EUMETSAT

Introduction to Lightning

LI Training Course, 5 September 2024

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Agenda

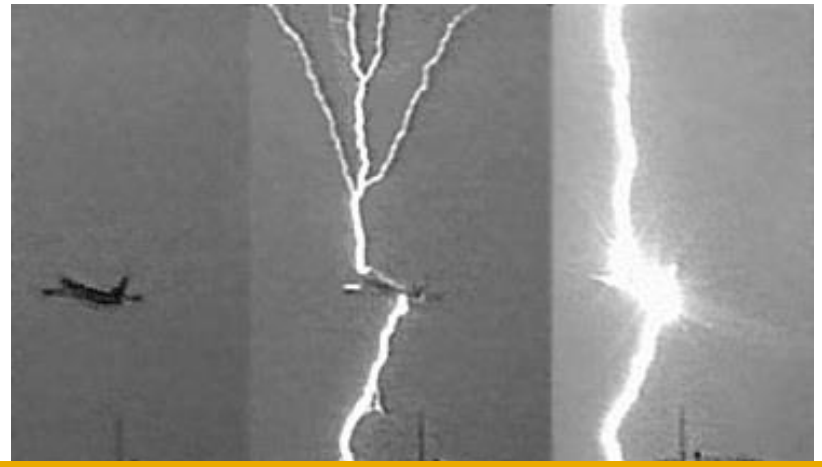
- What is lightning?
- How does lightning form?
- What are the main types of lightning?
- Lightning incidence worldwide and in Europe.
- The very basics of lightning detection.

What is lightning?

Lightning is a sudden electrostatic discharge/a giant electric spark in the atmosphere.

- A typical lightning flash…
  - …is a few to a few tens of km-s long;
  - …has a peak current of 20-30 kA;
  - …has a temperature of 30 000 degrees K;
  - …lasts only about 0.2-0.3 seconds.

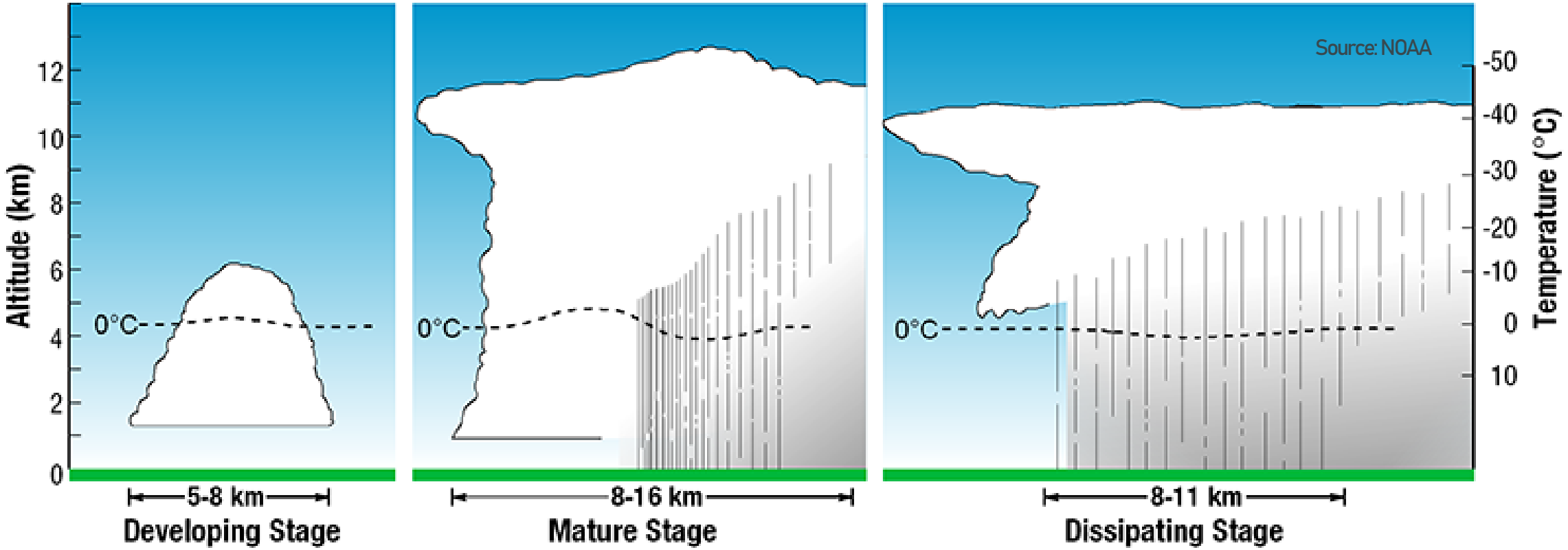
Lightning can be very dangerous…



Annually, lightning kills 6 000 – 24 000 people worldwide while ~10x more get injured.

