

Mid-Latitude Cyclones & Thunderstorms

AOSC 200

Tim Canty

Class Web Site: <http://www.atmos.umd.edu/~tcanty/aosc200>

Topics for today:

Finishing mid-latitude cyclones
Thunderstorms

Lecture 22
Nov 12, 2019

Regions of Cyclogenesis

East Coast Lows

Gulf Low:

Form along southern coast. Cold land and warm ocean means good probability of precipitation

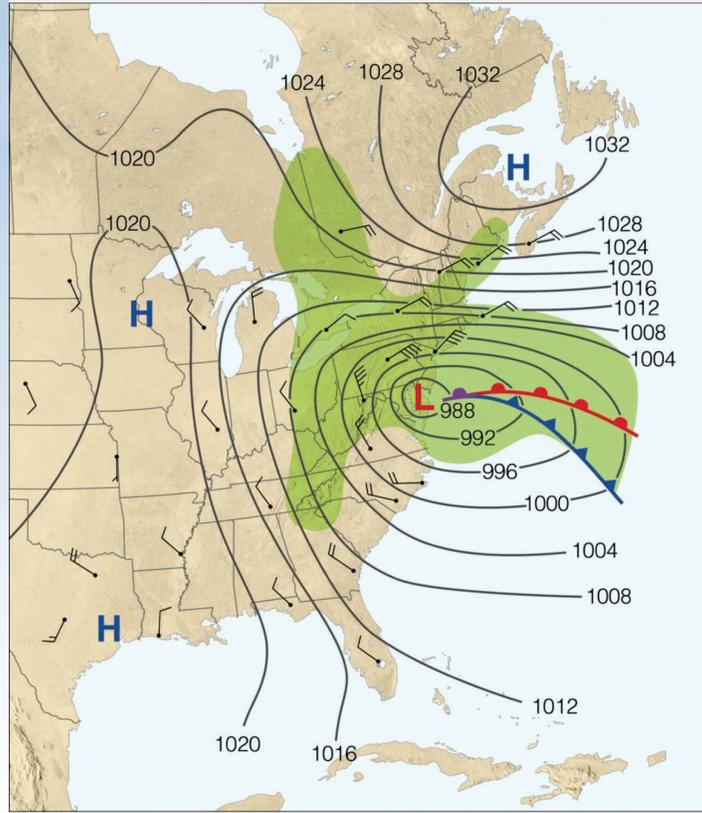
Hatteras Low (Nor'easter):

Form along eastern coast (Carolinas). Warm gulf stream water provides warm air and moisture that interacts with cold air on land.

If the pressure of a Hatteras Low drops by 24mb in 24 hrs, it's considered a "bomb"

Can produce hurricane strength winds, flooding, heavy snow.
Can last for days!!!

Nor'easters



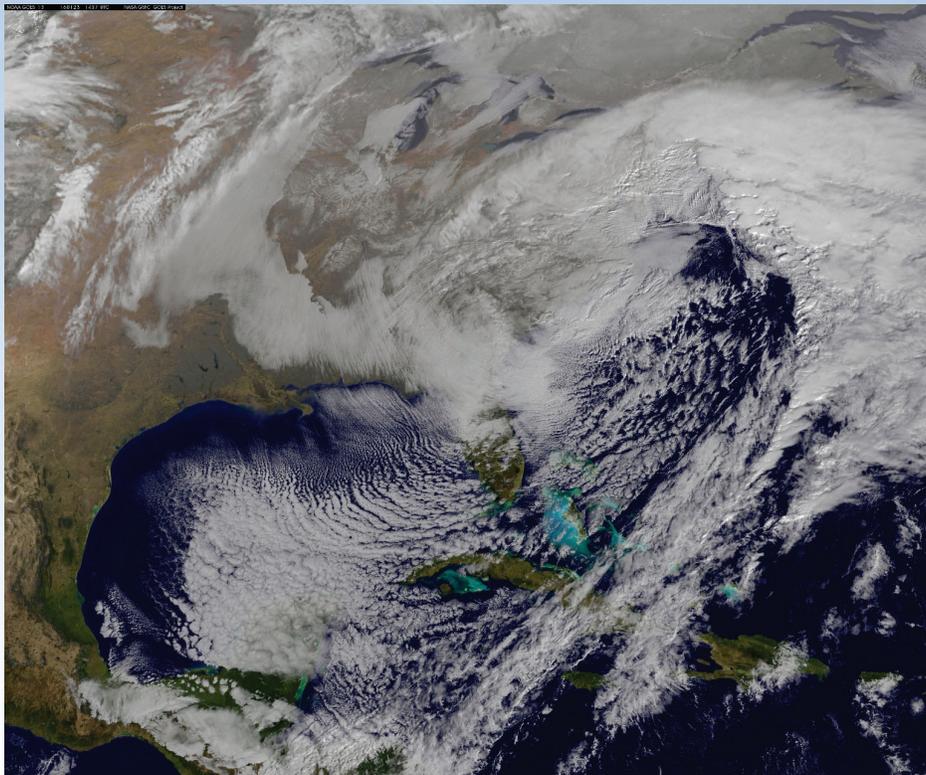
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Fig 8.U1: *Essentials of Meteorology*

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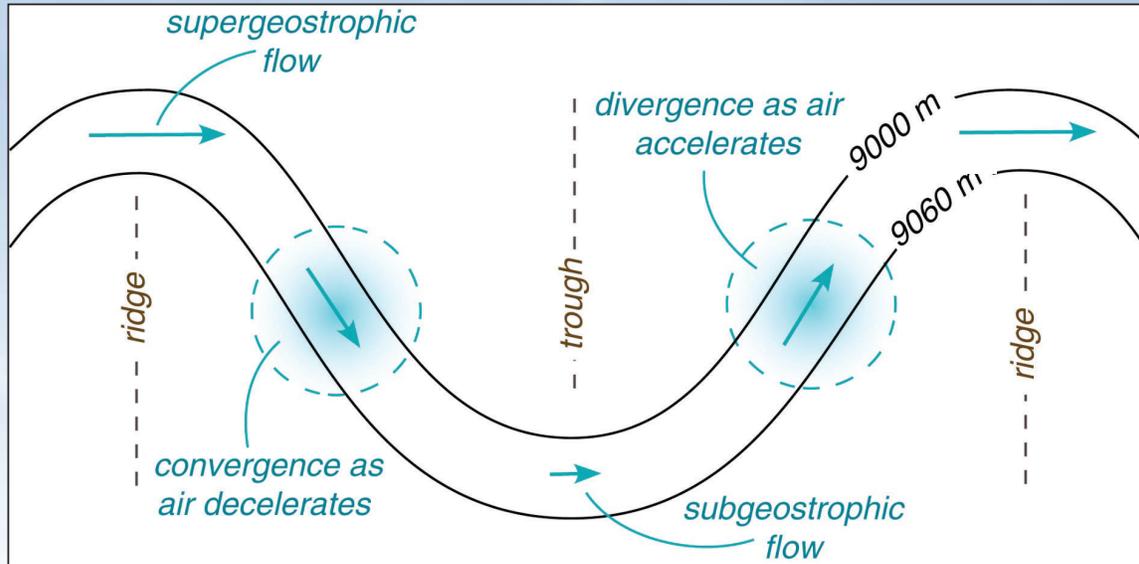
Snowzilla: January 2016



