



# **ATMO 102 Pacific Climates and Cultures**

## **Lecture: Thunderstorms in the Pacific**

# Thunderstorm Introduction

- A storm that generates **lightning** and **thunder**.
- Are characterized by strong “**up**” and “**down**” motions
- Frequently produces **gusty winds, heavy rain and hail**.
- They can form on their **own** or they can form **in conjunction with mid-latitude cyclone** on the edge of a Cold-Front
- They can form in conjunction with **hurricanes**
- **Locations in the continental US**
  - **Florida** has the most thunderstorms (100s per year)
  - Commonly occur in the foothills of the **Rocky Mountains**
  - Associated with **Tornado Alley** in the middle of the country
  - Associated with **drylines** and air with different humidities



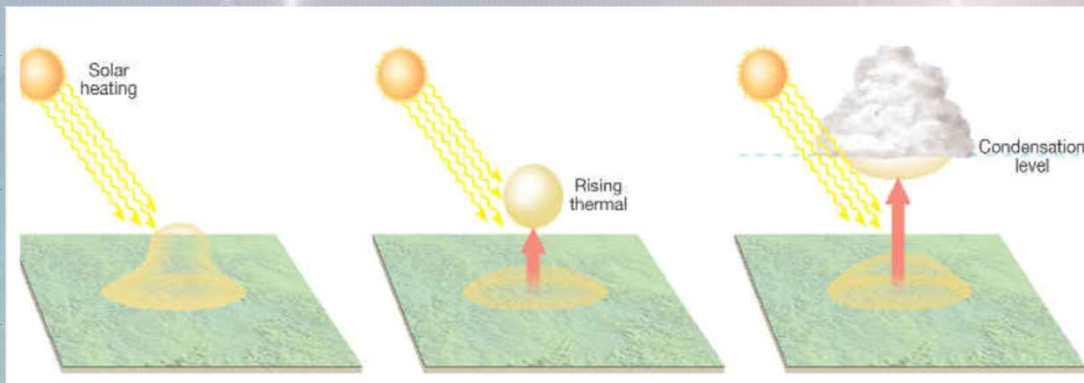
# Thunderstorm Formation Introduction

- Form when warm, humid air rises in a conditionally unstable or unstable environment
- There are two categories:
  1. **Air Mass Thunderstorms** – formed by *unequal heating* of the Earth's surface within a *maritime tropical (mT)* air mass.
  2. **Severe Thunderstorms** – formed by *unequal heating* & *lifting of warm air* along a **front** or **mountain**.



# Air Mass Thunderstorms

- Happens inside an air mass (**usually mT**)
- Usually in **spring** and **summer**
- Usually in **mid-afternoon**
- Not associated with a **front**
- Due to **local differences in temperature**

