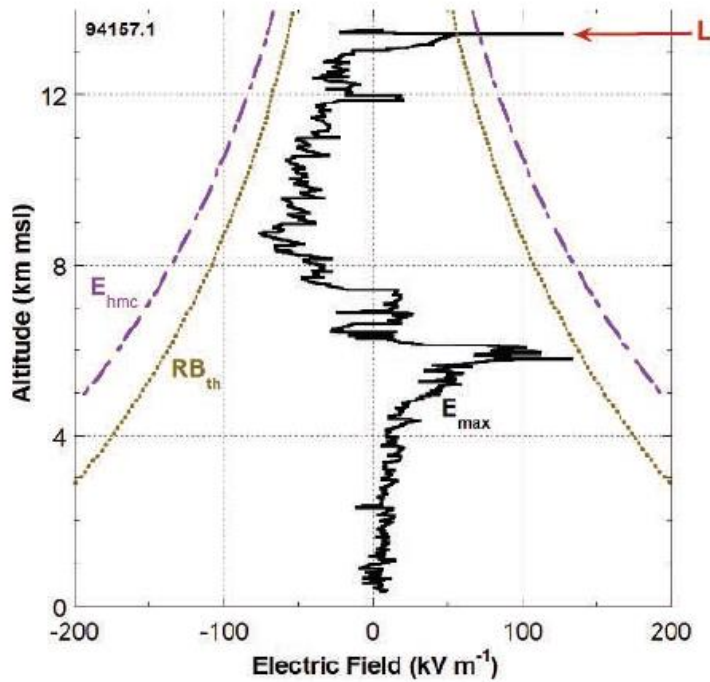
Review of Modern Lightning Research

(Springer, 2008)

