2019 SKYWARN Spotter Training

*In Search of Truth*

- In the Sky
- In-between
- On the ground
During your lives you may encounter...

How will you respond?

Provide you with the tools to help make the right decision. Life or Death?

Understanding only German, Fritz was unaware that the clouds were becoming threatening.
Why are we here?

NWS Mission:
• Protection of Life and Property
SKYWARN Agenda

- Signup Sheets: Weather Stations (Davis) notes / Physical Addresses if P.O. Box
- NWS Overview
- Weather Safety
- Thunderstorm basics
- Spotting storms

Break Time!
- Reporting/Procedures
- Radar/Case studies

Photo Courtesy from Jennifer Borders, Arriba, CO. July 21st 2015
122 Offices in the NWS
Inside our shop: 24x7x365

- 2 forecasters updating the forecast
  - Short term (0-36 hr) and Long Term (36 hr - Day 7)
- 1-3 others from 6 AM - 11 PM (more if needed)
- Dedicated Severe Forecaster in summer
SKYWARN Team Locations

You too can have your own little green dot!
Lightning Fatalities 2018
0 Fatalities in Colorado!

U.S. Lightning Fatalities
2009-2019

2009: 35
2010: 29
2011: 26
2012: 29
2013: 23
2014: 26
2015: 28
2016: 40
2017: 16
2018: 20
2019: 0 so far this year

For more information:
https://www.weather.gov/safety/lightning-victims
Out of the 20 Nat’l Lightning deaths...

- 8 - standing under or near tree
- 5 - in/near water
- 7 - Other

Nearly 2/3 deaths

- trees
- water

Source: CBS, May 3, 2018 in SW Denver
Backcountry Lightning Risk Management

Source: Dr. John Gookins
Warning Signs

• Thunder!
  – First strike arrives before any thunder
• Static charge
Lightning Density - Time of Day

Source: Vaisala (data), Brandon Vogt (maps)
Just when you thought it was safe

15% of all strikes occur outside the rain area
Let's Play...
Safe or Not safe
If you’re hit

• Victims are not electrically charged & can be attended to

• Basic CPR:
  – check for heart/breathing problems
  – Call for help
  – Begin CPR
Advice from Lightning™

Stay current
Follow the flash of inspiration
Spark new ideas
Strike out on your own
Light up the night
Know when to bolt
Charge ahead!

Your True Nature™

ROCKY MOUNTAIN NATIONAL PARK
Tornado Safety On the Road

• Keep your distance from storm
• Always leave an avenue of escape
• Be prepared for storms to change direction
• Never outrun a tornado
  – Get to a sturdy shelter
  – Stay away from overpasses/bridges

• **Last Resort: 2 options. No Guarantees!**
  – Abandon vehicle if area lower than level of the roadway.
  – Stay in car: buckle up, cover head, stay low
What happens to cars in Tornados

South of Byers, 7/27, 2018

Elbert County F2 tornado May 10, 2004
Tornado Safety

In a home:
• Move to the basement
  – Protect yourself from flying/falling debris
• If no basement, seek small interior room
  – As many walls between you and outside as possible

In a mobile home:
• Go to a designated shelter
• Go to a home with a basement
Flash Flooding

Do You Really Know How Deep the Water is?

12 inches of fast-moving water can carry away a small car.

WHEN FLOODED TURN AROUND DON’T DROWN

6 inches of fast-moving water can knock over and carry away an adult.

18-24 inches of fast-moving water can carry away most large SUVs, vans and trucks.
Flash Flooding-Sep 2013
Big Thompson Canyon Flash Flood 1976

- 90% of victims of the flood tried to escape using a vehicle, instead of climbing to safety
- 144 were killed
- Rapidly rising water may engulf the vehicle and its occupants and sweep them away.
Rivers and Streams
weather.gov/bou/rivers
Flash Flooding Alerts-Redstone Canyon
SKYWARN Agenda

• NWS Overview
• Weather Safety
• Thunderstorm Basics
How to cook up a Thunderstorm

Ingredients Necessary!

