Weather Gone Wild

Monday, March 21, 2016 | 2:00 p.m. – 3:00 p.m.

PRESENTED BY:
Mike Wittman / Session Coordinator
Elizabeth Krajewski / Speaker
Rich Nath / Speaker
Aviation Weather – and the IOC

Focus on safety and related factors

- Odds are much higher – just because
- Knowledge and planning
- Resources and tools
Tornados are most common in mid-latitudes

Audience Question

Where are 80% of the worlds tornados found?
A. Over water
B. In warm moist tropical air masses
C. In Canada and the USA
D. In the Southern Hemisphere

Source: The Weather Channel
Weather Gone Wild

Monday, 21 March | 2:00 p.m. – 3:00 p.m.

PRESENTED BY:
Elizabeth Krajewski

International Operators Conference | San Diego, CA | March 21 – 24, 2016
Agenda

• Why do I care about turbulence?
• Convective Induced Turbulence
• The Jet Stream
• Identifying Clear Air Turbulence
Turbulence incidents cost millions of dollars in crew and passenger injuries, maintenance costs and lost revenue. Plus, it just makes passengers uncomfortable.
What is Turbulence?

- Clear-air Turbulence (CAT)
- Mountain wave Turbulence (MWT)
- Cloud-induced or Convectively-induced Turbulence (CIT)
- In-cloud turbulence
- Low level Terrain-induced Turbulence (LLT)
- Convective boundary Layer turbulence
Convection

What are the three ingredients for thunderstorm formation?

A. High Dew Point, Heat, Lifting Mechanism
B. Wind Shear, Cold Front, Moisture
C. Moisture, Instability, Lifting Mechanism
D. Heat, Instability, Wind Shear
Surface Features and ITCZ

Sources: The Comet Program
Surface Features and ITCZ

Sources: The Comet Program
Monsoons

Sources: The Comet Program
Jetstreams

On upper-tropospheric synoptic charts, jetstreams are identified where the wind speed equals or exceeds…

A. 50 knots
B. 75 knots
C. 100 knots
D. 25 knots
The main jet is often called the polar jet because it forms above the polar frontal zone. Cold air lies to the north of the jet.

The southern branch of the jet is called the sub-tropical jet. When there is an active sub-tropical jet, the air to the north of it is usually “mild” or “cool” and the air to the south is warm and humid.

When deep troughs and ridges exist, we call the jet stream pattern meridional.

A flat jet stream flow is termed zonal. Weather systems tend to be weaker and faster moving in zonal flow.
Jetstreams
Summer

Sources: esrl.noaa.gov
Jetstreams

Winter

Sources: esrl.noaa.gov
Jet Streams

Profile of Jet Core

- Jet core near tropopause
- Greatest horizontal shear zones above and on cold side of the core
- Strong horizontal wind shear (25kts or greater per 100 miles), mostly found on the pole-ward side of the jet core.
- Strong vertical wind shear (6kts or greater shear per 1,000 feet), mostly above the jet core.
Split/Divergent Flow

- Turbulence found from the split outward in a conical shape
- Not unusual to find moderate or even severe turbulence in these zones
- Also favorite place for thunderstorm development
Anticyclonic Curvature

- Turbulence intensity depends upon the sharpness of the curvature plus the velocity of the winds
- Rough air usually along and north of the anticyclonic jet core
Converging Jet Streams

- As with split flow, the turbulent area is general in a conical area from the convergence point outwards.
- Tends to be more moderate turbulence and less severe than with split flow situations.
A strong jet can be located by the sharp, well defined pole ward cloud edge of an associated cirrus cloud shield.

The stronger the jet, the better defined the edge and the less ambiguity in interpretation.

Turbulence is usually within 3° latitude of the cloud or moisture edge.

Transverse bands and billows indicate the presence of strong vertical and possibly horizontal wind shears and turbulence.
Shear-induced waves and vortices

- Need a stable layer above shear zone
- Transverse cloud banding and swirls

Clear Air Turbulence
24 Nov 95 - GOES Vis

Transverse Bands

Billows

Moderate

Mod. Severe
Satellite Imagery

Water Vapor

- Important guide to the presence and position of a jet stream axis when clouds are absent particularly over areas devoid of information such as the oceans.

- A dark zone which parallels the jet axis often appears. Darkening with time of water vapor imagery with a sharp leading edge of moisture is a good CAT indicator in the tropics within 25E of the equator.