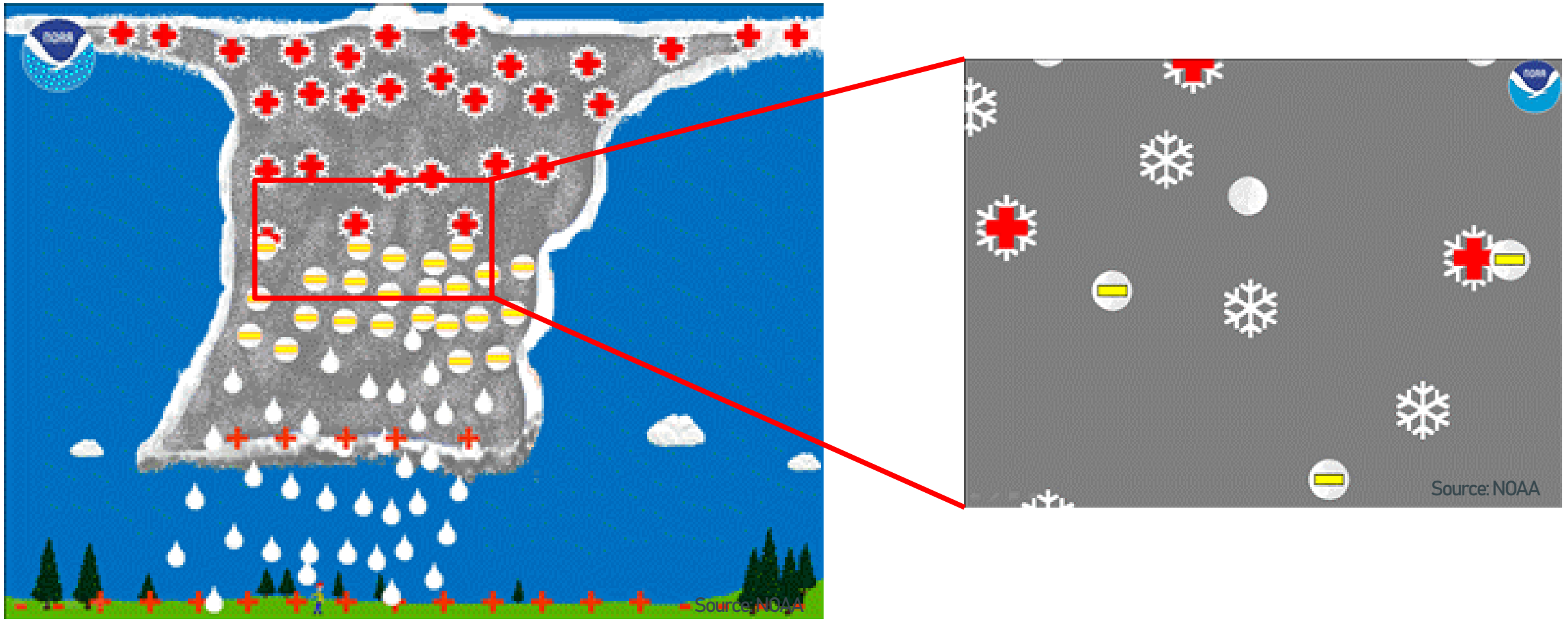
Lightning can also be a warning of approaching severe weather

Thunderstorm development stages



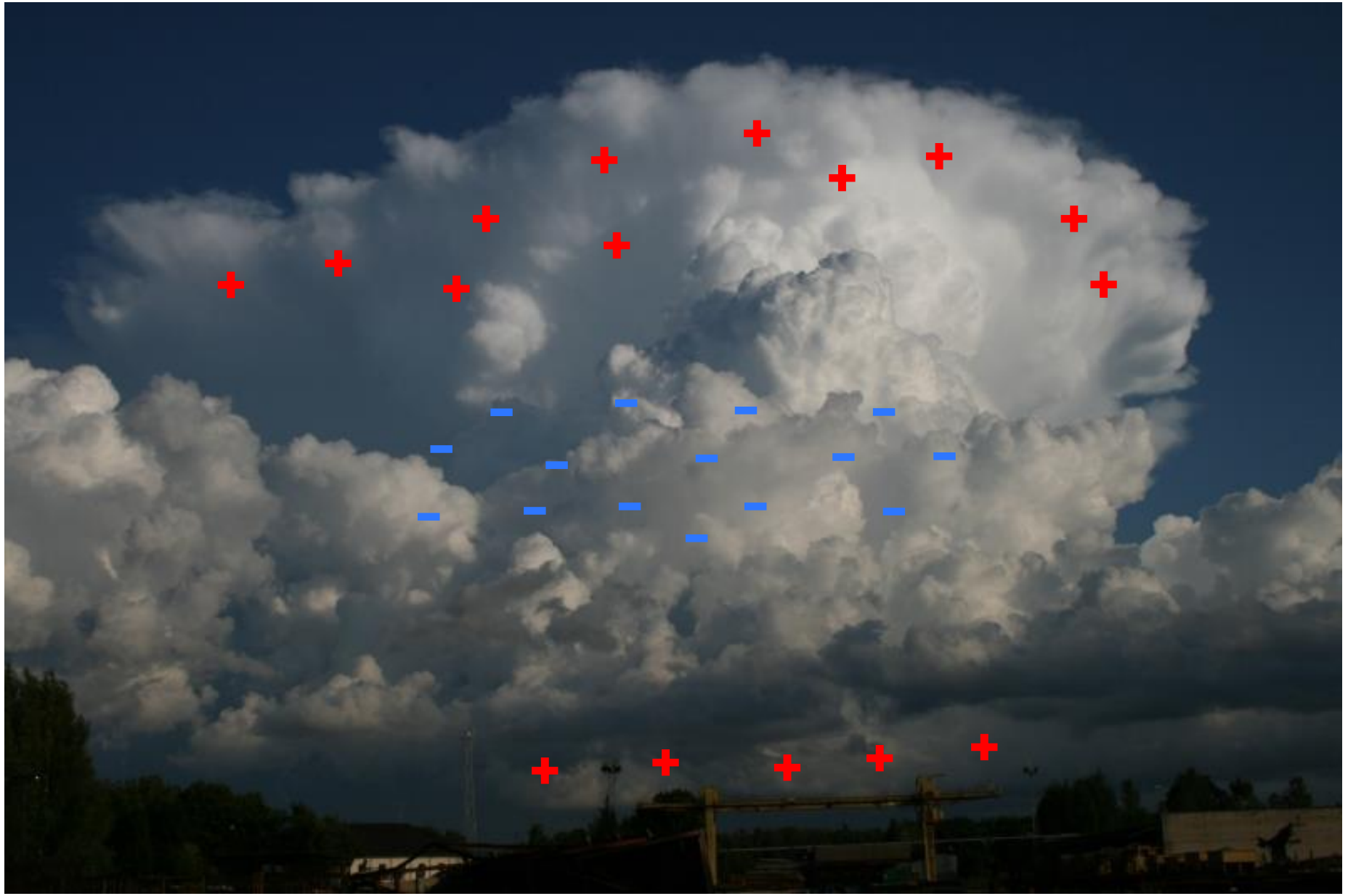
Lightning formation typically requires a well-developed *Cumulonimbus* cloud (except some rare cases of volcanic lightning).