• **Moisture**: especially near the ground
  – Humidity, dew point, fuel for storms

• **Instability**:
  – *tendency for air to rise on its own*

• **Lift**:
  – *mechanism to make air start to rise*
Moisture sources
Instability

• “Parcel” of air
• Hot Air Balloon
  – Rises because warmer than surrounding air
  – Unstable
• Parcel of air becomes a thunderstorm
Atmospheric stability

Unstable

Stable
Lift

• Need to get an unstable parcel moving
• Lifting mechanisms
  – Cold Front
Lift

- Need to get an unstable parcel moving
- Lifting mechanisms
  - Cold Front
  - Warm Front
Lift

- Need to get an unstable parcel moving
- Lifting mechanisms
  - Cold Front
  - Warm Front
  - Low Pressure
Lift

- Need to get an unstable parcel moving
- Lifting mechanisms
  - Cold Front
  - Warm Front
  - Low Pressure
  - Dryline
Lift

• Need to get an unstable parcel moving
• Lifting mechanisms
  – Cold Front
  – Warm Front
  – Low Pressure
  – Dryline
  – Upper Trough
  – Jet Stream
Lift

- Need to get an unstable parcel moving
- Lifting mechanisms
  - Cold Front
  - Warm Front
  - Low Pressure
  - Dryline
  - Upper Trough
  - Jet Stream
  - Thunderstorm outflow
Lift

- Need to get an unstable parcel moving
- Lifting mechanisms
  - Cold Front
  - Warm Front
  - Low Pressure
  - Dryline
  - Upper Trough
  - Jet Stream
  - Thunderstorm outflow
  - Upslope
Thunderstorm Types

- Single Cell (Pulse)
- Multicell
- Multicell in line (squall line, bow echo)
- Supercell
Single Cell Storm Life Cycle

- **Towering Cumulus Stage**
- **Mature Stage**
- **Dissipating Stage**
Single Cell Storms

- Weak winds aloft
- Typically during or just after peak afternoon heating
- Intense updrafts
- Collapsing downdraft:
  - Strong/damaging winds
  - Short duration rain/hail ~ 5-10 min
Single Cell Storm on Radar
Multi-Cell Thunderstorm

- Most common thunderstorm type
  - Multiple cells
  - Updrafts and downdrafts in different stages of development
- Each cell may last only 30 minutes
- Life cycle of the cluster may last several hours
- Severe weather usually isolated and short duration.
Multi-Cell Thunderstorm
Multi-Cell Line Storm (Squall Line)

- A long line of storms with a continuous, well developed gust front along the leading edge
- May be a solid line, or may be breaks
- Main threat is damaging straight line winds - Up to 100 mph!
- Bow echo – when portion of the leading edge downdraft accelerates ahead of the main line
Supercell Thunderstorm

- Characterized by persistent rotating updraft
- Rotation transports precipitation away from main updraft
- Precipitation induced downdrafts do not fall back down through updraft
- Storm can survive for long periods of time
  - March 18 1925, deadliest tornado event in US history- 12 hour lifespan, 300 miles
Supercell Ingredients

- 3 Ingredients for Thunderstorms:
  - Moisture
  - Instability
  - Lift

- Additional ingredient for Supercell:
  - Shear (2 types)
    1. Directional (wind direction changes with height)
    2. Speed (wind increases with height)

Photo by Mike Charnick
Wind Shear

- Weak Shear

- Strong shear
Updraft in weak wind SPEED shear

Courtesy David Floyd (WFO GLD)
Updraft in **STRONG** wind **SPEED** shear

Courtesy David Floyd: (WFO GLD)
Wind Shear

Courtesy of Mike Nelson, KMGH, and Viaero
Role of Shear in Supercells

- Wind Shear
  - Speed Shear
  - Directional Shear
- Shear is tilted in updraft,
- Leads to supercell rotation
Supercell Cloud Features

• Mesocyclone
• Wall Cloud
• Rear Flank downdraft (RFD)
Mesocyclone

“Barber Pole”

Striations or cork-screw look indicate mid-level updraft rotation
Montana Mesocyclone

2004 Bruce Sherbon
Mesocyclone ‘barber pole’

Courtesy of Mike Nelson, KMGH, and Viaero
Supercell Cloud Features

- Mesocyclone
- Wall Cloud
- Rear Flank downdraft (RFD)
Wall Cloud Features

- Presence of a wall cloud indicates a strong updraft.

- Wall clouds usually slope down toward rain core.

- Look for rotation.