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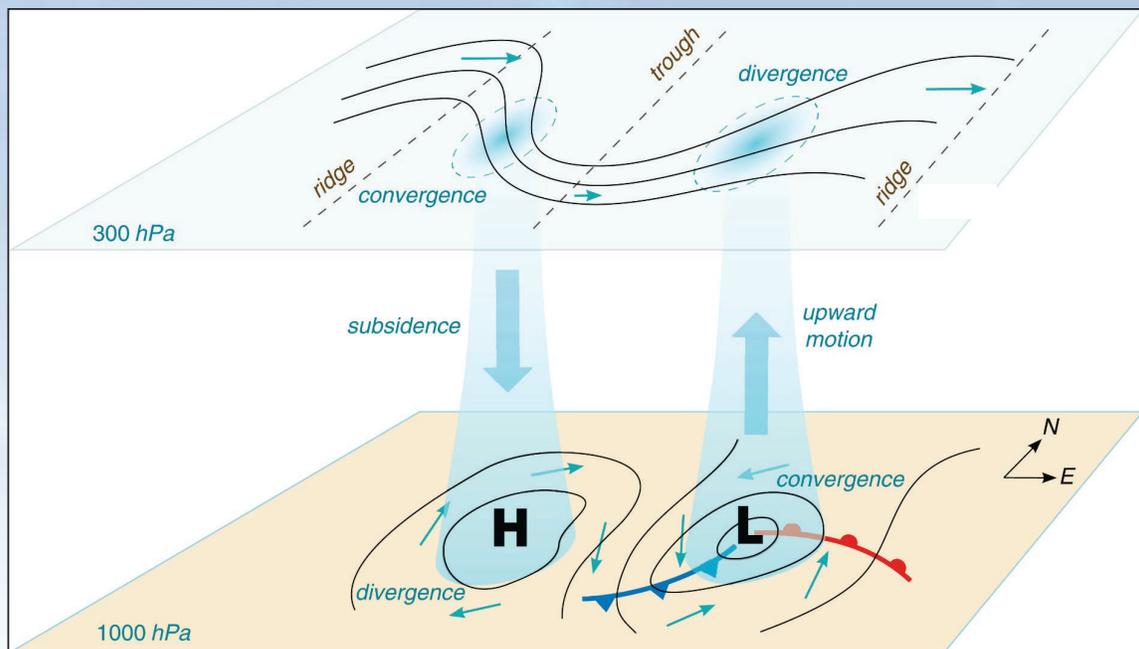
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Cyclogenesis in 3-D



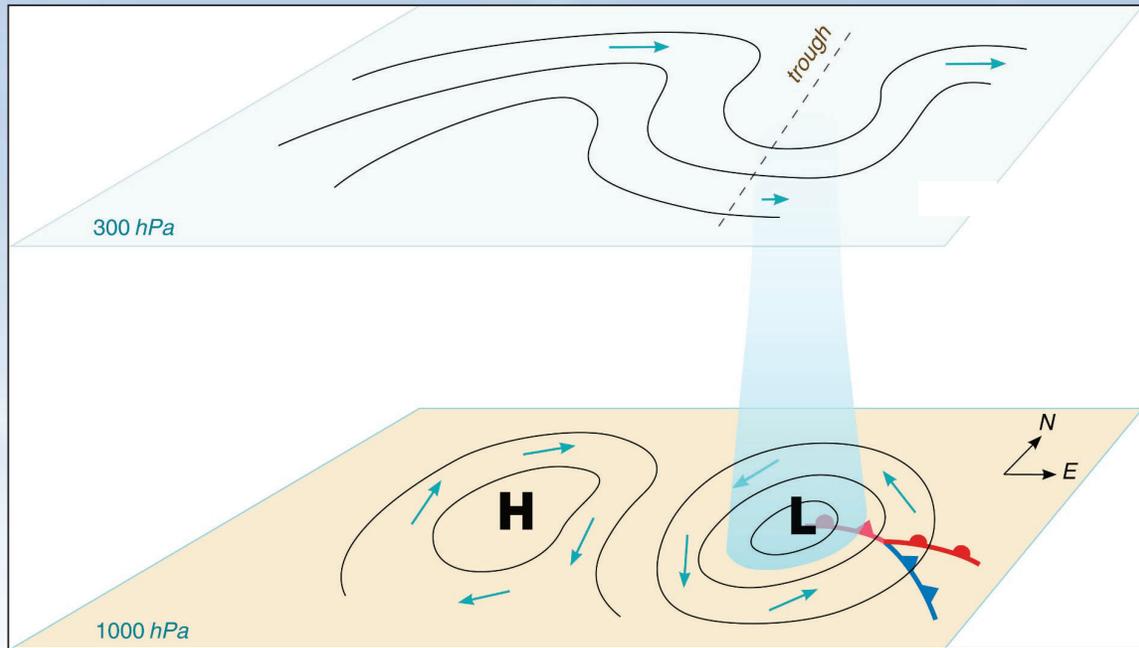
Surface high pressure directed to southeast by jet stream
Surface low pressure directed northeast by jet stream

Cyclogenesis in 3-D



Surface high pressure directed to southeast by jet stream
Surface low pressure directed northeast by jet stream

Cyclogenesis in 3-D



Upper level trough moves over the surface low and the cyclone begins to decay.

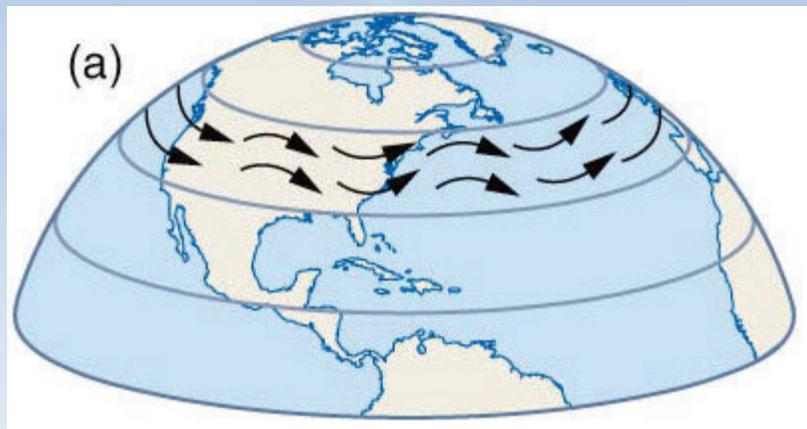
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Fig 10.12 *Weather: A Concise Introduction*

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Rossby Waves



Zonal Flow: Jet stream moves from west to east without meandering around much

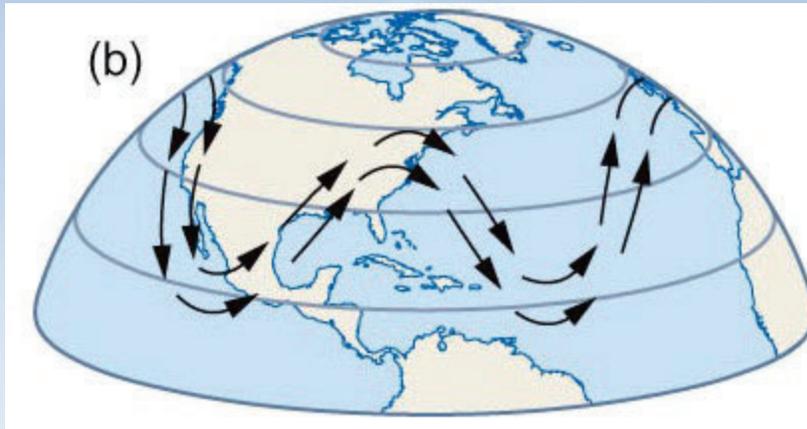
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Fig 7-15 *Meteorology: Understanding the Atmosphere*