- Since water vapor imagery helps to locate and diagnose upper level circulation features such as wind maxima, circulation centers and deformation zones in the absence of cirrus clouds it is a useful tool for identifying such areas of potential turbulence.
Deformation Zone Turbulence

- Look for “darkening” or drying with time
Transverse bands

- If wave clouds develop a more conical, carrot-like shape often the associated turbulence is more severe.
Deformation Zone

- Turbulence mainly between the feature and the edge of the darkened area
Transverse Cirrus Bands
Water Vapor Dry Slot
SIGWX Chart
Upper Level Wind Chart

Sources: pilotbrief.com
Graphical Turbulence Guidance

Sources: aviationweather.gov
Global Turbulence Algorithms

Sources: pilotbrief.com
Summary

• Converging wind in ITCZ make it favorable for Convective Induced Turbulence
• Jetstream stronger in winter, and related to greater risk of CAT
• Use upper level wind charts (200mb) to find help identify turbulence patterns
• Look for signature in satellite data
Significant Aviation Weather

Monday, 21 March | 2:00 p.m. – 3:00 p.m.

PRESENTED BY:
Rich Nath
Significant Aviation Weather

Overview

• Going to cover phenomena that can potentially be causes of dangerous situations.
  – Lightning
  – Dust storms / Sandstorms
  – Low Level Wind Shear (LLWS)
  – Icing
Significant Aviation Weather

Polling Question 1

How many pilots in the room have experienced a lightning strike?

A. Yes
B. No

Lightning
Significant Aviation Weather

Lightning

• Lightning – Any visible atmospheric electrical discharge.
• Caused by separation of charges within the cloud.
  – Typically a CB, but also observed in volcanic eruption ash clouds.
• Can occur:
  – Within a cloud.
  – Cloud-cloud.
  – Cloud-ground.
  – Even between CB and clear air around the storm.
• 5 to 10 times more cloud-cloud strikes than cloud-ground.
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Lightning – Strike Effects

• Multiple adverse effects from a lightning strike.
  – Most are minor, but some can be significant or severe.

• Temporary Blindness
  – Happens mostly at night or when the sun is obscured.
  – Could result in both pilots being impaired for significant time.

• Structural Damage
  – Small holes in fuselage.
  – Any parts that extends out from the fuselage are more susceptible.
    • Antenna damage.
      – Limited or loss of comms and/or nav equipment.
    • Pitot tube damage.
      – False airspeed indications.
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Lightning – Strike Effects (cont.)

• Electrical System Interference
  – Damage to the electrical system(s) is worse than visible damage.
  – More and more fly-by-wire systems versus mechanical ones.
  – A lightning strike can cause interruptions in these systems.
  – Errors in the output from instruments, avionics, radar, and nav systems.
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Lightning

The fuselage acts as a Faraday Cage and generally allows the lightning to pass through it without too much damage, but the entrance and exit holes have to be fixed. I was in an EP-3E that was struck by lighting while circumnavigating some thunderstorms. It entered the radome on the nose and exited at the right side HF antenna, causing the antenna to come off the airplane. We had a GIV struck in a similar manner and the FA said it looked like a blue light ball came through the cabin along the overhead. That airplane was down for a week to repair the two holes in the fuselage and winglet and for Gulfstream to perform the mandatory inspections.

Chris Strand
G550 & BBJ Captain and Former EP3E Naval Flight Officer
Significant Aviation Weather

Lightning

We have been struck by lightning before as well. We didn't notice anything abnormal in the cockpit. We found the evidence when we landed and had to do an inspection per the manufacturer.

G550 Captain
Significant Aviation Weather

Lightning Strike Example

• A320 during approach into Barcelona, Spain (LEBL).
• Several CBs in vicinity of the airport.
• Arrival brings the aircraft into one of the storms…

• Video courtesy of YouTube: https://youtu.be/xM-MQdQKIQU
Significant Aviation Weather

Polling Question 2

How many pilots in the room have experienced a dust storm or sandstorm during take-off or arrival?

A. Yes
B. No Dust Storms / Sandstorms
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Dust Storms / Sandstorms

• Can be referred to as Haboobs (Arabic for strong wind).²
• Dust storms – Can occur anywhere the soil is dry, often when drought conditions are present.
• Sandstorms – Only occur where there is actual sand in the air, so confined to desert regions and surroundings.
• True sandstorms will not get as high into the atmosphere as dust storms, since sand is heavier.²
Significant Aviation Weather
Dust Storms / Sandstorms (cont.)