- Persistent, rotating wall clouds are important. Report these at once!
Updraft/Downdraft

- Inflow side of storm
- Rain free base
- Upward cloud motion
- Wall cloud / tornado area
- Supercells have rotating updrafts
- Downward Motion — Rain/Hail/Winds

Courtesy Dave Chapman
Updraft/Downdraft
Inflow/Updraft
Wall Cloud/Outflow

Courtesy of Mike Nelson, KMGH, and Viaero
Supercell Thunderstorms

- Rotating Updraft
- Downdraft
- Overshooting top
- Anvil
- Flanking Line
- Cumulonimbus
- Wall Cloud
- Rain and/or Hail
- Tornado
Supercell Cloud Features

- Mesocyclone
- Wall Cloud
- Rear Flank downdraft (RFD)

Photo Courtesy: Dalton Beringer
RFD/tornado formation

1. Developing RFD - brighter clouds
2. RFD rotating around storm
3. Tornado on ground
4. Roping out-funnel
Supercell Storm structure

Courtesy of NWS, Jeff Haby
Outflow/Shelf Cloud

Courtesy of NWS, Jeff Haby
**Downdraft: Shelf Cloud**

* Marks the leading edge of the gust front (ahead of the storm)
* Produced by the rain-cooled air
* Cloud slopes down away from the rain
* Often associated with straight line wind damage (not tornadoes)

**Cool Outflow**

(NOAA)
Outflow/downdraft/shelf cloud

Courtesy of Mike Nelson, KMGH, and Viaero
**Wall Cloud**

- Abrupt or “blocky” lowering
- Associated with storm inflow and under rain free base
- Slopes toward the rain
- Moves along with storm

**Shelf Cloud**

- Linear feature
- Associated with storm outflow
- Slopes away from the rain
- Moves ahead of rain area
Downdraft Features: Roll Cloud
Supercell Features

- Striations or cork-screw look indicate mid-level updraft rotation
- Inflow band (Beaver’s Tail)
- Updraft
- Downdraft
SKYWARN Agenda

• NWS Overview
• Weather Safety
• Thunderstorm Basics

Break Time!

• Spotting Storms
  – More cloud features, tornadoes
• Advanced Portion
Break Time Enjoyment
Spotting Storms

• What you see will be dependent on:
  – What side of storm you are on
  – Distance to storm
  – Visibility (humidity, haze, blowing dust)
  – Trees, buildings, other storms

• Your primary goal – SAFELY determine the strength and rotation of the updraft.
Supercell Storm structure

Courtesy of NWS, Jeff Haby
Supercell Storm structure

Forward Flank Downdraft

Courtesy of NWS, Jeff Haby
Upper level storm clues

• Best seen 30-40 miles from storm
  – Look for sharp, well defined edges on cirrus anvil
  – Look for overshooting top
Anvil/Overshooting Tops
Courtesy of Mike Nelson, KMGH, and Viaero
Other Cloud Feature with Anvil

Mammatus Clouds
• Associated with Anvil cloud
• Clouds in sinking air
• Can be associated with severe storms
• Does not mean a tornado will form

Photo Courtesy by Candice Bivens
Mid level storm clues

- **Main Storm Tower**
  - Best seen 10-20 miles from the storm
  - As buoyancy increases, so does updraft strength

- **Flanking Line:**
  a row of towering cumulus clouds stair-stepping up to the main

Photo by Tom Warner
"Accessory" Clouds

- Often turbulent with small scale twisting and curling motions in clouds.
- Motion is neither organized nor persistent.
- Scud clouds may form and dissipate rapidly.
Downdraft Indicators-Virga
Downdraft/Microburst

Photo Courtesy: Rhonda Spencer, W276. Aug 2, 2017
Microburst: affecting an area less than 2.5 miles across.

Macroburst: winds extending in excess of 2.5 miles across.
Tornado

• A rotating column of air, *in contact with the surface*,
• Pendant from a cumuliform cloud,
• Often visible as a funnel cloud and/or circulating debris/dust at the ground.

Glossary of Meteorology, American Meteorological Society
Different Types of Tornadoes

- Rope-
- Cone or elephant trunk-
- Wedge-
- Supercell-
- Non-Supercell (landspout)
These are both tornadoes

**Supercell**
- Stormscale rotation
- Mesocyclone
- Tornado forms in mature thunderstorm.
- On radar, look for large rotating storm.
- Good warning verification
- Can be violent or weak

**Non supercell**
- No storm rotation
- No mesocyclone
- Tornado forms in early stage of development.
- On radar, look for a boundary.
- Poor warning verification
- Tend to be weak
## Enhanced Fujita Scale

