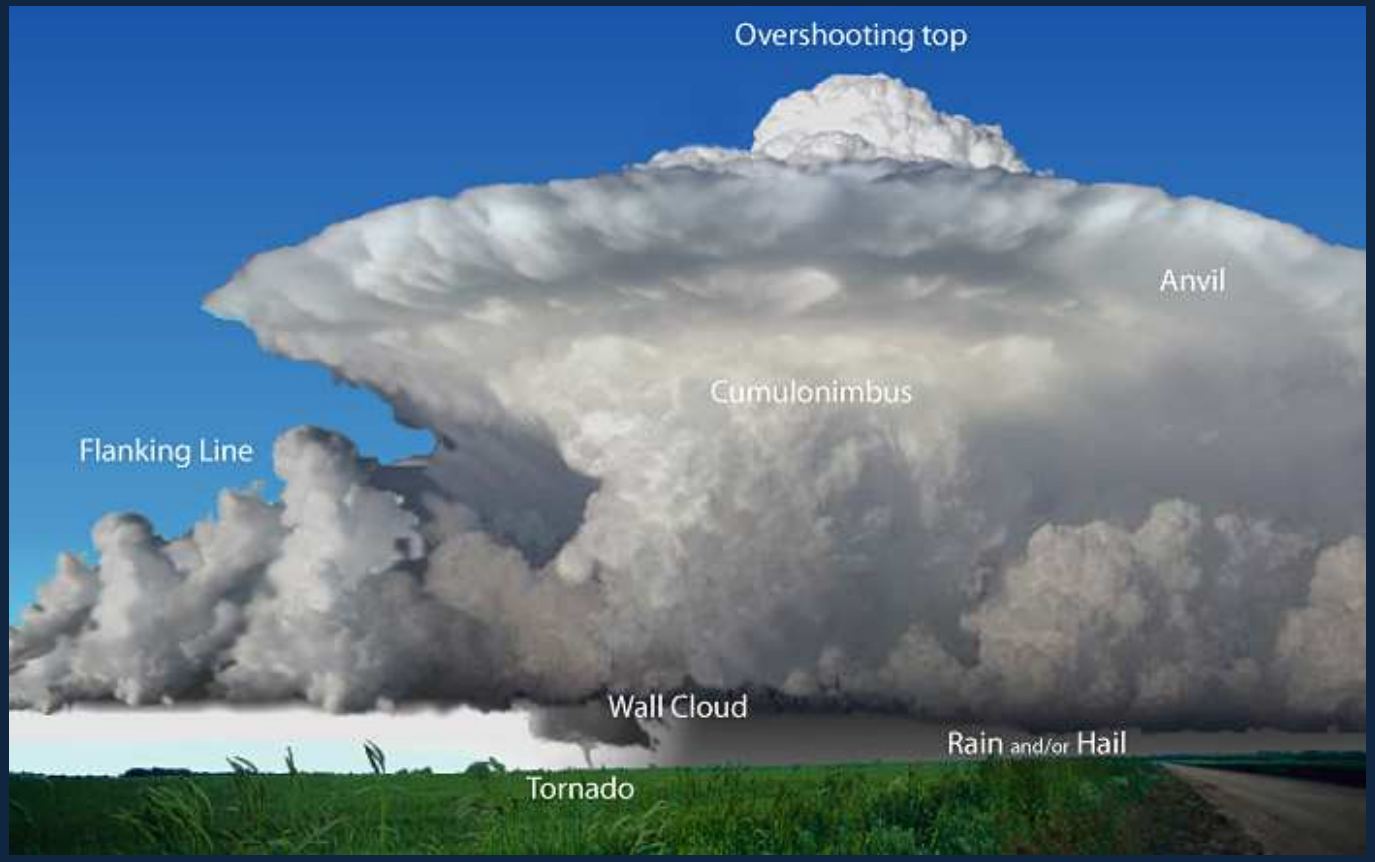
Meteorology



Convective Weather

Overview

- Introduction to Convection
- Thunderstorms
  - Requirements for
  - Stages of
  - Types of
- Hazards associated with Thunderstorms
- Incidents and Impacts
- Forecast Products
  - Types of
  - Verification of
- Tools used in forecasting Thunderstorms
  - Numerical Weather Model
  - Radar
- Future of Thunderstorm Forecasting

