Thunderstorms and Lightning
AOSC 200

Tim Canty

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

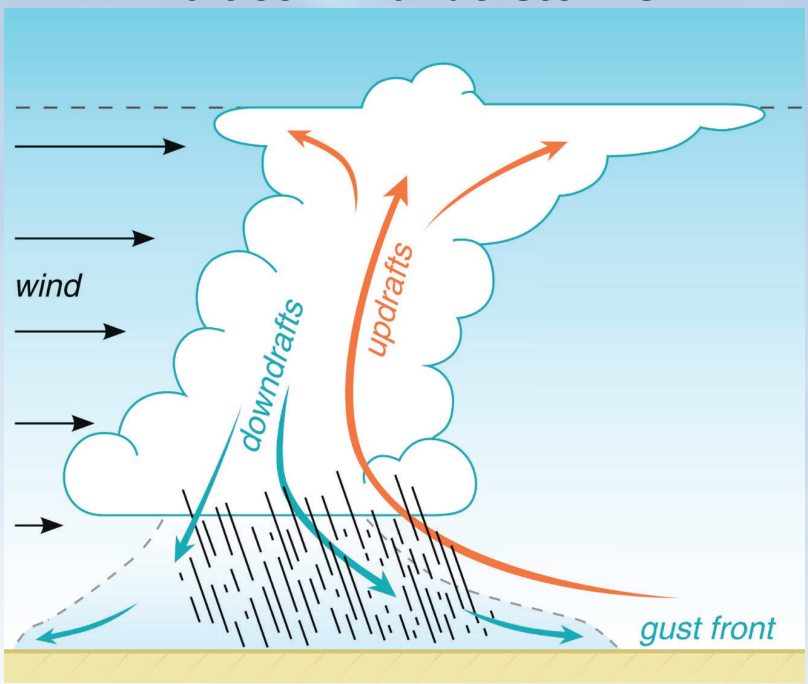
Topics for today:

Thunderstorms

Lecture 22
Nov 14, 2019

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Multicell Thunderstorms



Wind shear keeps the downdraft from interfering with updraft

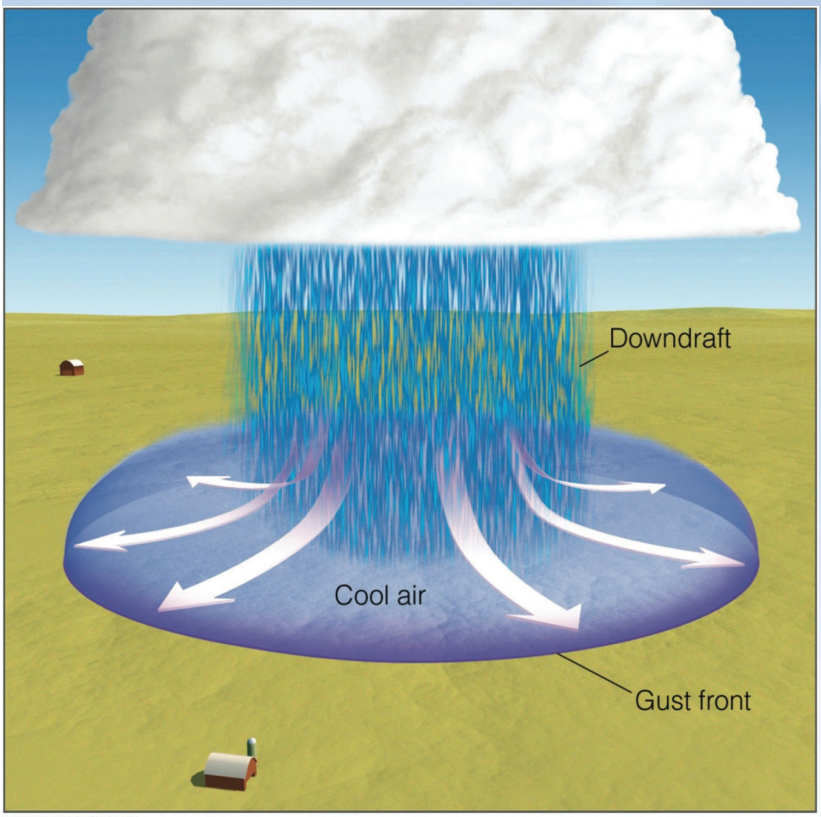
Strong down draft aids the updraft (gust front)

Increased updraft aids in formation of new cells

Fig 11-5 *Weather: A Concise Introduction*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Gust Front



© Cengage Learning. All Rights Reserved.

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

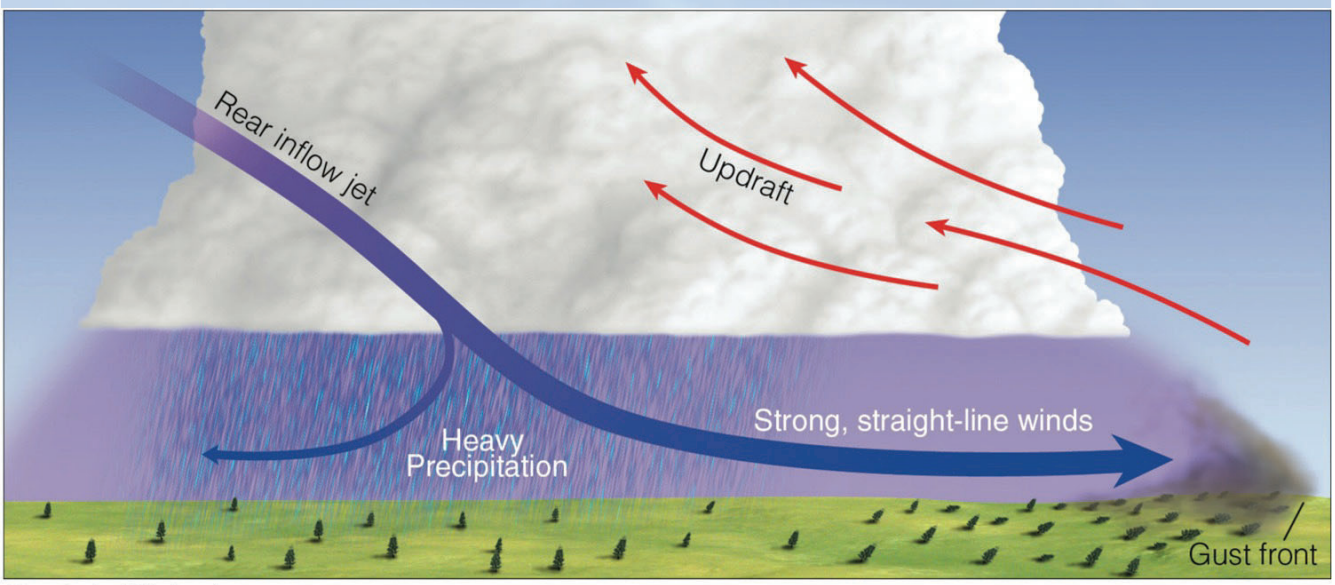
Acts like a cold front and forces up warmer air

