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Flight Safety News Letter

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In Focus

Turbulence due to Climate change

Our skies are getting bumpier, making the need to understand and predict turbulence increasingly urgent. Researchers propose birds could provide clues.

When you look up, the sky may seem calm – still even – but air is always on the move. Fluid, it flows like water, with eddies and currents, sometimes smooth and serene, sometimes tumultuous and violent. Turbulence is one of the most unpredictable of all weather phenomena. And research shows that severe turbulence is becoming more likely as the planet warms.

If an aircraft strikes it, the most turbulent air can cause injuries or even death, as well as structural damage to planes. On Tuesday, a Singapore Airlines flight from London encountered severe turbulence: 31 people were injured, and one died. Passengers aboard the Boeing 777-300ER told the BBC the plane began to tilt and shake, before dropping suddenly, and "people and objects were thrown around the cabin".

Could there be better ways to predict and cope with turbulence? Some researchers believe that answers lie in the animal world.

Birds often encounter choppy skies. While only a few species reach the height of a cruising commercial aircraft, studying how they respond at lower altitudes could help meteorologists build better models to predict turbulence, says Emily Shepard, an expert in bird flight and air flow at Swansea University in Wales. And that's not all we could learn from our avian friends: some species have adapted to deal with "extreme turbulence", she says. Analysing how they exploit it to their advantage could inform aircraft design, especially in urban environments where smaller aircraft and unmanned aerial vehicles (UAVs) could fly.

In Focus

Turbulence due to Climate change

According to a 2024 study, aircrafts encounter moderate to "severe-or-greater" turbulence 68,000 times every year. Turbulence is defined as "an irregular motion of the air" caused by eddies and vertical currents, and is associated with weather events such as fronts, wind shear and thunderstorms. Turbulence can cause a few uncomfortable bumps – or throw an aircraft out of control, inducing "chaotic rolls, pitches and yaws".

Modern aircraft are equipped with sophisticated weather radar systems that pilots use to identify and navigate around areas of turbulence. "We can successfully predict around 75% of turbulence up to 18 hours ahead," says Paul Williams, an atmospheric scientist at the University of Reading.

However, there are many types of turbulence – and some can be harder to spot. The severe turbulence that struck the Singapore Airlines flight is often caused by invisible "clear air turbulence". This can strike without warning, and is one of the biggest causes of weather-related aviation accidents.

Clear air turbulence occurs at high altitudes, where aircraft cruise in seemingly calm blue skies. It can't be seen by the naked eye and is undetectable by onboard sensors. Even satellites can't see this kind of turbulence, only the structure and shape of the jet stream which may hint at its presence. Pilots often have to rely on any aircraft flying the same path ahead of them of them to report clear air turbulence, so they can adjust their path.

Climate change is making clear air turbulence more common, says Williams, who has studied the rise. "In simple terms, climate change is increasing the temperature difference between the warm and cold air masses that collide to form the jet stream in the upper atmosphere," he says. "This effect is making the jet stream less stable and allowing more turbulence to break out."

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Meteorologists are now seeking to develop better methods of forecasting all types of turbulence, using computer modelling. However, one source of data that's gone untapped until recently are the creatures we share the skies with: birds. Previous studies have shown that animal movements can help us determine the strength of thermal updrafts, wind direction and wind speed.

Now researchers from Swansea University say birds' experience of the winds could help provide predictions of turbulence. Birds often migrate for thousands of miles – with wind speed, direction and turbulence all dictating the route they travel and the amount of energy they have to expend. And when you're running on reserves at the end of an epic trip half way around the world, catching the wrong winds can mean the difference between life and death.

While most species don't fly alongside cruising commercial jets, some get extremely high. Take frigate birds, for example. Their flight is a "roller-coaster", says Shepard. They rely on thermals and wind to stay aloft for months one end and can fly at extreme altitudes, as high as 13,000ft (4km/2.5 miles) above the ground. To reach this great height, they often catch strong updrafts in mountainous cumulus clouds.

"They gain altitude within these really, really turbulent cloud systems," says Shepard. "You get monstrous updrafts and downdrafts. They are operating in incredibly turbulent environments – and we know so little about how they are able to maintain flight control. "By studying how such birds respond to turbulence, Shepard and her colleaues at Swansea University's Laboratory for Animal Movement aim to "visualise the invisible", and to map what the air is doing.