Wind estimates based on damage

<table>
<thead>
<tr>
<th>Category</th>
<th>Speed Range</th>
<th>3-second gusts</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF0 (Gale)</td>
<td>65-85 mph</td>
<td></td>
</tr>
<tr>
<td>EF1 (Weak)</td>
<td>86-110 mph</td>
<td></td>
</tr>
<tr>
<td>EF2 (Strong)</td>
<td>111-135 mph</td>
<td></td>
</tr>
<tr>
<td>EF3 (Severe)</td>
<td>136-165 mph</td>
<td></td>
</tr>
<tr>
<td>EF4 (Devastating)</td>
<td>166-200 mph</td>
<td></td>
</tr>
<tr>
<td>EF5 (Incredible)</td>
<td>over 200 mph</td>
<td></td>
</tr>
</tbody>
</table>
Tornadoes in Colorado

• Colorado averages 41 tornadoes a year
• 94% of tornadoes since 1950 are EF-0 or EF-1
• Downward trend of tornadoes in last 20-25 years

![Pie chart showing Colorado Tornadoes by EF-Scale: EF-0 (65.8%), EF-1 (27.1%), EF-2 (5.4%), EF-U (0.6%) with a total of 1402, 577, 116, and 10 tornadoes respectively.](image)
2018 Tornadoes in Colorado: 45 total
Tornadoes in Colorado: 1950-2018
Denver Cyclone
Terrain Effects

Szoke et. al. 2005

Fig. 1. Schematic of the Denver Cyclone overlaid on a topographic map (m), with the PROFS mesonet stations shown by open circles and the standard NWS stations by darkened circles.
Denver Cyclone Wind Challenges
Denver Convergence Vorticity Zone (DCVZ)

The Eastward Progression of the Denver Cyclone and Its Trailing Wind Convergence Boundary

- Late morning or early afternoon
- Early to Mid-Afternoon
- Late Afternoon or Evening
Funnel Clouds - circulation does not extend to the ground level

N Elizabeth, May 15, 2018
Find the Funnel?
What is a gustnado?

- Small short-lived, low-level rotation along the storm’s outflow winds.

- Can cause damage…but technically it is *not* a tornado because the circulation does NOT extend up to the base of the cloud.
Tornado or Not?
May 30, 2018, near Stapleton
Funnel or Tornado?

Rogge, June, 2014
Marcelo Albuquerque

Broomfield, June, 2009
1\textsuperscript{st} Tornado 2019!-March 22\textsuperscript{nd}
East of Eaton

Photo Sources: Richard Romkee
Eaton Landspout Tornado

Photo/Video Source: Sue Ann Duran
Bonus Question?
SKYWARN Agenda

• NWS Overview
• Weather Safety
• Thunderstorm Basics
• Spotting Storms
  – Cloud features, tornadoes

Break Time!

• Reporting Procedures
Where do you get Warnings?

- Media
- NOAA Weather Radio
- WEA (wireless emergency alerts) to cell phones
- Area sirens
- Private vendors
- Reverse 911 capability from county or city
- Family or neighbors
- Social media (Facebook, Twitter)
Where to Look...Local

- News Headlines
- Weather Story
- Hazard Map
- Point and Click
- Forecast Discussion
  - weather.gov/bou/afd
- Hazardous Weather Outlook
  - weather.gov/bou/hwo
- Radar
- Facebook
- Twitter
Weather on your mobile phone

Mobile.weather.gov
- Android
- Iphone

Other 3rd Party Sites?
Countdown to Convection

Severe Thunderstorm and Tornado Watches and Warnings

Thunderstorm, Severe Weather OUTLOOKS

Detailed Mesoscale DISCUSSIONS

SVR/TOR WATCHES

WARN
SPC.noaa.gov

Storm Prediction Center

Critical Fire Weather Conditions Today
...CRITICAL FIRE WEATHER AREA FOR PORTIONS OF SOUTHWEST TEXAS, EDWARDS PLATEAU, RIO GRANDE VALLEY, AND DEEP SOUTH
» For additional details, see the latest Day 1 Fire Weather Forecast

Overview: Conv. Outlook | Watches | MDs | Storm Reports | Mesoanalysis | Fire | Hazards

Created: 01/26/2017 at 02:25 UTC

Thunderstorm Outlook
- Issued: 01/26/2017 at 0102Z

Day 1 Convective Outlook
- Categorical Risk: No Severe
- Issued: 01/26/2017 at 0057Z

Day 2+6 Fire Weather Outlook
- Categorical Risk: No Areas
- Issued: 01/25/2017 at 2116Z

Day 2 Convective Outlook
- Categorical Risk: No Thunder
- Issued: 01/25/2017 at 1746Z