Warm air rises, condenses and can form a shelf cloud

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Fig 10-6 *Essentials of Meteorology*

Squall Line: Side View



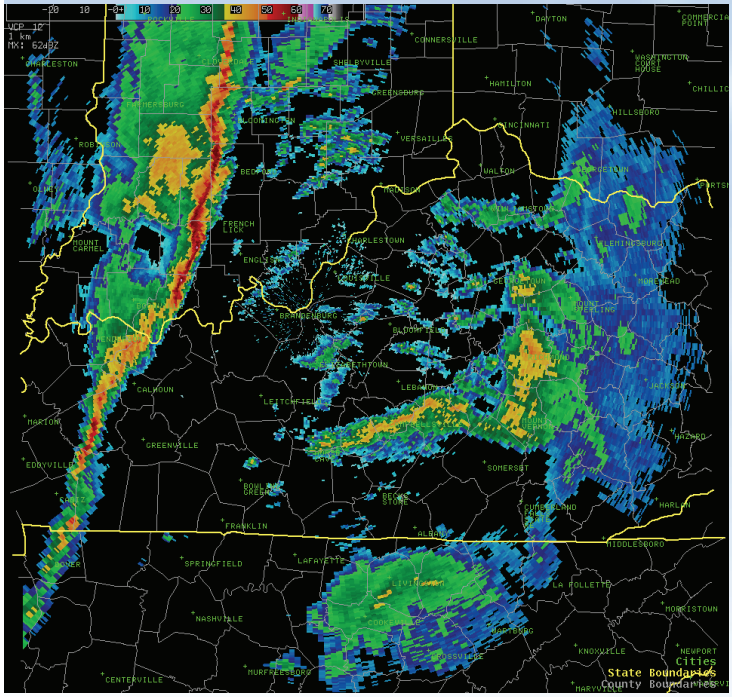
© Cengage Learning. All Rights Reserved.

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

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Fig 10-13 *Essentials of Meteorology*

Multicell Thunderstorms: Squall Lines



Line of intense, individual storms

May last 6-12 hours

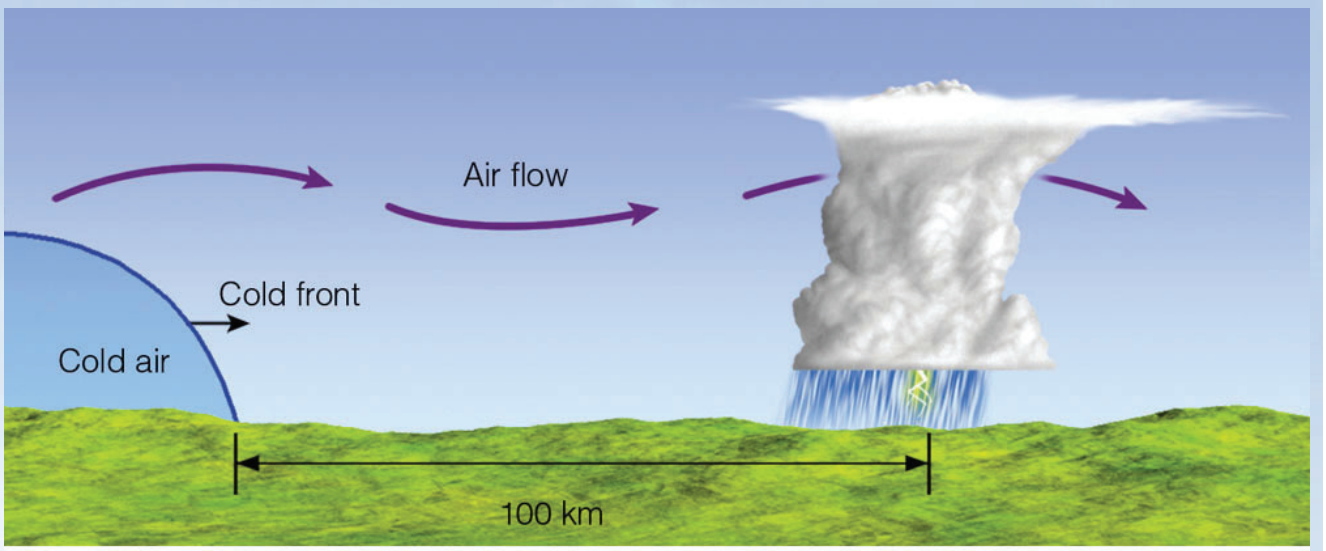
Occur along or ahead of frontal boundary (i.e. cold front)

Strong wind shear tilts updraft and separates it from downdraft

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

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Multicell Thunderstorms: Squall Lines