Introduction

Convection –

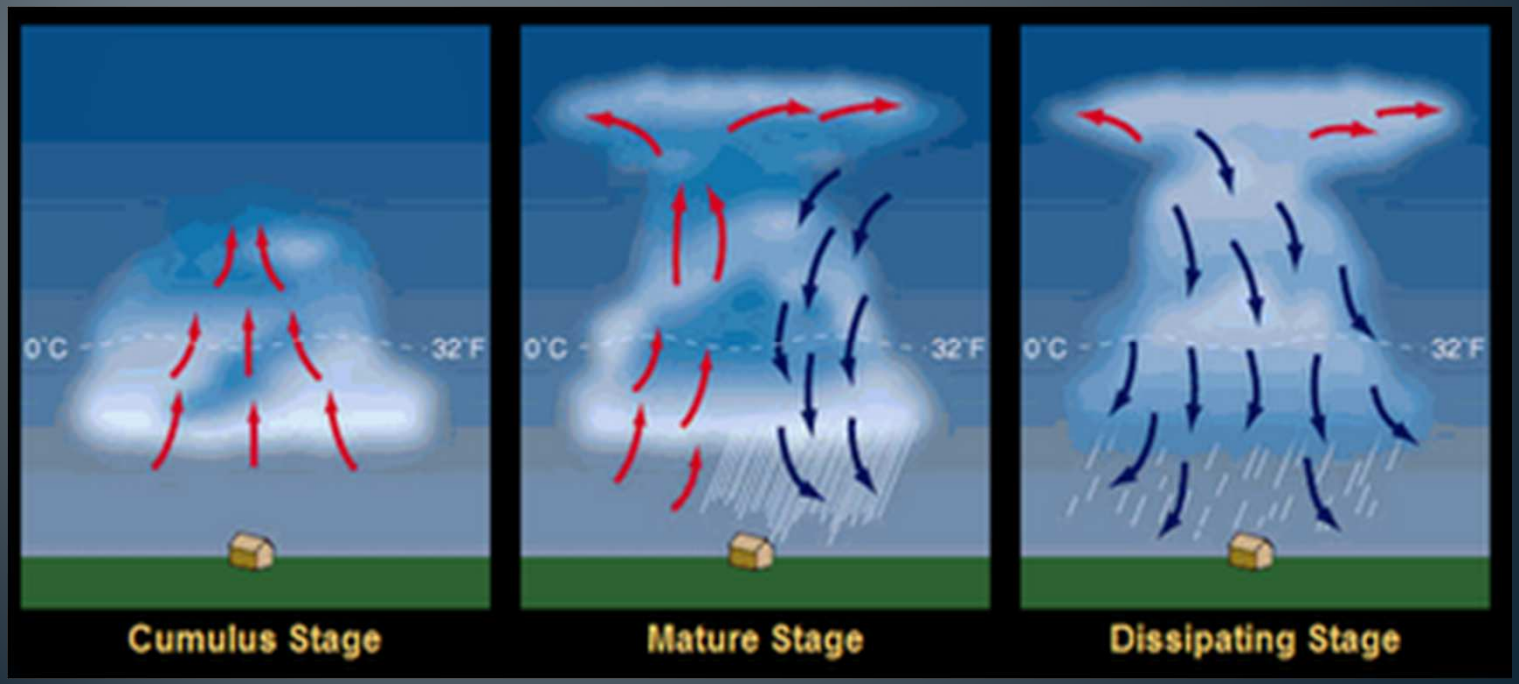
- The transport of heat within a fluid caused by the mass movement of fluid.