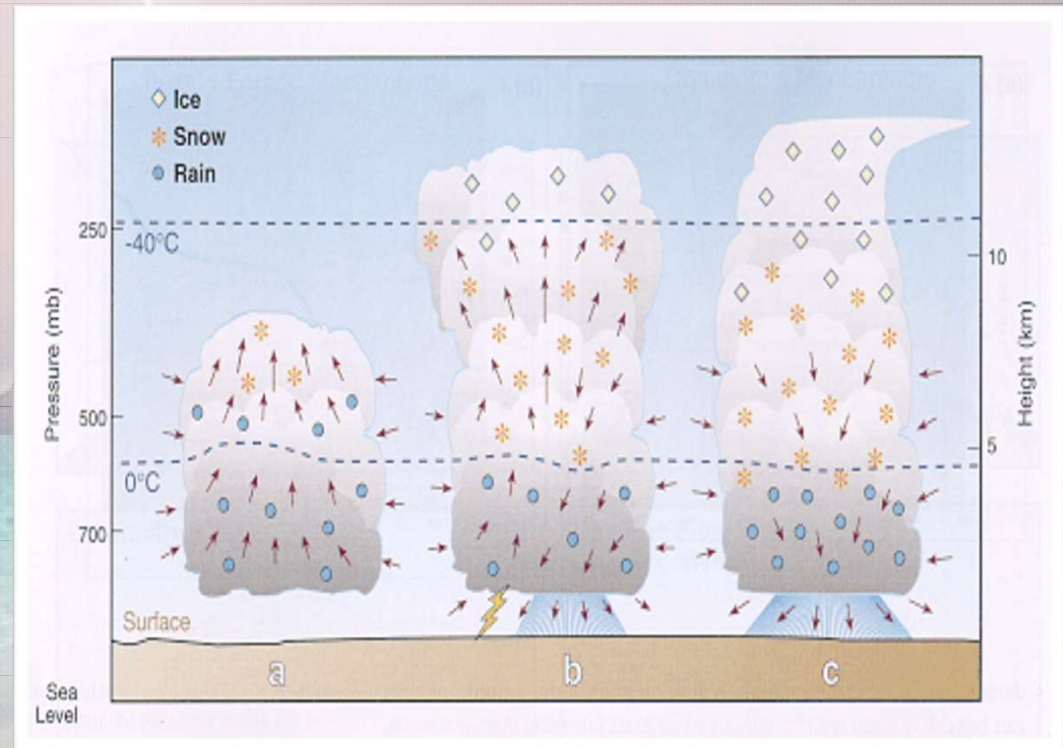


# Air Mass Thunderstorm Life Cycle

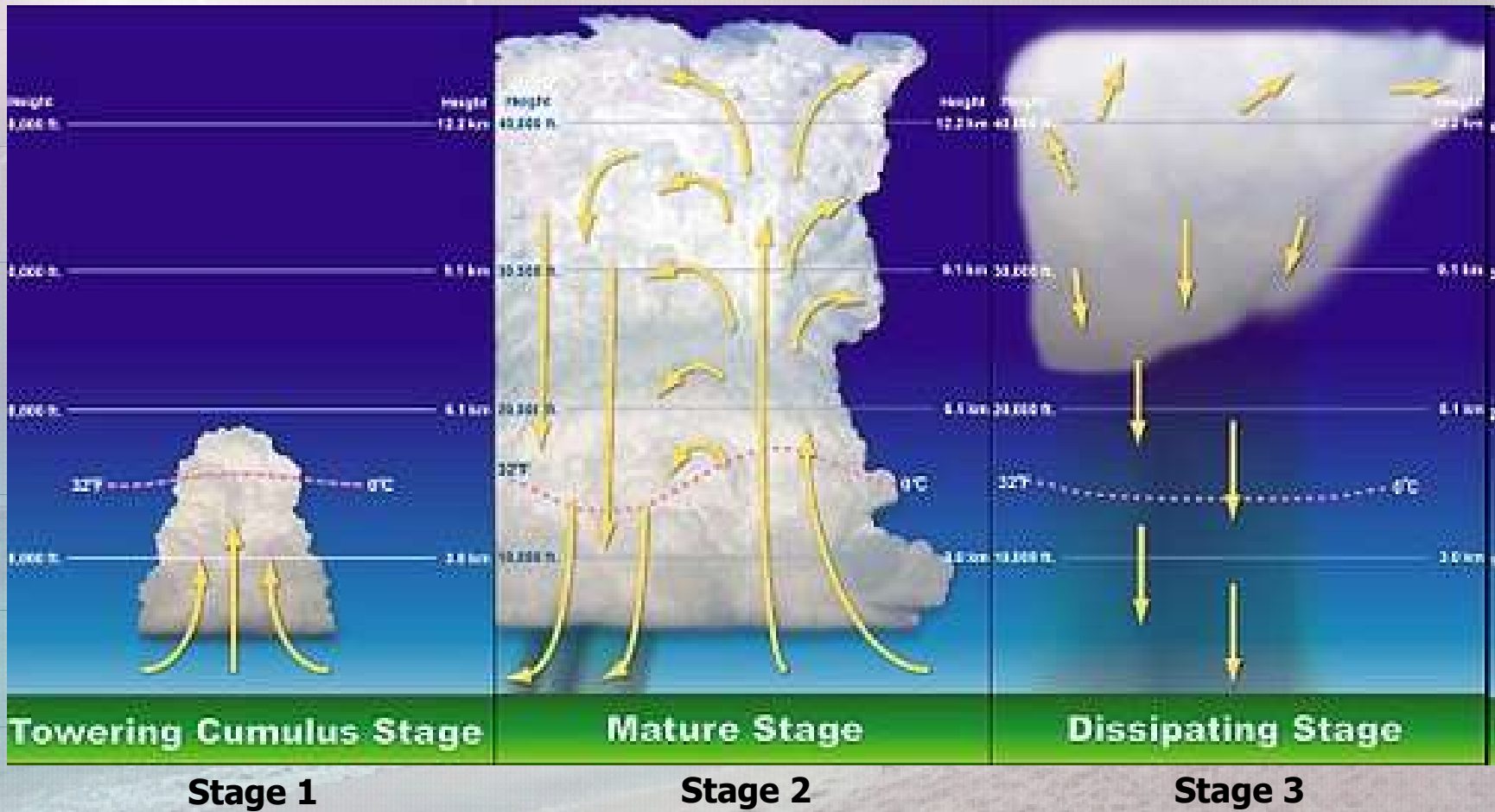
- Like mid-latitude cyclones T-Storms have a “**Life Cycle**”

- **Stages of Development**

- Stage 1: Cumulus Stage
- Stage 2: Mature Stage
- Stage 3: Dissipating Stage

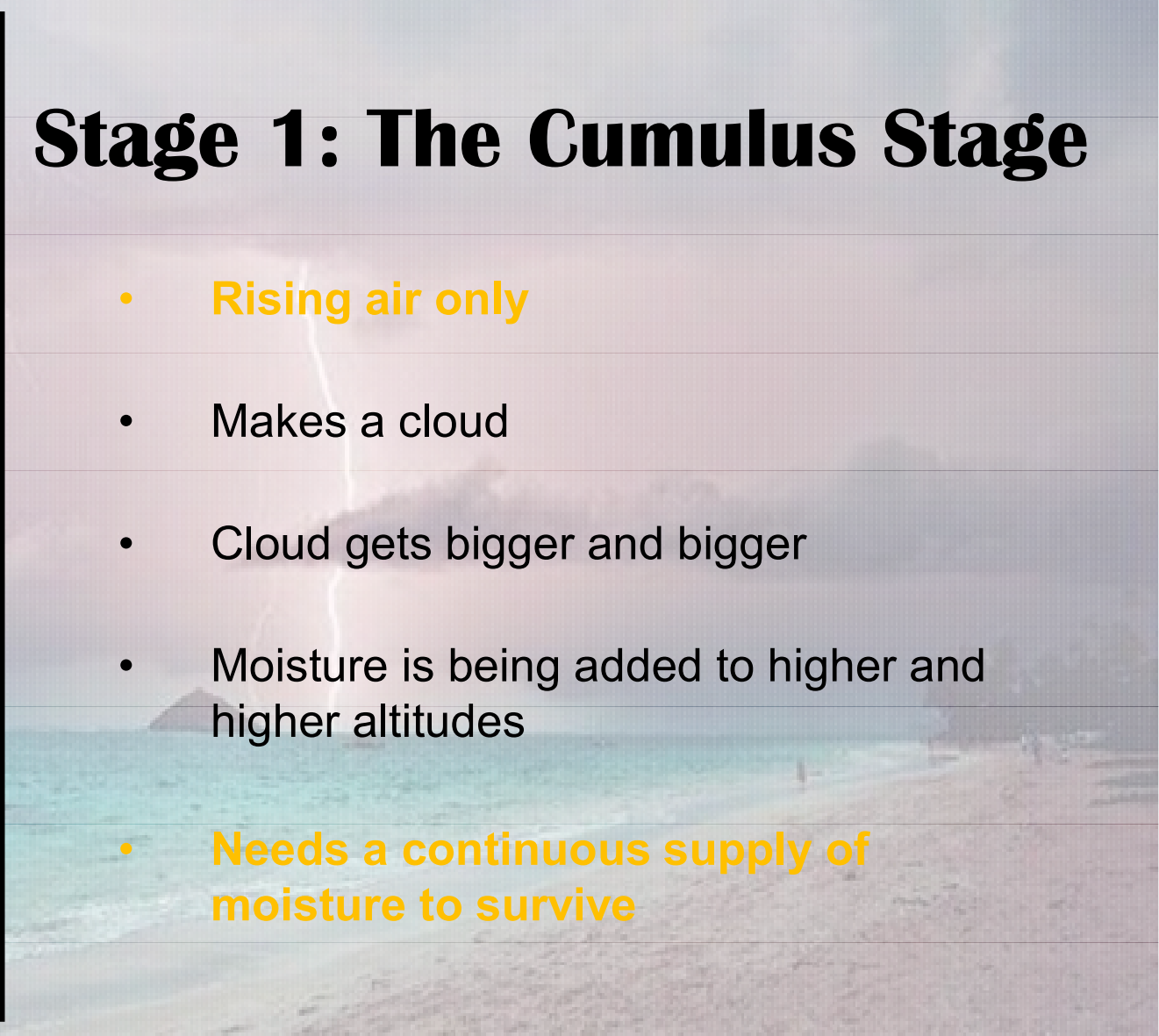
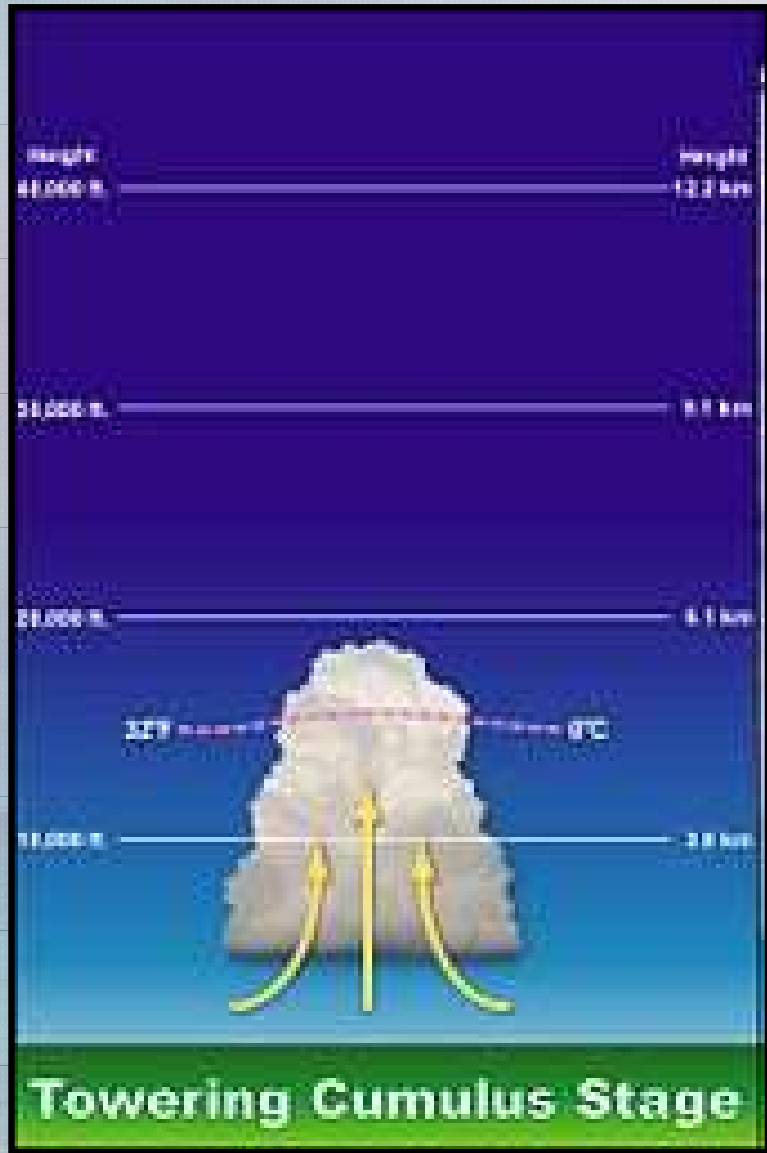