Thunderstorm electrification

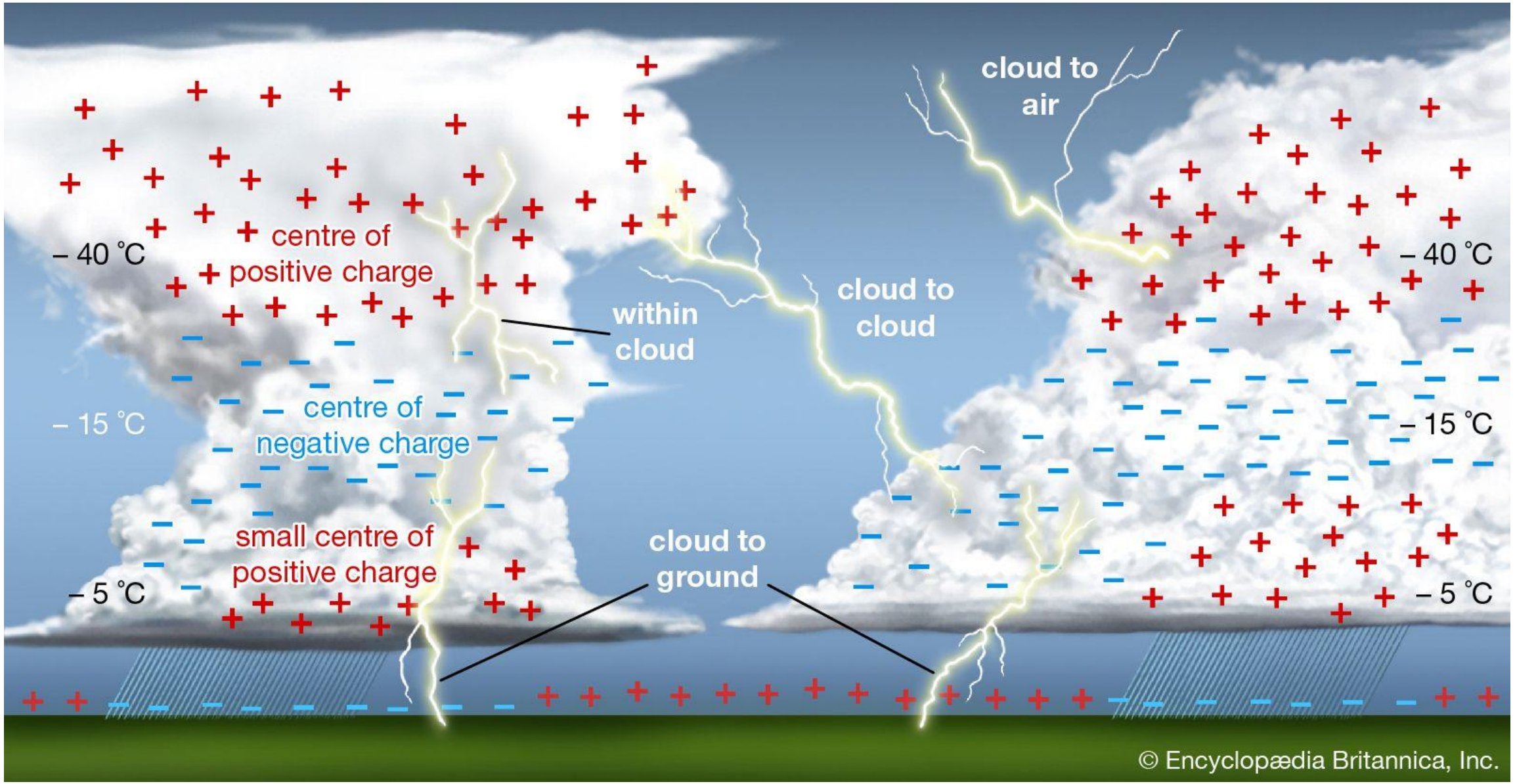


The electric field in the cloud has to reach the air breakdown voltage (3×10^6 V/m), before lightning develops.

A typical thunderstorm



Different types of lightning



Most common types of lightning

Cloud lightning (IC): 75-80% of all lightning.

Cloud-to-ground (CG) lightning: 20-25% of all lightning.