## Átütési „feszültség”:

- tiszta levegő: 3000 kV/m
- vízcseppek: 350 kV/m
- „elektron lavinák”: 280 kV/m

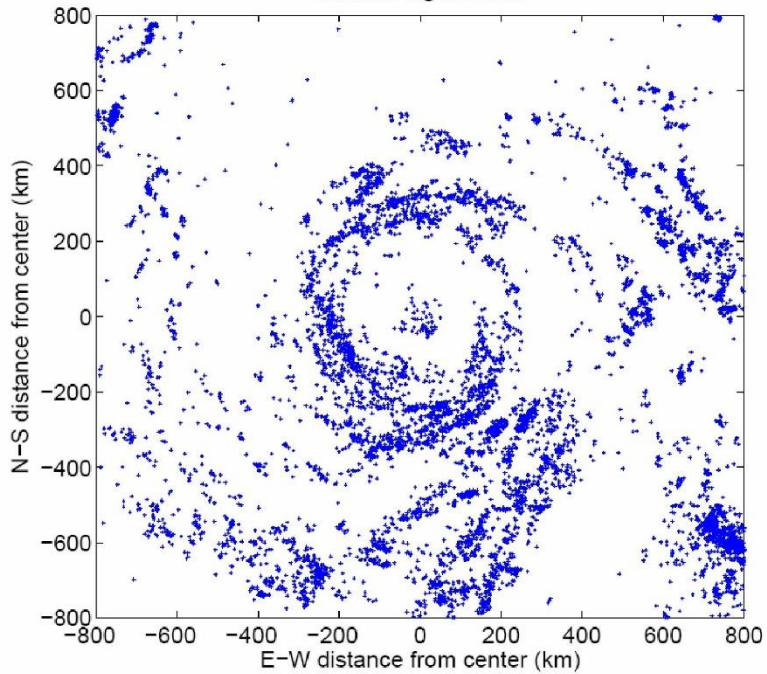




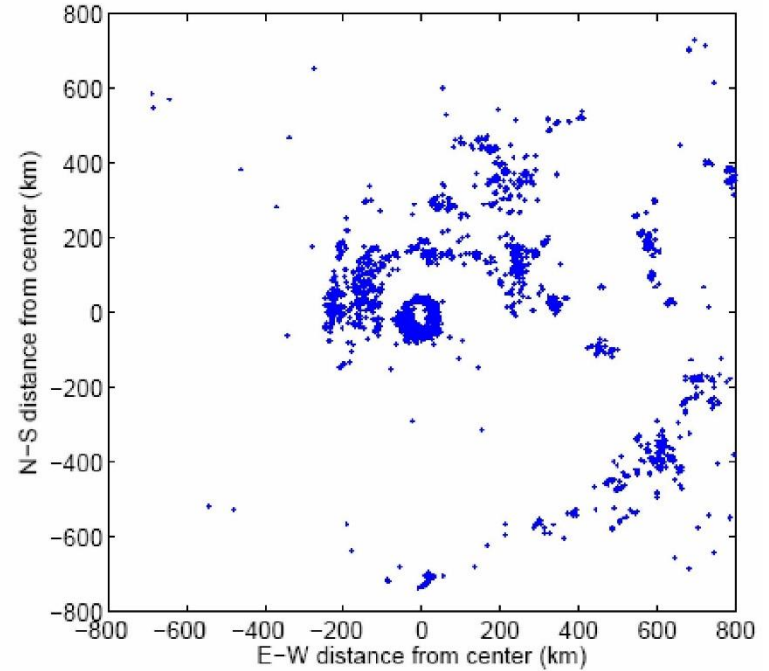




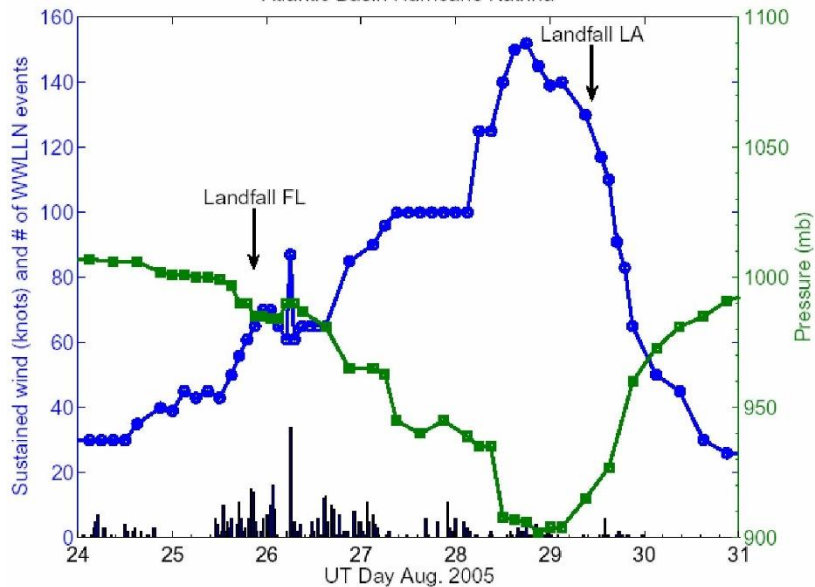
Katrina Aug 28 2005



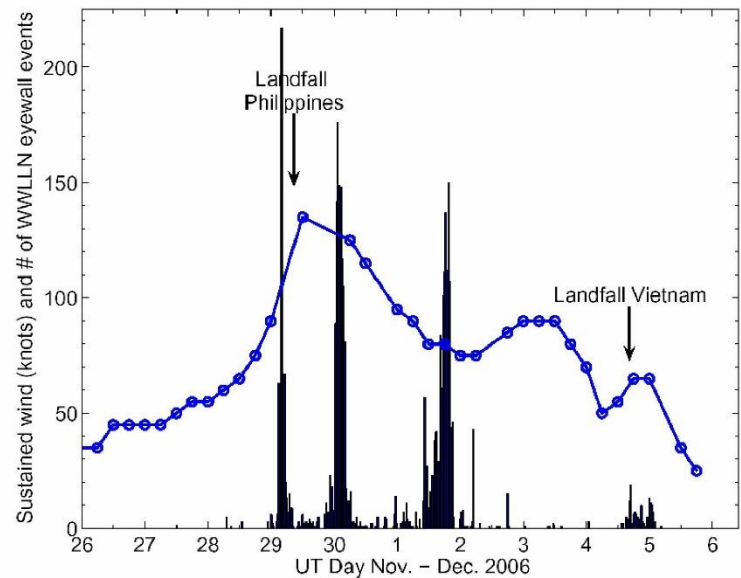
DURIAN-06 11\30\2006



Atlantic Basin Hurricane Katrina

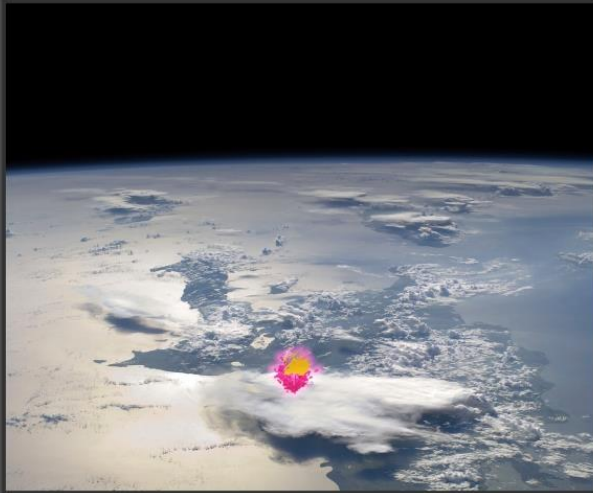


Western Pacific Typhoon Durian





# How thunderstorms launch particle beams into space



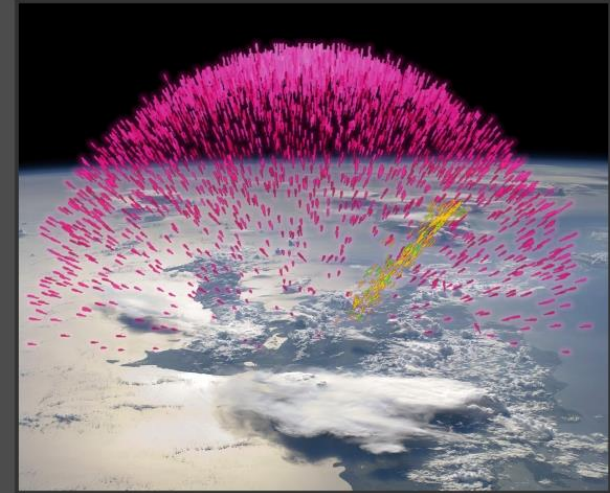
- 1.** Electric fields near the top of the storm create an upward-moving avalanche of **electrons**. When their paths are deflected by molecules in the air, these electrons emit **gamma rays**, the highest-energy form of light.

These images are based on a TGF simulation by Joseph Dwyer at the Florida Institute of Technology. This frame tracks the gamma rays and particles from a 0.2-millisecond-old TGF that began at an altitude of 9.3 miles (15 km).



