

Task 4 / Project 5 report

How do thunderstorm activities interact with the atmosphere, ionosphere and magnetosphere?

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Project plan

- 1) Investigate dynamical effect of thunderstorm activity in the middle and upper atmosphere, including wave-4 structures.
- 2) Investigate the effect of electrical discharges on ion/electron density in the ionosphere and atmospheric constituents.
- 3) Establish the global electric circuit model, covering surface, atmosphere, ionosphere and magnetosphere.
- 4) Investigate the relationship between high energy particles and thunderstorms.
- 5) Investigate the relationship between thunderstorm and solar activities. (collaborating with TG1)

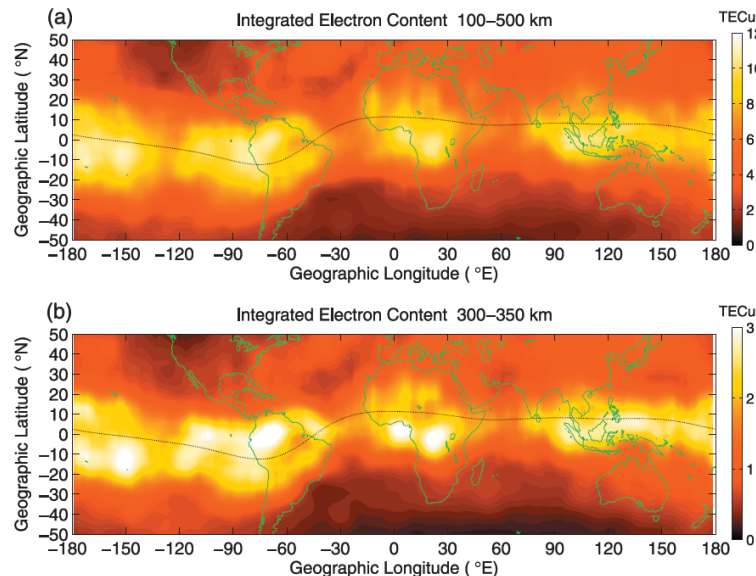
1) Dynamical effect of thunderstorm activity in the middle and upper atmosphere, including WAVE-4 structures.

- Lightning data provide information on lower boundary condition (forcing) for numerical modeling with temporal variation of horizontal distribution.
- no other good observational information available especially for vertical flux.

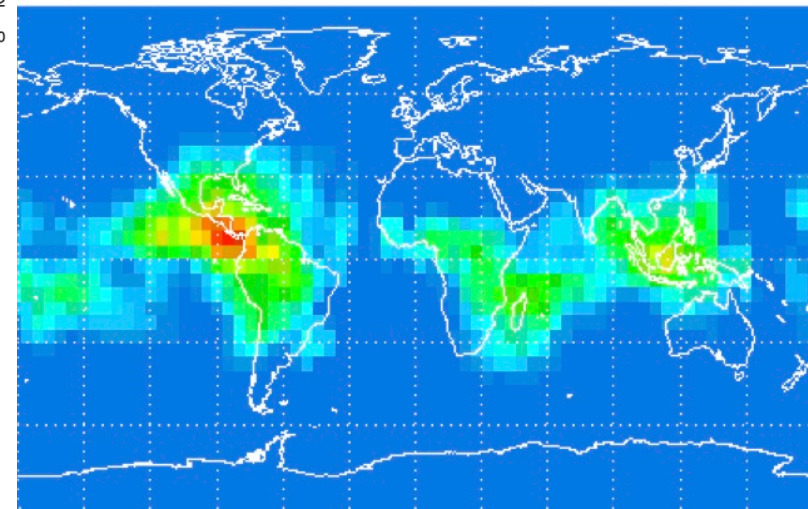
-Recent Progress:

Lightning Detection Networks improved:

WWLLN (Washington Univ.) , ATDnet (MetOffice, UK) ,
GEON/AVON (Hokkaido Univ., Japan),,,,