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Rossby Waves

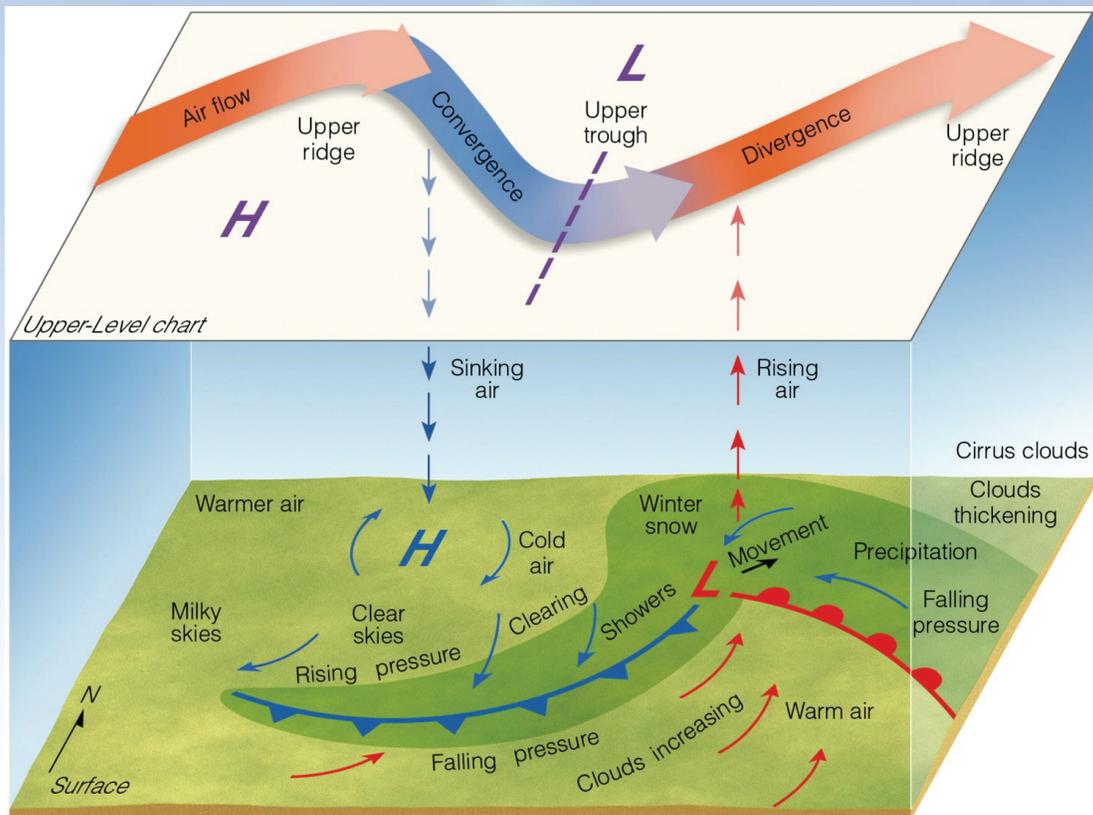


Meridional Flow: Jet stream wanders around a lot as the wind moves from west to east

Sometimes happens when a large pacific storm hits the jet stream

Fig 7-15 *Meteorology: Understanding the Atmosphere*

Rossby Waves



Thunderstorms

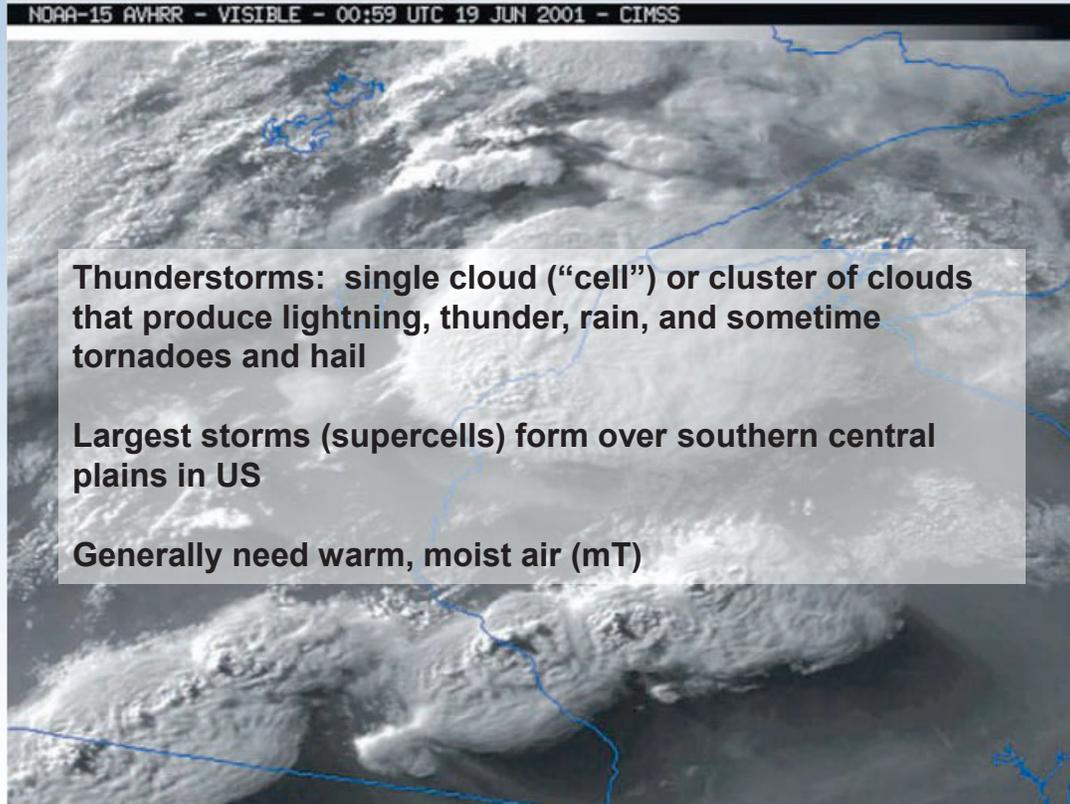
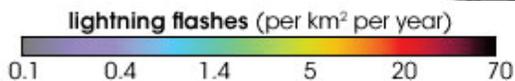
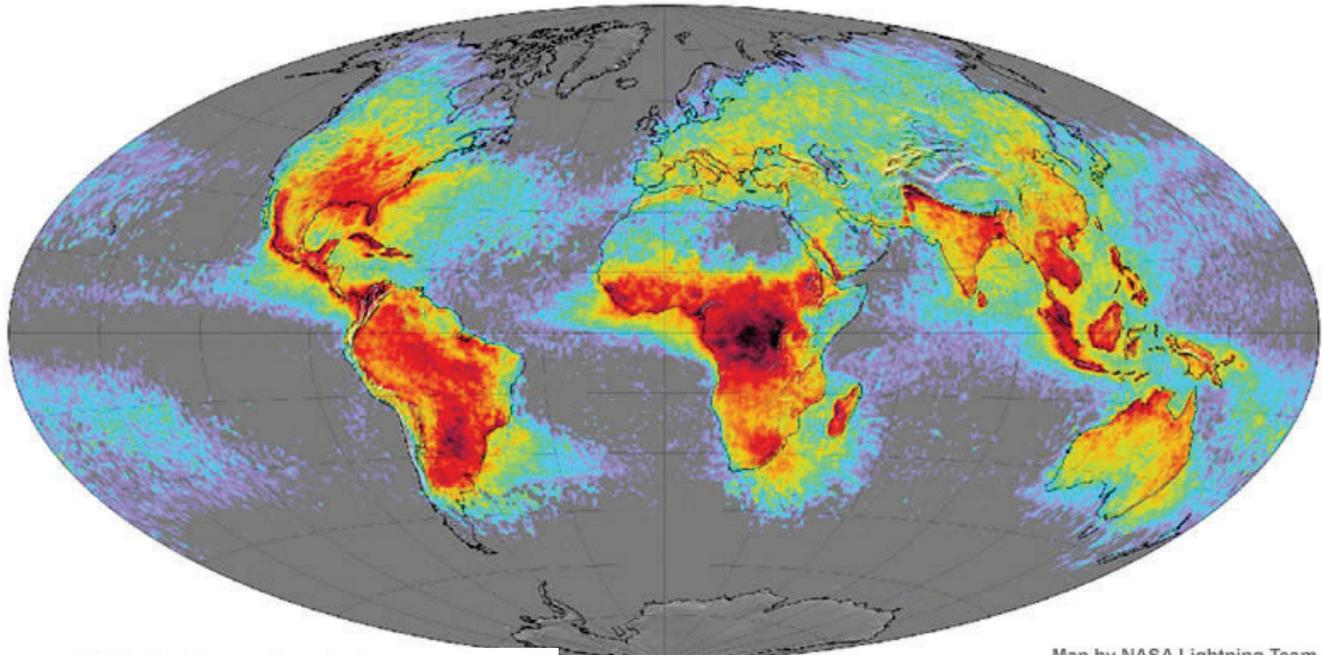


Fig 11-2 *Meteorology: Understanding the Atmosphere*

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Global Lightning Distribution: 1995-2002



Thunderstorms need convection of warm, moist air

Most likely to occur around ITCZ

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<http://geology.com/articles/lightning-map.shtml>

What affects thunderstorm growth?

- **Lifting mechanism: thunderstorms can't grow unless something causes the air to rise in the first place**
- **Environmental temperature**
- **Moisture**
- **Wind speed and direction at all levels**

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What affects thunderstorm growth?