- 2.** When gamma-ray energy collides with electrons, they accelerate to near the speed of light. Some gamma rays pass near the nuclei of atoms. When this happens, the gamma ray transforms into an electron and its antiparticle, a **positron**.

These high-energy electrons and positrons escape into space by spiraling along Earth's magnetic field. In this frame, the TGF is 1.4 milliseconds old.



- 3.** Here the TGF is 1.98 milliseconds old, and its electron/positron beam is reaching altitudes where it may intercept spacecraft, such as NASA's Fermi Gamma-ray Space Telescope.

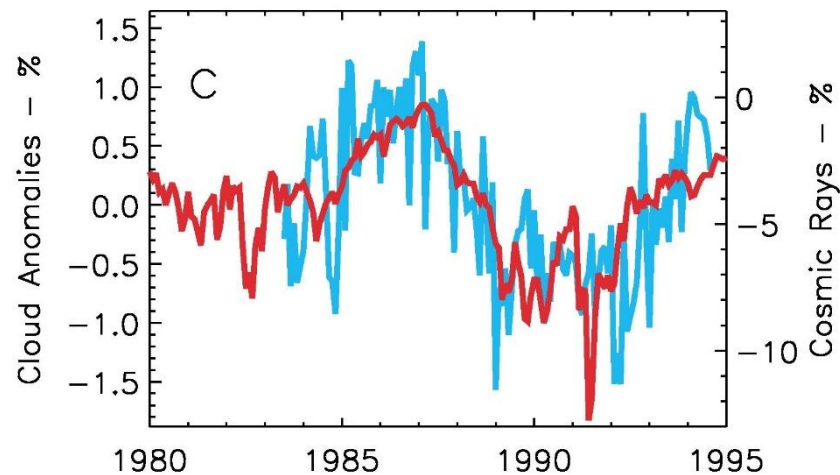
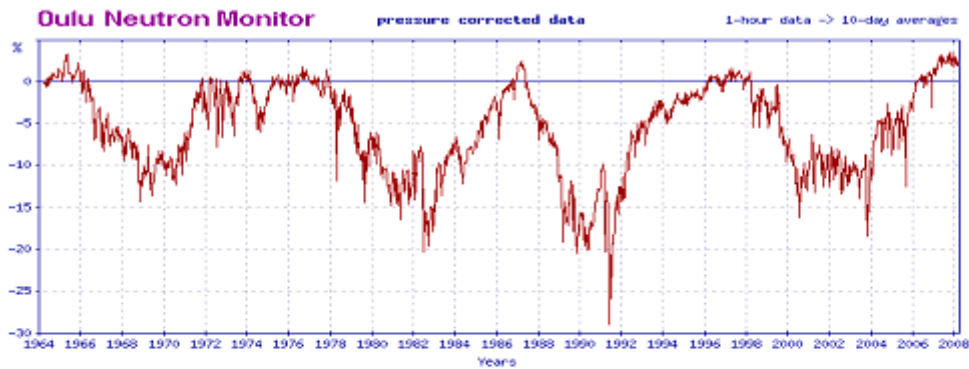
Fermi's Gamma-ray Burst Monitor detected a signal characteristic of positron annihilation. When a positron collided with an electron on the spacecraft, the two particles transformed into gamma rays.