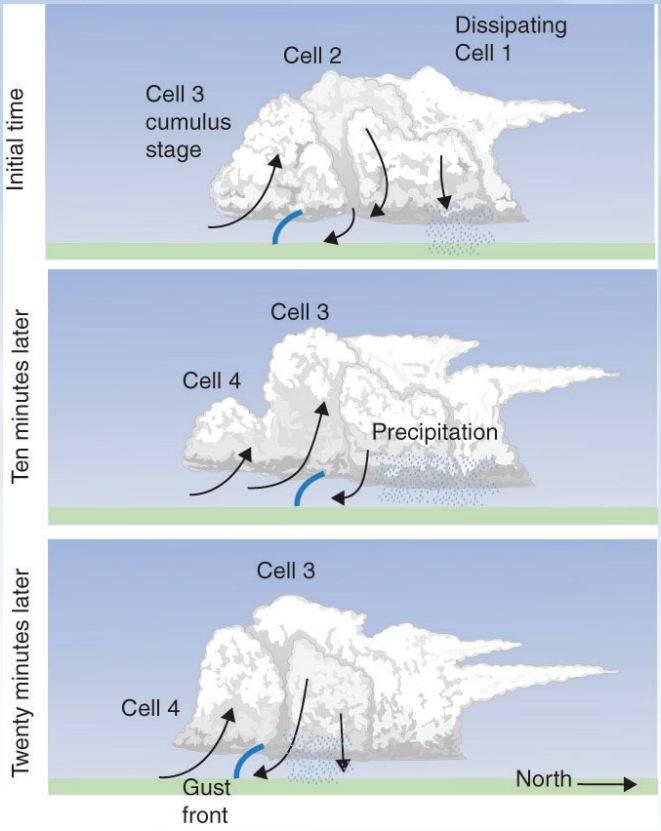


© 2007 Thomson Higher Education

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

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Multicell Thunderstorms: Mesoscale Convective Complex

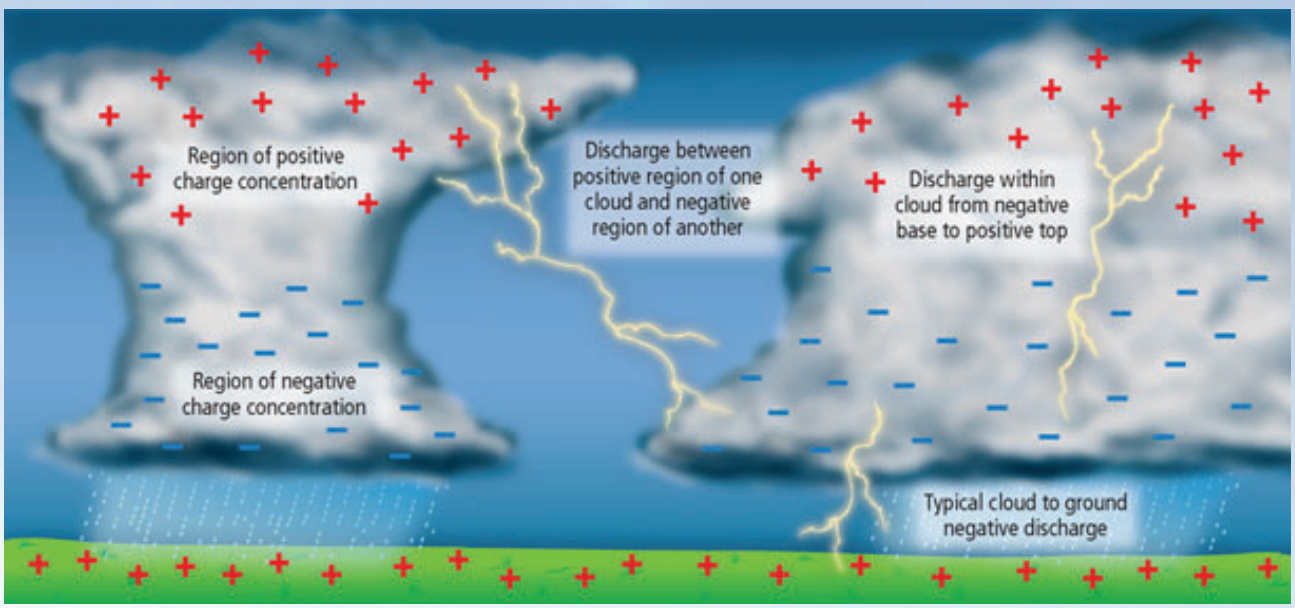


- **Composed of multiple single-cell storms in different stages of development**
- **Individual thunderstorms supports formation of other convective cells**
- **To last a long time, good supply of moist air near surface is needed**

Fig 11-14 *Meteorology: Understanding the Atmosphere*

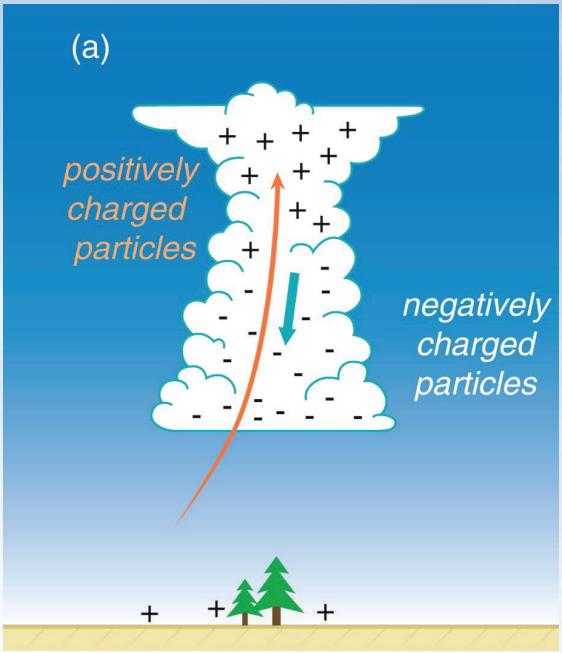
Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Lightning



Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Lightning

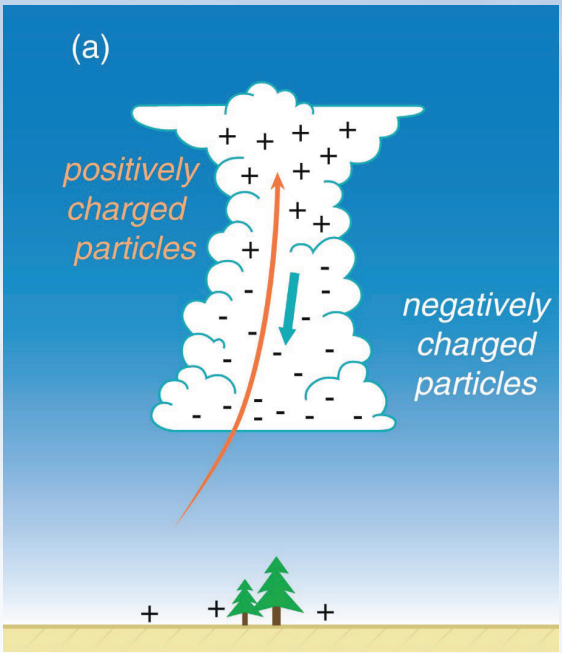


Charge separation: occurs due to collisions between ice crystals and droplets and/or …

Fig 10-27 *Essentials of Meteorology*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Lightning



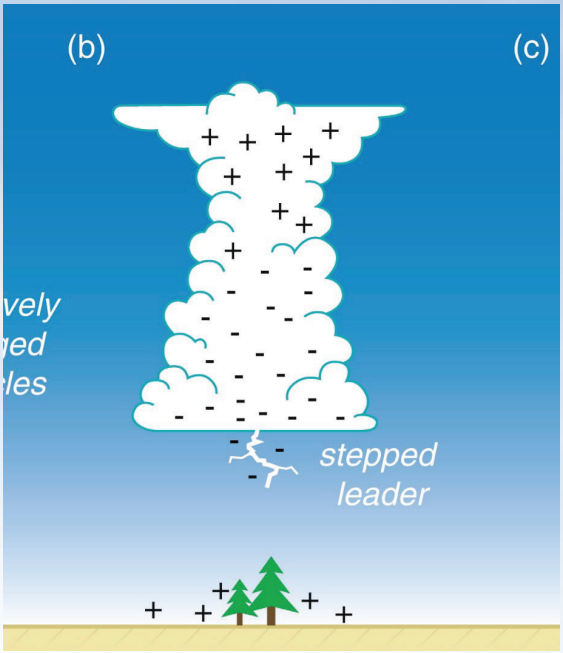
Charge separation occurs due to collisions between ice crystals and water droplets and/or graupel…

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

Fig 10-27 *Essentials of Meteorology*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Lightning



When the charge builds up enough:

Induced charge forms at surface

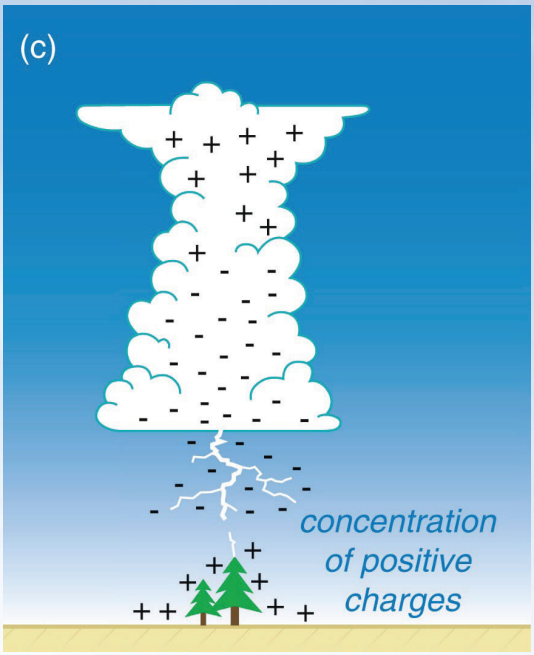
Cloud sends out pilot leader followed by a *stepped leader*

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

Fig 10-28 *Essentials of Meteorology*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Lightning



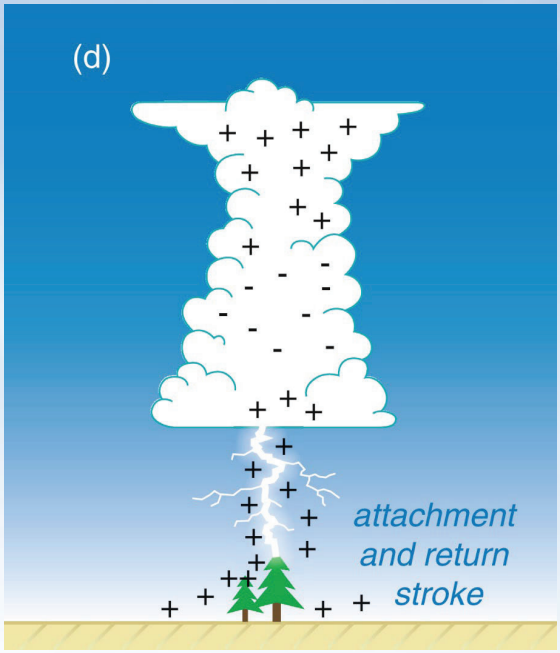
Ground sends out positive streamers that wait for the stepped leaders to make contact

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

Fig 10-28 *Essentials of Meteorology*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

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*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

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*

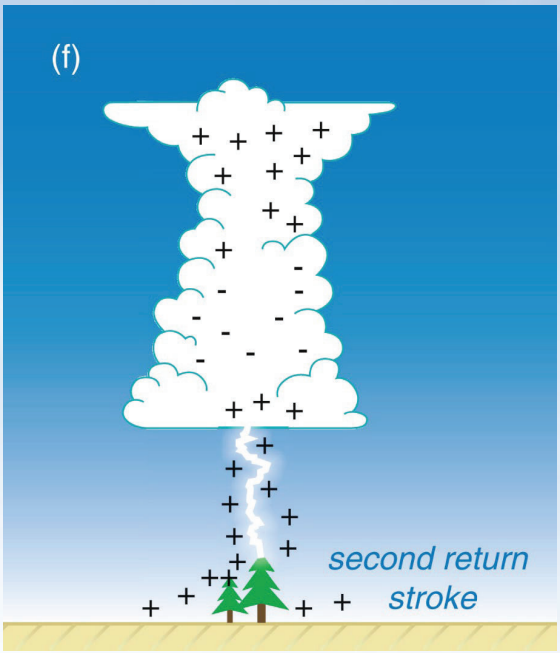


Fig 10-28 *Essentials of Meteorology*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

How can we study lightning?