Thunderstorms

Requirements for a Thunderstorm

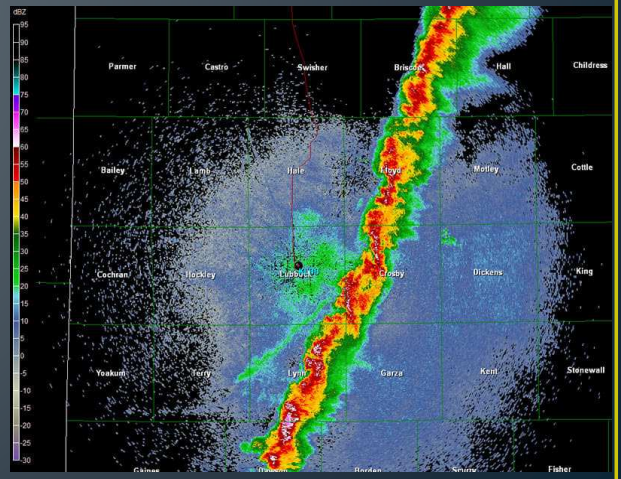
- atmospheric instability
- adequate moisture
- lifting mechanism

Stages of a Thunderstorm



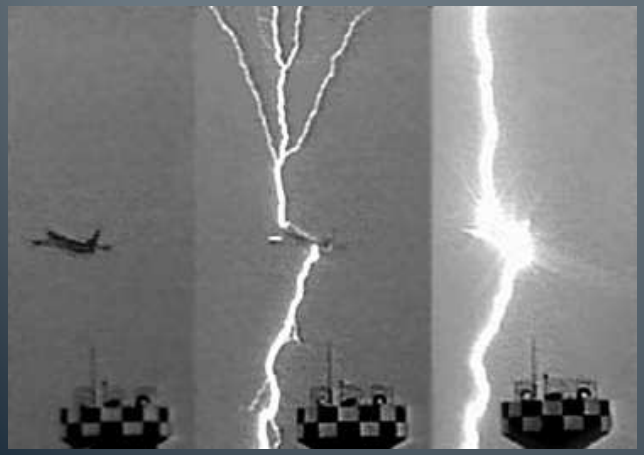
Types of Thunderstorms

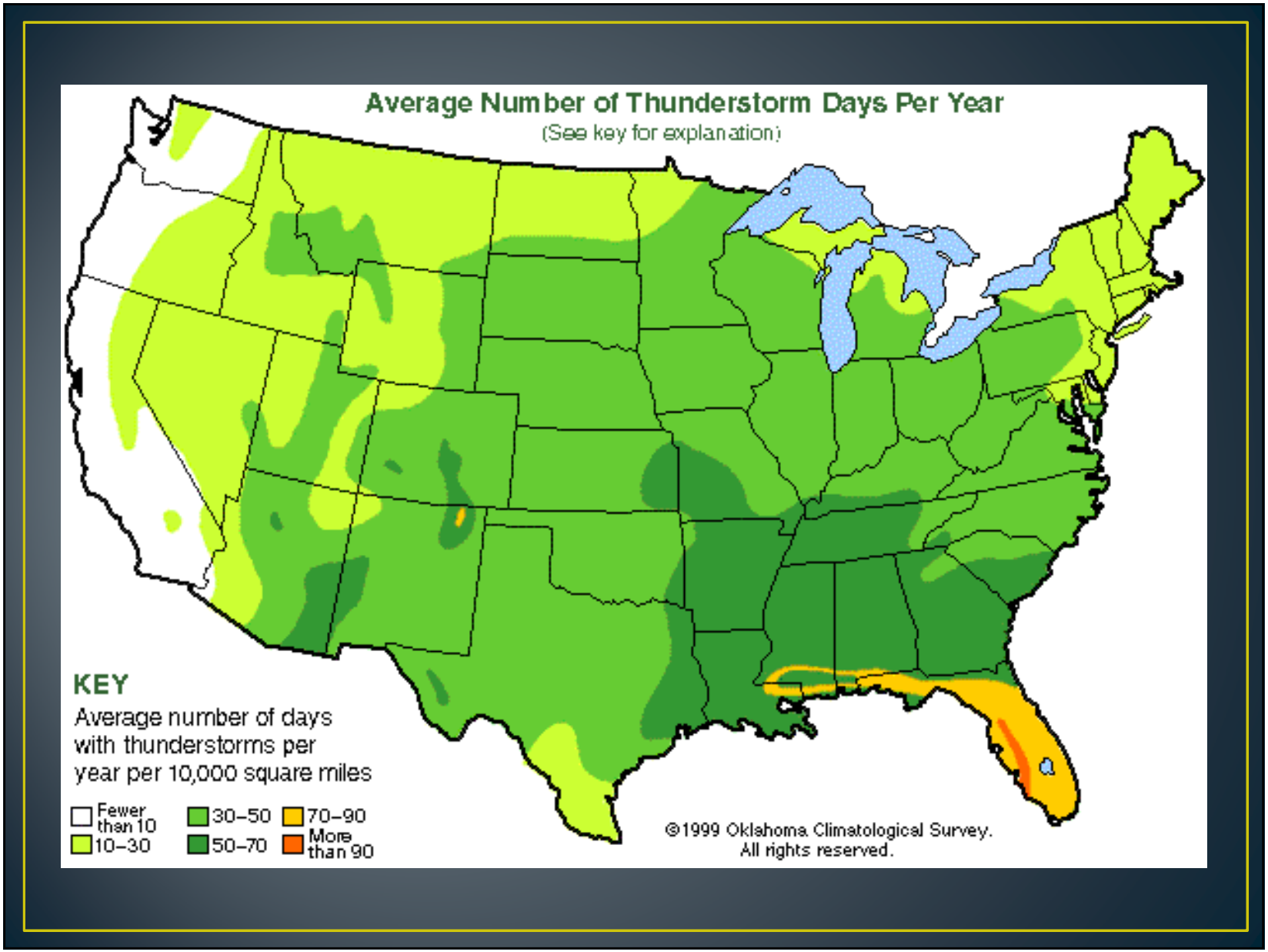
- Single Cell
  - Relatively weak
- Multi-cell clusters
  - Circular cluster of storms that develop during weak flows
  - New cells form while old cells dissipate
- Multi-cell lines (Squall lines)
  - Elongated clusters of storms accompanied by a gust front
  - Typically develop in the SE sector of a mature mid-latitude cyclone
  - Most common
- Super-cell
  - Deep rotating updraft in extreme instability
  - Strongest type of thunderstorm
  - Associated with severe weather