A „kozmos kapcsolat”



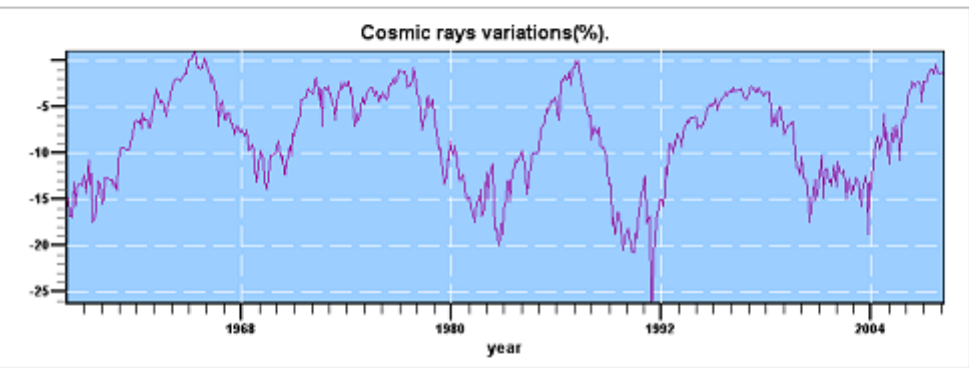
# A „kozmosz kapszula”





N.D. Marsh, H. Svensmark, *PRL*, 2000.

**Moscow**



**Climax & Haleakala**

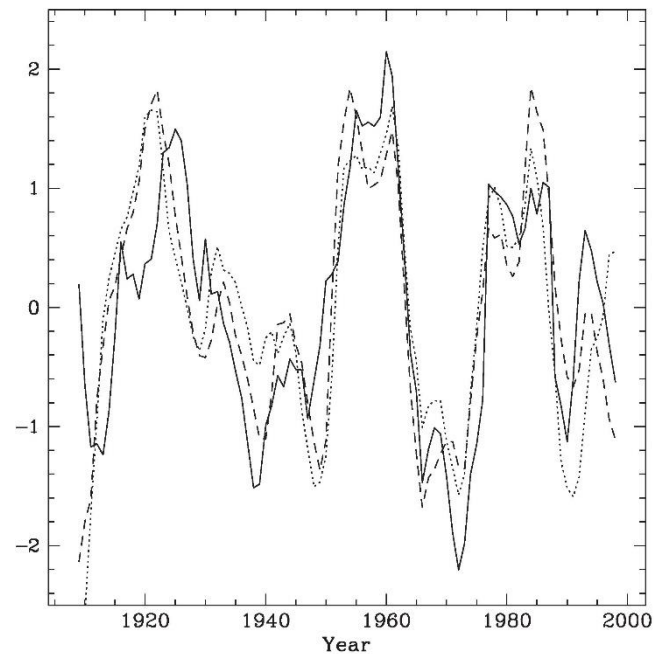
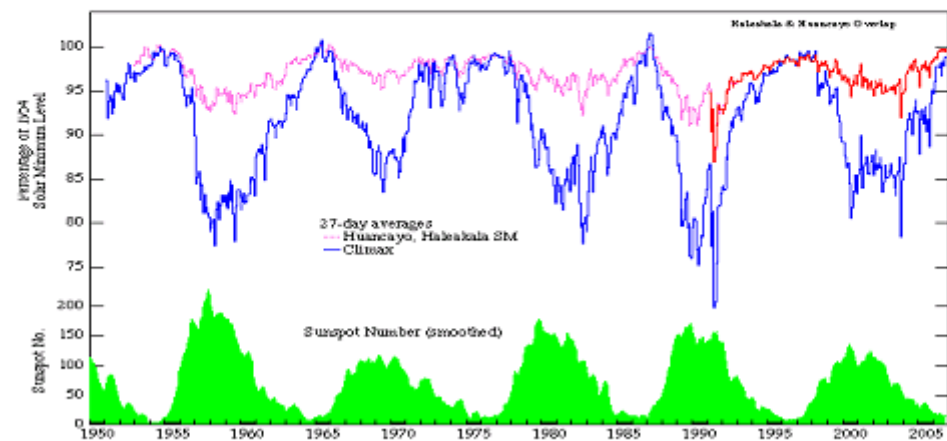


FIG. 2. The detrended time series for the Paraná's stream flow (full line), the sunspot number (dashed line), and the irradiance reconstruction (dotted line). The detrended series were obtained

P.J. Mauas, E. Flamenco, A.P. Buccino, *PRL*, 2008.