Day 1 Fire Weather Outlook
- Categorical Risk: Critical

Severe Weather Climatology (1982-2011) 2017 Tornado Watch Summary

Severe Hail Probabilities: 26 Jan

Did You Know?
### SPC’s Thunderstorm Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 - MARGINAL (MRGL)</strong></td>
<td>No severe thunderstorms expected. Limited in duration and/or coverage and/or intensity.</td>
</tr>
<tr>
<td><strong>2 - SLIGHT (SLGT)</strong></td>
<td>Isolated severe thunderstorms possible. Scattered severe storms possible. Short-lived and/or not widespread, isolated intense storms possible.</td>
</tr>
<tr>
<td><strong>3 - ENHANCED (ENH)</strong></td>
<td>Numerous severe storms possible. Long-lived, widespread and intense.</td>
</tr>
<tr>
<td><strong>4 - MODERATE (MDT)</strong></td>
<td>Widespread severe storms likely.</td>
</tr>
<tr>
<td><strong>5 - HIGH (HIGH)</strong></td>
<td>Widespread severe storms expected. Long-lived, very widespread and particularly intense.</td>
</tr>
</tbody>
</table>

- **Winds to 40 mph**
- **Small hail**
- **Winds 40-60 mph**
- **Hail up to 1”**
- **Low tornado risk**
- **One or two tornadoes**
- **Reports of strong winds/wind damage**
- **Hail ~1”, isolated 2”**
- **A few tornadoes**
- **Several reports of wind damage**
- **Damaging hail, 1 - 2”**

* *NWS defines a severe thunderstorm as measured wind gusts to at least 58 mph, and/or hail to at least one inch in diameter, and/or a tornado. All thunderstorm categories imply lightning and the potential for flooding. Categories are also tied to the probability of a severe weather event within 25 miles of your location.*
Thunderstorms with locally heavy rainfall will occur today. Storms will first develop across the mountains and foothills late this morning, and then spread eastward across the plains this afternoon and evening. Stronger storms will be capable of producing 1 inch of rain in 30 minutes, and up to 2 inches in an hour from a slower moving storm. Burn scars will be most prone to flash flooding, but the Palmer Divide area may also see very heavy rain from thunderstorms through this evening. In the I-25 Corridor, locally heavy rain may also occur and some street flooding would be possible should a stronger storm move through. Isolated severe storms are also possible in and near the Front Range with 1 inch diameter hail and wind gusts to around 60 mph.

SPOTTER INFORMATION STATEMENT...

Spotter activation is not anticipated today or tonight. However, any heavy rain or severe weather reports would be appreciated.
On the Day of Storms

- **Watch** – Tornado, Severe Thunderstorm
  - Issued by Storm Prediction Center (SPC)
  - Conditions become favorable for organized severe storms
  - Issued for multiple counties for 4-6 hours
  - **Exception**: Flood (Issued by WFO/local forecast offices)

- **Warning** – Flash flood, tornado, severe thunderstorm.
  - Issued by local National Weather Service Office
  - Severe weather is occurring or imminent.
  - Issued for usually one or two counties
  - for an hour or less (longer for flooding)
On the Day of Storms

Severe Thunderstorm Watch

Valid Until 9:00 PM MDT Saturday June 30, 2018

Threat Information
- TORNADOES: A Couple Tornadoes Possible
- HAIL: Scattered Hail Up To Lime Size Possible
- WIND: Scattered Gusts Up To 70 MPH Possible

Potential Exposure
- Population: 2,608,592
- Schools: 896
- Hospitals: 45

Severe Thunderstorm Warning

Valid Until 5:30 PM MDT Saturday June 30, 2018

Threat Information
- WIND: Up to 50 MPH
- HAIL: Quarter Sized Possible

Potential Exposure
- Population: 90,924
- Schools: 26
- Hospitals: 1
Types of warnings

- Tornado
- Severe Thunderstorm  
  (58 mph wind, large hail)
- Flash Flood
One inch hail for Warnings

Severe Thunderstorm Warning
one inch or greater

(SPS)

<1”
Reporting Procedures

• Maintain your situational awareness
• Know your position relative to the storm ...ALWAYS
• Know your location on a map ...ALWAYS
• Know what the storms are capable of producing in the current environment
• Reporting: Specific location, Spotter#, report
Making your weather report

1. Dedicated Toll Free number:
   - 1-800-287-2498 (Reserved for severe reports only!)
   - or local 303-494-2884
   - For general, non-severe questions call us at 303-494-4221