- **Lifting mechanism: thunderstorms can't grow unless something causes the air to rise in the first place**
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What affects thunderstorm growth?

- **Lifting mechanism: thunderstorms can't grow unless something causes the air to rise in the first place**
- **Environmental temperature: determines stability of atmosphere**
- **Moisture**
- **Wind speed and direction at all levels: wind shear helps increase duration of thunderstorm**



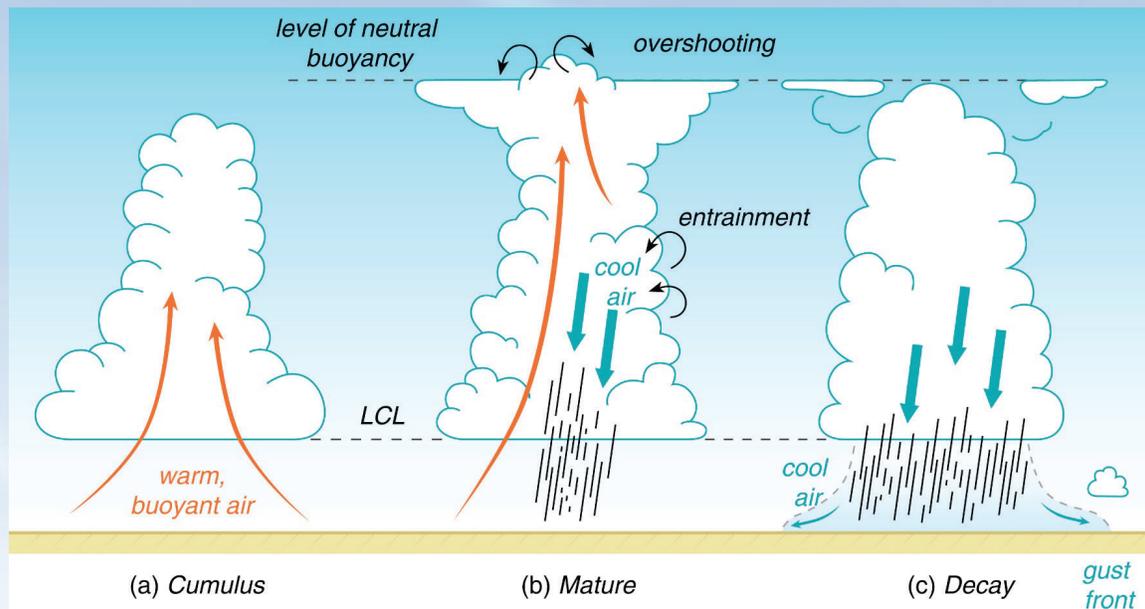
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Types of Thunderstorms

- **Single cell**
- **Multicell**
 - **Squall line**
 - **Mesoscale Convective Complex**
- **Supercell**

Single Cell (Air-mass thunderstorm)



Cumulus stage: needs source of warm, moist air

Water condenses and cloud spreads out in all directions

Dry air entrained in from all sides – promotes growth of droplets

Precipitation begins to form

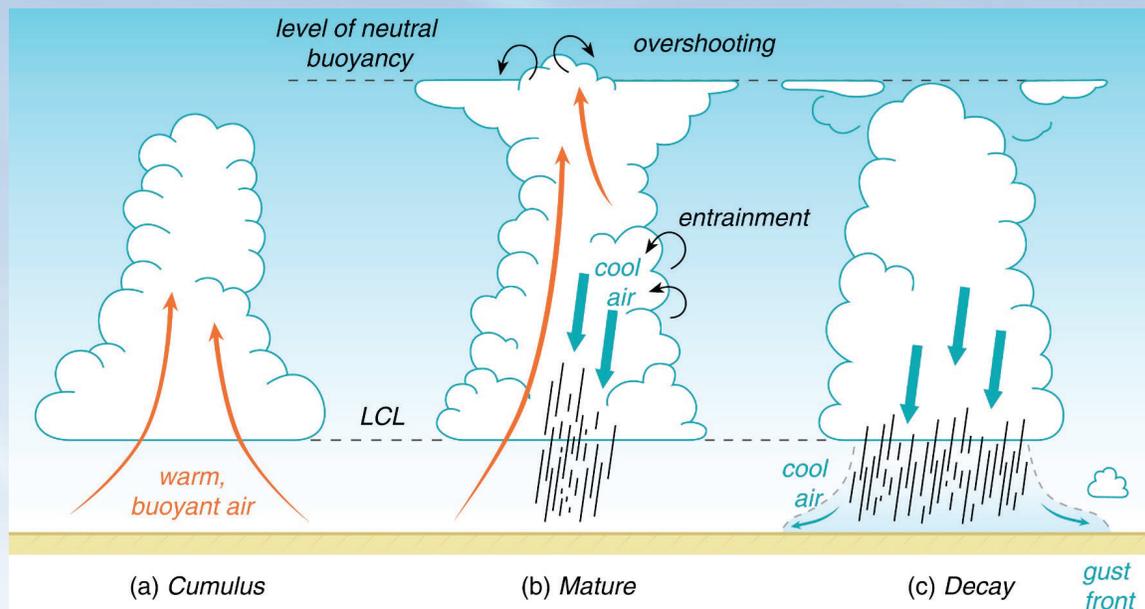
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Fig 11-2 Weather: A Concise Introduction

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Single Cell (Air-mass thunderstorm)



Mature stage: lightning, rain, and small hail

Updrafts increase – promotes further droplet growth (see Ch 5)

Precipitation falls and evaporates, cooling air beneath cloud. Downdraft begins and increases in strength

Downdraft hits ground and interacts with updraft

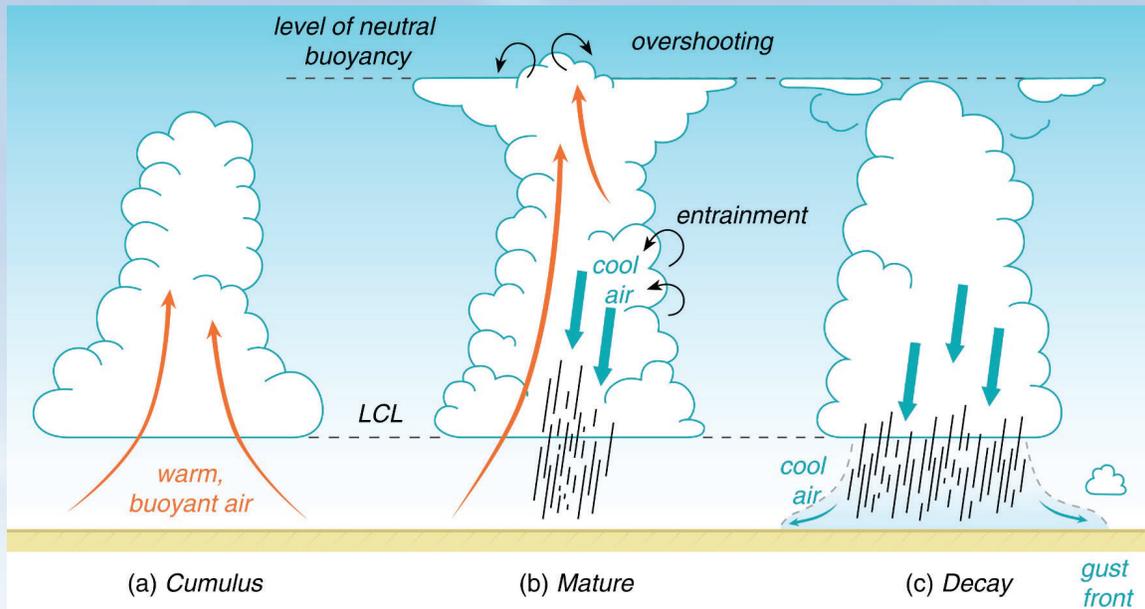
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Single Cell (Air-mass thunderstorm)