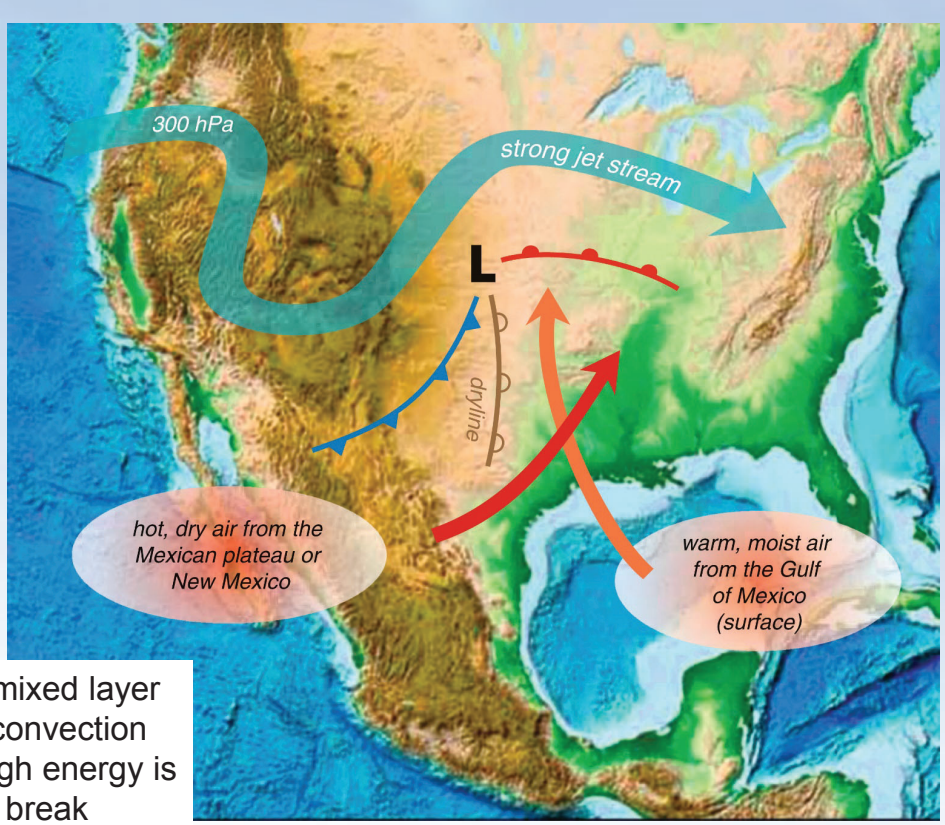
Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Supercells Thunderstorms

http://addins.waow.com/blogs/weather/2012/06/amazing-ufo-like-clouds/supercell-vega-tx

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Supercells Thunderstorms



Elevated mixed layer prevents convection until enough energy is built up to break through the inversion

Fig 11-19 *Weather A Concise Introduction*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Supercells Thunderstorms