2. Internet web page at www.weather.gov/bou
How to submit an on-line report
www.weather.gov/bou
How to send us an on-line report
https://inws.ncep.noaa.gov/report/
How to send us an on-line report

Storm Reports
Alerting the NWS to local weather

Report Type -> Details -> Location -> Review and Send

Time you observed this weather
1233 PM 03/22/2018

1.50 Ping Pong Ball

- I’m estimating the hail size
- I measured the hail
- I don’t have a reading, just some details below

Please provide details (if any) of hail damage or depth:
hail is covering the ground
Storm Reports: Event Types

Your report is at:
Latitude: 40.1196
Longitude: -104.9640

Automatically use your device's location:
Use my device's current location

Search for your address:
4833 Falcon Drive, Frederick, CO 80504

Or, you can click your location on the map:

Here is the information you'll be sending:

Report time: 1233 PM 03/22/2018
Latitude: 40.1196
Longitude: -104.9640

You are reporting 1.50 Ping Pong Ball sized hail
(measured).

Details:
hail is covering the ground

If you wish to provide a name, spotter ID, or contact info,
you can do so here.
This is optional, and if provided, will only be used if additional information is needed.

Input Spotter #

W200
Local Skywarn Page

www.weather.gov/bou/skywarn

For trained, current SKYWARN members, updated information and changes on the program can be found on our web page, via the “news of the day” under the link: Skywarn Spotter News

What to report:

Severe Weather

- Tomatoes, funnel and wall clouds
- Hail size of half inch diameter or larger: Hail Size Chart
- Winds sustained at 50 mph or higher and any gusts 60 mph or greater
- Heavy Rainfall and/or flooding
  - 1.0” rain/hr or greater for urban areas.
  - 1.5” rain/hr or greater for rural areas.
  - Also call 911 for flooding
- Significant damage
- River/creek flooding or flash flooding

Winter Weather

- Heavy snow (snowfall rates 1” per hour or greater)
- Blizzard (winds 35 mph or greater, and visibilities less than 1/4 mile in snow/blowing snow.
- Dense Fog: 1/4 mile or less
- Freezing drizzle (road surfaces becoming icy and slick)
- Rain vs. snow (changeover from rain to snow and vice versa)
- Impassable roads and road closures due to snow and wind
- High winds: 50 mph or higher, sustained and/or gusts: 75 mph or greater in the mountains and foothills.

Where to report:

- Submit a report on the web
- Use the dedicated, severe weather 900# to call in reports (provided during spotter training)
- local 911 dispatch
- Social Media (great for sending in pictures/videos!)

Local Resources

- Local Storm Reports (LSR)
- Area Forecast Discussion
- Hazardous Weather Outlook
- Spotter and COOP Snowfall tables
- Spotter and COOP Snowfall Maps
- CoCoRaHS

SKYWARN Amateur Radio Local Groups

- Northern Colorado Group: ARES R3D2 (covers Larimer and Western Weld counties). Frequency: 146.625

On-Line Severe Weather/Training Resources

- 2016 SKYWARN Spotter Presentation Boulder CO
- Severe Thunderstorm Forecasting Video Lecture Series (SPC)
- Spotters Field Guide (PDF)
- COMET SKYWARN Spotter Training (PDF)
- Beaufort Wind Scale
- CoCoRaHS Training slides

Additional National Resources

- Storm Prediction Center (SPC)
- National SKYWARN Page
- Emergency Managers Weather Information Network
- National Hazards Statistics
- Storm Chaser’s Homepage
- Spotter Network
- Severe Studios
Reporting Hail

- Average depth and size of hail (also report largest hailstone)
  - Measure with ruler
  - Compare to coin or ball.
- If 4.5” or larger it could be a record hailstone for Colorado...preserve it and report! Preserve stone in zip lock bag and freeze.

Denver Hailstorm, 5/8, 2017
Grapefruits in Colorado

Out of the Archives:
The Coloradoan, Sara Hoffman
Hail Sizes: What about marbles?