Less common types of lighting – positive CG lightning

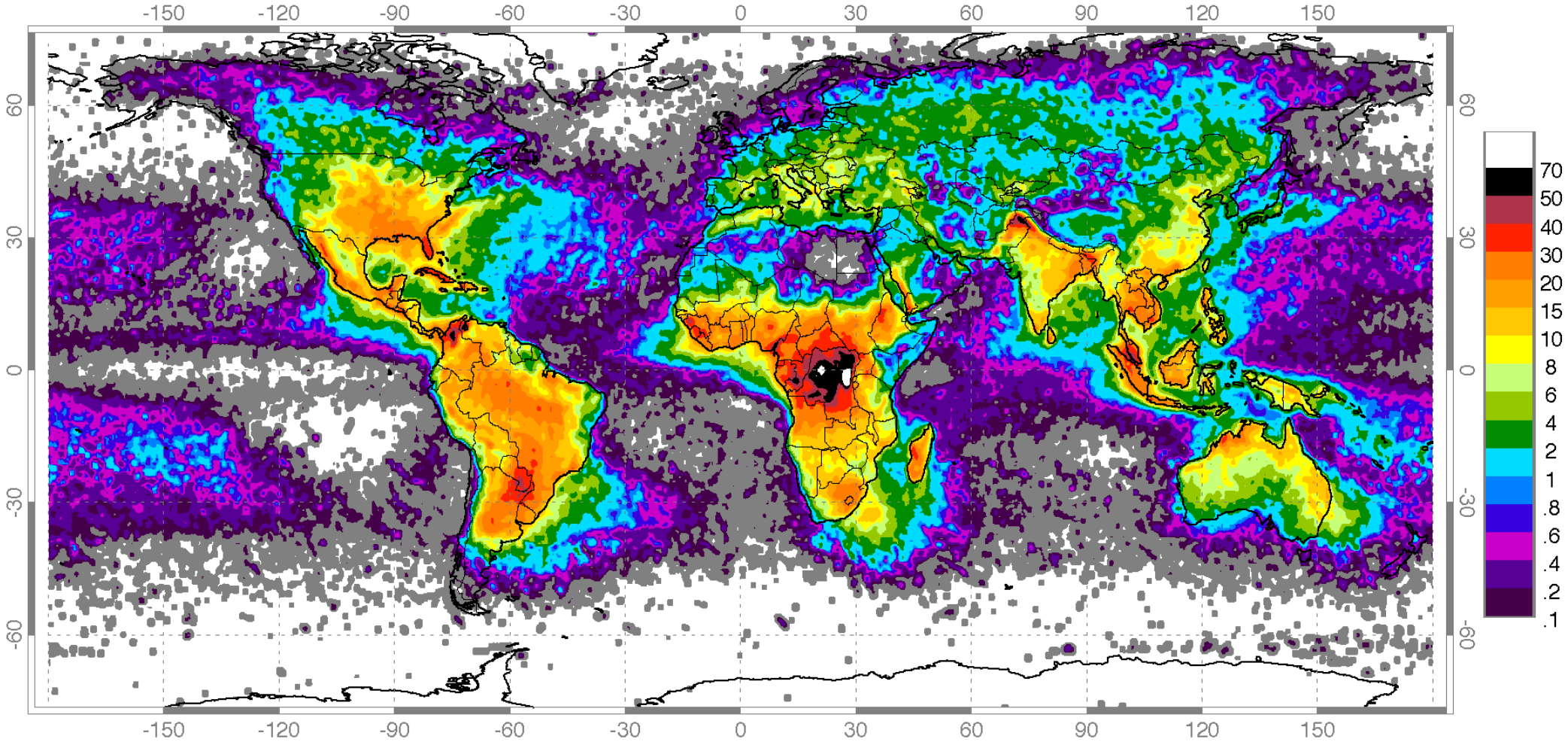
- Anvil-to-ground lightning, only 5-10% of all CG lightning.
- Between positive cloud top charge and negative surface charge around the storm.
- Often hits the ground outside the precipitation area, sometimes even under blue skies, miles from the parent thunderstorm => **often unexpected**.
- Generally (much) higher peak current and longer duration => **very high fire risk**.

https://www.weather.gov/source/zhu/ZHU_Training_Page/lightning_stuff/lightning2/positive.html

Lightning is more than just an instantaneous flash

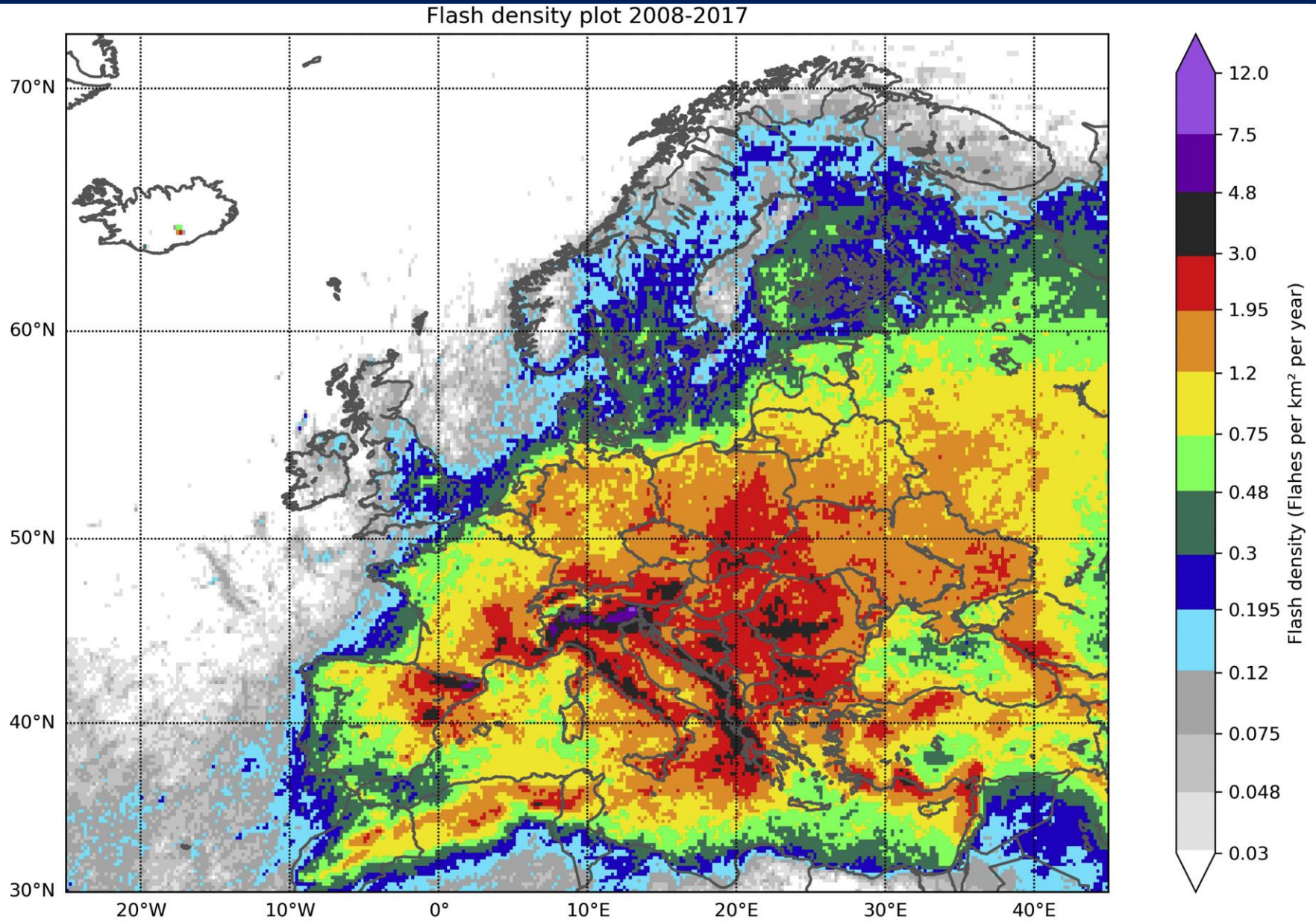
For example, cloud-to-ground lightning flash starts with leaders, followed by one or more return strokes.
Return strokes only last ~1% of the duration of the flash, but ~99% of flash energy is released in this phase.