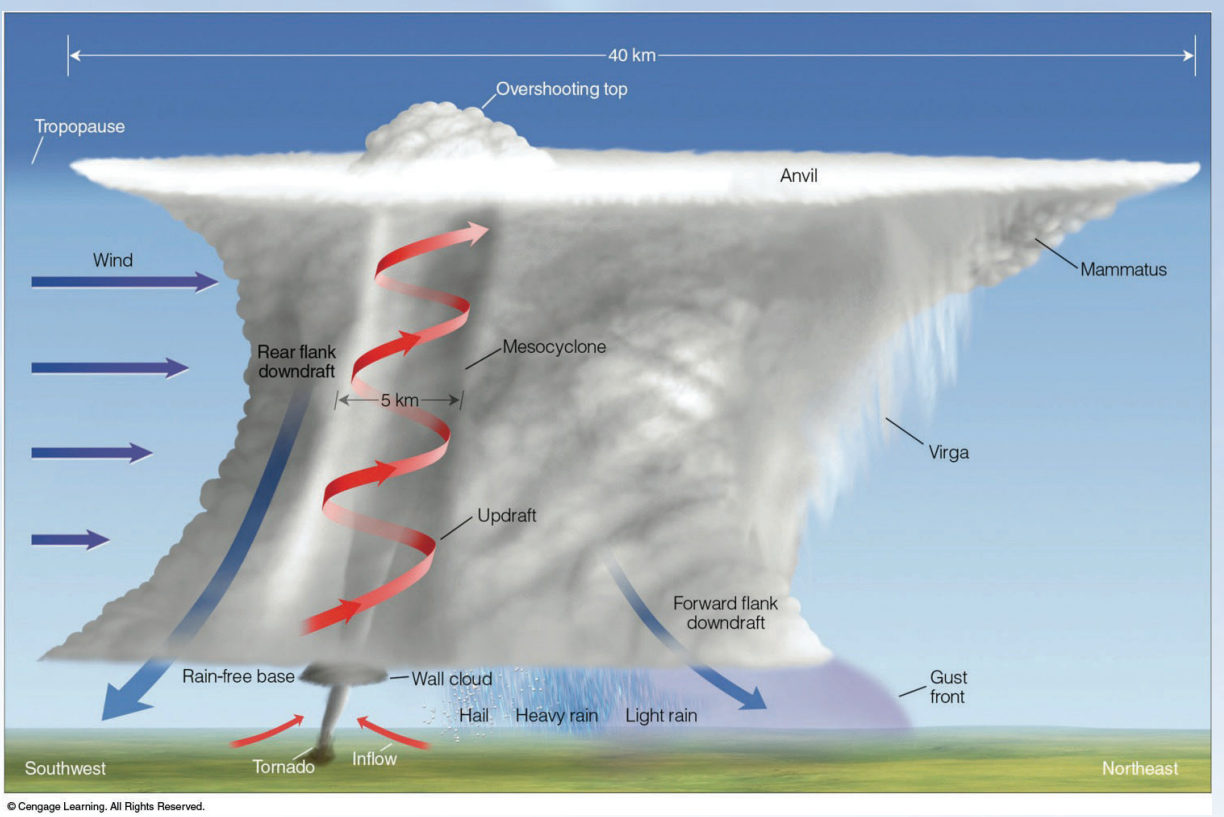
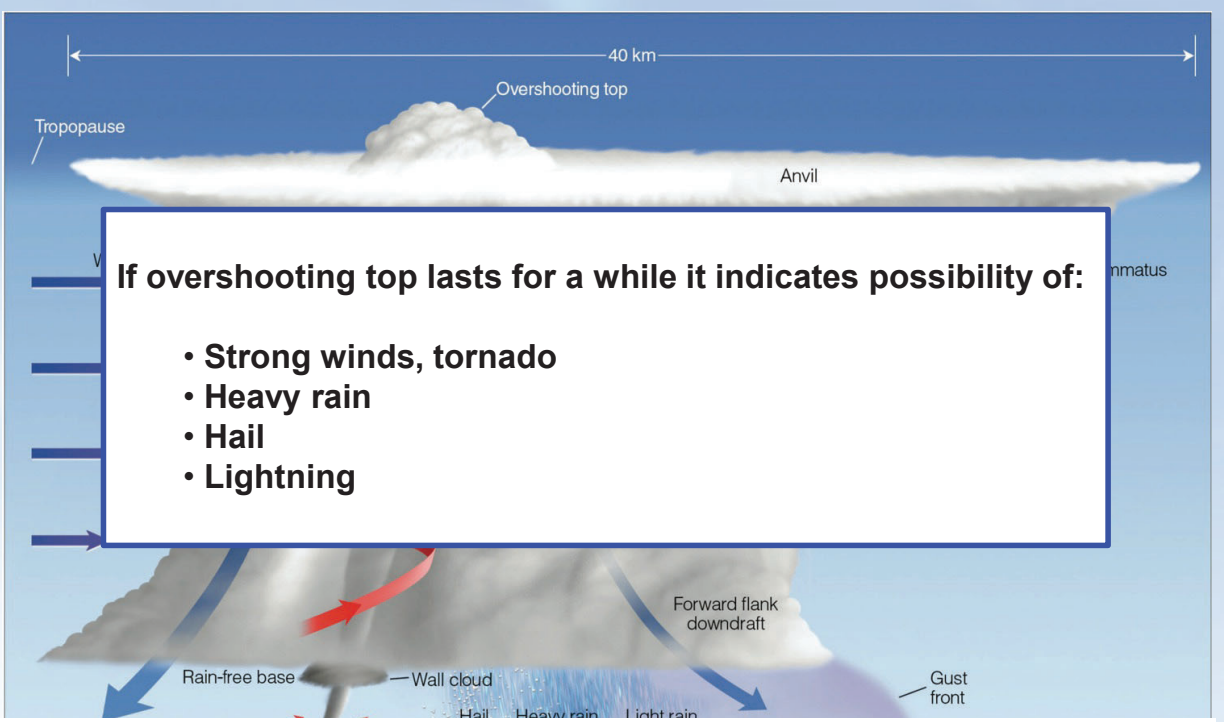


Fig 10-17 *Essentials of Meteorology*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Supercells Thunderstorms