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The Swansea University research suggests the possibility of using bird-borne sensors to shed light on air turbulence, much like the seal-borne sensors used to measure salinity and sea temperature.
"People are already equipping animals with tags for lots of different reasons and in lots of different environments," says Shepard. "They're effectively sampling in the environment all the time."

Birds could act as meteorological sensors on the move, she says, continuously collecting data about the turbulence they're experiencing along their flight paths. This, she adds, would be cheaper than using sensors fitted to aircraft, plus birds can fly in conditions that planes can't.

In another 2020 study, Shepard and her colleagues followed the flight of Andean condors, the world's heaviest soaring birds. They documented when and how individuals gained altitude, and recorded each and every wingbeat.

The data revealed the lowest levels of flapping flight recorded for any free-ranging bird, with the condors spending an incredible 99% of all flight time in glide-mode – without flapping at all. One bird even remained airborne for more than five hours – covering over 170km (100 miles) – without a single flap. This research provides insight into the way soaring birds exploit thermals, knowledge which could potentially feed into the programming of autonomous flying vehicles.

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Sometimes that even involves flying alongside the birds. From 2018 to 2019, Shepard's team flew an ultralight aircraft alongside a flock of homing pigeons. Using GPS, barometric pressure and acceleration data loggers attached to the birds – over 88 flights – they measured the turbulence levels during the journeys the birds took to return to their lofts.

"You're pretty exposed up there," says Shepard. "You're open to the elements. It's a very direct experience." The team flew in a variety of conditions; early morning when there was little ground heat to cause bumpy convective currents, later in the day when the thermals were stronger, and at different times of year.

"There were several occasions when the pilot was forced to land or decided he wasn't going to fly again that morning, because the turbulence was so strong and it was affecting his ability to maintain flight control. It was too bumpy for him," says Shepard. "But the pigeons returned to the loft with no problem. So, pigeons can deal with high levels of turbulence – more so than the ultralight. They clearly have mechanisms of coping with this turbulence."

How Inter Tropical Convergence Zone (ITCZ) affect the flight

Definition:-The Inter Tropical Convergence Zone, or ITCZ, is a belt of low pressure which circles the Earth generally near the equator where the trade winds of the Northern and Southern Hemispheres come together. It is characterised by convective activity which generates often vigorous thunderstorms over large areas. It is most active over continental land masses by day and relatively less active over the oceans.

Description:- The position of the ITCZ varies with the seasons, and lags behind the sun's relative position above the Earth's surface by about 1 to 2 months, and correlates generally to the thermal equator. Since water has a higher heat capacity than land (the ocean heats up more slowly than the land), the ITCZ propagates poleward more prominently over land than over water, and over the Northern Hemisphere than over the Southern Hemisphere. In July and August, over the Atlantic and Pacific, the ITCZ is between 5 and 15 degrees north of the Equator, but further north over the land masses of Africa and Asia. In eastern Asia, the ITCZ may propagate up to 30 degrees north of the Equator. In January, over the Atlantic, the ITCZ generally sits no further south than the Equator, but extends much further south over South America, Southern Africa, and Australia. Over land, the ITCZ tends to follow the sun's zenith point.

How Inter Tropical Convergence Zone (ITCZ) affect the flight

Threats to Flight Safety:- Aircraft flying through an active ITCZ (strong trade winds) will probably encounter some or all of the hazards associated with Cb clouds such as icing, turbulence, lightning, and wind shear. However, it is in this zone that the most severe effects may often be encountered. In particular, it is within the ITCZ that convective breakthroughs of the tropopause often occur, with the majority occurring over land, especially in the second half of each day. Convective penetration of the tropopause is less common over oceanic areas where the phenomenon is more likely to occur in the early hours of each day, generating more isolated cells. Research sponsored by National Aeronautics and Space Administration has shown that 1% of tropical deep convective activity exceeds 46,000 ft. altitude, with a small proportion of this reaching much greater heights. For further information on the potential hazards of transit through or near Cb cloud, see the article Cumulonimbus (Cb).