Where and when lightning happens?



- Globally 40-50 lightning flashes per second or 1.4 billion flashes per year!
- 80% of global lightning occurs in the tropics between 30°N and 30°S.
- 90% of global lightning occurs over land and only 10% over the oceans.
- Lightning has normally seasonal cycle and over land also strong diurnal cycle.

ATDnet annual lightning flash density in Europe 2008-2017

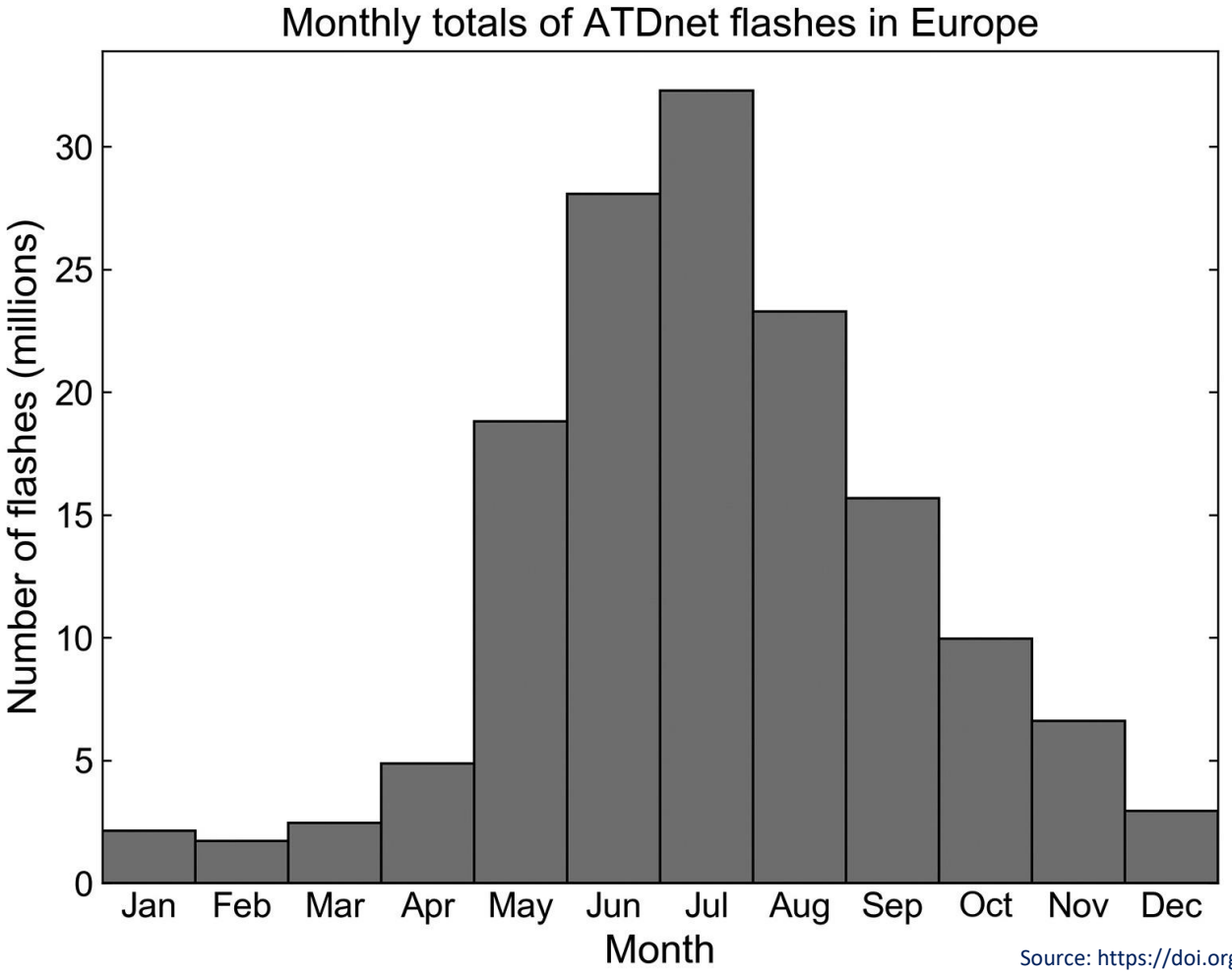


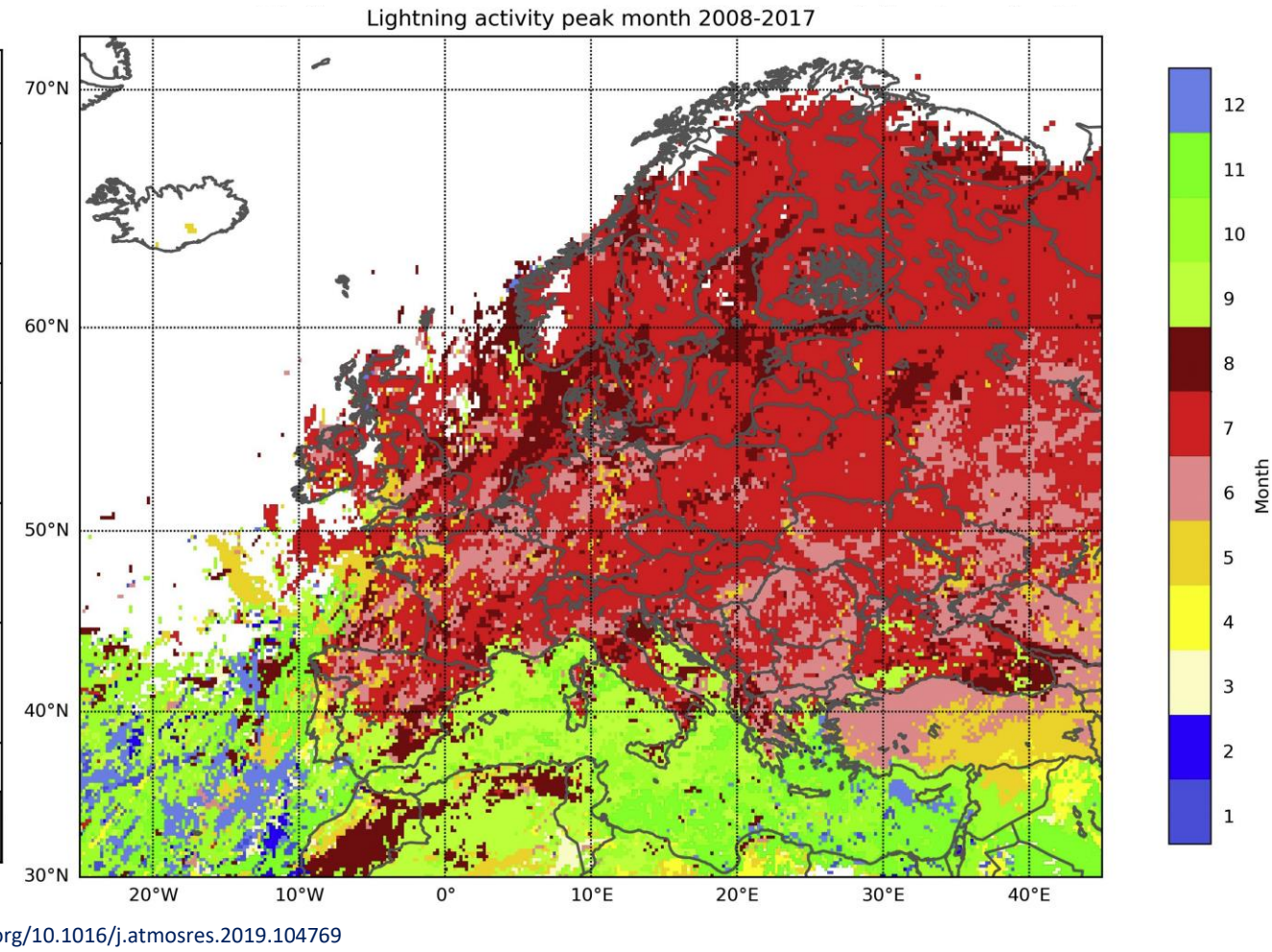
Resolution = 0.20°

Max. density = 7.8 flashes per km² per year