WAVE-4 observed in electron density



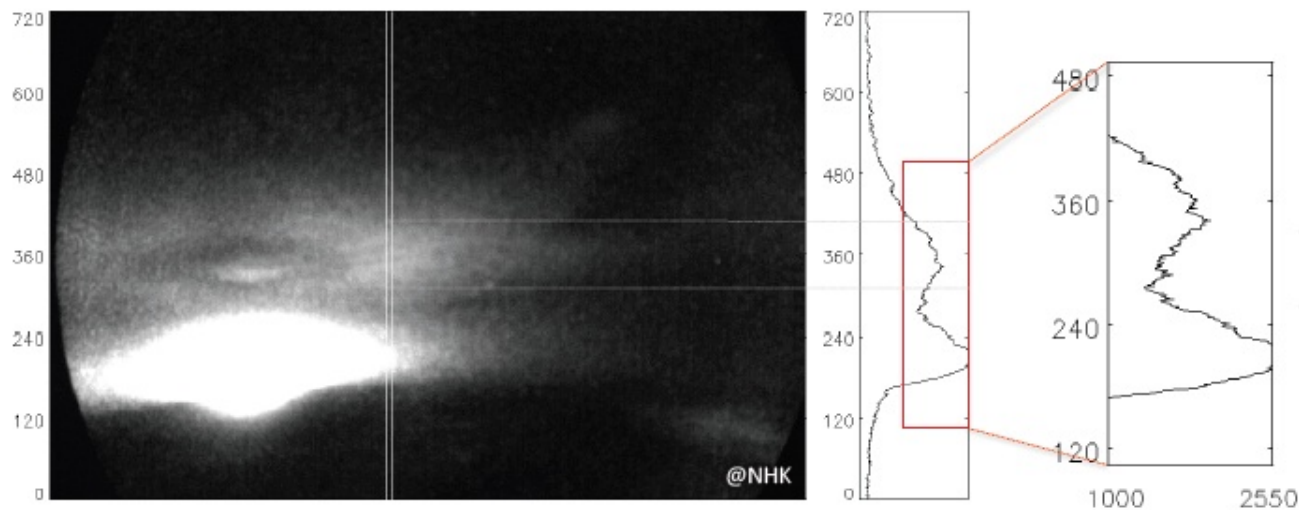
Lightning distribution by GEON

2) Effect of electrical discharges on ion/electron density in the ionosphere and atmospheric constituents

- TLEs could cause electron density modulation, inducing chemical effects.
- TLEs could indicate the electron density structures.

Recent Progress:

Wave structures in elves were found, which show the inhomogeneous electron density structure caused by gravity wave.

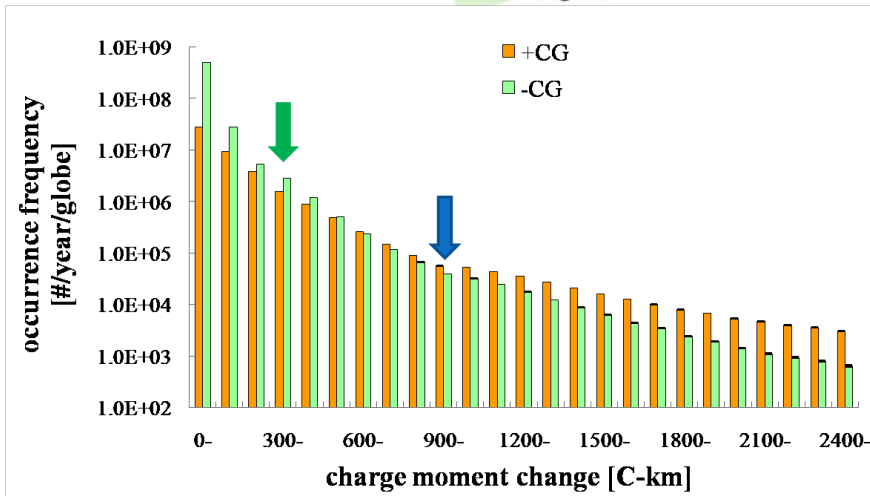
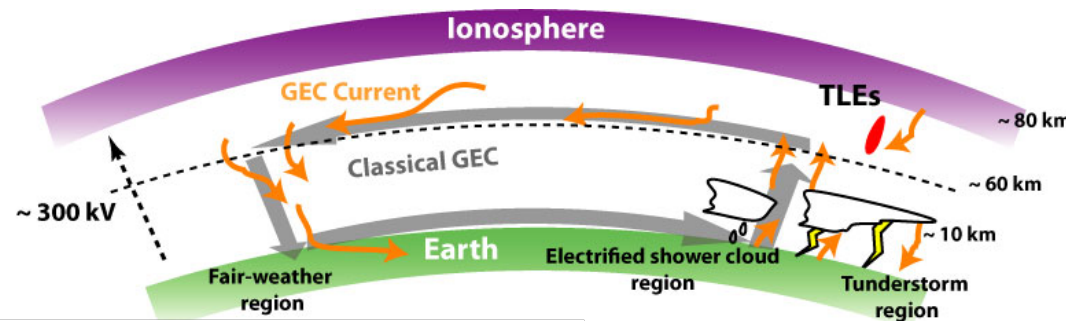