• Both are caused by high winds.
• These are required to mix the particles into the air, keep it there for a significant time, and push it downwind. ²
• Atmospheric instability plays a role, too, as more vertical mixing can take the particles to greater heights. ²
• Common areas of dust storms/sand storms include the U.S. desert southwest, Saharan Africa, and the Arabian Peninsula.
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Dust Storms / Sandstorms (cont.)

- Can be caused by large, synoptic scale storms or more local, mesoscale/macroscale storms.²

- While difficult to predict, dust storms/sandstorms caused by synoptic factors have a higher probability to be forecasted verses those caused by convective, mesoscale/macroscale factors.

- High northwest winds over Saudi Arabia tend to cause sandstorms over a wide spread area of the western Persian Gulf.
  - Can affect hundreds or even thousands of square miles.

- A thunderstorm in southwest Arizona may cause a dust storm over Phoenix as the dry outflow boundary pushes to the northeast.
  - Typically affect a local area on the scale of a few square miles.
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Dust Storms / Sandstorms – Effects

• Reduced visibility.
  – Can drop from unrestricted to less than 1/4 mile in minutes.\(^2\)
• “Wall of air” leads to a loss of forward movement or lift.\(^2\)
  – Relatively light winds give way to 30-40 kt gusts almost instantaneously.\(^2\)
• Aircraft damage:
  – Engine issues (intake of loose particles).
  – Windscreen damage causing a loss of visibility.
  – Fuselage/leading edge surface damage.
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Dust Storms / Sandstorms

The basic premise (with sand) is to 1) protect the airplane if it has to sit outside and 2) avoid drawing sand into the engines during taxi, takeoff, and landing. High power settings in the BBJ (or any jet) cause low pressure in the fan inlet and can lead to sucking up water, sand, etc. into the intake. Water is ok; sand is not. In most jets you also don’t want to use a lot of reverse thrust on landing because that throws the sand forward, right around the fan inlet; again, sand is bad.

Chris Strand
G550 & BBJ Captain and former Naval Flight Officer
Significant Aviation Weather

Dust Storms / Sandstorms

With regards to Sand Storms, We have cancelled flights into Africa due to Sandstorms and proceeded with the rest of our trip. EVS can be very useful in case you are faced with a low approach due to a Sand/Dust Storm. Normally we try to avoid this type of weather. Visibility can be down to zero with strong winds. Unlike fog which normally has very little wind.

G550 Captain
Significant Aviation Weather

Landing in a Sandstorm Example

• Would you like to try what this pilot had to do?

• Video courtesy of YouTube: https://youtu.be/DvMqMIG81gw
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Polling Question 3

How many pilots in the room have experienced low level wind shear?

A. Yes
B. No

Low Level Wind Shear
Significant Aviation Weather
Low Level Wind Shear (LLWS)

• Wind shear is defined as a change in speed or direction over a given distance.
• LLWS is wind shear from the ground up to 2000 feet AGL. ³
• LLWS can be caused by both convective and non-convective phenomena.⁴
  – Convective example – Thunderstorm
  – Non-convective example – Frontal passage
Microburst

Storm motion →

Cold air

Downflow

Vortex circulation

Winds speeds can exceed 80 mph

Impact on the ground

Speed & Directional Shear Example

Courtesy NWS – Birmingham, AL Office
 Significant Aviation Weather
Low Level Wind Shear (cont.)

• Direction changes over a given distance causes the actual shear to be greater than what the speed shear alone would be.\(^4\)

Credit: Aviation Weather
Significant Aviation Weather
Low Level Wind Shear (cont.)

- Non-convective LLWS forecasts can be found in TAFs when applicable.\(^3\)

TAF
KPUB 181122Z 1812/1912 13012KT 5SM -RA SCT010 OVC035 **WS020/27055KT**
FM181400 32010KT PS6M FEW008 BKN045

- **WS** – Indicated non-convective wind shear
- **020** – Top of the shear layer, in this case 2000 feet. Floor of the layer is the ground.
- **270** – Wind direction at the top of the shear layer.
- **55** – Speed of the wind at the top of the shear layer.
- **KT** – Speed unit, in this case, knots.