Hazards associated with Thunderstorms

- Turbulence
- Wind shear
- Microbursts
- Lightning
- Hail
- Icing
- Tornadoes




Average Number of Thunderstorm Days Per Year
(See key for explanation)
KEY
Average number of days with thunderstorms per year per 10,000 square miles
Fewer than 10
10–30
30–50
50–70
70–90
More than 90
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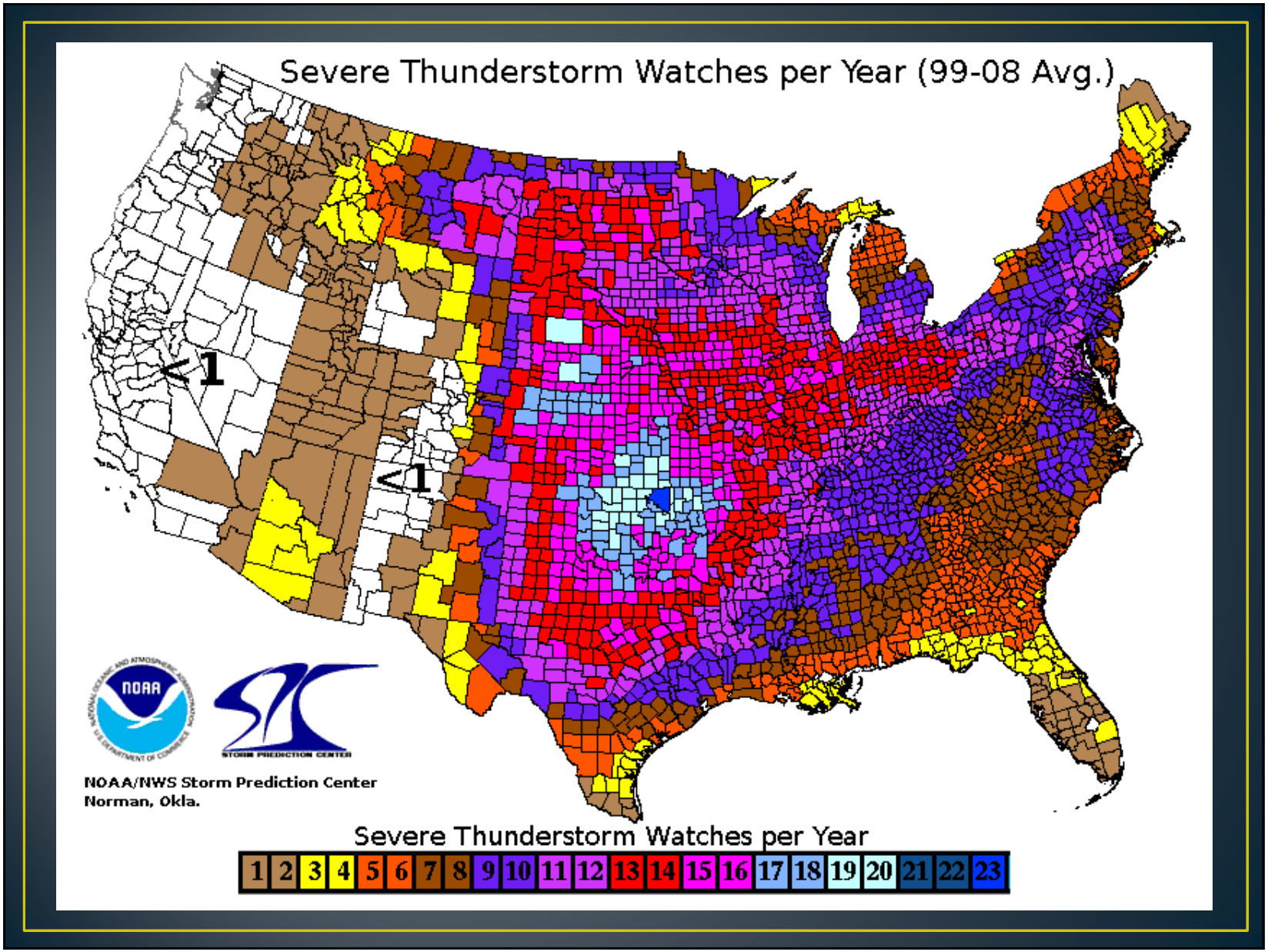
Severe Thunderstorm Watches per Year (99-08 Avg.)
<1
<1
NOAA
STORM PREDICTION CENTER
NOAA/NWS Storm Prediction Center
Norman, Okla.
Severe Thunderstorm Watches per Year
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Aviation Incidents and Impacts

- Eastern Air Lines Flight 66 (Boeing 727-225) – June 24, 1975
  - Microburst
  - 113 casualties, 11 survivors, deadliest in US history at the time.
- Southern Airways Flight 242 (DC-9-31) – April 4, 1977
  - Hail
  - 64 casualties on the aircraft, 9 casualties on the ground
- Wuhan Airlines Flight 343 – June 22, 2000
  - Lightning / Wind Shear
  - 44 casualties on the aircraft, 7 casualties on the ground
- Raleigh Durham International Airport – September 17, 2004
  - Tornadoes and wind gusts
  - Extensive damage to the terminals
  - 12 small fixed wing aircraft destroyed on the ground
- LaGuardia, Kennedy, and Newark Airports – December 2010
  - Thundersnow storm, poor visibility, wind shear
  - 24-hours closure of New York's major airports.

The 1975 aftermath of Eastern Airlines Flight 66.

The 1977 aftermath of Southern Airways Flight 242

The 2004 storm damage at the RDU airport.

Forecast Products

- Convective Outlooks
  Storm Prediction Center
  - Probabilities of Convective storm formation
  - Forecasted for up to 8 days
- Severe Thunderstorm/Tornado Watches
  Storm Prediction Center
  - Duration from 2 to 6 hours
  - Warnings released when severe weather is about to occur
- Convective Significant Meteorological Information (C-SIGMET)
  Aviation Weather Center
  - Warns of convective weather that maybe hazardous to aviation
  - Issued hourly, valid for 2 hours.
- Terminal Aerodrome Forecast (TAF)
  Weather Forecast Office
  - Issued 4 times a day, valid for 6 hours.
- Collaborative Convective Forecast Product (CCFP)
  - Used to depict predicted areas where convective weather is occurring.