Brightness modulation in elves with an amplitude of 10%

3) Global electric circuit model, covering surface, atmosphere, ionosphere and magnetosphere

Recent Progress:

- The height of upper boundary should be re-considered.
- Number of measuring sites for Potential Gradient (PG) are increasing.
- These are compared each other and with currents carried by cloud-to-ground discharges estimated by lightning detection network.



From GEON

Positive discharge: 20 A

Negative discharge: 210 A

190A Upward current

10-20 % of total current

4) Relationship between high energy particles and thunderstorms.

- Terrestrial Gamma-ray Flashes (TGFs) produced by high energy electronsup to 100 MeV
- Lightning origin positron is also confirmed in space.

Recent Progress:

ADELE campaign in US

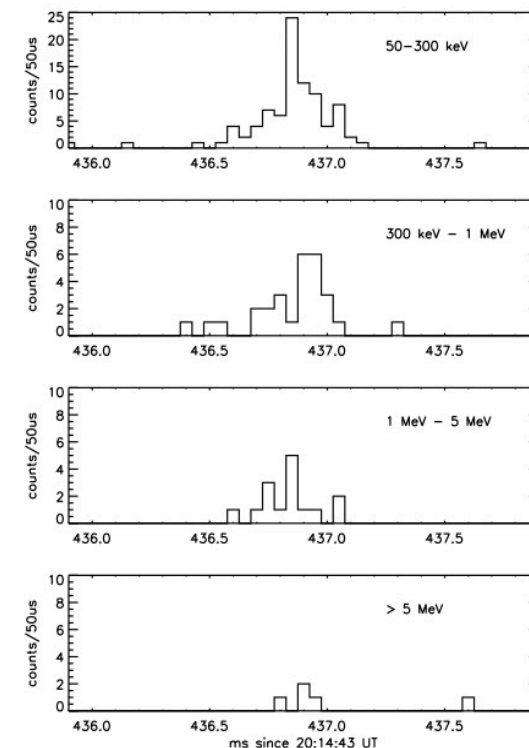
Flew on the NCAR Gulfstream V

37 flight hours in areas near Colorado/Florida from August 7-September 2

1 TGF observed, multiple x-ray glows observed



Lots of lightning without a TGF...