Source: https://doi.org/10.1016/j.atmosres.2019.104769

ATDnet monthly lightning distribution in Europe 2008-2017





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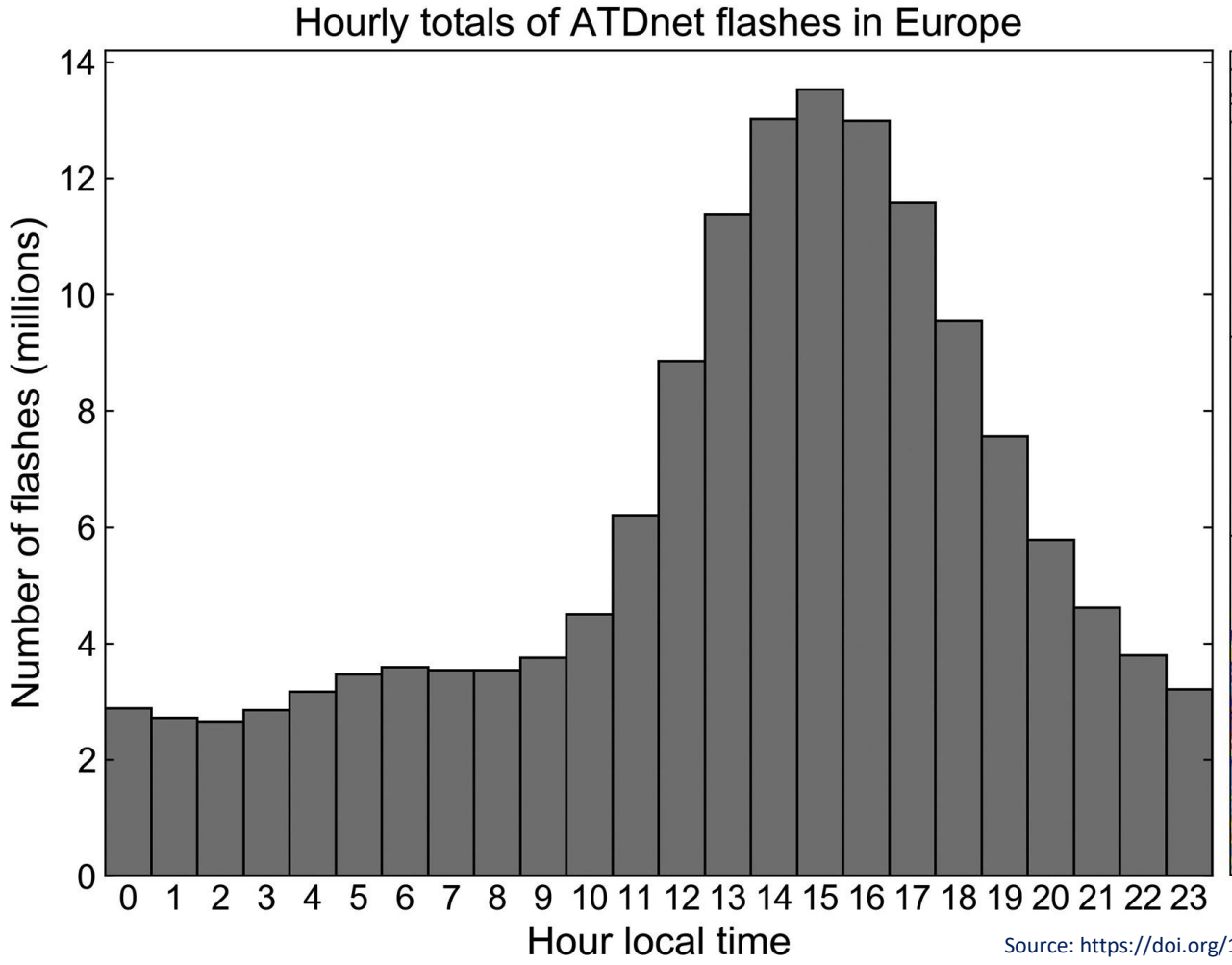
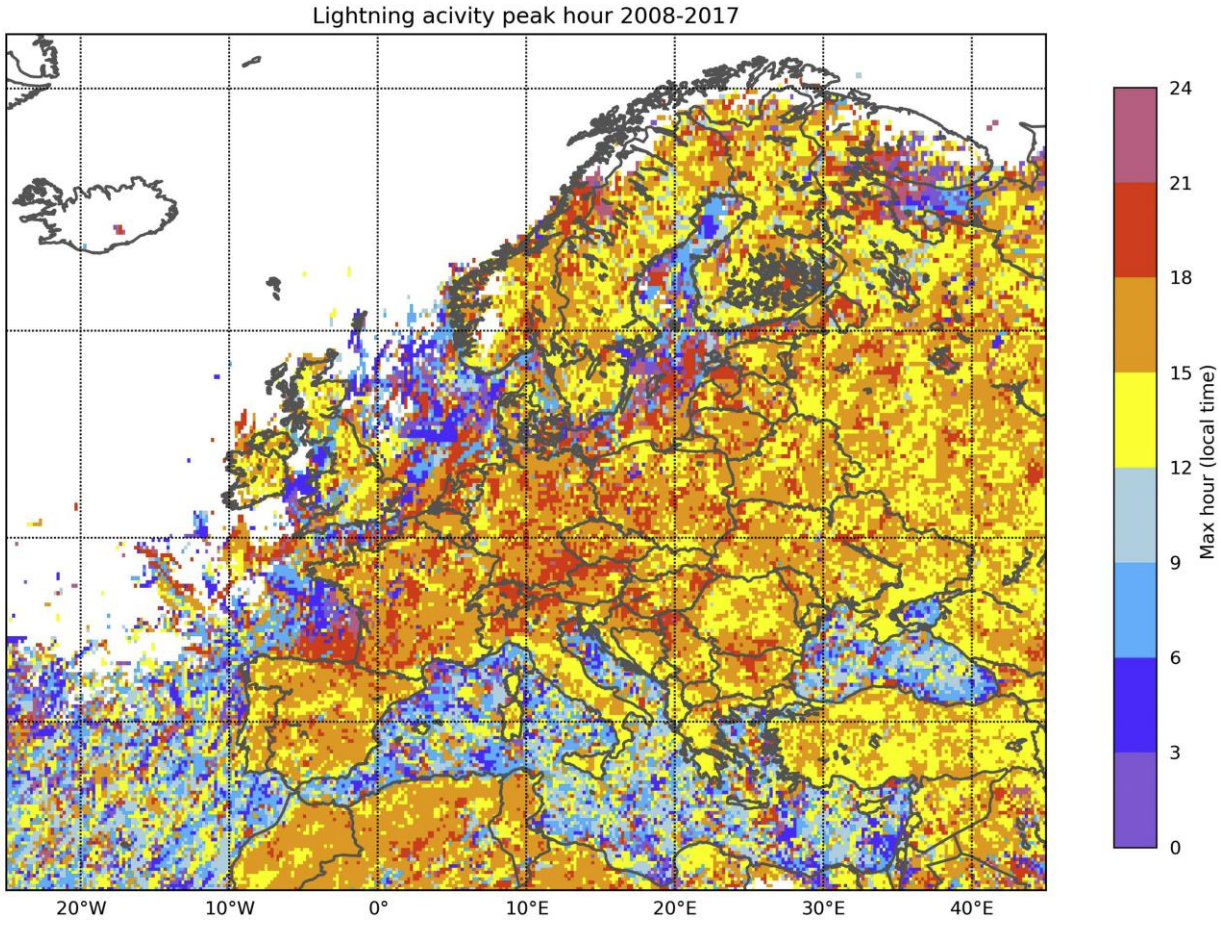
ATDnet diurnal lightning distribution in Europe 2008-2017





