**1.1: Thunderstorm sever weather/lightning**

* property damage can be caused by intense lightning, large hail, heavy precipitation, strong winds, tornadoes
* lightning is the main cause of transients, faults, and outages in electric power transmission and distribution systems
* also main cause of electromagnetic interference
* lightning flash rates, changes in flash rates, and lightning jumps (increase in total lightning) are associated with severe weather potential
  + flash rates peaked during deep hail observations

**1.2: Energetic Intra-Cloud lightning (EIC)**

* Produce intense RF radiation, have different production mechanisms/occurrence contexts
* Compact Intra-Cloud discharges
  + Intensive form of lightning that produces radio waves/visible light
  + Studied in context of “convection strength, convection core motion, and charge layer”
  + Narrow Bipolar Events
  + Occur in isolation
* Energetic Intra-Cloud pulses
  + Associated with terrestrial gamma ray flashes (most energetic natural emissions on earth)
    - TGFs produced inside of thunderstorms may pose a radiation risk to aircraft
  + Last longer than CIDs, not isolated (spacially or temporally), associated w smaller discrete pulses

**1.3: Lightning Remote Sensing**

* Used to address hazards associated w lightning in electric power utilities, aviation, forestry, and weather forecasting
* Lightning location systems (LLS) have been built to determine location, intensity and movements
* Remote sensing accomplished by observing the radio/optical emissions associated with lightning

**Lightning Type Classification**

CG- cloud to ground (a discharge between opposite charges in the cloud and on the ground)

CC- cloud to cloud

CA- cloud to air

IC (most common)- intracloud (electrical discharge between oppositely charged areas within the thunderstorm cloud)

CID, EIP

Lightning – giant spark of electricity that occurs when pos. and neg. charges build up

**2.1: Lightning remote sensing**

* Remote sensing accomplished by observing the radio/optical emissions associated with lightning
* 3 main types of lightning detection sensors:
  + short-range VHF mapping systems
  + longer-range VLF/LF/HF systems
  + global VHF systems/satellite based systems
  + Unique information from VLF/LF systems: discharge peak current, polarity, lightning type classification
  + **LF Sferic**
    - Lightning discharges release energetic EMPS (sferics)
  + **LF Receiver**
    - Based on 100 kHz sampling rate VLF instrument
    - New receiver covers frequencies from around 300-400 kHz
    - Raw LF data filtered using “Humstractor” algorithm
  + **LF geolocation** 
    - Uses time of arrival (TOA) and magnetic direction finding (MDF) techniques
  + **Magnetic Direction Finding (MDF)**
    - Configuration of 2 orthogonal antennas can be used for direction finding through simple trigonometric relation
  + **Time of arrival**
    - Sferic signal will have time delay according to propogation speed, and distance btw. source/observer
  + **Peak magnitude** 
    - Statistical estimate using attenuation forward model (LWPC)
      * “Range-normalize the peak amplitude in the sferics using propagation decay model and apply empirical calibration against known sources”
    - Attenuation model based on finite difference time domain (FDTD)
      * Used with assumption that peak radiated a distance away from the source
      * Based on power law
  + **GLM and ABI**
    - Geostationary Lightning Mapper (GLM) – high speed event detector operating in the infrared, measuring radiances at cloud tops from IC and CG lightning
    - Advanced Baseline Imager (SBI) – images the Earth at several diff. bands and provides a multitude of level 2+ science data products
  + **ENTLN**
    - Provide lightning pulse and flash data using more than 700 radio receivers worldwide
  + **NLDN**
    - Provides lightning flash data rate using network of ground-based radio receivers
  + **GLD360**
    - Uses ground based VLF sensors to geolocate a fraction of global lightning

Power grid