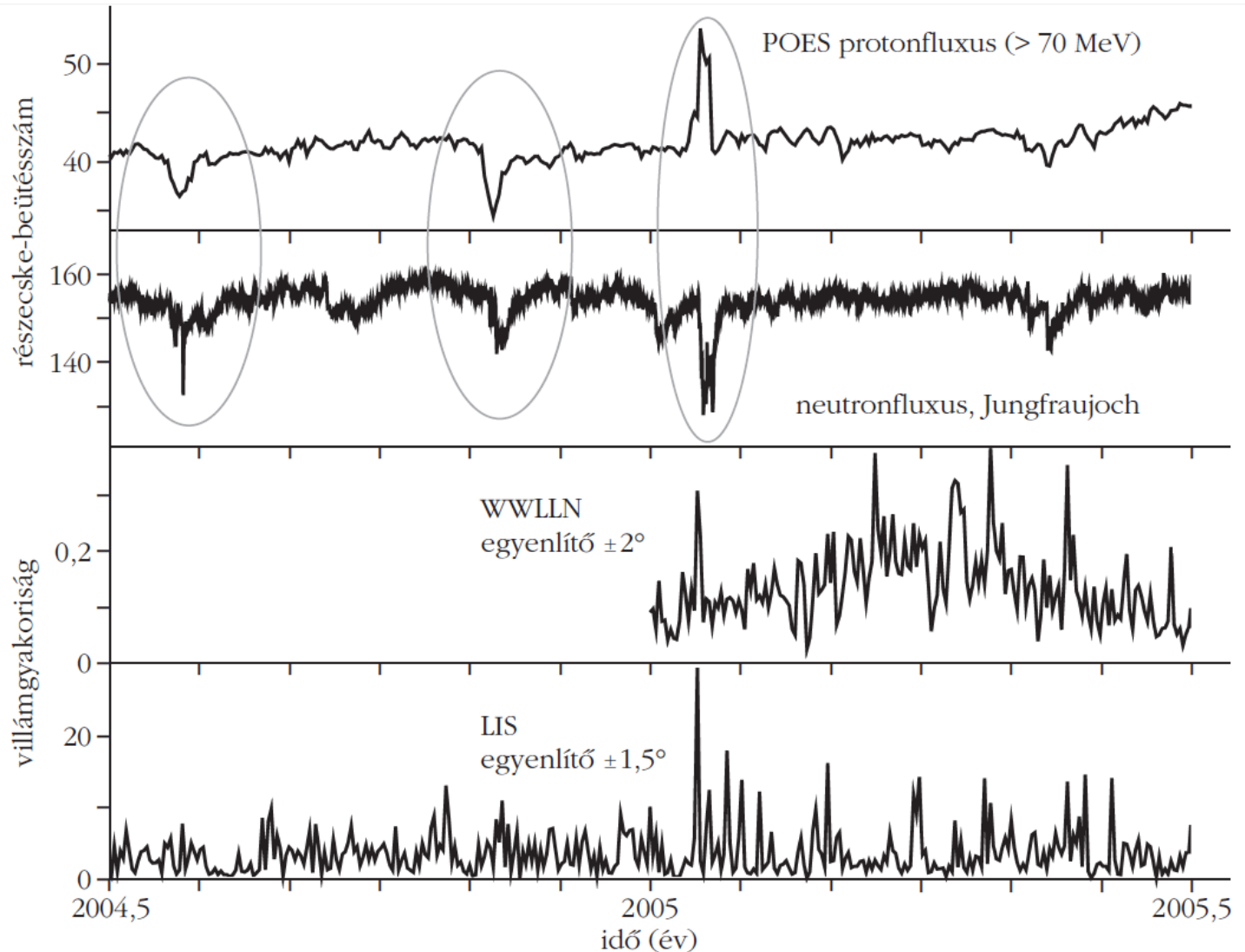
# A „kozmos kapcsolat” (?)



# Kozmikus sugárzás, időjárás, éghajlat: hol a hiányzó láncszem?

Kiss Péter, Csabai István, Lichtenberger János, Jánosi Imre

Fizikai Szemle, **59/7-8**, 238-243 (2009).