Dissipating stage: updraft weakens, downdraft dominates

Source of moisture and energy shuts down, storm weakens

Cloud begins to disappear as dry air entrained into cloud, evaporates droplets

Often develop in mT air masses, last ~ 1 hour

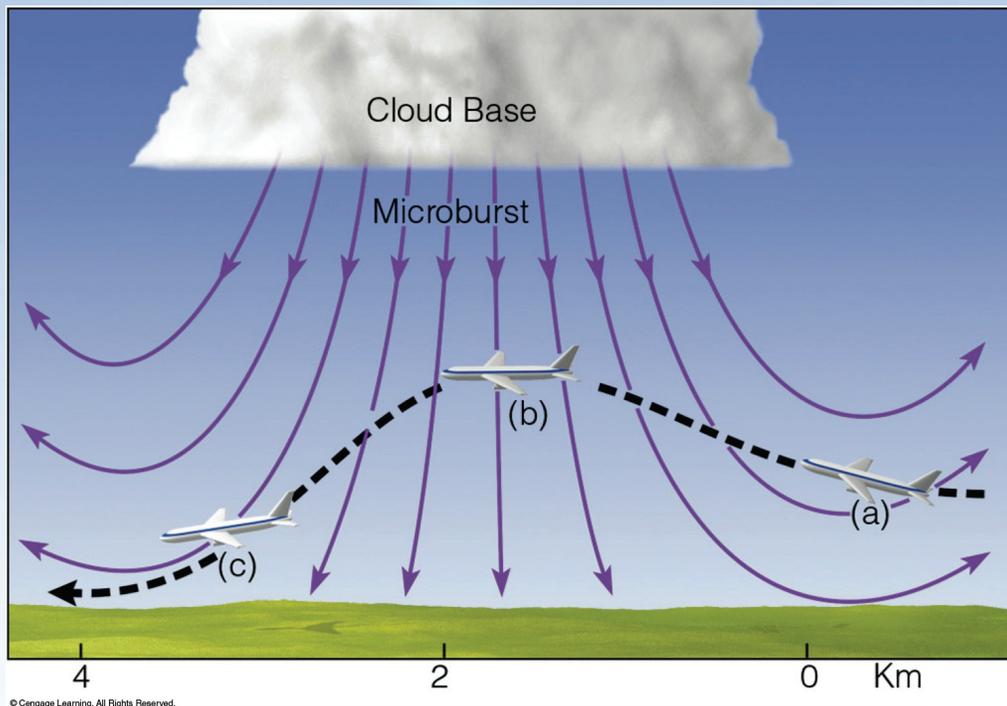
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Microbursts



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**Winds extend less than 4km
Can be very damaging**

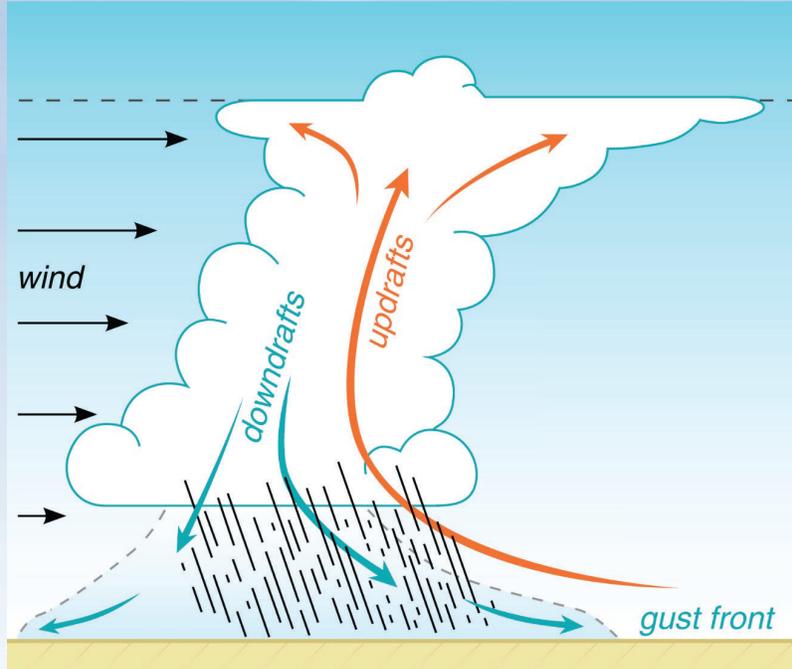
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Fig 10-11 Essentials of Meteorology

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Multicell Thunderstorms



Wind shear keeps the downdraft from interfering with updraft

Strong down draft aids the updraft (gust front)

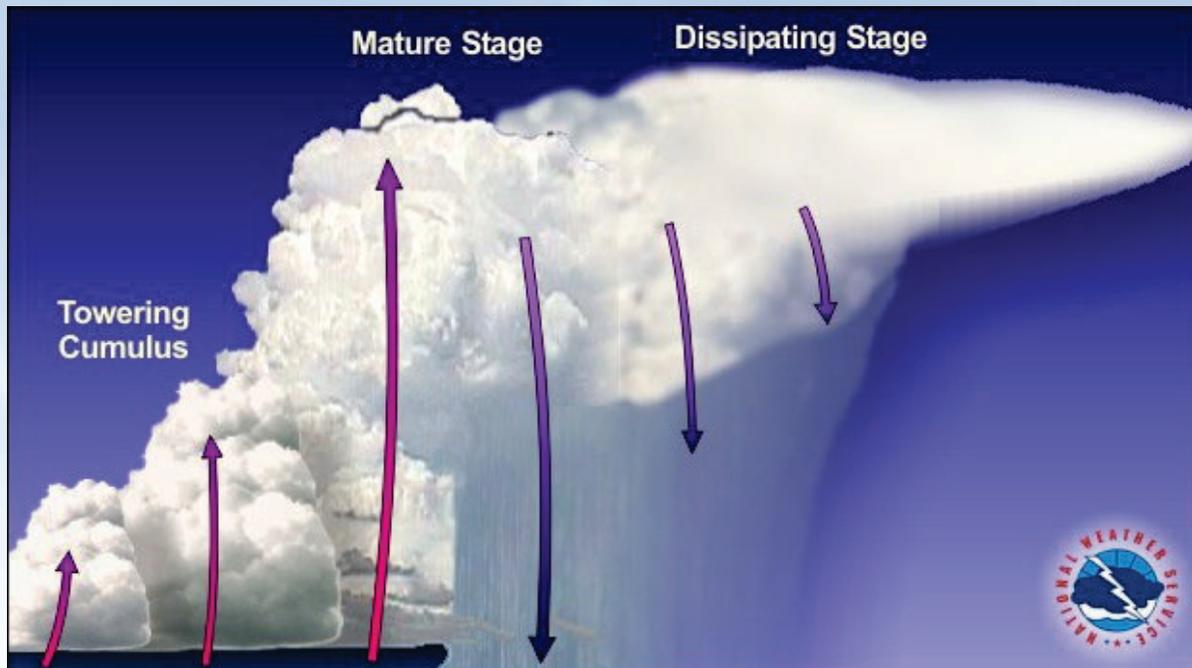
Increased updraft aids in formation of new cells

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Fig 11-5 *Weather: A Concise Introduction*

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Multicell Thunderstorms

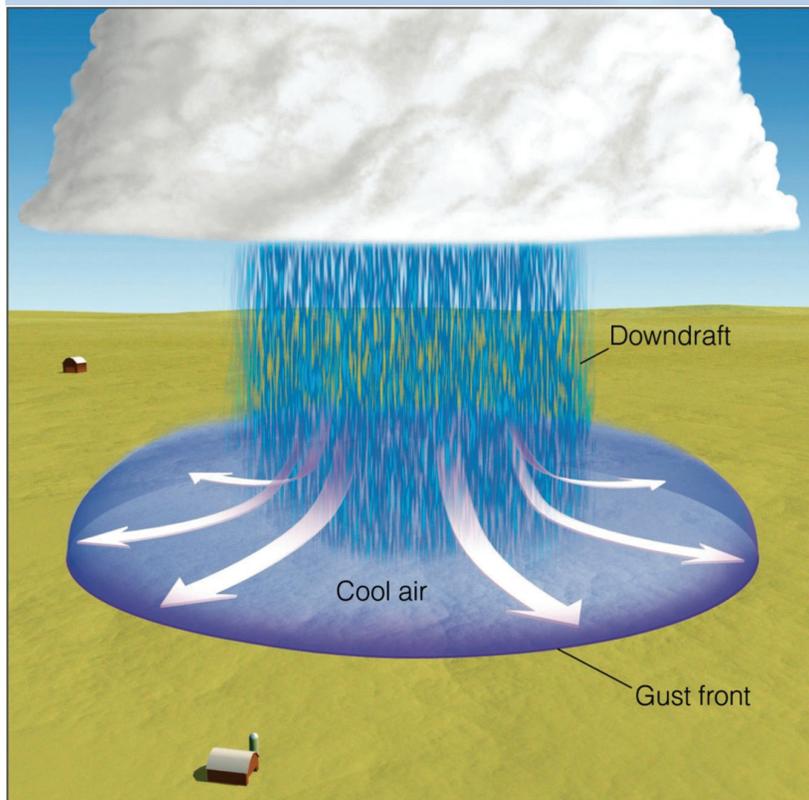


<http://www.srh.noaa.gov/jetstream/tstorms/tstrmtypes.htm>

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Gust Front



Cold air (downdraft) hits the grounds and spread out.