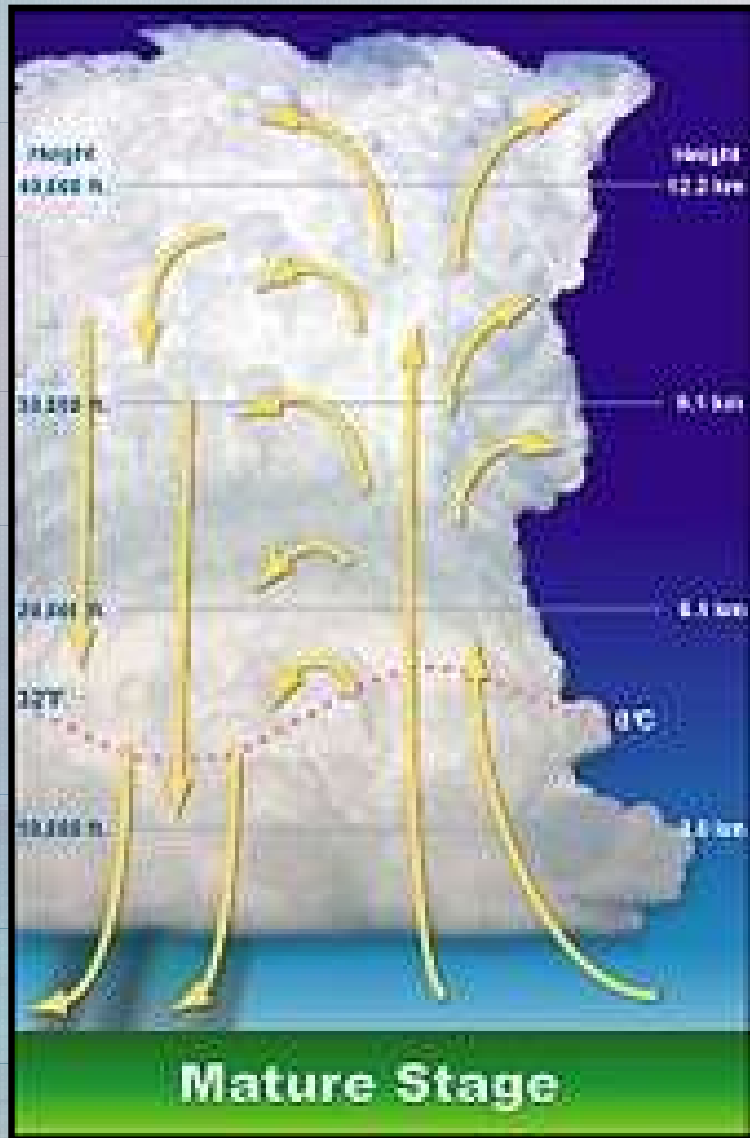
# Air Mass Thunderstorm Life Cycle



# Stage 1: The Cumulus Stage

- **Rising air only**
- Makes a cloud
- Cloud gets bigger and bigger
- Moisture is being added to higher and higher altitudes
- **Needs a continuous supply of moisture to survive**