**NO marbles please!!**
Thunderstorms that produce large amounts of hail or...

“Plowable Hail”

- May 14 Hail Storm from the Pinery
  ➢ Source-Joe Dahlke
CU Hail Accumulation Algorithm

Hail Accumulation
10 Aug 2017 17:28Z to 20:14Z

Minimum HAI Radius: 50.12 km
8.5 deg lat 0.9 deg long

HAI Limit

Hail Accumulation (cm)

VII (kg m⁻²)

10
50
100
150
200

1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
Katie Sloop @slopkatie · 13h
Replying to @NWSBoulder
Hail was clearly visible from 12k ft! Picture taken south of Parker on a flight inbound to Denver. #cowx #deep hail

Joe Dahike @TheJoeDahike · 18h
So much hail fell near The Pinery that it looks like it snowed! These are shots from the Pinpoint Weather Beast. #COwx
From the Satellite

GOES-16 Visible Imagery 5:27 PM MDT 5/14/18

Hail Swaths

NWS Boulder • @NWSBoulder • 14h
Still image highlighting the hail swaths. #cowx #deephail
More Hail Further North... Wellington

Incredible birds eye view of the hail swath north of Wellington on Monday! Love seeing it's precise path from above. 📸: Jane Carpenter #9wx #cowx

Incredible birds eye view of the hail swath north of Wellington on Monday! Love seeing it's precise path from above. 📸: Jane Carpenter #9wx #cowx
CoCoRaHS.org
Community Collaborative Rain, Hail, & Snow Network
Social Media: Monitoring...

- https://twitter.com/NWSBoulder
- https://www.facebook.com/NWSBoulder
- http://www.spotternetwork.org/
- http://severestudios.com/

#COWX, @NWSBoulder
Skywarn in the field and at the WFO

• During Severe Weather
  – May Have Amateur Radio Presence in our Office!
  – Allows direct communication between spotters in the field and warning forecasters
SKYWARN Agenda

- NWS Overview
- Weather Safety
- Thunderstorm Basics
- Spotting Storms
  - Cloud features, tornadoes

Break Time!

- Reporting Procedures
- Advanced Spotter Training
88D-Doppler Weather Radar

Radar Scanning Pattern

Footnote: Elevation angle and scanning increased to show detail

©The COMET Program
KFTG – 0.5 reflectivity and velocity

05:44 – 08:18 Z on 12 Sept. 2013
Base Radar Rainfall Estimates

NEXRAD LEVEL-II
DIG. STORM TOT. (D.P.)
KFTG - DENVER, CO
09/12/2013 23:57:34 GMT
LAT: 39/47/09 N
LON: 104/32/45 W
ELEV: 5610 FT
MODE/VCP: A / 212
MAX: 29.50 IN
BEG: 09/09/2013 17:39 GMT
END: 09/12/2013 23:58 GMT

Legend: IN
- 15.0
- 12.0
- 10.0
- 8.0
- 6.0
- 5.0
- 4.0
- 3.0
- 2.5
- 2.0
- 1.5
- 1.0
- 0.6
- 0.3
- 0.01
- 0.0
Why we need spotters

Radar can detect a Meso-cyclone

Radar beam cannot see lower portion of storm "B"
Fancy Meteorological Terms-AFD

• CAPE (Convective Available Potential Energy)
  – Related to updraft strength
    • 1000-2000j/kg (Front Range)
    • 1500-3000j/kg (Eastern plains)

• CIN (Convective Inhibition)
  – Tied to the strength of the inversion

• Helicity-ability to produce a rotating updraft
  – Speed and directional shear are important
Mountain Tornadoes this Summer!

Jackson Co.-June 29

Weston Pass-July 5
Park County Tornado - July 5, 2018
Weston Pass Tornado

Photo Courtesy: Shell Blanscet, E474
Weston Pass Tornado

- Rating: EF1~ estimated wind speed: 90 mph
- Path Length: 1.5 miles, width~100 yards
- 1” diameter hail

![Map of Weston Pass Tornado Path Imagery 7/12/18](image)
Playing it Safe?
Weston Pass Tornado- Damage

- Aspen trees 12-18” diameter were snapped off/uprooted
- Spruce trees uprooted
Jackson County Tornado - June 24

Photo Courtesy: Dave Martinez: East side Rabbit Ears Pass

Photo Courtesy of Jeff Walls
Morgan County Tornadoes

Tornadoes #3 (9 mi southeast of Brush)
Morgan/Washington Counties (red path)

<table>
<thead>
<tr>
<th>Date</th>
<th>July 29, 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (Local)</td>
<td>4:50 - 5:00 PM</td>
</tr>
<tr>
<td>EF Rating</td>
<td>2</td>
</tr>
<tr>
<td>Est. Peak Winds</td>
<td>115 mph</td>
</tr>
<tr>
<td>Path Length</td>
<td>7 miles</td>
</tr>
<tr>
<td>Max Width</td>
<td>Est. 300 yards</td>
</tr>
<tr>
<td>Injuries/Deaths</td>
<td>0/0</td>
</tr>
</tbody>
</table>