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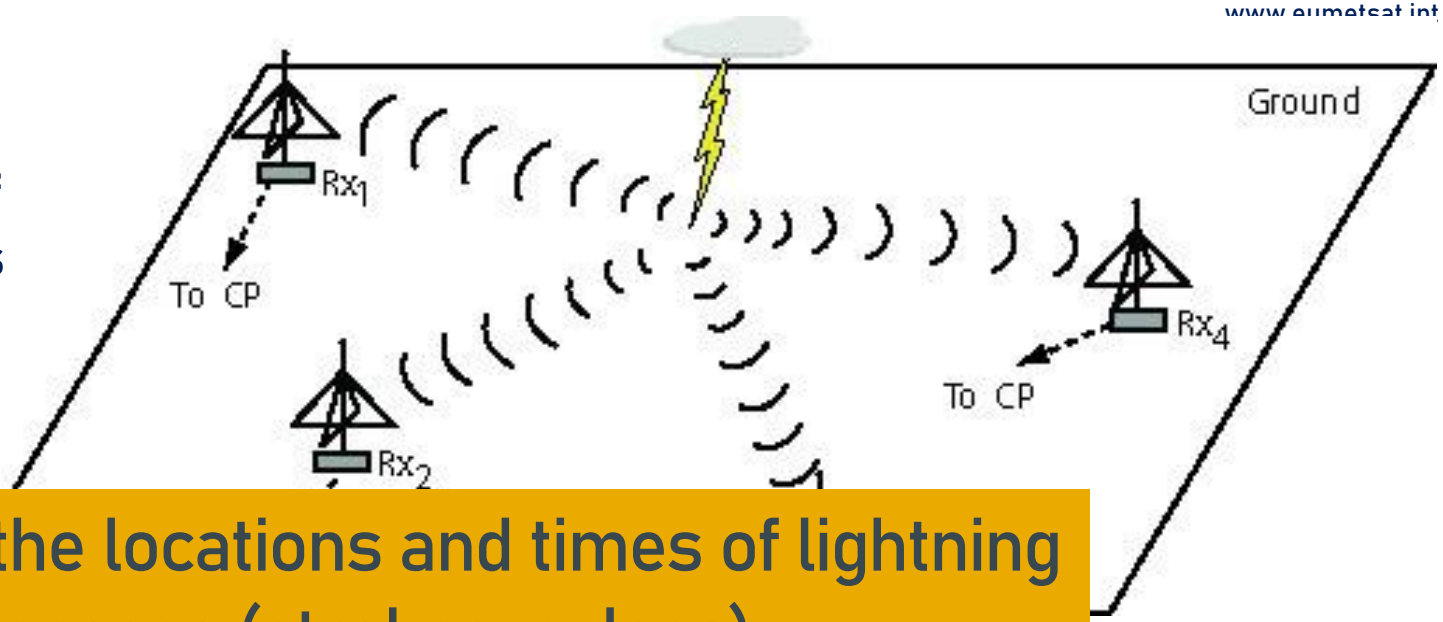
The very principles of lightning detection

GROUND-BASED

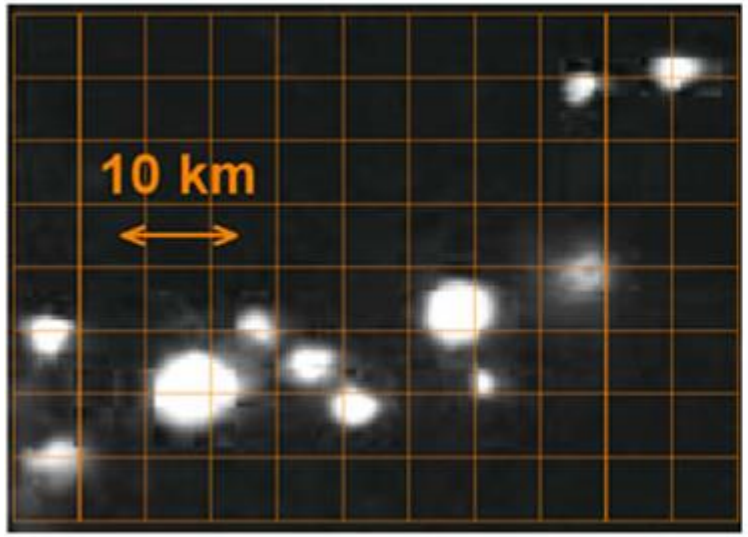
A network of **radio sensors** plus central station that compares the observations of the sensors and computes lightning times and locations.

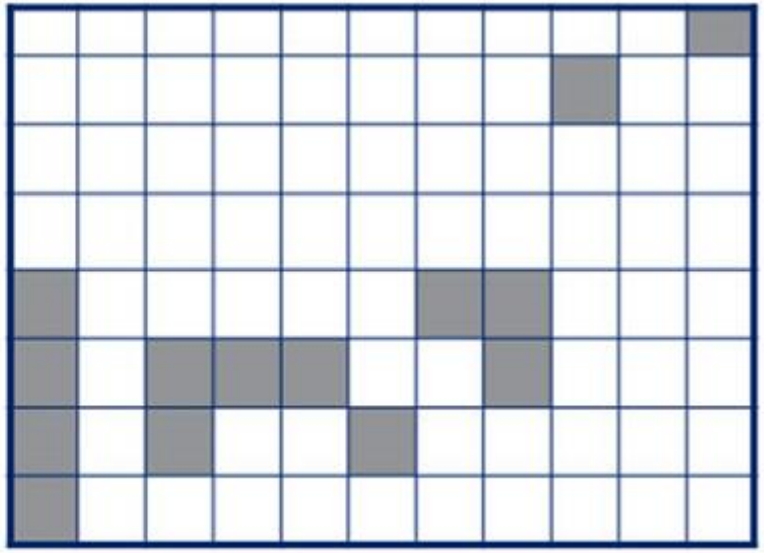


SPACE-BORNE

An **optic**
lightning
cloud to

Both can quickly provide the locations and times of lightning flashes and their sub-processes (strokes, pulses).





Thank you!

Questions are welcome.