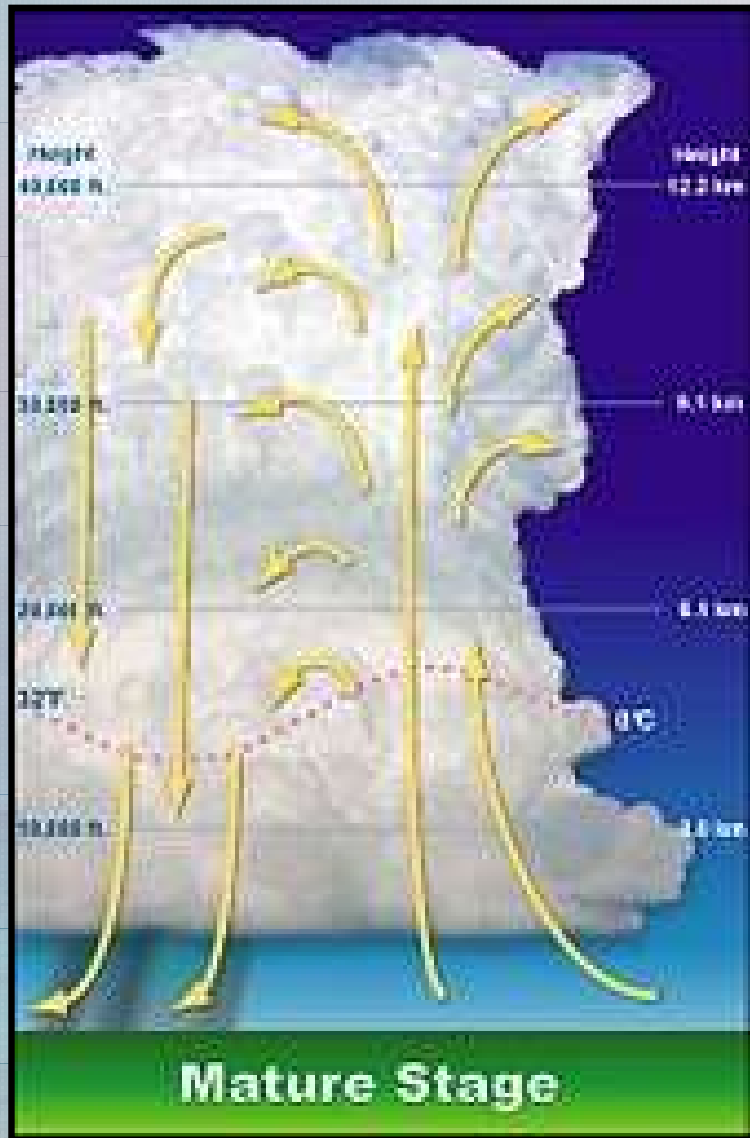




## Stage 2: The Mature Stage

- **Precipitation forms**
  - Mainly by the *Bergeron Process*
- **Rain** begins to fall
  - Associated with the downdraft (air going down)
- Most **active** stage
  - Gusty winds, lightning, heavy rain, hail
- **Updrafts and downdrafts exist side by side**



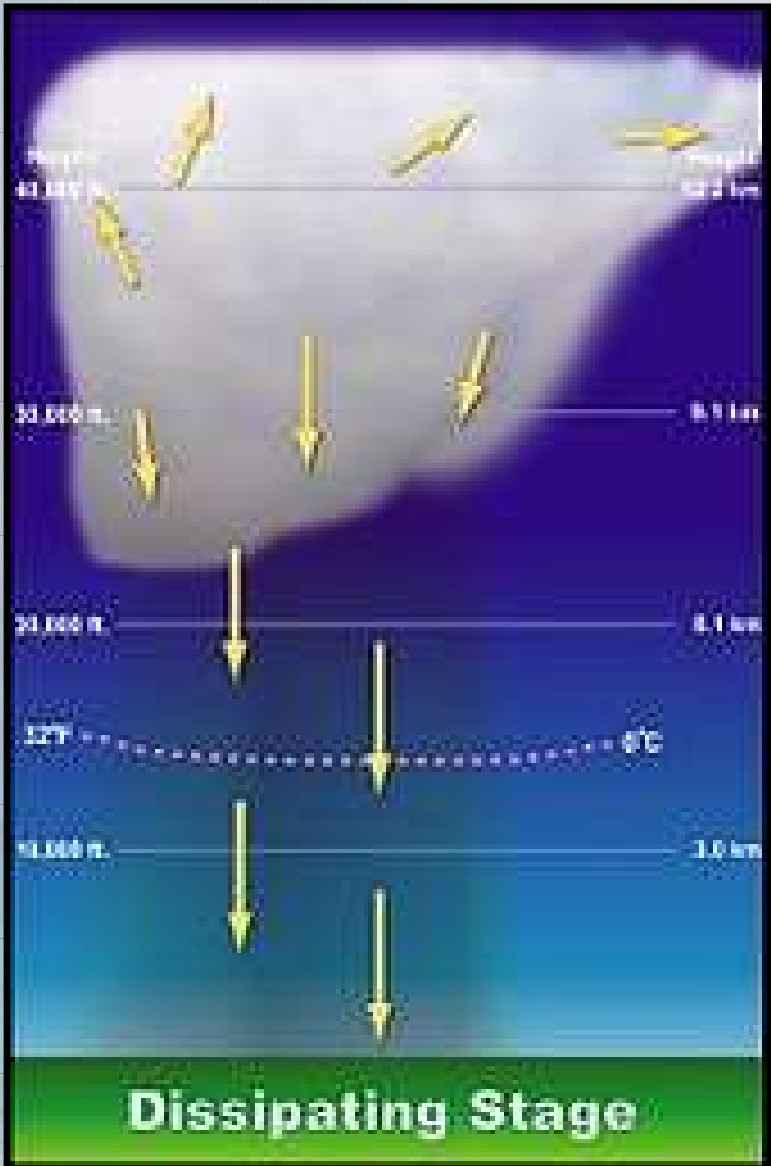


## Stage 2: The Mature Stage

- **Downdrafts** form for two reasons
  - **Entrainment** – mixing of dry air with cloud air at the edge of the cloud
    - Causes the cloud drops to evaporate
    - Energy from evaporation comes from the temperature of the air parcel
    - By evaporating drops, you use up the energy and end up cooling the air parcel
    - Temperature drops, parcel cools
    - Cooler air sinks to the surface
  - **Drag** – Air is dragged downwards as precipitation falls.

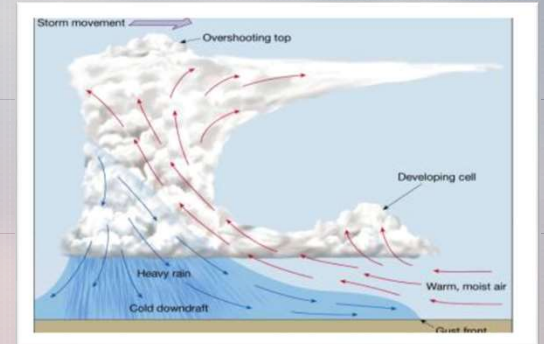
## Stage 3: Dissipating Stage

- **Cooling effect** of falling precipitation and **influx of colder air up top** mark it's END!
- **Downdraft** cuts off updraft
- Cloud stops growing
- You're left with weakly descending air parcels
- The cloud basically KILLS itself