Acts like a cold front and forces up warmer air

Warm air rises, condenses and can form a shelf cloud

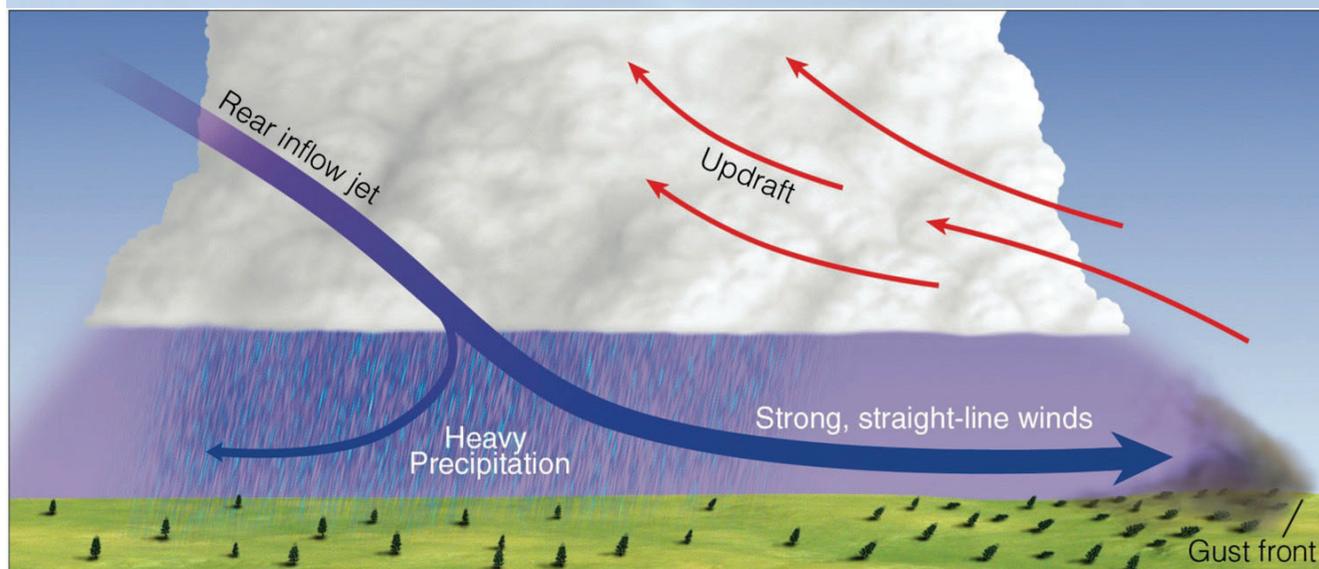
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Fig 10-6 *Essentials of Meteorology* 23

Squall Line: Side View



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Downdraft can re-direct upper level, fast moving wind (rear inflow jet) toward the surface. This wind will push up the warm air in front of the squall line

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Fig 10-13 *Essentials of Meteorology* 24

Multicell Thunderstorms: Squall Lines



Line of intense, individual storms

May last 6-12 hours

Occur along or ahead of frontal boundary (i.e. cold front)

Strong wind shear tilts updraft and separates it from downdraft

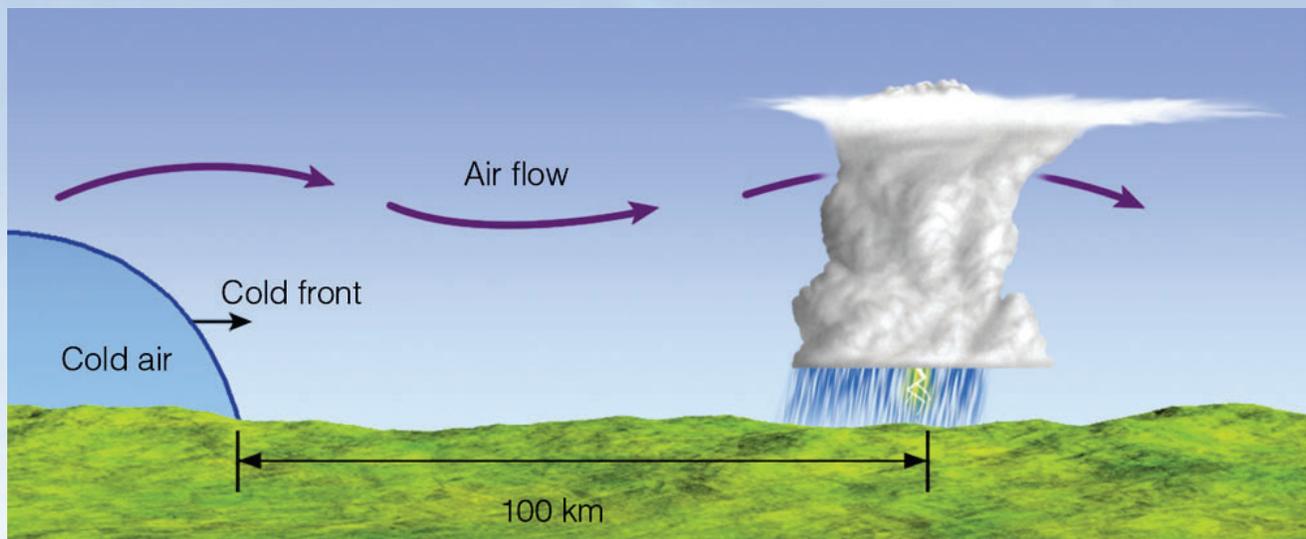
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<http://www.crh.noaa.gov/images/lmk/012908web/animation.gif>

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Multicell Thunderstorms: Squall Lines



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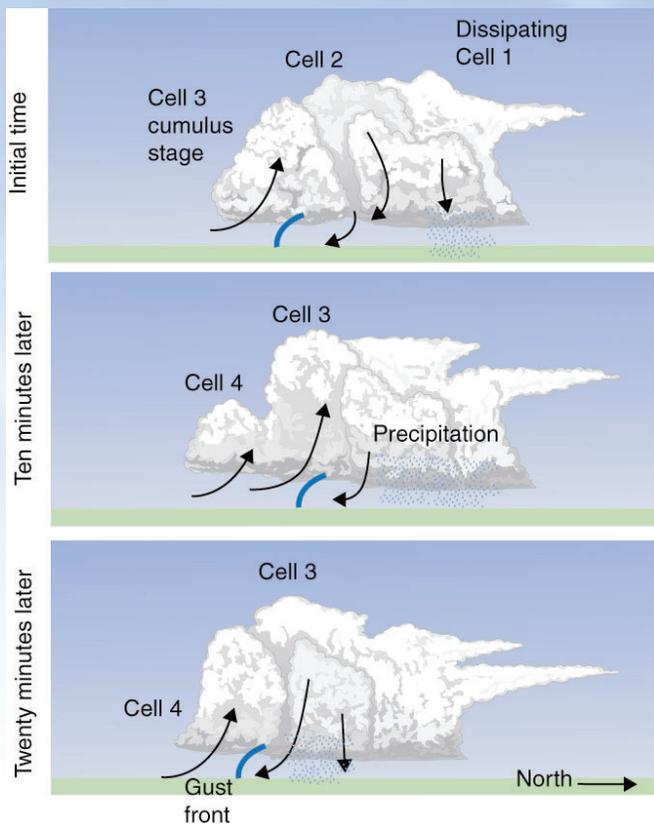
Pre-frontal squall lines may form ahead of an advancing cold front as the air aloft forms waves downwind from the cold front