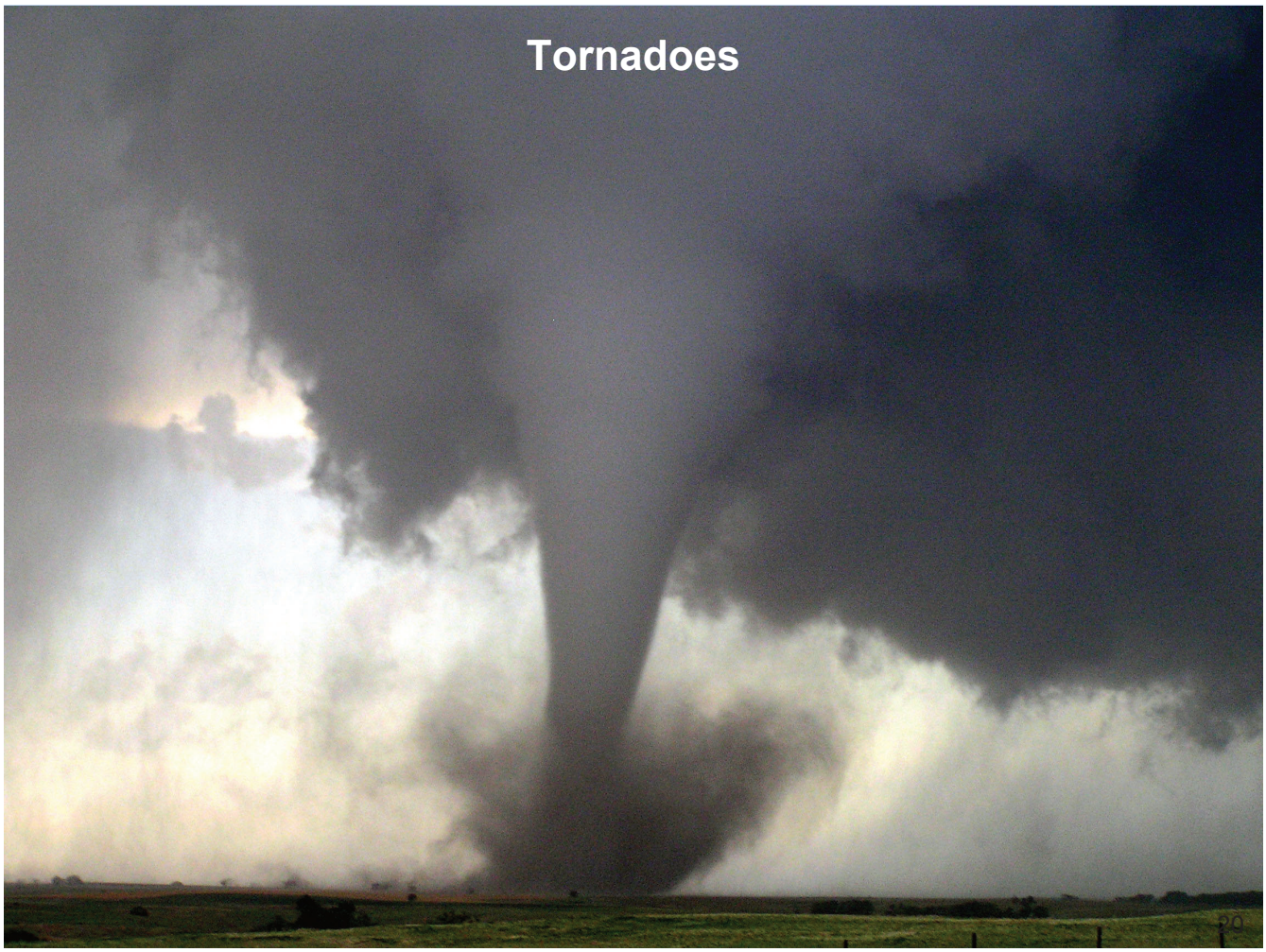


Strong convection, air rises rapidly and retains some momentum when it reaches the tropopause. Air may push into tropopause (and rebound).

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Fig 10-17 *Essentials of Meteorology*

Tornadoes



Supercells Thunderstorms

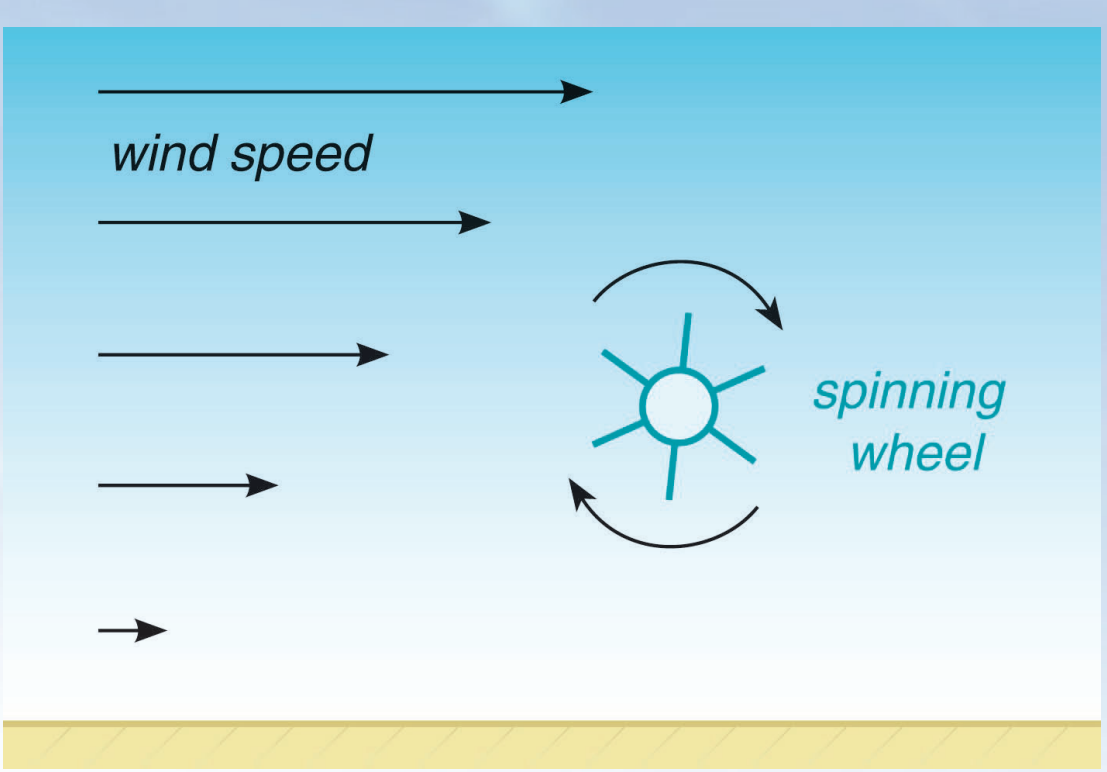


Fig 11-10 *Weather A Concise Introduction*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Supercells Thunderstorms