Summary: A tornado developed north of County Road K in Morgan county and then moved southeast into Washington county. Numerous power poles were snapped along its path which was indicative of 115 mph winds.
250mb, July 29, 5 pm
SPC DAY 1 Outlook

Jul 29, 2018 1630 UTC Day 1 Convective Outlook

Categorical Graphic

Day 1 Risk | Area (sq. mi.) | Area Pop. | Some Larger Population Centers in Risk Area
--- | --- | --- | ---
ENHANCED | 21,987 | 243,925 | Greeley, CO...Cheyenne, WY...Evans, CO...Sterling, CO...Fort Morgan, CO...Denver, CO...Aurora, CO...
SLIGHT | 143,372 | 6,934,571 | Oklahoma City, OK...Tulsa, OK...Colorado Springs, CO...Aurora, CO...Denver, CO...
MARGINAL | 260,591 | 15,551,394 | Phoenix, AZ...Tucson, AZ...Mesquite, AZ...Wichita, KS...St. Louis, MO...
Weather Story/Hazardous Wx Outlook

Severe Storms Likely this Afternoon/Evening

Potential Hazards
- Up to baseball sized hail
- Wind gusts up to 80 mph
- Isolated Tornadoes

Severe Weather Outlook: Sunday, July 29, 2018

Spotter Information Statement...

Spotter activation is expected to be needed over the northeast plains and possibly across the Urban Corridor this afternoon and evening.
Situation Report

- SPC Outlook
  - Enhanced
  - Enhanced +10% tornado
  - Moderate or higher

Today’s Tornado, Severe Hail, & Damaging Wind Risk

Key Points:
- **Hazard:** Long track severe storms today, with possible tornadoes, very large hail, and damaging winds.

Timing & Duration: 2 PM – 10 PM. Two rounds of storms possible.

Impacts: Damage to vehicles, roofs, windows, crops, and power supply interruptions. Damaging tornadoes possible, too. Isolated flooding from stronger storms.

Certainty & Considerations: Moderate Confidence
SPC Mesoscale Discussion/Watch

- Strong Northwest Flow aloft with 100kt jet
- CAPE values up to 2500j/kg
- Higher CIN more stable airmass

Further west
Radar Imagery - July 29th
Radar Imagery - July 29th
Storm damage to Vegetation

Before

After
Hail/Wind Damage

Synthetic True Color Visible Satellite Image

Swath of 7/29 Hail/Wind Damage

Swath of 7/28 Hail/Wind Damage

Smoke

Clouds

Image at 9AM 7/31/18

7/31/2018 10:06 AM
National Weather Service – Denver/Boulder, Colorado
Damage Reports

- 20 Injuries, some serious
- Numerous trees/power poles blown down or snapped.
- High tension power lines taken out
- Flooding with storms around Brush and Hillrose.
- Direct hit to feedlot with several livestock injured or killed
- Large hail with crop damage
- Wind gusts to 70 mph
What's up with the Green Skies?

Trevor White @twhitephoto
The green monster I saw with @KathrynProciv and @N3MRA yesterday. Shot just north of Arriba, dropping south to avoid hail. #cowx
Green Skies and Severe Weather

- Water droplets absorb red light which makes the scattered light appear blue
- If blue light is set against an environment heavy in reddish light (sunset)
- Net effect can make the sky appear green
- “Green” thunderstorms reported in the late day
- No scientific conclusive evidence

Photo Source: Niccolo Ubalducci
SKYWARN Toolbox

• Safety Hazards with thunderstorms
• How to identify cloud types and association with severe thunderstorms
• Determine visual types of thunderstorms and dangers they pose
• Safely and accurately report severe weather to NWS office
For Your Information

- **New Spotters:**
  - New spotter letters will be mailed to your location
  - Make sure you have signed up on the sheets if you want to be included.
    - Include **physical address** if you have a P.O. Box
    - If you have Davis Weather Equipment, add your e-mail to the signup sheet and you will be contacted
    - If you **do not** receive a welcome letter in 30 days, please email Scott.entrekin@noaa.gov

- **Existing, Re-trained spotters:**
  - Your information will be updated in our database
  - No formal re-notification given

- Spotter guides are available online at: weather.gov/os/brochures.shtml
- On-line spotter training (for review) meted.ucar.edu/training_course.php?id=23

**Questions on training:** Contact Greg Hanson (WCM) or Scott Entrekin @noaa.gov