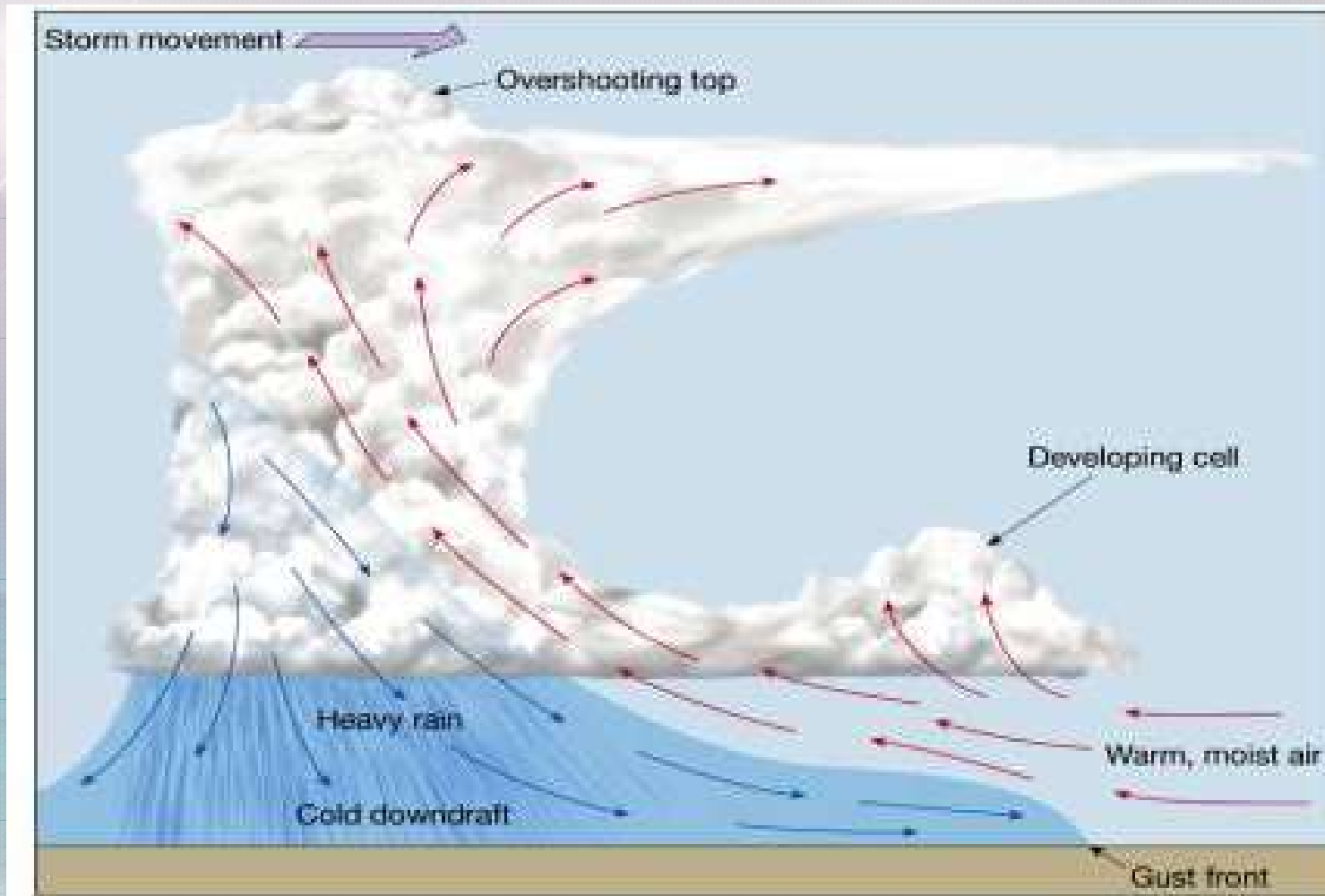


# Severe Thunderstorms

- Heavy downpours, flooding, gusty straight-line winds, large hail, lightning and tornadoes!
- **NOT Common** on the Hawaiian and Pacific Islands.
- To be classified as **Severe**:
  - Must have winds in excess of 93 km/h or 58 mph
  - or hail 0.75 inches
  - or a confirmed tornado



# Severe Thunderstorm



# Severe Thunderstorm

Overshooting Top



Anvil



- Persist for many hours
  - Vertical wind shear causes precipitation to fall in downdraft, allowing the updraft to retain strength.
  - Sometimes the updraft is so strong you get **overshooting tops and anvils!**
- Cold air of the downdrafts spread out making:
  - “mini cold front”
  - Called a **GUST FRONT**
  - Called an **Outflow Boundary**
  - Can form a **Roll Cloud**