Real Time Verification System (RTVS)

Statistic	Definition	Description
PODy	$\frac{YY}{(YY+NY)}$	*Probability of Detection* of "Yes" observations: Proportion of "Yes" obser vations that were fore casted correctly
PODn	$\frac{NN}{(YN+NN)}$	*Probability of Detection* of "No" observations: Proportion of "No" obser vations that were fore casted correctly
FAR	$\frac{YN}{(YY+YN)}$	*False Alarm Ratio*: Proportion of "Yes" fore casts that were incorrect
CSI	$\frac{YY}{(YY+YN+NY)}$	*Critical Success Index*: Number of correct "Yes" forecasts relative to num ber of "Yes" forecasts or observations
TSS	PODy +PODn-1	*True Skill Statistic A measure of discrimination*
PC	$\frac{(YY+NN)}{T}$	*Proportion Correct*: Proportion of "Yes" and "No" observations that were forecasted correctly
Bias	$\frac{(YY+YN)}{(YY+NY)}$	*Bias*: Frequency of "Yes" forecasts relative to frequency of "Yes" observations
% Volume	Forecast Volume divided by Total Volume x 100	*% of the total airspace that is impacted by the forecast*

Verification Statistics

- Convective Significant Meteorological Information (C-SIGMET)
  - FAR = 0.93, PODy = 0.52
  - Should be FAR < 0.25, PODY > 0.75
- Collaborative Convective Forecast Product
  - FAR = 0.96, PODy = 0.48
  - 2003 standard state values should be FAR ≤ 0.20 and PODy ≥ 0.80
- Mahoney, Brown, and Hart in 2000, found low values of PODy and high values of FAR in C-SIGMET, CCFP, and Convective outlook products.

Tools used for Thunderstorm Forecasting

- Numerical Weather Model
  - Use complex mathematical equations to simulate weather patterns
  - Initial data taken from Radiosondes and Satellites
  - Errors occur due to incorrect data being entered
  - Inability to detect initial trigger

- Radar
  - Beams microwaves towards an object or storm and reads the reflection
  - Can only detect convection once its has formed
  - NEXRAD – current Next Generation Radar
    - Erin Scottberg states NEXRAD is "deeply flawed"
    - Radars are tilted upward half a degree
    - Earth is curved
    - Resulting in at a distance of 50 miles, the radar beams are ½ mile high.

Future of Forecasting

- Need for increased Accuracy
  - The current forecasting for convective weather does not meet the requirements for NextGen systems.
  - Inability of current technology to detect the triggering event of a thunderstorm
- Collaborative Adaptive Sensing of the Atmosphere (CASA)
  - Radar systems designed to be mounted a few miles apart on rooftops, cell towers, and other existing infrastructure.
  - Can scan as low as 250 meters
  - Can pinpoint storm activity to a tenth of a square mile.
  - Cost per CASA radar significantly cheaper than one NexRad.
    - $500,000 dollars compared to $4 million dollars
  - Requires 16 to 20 CASA radars to cover an area the size of Dallas Fort Worth as compared to one NEXRAD.

Summary

- Defined convection
- Thunderstorms
  - Requirements - atmospheric instability, adequate moisture, lifting mechanism
  - Stages – Cumulus (building), Mature, Dissipating
  - Types – Single-cell, Multi-cell Cluster, Multi-cell Line, Super-cell
- Hazards associated with Thunderstorms
  - Turbulence, Wind shear, Microbursts, Lightning, Hail, Icing, Tornadoes
- Incidents and Impacts
- Forecast Products
  - Types – Convective outlooks, watches, C-SIGMETs, TAFs, CCFP
  - Verification - RTVS
- Tools used in forecasting Thunderstorms
  - Numerical Weather Model
  - Radar – NEXRAD, CASA
- Future of Thunderstorm Forecasting
  - Need for Accuracy
  - Need for better technology to detect the initial trigger

DAYTONA STATE COLLEGE

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