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Multicell Thunderstorms: Mesoscale Convective Complex



Composed of multiple single-cell storms in different stages of development

Individual thunderstorms supports formation of other convective cells

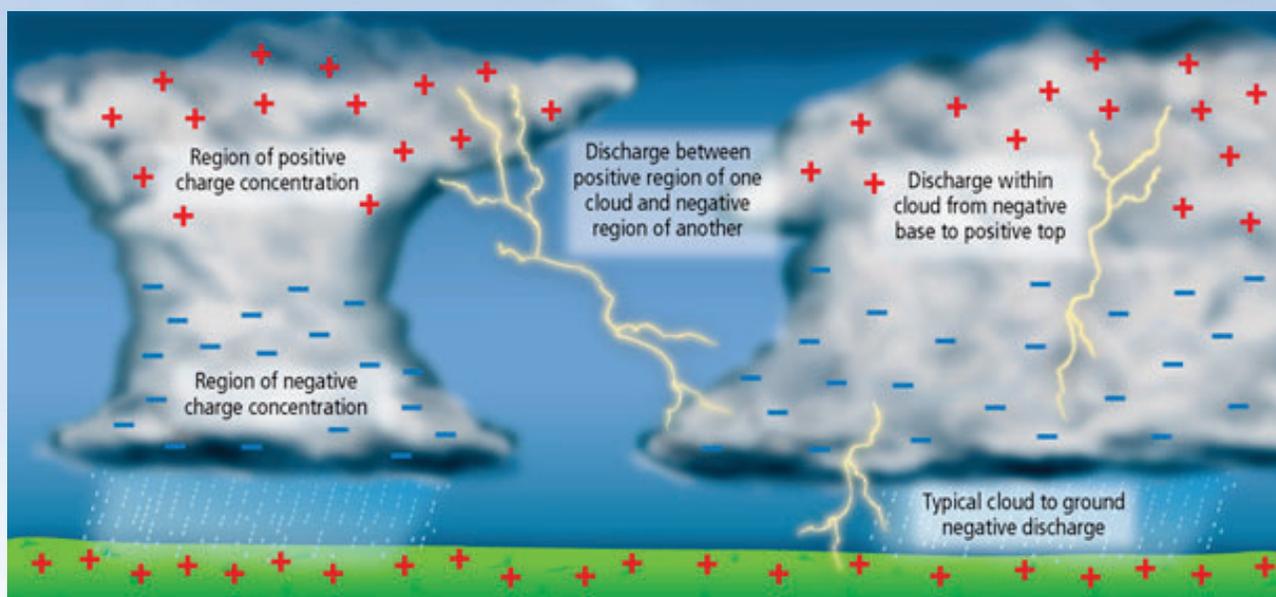
To last a long time, good supply of moist air near surface is needed

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Fig 11-14 *Meteorology: Understanding the Atmosphere*

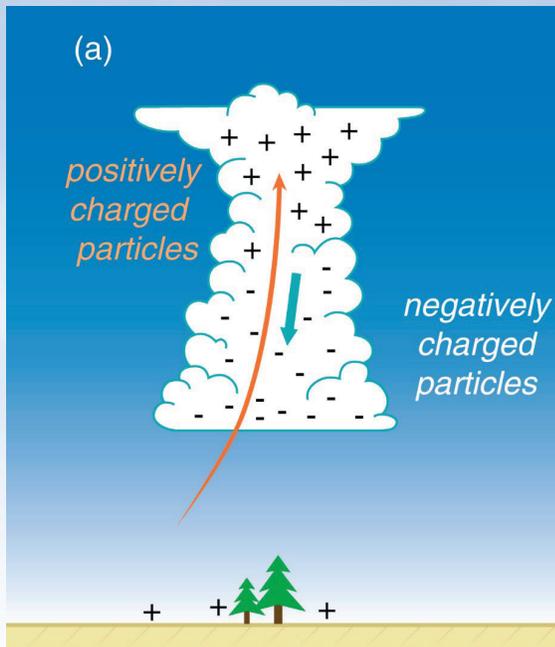
Lightning



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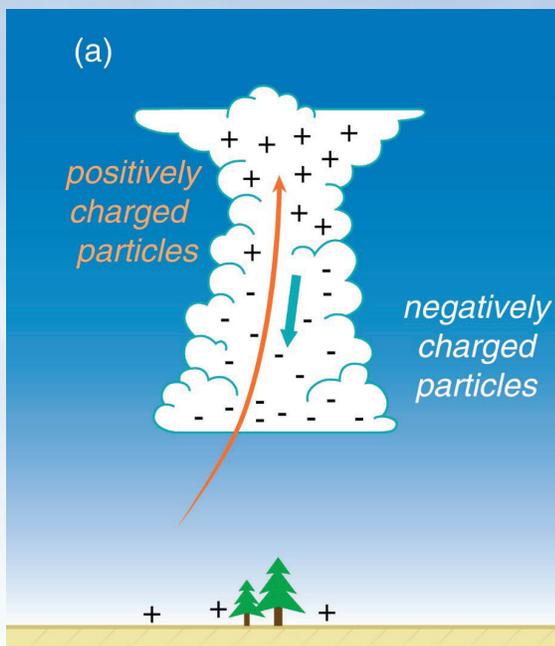
Lightning



Charge separation: occurs due to collisions between ice crystals and droplets and/or ...

Fig 10-27 *Essentials of Meteorology*

Lightning

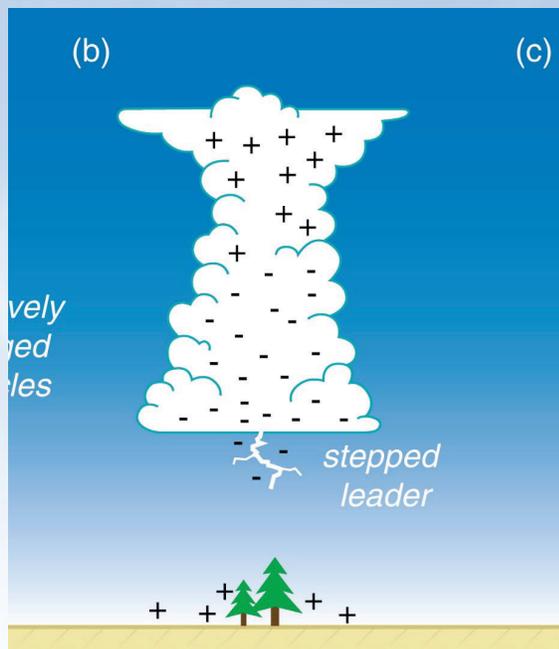


Charge separation occurs due to collisions between ice crystals and water droplets and/or graupel...

Updrafts carry positive charges up and the negatively charged graupel sink to cloud base

Fig 10-27 *Essentials of Meteorology*

Lightning



When the charge builds up enough:

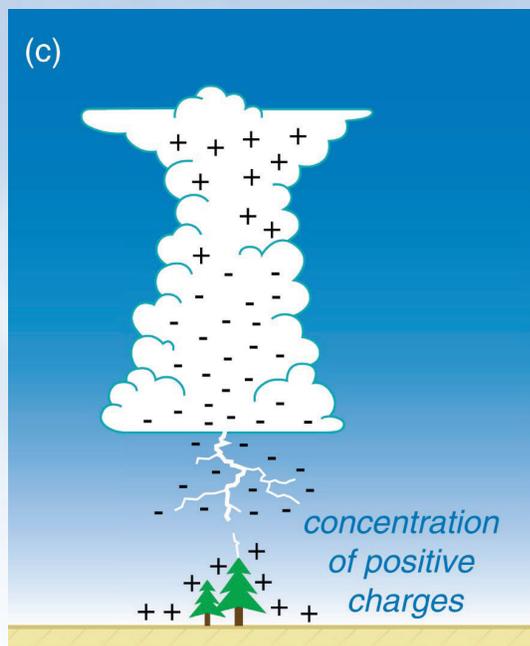
Induced charge forms at surface

Cloud sends out pilot leader followed by a *stepped leader*

Basically, the negative charges are trying to find a way to get to the ground

Fig 10-28 *Essentials of Meteorology*

Lightning

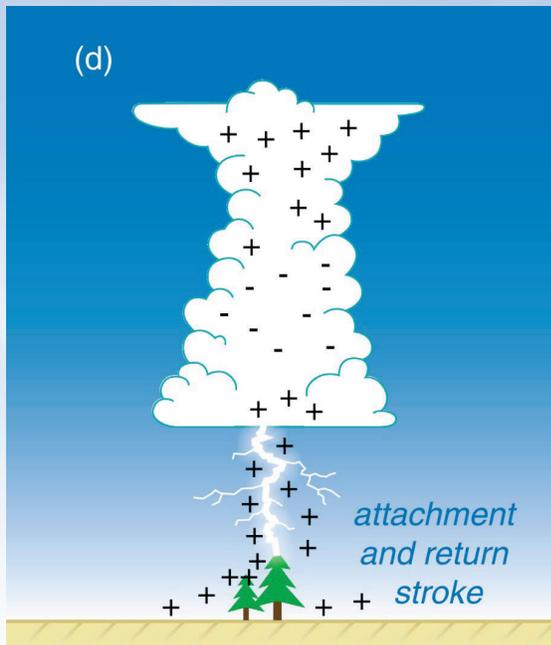


Ground sends out positive streamers that wait for the stepped leaders to make contact

Once contact is made, an ionized channel is created between cloud and ground

Fig 10-28 *Essentials of Meteorology*

Lightning



Ground sends out positive streamers that wait for the stepped leaders to make contact

Once contact is made, an ionized channel is created between cloud and ground

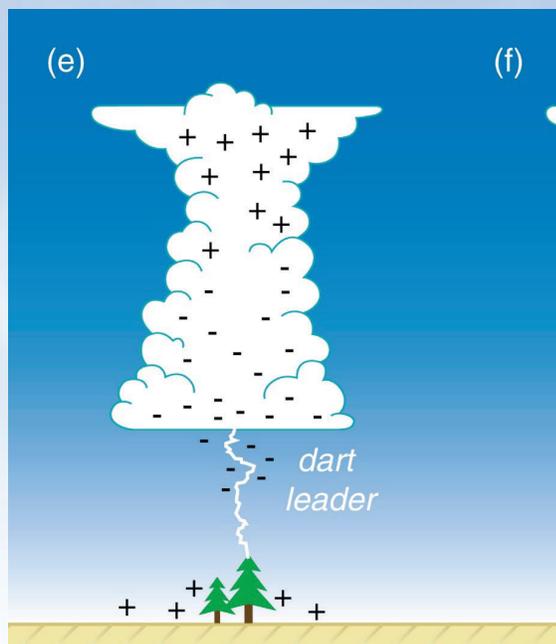
Positive charges rush up through the channel making the *return stroke*

This is the brightest part of the lightning

Process can happen several times, very rapidly

Fig 10-28 *Essentials of Meteorology*

Lightning



Process can happen several times, very rapidly

If there is still negative charge left, this can flow through the *dart leader*

Which leads to a ...

Fig 10-28 *Essentials of Meteorology*

Lightning

Process can happen several times, very rapidly

If there is still negative charge left, this can flow through the *dart leader*

Which leads to a ... *second return stroke*

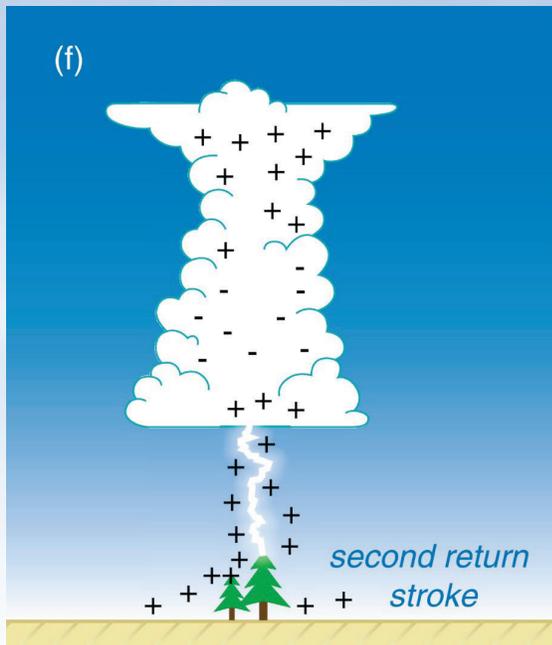


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Lightning

When the charge builds up enough:

Repeated flashes drain charge from different parts of the cloud

May reach higher into the cloud or across the base, etc.

Process describes “negative cloud to ground” – 90% of cloud to ground lightning but only ~25% of total lightning.



http://www.srh.noaa.gov/jetstream/lightning/lightning_max.html

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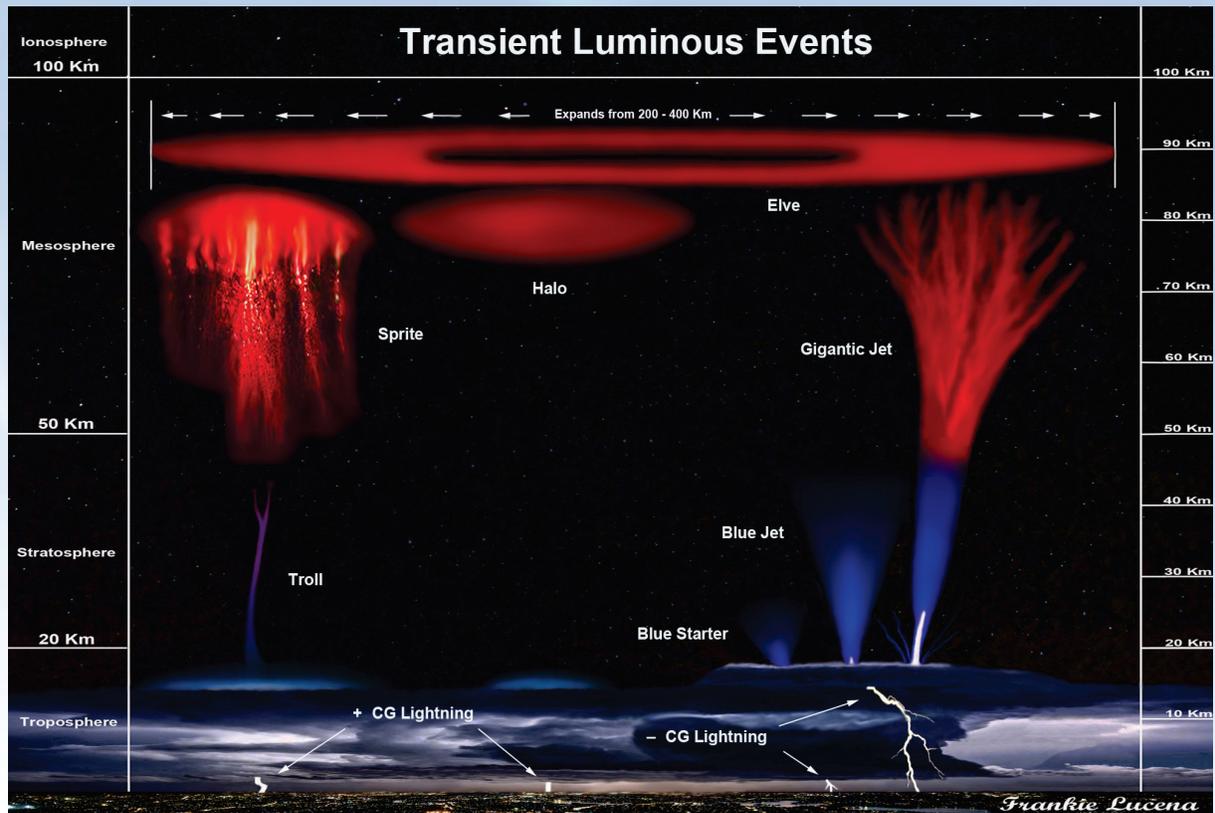
How can we study lightning?

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Some Types of Lightning



http://spaceweathergallery.com/indiv_upload.php?upload_id=119328

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