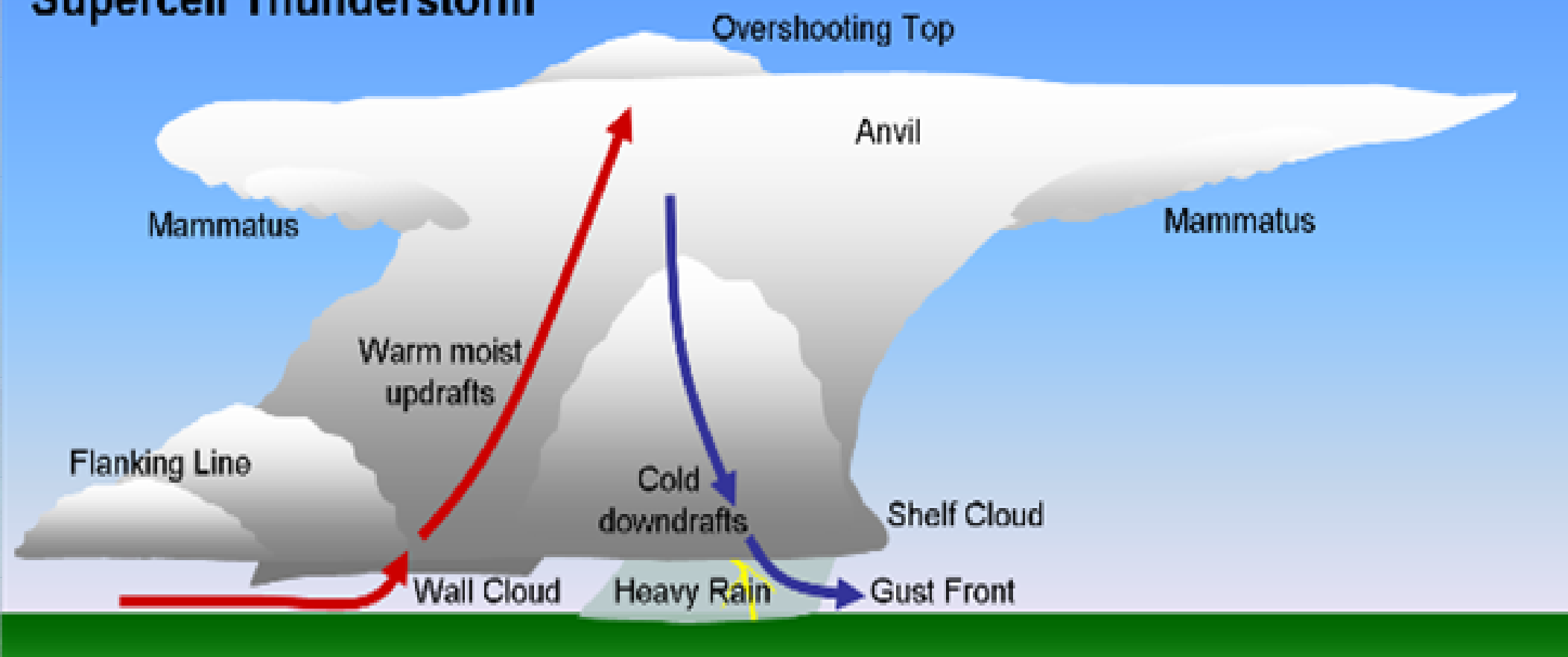
# Supercell Thunderstorm

- Causes dangerous weather
- Large, very powerful, up to 20 km in height
- Last many hours
- 20-50 km in diameter
- Vertical wind profile may cause the updraft to **ROTATE!**
  - **MESOCYCLONE** – usually spawns Tornadoes!
- Need a lot of **Latent Heat**
  - Requires moist troposphere
  - An inversion a couple of km above the surface (caps moisture)
  - Unstable air can break through the inversion by “eroding” it



# Supercell Diagram

## Supercell Thunderstorm



# Lightning and Thunder

- Lightning is **ulia** in Hawaiian
- Thunder is **hekili** in Hawaiian
- A storm is classified as a thunderstorm only after **thunder** is heard!!
  - Because **thunder is produced by lightning**, lightning must also be present!