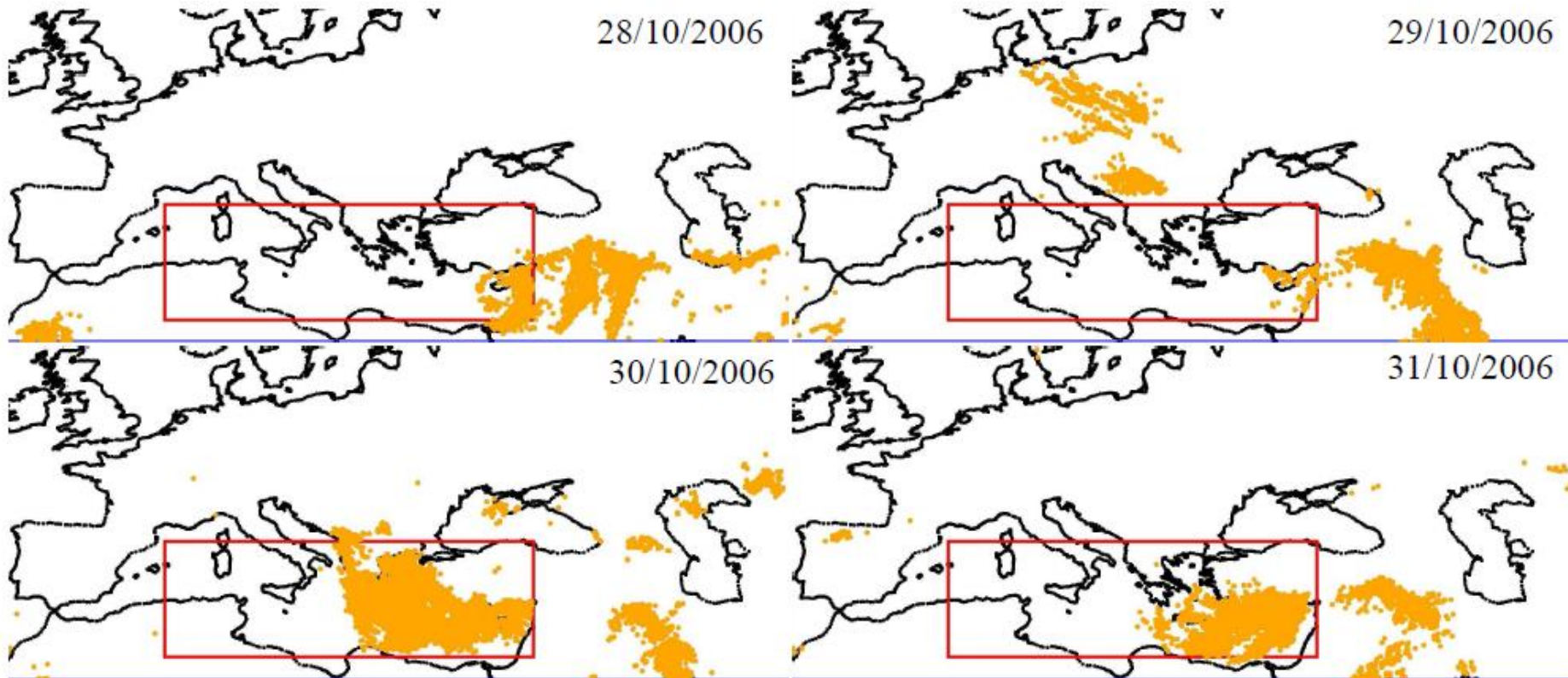
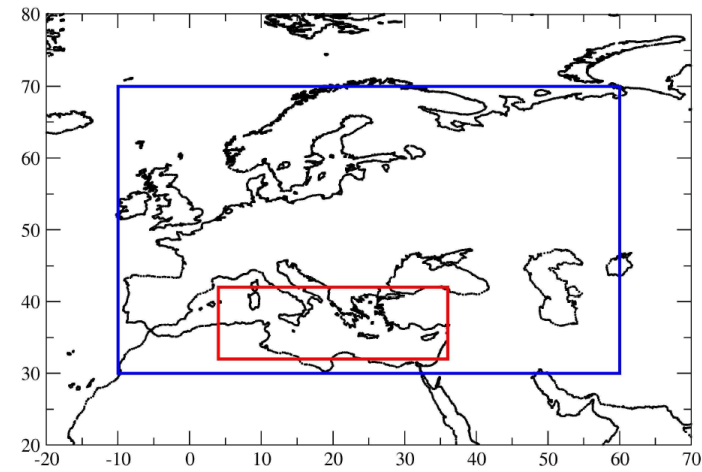
8. ábra. Műholdon mért protonfluxus (legföül), a Jungfraujoch (Svájc) földi állomás neutronfluxusa (alatta), illetve egy WWLLN és LIS műholdas adatbázisból kinyert villámgyakoriság időfejlődése. Az első két ellipszis Forbush-eseményeket, a harmadik a Napból érkező 2005. január 15-i protonzáport



Search for possible relationship between volcanic ash particles and thunderstorm lightning activity.

*A. Várai, M. Vincze, J. Lichtenberger, and I. M. Jánosi*

IOP Journal of Physics: Conference Series, **333**, 012016 (2011).