- In this example, the wind shear is a prevailing condition from 18/1200Z through 18/1400Z, up to 2000 feet with a westerly 55 kt wind at the top of the layer.
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LLWS – Effects

• Landing
  – Sudden wind speed and/or directional changes will affect airspeed and lift
    • Results are possible undershoot or overshoot of the runway.\(^4\)
• Take-off
  – Sudden wind speed and/or directional changes will affect angle and rate of climb.\(^4\)
• If a crosswind component is present, could be moved off centerline.\(^4\)
• Obstacles that normally would not be concerns may now be difficult, if not impossible, to avoid.\(^4\)
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LLWS Example

• This aircraft was making an initial landing attempt at EGBB – Birmingham, UK.

• Video courtesy of YouTube: https://youtu.be/l3SDtn3w_rc
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Polling Question 4

How many pilots in the room have experienced ice accretions?

A. Yes
B. No

Icing
Significant Aviation Weather

Icing

• In aviation, icing is any deposit or coating of ice on the airframe, including frost.

• Two main categories:
  – Structural Icing – Accumulation of ice on the exterior of the aircraft.\(^4\)
  – Induction Icing – Icing that affects the powerplant by accumulating on the air intakes.\(^4\)

• Causes of Structural Icing:
  – Passing through rain drops or a cloud with supercooled liquid water droplets when the aircraft skin is at or below 0°C and the air temp is between 2°C and -10°C.\(^5\)

• Causes of Induction Icing:
  – As air moves through the intakes it is adiabatically cooled. If there is enough moisture in the air and it is cooled to a temp at or below 0°C, the water vapor will condense into droplets which will then freeze to the intakes.\(^4\)
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Icing – Types

• Clear Ice (aka Glaze Ice)$^5$
  – Sometimes clear and smooth, but usually a lumpy translucent appearance.
  – Supercooled drops/droplets striking the surface but do not freeze rapidly on contact.
  – Denser, harder, and sometimes more transparent than rime ice.
  – With larger accretions, the ice shape typically includes “horns” protruding from unprotected leading edge surfaces.
  – “Clear” and “glaze” basically are interchangeable terms, but some reserve “clear” for thinner accretions which are smoother and conform to the airfoil.
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Icing – Types (cont.)

- **Rime**
  - Rough, milky, opaque ice formed by supercooled drops/droplets rapidly freezing on the airframe.
  - Rapid freezing traps air, resulting in opaque appearance. It also makes the ice porous and brittle.
  - Typically accretes along the stagnation line of an airfoil, thus resulting in a more regular shape conforming to the airfoil than clear ice.

- **Mixed**
  - Simultaneous appearance or a combination of rime and clear ice characteristics.

- Best way to differentiate between the types from the cockpit is by shape.

- Determining mixed ice is the hardest since it combines the two.
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Icing – Effects

• Structural icing leads to the following\(^4\):
  – Distortion of the lifting surface aerodynamic shapes.
  – Increase in weight and drag.
  – Decrease in lift.
  – Operation of control surfaces and/or landing gear could be compromised due to heavy icing.
  – Surface damage from ice breaking loose.
  – Unreliable readings (airspeed, altitude, etc).
  – Radio interference.

• Induction icing leads to the following\(^4\):
  – Loss of power.
  – Stall speed increase.
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Icing

The worst icing I have ever experienced was in China in a G5. It didn't turn out to be a huge deal because we were landing and weren't in it for too long. We built up ice in places I've never seen a Gulfstream build up ice. The lesson learned there was that when you are in foreign airspace, most of the time they will not warn you of adverse weather conditions like in the U.S. Example: Severe Icing. They don't give PIREPs like in the U.S.

G550 Captain
Significant Aviation Weather

Summary

• Lightning, dust storms/sandstorms, LLWS, and icing can cause significant concern to flight crews.
• Ensure to have an updated weather brief for each flight.
• If any doubt of what could be encountered, ensure to consult your weather provider.
Sources


Significant Aviation Weather

Contact Info

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solution to address this issue.
To view images, select a Model Area and Model Type.

We are experiencing spikes in traffic that are leading to delays in downloading images from this site, especially when accessing the GFS model data. We appreciate your patience as we implement a solution to address this issue.
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**Loop All**
Weather tools pilots can use

Weather information for the world airspace system
http://www.aviationweather.gov/

Worldwide weather models Surface to Top of Trop
http://mag.ncep.noaa.gov/

Aviation weather for pilots including your custom design
http://www.aviationweather.gov/adds/
Thank You!

Q & A

Mike Wittman

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