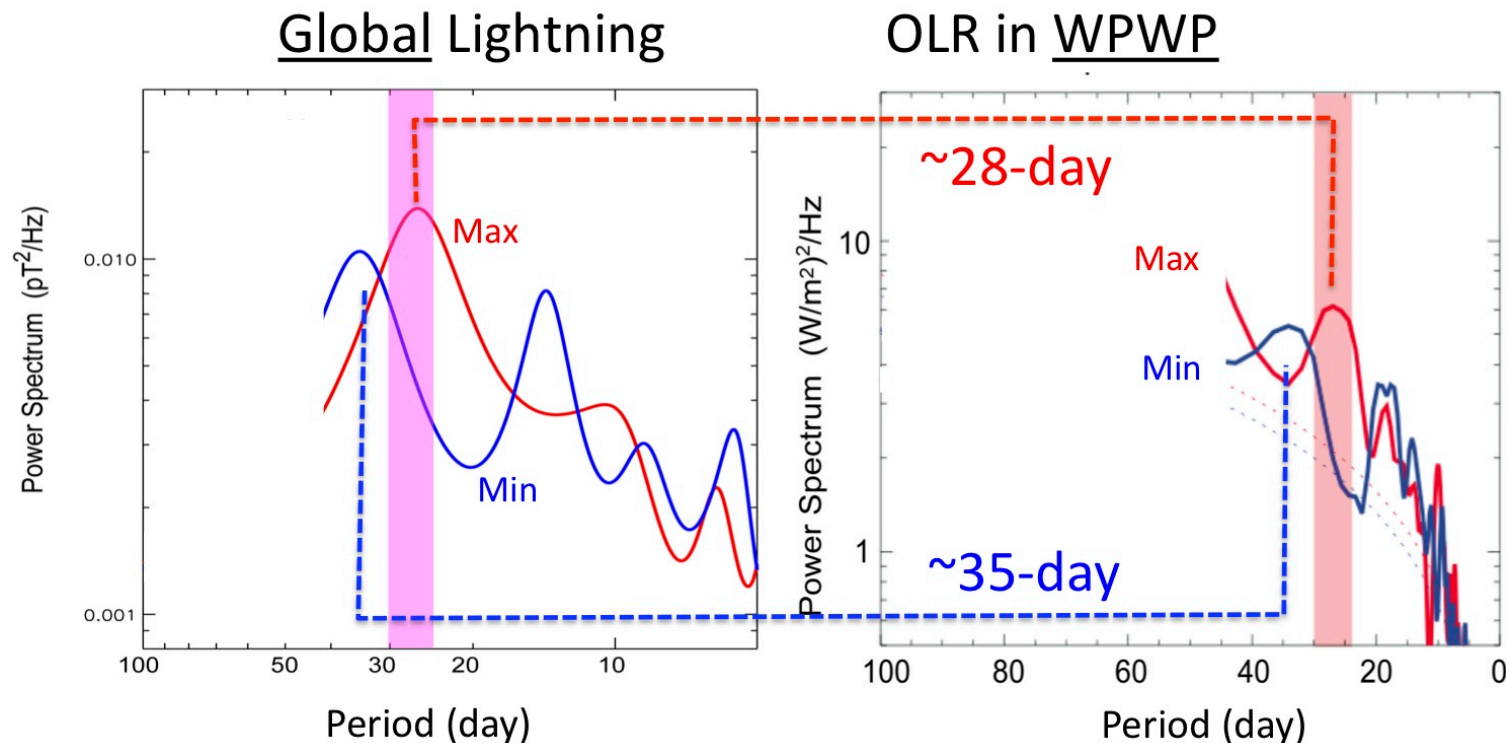


5) Relationship between thunderstorm and solar activities (solar activity and climate, collaborating with TG1)

- Lightning activity is an excellent proxy to monitor the global climate.
- It is pointed out that PG of global circuit may control the cloud thickness

Recent Progress:

28-day periodicity in solar max., which corresponds to solar rotation, was found both in global lightning activity and in OLR in WPWP, while 35-day in solar min.



Publication plan:

Summary paper of recent progress and future scope of lightning study will be published in Surveys in Geophysics, being led by Michael Rycroft.

Observation campaigns:

- Colorado TLE observation campaign with jet planes (2011.6-8)

Data analysis:

- FLASH

Space projects:

- RISING (2009-), ISS/GLIMS (2012), RISING-2 (2013), RISESAT (2013)
- TARANIS (2014), ISS/ASIM (2014)
- FORMOSAT-5, FORMOSAT-7