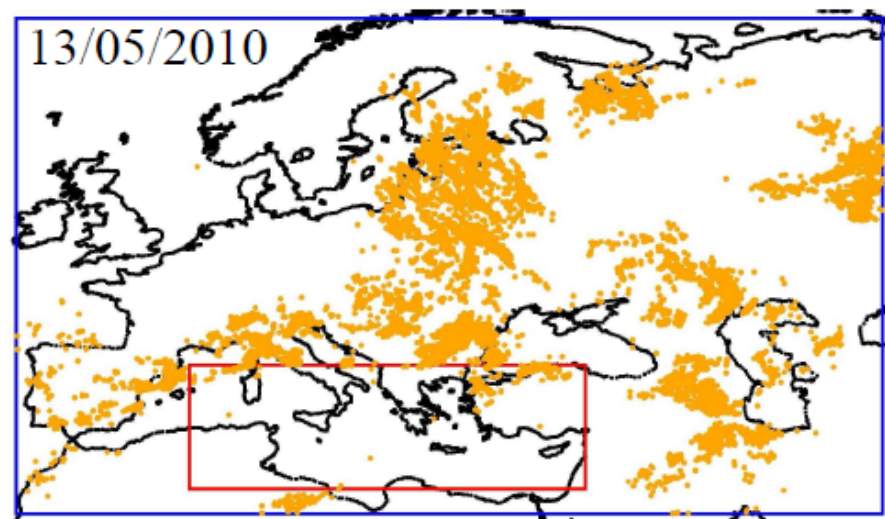
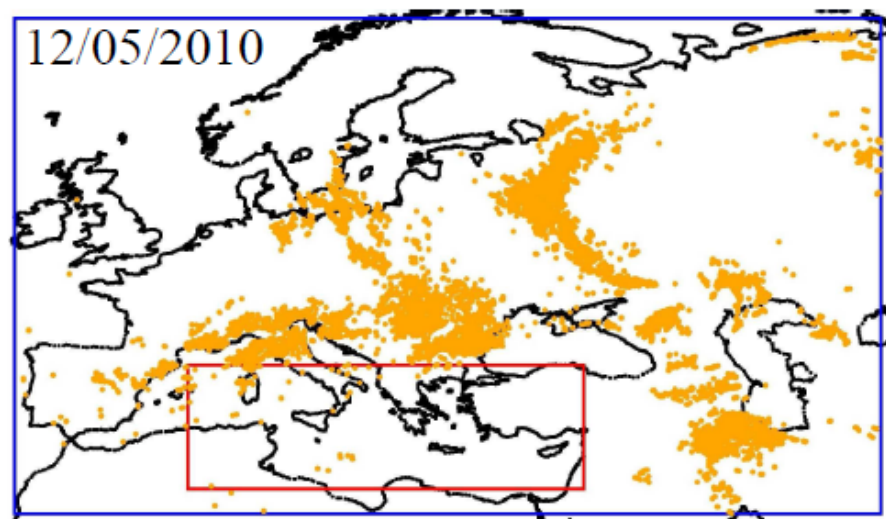
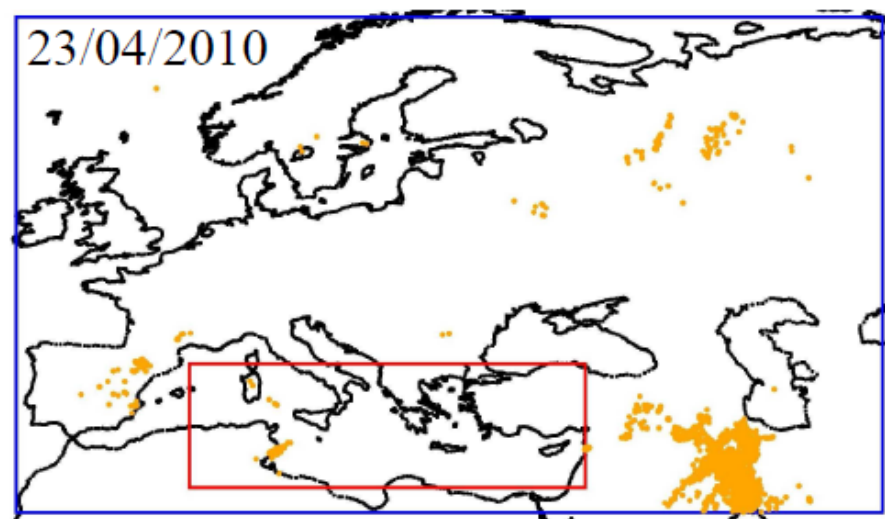
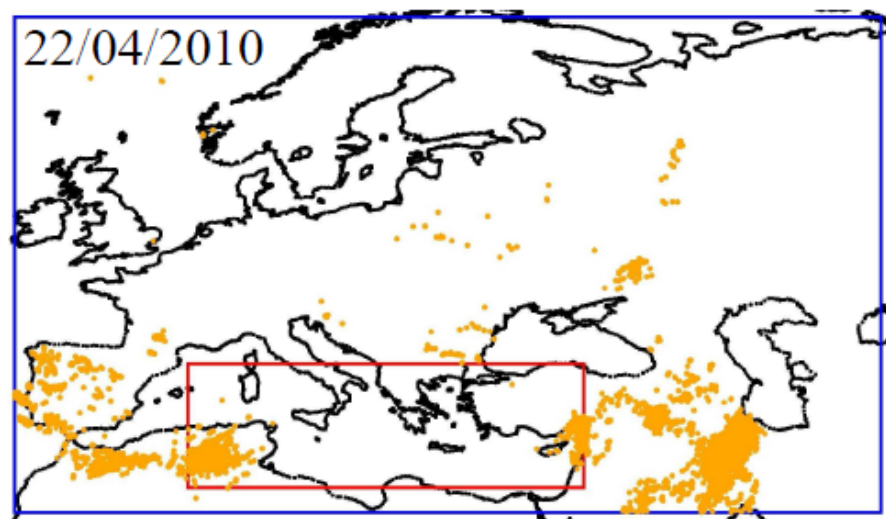
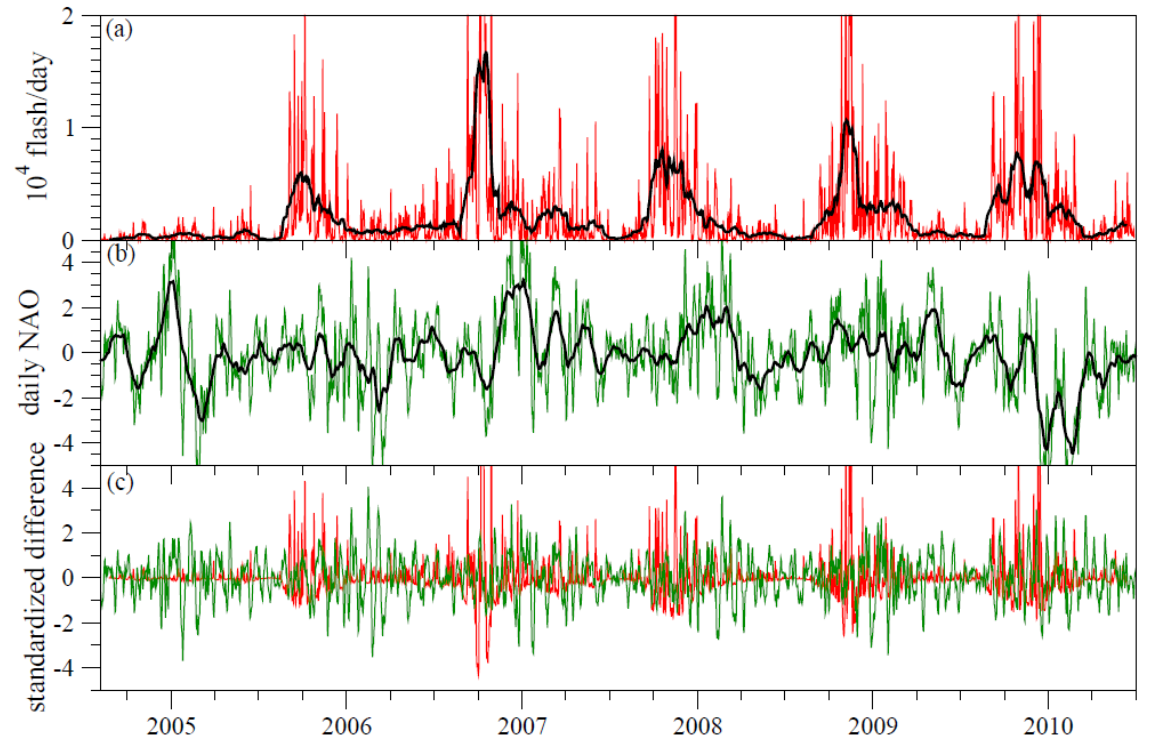
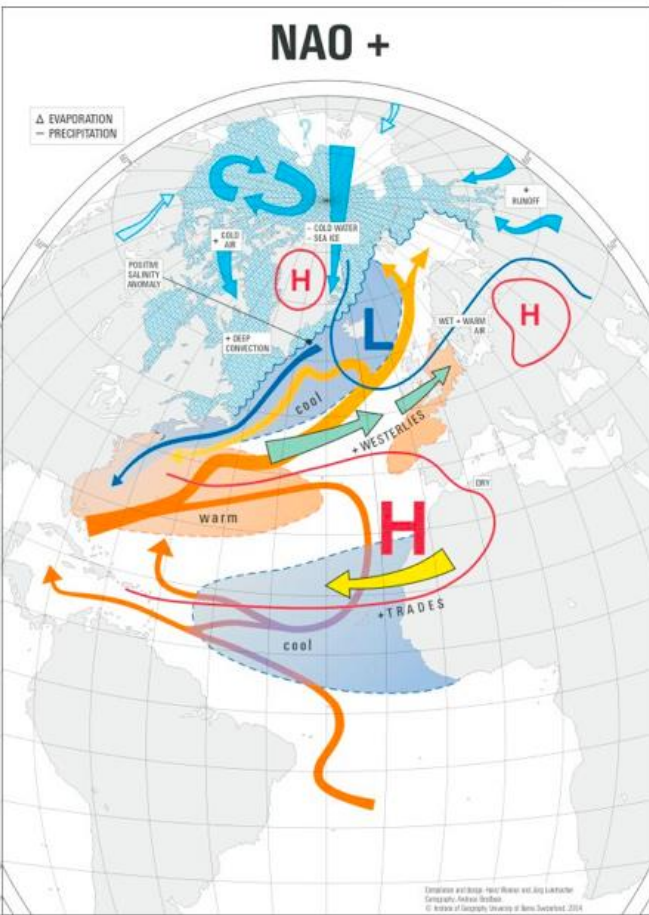


Figure 5. Lightning activity on four days over Europe (see Fig. 1), April and May 2010, when airport closures are reported.



**Figure 6.** (a) WWLLN lightning counts over the Mediterranean Sea (red), and 31-day running mean (black). (b) Daily NAO index (green) from the same period as in (a), and 31-day running mean (black). (c) Lightning anomaly (red) and NAO anomaly (green) computed as the difference between the daily value and the 31-day running mean.

# Orvos Péter, Homonnai Viktória, J.I.: Korreláció MODIS szárazság indexekkel?