Even at the altitudes flown by modern jet air transport aircraft, it is likely that minor adjustments to route will be required to avoid either passing through or above significant convective build-ups. Turboprop aircraft are unlikley to be able to climb over such convection activity and weather avoidance actions can take aircraft significantly off track. It is therefore prudent to carry additional contingency fuel forweather avoidance and icing.

How Clear Air Turbulence (CAT) affect the flight

Definition:-

Clear Air Turbulence (CAT) is defined as sudden severe turbulence occurring in cloudless regions that causes violent buffeting of aircraft. CAT is a higher altitude turbulence (normally above 15,000 ft.) particularly between the core of a jet stream and the surrounding air. This includes turbulence in cirrus clouds, within and in the vicinity of standing lenticular clouds and, in some cases, in clear air in the vicinity of thunderstorms. Generally, though, CAT definitions exclude turbulence caused by thunderstorms, low-altitude temperature inversions, thermals, strong surface winds, or local terrain features.

Description:-

There are two types of CAT:

(i) Mechanical- Disruption to the smooth horizontal flow of air.

(ii) Thermal- Turbulence caused by vertical currents of air in an unstable atmosphere.

Common causes and sources of CAT are:

(i) Jet Stream- A Jet Stream is a narrow, fast moving current of air, normally close to the Tropopause and generated as a result of the temperature gradient between air masses. Although not all jet streams have CAT associated with them, there can be significant vertical and

How Clear Air Turbulence (CAT) affect the flight

horizontal Wind Shear on the edges of the jet stream giving rise to sometimes severe clear air turbulence. Any CAT is strongest on the cold side of the jet stream where the wind shear is greatest. In the vicinity of a jet stream, CAT can be encountered anywhere from 7,000 feet below to about 3,000 feet above the tropopause. Because the strong vertical and horizontal wind shear occurs over short distances, this jet stream related CAT tends to be shallow and patchy so a descent or climb of as little as 2,000 feet is often enough to exit the turbulence.

(ii) Terrain- High ground disturbs the horizontal flow of air over it, causing turbulence. The severity of the turbulence depends on the strength of the air flow, the roughness of the terrain, the rate of change and curvature of contours, and the elevation of the high ground above surrounding terrain. For further information, refer to the article entitled Mountain Waves.

(iii) Thunderstorm Complexes- Cumulonimbus (Cb) cells have strong vertical currents. Aircraft passing within 20 nautical miles horizontally, or less than 5,000 feet above the top, of a Cb may encounter CAT.

How Clear Air Turbulence (CAT) affect the flight

Effects:-

(i) Structural Damage. Aircraft can suffer structural damage as a result of encountering severe clear air turbulence. In extreme cases this can lead to the break-up of the aircraft. In even moderate turbulence, damage can occur to fittings within the aircraft, especially as a result of collision with unrestrained items of cargo or passenger luggage. Prolonged exposure to turbulence will shorten the fatigue life of the aircraft.

(ii) Physical Injury to Crew/Passengers. If caught unaware, passengers and crew moving around in the aircraft cabin can be injured. In one case, where a B747 encountered CAT over the Pacific ocean, several passengers and crew were severely injured and one passenger subsequently died.

(iii) Impaired Flight Crew Performance. Moderate or Severe turbulence can make simple tasks, including reading instruments, near impossible.

How Clear Air Turbulence (CAT) affect the flight

Defences:-

(i) Awareness. SIGMET charts give forecasts of the location and level of clear air turbulence. Information on local terrain induced CAT may be contained in appropriate Aeronautical Information Publications (AIPs) e.g. Approach plates for Gibraltar contain information on turbulence to be expected for given wind directions.

(ii) Restraint Systems. Passengers and crew should fit seat belts and harnesses when seated to protect them in the event of unforeseen turbulence.

Scenarios:-

An aircraft descending for an approach into Milan encounters moderate turbulence associated with a southerly airflow over the Alps. A member of the cabin crew checking the security of the cabin falls breaking an arm.