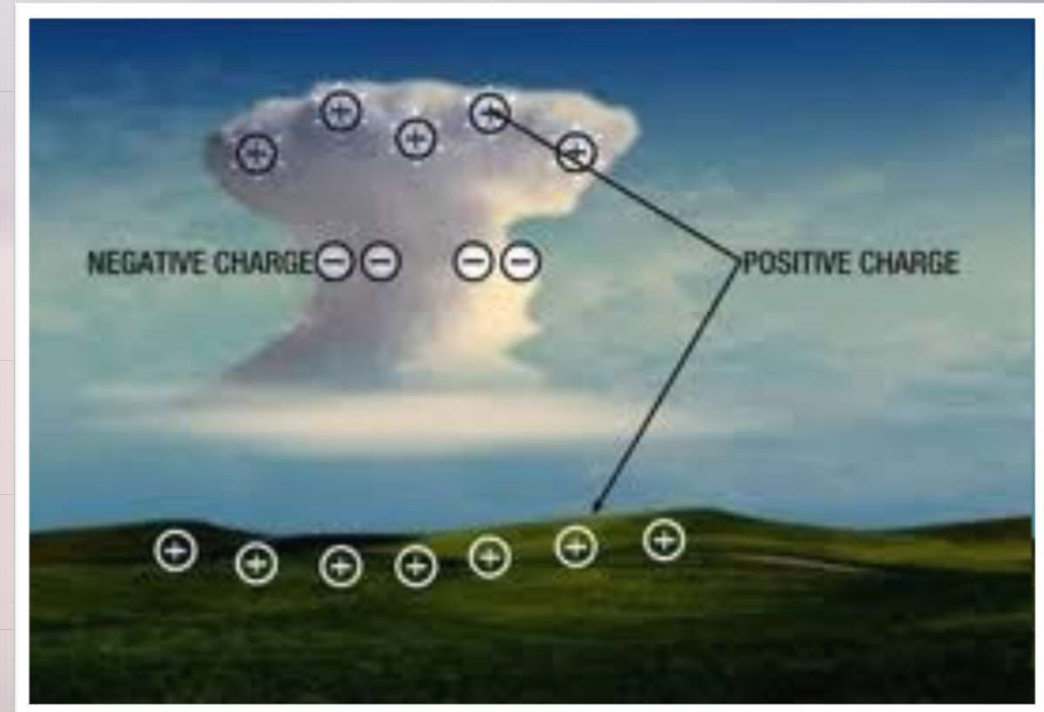


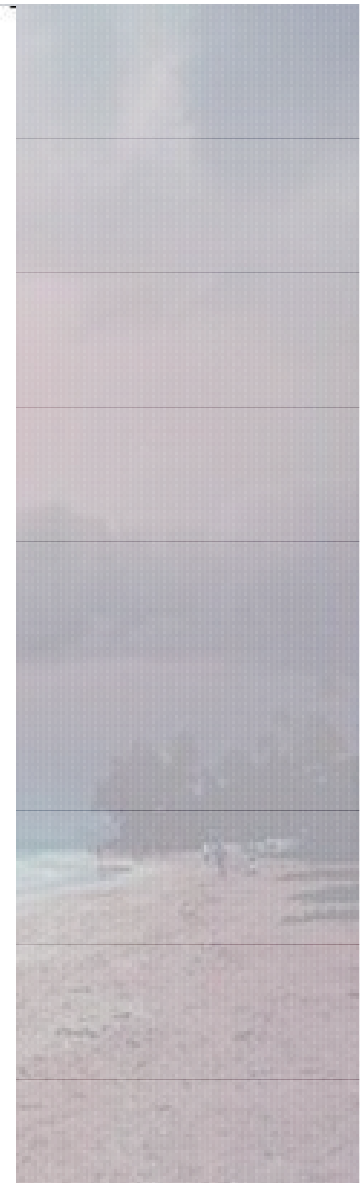
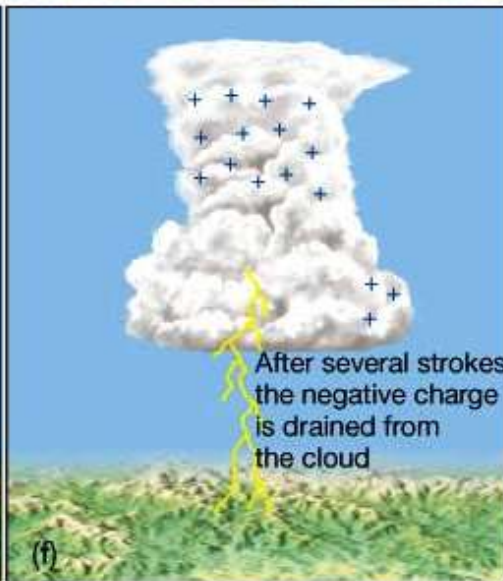
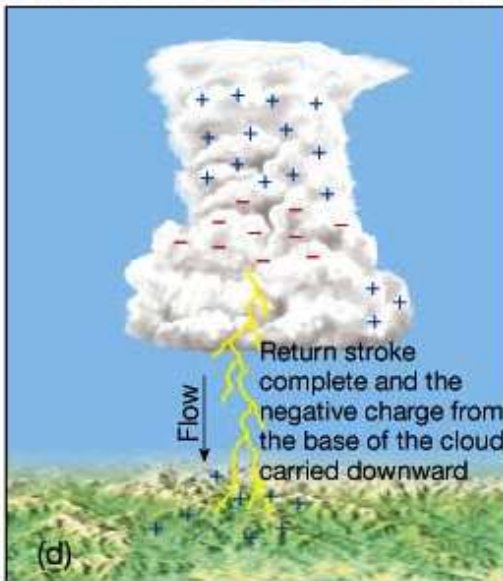
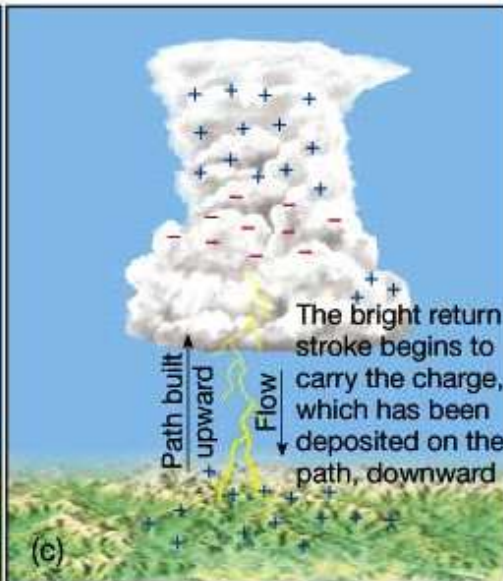
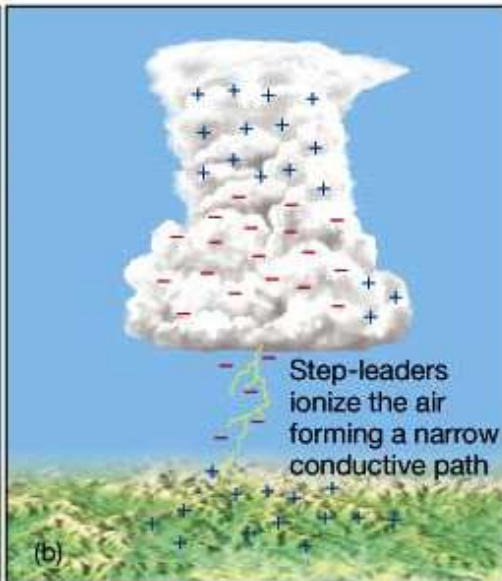
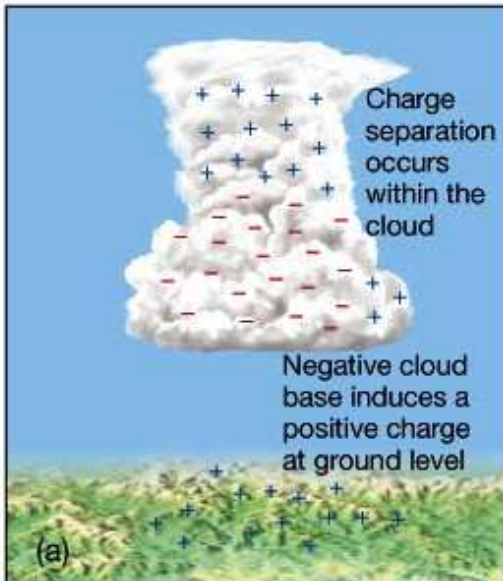
- Lightning is a **discharge of electrical energy**.
- Essentially a **giant “spark”** between regions of positive (+) and negative (-) charge.



# Lightning

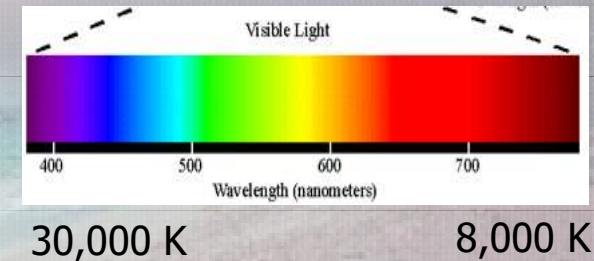
- May occur:
  - Between cells in the same storm
    - **inter-cloud lightning**
  - Within a cloud
    - **intra-cloud lightning**
  - **Cloud to air**
  - **Cloud to ground (CG)**
- Lightning forms when a charge separation occurs in a cloud
  - **The earth is trying to equalize the electrical difference**
  - **Negative charges want to flow to the ground.**