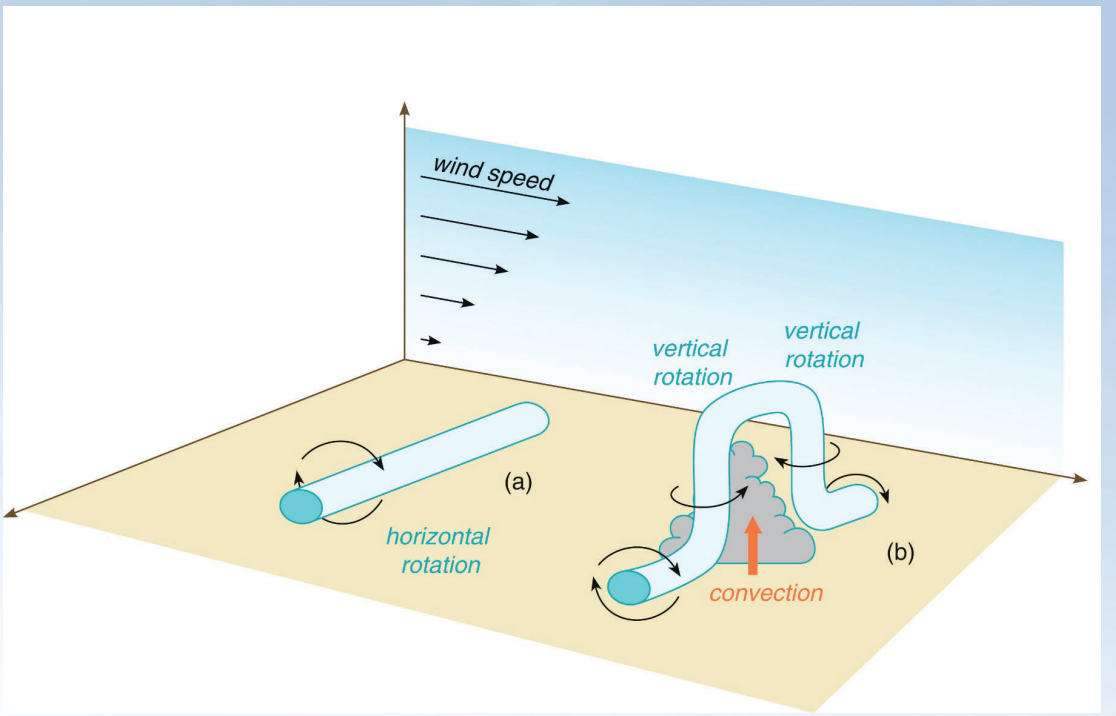


Fig 11-11 *Weather A Concise Introduction*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Supercells Thunderstorms

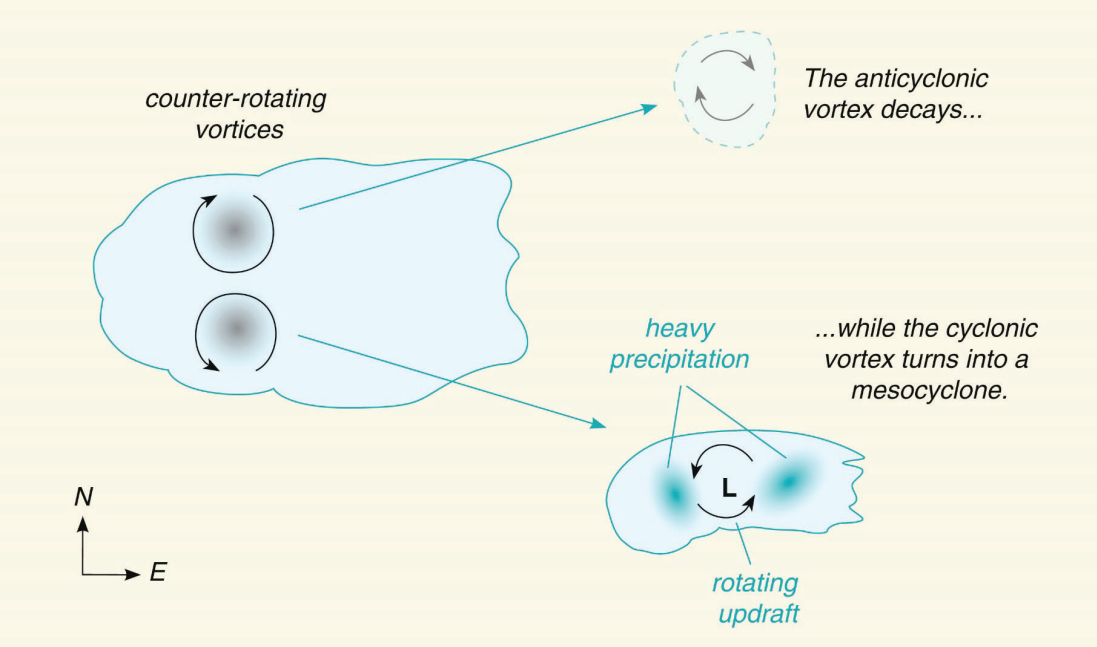
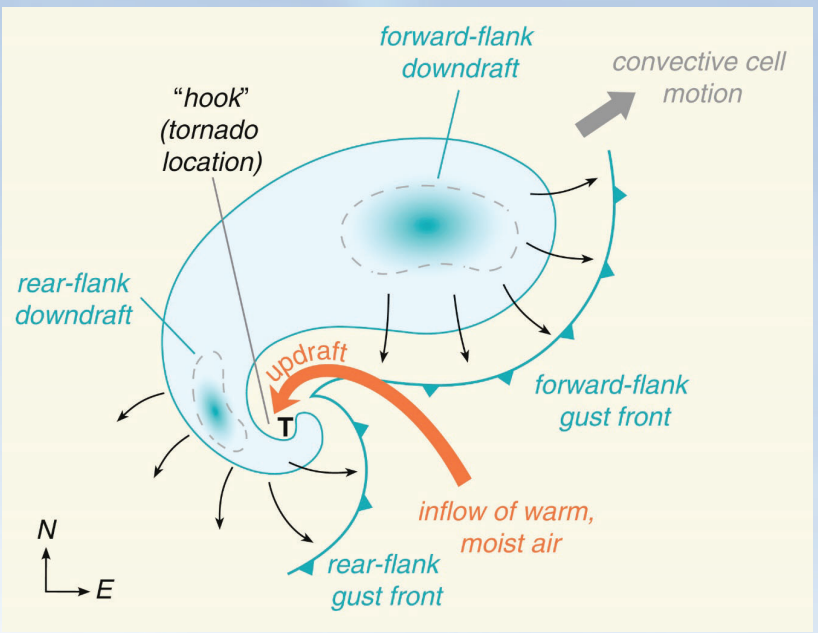


Fig 11-12 *Weather A Concise Introduction*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty

Tornadoes



Cold downdraft supports strong updraft

Warm, moist air brought in to storm where up and down drafts meet

Tornado typically forms on southern edge of storm

Fig 11-13 *Weather A Concise Introduction*

Copyright © 2019 University of Maryland
This material may not be reproduced or redistributed, in whole or in part, without written permission from Tim Canty