How Clear Air Turbulence (CAT) affect the flight

Solutions:-

- **Slow down-** Reducing the aircraft speed reduces the risk of structural damage and reduces vibration making instruments easier to read.
- **Strap in-** Notify the crew/illuminate seat belt sign. All passengers and crew should immediately sit down and fit seat belts/harnesses.
- **Switch on Engine Ignition** - Certain aircraft types recommend turning ignition on to prevent the turbulent airflow from flaming out engines.
- **Inform ATC-** Notify ATC/warn other aircraft on chat or guard/emergency frequency (121.5 or 243.0). Request clearance to climb/descend or diverge from track to escape turbulence.
- **Assess Damage/Injuries-** Carry out a damage assessment and ascertain condition of any injured passengers. Consider precautionary diversion.
- **Suspend Cabin Service-** Obviously the serving of hot drinks and meals during turbulent conditions puts both cabin crew and passengers at risk.

Case Study

Turbulence Hits Qatar Airways & Singapore Airlines

12 people have been injured due to turbulence on a flight from **Doha to Dublin** dated 26 May 2024**.**

The Boeing 787-9 dreamliner experienced turbulence while airborne over Turkey, Dublin Airport's operator DAA said. Upon landing shortly before 13:00 local time, Qatar Airways flight QR017 was met by emergency services including airport police, ambulance and fire officers.

06 passengers and 06 crew members reported injuries - of these, eight people have been taken to hospital. Ireland's National Ambulance Service said it received a pre-alert to attend the airport and was "on site facilitating and supporting the disembarkment of passengers". Dublin Fire Brigade staff and emergency vehicles also attended.

A DAA spokesperson said: "The Dublin Airport team continues to provide full assistance on the ground to passengers and airline staff.“

Case Study

Turbulence Hits Qatar Airways & Singapore Airlines

Passengers described the incident as frightening:-

- They said the plane seemed to drop out of the air for about five seconds during food-and-drinks service.
- One passenger, named Cathal, who was travelling home to Ireland from Doha, told Irish broadcaster that the seatbelt signs were off during the incident and that his dinner had come off his lap.
- "Just food all over the plane, on the ceiling, everywhere," he said.
- Another, Paul Mocc, said he saw people hitting the roof of the aircraft.
- "I had my seatbelt on at the time, but they were serving food at the time so a lot of the crew were injured."
- Mr. Mocc added that he saw crew members limping after the incident, some with bandages on, but said that they continued to serve passengers.
- He also described seeing one passenger on oxygen with suspected back injuries who had been placed lying down across a number of seats.
- Emma Rose Power and Conor Buckley were travelling back to Dublin from Thailand when they were caught up in the incident.
- Mr. Buckley said he felt the plane drop and a flight attendant went "up in the air".
- Ms. Power said she was asleep when the plane hit turbulence but described seeing a "look of panic on everyone's faces" when she was woken.
- She added that flight attendants had scratches on their faces and one had their arm in a sling afterwards.

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Case Study

Turbulence Hits Qatar Airways & Singapore Airlines

Worst experience flying:-

- Another passenger, Eileen, said it was the "worst experience" she ever had on a plane.
- Her partner Tony said he had to hold her down as she had not been wearing her seatbelt and she had been asleep when the aircraft hit turbulence.
- "I am not in a hurry to get back on a plane I can tell you," Eileen said.
- Qatar Airways has given a statement that "a small number of passengers and crew sustained minor injuries in flight and are now receiving medical attention".

Overall operations at Dublin Airport were unaffected, DAA said. It said the return flight to Doha was scheduled to operate as normal on Sunday afternoon, "albeit with a delay".
The incident follows the death of a 73-year-old British man on a Singapore-bound flight which experienced severe turbulence earlier this week.

More than 100 people were injured, 20 of whom are in intensive care with spinal injuries.

Singapore Airlines CEO Goh Choon Phong apologised, offering his “deepest apologies to everyone affected” by the “sudden extreme turbulence”. Singapore's government has promised a thorough investigation.

Upcoming Event

Pilot Engineer Interactive Meet Planned in July 2024

Meeting and Engagement

SRBM (Safety Review Board Meeting)
Conducted on 15th May 2024

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Our Fleet

ATR 72-600

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Azadi Ka Amrit Mahotsav

सादर/ Regards,

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उड़ान संरक्षा प्रमुख / Chief of Flight Safety, Head-ERP
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Flight Safety Department, AAAL