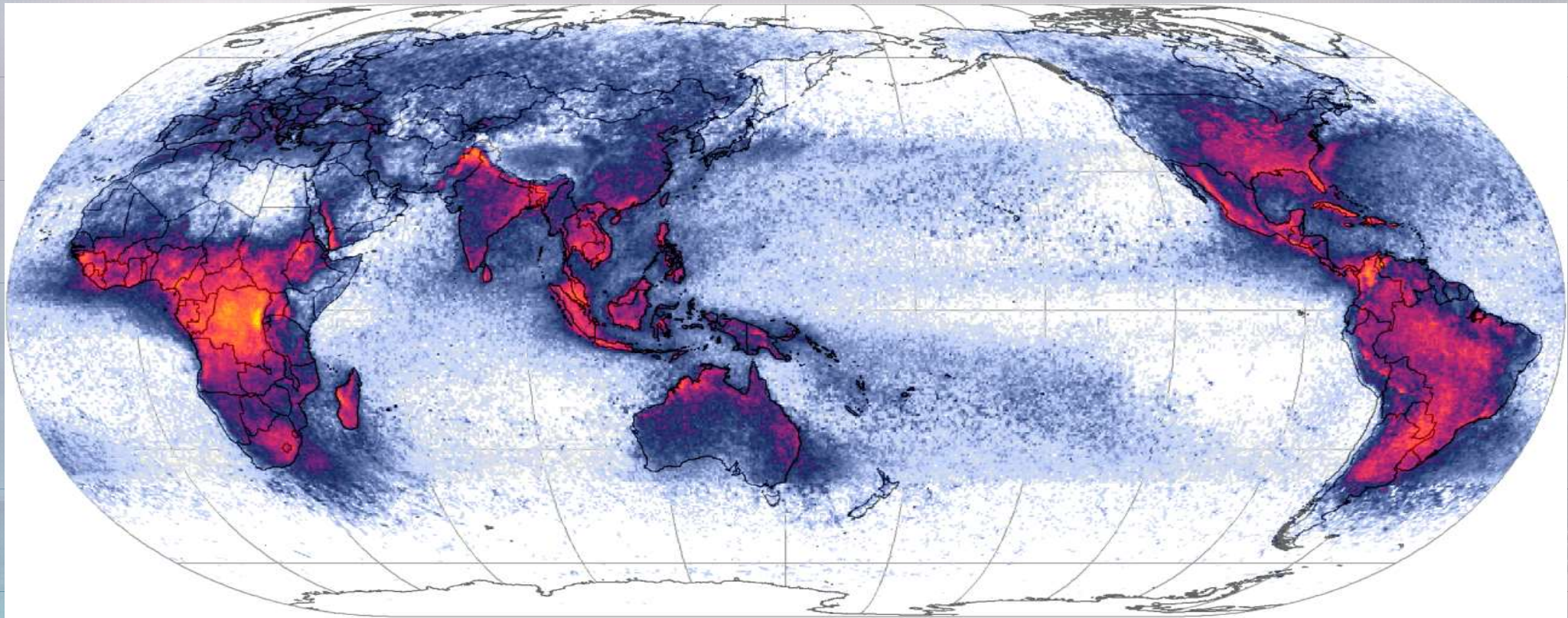


# Lightning Formation

- **AGAIN:** Electrons are drained at the surface first so the **FLASH starts at the ground!!!**
  - This is why lightning is said to **GO UP**, rather than down
- The movement is **STILL from CLOUD to GROUND**
  - But the “heating” happens at the surface **FIRST**.
- The electrons closest to Earth are “**discharged**” first
- **Heat** that is released causes air around a step-leader to reach 30,000°C (54,000°F)
  - The warmer, the shorter the shorter the wavelength



# Global Lightning Occurrence



Average strikes per square kilometre per year

0.1 0.2 0.5 1 2 5 10 20 50 100 200

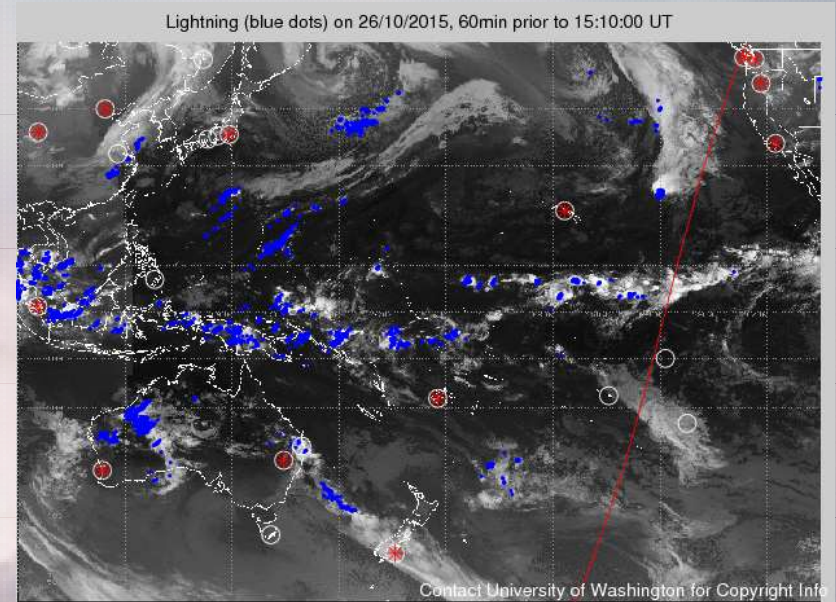
# Real-time Lightning Websites

- **World Wide Lightning Location Network**

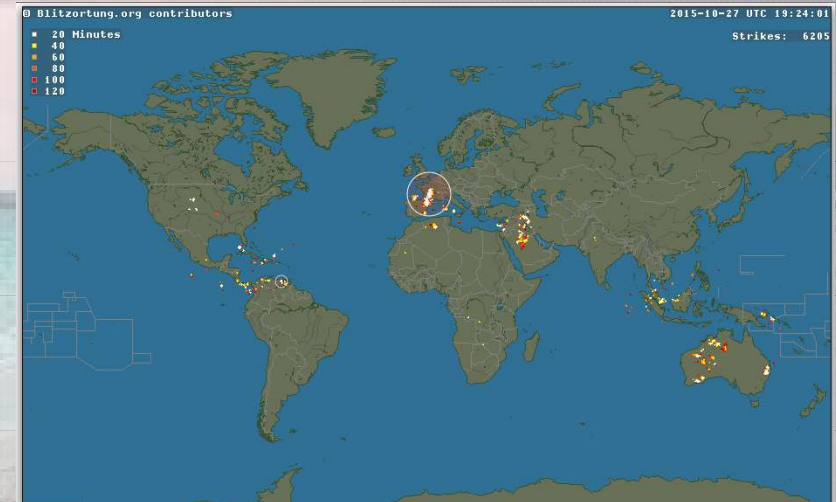
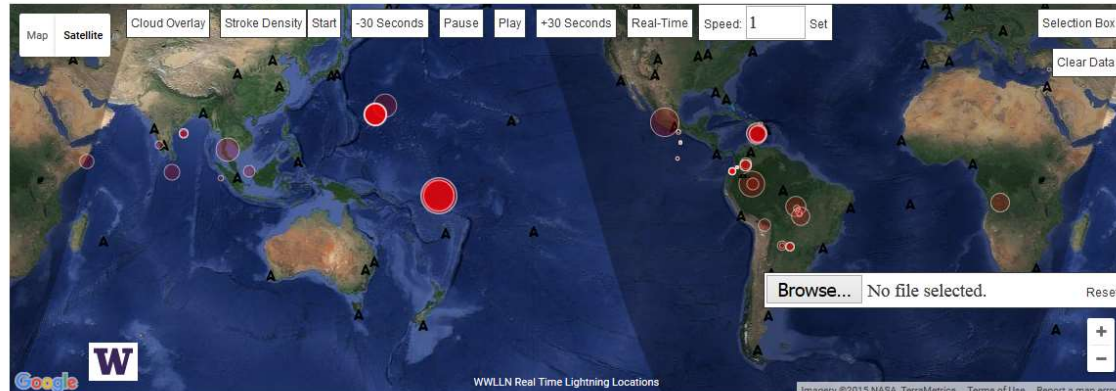
- <http://wwln.net/>
- <http://wwln.net/new/map/>

- **Blitzortung.org - Oceana**

- [http://www.blitzortung.org/Webpages/index.php?lang=en&page\\_0=20](http://www.blitzortung.org/Webpages/index.php?lang=en&page_0=20)



## WWLLN Streaming Data



# Thunder

- When air is heated quickly a shockwave forms → causes thunder
- Similar to planes crossing the sound barrier, firecrackers and gun shots
- Sound travels at **330 m/s or 1000ft/s**
- If thunder takes 3 seconds to happen after observing lightning then the storm is:
  - $3 \text{ s} * 1000 \text{ ft/s} = 3000 \text{ ft}$  away (6/10 of a mile away).

