Southwest Aviation
Weather Safety Workshop
Salt River Project
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Cloud Recognition Training
For Pilots

Jody James
Warning Coordination Meteorologist
National Weather Service, Lubbock, TX
FAA FAAST Team Counselor
Private Pilot – Single Engine Land
Cloud Recognition Training for Pilots

Jody James
Private Pilot
(approx. 200 hours)
WCM - NWS Lubbock
Outline:

I. Convective Clouds
   Thunderstorms
   Severe Thunderstorm Signatures
   Severe Weather Clues

II. Other Turbulent Clouds
   ACCAS Altocumulus Castellanus
   Mountain Waves
   Kelvin Helmholtz Clouds
   Volcanic Eruption
   Others
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Convective Clouds

Thunderstorms

- Severe or Extreme Turbulence
- Severe Icing
- Low Level Wind Shear (Mechanical)
- Microbursts (Convective LLWS)
- IFR or LIFR Conditions
- Strong surface winds…30 knots or greater
A pilot can expect:

- updrafts to reach 4000 to 5000 feet per minute
- Severe or greater turbulence
- Moderate or greater icing

**Height of TCU and texture may help estimate with severity of conditions**

Image courtesy UCAR, photo by Carlye Calvin.
All Thunderstorms Are Not Equal!

Thunderstorm Spectrum

- **Pulse**: Minimal threat (?)
- **Multicell Cluster**: Moderate threat
- **Multicell Line**: Moderate threat
- **Supercell**: High threat, Mesocyclone present
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Thunderstorms

Overshooting top

back sheared Anvil

Main storm tower marks updraft

Hard Cauliflower Edges Signify Strong Updraft
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Thunderstorm Avoidance

At least 20 miles from Severe Thunderstorm Such as this

Overshooting Top

Mixed Icing

Hard Edges

Clear Icing Severe or Extreme Turbulence

Area with Low Visibilities Hail, Wind Shear

Microbursts
The Downburst

- Precipitation induced downdraft which can produce winds to 100 knots or greater.
- Has caused numerous airline crashes through the years including Delta Flight 191 an L-1011 on August 2, 1985 at DFW Airport.

Cross section of vortex ring model (Caracena, 1982)
Dry Microburst forming under prominent virga shaft. Note ring of dust beneath rain shaft.

(Photograph by E. Szoke, 14 July 1982, National Center for Atmospheric Research/National Science Foundation.)
Outward deflection of rain or dust along ground.

Both indicate strong or damaging winds are underway.
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Convective Clouds
Haboob

Strong Thunderstorm Outflow – indicates very strong winds and low visibilities. Winds Speeds usually exceed 30 mph, and dust can be raised to 3000 feet.
A pilot can expect:

Severe to extreme turbulence in this highly sheared environment

Can have hail fall beneath these clouds

Indicative of strong storm
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Convective Clouds

Wall Clouds/Funnels/Tornadoes

Wall Clouds indicate an area of rapid ascent beneath very strong updraft.

Strong inflow into these clouds.

Many times, this feature will precede tornado development.

Photo: Mike Umscheid
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Convective Clouds

Funnel Clouds

Indicates rapid rotation

Connected to cloud base

Violent rotation not in contact with ground

Often times, this feature will precede tornado development

Funnel Cloud, NWS San Antonio, TX; NOAA Central Library
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Convective Clouds
Tornadoes

Violent rotation attached to cloud, in contact with ground

Usually develop in association with “Supercells”

Can develop from towering cumulus clouds
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Convective Clouds

Outflow Clouds – Shelf Cloud

Indicates thunderstorm outflow

Usually slopes away from the rain area

Strong winds, heavy precipitation can occur immediately following passage

Photo – National Weather Service
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Convective Clouds

Outflow Clouds – Roll Cloud

Indicates thunderstorm outflow

Can have horizontal rotation

Strong winds, heavy precipitation can occur immediately following passage

Photo – John Wright
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Convective Clouds

Outflow Clouds – Gustnado

Develops in area of thunderstorm outflow

Circulation is shallow (200-300 ft), and does not extend to cloud base

Winds speeds can reach 80 mph

Gustnado east of Tulia, TX – July 2009
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Convective Clouds
Dust Devil

Develops due to intense heating at the surface

Circulation can extend several hundred feet

Winds speeds can reach 60 mph

“dust devils are implicated in ~100 light aviation accidents in the last 15 years and thus can be considered a genuine hazard“

– NASA, Applied Information Systems Research

Dust Devil: Glendale Community College, Earth Science Image Archive
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Turbulent Clouds

Mountain Wave Clouds

Form in stable conditions

Can indicate turbulence near this level

Photo of the Moul n'ga Cirque in the Tadrart region, Southeast Algeria, with wave clouds above.
Lenticular Cloud is a signpost in the sky that indicates Mountain Wave Activity.

Extreme turbulence can exist.

Lenticularis cloud formation over Mt Wash, 2004.
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Turbulent Clouds

Mountain Wave Clouds

Lenticular Cloud is a signpost in the sky that Indicates Mountain Wave Activity

Extreme turbulence can exist

Image Courtesy of UCAR
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Turbulent Clouds

Mountain Wave Clouds

Lenticular Cloud is a signpost in the sky that indicates Mountain Wave Activity.

Watch for rotor clouds near the ground.

Cross barrier flow and strong winds (<30 knots).

Image Courtesy of UCAR/Comet
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Turbulent Clouds

Kelvin-Helmholtz Wave Clouds

KH clouds also indicate Severe Wind Shear

Usually less than 2 miles

Develop in stable environments with balance of wind shear and stability

Use Caution!

Kelvin-Helmholtz breaking wave cloud over Laramie, Wyoming; Photo by Brooks Martner
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Turbulent Clouds

Alto-cumulus Castellanus (ACCAS)

Indicate Instability

Should Expect light to moderate turbulence

Often a pre-cursor to thunderstorm activity

ACCAS Clouds
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Turbulent Clouds

Cirrus Fall Streaks

Indicate Strong Winds Aloft

May Encounter Turbulence near this altitude

Usually well into the Flight Levels, FL180 and above

Cirrus with evaporating ice crystals; Photo by Ronald L. Holle, Univ. of Illinois Cloud Catalog
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Turbulent Clouds

Volcanic Clouds

Indicate Volcanic Eruption

Should Avoid Low Visibilities, Problematic for jet engines

Eyjafjallajökull glacier in Iceland, Wednesday April 14; Xinhua/Reuters
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Convective Clouds

CAT Clouds

Region with no cumuloform clouds

Most likely in the upper atmosphere near tropopause

Cirrus can indicate potential for CAT
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Convective Clouds

CAT Clouds

Region with no cumuloform clouds

Most likely in the upper atmosphere near tropopause

Cirrus can indicate potential

Cirrus will often develop along the axis of stronger upper level winds; RUC80 model with streamlines and water vapor satellite imagery.
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Questions?
Thank You…

Please Fly Safely!